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Technical Report

Oyu Tolgoi 2020 Technical Report

Turquoise Hill Resources Ltd.

Ömnögovi Aimag, Mongolia

Prepared in accordance with the requirements of National Instrument 43-101 "Standards of Disclosure for Mineral Projects" of the Canadian Securities Administrators

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AMC Project 320006

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Important Notice

As set out in General Guidance (3) in the Companion Policy 43-101CP to NI 43-101 - Standards of Disclosure for Mineral Projects, a mining issuer must comply with the requirements of Part 4A of NI 51-102, including identifying forward-looking information.

Certain statements made in this technical report, including statements relating to matters that are not historical facts and statements of beliefs, intentions and expectations about developments, results and events which will or may occur in the future, constitute "forward-looking information" within the meaning of applicable Canadian securities legislation and "forward-looking statements" within the meaning of the "safe harbor" provisions of the United States Private Securities Litigation Reform Act of 1995. Forward-looking statements and information relate to future events or future performance, reflect current expectations or beliefs regarding future events and are typically identified by words such as "anticipate", "could", "should", "expect", "seek", "may", "intend", "likely", "plan", "estimate", "will", "believe" and similar expressions suggesting future outcomes or statements regarding an outlook.

These include, but are not limited to, statements and information regarding: economic analyses; cost reporting, operating costs and capital expenditures; development plans for processing reserves; projected recovery rates; the generation of cash flows; matters relating to exploration and expansion; project schedule; communications with local stakeholders and community relations; negotiation and completion of transactions; commodity prices; exchange rates; mineral resources, mineral reserves, realization of mineral reserves; the development approach including concepts for developing Oyu Tolgoi Mineral Resources; the timing and amount of future production; liquidity, funding sources, funding requirements and planning; timing of studies, announcements and analyses; timing and status of underground development; the mine design for Panel 0 of Hugo North Lift 1 and the related cost and production schedule implications; the re-design studies for Panels 1 and 2 of Hugo North Lift 1 and the possible outcomes, content and timing thereof; expectations regarding the possible recovery of ore in the two pillars, to the north and south of Panel 0; the possible progression of a state-owned power plant and related amendments to the Power Source Framework Agreement as well as power purchase agreements; the timing of construction and commissioning of the potential state-owned power plant; sources of interim power; the potential impact of COVID-19 on the Turquoise Hill Resources Ltd. (TRQ)'s business, operations and financial condition; economic conditions; exploration plans; anticipated business activities; planned expenditures; corporate strategies and any and all other timing, exploration, development, operational, financial, budgetary, economic, legal, social, regulatory and political matters that may influence or be influenced by future events or conditions and other statements that are not historical facts.

Forward-looking statements and information are made based upon certain assumptions and other important factors that, if untrue, could cause the actual results, performance or achievements of TRQ to be materially different from future results, performance or achievements expressed or implied by such statements or information. There can be no assurance that such statements or information will prove to be accurate. Such statements and information are based on numerous assumptions regarding present and future business strategies, local and global economic conditions, and the environment in which TRQ will operate in the future, including:

- present and future business strategies.
- local and global economic conditions, and the environment in which TRQ will operate in the future.
- the price of copper, gold and silver.
- projected gold, copper and silver grades.
- anticipated capital and operating costs.
- anticipated future production and cash flows.
- anticipated location of certain infrastructure in Hugo North Lift 1.
- sequence of mining within and across panel boundaries.

- the availability and timing of required governmental and other approvals for the construction of the state-owned power plant.
- the ability of the Government of Mongolia to finance and procure the state-owned power plant within the timeframes anticipated in the Power Source Framework Agreement, as amended.
- the willingness of third parties to extend existing power arrangements.
- the status of TRQ's relationship and interaction with the Government of Mongolia on the continued operation and development of the Oyu Tolgoi mine and Oyu Tolgoi LLC internal governance.

Certain important factors that could cause actual results, performance or achievements to differ materially from those in the forward-looking statements and information include, among others: copper, gold and silver price volatility; discrepancies between actual and estimated production; mineral reserves and resources and metallurgical recoveries; development plans for processing resources; the outcome of the definitive estimate review; public health crises such as COVID-19; matters relating to proposed exploration or expansion; mining operational and development risks, including geotechnical risks and ground conditions; litigation risks; regulatory restrictions (including environmental regulatory restrictions and liability); Oyu Tolgoi LLC or the Government of Mongolia's ability to deliver a domestic power source for the Oyu Tolgoi project within the required contractual time frame; communications with local stakeholders and community relations; activities, actions or assessments, including tax assessments, by governmental authorities; events or circumstances (including strikes, blockades or similar events outside of TRQ control) that may affect TRQ's ability to deliver its products in a timely manner; currency fluctuations; the speculative nature of mineral exploration; the global economic climate; dilution; share price volatility; competition; loss of key employees; cyber security incidents; additional funding requirements, including in respect of the development or construction of a long-term domestic power supply for the Oyu Tolgoi project; capital and operating costs, including with respect to the development of additional deposits and processing facilities; and defective title to mineral claims or property. Although each of the qualified persons and TRQ have attempted to identify important factors that could cause actual actions, events or results to differ materially from those described in forward-looking statements and information, there may be other factors that cause actions, events or results not to be as anticipated, estimated or intended. All such forward-looking statements and information are based on certain assumptions and analyses made by each of the qualified persons and TRQ in light of their experience and perception of historical trends, current conditions and expected future developments, as well as other factors management believes are reasonable and appropriate in the circumstances. These statements, however, are subject to a variety of risks and uncertainties and other factors that could cause actual events or results to differ materially from those projected in the forward-looking statements or information.

With respect to specific forward-looking information concerning the continued operation and development of Oyu Tolgoi, each of the qualified persons have based their assumptions and analyses on certain factors which are inherently uncertain. Uncertainties and assumptions include, among others: the timing and cost of the construction and expansion of mining and processing facilities; the timing and availability of a long-term domestic power source (or the availability of financing for TRQ or the Government of Mongolia to construct such a source) for Oyu Tolgoi; the ability to secure and draw down on the supplemental debt under the Oyu Tolgoi project financing facility and the availability of additional financing on terms reasonably acceptable to Oyu Tolgoi LLC, Rio Tinto and TRQ to further develop Oyu Tolgoi; the potential impact of COVID-19; the impact of changes in, changes in interpretation to or changes in enforcement of, laws, regulations and government practices in Mongolia; the availability and cost of skilled labour and transportation; the obtaining of (and the terms and timing of obtaining) necessary environmental and other government approvals, consents and permits; delays, and the costs which would result from delays, in the development of the underground mine (which could significantly exceed the costs projected in this Report); projected copper, gold and silver prices and their market demand; and production estimates and the anticipated yearly production of copper, gold and silver at Oyu Tolgoi.

The cost, timing and complexities of mine construction and development are increased by the remote location of a property such as Oyu Tolgoi. It is common in mining operations and in the development or expansion of existing facilities to experience unexpected problems and delays during development, construction and mine start-up. Additionally, although Oyu Tolgoi has achieved commercial production, there is no assurance that future development activities will result in profitable mining operations.

This technical report also contains references to estimates of mineral reserves and mineral resources. The estimation of reserves and resources is inherently uncertain and involves subjective judgments about many relevant factors. The mineral resource estimates contained in this technical report are exclusive of mineral reserves. Further, mineral resources that are not mineral reserves do not have demonstrated economic viability. The accuracy of any such estimates is a function of the quantity and quality of available data, and of the assumptions made and judgments used in engineering and geological interpretation (including future production from Oyu Tolgoi, the anticipated tonnages and grades that will be achieved or the indicated level of recovery that will be realised), which may prove to be unreliable. There can be no assurance that these estimates will be accurate or that such mineral reserves and mineral resources can be mined or processed profitably. Such estimates are, in large part, based on the following:

- Interpretations of geological data obtained from drill holes and other sampling techniques. Large scale mineral continuity and character of the deposits can be improved with additional drilling and sampling; actual mineralization or formations may be different from those predicted. It may also take many years from the initial phase of drilling before production is possible, and during that time the economic feasibility of exploiting a deposit may change. Reserve and resource estimates are materially dependent on prevailing metal prices and the cost of recovering and processing minerals at the individual mine sites. Market fluctuations in the price of metals or increases in the costs to recover metals or the actual recovery percentage of the metal(s) from TRQ's mining projects may render mining of mineral reserves uneconomic and affect TRQ's operations in a materially adverse manner. Moreover, various short-term operating factors may cause a mining operation to be unprofitable in any particular accounting period.
- Assumptions relating to commodity prices and exchange rates during the expected life of production, mineralization of the area to be mined, the projected cost of mining, and the results of additional planned development work. Actual future production rates and amounts, revenues, taxes, operating expenses, environmental and regulatory compliance expenditures, development expenditures, and recovery rates may vary substantially from those assumed in the estimates. Any significant change in these assumptions, including changes that result from variances between projected and actual results, could result in material downward revision to current estimates.
- Assumptions relating to projected future metal prices. TRQ uses prices reflecting market pricing projections in the financial modeling for Oyu Tolgoi which are subjective in nature. It should be expected that actual prices will be different than the prices used for such modeling (either higher or lower), and the differences could be significant.
- Assumptions relating to the costs and availability of treatment and refining services for the metals mined from Oyu Tolgoi, which require arrangements with third parties and involve the potential for fluctuating costs to transport the metals and fluctuating costs and availability of refining services. These costs can be significantly impacted by a variety of industry specific as well as regional and global economic factors (including, among others, those which affect commodity prices). Many of these factors are beyond the control of TRQ and the qualified persons.

Readers are cautioned not to place undue reliance on forward-looking information or statements. By their nature, forward-looking statements involve numerous assumptions, inherent risks and uncertainties, both general and specific, which contribute to the possibility that the predicted outcomes will not occur. Events or circumstances could cause TRQ's actual results to differ materially from those estimated or projected and expressed in, or implied by, these forward-looking statements. Important factors that could cause actual results to differ from these forward-looking statements are included in the "Risk Factors" section of the 2019 AIF, as supplemented by the "Risks and Uncertainties" section of TRQ's management's discussion and analysis for the three and six months ended June 30, 2020 (Q2 MD&A).

Readers are further cautioned that the list of factors enumerated in the "Risk Factors" section of the 2019 AIF and in the "Risks and Uncertainties" section of the Q2 2020 MD&A that may affect future results is not exhaustive. When relying on forward-looking statements and information to make decisions with respect to TRQ, investors and others should carefully consider the foregoing factors and other uncertainties and potential events. Furthermore, the forward-looking statements and information contained herein are made as of the date of this document and each of the qualified persons and TRQ do not undertake any obligation to update or to revise any of the included forward-looking statements or information, whether as a result of new information, future events or otherwise, except as required by applicable law. The forward-looking statements and information contained herein are expressly qualified by this cautionary statement.

Note to United States investors concerning estimates of Measured, Indicated and Inferred Resources.

This technical report has been prepared in accordance with the requirements of Canadian securities laws, which differ from the requirements of U.S. securities laws. Unless otherwise indicated, all reserve and resource estimates included in this technical report have been prepared in accordance with NI 43 -101, and the Canadian Institute of Mining, Metallurgy and Petroleum Definition Standards for mineral resources and mineral reserves. NI 43-101 is a rule developed by the Canadian Securities Authorities that establishes standards for all public disclosure an issuer makes of scientific and technical information concerning mineral projects. NI 43-101 differs significantly from the disclosure requirements of the Securities Exchange Commission ("SEC") generally applicable to U.S. companies. For example, the terms "Mineral Reserve", "Proven Mineral Reserve", "Probable Mineral Reserve", "Mineral Resource", "Measured Mineral Resource", "Indicated Mineral Resource", and "Inferred Mineral Resource" are defined in NI 43-101. These definitions differ from the definitions in the disclosure requirements promulgated by the SEC. Accordingly, information concerning mineral deposits set forth herein may not be comparable with information made public by companies that report in accordance with SEC disclosure requirements.

Cautionary Note regarding Non- Generally Accepted Accounting Principles Measures

This Technical Report contains certain non-Generally Accepted Accounting Principles (GAAP) measures such as C1 Cash Costs. Such measures have non-standardised meaning under International Financial Reporting Standards and may not be comparable to similar measures used by other issuers. These measures are presented in order to provide investors and other stakeholders with additional understanding of performance and operations at the Oyu Tolgoi mine and are not intended to be used in isolation from, or as a replacement for, measures prepared in accordance with International Financial Reporting Standards. See TRQ's 2020 Q2 MD&A for more information about non-GAAP measures reported by TRQ.

Date and Signature Page

This report entitled Oyu Tolgoi 2020 NI43-101 Technical Report, effective as of 30 June 2020 was prepared and signed by the following authors:

Original document signed and sealed by:

Michael Thomas	"Signed and sealed original on file"	28 August 2020
Michael Thomas, FAusIMM (CP)		Date Signed
Roderick Carlson	"Signed and sealed original on file"	28 August 2020
Roderick Carlson, MAIG (RPGeo - Mining and Exploration)		Date Signed
Jo-Anne Dudley	"Signed and sealed original on file"	28 August 2020
Jo-Anne Dudley, FAusIMM (CP)		Date Signed
Racquel Kolkert	"Signed and sealed original on file"	28 August 2020
Racquel Kolkert, MAusIMM (CP)		Date Signed

1 Summary

1.1 Introduction

The Oyu Tolgoi Property containing the Oyu Tolgoi Project (Oyu Tolgoi or the Project) is located in the South Gobi region of Mongolia, approximately 645 km by road south of the capital, Ulaanbaatar. The Project is being developed by Oyu Tolgoi LLC[1] and consists of a series of deposits containing copper, gold, and silver.

Turquoise Hill Resources Ltd[2] (TRQ) holds a 66% interest in Oyu Tolgoi LLC. The remaining 34% interest is held by the Government of Mongolia through Erdenes Oyu Tolgoi LLC. Oyu Tolgoi is TRQ's principal and only material mineral resource property. Rio Tinto, with other Rio Tinto affiliates, hold a 50.8% majority interest in TRQ, and provide strategic and operational management services and support to Oyu Tolgoi LLC in respect of its operations and activities.

In October 2016, TRQ filed a Technical Report[3] (2016 Technical Report) to provide updated scientific and technical information in respect of Oyu Tolgoi. This Oyu Tolgoi 2020 Technical Report (2020 Technical Report) has been prepared under National Instrument 43-101 – Standards of Disclosure for Mineral Projects (NI 43-101) to provide a further update of the scientific and technical information in respect of the Project.

The mineral deposits at Oyu Tolgoi lie in a structural corridor where mineralization has been discovered over a 26 km strike length. Four deposits hosting Mineral Resources have been identified: Oyut, Hugo North, Hugo South, and Heruga.

Mineral Reserves have been reported at the Oyut and Hugo North Deposits. The Oyut deposit is currently being mined as an open pit using conventional drill, blast, load, and haul methods. The Hugo North deposit is currently being developed as an underground mine using the block caving mining method. A staged approach is envisaged for developing the Hugo North deposit, involving mining two block cave lifts (Lift 1 and potentially Lift 2). Mineral Reserves have been estimated for Lift 1, which comprises three panels (Panel 0, Panel 1, and Panel 2).

This 2020 Technical Report has been filed because updated geotechnical stability modelling from the latest geotechnical information identified several critical stability risks to the first panel to be mined, Panel 0. This has necessitated changes to some aspects of the Panel 0 and Lift 1 design presented in the 2016 Technical Report. The design changes include leaving two 120 m wide pillars, one separating Panel 0 from Panel 1 and a second separating Panel 0 from Panel 2. The redesign has had the effect of reducing the Hugo North Mineral Reserve estimate but has also increased confidence in the projected performance of the planned mining operation.

All forward looking schedules and cost estimates presented in this 2020 Technical Report are subject to any delays arising from the COVID-19 pandemic and are subject to further study and assessment as part of Oyu Tolgoi LLC's cost and schedule estimation update which is expected later in 2020 and subject to further study and analysis on Panels 1 and 2.

1.2 Mining Licences

The Oyu Tolgoi Property comprises five mining licences held by Oyu Tolgoi LLC and Entrée LLC, a subsidiary of Entrée Resources Ltd., formerly known as Entrée Gold Inc. The mining licences provide rights to the holders to explore, develop mining infrastructure, and conduct mining operations at Oyu Tolgoi.

Oyu Tolgoi LLC owns 100% of three licences; MV-006708 (the Manakht licence), MV-006709 (the Oyu Tolgoi licence), and MV-006710 (the Khukh Khad licence) while legal title to MV-015226

[1] formerly known as Ivanhoe Mines Mongolia Inc. LLC

[2] Formally Ivanhoe Mines Ltd., a Canadian entity that later changed its name to Turquoise Hill Resources Ltd.

[3] Turquoise Hill Resources Ltd, October 2016, 2016 Oyu Tolgoi Technical Report

(the Shivee Tolgoi Licence) and MV-015225 (the Javkhlant Licence) is currently held by Entrée LLC, subject to the conditions described below.

Oyu Tolgoi's legal title to the Shivee Tolgoi and Javkhlant licences is subject to the equity participation and earn-in agreement dated 15 October 2004, as amended on 9 November 2004, between Entrée LLC and TRQ (the Earn-In Agreement), which established of a joint venture arrangement between Oyu Tolgoi LLC and Entrée LLC, which provides for Oyu Tolgoi LLC to hold legal title in the licences, subject to the terms of the agreement, and to Oyu Tolgoi LLC meeting prescribed earn-in expenditures. Although a formal joint venture agreement has not been signed, the earn-in requirements have been met. Both the Shivee Tolgoi and Javkhlant licences are planned to be operated by Oyu Tolgoi LLC.

Under the Earn-in Agreement, Oyu Tolgoi LLC's participating interest in the proposed joint venture arrangements (including the licences) consists of:

- 70 percent of the proceeds from mining from the surface to 560 m below the surface; and
- 80 percent of the proceeds from mining from depths below 560 m.

Most of the identified mineralization at Oyu Tolgoi occurs at the Hugo North and Oyut deposits within the Oyu Tolgoi licence (MV006709). The northernmost extension of the Hugo North deposit extends onto the Shivee Tolgoi Licence and is subject to the terms of the Earn-In Agreement.

The three Oyu Tolgoi mining licences have 30-year terms from 23 December 2003, the Shivee Tolgoi Licence and the Javkhlant Licence each have 20-year terms from 27 October 2009. Each of the five mining licences has two 20-year extensions.

1.3 Agreements and permits

The following key agreements relating to the development and operation of the Project have been entered into by TRQ, the Government of Mongolia, and other entities and have an impact on TRQ's interest in, and obligations relating to the Oyu Tolgoi Property:

- Investment Agreement dated 6 October 2009, between the Government of Mongolia, Oyu Tolgoi LLC, TRQ, and Rio Tinto in respect of Oyu Tolgoi (Investment Agreement).
- Amended and Restated Shareholders Agreement (ARSHA) dated 8 June 2011 among Oyu Tolgoi LLC, THR Oyu Tolgoi Ltd. (formerly Ivanhoe Oyu Tolgoi (BVI) Ltd.), Oyu Tolgoi Netherlands B.V. and Erdenes MGL LLC. Erdenes MGL LLC since transferred its shares in Oyu Tolgoi LLC and its rights and obligations under the ARSHA to its subsidiary, Erdenes Oyu Tolgoi LLC.
- Oyu Tolgoi Underground Mine Development and Financing Plan (Underground Development Plan) dated 18 May 2015, between TRQ, the Government of Mongolia, Erdenes Oyu Tolgoi LLC, THR Oyu Tolgoi Ltd., Oyu Tolgoi Netherlands B.V., Rio Tinto and Oyu Tolgoi LLC.
- Power Source Framework Agreement (PSFA) dated 31 December 2018, between the Government of Mongolia and Oyu Tolgoi LLC, including the amendment to the PSFA dated 26 June 2020

These agreements establish obligations and commitments of the involved parties, including the Government of Mongolia, providing clarity and certainty in respect of the development and operation of Oyu Tolgoi. The Investment Agreement also includes a dispute resolution clause that requires the parties to resolve disputes through international commercial arbitration procedures. Copies of each agreement have been filed with the Canadian Securities Authorities on SEDAR at www.sedar.com.

In December 2019, a Resolution of the Parliament of Mongolia was published that included resolutions to take comprehensive measures to improve the implementation of the Investment Agreement and the ARSHA, to improve the Underground Development Plan, and to explore and resolve options to have a product sharing arrangement or swap Mongolia's equity holding of 34% in Oyu Tolgoi LLC for a special royalty.

Activities related to the Project must be carried out in accordance with these agreements and the laws of Mongolia. As of the date of this 2020 Technical Report, material permits and authorizations necessary to develop and operate the Project have been obtained.

1.4 Investment decision

The initial investment decision to construct Phase 1 of Oyu Tolgoi was made in 2010. Phase 1 consisted of developing the Oyut open pit mine, concentrator and supporting infrastructure. These facilities are complete, and first concentrate was exported from Phase 1 of the Project in October 2013. Phase 1 mining and processing operations are ongoing and are meeting or exceeding the performance objectives of the initial investment decision, with industry leading productivity from haul truck and other performance metrics.

Part of the initial investment decision included continued investment on Phase 2, the development of the Hugo North Lift 1 underground mine and modifying the concentrator and Project infrastructure to enable simultaneous processing of ore from Oyut open pit and Hugo North underground mine. The decision to resume Phase 2 was made in 2016, and the Hugo North underground mine development is now at an advanced stage, with actual expenditure of over US$3.4 billion to 31 December 2019, and with a further $3.4 billion forecast to be required to complete the Phase 2 scope of the underground capital works. The completed work includes commissioning of Shaft 2, which incorporates one of the world's largest production winders.

The Oyu Tolgoi Project is in a remote area of Mongolia which has necessitated the establishment of supporting infrastructure including power connection to the grid, water supply, all-weather airport, and accommodation camp. The surface infrastructure to support the Phase 1 operation is complete. Only minor additions to the infrastructure facilities are required in Phase 2, and establishment of these is well advanced.

1.5 Geology and mineralization

The Oyu Tolgoi Cu-Au porphyry deposits are distributed along a 12 km NNE striking corridor. From north to south, the deposits comprise Hugo North, Hugo South, Oyut, and Heruga.

These deposits lie within the Gurvansayhan island-arc terrane, a fault bounded segment of the broader Silurian to Carboniferous Kazakh-Mongol arc, located towards the southern margin of the Central Asian Orogenic Belt.

Mineralization is associated with multiple, overlapping, intrusions of late Devonian quartz-monzodiorite intruding Devonian (or older) juvenile, probably intra-oceanic arc-related, basaltic lavas and lesser volcaniclastic rocks, unconformably overlain by late Devonian basaltic to dacitic pyroclastic and volcano sedimentary rocks. These quartz-monzodiorite intrusions range from early-mineral porphyritic dykes, to larger, linear, syn-, late- and post-mineral dykes and stocks.

1.6 Mineral Resources

The individual Mineral Resources for Oyu Tolgoi by deposit are shown in outlined in Table 1.1 to Table 1.5. The total Mineral Resources for Oyu Tolgoi are shown Table 1.6. The 2019 Mineral Resources have been prepared in accordance with the CIM Definition Standards for Mineral Resources and Mineral Reserves (the CIM Definition Standards (2014)) and in accordance with the requirements of NI 43-101.

The Mineral Resources for the Hugo North deposit reported in this 2020 Technical Report have been updated from the Mineral Resources reported for the deposit in the TRQ Annual Information Form (AIF) for the year ended 31 December 2019 (2019 AIF), the update reflects changes to the Hugo North Lift 1 Mineral Reserve resulting from the redesign of the panels in Lift 1 including leaving two pillars separating panels. There has been no update to the Mineral Resource estimates for the Oyut, Hugo South, or Heruga deposits. In the Mineral Resource tabulations, the term Entrée LLC refers to ownership by the proposed joint venture arrangement between Oyu Tolgoi LLC and Entrée LLC.

The Oyu Tolgoi deposits in total, including the updated Mineral Resources for Hugo North, contain estimated Measured and Indicated Mineral Resources of 8.5 Mt (18.7 billion pounds) of contained copper, 9.4 Moz of contained gold, and estimated Inferred Mineral Resource of 22 Mt (48 billion pounds) of contained copper and 34 Moz of contained gold.

Table 1.1 Oyut Deposit – Open Pit Mineral Resources Summary, as of 31 December 2019

Classification	Ownership	Tonnage (Mt)	Cu (%)	Au (g/t)	Ag (g/t)	Contained Metal		
						Cu (Mt)	Au (Moz)	Ag (Moz)
Measured	Oyu Tolgoi LLC	16	0.39	0.41	1.2	0.1	0.2	0.6
Indicated	Oyu Tolgoi LLC	80	0.34	0.29	1.2	0.3	0.8	3.0
Total Measured + Indicated	Oyu Tolgoi LLC	95	0.35	0.31	1.2	0.3	1.0	3.6
Inferred	Oyu Tolgoi LLC	320	0.29	0.17	1.0	0.9	1.8	10

See notes for Table 1.6

Table 1.2 Oyut Deposit – Underground Mineral Resources Summary, as of 31 December 2019

Classification	Ownership	Tonnage (Mt)	Cu (%)	Au (g/t)	Ag (g/t)	Contained Metal		
						Cu (Mt)	Au (Moz)	Ag (Moz)
Measured	Oyu Tolgoi LLC	14	0.47	0.88	1.3	0.1	0.4	0.6
Indicated	Oyu Tolgoi LLC	69	0.38	0.59	1.1	0.3	1.3	2.5
Total Measured + Indicated	Oyu Tolgoi LLC	83	0.39	0.64	1.1	0.3	1.7	3.0
Inferred	Oyu Tolgoi LLC	180	0.39	0.40	1.2	0.7	2.2	6.8

See notes for Table 1.6

Table 1.3 Hugo North Deposit Underground Mineral Resources Summary, as of 31 December 2019 (updated 30 June 2020)

Classification	Ownership	Tonnage (Mt)	Cu (%)	Au (g/t)	Ag (g/t)	Contained Metal		
						Cu (Mt)	Au (Moz)	Ag (Moz)
Measured	Oyu Tolgoi LLC	58	1.9	0.48	4.2	1.1	0.9	7.8
	Entrée LLC	-	-	-	-	-	-	-
	All Hugo North	58	1.9	0.48	4.2	1.1	0.9	7.8
Indicated	Oyu Tolgoi LLC	401	1.3	0.34	3.1	5.4	4.4	41
	Entrée LLC	87	1.6	0.54	4.1	1.4	1.5	12
	All Hugo North	488	1.4	0.38	3.3	6.8	5.9	52
Measured + Indicated	Oyu Tolgoi LLC	459	1.4	0.36	3.3	6.5	5.3	48
	Entrée LLC	87	1.6	0.54	4.1	1.4	1.5	12
	All Hugo North	546	1.4	0.39	3.4	7.8	6.8	60
Inferred	Oyu Tolgoi LLC	765	0.8	0.28	2.4	6.1	6.9	59
	Entrée LLC	167	1.0	0.36	2.8	1.7	1.9	15
	All Hugo North	932	0.8	0.29	2.5	7.8	8.8	74

See notes for Table 1.6.

Table 1.4 Hugo South Deposit Underground Mineral Resources Summary, as of 31 December 2019

Classification	Ownership	Tonnage (Mt)	Cu (%)	Au (g/t)	Ag (g/t)	Contained Metal		
						Cu (Mt)	Au (Moz)	Ag (Moz)
Inferred	Oyu Tolgoi LLC	720	0.84	0.07	1.9	6.1	1.7	44

See notes for Table 1.6

Table 1.5 Heruga Deposit Underground Mineral Resources Summary, as of 31 December 2019

Classification	Ownership	Tonnage (Mt)	Cu (%)	Au (g/t)	Ag (g/t)	Mo (ppm)	Contained Metal			
							Cu (Mt)	Au (Moz)	Ag (Moz)	Mo (Mlbs)
Inferred	Oyu Tolgoi LLC	110	0.42	0.30	1.6	110	0.4	1.0	5.3	26
Inferred	Entrée LLC	1400	0.41	0.40	1.5	120	6.0	19	68	390
Inferred	All Heruga	1600	0.42	0.39	1.5	120	6.5	20	73	410

See notes for Table 1.6.

Table 1.6 Total Mineral Resources estimates for all Oyu Tolgoi Deposits, as of 31 December 2019 (updated 30 June 2020)

Classification	Tonnage (Mt)	Cu (%)	Au (g/t)	Ag (g/t)	Contained Metal		
					Cu (Mt)	Au (Moz)	Ag (Moz)
Measured	87	1.4	0.53	3.2	1.2	1.5	9.0
Indicated	640	1.2	0.39	2.8	7.3	8.0	58
Total Measured + Indicated	720	1.2	0.41	2.9	8.5	9.4	67
Inferred	3,700	0.6	0.29	1.8	22	34	210

Notes to the Mineral Resources:

1. CIM Definition Standards (2014) are used for reporting of Mineral Resources.
2. The Mineral Resources exclude Mineral Reserves.
3. The following copper equivalent (CuEq) formulae have been used for cut-off grade determination in each deposit.

   Oyut: CuEq = Cu + ((Au x 35.4938) + (Ag x 0.4101)) / 67.9023

   Hugo North: CuEq = Cu + ((Au x 35.7175) + (Ag x 0.5353)) / 67.9023

   Hugo South: CuEq = Cu + ((Au x 37.7785) + (Ag x 0.5773)) / 67.9023

   Heruga: CuEq = Cu + ((Au x 37.0952) + (Ag x 0.5810) + (Mo x 0.0161)) / 67.9023

4. The metal prices used in determining the CuEq formulae are:

   3.08 $/lb for copper, 1,292 $/oz for gold, 19.00 $/oz for silver, and 10.00 $/lb for molybdenum.

5. The metallurgical recoveries used in determining the CuEq formulae for each deposit are:

   Oyut deposit: Copper 78%, Gold 67%, Silver 52%.

   Hugo North deposit: Copper 93%, Gold 80%, Silver 81%.

   Hugo South deposit: Copper 89%, Gold 81%, Silver 84%

   Heruga: Copper 82%, Gold 73%, Silver 78%, Molybdenum 60%.

6. For the Oyut deposit, a cut-off grade of 0.24% CuEq has been used for Mineral Resources with open pit potential. A cut-off 0.41% CuEq has been used for Mineral Resources with underground mining potential.
7. For the Hugo North, Hugo South, and Heruga deposits a cut-off grade of 0.41% CuEq grade used based on the assumption that the deposits will be mined using underground mining methods.
8. The effective date of the Mineral Resources estimates is December 31, 2019 (updated on June 30, 2020). The Mineral Resources do not account for resources mined after the effective date.
9. Totals may not match due to rounding to two significant figures. This results in differences to previously reported figures but is in line with industry best practice.
10. The Shivee Tolgoi and Javkhlant licenses are held by Entrée LLC. The Shivee Tolgoi and Javkhlant Licenses are planned to be operated by Oyu Tolgoi LLC. Oyu Tolgoi LLC will receive 80% of cash flows after capital and operating costs for material originating below 560 m, and 70% above this depth.TRQ holds a 7.9% interest in Entrée LLC.
11. In the Mineral Resource tabulations, the term Entrée LLC refers to ownership by the proposed joint venture arrangement between Oyu Tolgoi LLC and Entrée LLC.
12. Mineral Resources that are not Mineral Reserves do not have demonstrated economic viability.
13. The Oyut deposit was formerly known as Southern Oyu Tolgoi.
14. Molybdenum is excluded from the Total Resources in Table 1.1.
15. The contained copper, gold, silver, and molybdenum estimates in the tables have not been adjusted for metallurgical recoveries.

The estimate of Mineral Resources may be materially affected by environmental, permitting, legal, title, socio-political, marketing, or other relevant issues including risks set forth in the 2019 AIF and other filings made with Canadian securities regulatory authorities and available at www.sedar.com. These updated estimates differ from those reported in the 2019 AIF and reflect changes in the Hugo North Panel 0 design.

The updated Hugo North Measured and Indicated Mineral Resources contains 14% higher tonnage, 27% more copper metal, and 23% more gold metal than was reported in the 2019 AIF. The increases result mainly from returning the Mineral Reserves in the pillars to Mineral Resources. Other minor increases result from optimizing the cave shapes used to prepare the updated Hugo North Mineral Reserve estimate.

1.7 Mineral Reserves

The Mineral Reserves for Oyu Tolgoi are shown in Table 1.7 (Oyut open pit), Table 1.8 (surface stockpile), Table 1.9 (Hugo North underground) and Table 1.10 (the total Mineral Reserve). The Mineral Reserves have been prepared in accordance with the CIM Definition Standards (2014) and the requirements of NI 43-101. In the Mineral Reserves tabulations, the term Entrée LLC refers to ownership by the proposed joint venture arrangement between Oyu Tolgoi LLC and Entrée LLC.

The Mineral Reserves are based on mine planning work, including the development of modifying factors and cost estimates prepared by Oyu Tolgoi LLC as part of the Oyu Tolgoi Feasibility Study 2020 (2020 Feasibility Study), which has been prepared by Oyu Tolgoi LLC for the Professional Minerals Council of Mongolia pursuant to Mongolian regulatory requirements and submitted to the Government of Mongolia on 1 July 2020.

The estimate of Mineral Reserves may be materially affected by environmental, permitting, legal, title, sociopolitical, marketing, or other relevant issues including risks set forth in this Technical Report and in other filings made by TRQ with Canadian securities regulatory authorities and available at www.sedar.com.

Preparation of the Mineral Reserves has been guided by the CIM Best Practice Guidelines (2019).

Table 1.7 Oyut open pit Mineral Reserve as of 31 December 2019

Classification	Ownership	Mineral Reserve				Contained Metal		
		(Mt)	Cu (%)	Au (g/t)	Ag (g/t)	Cu (Mt)	Au (Moz)	Ag (Moz)
Proven	Oyu Tolgoi LLC	310	0.52	0.39	1.3	1.6	3.8	13
Probable	Oyu Tolgoi LLC	480	0.39	0.23	1.1	1.9	3.5	17
Total (Proven + Probable)	Oyu Tolgoi LLC	780	0.44	0.29	1.2	3.5	7.2	30

See notes for Table 1.10

Table 1.8 Oyut surface stockpile Mineral Reserve as of 31 December 2019

Classification	Ownership	Mineral Reserve				Contained metal		
		(Mt)	Cu (%)	Au (g/t)	Ag (g/t)	Cu (Mt)	Au (Moz)	Ag (Moz)
Proven	Oyu Tolgoi LLC	48	0.33	0.12	0.93	0.16	0.19	1.40

See notes for Table 1.10

Table 1.9 Hugo North underground Mineral Reserve as of 31 December 2019 (updated 30 June 2020)

Classification	Ownership	Mineral Reserve				Contained metal		
		(Mt)	Cu (%)	Au (g/t)	Ag (g/t)	Cu (Mt)	Au (Moz)	Ag (Moz)
Probable	Oyu Tolgoi LLC	400	1.5	0.29	3.1	6.0	3.8	40
Probable	Entrée LLC	40	1.5	0.53	3.6	0.6	0.7	4.6
Total Probable		440	1.5	0.32	3.2	6.7	4.5	45

See notes for Table 1.10.

Table 1.10 Total Oyu Tolgoi Mineral Reserve as of 31 December 2019 (updated 30 June 2020)

Classification	Mineral Reserve				Contained metal		
	(Mt)	Cu (%)	Au (g/t)	Ag (g/t)	Cu (Mt)	Au (Moz)	Ag (Moz)
Proven	350	0.49	0.35	1.3	1.7	4.0	14
Probable	920	0.93	0.27	2.1	8.5	7.9	62
Total (Proven + Probable)	1,270	0.81	0.29	1.9	10	12	77

Notes applying to the Mineral Reserves:

1. Totals may not match due to rounding to two significant figures in line with industry best practice.
2. CIM Definition Standards (2014) are used for reporting of Mineral Reserves.
3. The effective date of the Oyut open pit and surface stockpile Mineral Reserve is 31 December 2019. The effective date of the Hugo North Mineral Reserve is 31 December 2019 (updated on 30 June 2020).
4. The Oyut Mineral Reserve is currently being mined by open pit mining methods. The Stockpile Mineral Reserve is on surface close to the Oyut open pit. The Hugo North Mineral Reserve will be mined by underground mining methods.
5. Net Smelter Return (NSR) values used for estimating Mineral Reserves are based on forecast long-term copper, gold, and silver prices of 3.08 US$/lb, 1,292 US$/oz, and 19.00 US$/oz, respectively.
6. Assumptions for smelting refining and treatment, charges, deductions, and payment terms, concentrate transport, metallurgical recoveries and royalties are included in the NSR values.
7. For the Oyut Mineral Reserve processing and general and administration (G&A) costs used to determine NSR cut-off values vary between 7.18 US$/t and 10.14 US$/t depending on the ore type processed.
8. For the Hugo North Mineral Reserve, an NSR shut off grade of 17.84 US$/t is used to determine the point at which each underground drawpoint is closed. This NSR value is based on estimated mining, processing and G&A costs which range from 17.27 US$/t to 17.90 US$/t across the five different ore types.
9. For the Oyut deposit, the Proven Mineral Reserve is derived only from Measured Mineral Resources. The Probable Mineral Reserve is derived only from Indicated Mineral Reserves.
10. For the Hugo North deposit, the Probable Mineral Reserve is derived from a combination of Measured and Indicated Mineral Resources.
11. The Shivee Tolgoi Licence and the Javkhlant Licence are held by Entrée LLC. The Shivee Tolgoi Licence and the Javkhlant Licence are planned to be operated by Oyu Tolgoi LLC. Oyu Tolgoi LLC will receive 80% of cash flows after capital and operating costs for material originating below 560 m and 70% above this depth TRQ holds a 7.9% interest in Entrée Resources Ltd.
12. The term Entrée LLC refers to ownership by the proposed joint venture arrangement between Oyu Tolgoi LLC and Entrée LLC.
13. The Hugo North Mineral Reserve has been updated from that reported in TRQ's AIF dated 31 March 2020 and reflects changes in the Hugo North Lift 1 Panel 0 design. No mineral reserves were mined from Hugo North between 31 December 2019 and 30 June 2020 other than a small (non-material) quantity of development ore.
14. The Total Oyu Tolgoi Mineral Reserve combines the Oyut Mineral Reserve as of 31 December 2019 with Hugo North Mineral Reserve as of 31 December 2019 updated on 30 June 2020.

There has been no change to the Oyut Mineral Reserve, or the stockpile Mineral Reserve reported in the 2019 AIF.

The Hugo North Probable Mineral Reserve has been updated as at 30 June 2020 and differs from the Mineral Reserve reported in the 2019 AIF. The differences, an 8% reduction in tonnage and copper grade and 15% less copper metal, results from the redesign of Lift 1, Panel 0. Key aspects of the redesign are discussed in Section 1.2 and are summarized below:

- Redesign of Panel 0 to leave pillars separating Panel 0 from Panels 1 and 2.
- Realignment of the drawpoints, including an increase in the drawpoint spacing from 16 m to 18 m.
- Adjustment to the boundary of the footprint[4] in some areas to improve the stability of the excavations in the vicinity of the footprint and to improve the expected caving characteristics. This resulted in the addition and deletion of some drawpoints from the planned footprint.

[4] The mining footprint is the horizontal projection of the part of the deposit that is to be mined to recover the mineral reserves. The size and shape of the mining footprint is established by analysing the value of the material that can be recovered by making the footprint either larger or smaller.

- Change to the draw zone width from 19.5 m to 30 m
- Allowance made for the premature failure of 50% of drawpoints within the influence of the lower fault zone.

1.8 Oyut open pit

The Oyut open pit is a low-grade copper gold open pit operation with a current production rate of approximately 40 million tonnes per annum (Mtpa) and a planned remaining overall waste to ore strip ratio of 2.3 to 1. Mining is carried out using conventional drill, blast, load, and haul methods and is conducted 24 hours per day, 365 days per year.

Mining has proceeded generally in accordance with the mine plan developed in 2012 and as reported in the 2016 Technical Report, However, the pit phase design and sequence has been updated since 2012 and now represent a more optimised approach to mining.

The current production rate from the Oyut open pit is planned to continue until 2023, after which it will be progressively reduced as production increases from Hugo North underground. Open pit mining will then continue in parallel with Hugo North Lift 1 until the Mineral Reserves in Lift 1 are depleted. Production from the Oyut open pit will then be increased to meet mill capacity until open pit mining and recovery of the associated stockpiles is complete.

1.9 Hugo North development

The Lift 1 Panels are designed to extract the high-grade core of the Hugo North deposit and the Mineral Resources therein have been converted to a Mineral Reserve. The extraction level for Lift 1 is approximately 1,300 m below surface. Concepts have been developed for a potential further extraction level, Lift 2, about 400 m below Lift 1.

Inferred Mineral Resources associated with Lift 2, and some lower grade Inferred Mineral Resources above the Lift 1 footprint elevation, have not yet been sufficiently explored and evaluated to convert them to Mineral Reserves. Mineral Resources are not Mineral Reserves and do not have demonstrated economic viability. As mining and more detailed exploration from surface and underground drill sites continues, upgrading the Mineral Resource classifications in Lift 2 and in the lower grade areas above the Lift 1 elevation is envisaged.

A total of five shafts are planned to access the Hugo North Deposit and of these, three shafts have been completed (two for access and one for exhaust ventilation). Construction of the final two ventilation shafts (Shaft 3 intake ventilation and Shaft 4 exhaust ventilation) has commenced. A decline conveyor system from surface to the underground crushing system is being developed. Two underground crushers are planned to crush ore from Lift 1. One crusher (Crusher 1) is under construction. Construction of the second crusher (Crusher 2), which will be required as production from Lift 1 increases, is yet to commence.

Production operations are planned to commence in Panel 0 and progress into Panel 2 and later into Panel 1. Development of Panel 0 is well advanced with development ongoing on the extraction, undercut, and apex levels.

Development of Panel 0, combined with detailed geotechnical drilling and analysis, has identified greater structural complexity in Panel 0 than was originally anticipated in the 2016 Feasibility Study. The increased structural complexity has necessitated the redesign of aspects of Panel 0 and Lift 1 to increase confidence in the planned performance of the caving operation. The redesign includes leaving two 120 m wide pillars, one separating Panel 0 from Panel 1 and a second separating Panel 0 from Panel 2.

The redesign of Panel 0 includes relocating ore passes, ventilation raises, and access crosscuts that are critical to the successful operation of Panel 0 from their original positions to more secure positions within the two pillars. Several other changes have also been made to the design and sequencing of Panel 0 to reduce the impact of the more complex structural environment now known to exist in Panel 0.

Had the mining of Panel 0 progressed as envisaged in the 2016 Feasibility Study, a large part of the Mineral Reserves in Panel 0 may not have been recoverable and the planned production rate from the panel may not have been achievable. The delays associated with managing the difficult mining conditions in Panel 0 could have also slowed the development of Panels 1 and 2.

The pillars between the three panels provide the opportunity to optimise the design of Panels 1 and 2 to best suit the geology, geotechnical characteristics, and economic return of each panel. Work is ongoing to extend the detailed geotechnical drilling and structural investigations into Panels 1 and 2, and by the end of 2021, the planned data collection program for these panels will be complete and studies well advanced. Studies are also ongoing to evaluate design options for Panels 1 and 2 and into methods for recovering mineral resources within the pillars. These studies are investigating the possibility of changing the footprint elevation of Panels 1 and 2 to optimise the value of the Project.

An iterative process has been used to develop the key completion dates for the underground project. Construction activities, such as conveyor installations, are linked to the excavation schedule to determine dates when construction sites become available. In turn, construction durations and completion dates are feedback into the excavation schedules.

Key completion dates were initially estimated by deterministic scheduling methods using scheduling software. The deterministic schedules were then subjected to a semi-quantitative risk analysis (SQRA) process to assess the probability of the dates being achieved. The SQRA analysis generally extended the key deterministic milestone dates by approximately five months.

Subject to any delays arising from the COVID-19 pandemic, sustainable cave propagation[5] (Sustainable Production) is expected to occur in February 2023, followed by a six-year production build up to a maximum underground production rate of 33 Mtpa.

1.10 Oyu Tolgoi concentrator

The Oyu Tolgoi concentrator uses conventional crushing, grinding, and froth flotation technology. The Phase 1 concentrator had an initial nameplate capacity of 32 Mtpa. Annual throughput has progressively increased as a result of operating experience and minor plant modifications such that annual production rates exceeding 40 Mtpa have been achieved.

Because of its higher grade, ore from Hugo North will be fed to the concentrator in preference to ore from the Oyut open pit. Mining from the open pit will continue in parallel with Hugo North Lift 1 to keep the Oyu Tolgoi concentrator operating at its maximum capacity.

Modifications to the concentrator (Phase 2) to process the combined production from the Hugo North and Oyut deposits required installation of an additional ball mill, additional rougher and cleaner flotation equipment, and additional concentrate thickening, filtering, and handling facilities.

The anticipated metal recovery to concentrate from the Oyu Tolgoi Mineral Reserve is summarised in Table 1.11.

Table 1.11 Forecast average metal recovery to concentrate

Mineral Reserve	Ownership	Recovery		
		Cu (%)	Au (%)	Ag (%)
Oyut open pit	Oyu Tolgoi LLC	78	67	52
Stockpiles	Oyu Tolgoi LLC	73	44	47
Hugo North	Oyu Tolgoi LLC	93	79	80
Hugo North	Entrée LLC	92	81	83

[5] Sustainable cave propagation is expected to occur after blasting approximately 30 drawbells (60 drawpoints).

Mineral Reserve	Ownership	Recovery		
		Cu (%)	Au (%)	Ag (%)
Total Hugo North	Oyu Tolgoi LLC + Entrée LLC	93	79	80
Total Project	Oyu Tolgoi LLC + Entrée LLC	87	71	69

The concentrator currently produces copper concentrate with a grade of approximately 22% from the Oyut open pit. Copper recovery and concentrate grades are forecast to increase as production increases from Hugo North where the mineralization is more favourable to achieving higher recoveries and to the production of higher-grade concentrates (above 30% Cu), making it more attractive to customers for blending with lower grade concentrates sourced from elsewhere.

The copper concentrate, which contains significant gold credits, is sold to smelters in China on commercial terms that are generally consistent with the international trade in copper concentrates.

1.11 Marketing

The Oyu Tolgoi Copper Concentrate Sales and Marketing group (CCSM) is responsible for all aspects of concentrate marketing and sales, including, updating product specifications, negotiating sales and logistics contracts, and analysing supply-and-demand trends in the Chinese and global markets. CCSM is supported by Rio Tinto's Copper Concentrate Sales and Marketing team.

An established customer database has been established for Oyu Tolgoi concentrate with thirteen long-term contracts and several spot agreements. Customers are based in various provinces throughout China, while trader customers allow Oyu Tolgoi concentrate broad and far-reaching uptake across China's many smelters. More than 60% of concentrates are sold on term contracts and the balance on spot contracts tendered to smelters or traders. The terms of the current contracts range from one to five years, to reduce contract renewal risk. Smelter terms are based on standard smelter terms in general use through the industry.

1.12 Infrastructure

Most surface infrastructure facilities that are required for the open pit, underground, and concentrator operations have been constructed and are operational.

1.13 Environmental and social impact assessment

The operation's commitment to sound environmental and social planning is based on two important policies:

- TRQ's Statement of Values and Responsibilities, which declares its support for human rights, social justice, and sound environmental management, including the United Nations Universal Declaration of Human Rights (1948).
- Rio Tinto's Global Code of Business Conduct "The Way We Work" 2009, which defines the way Rio Tinto manages the economic, social, and environmental challenges of its global operations.

To meet its environmental and social obligations and commitments, Oyu Tolgoi LLC has completed a comprehensive Environmental and Social Impact Assessment (ESIA) for the Project. Oyu Tolgoi LLC has also implemented and audited health environmental management systems (EMS) that conform with the requirements of ISO 14001:2004.

The ESIA sets out measures to avoid, minimize, mitigate, and manage potential adverse impacts to acceptable levels established by Mongolian regulatory requirements and good international industry practice, as defined by the requirements of the Equator Principles, and the standards and policies of the International Finance Corporation (IFC), European Bank for Reconstruction and Development (EBRD), and other financing institutions.

Oyu Tolgoi LLC has developed a suite of management systems to ensure compliance with its environmental and social obligations, these include systems for:

- Managing water resources.
- Managing and mitigating cultural heritage impacts.
- Monitoring and managing air quality, noise, and vibration impacts.
- Managing biodiversity impacts, with a commitment to achieving a net positive impact on biodiversity where any residual impacts on priority biodiversity features will be offset.
- Establishing and managing community programs, with the aim of achieving a positive impact on the communities surrounding the mine.
- Managing mineralised and non-mineralised waste and managing hazardous materials.
- Rehabilitation and closure planning.

The Project has a health, safety, environment, and community policy that affirms its commitment to protecting the environment and to safeguarding the health, safety and welfare of people affected by the Project including employees, contractors, and communities.

The Government of Mongolia awarded a water utilization contract to Oyu Tolgoi LLC until 2040, which can be extended for 20-year periods beyond 2040. Oyu Tolgoi LLC is currently entitled to utilize water at a rate of 918 L/s. The total site design raw water demand ranges from 588–785 L/s, with an average of 628 L/s, at the planned production rate. More than 80% of the water used at the Project consists of recycled water.

Oyu Tolgoi LLC’s environmental work for the Project is compliant with Mongolian regulatory requirements, internal policies and procedures, and external agreements. The environmental management plans for the Project are designed to ensure that key environmental factors are monitored and protected.

1.14 Development Capital

The actual and forecast development capital expenditures for Phase 2 are summarized by year in Table 1.12. A breakdown of the major cost areas for the Phase 2 development capital is shown in Table 1.13. Costs presented in this Section are reported on a 100% Project basis.

The forecast development capital expenditure estimate targets an accuracy of ±20% in line with Mongolian regulatory requirements. The estimate is subject to further study and assessment as part of Oyu Tolgoi LLC’s ongoing cost estimation and project management processes, including preparation of a cost and schedule update and on-going studies for Panels 1 and 2.

The forecast development capital includes contingency and escalation but excludes interest costs during construction. The base date for the cost estimates is the first quarter (Qtr1) 2020, and the cost estimates are expressed in nominal terms.

Table 1.12 Actual and planned Phase 2 development capital expenditures by year

Year	Phase 2 ($ billion)
Spent to from 1 January 2015 to 31 December 2019	3.4
2020	1.2
2021	1.0
2022	0.6
2023	0.4
2024	0.2
2025	0.0
Total	**6.8**

Note: Amounts are rounded and exclude any impacts of Covid-19 and are subject to further study and assessment as part of Oyu Tolgoi LLC's cost and schedule estimation update which is expected later in 2020; they are expressed in nominal terms and are inclusive of any applicable taxes.

Table 1.13 Phase 2 Development Capital by area

Description	Spent from 1 January 2015 to 31 December 2019 ($ billion)	Forecast to complete from 1 January 2020 ($ billion)	Total Phase 2 ($ billion)
Underground mine (Hugo North Lift 1)	1.4	1.3	2.7
Site development	0.0	0.0	0.0
Concentrator Modifications	0.0	0.2	0.2
Utilities and ancillaries	0.1	0.0	0.1
Offsite facilities	0.1	0.1	0.2
Subtotal direct costs	**1.6**	**1.6**	**3.2**
Indirect costs	0.8	0.7	1.4
Owner's costs, escalation, growth, forex, contingency	1.0	1.2	2.2
Subtotal – indirect costs	**1.8**	**1.8**	**3.6**
Total	**3.4**	**3.4**	**6.8**

Note: Amounts are rounded and exclude any impacts of Covid-19 and are subject to further study and assessment as part of Oyu Tolgoi LLC's cost and schedule estimation update which is expected later in 2020; they are expressed in nominal terms and are inclusive of any applicable taxes.

Actual capital expenditure on Phase 2 from 1 January 2015 until 31 December 2019 was approximately $3.4 billion, and a further $3.4 billion (including 2020 development capital expenditure of $1.2 billion[6]) is forecast to be required to complete the Phase 2 scope of work.

The scope of the remaining capital program includes:

- All remaining shaft construction and commissioning work including installation of the associated permanent ventilation equipment.
- The construction of all facilities required to crush and transfer ore from Panel 0 production to the concentrator, including Crusher 1 and the conveyor to surface system.
- All Panel 0 development required to be completed prior to Sustainable Production.

[6] As the base date for the cost estimates is Qtr1 2020, this amount excludes any impacts of Covid-19. As a result, it differs from TRQ's 2020 underground capital guidance, which was revised to a range of $1.0 billion to $1.1 billion in its May 13, 2020 press release.

- Construction and maintenance of temporary construction facilities to support ongoing construction activities after the start of Sustainable Production.
- Carrying out the modifications to the Oyu Tolgoi concentrator.
- Completing any remaining additions or modifications to the project infrastructure required to enable Hugo North Lift 1 to meet its planned production rate of 33 Mtpa.

1.15 Sustaining capital

The total sustaining capital estimate over the life of the Project from 1 January 2021 is summarised in Table 1.14. The estimate has been prepared by Oyu Tolgoi LLC. Sustaining capital costs are expressed in 2020 US dollars based on fixed exchange rates. The costs are un-escalated and are presented on a 100% Project basis.

Table 1.14 Total sustaining capital estimate

Description	Total ($ billion)
Open Pit	0.8
Hugo North Lift 1	2.7
Concentrator	0.1
Tailings	0.8
Infrastructure	0.3
Other	0.2
Sub-total	**5.0**
Value Added Tax (VAT) and duties	0.5
Total	**5.5**

Note: Amounts are rounded and exclude any impacts of Covid-19 and are subject to further study and assessment as part of Oyu Tolgoi LLC's cost and schedule estimation update which is expected later in 2020 and subject to further study and analysis on Panels 1 and 2.

1.16 Operating costs

The total operating cost over the life of the Project from 1 January 2021 onwards are summarised in Table 1.15. Operating costs are un-escalated and are expressed on a 100% Project basis in real 2020 US dollars based on fixed exchange rates.

The estimates include all expenses required to operate and maintain the open pit mine, the underground mine, the concentrator, and the Project support activities. The following are excluded from the operating cost estimates

- Escalation.
- Financing costs.
- Royalties.
- Selling costs.

The estimates are built up on the fundamental principle of centrality, giving them an equal probability of upside and downside. The cost estimate for the open pit includes an adjustment for deferred waste stripping.

Table 1.15 Operating cost summary

Description	Total ($ billion)
Oyut open pit[7]	3.5
Hugo North	3.4
Concentrator	7.7
Infrastructure	2.5
G&A, including exploration and evaluation, and technical support costs	2.3
Sub-total	**19.4**
VAT and duties	1.8
Total	**21.1**

Power is a significant component of the Project's operating cost. The Project currently sources its power under an agreement from the Inner Mongolia Power International Cooperation Company Ltd. (IMPIC), via the Mongolian National Power Transmission Grid (NPTG) authority. This agreement is due to expire in 2023. Subsequently, power costs reflect the assumed outcome of Oyu Tolgoi LLC's negotiations with IMPIC/NPTG and the Government of Mongolia.

1.17 Economic analysis

The economic analysis presented in this section contains forward looking information about Mineral Reserve estimates, commodity prices, exchange rates, proposed mine production plans and cash flows, projected recovery rates, operating costs, capital expenditures project schedules, head grades, payback, net present value (NPV), and internal rate of return (IRR). The results of the economic analysis are subject to several known and unknown risks, uncertainties and other factors that may cause actual results to differ materially from those presented here. The reader is referred to the Important Notice at the beginning of the 2020 Technical Report.

The results of the economic analysis of the Oyu Tolgoi Mineral Reserves are presented on a after-tax net cashflow 100% pre-finance basis (except payback period). The NPV at a discount rate of 8% (NPV8) is $10.0 billion. The analysis also exhibits an after-tax IRR of around 46% and a payback period of around six years (including interest and similar costs on the existing project finance facility). The analysis is assessed as at 1 January 2021, with all cash expenditures prior to this date excluded.

The results of the economic analysis of the Oyu Tolgoi Mineral Reserves are summarized in Table 1.16.

[7] Excludes costs associated with deferred stripping of $1.3 billion (pre-tax) which are capitalized

Table 1.16 Production and financial evaluation summary from 1 January 2021[1, 2, 3, 4, 5]

Description	Units	Value (life-of-mine)
Material processed	Billion tonnes	1.2
Copper (Cu) head grade	%	0.82
Gold (Au) head grade	g/t	0.30
Silver (Ag) head grade	g/t	1.89
Cu in concentrate	Mt (Billion pounds)	8.8 (19.5)
Au in concentrate	Moz	8.4
Ag in concentrate	Moz	51.7
Concentrate	Mt	31.1
Payable Cu	Mt (Billion pounds)	8.5 (18.8)
Payable Au	Moz	8.0
Payable Ag	Moz	46.5
Mine life[6]	years	31
Development capital[7]	$ billions (nominal)	2.3
Development capital[7]	$ billion (real)	2.2
Payback period[8]	years	6
Internal Rate of Return (after tax)[9]	%	46%
NPV8 (after tax)[10]	$ billion	10.0

Notes:

1. Cost estimates are prepared in 2020 real terms (see Section 21).
2. The financial analysis uses the Mineral Reserves reported in Table 1.10 and Section 15. The estimate of Mineral Reserves may be materially affected by environmental, permitting, legal, title, sociopolitical, marketing, or other relevant issues including risks set forth in 2019 AIF and other filings made with Canadian securities regulatory authorities and available at www.sedar.com. These updated estimates differ from those reported in the 2019 AIF and reflect incorporation of changes in the Hugo North Panel 0 design and incorporated into this 2020 Technical Report.
3. The financial analysis uses long-term metal prices of 3.03 $/lb copper, 1,474 $/oz gold, and 17.85 $/oz silver. The analysis was calculated with assumptions for smelter refining and treatment charges, deductions, and payment terms, concentrate transport, metallurgical recoveries, and royalties.
4. Mine life is calculated from 1 January 2021.
5. Economic analysis is calculated as of 1 January 2021 and excludes development capital spend up to 31 December 2020. Underground project spend includes development capital and VAT and excludes capitalized interest. Development capital is presented in nominal terms for convenience in agreeing amounts to Section 21.
6. Payback period is calculated from 1 January 2021 and is rounded to years. Payback is calculated on undiscounted real cash flows including the interest and similar charges associated with the in-place project finance facility.
7. IRR is the discount rate that makes the net present value of all net cash flows after tax from Mineral Reserves equal to zero, calculated at 1 January 2021, based on expected net cash flows after tax from and after that date.
8. NPV8 is the net present value of Mineral Reserves at a discount rate of 8% for all years, calculated at 1 January 2021, based on expected cash flows from and after that date.

1.17.1 Economic assumptions

The economic model is based on the Oyu Tolgoi Mineral Reserves reported in Table 1.5. Assumed metal prices and smelting and refining charges use in the economic analysis are shown in Table 1.17. Treatment and refining charges form part of the deductions made in determining net revenue (other deductions include freight charges, penalty charges and royalties). The metal prices are based on TRQ's price forecasts, which assume that short term observable market prices will revert to TRQ's assessment of the long-term price, generally over a period of three to five years. These long-term forecast prices are derived from industry analysts' consensus (drawn from a pool of leading international financial institutions) published as at 30 June 2020. Treatment and refining charges were selected from internally prepared forecasts and assessed for reasonability against proprietary research by TRQ's financial advisors. Smelter terms used in the analysis are terms typically used throughout the copper smelting industry. Payable metals in the copper concentrate are copper, gold, and silver.

Table 1.17 Assumed metal prices and smelting and refining charges

Parameter	Unit	2021	2022	2023	Long-term assumptions
Cu price	$/lb	2.67	2.80	2.88	3.03
Au price	$/oz	1,694	1,616	1,549	1,474
Ag price	$/oz	17.64	17.55	17.40	17.85
Treatment charges	$/dmt concentrate	67.37	79.24	91.12	91.12
Cu refining charge	$/lb	0.07	0.08	0.09	0.09
Au refining charge	$/oz	4.50	4.50	4.50	4.50

Oyu Tolgoi is subject to a stabilized 5% royalty payable to the Government of Mongolia on a gross sales value basis (i.e. no deductions from sales for realisation costs including, but not limited to, treatment charges and refining charges, freight differentials, penalties and / or payables). This royalty is governed by the Investment Agreement.

The Underground Development Plan specifies the international markets in which specific prices are to be used in determining sales values to calculate the mineral royalties payable, as referenced and published in Metals Daily, for the day of shipment, as follows:

- Copper - the average monthly price determined by the London Metal Exchange Copper Grade A Settlement quotation.
- Gold - the London Bullion Market Association Final Gold quotations.
- Silver – the London Bullion Market Association Spot Silver quotations.

The Underground Development Plan sets out provisions if these market-pricing mechanisms cease to be available.

1.17.2 Taxation

Under the terms of the Investment Agreement, several forms of taxation have been identified as stabilized for the term of the agreement at the rates and bases applicable at the date of the agreement. The taxes and fees payable to the Government of Mongolia, and their rates, include:

- Corporate income tax: 25%
- Value added tax: 10%
- Customs duties: 5%
- Withholding tax: up to 20% (services provided in Mongolia, subject to reductions based on tax treaties in force at the date the Investment Agreement stabilized taxes).

The analysis does not include any potential withholding tax for the repatriation of dividends or interest charges outside of the country. Interest charges from shareholder loans and project financing are not included in the operating and capital costs but are allowed for in the calculation of tax. Additionally:

- In accordance with the Investment Agreement, Oyu Tolgoi LLC is not subject to an excess profits tax or any similar windfall tax.
- The copper concentrate does not qualify as a "finished product" for VAT purposes; as such, Oyu Tolgoi LLC is unable to claim back any associated credits / refunds.
- The Investment Agreement allows for the tax loss carry-forward period in relation to Corporate Income Tax losses of eight years and that tax losses can be applied to offset 100% of taxable income.
- Customs duty of 5% is payable on all imported goods and associated inbound logistics costs incurred outside of Mongolia, including ocean freight, air freight, and land transportation.

- Several other non-stabilized taxes and levies will affect Oyu Tolgoi LLC. Examples include social security obligations, work placement fees, car registration taxes, royalties on the use of sand and gravel, and water levies.
- The Investment Agreement provides the depreciation rates applicable to different asset classes that have a useful life exceeding one year.

A management services payment, based generally on 3% of development capital costs and 6% of operating and sustaining capital costs during production, is payable by Oyu Tolgoi LLC to the management team[8], who may in turn direct payment to TRQ or a member of the Rio Tinto group.

1.17.3 Production and cashflow

The production statistics and financial results for the Project are summarized in Table 1.18. All tables and charts presented in this section are on a 100% Project basis.

Table 1.18 Summary production and cash flow results from 1 January 2021

Category	Units	Total			Annual Average		
		First 5 years	First 10 years	Project life	First 5 years	First 10 years	Project Life
Processing							
Total ore processed	Mt	199	403	1,228	40	40	40
Head grade - Cu	%	0.67	1.04	0.82	0.67	1.04	0.82
Head grade - Au	g/t	0.38	0.40	0.30	0.38	0.40	0.30
Head grade - Ag	g/t	1.7	2.4	1.9	1.7	2.4	1.9
Production							
Recovery - Cu	%	85	89	88	85	89	88
Recovery - Au	%	71	74	71	71	74	71
Recovery - Ag	%	64	74	69	64	74	69
Concentrate	Mt	4.2	12	31	0.8	1.2	1.0
Cu in concentrate	Mt	1.1	3.7	8.8	0.23	0.37	0.29
Cu in concentrate	Billion lb	2.5	8.3	19	0.50	0.83	0.63
Au in concentrate	Moz	1.7	3.9	8.4	0.35	0.39	0.27
Ag in concentrate	Moz	6.9	23	52	1.4	2.3	1.7
Cu Concentrate grade	%	27	32	28	27	30	28
Au Concentrate grade	g/t	13	10	8.4	13	10	8.4
Ag Concentrate grade	g/t	52	60	52	52	60	52
Payable metal							
Cu payable metal	Mt	1.1	3.6	8.5	0.22	0.36	0.27
Cu payable metal	Billion lb	2.4	8.0	19	0.48	0.80	0.61
Au payable metal	Moz	1.7	3.8	8.0	0.34	0.38	0.26
Ag payable metal	Moz	6.2	20	46	1.2	2.0	1.5
Financial Summary							
Net revenue	$ billion	8.3	25.4	58.1	1.7	2.5	1.9
Operating surplus before tax	$ billion	4.0	17.0	34.1	0.8	1.7	1.1
Net cash flow after tax	$ billion	(0.4)	10.8	22.9	(0.1)	1.1	0.7
Cash costs							
C1 Cash costs (total)	$ billion	2.5	5.4	18.9	0.5	0.5	0.6
C1 Cash costs (unit)	$/lb	0.99	0.65	0.97	0.99	0.65	0.97

Note: Amounts are rounded and exclude any impacts of Covid-19 and are subject to further study and assessment as part of Oyu Tolgoi LLC's cost and schedule estimation update which is expected later in 2020 and subject to further study and analysis on Panels 1 and 2.

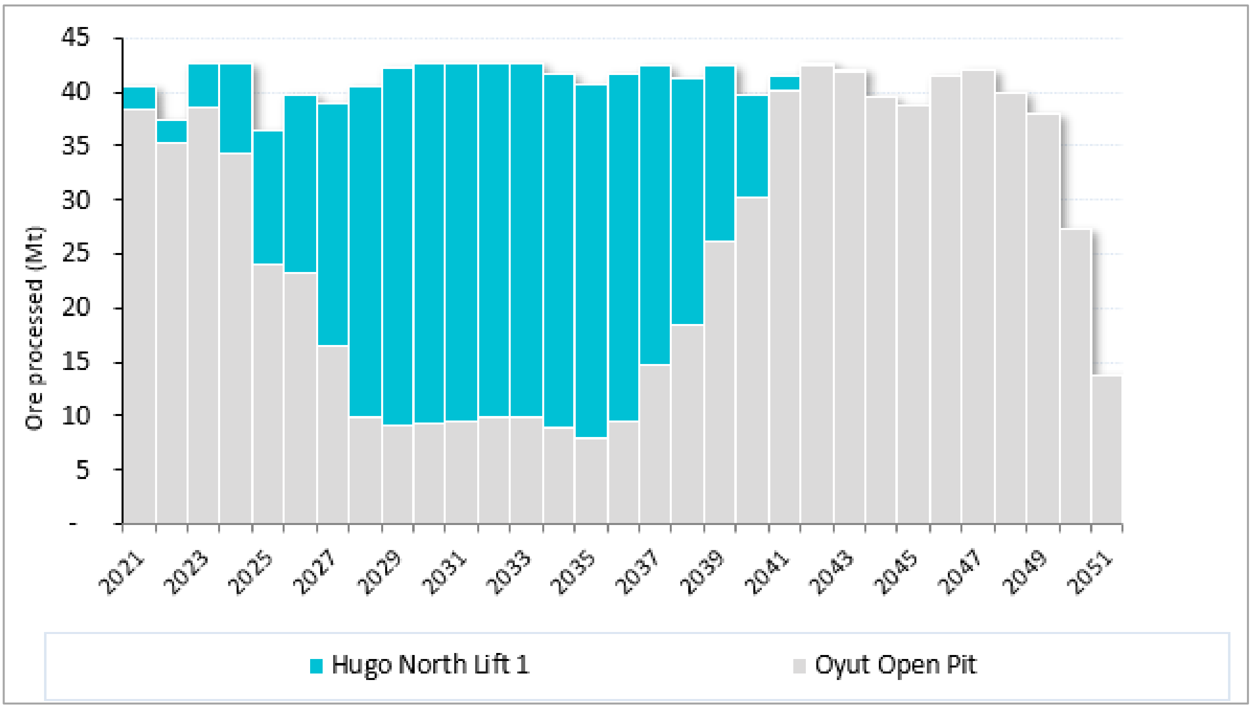
[8] Refer to Section 4.3.3

C1 cash cost[9] (total and per pound of copper produced), presented in Table 1.18 is a metric representing the cash cost and per unit cash cost of extracting and processing the principal metal product, copper, to a condition in which it may be delivered to customers, net of gold and silver credits from concentrates sold. This metric is provided in order to support peer group comparability and to provide investors and other stakeholders with additional information about the underlying cash costs of the Oyu Tolgoi mine and the impact of gold and silver credits on the operation's cost structure. C1 cash costs are relevant to understanding the Project's operating profitability and ability to generate cash flow. When calculating costs associated with producing a pound of copper, gold and silver revenues are deducted, as the production cost is reduced by selling these products.

Figure 1.1 shows the ore processed by ore source (Oyut and Hugo North), annually over the Project life. Figure 1.2 shows the copper contained in concentrate (before payability factors are applied) by ore source, annually over the Project Life. Hugo North Lift 1 ultimately provides most of the copper produced, while the Oyut pit supplies most of the ore to be processed.

The annual and cumulative after-tax net cashflows generated by the Project are shown in Figure 1.3.

Figure 1.1 Ore processed by ore source

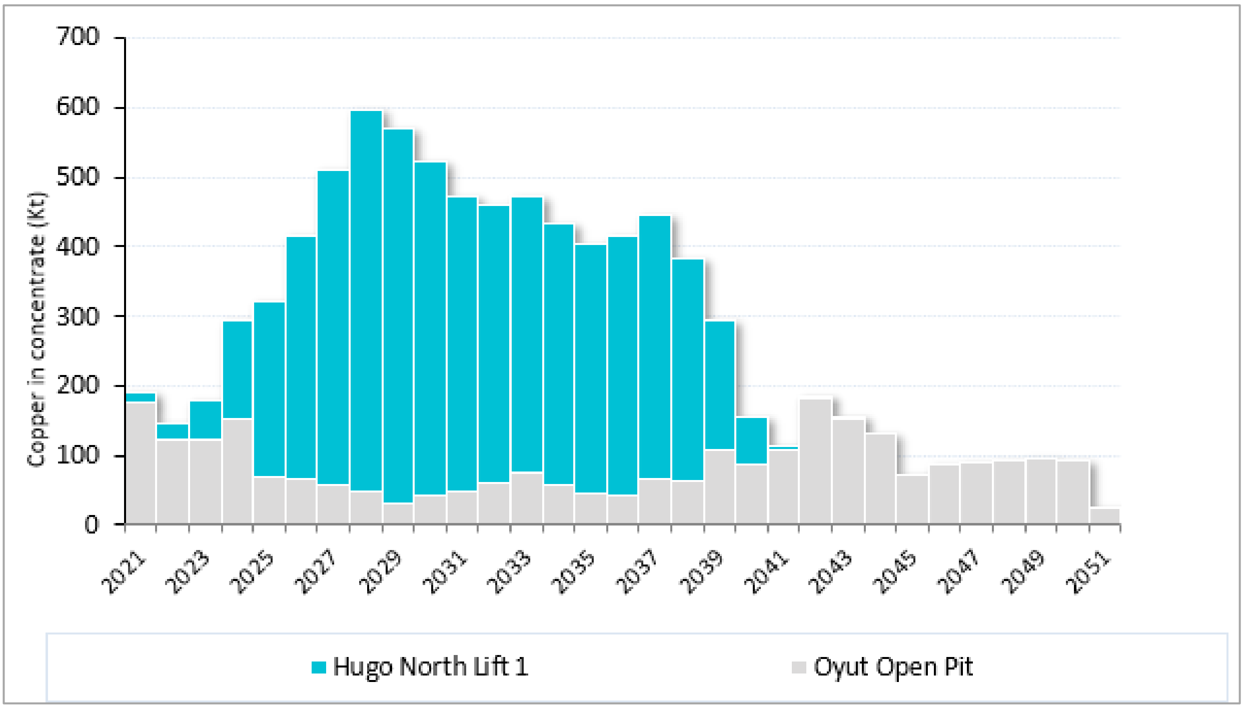


Source: AMC from TRQ data. Date: 8 August 2020.

Note: Values shown in the figure exclude any impacts of Covid-19 and are subject to further study and assessment as part of Oyu Tolgoi LLC's cost and schedule estimation update which is expected later in 2020 and subject to further study and analysis on Panels 1 and 2.

[9] C1 cash costs are a non-GAAP (Generally Accepted Accounting Principles) measure (i.e. not defined by International Financial Reporting Standards (IFRS)). It is presented in order to provide investors and other stakeholders with an additional understanding of performance and operations at the Oyu Tolgoi mine and is not intended to be used in isolation form, or as a replacement for, measures prepared in accordance with IFRS

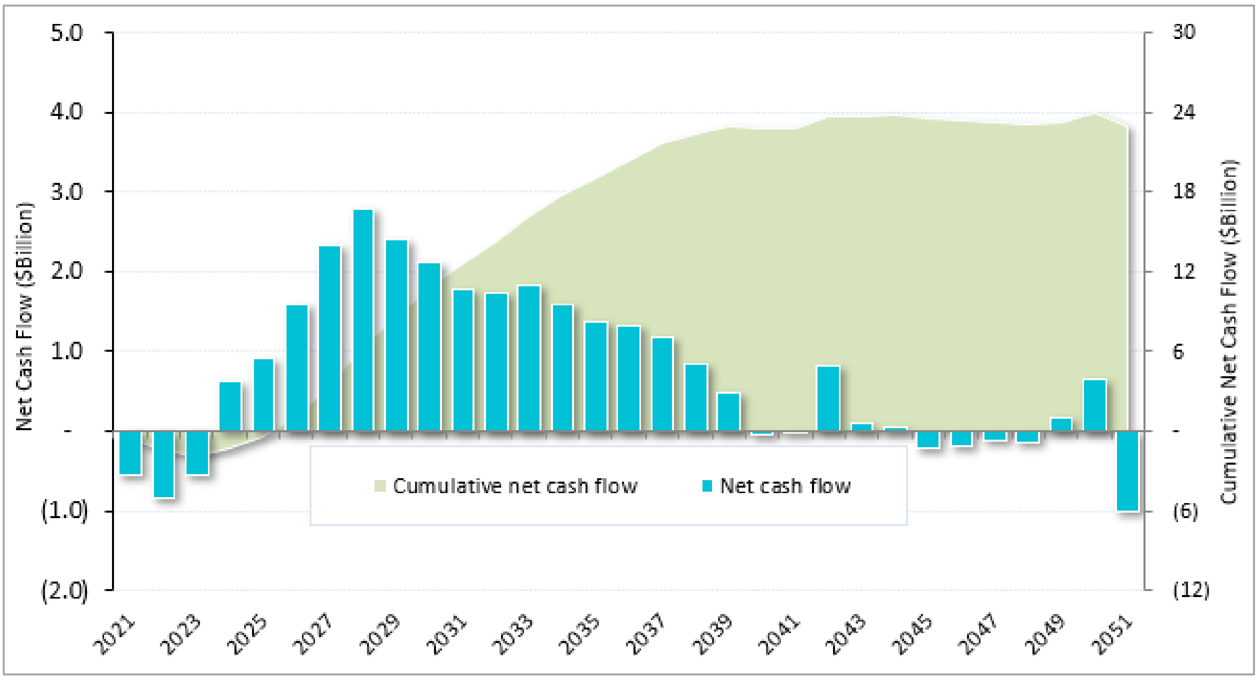
Figure 1.2 Copper contained in concentrate by ore source



Source: AMC from TRQ data. Date: 8 August 2020.

Note: Values shown in the figure exclude any impacts of Covid-19 and are subject to further study and assessment as part of Oyu Tolgoi LLC's cost and schedule estimation update which is expected later in 2020 and subject to further study and analysis on Panels 1 and 2.

Figure 1.3 Cumulative cash flow



Source: AMC from TRQ data. Date: 8 August 2020.

Note: Values shown in the figure exclude any impacts of Covid-19 and are subject to further study and assessment as part of Oyu Tolgoi LLC's cost and schedule estimation update which is expected later in 2020 and subject to further study and analysis on Panels 1 and 2.

1.17.4 Sensitivity analysis

The sensitivity of the after-tax NPV of the Project to the application of different discount rates is summarised in Table 1.19.

The sensitivity of the after-tax NPV of the Project to changes in commodity price assumptions, head grades (Cu and Au), operating costs, total capital, and development capital is shown in Table 1.20.

Table 1.19 Sensitivity of NPV to changes in discount rate

Discount rate (%)	After tax ($ billion)
Undiscounted	23.9
5	13.6
6	12.3
7	11.1
8	**10.0**
9	9.0
10	8.2
11	7.4
12	6.7

Note: Amounts are rounded and exclude any impacts of Covid-19 and are subject to further study and assessment as part of Oyu Tolgoi LLC's cost and schedule estimation update which is expected later in 2020 and subject to further study and analysis on Panels 1 and 2.

The sensitivity of the financial results for a range of copper and gold prices, is shown in Table 1.20. The prices shown in the tables have been held constant in all years.

Table 1.20 Sensitivity of after-tax NPV to changes key input assumptions

Item	Item Sensitivity Range				
Long-term copper price ($/lb) After tax NPV8 ($ billions)	2.80 8.7	2.90 9.3	3.03 10.0	3.10 10.4	3.20 11.0
Long-term gold price ($/oz) After tax NPV8 ($ billions)	1,275 9.6	1,375 9.8	1,473 10.0	1,575 10.2	1,675 10.4
Copper grade (± %) After tax NPV8 ($ billions)	-20% 5.5	-10% 7.9	0% 10.0	+10% 12.0	+20% 13.8
Gold grade (± %) After tax NPV8 ($ billions)	-20% 9.1	-10% 9.5	0% 10.0	+10% 10.5	+20% 10.9
Operating cost (± %) After tax NPV8 ($ billions)	-20% 11.6	-10% 10.8	0% 10.0	+10% 9.2	+20% 8.3
Total capital cost (± %) After tax NPV8 ($ billions)	-20% 10.9	-10% 10.5	0% 10.0	+10% 9.5	+20% 9.1
Development capital (± %) After tax NPV8 ($ billions)	-20% 10.4	-10% 10.2	0% 10.0	+10% 9.8	+20% 9.6

Note: Long-term silver price of 17.85 $/oz assumed for all cases.
Amounts are rounded and exclude any impacts of Covid-19 and are subject to further study and assessment as part of Oyu Tolgoi LLC's cost and schedule estimation update which is expected later in 2020 and subject to further study and analysis on Panels 1 and 2.

1.18 Risks

The main technical risks to the anticipated economic performance of the Project relate to the timing and cost of completing the development of the Hugo North underground mine and achieving the planned build-up to full production.

The start of undercutting in Panel 0 depends on commissioning Crusher 1 and the associated materials handling system to Shaft 2. COVID-19 related delays in progressing aspects of the construction of Crusher 1 and the materials handling system could delay the start of undercutting and the start of Sustainable Production.

COVID-19 related delays to sinking activities in Shafts 3 and 4, are unlikely to adversely impact the key milestone dates for Panel 0, but could impact the ability to extend the footprint development into Panels 1 and 2 because of limited ventilation until these shafts are commissioned.

Although reasonable allowances have been made, difficult ground conditions may slow the undercutting and drawbell construction process in Panel 0. There is also a risk that localised poor ground conditions could delay development of drawpoints, ore passes, and truck loading chutes required for production from Panel 0.

There is a risk that the capital estimate to complete development of Lift 1 will be higher than forecast because of COVID-19 relate delays or other unforeseen factors. Unforeseen factors, including geotechnical risks associated with high stress and faulting, may result in increased operating and sustaining capital costs.

The technical risks relating to the Hugo North underground mine described above could result in increases in development capital, sustaining capital, and operating costs. However, as indicated by the economic analysis in Section 22, the impact of the reasonably foreseeable cost increases that might result from these risks and uncertainties do not affect the potential economic viability of the Project.

1.19 Recommendations for further work

The Qualified Persons (QP's) recommend that the following work be carried out:

Open pit mining:

- Continue geotechnical data gathering and investigations into the potential for steepening the pit walls.

Underground mining

- Update the Hugo North project development and construction schedule, and the remaining capital expenditure estimate to increase confidence in the accuracy of the forecast Project completion date and cost estimate.
- Carry out further detailed implementation planning for Panel 0 to reduce construction schedule and operational risks. This includes simulation work to sequence and schedule development and production activities focusing on interaction and congestion management.
- Implement the planned real-time cave monitoring program prior to start of undercutting to monitor the ground reaction from undercut initiation. Proceed with preparation for installing equipment to acquire high-quality seismic data from Hugo North Lift 1.
- Investigate methods to increase the performance of construction activities associated with the installation of Crusher 1 and the associate materials handling system and sinking of Shafts 3 and 4. Construction of these facilities is currently being delayed by COVID-19 restrictions and are likely to be on the critical path.
- 72 km of drilling in Hugo North Panels 1 and 2 is planned of which 30 km has been approved for geotechnical assessments of Lift 1 at a cost of $20 million. The objective of the study is to apply the lessons learned from Panel 0 to the remainder of the footprint, considering the updated geological and geotechnical information acquired from the drilling program.
- Continue to investigate design options for Panels 1 and 2 using the learnings from redesign of Panel 0 and the additional geotechnical data collected from the further drilling program. The studies should include options for optimising the elevation of the Panels 1 and 2 footprints and methods for recovering mineral resources in the pillars.

- Carry out exploration drilling from surface and underground drill sites focused on upgrading the Mineral Resource classifications in Lift 2 and in the lower grade areas above the Lift 1 footprint elevation.

Oyu Tolgoi concentrator

- Carry out testwork on samples from the open pit and Hugo North to confirm the proposed flowsheet and specifications for upgrading the Oyu Tolgoi concentrator. This includes further testing and evaluation to confirm the need for a third concentrate thickener.

Many of the programs are ongoing, and their cost is included in the development capital and operational budgets.

Contents

Tables

Figures

ABBREVIATIONS

Abbreviation	Term
µg, mg	microgram, milligram
ARSHA	Amended and Restated Shareholders Agreement
Ci	Minnovex crushing index
CO_2-e	carbon dioxide equivalent
CCSM	Copper Concentrate Sales and Marketing
CuEq	Copper equivalent
dB	decibel
dmt	Dry metric tonnes
DCF	Discounted cash flow
DEIA	Detailed Environmental Impact Assessment
EBRD	European Bank for Reconstruction and Development
EMS	environmental management systems
ESIA	Environmental and Social Impact Assessment
GAAP	Generally Accepted Accounting Principles
GHG	greenhouse gases
G&A	General and Administration (relating to costs)
ha	hectare
HSEC	health, safety, environmental and community
ICP	Inductively coupled plasma
IFC	International Finance Corporation
IMPIC	Inner Mongolia Power International Cooperation Company Ltd
IRR	internal rate of return
KPI	key performance indicator
L/s	litres per second
mm, cm, m, m^3	millimetre, centimetre, metre, cubic metre
MASIA	Mongolian Academy of Science, Institute of Archaeology
MBI	Modified bond index
MNS	Mongolian National Standard
Mtpa	Million tonnes per annum
NGO	Non-government agency
NN	Nearest neighbour (modelling method)
NPTG	Mongolian National Power Transmission Grid
NPV, NPV8	net present value, net present value at a discount rate of 8%
NSR	net smelter return
OK	Ordinary Kriging (modelling method)
QEMSCAN	Quantitative evaluation by scanning electron microscopy
RC	Reverse circulation (drilling)
PSFA	Power Source Framework Agreement
PM_{10}, $PM_{2.5}$, PM_1	particulate matter
RL	Reduced Level (height datum)
RQD	rock quality designation
SAG	semi autogenous grinding
SMU	selective mining unit (mining block size)
SPI	SAG power index
SRM	Standard reference material
TRQ	Turquoise Hill Resources Ltd
TSF	tailings storage facility
TTPP	Tavan Tolgoi power plant
VAT	Value added tax

2 Introduction

2.1 Issuer for whom the report is prepared

This report is titled the Oyu Tolgoi 2020 Technical Report (2020 Technical Report) and has been prepared for Turquoise Hill Resources Ltd (TRQ). TRQ is an international mining company focused on the operation and further development of the Oyu Tolgoi Project (Oyu Tolgoi or the Project) located in the Southern Gobi region of Mongolia. The Project is being developed by Oyu Tolgoi LLC (formerly known as Ivanhoe Mines Mongolia Inc. LLC) and consists of a series of deposits containing copper, gold, and silver.

2.2 Purpose of the Technical Report

The Oyu Tolgoi Property, which contains the Project, is TRQ's principal and only material mineral resource property and is held through a 66% interest in Oyu Tolgoi LLC; the remaining 34% interest is held by the Government of Mongolia through Erdenes Oyu Tolgoi LLC. Rio Tinto, with other Rio Tinto affiliates, hold a 50.8% majority interest in TRQ, and provide strategic and operational management services and support to Oyu Tolgoi LLC in respect of its operations and activities.

In October 2016, TRQ filed the 2016 Technical Report to provide updated scientific and technical information in respect of the Oyu Tolgoi Property. This 2020 Technical Report has been prepared under National Instrument 43-101 – Standards of Disclosure for Mineral Projects (NI 43-101) to provide a further update of the scientific and technical information in respect of the Oyu Tolgoi Property.

2.3 Report authors

This report was prepared by the QP's[10] listed on the title page. Persons who prepared or contributed to this technical report are listed in Table 2.1.

Table 2.1 Persons who prepared this 2020 Technical Report

QP	Position	Employer	Independent of TRQ	Date of site visit	Professional designation	Sections of report
QP's responsible for the preparation and signing of this Technical Report						
Roderick Carlson	Principal Geologist	AMC Consultants Pty Ltd	Yes	-	MAIG RPGeo, MAusIMM	1 (co-author), 4, 7, 8, 9, 10, 11, 12 (co-author), 14 (co-author), 27
Michael Thomas	Principal Mining Consultant	AMC Consultants Pty Ltd	Yes	-	FAusIMM (CP)	1 (co-author), 2, 3, 5, 12.2, 12.3, 13, 15, 16, 17, 18 (except 18.6), 19, 20, 24, 25, 26 (co-author)
Jo-Anne Dudley	Chief Operating officer of TRQ	TRQ	No	24 Sept 2019	FAusIMM (CP)	6, 12.1, 18.6, 21, 22, 26 (co-author)
Racquel Kolkert	Director, Resources & Exploration	TRQ	No		MAusIMM (CP)	1 (co-author), 14 (co-author), 23

Note: QP responsibility for 'co-author' sections are governed by their respective areas of expertise: Mr R. Carlson – geological aspects; Ms J Dudley - tailings storage aspects; Mr M. Thomas - underground mining, metallurgical and mineral processing aspects; Ms R Kolkert - Mineral Resource aspects.

[10] As defined by NI 43-101 reporting standard.

2.4 Sources of information

The QP's have reviewed available study reports, documents and other data relating to the Oyu Tolgoi Property. The sources of information for this 2020 Technical Report are:

- The Oyu Tolgoi Feasibility Study 2020 (2020 Feasibility Study), which has been prepared by Oyu Tolgoi LLC for the Professional Mineral Resources Council of Mongolia.
- The Oyu Tolgoi 2016 Feasibility Study (2016 Feasibility Study).
- The 2016 Oyu Tolgoi Technical Report (2016 Technical Report).
- TRQ AIF for the year ended 31 December 2019 (2019 AIF).
- Technical reports prepared by specialist independent consultants engaged by Oyu Tolgoi LLC.
- Mineral resource and mineral reserve reports and supporting data prepared by Competent Persons employed by Oyu Tolgoi LLC in accordance with the Australian Code for Reporting of Exploration Results, Mineral Resource and Ore Reserves (the JORC Code).

A comprehensive reference list in included in Section 27.

2.5 Personal inspections of the Oyu Tolgoi Property

Jo-Anne Dudley visited the Oyu Tolgoi Property in January 2019, March 2019, July 2019, and 24 September 2019. Areas inspected included underground project, Shaft 2, open pit, processing plant and core shed facilities.

The other QP's have been unable to carry out a site visit due to COVID-19 Travel restrictions.

2.6 Conventions

2.6.1 Units of measurement

Measurements are generally reported in the appropriate metric (SI) unit. The use of SI symbols, such as kPa and Mt, follow the ISO standard. Where non-SI units are used, usage conforms with industry conventions, such as bcm (bank cubic metres) and tph (tonnes per hour). Refer to the list of abbreviations and symbols provided at the front of this report for definitions of all non-SI units and SI units that are not in common use.

For ease of reference, the conversion factors of commonly used units of measurement are provided in Table 2.2.

Table 2.2 Conversion factors

Metric unit =	Imperial units
1 hectare (ha)	2.471 acres
1 metre (m)	3.280 feet
1 kilometre (km)	0.621 miles
1 gram (g)	0.032 ounces (troy)
1 kilogram (kg)	2.205 pounds
1 tonne (t)	1.102 tons (short)
1 cubic metre (m^3)	1.308 cubic yards

Imperial unit =	Metric units
1 acre	0.405 ha
1 foot	0.305 m
1 mile	1.609 km
1 ounce (troy)	31.104 g
1 pound (lb)	0.454 kg
1 ton (short)	0.907 t
1 cubic yard	0.765 m^3

2.6.2 Currency

Monetary values are reported in US dollars unless otherwise stated. References to "$" and "US$" are to US dollars.

2.6.3 Dates

Where space is a consideration, dates are abbreviated in the form dd/mm/yyyy. For example, the abbreviation 31/03/2020 is read as 31 March 2020.

2.6.4 Coordinates

Geodetic Universal Trans Mercator (UTM) coordinates are stated in metres east and north of the UTM zone 48N datum. Mine grid coordinates correspond to the UTM coordinates.[11]

Geographic coordinates are stated in degrees, minutes and seconds of longitude and latitude are relative to the World Geodetic System (WGS) 1984 datum.

2.6.5 Elevation and reduced level

Elevations are stated in metres above Baltic Sea mean sea level. Reduced level (RL) is reported in metres above the mine height datum (m RL) at an elevation of 0 metres above mean sea level.

2.6.6 Dip and azimuth

Hole dips are reported in decimal degrees down from horizontal. Hence, a negative dip indicates an up-hole. Azimuths are reported in decimal degrees clockwise from grid north. Negative azimuth is added to 360.

2.7 Terminology

Use of the (capitalised) terms "Mineral Resource", "Measured Mineral Resource", "Indicated Mineral Resource", "Inferred Mineral Resource", "Mineral Reserve", "Proven Mineral Reserve", "Probable Mineral Reserve" in this report is in accordance with CIM Definition Standards adopted on 10 May 2010, and the definition of "QP" is in accordance with the NI 43-101 reporting standard. Capitalised terms can be shown shortened, such as "Inferred", without loss of meaning. Uncapitalised terms, such as "resource" and "persons", are generic and do not imply (nor preclude) the application of a reporting standard.

In this 2020 Technical Report, the term block caving has been used as the generic term to describe the caving mining method proposed for the Hugo North and other deposits at Oyu Tolgoi. It includes the progressive extension of block caving into unmined areas of the orebody, a process often referred to as panel caving.

Sustainable Production is the point at which the cave starts to self-propagate, and production ramp-up commences.

2.8 Abbreviations and symbols

References cited in this report used in this report are provided in Section 27.

[11] The official Mongolian survey datum was changed in 2011 to WGS 84 / UTM zone 48N. Coordinate differences with the former MSK42 standard were noted as minor by Ivanhoe (IMMI).

3 Reliance on other experts

To complete the 2020 Technical Report, the QP's have relied on certain information provided by TRQ or its agents relating to:

- The legal matters including, the standing of lease, the status and standing of material licences, permits, contracts and agreements that are reported in Section 4.
- Material environmental and social impact matters that are reported in Section 20.
- Taxation, duties, royalties, and related financial matters including the economic modeling of these matters that are reported as at 30 June 2020 in Sections 21 and 22.

The information relied upon by the QP's in relation to legal matters has been sourced from TRQ, the 2020 Feasibility Study prepared by Oyu Tolgoi LLC, and from the 2019 AIF.

The information relied upon by the QP's in relation to material environmental and social matters has been sourced from the 2020 Feasibility Study prepared by Oyu Tolgoi LLC.

The information relied upon by the QP's in relation to taxation, duties, royalties, and related financial matters has been sourced from the 2020 Feasibility Study prepared by Oyu Tolgoi LLC and from cost models prepared by Oyu Tolgoi LLC and reviewed by TRQ.

The QP's have fully relied on the information provided and believe there is a reasonable basis for this reliance.

4 Property description and location

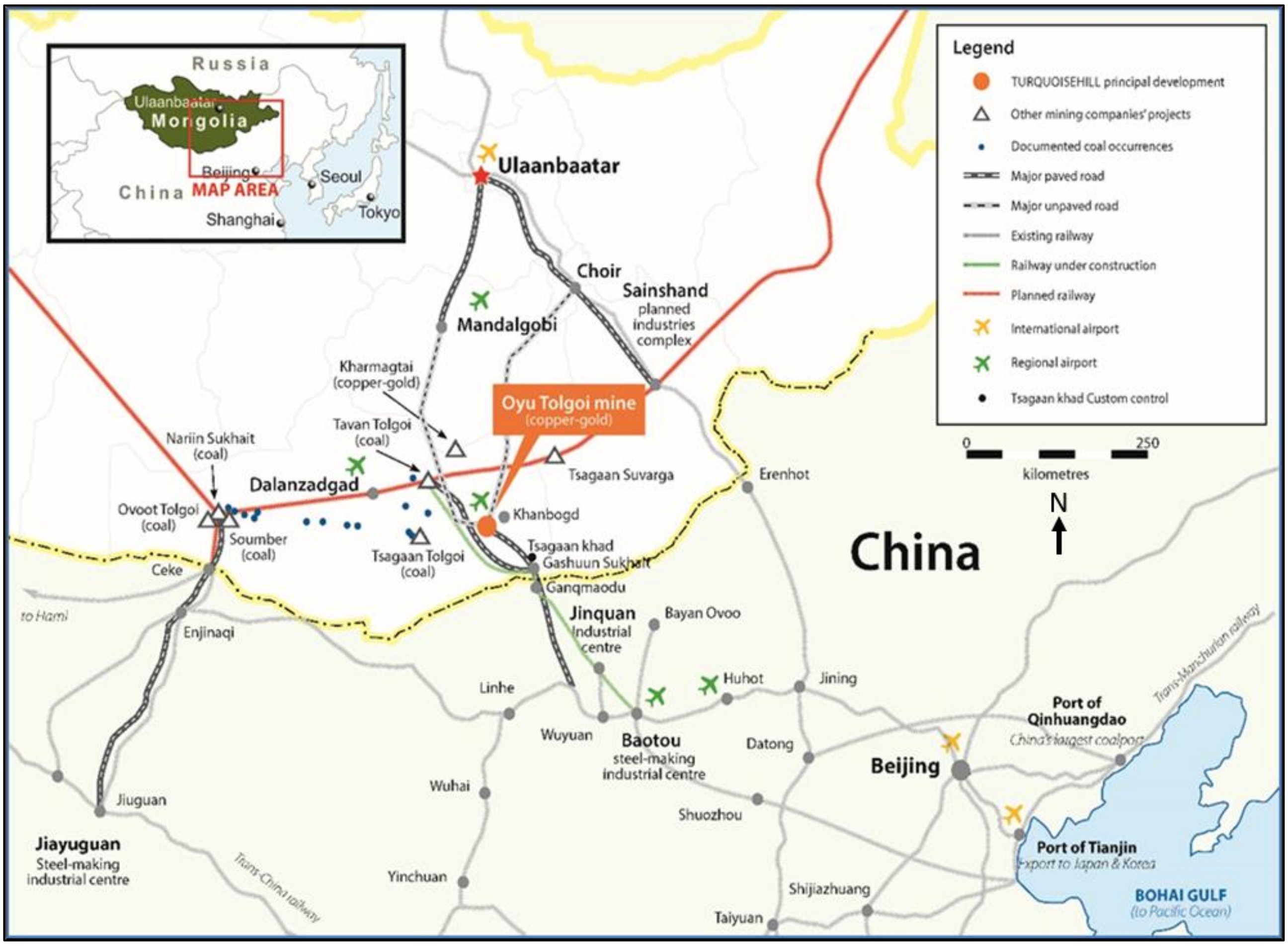
4.1 Overview

The Oyu Tolgoi Property is approximately 645 km by road south of the capital of Mongolia, Ulaanbaatar. The location of the Property and its proximity to major national infrastructure is illustrated in Figure 4.1.

The mineral deposits at the Oyu Tolgoi Property lie in a structural corridor where mineralization has been discovered over a 26 km strike length. Four deposits hosting mineral resources have been identified within the Property: Hugo North, Hugo South, Oyut and Heruga.

Hugo North and Hugo South are also known as the Hugo Dummett deposits. The Oyut deposit, formerly known as Southern Oyu Tolgoi, is currently mined as an open pit using a conventional drill, blast, load, and haul method. The Hugo North deposit is currently being developed as an underground mine.

Figure 4.1 Project location



Source: Compiled by AMC from information provided by TRQ, Date: 30 June 2020

4.2 Mining licences

The Oyu Tolgoi Property comprises five mining licences held by Oyu Tolgoi LLC and Entrée LLC, a subsidiary of Entrée Resources Ltd., formerly known as Entrée Gold Inc. The mining licences provide rights to the holders to explore, develop mining infrastructure, and conduct mining operations at Oyu Tolgoi.

Oyu Tolgoi LLC owns 100% of three licences; MV-006708 (the Manakht licence), MV-006709 (the Oyu Tolgoi licence), and MV-006710 (the Khukh Khad licence) while legal title to MV-015226 (the Shivee Tolgoi Licence) and MV-015225 (the Javkhlant Licence) is currently held by Entrée LLC, subject to the conditions described below.

Oyu Tolgoi's legal title to the Shivee Tolgoi and Javkhlant licences is subject to the equity participation and earn-in agreement dated 15 October 2004, as amended on 9 November 2004, between Entrée LLC and TRQ (the Earn-In Agreement), which established a joint venture arrangement between Oyu Tolgoi LLC and Entrée LLC, which provides for Oyu Tolgoi LLC to hold legal title in the licences, subject to the terms of the agreement, and to Oyu Tolgoi LLC meeting prescribed earn-in expenditures. Although a formal joint venture agreement has not been signed, the earn-in requirements have been met. Both the Shivee Tolgoi and Javkhlant licences are operated by Oyu Tolgoi LLC.

Under the Earn-in Agreement, Oyu Tolgoi LLC's participating interest in the joint venture arrangements (including the licences) consists of:

- 70 percent of the proceeds from mining from the surface to 560 m below the surface; and
- 80 percent of the proceeds from mining from depths below 560 m.

Most of the identified mineralization at Oyu Tolgoi occurs at the Hugo North and Oyut deposits within the Oyu Tolgoi Licence MV006709. The northernmost extension of the Hugo North deposit extends onto the Shivee Tolgoi Licence and is subject to the terms of the Earn-In Agreement.

The three Oyu Tolgoi mining licences have 30-year terms from 23 December 2003, while the with Shivee Tolgoi Licence and the Javkhlant Licence have 30-year terms from 27 October 2009. Each mining licence has two 20-year extensions.

The five mining licences comprising the Oyu Tolgoi Property are listed in Table 4.1 and shown in Figure 4.2.

Table 4.1 Mining Licences comprising the Oyu Tolgoi Property

Licence number as at June 2020	Area (ha)	Legal owner	Oyu Tolgoi's interest
MV-006708	4,533	Oyu Tolgoi LLC	100%
MV-006709	8,490	Oyu Tolgoi LLC	100%
MV-006710	1,763	Oyu Tolgoi LLC	100%
MV-015225 (Javkhlant)	20,327 all under agreement	Entrée LLC (a subsidiary of Entrée Resources Ltd)	70% from the surface to 560 m below the surface; and 80% from below 560 m
MV-015226 (Shivee Tolgoi)	42,592.58 all under agreement	Entrée LLC (a subsidiary of Entrée Resources Ltd)	70% from the surface to 560 m below the surface; and 80% from below 560 m

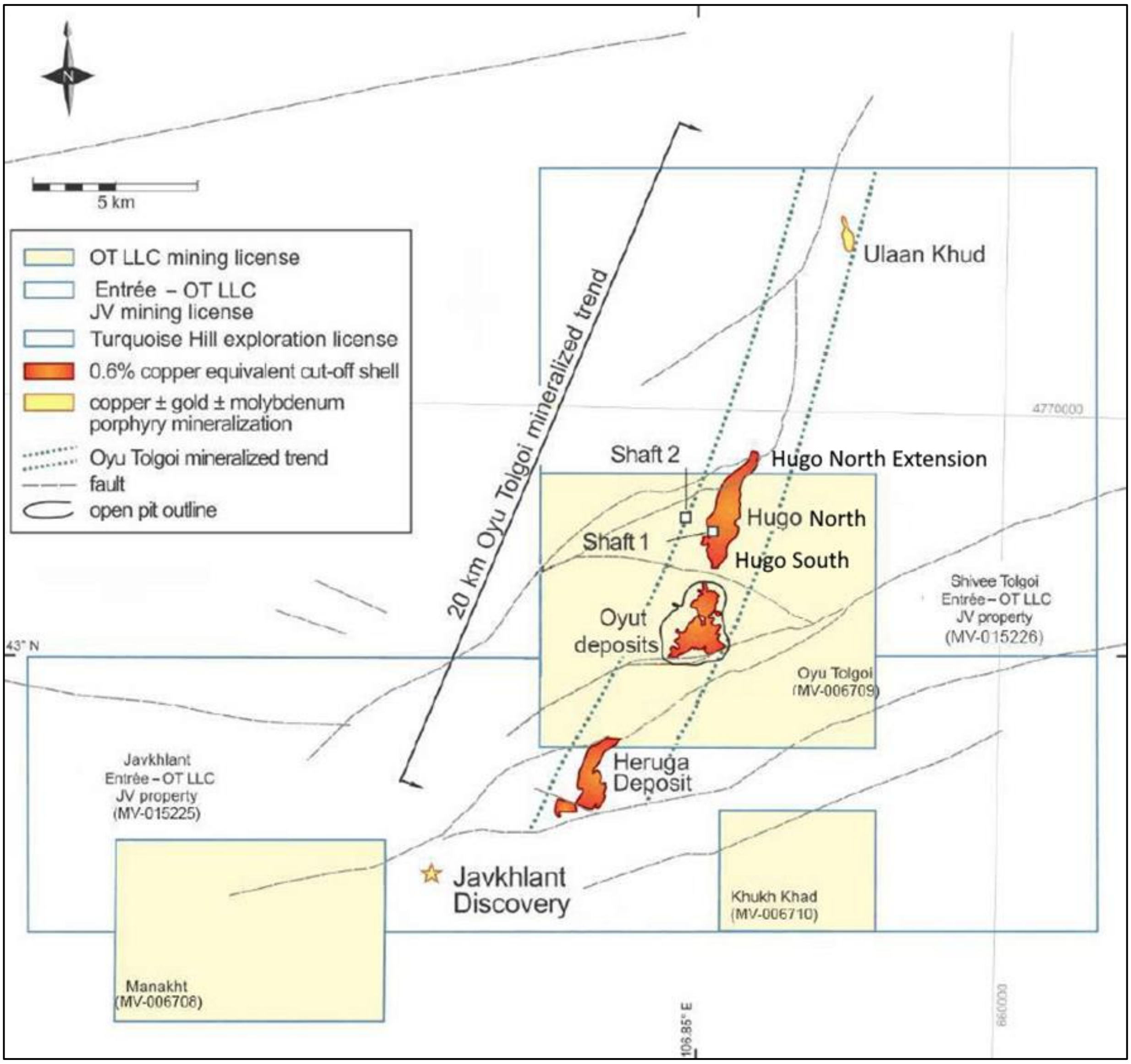
Most of the identified mineralization at Oyu Tolgoi occurs within mining licence MV006709, which contains the Oyut, Hugo North, Hugo South deposits, and the northern tip of Heruga. The Government of Mongolia granted mining licences MV006708, MV006709, MV006710 to Oyu Tolgoi LLC in 2003. There are numerous exploration targets across MV006708, MV006709, and MV006710.

Entrée LLC holds mining licences (Javkhlant and Shivee Tolgoi) contain the Heruga deposit and northernmost extension of the Hugo North deposit. There are numerous exploration targets across MV015225 and MV015226.

The mining licences comprising the Oyu Tolgoi Property were surveyed by an independent consultant in 2002 and by a qualified Mongolian Land Surveyor in 2004. In early-2011, the

Government of Mongolia changed its official survey datum to WGS 84 / UTM zone 48N. In accordance with the requirements of the change, Geomaster Co. Ltd. resurveyed the licences and new licence certificates reflecting the slight change from prior surveys were issued to Oyu Tolgoi LLC. The Project is centred at approximately latitude 43°00'45"N, longitude 106°51'15"E.

Figure 4.2 Location of the Oyu Tolgoi mining licences



Source: Compiled by AMC from information provided by TRQ, Date: 30 June 2020

4.3 Agreements

The following agreements relating to the Project have been entered into by TRQ, the Government of Mongolia, and other entities and have an impact on TRQ's interest in, and obligations relating to the Oyu Tolgoi Property:

- Investment Agreement dated 6 October 2009, between the Government of Mongolia, Oyu Tolgoi LLC, TRQ, and Rio Tinto in respect of Oyu Tolgoi (Investment Agreement).
- Amended and Restated Shareholders Agreement dated 8 June 2011 among Oyu Tolgoi LLC, THR Oyu Tolgoi Ltd. (formerly Ivanhoe Oyu Tolgoi (BVI) Ltd.), Oyu Tolgoi Netherlands B.V. and Erdenes MGL LLC (ARSHA). Erdenes MGL LLC since transferred its shares in Oyu Tolgoi LLC and its rights and obligations under the ARSHA to its subsidiary, Erdenes Oyu Tolgoi LLC.

- Underground Mine Development and Financing Plan (Underground Development Plan) dated 18 May 2015, between TRQ, the Government of Mongolia, Erdenes Oyu Tolgoi LLC, THR Oyu Tolgoi Ltd., Oyu Tolgoi Netherlands B.V., Rio Tinto and Oyu Tolgoi LLC.
- PSFA dated 31 December 2018, between the Government of Mongolia and Oyu Tolgoi LLC, including the amendment to the PSFA dated 26 June 2020

These agreements establish obligations and commitments of the involved parties, including the Government of Mongolia, providing clarity and certainty in respect of the development and operation of Oyu Tolgoi. The Investment Agreement also includes a dispute resolution clause that requires the parties to resolve disputes through international commercial arbitration procedures. Copies of each agreement have been filed with the Canadian Securities Authorities on SEDAR at www.sedar.com.

The key terms of these agreements are summarised in the following sections. In December 2019, a Resolution of the Parliament of Mongolia was published that included resolutions to take comprehensive measures to improve the implementation of the Investment Agreement and the ARSHA, to improve the Underground Development Plan, and to explore and resolve options to have a product sharing arrangement or swap Mongolia's equity holding of 34% for a special royalty.

4.3.1 Rio Tinto Agreements

Since 2006, Rio Tinto has entered into several agreements to increase its indirect ownership interest in Oyu Tolgoi LLC and to secure funding and management control of the Project development and operation. A summary of significant agreements is included in Table 4.2. Copies of the significant agreements have been filed on SEDAR and can be accessed at www.sedar.com.

Table 4.2 Key Rio Tinto Agreements

Date	Agreement Description	Terms, Provisions and Outcomes
18-Oct-2006	Private Placement Agreement	• Acquisition of 19.7% stake in TRQ by way of two tranches, the first of which closed in October 2006 and the second of which closed in October 2009. • Granting of certain pre-emptive rights to RTIH entitling it to participate, subject to certain exceptions, in future issuances of common shares of TRQ, which pre-emptive rights remain in effect. • Formation of a joint "Technical Committee" to oversee and approve the Project development.
08-Dec-2010	Heads of Agreement	• Provided for series of funding measures, including $1.8 billion interim funding facility from Rio Tinto. • Establishment of a joint "Operating Committee". • Granting of the right to Rio Tinto to appoint an affiliate to manage Oyu Tolgoi pursuant terms of a management agreement.
17-Apr-2012	Memorandum of Agreement (MoA)	• Rio Tinto to provide $1.5 billion of bridge financing and standby commitment to $1.8 billion rights funding by TRQ • Rio Tinto to support Project funding, including granting of a completion support guarantee by a Rio Tinto affiliate • Reduction of TRQ Board of Directors to 13 members, from the initial 14 members.
28-Jun-2013	Short-Term Bridge Funding Agreement	• Rio Tinto to make available to TRQ a convertible non-revolving term credit facility of up to $225 million.
7-Aug-2013 23 Aug 2013	New Bridge Funding Agreement and 2013 MoA	• Rio Tinto and TRQ to amend the short-term bridg.e funding agreement to extend the Maturity Date to 28 August 2013 • Rio Tinto to provide TRQ a new secured bridge funding facility in the amount of $600 million. • If required, TRQ agreed to conduct a further rights offering prior to 30 December 2013 to cover interim funding and bridge facility amounts with a Rio Tinto standby commitment. • TRQ agreed to enter into a general security agreement with Rio Tinto and reimburse Rio Tinto associated costs.
15-Dec-2015	Project Finance Facility and Financing Support Agreements	• Syndicated $4.4 billion project finance facility intended for the development of the underground mine of the Project with Rio Tinto completion support. • TRQ entered into a number of agreements in connection with the project financing, including: a financing support agreement with Rio Tinto, a financing support agreement with Oyu Tolgoi LLC and Rio Tinto, a cash management services agreement with affiliates of Rio Tinto, and a sponsor debt service undertaking agreement pursuant to which, among other things, TRQ and Rio Tinto guaranteed to the finance parties payment of principal, interest and fees owed by Oyu Tolgoi to the senior lenders under the project financing payable prior to completion.

4.3.2 Investment Agreement

The Investment Agreement provides for, among other things, a framework for undertaking mining activities in compliance with all laws relating to the environment and human health, the rehabilitation of the environment, the social and economic development of the Southern Gobi region, and the creation of new jobs in Mongolia.

The Investment Agreement became effective on 31 March 2010 and has an initial term of 30 years (until 31 March 2040). Oyu Tolgoi LLC has the right, by giving notice not less than 12 months prior to the expiry of the initial term and subject to the fulfilment of certain conditions, to extend the initial term of the Investment Agreement for an additional term of 20 years.

To exercise its right to extend the initial term, Oyu Tolgoi LLC must have performed certain obligations during the initial 30-year term, including, among others:

- Having demonstrated that Oyu Tolgoi has been operated to industry best practice in terms of national and community benefits, environmental health and safety practices.
- Having made capital expenditures in respect of Oyu Tolgoi of at least $9 billion.
- Having complied in all material respects with its obligations to pay taxes under the laws of Mongolia, as stabilized under the terms of the Investment Agreement.
- If, as part of the development of Oyu Tolgoi, Oyu Tolgoi LLC has constructed a copper smelter, Oyu Tolgoi LLC must have constructed or be constructing such smelter in Mongolia.
- If the development and operation of Oyu Tolgoi has caused any unanticipated and irreversible ecological damage to natural resources in Mongolia, then Oyu Tolgoi LLC must have paid compensation based on the value of any such permanently damaged natural resources in accordance with the applicable laws of Mongolia.
- Having secured the total power requirements for Oyu Tolgoi from sources within the territory of Mongolia within four years of commencement of production. This obligation has been subsequently amended and restated through the Power Sector Cooperation Agreement, which was in turn superseded by the PSFA, amended in 2020. Please see Power discussion below.

Sale of mineral products

The Investment Agreement confirms Oyu Tolgoi LLC's rights to market sell and export mineral products from Oyu Tolgoi at international market prices and to freely expend and repatriate its sale proceeds in Mongolian Togrogs and foreign currencies. It also conveys legal protection on capital, property and assets of Oyu Tolgoi LLC and its affiliates, and the requirement that any expropriation action must be in accordance with due process of law on a non-discriminatory basis and with the condition of full compensation by the Government of Mongolia to the affected party.

Taxes royalties and fees

Throughout the term of the Investment Agreement, if any, all taxes as set out in Section 2.1 of the Investment Agreement payable by Oyu Tolgoi LLC will remain stabilized including the corporate income tax rate, customs duties, value-added tax, excise tax (except on gasoline and diesel fuel purchases), royalties, mineral exploration and mining licence payments, and immovable property tax and/or real estate tax. Non-stabilized taxes will apply to Oyu Tolgoi LLC on a non-discriminatory basis. Examples of non-stabilized taxes are social security obligations, work placement fees, royalties on the use of sand and gravel and water levies, some of which are paid locally.

Infrastructure, roads, and water

The Investment Agreement permits Oyu Tolgoi LLC to construct a road between the Oyu Tolgoi site and the Gashuun Sukhait border crossing with China. Oyu Tolgoi LLC may deduct the road construction expenses from its annual taxable income. 19 km of the road remains to be constructed.

Oyu Tolgoi LLC has the right to access and use self-discovered water resources for any purpose connected with Oyu Tolgoi during the life of the Project. Oyu Tolgoi LLC is required to pay fees for its water use, but such fees must be no less favourable than those payable from time to time by other domestic and international users, must take into account the quantity and quality of the water removed and consumed, and are treated as a deductible expense from Oyu Tolgoi LLC's taxable income.

Power Source Framework Agreement Amendment

Oyu Tolgoi LLC currently sources power for the Oyu Tolgoi mine from China's Inner Mongolian Western Grid, via overhead power line, pursuant to back-to-back power purchase arrangements with Mongolia's National Power Transmission Grid JSC, (NPTG) the relevant Mongolian power authority, and Inner Mongolia Power International Cooperation Co., Ltd (IMPIC), the Chinese power generation company.

Oyu Tolgoi LLC is obliged under the 2009 Oyu Tolgoi Investment Agreement to secure a long-term domestic source of power for the Oyu Tolgoi mine. The Power Source Framework Agreement entered into between Oyu Tolgoi LLC and the Government of Mongolia on 31 December 2018 provides a binding framework and pathway for long-term power supply to the Oyu Tolgoi mine. The Power Source Framework Agreement originally contemplated the construction of a coal-fired power plant at Tavan Tolgoi (TTPP), which would be majority-owned by Oyu Tolgoi LLC and situated close to the Tavan Tolgoi coal mining district located approximately 150 kilometres from the Oyu Tolgoi mine. In April 2020, the Government of Mongolia advised that it was unwilling to support Oyu Tolgoi LLC's proposal to develop the TTPP and announced its intention to fund and construct a state-owned power plant at Tavan Tolgoi.

On 26 June 2020, Oyu Tolgoi LLC and the Government of Mongolia amended the Power Source Framework Agreement (the Power Source Framework Agreement Amendment) to reflect their agreement to jointly prioritise and progress the state-owned power plant, in accordance with and subject to agreed milestones, as the domestic source of power for the Oyu Tolgoi mine. The milestones include: signing a Electricity Purchase and Sale Agreement(Power Purchase Agreement) for the supply of power to the Oyu Tolgoi mine by March 31, 2021, commencing construction of a state owned power plant by no later than 1 July 1 2021, commissioning the state-owned power plant within four years thereafter, and reaching agreement with IMPIC on an extension to the existing power import arrangements by 1 March 2021 in order to ensure there is no disruption to the power supply required to safeguard the Oyu Tolgoi mine's ongoing operations and development pending start of the supply from the state-owned power plant.

The Power Source Framework Agreement Amendment provides that if certain agreed milestones are not met in a timely manner (subject to extension for defined delay events) then Oyu Tolgoi LLC will be entitled to select from, and implement, the alternative power solutions specified in the Power Source Framework Agreement (as amended), including an Oyu Tolgoi LLC led coal-fired power plant and a primary renewables solution, and the Government of Mongolia would be obliged to support such decision.

Local communities and employment

The Investment Agreement requires that at least 90% of the employees at Oyu Tolgoi and at least 50% of Oyu Tolgoi LLC engineers at Oyu Tolgoi are Mongolian nationals. Oyu Tolgoi LLC currently meets these requirements. Oyu Tolgoi LLC must also use its best endeavours to ensure that at least 70% of its engineers are Mongolian nationals after September 2023. Oyu Tolgoi LLC must also use its best efforts to ensure that not less than 60% of its contractors' employees are Mongolian nationals for construction work and 75% of its contractors' employees are Mongolian nationals for mining and mining related work.

Oyu Tolgoi LLC will conduct, implement, and update, from time to time, socio-economic impact assessments, socio-economic risk analyses, multi-year community plans, community relations management systems, policies, procedures and guidelines, and mine closure plans, all of which shall be produced with community participation and input and be consistent with international best practices. Oyu Tolgoi LLC will also conduct community development and education programs.

Oyu Tolgoi LLC will prioritize the training, recruiting and employment of citizens from local communities for Oyu Tolgoi, giving specific preference to the citizens of Umnugobi Aimag.

Environment

The Investment Agreement requires that every three years Oyu Tolgoi LLC provides the Government of Mongolia an independent report on its progress in implementing the environmental protection plan set out in the Detailed Environmental Impact Assessments submitted to the Government of Mongolia in 2012. The required independent report was submitted in 2016. The Detailed Environmental Impact Assessment will be reviewed and any amendments submitted during 2021. The report is subject to periodic review on 5-year cycles or when there are significant changes to the description of the Project.

4.3.3 ARSHA

The ARSHA forms the basis upon which the Government of Mongolia, through Erdenes Oyu Toigoi LLC, acquired an initial 34% equity interest in Oyu Tolgoi through a shareholding in Oyu Tolgoi LLC. It also provides for the respective rights and obligations of the parties as shareholders of Oyu Tolgoi LLC.

Under the terms of the ARSHA, if Oyu Tolgoi LLC exercises its right to extend the initial term of the Investment Agreement for an additional term of 20 years, Erdenes Oyu Tolgoi LLC has the option to acquire additional Oyu Tolgoi shares on terms to be agreed upon between Erdenes and the Oyu Tolgoi Shareholder Holdcos, (being THR Oyu Tolgoi Ltd. and Oyu Tolgoi Netherlands B.V., the two indirect, wholly-owned subsidiaries through which TRQ holds its interest in Oyu Tolgoi LLC), to increase its shareholding in Oyu Tolgoi LLC to 50%.

The ARSHA requires that the Oyu Tolgoi LLC's board of directors appoint a management team for Oyu Tolgoi as nominated by the Oyu Tolgoi Shareholder Holdcos to provide management services to Oyu Tolgoi LLC for the Project.

4.3.4 Underground Development Plan

The Underground Development Plan addressed several matters, including that Oyu Tolgoi LLC pay a 5% sales royalty to the Government of Mongolia calculated on gross revenues by not allowing deductions for the costs of processing, freight differentials, penalties, or payables.

The Underground Development Plan also revised the management services payment rates, established by the ARSHA, to the management team. In calculating the management services payment, the rate applied to capital costs of the underground development was reduced from 6% to 3%. The management services payment rate on operating costs and capital related to current operations remains at 6%.

4.4 Environmental liabilities

The Oyu Tolgoi is required to comply with the environmental requirements set out in the Investment Agreement and in other permits and agreements. These include remediation of the environment, mine decommissioning and reclamation, the safe management of toxic substances, tailings and waste storage, and other matters. Details of the environmental matters including liabilities are discussed in Section 20.

4.5 Permits and authorizations

All work at Oyu Tolgoi must be carried out in accordance with the laws of Mongolia. This requires obtaining numerous permits and authorizations from Mongolian regulatory authorities. As of the date of this 2020 Technical Report, material permits and authorizations necessary to develop and operate the Project have been obtained. Subject to the risks discussed below, it is reasonable to expect that future permits and authorizations required to continue the development and operation of the Project as currently planned, will be granted.

4.6 Risks

The nature and location of Oyu Tolgoi exposes the Project to factors and risks that may affect access, title, and or the right to develop and operate the Project as envisaged in the 2020 Feasibility Study. Many of the risks are of a legal, political, or commercial nature associated with the agreements with Rio Tinto, the sovereign government of Mongolia and other entities. These risks are set out in detail in the 2019 AIF available on SEDAR at www.sedar.com. Risks of a technical nature are discussed in various sections of this 2020 Technical Report and in Section 25.

5 Accessibility, climate, local resources, infrastructure, and physiography

5.1 Topography and vegetation

The topography of the Oyu Tolgoi Property largely consists of gravel-covered plains, with low hills along the northern and western borders of the licence areas. Small, scattered rock outcrops and colluvial talus are widespread within the northern, western, and southern parts of the Property. The elevations of the central portion of the Property range from approximately 1,140–1,215 metres amsl.

The surrounding mountains (Khanbogd, Dalain Duulga, and Javkhlant Khairkhan) are relatively high and considered places of worship and of other cultural and religious significance. The Gunii Khooloi basin is a hilly area in the east and south of the valley. The concentrate transportation corridor or the Oyu Tolgoi to Gashuun Sukhait paved road transects the Galbyn Gobi lowlands, and the lowest lying area is depression called Khuurai Nuur.

The Undai River is one of the key elements within the Oyu Tolgoi Property in terms of surface features. Although there are no special protected areas within the Oyu Tolgoi Property, the surrounding hills are considered of high importance. There are no significant places within the Gunii Khooloi valley and along the transport corridor.

There is limited vegetation in Oyu Tolgoi area, which lies in the desert steppe, semi-desert and desert zone of the South Gobi ecosystem.

5.2 Access

5.2.1 Road

Road access to the Oyu Tolgoi Property from Ulaanbaatar is currently by an unpaved road, via Mandalgovi (Figure 4.1). The Chinese Government has upgraded 226 km of road from Ganqimaodao to Wuyuan, providing a direct road link between the Mongolian border crossing at Gashuun Sukhait, 80 km south of Oyu Tolgoi, and the Trans-China railway system. A 105 km sealed road is currently being constructed from Oyu Tolgoi to the Mongolian-Chinese border crossing at Gashuun Sukhait. Approximately 23 km of the road are pending final construction to a fully paved standard.

5.2.2 Air

A permanent domestic airport designed to accommodate commercial aircraft up to the Boeing 737-800 series has been constructed 11 km north of the Oyu Tolgoi camp area. The flight time from Ulaanbaatar is just over one hour. The airport also serves as the regional airport for the town of Khanbogd.

5.2.3 Rail

The Trans-Mongolian Railway crosses the Mongolia-China border approximately 420 km east of Oyu Tolgoi, traversing the country from south-east to north-west through Ulaanbaatar to the border with Russia. There is currently no access from the Project site to the Mongolian railway network except along a 330 km desert trail north-east to Sainshand. At the Mongolian / Chinese border, the rail gauge changes from the Russian standard to the Chinese standard.

The Government of Mongolia may construct or facilitate construction and management of a railway in the vicinity of the Project. Oyu Tolgoi LLC will be consulted regarding the railway route. If constructed, the Government of Mongolia is obliged to make the railway available for use by Oyu Tolgoi on commercial and non-discriminatory terms.

A single-track heavy-haul railway from the Erdenes Tavan Tolgoi coal mine (approximately 150 km to the north-west of Oyu Tolgoi) to Gashuun Sukhait, ultimately to be interconnected with the Chinese rail network at Ganqimaodao. Once constructed, the rail line will pass within

12 km of Oyu Tolgoi and therefore represents an opportunity for eventual connection of Oyu Tolgoi to the rail network.

5.2.4 Port access

Oyu Tolgoi makes use of the Chinese Port of Tianjin, the largest port in northern China, some 150 km south-east of Beijing, to import freight from overseas. The port is open year-round and has no ice restrictions during winter. Road delivery from Tianjin is via Chinese highways connecting Tianjin to Wuyuan, about 1,050 km, from there along a state highway to Hailiutu, about 60 km, and then on to the China-Mongolia border crossing at Ganqimaodao-Gashuun Sukhait. This is the primary border crossing for both cargo and Chinese personnel immigration for the Project. Baotou, just east of Wuyuan, is the consolidation point for freight originating from China.

5.3 Population centres

There are several communities in the South Gobi Province (Ömnögovi aimag) relatively near Oyu Tolgoi. The most prominent is Dalanzadgad, which is the centre of the Ömnögovi aimag, and is 220 km north-west of the Oyu Tolgoi. Facilities at Dalanzadgad include a regional hospital, tertiary technical colleges, and a domestic airport.

Other communities that could be subject to the effects of the Project include:

- Khanbogd, 45 km to the north-east and closest to the Project, with a population of approximately 8,700 as at the end of 2019.
- Bayan Ovoo, 65 km to the west of the Project site, (approximate population 1,800)
- Manlai, 150 km to the north of the project site, (approximate population 2,600).
- Dalanzangrad, 220 km north of the Project on the road to Ulaanbaatar (approximate population 26,000).

The populations of these communities could all conceivable increase as a result of the Project.

The land surrounding the Project is predominantly used for nomadic herding of goats, camels, and sheep by small family units. Use is based on informal shared grazing rights with limited land tenure for semi-permanent winter shelters and other improvements.

5.4 Climate

The South Gobi region has a continental, semi-desert climate. The spring and autumn seasons are cool, summers are hot, and winters are cold. The climatic conditions are such that normal operations can continue throughout the year. Minor weather-related operational disruptions are expected to occur.

5.4.1 Temperature

Temperatures range from a maximum of about 42 °C to a minimum of −31 °C. Typical air temperature in winter fluctuates between +6 °C and −21 °C. In the coldest month, January, the average temperature is −13 °C. The ground surface can freeze to a depth of 2.5 m in some soil types.

5.4.2 Humidity

The average relative humidity (at Khanbogd) ranges from approximately 18% in May to 41% in January. Daily relative humidity varies considerably.

5.4.3 Solar radiation

The average daily maximum solar radiation is 426 watts per square metre (W/m^2) in January and 849 W/m^2 in July.

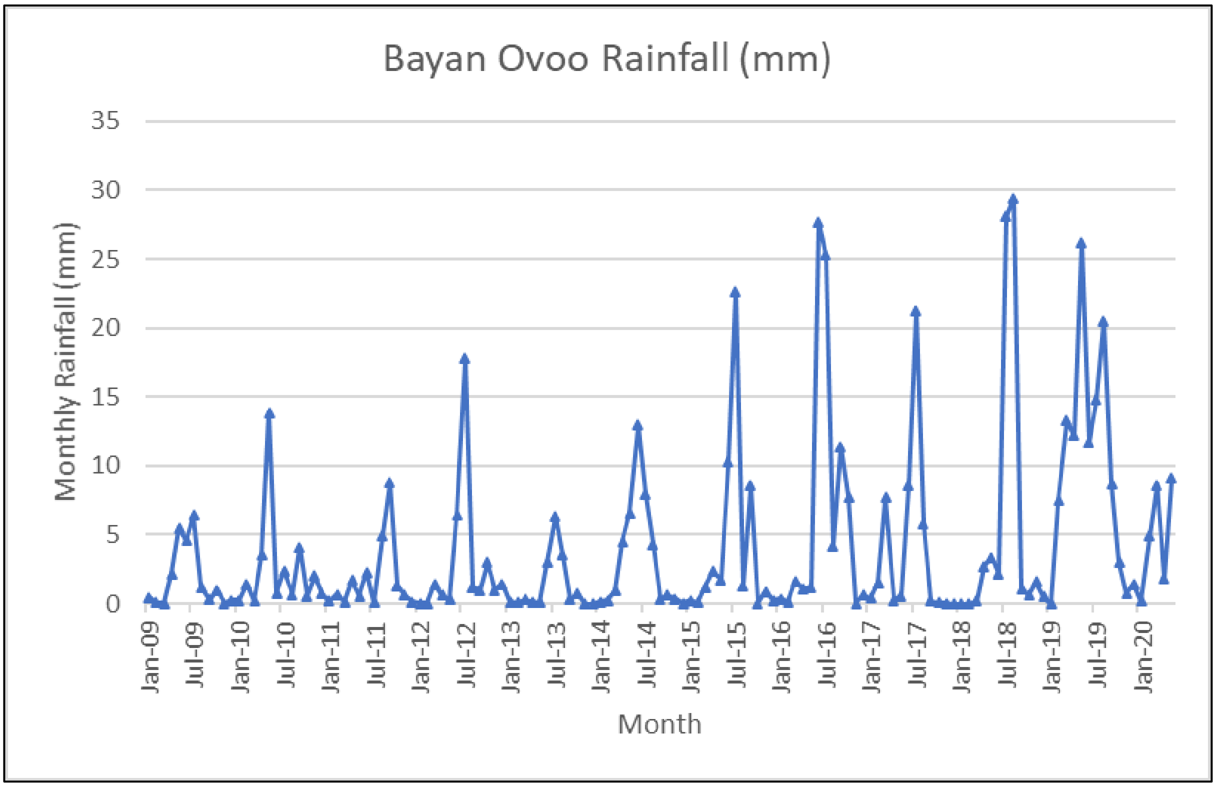
5.4.4 Rainfall

Monthly rainfall data are shown in Table 5.1 and Figure 5.1. The table is derived primarily from climatic records between 2009 and 2020 for Bayan Ovoo, approximately 65 km west of Oyu Tolgoi.

Table 5.1 Annual rainfall statistics 2009 to 2020

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Maximum daily (mm)	2.1	3.8	4.4	10.4	19.0	16.2	29.5	102.0	19.2	4.0	4.3	1.5
Avg. monthly (mm)	0.2	1.4	3.0	2.8	5.8	8.2	13.9	7.0	4.1	1.7	0.7	0.5
Avg. rain days per month (days)	1	1	3	3	3	6	8	4	3	1	0	4

Figure 5.1 Monthly rainfall at Bayan Ovoo Jan-09 to Apr-20



Source: https://www.worldweatheronline.com/bayan-ovoo-weather-averages/omnogovi/mn.aspx accessed 9 June 2020.

Average annual precipitation is 97 mm, 90% of which falls as rain and the rest as snow. Snowfall accumulations rarely exceed 50 mm. Maximum rainfall events of up to 44 mm/h for a 1-in-10 year, 10-minute storm event have been recorded. In an average year, rainfalls occur on only 19 days, and snow falls on 10–15 days.

5.4.5 Electrical activity

Records indicate that thunderstorms are likely to occur from 4 to 43 days each year. Electrical activity generally totals about 32 hours each year.

5.4.6 Evaporation

Evaporation significantly exceeds precipitation with data indicating typical annual evaporation rates of about 2,370 mm.

5.4.7 Wind

Wind is predominantly from the north. Very high winds are accompanied by sandstorms that often severely reduce visibility for several hours at a time. Windstorms can have gusts up to 50 m/s. Dust storms are far more frequent in spring and can continue through June and July. The average storm duration is six to seven hours. An average of 120 hours of dust storm activity and 220 hours of drifting dust are recorded each year.

Snowstorms and blizzards with winds up to 144 km/hr occur for five to eight days each winter.

5.4.8 Seismicity

The easternmost extension the Mongolian Altai—a tectonically active mountain range stretching 1,700 km from south-west Siberia to the Gobi Desert—lies approximately 50–100 km west of Oyu Tolgoi. A seismic hazard assessment of Oyu Tolgoi completed in 2011 determined that the seismicity of the Oyu Tolgoi area was low.

5.5 Surface water

The Project area is located within the closed Central Asian drainage basin and has no outflow to the ocean. Most riverbeds in this drainage basin are ephemeral creeks that remain dry most times of the year. The Undai River is the most significant hydrological feature of the Oyu Tolgoi area. A tributary of the river passes through the site. Flows in riverbeds after heavy summer rainstorms often result in very turbulent, high-velocity mud flows.

Shallow springs are used by wildlife and livestock. Migratory wildlife movements during summer months are likely to be dictated by the presence of surface water in natural springs.

5.6 Groundwater

Surface hydrogeological exploration drilling and pumping tests conducted between 2003 and 2007 identified the Gunii Hooloi which extends 35–75 km north of Oyu Tolgoi. Oyu Tolgoi LLC has constructed a borefield in the south-west and north-east areas of the aquifer. The borefield and pumping facility has the capacity to extract 77,760 m^3 per day from the aquifer. The total approved reserve of Gunii Hooloi aquifer is based on an extraction rate of 918 L/s.

Oyu Tolgoi LLC has developed a groundwater model to assess flow patterns and potential connectivity with the shallow aquifers. Modelling and independent groundwater studies (Aquaterra, 2013) indicate that the Gunii Hooloi aquifer can be used for 40 years at a maximum of 1,475 L/s. These studies also indicate that there is limited potential for connection between the shallow streambed aquifers and the deeper Gunii Hooloi aquifer.

An updated groundwater model is being developed for the mine site using well monitoring data. This model will assist with the assessment of the water level decline in the impact area. Groundwater investigations in the Project area are focused primarily on assessing the dewatering rates required for open pit and underground mining, and to assess the environmental impact of dewatering. Studies are ongoing to confirm groundwater model predictions.

5.7 Local water supply

Water resource prospecting and exploration works on water supply for Khanbogd soum centre was funded by Oyu Tolgoi LLC in 2013–14. A bulk water facility was built at a cost of $6.9 million, and a reliable supply of clean drinking water to Khanbogd soum has been provided via a 6.6 km pipeline. The bulk water facility was handed over to Khanbogd soum on 18 April 2017.

5.8 Sufficiency

There are sufficient surface rights for mining operations, availability and sources of power, water, mining personnel, tailings storage areas, waste disposal areas, and processing plant sites for Oyu Tolgoi to be an operational mine.

6 History

6.1 Early history

The existence of copper in the Oyu Tolgoi area has been recognized since the Bronze Age, but contemporary exploration for mineral resources did not begin until the 1980s, when a joint Mongolian and Russian geochemical survey team identified a molybdenum anomaly. Evidence of alteration and copper mineralization in the area of the Oyut deposit was first noted in 1983. In September 1996, geologists from the Magma Copper Company identified a porphyry copper leached cap over what is now known as the Central zone of the Oyut deposit. The Magma Copper Company subsequently secured exploration tenements in the area. Magma Copper Company was subsequently acquired by BHP, which became BHP-Billiton (BHP).

Geophysical surveying on the Oyu Tolgoi mining licence (MV-006709) was first conducted by BHP in 1997. An airborne magnetometer survey was carried out, followed by induced polarization (IP) surveys. The surveys covered exploration targets in the area of the Oyut deposit but did not extend into the northern area that ultimately became the Hugo Dummett deposits (Hugo North and Hugo South).

Between 1997 and 1998, BHP also carried out geological, geophysical, and geochemical (stream sediment and soil) surveys, and diamond drilling programs (23 drillholes in total) in the Central and South zones of the Oyut deposit. Copper and gold values were encountered at depths from 20 m to 70 m below the surface, and a supergene-enriched, chalcocite blanket was encountered in one drillhole. Based on the results of this drilling, BHP prepared a mineral resource estimate in 1998, but the resulting tonnage and grade estimate was considered too small to meet BHP corporate objectives, and BHP elected to offer the property for joint venture.

In 1999, TRQ (known at the time as Ivanhoe Mines Ltd.) visited Oyu Tolgoi and agreed to acquire 100% interest in the property, subject to a 2% NSR royalty. TRQ subsequently acquired the 2% NSR royalty payable by Oyu Tolgoi LLC in November 2003, thereby removing any future obligations to BHP.

6.2 2000 to 2009

In 2000, Ivanhoe, through its subsidiary Oyu Tolgoi LLC (known at the time as Ivanhoe Mines Mongolia Inc. LLC (IMMI)), completed 8,000 m of reverse circulation (RC) drilling, mostly at the Central zone, to explore the chalcocite blanket discovered earlier by BHP, and updated the BHP mineral resource estimate.

In 2001, Oyu Tolgoi LLC continued RC drilling, mostly in the South zone area, to test for additional supergene copper mineralization. Oyu Tolgoi LLC then drilled three diamond core holes to test the deep hypogene copper-gold potential. One of these holes, drilled over the Southwest zone, intersected 508 m of chalcopyrite mineralization from a depth of 70 m, grading 0.81% Cu and 1.17 g/t Au. This marked the discovery of the Oyut deposit.

These results encouraged Ivanhoe to mount a major follow-up drilling program. In late-2002, drilling in the far northern section of the property intersected 638 m of bornite-chalcopyrite-rich mineralization, starting at a depth of 222 m. This hole marked the discovery of the Hugo Dummett deposits (Hugo North and Hugo South).

In 2003, the Government of Mongolia granted mining licence MV-006709 to IMMI, along with mining licences for MV-006708 and MV-006710.

In 2004, a NI 43-101 Preliminary Economic Assessment (PEA) was completed on the economics of open pit mining the Oyut deposit.

In 2004, a first-time Mineral Resource estimate was reported for the Hugo South portion of the Hugo Dummett deposits.

In November 2004, following the signing of an Equity Participation and Earn-in Agreement with Entrée LLC (refer to Section 4). Oyu Tolgoi LLC initiated exploration work on the Javkhlant and Shivee Tolgoi licences. Entrée LLC had previously undertaken soil geochemical surveys, geophysical surveys and geological mapping, but had failed to locate any mineralization of significance.

In 2005, the Hugo Dummett Mineral Resource estimate was updated to include Hugo North.

In 2005, a PEA was prepared based on an integrated development plan for open pit mining of the Oyut deposit, two block caves on the Hugo North deposit, and one block cave on Hugo South. The integrated development plan included a processing plant with a capacity of 25.5 million tonnes per annum (Mtpa), with an expansion to 51 Mtpa.

In 2006, following further geophysical exploration and drilling, Oyu Tolgoi LLC reported a first-time resource estimate for the part of the Hugo North deposit that extends onto the Shivee Tolgoi mining licence. This area is known as the Hugo North Extension.

In 2006, a mineral reserve estimate for the Oyut deposit was reported, based on a feasibility study of an open-pit only mining scenario.

In January 2006, Shaft 1 headframe, hoisting plant, and associated infrastructure were completed. By January 2008, the shaft had been sunk to a depth of 1,385 m enabling underground exploration development for the Hugo North deposit to commence.

In early 2007, core drilling was initiated to test induced polarity (IP) anomalies on Entrée LLC's Javkhlant licence. The drilling identified the Heruga deposit in 2008.

In 2007, the Hugo North mineral resource estimate was updated.

In 2008 a first-time mineral resource estimate was reported for the Heruga deposit.

In 2009, the Investment Agreement between Oyu Tolgoi LLC and the Government of Mongolia was signed (refer to Section 4). As part of the agreement process, Oyu Tolgoi LLC prepared a Mongolian feasibility study (MFS09) for the Government of Mongolia. MFS09 envisaged open-pit mining on the Oyut deposit and underground mining by block caving on Hugo North, Hugo South, and the Heruga deposits. A processing plant capacity of 36.5 Mtpa expanding to 58 Mtpa was envisaged.

6.3 2010 to 2013

In 2010, an NI 43-101 Technical Report (2010 Technical Report) was released based on an integrated development plan for the Project. The 2010 Technical Report included a Mineral Reserve for the Oyut deposit based on open-pit mining and an ore reserve for part of the Hugo North deposit (Lift 1) based on the block caving method. The report envisaged the same plant capacity as MFS09.

In 2010, a decision was made to construct the Oyut open pit mine and to construct a 36.5 Mtpa concentrator and supporting infrastructure.

In 2011, an updated NI 43-101 Technical Report was released that updated the 2010 Technical Report while maintaining the same concentrator feed capacity.

In 2011, sinking of Shaft 2 (the main personnel, rock hoisting, and intake ventilation shaft) commenced.

In 2012, Rio Tinto Ltd became the majority shareholder of Ivanhoe.

In 2012, Ivanhoe was renamed Turquoise Hill Resources Ltd and the Detailed Integrated Development and Operating Plan was prepared examining the scenario of open-pit mining on the Oyut deposit and underground block caving on Hugo North Lift 1, without a plant expansion.

In November 2012, Oyu Tolgoi LLC, Inner Mongolia Power International Corporation and Oyu Tolgoi LLC executed the Power Purchase Agreement to supply power to Oyu Tolgoi.

In January 2013, Oyu Tolgoi processed its first ore through the concentrator, and shortly thereafter, produced the first copper-gold concentrate.

In March 2013, Detailed Integrated Development and Operating Plan and a further Technical Report (2013 Technical report) was released based on a more detailed feasibility study of open pit mining on the Oyut deposit and underground block caving of Hugo North Lift 1.

In June 2013, more than 40,000 t of concentrate had been produced. The concentrator was reported to be running at full capacity in September 2013.

In August 2013, development of the underground mine was suspended to allow matters to be resolved between the parties to the Investment Agreement, including a tax dispute, approval of the Detailed Integrated Development and Operating Plan by Oyu Tolgoi's shareholders and by the Mongolian Minerals Council, agreement of a comprehensive funding plan, and receipt of all necessary permits.

6.4 2014 to 2016

In 2014, the Hugo North mineral resource estimate was updated, and Oyu Tolgoi LLC submitted a Statutory Feasibility Study with the Mongolian Minerals Council. The Statutory Feasibility Study envisaged open pit mining on the Oyut deposit and underground block caving on Hugo North Lift 1. In addition, the study considered the development of mineral resources at Hugo North Lift 2, Hugo South, and Heruga). A concentrator throughput rate of 36.5 Mtpa was envisaged.

In March 2014, TRQ announced that it was continuing to work together with Rio Tinto and the Government of Mongolia with the aim of resolving outstanding shareholder matters and finalizing Oyu Tolgoi project financing.

In October 2014, TRQ filed a Technical Report (2014 Technical Report) for the Project. The 2014 Technical Report was based on a new feasibility study prepared by Oyu Tolgoi LLC. The study envisaged the same integrated mining concept as the 2013 Technical Report.

In 2014, Oyu Tolgoi LLC produced 148,400 t of copper and 589,000 oz of gold in concentrates.

In March 2015, Oyu Tolgoi LLC filed the Statutory Feasibility Study with the Mongolian Minerals Council and in May 2015, TRQ announced the signing of the Underground Development Plan by the Government of Mongolia, TRQ and Rio Tinto (refer to Section 4), which addressed key outstanding shareholder matters and set out an agreed basis for the funding of the Project. The Statutory Feasibility Study (updated in 2016) incorporated matters resolved between the shareholders and was approved by the Oyu Tolgoi LLC board of directors and shareholders.

In August 2015, Oyu Tolgoi LLC filed revised schedules for the Statutory Feasibility Study with the Mongolian Minerals Council. The filing aligned the Statutory Feasibility Study with the Underground Development Plan.

In 2015, Oyu Tolgoi LLC produced 202,200 t of copper and produced 653,000 oz of gold in concentrate. It recorded net revenue of approximately $1.6 billion in sales on approximately 820,000 t of concentrates. Mill throughput increased by 23.9% compared to 2014, driven by operational improvements.

In May 2016, Oyu Tolgoi LLC received the formal notice to restart underground development. Underground construction began in mid-2016.

In October 2016, TRQ released the 2016 Technical Report, which updated and replaced the 2014 Technical Report.

6.5 2017 to 2020

In May 2017, Oyu Tolgoi LLC signed a new power purchase agreement with the National Power Transmission Grid of Mongolia. The power purchase agreement was executed in connection with the power import arrangement between National Power Transmission Grid of Mongolia and the Inner Mongolia Power International Corporation.

In January 2018, Shaft 2 shaft sinking was completed, enabling shaft equipping to commence.

In March 2018, the sinking of Shaft 5 (an exhaust ventilation shaft) was completed to its final depth of 1,178 m.

In July 2018, the Shaft 5 commissioning was completed.

In October 2018, TRQ reported that Rio Tinto in its role as manager of Oyu Tolgoi and underground construction contractor had undertaken its second annual schedule and cost re-forecast for the Project (2018 Rio Tinto Review) and had notified TRQ that, based on preliminary results, the achievement of sustainable first production from Hugo North was expected to occur by the end of the third quarter of 2021 instead of the first quarter of 2021, a delay of nine months.

In December 2018, Oyu Tolgoi LLC and the Government of Mongolia announced the signing of the Power Source Framework Agreement, which provided a binding framework and pathway forward for the construction of the TTPP and established a basis for a long-term domestic power solution for the mine.

In March 2019, TRQ announced that, following its own independent review performed after the 2018 Rio Tinto Review, the following key risks to the development of the Project were developing:

- Shaft 2 equipping delays were occurring due to lower than expected productivity in steel and electrical installation as well as increased quality assurance measures. This was likely to impact overall underground development rate increases.
- There had been delays to development progress and productivities in key areas.
- In some areas there was a delay to the critical path activities from scope growth in mass excavation and additional ground support due to unexpectedly adverse geotechnical conditions.

TRQ announced that further delays on the Shaft 2 equipping were expected to contribute to an overall delay to sustainable first production beyond the end of the third quarter of 2021. The management team was also studying relocating the ore passes on the footprint and this may modify the initiation sequence within the first panel (Panel 0) to be mined.

In July 2019, TRQ announced that improved rock mass information and geotechnical data modelling had confirmed stability risks with components of the existing mine design. To address these risks, several mine design options were under consideration to determine the final design of Panel 0, and that this work was anticipated to continue into early 2020.

TRQ also announced that preliminary estimates indicated that sustainable first production could be delayed by 16 to 30 months compared to the schedule provided in the 2016 Technical Report. The delay included a contingency of up to eight months.

In November 2019, the equipping of Shaft 2 was completed, and the shaft was in the final stages of commissioning.

In November 2019, TRQ announced that a decision had been made to retain a mid-access drive on the apex level and remove the originally planned mid-access drives on the undercut and extraction levels of Panel 0. The mid-access drives provide easy access to the levels but increase the stress concentration on the levels during the undercutting process.

In February 2020, TRQ announced the submission of the feasibility study for the TTPP to the Government of Mongolia. TRQ also announced that Oyu Tolgoi LLC would enact the contingency arrangements under the Power Source Framework Agreement. This commenced a negotiation process to confirm a mutually acceptable pathway to secure a domestic power supply for Oyu Tolgoi.

In April 2020, Phase One of the contingency arrangements under the Power Source Framework Agreement concluded on 14 April 2020. The parties had not been able to agree a way forward for a TTPP. This commenced Phase Two of the contingency arrangements, which is the consideration of the alternatives specified in the Power Source Framework Agreement, including an Oyu Tolgoi mine site-based power plant, a primary renewables solution and a grid power supply.

In May 2020, TRQ announced that the updated Panel 0 mine design was approved. The approved design is based on a block cave method and includes two pillars, one to the north and one to the south of Panel 0. As a result of the updated design, a delay was anticipated to the 2016 Feasibility Study key project milestone of Sustainable Production by 25 months (with a range of 21 to 29 months) and an increase in development capital cost of $1.5 billion (with a range of $1.3 to $1.8 billion).

In June 2020 Phase Two of the contingency arrangements under the Power Source Framework Agreement concluded. TRQ also announced that the Government of Mongolia and Oyu Tolgoi LLC reached an agreement to amend the Power Source Framework Agreement. This amendment would prioritise a state-owned power plant. The agreement envisages the funding and construction of the state-owned power plant by the Government of Mongolia.

In July 2020, TRQ announced that the 2020 Feasibility Study was delivered to the Government of Mongolia. The announcement included updated mineral resources and mineral reserves. The Feasibility Study was submitted to the Government of Mongolia to comply with local regulatory requirements.

7 Geological setting and mineralization

7.1 Regional geology

The Oyu Tolgoi porphyry deposits are hosted within the Gurvansaikhan Terrane, part of the Central Asian Orogenic Belt, rocks of which now comprise the South Gobi region of Mongolia (Figure 7.1).

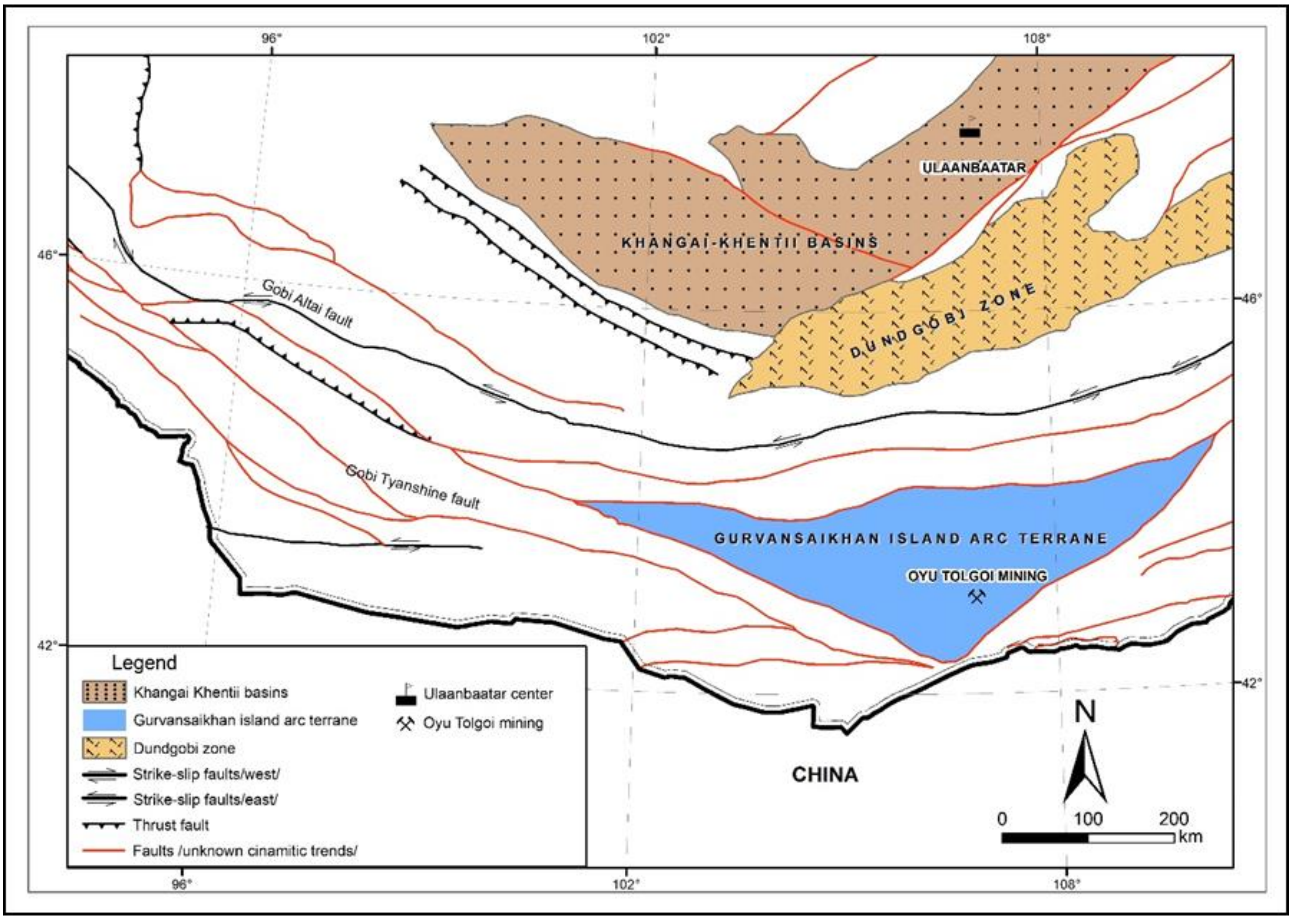
Development of the Central Asian Orogenic Belt consisted of Palaeozoic age accretionary episodes that assembled several island and continental margin magmatic arcs, rifted basins, accretionary wedges, and continental margins. Arc development ceased by about the Permian. During the Late Jurassic to Cretaceous, north–south extension occurred, accompanied by the intrusion of granitoid bodies, unroofing of metamorphic core complexes, and formation of extensional and transpressional sedimentary basins. North-east–south-west shortening is superimposed on the earlier units and is associated with major strike-slip faulting and folding within the Mesozoic sedimentary basins.

The Gurvansaikhan Terrane is interpreted to be a juvenile island arc assemblage that consists of highly deformed accretionary complexes and volcanic arc assemblages dominated by imbricate thrust sheets, dismembered blocks, mélanges, and high-strain zones. Lithologies identified to date in the Gurvansaikhan Terrane include Silurian to Carboniferous terrigenous sediments, volcanic-rich sediments, carbonates, and intermediate to felsic volcanic rocks.

Sedimentary and volcanic units have been intruded by Devonian granitoids and Permo-Carboniferous diorite, monzodiorite, granite, granodiorite, and syenite bodies, which can range in size from dykes to batholiths.

Major structures to the west of the Gurvansaikhan Terrane include the Gobi-Tyanshine sinistral strike-slip fault system that splits eastward into a number of splays in the Oyu Tolgoi area, and the Gobi Altai Fault system, which forms a complex zone of sedimentary basins over-thrust by basement blocks to the north and north-west of Oyu Tolgoi (Figure 7.1). To the east of the Gurvansaikhan Terrane, regional structures are dominated by the north-east striking East Mongolian Fault Zone, which forms the south-east boundary of the terrane. This regional fault may have formed as a major suture during Late Palaeozoic terrane assembly, with Mesozoic reactivation leading to the formation of north-east elongate sedimentary basins along the fault trace.

Figure 7.1 Regional setting, Gurvansaikhan Terrane



Source: Compiled by AMC from information provided by TRQ, Date: 30 June 2020. Projection WGS84 Lat/Long.

7.2 District geology

7.2.1 Overview

The Oyu Tolgoi copper-gold porphyry deposits are situated in a poorly exposed inlier of Devonian mafic to intermediate volcanic, volcaniclastic, and sedimentary rocks that have been intruded by Devonian to Permian felsic plutons. These rocks are unconformably overlain by poorly consolidated Cretaceous sedimentary rocks and younger unconsolidated sedimentary deposits.

The stratigraphic sequences recognized in the Project area, from oldest to youngest, include:

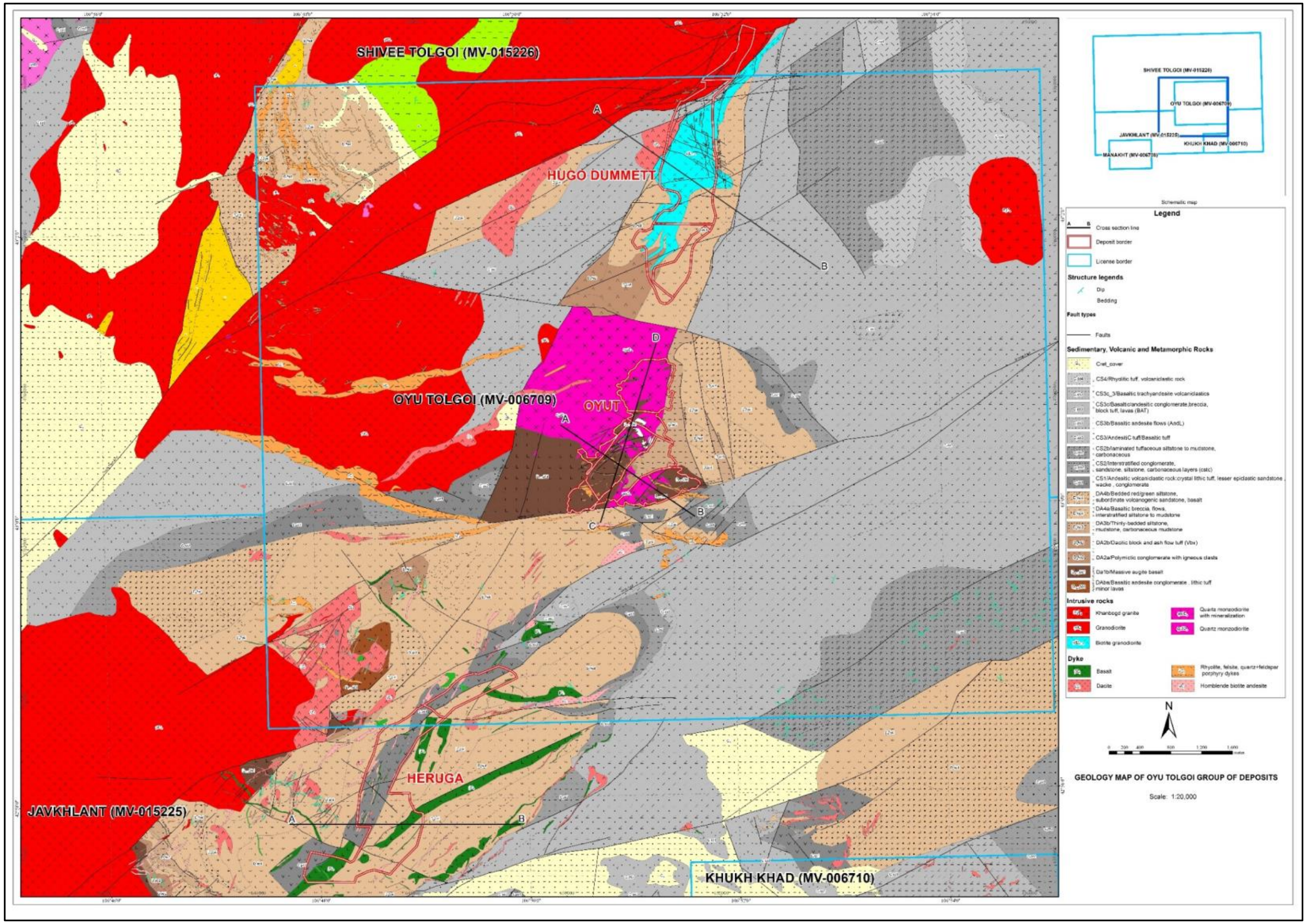
- Alagbayan Group – comprising the Bulagbayan and Khalzan-Ovoo Formations that consist of tuffs, basaltic rocks, and sedimentary strata of probable island-arc affinity assigned to the Upper Devonian.
- Sainshandhudag Formation - an overlying succession containing conglomerates, fossiliferous marine siltstones, sandstones, water-lain tuffs, and basaltic to andesitic flows and volcaniclastic rocks, assigned to the Carboniferous.
- Bayanshiree Formation - overlying Upper Cretaceous clays and gravels.
- Quaternary sediments.

The Alagbayan and Sainshandhudag sequences are separated by a regional unconformity that, in the Oyu Tolgoi area, is associated with a time gap. The volcanic and sedimentary rocks are cut by several phases of intrusive rocks ranging from batholithic intrusions to narrow discontinuous dykes and sills. Compositional and textural characteristics vary.

The Project area is underlain by complex networks of poorly exposed faults, folds, and shear zones. These structures influence the distribution of mineralization by both controlling the original position and form of mineralized bodies and modifying them during post-mineral deformation events.

The mineralized porphyry centres define a north-northeast trending corridor underlain by east-dipping panels of Upper Devonian or older layered sequences intruded by quartz-monzodiorite and granodiorite stocks and dykes (Figure 7.2).

Figure 7.2 Geology map of Oyu Tolgoi licenced area



Source: Compiled by AMC from information provided by TRQ, Date: 30 June 2020. Projection WGS84 Lat/Long

7.2.2 Sedimentary host sequence

The volcanogenic-sedimentary rocks distributed through the Oyu Tolgoi area referred to as the Upper Devonian Alagbayan group and Lower Carboniferous Gurvankharaat group (Table 7.1 and Table 7.2) because those rocks are similar to the rocks distributed in the South Mongolian volcanic zone.

Upper Devonian Alagbayan Group

The Alagbayan suite, which was first outlined by Goldenberg et al. (1978), is classified as a group consisting of the Tsavchir, Bulagbayan and Khalzan-Ovoo Formations (Minjin 2004). Only the Bulagbayan and Khalzan-Ovoo Formations are distributed in the Oyu Tolgoi area. A stratigraphic column that shows the relative thicknesses of the various lithologies in the Project area is presented in Figure 7.3.

- **Bulagbuyan Formation**

  Distributed through the Alagbayan district, the formation was cross sectioned near the area of the Bulagbayan well. The lower part of the formation, approximately 750 m thick, consists of green sandstone interlayered with siltstone containing andesite, andesite-basalt, porphyry with sulfide mineralization. Late Devonian brachiopods and faunal remains are also found. the upper part consists of basalt lapilli tuff, conglomerate containing volcanoclastics conglomerate and conglomerate-breccia.
  The formation typically corresponds to the DA1 member units and is composed of thinly bedded siltstone (DA1a), basalt with augite (DA1b) and basaltic-clastic rock (DA1c).

- **Khalzan-Ovoo Formation**

  The Khalzan Ovoo formation is distributed through the Alagbayan Mountains forming rolling hills such as Khalzan Ovoo, Shavagtai Mountain, Nuden khudag, and near Ger Chuluu well in the southeast of the Tsagaan Suvarga mine. The lower part (DA2) is 200 m thick, composed of polymictic conglomerate and a blocky tuff of dacite composition, the middle part (DA3) is 50 m to 400 m thick, comprising grey and green grey sandstone interlayered with basalt, andesite and siltstone. The upper part (DA4) is poorly exposed in the mine area and appears to be similar to the basalt tuff unit (DA4a).
  Sediments typically correspond to the DA2-DA4 units and include tuff (DA2b2) with ash flow of dacitic composition and blocky and ashy tuffs, and flow-like breccia of basaltic composition and coarse-grained volcanoclastic rocks (DA4) and red, green and variegated sedimentary series.

Table 7.1 Major units of the Alagbayan Formation

Fm	Unit	Lithologies	Description
Bulagbuyan	DA1	Basaltic flows and volcaniclastic rocks; several hundred metres in thickness.	Two subunits: Lower: grey to green, finely laminated, volcanogenic siltstone and interbedded fine sandstone (DA1a). Upper: dark green, massive porphyritic (augite) basalt. Overlies and partially intercalated with basal unit (DA1b). Basalt lapilli tuff (DA1c) overlies DA1b in some locations
Khalzan-Ovoo	DA2	Dacite tuff / volcaniclastic rocks; at least 200 m thick	Three subunits: Lower: monolithic to slightly polylithic basaltic lapilli tuff to volcaniclastic conglomerate/breccia. Underlies and partially intercalated with middle unit (DA2a) Middle: buff to dark green, dacite lapilli tuff. Overprinted by intense sericite and advanced argillic alteration (DA2b_1) Upper: weakly altered to unaltered polymictic block tuff to breccia, with lesser intercalated lapilli tuff (DA2b_2).

Fm	Unit	Lithologies	Description
	DA3	Clastic sedimentary sequence; approximately 100 m thick	Two subunits: Polylithic conglomerate, sandstone, and siltstone. Abundant in the South zone and parts of the Hugo South deposit (DA3a). Rhythmically interbedded carbonaceous siltstone and fine brown sandstone. Ubiquitous in drillholes in Hugo North and is also discontinuously distributed in the more southerly deposits (DA3b).
	DA4	Basaltic flows / fragmental rocks, siltstone; approximately 600 m thick	Three subunits: Dark green basaltic volcanic breccia with vesicular, fine-grained to coarsely porphyritic basaltic clasts is the dominant lithotype; interlain with volcanogenic sandstones and conglomerates (DA4a). Thinly interbedded red and green siltstone, which contain subordinate basalt layers in their lower levels (DA4b). Massive green to grey sandstone with rare siltstone interbeds (DA4c).

Lower Carboniferous Gurvankharaat Group

The Gurvankharaat Group units lie to the east of the Oyu Tolgoi mineralized sequence. They were previously classified as separate units by Suetenko and Durante (1976) near Tsokhiot massive and Gurvan Kharaat Mountain on the border of Khanbogd and Manlai soums of Umnugovi Aimag but were classified as a group by Goldenberg et al. (1978). This group consists of three formations, including Sainshandkhudag, Murgutsug and Tsohiot. Lower Carboniferous rocks distributed through the Oyu Tolgoi area are referred as Sainshand Formation.

- **Sainshandkhudag Formation**

  The Sainshandkhudag Formation is divided into three major units (Table 7.2) at Oyu Tolgoi:

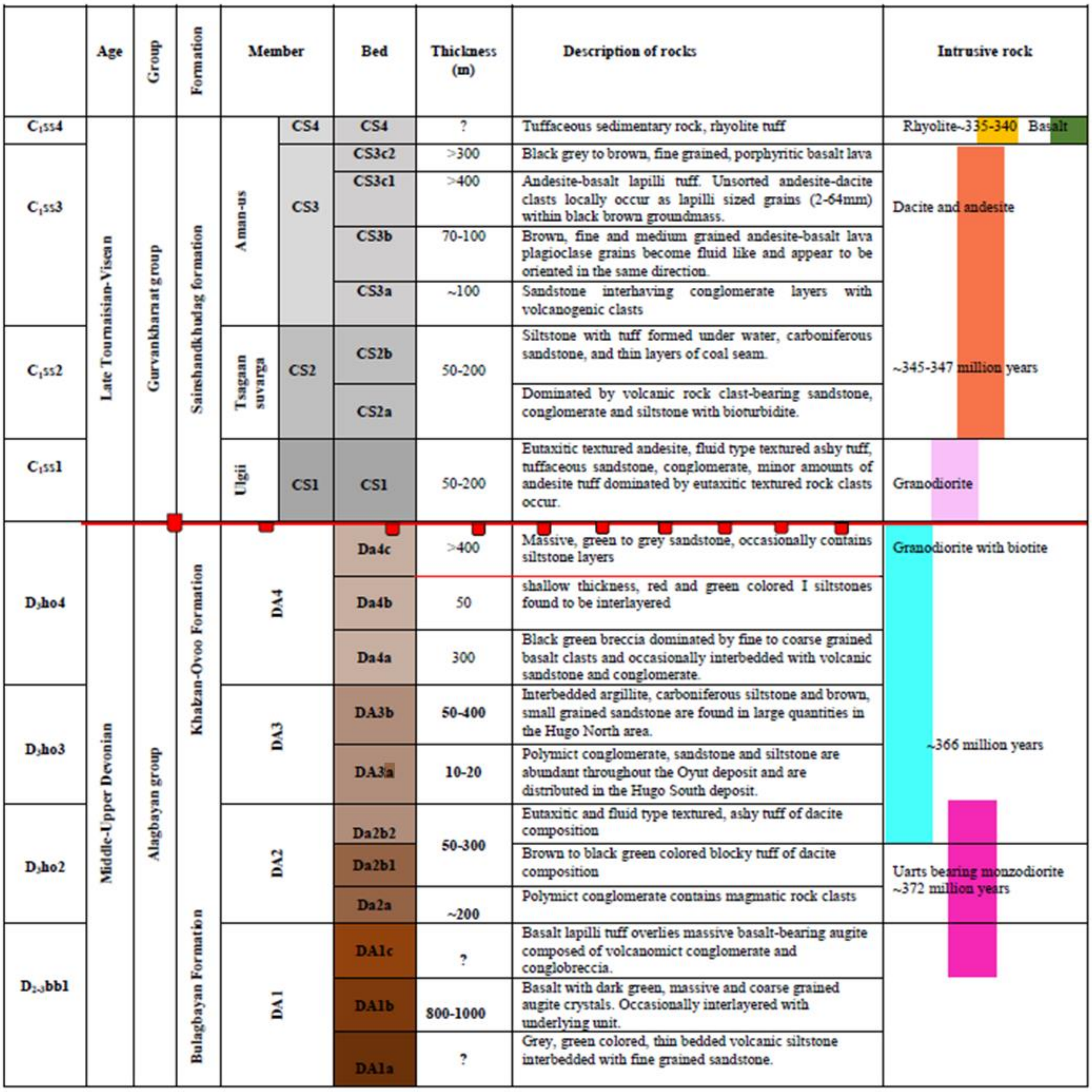
  - Ulgii—a lowermost tuffaceous sequence (CS1)
  - Tsagaan Suvarga—an intermediate clastic package (CS2)
  - Aman-us—an uppermost volcanic/volcaniclastic sequence (CS3)

The unit post-dates porphyry mineralization and is separated from the underlying Devonian rocks by a regional unconformity.

Table 7.2 Major units of the Sainshandhudag Formation

Fm	Unit	Lithologies	Description
Sainshandkhudag	CS1	Andesitic lapilli tuff and volcaniclastic rocks; approximately 200 m thick	Andesitic lapilli tuff with abundant fiamme, and subordinate block tuff to breccia.
	CS2	Conglomerate, sandstone, tuff, and coal; approximately 200 m thick	Typically shows a progression from a lower conglomerate- sandstone-siltstone dominant unit (CS2a) to an overlying siltstone- waterlain tuff unit (CS2b). Carbonaceous siltstone and coal beds occur in the lower part of the sequence.
	CS3	Basaltic and andesite lava and volcaniclastic rocks; approximately 800 m thick	Four sub-units: Basal: thin volcanic sandstone (CS3a). Lower middle: discontinuous porphyritic basaltic andesitic lava sequence (CS3b). Upper middle: thick basaltic breccia-to-block tuff unit (CS3c_1). Upper: intercalated to overlying porphyritic basalt flow sequence (CS3c_2).

Figure 7.3 Stratigraphy of the Oyu Tolgoi area



	Age	Group	Formation	Member		Bed	Thickness (m)	Description of rocks	Intrusive rock
C_1ss4	Late Tournaisian-Visean	Gurvankharat group	Sainshandkhudag formation	Aman-us	CS4	CS4	?	Tuffaceous sedimentary rock, rhyolite tuff	Rhyolite~335-340 Basalt
C_1ss3					CS3	CS3c2	>300	Black grey to brown, fine grained, porphyritic basalt lava	Dacite and andesite
						CS3c1	>400	Andesite-basalt lapilli tuff. Unsorted andesite-dacite clasts locally occur as lapilli sized grains (2-64mm) within black brown groundmass.	
						CS3b	70-100	Brown, fine and medium grained andesite-basalt lava plagioclase grains become fluid like and appear to be oriented in the same direction.	
						CS3a	~100	Sandstone interhaving conglomerate layers with volcanogenic clasts	
C_1ss2				Tsagaan suvarga	CS2	CS2b	50-200	Siltstone with tuff formed under water, carboniferous sandstone, and thin layers of coal seam.	~345-347 million years
						CS2a		Dominated by volcanic rock clast-bearing sandstone, conglomerate and siltstone with bioturbidite.	
C_1ss1				Ulgii	CS1	CS1	50-200	Eutaxitic textured andesite, fluid type textured ashy tuff, tuffaceous sandstone, conglomerate, minor amounts of andesite tuff dominated by eutaxitic textured rock clasts occur.	Granodiorite
D_3ho4	Middle-Upper Devonian	Alagbayan group	Khalzan-Ovoo Formation	DA4		Da4c	>400	Massive, green to grey sandstone, occasionally contains siltstone layers	Granodiorite with biotite
						Da4b	50	shallow thickness, red and green colored I siltstones found to be interlayered	
						Da4a	300	Black green breccia dominated by fine to coarse grained basalt clasts and occasionally interbedded with volcanic sandstone and conglomerate.	
D_3ho3				DA3		DA3b	50-400	Interbedded argillite, carboniferous siltstone and brown, small grained sandstone are found in large quantities in the Hugo North area.	~366 million years
						DA3a	10-20	Polymict conglomerate, sandstone and siltstone are abundant throughout the Oyut deposit and are distributed in the Hugo South deposit.	
D_3ho2				DA2		Da2b2	50-300	Eutaxitic and fluid type textured, ashy tuff of dacite composition	
						Da2b1		Brown to black green colored blocky tuff of dacite composition	Uarts bearing monzodiorite ~372 million years
						Da2a	~200	Polymict conglomerate contains magmatic rock clasts	
$D_{2\text{-}3}bbl$			Bulagbayan Formation	DA1		DA1c	?	Basalt lapilli tuff overlies massive basalt-bearing augite composed of volcanomict conglomerate and conglobreccia.	
						DA1b	800-1000	Basalt with dark green, massive and coarse grained augite crystals. Occasionally interlayered with underlying unit.	
						DA1a	?	Grey, green colored, thin bedded volcanic siltstone interbedded with fine grained sandstone.	

Source: Otgonbayar at al. (2014). Note Bayanshiree and Quaternary sediments overlie this stratigraphy.

Upper Cretaceous Bayanshiree Formation

Bayanshiree Formation sediments unconformably overlie the mineralized sequence at Oyu Tolgoi and are distributed in the north of the Oyu Tolgoi deposit. They were initially mapped (1:200,000 scale) as individual Bayanshiree Formations by Burenkhuu et al. (1995). The Formation sediment is composed of uncemented or weakly cemented, dark-brown, reddish-yellow clay and clayey gravel and is locally poorly sorted with occasional coarse gravels. These sediments overlay secondary enrichment and weathering zones and are in turn overlain by quaternary sediments.

7.2.3 Intrusive rock

Intrusive rocks are widely distributed through the Project area and range from large batholithic intrusions to narrow discontinuous dykes and sills. At least seven classes of intrusive rocks are recognised based on compositional and textural characteristics. Intrusive composition, structure, texture, distribution and ages are presented in Table 7.3.

Copper-gold porphyry mineralization is related to the oldest recognized intrusive suite, consisting of large Devonian quartz-monzodiorite intrusions that occur in the deposit areas.

Table 7.3 Major intrusive rock units

Unit	Lithologies	Age	Description
Intrusions	Quartz-monzodiorite to monzodiorite	371 ± 2 Ma	Texturally and compositionally varied. Typically, phenocryst-crowded, with >40% plagioclase phenocrysts up to 5 mm long, and 10–15% biotite and hornblende. Abbreviated to QMD.
Intrusion, dykes and sills	Biotite granodiorite	366 ± 4 Ma	Contain large plagioclase phenocrysts with lesser small biotite phenocrysts, within a fine-grained to aphanitic brown groundmass. Intrusions are compositionally and texturally varied and probably include several intrusive phases. Forms a large stock at Hugo North (BiGd)
Intrusions	Syenite, granite, quartz-monzonite, quartz diorite, and quartz syenite	348 ± 3 Ma	Large, polyphase granitic complex bounding the Project to the northwest.
Dykes	Hornblende-biotite andesite and dacite	343 ± 3 Ma	Typically, strongly porphyritic with feldspar, hornblende, and biotite. Quartz phenocrysts are common.
Dykes and sills	Rhyolite; range from metres to a few tens of metres wide	320 ± 10 Ma	Aphanitic and aphyric. Intrusive breccias are common along dyke contacts, commonly incorporating both rhyolitic and wall rock fragments within a flow-banded groundmass.
Dykes	Basalt/dolerite; in deposit area range from metres to a few tens of metres wide; in southwest part of the Project area can occur as large, sill-like intrusive masses	Carboniferous	Intrude all stratified units. Typically, aphanitic to fine-grained, locally vesicular, and contain variable amounts of plagioclase phenocrysts.
Intrusions	Alkaline granite	Permian	Large, circular intrusion exposed just east of the Project that is defined by abundant pegmatite dykes.

7.2.4 Structural setting

Variations in bedding attitude recorded in both oriented drill core and surface outcrops define two orientations of folds at Oyu Tolgoi: a dominant set of north-east trending folds, and a less-developed set of north-west trending folds. These folds are well defined in bedded strata of both the Sainshandhudag Formation and Alagbayan Group. They may be present in stratified rocks throughout the Oyu Tolgoi Property, but outcrop and drillhole data are insufficient to define them in many areas. There is no evidence of a penetrative fabric (e.g., cleavage) associated with folding.

Together, the two orientations of folds form a dome-and-basin interference pattern, but it is not possible to determine their relative ages. Both dominant fold orientations occur in Lower Carboniferous strata, indicating that both folding events post-date mineralization.

Sedimentary facing direction indicators, including grading, scour and fill structures, load casts, and crossbedding, are sporadically observed in drill core by Oyu Tolgoi geologists along the east flank of the Hugo Dummett deposits. These suggest that parts of the Alagbayan Group are overturned. However, no large isoclinal folds have been mapped from drill core. These folds are cut by dykes of the 366 Ma biotite-granodiorite suite and therefore were formed within the Late Devonian. Such folds and geopetal features are difficult to ascribe to regional tectonic events and may simply be localized features of rapid facies changes in a proximal submarine volcanic environment.

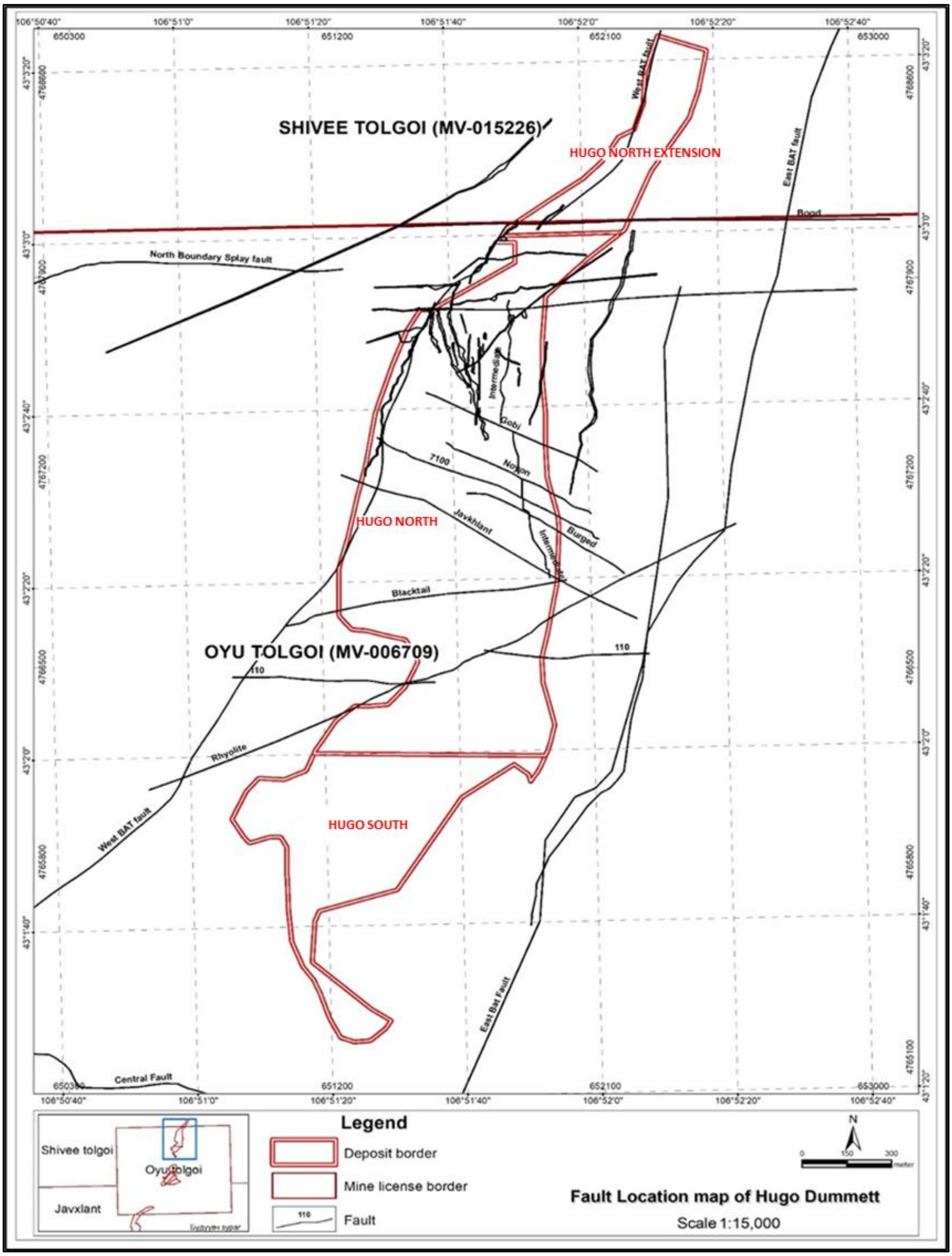
The Project area is underlain by complex networks of faults, folds, and shear zones. Most of these structures are poorly exposed on surface and have been defined through integration of detailed exploration data (primarily drill-hole data), property-scale geological mapping, and geophysical data. There is evidence for several phases of deformation and reactivation of the early faults during later deformational events. The areas defined structural elements are summarized in Table 7.4 and shown in Figure 7.4 for the Hugo Dummett deposits.

Table 7.4 Defined structures within the Oyu Tolgoi area

Structure	Setting	Description
Central Fault	West-north-west striking, moderately north dipping structure that lies between the Hugo South deposit and the Central zone of the Oyut deposit.	Fault consists of several splays and may have experienced multiple periods of displacement. Early fault displacement resulted in north side down apparent offset, followed by a later apparent reverse displacement of lesser magnitude. Visible as linear magnetic feature cutting the overlying Sainshandhudag Formation.
Contact Fault	Low-angle thrust fault generally parallel to bedding; occurs from Heruga in the south to the Hugo Dummett deposits in the north.	Places overturned upper Devonian sedimentary and volcanic rocks belonging to the DA4 unit over upright Devonian sediments of unit DA3b. Does not truncate mineralization.
7100 Fault	North-west strike, steep dip	Offset of north side down, displacement of all rock units
Bogd Fault	East–west strike, steep dip	Oblique slip fault with dextral lateral displacement
Lower Fault	North-north-west striking, moderate dip	Deposit parallel fault, shear zone
110 Fault	East–west strike, moderate dip to North	Boundary between Hugo North and Hugo South
Axial Fault	Hypothetical, based on alignment of the Southwest and Central zones and the Hugo Dummett deposits, and the elongate form of the Hugo Dummett deposits.	Alignments suggest an underlying north-north-east striking fault or fault-zone controlled emplacement of porphyry intrusions and related hydrothermal activity.
West Bat, East Bat Faults	North-north-east trending, bounding Hugo Dummett deposits.	Control the structural high, which hosts Hugo Dummett. Offsets of post-mineralization stratigraphic contacts measure at least 1 km (east side up) for the West Bat Fault, and 200–300 m (west side up) for the East Bat Fault.
East Bounding and West Bounding Faults	North-east to north-north-east trending; bounding the Southwest zone.	Form a primary control on the distribution of copper and gold mineralization. Presence of mineralized clasts within the fault zones implies faults were active post-mineralization. East bounding fault is a gently listric, steeply west dipping fault zone in the order of >50 m wide. The fault has been modelled as a series of segments displaced across newly interpreted north-west–south-east trending faults.
Bor Tolgoi and Bor Tolgoi West Faults	North-east to north-north-east trending; bounding the Heruga deposit.	Display 300–500 m of west side down apparent offset of stratigraphic contacts.
Boundary Fault system	East-north-east striking fault zone; juxtaposes the Devonian sequence hosting and overlying the Oyu Tolgoi deposits against the Carboniferous granitic complex to the north.	Faults within this system include the North Boundary Fault, an unnamed splay of the North Boundary Fault, and the Boundary Fault. Faults dip steeply to the north or north-west, and occur as strongly developed, foliated gouge and breccia zones ranging from tens of centimetres to several tens of metres wide.
North-west Shear Zone	Ductile shear zone that cuts across the far north-west corner of the Oyu Tolgoi area.	Wide shear zone with mylonitic to ultra-mylonitic rocks in the centre, grading outward over about 200 m to rocks lacking visible ductile strain. Marks the break between the Alagbayan and Sainshandhudag Formations and the Carboniferous granitic complex.
Solongo Fault	East to east-north-east striking, subvertical structure; cuts across Oyu Tolgoi just south of the Southwest and South zones.	Typically occurs as a strongly tectonized, foliated zone up to several tens of metres wide. Forms a major structural break; a minimum of approximately 1,600 m of south side down stratigraphic offset where it juxtaposes mineralized basalt (unit DA1) in the South zone against sediments correlated with the upper Alagbayan Formation (unit DA4) to the south.
North-west trending faults	Oyut	Subvertical to steeply north-east dipping faults associated with rhyolite dykes.

Structure	Setting	Description
East-north-east striking faults	Regional bounding faults at Heruga deposit.	Form prominent features on both magnetic and satellite images. Geological mapping shows a 500 m apparent dextral displacement of dykes and stratigraphic contacts across the faults.

Figure 7.4 Hugo South, Hugo North including Hugo North Extension structural setting



Source: Compiled by AMC from information provided by TRQ, Date: 30 June 2020. Projection WGS84 Lat/Long

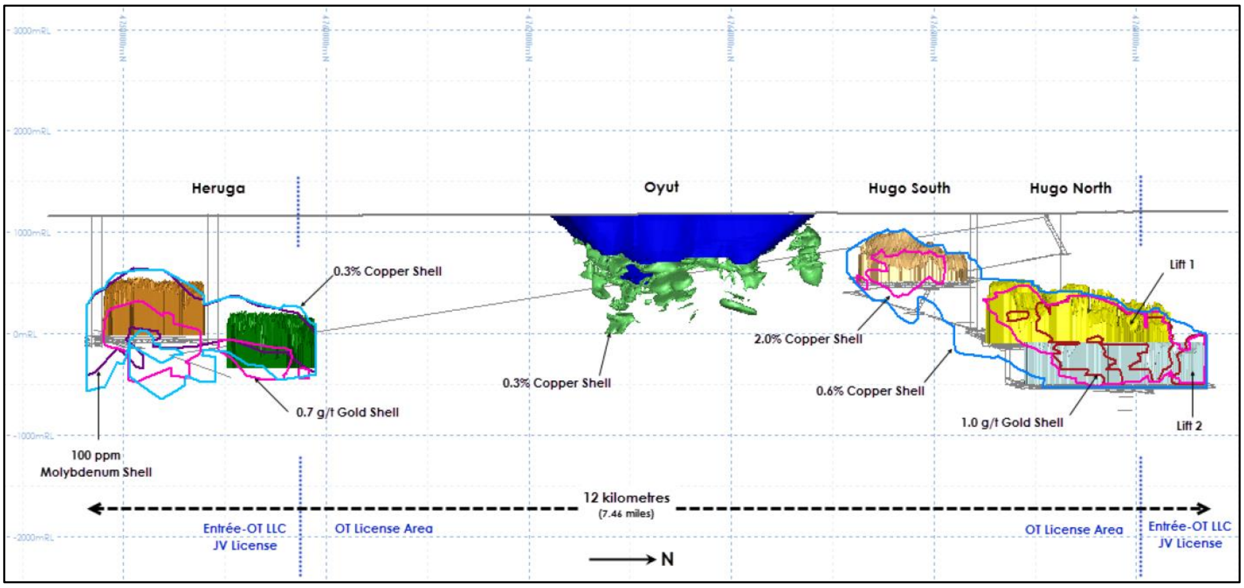
7.3 Local geology

Oyu Tolgoi consists of Oyut, Hugo Dummett (Hugo South and Hugo North) and Heruga deposits. In this section a discussion of the geology and mineralization at each deposit is discussed. The Oyu Tolgoi copper-gold deposits currently comprise, from north to south:

- Hugo North – The Hugo Dummett Deposit north of approximately 4766300 N (or the 110 Fault).
- Hugo South - The Hugo Dummett Deposit south the 110 Fault.
- Oyut - The Oyut Deposit includes the Southwest Oyu, South Oyu, Wedge, Central Oyu, Bridge, Western, and Far South zones within mining licence MV-006709.
- Heruga – is within the area governed by the arrangements between Oyu Tolgoi LLC and Entrée LLC except for a small northern portion that lies within the Oyu Tolgoi mining licence MV-006709.

A long section showing the spatial distribution of the Oyu Tolgoi deposits is shown in Figure 7.5.

Figure 7.5 Idealized view of the Oyu Tolgoi mineral deposits (long-section looking west)



Source: Compiled by AMC from information provided by TRQ, Date: 30 June 2020

7.3.1 Hugo Dummett deposits

7.3.1.1 Hugo South and Hugo North

The Hugo Dummett deposits, Hugo North and Hugo South, contain porphyry-style mineralization associated with quartz-monzodiorite intrusions, concealed beneath a sequence of Upper Devonian and Lower Carboniferous sedimentary and volcanic rocks. The deposits are highly elongated to the north northeast and extend over 3 km.

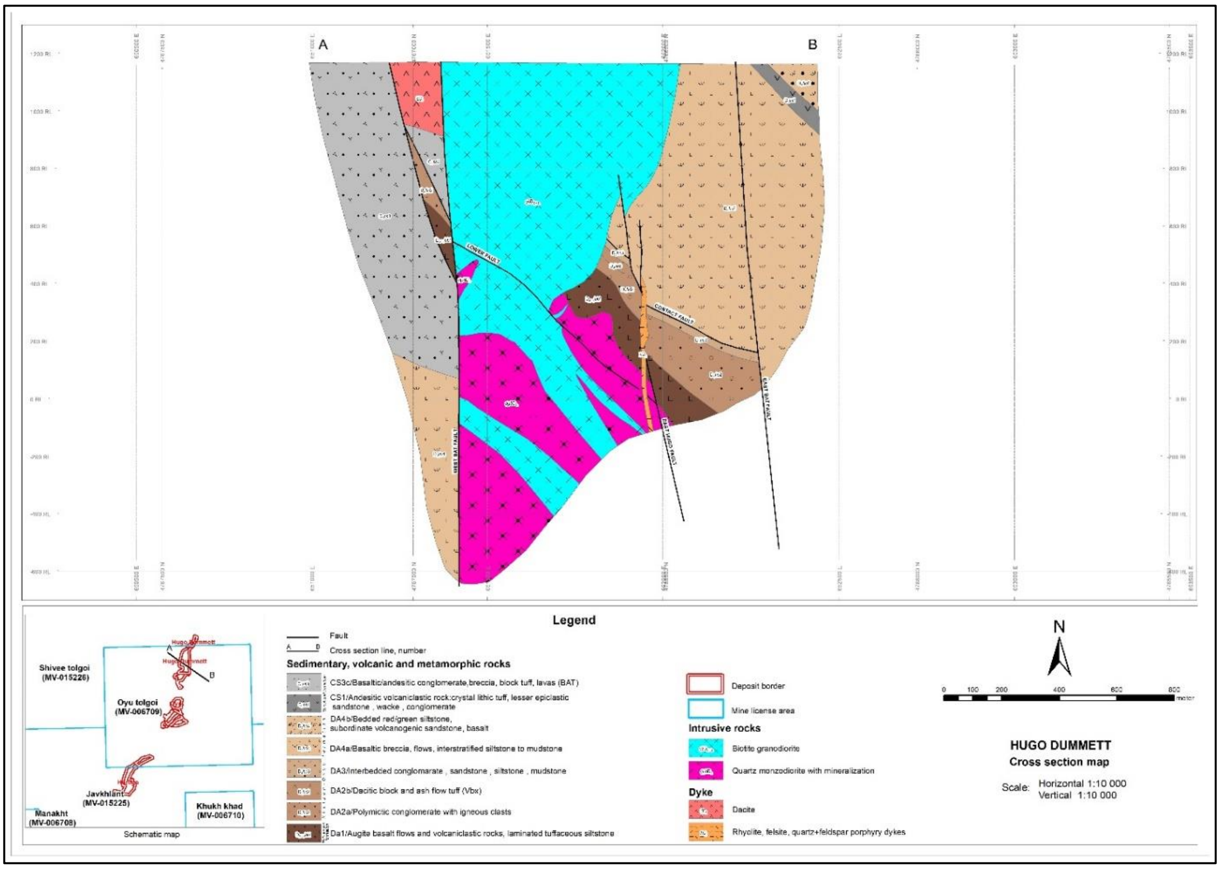
The Hugo North zone is virtually contiguous with the Hugo South zone and lie within a similar geological setting. The two deposits are separated by a 110°-striking, 45° to 55° north-dipping fault that displaces Hugo North vertically down a modest distance from Hugo South. The dividing line between the two deposits is approximately 4766300 N, a location marked by the thinning and locally discontinuous nature of the high-grade copper mineralization (defined by greater than 2% copper). The east-striking 110° Fault (Figure 7.5) for the projections of the major faults in the area of the Hugo Dummett deposits), delineates the gold- and copper-rich zone hosted in augite basalt and quartz–monzodiorite of the Hugo North deposit from the more southerly, gold-poor, ignimbrite- and augite basalt-hosted mineralization at Hugo South.

The quartz monzodiorite bodies are contemporaneous with alteration and mineralization. The quartz monzodiorite is considered to be the progenitor porphyry, and two zones are distinguished on the basis of alteration characteristics and position within the deposit.

A late to post-mineralization biotite-granodiorite intrusion forms a northerly striking dyke complex cutting across the western edge and deeper levels of the deposit. At higher levels, the biotite-granodiorite flares out considerably to form a voluminous body (Figure 7.6). Although this intrusion locally contains elevated copper grades adjacent to intrusive contacts or within xenolith-rich zones, it is essentially barren.

Based on correlations between drillhole intersections and measurements of individual contacts using oriented drill core, the positions and orientations of dyke contacts are reasonably well established in the Hugo North deposit area. Dominant dyke orientation varies with depth. At levels above approximately 250 mRL, where the biotite-granodiorite cuts through the non-mineralized hanging wall strata, it is present as a single intrusive mass with contacts dipping moderately to steeply to the west. The hanging wall sequence model should identify the nature of the contact between the hanging wall strata and the biotite-granodiorite and assist in modelling the subsidence zone. Below this level, the biotite-granodiorite is more complex, found as multiple and sub-parallel to anastomosing dykes that cut through the quartz monzodiorite intrusion and mineralized Alagbayan Group strata.

Figure 7.6 Hugo North geological cross-section



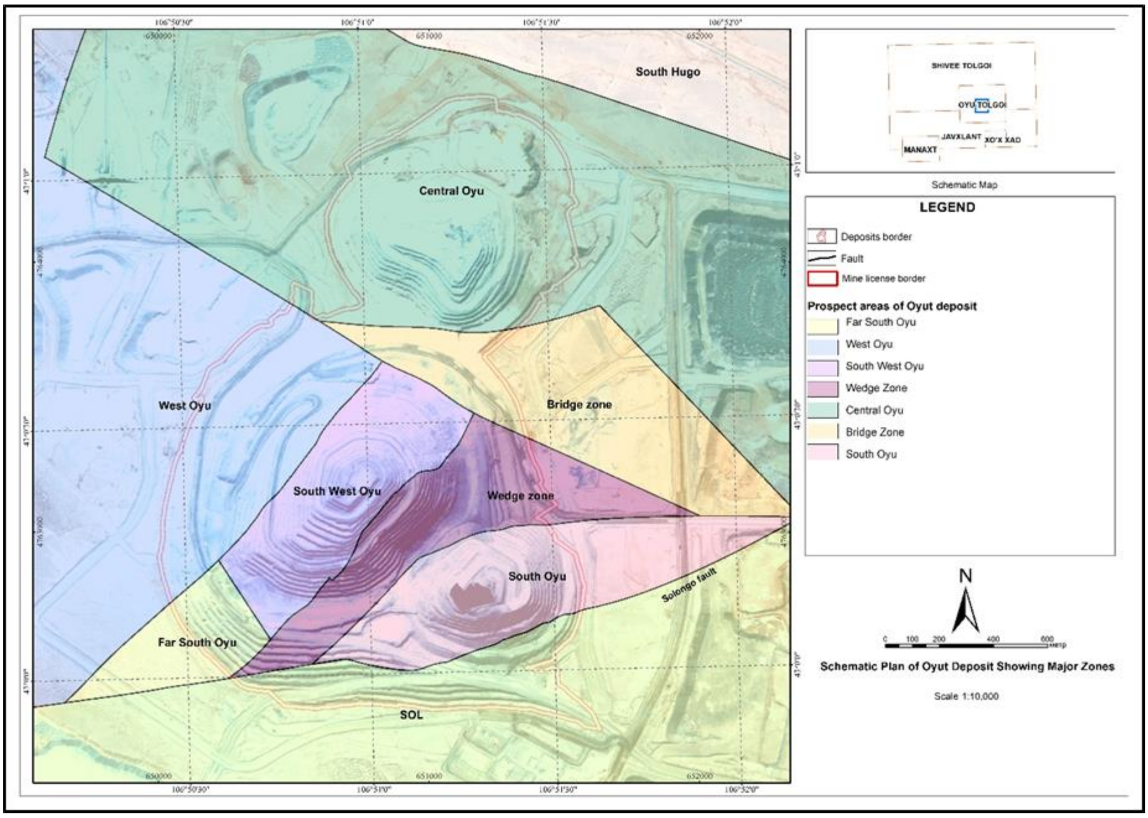
Source: Compiled by AMC from information provided by TRQ, Date: 30 June 2020

The highest-grade copper mineralization in the Hugo North deposit is related to a zone of intensely stockworked to sheeted quartz veins known as the QV90 zone, so named because >90% of the rock has >15% quartz veining. The high-grade zone is centred on thin, east dipping quartz monzodiorite intrusions or within the apex of the large quartz monzodiorite body and extends into the adjacent basalt. In addition, moderate-to-high grade copper and gold values occur within quartz monzodiorite below and to the west of the intense vein zone, in the Hugo North gold zone. This zone is distinct and has a high Au (ppm) to Cu (%) ratio of 0.5 to 1.

7.3.2 Oyut deposit

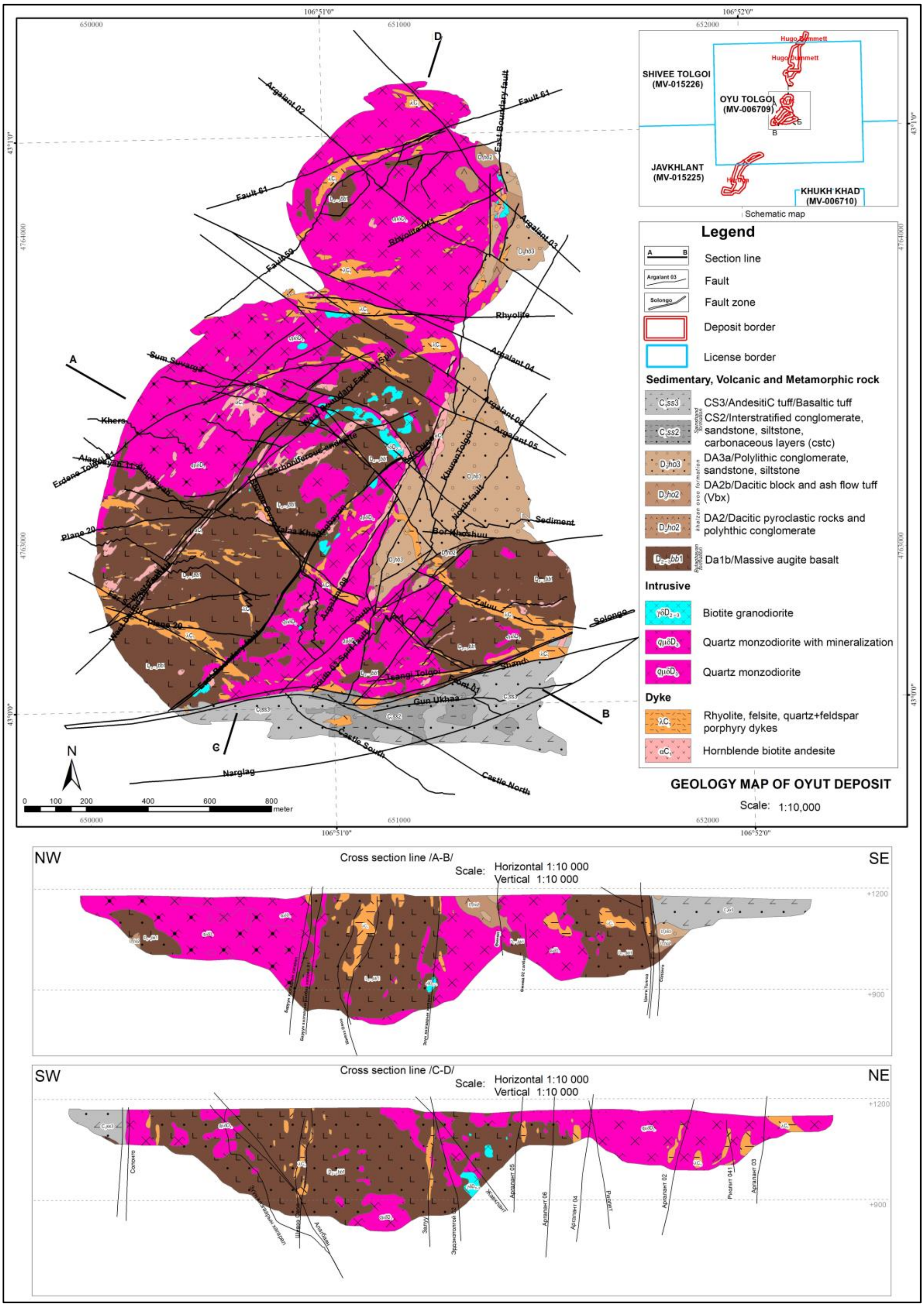
The Oyut deposit includes the most mineralized domain called Southwest Oyu (Southwest), but also includes South Oyu (South), Wedge, and Central Oyu (Central) domain (Figure 7.7) and several smaller, fault-bounded zones. The open pit incorporates most of these domains. They form contiguous sectors of mineralization representing multiple mineralizing centres, each with distinct styles of mineralization, alteration, and host rock lithology. The boundaries between the individual zones coincide with major faults. Faulting has resulted in different erosional histories for the zones, depending on the depth to which a zone has been downfaulted or uplifted relative to neighbouring zones. Geological mapping of the pit walls is compiled in the plan and section views shown in Figure 7.8.

Figure 7.7 Oyut deposit schematic plan showing major zones



Source: Compiled by AMC from information provided by TRQ, Date: 30 June 2020. Projection WGS84 Lat/Long

Figure 7.8 Oyut deposit geological map and cross-sections



Source: Compiled by AMC from information provided by TRQ, Date: 30 June 2020. Projection WGS84 Lat/Long

7.3.2.1 Southwest Oyu zone

The Southwest Oyu zone is a gold-rich porphyry system characterized by a south-west–plunging, pipe-like geometry that has a vertical extent of as much as 700 m. The high-grade core of the zone is about 250 m diameter; the low-grade shell (0.3% Cu) surrounding the core may extend for distances as much as 600 m by 2 km.

Over 80% of the deposit is hosted by massive to fragmental porphyritic augite basalt of the Upper Devonian Alagbayan Group, with the remainder hosted by intra-mineral, Late Devonian quartz-monzodiorite intrusions. The quartz-monzodiorite intrusions form irregular plugs and dykes related to several distinct phases:

- Early, strongly altered quartz-veined dykes mainly limited to the high-grade central Central deposit core (informally referred to as OT–QMD)
- Superimposed younger fragmental dykes entraining early quartz vein clasts but lacking strong sulfide mineralization (informally referred to as xQMD)
- Voluminous massive quartz-monzodiorite (informally referred to as QMD) containing weaker mineralization, flanking and underlying the high-grade deposit core

Several phases of post-mineral dykes cut the Southwest zone. Most of the dykes belong to the rhyolite, hornblende-biotite andesite, or biotite granodiorite intrusive phases. Dykes commonly have steep dips, and many are localized along faults. The rhyolite dykes tend to strike west to west-northwest in the deposit core and north-east when emplaced along major faults. Hornblende-biotite andesite dykes strike east-north-east except where they intrude along the major north-east trending faults.

Most of the Southwest zone, including the entire high-grade, gold-rich core of the zone, lies between two north-east striking faults, termed the West Bounding Fault and the East Bounding Fault. Both faults are clearly defined on ground-magnetic geophysical images, and their positions and orientations are well constrained by numerous drillhole intersections.

The bounding faults consist of foliated cataclasite, gouge/breccia, and mylonitic bands that occur in zones ranging from a few metres to a few tens of metres wide. The cataclasite within the fault zones contains abundant quartz, quartz sulfide, and sulfide (pyrite, chalcopyrite, sphalerite, and galena) clasts in a comminuted matrix that is locally overprinted by fine-grained pyrite and chalcopyrite. These relationships imply that at least some of the fault movement was contemporaneous with mineralization. Kinematic indicators within the fault zones imply dominantly sub-horizontal, sinistral movement on the bounding faults. Both faults have local subparallel splays. Correlation of drillhole intersections constrains an average fault dip of 80° towards 310° for both faults.

The East Bounding Fault juxtaposes younger rocks to the south-east against the Alagbayan Group rocks (augite basalt) hosting the deposit, while the West Bounding Fault is mainly intra-formational within the augite basalt. The West Bounding Fault is commonly intruded by hornblende-biotite andesite dykes, whereas rhyolite dykes are more common along the East Bounding Fault.

7.3.2.2 Central zone

The Central zone is about 2,300 m wide and tapers from about 200 m long in the east to more than 600 m to the west (Figure 7.6). Mineralization extends to depths of over 500 m.

The Central zone is hosted within a swarm of feldspar-phyric quartz-monzodiorite intrusions, emplaced into porphyritic augite basalt and overlying basaltic tuff of the Alagbayan Group. The basaltic tuff is in turn overlain by unmineralized sedimentary and mafic volcanic rocks of the Alagbayan Group unit DA4, which dip moderately to the east (30–60°).

Several phases of intra-mineral and late-mineral quartz-monzodiorite intrusions have been distinguished in the Central zone based on textural variations and intensity of mineralization and alteration. Most have dyke forms, emanating from a larger intrusive mass to the north and west of the deposit area. The quartz-monzodiorite dykes terminate within the base of the sedimentary units of the upper Alagbayan Group.

7.3.2.3 South Oyu zone

The South Oyu zone is developed mainly in basaltic volcanics and related to small, strongly-sericite altered quartz–monzodiorite dykes. Zone dimensions are about 400 m by 300 m in area, and mineralization extends to depths of more than 500 m.

7.3.3 Heruga

The Heruga deposit is the most southerly of the currently known deposits at Oyu Tolgoi. The deposit is a copper–gold–molybdenum porphyry deposit and is zoned with a molybdenum-rich carapace at higher elevations overlying gold-rich mineralization at depth. The top of the mineralization starts 500–600 m below the present ground surface. The deposit has been drilled over a 2.3 km length, is elongated in a north–northeast direction and terminates to the north on an east–northeast-trending regional fault with 500 m of apparent dextral displacement.

Quartz monzodiorite intrudes the Devonian augite basalts as elsewhere in the district, and again are the progenitors of mineralization and alteration. The quartz monzodiorite intrusions are small compared to the stocks present in the Hugo Dummett and Oyut areas, perhaps explaining the lower grade of the Heruga deposit. Non-mineralized dykes, comprising about 15% of the volume of the deposit, cut all other rock types.

The deposit is transected by a series of north–northeast trending vertical fault structures that step down 200 m to 300 m at a time to the west and have divided the deposit into at least two structural blocks.

Mineralized veins have a much lower density at Heruga than in the more northerly Oyut and Hugo Dummett deposits. High-grade copper and gold intersections show a strong spatial association with contacts of the mineralized quartz monzodiorite porphyry intrusion in the southern part of the deposit, occurring both within the outer portion of the intrusion and in adjacent enclosing basaltic country rock.

At deeper levels, mineralization consists of chalcopyrite and pyrite in veins and disseminated within biotite–chlorite–albite–actinolite-altered basalt or sericite–albite-altered quartz monzodiorite. The higher levels of the orebody are overprinted by strong quartz–sericite–tourmaline–pyrite alteration where mineralization consists of disseminated and vein-controlled pyrite, chalcopyrite and molybdenite.

There is no oxide zone at Heruga, nor is there any high-sulphidation style mineralization known to date.

8 Deposit types

8.1 Geological model of typical porphyry copper systems

The information in Section 8.1 is collated from geological and technical reports completed on the Project during the period 2003 to 2019, the PhD thesis completed by Alan Wainwright in 2008, and other sources as noted.

The discussion of the typical nature of porphyry copper deposits is sourced from Sillitoe (2010), Singer et al. (2008), and Sinclair (2007).

The Oyu Tolgoi deposits are characterised as copper-gold porphyry and related high-sulfidation copper-gold deposit styles.

Porphyry copper systems commonly define linear belts, some many hundreds of kilometres long, and some occurring less commonly in apparent isolation. The systems are closely related to underlying composite plutons, at paleo-depths of 5–15 km, which represent the supply chambers for the magmas and fluids that formed the vertically elongate (>3 km) stocks or dyke swarms and associated mineralization.

Commonly, several discrete stocks are emplaced in and above the pluton roof zones, resulting in either clusters or structurally controlled alignments of porphyry copper systems. The rheology and composition of the host rocks influence the size, grade, and type of mineralization generated in porphyry copper systems. Individual systems have life spans of circa 100,000 years to several million years, whereas deposit clusters or alignments, as well as entire belts, may remain active for 10 million years (Ma) or longer.

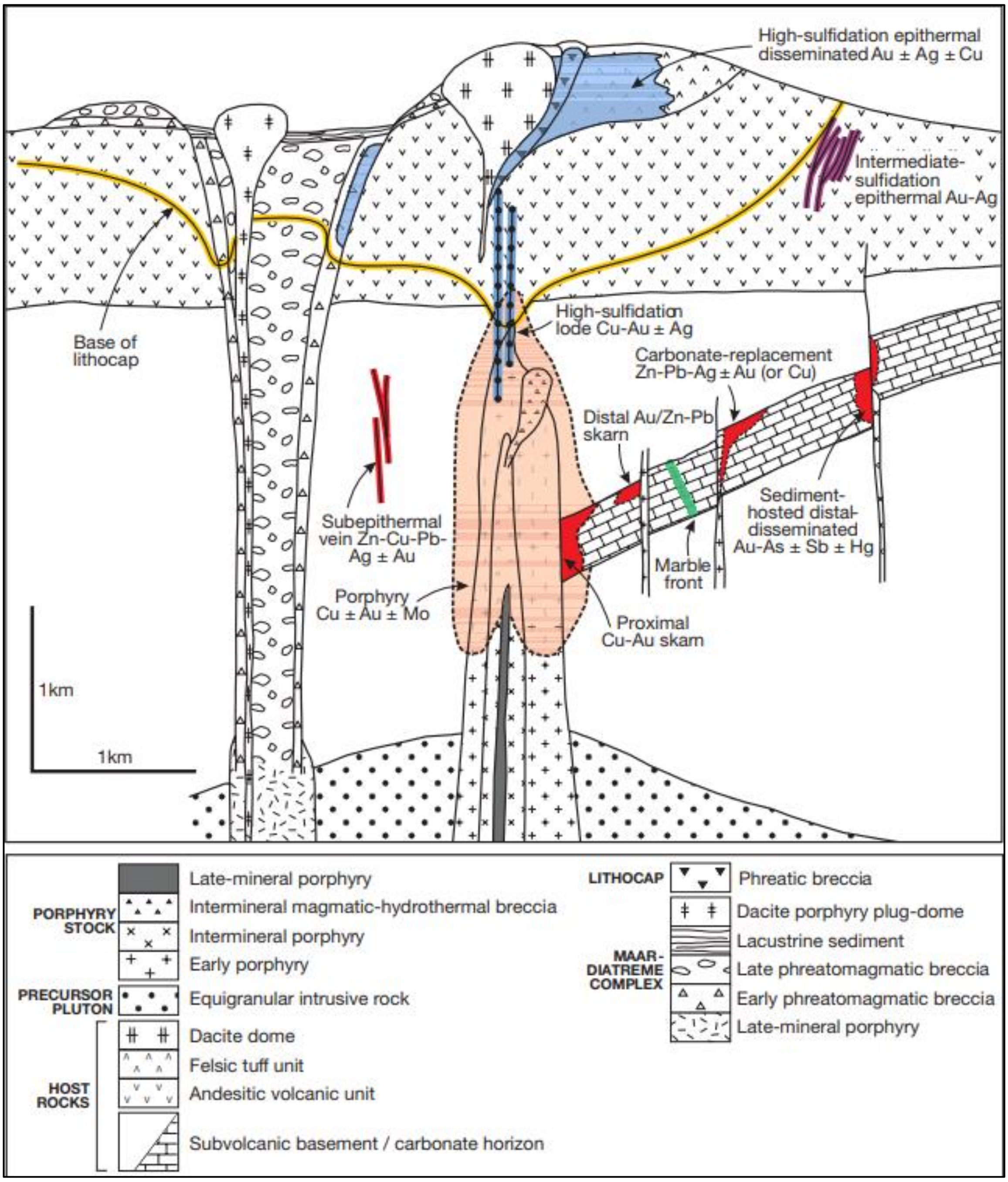
Deposits are typically semicircular to elliptical in plan-view. In cross-section, ore-grade material in a deposit typically has the shape of an inverted cone with the altered, but low grade, interior of the cone referred to as the "barren" core. In some systems, the barren core may be a late-stage intrusion.

The alteration and mineralization in porphyry copper systems are zoned outward from the stocks or dyke swarms, which typically comprise several generations of intermediate to felsic porphyry intrusions. Porphyry copper-gold-molybdenum deposits are centred on the intrusions, whereas carbonate wall rocks commonly host proximal copper-gold skarns and less commonly, distal base metal and gold skarn deposits. Beyond the skarn front, carbonate-replacement copper or base metal–gold deposits, and sediment-hosted (distal-disseminated) gold deposits can form. Peripheral mineralization is less conspicuous in non-carbonate wall rocks but may include base metal or gold-bearing veins and mantos. Data compiled by Singer et al. (2008) indicate that the median size of the longest axis of alteration surrounding a porphyry copper deposit is 4 to 5 km, while the median area of alteration is 7 km^2 to 8 km^2.

High-sulfidation epithermal deposits may occur in lithocaps above porphyry copper deposits, where massive sulfide lodes tend to develop in their deeper feeder structures, and precious metal-rich, disseminated deposits form within the uppermost 500 m.

Figure 8.1 shows a schematic section of a porphyry copper deposit, illustrating the relationships of the lithocap to the porphyry body and associated mineralization styles.

Figure 8.1 Schematic section of porphyry copper deposit



Source: Sillitoe (2010)

8.1.1 Porphyry copper mineralization

Porphyry copper mineralization occurs in a distinctive sequence of quartz-bearing veinlets as well as in disseminated forms in the altered rock between them. Magmatic-hydrothermal breccias may form during porphyry intrusion, with some breccias containing high-grade mineralization because of their intrinsic permeability. In contrast, most phreatomagmatic breccias, constituting maar-diatreme systems, are poorly mineralized at both the porphyry copper and lithocap levels, mainly because many such phreatomagmatic breccias formed late in the evolution of systems, and the explosive nature of their emplacement fails to trap mineralizing solutions.

Copper mineral assemblages are a function of the chemical composition of the fluid phase and the pressure and temperature conditions affecting the fluid. In primary, unoxidized or non-supergene-enriched ores, the most common sulfide assemblage is chalcopyrite ± bornite, with pyrite and minor amounts of molybdenite. In supergene-enriched ores, a typical assemblage can comprise chalcocite + covellite ± bornite, whereas in oxide ores a typical assemblage could include malachite + azurite + cuprite + chrysocolla, with minor amounts of minerals such as carbonates, sulfates, phosphates, and silicates. Typically, the principal copper sulfides consist of millimetre scale grains but may be as large as 1 cm to 2 cm in diameter and, rarely, pegmatitic (larger than 2 cm).

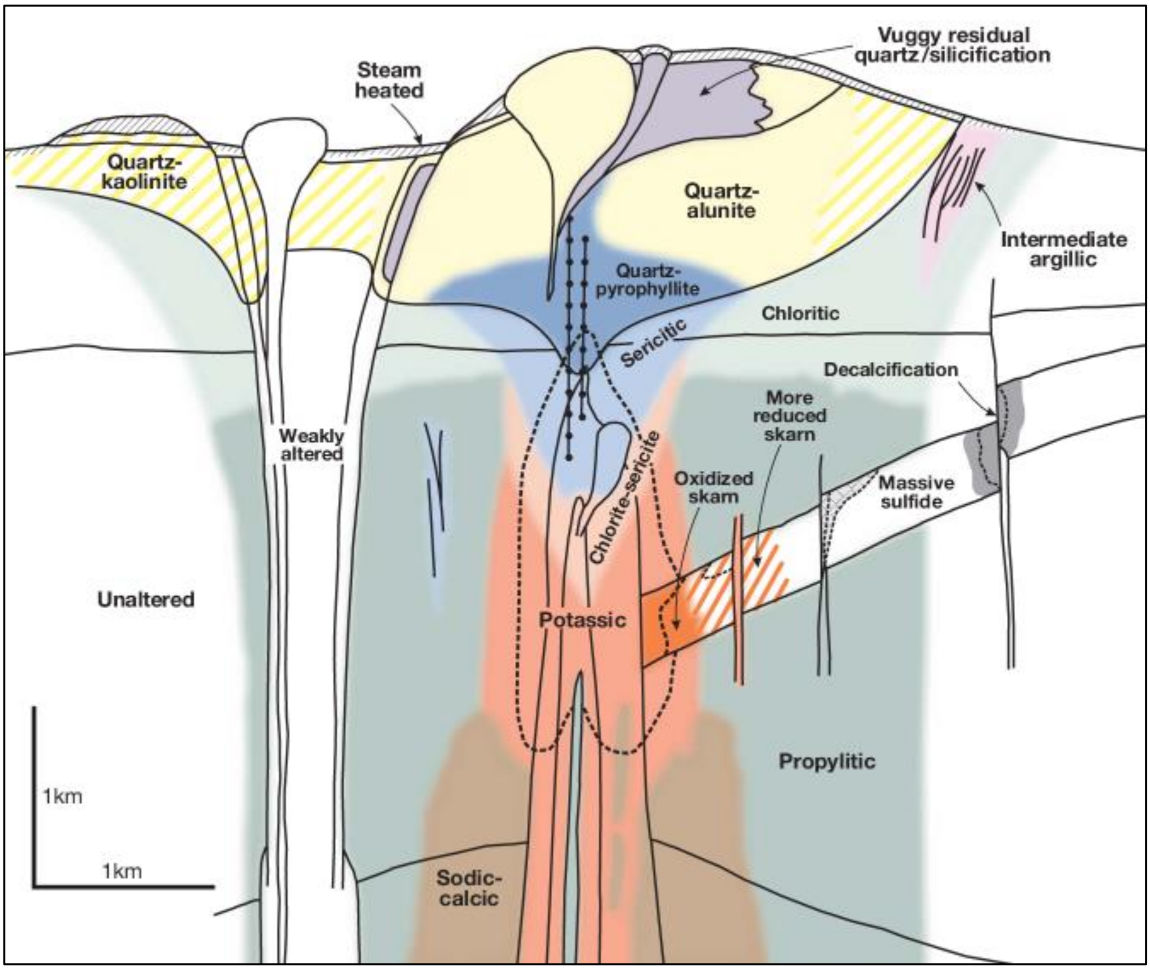
8.1.2 Alteration zones

Alteration zones in porphyry copper deposits are typically classified based on mineral assemblages. In silicate-rich rocks, the most common alteration minerals are potassium (K) -feldspar, biotite, muscovite (sericite), albite, anhydrite, chlorite, calcite, epidote, and kaolinite. In silicate-rich rocks that have been altered to advanced argillic assemblages, the most common minerals are quartz, alunite, pyrophyllite, dickite, diaspore, and zunyite. In carbonate rocks, the most common minerals are garnet, pyroxene, epidote, quartz, actinolite, chlorite, biotite, calcite, dolomite, K-feldspar, and wollastonite. Other alteration minerals commonly found in porphyry copper deposits are tourmaline, andalusite, and actinolite. Figure 8.2 shows the typical alteration assemblage of a porphyry copper system.

Porphyry copper systems are initiated by injection of oxidized magma saturated with sulfur-rich and metal-rich, aqueous fluids from cupolas on the tops of the subjacent parental plutons. The sequence of alteration and mineralization events is principally a consequence of progressive rock and fluid cooling, from >700 °C to <250 °C, caused by solidification of the underlying parental plutons and downward propagation of the lithostatic-hydrostatic transition. Once the plutonic magmas stagnate, the high temperature, generally two phase hyper-saline liquid and vapour responsible for the potassic alteration and contained mineralization at depth and early overlying advanced argillic alteration, respectively, gives way, at <350 °C, to a single-phase, low-to-moderate salinity liquid that causes the sericite-chlorite and sericitic alteration and associated mineralization. This same liquid also is a source for mineralization of the peripheral parts of systems, including the overlying lithocaps.

The progressive thermal decline of the systems combined with syn-mineralization paleo-surface degradation results in the characteristic overprinting (telescoping) and partial to total reconstitution of older by younger alteration and mineralization types. Meteoric water is not required for formation of this alteration and mineralization sequence, although its late ingress is commonplace.

Figure 8.2 Generalized alteration-mineralization zoning pattern for telescoped porphyry copper deposits



Source: Sillitoe (2010)

8.2 Applicability of porphyry copper model to Oyu Tolgoi

Features that classify the Oyu Tolgoi deposits as porphyry copper-type deposits include:

- Mineralization is in or adjoining porphyritic intrusions of quartz monzodiorite composition.
- Multiple emplacements of successive intrusive phases and a variety of breccias are present.
- Mineralization is spatially, temporally, and genetically associated with hydrothermal alteration of the intrusive bodies and host rocks.
- Large zones of veining and stockwork mineralization, together with minor disseminated and replacement mineralization, occur throughout large areas of hydrothermally altered rock, commonly coincident wholly or in part with hydrothermal or intrusion breccias.
- Hydrothermal alteration is extensive and zoned, which is common to porphyry copper deposits. Major alteration minerals in the biotite-chlorite, intermediate argillic, sericite, and K-feldspar alteration zones include quartz, chlorite, sericite, epidote, albite, biotite, hematite-magnetite, pyrophyllite, illite, and carbonate. Advanced argillic alteration zones can contain minerals such as kaolinite, zunyite, pyrophyllite, muscovite, illite, topaz, diaspore, andalusite, alunite, montmorillonite, dickite, tourmaline, and fluorite. In the leached cap, smectite and kao-smectite can also occur. The alteration assemblages are consistent with the physio-chemical conditions of a porphyry environment.
- Pyrite is the dominant sulfide, reflecting the typical high-sulfur content of porphyry copper deposits. The major ore minerals include chalcopyrite, bornite, chalcocite, covellite, and enargite. In some zones, minerals such as tennantite, tenorite, cubanite, and molybdenite have been identified. Gold typically occurs as inclusions in the sulfide minerals.

- Copper grades are typical of the range of porphyry copper grades (0.2% Cu to >1% Cu).

The Oyu Tolgoi porphyry copper deposits display a range of mineralization styles, alteration characteristics, and deposit morphologies that are likely to reflect differences in structural controls, host rock lithology, and depth of formation. For the most part, structural influences account for the differences in shape and distribution of mineralization within the deposits. The more typical copper-gold porphyry style alteration and mineralization tend to occur at deeper levels, predominantly within quartz monzodiorite extending into the host basaltic rocks.

High-sulfidation mineralization and associated advanced argillic alteration are most common within the wall rocks (basaltic tuffs and fragmental rocks) to the quartz monzodiorite, where it intrudes to levels high in the stratigraphic succession and in narrow structurally controlled zones. High-sulfidation mineralization often forms in steam condensate zones and then collapses back into the hypogene zone, causing overprinting and textural destruction.

The Hugo Dummett deposits have several features that are unusual when compared with typical porphyry copper systems, including:

- Anomalously high copper and gold grades, particularly in the northern part.
- An unusually weakly altered pre-mineralization volcano-sedimentary cover sequence that lies just above the porphyry system.
- Quartz + sulfide vein contents commonly exceeding 15%, and locally in excess of 90%, in the high-grade part of the deposit.
- A highly elongate, gently plunging tabular shape to the high-grade stockwork system.

The formation of the known, 800 m extent, high-grade portion of the Hugo Dummett deposits as a tabular, intensely veined, sub-vertical body contrasts markedly with most porphyry copper deposits, which tend to have steep, roughly cylindrical, or elongate forms. The unusual form of the Hugo Dummett deposits could be the result of emplacement within a structurally restricted zone. The lack of alteration in the overlying sequence is likely a reflection of the chemical inertness of the siltstone sequences.

The Heruga deposit is also slightly unusual in that, unlike the other Oyu Tolgoi deposits, it has distinctly higher grades of molybdenum, which form a molybdenum-rich carapace at higher elevations overlying gold-copper–rich mineralization at depth.

9 Exploration

Exploration activities have been undertaken by TRQ subsidiary companies, its precursor companies, consultants, and contractors (e.g., geophysical surveys).

Currently, exploration within the Project area is focused on the identification of new target areas and extensions to known deposits.

9.1 Fundamental data

9.1.1 Grids and surveys

The boundary coordinates of the mining and exploration licenses are defined by latitude and longitude coordinates. The official Mongolian survey datum was MSK42 using the Baltic mean sea level as the elevation datum and used until 2011. The coordinates used by Oyu Tolgoi LLC and its predecessors, for exploration are mostly UTM coordinates with the datum set to WGS 84 / UTM zone 48N.

In 2014, 8,760 hectares of land was mapped using an unmanned drone (Gatewing H100) to generate topography to 0.5 m accuracy. Flight height was 250 m high and with a 70 percent coverage overlap. The survey was conducted in UTM (WGS 84 / zone 48N) with altitude for Baltic Sea Height datum.

In 2017, a further topographical mapping exercise was carried out, this time using the Trimble UX5 unmanned aircraft system. Flight altitude was 350 m, with a horizontal and vertical overlap of 75%.

9.2 Imaging

Satellite imaging has been used throughout the history of the Project to provide regional and detailed geological information.

Since 2017, Interferometric Synthetic Aperture Radar (InSAR) data is obtained on an 11-day cycle to detect and monitor surface movement (land subsidence). This is used at Oyu Tolgoi to monitor the tailings storage facility. InSAR is obtained from the TerraSAR-X satellite with a phased array synthetic aperture radar (SAR) antenna (X-band wavelength 31 mm, frequency 9.6 GHz), TerraSAR-X acquires new high-quality radar images of the entire planet whilst circling Earth in a polar orbit at 514 km altitude.

9.3 Geological mapping

9.3.1 Surface mapping

Outcropping mineralized zones (Southwest, South, and Central) were mapped at 1:1,000 scale and the central part of the Oyu Tolgoi licence at 1:5,000 scale in 2001. The entire Oyu Tolgoi Property was mapped at 1:10,000 scale in 2002 (see Figure 7.5). Additional geological and structural mapping was completed by Alan Wainwright during 2005–2008 as part of his PhD thesis research.

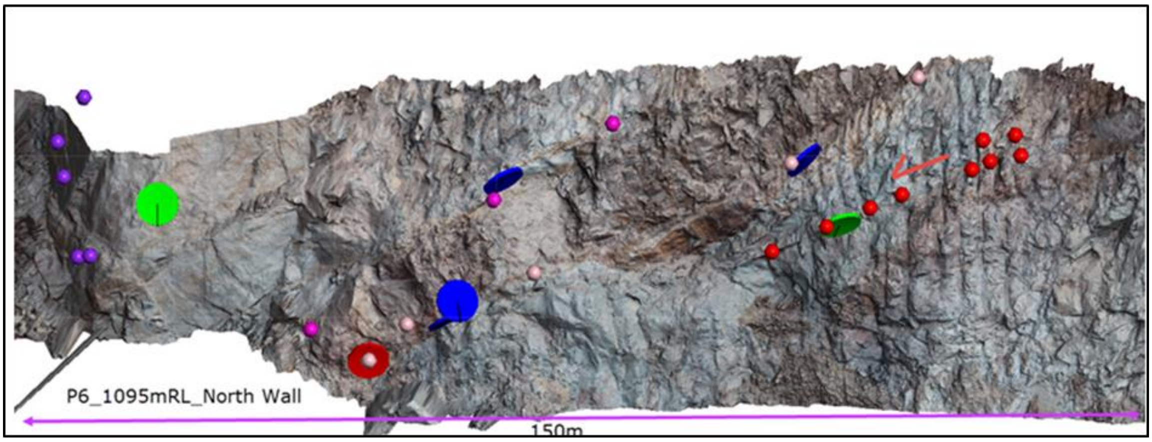
Mapping on the Shivee Tolgoi licence area consists of 1:20,000 and 1:10,000 scale regional mapping, with detailed prospect-scale mapping at 1:2,000 scale, undertaken between 2004 and 2008.

In 2011, a detailed 1:2,500 surface geological mapping program was initiated across part of the Javkhlant area west and south-west of Heruga. This program focused on determining stratigraphic relations that may indicate vectors to prospective stratigraphy.

Open-pit face mapping has been conducted since 2011 to improve open-pit fault modelling, and to predict and mitigate further pit failures. Due to accelerated rate of mining development, increased number of active mining areas and dangerous geotechnical areas, comprehensive face mapping is not achievable throughout the mine.

Photogrammetric mapping is used in the pit for geological and geotechnical interpretation (Figure 9.1).

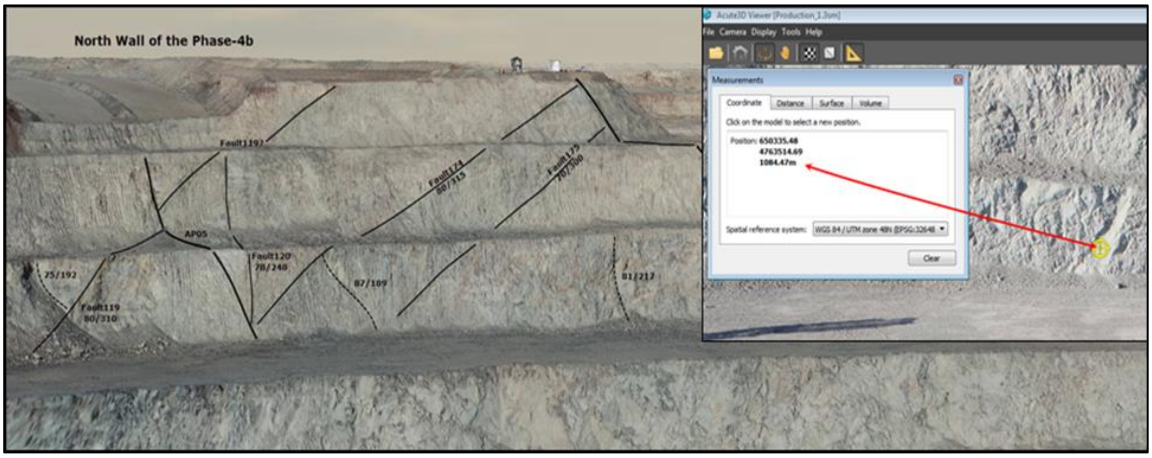
Figure 9.1 Oyut photogrammetric image of pit wall with annotations



Source: Compiled by AMC from information provided by TRQ, Date: 30 June 2020

Drone imagery survey has been used in the Oyut open pit since 2018 for geological and geotechnical modelling (Figure 9.2).

Figure 9.2 Oyut drone imagery of open pit wall



Source: Compiled by AMC from information provided by TRQ, Date: 30 June 2020

9.3.2 Underground mapping

Detailed geological mapping is undertaken during the development of Hugo North to systematically update geological interpretation and modelling.

The mapping of underground areas continues to define relationships between mineralization, lithology and fault structures. A total of 24,500 m of development has been mapped since 2016.

In 2018, an in-house underground mapping tablet-based application was deployed, called Facemapper. The application allows both geotechnical and geological data to be collected simultaneously at the face, as well as drawing a digital map, which is easily uploaded into a central data base. The data collected from the mapping is used to help predict ground conditions in front of planned development. The mapping is used to validate and update the geology model which was initially generated from diamond drillholes.

Prior to 2018, geological maps were scanned and converted to digital format, and imported to Vulcan software and geo-referenced for structural interpretation.

The geology model updates continuously incorporate information from the underground mapping, such as the location and nature of contacts between the biotite granodiorite and quartz monzodiorite units, the location and orientation of the major structures, exposure of minor structures, and cross-cutting relationships.

In addition to the underground mapping data, historical diamond drilling was scrutinised to validate and update the structural model for Panel 0.

The hangingwall sequence east of the Hugo North deposit and west of the West Bat Fault continues to be studied. This work will lead to a better understanding of the continuity of structures across the West Bat Fault and the relationship with the overlying carboniferous sediments.

9.4 Structural Studies

9.4.1 Oyut

The structural understanding of the overall Project area and within Oyut open pit has increased through time and access. Currently, a total of 81 first- and second-rank faults (identified in drilling and pit walls), 295 third-rank faults (identified in pit wall, but relationship to first- and second-rank faults is unclear) and 11 fourth-rank faults (identified by magnetic surveys) is recognized.

The time sequence of faulting within the licence area has been defined in the following stages (in a sequence of young to old):

1. Late stage: East-north-east trending faults (Solongo fault system and splays, Central fault)
2. North-west trending faults: These faults cut and displaced Devonian and carboniferous rocks and dykes
3. North-east trending faults filled with carboniferous rhyolite dykes
4. West and north-west trending faults: filled with rhyolite dykes forming right-lateral displacements
5. North-east trending faults: filled with andesite dykes
6. Pre-Devonian: These faults are defined in the pit wall as cut and displaced by other faults

Geotectonically, the deposit has complex structure and some major faults were activated two to three times. A summary of the characteristics of the faults in the Oyut area is shown in Table 9.1.

Table 9.1 Stages and evolution characteristics of faults in Oyut area

No	Stage	Major faults	Dip angle	Cut by	Filled dykes	Fault characteristics
11	Late fault	SOL, SND, NAR	NW/80-90	All rocks	Rhyolite	Non-foliated breccia
		CENT	N/50		–	Non-foliated breccia
12	North-west trending	JK, SZ, AB, Plan 20, Fault 100, F01, AP01	NE/45-60	Devonian & Carboniferous sediment, rhyolite, andesite, granodiorite	–	Foliated gouge
		AP02, AP03, AP04, AP05, AP06, ET02	NE/80-90			
33	North-east trending	Fault61, Fault59, ER01, STH, STH025	NE/70-85	Devonian sediment, granodiorite, andesite rhyolite	Rhyolite/ Dacite	Foliated gouge
		BO, HUT, HUT01S	NE/45-50		–	Non-foliated breccia
		EB, WB (next action)	NW/80-85		Rhyolite	
44	North-east trending	RHY, RHY03S, AP11, FRS, SHO, CST, ZALUU, ABU	NNE/80-90	Devonian sediment, granodiorite, andesite	Rhyolite	Foliated gouge
55	North-east trending	AND, CAD, EB, WB, STH01S, STH03S, AND154	NW80-90	Devonian sediment, granodiorite	Andesite/ Rhyolite	Non-foliated breccia
		AP08, BO	SE/45-50			
56	Early faults	EB, ZL, ZL01S, BOZ, SED, NF, Plan 18, 3rd rank fault	various	Devonian sediment	Granodiorite	Foliated gouge

9.4.2 Hugo Dummett

The interpretation of the structural framework of Hugo North has evolved over time. Rio Tinto staff, on behalf of Oyu Tolgoi LLC, performed an initial structural review of the faulting and fault models during 2009-2010 for the Hugo Dummett deposit area in support of the planned caving operation.

In 2018, a mine design scale structural model for the Panel 0 mining volume at Hugo North was completed. The regional structural geology model was used as a guide. All diamond drillhole core photographs were scrutinized in conjunction with available mapping for structural modelling purposes. The regional structural model was generated as planes, but the local structural model update generated three dimensional shapes, snapping to drillholes logged as fault zones, which were verified by core photographs. Fault planes were also mapped from development, with dip and dip direction measurements used for fault orientations and projections.

The 2018 structural model updated in 2019 for the Panel 0 design studies includes the following changes:

- Lower fault. Eight splays were recently interpreted, compared to the two main limbs from 2016 regional model update.
- WBAT fault. The 2018 WBAT fault is modelled to be offset by both the Bumbat fault and the Dugant fault. Recent drilling has also indicated the high probability of the WBAT being offset by the Dugant fault farther north of the Bumbat fault
- Bumbat fault. The 2018 Bumbat fault has been modelled farther north compared to the 2016 Bumbat fault. The Bumbat fault offsets the WBAT fault and is associated with the movement of the North Boundary fault to the west.

- Dugant fault. The 2018 Dugant fault has been modelled slightly north compared to the 2016 Dugant fault. The 2018 Dugant fault has also been modelled to offset the WBAT fault.
- Intermediate fault. The Intermediate fault has been removed. This was based on the review of core intercepts along the 2014 Intermediate fault model, which lacked fault intercepts and continuity.
- Intermediate splay faults. The 2018 model update has identified two small, highly damaging structures with orientations subparallel to the Lower fault. It is possible these two structures are part of the Lower fault system.
- Gobi fault. The 2018 model update removed the Gobi fault. This was based on the review of core intercepts and development and mapping along the 2014 Gobi fault model, which lacked fault intercepts and continuity.

9.4.3 Heruga

In 2013, the geological and structural model of the Heruga deposit was updated. Mapping shows a north-east trending carboniferous syncline axial trace directly above the Heruga deposit footprint. At 1 km depth the mineralized zone shows the existence of the Devonian sequence at the core and Carboniferous sediments at the flanks, indicating the potential of an anticline fold. The corresponding anticline axial trace at surface lies ~500 m to the east, suggesting that the axial surface dips in the order of approximately 60°to 70° to the west-northwest. Faults are modelled as vertical.

The current interpretation of Heruga is valid based on widely spaced drilling, which is taken into consideration with the classification of the resource. Further work is required to increase confidence of structural and mineralization interpretations. No recent work has been conducted at Heruga.

9.5 Geochemical surveys

In 2011, a summary of all geochemical studies carried out on the Oyu Tolgoi Property was consolidated by Sketchley (2011). On that basis, an independent database was created with the categories of geochemical anomaly and type (Bell et al. 2011).

The soil sampling programs between 1997 and 2018 are summarized in Table 9.2. Trenching, soil sampling (mobile metal ion—MMI), grab sampling, stream sampling and heavy concentrate sampling were conducted over the areas covered by the joint venture arrangements. The numbers of geochemical samples taken are shown in the Table 9.3.

The locations of soil geochemical copper, lead, molybdenum and tungsten anomalies are shown in Figure 9.3. Soil sampling is not a material factor in current or planned mining.

Table 9.2 Soil sample surveys by area and year

Area/Prospect	Year	Company
Southwest	1997–1999	BHP
Copper Flats	2002–2003	Entrée LLC
Eastern Entrée	2003–2004	Entrée LLC
Oortsog	2003–2004	Entrée LLC
Southwest	2004	EntréeLLC
West RAB	2004	TRQ
Western Entrée	2004–2005	Entrée LLC
Exotic Cu	2005	TRQ
OT South	2005	TRQ
Hugo South	2005–2006	TRQ
West	2006	TRQ

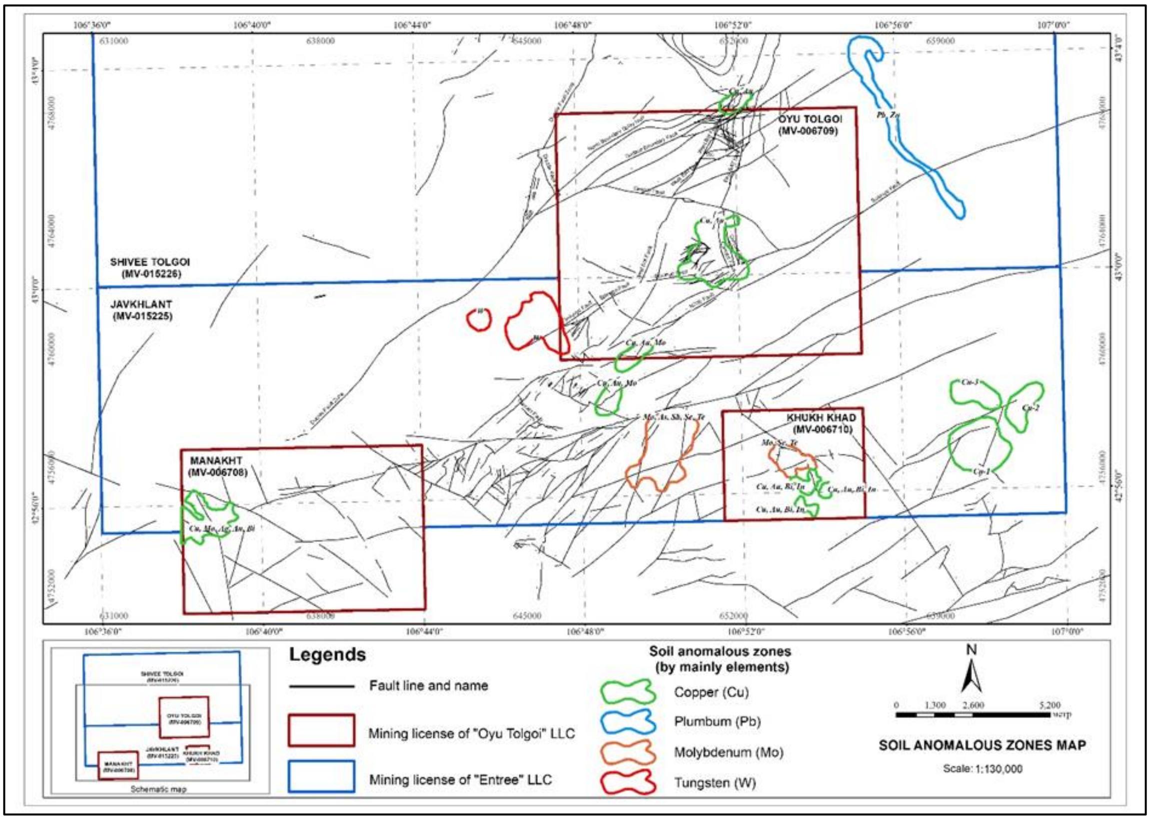
Area/Prospect	Year	Company
Gandulga	2006	TRQ
Ulaan Khuud	2006	TRQ
BHP3	2006	TRQ
Heruga	2008	Entrée LLC
SEIP	2016-17	Entrée LLC
Western Mag	2016	Entrée LLC
Castle rock	2016	Entrée LLC
Bumbat Ulaan	2018	Entrée LLC
West Corridor	2018	Entrée LLC
Central Javkhlant	2018	Entrée LLC
Heruga corridor	2018	Entrée LLC

Source: Oyu Tolgoi LLC (2019)

Table 9.3 Geochemical sampling of areas covered by the joint venture arrangements

Licence	Year	Rock grab sample	Soil sample	Stream sediment sample	Channel sample
Shivee Tolgoi	2003–2003	75	2140	–	450
	2004	–	–	–	1363
Javkhlant	2002–2003	45	–	25	–
	2006–2007	43	314	–	–
	2016-2018	11	2583	–	–

Figure 9.3 Regional soil geochemistry – anomaly map



Source: Compiled by AMC from information provided by TRQ, Date: 30 June 2020. Projection WGS84 Lat/Long

The analysis of the results from these programs show that:

- The anomalies detected in the areas are caused by either identified ore mineralization or lithological types.
- The areas that had not been covered by soil geochemistry are underlain by large intrusions, non-prospective rock outcrops or thick alluvial blankets.
- Highly prospective areas have been explored by several drilling programs.
- Thick cover sequences render buried mineralization undetectable by surface geochemical methods.

9.6 Geophysics

9.6.1 Oyu Tolgoi Property

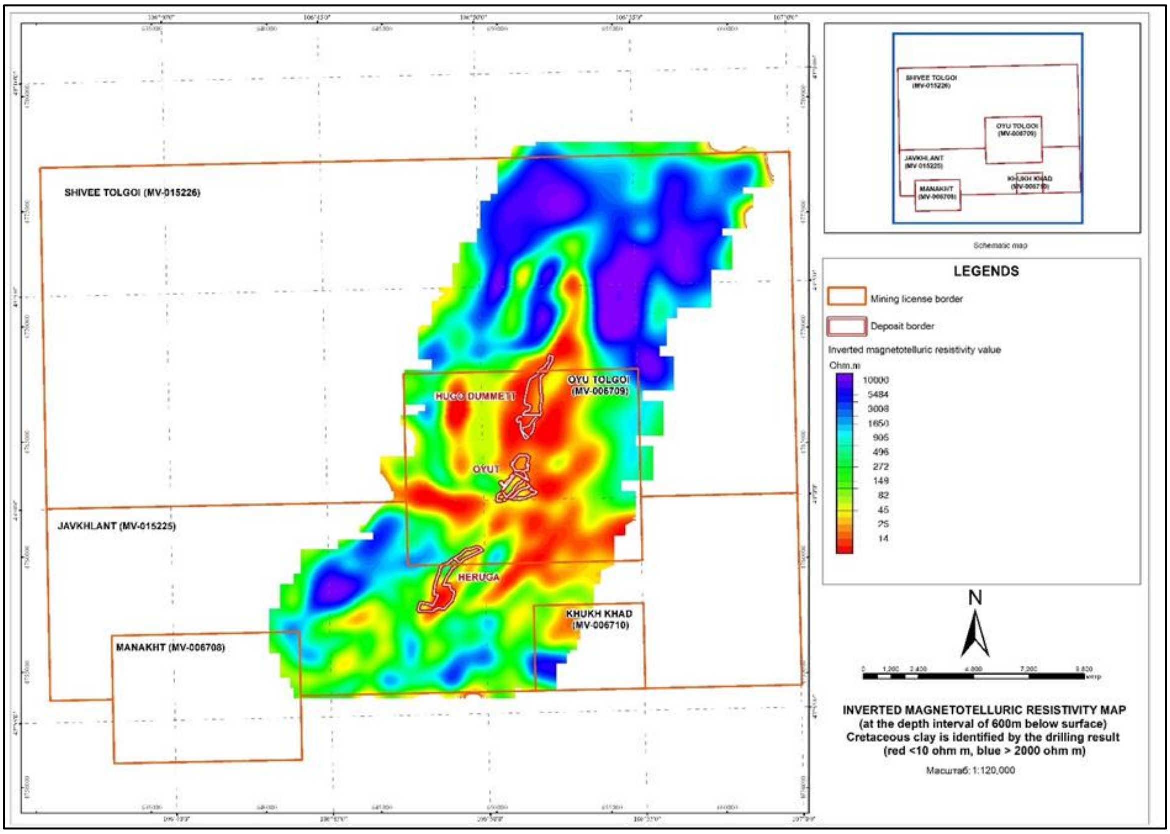
Geophysical surveys have been conducted regularly and consistently updated throughout the exploration timeline for Oyu Tolgoi. A summary of geophysical surveys completed in the Oyu Tolgoi Property are shown in Table 9.4.

Table 9.4 Geophysical survey completed in Oyu Tolgoi Property

Company	Timeline	Type of survey	Survey information	Area
BHP LLC	1997-1998	Gradient array induced polarization (IP)	250 m line spacing	Central, South, Southwest Oyu
		Airborne magnetics	300 m line spacing	Oyu Tolgoi
		Ground magnetics	250 m line spacing	Central, South, Southwest Oyu
TRQ	2001	Gradient array IP	100 m north-south	Oyu Tolgoi
		Gradient array IP	100 m east-west	Hugo Dummett
		Ground magnetic	25 m by 5 m and 50 m by 10 m	Oyu Tolgoi
TRQ	2002	Gravity	100 m by 50 m	Oyu Tolgoi
	2005	Transient electromagnetic		Eastern half of concession for water
	2009	Zeus IP	East – west	Oyu Tolgoi
	2011	Magnetotelluric	1,006 stations	Regional

A districtwide magnetotelluric survey provided a method that can potentially detect and delineate isolated conductors at substantial depths and reliable 3D models of conductivity can be derived that are readily integrated with geology (Figure 9.4). Approximately 30 planned stations around the South Oyu and to the west of the Hugo Dummett areas were omitted because of mine construction activities.

Figure 9.4 Regional inverted magnetotelluric sections at the depth interval of 600 m below surface



Source: Compiled by AMC from information provided by TRQ, Date: 30 June 2020. Projection WGS84 Lat/Long

9.6.2 Entrée LLC-Oyu Tolgoi LLC joint venture arrangements area

A summary of geophysical surveys completed in the Entrée LLC joint venture arrangements area are shown in Table 9.5.

Table 9.5 Geophysical survey completed Entrée LLC joint venture arrangements areas

Company	Timeline	Type of survey	Survey information	Area
Oyu Tolgoi LLC	2005	Gradient array induced polarization (IP)		Shivee Tolgoi, Javkhlant
	2008	Ground magnetic	26.6 km^2, east-west 25 m line spacing	Heruga
	2008	Magnetic	26.6 km^2, east-west 25 m line spacing	Hugo North Extension
	2011	Magnetic	Manakht licence: 1,138 line-km over 161 lines with east-west 25 m line spacing	
	2016	Gravity (surface)	100 m by 200 m out to 200 m by 200 m	
		IP dipole-dipole	8-11 channel, 200 m dipole spacing, electrode 200 m spacing	
	2016	IP dipole-dipole	Two east-west lines (total 14.4 line km)	Castle Rock
	2017	Ground magnetic	25 m line spacing	Northern part of SE anomaly (Javkhlant)
	2018	Ground gravity	200 m by 200 m (3245 stations)	West and east of Javklant
		Seismic	Nine lines at 300 m to 400 m spacing for 294 stations	Airstrip (Shivee Tolgoi)
		IP dipole-dipole	Three east-west lines (14 km)	Airstrip (Shivee Tolgoi)

9.7 Petrology, mineralogy and other research studies

Several petrological, mineralogical and other research studies have been undertaken. These include age dating of key lithological units, detailed stratigraphic reviews, petrographic and spectral analysis of alteration products and minerals, and detailed structural reviews, particularly in the areas proposed for the block caving operation at Hugo Dummett.

TRQ established and Oyu Tolgoi LLC maintains an in-house petrology laboratory in the Oyu Tolgoi Geosciences Department. Equipment for making polished mineral specimen blanks and polished thin sections is currently housed there.

Alteration minerals are determined by short-wave infrared spectrometry (short-wave infrared (SWIR) or portable infrared mineral analyzer (PIMA) analysis) on typical specimens from several alteration zones in each drillhole.

A program of preparing mineralization samples and making metallurgical index estimates from all the Oyu Tolgoi deposits was undertaken between 2002 and 2006.

9.7.1 Research studies

Several research theses have been completed on the Project area and are listed below in alphabetical order by author surname:

- Ayush, O 2006, "Stratigraphy, geochemical characteristics and tectonic interpretation of Middle to Late Paleozoic arc sequences from the Oyu Tolgoi porphyry Cu-Au deposit", MSc thesis (in Mongolian), Mongolian Univ. Science and Technology, Ulan Bator, Mongolia, 80 p.
- Jargaljav, G 2009, "Mineralization and metasomatic alteration of Central Oyu copper-gold deposit", PhD thesis (in Russian), Irkutsk Technical University, Irkutsk, 129 p.
- Khashgerel, B 2010, "Geology, whole-rock geochemistry, mineralogy and stable isotopes (O, H and S) of sericitic and AA alteration zones, Oyu Tolgoi porphyry Cu-Au deposits, Mongolia", PhD thesis, Univ. of Tsukuba, Japan, 114 p.

- Myagmarsuren, S 2007. "Sulphide mineral paragenesis at the Hugo Dummett porphyry Cu-Au deposit, Oyu Tolgoi, Mongolia", MSc thesis, Tohoku University, Japan, 93 p.
- Oyunchimeg, R 2008, "Sulphide mineralogy and gold mineralization at Hugo Dummett porphyry Cu-Au deposit, Oyu Tolgoi mineral district, Mongolia", PhD thesis (in Mongolian), Mongolian Univ. Science and Technology, Ulan Bator, Mongolia, 116 p.
- Savage, N 2010, "Origin of clasts, mineralization and alteration within the DA2a conglomerate, Heruga porphyry Cu-Au-Mo deposit, Oyu Tolgoi, Mongolia: evidence for an older porphyry system or part of the early Oyu Tolgoi paragenesis?", MSc mining geology dissertation, Cambourne School of Mines, UK, 119 p.
- Wainwright, AJ 2008, "Volcanostratigraphic framework and magmatic evolution of the Oyu Tolgoi porphyry Cu-Au district, South Mongolia", PhD, Univ. British Columbia, Vancouver, 263 p.

10 Drilling

10.1 Drill programs

Diamond core drillholes (DDH) are the principal source of geological and grade data for Oyu Tolgoi. A small percentage of the total drilling comes from reverse circulation (RC) or combined RC / DDH drilling (RCD) (RC at the collar and DDH at depth). Most of the RC holes were drilled in the early days of exploration at the Oyut deposit. RCD holes make up a small percentage (<2%) of the total number of holes on the Project. Fifty-two polycrystalline (PCD) holes were also drilled, but these are peripheral to the mine area.

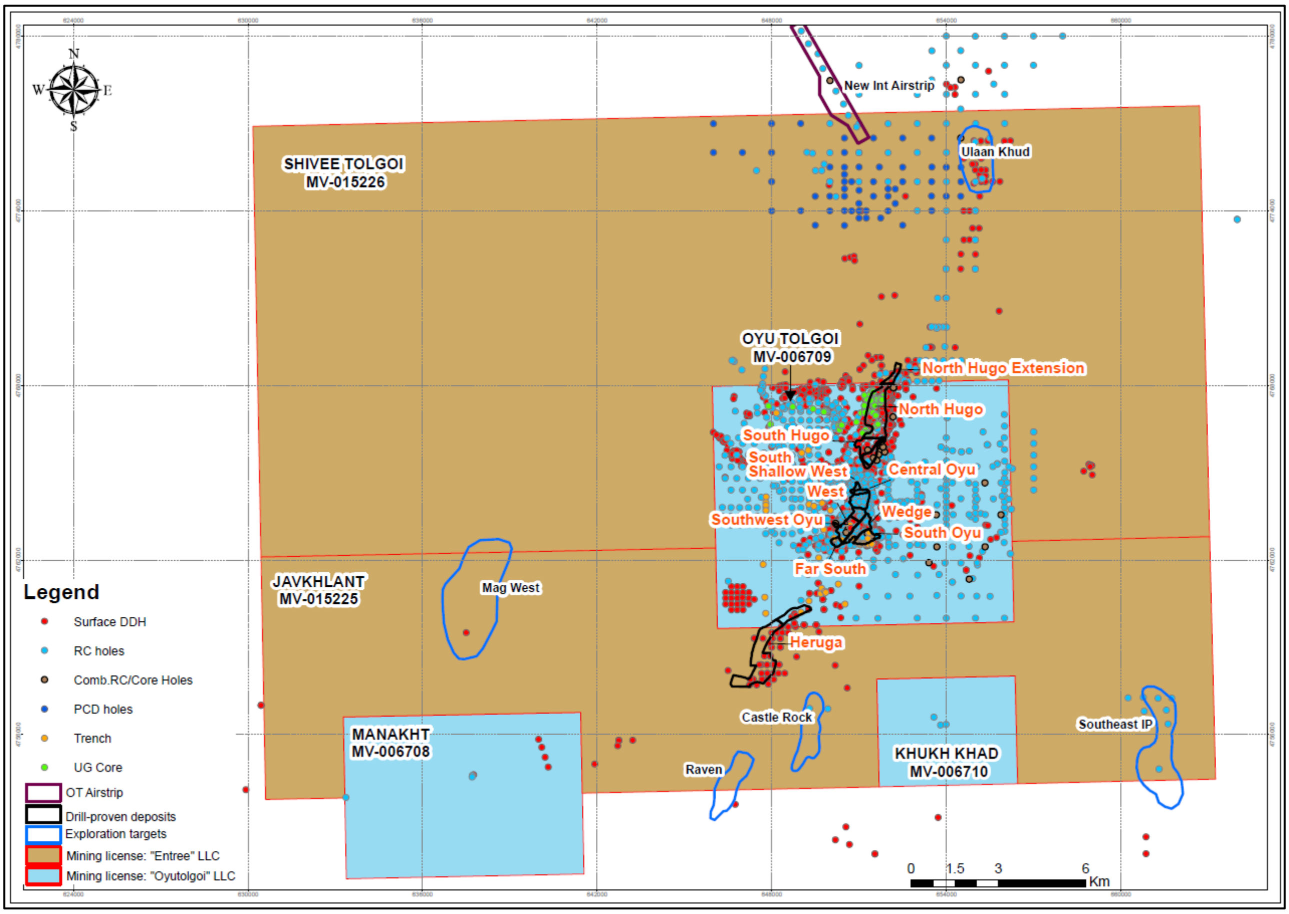
The first drilling was completed by BHP between 1997 and 1998, when 23 diamond core holes (3,902 m) were drilled at the deposit now known as Oyut TRQ completed approximately 109 holes (8,828 m) of RC drilling in 2000, mainly at Central zone, to explore the chalcocite blanket discovered earlier by BHP.

In 2001, TRQ continued RC drilling (16 holes totalling approximately 2,091 m), mostly in the South zone area; however, an RCD method was tested for hole number OTRCD149. TRQ drilled two additional holes using RCD method (OTRCD50 and OTRCD52), along with seven additional RC holes totalling 801.5 m (up to drillhole OTRC158), before switching to diamond core drilling methods for all exploration.

As on 31 December 2019, a total of approximately 1,247,342 m of drilling in 3,100 holes has been completed on the Project. Of this, 1,079,605 m was diamond core drilling in 1,874 holes and 95,248 m was completed in 820 RC holes. The drilling has been spread mostly over the Hugo Dummett, Oyut, and Heruga deposits. These totals include approximately 525 holes (75,427 m) drilled as part of a condemnation program to assist in the determination of suitable sites for the proposed plant, infrastructure, and dumps, and for water and geotechnical purposes.

Table 10.1 provides a summary of all drilling to 31 December 2019. The near-mine drillhole collar locations and types are shown in Figure 10.1.

Figure 10.1 Near-mine drillhole collar locations



Source: Compiled by AMC from information provided by TRQ, Date: 30 June 2020. Projection UTM (WGS84) Z48N.

Table 10.1 Drillhole summary table to 31 December 2019

Location	Surface DDH Count	Length of Surface DDH (m)	RC Holes Count	Length of RC (m)	RCD Holes Count	Length of RCD (m)	UG DDH Count	Length of UG DDH (m)	PCD Holes Count	Length of PCD Holes	All Holes Count	Total Length (m)
Others drilling	338	80,152	311	36,054	10	2,739	41	3,434			700	122,378
Others	220	36,504	115	15,313	2	339	1	795			338	52,950
East side licence	25	5,974	159	19,557	8	2,400					192	27,931
Shaft exploration geotechnical	87	37,103	37	1,184			40	2,639			164	40,927
X Grid	6	571									6	571
Entrée LLC JV drilling	240	238,995	85	7,796	2	736			58	3,754	385	251,281
Far South	68	70,628	12	2,928							80	73,556
Heruga	54	72,317									54	72,317
Hugo North Extension	118	96,049	73	4,868	2	736			58	3,754	251	105,408
Hugo Dummett deposit	494	421,189	49	3,582	16	10,406	274	48,438			833	483,615
Hugo North	367	333,941	4	319	4	2,418	273	47,793			648	384,470
Hugo South	127	87,248	45	3,263	12	7,989	1	645			185	99,145
Oyut Deposit	802	339,269	375	47,816	5	2,983					1182	390,068
Central	268	96,084	72	6,795							340	102,879
Shallow Hugo West	43	15,773	49	12,169							92	27,942
South	104	38,517	43	3,981	2	891					149	43,389
Southwest	284	140,804	79	17,403	3	2,092					366	160,299
Wedge	47	27,187	12	1,338							59	28,524
West	56	20,904	120	6,131							176	27,035
Grand Total	**1,874**	**1,079,605**	**820**	**95,248**	**33**	**16,864**	**315**	**51,871**	**58**	**3,754**	**3,100**	**1,247,342**

10.2 Drill orientations

Drillholes have been drilled at a wide range of azimuths and dips depending on the orientation of the mineralization, but an east-to-west orientation is dominant throughout the Project area. Drilling is normally oriented perpendicular to the strike of the mineralization. Depending on the dip of the drillhole and the dip of the mineralization, drill intercept widths are typically greater than true widths. Average drillhole lengths at the Hugo Dummett and Oyut deposits range from 316 m (South zone) to 894 m (Hugo North) and the average overall is approximately 525 m. The drill spacing is a nominal 70 m on and between drill sections in the Oyut zones. Drill spacing at Hugo North is on approximate 125 m by 75 m centres. Drill spacing typically widens toward the margins of the deposits.

10.3 Diamond core diameters

The vast majority of the core holes have been drilled with PQ (85 mm), HQ (63.5 mm), NQ (47.6 mm) or BQ (36.4 mm) diameters. Core diameter is reduced at depth depending on drilling condition, and it is also reduced to HQ when daughter holes split off the main drillhole. As of 31 December 2019, 92% of total drilling was diamond and the remaining 8% was RC drilling.

Many of the deeper holes were drilled with multiple drilling methods and hole deviation equipment. The Navi-Drill® hole deviation equipment can create daughter holes from parent holes by using a motorized bit to achieve 1° gradient deviation every 3 meters.

10.4 Diamond core transport

At the drill rig, the drillers remove the diamond core from the core barrel and place it directly in wooden or plastic core boxes. Individual drill runs are identified with small wooden or plastic blocks, where the depth (m) and drillhole number are recorded. Unsampled core is never left unattended at the rig; boxes are transported to the Oyu Tolgoi LLC core logging facility at the main camp twice a day under a geologist’s or technician’s supervision. Core is transported in open boxes in the back of a truck. Those holes drilled specifically for geotechnical purposes, typically use triple tube methods, are pumped out at the rig, transferred to a steel V-rail, and logged on-site before transport back to the core shed.

10.5 Geological logging

Diamond core logging facilities are indoors. Core logging takes place on sturdy steel racks, each of which can hold upwards of 25 or more core boxes. Upon arrival at the core shed, the core is subject to the following procedures shown in Table 10.2.

Table 10.2 Diamond drill core logging procedure

Step	Description
1. Quick review	Review core
2. Box labelling check	The core boxes are checked to ensure they are appropriately identified with the drillhole number, metres from and to, and box number written with an indelible marker on the front.
3. Core rebuilding	Core is rotated to fit the ends of the adjoining broken pieces.
4. Core photography	Take photographs
5. Geotechnical logging	Using pre-established codes and logging forms, includes length of core run, recovered, drilled ratio, rock quality designation (RQD), maximum length, structural data, and oriented core data. Orientated core measurements were logged as interval data using standardised codes for structural and vein data only; the orientated core measurement did not usually begin until the hole was within the mineralized zone.
6. Geological logging	Until August 2010 this was completed on paper logging forms. Subsequently, Oyu Tolgoi LLC implemented a digital logging data capture system, using commercially available (acquire) software, which uses standardised templates and validated logging codes that must be filled out prior to log completion. The logging is entered directly into laptops at the core shed and is wirelessly synchronized with the geological database. The template includes header information, lithology description and lithology code, graphic log, coded mineralization, and alteration.
7. Mark cutting line	The geologist marks a single, unbiased cutting line along the entire length of the core for further processing.

The RC logging involves capture of geological, alteration, and mineralization data on paper logging forms.

10.6 Recoveries and rock quality designation

Oyu Tolgoi LLC’s geological staff measure the following core recovery and rock quality designation (RQD) parameters at the core logging area:

- Block interval
- Drill run (m)
- Measured length (m)
- Calculated recovery (%)
- RQD measured length (m)
- Calculated RQD (%)

The RQD method used for measuring recovery is standard industry practice.

In general, Oyu Tolgoi LLC reports that core recoveries obtained by the various drilling contractors have been very good, averaging between 97% and 99% for all deposits. In localized areas of faulting or fracturing, the recoveries decrease; however, this occurs in a very small percentage of the overall mineralized zones. In addition, Oyu Tolgoi LLC notes decreased recoveries near surface in overlying non-mineralized Cretaceous clays and to a lesser extent in some of the oxidized rocks (generally above 100 m depth below surface), owing to the lower competencies of these units.

Table 10.3 shows the recovery averages per year from 1998 to 2013. Only a further 26 holes have been drilled at Oyut to 2019. Other drilling has not been included in any resource estimates to date. Recovery data was not collected for the RC drilling programs.

Table 10.3 Summary of average drill recovery

Year	All Drilling		Drilling >100 m Below Surface	
	Recovery (%)	No. of Measurements	Recovery (%)	No. of Measurements
1998	75.6	19	n/a	n/a
2001	97.4	5,784	98.4	3,876
2002	97.8	33,964	98.6	26,359
2003	97.4	61,182	98.8	48,722
2004	97.7	66,116	98.6	54,605
2005	98.6	25,224	99.1	21,927
2006	98.5	21,570	99.1	17,909
2007	98.3	17,986	98.4	15,867
2008	99.5	8,905	99.6	8,151
2009	99.8	1,956	99.8	1,845
2010	99.3	12,312	99.9	11,741
2011	99.5	22,117	99.8	21,524
2012	99.5	15,832	99.8	15,384
2013	99.4	9,598	99.7	9,390
2014	99.1	669	99.4	882
2015	99.0	245	99.1	403

Most core has been drilled using Ball Mark™ or Ace™ oriented core marking systems to assist with geological and structural interpretations and for geotechnical purposes.

10.7 Collar surveys

Collar survey methods are similar for diamond core and RC drillholes.

Upon completion of a drillhole, collar and anchor rods are removed, and a PVC pipe is inserted into the hole. The drillhole collar is marked by a cement block inscribed with the drillhole number (e.g. OTD663). Proposed drillhole collars are surveyed by a hand-held global positioning system (GPS) unit for preliminary interpretations. After the hole is completed, a Nikon theodolite or Differential GPS (DGPS) instrument is used for final survey pickup. The two collar readings are compared, and if any significant differences are noted the collar is resurveyed; otherwise, the final survey is adopted as the final collar reading in AcQuire.

10.8 Downhole surveys

RC drillholes have been drilled mostly in the vertical position and typically not downhole surveyed. In general, most RC holes are less than 100 m in depth and are therefore unlikely to experience excessive deviations in the drill trace. These holes are assumed to have minimal deviation from the collar survey. Most core drilling programs use downhole survey instruments like Eastman Kodak, Flexit, Ranger, and Gyro to collect azimuth and deviation with specific intervals for most of the diamond drilling programs.

Downhole survey data was not conducted on the first 149 holes, including initial core drilling program by BHP in 1998 and RC holes completed by TRQ in 2001 and 2002.

The first surveys, initiated by TRQ, for holes OTRCD149, 150, and 152 were surveyed by the Eastman Kodak method. This method was used interchangeably with Gyro and Ranger as the principal means of measuring deviations until hole OTD397, after which Gyro, North-Seeking Gyro, Flexit, and Ranger methods were used. It should be noted that the Eastman Kodak, Pontil, Flexit, and Ranger methods derive azimuth measurements using a magnet and therefore could be problematic for some deposits due to their content of magnetic minerals.

Since January 2006, procedures are to measure deviations using a Flexit instrument at 60 m intervals to monitor the drillhole progress. At completion, all holes are re-surveyed with a north-seeking gyro or SRG-gyro instrument at approximately 5 m to 20 m intervals. The gyro instruments are not dependent on magnetic readings and are therefore considered to be more appropriate methods for this type of deposit. The hole deviations are checked for irregularities such as kinks or significant deviations in the downhole data. All data are checked and adjusted, if required, before finalizing the database.

10.9 Acoustic televiewer data

Acoustic borehole imaging devices, also known as acoustic televiewers, generate an image of the drillhole wall by transmitting ultrasound pulses and recording the amplitude and the travel time of the reflected signal. The system assists in identifying faults, fractures, layers, and geological boundaries in the drillhole wall. The nature, azimuth and inclination of these features can be determined with high resolution from the data obtained.

This methodology has been used on drillholes at Oyu Tolgoi since 2010. A total of 270 drillholes have been completed with a total of 136,604 m logged by the acoustic televiewer system. Interpretation of these logs has defined the number and orientation of fractures and discontinuities in the drillholes.

10.10 Core storage

All core is stored in a secure location at the main camp. Core is stacked on pallets in a stable, 3 by 3 box configuration to a height of approximately 1 m (15 boxes per pallet). Each pallet is covered with a canvas tarpaulin, which is labelled with drillhole identification and the interval stacked in the pallet.

11 Sample preparation, analyses, and security

11.1 Sampling methods

11.1.1 Geochemical sampling

TRQ’s sampling programs at Oyu Tolgoi included stream sediment, soil, trench, and rock chip samples. All the sampling was carried out by TRQ personnel or contractors.

Sampling performed by Entrée LLC and TRQ personnel on the Entrée Shivee Tolgoi licence also included stream sediment, soil, trench, and rock chip samples.

Because all these early–stage sampling methods have been superseded by drill data, which form the basis of the Mineral Resources estimates, the early–stage sampling methods are not discussed further.

11.1.2 Core sampling

The core cutting protocols at the now decommissioned Oyu Tolgoi Camp core shed for core drilling in both the Oyu Tolgoi LLC and Entrée LLC proposed joint venture arrangement areas were as follows:

- Core is photographed.
- The uncovered core boxes are transferred from the logging area to the cutting shed (approximately 50 m) by forklift on wooden pallets.
- Long pieces of core are broken into smaller segments with a hammer.
- Core is cut with a diamond saw, following the line marked by the geologist. The rock saw is regularly flushed with fresh water.
- Both halves of the core are returned to the box in their original orientation.
- The uncovered core boxes are transferred from the cutting shed to the sampling area (approximately 50 m) by a forklift carrying several boxes on a wooden pallet:
  - Constant two metre sample intervals are measured and marked on both the core and the core box with a permanent marker.
  - A sample tag is stapled to the box at the end of each two-metre sample interval.
  - Sample numbers are pre–determined and account for the insertion of quality assurance and quality control (QA/QC) samples (core twins, standards, blanks).
- Samples are bagged. These are always half–core samples collected from the same side of the core. Each sample is properly identified with inner tags and marked numbers on the outside. Samples are regularly transferred to a sample preparation facility operated by SGS Mongolia LLC (SGS Mongolia) approximately 50 m from the sample bagging area.

The core cutting and sampling procedures in the new Crane–Kavalieris core shed have been modified slightly to the following.

- After being photographed, a pallet jack transfers the core boxes on pallets to the core cutting room.
- Long pieces of core are broken into smaller segments with a hammer.
- The core is placed in a core cradle and cut in half using automated feed Almonte core saws.
- Half the core is placed directly into a pre–numbered sample bag and half the core is returned to the core tray. Samples are collected nominally on 2 m intervals.

The unsampled half of the core remains in the box, in its original orientation, as a permanent record. Where additional sampling is required (e.g., for metallurgical testwork), a skeleton core is left. In some cases, however, the additional testwork has consumed the entire core, and only photographic records remain. Core boxes are subsequently transferred to the on–site core storage area.

Non–mineralized dykes that extend more than 10 m along the core length are generally not sampled.

11.1.3 Dry bulk density determination

There are approximately 52,000 specific gravity determinations in the database relating to the deposits. Details of sampling by deposit are included in Table 11.1. Dry bulk density (commonly incorrectly referred to as specific gravity or SG) is measured using the Marcy or immersion method (Dry bulk density = weight in air / (weight in air-weight in water)). Alternatively, measurements were taken using weight in air, weight in water and saturated weight to account for porosity. Quality checks using a caliper method of measuring cylinder lengths and widths is also used.

Table 11.1 Number of density measurements for each deposit

Deposit	Number of Measurements	Dry bulk density (g/cm^3)
Hugo North	25,632	2.75
Hugo South	8,600	2.76
Oyut	24,780	2.75
Heruga	2,898	2.82
Others	446	2.70
Total	**62,356**	**2.76**

The QP considers the sampling protocols to be appropriate for use in the reporting of Mineral Resource estimates.

11.2 Analytical laboratories

During 2002 and 2003, the on–site sample preparation facility and analytical laboratory were operated under the name Analabs Co. Ltd. Analabs Co. Ltd was an Australian–based company controlled by Scientific Services Limited, which was acquired by the SGS Group in 2001. SGS is an internationally recognized organization that operates more than 320 laboratories worldwide, many of which have ISO 9002 certification. The operating name of the Mongolian subsidiary was changed to SGS Mongolia in 2004.

Check assays in the early phases of drilling programs were performed by Bondar Clegg and Chemex laboratories. It is not known what certification these laboratories held at the time of the check assay programs.

Until May 2005, SGS Welshpool in Perth, Australia, was designated as the secondary (check) laboratory. This laboratory currently has ISO 17025 accreditation, but whether it did at the time of the analyses is unknown.

After May 2005, the secondary laboratory was changed to Genalysis Laboratory Services Pty Ltd. (Genalysis), also in Perth. The National Association of Testing Authorities Australia has accredited Genalysis to operate in accordance with ISO/IEC: 17025 (1999), which includes the management requirements of ISO 9002:1994.

Check assays were also performed by ActLabs Asia LLC, part of the global ActLabs Group, which has maintained a full–service laboratory in Ulaanbaatar since 2006. The laboratory has sample preparation, weighing, fire assaying, wet laboratory, and instrumentation sections. It maintains an ISO 17025 accreditation and participates in CANMET and Geostats Proficiency Testing programs.

Until September 2011, all routine sample preparation and analyses of the Oyu Tolgoi samples were carried out by SGS Mongolia, which operates an independent sample preparation facility at the Oyu Tolgoi site and an analytical laboratory in Ulaanbaatar. SGS Mongolia, part of the global SGS Group, and predecessors have maintained a full–service laboratory in Ulaanbaatar since the late 1990s. This laboratory was recognized as having ISO 9001:2000 accreditation and conforms to the requirements of ISO/IEC 17025 for specific registered tests. The laboratory performs all fire assay analyses.

Between 2011-2016, the samples were submitted to SGS Mongolia for preparation and gold analysis and ALS (Canada) for multi-element analysis. Since 2016, the sample preparation for exploration and resources estimation has been carried out by SGS Mongolia located in Ulaanbaatar and umpire assay analysis has been performed at ALS laboratory in Perth, Australia and Canada.

Since September 2011, a second pulp has also been sent to the ALS Chemex (ALS) facility in Vancouver, Canada, for inductively coupled plasma and LECO analyses. ALS also acts as the check assay lab for SGS and vice versa. Since 2005, ALS has held ISO/IEC 17025 accreditation.

11.3 Sample preparation

An on-site preparation laboratory was installed in 2002 as a dedicated facility for Oyu Tolgoi during exploration and resource definition stages. The laboratory was operated by Analabs Co. Ltd and later by SGS Mongolia continuously up to the end of 2008, when it was put on care and maintenance during a slowdown in drilling operations. It re–opened sporadically during 2009, and resumed continuous operations in mid–2010, when drilling operations increased. Although the facility has mostly dealt with samples from the Project, it also has, on occasion, prepared some samples from other TRQ projects in Mongolia. In March 2014, the facility was again put under care and maintenance as drilling operations ceased.

Split–core samples were prepared for analysis at the on–site sample preparation facility operated by SGS Mongolia. The prepared pulps were then shipped by air to Ulaanbaatar under the custody of either TRQ or Oyu Tolgoi LLC personnel, where they were assayed at the laboratory facility operated by SGS Mongolia.

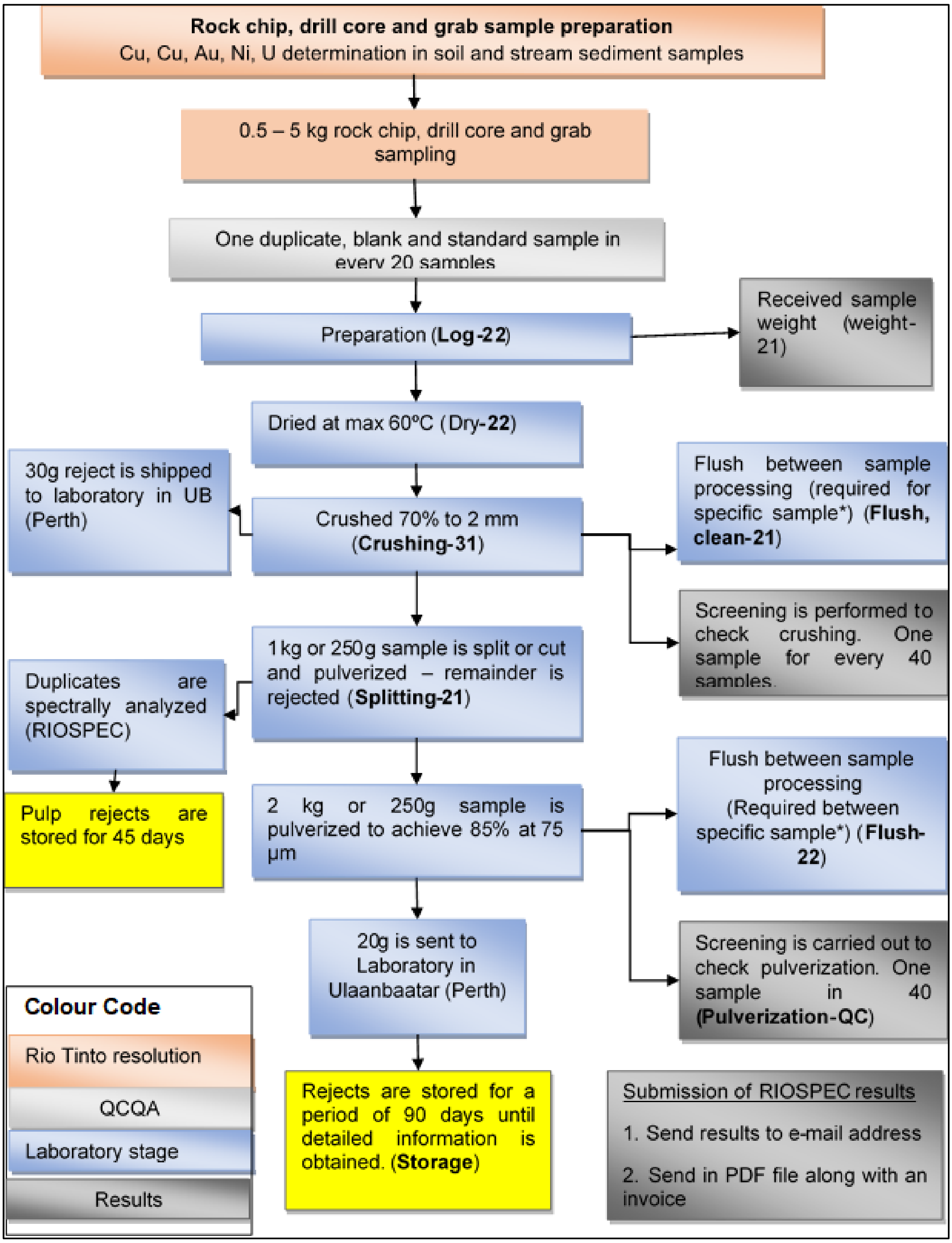
All sample preparation procedures and QA/QC protocols were established by TRQ in consultation with SGS Mongolia and have been continued by Oyu Tolgoi LLC (Figure 11.1). The maximum sample preparation capacity has been demonstrated to be around 600 samples per day when the sample preparation facility is fully staffed.

The sample preparation facility has one large drying oven, two Terminator jaw crushers, and three LM2 pulverizers. The crushers and pulverizers have forced air extraction and compressed air for cleaning.

The sample preparation protocol for Oyu Tolgoi samples is as follows:

- Coding – An internal laboratory code is assigned to each sample at reception.
- Drying – The samples are dried at 75°C for up to 24 hours.
- Crushing – The entire sample is crushed to obtain nominal 90% at 3.35 mm.
- Splitting – The sample passes twice through a nominal one-inch (approximately 2.5 cm) Jones splitter, reducing the sample to approximately 1 kg. The coarse reject is stored.
- Pulverization – The sample is pulverized for approximately five minutes to achieve nominal 90% at 75 µm (200–mesh). A 150 g sample is collected from the pulverizer and sealed in a Kraft envelope. The pulp rejects are stored on–site.
- The pulps are put back into the custody of Oyu Tolgoi LLC personnel, and standard reference materials (SRM) control samples are inserted as required.
- Shipping – The pulps are stored in a core box and locked and sealed with tamper–proof tags. Sample shipment details are provided to the assaying facility both electronically and as paper hard copy accompanying each shipment. The box is shipped by air to Ulaanbaatar where it is picked up by SGS Mongolia personnel and taken to the analytical laboratory. SGS Mongolia staff confirm by electronic transmission that the seal on the box is original and has not been tampered with.
- Storing and submitting – The pulp rejects are stored on–site at the laboratory for several months and then returned to the project office in Ulaanbaatar for storage.

Figure 11.1 Rock chip, drill core and grab sample preparation



Source: Compiled by AMC from information provided by TRQ, Date: 30 June 2020

Between sample processing, all equipment is flushed with barren material and blasted with compressed air. Screen tests are done on crushed and pulverized material from one sample taken from the processed samples that make up part of each final batch of 20 samples to ensure that sample preparation specifications are being met.

Reject samples are stored in plastic bags inside the original cloth sample bags and are placed in bins on pallets and stored at site. Duplicate pulp samples are stored at site in the same manner as reject samples.

11.4 Analytical methods

SGS Mongolia routinely assayed all samples submitted for gold, copper, iron, molybdenum, arsenic, and silver on two-metre composite intervals.

Up to September 2011, copper and molybdenum were determined by acid digestion of a subsample, followed by an AAS finish. Samples were digested with nitric, hydrochloric, hydrofluoric, and perchloric acids to dryness before being leached with hydrochloric acid to dissolve soluble salts and made to volume with distilled water. Routine assays up to 2% Cu used a sub–sample size of 0.5 g, whereas a sub–sample size of 0.25 g was used for samples expected to be over–range, or >2% Cu. The detection limits of the copper and molybdenum methods were 0.001% and 10 ppm, respectively.

Gold was determined using a 30 g fire assay fusion cupelled to obtain a bead and digested with aqua regia, followed by an atomic absorption spectroscopy (AAS) finish, with a detection limit of 0.01 g/t. The same acid digestion process used for copper and molybdenum was also used for analyses of silver and arsenic with detection limits of 1 ppm and 100 ppm, respectively.

A trace element composites (TEC) program was undertaken in addition to routine analyses. Ten metre composites of equal weight were made up from routine sample pulp reject material. The composites were subject to multi–element analyses comprising a suite of 47 elements determined by inductively coupled plasma atomic emission spectroscopy/mass spectrometry (ICP–AES/MS) after four–acid digestion. Additional element analyses included mercury by cold vapour AAS, fluorine by potassium hydroxide (KOH) fusion / specific ion electrode, and carbon/sulphur by LECO furnace. Results from the TEC program were used for deleterious element modelling.

During 2011, an audit of assay techniques was instigated on the restricted suite of Cu, Au, Fe, Mo, Ag, and As. It was determined that the higher than optimum detection limits was resulting in limit capability to interpret low grades mineralization, including interpretation of arsenic zones. Also, gold detection limits were lowered by a factor of 10 when detection by AAS was changed to ICP-AES. Consequently, a shift to high–resolution ICP–MS for routine samples was implemented in September 2011. Given the relative complexity of ICP–MS equipment and the tendency for laboratories to centralize them globally to assist with operation and maintenance, this has necessitated a shift to an off–shore laboratory for analysis of all resource and exploration samples.

As a result, the following actions were taken:

- SGS continued to manage the on–site sample preparation facility.
- SGS in Ulaanbaatar was appointed the primary laboratory for Au and F to ensure rapid turnaround of gold values.
- ALS (Vancouver) was appointed the primary laboratory for the high resolution multi–element ICP–MS based suite (42 elements) and LECO sulphur and carbon analyses.
- ALS and SGS were to act as the secondary laboratories for each other, reinstating the secondary laboratory checks systematically in resource and exploration drilling. The check sample rate was at a nominal check rate ratio of one sample in 20.

The intended outcome for this was to:

- Identify grade and mineralization type (Cu, Au).
- Identify new mineralization from pathfinder elements (As, Bi, Pb, Zn, etc.).
- Determine the distribution of potential credit elements (Ag, Mo).
- Determine deleterious elements and allow mitigation procedures to be prepared (S, As, F, Cl, Se, and Ti).
- Support the mapping of deleterious alteration or rock types to allow mitigation procedures to be prepared (Si, K, Na, and Ca).
- Support the mapping of rock types for appropriate logging of litho–types.

Run–of–mine samples from the open pit and concentrator are subject to a separate analytical flowchart at the mine laboratory situated within the concentrator complex on–site.

The QP considers the preparation and analytical protocols used to generate the data to be appropriate for use in the generation of this Mineral Resource estimate.

11.5 Quality assurance and quality control methods

11.5.1 QA/QC program outline

Five QA/QC samples are routinely included in every batch of 15 samples to make up a batch of 20 samples. QA/QC samples consist of one duplicate split core sample, one uncrushed field blank, a reject or pulp preparation duplicate, and one or two SRM samples (<2% Cu and >2% Cu if higher grade mineralization is present based on visual estimates). The SRMs are matrix–matched to ensure consistency with routine analytical samples.

The split core, reject, and pulp duplicates are used to monitor precision at the various stages of sample preparation. The field blank can indicate sample contamination or sample mix–ups, and the SRM is used to monitor accuracy of the assay results.

11.5.2 Standard reference materials

SRMs are prepared from Oyu Tolgoi site material of varying matrices and grades to formulate bulk homogenous samples. Ten samples of this material are sent for round–robin testing by at least seven international laboratories. The resulting assay data are analyzed statistically to determine a representative mean value and standard deviation necessary for setting acceptance/rejection tolerance limits. Blank samples are also subjected to a round–robin program to ensure the material is devoid of any of the elements of interest so they can be confidently used to monitor potential contamination.

The performance of the SRM samples has been monitored throughout the life of the program for this resource statement. The ability of the laboratories to return assay values in the prescribed SRM ranges has steadily improved to greater than 99%. All samples were given a “fail” flag as a default entry in the geological database. Each sample was re-assigned a date-based “pass” flag when assays have passed acceptance criteria. Samples

Owing to the change in analytical techniques, recertification of the SRMs was completed in 2012.

11.5.3 Blanks

Field blanks are used for checking whether there is a source of any contamination or sample mix–ups during the sample preparation, ensuring that laboratory instrument and devices are cleaned properly between samples. Field blanks are taken from the pit waste dump quarry in the north–north–east corner the of the mining license area and re–assayed to ensure the material is barren. Previously, field blanks were granodiorite or granite that are similar to the rocks of the Southwest Oyu area. Currently, field blanks are 1 cm quarry stone and are stored in big wooden box nearby the open pit office.

The lower detection limits of the gold and copper methods are 0.01g/t Au and 0.001% Cu and expected value for field blanks are set at 0.06 g/t Au and 0.06% Cu. Batches get automatically failed and sent for re–assay test if these expected values are exceeded.

Evaluation of the blank samples submitted to the laboratory in the period 2009–2019 indicated a low incidence of contamination for the analytical programs. A few cases of sample mix–ups were identified during the review of the blank performance, which were investigated at site and corrected. No evidence of systematic contamination was noted for the review of data from 1 January 2008 to 1 November 2010 (Sketchley, 2011) and from 2011 to 31 December 2018 (Odonchimeg.A, 2013; 2014; 2015; 2016).

11.5.4 Duplicate samples

Duplicates routinely used at Oyu Tolgoi comprise core, coarsely crushed rejects, and pulps. Core duplicates are taken in the field from one-half of core that has been split parallel to the long axis. Coarsely crushed rejects and pulp duplicates are taken in the laboratory by using a riffle splitter. Assays of each type follow the parent sample in a batch.

Duplicates data were plotted using the acQuire QA/QC module. The only issue of significance is for gold duplicates where a strong bias is noted for several samples, which is most likely related to sample mix-ups as that pattern is present for core, coarsely crushed, and pulp samples. The remaining data display normal distribution patterns, and the precision is deemed acceptable for the types of material and mineralization being examined.

Copper generally performed very well with results well within expected limits; gold results are higher than copper but considered acceptable.

11.5.5 Sample security

Samples are always attended to or locked in a secure sample dispatch facility. Sample collection and transportation were always undertaken by company or laboratory personnel using company vehicles. Chain–of–custody procedures included filling out sample submittal forms that were sent to the laboratory with the sample shipments to ensure that the laboratory received all the samples.

The QP considers the QA/QC and security protocols used on the Project to be appropriate in regard to the data used in the generation of this Mineral Resource estimate.

11.6 Databases

Before August 2010, all geological and geotechnical drillhole data were entered into an MS Access relational database that had been developed in-house. Data were exported from the main database to meet end-user requirements.

In August 2010, Oyu Tolgoi LLC elected to migrate the MS Access database to a full Microsoft SQL Server (ODBC) acQuire database with links to the end-user software programs. The database is read-only for these programs, preventing accidental overwriting and ensuring up-to-date live and centralized data, rather than distributed databases.

Before August 2010, all drillhole data were initially manually recorded in the field or in the core logging shed on paper logging sheets. The logging geologist then introduced logging information into the MS Access database, which had a series of embedded checking programs to look for obvious errors. Formational names were subsequently assigned according to the accepted geological interpretation and position within the stratigraphic column.

With the move to the acQuire database, which instituted direct digital data capture, the design stubs for the logging sheets do not permit any invalid data. No drillhole can be completed and entered into the database until the logging is correctly entered.

Analytical laboratories report results digitally by email and submit signed paper certificates. All hard copy assay certificates are stored in a well-organized manner in a secure location on-site.

Before August 2010, the digital assay results were imported to the MS Access files once the assay data had been received from the laboratory. With the subsequent direct import to the acQuire database, none of the assay data are entered manually. Project personnel visually check each assay on the signed paper certificate against the assay entry in the digital database.

Final surveyed collars (total station) are entered manually into the database and are visually checked against the preliminary, hand-held GPS readings. No double data entry is applied during the entry of the final collar coordinates. Digital data is backed up regularly.

The extracts for Mineral Resource estimation are made for certain periods for boundaries of the deposits and relevant areas. Data for the Oyut estimate was extracted as of 23 February 2016, whereas that of Hugo North were extracted as of 14 February 2014. Hugo South was extracted 1 November 2003. Heruga was extracted 21 June 2009.

The QP considers the current protocols in place for electronic data storage and extraction are in line with industry best practice. The database has been held in one place since inception and the implementation of an industry leading software such as AcQuire provides a high level of data integrity on importation and security. The QP considers the data importation and storage systems to be adequate.

12 Data Verification

12.1 Data verification

TRQ has provided the QP's with detailed reports and source technical data used to prepare key aspects of 2020 Feasibility Study. These include:

- The source data and calculations used to estimate the Mineral Resources and Mineral Reserves for the Project.
- Detailed designs of the actual and proposed mine workings, including documentation and analysis used to evaluate and select the proposed designs.
- Estimates of forecast capital costs, operating costs, and construction schedules for the Project.
- Other documents and reports relating the Project, prepared by Oyu Tolgoi LLC or by specialist professional companies acting on their behalf.
- The only resource model updated since the last NI43–101 technical report is for the Oyut deposit. The resource was updated from a set of drillhole data extracted from the Oyu Tolgoi acQuire database to a Vulcan ISIS relational database on 23 February 2016. That drillhole database contained 1,023 unique drillhole collar records with a total core length of over 413,344 m. Of the total of 1,023 drillholes, 262 drillholes were excluded from geologic modelling and grade estimation because of holes being drilled outside the mineralised areas, the assay data related to these holes being considered not suitable for resource estimation due to sample type (reverse circulation) or not passing quality control, or the absence of assay data.

The QP's carried out the following procedures in respect of the verification of the data in their respective sections of the 2020 Technical Report:

Geological and Mineral Resource data

In respect of the geological and Mineral Resource data, the checks included:

- Review drilling and composite statistics.
- Review the variograms used in estimates.
- Recalculating block model tonnes and grade used in the estimates.
- Visually validate drilling data to the data in the block models.
- Assess swath plots to verify estimate bias.

Mining and Mineral Reserves data

In respect of the mining and Mineral Reserves data, the checks included:

- Reviewing the input parameters used to convert the Mineral Resources to Mineral Reserves and checking that inputs were applied in a manner consistent with industry standards.
- Superimposing the caving outline over the Mineral Resource model to confirm that no unexpected material differences exist between the Mineral Reserve estimate and the contents of the Mineral Resource model within the caving outlines.
- Confirming that the Geovia PCBC™ software used to estimate the mineral reserve was rerun by Oyo Tolgoi LLC to confirm that the Mineral Reserve estimate could be reproduced.
- Reviewing the detailed output from the PCBC modelling and carried out spot checks to ensure that the data was correctly compiled and scheduled as reported and that no Inferred Mineral Resources were included in the Mineral Reserve estimate.
- Reviewing and confirming the NSR calculations and the appropriate application of cut-offs used to estimate the Mineral Reserve.
- Reviewing the Lerchs-Grossman pit optimization model, results and analysis used to guide the pit design used to estimate the Mineral Reserve.

- Reviewing the final pit, pit stage, and waste dump designs to confirm that pit slope design criteria were applied correctly and that designs were practical and achievable for the planned mining equipment.
- Confirming that the reported Oyut Mineral Reserve was aligned with the mining schedule inventory.
- Reviewing mining factors and assumptions applied to the mining schedule to confirm that the equipment parameters are based on demonstrated performance and that planned material movement rates were reasonable.

Cost estimates

In respect of cost estimates, the validation checks included:

- A detailed review of the calculations used to prepare the projected operating cost estimates for the open pit and the underground project to confirm that the estimates were soundly based. Checks were also made against AMC benchmark data to confirm the reasonableness of the estimates.
- A detailed review of the processes and inputs used by Oyu Tolgoi LLC to prepare the schedules and capital cost estimates for the underground development. The validation checks included:
  - Comparing the reported quantity of development required to be completed against the layout drawings.
  - Comparing the productivity rates used to prepare the estimates with AMC's benchmark data and historical performance.
  - Review the detailed calculations underlying the cost estimates and schedules to check for errors in the compilation of the cost estimates.
  - Reviewing summary information by work breakdown structure for the capital cost for Hugo North construction activities to check for consistency with the information provided in the 2020 Feasibility Study.

Inputs to financial analysis

In respect of financial analysis, the validation checks included a detailed review of the production, cost, and revenue inputs to the to the financial model to confirm that they were consistent with the values estimated in the 2020 Feasibility Study.

Other data

In respect of other data, the QP's discussed key technical aspects of the Project with senior members of the Oyu Tolgoi planning and engineering team on multiple occasions. The Project site was visited on multiple occasions by the QP's, as reported in Section 2 of this Technical Report. During the site visits, key aspects of the drill core logging sampling, and sample handling processes were observed; the open pit, underground project, and concentrator were inspected.

12.2 Limitations

The following limitations to data used to prepare key aspects of 2020 Feasibility Study should be noted. In respect of the geological and mineral resource data, the QP's did not verify reported vs recorded assays. Automatic loading of digital data from analyses and verification systems built into AcQuire, however, eliminate this risk. No independent sampling was carried out by the QP's.

In respect of cost estimates, the QP's did not verify the detailed capital cost data or schedule underlying the Hugo North construction activities. However, The QP's have confirmed that the estimates have been prepared by Rio Tinto following standard practice for estimating construction costs for major projects. Quantities are validated and signed-off by appropriate engineering staff based on the level of detailed design completed. For work yet to be awarded material take-offs, scopes of work, and specifications are developed and combined with benchmark data (actual to date installation rates and productivity). First principles estimates are also prepared where appropriate. Allowances are included in estimate of major contract packages for growth in scope and cost, scope and for risk.

12.3 Adequacy of the data

The QP's are satisfied as to the adequacy of the data provided by TRQ for the purpose of preparing this 2020 Technical Report.

13 Mineral processing and metallurgical testing

13.1 Introduction

The Oyu Tolgoi concentrator was designed to initially process ore only from the Oyut deposit (Phase 1) and, after modifications, to process a blend of ore from both the Hugo North and Oyut deposits (Phase 2). Currently, only ore from the Oyut deposit is processed.

13.2 Geometallurgical characterization of Oyut and Hugo North deposits

The geometallurgical characteristics of the different ore types in the Oyut and Hugo North deposits are based on a reconciliation of a large database of metallurgical testwork completed to date. The database includes seven years of Phase 1 operating data.

In 2018, the geometallurgical ore types were redefined for the Oyut deposit. Nine ore types were identified based largely on the geological domains used to define the earlier five ore types used. The nine ore types provide an increased level of definition relating to ore hardness, flotation recovery and flotation concentrate grade. The geometallurgical ore types for the Oyut deposit are described in Table 13.1.

Five geometallurgical ore types were identified for the Hugo North deposit, compared with the one ore type used prior to 2018. The ore types are based on the observed differences in flotation recoveries from samples with varying chalcopyrite and bornite content and on the influence of pyrite on concentrate grade. The five ore types are summarized in Table 13.2.

Table 13.1 Oyut geometallurgical ore type definitions

Pit zones	Ore type	Abbrev.	Geo metallurgical description
Southwest Zone (Southwest, South, Wedge, Bridge, and West)	Hard Gold	HG	Hard, chalcopyrite / bornite, high copper and gold recovery, low arsenic bearing
	Hard	H	Hard, chalcopyrite/bornite, high copper and low to moderate gold recovery, low arsenic bearing
	Moderate Gold	MG	Moderate hardness, chalcopyrite/bornite, high copper and gold recovery, low arsenic bearing
	Moderate	M	Moderate hardness, chalcopyrite/bornite, high copper and low to moderate gold recovery, low arsenic bearing
Central Zone	Soft Supergene Enargite	SSE	Soft, chalcocite, low to moderate copper and gold recovery, high copper-arsenic sulfosalts
	Soft Supergene	SS	Soft, chalcocite, low to moderate copper and gold recovery, copper-arsenic sulfosalts
	Soft Hypogene Enargite	SHE	Soft, covellite/chalcopyrite, high copper and low to moderate gold recovery, high copper-arsenic sulfosalts
	Soft Hypogene	SH	Soft, covellite/chalcopyrite, high copper and low to moderate gold recovery, copper-arsenic sulfosalts
	Soft Hypogene Gold	SHG	Soft, covellite/chalcopyrite, high copper and gold recovery, copper-arsenic sulfosalts

Table 13.2 Hugo North geometallurgical ore type definitions

Ore type	Abbrev.	Criteria[a]	Processing characteristics
High arsenic	HI-AS	As ≥ 200 ppm	Potential to produce flotation concentrate with over 2,000 ppm As. Distributed mainly in augite basalt and ignimbrite rock types in the hanging wall of Lift 1 and overprinting BN-CP ore in the core of Lift 2.
High Cu grade, high bornite content with little pyrite	BN-CP	Cu ≥ 1.25% Cu:S ≥ 1.2	Soft, strongly phyllic altered quartz monzodiorite and augite basalt at the core of the Hugo North resource. Higher copper and gold head grades and recoveries with potential to produce concentrate with copper grades from 30% to over 50%.
High Cu grade, most Cu in chalcopyrite, high pyrite	CP-PY	Cu ≥ 1.25% Cu:S < 1.2	Soft, strongly phyllic altered augite basalt and quartz monzodiorite overlying the BN-CP zone. High copper grades with moderate gold grades. High copper recovery and concentrate copper grades ranging from 20% to 40%, variable gold recovery.
Lower Cu grade, high pyrite, generally has most Cu in chalcopyrite	LG-PY	Cu < 1.25% S ≥ 1%	Pyrite rich augite basalt and ignimbrite in the hanging wall of the BN-CP and CP-PY zones. Moderate to poor copper and gold recovery and potential to produce low concentrate copper grades.
Lower Cu grade with little pyrite	LG	Cu < 1.25% S < 1%	Hard, potassic altered low sulphide BiGD and QMD in the footwall of the BN-CP zone. Moderate copper recovery, variable gold recovery with potential to produce concentrate with grades from 20% to 30%.

Note: a. Ore types are assigned in the top-down order shown, e.g. all blocks with As ≥ 200 ppm are assigned as HI-AS, regardless of copper and sulfur grades.

13.3 Metallurgical testwork

The initial metallurgical testwork programs on Oyu Tolgoi mineralization were carried out between 2001 and 2007. The testwork formed the basis for the design of the Phase 1 concentrator.

The testwork programs were carried out on drillcore samples from various deposits. The focus was on the Oyut and Hugo North deposits. The testwork programs identified the mineralogical characteristics and the metallurgical response of the individual deposits and the various blends of ore to be processed through the concentrator at different periods in the planned production schedule.

The testwork programs were performed by:

- SGS Lakefield Research Limited (SGS Lakefield).
- A.R. MacPherson Consultants Ltd (ARM).
- Terra Mineralogical Services (TMS).
- Ammtec (now ALS in Perth, Australia).
- Blue Coast Metallurgy and Research (Blue Coast).
- Minnovex Technologies (Minnovex).
- Process Research Associates (PRA).

The testwork programs included:

- Comminution testwork, including semi autogenous grinding (SAG) pilot plant tests using a 250 t bulk sample of mined rock from the Southwest Zone. The sample was shipped to SGS Lakefield in 2005.
- Gravity concentration testwork to estimate gold recovery.
- Flotation testwork to determine copper and gold recoveries.
- Laboratory bench-scale and pilot plant flotation testwork programs.

- Confirmatory cleaner flotation testwork on the Southwest and Central ore zones.

Blue Coast Metallurgy managed further testwork in 2013, to assess the impact of a change in the expected feed blend to the concentrator. The work focused on investigating interactions between the open pit ore types and Hugo North Lift 1 ore. The testwork achieved above predicted performance on blends of ore but was unable to obtain the same performance achieved in the earlier testwork when testing 100% Hugo North Lift 1 ore. This was partly attributed to the age (approximately eight years old) of the core used in the testwork.

The 2013 testwork programs and the earlier testwork programs were used to estimate plant throughput, copper and gold recoveries, and concentrate grades for the Phase 1 concentrator. These were reported in the 2014 and 2016 Technical Reports.

In 2016-17, a further testwork program was completed at ALS to confirm and update metallurgical predictions for the Hugo North Lift 1 ore. The testwork program was performed on drill core from the 2011-2013 drilling programs. The objectives of the program were to:

- Complete further and more extensive locked cycle flotation testwork of the first 10 years of underground ore production.
- Confirm or update current assumptions regarding the flotation scale-up factors.
- Carry out limited comminution tests to improve the density and coverage of the Hugo North Lift 1 hardness data.
- Conduct limited alternative comminution tests.
- Confirm the effect of grind size P_{80} (the 80% passing size of grinding circuit product) on flotation performance.
- Increase the density of quantitative mineralogy.
- Quantify any differences in tailings rheology and thickening performance between Hugo North Lift 1 ore and the Southwest Zone ore.

During the program, 20 samples underwent comminution and flotation testwork to improve sampling density in the early years of the underground mine life; 40 Hugo North Lift 1 samples underwent quantitative mineralogy to improve copper speciation models; and 40 Oyut samples underwent comminution testwork and quantitative mineralogy to improve the comminution sampling density on ore to be processed through to 2023.

13.3.1 Sample spatial representation

The number of tests completed on samples from Oyut and Hugo North is summarized in Table 13.3, Table 13.4, and Table 13.5. The Oyut Southwest Zone refers to Southwest, South, Wedge, Bridge, and West zones within the Oyut pit (see map in Section 8 “Deposit types”, Figure 7.7).

Table 13.3 Number of samples used for metallurgical testwork programs

Deposit/Zone	Years of scheduled production	No. of holes sampled	No. of samples tested
Oyut Southwest Zone	0–9, 13–30	77	224
Oyut Central Zone	0–20	25	94
Hugo North	0–20	99	299

Table 13.4 Minnovex comminution tests

Deposit/Zone	SPI tests	Modified Bond tests	BWI tests	SPI density (Mt per test)
Oyut Southwest Zone	304	295	34	2.6
Oyut Central Zone	88	85	7	3.0
Hugo North	253	246	21	1.7
Total	645	626	62	2.3

SPI = SAG mill power index, BWI = bond work index, SPI density = the approximate mineral reserve tonnage divided by the number of SPI tests carried out (includes tonnage or ore processed since concentrator commissioning).

Table 13.5 Flotation tests

Deposit/Zone	Rougher tests	Rougher + cleaner tests	Locked cycle tests	Column tests	Pilot plant runs
Oyut Central Zone	196	165	4	0	0
Hugo North	214	118	10	2	1
Composites	26	37	7	0	0
Total	669	754	29	10	5

The sampling density in the Oyut open pit mineral reserve is two to four times higher in the early production years than for the life-of-mine. This is consistent with normal open-pit mining practice for large orebodies.

For Hugo North Lift 1, the sampling density for the-life-of-mine is approximately double that of the Oyut orebody. This is because of the inability to resample the Lift 1 mineral reserve by drilling once caving has commenced.

The QP considers that the samples on which metallurgical testwork has been carried are reasonably representative of the mineral reserves that are planned to be mined.

13.4 Processing rate

The target primary grind size for each ore type was determined from a comprehensive series of kinetic flotation tests carried out in 2007 by PRA in Vancouver. The testwork optimized the P_{80} feed sizes for the rougher and the cleaner flotation circuits. The rougher testwork was carried out on samples from the Southwest and Central zones and from Hugo North. The testwork formed the basis of the detailed design of the Phase 1 milling and flotation circuits.

Comminution testwork has been used to develop equations and input parameters to predict the primary milling capacity for the Phase 1 concentrator and the Phase 2 modifications. The predictions were for each ore type at the target flotation feed P_{80}.

The following comminution parameters are used in the equations:

- SAG power index (SPI) in minutes).
- Modified bond index (MBI) in kWh/t – a short form of the bond ball mill index test.
- Minnovex crushing index (Ci) – developed from the sample preparation process for the SPI.

The equations have been used to predict circuit throughput in tonnes per hour (t/h) at a nominated P_{80}.

The equations are shown in Table 13.6. The results from the equations compare well with other commonly used equations and reconcile well with the actual performance of the Phase 1 concentrator.

Table 13.6 Processing rate model

$Tonnes\ per\ operating\ hour = z \times r \times SPI^s \times MBI^t \times Ci^u$					
Ore	**Z**	**r**	**s**	**t**	**u**
Oyut (SPI ≤ 60)	1.000	32 920	-0.345	-0.07	0.00
Oyut (SPI > 60)	1.000	26 649	-0.208	-0.24	0.00
Hugo North	1.000	29 320	-0.360	-0.24	0.19

Note: The relationship between C*i* and processing rate is weak, therefore the exponent for Ci has been set to zero for the Oyut deposit.

The comminution dataset, used to estimate grinding circuit capacity, contains 645 SPI results and 626 MBI results. The results show a large overlap between the Oyut and Hugo North deposits. Summaries of the datasets for the Oyut Central and Southwest zones and Hugo North are shown in Table 13.7, Table 13.8 and Table 13.9. Throughput values are for the Phase 1 concentrator.

Table 13.7 Oyut Central Zone ore comminution indices

Percentile	SPI (min)	MBI (kWh/t)	Ci	Throughput (t/h)
20th percentile	26.0	9.8	33.0	10,053
50th percentile	49.2	13.0	24.7	6,895
80th percentile	65.2	14.7	21.0	6,062

Table 13.8 Oyut Southwest Zone ore comminution indices

Percentile	SPI (min)	MBI (kWh/t)	Ci	Throughput (t/h)
20th percentile	90.0	18.3	22.0	5,145
50th percentile	132.4	19.9	16.6	4,158
80th percentile	188.1	21.4	12.8	3,492

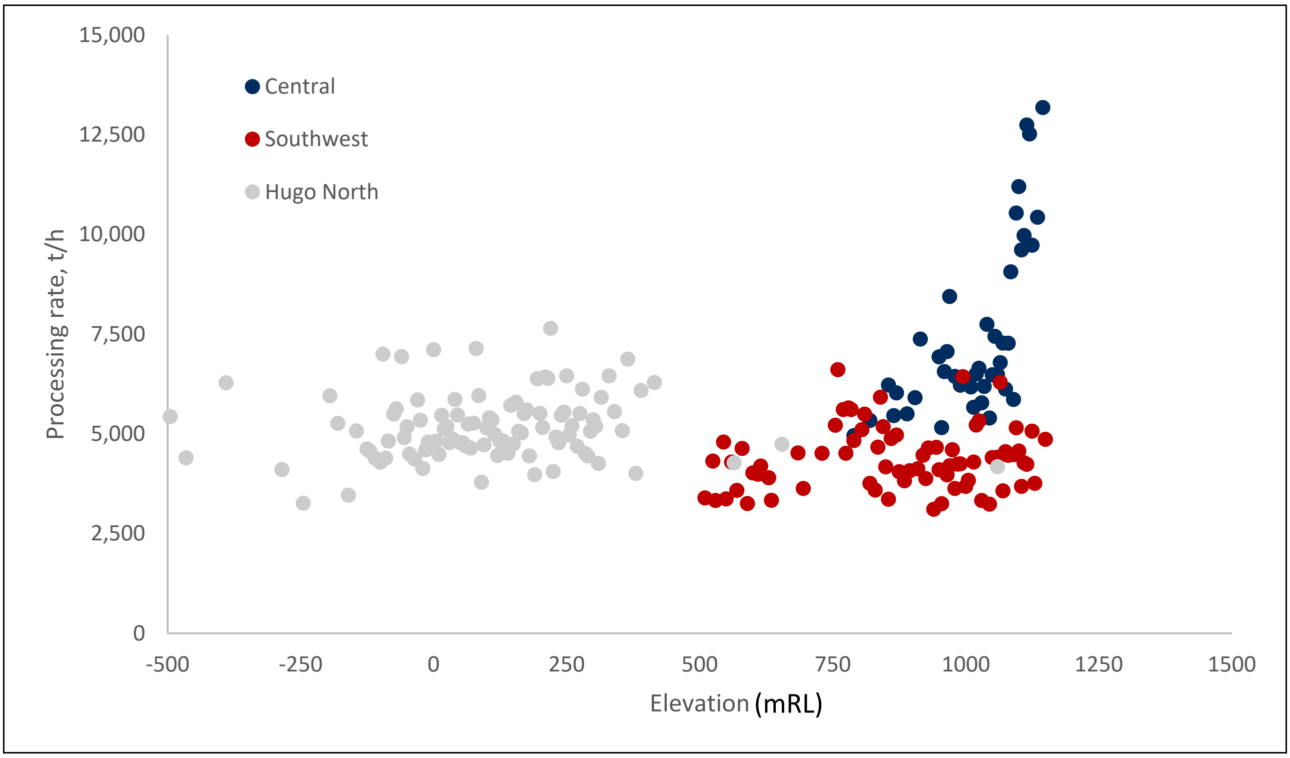
Table 13.9 Hugo North ore comminution indices

Percentile	SPI (min)	MBI (kWh/t)	Ci	Throughput (t/h)
20th percentile	61.9	16.4	24.3	5,898
50th percentile	76.4	17.7	16.6	5,063
80th percentile	104.4	20.1	9.7	4,319

For the Central Zone samples, there is a strong relationship between ore competence and depth below surface. Shallow ore is significantly softer than deeper ore. There is no significant relationship between ore competence and depth (elevation) for Southwest Zone or the Hugo North deposit (Figure 13.1).

Based on the comminution testwork, the Phase 1 and Phase 2 grinding circuits are expected to have sufficient capacity when processing the planned ore blends.

Figure 13.1 Relationship between elevation and predicted processing throughput



Source: Oyu Tolgoi LLC, Date: 29 May 2020

13.5 Mineralogical assessments

Many mineralogical assessments have been carried out on ore samples and flotation products. The most recent assessments have been carried out by TMS, Blue Coast and ALS.

The assessments included the following:

- Routine assessments of thin sections on intervals of core to qualitatively assess the nature of the copper mineral and gangue mineral assemblage.
- Routine semi-quantitative clay mineral measurements by infrared spectroscopy to assist in alteration classification and to potentially identify rheology-modifying species that could be problematic in processing.
- Mineralogical assessment of ore sections from all deposits. These include analysis of gold association, fluorine deportment in ore and concentrate, copper mineral associations in tailing, and leach residues.
- Visual logging of all core with respect to estimated sulphide mineral totals.
- Diagnostic leach testwork on oxide and secondary copper zones to distinguish between chalcocite, chalcopyrite and covellite.
- Quantitative evaluation by scanning electron microscopy (QEMSCAN) on particulate Southwest Zone and Hugo North composites (flotation feed and rougher concentrates).
- QEMSCAN analysis on 20 flotation feed composites from Hugo North and Central Zone testwork programs.
- X-ray diffraction and QEMSCAN on flotation tailings to assess the potential for acid generation.
- 48-element inductively coupled plasma mass spectrometry (ICP-MS) assays on 24,000 intervals over all deposits.
- Liberation analysis by conventional particle counts on Heruga.
- QEMSCAN analysis on an additional 40 Hugo North samples.

- QEMSCAN analysis on monthly composites of Phase 1 concentrator key process streams for 2014, 2015, 2017 and 2018, which remain ongoing.

13.5.1 Oyut copper mineralogy

In 2015, a mineralogical study was completed by ALS on samples from the Central Zone. Two master composites were prepared from drillhole samples, one for the chalcocite zone and one for the covellite zone. The deeper chalcopyrite zone was excluded from the study. A medium-grade composite sample from the Southwest Zone was also collected from blasted ore. The three composites were ground to a P_{80} of 150 µm, screened and subjected to QEMSCAN analysis.

The testwork results from the 2015 study, which are described below, generally aligned with previous studies.

The bulk mineralogy of the chalcocite and covellite composites is very similar. Quartz (about 38% w/w in each) and muscovite/K-feldspar (about 28% w/w) are the main non-sulfide gangue minerals. Quartz is the least abundant in the -25 µm fraction, while muscovite/K-feldspars are the most abundant. Pyrite is the main sulfide gangue mineral (about 14% w/w), and it is significantly less abundant in the coarsest and finest fractions.

The bulk mineralogy of the Southwest Zone composite is distinctly different, containing about 20% w/w each of chlorite, plagioclase, and muscovite/K-feldspar and approximately 10% quartz. Iron oxides/oxyhydroxides, amphibole and calcite, which are mostly absent in the composites from the Central Zone, account for about 6% of the sample mass. Chalcopyrite is the main copper mineral and carries almost all the copper.

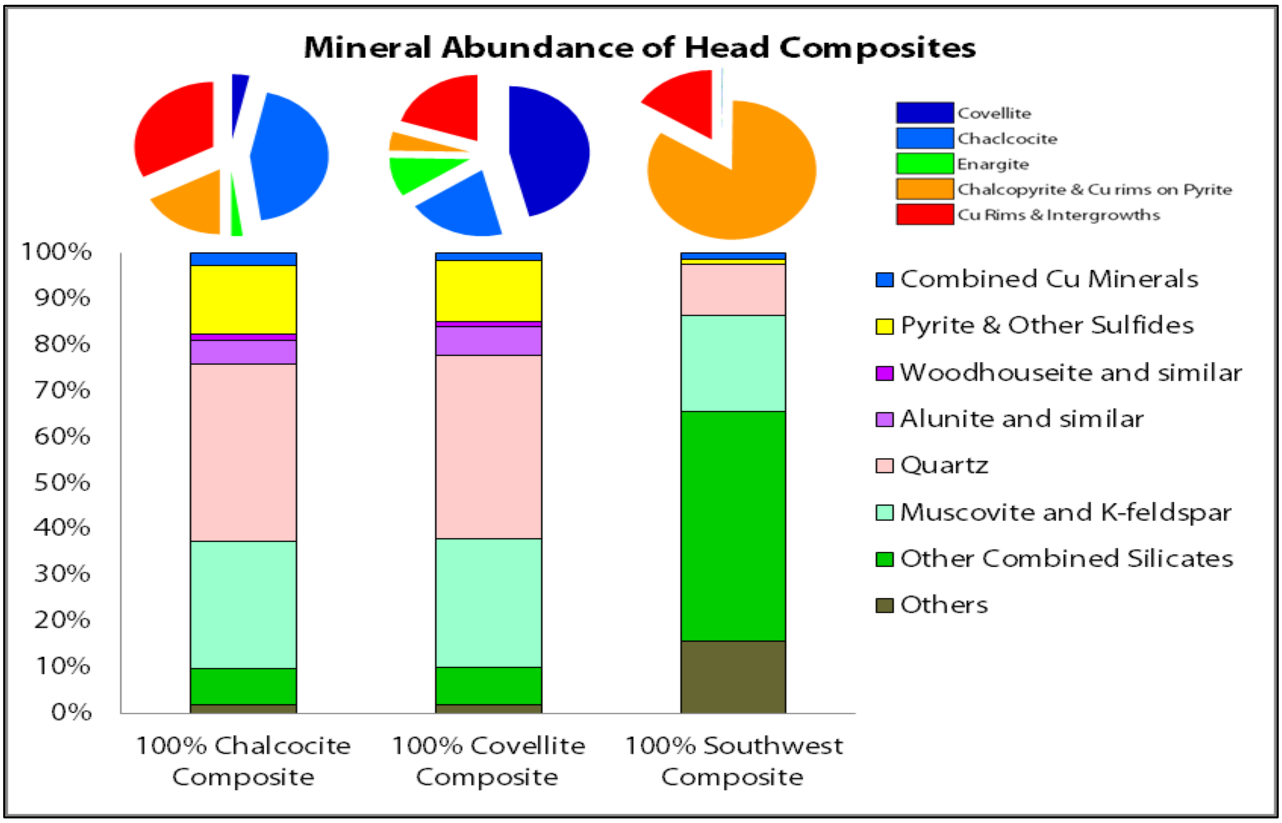
Copper deportment is distinctly different for the three composites. In the chalcocite composite, chalcocite and digenite account for 60% of the copper. The remaining copper is carried in chalcopyrite/covellite rims (27%), enargite (2%) and covellite (4%). In the covellite composite, covellite accounts for 50% of the copper and chalcocite/digenite accounts for 20%. The remaining copper is accounted for in enargite (8%) and chalcopyrite/covellite rims (15%).

Enargite (Cu_3AsS_4), which is a significant host to arsenic, accounted for around 10% of copper in the covellite composite and about 2% in the chalcocite composite. It is practically absent in the Southwest Zone composite. Enargite tends to be well-liberated in the finer size fractions, but occurs in complex particles in the coarser fractions, where it is mainly locked with pyrite and silicates. Pyrite is host to some arsenic, with an average concentration of 200 ppm in the chalcocite and covellite composites.

Liberation of copper sulfide minerals is poor, particularly in the chalcocite composite (about 20% is well liberated), where a significant proportion of the copper sulfides occur as rims on pyrite. This rimming is likely to have a significant impact on pyrite rejection during flotation. Liberation of copper minerals is slightly better in the covellite composite and Southwest Zone composites (about half are considered well liberated). The unliberated copper minerals are mainly locked with silicates and pyrite in the covellite composite and exclusively with silicates in Southwest Zone composite. Liberation of copper minerals improves significantly in the fine size fractions (e.g. +38 µm, +25 µm and –25 µm) in all composites.

Figure 13.2 shows the mineral abundance of three main composites and the elemental deportment of copper minerals.

Figure 13.2 Mineral abundance of three composites from 2015 ALS mineralogy program



Source: Oyu Tolgoi LLC, Date: 29 May 2020

13.5.2 Hugo North copper mineralogy

Within the Hugo North mineral reserve outline, the dominant rock forming minerals are quartz (average 43%) and micas (average 31%), with varying proportions of chlorite (maximum 23%), feldspars (maximum 23%), and oxides (mostly iron oxides, maximum 14%). Samples with the lowest copper grade, generally show more complicated mineralogy with some kaolinite or clays (maximum 20%) and elevated levels of pyrite (maximum 19%). These low-grade samples originate from parts of the Hugo North mineral reserve that will be mined late in the production schedule. This is when the effect of the elevated clay and pyrite contents are expected to be mitigated by the natural ore blending that occurs during the caving process.

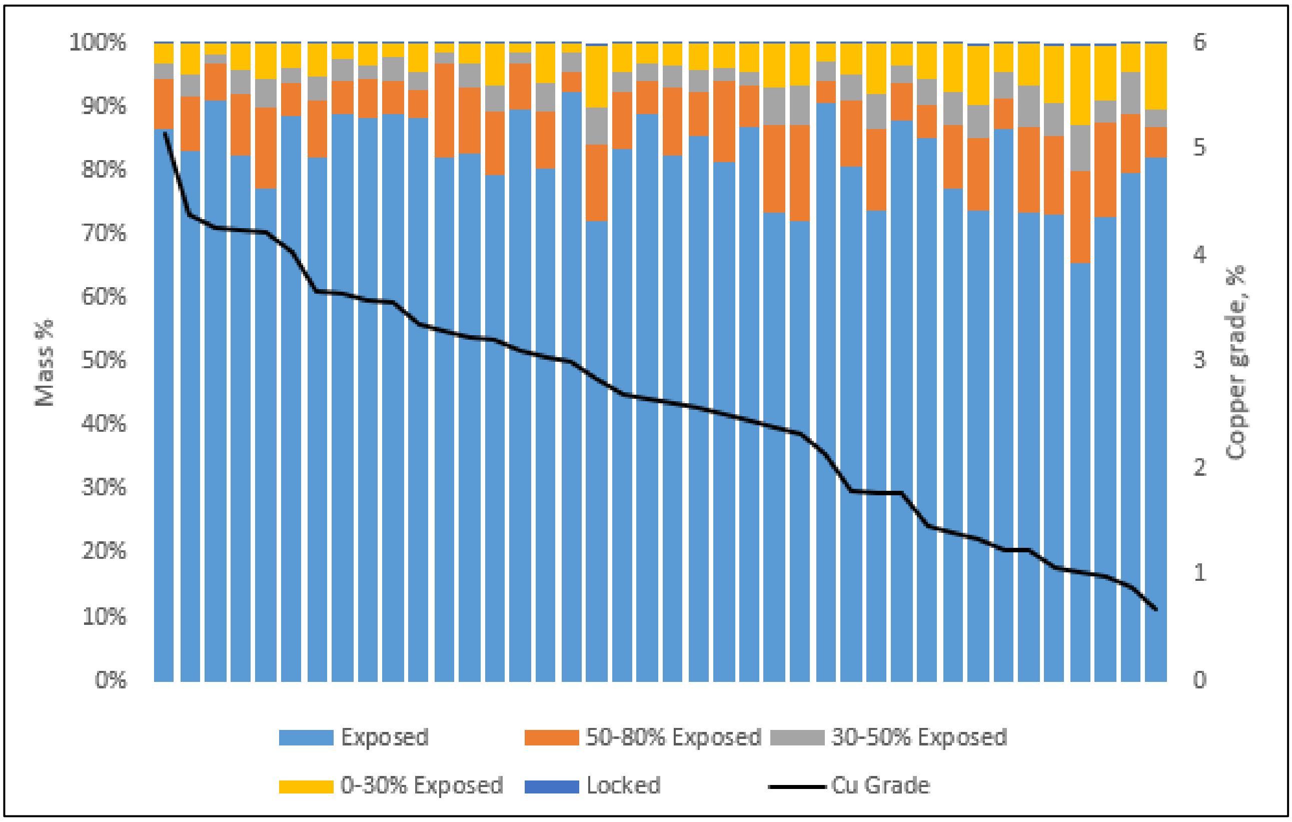
The quantitative mineralogy results generally show low amounts of pyrite and low ratios of pyrite to copper sulfides (averaging 0.7:1). These are influenced by the high pyrite content in the lower grade samples from the edge of the mineral reserve outline. The average pyrite to copper sulfide ratio of samples with more than 1% copper is 0.2:1. The grades from flotation testing show little dilution in concentrate by pyrite, as would be expected given the low overall pyrite content.

Across the samples measured, 49% of the copper was in bornite and 48% was in chalcopyrite. Minor amounts of other copper sulfides (mostly chalcocite, covellite, and enargite/tennantite) or pyrite were present. There is a general trend of decreasing bornite content with decreasing copper grade.

A reasonable level of liberation is achieved for rougher flotation feed (P_{80} of 140 µm). The mass of liberated particles (those with more than 30% surface sulfide exposure) increases from around 60% at low copper grades, to around 10% at high copper grades.

The expected mineral liberation at the target regrind size (45 µm) is shown in Figure 13.3. The typical desired level of 90% liberation is not achieved with most of the samples. However, the high proportion of bornite in Hugo North ore allows target concentrate grade to be achieved at the expected 80% liberation.

Figure 13.3 Hugo North copper mineral liberation at P_{80} of 45 µm



Source: Oyu Tolgoi LLC, Date: 29 May 2020.
The vertical bars represent individual samples.

13.5.3 Oyut gold mineralogy

Plant sampling campaigns were conducted in early 2014, early 2018 and late 2018. Samples were taken of rougher feed, rougher tails, cleaner scavenger tails and final concentrate. In the 2018 sampling campaigns, regrind mill cyclone overflow and underflow were also sampled.

The analysis showed that gold typically occurs mainly as gold minerals, but also as submicroscopic inclusions or gold in solid solution. The proportion of submicroscopic gold increases as gold grade decreases. Submicroscopic gold is primarily carried by sulfides. The concentration of submicroscopic gold is the same in pyrite and chalcopyrite. However, in lower grade ore, pyrite carries a larger portion of the gold. In ore samples with high gold grade, the average silver content of gold grains is 16.6% by weight. Native gold (Au>80%) and electrum (Ag>20%) are equally abundant.

Most of the gold in the rougher feed occurs as free gold and free sulfide particles of readily floatable size (>7 µm). Free gold particles are small, with an average size of 22 µm. The largest gold grain observed was 90 µm in diameter. Approximately 18% w/w of the gold in very high-grade samples is recoverable by gravity recovery methods. Gravity recoverable gold in the rougher feed stream is significant only in very high-grade samples from the Southwest Zone.

Most of the gold losses are in the rougher tailings stream. Free gold in rougher tails is low with most loss carried by gold grains less than 7 µm. In samples from the Southwest Zone the bulk of the gold loss is carried by composite particles.

13.5.4 Hugo North gold mineralogy

A re-analysis of the available gold microscopy completed on Hugo North was completed as part of the Hugo North geometallurgical program. The analysis found that while most of the gold grains were fine (68% w/w were <10 µm), most of the gold mass was in coarser gold grains (72% w/w were >40 µm). The analysis showed that most of the gold in the high-grade samples was in coarser size classes, and that most of the gold in the low-grade samples was in finer size classes and had a lower association with copper sulfides.

13.6 Flotation testwork

Many flotation testwork programs have been undertaken on Oyu Tolgoi ore types. The testwork has been carried out on individual samples of different ore types and on various blended samples. Tests include:

- Rougher flotation tests
- Rougher and cleaner flotation tests
- Locked cycle flotation tests
- Column flotation tests
- Pilot plant flotation campaigns

The laboratory testwork has been supplemented by concentrator operating experience. As a result, the characteristics of the processing characteristics of the Oyut ore types are well defined. The characteristics of blends of Hugo North and Oyut ore types have not yet been processed through the concentrator and are therefore based on the findings from the extensive testwork programs.

Kinetic flotation testwork carried out in 2007, resulted in the selected rougher flotation feed sizes shown in Table 13.10. The Phase 1 concentrator was designed on the results of this program. The current target grind size is based on a detailed analysis of the testwork and plant operating experience.

Table 13.10 Primary grind size P_{80} for each ore source

Deposit / zone	2007 testwork P_{80} (µm)	Current target P_{80} (µm)
Southwest	180	150
Central (average)	158-179	180
Hugo North	100-140	140

The regrind size for covellite and chalcocite indicates a preferred P_{80} of 25–30 µm, although many comparative tests with regrind levels between 30 µm and 40 µm provided similar flotation performance. In most cases, finer regrinds did not provide higher cleaner stage copper recoveries or copper concentrate grades for covellite or chalcocite ore types.

Testwork indicates a preferred regrind P_{80} for ore from the Southwest Zone of 25 µm. The plant has averaged only 72% passing 25 µm, rather than 80%. A finer size could be achieved but the coarser grind is preferred because of concerns with froth-carrying capacity and flotation rates at fine sizes in flotation columns, where bubble–particle contacts have relatively low energy.

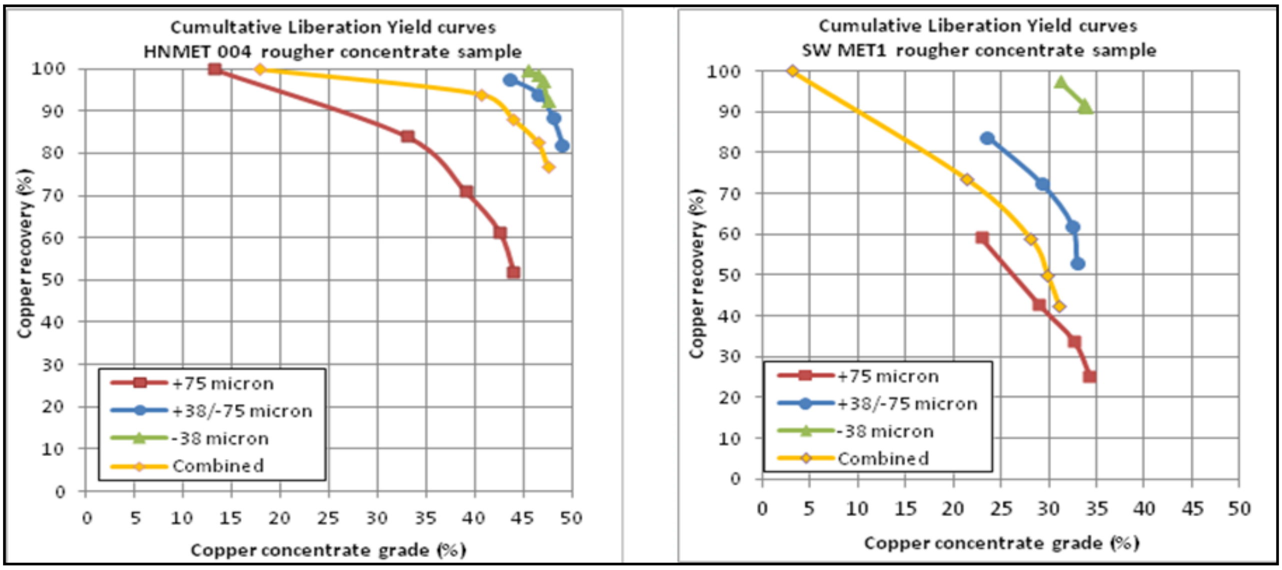
The regrind size requirement for Hugo North ore types is different than for Southwest ore types for the following reasons:

- Liberation of copper sulfides is much higher in Hugo North rougher concentrate at all particle sizes.
- Most of the Hugo North orebody is hosted in quartz-rich areas, resulting in lower levels of fluorine-bearing sericite in the final concentrate.

- The copper to fluorine ratio in Hugo North ore is much higher than in Southwest ore, which is also reflected in higher copper to fluorine ratios in the concentrate.
- Considering the large volume of concentrate production, keeping the regrind P_{80} as coarse as possible allows higher froth loading and better concentrate dewatering. It is still possible, however, to achieve a finer regrind at the same power input by using finer grinding media (12.5 mm rather than 15 mm). This may be required if less-liberated zones are encountered.
- In contrast to the open pit, given the large number of drawpoints planned for Hugo North, there will be a high degree of blending but limited opportunity for selective grade control. Fluorine content is expected to be less variable.

Cumulative liberation yield curves for Hugo North ore and the Southwest Zone are shown in Figure 13.4. The Cumulative liberation yield curves represent the theoretical grade-recovery curve obtained by recovering all copper sulfide particles in order of declining degree of liberation. Higher liberation is achieved for Hugo North ore in each of three particle size fractions, as well as in the combined product. The normal criterion for final concentrates, 90% liberation, is achieved in the −75 µm to +38 µm fraction for Hugo North cleaner feed, while this is only achieved in the −38 µm fraction for Southwest cleaner feed. It is noted that actual cleaner grade–recovery curves are a few percentage points below the theoretical curves.

Figure 13.4 Hugo North and Oyut Southwest sample cumulative liberation yield curves for regrind product



Source: Oyu Tolgoi LLC, Date: 29 May 2020

A planned regrind P_{80} of 40 µm results in very high liberation for Hugo North ore and reasonable liberation for Southwest ore types. It is recognized that conditions will be non-optimal for the covellite and chalcocite ore types in the Central Zone when blending with Hugo North ore.

13.6.1 Testwork for other elements

Silver

The assay method used in most testing programs was not sensitive enough to detect silver in test tailings samples, and silver recovery was not measured in the Ammtec or Blue Coast test programs. A reduced database only including the rougher kinetic test results with silver assays on the tailings has been used to develop a silver recovery model. This database, combined with the database of actual recoveries from plant operations, has been used to estimate average silver recovery for Oyut (52%) and Hugo North (80%).

Molybdenum

At the Oyut and Hugo North deposits, the molybdenum head grades are considered too low to justify the capital required to add a molybdenum recovery circuit to the Oyu Tolgoi concentrator. Consequently, no significant testwork has focused on molybdenum recovery. No payment or penalty is applied for molybdenum in a copper concentrate.

A common rule-of-thumb is that a molybdenum head grade of 150 ppm is required for economic molybdenum recovery, whereas Hugo North grades are in the order of 27 ppm. The Heruga deposit has grades of around 140 ppm molybdenum, which may be high enough for economic production of a molybdenum flotation concentrate in the future.

13.6.2 Testwork on Hugo South, and Heruga deposits

The Hugo South, and Heruga deposits remain in the assessment phase. A metallurgical scoping study was conducted at G&T Metallurgical Services in 2008 for the Heruga deposit. Nine composite samples from the deposit were sent to G&T laboratory for initial scoping testwork programs. These programs assessed the mineralogical characteristics of plant feed and flotation products, the flotation response of each sample, and the bond ball mill work index. These programs also analysed the exit streams from the flotation testwork to identify opportunities for further improvement in metallurgical performance. Overall, the composites responded well to the applied Oyu Tolgoi flowsheet envisaged at the time.

Based on the testwork carried out to date on the Hugo South and Heruga zones, the estimated flotation metal recoveries are summarised in Table 13.11.

Table 13.11 Hugo South and Heruga estimated flotation metal recovery to concentrate

Deposit	Estimated flotation recovery			
	Cu	Au	Ag	Mo
Hugo South	89%	81%	84%	–
Heruga	82%	73%	78%	60%

13.7 Penalty elements

Arsenic and fluorine are the only penalty elements that have been identified thus far. For arsenic in copper concentrate, a typical penalty rate of 2.00 $/t for every 1,000 ppm above a 2,000 ppm arsenic threshold applies. This applies up to the rejection level of 5,000 ppm, which is based upon the threshold for importation to China from the Chinese regulatory authorities. For fluorine in copper concentrate, penalties apply between the 500 ppm up until the 1,000 ppm rejection level.

13.7.1 Arsenic

Enargite is the primary arsenic carrier in all orebodies, although other sulfosalts, tennantite and arsenopyrite are also found. Enargite flotation recovery is almost the same as the flotation recovery of primary copper minerals. Enargite accounts for nearly all the elemental arsenic in the final concentrate.

The Central Zone ore types contain moderate to high levels of arsenic sulfosalts and contributes the highest proportion of arsenic in concentrate. The Southwest Zone contribution of arsenic in the flotation concentrate is very low, which is due to low arsenic feed grades and a larger portion of arsenic being in arsenopyrite, which can be rejected with high pH in the cleaner flotation circuit. Hugo North samples show that lower arsenic grades are generally associated with an increasing proportion of arsenic in arsenopyrite.

High flotation pH is the primary control on arsenic recovery, but it is only partially effective because of the difficulty in depressing enargite. In addition, high pH has an adverse impact on gold recovery and is therefore not often used. The most robust management approach for arsenic content in Central Zone ore types is blending with Southwest and Hugo North ores, which contains lower levels of arsenopyrite.

Projected arsenic levels in concentrate are expected to decline from around 4,000 ppm to a range between 2,000 to 3,000 ppm as ore feed from Hugo North increases.

13.7.2 Fluorine

Fluorine is present, primarily as fluorite with lesser amounts of topaz and sericite. It is believed that fluorine in finely intergrown topaz may be more difficult to reject.

Concentrates from locked cycle testwork shows that Central Zone concentrates contain higher fluorine levels than concentrates from the Southwest Zone. Tests on Hugo North ore show uniformly lower fluorine levels than concentrates from the Southwest Zone ore.

Testwork has been carried out to determine the practicality of acid leaching concentrates to remove fluorine. The testwork removed 60% of the fluorine in concentrate produced from Southwest Zone samples, but almost none from Hugo North concentrate. Acid leaching is inappropriate for the secondary copper minerals in Central Zone as it will leach the copper.

The concentrator currently produces concentrates containing about 700 ppm fluorine, which is 300 ppm below the rejection level. It is noted that there has been no rejection of concentrate based on fluorine levels.

It planned to manage fluorine levels below the rejection level through ore blending and operational control of the plant.

Fluorine in the Central Zone and Hugo North ore shows a roughly linear relationship between fluorine in the feed and fluorine in concentrate. In both cases, the fluorine assay in concentrate is about 15% of fluorine in feed, but plant performance observed in the first year of operation with Southwest Zone brought the ratio up to 30% of the feed grade. This has been also expected to apply to other ore types.

In all the months for which discrete data is available, fluorine grades in concentrate have been well below rejection level.

13.8 Other testwork

13.8.1 Water quality

Testwork was conducted at SGS using bore water collected from the Gunii Hooloi bore field. A simple average of samples from individual wells was used, and Vancouver tap water was used as a control. For the higher-grade ore samples from the Southwest Zone, this testwork showed that copper recoveries were higher compared to tests using recycled water. At lower grades, the recycle water achieved higher copper recoveries (possibly due to recycled collector). Experience since Phase 1 commissioning has shown no detrimental effects from using process water.

13.8.2 Thickening and concentrate filtration

As part of the initial testwork program for the design of the Phase 1 concentrator, large composites of Southwest Zone and Hugo North samples were made up from surplus sample at the AMMTEC laboratory. These samples were processed through pilot-scale equipment to generate large samples of concentrate and tailings for further testing. Concentrate was used for marketing analysis and to measure the thickening and filtration design parameters. Tailings material was used to confirm the design parameters for the thickeners, pumps and tailings deposition. Tailings were also evaluated to define environmental parameters.

The same thickening and filtration parameters developed for the Phase 1 design have generally been retained for Phase 2 design work, despite the coarser regrind targets. This was the case for the final tailings area, where the dewatering duty for blended Southwest, Central, and Hugo North tailings is similar to those determined for Phase 1.

Some concentrate thickening work was completed on laboratory products from the Hugo North metallurgical testwork in 2016, but the volumes of concentrate and tailings were small and not well suited to thickening and filtration testwork. However, the 2016 testwork program confirmed that the Phase 1 design thickener capacities were appropriate.

13.9 Recovery and concentrate grade prediction

Based on the results of the testwork programs the ongoing plant operations, a series of equations have been developed to predict current and future metal recoveries and concentrate grades of the various ore types. The equations for copper gold and silver recovery are shown in Table 13.12 through Table 13.16. The equations for estimating concentrate grade are shown in Table 13.17 and Table 13.18. The ore type definitions are shown in Table 13.1 and Table 13.2. Where:

- Ore types are defined in Table 13.1 and Table 13.2
- a, b, c, d, e, f, g, h are constants, which vary by ore type
- CuF is the feed copper assay in percent (%)
- AuF is feed gold assay in grams per tonne (g/t)
- AgF is feed silver assay in grams per tonne (g/t)
- SF is feed sulfur assay in percent (%)
- CuRec is copper recovery in percent (%)
- AuRec is gold recovery in percent (%)

Table 13.12 Global copper recovery model

$\boldsymbol{Copper\ recovery}\ (\%) = \boldsymbol{a} \times \frac{\boldsymbol{b \times CuF}}{\boldsymbol{1 + b \times CuF}} \times \left(\boldsymbol{1} - \boldsymbol{e}^{(-\boldsymbol{b \times CuF})}\right)$			
Code	**Ore Type**	**a**	**b**
1–4	HG, H, MG, M	98.0	14.5
5–6	SSE, SS	72.0	15.0
7–9	SHE, SH, SHG	80.7	15.0
10, 12–14	CP-PY, LG-PY, LG, HI-AS	96.0	20.0
11	BN-CP	95.0	15.0

Table 13.13 Oyut gold recovery model

AuF < 0.25	$\boldsymbol{Gold\ recovery}\ (\%) = \boldsymbol{c \times AuF + d}$						
0.25 ≤ AuF < 2.5	$\boldsymbol{Gold\ recovery}\ (\%) = \mathbf{u} \times \frac{\boldsymbol{f \times AuF}}{\boldsymbol{1 + f \times AuF}} \times (\boldsymbol{1} - \boldsymbol{e}^{-\boldsymbol{f \times AuF}}) + \boldsymbol{g \times AuF}$						
AuF ≥ 2.5	$\boldsymbol{Gold\ recovery}\ (\%) = \boldsymbol{h}$						
Code	**Ore Type**	**c**	**d**	**u**	**f**	**g**	**h**
1-4	HG, H, MG, M	164	25	79	20	1	80.0
5-9	SSE, SS, SHE, SH, SHG	249	0	70	30	1	71.6

Table 13.14 Hugo North gold recovery model

$\boldsymbol{Gold\ recovery}\ (\%) = (\boldsymbol{c} + \boldsymbol{d} \times \boldsymbol{CuRec}) \times \frac{\boldsymbol{u} \times \boldsymbol{AuF}}{1 + \boldsymbol{u} \times \boldsymbol{AuF}}$				
Code	**Ore Type**	**c**	**d**	**u**
10	CP-PY	0	0.89	90
11	BN-CP	0	0.89	85
12	LG-PY	0	0.79	260
13	LG	0	0.86	70
14	HI-AS	0	0.87	120

Table 13.15 Oyut silver recovery model

$\boldsymbol{Silver\ recovery}\ (\%) = \boldsymbol{i} \times \boldsymbol{AuRec} + \boldsymbol{j} \times \frac{\boldsymbol{AuF}}{\boldsymbol{AgF}} + \boldsymbol{k}$				
Code	**Ore Type**	**i**	**j**	**k**
1-4	HG, H, MG, M	0.48	16.670	19.49
5-9	SSE, SS, SHE, SH, SHG	0.19	0.001	47.12

Table 13.16 Hugo North silver recovery model

$\boldsymbol{Silver\ recovery}\ (\%) = (\boldsymbol{c} + \boldsymbol{d} \times \boldsymbol{CuRec}) \times \frac{\boldsymbol{e} \times \boldsymbol{AgF}}{1 + \boldsymbol{e} \times \boldsymbol{AgF}}$				
Code	**Ore Type**	**c**	**d**	**e**
10	CP-PY	0	0.92	6
11	BN-CP	0	0.98	4
12	LG-PY	0	0.76	25
13	LG	0	0.79	2
14	HI-AS	0	1.00	2

Table 13.17 Oyut concentrate copper grade model

$\boldsymbol{Concentrate\ copper\ grade}\ (\%) = \boldsymbol{n} \times \frac{\boldsymbol{CuF}}{\boldsymbol{SF}} + \boldsymbol{o} \times \left(\frac{\boldsymbol{CuF}}{\boldsymbol{SF}}\right)^2 + \boldsymbol{p}$				
Code	**Ore Type**	**n**	**o**	**p**
1-4	HG, H, MG, M	12.8	−3.6	22.5
5-6	SSE, SS	20.0	2.0	16.0
7-8	SHE, SH, SHG	20.0	2.0	16.5

Table 13.18 Hugo North concentrate copper grade model

$\boldsymbol{Concentrate\ copper\ grade}\ (\%) = \boldsymbol{n} \times \boldsymbol{CuF} + \boldsymbol{o} \times \frac{\boldsymbol{CuF}}{\boldsymbol{SF}} + \boldsymbol{p}$				
Code	**Ore Type**	**n**	**o**	**p**
10	CP-PY	0.1	20.1	14.9
11	BN-CP	1.7	13.8	16.7
12	LG-PY	5.2	20.7	6.5
13	LG	8.6	17.6	5.9
14	HI-AS	0.0	21.0	11.8

The equations are applied to the grades and ore types assigned to the mineral resource and ore reserve block models to estimate the metallurgical performance of the ore blend scheduled to be processed in various mill feed schedules, including the schedules underlying the ore reserve estimates.

The average metal recoveries for the mineral reserves reported in Section 15 "Mineral Reserves", Table 15.4 are shown in Table 13.19. The average metal recoveries for the Hugo South and

Heruga mineral resources reported in Section 14 "Mineral Resources" are summarised in Table 13.20.

The copper grade of the concentrate produced from processing the Mineral Reserves varies between 22.3% and 35.7% Cu over the planned life of the Mineral Reserves depending on the mineralogy of the ore being processed.

Table 13.19 Oyut and Hugo North estimated metal recoveries

Deposit	Estimated metal recoveries			
	Cu	Au	Ag	Mo
Oyut	78%	67%	52%	-
Hugo North	93%	80%	81%	-

Table 13.20 Hugo South and Heruga estimated metal recoveries

Deposit	Estimated metal recoveries			
	Cu	Au	Ag	Mo
Hugo South	89%	81%	84%	-
Heruga	82%	73%	78%	60%

14 Mineral Resource estimates

14.1 Mineral Resource statement

The individual Mineral Resources for Oyu Tolgoi by deposit are shown in Table 14.1 to Table 14.5. The total Mineral Resources for Oyu Tolgoi are shown Table 14.6. The 2019 Mineral Resources have been prepared in accordance with the CIM Definition Standards (2014) and in accordance with the requirements of NI 43-101. Compared to the Company's 2019 AIF for the year ended 31 December 2019, the 2020 Feasibility Study incorporates updated Mineral Resource and Mineral Reserve estimates for Hugo North Lift 1 while there has been no change to the Oyut open pit. As such, Mineral Resource estimates for Hugo North have been updated compared to the 2019 AIF whilst, Hugo South, Oyut and Heruga remain unchanged.

The Oyu Tolgoi deposits contain estimated Measured and Indicated Mineral Resources of 8.5 Mt (18.7 billion pounds) of contained copper, 9.4 Moz of contained gold, and an estimated Inferred Mineral Resource of 22 Mt (48 billion pounds) of contained copper and 34 Moz of contained gold.

For the Oyut and Hugo North deposits, the 2019 Mineral Resources have been reported after excluding the portion of each resource that has been converted to a Mineral Reserve. This differs from the Mineral Resource reports for Oyut and Hugo North reported in the 2016 Technical Report, which, for each deposit, included the entire resource without removing the Mineral Resources that had been converted to Mineral Reserves. The change is in keeping with good industry practice and provides clear delineation between resources and reserves.

The Mineral Resource estimates have been rounded to two significant figures. This results in differences to previously reported figures but is in line with industry best practice.

CuEq grades have been used to define the limits of the Mineral Resource for each of the deposits. The CuEq cut-off grade for each deposit is determined based on the estimated value recovered from the subsidiary metals (gold, silver and molybdenum[12]) relative to the estimated recovered value of the contained copper. The assumed metal prices used to estimate relative value in the 2019 CuEq formulae are 3.08 $/lb for copper, 1,292 $/oz for gold, 19.00 $/oz for silver, and 10.00 $/lb for molybdenum.

Mineral Resources are not Mineral Reserves until they have demonstrated economic viability based on a feasibility study or pre-feasibility study. The resource classifications of Measured, Indicated, and Inferred are Mineral Resource classification confidence categories defined by the CIM. Although they are recognized and required to be disclosed by NI 43-101, the SEC does not at present recognize the classifications under Guide 7. The SEC's S-K 1300 guide, due for full implementation in 2021, is aligned with the CRIRSCO standards of disclosure and recognizes the same Mineral Resource classifications. Disclosure of the terms in the Mineral Resource tables is permitted under NI 43-101; however, the SEC permits mineralization that does not constitute "reserves" by SEC standards to be reported only as tonnage and grade. In the Mineral Resource tabulations, the term Entrée LLC refers to ownership by the proposed joint venture arrangement between Oyu Tolgoi LLC and Entrée LLC.

[12] Note: At current prices and costs, revenue may not be expected from molybdenum in concentrate.

Table 14.1 Oyut Deposit – Open Pit Mineral Resources Summary, as of 31 December 2019

Classification	Ownership	Tonnage (Mt)	Cu (%)	Au (g/t)	Ag (g/t)	Contained Metal		
						Cu (Mt)	Au (Moz)	Ag (Moz)
Measured	Oyu Tolgoi LLC	16	0.39	0.41	1.2	0.1	0.2	0.6
Indicated	Oyu Tolgoi LLC	80	0.34	0.29	1.2	0.3	0.8	3.0
Total Measured + Indicated	Oyu Tolgoi LLC	95	0.35	0.31	1.2	0.3	1.0	3.6
Inferred	Oyu Tolgoi LLC	320	0.29	0.17	1.0	0.9	1.8	10

See notes for Table 14.6

Table 14.2 Oyut Deposit – Underground Mineral Resources Summary, as of 31 December 2019

Classification	Ownership	Tonnage (Mt)	Cu (%)	Au (g/t)	Ag (g/t)	Contained Metal		
						Cu (Mt)	Au (Moz)	Ag (Moz)
Measured	Oyu Tolgoi LLC	14	0.47	0.88	1.3	0.1	0.4	0.6
Indicated	Oyu Tolgoi LLC	69	0.38	0.59	1.1	0.3	1.3	2.5
Total Measured + Indicated	Oyu Tolgoi LLC	83	0.39	0.64	1.1	0.3	1.7	3.0
Inferred	Oyu Tolgoi LLC	180	0.39	0.40	1.2	0.7	2.2	6.8

See notes for Table 14.6

Table 14.3 Hugo North Deposit Underground Mineral Resources Summary, as of 31 December 2019 (updated 30 June 2020)

Classification	Ownership	Tonnage (Mt)	Cu (%)	Au (g/t)	Ag (g/t)	Contained Metal		
						Cu (Mt)	Au (Moz)	Ag (Moz)
Measured	Oyu Tolgoi LLC	58	1.9	0.48	4.2	1.1	0.9	7.8
	Entrée LLC	-	-	-	-	-	-	-
	All Hugo North	58	1.9	0.48	4.2	1.1	0.9	7.8
Indicated	Oyu Tolgoi LLC	401	1.3	0.34	3.1	5.4	4.4	41
	Entrée LLC	87	1.6	0.54	4.1	1.4	1.5	12
	All Hugo North	488	1.4	0.38	3.3	6.8	5.9	52
Measured + Indicated	Oyu Tolgoi LLC	459	1.4	0.36	3.3	6.5	5.3	48
	Entrée LLC	87	1.6	0.54	4.1	1.4	1.5	12
	All Hugo North	546	1.4	0.39	3.4	7.8	6.8	60
Inferred	Oyu Tolgoi LLC	765	0.8	0.28	2.4	6.1	6.9	59
	Entrée LLC	167	1.0	0.36	2.8	1.7	1.9	15
	All Hugo North	932	0.8	0.29	2.5	7.8	8.8	74

See notes for Table 14.6.

Table 14.4 Hugo South Deposit Underground Mineral Resources Summary, as of 31 December 2019

Classification	Ownership	Tonnage (Mt)	Cu (%)	Au (g/t)	Ag (g/t)	Contained Metal		
						Cu (Mt)	Au (Moz)	Ag (Moz)
Inferred	Oyu Tolgoi LLC	720	0.84	0.07	1.9	6.1	1.7	44

See notes for Table 14.6

Table 14.5 Heruga Deposit Underground Mineral Resources Summary, as of 31 December 2019

Classification	Ownership	Tonnage (Mt)	Cu (%)	Au (g/t)	Ag (g/t)	Mo (ppm)	Contained Metal			
							Cu (Mt)	Au (Moz)	Ag (Moz)	Mo (Mlbs)
Inferred	Oyu Tolgoi LLC	110	0.42	0.30	1.6	110	0.4	1.0	5.3	26
Inferred	Entrée LLC	1400	0.41	0.40	1.5	120	6.0	19	68	390
Inferred	All Heruga	1600	0.42	0.39	1.5	120	6.5	20	73	410

See notes for Table 14.6.

Table 14.6 Total Mineral Resources estimates for all Oyu Tolgoi Deposits, as of 31 December 2019 (updated 30 June 2020)

Classification	Tonnage (Mt)	Cu (%)	Au (g/t)	Ag (g/t)	Contained Metal		
					Cu (Mt)	Au (Moz)	Ag (Moz)
Measured	87	1.4	0.53	3.2	1.2	1.5	9.0
Indicated	640	1.2	0.39	2.8	7.3	8.0	58
Total Measured + Indicated	720	1.2	0.41	2.9	8.5	9.4	67
Inferred	3,700	0.6	0.29	1.8	22	34	210

Notes to the Mineral Resources:

1. CIM Definition Standards (2014) are used for reporting of Mineral Resources.
2. The Mineral Resources exclude Mineral Reserves.
3. The following CuEq formulae have been used for cut-off grade determination in each deposit.

   Oyut: CuEq = Cu + ((Au x 35.4938) + (Ag x 0.4101)) / 67.9023

   Hugo North: CuEq = Cu + ((Au x 35.7175) + (Ag x 0.5353)) / 67.9023

   Hugo South: CuEq = Cu + ((Au x 37.7785) + (Ag x 0.5773)) / 67.9023

   Heruga: CuEq = Cu + ((Au x 37.0952) + (Ag x 0.5810) + (Mo x 0.0161)) / 67.9023
4. The metal prices used in determining the CuEq formulae are:

   3.08 $/lb for copper, 1,292 $/oz for gold, 19.00 $/oz for silver, and 10.00 $/lb for molybdenum.
5. The metallurgical recoveries used in determining the CuEq formulae for each deposit are:

   Oyut deposit: Copper 78%, Gold 67%, Silver 52%.

   Hugo North deposit: Copper 93%, Gold 80%, Silver 81%.

   Hugo South deposit: Copper 89%, Gold 81%, Silver 84%

   Heruga: Copper 82%, Gold 73%, Silver 78%, Molybdenum 60%.
6. For the Oyut deposit, a cut-off grade of 0.24% CuEq has been used for Mineral Resources with open pit potential. A cut-off 0.41% CuEq has been used for Mineral Resources with underground mining potential.
7. For the Hugo North, Hugo South, and Heruga deposits a cut-off grade of 0.41% CuEq grade used based on the assumption that the deposits will be mined using underground mass mining methods.
8. The effective date of the Mineral Resources estimates is December 31, 2019 (updated on June 30, 2020). The Mineral Resources do not account for resources mined after the effective date.
9. Totals may not match due to rounding to two significant figures. This results in differences to previously reported figures but is in line with industry best practice.
10. The Shivee Tolgoi and Javkhlant licenses are held by Entrée LLC. The Shivee Tolgoi and Javkhlant Licenses are planned to be operated by Oyu Tolgoi LLC. Oyu Tolgoi LLC will receive 80% of cash flows after capital and operating costs for material originating below 560 m, and 70% above this depth. TRQ holds a 7.9% interest in Entrée LLC.
11. In the Mineral Resource tabulations, the term Entrée LLC refers to ownership by the proposed joint venture arrangement between Oyu Tolgoi LLC and Entrée LLC.12. Mineral Resources that are not Mineral Reserves do not have demonstrated economic viability.
13. The Oyut deposit was formerly known as Southern Oyu Tolgoi.
14. Molybdenum is excluded from the Total Resources in Table 14.6.
15. The contained copper, gold, silver, and molybdenum estimates in the tables have not been adjusted for metallurgical recoveries.

The metallurgical recovery estimates for the contained metals in each deposit are shown in Table 14.7. The estimates are based on metallurgical testwork, and, in the case of the Oyut deposit, actual concentrator performance.

Table 14.7 Mineral Resource metallurgical recoveries

Deposit	Anticipated metallurgical recovery			
	Cu	Au	Ag	Mo
Oyut	78%	67%	52%	-
Hugo North	93%	80%	81%	-
Hugo South	89%	81%	84%	-
Heruga	82%	73%	78%	60%

Gold and silver are expected to be recovered in all the deposits.

14.2 Factors that could affect the Mineral Resource estimates

Areas that could materially affect the Mineral Resource estimates include the following:

- Commodity pricing
- Interpretations of fault geometries
- Effect of alteration as a control on mineralization
- Lithological interpretations on a local scale, including dyke modelling and discrimination of different Qmd phases
- Pit slope angles
- Geotechnical assumptions related to the proposed block cave design and material behaviour
- Metal recovery assumptions
- Dilution considerations
- The estimate of Mineral Resources may be materially affected by environmental, permitting, legal, title, socio-political, marketing, or other relevant issues including risks set forth in the 2019 AIF and other filings made with Canadian securities regulatory authorities and available at www.sedar.com.

14.3 Database

The database is maintained in an acQuire database management system implemented in August 2010. Before 2010, data were stored in a Microsoft Access database referred to as Geological Oyu Tolgoi Database. For resource modelling, all data were exported from acQuire as comma delimited text files. The elements exported from acQuire are Ag, As, Au, C, Cu, Fe, F, Mo, and S. Ag, Au, Cu and Mo are considered elements with potential value, the remaining elements are modelled for the purposes of understanding penalty element distributions.

Additional values/indexes extracted are bulk density (SG), Ci, MBI, and SPI. Bulk density is modelled for estimating tonnage. The other indexes are geometallurgical, relating to processing, and are described in Section 13.4.

The dataset for the Oyut, Hugo South, Hugo North and Heruga contains 3,100 drillholes (as outlined in Section 10.1. Database close-off dates for the Mineral Resource estimates are summarized in Table 14.8).

Table 14.8 Database close-off dates

Deposit	Data Close-off Date
Oyut	23 February 2016
Hugo South	1 November 2003
Hugo North	14 February 2014
Heruga	21 June 2009

14.4 Resource estimation – Oyut

The following subsections describe the methodology for and results of the Mineral Resource estimates for the Oyut zones.

An updated optimized pit shell using the latest metal price assumptions was used for the open pit Mineral Resource statement. Underground mining shapes developed in 2011 have not been reassessed, however, reporting within these shapes has been updated to the latest copper equivalent cut-off.

14.4.1 Modelling

Domains developed using lithological, structural and geometallurgical information are used for all elements. These shapes were then edited on plan and section views to be consistent with the structural and lithological models and the drill assay data. Checks on the structural, lithological, and grade shell models indicated that the shapes honoured the drillhole data and interpreted geology. The geological shapes for Oyut are listed in Table 14.9 and Table 14.10. At Oyut, grade shells for copper and gold were not used for the final iteration of block grade estimation because the domaining, outlier restriction, and kriging estimation parameters proved adequate for ensuring that the requirement of stationarity was met.

Arsenic grade shells (Table 14.11) were defined, as the arsenic distributions are not well defined by the litho-structural domains. The arsenic 200 ppm grade shell domain (Figure 14.1) was used to restrict the arsenic estimation to mitigate smoothing of block grades in areas with mixed populations of high and low grade.

Density estimation domains are based on mineralized zones, the oxidation surface (above or below the lowest modelled limit of oxidation), and lithology and the metallurgical parameters estimation domains are based on mineralized zones, alteration zones, and rock types (lithology). Final estimation domain groupings were defined based on the statistical analysis of the box plots, histograms and probability plots.

The solids and surfaces were used to code the drillhole data. Sets of plans and cross-sections that displayed colour-coded drillholes were plotted and inspected to ensure the proper assignment of domains to drillholes.

Table 14.9 Oyut geological surfaces used in geological modelling

Model Component	Comment
Surfaces – General	
Topography	Project-wide
Base of Quaternary cover	Project-wide
Base of Cretaceous clays and gravels	Project-wide
Base of oxidation	Project-wide, but relevant only for Oyut deposit
Base of supergene alteration	Project-wide, but relevant only for Oyut deposit
Advanced argillic alteration zone	To constrain the altered sections of deposit, Oyut deposit
Phyllic alteration zone	To constrain the altered sections of deposit, Oyut deposit
Prophylitic alteration zone	To constrain the altered sections of deposit, Oyut deposit
Potassic alteration zone	To constrain the altered sections of deposit, Oyut deposit
Solids/Surfaces – Lithology	
Quartz monzodiorite (Qmd) solid	Hugo North, Hugo North Extension, Oyut deposits
Augite basalt (Va) D1	Oyut deposit
Ignimbrite (Ign) DA2	Oyut deposit
Base of ash flow tuff (DA2a - Ign)	Project-wide
Base of unmineralized volcanic and sedimentary units; DA2b or DA3 or DA4	Project-wide. Used as a hanging wall limit to grade interpolation
Hangingwall sequence (HWS), DA3, DA4, CS1–CS4	Oyut deposit zones
Biotite-granodiorite (BiGd) dykes	Project-wide, most important in Hugo deposits, unmineralized unit
Rhyolite (Rhy) dykes	Project-wide, most important in Oyut deposit zones, unmineralized unit
Hornblende–biotite, andesites, dacites (and) dykes; HbBiAnd, Dac	Oyut deposit zones

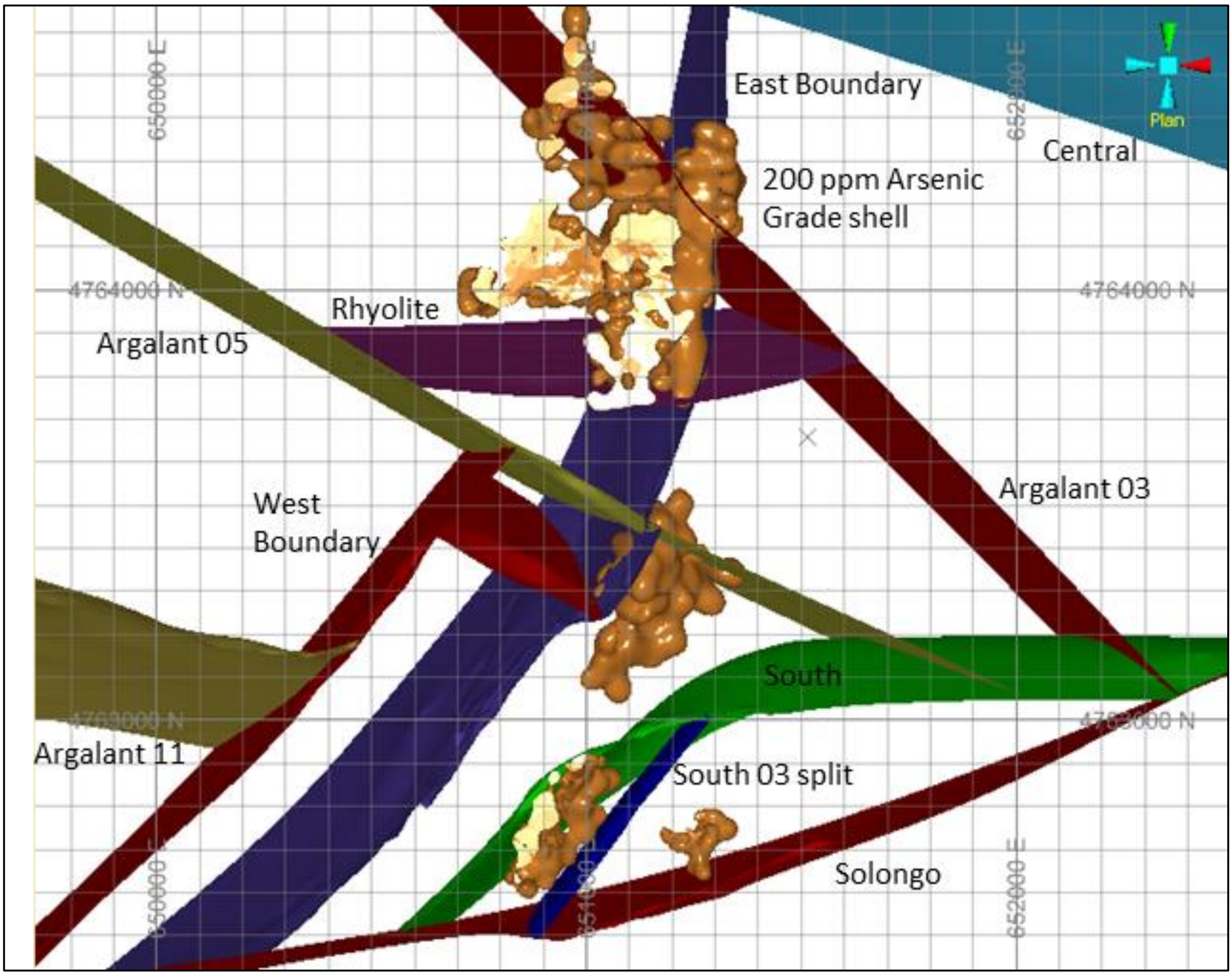
Table 14.10 Oyut fault surfaces used in geological modelling

Fault surfaces	Comment
East Bounding Fault	Oyut deposit area: forms eastern boundary to the Southwest zone and western boundary to the Wedge zone
West Bounding Fault	Oyut deposit area: forms informal western boundary to the Southwest zone (generally marks contact between unmineralized Qmd and mineralized Va)
Rhyolite Fault	Oyut deposit area: marks boundary between Southwest and Central zones, Hugo North
South Fault (includes South Splay 3)	Oyut deposit area: marks boundary between Wedge and South zones
Solongo Fault	Oyut deposit area: defines the southern edge of the South zone
AP and KJ fault series	Oyut deposit area: Internal faults in the area of estimated Mineral Resources

Table 14.11 Oyut grade shell construction parameters

Deposit	As (ppm)
Oyut	> 200

Figure 14.1 Oyut deposit faults and arsenic grade shell modelling



Source: Compiled by AMC from information provided by TRQ, Date: 30 June 2020. Projection UTM (WGS84) Z48N.

The statistical analyses comprised generation and review of histograms, probability plots, box plots, and tables of summary statistics. The data analyses were conducted on composited assay data. The coding applied to the block model is shown in Table 14.12 and is defined as:

- The first digit in the domain code relates to the deposit zone (see Section 8.1).
- The second digit is used for three purposes: in arsenic estimation to show inside or outside grade shell, for density to show above or below oxidation boundary, and for geometallurgical estimation to show alteration domain.
- The third digit in the code was originally intended to accommodate a greater number of lithology codes but remains unused.
- The fourth digit relates to the lithological unit.

Each variable was flagged from the triangulations described in modelling, with higher flagging priority being given to higher codes. Domain codes were checked by performing visual checks of triangulations versus resulting composite flags.

Table 14.12 Oyut deposit DOMAIN codes

1st digit		2nd digit		4th digit	
Type	**Code**	**Type**	**Code**	**Type**	**Code**
Unknown	0	As grade shell (GS_AS)	100	Va	1
Southwest (SW)	1000	Outside 200 ppm As grade shells	200	Ign	2
Central (CO)	2000	Within 200 ppm As grade shells	100	Qmd	3
Southern Oyu (SO)	3000	Oxidation (OX)	200	HWS	4
Far South (FS)	4000	Below oxidation boundary	100	BiGd	5
Bridge (BZ)	5000	Above oxidation boundary	200	Ands	6
Wedge (WZ)	6000	Alterations (ALT)	300	Rhy	7
Western (WO)	7000	Potassium alteration	400	Clay	8
South of Solongo fault	8000	Propylitic alteration	–	–	–
Secondary enrichment region	9000	Phyllic alteration	–	–	–
Hugo South zone	0	Advanced argillic alteration	–	–	–

The secondary enrichment region (first digit = 9) domain (previously known as supergene domain) was updated in the 2018 resource model based on a combination of spectral, metallurgical index, geological and mineralization logging.

14.4.2 Compositing

The drillhole assays were composited into fixed-length, down-hole composites at a size that was considered appropriate when considering estimation block size, required lithological resolution, and probable mining method. This compositing honoured the domain zones by breaking the composites on the domain boundary. The domains used in compositing were a combination of the grade shells and lithological domains. Composite lengths of 8 m (approximately half the 15 m selective mining unit (SMU) size) were used for the Oyut deposits.

The following default values were applied to any gaps in the intervals of the assay table during compositing:

- Cu - 0.005%
- Au- 0.005 g/t
- Ag- 0.5 g/t
- As - 25 ppm
- Mo - 2.5 ppm

Intervals of less than 8 m represent individual residual composites from end-of-hole or end-of-domain intervals. Composites with lengths of less than 2 m were excluded from the dataset used in interpolation.

A post-processing step was applied to adjust negative or null composite values arising from non-assayed intervals. Intervals might not be assayed or logged for a variety of reasons:

- Lack of visible mineralization (not logged).
- Parent portion of a wedged daughter hole (not logged).
- "Navi" drill interval (not logged).
- Portion of a new drillhole for which assays are pending (below detection limit).

A separate composite file was created for each of estimated grade elements of Cu, Au, Ag, Mo, F, S, Fe, As, SG, and metallurgical parameters. Composites were not broken at intersections of the drillhole with the interpreted lithologies, dykes or overburden triangulations. Short-length composites <2 m at the ends of the drill-holes were ignored for block grade estimation.

14.4.3 Statistics

14.4.3.1 Basic statistics

The summary statistics for composites occurring within the exploratory data analysis (EDA) envelope, below the Cretaceous clay surface, and whose values have not been set to -99 are provided in Table 14.13.

Table 14.13 Oyut 8 m composite statistics inside EDA envelope and below clay

Parameter	Composite numbers	Minimum	Maximum	Mean	CV
Cu	44386	0.00	15.90	0.29	1.33
Au	36389	0.00	32.14	0.24	2.34
Ag	22466	0.005	110.50	1.19	1.63
As	22839	0.100	8050.00	89.95	2.25
F	14493	10.000	12550.00	1618.39	0.56
Fe	14508	0.005	22.88	5.78	0.39
Mo	26727	0.025	2222.50	48.33	1.42
S	14508	0.005	21.21	3.03	1.04
C	21240	0.010	4.24	0.32	1.28
SG	24780	1.480	4.23	2.75	0.06
SPI	530	12.000	307.00	121.78	0.51
MB	516	7.900	24.00	18.15	0.19

The geometallurgical variables SPI and MB are described in Section 14.3.

14.4.3.2 Contact grade profile analysis

Contact plots are used to illustrate the change in average grades within a chosen interval at increasing distances from a defined contact such as a structural boundary or a lithological contact. The change in average grades across and away from the contact can assist in understanding the nature of that boundary and, in doing so, inform the appropriateness of using a soft, firm, or hard boundary during grade estimation.

A strategy of soft, firm, and hard boundaries has been used to account for domain boundary uncertainty (dilution) and to reproduce the input grade sample distribution in the block model. Soft boundaries allowed full sharing of composites between domains during grade estimation; firm boundaries allowed sharing of composites from within a certain distance of the boundary and hard boundaries allowed no composite sharing between domains. Comparative basic statistics, such as mean grade, was carried out for each set of adjoining domains to establish the boundary as soft, firm, or hard. Contact plots and visual inspection of grade distributions were also used in cases where results were unclear or were contrary to geologic expectation.

The selection of each boundary as soft, firm, or hard was based on multiple criteria, including the influences of lithology, deposit, grade shell domains, and the element being considered. These relationships are complex enough that a “soft boundary domain matrix” was generated for each element.

14.4.3.3 Restriction of extreme grade values

Histograms and probability plots were inspected for all estimated grade elements to identify outliers and to devise capping strategies to control risk due to outliers.

A first range of the variograms was applied for the sample search distance during the estimation for the main lithological units Va, Ign, Qmd, and HWS. A 30 m by 30 m by 25 m isotropic outlier sample search distance was used during estimation for dykes. This approach was used for Cu only.

The first pass search distance was used for the rest of estimated grade variables. Density and the metallurgical variables were not capped. Capping was applied during the estimates using the "upper grade cut value" function in Vulcan. The thresholds for Oyut outlier search restriction and capping are shown in Table 14.14.

Table 14.14 Oyut outlier restrictions/top-cut threshold (Cu, Au, Ag)

Domain	Top-cut/ thresh-hold	Outlier restr/ threshold (ppm)	No. capped data	Top-cut/ thresh-hold	Outlier restr/ threshold (ppm)	No. capped data	Top-cut/ thresh-hold	Outlier restr/ threshold (ppm)	No. capped data
	Copper (%)			Gold (ppm)			Silver(ppm)		
1001	–	–	–	8.0	–	–	–	10	–
1003	–	1.80	–	3.0	–	–	5.0	–	–
1004	0.04	–	–	–	–	–	–	–	–
3001	–	2.30	–	1.1	–	–	8.0	–	–
3002	0.90	–	–	0.2	–	–	2.0	–	–
3003	2.00	–	–	1.1	–	–	13.0	–	–
3004	0.16	–	–	–	–	–	1.5	–	–
4001	–	1.00	–	1.3	–	–	–	6.0	–
4003	–	0.65	–	1.0	–	–	–	3.0	–
5001	–	1.10	–	0.3	–	–	3.0	–	–
5002	–	1.35	–	–	0.5	–	3.0	–	–
5003	–	1.45	–	0.4	–	–	4.0	–	–
5004	–	0.25	–	–	–	–	–	0.6	–
6001	–	–	–	–	1.0	–	3.0	–	–
6002	–	1.60	–	–	0.3	–	6.0	–	–
6003	–	–	–	0.7	–	–	10.0	–	–
6004	–	–	–	–	–	–	0.5	–	–
7001	0.68	–	–	1.1	–	–	10.0	–	–
7003	–	0.50	–	–	0.8	–	–	10.0	–
Bigd	–	0.65	–	–	0.4	–	2.3	–	–
And	–	1.10	–	–	0.7	–	2.9	–	–
Rhy	–	0.95	–	–	1.5	–	4.0	–	–

Note: Domains 2001,2002,2003,2004,7004,9001,9002,9003 had no data restrictions.

14.4.4 Variography

Semi-variograms were calculated and modelled for all grade elements plus SG in Supervisor software. The variograms were modelled with either exponential models, spherical models, or a combination of exponential and spherical models. Two structures were typically used to model the variograms with a few exceptions where a single structure or, rarely, three structures were used. The orientations of multiple structures were typically "locked" in the same direction to aid visualization and for checking against geologic reasonableness. Practical ranges were used, where a "practical range" is the range at which 95% of the sill is reached, which is three times longer than the "traditional range" used in some software. The nugget values were generally determined from down-hole variograms. Directional variograms were typically calculated in at least 30-degree increments both horizontally and vertically.

A variety of strategies was applied where it was not possible to calculate robust variograms. These strategies included:

- Recalculating variograms using larger lags.

- Combining data from adjacent domains of reasonably similar properties. In some cases data were pooled to achieve reasonably robust variograms even where a hard or firm estimation boundary was likely to be used.
- Adopting the variogram model from a well-informed domain that was considered to have similar properties.
- Using the correlograms instead of variograms.
- Transforming variograms to normal scores (normal data distribution) before variogram calculation to improve the experimental variogram. The variograms and models were back-transformed to real space before being used for block grade estimation.

Variograms were not calculated for the dykes.

The variogram parameters for copper and gold are shown in Table 14.15 and Table 14.16, respectively. The model parameters adhere to the Vulcan rotation conventions.

Table 14.15 Oyut copper variogram model parameters by domain

Domain	Nugget	Structure	Type	Sill	Major range (m)	Semi-major range (m)	Minor range (m)	Rotation angle alpha (degrees)	Rotation angle zeta (degrees)	Rotation angle beta (degrees)
SW	0.11	1	EXP	0.54	89	43	108	19	2	30
	0.11	2	SPH	0.35	315	191	127	19	2	30
CO	0.10	1	SPH	0.39	114	67	63	52	24	–106
	0.10	2	SPH	0.51	220	138	117	52	24	–106
SO	0.16	1	SPH	0.55	89	115	89	110	–44	–104
	0.16	2	EXP	0.29	515	229	361	110	–44	–104
FS	0.16	1	EXP	0.33	73	54	113	32	58	–90
	0.16	2	SPH	0.51	365	196	158	32	58	–90
BZ	0.19	1	SPH	0.49	104	110	65	200	52	20
	0.19	2	EXP	0.32	295	380	176	200	52	20
WZ	0.11	1	EXP	0.21	101	15	96	23	21	–41
	0.11	2	SPH	0.68	364	268	152	23	21	–41
WO	0.07	1	SPH	0.57	189	44	100	325	76	–45
	0.07	2	EXP	0.36	424	314	312	325	76	–45
Supergene	0.23	1	SPH	0.37	73	58	38	130	2	155
	0.23	2	SPH	0.40	119	107	52	130	2	155

Note: SW = Southwest, CO = Central, SO = South, FS = Far South, BZ = Bridge Zone, WZ = Wedge, WO = West

Table 14.16 Oyut gold variogram model parameters by domain

Domain	Nugget	Structure	Type	Sill	Major range (m)	Semi-major range (m)	Minor range (m)	Rotation angle alpha (degrees)	Rotation angle zeta (degrees)	Rotation angle beta (degrees)
SW	0.14	1	EXP	0.28	80	70	100	79	54	−149
	0.14	2	SPH	0.24	155	240	290	79	54	−149
	0.14	3	SPH	0.34	680	350	315	79	54	−149
CO	0.18	1	EXP	0.35	45	25	85	40	−4	−15
	0.18	2	EXP	0.35	240	105	160	40	−4	−15
	0.18	3	SPH	0.12	430	300	270	40	−4	−15
SO	0.24	1	EXP	0.48	117	34	170	1	69	−44
	0.24	2	SPH	0.28	347	446	293	1	69	−44
FS	0.20	1	EXP	0.48	39	93	190	300	60	0
	0.20	2	SPH	0.32	258	535	244	300	60	0
BZ	0.19	1	EXP	0.46	33	115	253	122	57	−156
	0.19	2	SPH	0.36	203	413	511	122	57	−156
WZ	0.20	1	SPH	0.19	127	250	90	50	3	−15
	0.20	2	SPH	0.61	365	296	313	50	3	−15
WO	0.50	1	EXP	0.35	45	45	5	40	−60	90
	0.50	2	EXP	0.15	381	240	120	40	−60	90

Note: SW = Southwest, CO = Central, SO = South, FS = Far South, BZ = Bridge Zone, WZ = Wedge, WO = West

14.4.5 Estimation

14.4.5.1 Model setup

The resource model block sizes are consistent with those defined for earlier estimates. The block model for resource reporting and mine planning is a regular block model with block dimensions of 20 m by 20 m by 15 m. This block size was selected with consideration given to the expected mining selectivity in the open pit. The resource block model was created by reblocking (regularizing) the sub-blocked grade estimation model.

The sub-blocked model used for resource estimation has parent (maximum) block dimensions equal to those of the resource block model (20 m by 20 m by 15 m) and child (minimum sub-block) block dimensions to as small as 5 m by 5 m by 5 m. The actual sub-block sizes vary as necessary to fit the specified boundaries of the wireframes used to tag the block model. Grade variables were regularized to the tonnage-weighted (volume x density) mean of the like-domained sub-cell source grade values enclosed in the parent blocks. The minimum sub-block size was selected to provide reasonable geological resolution while maintaining a workable number of blocks for computer processing. The block model limits and dimensions are provided in Table 14.17.

Table 14.17 Oyut block model limits

Block model limits	X	Y	Z
Origin (UTM)	649200	4761600	−30
Offset (m)	3300	3800	1230
Block size (m)	20	20	15
Parent block count	165	190	82

The resource block model contains variables for the metal grade estimates, zones and lithology identifiers, density, resource classification, and metallurgy parameters. The block models were tagged by wireframes of lithology and grade shells, zones, and wireframe surfaces of topography and the stratigraphic horizons. The wireframes were assigned a priority to ensure that the blocks were tagged in the correct order in the case of overlaps.

Following grade estimation, the sub-blocked model was reblocked (regularized) in Vulcan to a single block size of 20 m by 20 m by 15 m for resource reporting and mine planning. The re-blocked resource block model was not tagged by wireframes. The domain and grade variables were derived by regularizing blocks of the sub-blocked estimation block model. The lithology and domain variables were regularized using majority rules. The grade variables were regularized to the tonnage-weighted (volume multiplied by density) mean of the sub-block source grade values enclosed in the destination parent blocks.

14.4.5.2 Grade estimation

The grade estimation was performed using ordinary kriging (OK) of grade composites into a sub-blocked Vulcan block model. The block model was tagged from wireframe models of deposits, grade shells, and lithologies which form a variety of soft, firm, and hard domain boundaries during estimation.

The SG of the Oyut major lithologies, dykes, and overburden was estimated using simple kriging (SK). The metallurgical parameters (SPI and MB) were estimated using the OK and SK estimators in two passes. The stationary means for the SK runs were developed from the mean composite grades for each estimation domain.

Component domain codes were merged into the ultimate DOMAIN code variable. Search ellipsoid orientations for the grade elements were based on the variogram models which typically reflect the geological settings of the mineralized zones.

A three-pass kriging strategy was used to estimate the block grades. Grade estimations were run one domain at a time. The first and second estimation pass kriging neighbourhood approximately corresponds to blocks expected to satisfy Measured and Indicated classification criteria. The kriging neighbourhood was expanded and relaxed with each successive pass while maintaining the same axial ratios for samples searches as in the first pass. The second pass was executed on blocks that did not receive an interpolated grade in the first pass, and the third pass was executed on blocks that did not receive an interpolated grade in the first and second passes.

A block discretization of 4 by 4 by 2 was used when estimating block grades. Capping of composites or a high-grade restriction was applied during the estimation depending on the element, domain, and clustering characteristics (Table 14.14). If the highest grades were clustered, a high-grade restriction was used to reduce the impact. If the highest grades were not clustered a capping value was applied to reduce the coefficient of variation. The capping was applied using the upper grade cut value function in Vulcan.

For all elements, for the first and second block estimation passes, a minimum of six composites and maximum of nine composites were required, as well as a maximum of three composites per drillhole. For the third pass, a minimum of two composites and a maximum of eight composites were required, as well as a maximum of five used composites per drillhole. A single estimation pass was used to estimate dyke blocks, requiring a minimum of three composites, a maximum of eight composites, and a maximum of five composites per drillhole.

SG variable and metallurgical parameters were estimated by two passes. For the SG variable, the first and second block estimation passes, a minimum of five composites and maximum of eight composites were required, as well as a maximum of three composites per drillhole. For the metallurgical parameters, a minimum of one composite and maximum of five composites were required for the first and second block estimation passes. No restriction was used to limit the number of composites per drillhole due to the limited number of test works that have been used. No capping has been applied.

During the estimation of the sub-blocked model, the estimated grade of the parent cells is assigned to each sub cell. Grade composites flagged as less than zero grades were excluded from sample selection. Grade composites less than 2 m in length were also excluded. The composites were length-weighted during estimation. Composites were weighted by OK according to variogram parameters (Table 14.15), with the exception of dyke grades, which were estimated using inverse distance weighting at a power of two (ID2).

Estimated block grades in blocks coded as air, Cretaceous clay, or Quaternary cover were set to zero.

The blocks in the supergene zone were estimated with OK as a separate domain distinct from the other structural domains. No distinction or domaining was used for grade estimation for blocks above and below the limit of oxidation.

14.4.6 Validation of estimation

Extensive visual and statistical checks were performed comparing composites to blocks, as well as the behaviour of grade estimates near firm estimation boundaries. A nearest neighbour (NN) interpolated model was created to produce the declustered composite distributions. The NN model was used to check for global bias of the block grade estimates above zero cut-off with the local bias checked using swath plots. A support correction using a range of cut-offs was used to assess the risk of bias in the estimate. Contact plots generated from the block grade estimates were compared with the contact plots from the composites to ensure that the relationship across the boundary was preserved. Summary statistics, histograms, probability plots, and box plots were generated from uncapped and capped estimates and NN estimates.

A verification of the Vulcan kriging engine was completed by replicating the Cu block grade estimate for a single block using the proprietary AMEC Foster Wheeler single block Kriger tool.

The comparison of the effects of outlier restriction considered blocks with a preliminary confidence classification of Measured and Indicated in the sub-blocked model, prior to re-blocking and classification smoothing. This process is expected to provide an approximate amount of predicted metal removed by outlier restriction. The predicted metal removed for each element by capping, excluding blocks above the oxide surface and within Measured and Indicated classes, is Au 3.0%, Ag 5.0%, As 7%, C 1.7%, Cu 0.8%, F 0.6%, Fe 0.1% and S 1.1%. The higher metal removal for arsenic is an expression of the lower threshold used when assessing probability plots for top-cutting.

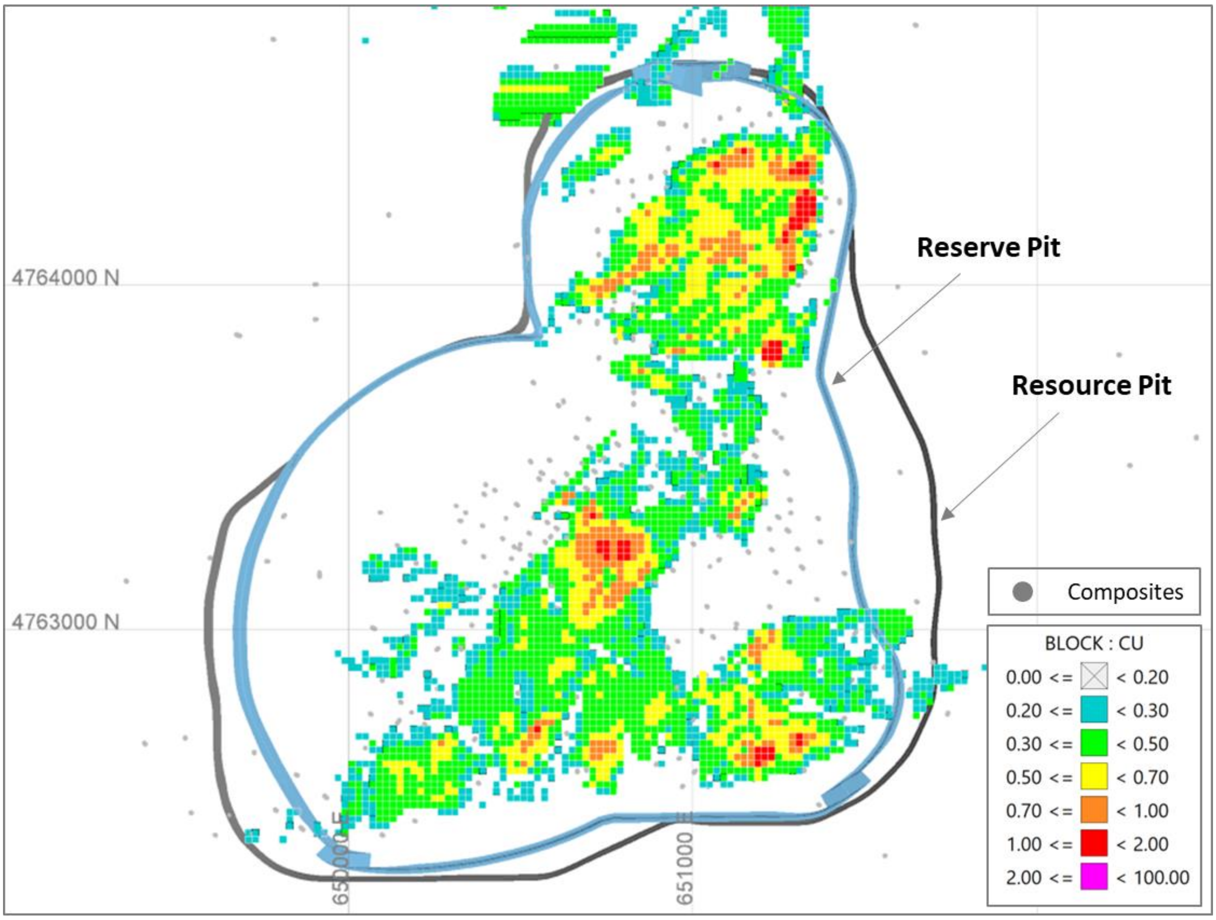
14.4.6.1 Visual inspection of estimates

A visual comparison was made of block grades against composites in plan and in north south and east west section views. The following is a partial list of items assessed:

- Local correlation between composites and block grades to identify basic problems in domaining and estimation.
- Presence of mosaic vs diffusion grade distribution within the composites of a given domain (e.g. sharp versus gradual grade transitions) and reflection within the block estimate.
- Behaviour at firm boundaries to assess smoothing and the projection of high grades across grade shell boundaries and lithologic boundaries.
- Control of grade projection from outliers in areas of sparser drilling.
- Local inconsistencies in composite grades to identify problems with the drill database or compositing.

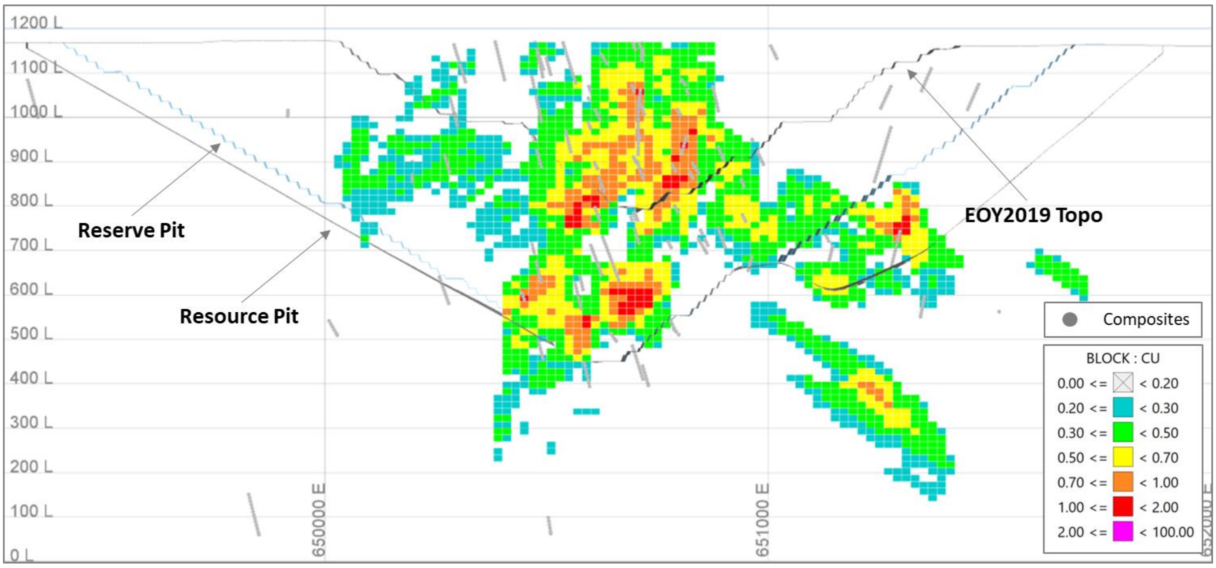
Examples of a plan and a vertical cross-section through the Cu grade model with composites within most up-to-date pit shells and 2019 end-of-year topography are shown in Figure 14.2 and Figure 14.3.

Figure 14.2 Oyut plan view through Cu block grade model and Cu composites at 997.5 RL



Source: Compiled by AMC from information provided by TRQ, Date: 30 June 2020. Projection UTM (WGS84) Z48N.

Figure 14.3 Oyut section view through Cu block grade model and Cu composites at 4763150 N



Source: Compiled by AMC from information provided by TRQ, Date: 30 June 2020. Cross section

14.4.6.2 Nearest neighbour model and global bias check

Two sets of nearest neighbour models were generated for model validation and classification:

- Uncapped NN models[13] for each of the nine grade elements, SG, and metallurgical variables. The uncapped NN block models represent the declustered grade distributions which are the target grade distributions for subsequent validation checks (see following sections). The NN model used a uniform (regular) block cell with dimensions of 10 m by 10 m by 7.5 m.
- A capped NN model for copper in to 20 m by 20 m by 15 m blocks. This additional interpolation run was used to capture the closest distance to samples for use in the calculation of the preliminary classification.

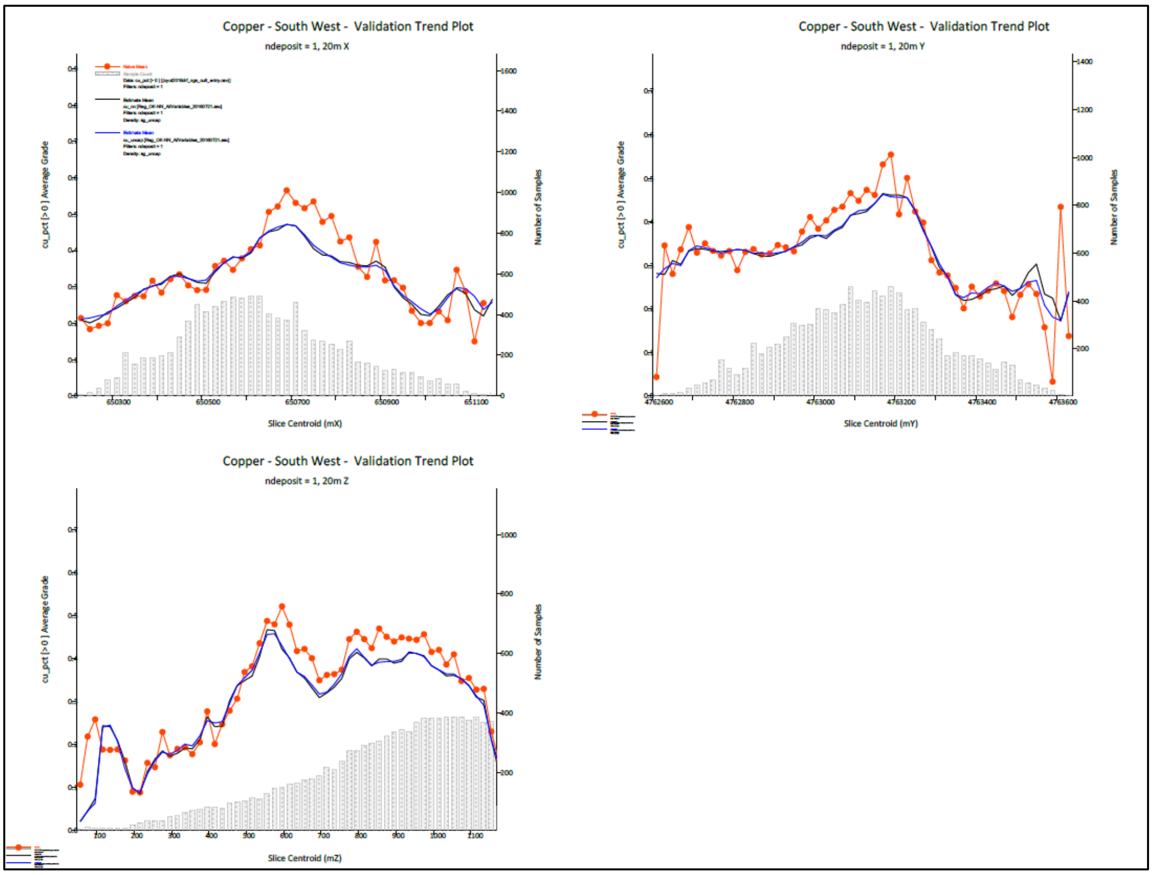
The OK and NN grade estimates for all grade elements and SG were compared to evaluate the OK estimates for global bias. The NN interpolation provides a reliable estimate of the declustered mean. Grade comparison charts for the OK and the NN interpolated models were prepared for each estimation domain for the analysis. The estimated mean grade differences between the OK and the NN models, in general, are within ±5% with few exceptions that occur in areas where there are limited numbers of samples available or where the mean grades are very low. The exceptions, which observed generally in hanging wall sediment domains, are considered to be immaterial and the overall global bias to be acceptable.

14.4.6.3 Local bias check

Grade profiles from the OK and NN models and grade composites for all grade elements were charted in the three principal directions (swath plots) to assist in validating the kriged estimates. The mean grades from the kriged and NN models were calculated within 50 m distance bins in the east-west and north-south directions and within 30 m in elevation bins. Examples of swath plots are shown in Figure 14.4. No significant local biases were found in the analysis. Small differences observed in mean grades between OK and NN estimates are immaterial.

[13] Outlier-restricted NN models are regarded as inappropriate for validation purposes because outlier restriction can often remove a different amount of metal from an OK model than from a NN model.

Figure 14.4 Swath plot for copper for SW domain



Source: Compiled by AMC from information provided by TRQ, Date: 30 June 2020

14.4.6.4 Change of support smoothing

Selectivity checks were conducted to assess the smoothing in the OK Cu block grade estimates. Two types of checks were performed. The first type was a global smoothing check which seeks to predict the selectivity in the block model relative to a SMU for an entire domain. A second selectivity analysis was completed using the discrete Gaussian model for change of support from composite size to an SMU size. This was done by a Hermitian correction (HERCO) method using Amec Foster Wheeler's in-house software.

The selectivity analyses were undertaken for the Southwest Oyu, Central Oyu, and South Oyu deposits as economically important representatives of the range of mineralization styles in the Oyut area. The deposit extents are effectively the block model domains. Only the mineralized rock types VA, IGN, QMD, and dykes were considered; HWS was excluded. The analyses were limited to Measured and Indicated blocks which are reasonably well-informed during block grade estimation. The variance reduction factors were calculated for each deposit in a single block Kriger tool using the same variogram models used for block grade estimation. The declustered grade composite distribution was generated from the NN block distribution (as discussed in Section 14.4.6.2).

Prediction of global smoothing

The predicted global smoothing in the OK Cu uncapped block grade estimate was checked using two methods of change of support analyses:

- Comparison of the OK Cu block grade estimate CV with a target CV
- Comparison of the OK Cu block grade estimate CV with the implicit SMU CV

Predictions of global smoothing at the resource block scale

The global smoothing comparisons were restricted to Measured and Indicated blocks at zero uncapped Cu grade cut-off. The target CVs for the SMUs were calculated using the following formula:

$$CV_{smu} = CV_{comp} \times \sqrt{BDV}$$

Where:

- CVsmu = coefficient of variation of the SMU
- CVcomp = coefficient of variation of the declustered 8 m grade composites
- BDV = block dispersion variance of the SMU

The BDV was calculated for Cu using 4 by 4 by 2 block discretisation of a 20 m by 20 m by 15 m SMU block size—that is, the resource block size. The results of this check are provided in Table 14.18.

Table 14.18 Global smoothing check for Cu for the resource block SMU

Domain	SMU block	OK model		NN model		SMU	Target	Variance reduction
	(m)	Mean	CV	Mean	CV	BDV	CV	(%)
Southwest	20 by 20 by 15	0.36	0.64	0.36	0.87	0.64	0.70	-8%
Central	20 by 20 by 15	0.39	0.79	0.39	1.05	0.66	0.85	-7%
Southwest	20 by 20 by 15	0.34	0.66	0.34	1.05	0.66	0.85	-22%

Negative change indicates the OK model is smoother than the target.

The analysis of the results indicates the following of the uncapped Cu OK block grade estimate:

- The model is somewhat smooth for the Southwest Oyu domain
- The model is only slightly smooth for the Central Oyu domain
- The model for the South domain is over-smooth

14.4.6.5 Validation of non-grade variables

The bulk density and metallurgical fields Ci, MBi and SPi were assessed using summary statistics by domain. No outliers or restrictions were placed on these estimates.

14.4.7 Resource definition

14.4.7.1 Open-pit Mineral Resource

In 2019, Oyu Tolgoi LLC developed a pit design (the Mineral Reserve Pit) to support declaration of open-pit Mineral Reserves using a copper price of 3.08 US$/lb, gold price of 1,292 US$/oz, and silver price of 19.0 US$/oz. The pit was optimized and designed using Measured and Indicated blocks only.

To confine the Mineral Resource estimate, a pit shell was optimized using the same metal prices and based on all Mineral Resources (Measured, Indicated and Inferred). This Mineral Resource pit shell) is a larger than the Mineral Reserve Pit and is used to report the Mineral Resources.

The Mineral Reserve pit contains Inferred Resources that are ignored in the estimation of Mineral Reserves. Given their location within the reserve pit, these blocks will be accessible to mining and, provided they are above cut-off, have reasonable prospects of future economic extraction, and thus can be stated as Mineral Resources.

Mineral Resources are reported exclusive of the Mineral Reserve so the Mineral Reserve Pit outline has been used to clip the Measured, Indicated and Inferred resources that are reported, with the exception of the Inferred material within the pit as discussed above.

Mining depletion has also been accounted for by using the 2019 year-end mining surface to constrain Inferred material reported within the Mineral Reserve Pit.

14.4.7.2 Underground Mineral Resources

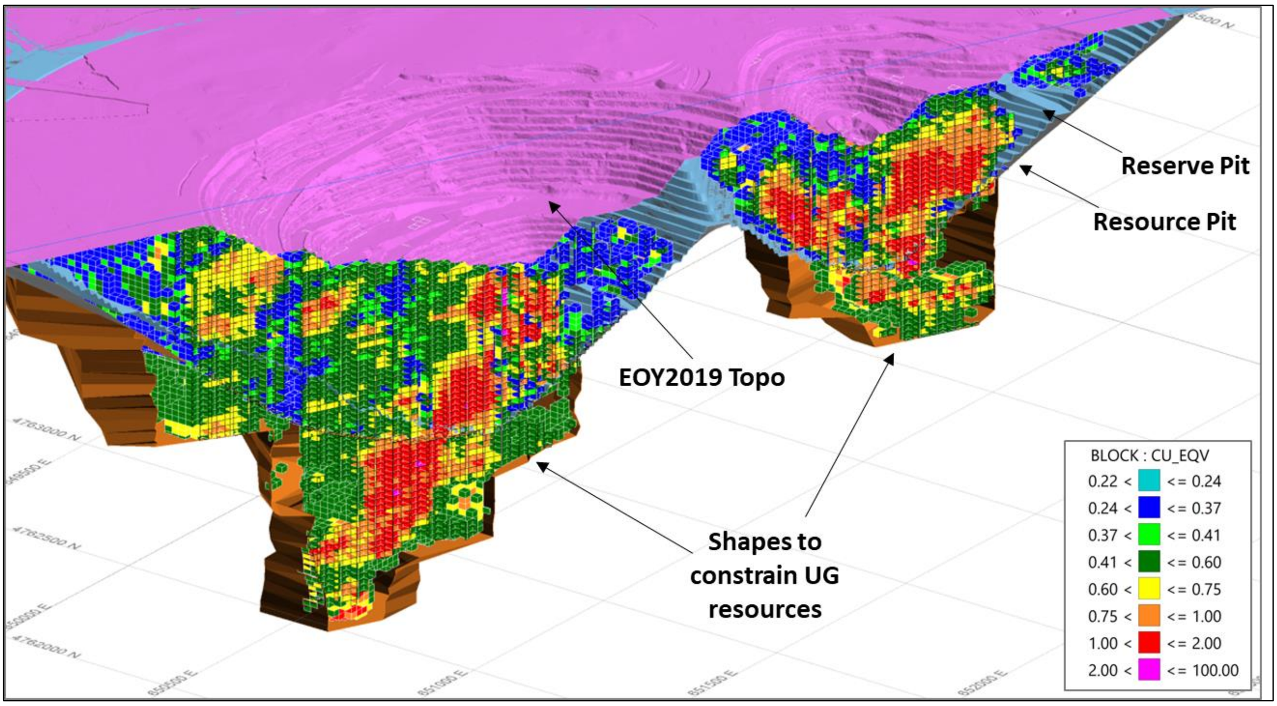
The Oyut deposit has four target areas for underground mining beneath the Mineral Resource pit. These are located within 3 km of the Hugo North underground mine and associated infrastructure.

Delineation of underground mining shapes for the Oyut deposits are based on a CuEq cut-off of 0.41% to cover a conceptual cost of 12.05 US$/t for mining and 8.37 US$/t for processing and G&A costs. No updates to the underground mining shapes were made from previous resource updates in 2011.

These mining shapes and the cost assumptions used to generate them were not updated in this study because the infrastructure built for Hugo North Lift #1, and perhaps in future for Hugo South, could provide synergies for lower capital intensity underground development at Oyut.

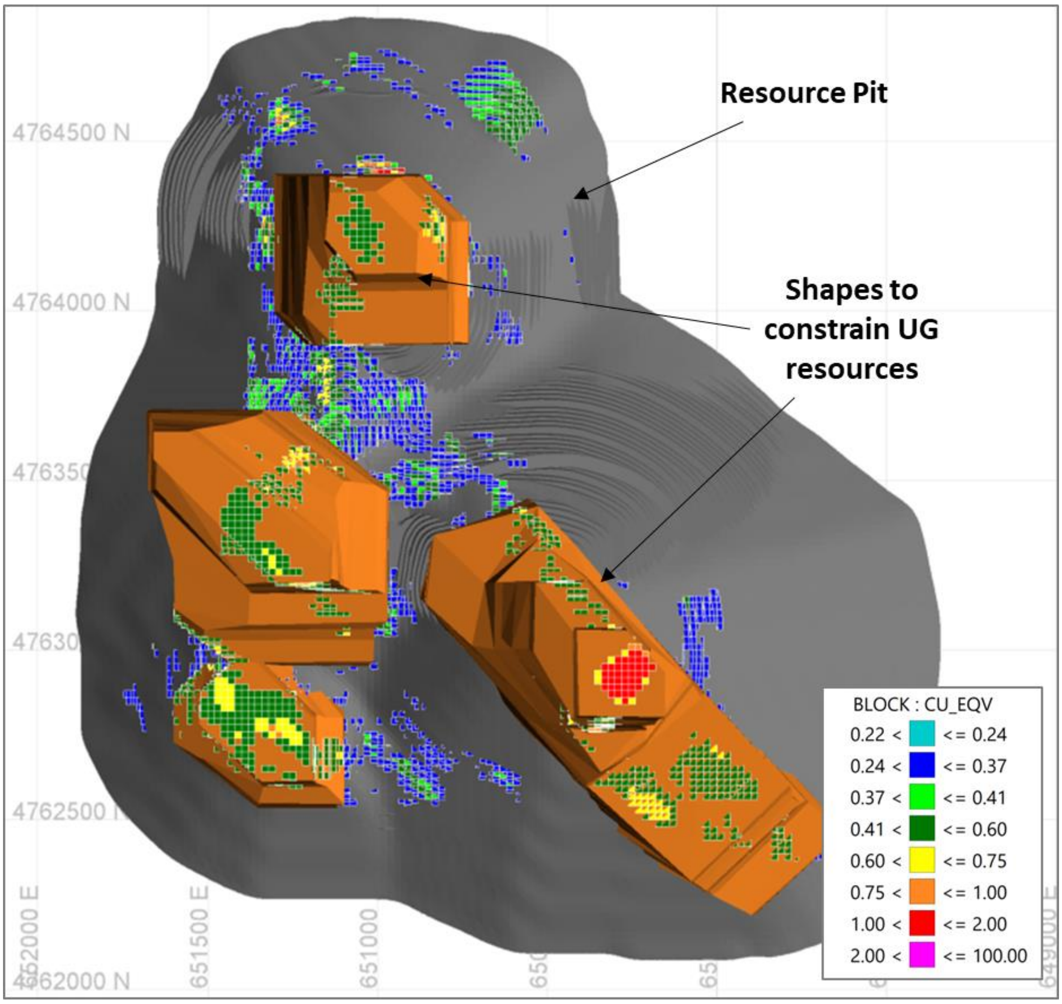
Using the MII pit shell and the underground constraining shapes, resources were stated for those blocks within the constraining underground mining shapes that met a marginal cut-off grade of 0.41% CuEq. Figure 14.5 and Figure 14.6 show the open-pit and underground constraints from different angles.

Figure 14.5 Oyut perspective view of block model CuEq grade looking north-west



Source: Compiled by AMC from information provided by TRQ, Date: 30 June 2020. Projection UTM (WGS84) Z48N.

Figure 14.6 Oyut underground deposits (Central Oyu, South Oyu, Southwest Oyu and Wedge Zone) viewed looking up



Source: Compiled by AMC from information provided by TRQ, Date: 30 June 2020. Projection UTM (WGS84) Z48N.

14.4.7.3 Use of copper equivalents

The 2019 copper equivalent formula incorporates copper, gold and silver prices and recoveries. Copper equivalence assumptions and calculation are shown in Table 14.19 and Table 14.20. Copper, gold and silver recoveries used in the copper equivalent formula are deposit averages within the updated MII pit shell.

Table 14.19 Oyut – CuEq assumptions

Variable	Cu (US$/lb)	Au (US$/oz)	Ag (US$/oz)
Metal prices	3.08	1292.00	19.00
Recovery	0.78	0.67	0.52
Recovery relative to Cu	1.00	0.85	0.67
Conversion	22.0462	0.0321507	0.0321507

Table 14.20 Oyut – CuEq calculation

	Cu (%)	Au (g/t)	Ag (g/t)	CuEq (%)	Revenue (US$/t)
% Cu	1.00	–	–	1.00	$67.90
g/t Au	–	1.00	–	0.52	$35.49
g/t Ag	–	–	1.00	0.01	$0.41
Total	1.00	1.00	1.00	1.53	$103.81

From Table 14.19 and Table 14.20, the base formula is calculated by:

$$\mathrm{CuEq} = \mathrm{Cu} + ((\mathrm{Au} \times 1292 \times 0.03215 \times 0.854) + (\mathrm{Ag} \times 19.00 \times 0.03215 \times 0.671)) / (3.08 \times 22.0462)$$

$$= \mathrm{Cu} + ((\mathrm{Au} \times 35.4938) + (\mathrm{Ag} \times 0.4101)) / 67.9023$$

14.4.7.4 Derivation of cut-off grades

The cut-off grade for open-pit Mineral Resources was revised compared to the 2016 statement using updated ore type definitions and associated recovery responses, and updated processing and operational cost basis to reflect long term estimates. Based on these updates, a marginal cut-off grade of 0.24% CuEq, which includes provision for processing and G&A costs, was used to tabulate open-pit Mineral Resources. An estimated marginal copper equivalent cut-off of 0.24% CuEq is a direct conversion of NSR to CuEq. Material is assessed at the pit rim to determine if it is economic to send to the mill (i.e. above the marginal cut-off grade) rather than to the waste dump. That is, the material is considered "ore" if its value is greater than the cost of processing it.

Cut-off grades for Oyut underground Mineral Resources were determined using assumptions defined for Hugo North underground mine. The NSR per tonne of ore needs to equal or exceed the production cost of a tonne of ore for the mine to break even or make money.

For the underground mine, the break-even cut-off grade needs to cover the costs of mining, processing, and G&A. An NSR of 17.59 US$/t would be required to cover costs of 7.03 US$/t for mining, 7.64 US$/t for processing, and 2.92 US$/t for G&A. The CuEq break-even underground cut-off grade of approximately 0.41% CuEq has been used for Oyut ore. This cut-off grade has been used for tabulating underground Mineral Resources in this report.

14.4.8 Classification

The confidence categories that were applied to the entire Oyut block model are in accordance with the 2014 CIM Definition Standards for Mineral Resources and Mineral Reserves.

The block classification confidence is based on the copper grade variable. A single-pass NN estimation of Cu composites was used to capture distance from block centroid to the nearest composite. A classification category was assigned to each estimated block using the classification criteria summarized in Table 14.21.

The Oyut deposit's geological and grade continuity support mineral confidence classifications of Measured, Indicated, and Inferred Mineral Resources.

Table 14.21 Oyut Mineral Resource initial classification parameters

Initial classification	Deposit	Minimum number of drillholes	Minimum number of composites	Composite spacing (m)	Closest composite (m)
Measured	All deposits	3	3	50	30
Indicated	Southwest Oyu	2	2	75	55
Indicated	Other deposits	2	2	65	45
Inferred	All deposits	1	1	150	

The block model has been classified into three categories: Measured, Indicated and Inferred.

14.4.8.1 Measured

A three-hole rule was used to classify blocks as Measured. This requires that to be classified as Measured, there must be at least three composites from three different holes within 50 m of the block centroid and at least one of these composites must be within 35 m of the block centroid.

14.4.8.2 Indicated

For blocks that do not meet the Measured classification criterion above, a two-hole rule was used to classify blocks as Indicated. This requires that, with the exception of the Southwest Oyu deposit, to be classified as Indicated, there must be at least two composites from two different holes within 65 m of the block centroid and at least one of these composites must be within 45 m of the block centroid. For the Southwest Oyu deposit there must be at least two composites from two different holes within 75 m of the block centroid and at least one of these composites must be within 55 m of the block centroid.

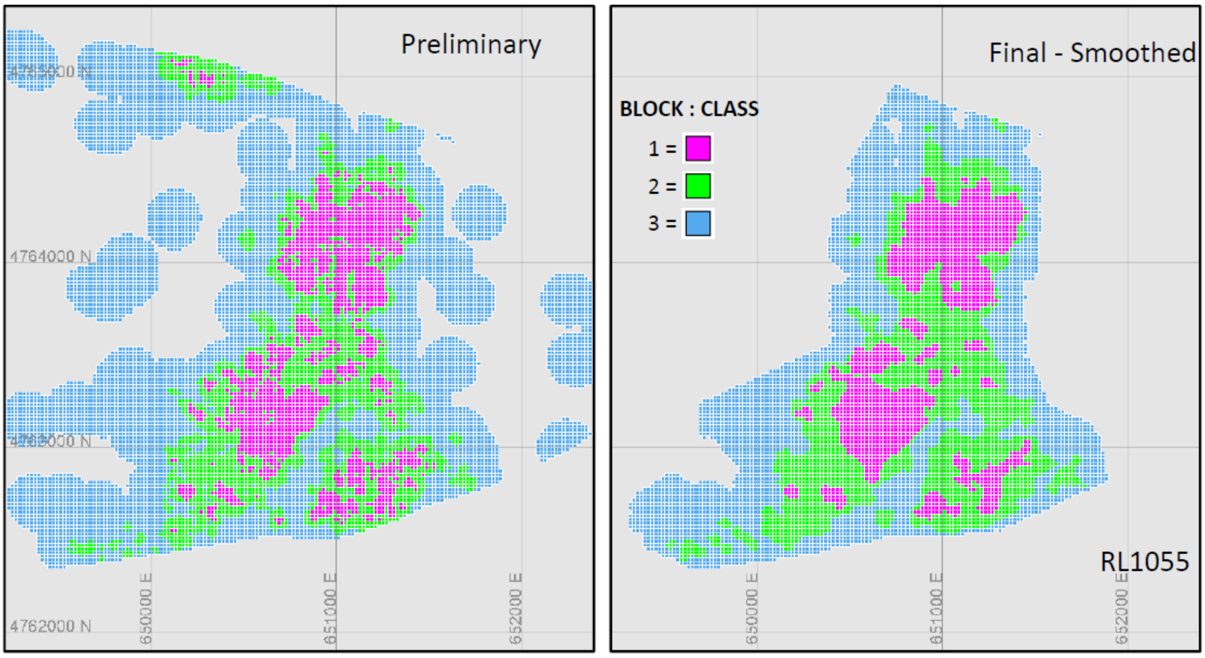
14.4.8.3 Inferred

For blocks that do not meet the Measured or Indicated classification criteria above, a one-hole rule was used to classify blocks as Inferred. This requires that there must be at least one composite within 150 m of the block centroid.

14.4.8.4 Classification smoothing

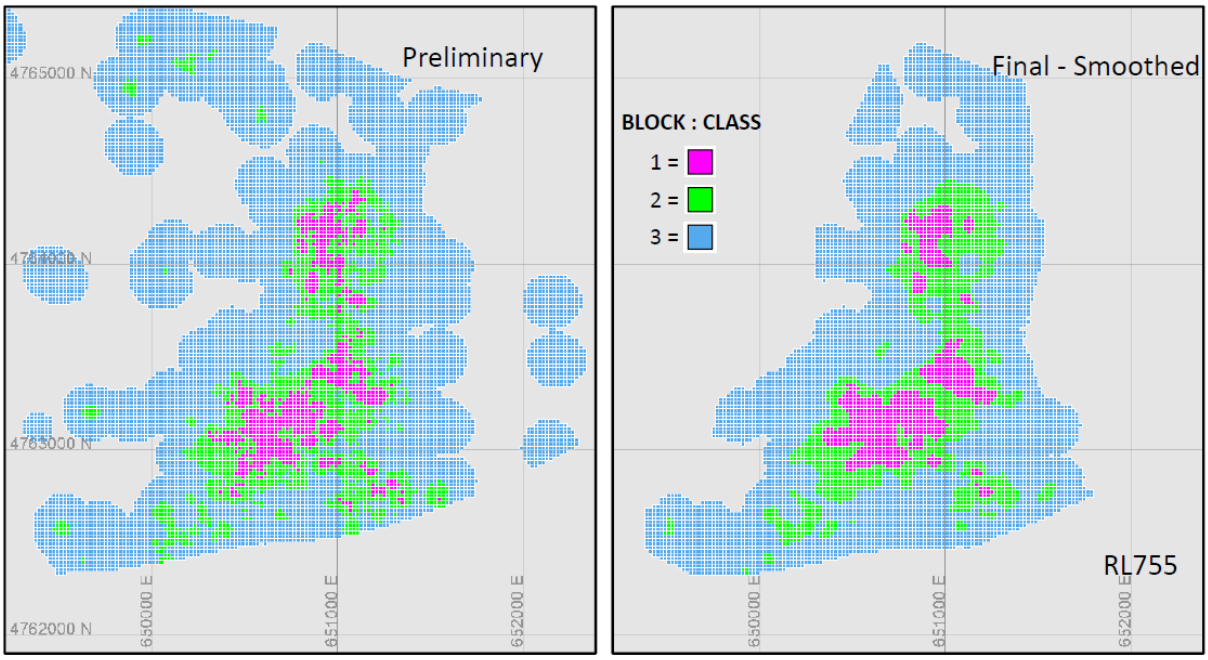
The first pass resource classification based on the rules defined for each category typically resulted in regions where a spotty pattern of a few isolated higher confidence blocks are surrounded by lower confidence blocks and vice versa. Consequently, a manual smoothing step followed where the copper composite database was back-tagged by the first-pass block model classification and imported into Leapfrog Implicit modelling software. The grade-shelling algorithm was used to create wireframes of the classes. If a small volume of a particular class was created inside another class it was switched to the surrounding class. Review of vertical section and bench classification maps from the results have been completed through the Oyut area. Plan view of the bench maps of the initial classification model and the corresponding smoothed classification model are shown in Figure 14.7 and Figure 14.8.

Figure 14.7 Oyut comparison of the initial and final smoothed Mineral Resource classification maps at 1055 RL (plan)



Source: Compiled by AMC from information provided by TRQ, Date: 30 June 2020. Projection UTM (WGS84) Z48N.

Figure 14.8 Oyut comparison of the initial and final smoothed Mineral Resource classification maps at 755 RL (plan)



Source: Compiled by AMC from information provided by TRQ, Date: 30 June 2020. Projection UTM (WGS84) Z48N.

14.4.9 Reasonable prospects of eventual economic extraction

CIM Definition Standards require reported Mineral Resources to have reasonable prospects for eventual economic extraction. The following addresses this requirement for the Oyut mineral resources.

The Oyut deposits is currently mined by open-pit methods and may possibly be mined by underground methods in the future. The open-pit resources are Measured, Indicated and Inferred (MII) Mineral Resources within a MII optimised pit above a 0.24% CuEq cut-off. Mining depletion has been accounted for by using the 2019 year-end mining surface to constrain reporting. The underground resources include Measured, Indicated and Inferred material within stope mining shapes at a cut-off of 0.41% CuEq. The parameters and modifying factors used to derive the underground cut-off is discussed in Sections 14.4.7.4 and 14.5.9.

Mine planning has been conducted on the Measured and Indicated subset of the declared Mineral Resources for Oyu Tolgoi from which combined cave schedules for known resources (Hugo North Lift 2, Hugo South, Heruga) can be prepared. These mine plans are collectively known as the life-of-mine (LOM) case and form the basis of business valuations and future resource planning.

14.5 Resource estimation – Hugo North

The following subsections describe the methodology for and results of the Mineral Resource estimates for the Hugo North deposit.

The new mine design for Panel 0 of Hugo North Lift 1 described in Section 16 reduces the Mineral Reserve estimate for the Hugo North underground mine due to the inclusion of two 120 m pillars, to the north and south of Panel 0. Studies are in progress to assess the recoverability of these pillars and pending on-going work in 2021, the material contained in the pillars has been converted from Mineral Reserves to Mineral Resources.

The updated Hugo North Measured and Indicated Mineral Resources contains 14% higher tonnage, 27% more copper metal, and 23% more gold metal than was reported in the 2019 AIF. The increases result mainly from returning the mineral reserves in the pillars to mineral resources. Other minor increases result from optimizing the cave shapes used to prepare the updated Hugo North Mineral Reserve.

14.5.1 Modelling

The geological shapes for the deposits are listed in Table 14.22 and Table 14.23 for each deposit. Appropriate gold, copper, molybdenum and arsenic shells at various cut-off grades (Table 14.24) were also defined. These shapes were then edited on plan and section views to be consistent with the structural and lithological models and the drill assay data. Checks on the structural, lithological, and grade shell models indicated that the shapes honoured the drillhole data and interpreted geology.

The lithological shapes and faults, together with copper and gold grade shells and deposit zones, constrain the grade analysis and interpolation. Typically, the faults form the first order of hard boundaries constraining the lithological interpretation. Previous modelling of quartz veining was removed for the 2014 resource estimate.

The solids and surfaces were used to code the drillhole data. Sets of plans and cross-sections that displayed colour-coded drillholes were plotted and inspected to ensure the proper assignment of domains to drillholes.

Table 14.22 Hugo North geological surfaces used in geological modelling

Model Component	Comment
Surfaces – General	
Topography	Project-wide
Base of Quaternary cover	Project-wide
Base of Cretaceous clays and gravels	Project-wide
Base of oxidation	Project-wide, but relevant only for Oyut
Base of supergene alteration	Project-wide, but relevant only for Oyut
Solids/Surfaces – Lithology	
Quartz monzodiorite (Qmd) solid	Hugo North, Oyut
Augite basalt (Va) D1 solid	Hugo North
Ignimbrite (Ign) DA2 solid	Hugo North
Hangingwall sequence DA3, solid	Hugo North
Base of ash flow tuff (DA2a - Ign)	Project-wide
Base of unmineralized volcanic and sedimentary units; DA2b or DA3 or DA4	Project-wide. Used as a hanging wall limit to grade interpolation
Biotite-granodiorite (BiGd) dykes	Project-wide, most important in Hugo deposits, unmineralized unit
Biotite-granodiorite (BiGd) dykes solid	Hugo North, unmineralized unit
Rhyolite (Rhy) dykes	Project-wide, most important in Oyut zones, unmineralized unit
Rhyolite (Rhy) dykes, solid	Hugo North, unmineralized unit
Hornblende–biotite granodiorite, solid	Hugo North, unmineralized unit

Table 14.23 Hugo North fault surfaces used in geological modelling

Fault surfaces	Comment
East Bat Fault	Hugo area: used to define Hugo North eastern limit
West Bat Fault	Hugo area: used to define Hugo North, Central and West zones western limits
Contact Fault	Hugo North: defines post volcanic sequence, subparallel to lithological contacts
7100 Fault	Hugo North, north-west trending fault
Lower and Intermediate Faults	Hugo North, north trending faults subparallel to lithological contacts
Bogd Fault	Hugo North, east–west fault in Hugo Northern area
Khar Suult Fault	Hugo North, east–west fault in Southern area
Kharaa and Eroo Faults	Hugo North, north-east trend fault in Northern area
Bumbat and Dugant Faults	Hugo North
Burged, Noyon, Gobi, Javkhlant Faults	Hugo North, north-west trending series of faults
160 Fault	Hugo North, north trending fault
110 Fault	Hugo area: forms boundary between Hugo South and Hugo North deposits
North Boundary Fault	Hugo North area: used to define north-western limit

Table 14.24 Hugo North grade shell construction parameters

Deposit	Grade shell			
	Au (ppm)	Cu (%)	Mo (ppm)	As (ppm)
Hugo North	>0.3, >1.0	>0.6, >2.0	–	> 200

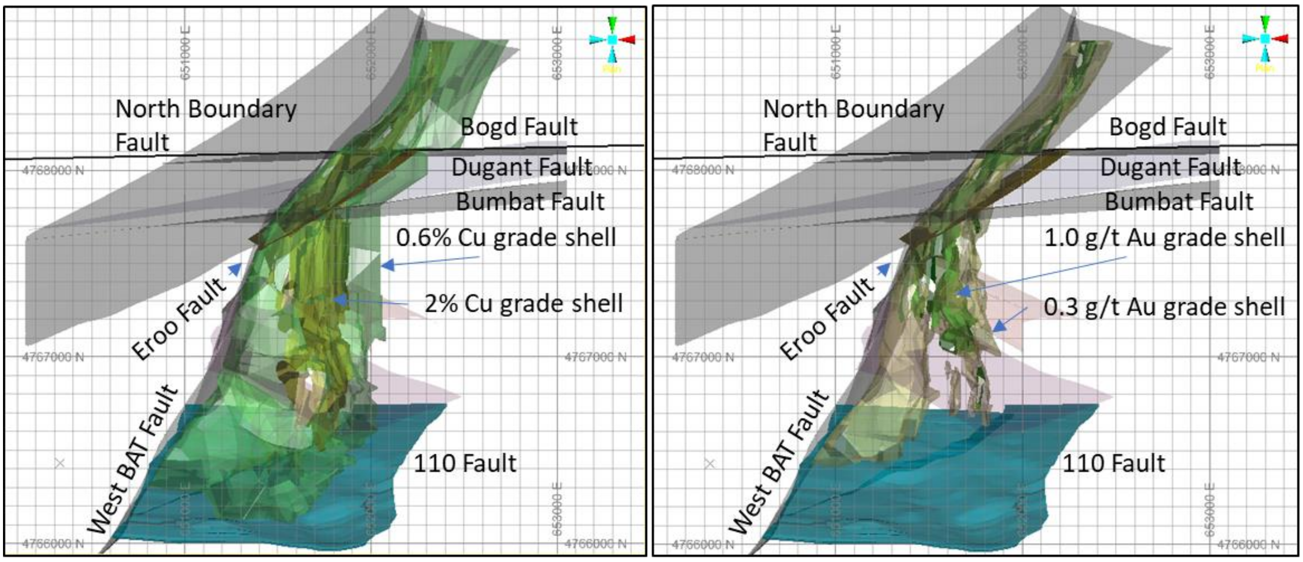
The resource estimation is applied to the Hugo North by using grade shell domains as shown in Table 14.25. The grade domain shells are generated with appropriate lithological and grade shell constraints (Figure 14.9).

Table 14.25 Hugo North domain codes

1st code	Code	2nd code	Code	3rd code	
Description		Description		Description	Code
Outside grade shell (basic)	100	–	–	VA	1
Inside Au 0.3 ppm grade shell	200	–	–	IGN	2
Inside Cu 0.6% grade shell	200	–	–	QMD	3
Inside As 200 ppm grade shell	200	–	–	HWS	4
Inside Au 1 ppm grade shell	300	–	–	BiGD	5
Inside Cu 2% grade shell	300	–	–	HBBIGD	6
–	–	–	–	RHY	7
–	–	–	–	CretClay	8
–	–	–	–	Qco	9
–	–	–	–	BAD	10

VA = augite basalt, IGN = ignimbrite, QMD = quartz monzodiorite, HWS = hanging wall sequence, HBBiGd = hornblende biotite granodiorite, BiGD = biotite granodiorite, And = andesite, Rhy = rhyolite, CretClay = Cretaceous clay BAD = basaltic dyke, Qco = quaternary cover

Figure 14.9 Hugo North grade shell modelling and faults of (left: copper, right: gold)



Source: Compiled by AMC from information provided by TRQ, Date: 30 June 2020. Projection UTM (WGS84) Z48N.

14.5.2 Compositing

The drillhole assays were composited into fixed-length, down-hole composites at a size that was considered appropriate when considering estimation block size, required lithological resolution, and probable mining method. The domains used in compositing were a combination of the grade shells and lithological domains. Composite lengths of 5 m lengths were used for Hugo North.

Intervals of less than 5 m lengths represented individual residual composites from end-of-hole or end-of-domain intervals. Composites that were less than 1.25 m long were excluded from the dataset used in interpolation.

A post-processing step was applied to adjust negative or null composite values arising from non-assayed intervals. The intervals were not assayed due to:

- A lack of visible mineralization
- Not logged intervals, such as the “parent” portion of a wedged daughter hole
- “Navi” drill interval
- The portion of a new drillhole for which assays are pending were replaced by lower detection limit for the valuable grade elements such as Cu, Au, and Ag

The lower detection limits were also assigned to the intervals of non-logged that were not sampled due to a lack of visible mineralization for the deleterious elements.

At Hugo North, the composites included any post-mineralization dyke intervals that were deemed too small to be part of a dyke geology model. Any unsampled material included in the composites for Hugo North was set to:

- Cu 0.001%
- Au 0.05 g/t

14.5.3 Statistics

14.5.3.1 Basic statistics

The lithological, structural, and mineralized domains were reviewed for the Hugo North zone to determine appropriate estimation or grade interpolation parameters. Several different procedures were applied to the data to discover whether statistically distinct domains could be defined using the available geological objects.

The data analyses were conducted on composited assay data, typically using 5 m down hole composites. Descriptive statistics (Table 14.26), histograms and cumulative probability plots, box and contact plots, and X–Y scatter plots were completed for copper and gold in each deposit area.

Results obtained were used to guide the construction of the block model and the development of estimation plans.

Copper grades in the mineralized units (Va, Ign, Qmd, and xBiGd) show single lognormal to near normal distributions inside each domain (0.6% and 2% Cu shells). Coefficients of variation values are low at 0.3 to 0.6. There are small variations in grade as a result of lithological differences within the copper domains: generally, Qmd and Va have the highest values, followed by ignimbrite. Xenolithic biotite granodiorite (xBiGd) has the lowest grades of all lithologies. The cumulative distribution function patterns of copper data for all domains show evidence for three populations: a higher-grade population (above a copper threshold value of 2.0% Cu to 2.5% Cu), a lower-grade zone (threshold value of 0.4% Cu to 0.5% Cu), and a background lowest-grade domain.

Gold grade distributions at Hugo North show typical positively skewed trends. The distributions are slightly more skewed than those for copper, but the level of skewness can still be described as only mild to moderate within each domain. The Qmd shows higher average gold values than the Va unit, which in turn is higher than the ignimbrite. Coefficients of variation values for the host lithologies are moderate, varying from 0.6 to 0.9. The cumulative distribution function pattern of gold data of all domains and the background domain shows evidence for three populations: a higher-grade population (above a gold threshold value of 1 g/t Au), a lower-grade zone (threshold value of 0.2 g/t Au to 0.3 g/t Au), and a background lowest-grade domain. The pattern supports the construction of the 1 g/t Au and 0.3 g/t Au grade shells.

Generally, two Cu-Au trends are observed. The more common is a low gold trend that outlines a gold-to-copper ratio of about 1:10 in the mineralized volcanic units. The Qmd unit also displays the 1:10 gold-to-copper ratio trend but also shows a more gold-enriched gold-to-copper ratio at about 1:2.

Table 14.26 Hugo North basic statistics of 5 m composites inside EDA domain

Parameter	Composite numbers	Minimum	Maximum	Mean	CV
Cu%	23,424	0.001	10.99	1.39	0.97
Au (ppm)	23,417	0.001	27.82	0.35	1.96
Ag (ppm)	23,313	0.005	278	3.23	1.22
As (ppm)	23,313	0.1	7,364	95.19	3.09
F (ppm)	13,484	10	18,950	2,144.97	0.79
Fe (%)	17,080	0.005	21.4	4.10	0.52
Mo (ppm)	23,300	0.025	2,477.12	34.56	1.37
S (%)	17,093	0.005	25.7	2.01	0.90
SG (g/cm3)	19,438	1.75	4.37	2.76	0.03

14.5.3.2 Contact grade profile analysis

A strategy of soft, firm, and hard boundaries was utilized to account for domain boundary uncertainty (dilution) and to reproduce the input grade sample distribution in the block model. Soft boundaries allowed full sharing of composites between domains during grade estimation; firm boundaries allowed sharing of composites from within a certain distance of the boundary; and hard boundaries allowed no composite sharing between domains. Comparative basic statistics, such as mean grade, was carried out for each set of adjoining domains to establish the boundary as soft, firm, or hard. Contact plots and visual inspection of grade distributions were also used in cases where results were unclear or were contrary to geological interpretations.

Different boundary designations of soft, firm, or hard can be used for the different lithologies, depending on the grade shell. The intra-domain contact boundaries are summarized in the matrix in Table 14.27 for copper and in Table 14.28 for gold.

Table 14.27 Hugo North intra-domain boundary contacts – copper

Lith	Dom code	Va			Ign			Qmd			HWS			BiGd		
		101	201	301	102	202	302	103	203	303	104	204	304	105	205	305
Va	101	S	H	H	F	H	H	H	H	H	F	H	H	H	H	H
	201	H	S	F	F	F	H	H	F	F	H	F	H	H	H	H
	301	H	F	S	H	F	F	H	H	F	H	H	H	H	H	H
Ign	102	F	F	H	S	F	H	F	H	H	F	H	H	F	H	H
	202	H	F	F	F	S	H	H	F	H	H	F	H	F	H	H
	302	H	H	F	H	H	S	H	H	H	H	H	H	H	H	H
Qmd	103	H	H	H	F	H	H	S	H	H	F	H	H	F	H	H
	203	H	F	H	H	F	H	F	S	F	F	F	H	F	H	H
	303	H	F	F	H	H	H	H	F	S	H	H	H	F	H	H
HWS	104	F	H	H	F	H	H	F	H	H	S	H	H	S	H	H
	204	H	F	H	H	F	H	H	F	H	H	S	H	H	H	H
	304	H	H	H	H	H	H	H	H	H	H	H	S	H	H	H
BiGd	105	H	F	H	F	F	H	F	F	F	S	F	H	S	H	H

Note: S is Soft, F is Firm and H is Hard

Table 14.28 Hugo North intra-domain boundary contacts – gold

Lith	Dom code	Va			Ign			Qmd			HWS			BiGd		
		101	201	301	102	202	302	103	203	303	104	204	304	105	205	305
Va	101	F	S	F	H	F	H	F	F	H	H	H	H	F	H	H
	201	F	H	H	S	H	H	F	H	H	S	H	H	S	H	H
	301	H	F	S	H	H	H	H	F	F	H	H	H	H	H	H
Ign	102	H	F	H	H	S	H	H	F	H	H	H	H	H	H	H
	202	H	H	H	H	H	S	H	H	S	H	H	H	H	H	H
	302	H	F	H	F	H	H	S	H	F	F	H	H	H	H	H
Qmd	103	H	F	F	H	H	H	H	S	F	F	F	H	H	H	H
	203	H	H	F	H	H	H	F	F	S	H	H	H	F	H	H
	303	H	H	H	H	H	H	H	F	H	H	S	H	H	H	H
HWS	104	H	H	H	H	H	H	H	H	H	H	H	S	H	H	H
	204	H	F	H	S	H	H	F	F	H	S	H	H	S	H	H
	304	H	H	H	H	H	H	H	H	H	H	H	H	H	S	H
BiGd	105	H	H	H	H	H	H	H	H	H	H	H	H	H	H	S

Note: S is Soft, F is Firm and H is Hard

14.5.3.3 Restriction of extreme grade values

A combination of outlier restriction or grade capping was applied during grade estimation for the Hugo North area. In most cases, an outlier restriction of 50 m was used to control the effects of high-grade samples within the domains, particularly in the background domains where unrestricted high-grade composites tended to result in over-representation of high-grade estimates owing to the disproportional numbers of high-grade to lower grade composites. In outlier-restricted kriging, outliers (i.e. values above the specified cut-off) are restricted to the specified threshold value if their distance to the interpolated block is greater than 50 m. If the distance to the interpolated block is less than 50 m outliers are used at their full value. The outlier thresholds applied at Hugo North were defined at the 99th percentile of their respective population. The grade capping applied to the estimation is shown in Table 14.29. The outlier restrictions used for the various grade domains are shown in Table 14.30.

Table 14.29 Hugo North grade caps applied to Cu, Au and Ag grade domains

Grade Domain	Cu (%)	Au (g/t)	Ag (g/t)
101	1.0	1.2	2.5
102	–	0.4	8
103	1.5	2.0	–
104	–	–	–
105	–	2.0	10.5
21+202+203+204	5.5	2.5	17
205	–	no cap	–
301+303	9.5	3.5	–
302	3.5	no cap	–
304	–	–	–
305	–	6.0	2.5

Table 14.30 Hugo North outlier restrictions applied to Cu, Au and Ag grade domains

Grade Domain	Cu (%)	Au (g/t)	Ag (g/t)
101	–	–	–
102	2.5	–	–
103	–	–	10.5
104	–	–	1.5
105	3.0	–	–
21+202+203+204	–	–	–
205	–	–	–
301+303	–	–	21
302	–	–	–
304	–	–	–
305	–	–	–

14.5.4 Variography

Semi-variograms were calculated and modelled for all grade elements and density in Supervisor software. The correlograms were modelled with spherical models. Two structures were typically used to model the correlograms. The orientations of multiple structures were typically "locked" in the same direction to aid visualization and for checking against geologic reasonableness. Practical ranges were used, where a "practical range" is the range at which 95% of the sill is reached, which is three times longer than the "traditional range" used in some software. The nugget values were generally determined from down-hole correlograms. Directional correlograms were typically calculated in at least 30-degree increments both horizontally and vertically.

The nugget variance tended to be low to moderate in all of the estimation domains. Copper variograms generally had nugget effects of between 15% and 20% (relative) of the total variation except in BiGd where the nugget is 38% of total variation. The nugget variance for gold variograms varied from 5% to 25%.

Data in some shells were subdivided into north and south sectors for the variographic analysis to take into account the flexure in direction of the deposit that occurs near the 4,767,600 m N coordinate.

The deposit displayed mineralization controls that were considered to be related to the intrusive history and structural geology (faults). The patterns of anisotropy demonstrated by the various correlograms tended to be consistent with geological interpretations, particularly to any bounding structural features (faults and lithological contacts) and quartz + sulphide vein orientation data.

Both copper and gold displayed short ranges for the first structure and moderate- to-long ranges for the second structure (where modelled).

The model parameters for all copper and gold domains are shown in Table 14.31 and Table 14.32.

Table 14.31 Hugo North copper correlogram model parameters

Domain	Rock Type	Zone Code	Nugget	Struct	Type	Sill	Major range (m)	Semi-major range (m)	Minor range (m)	Bearing (Z)	Plunge (Y)	Dip (X)
Outside 0.6% Cu grade shell	Va, Ign, Qmd	1,2	0.1	1	SPH	0.40	118	123	87	45	–15	–90
				2	SPH	0.50	675	382	99	45	–15	–90
		3,4,5, 6,7	0.17	1	SPH	0.39	88	16	69	270	60	0
				2	SPH	0.44	507	539	110	270	60	0
Inside 0.6% Cu grade shell and outside 1% Cu grade shell	Va, Ign, Qmd, HWS	1,2	0.06	1	SPH	0.40	47	104	20	5.854	56.7	–61.8
				2	SPH	0.54	224	356	40	5.854	56.7	–61.8
		3,4,5, 6, 7	0.11	1	SPH	0.59	175	140	103	181.1	25.6	56.3
				2	SPH	0.30	654	192	104	181.1	25.6	56.3
Inside 1% Cu grade shell	Va, Ign, Qmd	1,2	0.06	1	SPH	0.40	47	104	20	5.854	56.7	–61.8
				2	SPH	0.54	224	356	40	5.854	56.7	–61.8
		3,4,5, 6, 7	0.11	1	SPH	0.59	175	140	103	181.1	25.6	56.3
				2	SPH	0.30	654	192	104	181.1	25.6	56.3

Table 14.32 Hugo North gold correlogram model parameters

Domain	Rock Type	Zone Code	Nugget	Struct	Type	Sill	Major range (m)	Semi-major range (m)	Minor range (m)	Bear-ing (Z)	Plunge (Y)	Dip (X)
BiGd Au high-grade domain	BiGd	1,2,3, 4, 5,6,7	0.08	1	SPH	0.10	94	90	164	345	0	−65
				2	SPH	0.82	319	214	205	345	0	−65
BiGd Au outside grade shell	BiGd	1,2,3, 4, 5,6,7	0.38	1	SPH	0.19	42	25	12	356.3	−19.6	79.3
				2	SPH	0.43	133	129	58	356.	−19.6	79.3
Outside 0.3 g/t Au grade shell	Va, Ign, Qmd	1	0.23	1	SPH	0.32	179	174	98	45	−75	−90
				2	SPH	0.45	619	442	139	45	−75	−90
		2,3	0.23	1	SPH	0.36	150	125	200	355.7	−10.5	−44.0
				2	SPH	0.41	762	300	300	355.7	−10.5	−44.0
Inside 0.3 g/t Au grade shell and outside 1 g/t Au grade shell	Va, Ign, Qmd, HWS	1	0.18	1	SPH	0.19	61	63	26	45	0	120
				2	SPH	0.63	170	104	52	45	0	120
		2	0.22	1	SPH	0.35	94	32	57	345	0	90
				2	SPH	0.43	599	373	176	345	0	90
		3	0.15	1	SPH	0.85	36	89	106	281.3	−25.6	−16.1
Inside 1 g/t Au grade shell	Va, Ign, Qmd	1	0.18	1	SPH	0.19	61	63	26	45	0	120
				2	SPH	0.63	170	104	52	45	0	120
		2	0.22	1	SPH	0.35	94	32	57	345	0	90
				2	SPH	0.43	599	373	176	345	0	90
		3	0.15	1	SPH	0.85	36	89	106	281.3	−25.6	−16.1
BiGd lithology	BiGd	1,2,3	0.05	1	SPH	0.78	44	69	237	345	−45	0
				2	SPH	0.17	298	235	241	345	−45	0

14.5.5 Estimation

14.5.5.1 Model setup

At Hugo North, a sub-blocked model was used for resource estimation with parent (maximum) block dimensions equal to 15 m by 15 m by 15 m and child (minimum sub-block) block dimensions to as small as 5 m by 5 m by 5 m. The block model limits are shown in Table 14.33. Like Oyut, the actual sub-block sizes vary as necessary to fit the specified boundaries of the wireframes used to tag the block model. Bulk densities were assigned to a unique assay database file. A straight composite was used for Hugo North.

Table 14.33 Hugo North block model limits

Block model limits	X	Y	Z
Origin (UTM)	650600	4766000	-600
Offset (m)	2205	2700	1800
Block size (m)	15	15	15
Parent block count	147	180	120

Various coding was done on the block models in preparation for grade interpolation. The block models were coded according to zone, lithological domain, and grade shell. For Hugo North, subcelling was utilized to honour lithological, grade and structural contacts. Blocks above topography were removed from the block model. Non-mineralized units were flagged using a lithology code and were excluded during the interpolation process.

Once the Hugo North block model was generated, blocks were assigned an estimation domain using a combination of grade shells or alteration and lithology.

Interpolation was limited to the mineralized lithological units (Va, Ign, Qmd, and BiGd). Only blocks within those units were interpolated, and only composites belonging to those units were used. Metal values within blocks belonging to all other units (post-mineral dykes and sediments) were set to zero.

Modelling consisted of grade interpolation by OK except for bulk density, which was interpolated using a combination of SK and inverse distance weighting to the third power (ID3). Both restricted and unrestricted grades were interpolated to allow calculation of the metal removed by the outlier restriction. NN grades were also interpolated for validation purposes. Blocks and composites were matched on estimation domain.

14.5.5.2 Grade estimation

OK method was used in grade interpolation and SK method was used in evaluation for density, with outlier restriction used during evaluation. A check was conducted using the nearest-neighbour comparison method. The search ellipsoids for estimation were oriented preferentially to the general orientation of each estimation domain.

The search strategy employed concentric expanding search ellipsoids. The first pass used a relatively short search ellipse relative to the long axis of the correlogram ellipsoid. For the second pass, the search ellipse was increased by 50% (up to the full range of the correlogram) to allow interpolation of grade into those blocks not estimated by the first pass. A final, third pass was performed using a larger search ellipsoid.

To ensure that at least three drillholes were used estimate blocks in pass 1, the number of composites from a single drillhole that could be used was restricted to three composites. Similarly, pass 2 required a minimum of two boreholes to generate an estimate. The number of composites allowed from a single drillhole was restricted to three.

The search parameters for copper and gold are shown in Table 14.34. Similar tables of parameters were generated for each domain. These parameters were based on the geological interpretation, data analyses, and variogram analyses. The number of composites used in estimating grade into a model block followed a strategy that matched composite values and model blocks sharing the same feed code or domain. The minimum and maximum number of composites was adjusted to incorporate an appropriate amount of grade smoothing.

Estimation of subcells along a grade domain or lithological boundary was based on assigning the parent cell grade to the subcells. The result being that all like-flagged subcells within the larger parent cell contain the same grade.

Grade variables were regularized to the tonnage-weighted (volume times density) mean of the sub-cell source grade values enclosed in the destination parent blocks prior to providing for use with detailed engineering and tabulation of mineral resources.

14.5.6 Validation of estimation

14.5.6.1 Visual inspection of estimates

Detailed visual validation of the Hugo North model was performed in plan and section, comparing resource block grades to original drillhole data. The checks showed good agreement between drillhole composite values and model cell values. The addition of the outlier restriction values succeeded in minimizing grade smearing.

14.5.6.2 Global bias check

Block model estimates were checked for global bias by comparing the average metal grades (with no cut-off) from the model (OK) with means from NN estimates. In all cases, NN means were within 3.7% of the OK estimate except the background gold domain (Table 14.35).

14.5.6.3 Local bias check

Models were also checked for local trends in the grade estimates (grade slice or swath checks). This was undertaken by plotting the mean values from the NN estimate versus the kriged results for benches (in 30 m swaths) and for northings and eastings (both in 40 m swaths). The kriged estimate should be smoother than the NN estimate, thus the NN estimate should fluctuate around the kriged estimate on the plots. The two trends behaved as predicted and showed no significant trends of copper or gold in the estimates in both the Oyut and Hugo North models.

Swath plots of uncapped copper and gold estimates along easting, northing and elevation are presented in Figure 14.10 and Figure 14.11.

Table 14.34 Hugo North summary of search and sample selection parameters – copper and gold

Estimation Pass	Estimator	Geometric Domain	Search Distance (m)			Sample Counts			
			Major	Semi-major	Minor	Minimum samples per estimate	Maximum samples per estimate	Maximum samples per hole	Minimum samples per hole
Cu Pass 1	OK	1,2,3,4,5,6,7	120	80	40	9	15	3	3
Cu Pass 2	OK	1,2,3,4,5,6,7	180	120	60	6	12	3	2
Cu Pass 3	OK	1,2,3,4,5,6,7	360	240	120	3	9	3	1
Cu Domain 105 ID2	ID2	1,2,3,4,5,6,7	10	10	7.5	1	20	n/a	1
Cu Domain 105 Pass 1	OK	1,2,3,4,5,6,7	120	80	40	2	9	3	1
Cu Domain 105 Pass 2	OK	1,2,3,4,5,6,7	180	120	60	2	6	3	1
Cu Domain 105 Pass 3	OK	1,2,3,4,5,6,7	360	240	120	2	3	3	1
Au Pass 1	OK	1,2	120	80	40	9	15	3	3
Au Pass 2	OK	1,2	180	120	60	6	12	3	2
Au Pass 3	OK	1,2	360	120	240	3	9	3	1
Au Pass 1	OK	3	120	80	40	9	15	3	3
Au Pass 2	OK	3	180	120	60	6	12	3	2
Au Pass 3	OK	3	360	240	120	3	9	3	1
Au Domain 105 ID2	ID2	1,2,3	10	10	7.5	1	20	n/a	1
Au Domain 105 Pass 1	OK	1,2,3	120	40	80	3	9	3	1
Au Domain 105 Pass 2	OK	1,2,3	180	60	120	3	9	3	1
Au Domain 105 Pass 3	OK	1,2,3	360	240	1	3	9	3	1

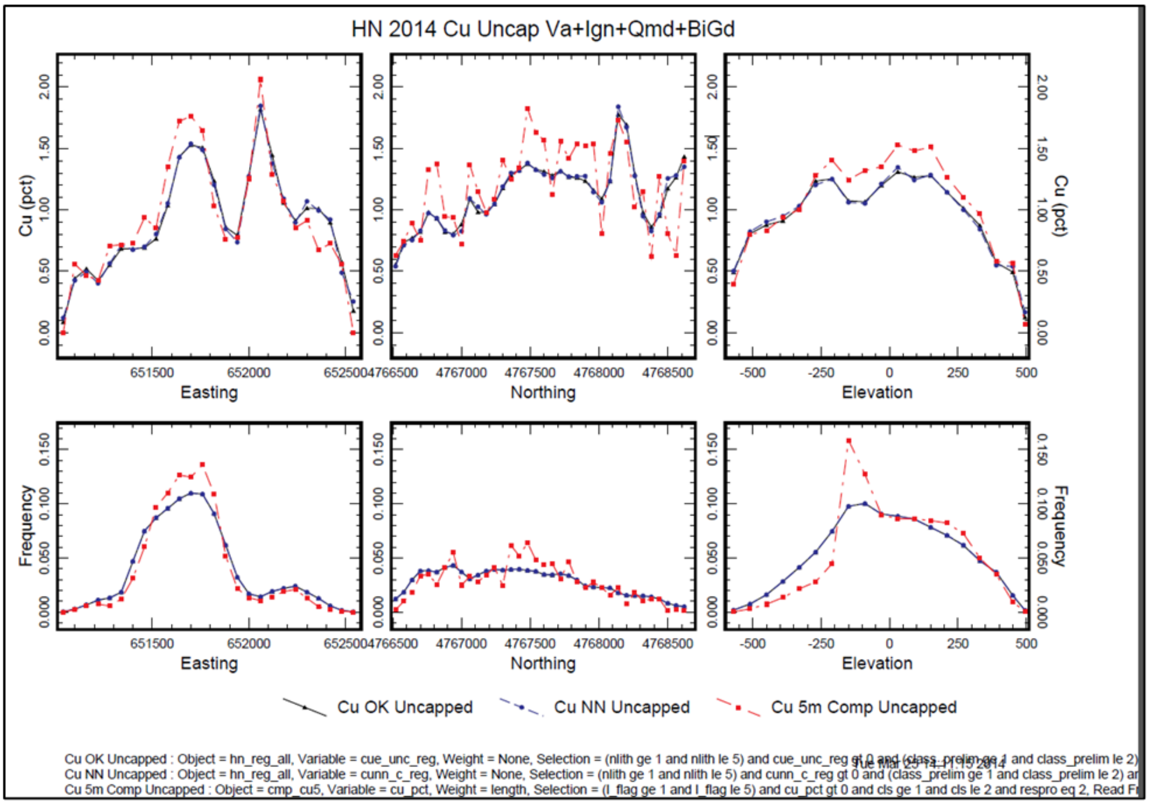
Notes: OK = Ordinary Kriging, ID2 = Inverse distance to the power of 2. Source: Hugo North Mineral Resource Estimation Update (2014)

Table 14.35 Hugo North summary statistics for Cu grade composite and block grade estimate comparisons

Est Dom	Grade Composites						OK Blocks						NN Blocks			Comparison of Mean Grades	
	Uncapped			Capped			Uncapped			Capped			Uncapped			OK Uncapped vs NN	OK Uncapped vs OK Capped
	Count	Mean	CV	Count	Mean	CV	Count	Mean	CV	Count	Mean	CV	Count	Mean	CV	Diff (%)	Diff (%)
101	32	0.54	0.63	32	0.51	0.41	930	0.62	0.63	930	0.61	0.63	946	0.61	0.66	2%	1%
102	2,228	0.20	1.39	2,228	0.20	1.39	17,491	0.26	0.96	17,491	0.26	0.95	17,515	0.24	1.22	6%	1%
103	638	0.38	0.77	638	0.38	0.76	5,247	0.37	0.88	5,247	0.37	0.87	5,237	0.36	1.00	3%	0%
104	1,280	0.02	6.60	1,280	0.02	6.60	3,421	0.11	2.45	3,421	0.11	2.41	3,406	0.05	3.77	-123%	1%
105	4,092	0.20	2.39	4,092	0.20	2.39	32,341	0.24	1.64	32,341	0.26	1.39	32,770	0.26	1.82	7%	7%
201+202+203 +204+205	9,607	1.00	0.63	9,607	0.99	0.63	71,735	0.97	0.54	71,735	0.97	0.54	71,775	0.96	0.64	1%	0%
301+302+303	6,722	2.90	0.51	6,722	2.90	0.51	36,943	2.76	0.38	36,943	2.75	0.38	36,943	2.78	0.46	-1%	0%

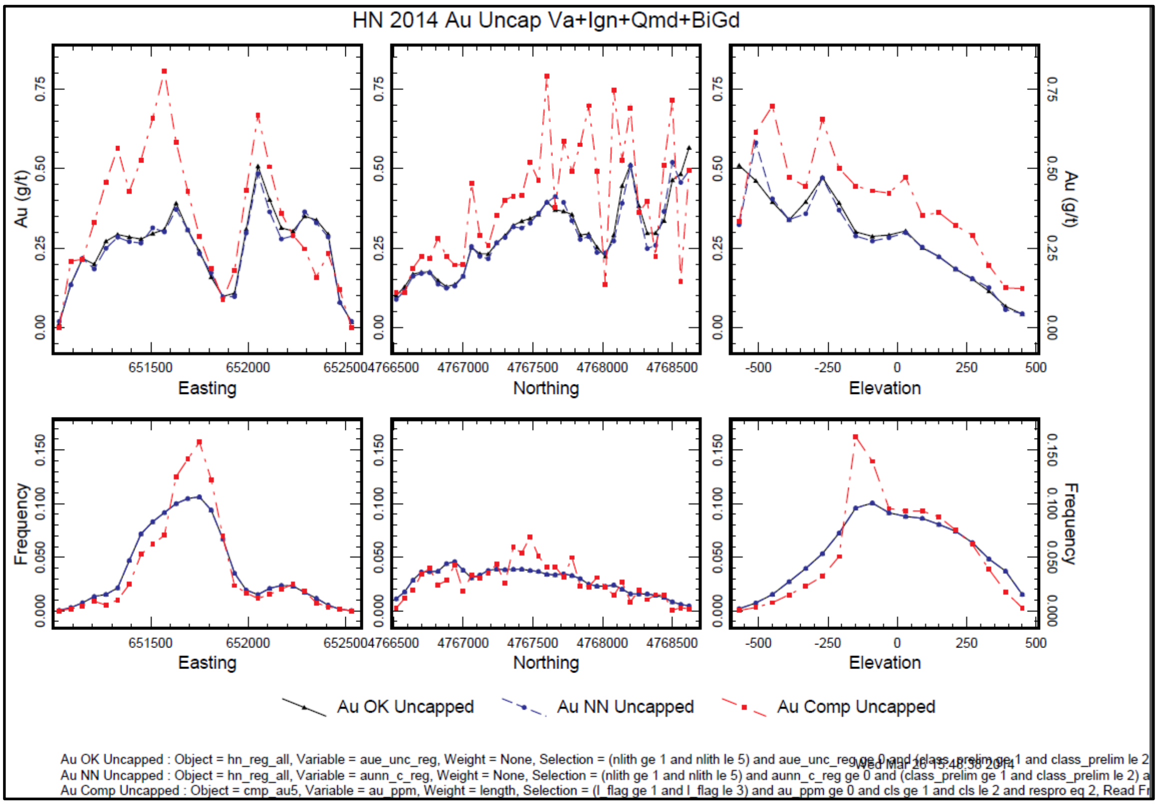
Source: Hugo North Mineral Resource Estimation Update (2014)

Figure 14.10 Hugo North swath plot comparison of kriged NN copper estimates (uncapped) and 5 m composites with depth.



Source: Compiled by AMC from information provided by TRQ, Date: 30 June 2020

Figure 14.11 Hugo North swath plot comparison of kriged NN gold estimates (uncapped) and 5 m composites with depth.



Source: Compiled by AMC from information provided by TRQ, Date: 30 June 2020

14.5.6.4 Validation of non-grade variables

The bulk density and metallurgical fields Ci, MBi and SPi were assessed using summary statistics by domain. No outliers or restrictions were placed on these estimates.

14.5.7 Resource definition

The mineralised envelope for Hugo Dummett North is defined by the West Bat Fault to the west, the Contact Fault to the East, and the 110 Fault to the South. Within this area, a CuEq cut-off is used, together with a reasonable prospects test, to further define the resource and inform the underground block cave mine designs.

The base of 2019 copper equivalent formula incorporates copper, gold and silver, as defined in Section 14.4.7.3. The assumed metal prices are 3.08 US$/lb for copper, 1,292 US$/oz for gold and 19.00 US$/oz for silver. Copper grade is expressed as percentage (%), and gold and silver grades are expressed as grams per tonne (g/t). Metallurgical recovery for gold and silver are expressed as percentage relative to copper recovery. The unit conversions used in the calculation are shown in Table 14.19.

Copper equivalence assumptions and calculation for the Hugo North deposit are shown in Table 14.36 and Table 14.37.

Table 14.36 Hugo North – CuEq assumptions

Variable	Cu (US$/lb)	Au (US$/oz)	Ag (US$/oz)
Metal prices	3.08	1292.00	19.00
Recovery	0.93	0.80	0.81
Recovery relative to Cu	1.00	0.86	0.88
Conversion	22.0462	0.0321507	0.0321507

Table 14.37 Hugo North – CuEq calculation

Variable	Cu (%)	Au (g/t)	Ag (g/t)	CuEq (%)	Revenue (US$/t)
% Cu	1.00	–	–	1.00	$67.90
g/t Au	–	1.00	–	0.56	$35.72
g/t Ag	–	–	1.00	0.01	$0.54
Total	1.00	1.00	1.00	1.56	$104.16

From Table 14.36 and Table 14.37, the base formula is calculated by:

$$\mathrm{CuEq} = \mathrm{Cu} + ((\mathrm{Au} \times 1292 \times 0.03215 \times 0.860) + (\mathrm{Ag} \times 19.00 \times 0.03215 \times 0.876)) / (3.08 \times 22.0462)$$

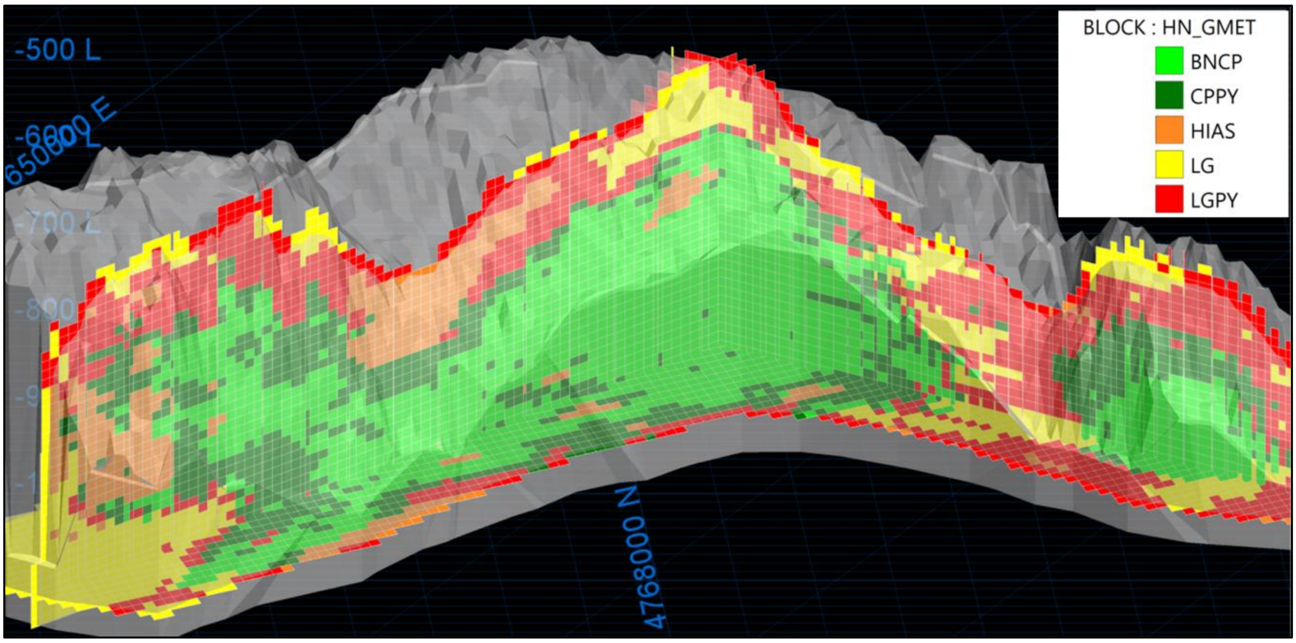
$$= \mathrm{Cu} + ((\mathrm{Au} \times 35.7175) + (\mathrm{Ag} \times 0.5353)) / 67.9023$$

All elements included in the copper equivalent calculation have a reasonable potential to be recovered and sold.

14.5.7.1 Derivation of cut-off grades

The CuEq cut-off is validated by comparing to NSR values. The NSR per tonne of ore needs to equal or exceed the production cost of a tonne of ore for the mine to break even or make money. For the underground mine, the break-even cut-off grade needs to cover the costs of mining, processing, and G&A. An NSR cut-off for a tonne of ore for Hugo North underground mine is different for each geomet ore type but, on average, an NSR of 17.59 US$/t would be required to cover costs of 7.03 US$/t for mining, 7.64 US$/t for processing, and 2.92 US$/t for G&A. This translates to a CuEq break-even underground cut-off grade of approximately 0.43% CuEq for Hugo North. However, with the exclusion of high-arsenic ore type and low-grade pyrite ore type, which in general sit in the top part of the cave (Figure 14.12), the CuEq break-even underground cut-off grade is approximately 0.41% and has been used for tabulating Mineral Resources for Hugo North in this report.

Figure 14.12 Hugo North geometallurgical domains within Lift 1 cave shape



Source: Compiled by AMC from information provided by TRQ, Date: 30 June 2020. Isometric view

14.5.8 Classification

14.5.8.1 Measured Mineral Resource

Recent underground drilling has resulted in sufficient confidence in geological and grade continuity to support Measured Resources in proximity to underground drillholes. The following conditions must be met for a block to be classified as Measured:

- There must be at least three composites from three different holes from three different octants within 50 m of the block centroid and at least one of these composites must be within 35 m of the block centroid, where the distance used is the closest anistropic distance captured from ID2 pass 1, and
- The block must be contained within the Measured classification solid generated using sectional interpretation and block probabilities.

14.5.8.2 Indicated Mineral Resource

The drillhole spacing over much of the Hugo North area is approximately 125 m x 75 m. The minimum nominal drillhole spacing of 75 m (horizontal) between drillholes and 150 m between drill fences for Indicated resources was determined in the course of a study on drillhole spacing conducted in 2004. For blocks that do not meet the Measured classification criterion above, the following conditions must be satisfied for a block to be classified as Indicated:

- There must be at least three composites from three different holes within 50 m of the block centroid, where the distance used is the closest anistropic distance captured from ID2 pass 1, or;
- There must be at least three composites from three different holes within 150 m of the block centroid and at least one of these composites must be within 105 m of the block centroid, where the distance used is the closest anistropic distance captured from ID2 pass 2, or;
- There must be at least two composites from two different holes within 150 m of the block centroid and at least one of these composites must be within 75 m of the block centroid, where the distance used is the closest anistropic distance captured from ID2 pass 2, and;

- The block must be contained within the Indicated classification solid generated using sectional interpretation and block probabilities.

14.5.8.3 Inferred Mineral Resource

For blocks that do not meet the Measured or Indicated classification criteria above, the following conditions must be satisfied for a block to be classified as Indicated:

- There must be at least one composite within 150 m of the block centroid, where the distance used is the closest anistropic distance captured from ID2 pass 3, and
- The block must be contained within the Inferred classification solid generated using sectional interpretation and block probabilities.

14.5.9 Reasonable prospects of eventual economic extraction

CIM Definition Standards require reported Mineral Resources to have reasonable prospects for eventual economic extraction. The following addresses this requirement for the Hugo North mineral resources.

The Hugo North deposit Mineral Resources, based on drilling as of 31 December 2013, at a CuEq cut-off of 0.41% are shown in Table 14.5, classified as Measured, Indicated and Inferred Mineral Resources.

To assess reasonable prospects for eventual economic extraction and to declare underground resources at Hugo North, the reasonable prospects of eventual economic extraction (RPEEE) shell was prepared on vertical sections using economic criteria that would pay for primary and secondary development, block-cave mining, ventilation, tramming, hoisting, processing, and G&A costs. The RPEEE shell was developed in 2012 as explained below and has not been updated in this study.

The RPEEE shape grade cut-off was defined using the following parameters:

- A primary and secondary development cost of 8.00 US$/t
- A mining, process, and G&A cost of 12.45 US$/t
- A gold price of 970 US$/oz
- A copper price of 3.00 US$/lb

From these inputs it was estimated that a 0.50% copper cut-off would return 21.74 US$/t, which would cover the RPEEE shape cut-off costs stated above. Hence, a CuEq cut-off of 0.50% was use for delineating the RPEEE shape for Hugo North. The infrastructure built for Hugo North Lift #1 would provide synergies for lower capital intensity underground development at subsequent Hugo North panels. The RPEEE shell is insensitive to CuEq cut-off changes as the cave footprint once established defines the economics. The 2012 shell is considered as being applicable to the current estimate.

Mineral Resources within the RPEEE shell at Hugo North are reported at a breakeven copper equivalent cut-off grade of 0.41%.

The Mineral Resources are reported exclusive of the reserves. Inferred blocks within the Lift #1 block cave shape, which had a minor update in 2019, are assigned a zero grade and treated as dilution in the reserve. Thus, they are not treated in the same way as Inferred blocks within the Oyut open pit final reserve shell.

All blocks occurring above the final height of draw (HOD) of the drawpoints in the Lift #1 block cave footprint are excluded from the resource tabulations. This is because there is no reasonable prospect of this material being recovered through the drawpoints, and if it were to be recovered, it would be heavily diluted by the time it presented at a drawpoint. Once the cave has propagated to this height, there is no other means of recovering the material. Some development below the extraction level has also been reported as Mineral Reserves. As such, this material has also been excluded from Mineral Resources.

14.5.10 Comparison of differences to previous estimates

A tabulation of the differences between the 2020 Oyu Tolgoi Feasibility Study Hugo North Mineral Resources (as announced 2 July 2020) and the 2019 AIF (as at 31 December 2019) is shown in Table 14.38Table 14.38. The increase in Mineral Resources for Hugo North is a result of the conversion of the material contained in the pillars and in unrecoverable material due to the Mineral Reserves cave shapes. The unrecoverable material refers to material above the cave shape excluded from resource and reserve. The Hugo North Mineral Reserves have decreased by 39 Mt and the Mineral Resources have increased by 69 Mt. The reason the Mineral Resources have increased more than the Mineral Reserves is decreased is discussed below.

The Mineral Reserves at Hugo North are based on an underground block cave design. The panel shape as defined by grade, geotechnical and structural limitations is used to define the boundary within which material can be defined as Mineral Reserves and hence be excluded from the Mineral Resources. Within the Mineral Reserves estimation process there are limitations imposed by the modifying factors due to ore loss at the top of the caving shape. This material is flagged with zero grade in the reserving process.

The implication is that some of the locations of the material with zero grade in the reserving process has now been converted back into Mineral Resources as the pillar zones are excluded from the Mineral Reserves. This accounts for the difference in tonnes.

Table 14.38 Hugo North Mineral Resource comparison for Measured & Indicated for the 2019 AIF to the 2020 Feasibility Study

Classification & Report	Ownership	Mineral Resources				Contained Metal		
		Tonnes	Cu	Au	Ag	Copper	Gold	Silver
		(Mt)	(%)	(g/t)	(g/t)	(Mt)	(Moz)	(Moz)
2020 Feasibility Study Measured & Indicated	Oyu Tolgoi LLC	460	1.4	0.36	3.3	6.5	5.3	48
	Entrée LLC	87	1.6	0.54	4.1	1.4	1.5	12
	Total	550	1.4	0.39	3.4	7.8	6.8	60
2019 AIF Measured & Indicated	Oyu Tolgoi LLC	390	1.2	0.32	3.0	4.8	4.0	38
	Entrée LLC	87	1.6	0.54	4.1	1.4	1.5	12
	Total	480	1.3	0.36	3.2	6.2	5.5	49
Difference Measured & Indicated	Oyu Tolgoi LLC	69	0.18	0.04	0.27	1.7	1.3	11
	Entrée LLC	-	-	-	-	-	-	-
	Total	69	0.14	0.03	0.20	1.7	1.3	11
% Difference Measured & Indicated	Oyu Tolgoi LLC	18%	15%	12%	9%	35%	32%	28%
	Entrée LLC	0%	0%	0%	0%	0%	0%	0%
	Total	14%	11%	7%	6%	27%	23%	22%

Notes:
1. CIM Definition Standards for Mineral Resources and Mineral Reserves (2014) are used for reporting of Mineral Resources.
2. 2019 AIF refers to the 2019 Company's Annual Information Form dated March 31, 2020.
3. The Mineral Resources exclude Mineral Reserves.
4. The following CuEq formulae have been used for cut-off grade determination in each deposit.
   Oyut CuEq = Cu + ((Au x 35.4938) + (Ag x 0.4101)) / 67.9023
   Hugo North CuEq = Cu + ((Au x 35.7175) + (Ag x 0.5353)) / 67.9023

Hugo South CuEq = Cu + ((Au x 37.7785) + (Ag x 0.5773)) / 67.9023

Heruga CuEq = Cu + ((Au x 37.0952) + (Ag x 0.5810) + (Mo x 0.0161)) / 67.9023

5. The metal prices used in determining the CuEq formulae are as follows: 3.08 $/lb for copper, 1,292 $/oz for gold, 19.00 $/oz for silver, and 10.00 $/lb for molybdenum.
6. The metallurgical recoveries used in determining the CuEq formulae for each deposit: Hugo North deposit: Copper 93%, Gold 80%, Silver 81%.
8. For the Hugo North, deposits a cut-off grade of 0.41% CuEq grade used based on the assumption that the deposits will be mined using underground mass mining methods.
9. The effective date of the Mineral Resource estimates is December 31, 2019 (updated on June 30, 2020).
10. The Shivee Tolgoi and Javkhlant licenses are held by Entrée LLC. The Shivee Tolgoi and Entrée LLC Javkhlant Licenses are planned to be operated by Oyu Tolgoi LLC. Oyu Tolgoi LLC will receive 80% of cash flows after capital and operating costs for material originating below 560 m, and 70% above this depth. TRQ holds a 7.9% interest in Entrée Resources Ltd.
11. Mineral Resources that are not Mineral Reserves do not have demonstrated economic viability.
12. The contained copper, gold and silver estimates in the tables have not been adjusted for metallurgical recoveries.
13. Totals may not match due to rounding to two significant figures. This results in differences to previously reported figures but is in line with industry best practice.

14.6 Resource estimation – Hugo South

The following subsections describe the methodology for and results of the Mineral Resource estimates for the Hugo South zone. The Hugo South zone has had no drilling since 2004 and hence has not been updated since the last technical report. Updated pricing assumptions have been utilized in the cut-off grade assumptions and the Mineral Resource re-reported using this cut-off. The summary below is taken from Ivanhoe’s September 2004 Technical Report.

14.6.1 Modelling

The geological shapes for the deposits are listed in Table 14.39 and Table 14.40 for Hugo South. Appropriate gold and copper shells at various cut-off grades (Table 14.41) were also defined. These shapes were then edited on plan and section views to be consistent with the structural and lithological models and the drill assay data.

Checks on the structural, lithological, and grade shell models indicated that the shapes honoured the drillhole data and interpreted geology.

The lithological shapes and faults, together with copper and gold grade shells and deposit zones, constrain the grade analysis and interpolation. Typically, the faults form the first order of hard boundaries constraining the lithological interpretation.

The solids and surfaces were used to code the drillhole data. Sets of plans and cross-sections that displayed colour-coded drillholes were plotted and inspected to ensure the proper assignment of domains to drillholes.

Table 14.39 Hugo South geological surfaces used in geological modelling

Model Component	Comment
Surfaces – General	
Topography	Project-wide
Base of Quaternary cover	Project-wide
Base of Cretaceous clays and gravels	Project-wide
Base of oxidation	Project-wide, but relevant only for Oyut
Base of supergene alteration	Project-wide, but relevant only for Oyut
Solids/Surfaces – Lithology	
Top of quartz monzodiorite (Qmd)	Hugo South only
Base of ash flow tuff (DA2a - Ign)	Project-wide

Base of unmineralized volcanic and sedimentary units; DA2b or DA3 or DA4	Project-wide. Used as a hanging wall limit to grade interpolation

Table 14.40 Hugo South fault surfaces used in geological modelling

Fault surfaces	Comment
West Bat Fault	Hugo area: used to define western limits
110 Fault	Hugo area: forms boundary between Hugo South and Hugo North deposits
Central Fault	Hugo South area: forms boundary between Hugo South deposit and Oyut Central zone

Table 14.41 Hugo South grade shell construction parameters

Deposit	Grade shell			
	Au (ppm)	Cu (%)	Mo (ppm)	As (ppm)
Hugo South	>0.3	>0.6, >1.0, >2.0	–	–

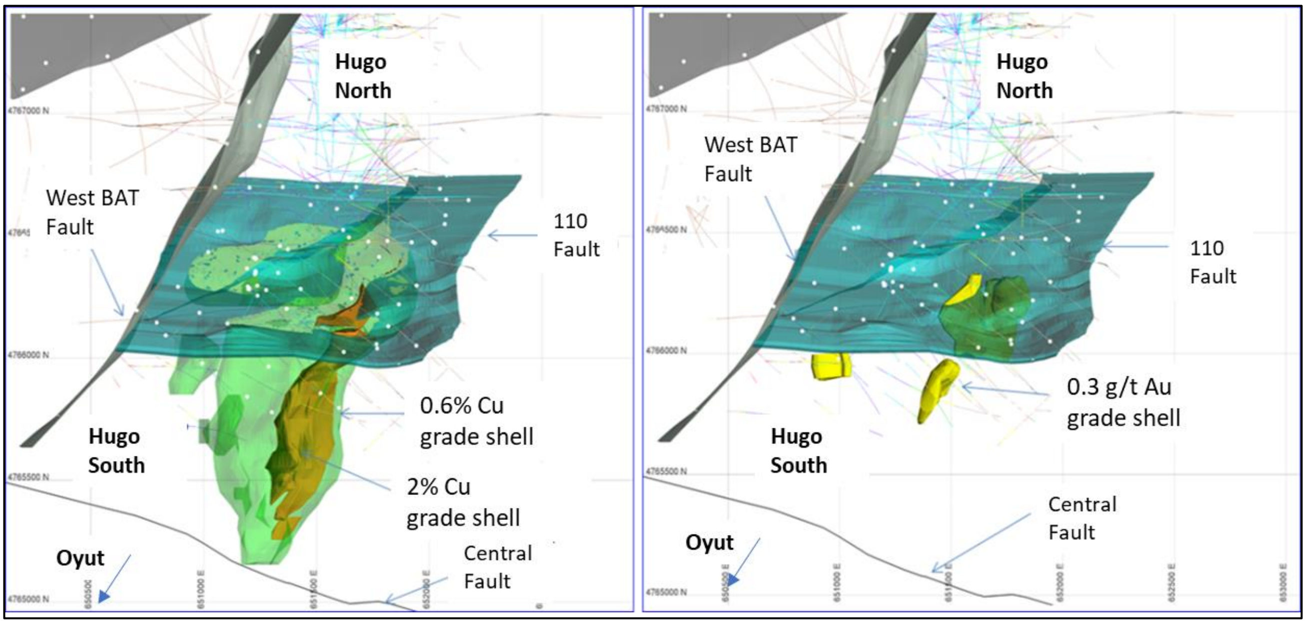
Due to the distinct differences between the Hugo North and Hugo South zones, a vertical dividing plane was selected at 4,766,300 N, a location marked by the thinning and locally discontinuous nature of the copper mineralization. The Hugo South assessment domains were constrained by copper grade shells as shown in Table 14.42 and Figure 14.13.

To constrain grade interpolations, Oyu Tolgoi LLC created three-dimensional mineralized envelopes based on copper grades of 0.6%, 1.0%, and 2.0%. The Hugo South grade shells are elongated in the north-northeast azimuth, dipping moderately steeply to the east with little or no plunge. The mineralized envelopes were used to code the drillhole data and model blocks. Cross sections and plans with drillholes and blocks colour-coded by domain were visually inspected on-screen to check the domain assignments.

Table 14.42 Hugo South deposit domain codes

1st code		2nd code		3rd code	
Description	Code	Description	Code	Description	Code
Inside Cu 0.6% grade shell	100	–	–	VA	1
Inside Cu 0.6% grade shell	100	–	–	IGN	2
Inside Cu 1.0% grade shell	200	–	–	QMD	3
Inside Cu 2.0% grade shell	300	–	–	HWS	4
Inside Au 0.3 ppm grade shell	600	–	–	BiGD	5
Outside grade shell (basic)	800	–	–	HBBIGD	6
–	–	–	–	RHY	7
–	–	–	–	CretClay	8
–	–	–	–	Qco	9
–	–	–	–	BAD	10

Figure 14.13 Hugo South grade shell modelling and faults (left: copper, right: gold)



Source: Compiled by AMC from information provided by TRQ, Date: 30 June 2020. Projection UTM (WGS84) Z48N.

14.6.2 Compositing

The drillhole assays were composited into fixed-length, down-hole composites at a size that was considered appropriate when considering estimation block size, required lithological resolution, and probable mining method. This compositing honoured the domain zones by breaking the composites on the domain boundary. The domains used in compositing are a combination of the grade shells and lithological domains. Composite lengths of 5 m are used.

Intervals of less than 5 m lengths represented individual residual composites from end-of-hole or end-of-domain intervals. Composites that were less than 2 m long were excluded from the dataset used in interpolation.

A post-processing step was applied to adjust negative or null composite values arising from non-assayed intervals. The intervals were not assayed due to:

- A lack of visible mineralization
- Not logged intervals, such as the "parent" portion of a wedged daughter hole
- "Navi" drill interval
- The portion of a new drillhole for which assays are pending were replaced by lower detection limit for the valuable grade elements such as Cu, Au, and Ag

The lower detection limits were also assigned to the intervals of non-logged that were not sampled due to a lack of visible mineralization for the deleterious elements.

14.6.3 Statistics

14.6.3.1 Basic statistics

Copper grade has low coefficients of variation in all grade shells (Table 14.43). No significant "within shell" variations due to lithology were observed. Gold grade distributions showed typical lognormal trends in all domains. Molybdenum grades were generally low, but Hugo South was observed to have higher molybdenum grades than Hugo North.

Table 14.43 Hugo South basic statistics of 5 m composites by lithology and grade domains

Grade shell	Parameter	Composite numbers	Minimum	Maximum	Mean	CV
Cu 2%	Cu (%)	537	0.01	12.82	2.85	0.47
	Au (ppm)	537	0	3.11	0.20	1.12
Cu 1%	Cu (%)	1,735	0.01	4.60	1.29	0.34
	Au (ppm)	1,735	0	0.76	0.05	0.94
Cu 0.6%	Cu (%)	2,026	0	2.42	0.78	0.37
	Au (ppm) vq	1,311	0	3.91	0.12	1.82
	Au (ppm) Ig	715	0	0.28	0.04	0.85
Background	Cu (%)	3,012	0	2.42	0.28	0.90
	Au (ppm) vq+Ig	2,588	0	10.72	0.05	4.66

Note: vq is the Va and Qmd rocktype areas. Ig is the Ign rocktype areas. Vq+Ig is the Va and Ign areas

14.6.3.2 Contact grade profile analysis

A strategy of soft, firm, and hard boundaries was utilized to account for domain boundary uncertainty (dilution) and to reproduce the input grade sample distribution in the block model. Soft boundaries allowed full sharing of composites between domains during grade estimation; firm boundaries allowed sharing of composites from within a certain distance of the boundary; and hard boundaries allowed no composite sharing between domains. Comparative basic statistics, such as mean grade, was carried out for each set of adjoining domains to establish the boundary as soft, firm, or hard. Contact plots and visual inspection of grade distributions were also used in cases where results were unclear or were contrary to geological interpretations.

The rock group contact plots demonstrate that no significant "within shell" variations due to lithology are present, other than the expected variations between mineralized rock types and post-mineral dykes or sediments. The grade shell contact plots demonstrate that the copper grade changes rapidly across the grade shell contacts, as expected.

Grades are similar for both the Hugo North and South zone composites when they are within 200 m of each other. This supports the use of soft boundaries for interpolation at the boundary between Hugo North and Hugo South.

14.6.3.3 Restriction of extreme grade values

The grade top-cuts on outlier grades employed at Hugo South are summarized in Table 14.44.

Table 14.44 Hugo South outlier threshold –resource domains (Cu, Au)

Grade Domain	Cu (%)	Au (g/t)
2% Cu Shell	11	2.0
1% Cu Shell	5	2.0
0.6% Cu Shell	3	2.0
Background	3	1.5
Number of Assays Capped	18	21.0

Further high-grade restrictions are used to control the effects of high-grade composites within each of the domains. For copper and gold, the threshold grades were generally set as the grade of the next highest grade shell. For the highest grade shells, the threshold was set at the grade where the composite distributions become erratic on their cumulative probability plots. Composites greater than the threshold grade were restricted to blocks within 50 m of that composite. Table 14.45 summarizes the threshold grade for restriction by domain and metal.

Table 14.45 Hugo South threshold grade for restriction by domain and metal

Metal	Shell	Threshold grade
Cu	2.00%	7.0% Cu
	1.00%	2.0% Cu
	0.60%	1.0% Cu
	Background	0.6% Cu
Au	0.3 g/t Au	3.0 g/t Au
	0.6% Cu	0.5 g/t Au
	Background	0.2 g/t Au

14.6.4 Variography

Semi-variograms were calculated and modelled for all grade elements plus SG in Supervisor software. The variograms were modelled with either exponential models, spherical models, or a combination of exponential and spherical models. Two structures were typically used to model the variograms with a few exceptions where a single structure or, rarely, three structures were used. The orientations of multiple structures were typically "locked" in the same direction to aid visualization and for checking against geologic reasonableness. Practical ranges were used, where a "practical range" is the range at which 95% of the sill is reached, which is three times longer than the "traditional range" used in some software. The nugget values were generally determined from down-hole variograms. Directional variograms were typically calculated in at least 30-degree increments both horizontally and vertically.

A variety of strategies was applied where it was not possible to calculate robust variograms. These strategies included:

- Recalculating variograms using larger lags.
- Combining data from adjacent domains of reasonably similar properties. In some cases data were pooled to achieve reasonably robust variograms even where a hard or firm estimation boundary was likely to be used.
- Adopting the variogram model from a well-informed domain that was considered to have similar properties.
- Using the correlograms instead of variograms.
- Transforming variograms to normal scores (normal data distribution) before variogram calculation to improve the experimental variogram. The variograms and models were back-transformed to real space before being used for block grade estimation.

Correlograms were used at Hugo South and indicated a north-easterly trend. The deposit displayed a consistent steep easterly dip with a flat plunge. Ranges were longest along strike of the respective trend for copper and a mixture of along-trend and down-dip of the trend for gold. Ranges tended to be less than 75 m for the first variogram structure in all metals and less than 200 m for the second variogram structure.

14.6.4.1 Copper

The direction of maximum continuity for copper in Hugo South plunges shallowly to the south (−18° toward 184°). The maximum range in this direction was 350 m. The intermediate axis was oriented at −58° toward 062°, with a total range of 300 m. Finally, the minor axis was oriented at −25° toward 283° and the total range in this direction was 104 m (Table 14.46). The nugget effect was modelled as 20% of the total variability.

14.6.4.2 Gold

The spatial continuity characteristics for gold in Hugo South are similar to those for gold in Hugo North, with shorter ranges and less anisotropy than copper (Table 14.46). Continuity in the dip plane is isotropic with the horizontal (00° toward 014°) and down-dip (−64° toward 104°)

directions displaying the longest ranges of 220 m. The minor axis is oriented at −25° toward 284° with a range of 90 m. The nugget effect accounts for 15% of the total variability.

Table 14.46 Hugo South Cu and Au variogram parameters

Metal	Axis	Dip / Dip Dir.	Gemcom Rot. Type	Rot. Angles	C0	C1	C2	Range 1	Range 2
Cu	Primary	−18 →184		184				200	350
	Int.	−48→062	ADA	-18	0.2	0.5	0.3	200	300
	Minor	−25→283		062				104	104
Au	Primary	−64→104		-14				50	220
	Int.	−00→014	ZYZ	-26	0.15	0.45	0.4	50	220
	Minor	−25→284		0				90	90

Models are spherical. ZYZ rotation is right-hand-rule for all axes. ADA rotation is defined by plunge direction of the principal axis, plunge of the principal axis, and plunge direction of the intermediate axis.

14.6.5 Estimation

The Hugo South deposit estimation plans (or sets of parameters used for estimating blocks) were designed using a philosophy of restricting the number of samples for local estimation.

Copper was interpolated into the three grade shells (0.6%, 1.0% and 2.0%) and the background material surrounding the grade shells. No grades were interpolated into the post-mineral dykes or sediments. The 0.6%, 1.0% and 2.0% copper grade shell contacts were treated as hard boundaries, i.e. composites on one side of the boundary could not inform blocks on the other side. To reduce the impact of locally inaccurate block grades due to conditional bias at the hard-shell boundaries, all blocks straddling those contacts were estimated twice, once with each of the composite sets on either side of the contact. The final block grade was calculated with a volume-weighted average of the two or more domain grades in that block. The effect is to slightly smooth the grades at the hard boundary so that the distribution of block grades more closely approximates the shape of the composite distribution.

The contact between Hugo North and Hugo South was set at 4,766,300 m N for the sake of consistency with previous modelling efforts. The boundary between Hugo North and Hugo South was treated as soft, with composites on either side able to inform blocks on the other side of the contact.

14.6.5.1 Model setup

At Hugo South, a sub-blocked model was used for resource estimation that has block dimensions equal to 20 m (Y) by 20 m (X) by 15 m (Z). The block model limits are shown in Table 14.47.

Table 14.47 Hugo South block model limits

Block model limits	X	Y	Z
Origin (UTM)	650600	4765000	-600
Offset (m)	2100	3700	1770
Block size (m)	20	20	15
Parent block count	105	185	118

14.6.5.2 Grade estimation

The interpolation utilized 4 to 16 composites in two passes. Search radii for the first two passes corresponded to one half and the full ranges of the variograms, respectively. A two-hole rule was applied with a maximum of three composites per drillhole. The minor axes of the search ellipses were widened slightly to help fill blocks around bends in the grade shells and to reduce the level of anisotropy striping. A third "blow-out" pass with search radii that were twice the variogram ranges (2 to 8 composites) was used to fill any remaining unestimated blocks in the grade shells. The third pass was not used for the background material.

The interpolation plan for gold was similar to copper. As with copper, three passes were used (only the first two were used for the background domain) with the first two passes utilizing 4 to 16 composites with a maximum of three composites per drillhole, and the third using 2 to 8 composites with no limit on composites. The search radii were roughly equivalent to 0.5x, 1x, and 2x the variogram ranges for passes 1, 2 and 3, respectively. As with copper, the minor axes of the search ellipses were set slightly longer than the variogram ranges.

14.6.5.3 Bulk density estimation

Bulk density values were incorporated into the resource model by interpolating 15 m long composites with the inverse distance squared method. A maximum of twelve and minimum of two 15 m composites were used for the interpolation. The search was isotropic with a 500 m radius. The assignment was constrained by matching composite values and model blocks that shared the same domain. Blocks not estimated were assigned a default bulk density value of 2.78.

14.6.6 Validation of estimation

Block grades were validated using four methods:

- Visual inspection of composite and kriged block grades on section
- Global comparisons of composite and kriged block grades
- Local comparisons of NN and kriged block grades on a series of parallel slices through the model
- Comparisons of kriged grade and tonnage curves with Herco-transformed NN curves.

The results of each validation effort are discussed below. All four validations were satisfactory and no problems were observed.

14.6.6.1 Visual inspection of estimates

Grade interpolation was examined relative to drillhole composite values by inspecting sections and plans on paper plots, and on-screen. The checks showed good agreement between drillhole composite values and model cell values.

14.6.6.2 Global bias check

The block model estimates were checked for global bias by comparing the average grades (at a zero cut-off) against: (1) the average composite grade, (2) the average cell declustered composite grade, and (3) the average nearest-neighbour grade. The cell declustered composite grade and the nearest-neighbour grade are theoretically unbiased estimates of the average block value when no cut-off grade is imposed. Therefore, they are a good basis for checking the performance of different estimation methods.

The results listed in Table 14.48 and Table 14.49 demonstrates that there is no evidence of global bias in the estimate.

Table 14.48 Hugo South global comparison results – Copper

Variable	Estimates	Mean	Variance	Standard deviation	CV	% Diff to kriged model
Composites	5,234	1.23	0.7	0.84	0.69	18.3
Composites cell declustered (240x240x180)	4,041	1.00	0.44	0.66	0.66	−3.8
NN Model (Inferred blocks only)	31,018	1.06	0.46	0.68	0.64	1.9
Kriged model (Inferred blocks only)	31,018	1.04	0.33	0.57	0.55	–

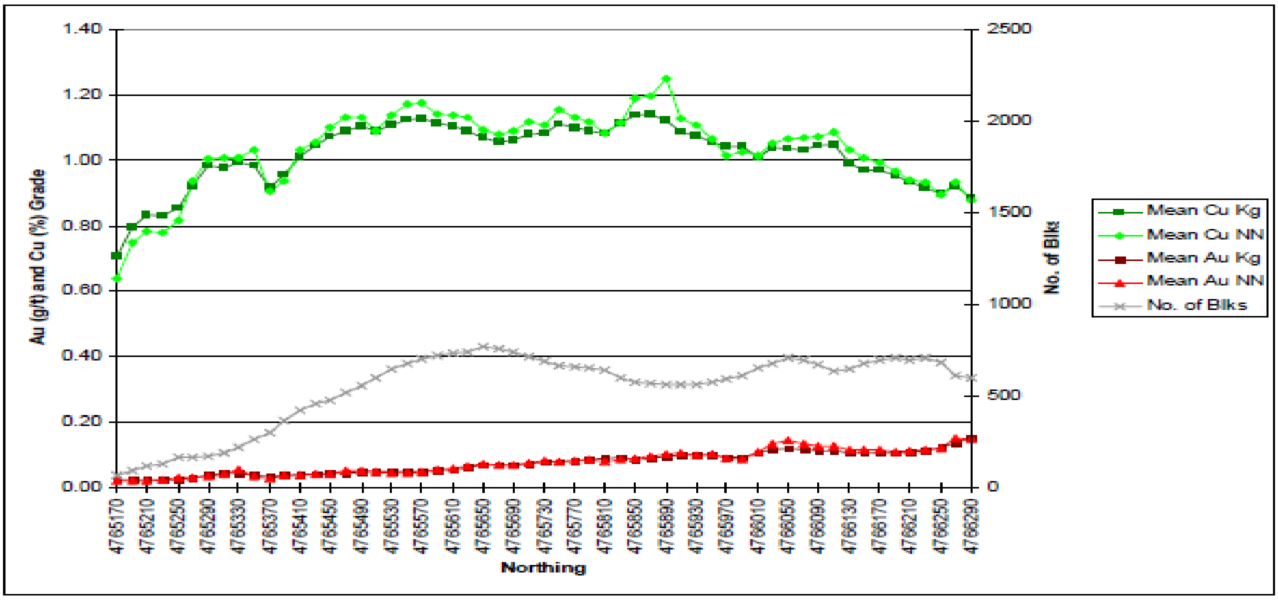
Table 14.49 Hugo South global comparison results – Gold

Variable	Estimates	Mean	Variance	Standard deviation	CV	% Diff to kriged model
Composites	5,155	0.09	0.02	0.14	1.63	3.7
Composites cell declustered (240x240x180)	4,041	0.08	0.02	0.13	1.61	−2.4
NN Model (Inferred blocks only)	31,018	0.09	0.02	0.12	1.41	4.9
Kriged model (Inferred blocks only)	31,018	0.08	0.02	0.08	0.93	–

14.6.6.3 Local bias check

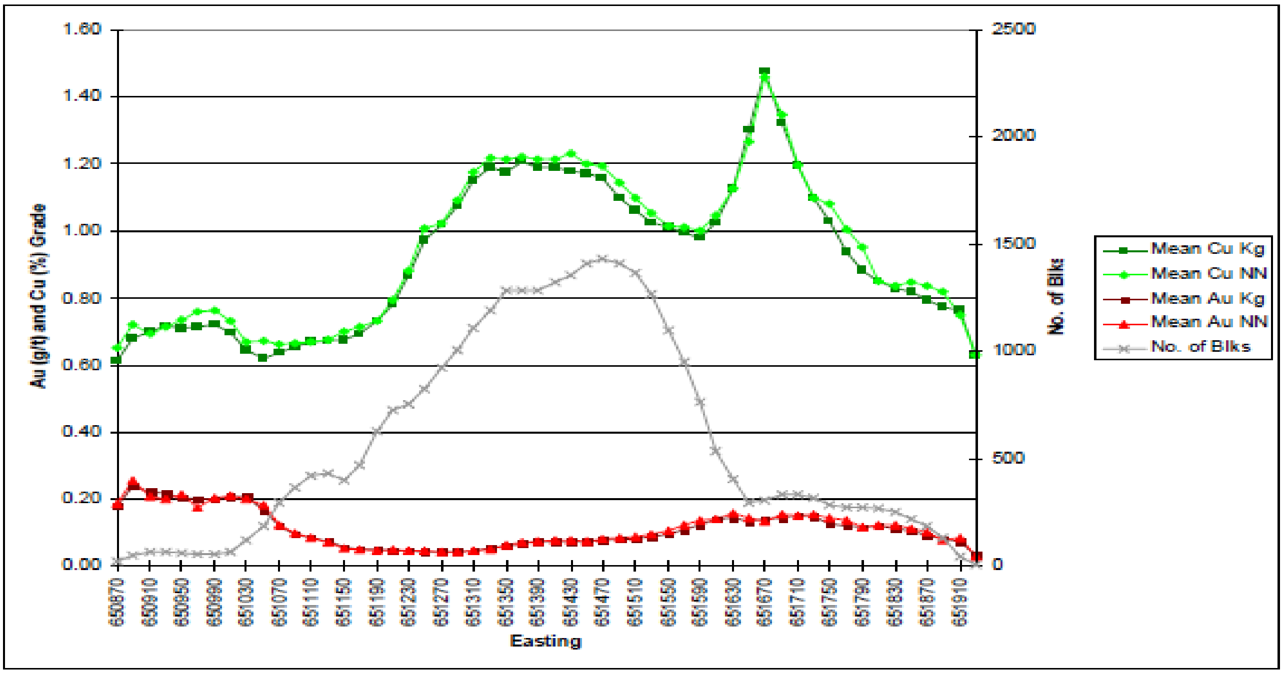
Checks for local trends in the grade estimates by plotting the mean values from the nearest-neighbour estimate against the mean kriged results on a series of parallel northing, easting and elevation slices are shown in Figure 14.14 to Figure 14.16Figure 14.16.

Figure 14.14 Hugo South grade by northing validation plot



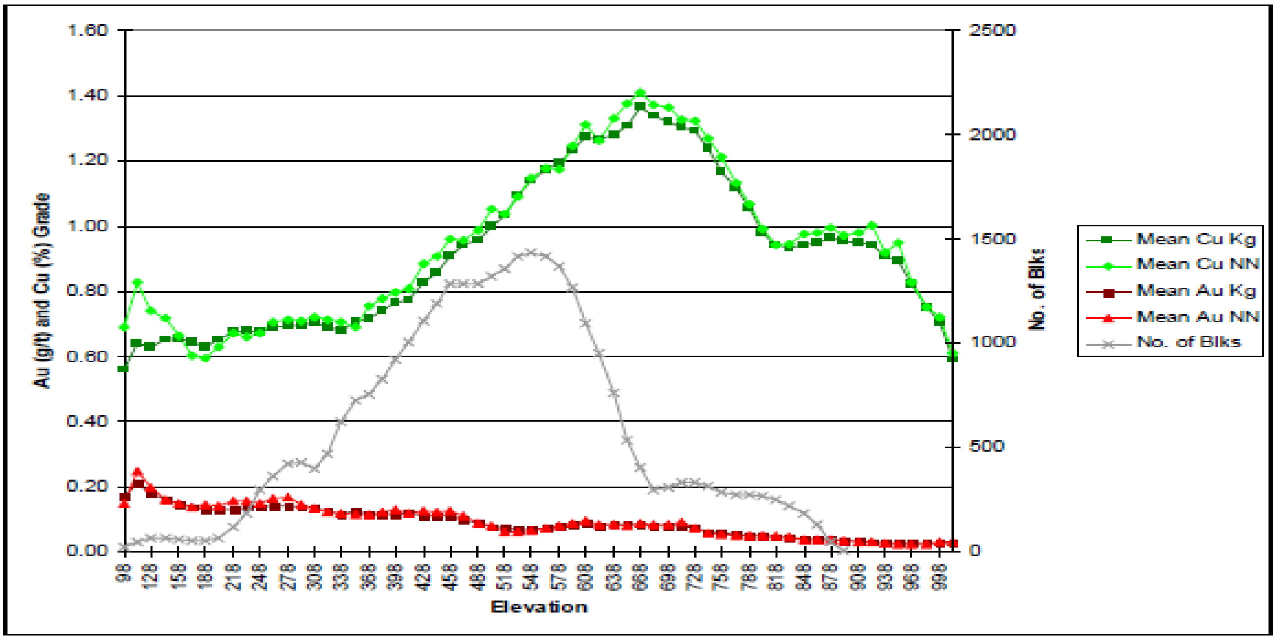
Source: Compiled by AMC from information provided by TRQ, Date: 30 June 2020

Figure 14.15 Hugo South grade by easting validation plot



Source: Compiled by AMC from information provided by TRQ, Date: 30 June 2020

Figure 14.16 Hugo South grade by elevation validation plot



Source: Compiled by AMC from information provided by TRQ, Date: 30 June 2020

Figure 14.14 to Figure 14.16 demonstrate that the kriged estimates are smoother than the nearest-neighbour estimates (as expected), and that trends in the NN models are honoured by the trends of the kriged estimates. The kriged estimates behaved as predicted and there is no evidence of bias on a local scale.

14.6.6.4 Validation of non-grade variables

The bulk density and metallurgical fields Ci, MBi and SPi were assessed using summary statistics by domain. No outliers or restrictions were placed on these estimates.

14.6.7 Resource definition

The base of 2019 copper equivalent formula incorporates copper, gold and silver as per the updated Base Data Template version 38. The assumed metal prices are 3.08 US$/lb for copper, 1,292 US$/oz for gold and 19.00 US$/oz for silver. Copper grade is expressed as percentage (%), and gold and silver grades are expressed as grams per tonne (g/t). Metallurgical recovery for gold and silver are expressed as percentage relative to copper recovery. The unit conversions used in the calculation are shown in Table 14.50 and Table 14.51. The metallurgical recovery assumptions are based on metallurgical testwork. Recoveries are relative to copper because copper contributes the most to the equivalent calculation.

All elements included in the copper equivalent calculation have a reasonable potential to be recovered and sold.

Table 14.50 Hugo South – CuEq assumptions

Variable	Cu (US$/lb)	Au (US$/oz)	Ag (US$/oz)
Metal prices	3.08	1292.00	19.00
Recovery	0.89	0.81	0.84
Recovery relative to Cu	1.00	0.91	0.95
Conversion	22.0462	0.0321507	0.0321507

Table 14.51 Hugo South – CuEq calculation

	Cu (%)	Au (g/t)	Ag (g/t)	CuEq (%)	Revenue (US$/t)
% Cu	1.00	–	–	1.00	$67.90
g/t Au	–	1.00	–	0.56	$37.78
g/t Ag	–	–	1.00	0.01	$0.58
Total	1.00	1.00	1.00	1.56	$106.26

From Table 14.50 and Table 14.51, the base formula is calculated by:

$$\mathrm{CuEq} = \mathrm{Cu} + ((\mathrm{Au} \times 1292 \times 0.03215 \times 0.810) + (\mathrm{Ag} \times 19.00 \times 0.03215 \times 0.84)) / (3.08 \times 22.0462)$$

$$= \mathrm{Cu} + ((\mathrm{Au} \times 37.78) + (\mathrm{Ag} \times 0.58)) / 67.9023$$

For the underground mine, the break-even cut-off grade needs to cover the costs of mining, processing, and G&A. A CuEq break-even underground cut-off grade of 0.41% for Hugo North was also used for Hugo South to tabulate its Mineral Resources. Inferred resources at Hugo South were constrained only by using a CuEq cut-off of 0.41%.

14.6.7.1 Derivation of cut-off grades

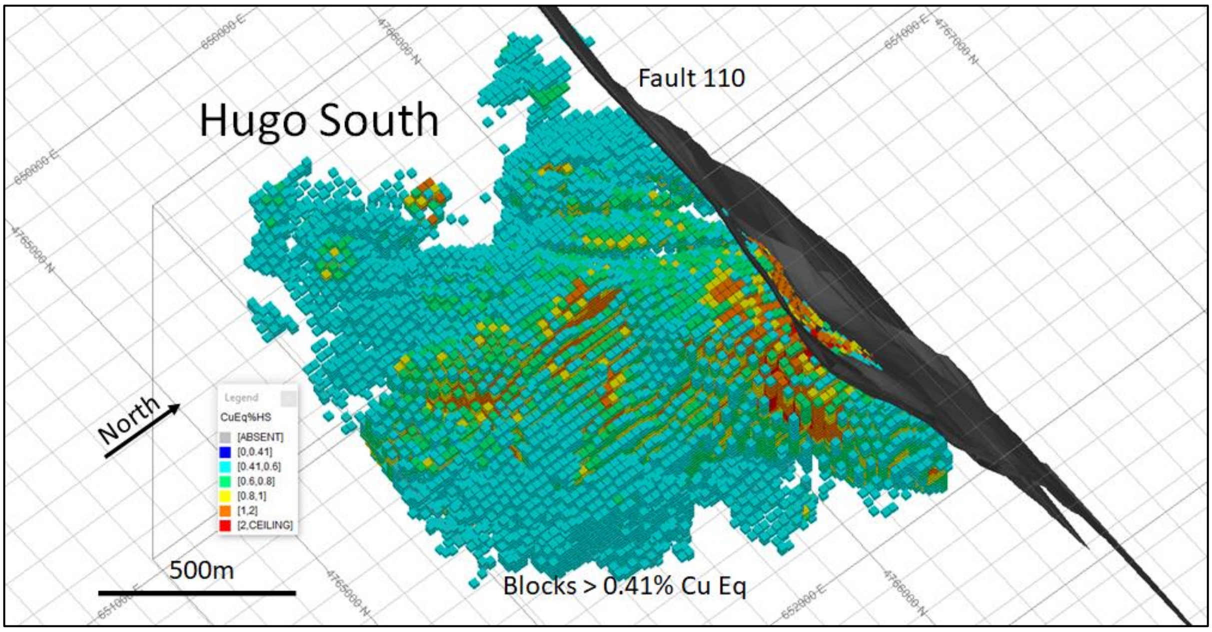
Cut-off grades for Hugo South were determined using assumptions defined for the Hugo North underground mine. The NSR per tonne of ore needs to equal or exceed the production cost of a tonne of ore for the mine to break even or make money.

For the underground mine, the break-even cut-off grade needs to cover the costs of mining, processing, andG&A. An NSR of 17.59 US$/t would be required to cover costs of 7.03 US$/t for mining, 7.64 US$/t for processing, and 2.92 US$/t for G&A. The CuEq break-even underground cut-off grade of approximately 0.41% CuEq has been used for Hugo South ore. This cut-off grade has been used for tabulating underground Mineral Resources in this report.

14.6.8 Classification

Hugo South has had all interpolated blocks >0.41% CuEq within 150 m of a drill composite and south of Fault 110 (field SDM 8000) classified as an Inferred Mineral Resource (see Figure 14.17). Blocks that were more than 150 m from a drillhole were not included in the mineral resource because the grade and geological continuity of resources defined by samples at this spacing cannot be reasonably assumed.

Figure 14.17 Hugo South block model isometric showing classified blocks (CuEq > 0.41%)



Source: Compiled by AMC from information provided by TRQ, Date: 30 June 2020. Projection UTM (WGS84) Z48N.

14.6.9 Reasonable prospects of eventual economic extraction

CIM Definition Standards require reported Mineral Resources to have reasonable prospects for eventual economic extraction. The following addresses this requirement for the Hugo South mineral resources. The Hugo South Mineral Resources as at 31 December 2019 are shown in Table 14.6.

The major constraint on demonstrating economic viability is timing of development. This requires further conceptual mine plans and costing. A 0.41% copper equivalent cut-off has been used and is considered appropriate based on selected underground block cave mining method. Further studies will be completed to determine if open pit or underground mining is viable for the Hugo South deposit.

The parameters and modifying factors used to derive the cut-off are discussed in Section 14.5.9.

14.7 Resource estimation – Heruga

The Mineral Resource estimate for the Heruga deposit was prepared by Stephen Torr of Ivanhoe Mines under the supervision of Scott Jackson and John Vann of Quantitative Group (QG). The estimates were in the form of three-dimensional block models utilizing commercial mine planning software (Datamine). The following summary is from the Ivanhoe June 2010 Technical Report (Ivanhoe 2010).

14.7.1 Modelling

The geological shapes for the deposits are listed in Table 14.52 and Table 14.53 for each deposit. Appropriate gold, copper and arsenic shells at various cut-off grades (Table 14.54) were also defined. These shapes were then edited on plan and section views to be consistent with the structural and lithological models and the drill assay data.

Checks on the structural, lithological, and grade shell models indicated that the shapes honoured the drillhole data and interpreted geology.

The lithological shapes and faults, together with copper and gold grade shells and deposit zones, constrain the grade analysis and interpolation. Typically, the faults form the first order of hard boundaries constraining the lithological interpretation.

The solids and surfaces were used to code the drillhole data. Sets of plans and cross-sections that displayed colour-coded drillholes were plotted and inspected to ensure the proper assignment of domains to drillholes.

Table 14.52 Heruga geological surfaces used in geological modelling

Model Component	Comment
Surfaces – General	
Topography	Project-wide
Base of Quaternary cover	Project-wide
Base of Cretaceous clays and gravels	Project-wide
Base of oxidation	Project-wide, but relevant only for Oyut
Base of supergene alteration	Project-wide, but relevant only for Oyut
Solids/Surfaces – Lithology	
Base of ash flow tuff (DA2a - Ign)	Project-wide
Base of unmineralized volcanic and sedimentary units; DA2b or DA3 or DA4	Project-wide. Used as a hanging wall limit to grade interpolation
Biotite-granodiorite (BiGd) dykes	Project-wide, most important in Hugo deposits, unmineralized unit
Rhyolite (Rhy) dykes	Project-wide, most important in Oyut zones, unmineralized unit

Table 14.53 Heruga fault surfaces used in geological modelling

Fault surfaces	Comment
Heruga North fault	East northeast trending fault. Constrains model to the north
West Bor Fault	Constrains model to the west
(Central) Bor Tolgoi Fault	Splits domains, and constrains model in part to the east
South Bor Tolgoi Fault	Splits domain, constrains model in part to the south

Table 14.54 Heruga grade shell construction parameters

Deposit	Zone	Grade shell		
		Au (ppm)	Cu (%)	As (ppm)
Heruga	Heruga	>0.3, >0.7	>0.3	–

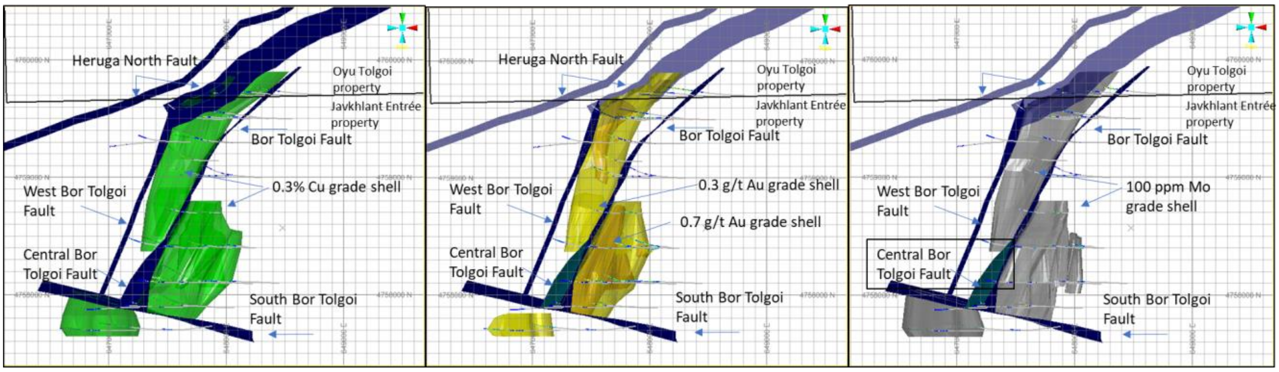
The Heruga assessment domains were constrained by lithology, fault boundaries, and copper and gold grade shells as shown in Table 14.55. The structures and grade shell modelling for three elements are shown in Figure 14.18.

Table 14.55 Heruga deposit domain codes

1st code		2nd code		3rd code	
Description	Code	Description	Code	Description	Code
West Bor Tolgoi	100	Inside grade shell (basic)	0	Va	0
East block Orebody	200	Inside 0.3 ppm Au grade shell	10	Qmd	3
Central block	300	Inside 0.6% Cu grade shell	10	And	8
West block Orebody	400	Inside 100 ppm Mo grade shell	10	BiGd	9
Bor Tolgoi south	500	Inside 0.7 ppm Au grade shell	20		

VA = augite basalt, QMD = quartz monzodiorite, And = andesite, Rhy = rhyolite, BiGd = biotite granodiorite

Figure 14.18 Heruga grade shell modelling and faults (left: copper, middle: gold, right: molybdenum)



Source: Compiled by AMC from information provided by TRQ, Date: 30 June 2020. Projection UTM (WGS84) Z48N.

14.7.2 Compositing

The drillhole assays were composited into fixed-length, down-hole composites at a size that was considered appropriate when considering estimation block size, required lithological resolution, and probable mining method. This compositing honoured the domain zones by breaking the composites on the domain boundary. The domains used in compositing were a combination of the grade shells and lithological domains. Composite lengths of 5 m lengths were used for Heruga.

Intervals of less than 5 m lengths represented individual residual composites from end-of-hole or end-of-domain intervals. Composites that were less than 2 m long are excluded from the dataset used in interpolation.

A post-processing step was applied to adjust negative or null composite values arising from non-assayed intervals. The intervals were not assayed due to:

- A lack of visible mineralization.
- Not logged intervals, such as the "parent" portion of a wedged daughter hole.
- "Navi" drill interval.
- The portion of a new drillhole for which assays are pending were replaced by lower detection limit for the valuable grade elements such as Cu, Au, and Ag.

The lower detection limits were also assigned to the intervals of non-logged that were not sampled due to a lack of visible mineralization for the deleterious elements.

For the Heruga deposit, the composites included any post-mineralization dyke material intervals that were deemed too small to be part of a dyke geology model. Any unsampled material included in the composites was set to:

- Cu 0.001%
- Au 0.01 g/t
- Mo 10 ppm

14.7.3 Statistics

14.7.3.1 Basic statistics

Copper grades within the 0.3% Cu shell generally displayed single distributions with some evidence of a lower-grade population due to the presence of unmineralized post-mineral dykes that had not been captured by wireframes. Coefficients of variation values were relatively low at 0.5% to 0.6%. The cumulative distribution function plot for the entire population supported the construction of a grade shell in the 0.3% to 0.4% Cu range.

Gold grades were observed to display moderate positive skewness and multiple populations with evidence of lower-grade populations in the range of 0.2 to 0.3 g/t Au.

Molybdenum grades within the 100 ppm Mo shell display low to moderate positive skewness and a single population distribution.

Bulk densities were assigned to a unique assay database file. This data was composited into 5 m fixed-length downhole values for the Heruga model.

The statistics of copper are summarized in Table 14.56 for the 5 m composites at Heruga. In the table, the coefficient of variation (CV), which is equal to the standard deviation divided by the mean, is a measure of relative variability. Extreme values or outliers were capped (top-cut) prior to compositing the data, which reduced both the skewness and the CV of the populations.

Table 14.56 Heruga statistics for 5 m composites Cu (%)

Lithology	Cu shell	Structural domain	No. of comps	Minimum	Maximum	Mean	CV
Va	Bkg	1000	114	0.001	0.37	0.03	1.55
Va	Bkg	2000	1058	0.001	3.11	0.19	0.93
LQmd	Bkg	2000	245	0.001	0.17	0.01	1.73
Va + Qmd	0.3%	2000	1246	0.001	2.91	0.52	0.57
Va	Bkg	3000	92	0.001	0.67	0.06	2.54
Va	Bkg	4000	579	0.001	1.21	0.17	0.97
Va	0.3%	4000	1051	0.001	1.88	0.52	0.51
LQmd	0.3%	4000	12	0.001	0.04	0.01	1.86
Va	Bkg	5000	175	0.001	0.51	0.10	0.85
Va	0.3%	5000	253	0.001	1.53	0.35	0.54

Va = basalt, Qmd = quartz monzodiorite, LQmd = Late quartz monzodiorite

14.7.3.2 Contact grade profile analysis

A strategy of soft, firm, and hard boundaries was utilized to account for domain boundary uncertainty (dilution) and to reproduce the input grade sample distribution in the block model. Soft boundaries allowed full sharing of composites between domains during grade estimation; firm boundaries allowed sharing of composites from within a certain distance of the boundary; and hard boundaries allowed no composite sharing between domains. Comparative basic statistics, such as mean grade, was carried out for each set of adjoining domains to establish the boundary as soft, firm, or hard. Contact plots and visual inspection of grade distributions were also used in cases where results were unclear or were contrary to geological interpretations.

Data analysis showed no discernible difference between the two main host lithologies, augite basalt and quartz–monzodiorite. For estimation purposes the two lithologies were grouped into a single lithological domain. The post-mineralization lithologies (LQmd, BiGd, HbBiAn), while represented in the block model, were not estimated, but rather were assigned zero grade. Within each structural block, the model was therefore split according to whether it was mineralized or unmineralized, and by grade shell.

14.7.3.3 Restriction of extreme grade values

As well as top-cutting of extreme grades, some outlier restriction was also applied for the Heruga deposit, particularly in the background domains. Top-cutting was generally applied at values close to or above the 99th percentile for gold and molybdenum. No top-cut was warranted for copper. Top-cut levels are shown in Table 14.57.

Table 14.57 Heruga outlier restrictions/grade caps (Au, Mo)

Domain	Top-cut threshhold	Outlier restriction threshold (g/t)	Top-cut threshhold	Outlier restriction threshold (ppm)
	Gold (g/t)		Molybdenum (ppm)	
Background domain 1000-4000	3.0	1.0	1,000	500
Background domain 5000	3.0	0.3	1,000	500
0.3 g/t Au shell domain 2000	3.0	–	–	–
0.3 g/t Au shell domain 4000	5.0	–	–	–
0.7 g/t Au shell domain 2000	10.0	–	–	–
100 ppm Mo shell	3000.0	–	–	–

14.7.4 Variography

Semi-variograms were calculated and modelled for all grade elements plus SG in Supervisor software. The variograms were modelled with either exponential models, spherical models, or a combination of exponential and spherical models. Two structures were typically used to model the variograms with a few exceptions where a single structure or, rarely, three structures were used. The orientations of multiple structures were typically "locked" in the same direction to aid visualization and for checking against geologic reasonableness. Practical ranges were used, where a "practical range" is the range at which 95% of the sill is reached, which is three times longer than the "traditional range" used in some software. The nugget values were generally determined from down-hole variograms. Directional variograms were typically calculated in at least 30-degree increments both horizontally and vertically.

A variety of strategies was applied where it was not possible to calculate robust variograms. These strategies included:

- Recalculating variograms using larger lags.
- Combining data from adjacent domains of reasonably similar properties. In some cases data were pooled to achieve reasonably robust variograms even where a hard or firm estimation boundary was likely to be used.
- Adopting the variogram model from a well-informed domain that was considered to have similar properties.
- Using the correlograms instead of variograms.
- Transforming variograms to normal scores (normal data distribution) before variogram calculation to improve the experimental variogram. The variograms and models were back-transformed to real space before being used for block grade estimation.

Copper and gold variograms show nuggets of 25% to 35% (relative) of the total variance, whereas molybdenum was moderate-to-high at 40% of the sill. All three metals showed relatively short first variogram structures and long second variogram structures of 250 m to 300 m. Copper, gold and molybdenum variogram values are shown in Table 14.58.

Table 14.58 Heruga variogram parameters

Parameter		Copper		Gold			Molybdenum	
		Grade shell	0.30%	Grade shell	0.3ppm	0.7ppm	Grade shell	100 ppm
		Sph	Sph	Exp	Exp	Exp	Exp	Exp
Sill	Nugget	0.32	0.4	0.33	0.37	0.25	0.41	0.41
	C1	0.27	0.37	0.42	0.2	0.53	0.23	0.37
	C2	0.41	0.23	0.25	0.43	0.22	0.36	0.32
Rotation	Z	105	127	−153	180	−155	−160	−175
	X	49	68	−10	0	−70	−5	−9
	Y	168	26	80	−110	90	90	60
Range	Y1	80	40	50	15	250	100	100
	X1	80	40	50	15	40	100	100
	Z1	40	40	40	15	30	100	103
	Y2	447	352	250	200	450	418	461
	X2	510	274	200	200	180	445	265
	Z2	204	257	200	200	130	252	207

14.7.5 Estimation

14.7.5.1 Model setup

The block size selected was 20 m by 20 m by 15 m. This allowed consistency with previous modelling at the Oyu Tolgoi deposits and is considered a suitable block size for mining studies using the block cave approach. The block model limits are shown in Table 14.59.

Table 14.59 Heruga block model limits

Block model limits	X	Y	Z
Origin (UTM)	646500	4757500	-700
Offset (m)	2060	2400	1950
Block size (m)	20	20	15
Parent block count	103	120	130

To accurately account for the volume of post mineral dyke material, sub-celling of the larger blocks was used when tagging the model with dyke wireframes. Each block was allowed to be split into four smaller cells in the x, y and z dimensions. Subcells were also permitted at grade shell boundaries to allow some smoothing of grades across the contact.

Various coding on the block models was performed in preparation for grade interpolation. The block model was coded according to zone, lithological domain, and grade shell. Post-mineral dykes and the late quartz-monzodiorite were assumed to represent zero-grade waste cutting the mineralized lithologies.

14.7.5.2 Grade estimation

Modelling consisted of grade interpolation by Ordinary Kriging. As part of the model validation, grades were also interpolated using nearest-neighbour, ID3, and OK of uncapped composites. Density was interpolated by ID3. The search ellipsoids were oriented preferentially to the general trend of the grade shells. (Table 14.60).

Table 14.60 Heruga search ellipsoids

	Z	X	Y	Range X (m)	Range Y (m)	Range Z (m)	Minimum samples per estimation	Maximum samples per estimation	Maximum samples per drillhole
Pass 1	-65	-80	0	200	200	100	8	30	6
Pass 2	-65	-80	0	400	400	200	8	30	6
Pass 3	-65	-80	0	400	400	200	6	30	6

14.7.6 Validation of estimation

14.7.6.1 Visual inspection of estimates

A detailed visual validation of the Heruga resource model was undertaken by Ivanhoe and QG, and it was found that tagging of the drill data file and the block model was done correctly. The model was also checked in plan and section to ensure that the grade interpolation accurately reflected the original drill assays. The grade shells appear to have adequately constrained the high values and no evidence of excessive smearing of high grades in the background was observed. In some areas the model showed evidence of nearest-neighbour striping due to a lack of data, although these areas were excluded when tagging the resource model for classification.

QG also built a model from scratch using the same wireframes and drill data used in the Ivanhoe model. Gold, copper and molybdenum were interpolated using independently generated variograms and search parameters. QG compared the two estimates and considered they were within acceptable limits, adding support to the Ivanhoe estimate. Minor differences noted in the resultant models were attributed to slight differences in variograms and search parameters.

14.7.6.2 Global bias check

The block model estimates were checked for global bias by comparing the average metal grades from the model with means from unrestricted nearest-neighbour estimates. The nearest-neighbour estimator declusters the data and produces a theoretically unbiased estimate of the average grade when no cut-off grade is imposed and is a good basis for checking the global performance of different estimation methods. The results, which are summarized in Table 14.61, show no evidence of global bias in the estimates.

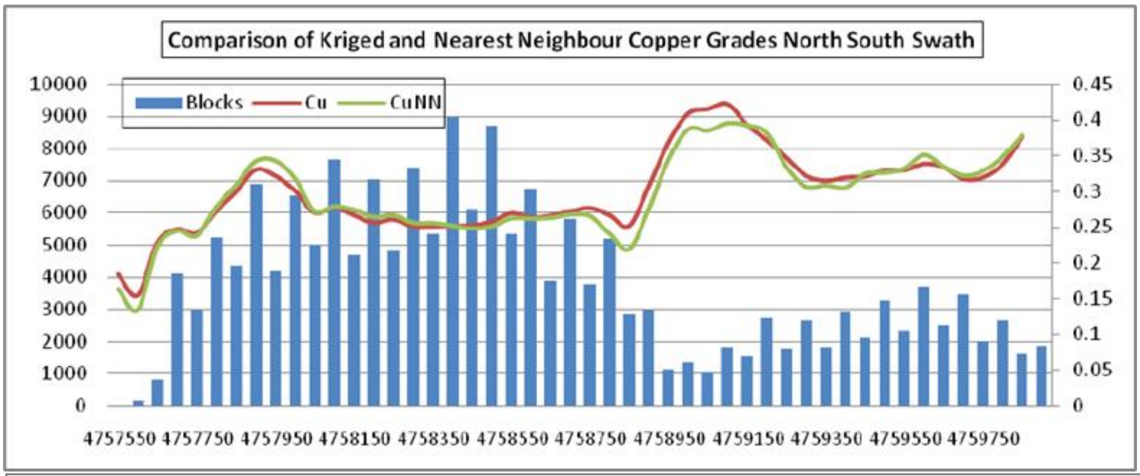
Table 14.61 Heruga model mean grade values by domain in each zone

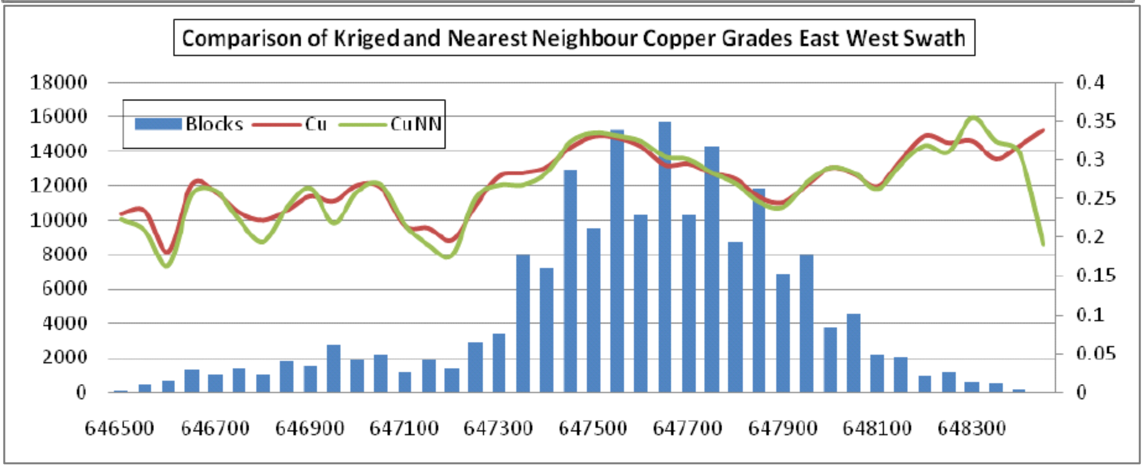
Domain/Zone	Kriged	Nearest-neighbour	Unrestricted kriged	Metal reduction
		Copper		
Background	0.18	0.18	0.18	0%
0.3% Shell	0.39	0.39	0.39	0%
All blocks	0.29	0.29	0.29	0%
Gold				
Background	0.15	0.16	0.18	-16%
0.3 g/t Au Shell	0.36	0.35	0.36	-2%
0.7 g/t Au Shell	0.94	0.92	1.00	-5%
All blocks	0.27	0.27	0.29	-9%
Molybdenum				
Background	46	46	48	-3%
100 ppm shell	165	163	165	0%
All blocks	83	83	85	-1%

14.7.6.3 Local bias check

The resource model was also checked for trends and local bias using 50 m swath plots that compared the restricted kriged estimates to nearest-neighbour estimates (Figure 14.19 and Figure 14.20). The nearest-neighbour estimates act as an unbiased declustered sample population and comparison should highlight areas of potential bias in the kriged estimate. The plots also show the number of model blocks in each 50 m swath.

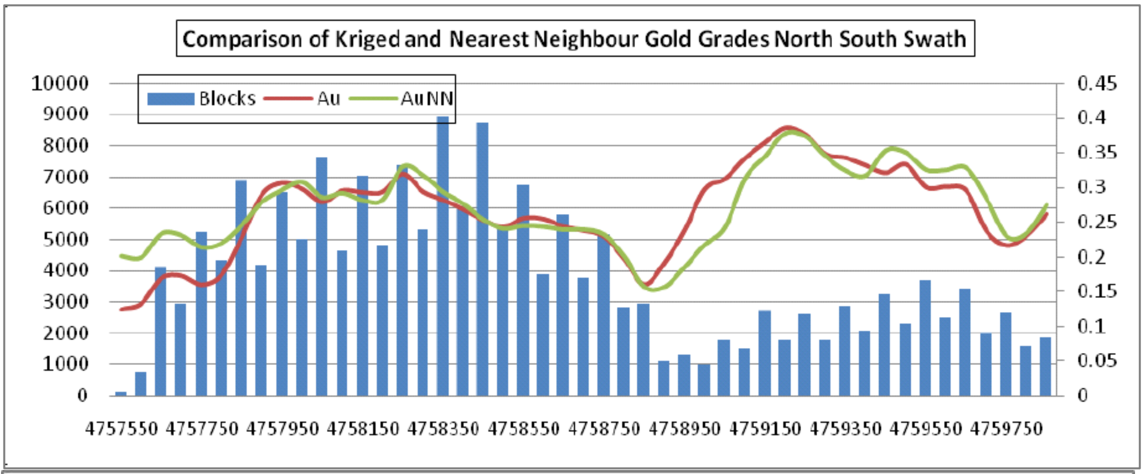
Figure 14.19 Heruga copper swath pots (N-S and E-W)

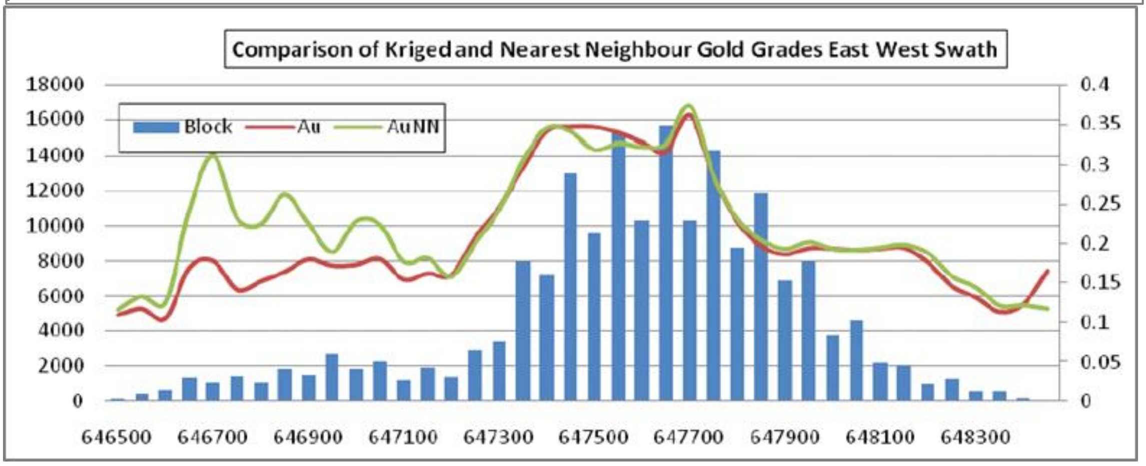




Source: Compiled by AMC from information provided by TRQ, Date: 30 June 2020

Figure 14.20 Heruga gold swath pots (N-S and E-W)





Source: Compiled by AMC from information provided by TRQ, Date: 30 June 2020

14.7.6.4 Validation of non-grade variables

The bulk density and metallurgical fields Ci, MBi and SPi were assessed using summary statistics by domain. No outliers or restrictions were placed on these estimates.

14.7.7 Resource definition

The base of 2019 copper equivalent formula incorporates assumed metal prices of 3.08 US$/lb for copper, 1,292 US$/oz for gold and 19.00 US$/oz for silver. Copper grade is expressed as percentage (%) and gold and silver grades are expressed as grams per tonne (g/t), and molybdenum grades are expressed as parts per million (ppm). Metallurgical recovery for gold and silver are expressed as percentage relative to copper recovery. The unit conversions used in the calculation are shown in Table 14.62. The metallurgical recovery assumptions are based on metallurgical testwork. Recoveries are relative to copper because copper contributes the most to the equivalent calculation.

All elements included in the copper equivalent calculation have a reasonable potential to be recovered and sold. Copper equivalence assumptions and calculations for Heruga are shown in Table 14.62 and Table 14.63.

Table 14.62 Heruga – CuEq assumptions

Variable	Cu (US$/lb)	Au (US$/oz)	Ag (US$/oz)	Mo (US$/lb)
Metal prices	3.08	1292.00	19.00	10.00
Recovery	0.82	0.73	0.60	0.60
Recovery relative to Cu	1.00	0.89	0.95	0.73
Conversion	22.0462	0.032151	0.032151	0.002205

Table 14.63 Heruga – CuEq calculation

	Cu (%)	Au (g/t)	Ag (g/t)	Mo (ppm)	CuEq (%)	Revenue (US$/t)
% Cu	1.00	–	–	–	1.00	$67.90
g/t Au	–	1.00	–	–	0.56	$37.78
g/t Ag	–	–	1.00	–	0.01	$0.58
ppm Mo	–	–	–	1.00	0.0002	$0.02
Total	1.00	1.00	1.00	1.00	1.53	$106.26

From Table 14.62 and Table 14.63, the base formula is calculated by:

$$\begin{aligned} CuEq &= Cu + ((Au \times 1292 \times 0.03215 \times 0.89) + (Ag \times 19.00 \times 0.03215 \times 0.95) + (Mo \times 10.00 \times 0002204 \times 0.73)) \\ &\quad / (3.08 \times 22.0462) \\ &= Cu + ((Au \times 37.10) + (Ag \times 0.58) + (Mo \times 0.02)) / 67.9023 \end{aligned}$$

Cut-off grades were determined using assumptions defined within the company. The NSR per tonne of ore needs to equal or exceed the production cost of a tonne of ore for the mine to break even or make money. For the underground mine, the break-even cut-off grade needs to cover the costs of mining, processing, and G&A. A CuEq break-even underground cut-off grade of 0.41% has been used for Heruga to tabulate its Mineral Resources.

14.7.7.1 Derivation of cut-off grades

Cut-off grades for Heruga were determined using assumptions defined for the Hugo North underground mine. The NSR per tonne of ore needs to equal or exceed the production cost of a tonne of ore for the mine to break even or make money.

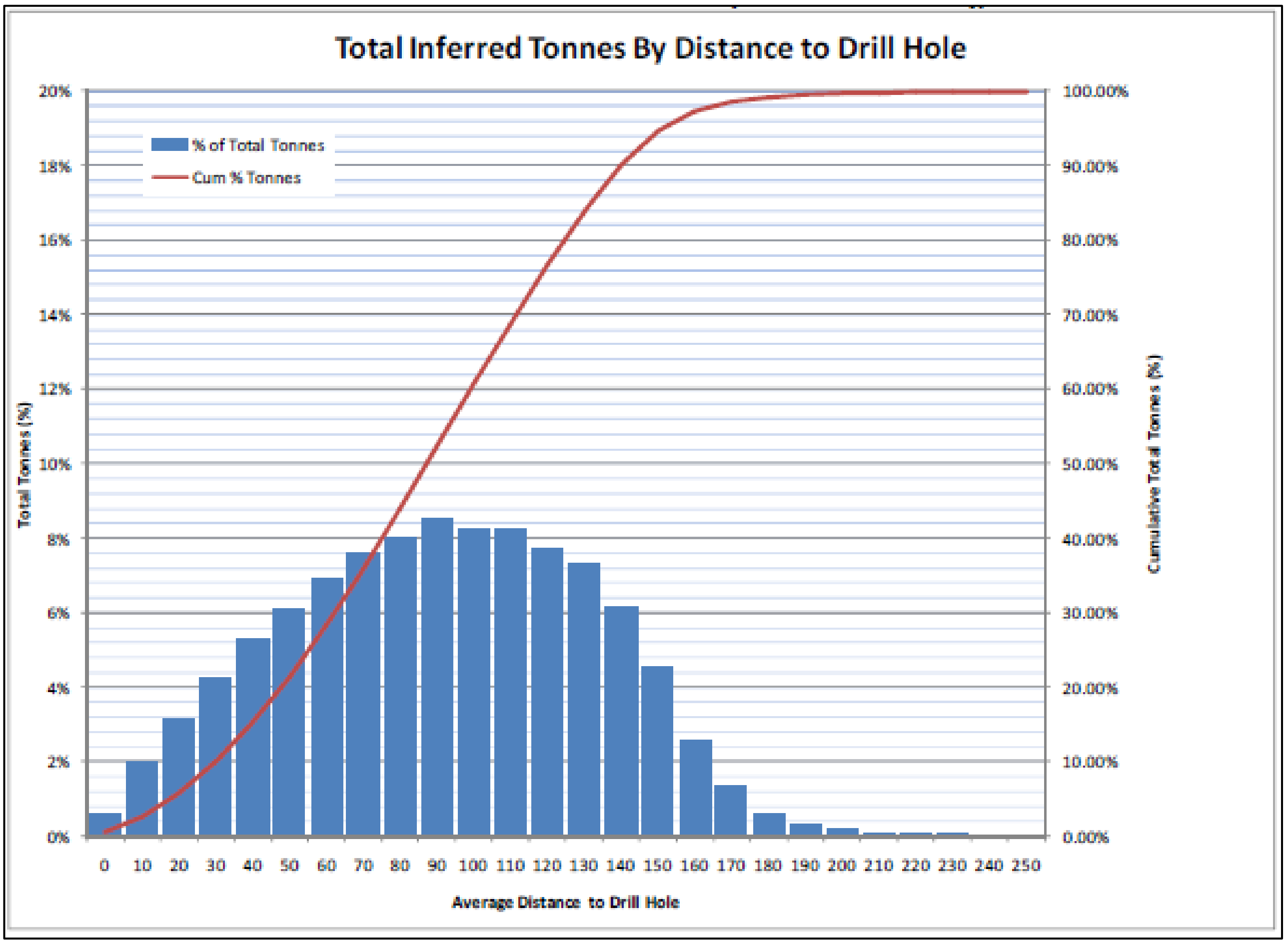
For the underground mine, the break-even cut-off grade needs to cover the costs of mining, processing, and G&A. An NSR of 17.59 US$/t would be required to cover costs of 7.03 US$/t for mining, 7.64 US$/t for processing, and 2.92 US$/t for G&A. The CuEq break-even underground cut-off grade of approximately 0.41% CuEq has been used for Heruga ore. This cut-off grade has been used for tabulating underground Mineral Resources in this report.

14.7.8 Classification

There are no Measured or Indicated Mineral Resources at Heruga.

Heruga classified blocks within 150 m of a drillhole initially as an Inferred Resource. A three-dimensional wireframe was constructed inside of which the nominal drill spacing was less than 150 m. The shape aimed to remove isolated blocks around drillholes where continuity of mineralization could not be confirmed. Within the 150 m shape there were a small number of blocks that were greater than 150 m from a drillhole. These were included because it was considered that geological and grade continuity could be reasonably inferred within the main part of the mineralized zone. The average distance of all the Inferred blocks in the resource model is displayed in the plot below. Of the total tonnes classified as Inferred approximately 95% are within 150 m of a drillhole while the average distance of the inferred blocks is approximately 100 m (Figure 14.21).

Figure 14.21 Heruga total Inferred Resource tonnes by distance



Source: Compiled by AMC from information provided by TRQ, Date: 30 June 2020

14.7.9 Reasonable prospects of eventual economic extraction

CIM Definition Standards require reported Mineral Resources to have reasonable prospects for eventual economic extraction. The following addresses this requirement for the Heruga mineral resources.

The Heruga deposit Mineral Resources, based on drilling as of 13 February 2008, at a CuEq cut-off of 0.41% are shown in Table 14.7. Owing to the split ownership of Heruga, material on the wholly owned Oyu Tolgoi licence is reported separately from that subject to the Oyu Tolgoi LLC - Entrée LLC joint venture arrangements.

The parameters and modifying factors used to derive the cut-off is discussed in Section 14.5.9.

15 Mineral Reserve estimates

15.1 Mineral Reserves

The Mineral Reserves were prepared in accordance with the CIM Definition Standards (2014) and the requirements of NI 43-101.

The Mineral Reserves are based on mine planning work, including the development of modifying factors and cost estimates prepared by Oyu Tolgoi LLC as part of the 2020 Feasibility Study. Preparation of the Mineral Reserves was guided by the CIM Best Practice Guidelines (2019).

Mineral Reserves have been estimated for the Oyut deposit and for the Lift 1 of the Hugo North deposit using the Oyut and Hugo North Mineral Resources reported in Section14. No mineral reserves have yet been estimated for the Hugo South and Heruga deposits.

The Mineral Reserves for the Project as of 31 December 2019 are shown in Table 15.1 (Oyut open pit), Table 15.2 (surface stockpile) and Table 15.3 (Hugo North underground). The total Mineral Reserve for the Project is shown in Table 15.4. The Mineral Reserves are further discussed in Sections 1 (Oyut open pit), 15.1.2 (surface stockpile) and 15.1.3 (Hugo North underground). Metallurgical recoveries used in preparing these estimates are described in Section 15.1.4. Values in the Mineral Reserve tables have been rounded to two significant figures in line with industry best practices. This may result in differences to previously reported values.

The NSR is an estimate of the revenue generated by the sale of concentrate at the "mine gate" that would be derived from a parcel of in situ mineralization if it were mined and processed. The NSR accounts for the metallurgical recovery of metals to concentrate and all off-site costs associated with concentrate transportation, smelter deductions, treatment and refining charges, and royalties. The cost of mining and processing the parcel of mineralization, and the site G&A costs that can be assigned to the parcel are not included in the NSR calculation. The NSR is used to rank the value of the parcel and defines ore and waste through application of a cut-off NSR value for each ore type.

The metal prices and concentrate transport, smelting, and refining costs used for estimating the NSR are based on the long-term metal prices and costs prepared by Oyu Tolgoi LLC in late 2019. The NSR calculation uses the geometallurgical criteria and operating costs described in Sections 17 and 21 of this technical report. The economic viability of the Mineral Reserves was demonstrated using the same cost and revenue assumptions used to determine the NSR values. The economic viability of the Mineral Reserves was also demonstrated at a range of metal price assumptions, including a 10% reduction in the long-term copper price used to estimate the NSR values. The sensitivities of the economic viability of the Mineral Reserves to changes in cost and revenue assumptions is reported in Section 22 "Economic Analysis".

The estimate of Mineral Reserves may be materially affected by environmental, permitting, legal, title, sociopolitical, marketing, or other relevant issues including risks set forth in this Technical Report and in other filings made by TRQ with Canadian securities regulatory authorities and available at www.sedar.com.

Table 15.1 Oyut open pit Mineral Reserve as of 31 December 2019

Classification	Ownership	Mineral Reserve				Contained Metal		
		(Mt)	Cu (%)	Au (g/t)	Ag (g/t)	Cu (Mt)	Au (Moz)	Ag (Moz)
Proven	Oyu Tolgoi LLC	310	0.52	0.39	1.3	1.6	3.8	13
Probable	Oyu Tolgoi LLC	480	0.39	0.23	1.1	1.9	3.5	17
Total (Proven + Probable)	Oyu Tolgoi LLC	780	0.44	0.29	1.2	3.5	7.2	30

See notes for Table 15.4

Table 15.2 Oyut surface stockpile Mineral Reserve as of 31 December 2019

Classification	Ownership	Mineral Reserve				Contained metal		
		(Mt)	Cu (%)	Au (g/t)	Ag (g/t)	Cu (Mt)	Au (Moz)	Ag (Moz)
Proven	Oyu Tolgoi LLC	48	0.33	0.12	0.93	0.16	0.19	1.40

See notes for Table 15.4

Table 15.3 Hugo North underground Mineral Reserve as of 31 December 2019 (updated 30 June 2020)

Classification	Ownership	Mineral Reserve				Contained metal		
		(Mt)	Cu (%)	Au (g/t)	Ag (g/t)	Cu (Mt)	Au (Moz)	Ag (Moz)
Probable	Oyu Tolgoi LLC	400	1.5	0.29	3.1	6.0	3.8	40
Probable	Entrée LLC	40	1.5	0.53	3.6	0.6	0.7	4.6
Total Probable		440	1.5	0.32	3.2	6.7	4.5	45

See notes for Table 15.4.

Table 15.4 Total Oyu Tolgoi Mineral Reserve as of 31 December 2019 (updated 30 June 2020)

Classification	Mineral Reserve				Contained metal		
	(Mt)	Cu (%)	Au (g/t)	Ag (g/t)	Cu (Mt)	Au (Moz)	Ag (Moz)
Proven	350	0.49	0.35	1.3	1.7	4.0	14
Probable	920	0.93	0.27	2.1	8.5	7.9	62
Total (Proven + Probable	1,270	0.81	0.29	1.9	10	12	77

Notes applying to the Mineral Reserves:

1. Totals may not match due to rounding to two significant figures in line with industry best practice.
2. CIM Definition Standards (2014) are used for reporting of Mineral Reserves.
3. The effective date of the Oyut open pit and surface stockpile Mineral Reserve is 31 December 2019. The effective date of the Hugo North Mineral Reserve is 31 December 2019 (updated on 30 June 2020).
4. The Oyut Mineral Reserve is currently being mined by open pit mining methods. The Stockpile Mineral Reserve is on surface close to the Oyut open pit. The Hugo North Mineral Reserve will be mined by underground mining methods.
5. NSR values used for estimating Mineral Reserves are based on forecast long-term copper, gold, and silver prices of 3.08 US$/lb, 1,292 US$/oz, and 19.00 US$/oz, respectively.
6. Assumptions for smelting refining and treatment, charges, deductions, and payment terms, concentrate transport, metallurgical recoveries and royalties are included in the NSR values.
7. For the Oyut Mineral Reserve, processing and G&A costs used to determine NSR cut-off values vary between 7.18 US$/t and 10.14 US$/t depending on the ore type processed.
8. For the Hugo North Mineral Reserve, an NSR shut off grade of 17.84 US$/t is used to determine the point at which each underground drawpoint is closed. This NSR value is based on estimated mining, processing and G&A costs which range from 17.27 US$/t to 17.90 US$/t across the five different ore types.
9. For the Oyut deposit, the Proven Mineral Reserve is derived only from Measured Mineral Resources. The Probable Mineral Reserve is derived only from Indicated Mineral Reserves.
10. For the Hugo North deposit, the Probable Mineral Reserve is derived from a combination of Measured and Indicated Mineral Resources.
11. The Shivee Tolgoi Licence and the Javkhlant Licence are held by Entrée LLC. The Shivee Tolgoi Licence and the Javkhlant Licence are planned to be operated by Oyu Tolgoi LLC. Oyu Tolgoi LLC will receive 80% of cash flows after capital and operating costs for material originating below 560 m and 70% above this depth TRQ holds a 7.9% interest in Entrée Resources Ltd.
12. The term Entrée LLC refers to ownership by the proposed joint venture arrangement between Oyu Tolgoi LLC and Entrée LLC.
13. The Hugo North Mineral Reserve has been updated from that reported in TRQ's AIF dated 31 March 2020 and reflects changes in the Hugo North Lift 1 Panel 0 design. No mineral reserves were mined from Hugo North between 31 December 2019 and 30 June 2020 other than a small (non-material) quantity of development ore.
14. The Total Oyu Tolgoi Mineral Reserve combines the Oyut Mineral Reserve as of 31 December 2019 with Hugo North Mineral Reserve as of 31 December 2019 updated on 30 June 2020.

15.1.1 Oyut open pit Mineral Reserve

The Oyut open pit Mineral Reserve was estimated from the 2018 Mineral Resource block model, which forms the basis of the Oyut Mineral Resource as at 31 December 2019, as described in Section 14. The Mineral Reserve is contained within an open pit design prepared in 2019 as described in Section 16.

The Mineral Reserve pit contains Inferred Resources that are ignored in the declaration of Mineral Reserves. Given their location within the reserve pit, these blocks will be accessible to mining and, provided they are above cut-off, have reasonable prospects of future economic extraction.

The NSR cut-off grades by ore type used for the Oyut Mineral Reserve are summarized in Table 15.5.

No change to the Oyut Mineral Reserve has occurred since the reporting date other than from depletion by mining.

Table 15.5 Oyut Mineral Reserve NSR cut-off grade by ore type

Ore type	Ore description	NSR cut-off (US$/t)
Hard Gold	Hard chalcopyrite / bornite, high copper and gold recovery, low arsenic bearing.	10.14
Hard	Hard chalcopyrite / bornite, high copper and low to moderate gold recovery, low arsenic bearing.	10.09
Moderate Gold	Moderate hardness chalcopyrite / bornite, high copper and gold recovery, low arsenic bearing.	9.06
Moderate	Moderate hardness chalcopyrite / bornite, high copper and low to moderate gold recovery, low arsenic bearing.	8.77
Soft Supergene Enargite	Soft chalcocite, low to moderate copper and gold recovery, high copper-arsenic sulfosalts.	7.18
Soft Supergene	Soft chalcocite, low to moderate copper and gold recovery, copper-arsenic sulfosalts.	7.31
Soft Hypogene Enargite	Soft covellite / chalcopyrite, high copper and low to moderate gold recovery, high copper-arsenic sulfosalts.	7.66
Soft Hypogene	Soft covellite / chalcopyrite, high copper and low to moderate gold recovery, copper-arsenic sulfosalts.	7.39
Soft Hypogene Gold	Soft covellite / chalcopyrite, high copper and gold recovery, copper-arsenic sulfosalts.	7.29

15.1.2 Surface stockpile Mineral Reserve

The surface stockpile Mineral Reserve originates from mineral resources mined from the Oyut open pit and placed on high-grade, medium-grade and low-grade stockpiles. The stockpiles were subjected to detailed sampling during the mining process and are classified as a Proven Mineral Reserve. The stockpiles will be recovered and processed mostly after processing higher-grade ore from the open pit fed directly to the processing plant.

15.1.3 Hugo North underground Mineral Reserve

The Hugo North Mineral Reserve is an update to the Mineral Reserve previously reported by TRQ in the 2019 AIF. The updated Hugo North Mineral Reserve reflects changes to the underground mine design that were finalized since publication of the 2019 AIF. The design changes are described in Section 16.3.

The Hugo North Mineral Reserve has been estimated from the mineral resource block model that forms the basis of the Hugo North Mineral Resource as at 31 December 2019 as described in Section 14. The Mineral Reserve is based on mining Lift 1 of the Hugo North deposit using the same caving method as envisaged in the 2016 Technical Report.

The boundary of the mining footprint[14] is based on an analysis of the net present value (NPV) generated from numerous production schedules generated by applying a range of footprint boundaries and cut-off values. The final reserve footprint boundary was selected based on consideration of the constructability and operability aspects of the footprint and the overall NSR value generated by the footprint.

The NSR in the mineral resources model used to establish the footprint boundary is based on metal prices of 3.08 $US/lb for copper, 1,292 $US/oz for gold, and 19.00 $US/oz for silver. The NSR values also consider the various metallurgical recovery formulas developed from test work on the Hugo North mineralization and ongoing process plant operations.

A break-even shut-off policy is used to define the draw column heights. The shut-off parameters are based on the unit cost estimates shown in Table 15.6. The processing cost is the tonnage weighted average cost of processing each ore type. Mining costs include 3.00 US$/t for sustaining capital. The costs exclude management fees and site services costs.

Table 15.6 Hugo North costs used to estimate the shut-off grade

Costs centre	Cost (US$/t)
Processing	7.60
G&A	3.21
Subtotal	10.81
Hugo North underground mining	7.03
Total	17.84

Note: Totals may not match due to rounding

The width of the footprint in the northern area of the cave is designed at a minimum mining width of 180 m to ensure adequate cave propagation. Some low value drawpoints were added to the footprint in this area to meet this minimum width criteria. The height of draw in these drawpoints has been limited to 100 m to minimize the quantity of waste drawn while ensuring full cave propagation.

The ore recovered from the caving process was modelled using PCBC, a cave modelling software package commonly used for estimating mineral reserves in block caving operations. Key inputs to the PCBC cave model are shown in Table 15.7.

Table 15.7 Hugo North key input parameters to PCBC cave model

Parameters	Value
Maximum draw column height	650 m
Minimum draw column height	100 m
Average draw column height	366 m
Height of interaction zone	200 m
Draw zone width	30 m
Drawpoint layout	El Teniente style
Extraction drive spacing	31 m
Drawpoint spacing	18 m

A geological hazard risk rating, guided by numerical stress modelling, was applied across the mining footprint to estimate the risk of premature drawpoint failure. This indicated that 20% of drawpoints can be expected to fail permanently before the full economic column could be drawn.

[14] The mining footprint is the horizontal projection of the part of the deposit that is to be mined to recover the mineral reserves. The size and shape of the mining footprint is established by analysing the value of the material that can be recovered by making the footprint either larger or smaller.

And 50% of drawpoints within the influence of the lower fault zone can be expected to fail prior to drawing any cave material.

Approximately 5% of the tonnage included in the Mineral Reserve is dilution originating from Inferred Mineral Resources. The grades of this material have been set to zero to ensure that only metal originating from Measured and Indicated Mineral Resources is included in the Mineral Reserve estimate.

Even though a portion of the Mineral Reserve originates from Measured Mineral Resources, the entire Hugo North Mineral Reserve is classified as Probable Mineral Reserves due to the mixing of material and the uncertainties associated with the caving process and the associated modifying factors.

15.1.4 Recovery of metal to concentrate

Copper recovery for the Oyut open pit varies based on copper grade and ore type. Ore type defines the expected copper speciation and the relationship between copper grade and copper recovery is different for each ore type. Gold and silver recovery are predicted based on observed performance in the concentrator, supported by metallurgical testwork.

Copper recovery for Hugo North varies based on the copper grade and ore types. Both gold and silver recovery vary with copper recovery and ore type. It is noted that silver only makes a small contribution to the value of the mineral reserve.

After processing, the estimated recovery of metal to copper concentrate from the Oyu Tolgoi Mineral Reserves are shown in Table 15.8.

Table 15.8 Estimate of metal contained in concentrate from each ore source

Mineral Reserve	Ownership	Recovery			Metal in concentrate		
		Cu (%)	Au (%)	Ag (%)	Cu (Mt)	Au (Moz)	Ag (Moz)
Oyut open pit	Oyu Tolgoi LLC	78	67	52	2.7	4.8	16
Stockpiles	Oyu Tolgoi LLC	73	44	47	0.1	0.1	1
Hugo North	Oyu Tolgoi LLC	93	79	80	5.6	3.0	32
Hugo North	Entrée LLC	92	81	83	0.6	0.5	4
Total Hugo North	Oyu Tolgoi LLC + Entrée LLC	93	79	80	6.2	3.5	36
Total Project	Oyu Tolgoi LLC + Entrée LLC	87	71	69	9.0	8.5	52

Note: Totals may not match due to rounding.

15.2 Changes to the Mineral Reserves

The difference between the Hugo North Mineral Reserve as of 31 December 2019 reported in the 2019 AIF, and the Hugo North Mineral Reserve as of 31 December 2019 Updated 30 June 2020 is shown in Table 15.9.

Table 15.9 Hugo North Mineral Reserves changes

Mineral Reserve as at	Classification	(Mt)	Grade			Contained metal		
			Cu (%)	Au (g/t)	Ag (g/t)	Cu (Mt)	Au (Moz)	Ag (Moz)
31 December 2019 reported in the 2019 AIF	Probable (Oyu Tolgoi LLC)	450	1.6	0.34	3.3	7.3	4.8	48
	Probable (Entrée LLC)	32	1.6	0.57	3.8	0.5	0.6	4
	Total Probable	480	1.6	0.35	3.4	7.9	5.4	52
31 December 2019 (updated 30 June 2020)	Probable (Oyu Tolgoi LLC)	400	1.5	0.29	3.1	6.0	3.8	40
	Probable (Entrée LLC)	40	1.5	0.53	3.6	0.6	0.7	5
	Total Probable	440	1.5	0.32	3.2	6.7	4.5	45
Difference	Probable (Oyu Tolgoi LLC)	-47	-0.13	-0.04	-0.24	-1.3	-1.0	-8.1
	Probable (Entrée LLC)	8	-0.10	-0.04	-0.21	0.1	0.1	0.7
	Total Probable	-39	-0.13	-0.04	-0.22	-1.2	-0.9	-7.4
Percent change	Probable (Oyu Tolgoi LLC)	-11%	-8%	-12%	-7%	-18%	-21%	-17%
	Probable (Entrée LLC)	24%	-6%	-6%	-5%	16%	16%	17%
	Total	-8%	-8%	-10%	-7%	-15%	-17%	-14%

Notes applying to the Mineral Reserve tables:

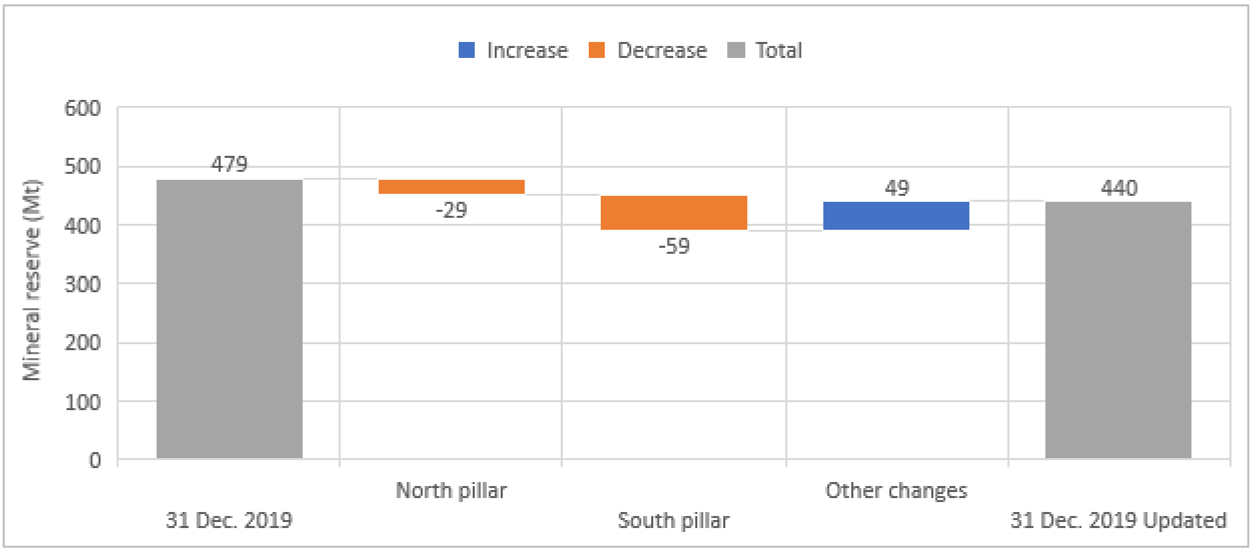
1. Totals may not match due to rounding to two significant figures in line with industry best practice.
2. CIM Definition Standards (2014) were used for reporting of Mineral Reserves.
3. The Mineral Reserves have an effective date of 31 December 2019 (updated on 30 June 2020).
4. NSR values used for Mineral Reserves estimation are based on forecast long-term copper, gold, and silver prices of 3.08 $/lb; 1,292 $/oz; and 19.00 $/oz respectively.
5. Assumptions for smelting refining and treatment charges, deductions, and payment terms, concentrate transport, metallurgical recoveries and royalties are included in the NSR values.
6. An NSR shut off grade of 17.84 $/t is used to determine the point at which each underground drawpoint is closed. This NSR value is based on an estimated mining, processing and G&A costs ranging from 17.27 $/t to 17.90 $/t across five independent ore types.
7. Measured and Indicated Mineral Resources were used to report Probable Mineral Reserves.
8. The Shivee Tolgoi License and the Javkhlant License are held by Entrée LLC. The Shivee Tolgoi License and the Javkhlant License are planned to be operated by Oyu Tolgoi LLC. Oyu Tolgoi LLC will receive 80% of cash flows after capital and operating costs for material originating below 560 m, and 70% above this depth. TRQ holds a 7.9% interest in Entrée Resources Ltd.

The changes to the Hugo North Probable Mineral Reserve resulting from the update at 30 June 2020 result from the redesign of Panel 0 and Lift 1. These changes are discussed in Section 16.3 and are summarized below:

- Redesign of Panel 0 to leave pillars separating Panel 0 from Panels 1 and 2.
- Realignment of the drawpoints, including an increase in the drawpoint spacing from 16 m to 18 m.
- Adjustment to the boundary of the footprint in some areas to improve the stability of the excavations in the vicinity of the footprint and to improve the expected caving characteristics. This resulted in the addition and deletion of some drawpoints from the planned footprint.
- Change to the draw zone width from 19.5 m to 30 m
- Allowance made for the premature failure of 50% of drawpoints within the influence of the lower fault zone.
- Change to the draw zone width from 19.5 m to 30 m.
- Allowance made for the premature failure of 50% of drawpoints within the influence of the lower fault zone.

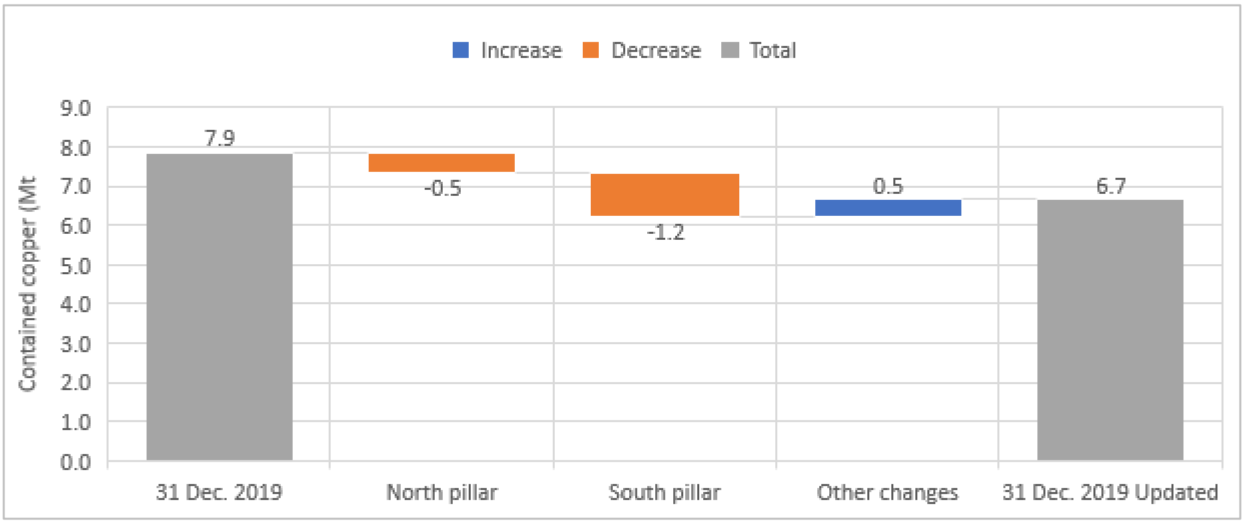
The impact of these changes are illustrated in Figure 15.1 and Figure 15.2.

Figure 15.1 Hugo North changes to tonnage in the Probable Mineral Reserve



Source: Compiled by AMC from information provided by TRQ, Date: 30 June 2020

Figure 15.2 Hugo North changes to contained copper in the Probable Mineral Reserve



Source: Compiled by AMC from information provided by TRQ, Date: 30 June 2020

16 Mining methods

16.1 Introduction

The initial investment decision to construct Phase 1 of Oyu Tolgoi was made in 2010. Mining of the Oyut deposit started in 2012 using open pit mining methods. The Oyut open pit mine currently has an ore production rate of about 40 Mtpa.

Part of the initial investment decision to develop Phase 1, included continued investment into the development of the Hugo North underground mine as a block caving operation (Phase 2 of the Project). Development of Phase 2 commenced in July 2016.

The Hugo North mine is being developed in two stages, Lift 1 and Lift 2. Development of Lift 1 is at an advanced stage with the first drawbell estimated to be blasted in mid-2022, subject to any delays arising from the COVID-19 pandemic and subject to further study and assessment as part of Oyu Tolgoi LLC's cost and schedule estimation update which is expected later in 2020.

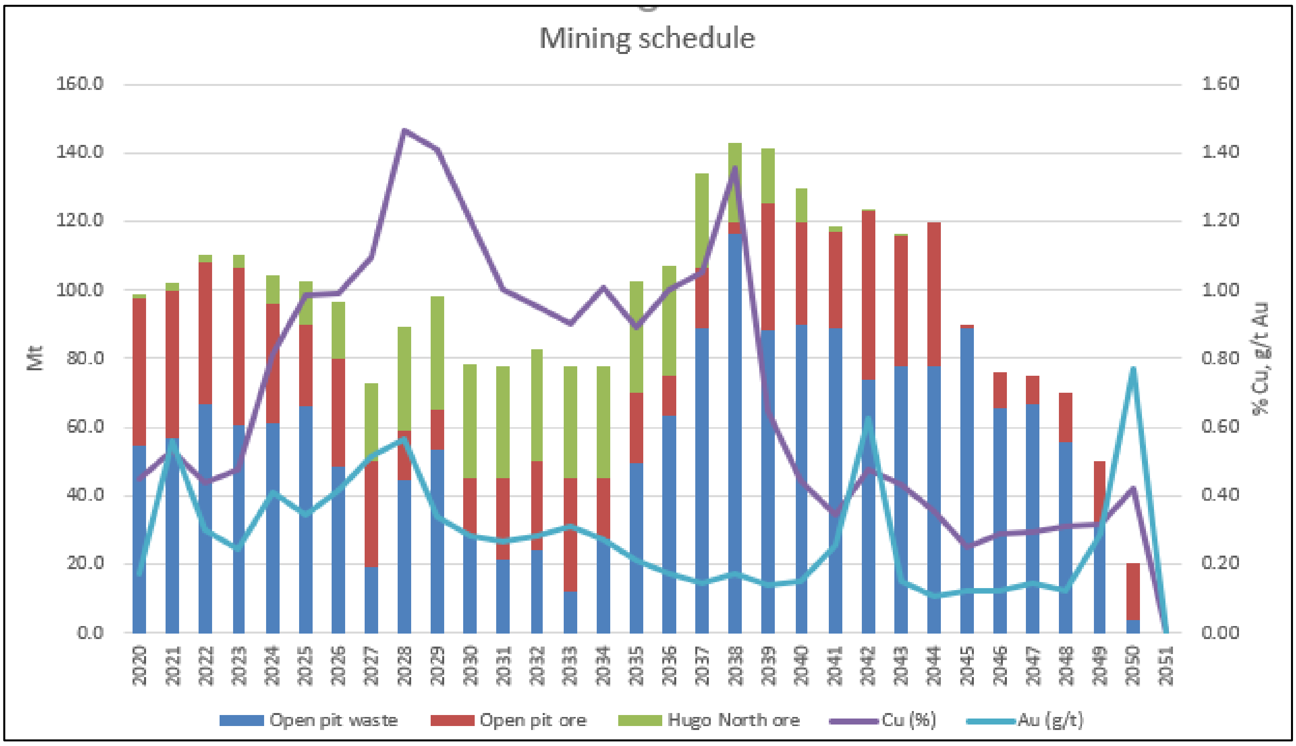
Concept studies have been carried out on developing Hugo North Lift 2, Hugo South, and Heruga deposits. The studies envisage that the Hugo South and Heruga deposits will be mined by underground caving methods similar to Hugo North. No mining or underground development is currently taking place at either Hugo South or Heruga.

16.1.1 Planned mine production

The planned production schedule for Oyu Tolgoi is shown in Figure 16.1 and Table 16.1. The current production rate from the Oyut open pit continues until 2023, after which it will be progressively reduced as production builds up from underground. Open pit mining will continue in parallel with Hugo North Lift 1 to keep the Oyu Tolgoi concentrator operating at its design capacity. Following depletion of Lift 1, production from the Oyut open pit will be increased to meet mill capacity.

The planned production schedule does not reflect the impacts of the COVID-19 pandemic which are ongoing and continues to be assessed. Several work fronts at Hugo North underground mine are directly impacted by the COVID-19 pandemic due to the lack of availability of critical resources and restrictions on site workforce numbers.

Figure 16.1 Planned Oyu Tolgoi mining schedule



Open pit ore mined comprises ore fed directly to the mill plus ore delivered to stockpiles that are subsequently recovered and delivered to the process plant. Source: Prepared by AMC from information provided by Oyu Tolgoi, Date: 30 June 2020.

Table 16.1 Planned Oyu Tolgoi mining schedule

	Oyut open pit				Hugo North ore mined			Total ore mined		
Year	Waste (Mt)	Ore (Mt)	Cu (%)	Au (g/t)	Ore (Mt)	Cu (%)	Au (g/t)	Ore (Mt)	Cu (%)	Au (g/t)
2020	54	43	0.44	0.16	1	1.0	0.27	44	0.45	0.16
2021	57	43	0.52	0.56	2	0.8	0.19	45	0.53	0.54
2022	66	41	0.41	0.28	2	1.1	0.30	44	0.44	0.28
2023	61	46	0.39	0.21	4	1.5	0.43	50	0.48	0.23
2024	61	35	0.57	0.38	8	1.8	0.49	43	0.81	0.40
2025	66	24	0.35	0.23	12	2.2	0.56	36	0.98	0.34
2026	48	32	0.31	0.26	16	2.3	0.56	48	0.99	0.37
2027	19	31	0.33	0.40	23	2.2	0.52	53	1.11	0.45
2028	45	14	0.49	0.76	31	1.9	0.47	45	1.47	0.56
2029	54	11	0.43	0.09	33	1.8	0.42	45	1.42	0.33
2030	29	16	0.50	0.15	33	1.6	0.35	50	1.22	0.28
2031	21	24	0.49	0.15	33	1.4	0.32	57	1.02	0.25
2032	24	26	0.57	0.17	33	1.3	0.34	59	1.00	0.26
2033	12	33	0.66	0.22	33	1.3	0.33	66	0.98	0.28
2034	27	18	0.66	0.24	33	1.2	0.27	50	1.04	0.26
2035	49	21	0.45	0.14	33	1.2	0.21	53	0.90	0.18
2036	63	12	0.40	0.16	32	1.3	0.17	44	1.02	0.16
2037	89	18	0.40	0.06	28	1.5	0.16	46	1.06	0.12
2038	116	4	0.38	0.11	23	1.5	0.15	26	1.36	0.14
2039	88	37	0.38	0.12	16	1.3	0.12	53	0.65	0.12
2040	90	30	0.34	0.18	10	0.8	0.07	40	0.44	0.15
2041	89	28	0.34	0.39	1	0.6	0.03	29	0.35	0.37
2042	74	49	0.51	0.62	0	0.6	0.02	49	0.51	0.62
2043	78	38	0.45	0.16	0	0.3	0.01	38	0.45	0.16
2044	78	42	0.42	0.10	–	–	–	42	0.42	0.10
2045	89	1	0.22	0.26	–	–	–	1	0.22	0.26
2046	66	10	0.31	0.19	–	–	–	10	0.31	0.19
2047	67	8	0.32	0.31	–	–	–	8	0.32	0.31
2048	56	14	0.42	0.13	–	–	–	14	0.42	0.13
2049	31	19	0.35	0.47	–	–	–	19	0.35	0.47
2050	4	16	0.50	1.24	–	–	–	16	0.50	1.24
2051	–	–	-	-	–	–	–	–	–	–
Total	**1,771**	**783**	**0.44**	**0.29**	**440**	**1.51**	**0.32**	**1,223**	**0.83**	**0.30**

Note: Ore mined from the Oyut open pit excludes ore recovered from surface stockpiles.

Amounts are rounded and exclude any impacts of Covid-19 and are subject to further study and assessment as part of Oyu Tolgoi LLC's cost and schedule estimation update which is expected later in 2020 and subject to further study and analysis on Panels 1 and 2.

16.2 Oyut open pit mining

Open pit mining is carried out using conventional drill, blast, load, and haul methods and is conducted 24 hours per day, 365 days per year.

Mining has proceeded generally in accordance with the mine plan developed in 2012, However, the phase design and sequence have been updated since 2012 and now represent a more optimised approach to mining. Delays to the start of mining at Hugo North have influenced the phase design and mining sequence.

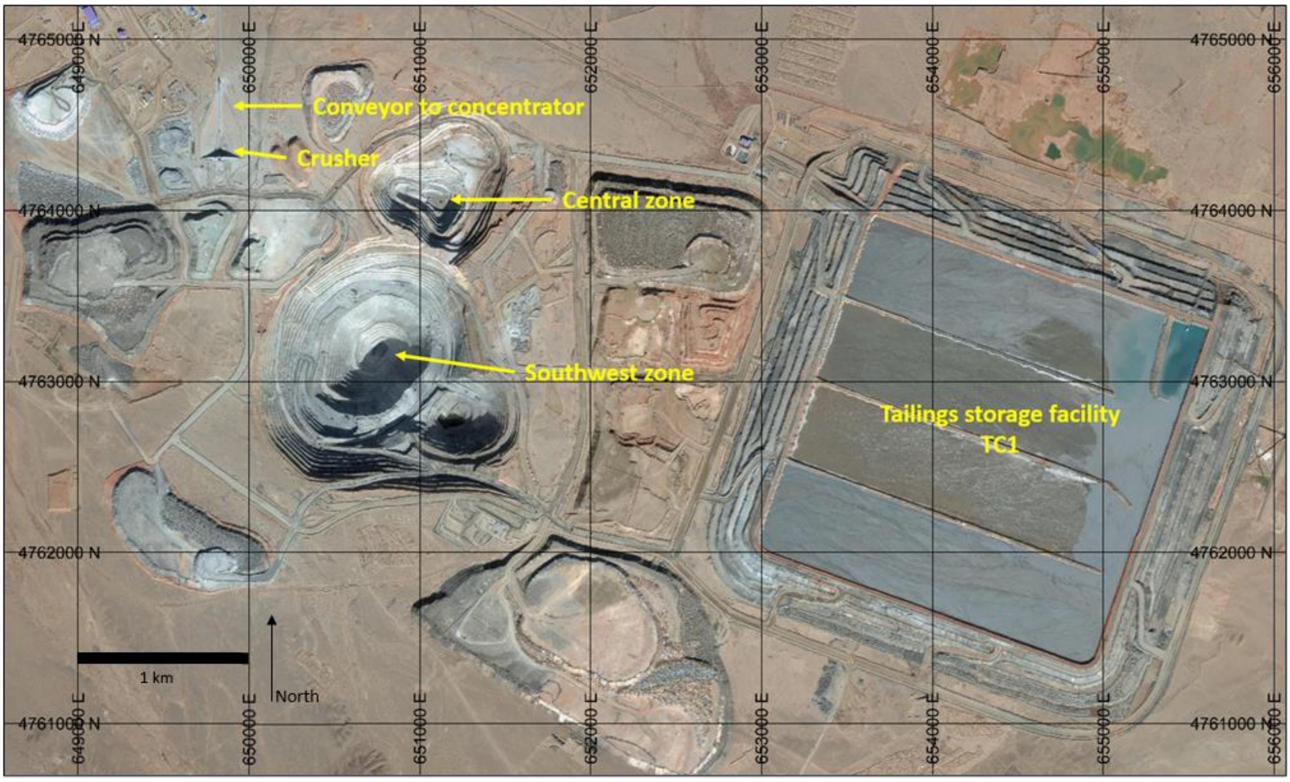
The production history from the Oyut open pit since mining commenced is summarized in Table 16.2. Mining to date has focused on the Central and Southern Oyut zones. An aerial photograph of the open pit and surrounding area is shown in Figure 16.2.

Table 16.2 Oyut open pit production history

Year	Ex-pit waste (Mt)	Ex-pit ore (Mt)	Ex-pit strip ratio (W:O) t	Direct mill feed (Mt)	Ore to stockpiles (Mt)	Stockpile reclaim (Mt)	Ore milled (Mt)	Total movement (Mt)
2012	66	9	7.0	0	9	0	0	76
2013	44	29	1.5	13	16	7	20	80
2014	49	36	1.4	21	15	7	28	93
2015	46	46	1.0	23	23	12	35	104
2016	56	40	1.4	22	18	17	38	113
2017	55	51	1.1	22	29	20	41	126
2018	45	46	1.0	24	21	15	39	106
2019	61	40	1.5	23	17	18	41	121
Total	**423**	**298**	**1.4**	**148**	**150**	**97**	**241**	**818**

Totals may not match due to rounding.

Figure 16.2 Oyut pit and surrounding area aerial photograph (November 2019)



Source: Compiled by AMC from information provided by TRQ, Date: 23 July 2020. Projection UTM (WGS84) Z48N.

16.2.1 Geotechnical investigations

The open pit design is based on geotechnical investigations reported by Golder Associates Inc. (Golder) in 2012 (the Golder 2102 Study). The Golder 2012 Study included field investigations undertaken during December 2010 through to February 2011. The investigations included drilling 12 cored geotechnical holes with core orientation and collection of rock samples for laboratory testing.

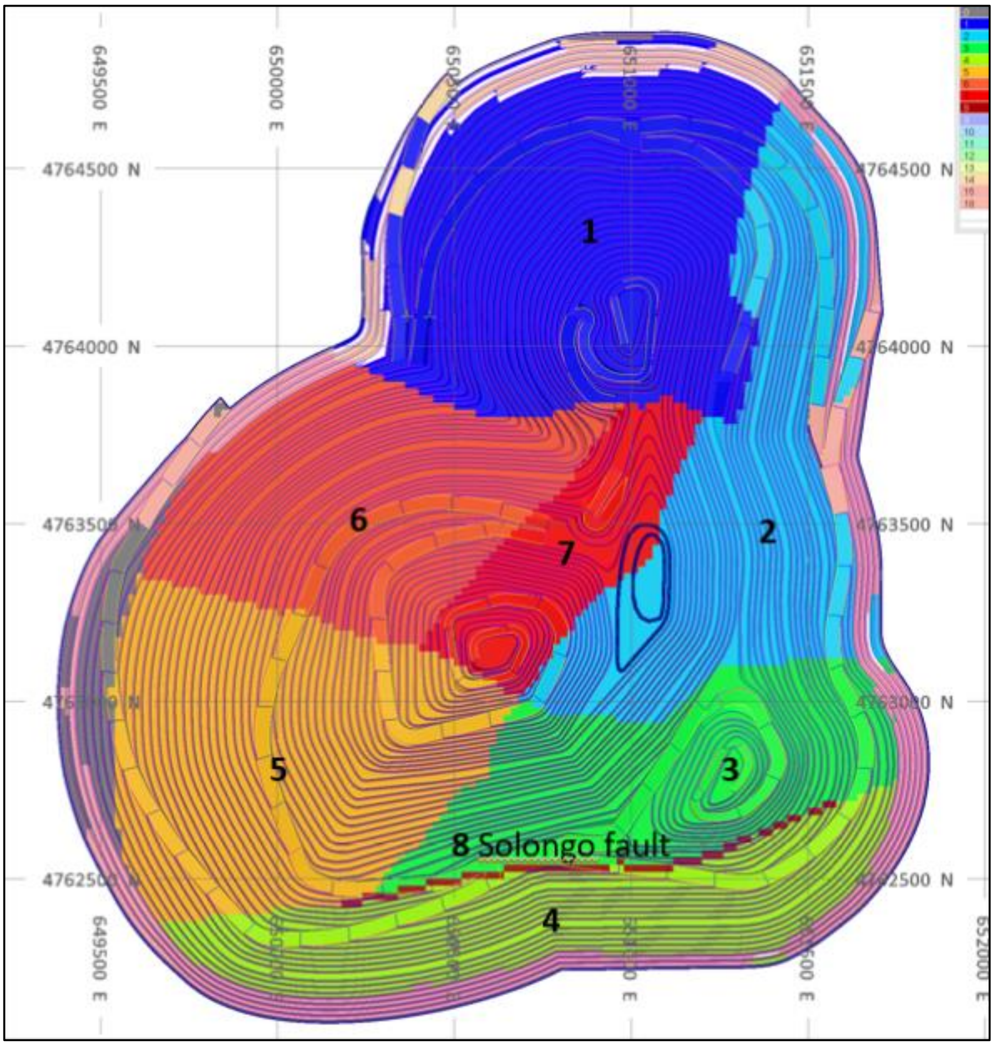
Twenty geotechnical domains were identified to guide pit wall design: eleven in fresh rock and nine in weathered material. The domains are modelled as 3D solids, based on the Golder 2012

Study. A geological map and cross sections of the Oyut deposit are shown in Figure 7.7. These structural models, together with rock mass quality estimates, form the basis of the geotechnical domains shown in Figure 16.3.

The slope design criteria set out in the Golder 2012 Study were used for the pit design, which determines the Mineral Reserve. The slope design criteria used for the internal (temporary) pit walls are based upon updated mapping, geotechnical test work, and analysis, which was conducted at various times since mining commenced.

A program of work is currently underway to produce a new consolidated set of slope design criteria for both the internal and final pit walls. The new slope design criteria will be based on re-analysis of the pre-2012 data, plus the extensive fault mapping, geotechnical monitoring, and analysis that has been undertaken since mining started. This program of work will form the basis of future open pit design optimizations and mineral reserve estimates.

Figure 16.3 Oyut geotechnical domains projected onto the Mineral Reserve pit shell



Source: Compiled by AMC from information provided by Oyu Tolgoi, Date: 4 February 2020. Projection UTM (WGS84) Z48N.

16.2.2 Slope design criteria

The slope design criteria which are based on the Golder 2012 Study are summarized as follows:

- Single, 15 m bench height (or batter) in all rock slopes.
- Maximum bench face angle of 65° in weathered zone.
- Average bench face angle of 70° in bedrock zone.
- Minimum berm width of 7.5 m.

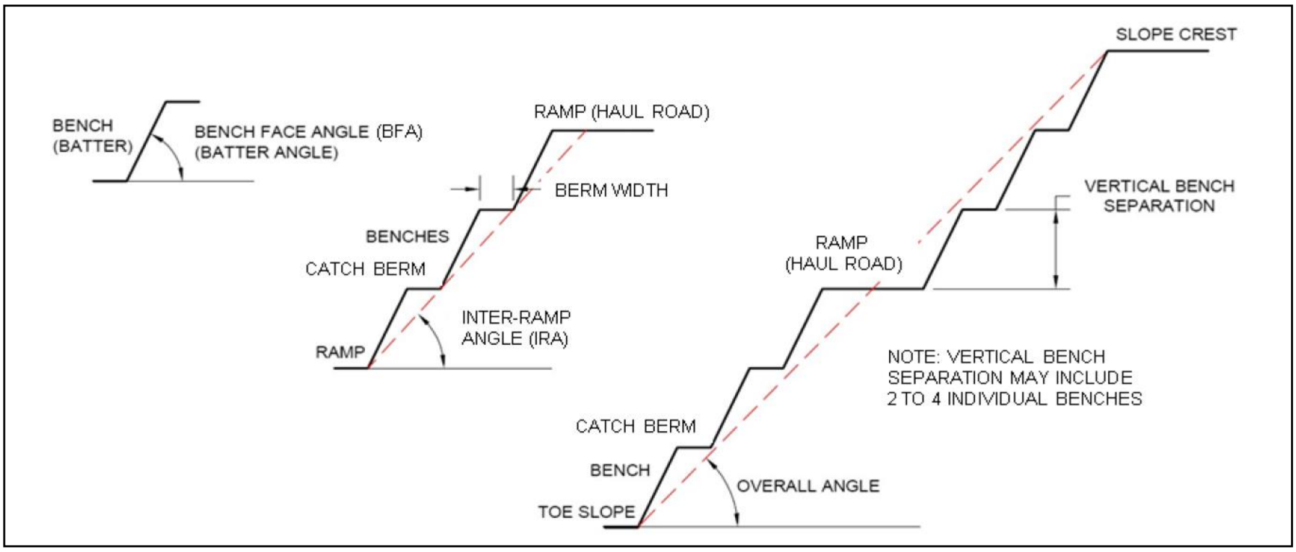
- Where structural controls are present, berm widths of 9 m, 12 m, and 15 m are applied to be consistent with recommended inter-ramp angles.
- Geotechnical catch berms at least 15 m wide at 90 m intervals where there are no ramp traverses to break the height of the slope.
- Ramp width of 40 m.

Application of the slope design criteria, in combination with haul road widths, determines the angle of the overall pit wall. The typical application of pit wall slope design criteria to batter, inter-ramp and overall slope angles is shown in Figure 16.4.

The inter-ramp angles vary with the geotechnical domain and the dip and strike direction of the pit wall. The inter-ramp angle in fresh rock domains range from 33º to 49º, with an average of about 44º. The range of inter-ramp angles for each geotechnical domain are summarized in Table 16.3.

Ramp gradients for the outer phases of the pit are planned at 11%. Ramps in the inner phases are currently designed a 10% gradient, but this may be increased in future designs.

Figure 16.4 Typical application of pit wall slope design criteria.



Source: Oyu Tolgoi, Date: 4 February 2020

Table 16.3 Range of inter-ramp angles for each geotechnical domain

Geotechnical domain names	Range of inter-ramp angles
Fresh rocks	
1_5 West (Combined)	33º to 47º
2_2 East (Volcanic)	41º to 46º
2_3 East (Intrusive)	38º to 48º
2_4 East (Sediment)	36º to 49º
3_2 South (Volcanic)	38º to 49º
3_3 South (Intrusive)	38º to 49º
3_4 South (Sediment)	35º to 49º
4_5Solongo (Combined)	42º to 49º
5_5Southwest (Combined)	33º to 49º
6_5 Northwest (Combined)	37º to 48º
7_5Middle (Combined)	33º to 47º
Weathered rocks	
Overburden	25º
Solongo Fault	45º
West	38º
East	42º
South	42º
Solongo	42º
Southwest	37º
Northwest	37º
Middle	42º

16.2.3 Hydrogeological assessment

Hydrogeological studies have been carried out by Schlumberger and RPS Aquaterra. The hydrogeological field program involving packer tests was carried out in six boreholes and involved 3,500 m of diamond drilling with downhole testing in each hole to quantify the hydrogeological characteristics of targeted fault and dyke structures and the rock mass fabric. Each hole was fitted with either a standpipe for monitoring or was fitted with cemented vibrating wire piezometers transducers.

The studies concluded that the rock mass exhibits low to very low hydraulic conductivity but recommended that long horizontal drain holes be drilled to ensure adequate depressurization behind the pit walls. The study also recommended that pore-pressure monitoring be carried out to investigate whether natural (or gravitational) drainage is adequate or if sub-horizontal drains are required.

Currently, horizontal drain holes and pit wall runoff drains to the base of the pit using an open drain that is designed into the haul road. A small sump and standpipe at the base of the pit are used to fill water trucks used for dust suppression, which is sufficient to manage the water that flows into the pit. Cut-off sumps are used in the upper benches to capture water perched in the weathered and clay zones close to the original ground surface.

As the open pit deepens, diesel-powered pumps will be installed in the pit sump and booster pump stations, if needed. Excess water will be pumped to a dam at the process plant.

Surface drainage ditches are maintained along the outside perimeter of the pit to collect and convey surface water away from the pit slopes in areas where water runoff could affect the stability of the pit walls.

16.2.4 Mining model

A 3D block model (mining block model) is used for long-term planning and scheduling of the open pit mining operation. The model is based on, and has the same block size, as the 2018 Oyut mineral resource block model (20 m x 20 m x 15 m). Each block includes the mineral resource data, the geometallurgical rock types, metallurgical indices, and an NSR value.

The NSR value is the revenue paid for the concentrate at the mine gate, excludes costs for the mining process and G&A. The NSR value represents the in situ (before mining) value of the mineralized block after allowing for metallurgical recovery to concentrate, smelter deductions, transportation of concentrate, smelter treatment and refining charges, and royalties. NSR values are based on long-term forecasts for metal prices, smelter and refinery terms, and off-site charges and costs.

The NSR value is used as a proxy for cut-off grade to rank parcels of mineralization and classify parcels as ore or waste, such that a parcel of mineralization is defined as waste where the cost of processing and general administration exceeds the NSR cut-off value. For the Oyut open pit, the NSR cut-off values vary between 7.18 $/t and 10.14 $/t for the different geometallurgical ore types.

Some allowance is made for ore loss and contact dilution in the resource estimation procedure. To date, there has been no detailed assessment of the impacts of ore loss and dilution on planned tonnes and grades. Ongoing reconciliation in the transfer of mineral reserves to actual production suggests that these impacts are not large.

16.2.5 Pit phases

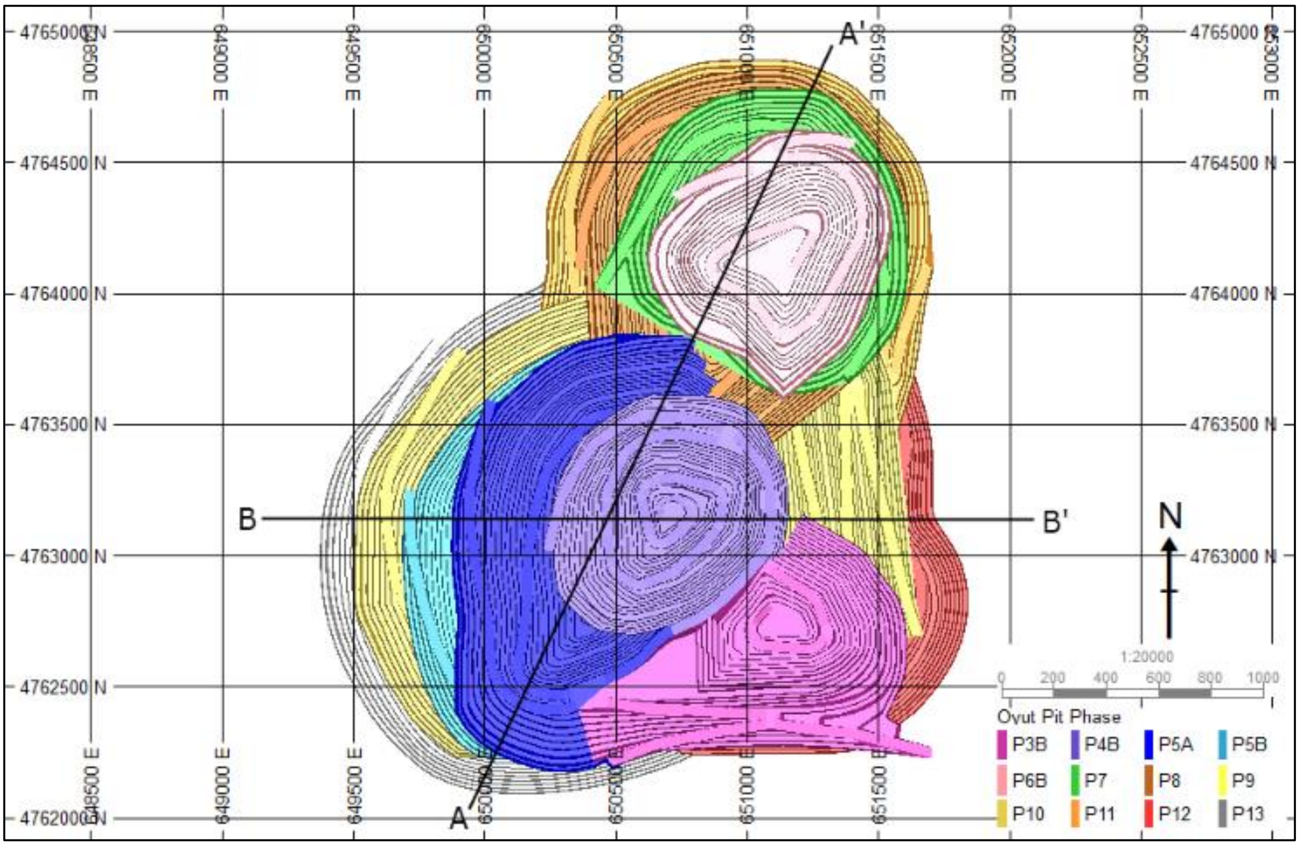
The current open pit design utilized an industry standard Lerchs-Grossmann (LG) pit optimization approach to produce a nested set of pit shells, which represent the best economic sequence of pit phase development. The nested pit shells are used to guide the design of practical pit phases and the sequence of mining. The pit optimization process used Measured and Indicated resource classification blocks only for potential revenue generation. Inferred mineral resources were treated as waste.

A plan showing the planned phases of the Oyut open pit is shown in Figure 16.5. Sections through the pit design are shown in Figure 16.6 and Figure 16.7. The sections show the outline of the currently planned phases superimposed on the mineral resource block model. The individual phase designs are shown in Figure 16.8. The tonnage and grade of ore contained in each phase is summarized in Table 16.4.

Phases 1 to 4a (excluding 3b) were extracted prior to 31 December 2019. Using the nested pit optimization shells and the slope design criteria, practical pit designs were prepared for the remaining 12 pit phases (3b, 4b, 5a, 5b, 6b, 7, 8, 9, 10, 11, 12, 13). The outlines of the practical pit phase designs correspond well with the LG optimization shells. The final phase (phase 13) is the 2019 Mineral Reserve pit and is based on the LG pit shell with a LG revenue factor of 1. The use of this factor maximises the life of the pit but does not necessarily maximise the NPV.

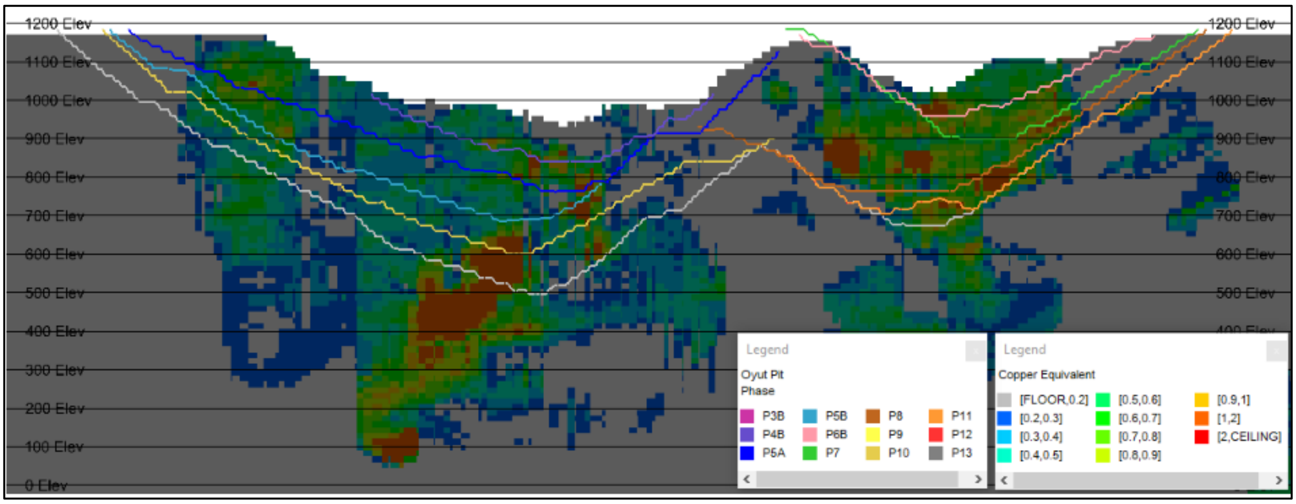
The 2019 Mineral Reserve pit contains the 2019 Mineral Reserve reported in Section 15. The pit phases and the Mineral Reserve pit outline may vary in future with changes in revenue factors, costs, and revised slope design criteria.

Figure 16.5 Oyut open pit plan design showing pit phases



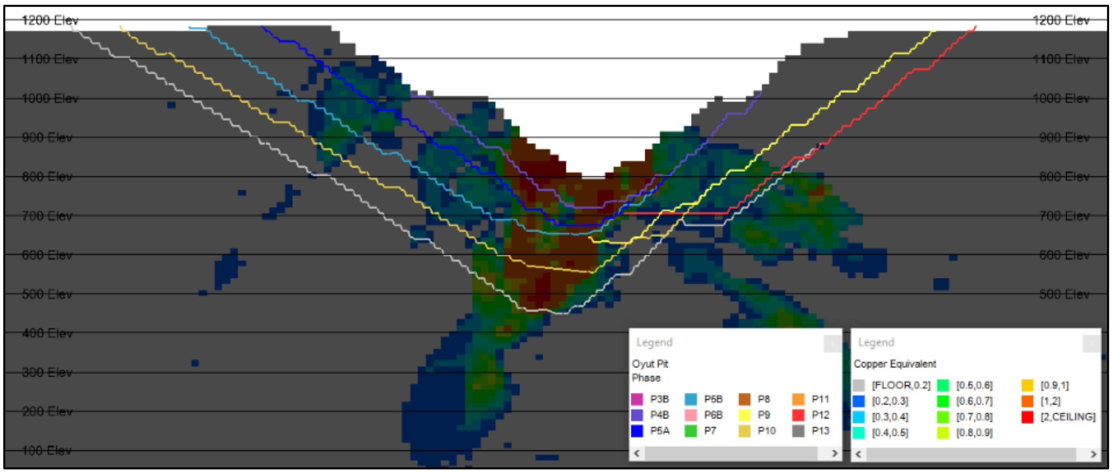
Source: Oyu Tolgoi LLC, Date: 28 May 2020. Projection UTM (WGS84) Z48N.

Figure 16.6 Oyut open pit design – Section A-A’



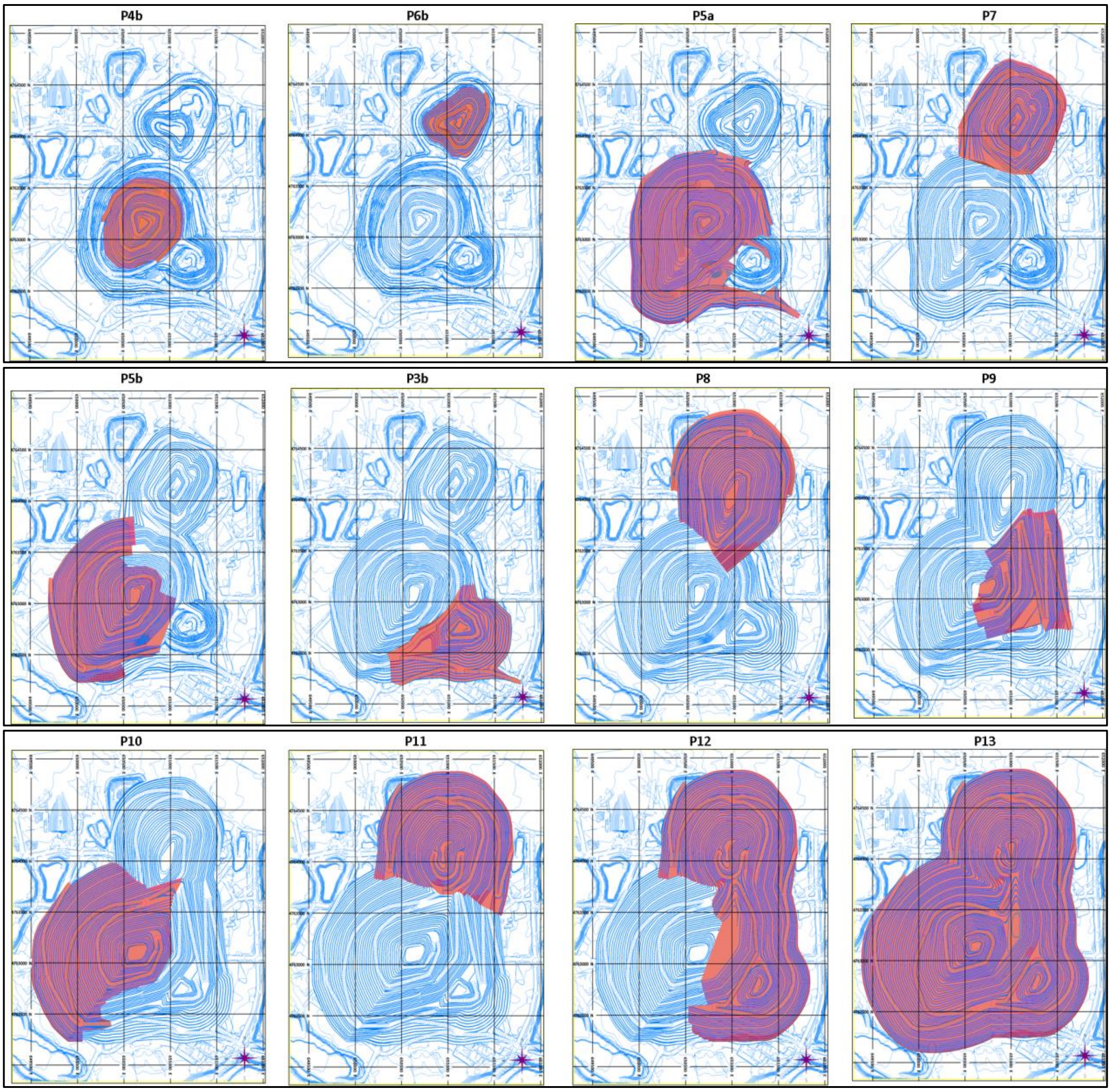
Source: Oyu Tolgoi LLC, Date: 28 May 2020

Figure 16.7 Oyut open pit design – Section B-B’



Source: Oyu Tolgoi LLC, Date: 28 May 2020

Figure 16.8 Oyut open pit phases (grid lines are at 500 m intervals)



Source: Oyu Tolgoi LLC, Date: 28 May 2020

Table 16.4 Oyut tonnage and grade of material in pit phases

Mining phase	Strip ratio	Waste (Mt)	Ore (Mt)	Cu (%)	Au (g/t)	Ag (g/t)
P4b	0.5	28	63	0.45%	0.48	1.29
P5a	2.0	194	75	0.38%	0.39	1.21
P3b	1.9	11	30	0.44%	0.17	1.66
P5b	1.7	178	101	0.35%	0.36	1.14
P6b	0.2	-3	35	0.60%	0.08	1.57
P7	1.6	53	38	0.62%	0.10	1.23
P8	1.5	201	124	0.54%	0.18	1.16
P9	1.6	138	79	0.40%	0.12	0.96
P10	4.9	277	56	0.38%	0.62	1.27
P11	3.5	141	40	0.52%	0.20	0.94
P12	2.2	171	80	0.39%	0.10	1.20
P13	6.2	383	62	0.39%	0.57	1.36
Total	**2.3**	**1,771**	**783**	**0.44%**	**0.29**	**1.21**

Note: Phases 1 to 4a were extracted prior to 31 December 2019.
Totals may not match due to rounding.

Short-term mine planning is guided by an ore control model that uses the results of blasthole sampling to manage the final selection of ore and waste. The ore control model also guides the delivery of ore directly to the concentrator or to stockpiles, which are used to blend the feed to the concentrator.

16.2.6 Waste dump and stockpile design

The following waste dumps and ore stockpiles have been designed:

Waste

- East dump and clay dump – non-acid forming (NAF) waste oxide, sediment, and clay material for construction of the TSF.
- South dump – potentially acid forming (PAF) material, which will be encapsulated with NAF material for closure and acid rock drainage (ARD) management.
- Tailings storage facility (TSF) embankments – run-of-mine (ROM) waste for construction of the tailings cells (TC) embankments.

Stockpiles

- The segregated oxide material (SOM) dump – oxide material with copper grades greater than 0.25%.
- HG, MG, and LG stockpiles – high grade (HG), medium grade (MG), and low grade (LG) ore, each subdivided into Southwest and Central.
- Mineralised waste stockpile (renamed as the mineralised waste stockpile) – material with an NSR value below the current estimated long-term economic cut-off grade but above the value defined in the 2012 Technical Report.

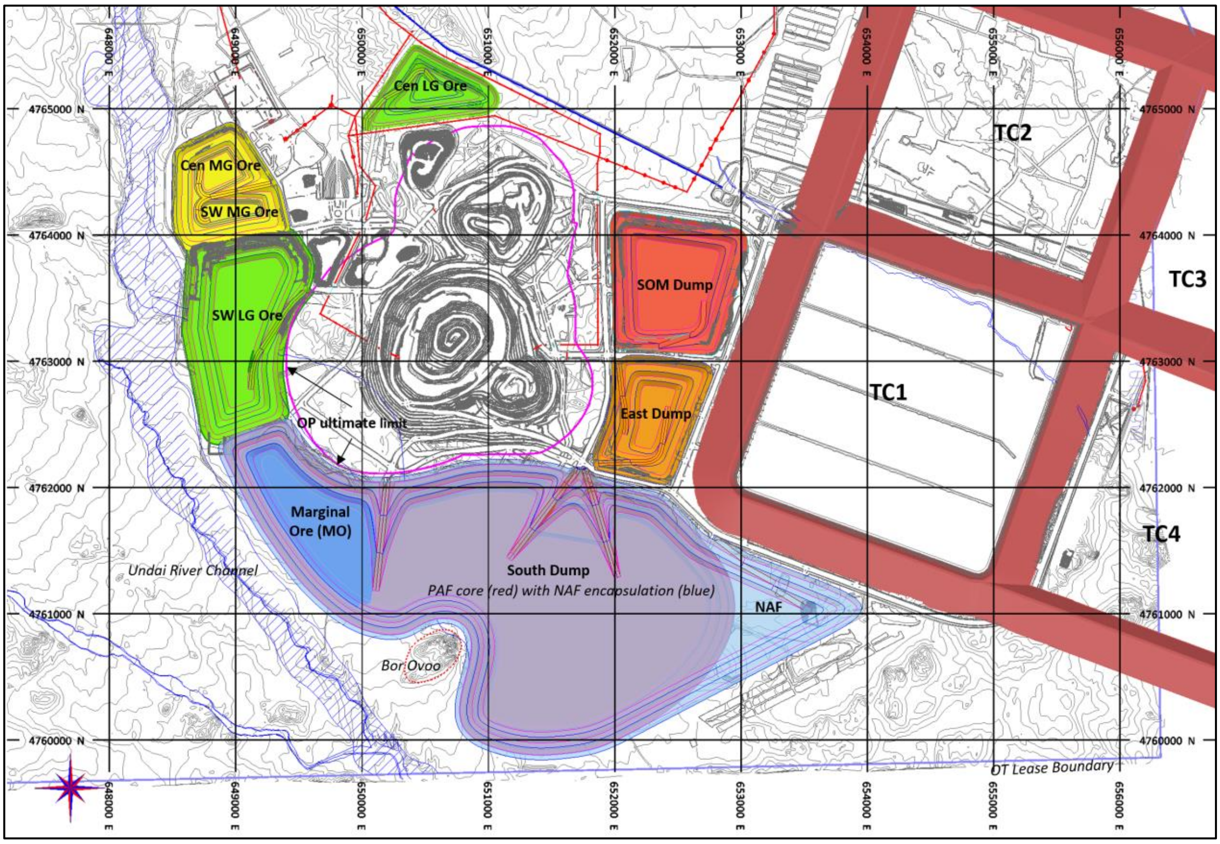
The location of the waste dumps and stockpiles is shown in Figure 16.9. The design capacity of the dumps and stockpiles is summarized in Table 16.5 and Table 16.6, respectively. Including the waste rock in the TSF embankments, the total waste storage capacity is approximately 1,600 Mt.

Waste dumps and stockpiles are designed to incorporate 30% swell, 10% natural compaction, and a 37° angle of repose. The dumps are built in 15 m lifts to establish 30 m benches to a maximum height of 90 m. Haul roads are 40 m wide at a 10% gradient.

PAF waste is selectively placed and encapsulated within the dump to migrate any risk from ARD. PAF is encapsulated with a minimum 10 m distance from the final recontoured surface slope and 1.5 m on the top of the final landform. In areas where the land surface does not contain clay, a 3 m thick lift of NAF waste is placed and compacted at the base of the dumps.

The HG, MG and LG stockpiles are part of the mine planning strategy to optimise Project value and are categorized as mineral reserves. The stockpiles will continue to grow over the LOM. As the higher-grade ore from the pit is depleted, the stockpiles will be drawn down and fed to the concentrator. The HG stockpile will also be used as an operating buffer if required.

Figure 16.9 Location of waste dump and stockpiles



The Marginal Ore (MO) dump has been renamed as the Mineralised Waste stockpile.
Source: Oyu Tolgoi LLC, Date: 28 May 2020. Projection UTM (WGS84) Z48N.

Table 16.5 Waste dump design capacities as at 2019 Q3)

Dump	Final capacity (Mt)
East dump	40
South dump (PAF)	615
South dump (NAF)	210
SOM dump	60
Tailings Cell 1	115
Tailings Cell 2	200
Tailings Cell 3	220
Tailings Cell 4	140
Total	**1,600**

Note: Totals may not match due to rounding.

Table 16.6 Stockpile design capacities as at 2019 (Q3)

Stockpiles	Final capacity (Mt)
Medium grade stockpile (SW and Central)	45
Low grade stockpile (SW and Central)	130
Marginal ore stockpile	40
Total	**215**

Note: Totals may not match due to rounding.

16.2.7 Open pit operations

The open pit mine is a conventional shovel-truck operation. The primary shovel fleet includes electric rope shovels and diesel hydraulic shovels with 290 t class haul trucks. The primary fleet is supported by front-end loaders and ancillary equipment.

The Oyu Tolgoi workforce carries out drilling, loading, hauling and associated production support roles. Equipment maintenance is conducted under service agreements with the selected original equipment manufacturer in-country dealers. Under the service agreement, the contractor provides personnel, supervision, and technical expertise at site.

The mine equipment fleet is monitored through Dispatch® and Mine Care monitoring and recording systems, a computerized system available in the mining industry. The information collected is used for fleet performance management and continuous improvement.

High-precision global positioning systems (GPS) are currently installed in the heavy mining equipment (HME), including the electric shovels, drills, hydraulic shovels, and loaders. This allows live monitoring and decision-making regarding truck allocation, load destination and performance. This maximises the feed tonnage and grade to the concentrator.

For reporting, Mine Monitoring and Reporting System (MMRS) is used as the primary reporting tool. MMRS reported grades are based on the average grade of the dig block rather than the block model grade being mined. The HME fleet required at five-year intervals is listed in Table 16.7.

Table 16.7 Open pit mining equipment requirement forecast

Equipment type	2020	2025	2030	2035	2040	2045	2050
Electric rope shovel - 495HR (56 m^3 bucket)	2	2	2	2	2	2	2
Diesel hydraulic shovel - RH340 (34 m^3 bucket)	2	2	–	1	3	3	-
FEL - WA1200 (18 m^3 bucket)	2	1	1	1	2	2	1
Truck 290 t – Komatsu 930E-4SE	30	30	14	19	49	44	14
Production drill- diesel - PV-351D	3	1	–	–	–	–	–
Production drill- electric - PV-351E	2	3	2	3	6	4	1
Small drill - DR009 (172 mm)	2	2	1	2	3	2	–
Water truck HD785-7	3	3	1	2	4	4	1
Grader CAT 16M	4	4	2	3	6	5	2
WD600-6	2	2	2	2	3	3	2
D475A-5	2	2	2	2	2	2	2
D375A-6	4	4	2	3	5	5	2
Komatsu HM400-2 articulated 6WD service truck	3	3	1	2	4	4	1
Cat 735 articulated 6WD service truck	1	1	1	1	2	2	1
Liebherr R9400 support excavator	2	2	2	2	2	2	2
PC600-8	1	2	1	1	2	2	1
WA500	1	2	1	1	2	2	1
WA250	3	3	1	2	4	4	1

16.2.8 Productivity assumptions

The mining fleet productivity and utilisation assumptions used as the basis for the mine production schedule are shown in Table 16.8. Shovel productivities shown are tonnes per direct operating hour when the shovel is loading.

Table 16.8 Equipment productivity assumptions

Equipment type	Units	Trucks (930E)	Electric shovels (495HR)	Hydraulic shovels (RH350)	Support excavator (L9400)	FELs (WA1200)
Initial fleet size	units	30	2	2	2	2
Service life	kh	125	170	85	80	80
Productivity	t/h	305	7,500	4,550	2,873	2,800
Payload	t	295	–	–	–	–
Availability	%	87.6%	85.0%	77.1%	74.7%	79.6%
Use of availability	%	92.5%	91.0%	90.0%	87.0%	83.0%
Operating efficiency	%	91.0%	56.0%	59.5%	61.0%	69.0%
Effective utilization	%	73.7%	43.3%	41.3%	40.3%	44.9%
Mining rate per unit	Mtpa	-	28.5	16.3	12.0	9.4

16.2.9 Drilling and blasting

Almost all materials within the open pit are assumed to be blasted before digging. Free-digging is only possible in the first or second benches covered by weathered or clay material.

Blasthole drilling is carried out by the Oyu Tolgoi production team, who also design, plan, fire and monitor the blasts. A blasting contractor provides blasting products and down-the-hole services, including the supply and storage of explosives. Ammonium nitrate fuel oil is used in dry holes and high-density explosives in wet holes.

Table 16.9 details the drilling and blasting design parameters for a typical production shot. Different burden, spacing and hole charging regimens are used for trim and interphase mining shots to protect pit walls and reduce overspill onto active faces below.

Table 16.9 Drilling and blasting design parameters

Parameter	Unit	Production shot		Trim shot	
		Ore	Waste	Front row	Buffer row
Blasthole diameter	mm	311	311	311	172
Penetration rate	m/h	30	32	30	32
Bench height	m	15	15	15	15
Burden	m	7.5	7.8	7.5	4.8
Spacing	m	8.6	9.0	8.6	5.5
Subdrill	m	1.25	1.25	1.25	0
Stemming	m	8	8	8	8
Charge length	m	8.25	8.25	8.25	7
Total hole depth	m	16.25	16.25	16.25	15

16.2.10 Open pit production schedule

The open pit mining operations are scheduled on a nominal 365-day calendar, 24 hours a day, resulting a total calendar hours of 8,760 hours per year. The highest-grade open pit material is fed to the plant on priority (direct mill feed) and lower grade ore is stockpiled on MG, LG and mineralised waste stockpiles. These stockpiles are available to be reclaimed as and when required. The open pit mining capacity is adjusted to fill the gap between underground ore feed and concentrator capacity.

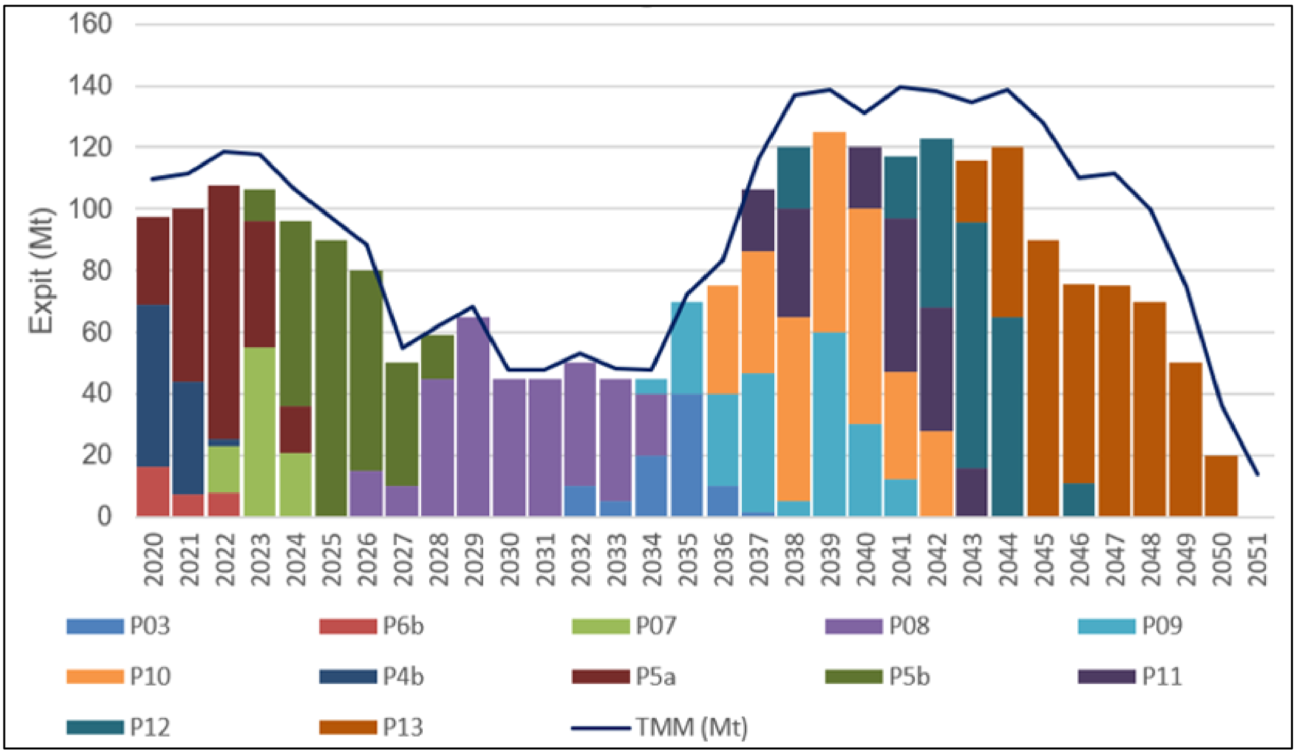
The planned open pit ore production schedules are shown in Table 16.10. The total material movement by pit phase is shown in Figure 16.10, and feed to the mill by ore type is shown in Figure 16.11. The planned production schedule does not reflect the impacts of the COVID-19 pandemic which are ongoing and continues to be assessed.

Table 16.10 Planned open pit production schedule

Year	Ex-pit waste (Mt)	Ex-pit ore (Mt)	Ex-pit strip ratio	Direct mill feed (Mt)	Ore to stockpile (Mt)	Stockpile reclaim (Mt)	Tactical rehandle (Mt)	Total m'ment (Mt)
2020	54	43	1.3	41	2	0	12	110
2021	57	43	1.3	38	5	0	11	111
2022	66	41	1.6	35	6	0	11	118
2023	61	46	1.3	39	7	0	12	118
2024	61	35	1.7	34	1	0	10	106
2025	66	24	2.8	24	0	0	7	97
2026	48	32	1.5	22	10	2	6	88
2027	19	31	0.6	16	15	0	5	55
2028	45	14	3.2	10	4	0	3	62
2029	54	11	4.7	8	3	1	2	68
2030	29	16	1.8	9	7	0	3	48
2031	21	24	0.9	10	14	0	3	48
2032	24	26	0.9	10	16	0	3	53
2033	12	33	0.4	10	23	0	3	48
2034	27	18	1.6	9	9	0	3	48
2035	49	21	2.4	8	13	0	2	72
2036	63	12	5.4	2	10	8	1	83
2037	89	18	5.0	7	11	8	2	117
2038	116	4	33.2	2	1	16	1	137
2039	88	37	2.4	18	19	9	5	139
2040	90	30	3.0	27	3	3	8	131
2041	89	28	3.2	25	3	15	8	139
2042	74	49	1.5	38	10	4	12	138
2043	78	38	2.0	33	5	9	10	135
2044	78	42	1.8	30	12	10	9	139
2045	89	1	61.4	1	–	37	0	128
2046	66	10	6.5	10	–	31	3	110
2047	67	8	8.2	8	–	34	2	111
2048	56	14	4.0	14	–	26	4	100
2049	31	19	1.7	19	–	20	6	75
2050	4	16	0.2	16	–	11	5	36
2051	–	–	-	–	–	14	–	14
Total	**1,771**	**783**	**2.3**	**573**	**210**	**257**	**172**	**2,983**

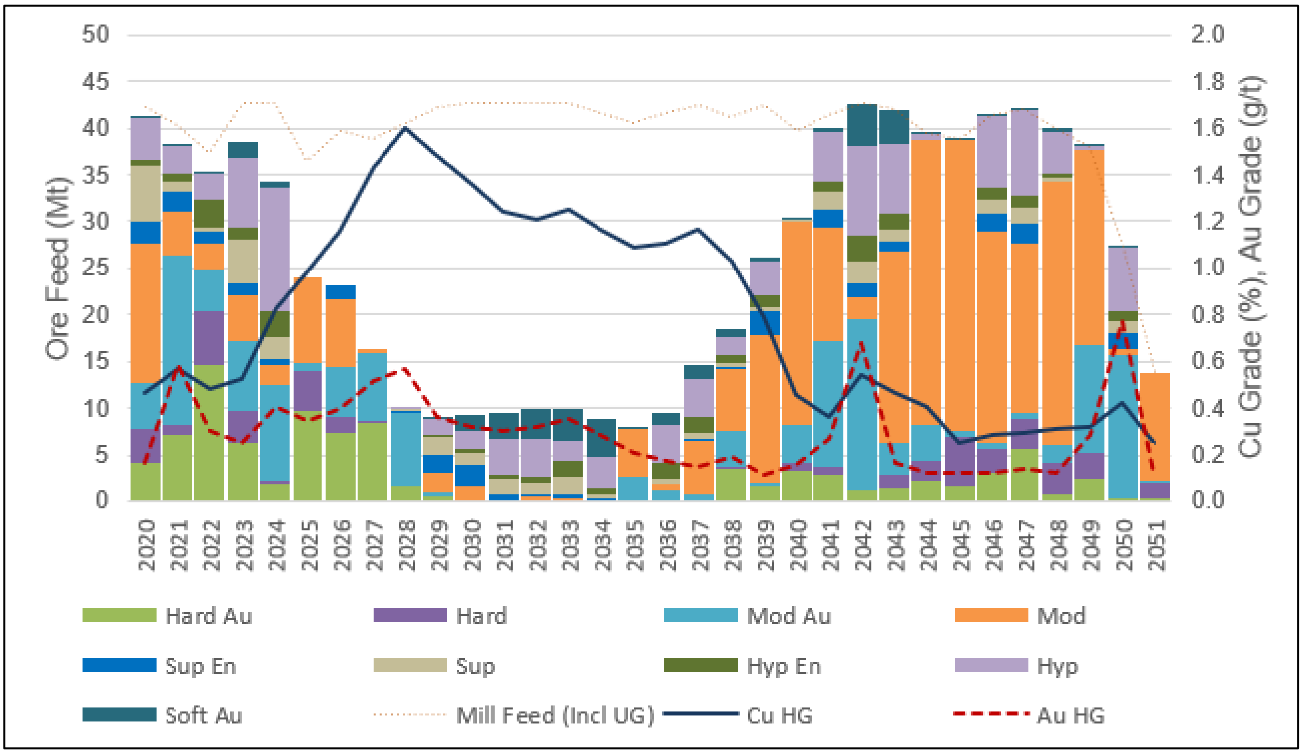
Note: Tactical rehandle is the movement of material on a day-to-day basis to provide the optimum mill feed balance. Amounts are rounded and exclude any impacts of Covid-19.

Figure 16.10 Total open pit mining (ore plus waste) by phase (P)



TMM = Total material moved from pit to crusher, stockpiles, and waste dumps plus mill feed reclaimed from stockpiles.
Source: Oyu Tolgoi LLC, Date: 28 May 2020

Figure 16.11 Open pit ore processed by material type



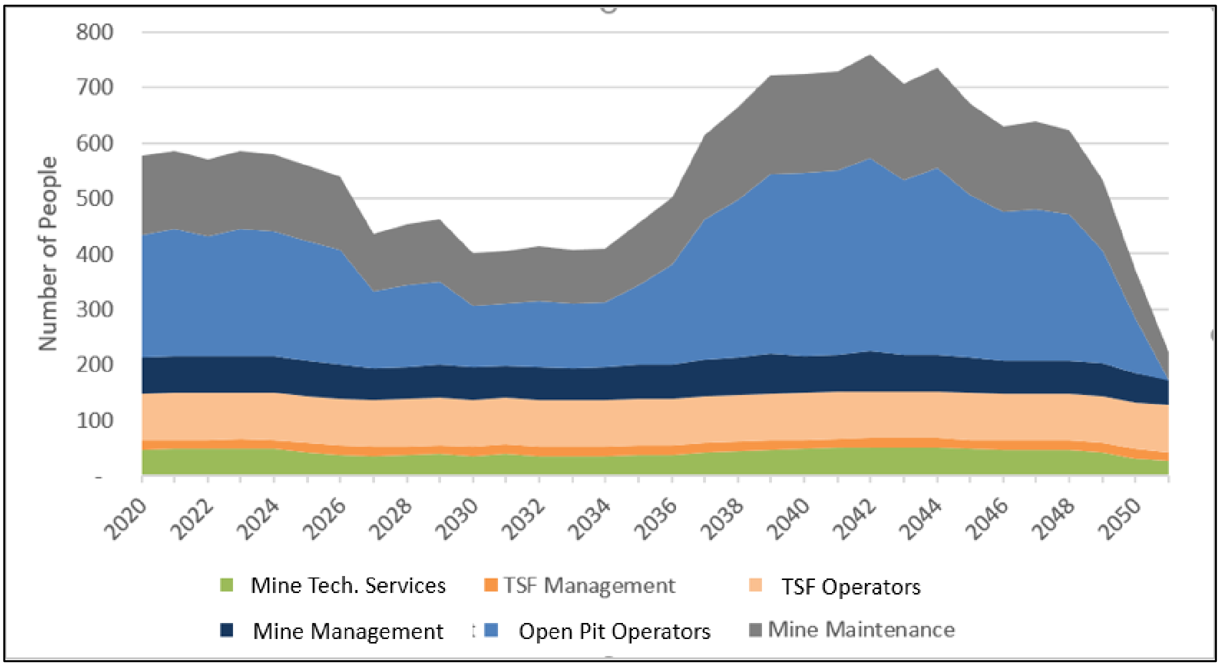
Source: Oyu Tolgoi LLC, Date: 28 May 2020

16.2.11 Labor

Although total open pit material movement significantly reduces as production from Hugo North Lift 1 increases, open pit labour levels do not reduce proportionally because of the need to strip waste for tailings dam wall construction and to cater for the increasing pit depth. The expatriate workforce is expected to reduce to about five people or approximately 1% of the workforce.

The anticipated labour requirements for the open pit operation are shown graphically in Figure 16.12.

Figure 16.12 Open pit labour requirements



Source: Oyu Tolgoi LLC, Date: 28 May 2020

16.3 Underground mining

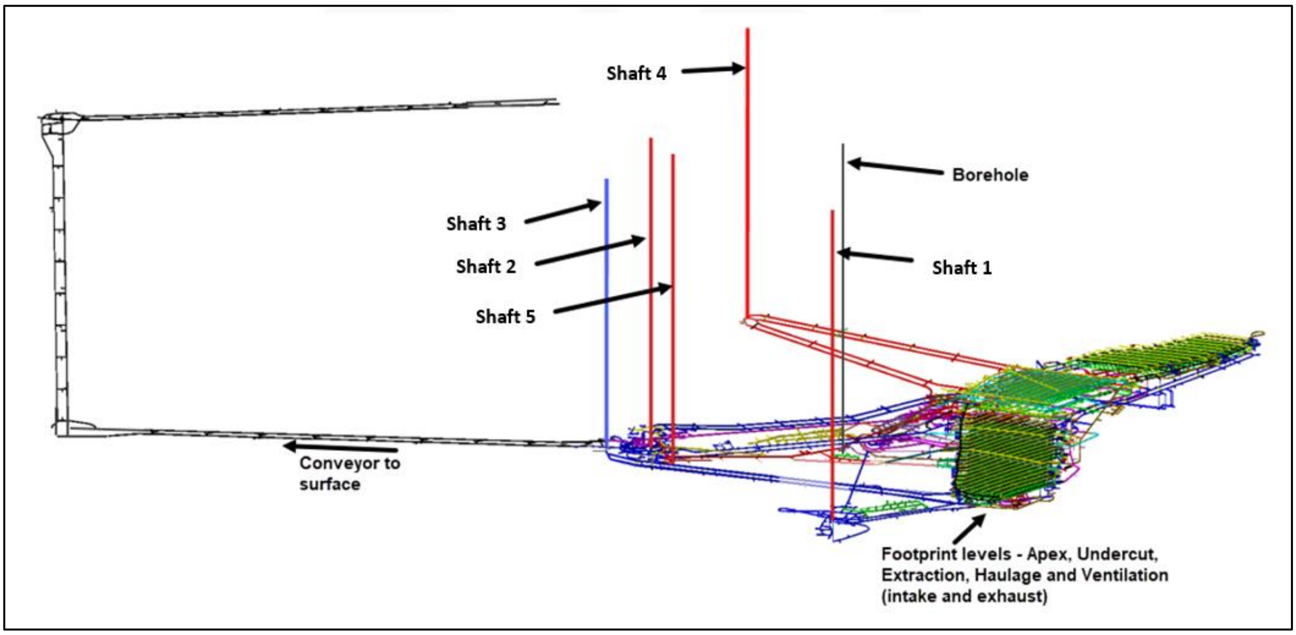
16.3.1 Background

An isometric view of the planned Hugo North Lift 1 underground mine is shown in Figure 16.13. The surface infrastructure and the relative location of the underground mine is shown in Figure 16.14. The Lift 1 footprint is approximately 1,300 m below surface, 2,000 m north-south, and 280 m east-west.

Sinking of a multipurpose shaft (Shaft 1) to access the Hugo North deposit began in February 2005 and reached its final depth in January 2008. A total of 15 km of lateral development was completed from Shaft 1 by August 2013, when the underground project was placed into care-and-maintenance.

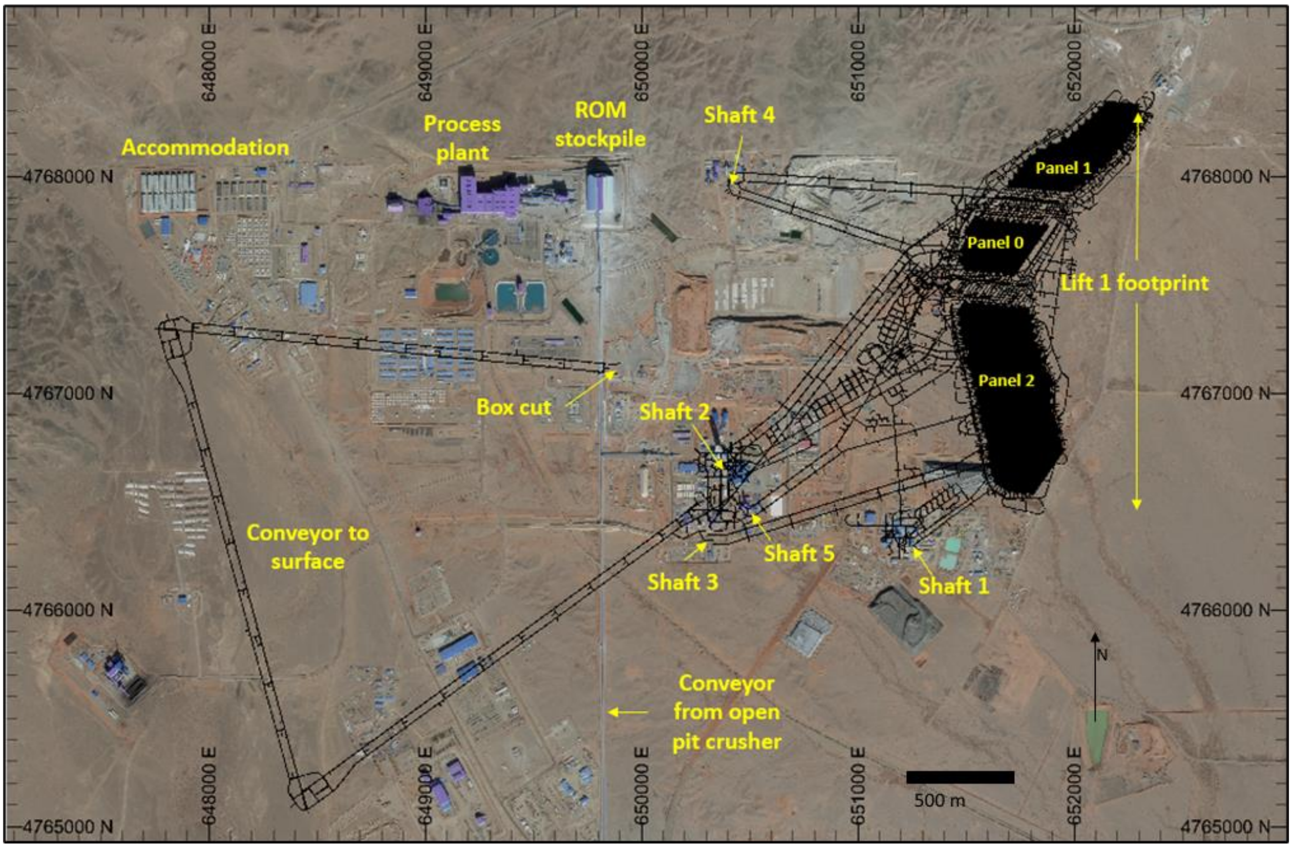
The Phase 2 commenced with sinking activities in Shaft 2 (a multipurpose shaft) and Shaft 5 (an exhaust ventilation shaft) and development of accesses to the Lift 1 footprint. Shaft 2 sinking and installation of fixed guides and other equipment was completed in October 2019 and became operational in December 2019. Shaft 2 is now the main access for personnel and materials and for rock hoisting. Previously, all personnel, materials, and rock hoisting were carried out through Shaft 1. Sinking of Shaft 5 was completed in early 2019. Work has recently started on construction of ventilation shafts Shaft 3 and 4, although Shafts 3 and 4 are now on care and maintenance as a result of the COVID-19 pandemic. The declines for the conveyor to surface are being driven down from the surface.

Figure 16.13 Hugo North isometric view of planned mine development arrangements



Source: Prepared by AMC from information provided by Oyu Tolgoi, Date: 30 June 2020

Figure 16.14 Hugo North surface infrastructure arrangements



Source: Prepared by AMC from information provided by Oyu Tolgoi, Date: 30 June 2020. Projection UTM (WGS84) Z48N.

The Hugo North mine plan envisages construction of a block cave operation with a nameplate production rate of 33 Mtpa. Lift 1 is planned to be extracted in three panels (Panel 0, Panel 1, and Panel 2). Mining is planned to start in Panel 0 followed by Panel 2 and Panel 1. Hugo North

Lift 2 is currently planned as a block cave operation with the footprint approximately 400 m below Lift 1. Development of Lift 2 is at a conceptual stage.

Mine development has progressed, essentially as envisaged in the 2016 Feasibility Study design. Development of the extraction, undercut, and apex levels for Panel 0 is currently taking place. However, delays to the construction of shafts, underground crushers, and underground development has delayed the planned date for blasting the first drawbell.

Since 2018, a detailed review of geological and geotechnical data was carried out. The review highlighted several critical stability risks with aspects of the 2016 Feasibility Study design of Panel 0. As a result, a new footprint design has been adopted for Panel 0, and changes have been made to aspects of Panels 1 and 2.

16.3.2 Geotechnical environment

The caving mining method is well suited to the geological and geotechnical characteristics of the Hugo North deposit. The moderate to high stress conditions, a fractured rock mass, and a large caving footprint minimise risks associated with cave propagation. However, the high stress environment and fractured rock mass will present challenges for excavation stability during construction and operations. Fragmentation analysis indicates fine fragmentation for all geotechnical domains. No significant natural surface features will be impacted by subsidence, and no critical mine infrastructure is planned within the likely subsidence area.

16.3.3 Geotechnical data collection

Geotechnical data for Hugo North was collected and analyzed during several geotechnical work programs over the past decade.

An initial program of geotechnical data collection and analysis was carried out prior to 2009, including 613 uniaxial compressive strength (UCS) tests, in situ stress measurements, and collection of a range of geotechnical data from orientated drill core logs.

Between 2009 and 2016, significant additional data was collected by extensive surface and underground drilling programs. This included approximately 32 km of drilling and sampling from five underground drill sites. The data collected was used to estimate rock mass quality, stress gradients and orientations, and to identify and characterize fault systems in Hugo North Lift 1.

From 2016 to 2019, development advanced from off-footprint infrastructure areas to the west and east sides of Panel 0 onto the footprint of Panel 0. Diamond drilling from surface and underground drill sites recommenced in 2017. The underground drilling aimed initially to increase the understanding of faulting near the planned off-footprint infrastructure and to further characterize faulting in Panel 0. Surface drilling predominantly focused on gaining additional orebody knowledge and to establish the cave monitoring system above Panel 0.

The diamond drilling for geotechnical purposes carried out between 2017 and 2019 is summarized in Table 16.11. The geotechnical parameters logged from drill core include:

- Down-hole interval location (from-to)
- Core recovery
- Rock quality designation (RQD)
- Lithological code
- Intact rock strength/hardness
- Degree and nature of rock weathering
- Total number of discontinuities
- Surface condition of discontinuities, including roughness, wall alteration and infilling
- Non-RMR interval – (soil or fault) including fault type (gouge, sheared or broken)
- Comments – lithology and rock mass

Table 16.11 Underground and surface diamond drilling from 2017 through 2019

Year	Underground drilling				Surface drilling	
	Holes drilled	Footprint drilling (m)	Off-footprint drilling (m)	Seismic monitoring holes (m)	Holes drilled	Hole length (m)
2017	4	-	-	-	24	16,484
2018	34	1,315	2,930	120	57	38,862
2019	90	5,265	3,706	222	28	18,159

Note: Excludes underground cover drilling for the conveyor to surface development and other non-geotechnical drilling.

In 2018, as part of the normal progression to execution level design for Panel 0, a detailed review of underground drilling indicated the presence of significant fault zones in the Panel 0 area that were not fully apparent at the time of the 2016 Feasibility Study. Of concern was the extent and ubiquity of the faulting in a zone known as the lower fault splay, where it was proposed to install critical infrastructure, including the Panel 0 ore-handling system.

In September 2018, three holes were drilled into the main section of the lower fault zone, approximately perpendicular to the strike of the fault. This drilling program increased the understanding of the significance of the fault zone identifying multiple anastomosing splays and varying amounts of gouge.

In 2019, further drilling was conducted to further characterize the other major faults within Panel 0. An extra hole was added to the 2019 drilling program to define the ground conditions of a proposed alternative ore-handling system in the northern part of Panel 0.

As the understanding developed of the characteristics of the lower fault zone via data collection and analysis, including numerical modelling, the implications for mine design and operations were assessed and work commenced to investigate how the impact could be minimized via increased ground support or design modifications.

16.3.4 Structural modelling

Regional, major, and minor geological fault structures are collectively used to inform the location and design of all Hugo North underground infrastructure and the layout of the Lift 1 footprint. A live database of the structural model has been developed and maintained by Oyu Tolgoi LLC.

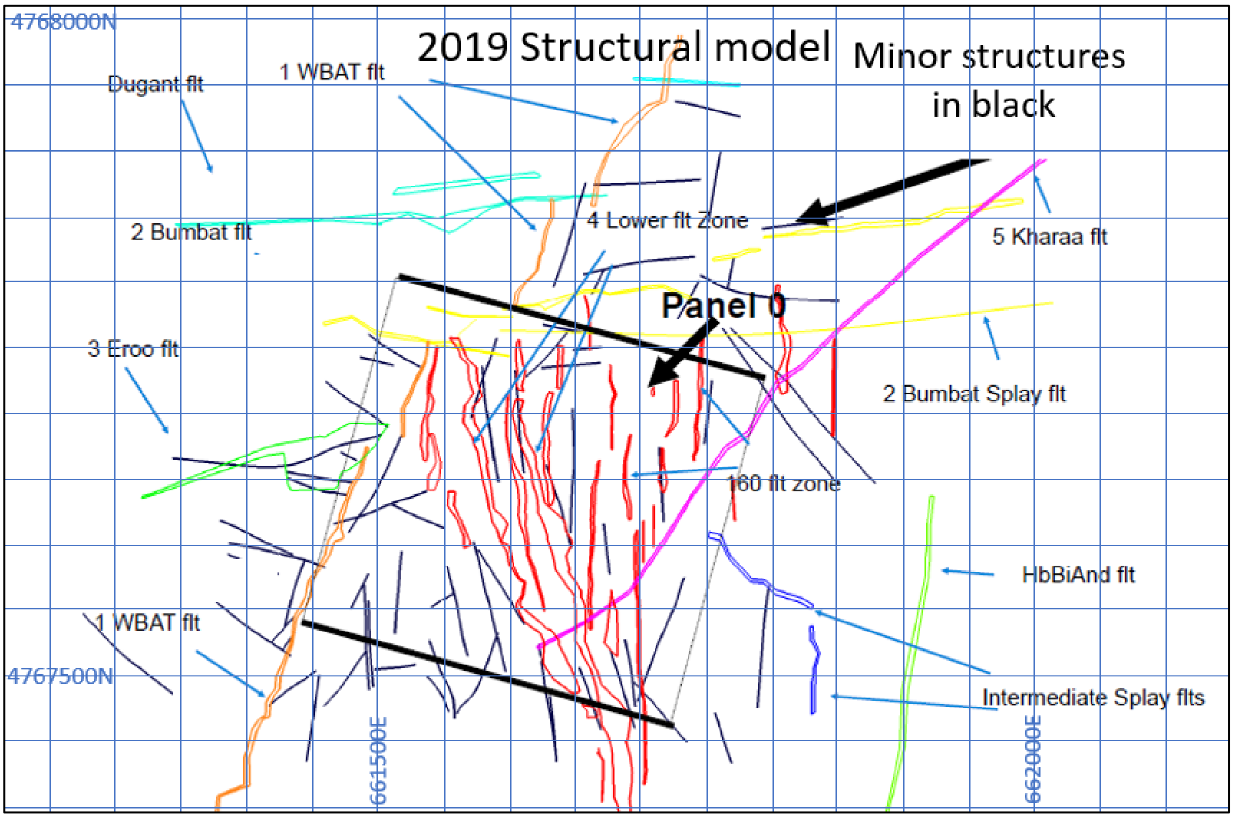
In 2019, SRK Consulting and geoscientists from the Oyu Tolgoi study team updated the structural model of the faults impacting Panel 0. To develop the updated model, all diamond drillhole core photographs were scrutinized in conjunction with available mapping of underground development. Three-dimensional shapes were created from the drillhole data and cross checked against core photographs. Dip and dip direction were used where data was available for fault orientation and projection.

Major faults were defined as having thicknesses ranging between a few metres to tens of metres, a significant amount of gouge and brecciation, strike lengths of hundreds to thousands of metres, and substantial damage zones. Minor faults have thicknesses between 0.6 m to 1.1 m, and strike lengths of approximately 50 m. They have minimal offset and exhibit less damage than the major faults.

A formal review of the new structural model of the Panel 0 area was carried out by Oyu Tolgoi LLC, which concluded that the modelled faults were geologically reasonable and compatible with the available data. The new model does not represent all the fault structures within Panel 0, and the process of investigating the major faults in Panel 0 and Panels 1 and 2 is ongoing.

The new structural model identified significantly more structure than had previously been identified in the 2016 Feasibility Study. Figure 16.15 shows a horizontal projection of the 2019 structural model on Panel 0 extraction level.

Figure 16.15 Hugo North structural model on Panel 0 extraction level (2019)



Source: Prepared by AMC from information provided by Oyu Tolgoi, Date: 24 July 2020. Projection UTM (WGS84) Z48N.

16.3.5 In situ stresses

In situ stress measurements with CSIRO HI cells were made at different sites on several occasions at Hugo North, most recently in 2017. The formulae for estimating the pre-mining stress field used in recent modelling is shown in Table 16.12.

Table 16.12 Formulae for estimating the in-situ stress field

Depth range below surface	σ_1 (MPa)	σ_2 (MPa)	σ_3 (MPa)
0 m to 600 m	0.047D	0.0265D	0.024D
600 m to 800 m	0.071D – 13.95	0.0265D	0.027D – 1.59
Below 800 m	0.031D – 17.5	0.0265D	0.015D + 7.66

D = depth below surface in metres

The in situ stress (sigma(σ) at the Lift 1 extraction horizon is estimated at:

σ1 = 58 MPa sub-horizontal with a dip direction of 054°
σ2 = 33 MPa sub-vertical
σ3 = 27 MPa sub-horizontal with a dip direction of 145°

In situ stresses are assumed to increase linearly with depth in the first 600 m below surface.

16.3.6 Rock strength properties

A comprehensive testwork program was carried out between July and September 2019 to determine the mechanical properties of the different rock types in the Hugo North deposit. The program focused mainly on the Panel 0 rock mass and significantly increased the number of samples tested since the 2016 Feasibility Study. A total of 813 core samples were tested for triaxial compressive strength (TCS), 141 sample for uniaxial compressive strength (UCS), and 151 samples for uniaxial tensile strength (UTS).

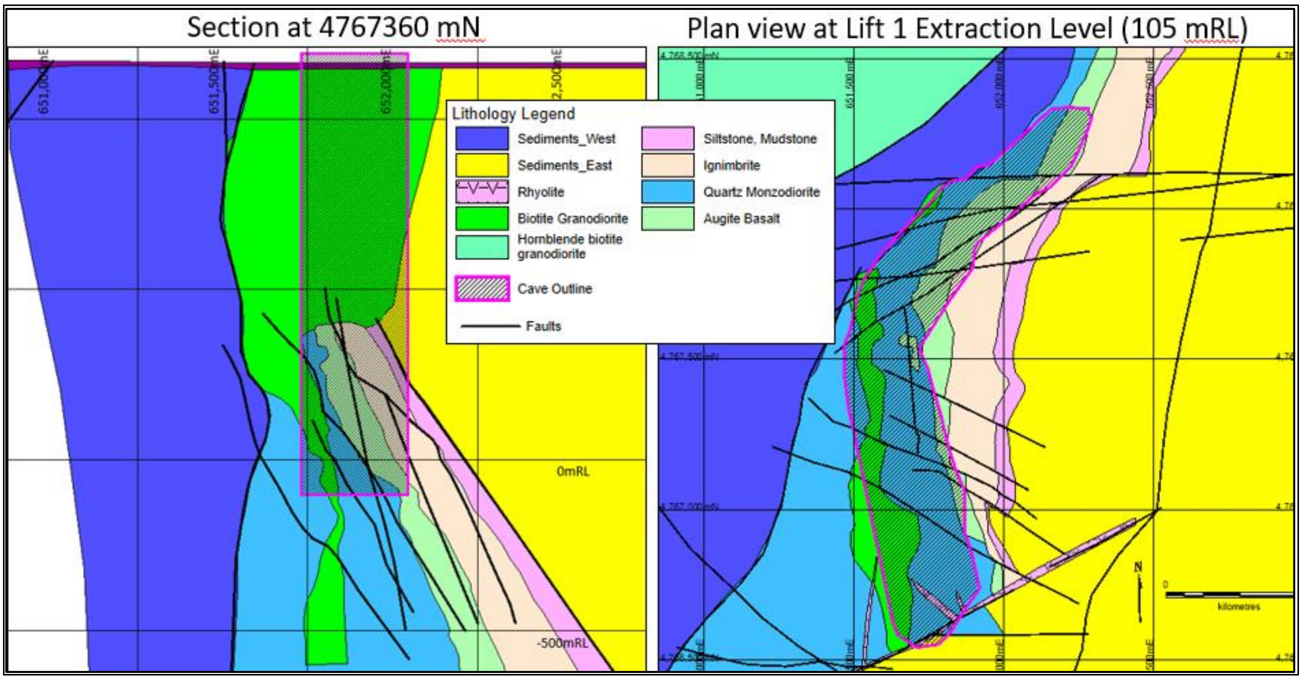
Drillholes were selected to provide the best possible spatial coverage over the Panel 0 footprint and overlying rock mass. Samples were selected from 16 surface and 8 underground drillholes based on preselected down-hole depths to limit any sampling bias towards intact strength. Samples were logged in detail and the vein mineralogy and defect intensity of each noted. Samples were photographed before being wrapped and sealed for transportation.

All geotechnical strength testing was conducted at Trilab in Brisbane, Australia. The laboratory holds soil, rock and calibration laboratory accreditation with the National Association of Testing Authorities, Australia. Samples were photographed prior to and after each test and a detailed laboratory report prepared for each sample in accordance with ISRM and ASTM requirements.

16.3.7 Rock mass properties

The distribution of the main rock types in the Oyu Tolgoi Lift 1 rock mass are shown in Figure 16.16. A summary description of the lithologies and their associated acronyms is provided in Table 16.13.

Figure 16.16 Hugo North east-west section and plan showing the geology in the Panel 0 area



Source: Prepared by AMC from information provided by Oyu Tolgoi, Date: 30 June 2020. Projection UTM (WGS84) Z48N.

Table 16.13 Summary of the lithology and rock descriptions of Panel 0 geological units

Acronym	Lithology
VA	Augite basalt (DA1) dark green massive porphyritic (augite) basalt
IGN	Ignimbrite (dacitic tuff/volcaniclastic rocks)
DA3	Polylithic conglomerate, rhythmically interbedded carbonaceous siltstone and fine brown sandstone
BiGd	Biotite granodiorite
CretClay	Cretaceous clay
QMD	Quartz monzodiorite
HWS_East	Hangingwall sequence east (mostly basaltic flows, fragmental rocks and siltstone)
HWS_West	Hangingwall sequence west (various combinations of basaltic flows, fragmental rocks and siltstone, andesitic lapilli tuff and volcaniclastic rocks, conglomerate sandstone, tuff and coal, basaltic and andesite lava and volcaniclastic rocks)

Empirical rock mass characterization and classification was carried out using the geological strength index (GSI)[15] and the in-situ rock mass rating (IRMR)[16] systems. In addition, Golder developed a geotechnical block model of the Panel 0 rock mass.

To create the geotechnical model, Golder integrated the geological model (lithological wireframes), the structural model (regional, major, and minor structure), the geotechnical interval and structural logging data, and the results from the laboratory rock strength tests. Wireframes for the main lithological units were used to constrain the model.

A discrete fracture network (DFN) approach was used by Golder to model the intensity of the structures (faults, individual vein types, open joints) and the block size distribution of the rock mass. This was then used to generate GSI values, which were applied to each block in the geotechnical block model. The DFN approach provided GSIs in the range of 60–75.

Rock mass strength estimates used in the model were based on the anticipated failure mechanisms of the rock mass when stressed. Where the rock mass was blocky (GSI≤65), the rock mass strength was scaled up from the rock strength test work using the generalized Hoek-Brown criteria. Where the rock mass was massive to moderately jointed (GSI>65), the rock mass strength was up from the rock strength test work using the spalling strengths.

The strengths for major faults with substantial damage zones, like the lower fault zone, were assigned rock mass strengths based on back-analyses of observed deformation of underground development. The back-analysis indicated rock mass strengths in the damaged zones of 3.2 MPa (GSI=40). The minor structures, mostly characterized by little to no thickness, were assigned a strength category by SRK and an associated Barton-Bandis strength criterion, which is commonly used for discontinuities and shears and similar to the Hoek-Brown criteria or Mohr Coulomb criteria used on rock masses.

The rock mass strengths were estimated from the laboratory test work results following the approach outlined by Bewick et al. (2018) for massive heterogeneous (i.e. veined) rock masses. The approach entails scaling laboratory intact core strength to trilinear rock mass strengths based on spalling strength at low confinement, and confined strength at higher confinement (adjusted for scaling effects), then fitting an equivalent Hoek-Brown rock mass strength envelope to the trilinear envelope. The failure type classifications from the laboratory test results were reclassified by Golder as:

- Homogeneous – Failure through the homogeneous rock matrix by extension at low confinement or shear rupture at high confinement.

[15] Hoek et al., 1995 and Hoek and Brown 2018.
[16] Laubscher 1990.

- Combined – Failure by a combination of shear slip on discrete features and extension or shear failure through the homogeneous rock matrix. This failure type also requires recording the orientation of the failure plane and the infilling characteristics (primary and secondary mineral infilling, thickness) and alteration.
- Weakness network (i.e. along veins) – Failure completely along multiple veins, or around clasts, etc.
- Discrete – Shear failure along one discrete feature.

The final geotechnical block model includes components of lithology, RQD, logged microdefect intensity, ISRM field strength estimates, intensity of dominant structure types block size, intact rock strength, and GSI. The GSI values from the DFN modelling used in the analyses were correlated by numerical modelling back-analysis. The final rock mass properties used in the geotechnical model are summarized in Table 16.14.

Table 16.14 Summary of the final rock mass properties used in the geotechnical model

Rock type	σci (MPa)	GSI	mi	mb	s	a	σt (MPa)	σcrm (MPa)
QMD	95	62	24	6.2	0.0147	0.502	−0.23	11.4
BiGd	95	61	18	4.5	0.0131	0.503	−0.28	10.8
VA	105	62	18	4.6	0.0147	0.502	−0.33	12.6
IGN	75	62	13	3.3	0.0147	0.502	−0.33	9.0
Fault - calibrated	98	40	15	1.8	0.0013	0.511	−0.07	3.2

Rock mass strengths predicted by the modelling are higher than those used in the 2016 Feasibility Study. For example, the mean rock mass strength for the QMD rock type used in the 2016 Feasibility Study was slightly below 8 MPa, whereas the value used in the 2020 modelling was 11.4 MPa.

The increased rock mass strength is mainly due to the improved sampling coverage and the higher GSI estimates derived by Golder. Itasca Australia benchmarked the final strength values against their database for porphyry copper deposits and deemed the values reasonable and in the range of other similar deposits. In addition, borehole camera surveys for stress and damage fracturing were conducted on several drives on the extraction and undercut levels and the depth of damage assessed in each hole. The depth of damage was back-analysed by Itasca and values matching the DFN modelling were obtained.

A comparison between the rock properties used for the 2016 Feasibility Study and the 2020 Feasibility Study and shown in Table 16.15.

Table 16.15 Comparison between the 2016 and 2020 feasibility study rock properties

Rock type	2016 Feasibility Study UCS mean (MPa)	2020 Feasibility Study UCS mean (MPa)	2016 Feasibility Study mi	2020 Feasibility Study mi	2016 Feasibility Study GSI	2020 Feasibility Study GSI
QMD	94	95	12	24	37	62
BiGd	126	95	14	18	40	61
VA	60	105	6	18	42	62
IGN	88	75	11	13	41	62

The Oyu Tolgoi rock mass is a typical massive-to-moderately veined porphyry deposit. Much of the rock is moderately to heavily micro-defected, and the core often breaks easily along these defects when handled. Examination of drill core suggests that many of the features logged as planar open joints might be counted more appropriately as irregular closed (healed) microdefects that have opened during drilling. Stronger microdefects tend to remain healed and uncounted as fractures (although their density is noted qualitatively). Neighbouring weaker microdefects that have opened appear to be regularly counted as open joints. These observations were historically not considered during the development of the rock mass ratings for the deposit and hence historic GSI ratings were lower than those currently estimated through the more detailed analysis carried out over the past two years.

16.3.8 Geotechnical modelling

Several geotechnical numerical models were prepared to assess the stability of mine designs and to investigate cave propagation. Key inputs to the numerical models included the lithology and structures and the rock mass strength characteristics of the various geological units. The focus of recent modelling was on Panel 0.

Two expert consultancies, Beck Engineering and Itasca, each using different modelling methodologies, were commissioned to develop geotechnical numerical models of Panel 0.

Initially, the models were used to evaluate risks associated with the 2016 Feasibility Study design of Panel 0 and to planned changes to the design driven by the increased understanding of the lower splay fault. Following the initial modelling, both Itasca and Beck conducted a more detailed stability review of all aspects of the Panel 0 design. This review included:

- The undercut initiation shape, orientation angle, and development sequence.
- The stability of the central ore-handling system (ore passes, truck loading chutes, and the associated ventilation excavations).
- Caving over the Panel 0 boundaries into Panel 1 and 2.
- Drawpoint stability.
- The stability of the rim drives and other excavations associated with Panel 0.

The modelling work included modelling cave progression and material flow within the cave.

As development into the Panel 0 footprint progressed, multipoint borehole extensometers were installed in the development tunnels to measure the rock mass response to mining. The closure information from the extensometers was compared to the closures predicated by the models.

16.3.9 Stability of the 2016 Feasibility Study footprint design

Modelling of the stability of the 2016 Feasibility Study design of Panel 0 using the latest geotechnical information identified several critical stability risks, mainly resulting from the impact of the more detailed understanding of the lower fault splay. The following aspects of the 2016 design were identified as requiring modification:

- The ore pass and truck loading arrangements were positioned in an area significantly impacted by the lower splay fault and other intersecting structures. Extreme damage to transfer boxes, truck chutes and ore passes was predicted. The stability assessment clearly indicated the need to relocate the ore passes to a less structurally disrupted area and to simplify the design of the ore pass arrangements to increase their ability to tolerate high stresses.
- The 2016 Feasibility Study proposed starting the Panel 0 undercut in a central position in Panel 0, opening out an undercut face across the full width of the footprint, and then extending the undercut in two directions. This arrangement was predicted to result in higher than expected abutment stress damage to the extraction level and undercut drives during the initial undercutting process.
- The proposed sequence of transitioning the undercut from Panel 0 to Panel 1 posed a risk of to the major apex pillars and to the north rim drive.
- The extraction drives extending across Panel 0 and Panel 2 lie roughly parallel to the long axis of the orebody—that is, a longitudinal arrangement as opposed to a transvers arrangement across the orebody. Because of the length of the extraction drives, crosscuts (rim drives and mid-access drives) are required to provide convenient access points to the

extraction drives. Damage to the southern Panel 0 rim drive was predicted to occur due to the planned prolonged exposure to abutment stress and the presence of intersecting large-scale structures.

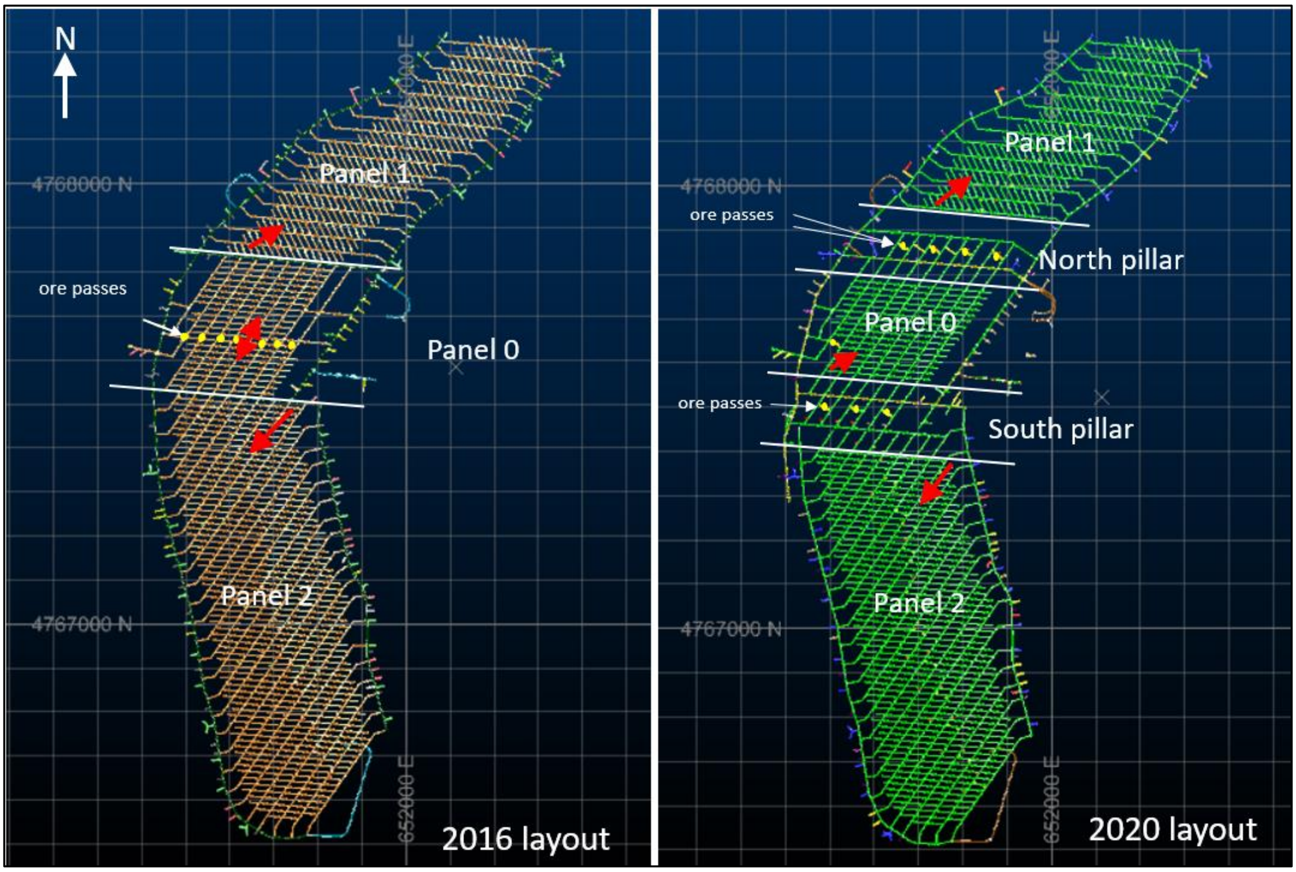
- Stability modelling indicated that, at the extraction drive and drawpoint spacing modelled (31 m by 16 m), failure could occur in up to 50% of the drawpoint pillars in the part of Panel 0 affected by the lower splay fault.

To address the stability risks, a comprehensive set of redesign options for the Lift 1 footprint were considered. The criteria used to select the new design were weighted towards minimizing the technical risk and maximizing the operability of the design. Economic considerations, driven by the impact of the design options on the production start date and the sustainability of the production buildup, also impacted the selection.

The new footprint design involves leaving 120 m wide pillars, as measured on the undercut level, separating Panel 0 from Panel 1 and from Panel 2. The pillar width was selected following geotechnical modelling work that considered a range of options. The pillars provide a more stable location for the ore-handling system and for the rim drives and increase optionality of sequencing Panel 1 and Panel 2. The redesign also includes a revised undercutting sequence for each of the panels and an overall increase in extraction drive and drawpoint spacing to 31 m by 18 m, respectively, improving extraction level stability.

Figure 16.17 shows a comparison of the 2016 Feasibility Study extraction level layout and the 2020 revised layout.

Figure 16.17 Hugo North extraction level layout changes 2016



Source: Prepared by AMC from information provided by Oyu Tolgoi, Date: 30 June 2020. Projection UTM (WGS84) Z48N.

16.3.10 Impact of the redesign of Lift 1 footprint

The new Lift 1 footprint design relocates the ore passes and loading chutes away from the poorer ground associated with the lower splay fault and locates them in the north and south pillars. The north and south rim drives are also located in the pillars.

When ore passes in the north and south pillars are complete, each extraction drive will have access to two tipping points. Average LHD unit (scoop) tramming distances are slightly longer than in the 2016 design. However, the arrangement provides easier access to alternative tipping points when a pass and loading chute is unavailable for maintenance or repair.

An advance undercut arrangement is proposed, which is similar to that proposed in the 2016 Feasibility Study. Undercutting of Panel 0 will start in the south-west corner of the panel and will advance as a single face in a north-easterly direction. Compared with the 2016 sequence, the arrangement reduces the undercut area needed to reach the hydraulic radius for caving and reduces the impact of abutment stress on the extraction level and undercut. It results in a single advancing undercut face rather than the two faces proposed in the 2016 Feasibility Study. This reduces the complexity of the undercutting and drawpoint construction process but also concentrates construction into a more confined area.

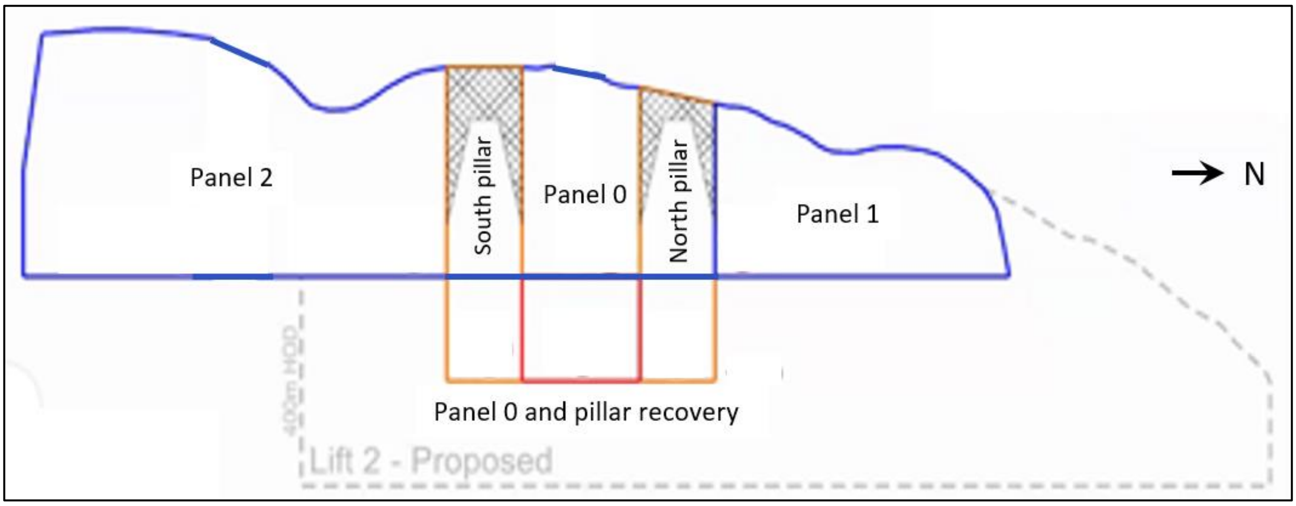
The undercutting direction in Panels 1 and 2 remains the same as the 2016 Feasibility Study, but in the 2020 design, the undercut advances away from the stable northern and southern pillars.

Increasing drawbell spacing improves the stability of the extraction level in zones of poorer rock mass quality. Flow modelling, using the latest modelling techniques available, was carried out to assess the impact of the spacing change on ore recovery. The modelling indicated that there will be minimal change in ore recovery resulting from the wider spacing. Despite significant advances in flow modelling and calibration of models against actual performance in other mines, the effect of drawpoint spacing on ore recovery is not well understood. When caving operations commence, the impact of drawbell spacing on material flow can be calibrated against actual performance in Panel 0. This will be facilitated by data from the extensive flow marker network being installed prior to the start of caving.

A significant adverse impact of the updated design is the amount of high-grade mineral resource that will remain in the pillars. The reduction in the mineral reserve between the 2016 Mineral Reserve estimate and the 2020 Mineral Reserve estimate is described in Section 15. The introduction of pillars between the panels provides an opportunity to change aspects of the Panel 1 and 2 designs to increase Project value by optimizing the extraction level elevation of each panel. Studies to investigate these opportunities and to recover mineral resources from the pillars have commenced. A concept for a recovery level below Panel 0 and the pillars is shown in Figure 16.18.

If, after caving commences, it is determined that rock mass conditions and abutment stresses are more favorable than currently envisaged, it may be possible to recover part of the mineral resource in the pillars from the current extraction level by extending Panel 0 or by modifying the start of Panels 1 and 2. Alternatively, a recovery level below the current extraction level could be constructed to recover some ore from the pillars and from areas in Panel 0 where recovery was incomplete because of poor rock mass conditions.

Figure 16.18 Concept for a recovery level below Panel 0 (looking west).



Source: Prepared by AMC from information provided by Oyu Tolgoi, Date: 30 June 2020

16.3.11 Strain burst potential

Rock burst index testing was conducted to assess the strain burst potential of different rock types. This testing identified the rhyolite dykes and some portions of the BiGd rock type that have properties that could allow them to fail suddenly under high differential stress conditions. The rhyolite dykes in the southern part of the mine appear more massive and may be prone to strain bursting. All such areas are planned to be identified and supported using yielding and dynamic support elements.

16.3.12 Ground support

Standardized ground support recommendations were prepared for all heading types and ground conditions. The ground support regimes are generally broken into three categories: good (Type 1), poor (Type 2), and ground with strain burst potential (Type 3). The categorization is influenced by the expected rock mass conditions and the induced stress regime.

For on-footprint development, approximately 55% of development is expected to require Type 1, 40% Type 2, and 5% Type 3. For off-footprint development, 90% of the development is anticipated to require Type 1 ground support and 10% as Type 2. For Panel 0, the forecast ground support requirements are 10% Type 1, 85% Type 2, and 5% Type 3.

The following ground support elements are included in all ground support designs:

- Fibre-reinforced shotcrete between 50 mm to 100 mm thickness, with a minimum UCS of 20 MPa in 72 hours, 30 MPa in 7 days, and 40 MPa in 28 days.
- Rock bolts 25 mm diameter, threaded, fully encapsulated resin-grouted thread bars with a minimum yield strength of 200 kN. All rock bolts have standard bearing and domed face plates. The minimum bolt length is 2.4 m.
- Cable bolts 18 mm and 22 mm single-strand cables with a minimum yield strength of 280 kN and 441 kN, respectively, with a high-tensile domed face plate, installed at all intersections and any drive profile greater than 6 m wide. For zones of high deformations such as on-footprint or strain burst prone rock masses, dynamic gracom cables will be installed and pre-tensioned to 8 t.
- The ground support for all major excavations (crusher chambers, ore bins, etc.) is designed to minimize the deformations predicted by the modelling and to avoid the need for any future rehabilitation.

Additional ground support elements include:

- A shotcrete layer from floor to floor in Type 2 and Type 3 categories, and for extraction-level and haulage-level drives for added support and to embed a mesh layer to protect support from equipment damage.
- Debonded cable bolts installed in type 2 zones.
- A yielding rock bolt, diamond/chain mesh, and dynamic cable bolt installation in type 3 zones.
- Strapping around pillar ribs, including bullnoses and camel backs on the extraction level.
- Steel brow sets installed in each drawpoint on the extraction level.

16.3.13 Caveability

Caveability assessments were conducted using three different analysis methods:

- Laubscher MRMR rock mass classification system combined with the Laubscher's (2000) MRMR stability graph.
- Extended Matthew's stability chart, based on the Matthews N value (a derivative of the NGI Q system).
- A coupled cave propagation simulation method described in Hebert and Sharrock (2018).

The Laubscher stability graph approach indicated a hydraulic radius (HR) to sustain continuous caving of between 20 m to 23 m (for median rock mass conditions). The extended Mathews stability chart indicated slightly larger range 25 m to 35 m; however, the Lift 1 cave lies outside the range of experience captured by the chart.

The coupled cave propagation simulation method implements a detailed and numerical approach to simulate cave propagation based on strong bidirectional coupling between FLAC3D (Itasca 2019) and CAVESIM (Sharrock 2019). Production advance is simulated in CAVESIM, where material is drawn from the drawpoints based on the input draw schedule. Material flow is simulated within CAVESIM, and the resulting air gap volume and volumetric flow rate in the cave are communicated to the FLAC3D model.

Using a range of properties, cave initiation is predicted at a HR between 25 and 29 (minimum span of 100 to 115 m) depending on the design and starting location. The caveability analysis indicates that faulting will significantly influence and promote caving and cave propagation.

16.3.14 Cave Monitoring

The proposed cave monitoring system includes a microseismic system, time domain reflectometers, extensometers, and open drillholes. Cave flow monitoring systems comprise smart markers, network markers, and cave trackers installed primarily down surface drillholes. These systems will provide safeguards against potential hazards and will increase the understanding of cave flow for adjusting draw strategy to optimize recovery.

16.3.15 Fragmentation

Fragmentation analyses were carried out by SRK using block cave fragmentation software. The input parameters used are based on core logging data and the average stress measurement for the site. Fragmentation is predicted to be "good" (as classified by Laubscher 1990) with all geotechnical domains having a primary fragmentation <2 m^3 of over 98%, progressively changing to between 99% and 100% through secondary fragmentation processes.

16.3.16 Subsidence

Numerical assessment of cave propagation has been carried out by Itasca using a coupled FLAC3D-CAVESIM model. The aim was to investigate the first 50 months of production, with focus on the period from cave initiation to surface breakthrough. The sensitivity of propagation to rock mass strength was assessed for P30 and P50 material properties (lower percentile values for UCS, mi and GSI).

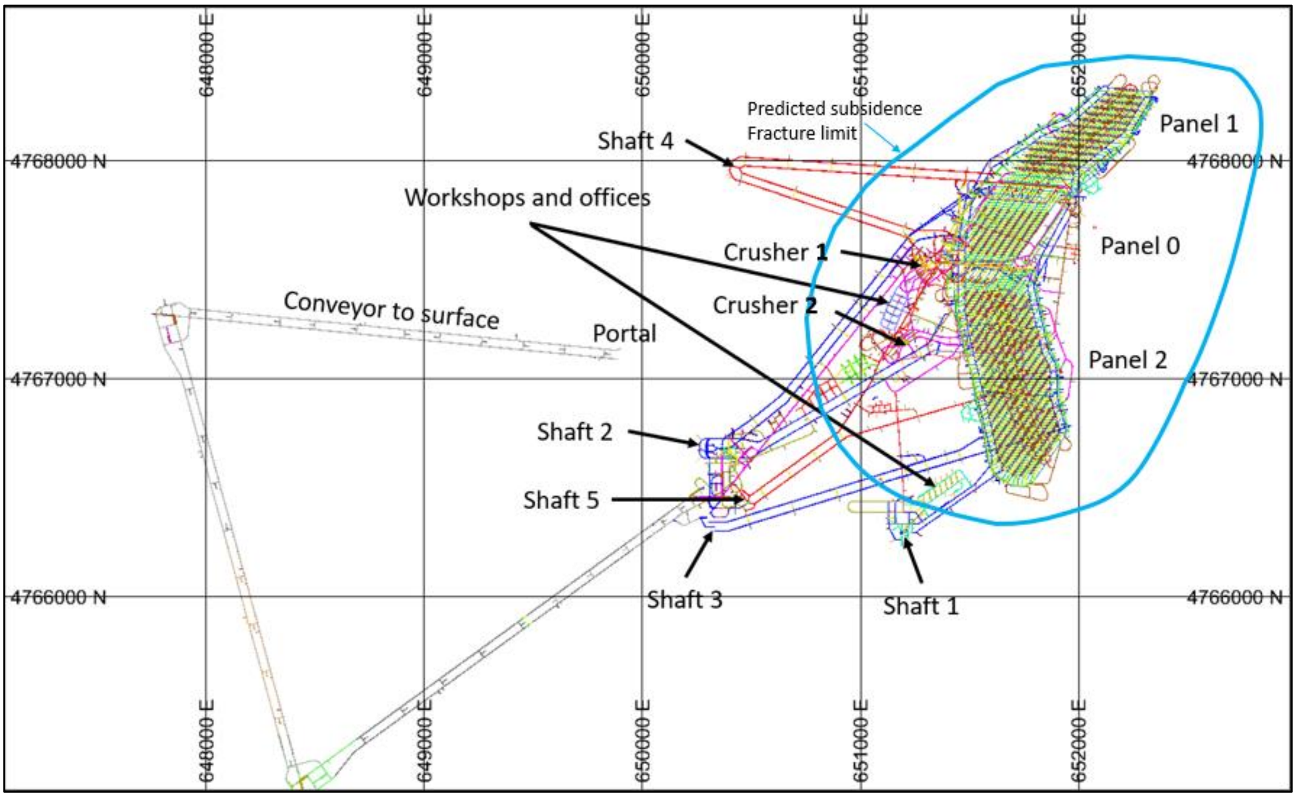
In addition to the rock mass properties, the rate of propagation depends on the start point and direction and rate of undercutting and the production rate. Using the planned undercut sequence and production rate, the cave is predicted to propagate to surface with no significant airgaps formed nor significant intermittent caving events.

Using P50 material properties and a bulking factor of 115%, surface breakthrough is predicted after 42 months of production (i.e. 30 months after cave initiation or 15 months after full undercutting). Using P30 material properties and a bulking factor of 108%, surface breakthrough is predicted to occur around 10 months earlier. However, the relatively high draw ramp up rate, combined with critical HR, results in a narrow, conical shaped cave at breakthrough. The formation of a conical cave is heavily influenced by the relatively low rock mass strength and large-scale structures that act as cave propagators, especially the Kharaa fault in the south-east corner of the footprint and the Bumbat and Wbat faults in the north-west.

After breakthrough, some cave sidewalls, particularly the north-east sidewall, have substantial overhangs. For P30 properties, these overhangs gradually collapse as draw progresses. For P50 material properties, a final state overhang or hang-up is predicted in the north-east cave sidewall. Also, a lower caving rate is predicted above the north-east corner of the footprint. The formation of the overhang is also influenced by the corner in the cave footprint. Based on the properties provided, the models indicate the risks of significant overhangs forming are low.

The predicted subsidence fracture limit (determined as the point of having a notable impact on key infrastructure) at the end of mining Lift 1 is shown by the red outline in Figure 16.19. The subsidence angles are predicted to be near-vertical at the northern and southern limits of the cave, where confinement is highest, and approximately 55° in the east and west directions, where confinement is lowest.

Figure 16.19 Hugo North predicted subsidence fracture limit



Source: Prepared by AMC from information provided by Oyu Tolgoi, Date: 30 June 2020. Projection UTM (WGS84) Z48N.

It is planned to construct a fence 100 m outside this red outline to restrict access, and to install a comprehensive subsidence monitoring system using extensometers, survey prisms, crack displacement monitors, and utilize additional remote monitoring techniques such as aerial photography, and satellite displacement detection monitoring.

Apart from Shaft 1, all shafts and permanent infrastructure are located well outside the predicted fracture limit. Shaft 1 is closest to the fracture limit and may be impacted by subsidence damage later in the mine life. Should subsidence encroach on this shaft, the hoisting system will be decommissioned, and the shaft will be used for ventilation purposes where some movement and cracking of the shaft lining can be tolerated.

16.3.17 Mine design

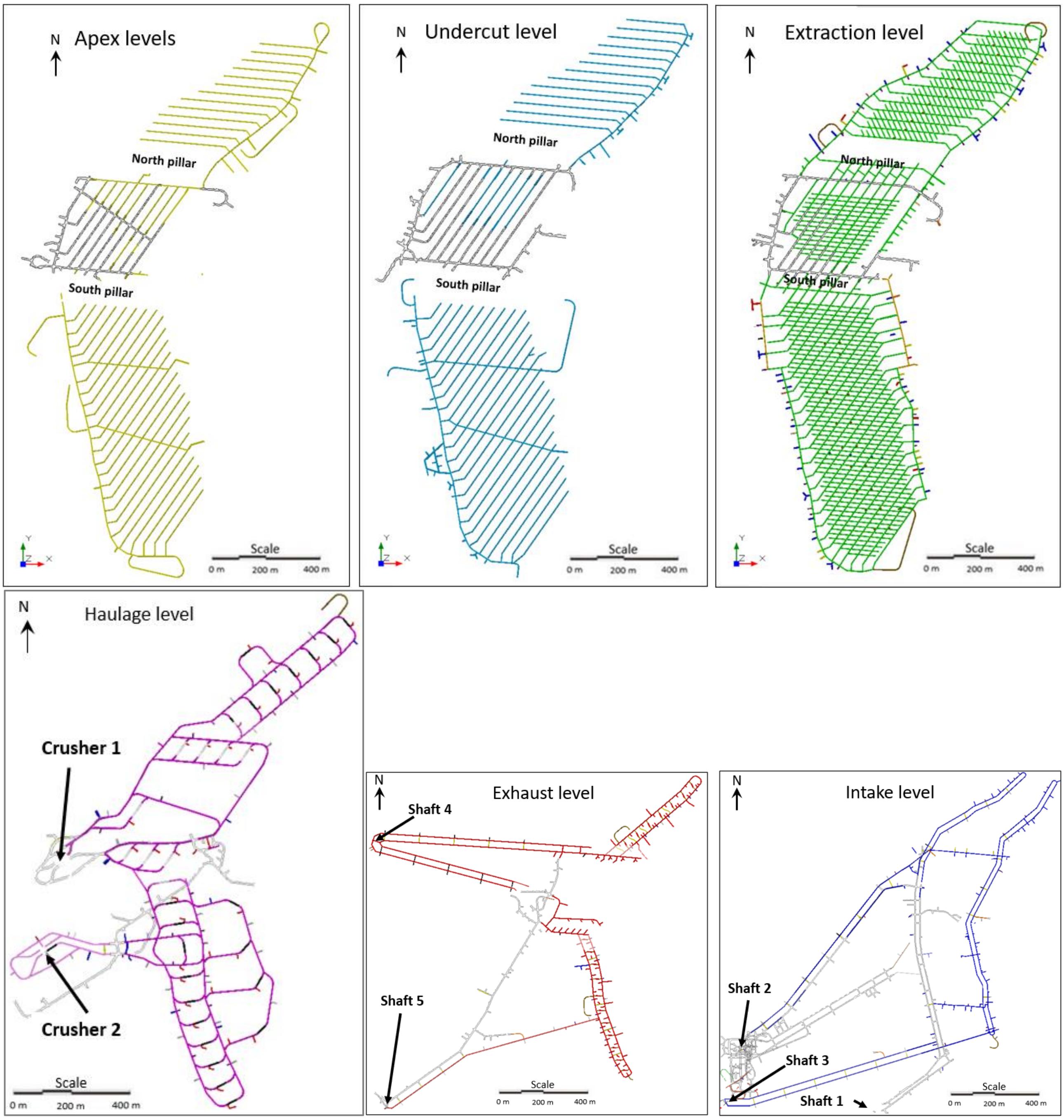
The mine design consists of 211 km of lateral development, five shafts, and two decline tunnels from surface. The primary life-of-mine ore-handling system will transport ore to surface by a series of conveyors to surface. An overview of the planned Lift 1 development is shown in Figure 16.19.

The Lift 1 mining levels are approximately 1,300 m below surface. Six distinct levels will be developed to mine Lift 1. The levels are shown in Figure 16.20. The Apex and undercut levels are shown in the left same image (the left-hand image). The apex level is 17 m above the undercut level, which in turn is 17 m above the extraction level (floor to floor). The haulage level is 44 m below the extraction level. In the footprint area, the exhaust ventilation level lies between the extraction and haulage levels.

Since the 2016 Feasibility Study, the mine design has been optimized to reflect detailed planning of underground infrastructure and mine level layouts. Close to 300 design changes have been recorded to date. The design changes are subject to a strict approval process within Oyu Tolgoi LLC.

Over 64 km of lateral development and over 5 km of vertical development have been completed since the Project commenced

Figure 16.20 Hugo North mine levels



Completed development is coloured grey

Source: Prepared by AMC from information provided by Oyu Tolgoi, Date: 30 June 2020

16.3.18 Shafts

Shaft 1

Shaft 1 is a 6.7 m diameter multipurpose service, production, and intake ventilation shaft sunk to a depth of 1,385 m. The shaft is concrete-lined and is equipped with two hoisting compartments each with fixed guides. The shaft is fitted with a double-deck cage (32 people per deck), and two 9.5 t skips. The shaft is equipped with power and communication cables, compressed air, service water dewatering pipelines, and concrete and shotcrete delivery lines. The shaft is complete and operating. Shaft 1 was constructed to provide initial access to the Hugo North deposit for underground exploration and initial development.

Shaft 2

Shaft 2 is a 10 m diameter multipurpose service, production, and intake ventilation shaft sunk to a depth of 1,284 m. The shaft is concrete-lined, equipped with fixed guides, and operates a single deck cage (150 people) and twin 60-tonne skips. The designed hoisting capacity of the production hoist is 10.8 Mtpa. The shaft is complete, and both the service winder and the production winder have recently been commissioned.

Power supply cables, instrumentation cables, compressed air, service water, and dewatering pipes are installed in the shaft. The shaft is equipped with two 150 mm slick lines (one active, one standby) to deliver concrete and shotcrete from surface to a receiving station at the shaft bottom. The main mine pump station is also located at the shaft bottom.

Shaft 3

Shaft 3 is a 10 m diameter concrete-lined intake shaft, with a planned depth of 1,148 m. The collar and shaft sinking facilities were established and the pre-sink has been completed. Shaft sinking is currently suspended due to the impact of Covid-19 travel restrictions.

Shaft 4

Shaft 4 is an 11 m diameter concrete-lined exhaust shaft, with a planned depth of 1,209 m. The collar and shaft sinking facilities were established and pre-sink work has been completed. Shaft sinking is currently suspended due to the impact of Covid-19 travel restrictions.

Shaft 5

Shaft 5 is a 6.7 m diameter concrete lined exhaust shaft, with two underground ventilation stations and a depth of 1,178 m. Shaft 5 is currently fitted with three surface fans that will provide the main exhaust pathway until the commissioning of Shaft 4.

Aggregate delivery raise

An abandoned pilot hole from surface originally intended to support the boring of a ventilation raise is currently being used to deliver aggregate to the underground workings.

16.3.19 Conveyor to surface

The planned conveyor to surface system comprises three identical 2,202 m long 1.6 m wide steel cord conveyors operating at 6 m/s and capable of conveying the full planned production rate of 32 Mtpa. The conveyors will be installed in a 6.0 m wide by 5.4 m high conveyor decline. The conveyor system has a vertical lift of 1,180 m, and each belt is driven by two 6 MW motors directly coupled to the drive. When operational, the conveyor will deliver all ore from Hugo North to surface, and the Shaft 2 rock hoisting system will operate as a standby system.

A service decline, driven parallel to the conveyor decline, will provide regular access points to the conveyor decline, mine access for materials and maintenance, and act as an alternative means of egress from the mine.

16.3.20 Access for personnel and materials

Prior to commissioning Shaft 2, all personnel, equipment, and materials for mine development were delivered to the underground workings via Shaft 1. Shaft 2 now provides the main access to the mine for personnel and materials. Two main access drives connect the Shaft 2 station to the main workshops, offices, and extraction level. Traffic travels in a clockwise direction to and from the shaft. Ramps from the main access drives provide access up to the undercut and apex levels, and down to the haulage and ventilation levels. The conveyor decline from surface will provide alternative access for materials.

16.3.21 Footprint layout

The orientation of the drives on the extraction, undercut, and apex level for Lift 1 remain as proposed in the 2016 Feasibility Study. Panel 0 and Panel 2 drives are oriented at 215°, while Panel 1 drill drives will be oriented at 95°.

Perimeter drives 5.0 m wide by 5.5 m high encircle the footprint to provide access, ventilation, and services to the operating levels.

16.3.22 Apex and undercut levels design

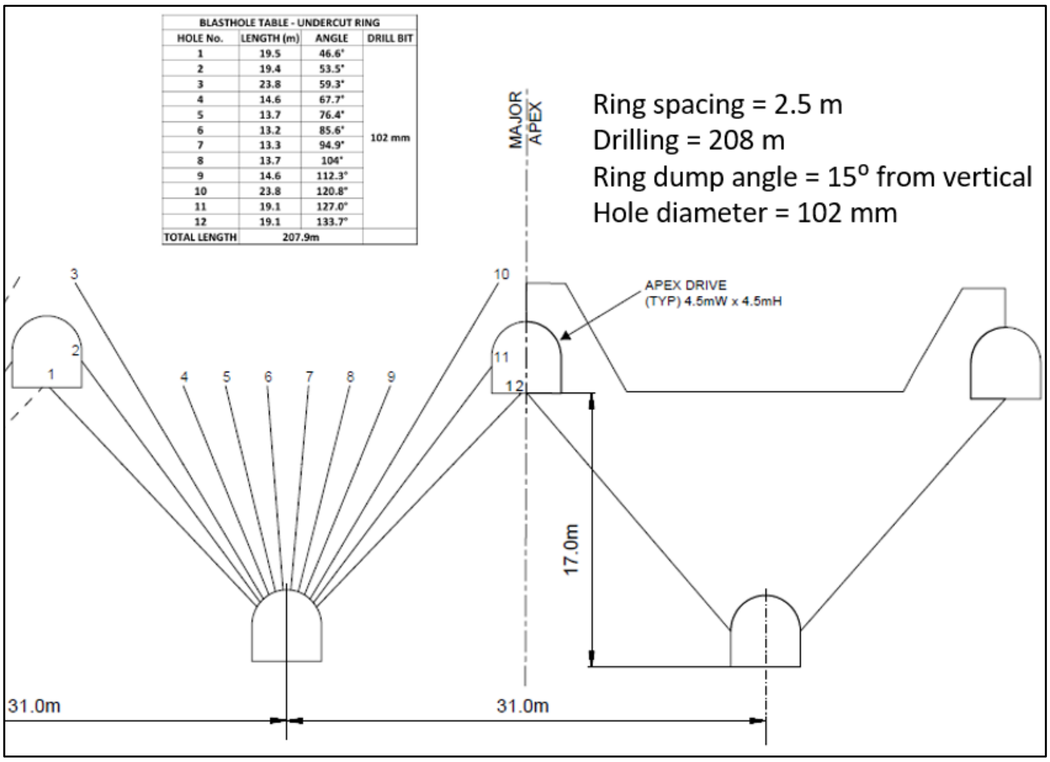
The apex and undercut levels provide access tunnels for production drilling and blasting to undercut the orebody. Blastholes are drilled from undercut level towards the apex level drives, which run parallel to the undercut drives. The apex level allows inspection for blasthole deviation prior to each blast. It also provides the ability to inspect the outcome of each blast. A cross-section of a typical undercut drill pattern is shown in Figure 16.21.

Undercut blasting extends 18 m (one drawbell spacing) from the centre of draw in each production drive to ensure cave propagation for drawbells along the cave edge.

The undercut and apex level perimeter drives are located a minimum of 32.5 m outside the undercut blasting area to protect against cave abutment stress.

After blasting an undercut ring approximately 60% of the blasted tonnage (the swell) from the ring will be mucked from the undercut level.

Figure 16.21 Typical undercut ring design



Source: Prepared by AMC from information provided by Oyu Tolgoi, Date: 30 June 2020

16.3.23 Extraction level design

A summary of the design parameters for the extraction level is provided in Table 16.16. The extraction level layout is shown in Figure 16.22.

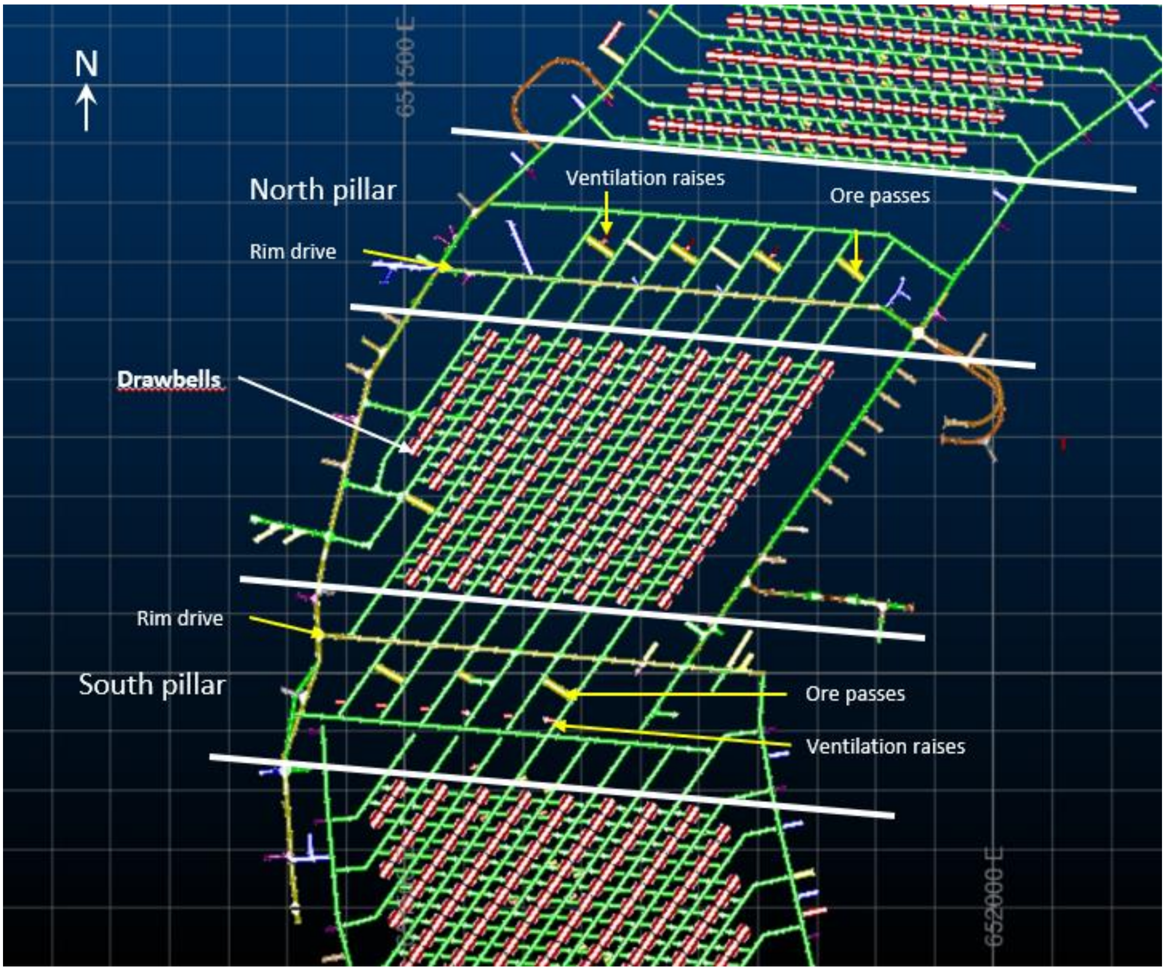
An El Teniente-style drawpoint layout is proposed for the entire footprint with drawpoints angled at 60º to the extraction drives. The 2016 Feasibility study proposed that the drives on both the apex, undercut levels and extraction levels would be spaced at 28 m centers. To increase stability, the spacing of the drives has been increased to 31 m.

Table 16.16 Extraction level design parameters

Extraction level	2016 FS	Panel 0	Panel 1 and 2
Extraction drive spacing	28 m	31 m	31 m
Drawpoint spacing	15 m	18 m	18 m
Extraction drive development width x height	4.5 m x 4.5 m	No change	No change
Extraction drive min. operating width x height[a]	4.2 m x 3.9 m	No change	No change
Number of extraction drives	53	9	36
Number of drawpoints	2,231	222	1,232
Drawbell blasthole diameter	89 mm	No change	No change
Drill meters per drawbell	1,528	No change	No change

Note: After installation of ground support and road base.

Figure 16.22 Hugo North Panel 0 extraction level



Source: Prepared by AMC from information provided by Oyu Tolgoi, Date: 30 June 2020

The extraction level perimeter drives on the east and west sides of the footprint are generally at least 50 m from the last bell to protect against cave abutment stress and are offset 5 m from the overlying undercut perimeter drifts. The rim drives of Panel 0 are offset three drawbells (54 m) from the first bell and approximately 36 m from the edge of the undercut.

Drawbells connect the extraction level to the blasted undercut, allowing caved ore to be drawn from the drawpoints. Each drawpoint brow will be supported by heavy-duty steel sets to support and protect the brow area. The sets will be installed with a purpose-built jig to minimize installation time and manual handling. The sets will be rock bolted and shotcreted in place. The type and number of sets installed in each drawpoint will depend on the rock mass quality around each drawpoint.

Concrete roadways will be constructed in the extraction drives and drawpoints. The construction will include a levelled and compacted sub-base, a layer of 200 mm 30 MPa concrete, and a final 200 mm layer of 80 MPa concrete. The concrete will be poured in segments matching the drawpoint spacing with the segments dowelled together to prevent movement. The roadways will be graded for drainage to the perimeter drives.

The ore passes for the new Panel 0 design are in the north and south pillars, with three in the south pillar and four in the north pillar. An ore pass will also be constructed on the western side of the panel to service two short extraction drives. Each ore pass serves two extraction drives. When fully developed, the arrangement enables two loaders to operate in each extraction drive, one tipping to the south and one to the north.

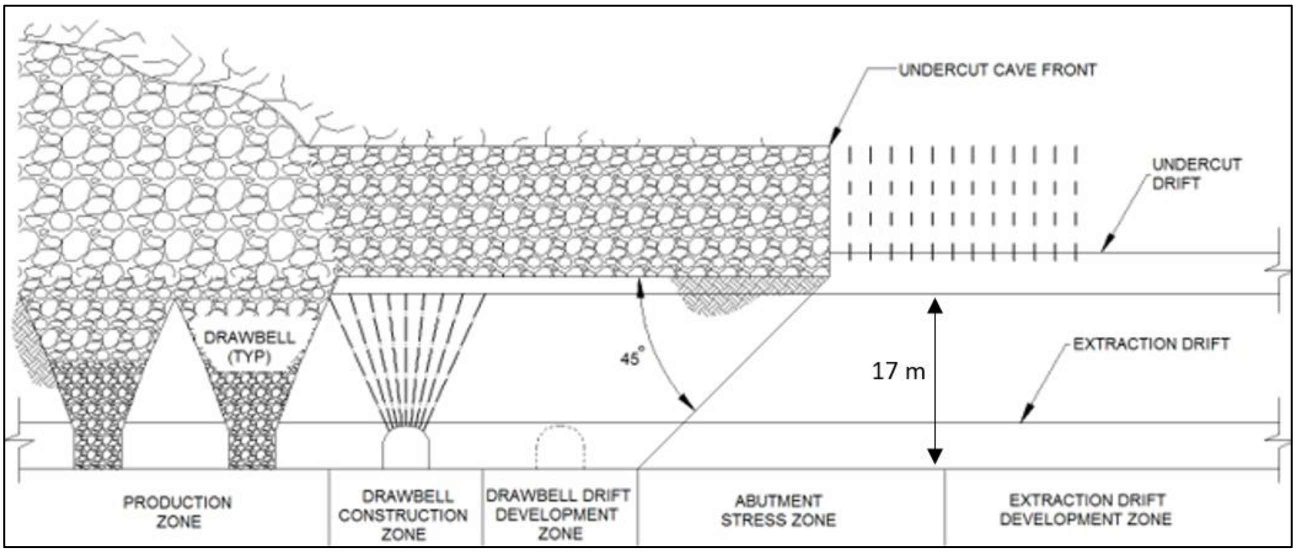
Airflow on Panel 0 will be from the north pillar rim drive through the extraction drives to exhaust raises in the south pillar. Fresh air will pass from development, to construction, to production work areas to minimize dust exposure to crews working outside enclosed equipment cabins. The arrangement avoids the need to construct ventilation infrastructure in the lower splay fault area but may limit some activities taking place in extraction drives where dusty conditions are created by drawpoint mucking operations.

For Panels 1 and 2, the ore passes and ventilation raises are currently planned to be located approximately in the centre of the footprint as proposed in the 2016 Feasibility Study. However, the location of the ore passes and the design of the ore handling system for Panels 1 and 2 is being reviewed as part of the ongoing optimization of the design of these panels.

16.3.24 Undercutting and development sequence

A typical advance undercut strategy is proposed whereby extraction drives will be mined well ahead of the undercut face. Drawpoint development and drawbell firing will take place behind the undercut face and behind the abutment stress zone. The planned sequence is shown in Figure 16.23.

Figure 16.23 Advance undercut extraction level development strategy



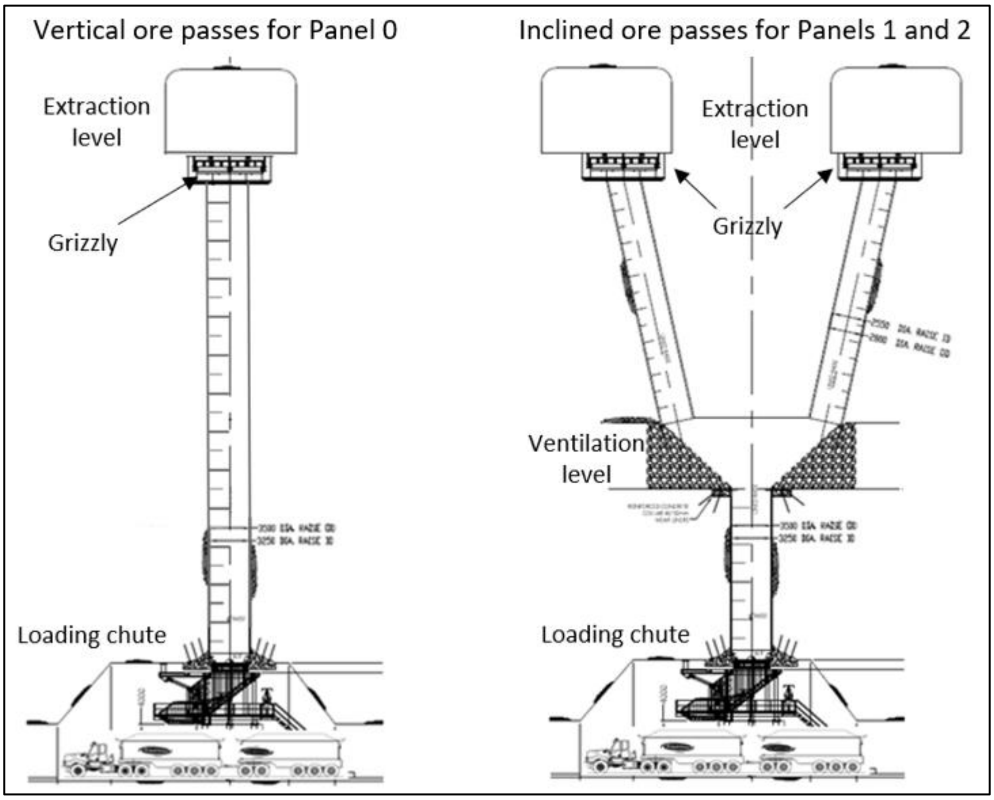
Source: Prepared by AMC from information provided by Oyu Tolgoi, Date: 30 June 2020

16.3.25 Ore pass arrangements

Broken rock from development and production will be mucked by load-haul-dump equipment (LHDs or scoops) and trammed to ore passes, which transfer the rock to truck loading chutes on a haulage level located 44 m below the extraction level. Grizzlies with 0.8 m by 0.8 m openings will be fitted to the passes. Oversize rock will either be removed by a loader for secondary breaking or broken by a mobile rock breaker. Ore passes will be covered when not in use.

For Panel 0, vertical raise bored ore passes will transfer ore from the extraction level to the loading chutes. The passes will be fitted with 40 mm thick wear resistant steel liners with a finished internal diameter of 3 m. For Panels 1 and 2, each ore pass system will comprise two inclined passes feeding a lined, 3 m internal diameter, ore bin above the loading chute. The inclined passes will be lined in a similar manner to those for Panel 0 but with a finished internal diameter of 2.4 m. The arrangement provides a live storage capacity of approximately 700 t. A total of 29 central truck chutes are planned. The planned ore pass arrangements are shown in Figure 16.24.

Figure 16.24 Extraction level ore pass arrangements



Source: Prepared by AMC from information provided by Oyu Tolgoi, Date: 30 June 2020

The in-line truck-loading chutes will be equipped with a hydraulically operated chute, with variable throat openings and an active lip for flow control. Locking pins and fail-to-safe systems will be installed, as will interlocking sensors to disable the chute until the truck is in position. Low-level sensor will also be installed.

16.3.26 Ore haulage

One-way trucking loops will allow 160 t capacity road trains to travel between the truck loading chutes and the two crusher stations. A fleet of 10 road trains, each comprising a prime mover and two side tipping trailers will be used for the main haulage duty. The prime movers will have a nominal power rating of 460 kW.

Haulage roadways will generally have a minus 2% gradient towards the crushers. Straight sections of the haulage will be developed 5.4 m wide x 6.1 m high. Corners will be widened to 6.0 m wide and have a 25 m centre line radius. After support, the drives will provide a 5.1 m minimum width.

Ore passes extending from perimeter drives on the apex, undercut, and extraction levels transfer rock mucked from the development and from undercutting to the haulage level. Articulated underground haulage trucks are used for rock haulage from development operations.

16.3.27 Underground crushers

The road-trains will haul the ore to one of the two gyratory crushers stations. Each crusher station comprises a 1,600 mm x 2,400 mm, 750 kW gyratory crusher able to process ore at a rate of 95 kt/d. Nominal feed size of 800 mm and P80 product size of 165 mm.

A two-sided dump arrangement is proposed at each crusher station, each suitable for the side tipping road trains. The crusher is also configured with one rear dump tip point for articulated trucks. The crusher stations will be equipped with a rock breaker and an overhead bridge crane for service. The crusher stations will be operated remotely from a central control facility on the surface.

Initially, material from the first operational crusher (Crusher 1) will be conveyed to Shaft 2, then hoisted to surface. After commissioning of the inclined conveyor system, crushed material will be conveyed directly to the surface stockpile.

A jaw crusher, with a capacity of approximately 6,000 tpd (2.0 Mtpa), is currently installed near the loading station at Shaft 2 to crush development rock prior to hoisting. A small crusher is also installed at Shaft 1.

The planned ore-handling arrangements are shown in Figure 16.25.

16.3.28 Underground workshops and offices

Three underground workshops are provided: a development workshop adjacent to Shaft 1 for maintenance of mine development equipment, a main workshop located on the same elevation as the extraction level for general and production mining equipment and one for the road trains operating on the haulage level. Refuelling and service stations and storage facilities are included in the design.

Underground offices and facilities are located close to the main workshop. When complete, the facility will include a main lunchroom, training and first-aid rooms, washrooms, a refuge area, and vehicle parking areas.

16.3.29 Primary ventilation circuit

The planned airflow to the mine at full production is 2,400 m^3 (surface air density), equivalent to between 0.025 to 0.026 m^3/s per t/d, which is slightly above the benchmarked average rate of 0.024 m^3/s per t/d.

Government regulations and international standards relating to temperature, dust, and diesel exhaust gas exposure levels have been considered when designing the ventilation system. The distribution of fresh air is determined by the location of materials handling equipment, operating machinery, shops, fuel bays, and the locations where personnel work or travel.

In general, airflow requirements have been determined by the diesel equipment used in each area, based on 0.06 m^3/s per kW of operating diesel power. In areas where people congregate, such as lunchrooms and workshops, the minimum airflow is based on 0.1 m^3/s for each person. Airflow through crusher chambers and explosive magazines is designed to exhaust directly to exhaust airways. Airways have been designed to ensure flow rates are managed within the maximum velocity design criteria for the type and use of the airway.

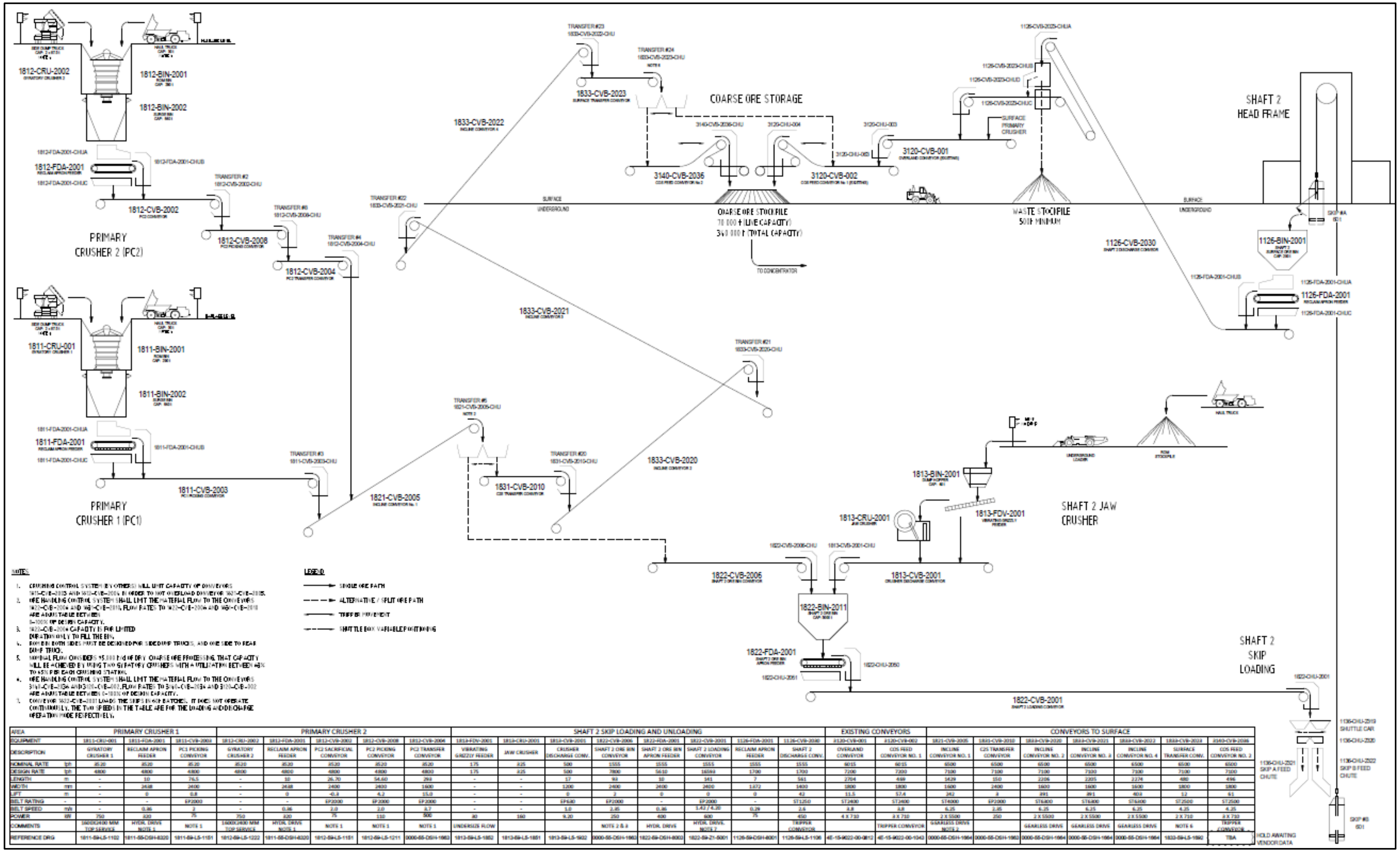
A diagram of the planned primary ventilation circuit is shown in Figure 16.26. Intake drifts are shown in blue and exhaust drifts in red.

Fresh air currently enters the mine through Shafts 1 and 2. Air from Shaft 1 travels along the access drifts to the workshops and the footprint area. Air from Shaft 2 travels along two main intake drifts towards Panel 0 and Panel 1. When Shaft 3 is completed, air will travel along two main intake drifts from the shaft towards Panel 2.

Fresh air is delivered to the main ventilation drifts to the east and west side of the footprint, with balancing fans used to ensure even distribution air. Intake air travels via ventilation raises to the apex, undercut, extraction, and haulage levels.

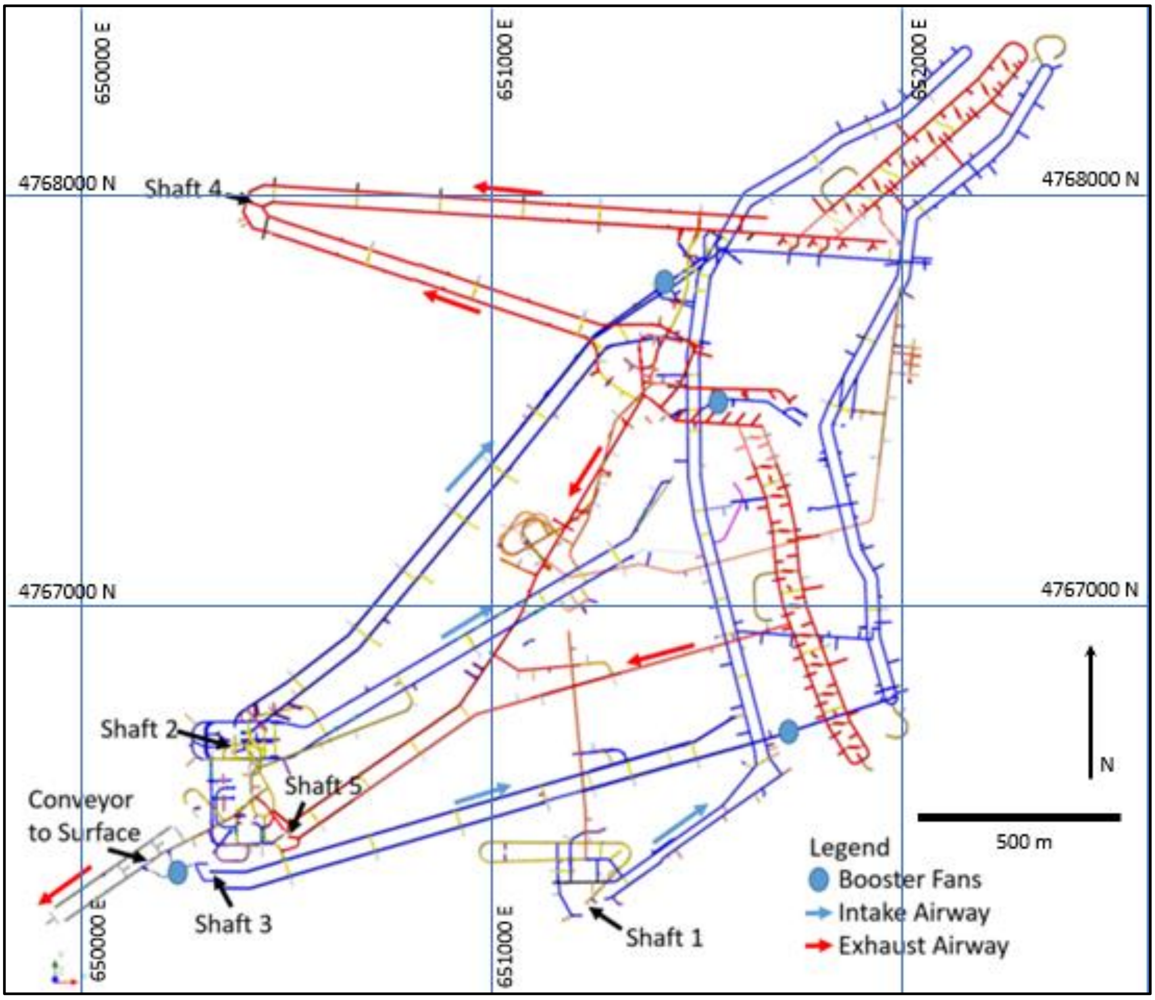
Exhaust air currently leaves the mine via Shaft 5. When Shaft 4 is complete, exhaust air will exit the mine through Shaft 4 which will be connected to the footprint by four main exhaust drifts. An underground booster fan will force fresh air from Shaft 3 up and out of the conveyor to surface drifts.

Figure 16.25 Lift 1 ore-handling flowsheet



Source: Jacobs Engineering Singapore PTE LTD, 12 June 2019.

Figure 16.26 Hugo North primary ventilation circuit



Source: Prepared by AMC from information provided by Oyu Tolgoi, Date: 30 June 2020. Projection UTM (WGS84) Z48N.

Fresh air enters the various levels on the footprint via raises and access drives from the main intake ventilation drifts. The air is distributed via the perimeter rim drives to the haulage level and apex, undercut and extraction drives on each level. Air exhausts from the levels exhausts via raises to twin parallel drives, 5.6 m wide x 6.7 m high, which will run along the centre of orebody axis.

Ventilation fans

Each exhaust shaft will each be fitted with multiple fans, operating in parallel. Variable blade pitch controls/radial control vanes will be fitted to the fans to achieve the required fan duties over the mine life.

The operating points for the fans have been determined through a set of models representing the preproduction and final steady state time phases. The estimated airflows in each shaft at full production are shown in Table 16.17. The estimated fan operating points during steady state operation are shown in Table 16.18.

Four underground booster/balance fans will be required to properly distribute air through the ventilation circuit. A booster fan will be installed at the base of Shaft 3 to force air up the conveyor and decline drifts.

Prior to completion of Shaft 4, all air from development and early production exhausts via Shaft 5. The Shaft 5 fans are sized to achieve a maximum operating duty of 950 m^3/s (installed duty) and a maximum pressure of 5.5 kPa during this period. The operating point for the fans will reduce once the primary ventilation circuit is complete.

Table 16.17 Estimated shaft airflows during full production

Shaft	Diameter (m)	Flow direction	Quantity (m^3/s)
Shaft #1	6.7	Intake	400
Shaft #2	10.0	Intake	950
Shaft #3	11.0	Intake	1,100
Total intake			**2,450**
Shaft #4	11.0	Exhaust	1,600
Shaft #5	6.7	Exhaust	600
Conveyor and service inclines		Exhaust	250
Total exhaust			**2,450**

Table 16.18 Estimated fan operating points at steady-state operation

Fan installation	Airflow (m^3/s)	Pressure (kPa)	Installed power (kW)
Shaft 4 (4 centrifugal fans)	1,600	5.50	16,600
Shaft 5 (3 mixed flow axial flow fans)	600	5.50	7,200
Conveyor incline (4 fans)	250	1.50	1,040
Balance fan C	250	1.50	600
Balance fan D	450	0.30	1,040
Booster fan (north high speed)	450	0.50	1,040
Haulage booster fan A	150	0.20	400
Haulage booster fan B	150	0.10	320
Total			**28,240**

Ventilation build-up

Models have been developed for each stage of the ventilation circuit development. Table 16.19 outlines the milestones and the estimated total airflow through the mine at each stage.

Table 16.19 Ventilation build-up

Ventilation connection	Air volume (m^3/s)	Comment
Shaft 5 (full volume)	950	Full exhaust capacity of Shaft 5.
Conveyor to surface	1,100	Conveyor to surface broken through.
Shaft 4 fans (Stage 1)	1,300	First phase of Shaft 4 fans commissioned.
Shaft 3 main airway connections	1,900	Shaft 3 completed.
Shaft 4 fans Stage 2 with Shaft 3 and Ventilation drive connection No. 2 completed.	2,450	Shaft 4-Vernd drive connections No. 3 and No.4 completed.

Dust control

For the most part, dust and other atmospheric contaminants will be controlled by managing airflow directions. All drawpoints will be fitted with water spays. Dust collectors will be located on apron feeders under each crusher. Transfer chutes will be enclosed and fitted with water sprays. Airflow where conveyors are installed is along the direction of ore travel. Dust created from the Shaft 2 loadout system will be exhaust directly to Shaft 5.

Fire protection

Fire protection systems, including sprinklers, standpipes and fire extinguishers will be installed at all fixed locations where flammable materials are used or stored or where a fire risk exists. Special hazards suppression systems (foam, gaseous, wet, and dry chemical) will be installed where appropriate. Fire detection and alarm signalling equipment will be installed and connected to the main fire alarm panel monitoring system via a fibre optic system.

All mobile equipment will be equipped with fire extinguishers and other fire suppression equipment where appropriate.

Fire simulation studies were carried to develop emergency procedures should a fire occur at various locations in the mine. The studies were used to guide the location and fixed refuge stations, the installation of ventilation doors and other ventilation control measures. Relocatable refuge stations will be used in areas where convenient access to fixed refuge chambers is not possible.

Mine air heaters

All intake shafts will be fitted with heaters to be used when there is a possibility that intake air will be below freezing. The design temperature for the heated air entering the mine is +2 °C. The system uses hot water delivered to glycol heat exchangers to transfer heat from a high temperature hot water pipeline. Hot water is supplied from a site central coal-fired boiler heating plant and pipe distribution network.

The total design mine air heating capacity is estimated at 103 MW for heating intake air from −25 °C to +2 °C.

16.3.30 Mine services

Compressed air

Compressed air is supplied by compressors installed on the surface at Shaft 1 and Shaft 2; dedicated air compressors in the various maintenance workshops; small portable, electric-driven compressors; and on-board compressors supplied with mobile equipment.

Water supply

Service water is be piped through Shafts 1 and 2 for distribution throughout the mine workings. A total flow rate of 200 L/s is required, which is distributed to multiple workplaces. Drinking water will be supplied in 19 L bottles filled at the surface bottling plant, transported underground, and distributed to the various shops, lunchrooms, and offices. Water for lavatories, washing, kitchen sinks, and boot washes will be provided by disinfecting service water using ultraviolet units.

Shotcrete and concrete distribution

Concrete and shotcrete are batched at a surface batch plan and transported to the slickline receiving facility located east of Shaft 2. Two 152 mm diameter slicklines deliver the product underground. Product can also be delivered underground via 152 mm diameter slicklines in Shaft 1 and by a backup slickline system in Shaft 2. Agitator trucks deliver concrete and shotcrete to the required locations. The combined system has the capacity to deliver approximately 13,000 m^3 of concrete products per month.

Mine dewatering

Mine water inflow and service water run-off will be collected in sumps strategically located throughout the mine. Each sump will have a dedicated pump delivering to the main mine dewatering sump and pump station close to Shaft 2. The station will be fitted with three positive displacement pumps, each capable of pumping 75 m^3/h to surface in a single stage via Shaft 2.

Two pumps would be in operating mode and one pump on standby or under maintenance. Water will be discharged at the concentrator.

The water management system is designed to handle water from severe rainfall events when the cave subsidence is at its greatest. The dewatering system is designed to handle a 100-year rainfall event in conjunction with the fresh air level acting as a floodable sump.

Fuel supply

The fuel will be received in surface storage tanks, sized for six weeks supply. The storage tanks will be located near Shaft 1. The fuel will be transferred underground through a 50 mm diameter fuel line in a borehole to two storage tanks, each sized for the maximum daily fuel usage. The fuel will then be piped to the fuelling stations on the main and haulage level workshops.

Explosives

The explosive supply company will deliver all blasting products to the Shaft 2 collar. Explosives and detonators will be transported separately in lockable containers supplied by the manufacturer that are clearly labelled with the product contained. The containers will be transported underground in the shaft cage. The containers will remain locked until they are unloaded in the main underground magazine. Bulk explosives will be transported in one cubic metre industrial containers.

Electrical distribution

The permanent reticulation system is based on 35 kV ring-main supplied from a main substation located on the surface near the main shaft complex. Separate ring-main segments will be installed in the service decline and down Shaft 2 and will interconnect substations strategically placed throughout the mine.

Prior to finalizing the 35 kV circuit, power at 10.5 kV will be supplied down Shafts 1 and 2.

The substations will step-down the 35 kV supply voltage to secondary reticulation and distribution voltages for a combination of radial and ring power supplies to satellite facilities. The 35 kV system is semi-redundant such that even with the loss of a cable segment or major piece of electrical equipment, the conveyor to surface or the Shaft 2 rock hoist will remain operational hoist at reduced capacity while repairs take place.

In the event of a plant-wide power loss, standby power from the surface diesel power station can be used to energize selected underground circuits and support sufficient mine ventilation. In the unlikely scenario that both normal line power and the diesel power station are unavailable, a dedicated generator at Shaft 2 will maintain supply for monitoring of critical systems.

Communications, instrumentation, and control systems

The planned mine communications systems will be based on a fibre optic network backbone and include Wi-Fi (available in all locations), voice-data systems, personnel and vehicle tracking, and CCTV.

An extensive mine monitoring and control system (MMC) will be installed to maximize safety and efficiency. The system will include:

- Personnel and equipment dispatch and location detection, including access control.
- Real-time monitoring and tracking of fixed and mobile equipment and work activities, including draw control and production systems.
- Equipment operation and maintenance programs.
- Ventilation system monitoring and control, including dust suppression control.
- Monitoring and control of ore passes, loading chutes, crushers, conveyors, skip loading, and hoisting.

Phase 1 of the MMC implementation program is complete and provides a basic management system based on a voice radio system from the temporary control room on surface at Shaft 1.

A second implementation phase will include establishing a remote management capability and automated functionality. The system will provide mobile equipment health monitoring and a supervisory control and data acquisition (SCADA) system for pumps, fans, and other services. During this second phase, the electronic personnel and mobile equipment tracking system will be implemented. Remote drill rig access will be phased in, providing the ability to deploy drilling patterns to rigs and to capture performance data.

The third implementation phase involves the integration of draw control, production scheduling, construction, and development activities. The MMC will be capable of managing remote crusher / rock breaker operation during this phase.

During Phase 2, the control centre at Shaft 1 will be relocated to its permanent surface location near Shaft 2. The control room will be used to monitor and control all underground operations. A monitoring and analysis centre will be developed off-site to enable analysis of the collected data to aid long-term planning.

16.3.31 Mobile equipment

The underground mobile equipment fleet will increase in size from more than 240 units at present to more than 300 units in 2021 and 2022. Fleet size and composition will fluctuate with demand and changes in the work requirements. The make-up of the planned mobile equipment fleet by main categories is shown in Figure 16.27. Equipment will meet Tier IV emission standards or be outfitted with a diesel particulate filter.

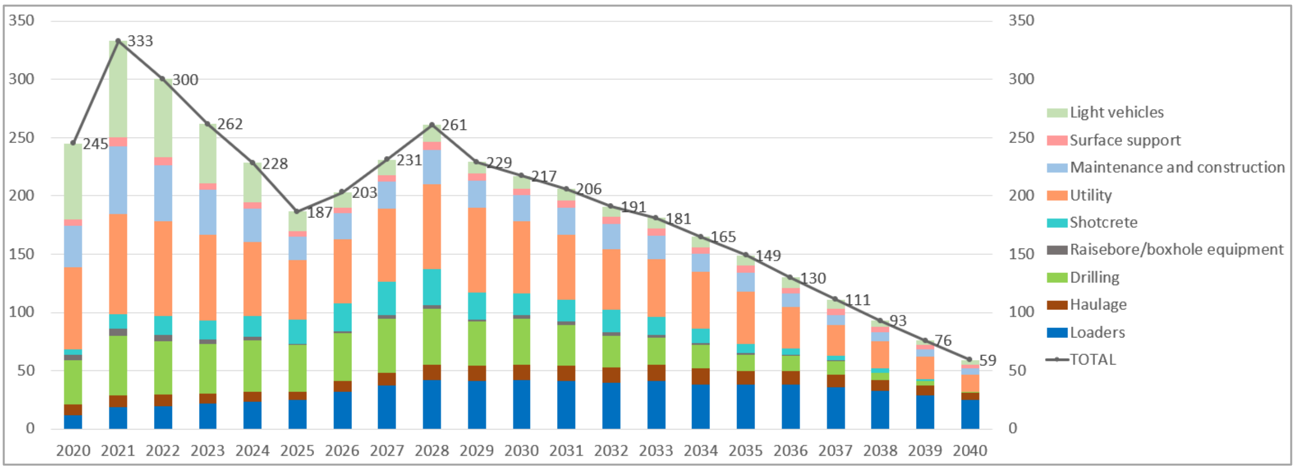
The equipment is planned to be provided by four primary vendors:

- Sandvik – mucking and development hauling.
- Epiroc – drilling and ground support.
- Normet – utility and service.
- Scania – production haulage.

A production fleet of twenty-six 14-tonne diesel LHDs is required to achieve the peak planned production rate of which 21 will be operating at a time. Three longhole rigs and two boxhole machines will be used to maintain the drawbell construction rate of up to nine drawbells per month. The equipment fleet sizes and vendors are subject to further review as part of operational readiness planning.

Hang-ups will be managed by a secondary breaking crew equipped with water cannons and a single-boom medium-reach drill rig equipped with a self-indexing charging arrangement for automated charging. Blasting will be done at the scheduled end of shift but could be done at mid-shift if needed. Non-explosive rock breaking technology will be used for oversize rocks removed from the drawpoint to secondary breaking locations.

Figure 16.27 Hugo North mobile equipment fleet by main category



Source: Prepared by AMC from information provided by Oyu Tolgoi, Date: 30 June 2020

16.3.32 Workforce

The underground mine operates 24 hours per day, 365 days per year. Current and planned working arrangements are based mainly on working two 12-hour shifts. Work schedules are aligned to support the continuous non-stop operations for the operational roles.

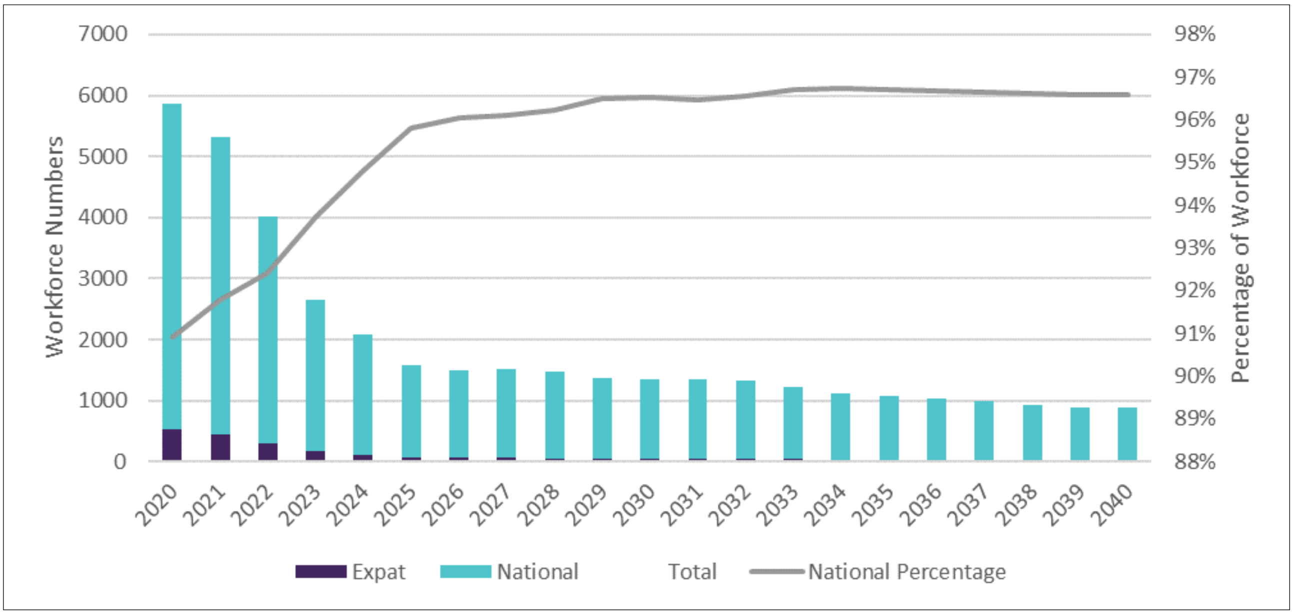
The region in which the Project is locate does not have a tradition of underground mining or heavy industry. Consequently, the current workforce includes a significant number of expatriate personnel who provide many of the specialist skills required for mine construction. The composition of the current underground workforce is summarized in Table 16.20.

Oyu Tolgoi LLC has developed and operates a training facility and program to train miners, mechanics, plant operators, and technicians. The training combined with the reduced need for specialist skills as mine construction is completed will lead to a progressive reduction in expatriate personnel. The reduction in the total underground workforce is illustrated in Figure 16.28.

Table 16.20 Composition of the current underground workforce

Project Stage	Mongolian (%)	Expatriates (%)
Mining contractor	75	25
Construction contractor	60	40
OT LLC operations	90	10

Figure 16.28 National and expatriate underground personnel



Source: Prepared by AMC from information provided by Oyu Tolgoi, Date: 30 June 2020

16.3.33 Development and construction schedules

Development

The total life-of-mine vertical development is summarized in Table 16.21. The quantities of lateral development for Lift 1 are summarized in Table 16.22. The quantities are reported in equivalent metres (eq-m), which are calculated by dividing the volume of mass excavations (crusher chambers etc.) by the area of a standard development heading (24.8 m^2).

Table 16.21 Vertical development

Area	Metres (m)
Completed shafts and other vertical development (as-built)	5,047
Remaining shaft development	2,195
Remaining raises 2.0–6.0 m (includes ore passes and ventilation raises)	5,817
Total	13,059

Table 16.22 Lateral development and mass excavation quantities (equivalent metres)

Area	Equivalent metres (eq-m)
Complete development (as-built)	64,168
Apex and undercut level (all panels)	38,100
Extraction level (all panels)	49,788
Haulage level	14,442
Intake drives	13,569
Exhaust drives	14,325
Conveyor drifts and associated development	2,530
Conveyor to surface	5,495
UG ramps (inclines and declines)	2,215
Crushers, transfer stations, shops, etc.	4,862
Transfer 20, Shaft 2 skip loading, bin top and bin 11	1,822
Total lateral development	**211,316**

Development quantities are based on the updated Panel 0 design with 31 m x 18 m spacing. The quantity take-offs for Panel 1 and Panel 2 development are based on a 31 m x 16 m drawpoint spacing rather than the planned 31 m by 18 m spacing. Consequently, the development required on the extraction level for Panel 1 and Panel 2 will be slightly less than that shown in Table 16.22.

Development schedules were developed using Deswik scheduling software. The productivity rates used for scheduling development and mass excavation are based on first principles calculations for each type of excavation, and type of ground support required (types 1, 2, and 3). Areas in poor ground conditions may have a heading rate adjustment (HRA) applied to account for shorter blast round length or the use of spiling bars. The development rates used to prepare the development schedules are summarized in Table 16.23. The overall maximum development rate has been capped at 1,800 eq-m per month.

The conveyor to surface is currently being developed from both surface and underground accesses. Transfer stations are developed off critical path behind the advancing decline face by a dedicated mass excavation crew.

Table 16.23 Planned development scheduling rates

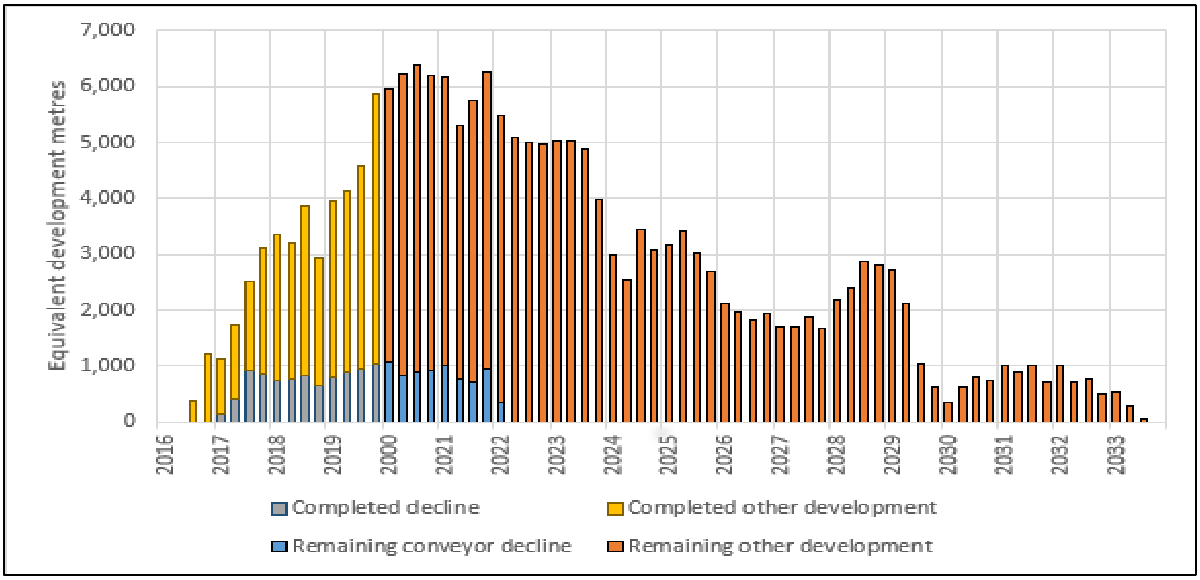
Mine Area	Primary Drive Type	Profile W x H (m)	Type 1 (m/mo)	Type 2 (m/mo)	Type 3 (m/mo)	HRA (m/mo)
APL and UCL	Rim drive	4.6 x 5.1	43	36	36	20
APL and UCL	Drill drive	4.5 x 4.5	72	45	54	24
EXL	Internal rim drive	4.6 x 5.1	43	30	36	20
EXL	External rim drive	5.0 x 5.5	43	36	43	20
EXL	Extraction drive	4.5 x 4.5	36	30	30	20
EXL	Drawpoint drive	4.5 x 4.5	30	30	30	24
SUB footprint	Vent drive	5.8 x 6.5	46	36	39	24
SUB footprint	Haulage drive	6.0 x 6.0	46	36	31	24
OFF footprint	Vent drive	6.0 x 7.0	69	36	–	–
OFF footprint	Haulage drive	5.5 x 6.0	46	45	–	–
OFF footprint	Access drive	5.0 x 5.5	92	45	–	–
C2S	Conveyor – decline	6.0 x 5.4	104	50	52	–
C2S	Conveyor – incline	6.0 x 5.4	72	45	43	–
C2S	Service – decline	5.4 x 5.85	104	60	52	–
C2S	Service – incline	5.4 x 5.85	72	45	43	–

APL = apex level, UCL = undercut level, Exl = extraction level, C2S = conveyor to surface.
Note: Subject to further study and assessment as part of Oyu Tolgoi LLC's cost and schedule estimation update which is expected later in 2020.

The planned schedule for completing the development of Lift 1 is shown in Figure 16.29 and Table 16.24. Approximately 30% of the total lateral development for Lift 1 has been completed. The development schedule does not reflect the impacts of the COVID-19 pandemic which are ongoing and continue to be assessed and subject to further study and assessment as part of Oyu Tolgoi LLC's cost and schedule estimation update which is expected later in 2020 and subject to further study and analysis on Panels 1 and 2.

The commissioning of Shaft 2 has enabled the hoisting rate to be increased from 3,500 t/d through Shaft 1 only to greater than 10,000 tpd through both shafts (the Shaft 2 hoisting rate is constrained by the throughput rate of the temporary crusher). The overall capacity of underground ore movement is constrained to 6,500 tpd based on the capacity of the mine development truck haulage rate to the two shafts. This constraint will remain until Crusher 1 is commissioned. At various stages, the mine development rate will be constrained by the quantity of air required to ventilate development and construction activities. These constraints will be progressively removed when Shafts 3 and 4 and the drives connecting the shafts to the mining areas and completed.

Figure 16.29 Planned lateral development schedule



Excludes 15,747 eq-m development completed prior to the restart of underground operations in 2016. Source: Prepared by AMC from information provided by Oyu Tolgoi, Date: 30 June 2020

Table 16.24 Lift 1 development schedule

Year	Quarter	Conveyor decline (eq-m)	Other development (eq-m)	Total (eq-m)
2020	Qtr1	1,072	4,902	5,974
	Qtr2	819	5,400	6,219
	Qtr3	888	5,488	6,376
	Qtr4	929	5,286	6,215
2021	Qtr1	1,015	5,158	6,173
	Qtr2	777	4,520	5,298
	Qtr3	708	5,056	5,764
	Qtr4	962	5,306	6,269
2022	Qtr1	344	5,148	5,492
	Qtr2	-	5,104	5,104
	Qtr3	-	5,015	5,015
	Qtr4	-	4,963	4,963
2023	Qtr1	-	5,017	5,017
	Qtr2	-	5,036	5,036
	Qtr3	-	4,892	4,892
	Qtr4	-	3,975	3,975
2024	Qtr1	-	2,996	2,996
	Qtr2	-	2,548	2,548
	Qtr3	-	3,442	3,442
	Qtr4	-	3,089	3,089
2025	Qtr1	-	3,179	3,179
	Qtr2	-	3,414	3,414
	Qtr3	-	3,015	3,015
	Qtr4	-	2,684	2,684

Year	Quarter	Conveyor decline (eq-m)	Other development (eq-m)	Total (eq-m)
2026 to 2033		-	41,49	41,490
Total		**7,515**	**146,124**	**153,638**

Note: Totals may not match due to rounding
Subject to further study and assessment as part of Oyu Tolgoi LLC's cost and schedule estimation update which is expected later in 2020 and subject to further study and analysis on Panels 1 and 2.

Construction

Key construction activities include the construction of shafts and the material handling system, electrical power reticulation underground, shops, offices, utilities, and other fixed facilities. Table 16.25 provides a summary of the status of the key facilities remaining to be completed to support the mining of Lift 1.

Table 16.25 Status of the key facilities to support the mining of Lift 1

Area	Status
Shaft 2	The shaft is complete and operating
Shaft 3	Awaiting installation of the headframe and sinking equipment. Construction work is currently suspended due to the impact of corona virus travel restrictions.
Shaft 4	Headframe and sinking equipment is in place. Headframe commissioning and sinking work is currently suspended due to the impact of corona virus travel restrictions.
Crusher 1	Excavation work is complete, and construction is progressing at reduced rates due to Covid-19 impacts.
Material handling system Crusher 1 to Shaft 2 (Stage 1)	Excavation work is complete, and construction is progressing at reduced rates due to Covid-19 impacts.
Conveyor to surface	Decline development is ongoing, the decline fit-out is yet to commence.
Underground services reticulation	UG Services reticulation is progressing to enable development as required.

The scheduling and duration of construction activities uses Primavera, a project management and scheduling software and is based on quantity take-offs from general arrangement drawings and construction team experience of the durations of activities from similar projects. Procurement activities are based on vendor-quoted delivery times and historical experience.

16.3.34 Key underground project milestones

The underground project schedule includes three major components: development, construction, and production.

An iterative process is used to develop the overall underground project schedule whereby the construction schedule is linked to the development schedule to determine dates when construction sites become available. In turn, construction durations and completion dates are used to adjust the development schedule. The development and construction scheduling processes result in the key underground project milestone dates shown in Table 16.26 and Table 16.27. These dates do not reflect the impacts of the COVID-19 pandemic, Shafts 3 and 4 being in care-and-maintenance, and Crusher 1 work, which although still progressing, has been slowed due to availability of experienced personnel and subject to further study and assessment as part of Oyu Tolgoi LLC's cost and schedule estimation update which is expected later in 2020 and subject to further study and analysis on Panels 1 and 2.

Dates were initially estimated by deterministic scheduling methods using Deswik and project scheduling software. The deterministic schedules were then subjected to a semi-quantitative risk analysis (SQRA) process to assess the probability of the dates being achieved. A company specializing in probabilistic schedule analysis has assisted the Oyu Tolgoi LLC team to develop the schedules. TRQ has disclosed a range of October 2022 and June 2023 for Sustainable Production, which is an outcome of a probabilistic schedule analysis.

Table 16.26 Schedule of key production milestones

Milestone	Date
Start undercut blasting	July 2021*
Crusher 1 and ore-handling system to Shaft 2 commissioned	Qtr 4, 2021*
First drawbell blasted	May 2022*
Sustainable Production achieved (60 drawpoints active)	February 2023*
Conveyor to surface commissioned	Qtr 3, 2023*
First drawbell fired in Panel 2	Qtr 4, 2024
Crusher 2 commissioned	1st half 2025*
Panel 0 at full production (10.5 Mtpa – 29 kt/d)	Qtr 2, 2025
First drawbell fired in Panel 1	2nd half 2026
Production rate of 60 kt/d achieved	2nd half 2027
Full production achieved (33 Mtpa - 95 kt/d)	1st half 2029

* P50 probabilistic dates.

Note: The scheduled dates exclude any impacts of Covid-19 and are subject to further study and assessment as part of Oyu Tolgoi LLC's cost and schedule estimation update which is expected later in 2020 and subject to further study and analysis on Panels 1 and 2.

Table 16.27 Schedule of key construction milestones

Milestone	Date
Shaft 3 ventilation system commissioned	1st half 2022
Shaft 4 ventilation system commissioned	1st half 2022
Concentrator upgrade complete	mid 2024

Note: Work on Shafts 3 and 4 is currently suspended due to the impact of Covid-19 restrictions. It is uncertain when work will recommence, consequently there is significant uncertainty on the commissioning dates for these shafts.

16.3.35 Hugo North production schedule

The Hugo North mine production schedule was developed using PCBC, a cave modelling software package. The development, undercutting, and construction schedules were coordinated with the production ramp-up schedule to ensure that planning for all facilities support the requirements for the planned production build-up.

In 2012 and 2016, discrete-event simulation model of the ore-handling system was developed and used to estimate the overall capacity of the ore-handling system and its ability to achieve the target production rate of 95 kt/d. This model was used to establish the baseline production capacity for the default ore-handling layout shown on the material handling flowsheet.

No changes have been made to the ore truck haulage, crushing and conveying system since the 2016 Feasibility Study that would materially impact the capacity of the ore-handling system. However, the relocation of the ore passes in the new Panel 0 design will increase the cycle times of the LHD equipment operating in the panel. For this reason, the maximum production rate for Panel 0 has been reduced from approximately 40 kt/d in the 2016 Feasibility Study to 30 kt/d.

The following is a summary of the key scheduling constraints applied to the production schedule:

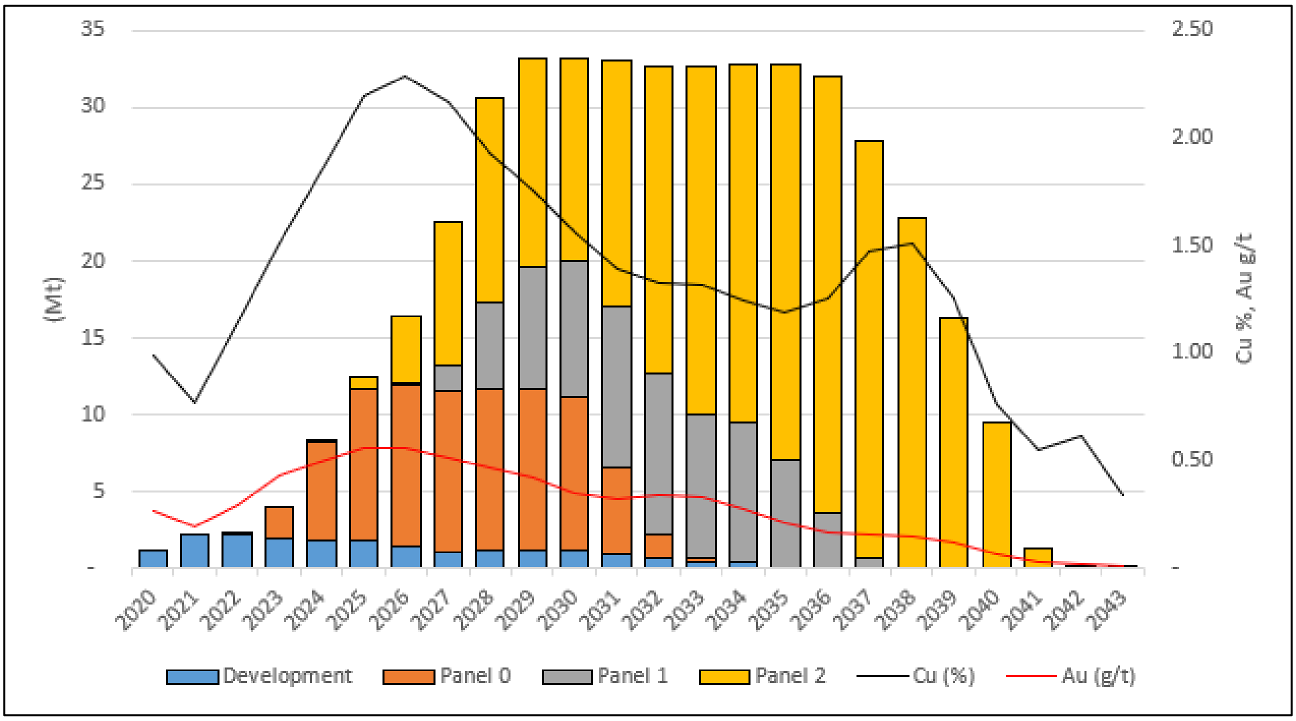
- A maximum undercut advance of 10 m per month (four rings in each undercut drive).
- Between four and five drawbells per month blasted per undercut face.
- Undercut mucking rates scheduled at 1,350 t/d.

- Undercut faces in Panel 1 and Panel 2 initiated once Panel 0 is operating sustainably and development, undercutting and construction resources can be relocated from Panel 0.
- The maximum production rate from Panel 0 and Panel 1 while undercutting activity is taking place is limited to 22 kt/d and 35 kt/d, respectively.
- After undercutting is complete, the maximum production rates from each panel are limited to 30 kt/d from Panel 0, 35 kt/d for Panel 1, and 95 kt/d from Panel 2.
- The production rate curve (PRC) used to control the initial rate of draw from individual draw points has been updated from the PRC used in the 2016 Feasibility Study. The update brings the PRC more in line with practice at similar caving operations.

After achieving sustainable cave propagation, which is estimated to occur after firing approximately 60 drawpoints, the production rate will ramp up between 2023 and 2029, to reach a steady-state rate of 95 kt/d (33 Mtpa).

The annualized production profile for Hugo North Lift 1 is shown in Figure 16.30 and in Table 16.28. The profile of the planned production ramp-up is similar to the ramp-up envisaged in the 2016 Feasibility Study. The production schedule does not reflect the impacts of the COVID-19 pandemic which are ongoing and continue to be assessed.

Figure 16.30 Hugo North Lift 1 production schedule by panel



Source: Prepared by AMC from information provided by Oyu Tolgoi, Date: 30 June 2020

Table 16.28 Hugo North Lift 1 production schedule

Year	Tonnes mined					Grade		
	Dev't	Panel 0	Panel 1	Panel 2	Total	Cu (%)	Au (g/t)	Ag (g/t)
2020	1.2	-	-	-	1.2	0.99	0.27	2.4
2021	2.1	-	-	-	2.1	0.77	0.19	1.8
2022	2.2	0.0	-	-	2.2	1.14	0.30	2.6
2023	2.0	2.1	-	-	4.0	1.51	0.43	3.6
2024	1.9	6.4	-	0.0	8.2	1.84	0.49	4.2
2025	1.9	9.7	-	0.8	12.4	2.20	0.56	4.8
2026	1.5	10.5	0.1	4.4	16.4	2.29	0.56	4.7
2027	1.1	10.5	1.6	9.3	22.5	2.17	0.52	4.4
2028	1.1	10.5	5.7	13.2	30.6	1.93	0.47	4.0
2029	1.2	10.5	8.0	13.5	33.2	1.76	0.42	3.9
2030	1.1	10.1	8.8	13.2	33.2	1.57	0.35	3.4
2031	0.9	5.6	10.6	16.0	33.0	1.40	0.32	3.1
2032	0.6	1.6	10.4	20.0	32.6	1.33	0.34	2.9
2033	0.4	0.3	9.3	22.7	32.7	1.32	0.33	2.8
2034	0.4	0.1	9.0	23.3	32.8	1.25	0.27	2.6
2035	0.1	-	7.0	25.7	32.7	1.19	0.21	2.4
2036	-	-	3.6	28.5	32.1	1.25	0.17	2.5
2037	-	-	0.6	27.2	27.8	1.48	0.16	2.8
2038	-	-	0.0	22.8	22.9	1.51	0.15	2.8
2039	-	-	-	16.2	16.2	1.25	0.12	2.3
2040	-	-	-	9.5	9.5	0.76	0.07	1.3
2041	-	-	-	1.3	1.3	0.55	0.03	0.9
2042	-	-	-	0.1	0.1	0.61	0.02	1.0
2043	-	-	-	0.0	0.0	0.34	0.01	0.6
Total	**20**	**78**	**75**	**268**	**440**	**1.51**	**0.32**	**3.2**

Note: Amounts are rounded and exclude any impacts of Covid-19 and are subject to further study and assessment as part of Oyu Tolgoi LLC's cost and schedule estimation update which is expected later in 2020 and subject to further study and analysis on Panels 1 and 2.

16.3.36 Hugo North Lift 1 future work

Future work will include an in-fill geotechnical drilling program covering the Panel 1 and Panel 2 areas. This drilling has commenced and by the end of 2021 the envisaged data collection program will be complete and studies well advanced. The drilling will provide a more robust structural interpretation, particularly the offsets of the WBAT fault on the western margin of the orebody and the nature of the lower faults within Panel 1.

Further design studies have commenced to investigate the recoverability of the pillars, and the opportunities presented by the inclusion of pillars, of allowing independent initiation of Panels 1 and 2. This opportunity includes a review the optimal elevation of these now independent mining panels.

The potential for a recovery level targeting the pillars is also being assessed. These studies have the potential to improve the operability of the underground project and increase the Lift 1 mineral reserve.

In addition, studies are ongoing to explore ways of increasing underground development rates in critical path areas. Simulation and planning studies are also being undertaken to integrate development and production activities, focusing on interaction and congestion during the underground project ramp-up phases.

Continuing long-term and strategic planning includes activities relating to the exploration and evaluation of mineral resources not yet converted to mineral reserves at Hugo North, Hugo South and the Heruga deposits. The development concepts for these deposits is discussed in Section 24.

17 Recovery methods

17.1 Background

The Phase 1 concentrator commenced operations in January 2013 and reached its nameplate throughput of 32 Mtpa in September 2013. Throughput has progressively increased since 2013 as the result of operating experience and minor plant modifications. In general, flotation recovery has also improved after allowing for the effect on recovery of the varying ore types and feed grades.

To date, all ore processed through the concentrator has originated from the Oyut open pit. A summary of the concentrator production history is shown in Table 17.1.

Table 17.1 Oyu Tolgoi concentrator production history

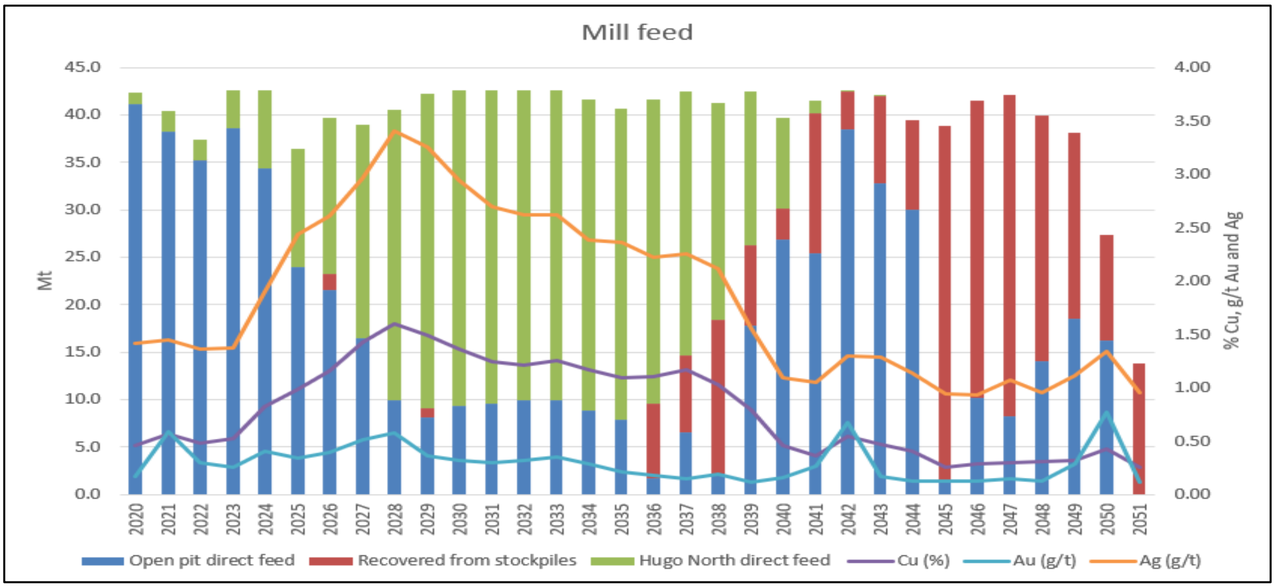
Mill feed					Recovery			Metal in concentrate			Conc. Cu grade (%)
Year	**(Mt)**	**Cu (%)**	**Au (g/t)**	**Ag (g/t)**	**Cu (%)**	**Au (%)**	**Ag (%)**	**Cu (Mt)**	**Au (t)**	**Ag (t)**	
2013	20.3	0.47	0.36	1.39	81.6	66.1	54.2	0.077	4.9	15.2	26.4
2014	27.9	0.60	0.86	1.60	89.1	76.6	62.3	0.148	18.3	27.8	26.3
2015	34.5	0.67	0.78	1.56	87.6	74.4	69.9	0.202	20.3	38.0	25.6
2016	38.2	0.65	0.36	1.83	81.0	68.5	63.1	0.201	9.3	44.2	23.8
2017	41.2	0.51	0.17	1.39	75.4	49.7	52.9	0.157	3.5	30.3	21.8
2018	38.7	0.51	0.36	1.22	81.4	65.2	60.9	0.159	8.9	28.4	21.9
2019	40.8	0.45	0.29	1.13	78.7	63.6	58.1	0.146	7.5	27.0	21.7
Total	**242**	**0.55**	**0.43**	**1.44**	**81.9**	**69.5**	**60.7**	**1.09**	**73**	**211**	-

Note: Totals may not match due to rounding

As ore from Hugo North Lift 1 becomes available, concentrator modifications (the Phase 2 modifications) will be required to process the blend of higher-grade ore from Hugo North with lower grade ore from the Oyut open pit. Significant study and design work have been carried to optimize the modifications. On depletion of Hugo North ore, the concentrator will be able to revert to processing the remaining mineral reserves in the Oyut open pit. Minimal allowance is included in the modification program for further expansion of the concentrator, whilst ensuring that the planned modifications do not interfere with any future possible expansion.

The planned feed to the concentrator over the mine life is shown in Figure 17.1 and Table 17.2. The planned feed schedule does not reflect the impacts of the COVID-19 pandemic which are ongoing and continue to be assessed.

Figure 17.1 Planned ore feed to the Oyu Tolgoi concentrator



Source: Prepared by AMC from information provided by Oyu Tolgoi, Date: 30 June 2020

Table 17.2 Planned ore feed to the Oyu Tolgoi concentrator.

Year	Mill feed				Recovery			Metal in concentrate			Con.
	(Mt)	Cu (%)	Au (g/t)	Ag (g/t)	Cu (%)	Au (%)	Ag (%)	Cu (Mt)	Au (Moz)	Ag (Moz)	Cu grade (%)
2020	42	0.46	0.17	1.4	77	57	50	0.15	0.13	1.0	22
2021	40	0.57	0.59	1.5	84	74	59	0.19	0.56	1.1	24
2022	37	0.48	0.30	1.4	81	67	55	0.14	0.24	0.9	24
2023	43	0.52	0.25	1.4	80	65	59	0.18	0.23	1.1	25
2024	43	0.82	0.41	1.9	84	72	67	0.29	0.40	1.7	26
2025	36	0.98	0.34	2.4	90	74	72	0.32	0.30	2.1	34
2026	40	1.16	0.39	2.6	91	75	76	0.42	0.38	2.5	35
2027	39	1.43	0.51	3.0	92	77	80	0.51	0.50	3.0	36
2028	40	1.60	0.57	3.4	92	79	81	0.60	0.58	3.6	35
2029	42	1.49	0.36	3.2	91	78	80	0.57	0.38	3.5	34
2030	43	1.36	0.32	2.9	90	76	79	0.52	0.33	3.2	31
2031	43	1.24	0.30	2.7	90	75	77	0.47	0.31	2.9	29
2032	43	1.21	0.32	2.6	89	75	76	0.46	0.33	2.7	28
2033	43	1.25	0.35	2.6	89	75	75	0.47	0.36	2.7	28
2034	42	1.16	0.29	2.4	89	74	75	0.43	0.29	2.4	28
2035	41	1.09	0.21	2.4	92	74	72	0.40	0.21	2.2	29
2036	42	1.11	0.17	2.2	90	70	74	0.41	0.16	2.2	28
2037	42	1.17	0.15	2.3	90	68	73	0.45	0.14	2.3	28
2038	41	1.03	0.19	2.1	90	69	73	0.38	0.17	2.0	28
2039	42	0.79	0.11	1.6	88	60	64	0.30	0.09	1.4	25
2040	40	0.45	0.15	1.1	86	63	56	0.15	0.12	0.8	22
2041	41	0.36	0.26	1.1	76	67	53	0.11	0.24	0.7	22
2042	43	0.55	0.68	1.3	79	74	62	0.18	0.68	1.1	23
2043	42	0.46	0.17	1.3	78	55	48	0.15	0.12	0.8	22
2044	39	0.40	0.12	1.1	83	56	44	0.13	0.09	0.6	25
2045	39	0.25	0.12	0.9	74	50	44	0.07	0.08	0.5	25

Year	Mill feed				Recovery			Metal in concentrate			Con. Cu grade (%)
	(Mt)	Cu (%)	Au (g/t)	Ag (g/t)	Cu (%)	Au (%)	Ag (%)	Cu (Mt)	Au (Moz)	Ag (Moz)	
2046	41	0.29	0.12	0.9	73	51	46	0.09	0.08	0.6	23
2047	42	0.29	0.14	1.1	73	54	49	0.09	0.11	0.7	23
2048	40	0.31	0.12	0.9	76	50	44	0.09	0.08	0.5	24
2049	38	0.32	0.29	1.1	79	67	51	0.09	0.24	0.7	25
2050	27	0.42	0.77	1.3	80	76	64	0.09	0.51	0.8	24
2051	14	0.25	0.12	1.0	74	49	43	0.03	0.08	0.3	24
Total	**1,272**	**0.81**	**0.29**	**1.9**	**87**	**71**	**69**	**9.0**	**8.5**	**53**	**28**

Note: Amounts are rounded and exclude any impacts of Covid-19 and are subject to further study and assessment as part of Oyu Tolgoi LLC's cost and schedule estimation update which is expected later in 2020 and subject to further study and analysis on Panels 1 and 2.

Please refer to TRQ's Q2 2020 guidance update for the latest production guidance for years 2020 and 2021.

17.2 Concentrator throughput constraints

Plant throughput varies with ore hardness and is also limited by the volumetric capacity of various components of the plant.

The volumetric limit of the existing concentrator is determined by the following:

- Rougher cell tailings valve capacity, which limits hourly throughput to about 5,800 t/h and occurs when the rougher cell tailing valves are completely open but restricting flow to avoid overflowing into the concentrate launders.
- Concentrate handling equipment, which limits concentrate handling to about 3,000 t/d (about 5,800 t/h of ore feed at peak Oyut head grades).
- Tailings thickener settling rate limit, which is not well defined, but is thought to restrict plant throughput to about 5,800 t/h.

The planned volumetric limit of the existing concentrator has been set at 5,200 t/h, to reflect the above constraints and the demonstrated achievable throughputs. These constraints limit the planned annual throughput to 41.9 Mtpa, based on 92% utilization. The same 5,200 t/h volumetric limit will be applied to the concentrator after completion of the Phase 2 modifications. However, the planned utilization has been increased to 93.5%, resulting in a maximum processing throughput of 42.6 Mtpa.

The capacity of the upgraded flotation circuits and the concentrate handling equipment is based on optimising recovery and grade, while processing the peak copper head-grades scheduled in the mine plan at the planned plant throughput.

17.3 Phase 2 modifications

The Phase 2 modification of the Oyu Tolgoi concentrator include:

- A fifth ball mill to achieve a finer primary grind P80 of 140 µm to 160 µm for a blend of Hugo North and open pit ores.
- Additional rougher and column flotation capacity.
- Additional concentrate dewatering and bagging capacity to process the higher level of concentrate production when processing the higher-grade Hugo North ore.

Most of the new equipment proposed for the modification is of proven design by respected technology suppliers, but some items are novel and have required research and development. The design is based on standards and specifications, that have been reviewed internally as well as in formal sessions with Project stakeholders.

A large amount of new piping, launders and plate work is required to be installed. Some demolition, relocation and modifications to existing piping and plate work will be required.

Normal concentrator operations are planned to continue during the period that modifications are undertaken. The modifications will be completed during routine planned maintenance shutdowns, where possible.

17.4 Description of the Phase 1 and Phase 2 concentrator

Figure 17.2 provides a schematic representation of the existing concentrator flowsheet. The figure also shows the planned Phase 2 modifications (shaded in blue). The major items of existing concentrator equipment are shown in Table 17.3. The major items of additional equipment to be installed are shown in Table 17.4.

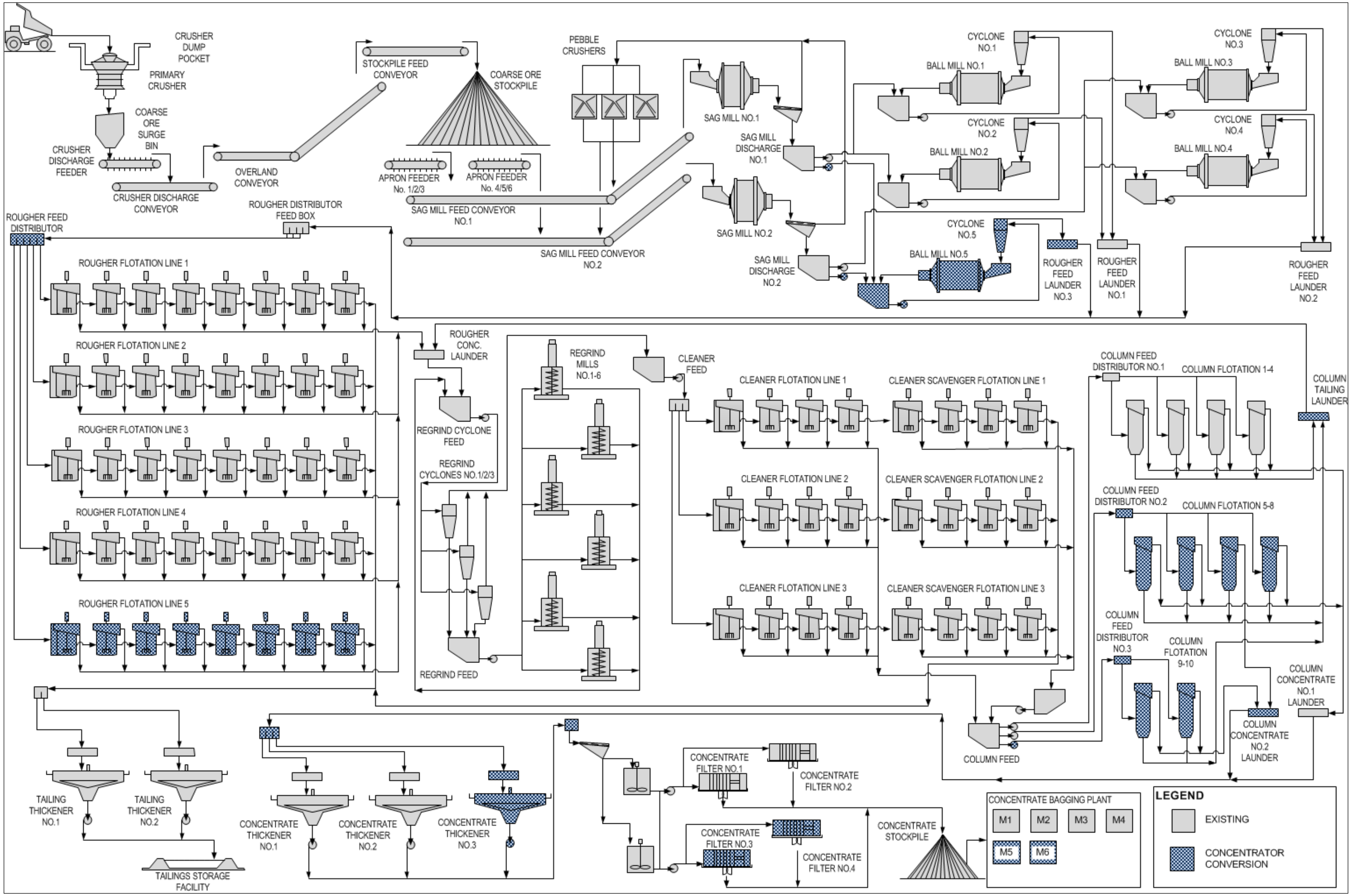
Table 17.3 Summary of existing concentrator major equipment

Equipment unit	No. of units	Description	Installed unit power (kW)
Primary crusher	1	60” x 113” Fuller-Traylor gyratory.	750
SAG mill	2	FLSmidth 11.6 m diameter x 6.9 m EGL with Siemens gearless mill drive.	20,000
Pebble crusher	3	Metso MP 1000 cone crusher.	750
Ball mill cyclone cluster	4	Weir Cavex 8 x 800CVX cyclones.	-
Ball mill	4	FLSmidth 7.3 m diameter x 11 m EGL, GE 5.7 kW twin pinion drives.	11,400
Tailings thickener	2	In-ground high rate, 80 m diameter.	-
Rougher flotation	4	8 x 160 m^3 Wemco tank induces-aeration cell bank.	187
Cleaner flotation cells	3	4 x 160 m^3 Wemco tank cell bank.	187
Cleaner-scavenger flotation cells	3	4 x 160 m^3 Wemco tank cell banks.	187
Regrind cyclone cluster	3	Weir Cavex 18 x 500CVX cyclones.	-
Regrind mill	6	Metso Vertimill VTM-1500-WB.	1,119
Recleaner column cell	4	CPT 5.5 m diameter x 16 m high.	-
Concentrate thickener	2	23 m diameter, high rate.	7.5
Concentrate pressure filter	2	Larox PF tower press, 144 m^2 filter area.	110

Table 17.4 Summary of major additional equipment required for concentrator modification

Equipment Unit	Number of Units	Description	Installed Unit Power (kW)
Ball mill cyclone cluster	1	10 x 800CVX cyclones	-
Ball mill	1	7.3 m diameter x 11 m EGL	11,400
Rougher flotation bank	1	8 x 160 m^3 Wemco tank cell bank	187
Column cell	6	5.5 m diameter x 16.0 m high	-
Concentrate thickener	1	23 m diameter high rate	7.5
Concentrate pressure filter	2	Tower press, 144 m^2 filter area	110

Figure 17.2 Schematic of the Oyu Tolgoi concentrator Phase 2 modifications for processing underground dominant ore



Source: Oyu Tolgoi LLC, Date: 23 July 2020

17.4.1 Delivery of ore to the concentrator

Mine haul trucks currently dump ore from the Oyut open pit directly to the dump pocket of the primary gyratory crusher. Crushed ore is then conveyed approximately 2.7 km to a coarse ore stockpile at the plant site.

Crushed ore from Hugo North will initially be trucked from the Shafts (Shafts 1 and 2) to the open pit crusher and then to the coarse ore stockpile. As underground production increases, a conveyor will be commissioned from the Shaft 2 headframe ore bin to the existing overland conveyor which feeds the existing coarse ore stockpile. When the underground incline conveyor to surface is commissioned, ore from the incline conveyor will discharge to a new conveyor running parallel to the open pit overland conveyor. Both overland conveyors will discharge to the coarse ore stockpile.

Ore from the open pit will continue to be trucked to the surface crusher and transferred to the coarse ore stockpile via the existing overland conveyor.

17.4.2 Comminution

Ore reclaimed from the course ore stockpile is currently fed to two comminution lines, each consisting of a SAG mill, two parallel ball mills, and associated downstream equipment. Cyclone overflow from the circuit at a P_{80} of 140–180 µm reports to the rougher flotation cells. The Phase 2 modifications include the installation of a fifth ball mill and associated equipment.

The parameters used to determine the design parameters of the Phase 2 comminution circuit have been determined by various testwork programs. The comminution characteristics of the different ore types for the main sources of feed are summarized in Table 17.5.

Table 17.5 Comminution characteristics

Parameters	Units	Hugo North	Southwest zone	Base on planned plant feed in 2027			
				Range	Mean	20th Percentile	80th Percentile
Abrasion index	-	0.35	0.21	-	-	-	-
Crushing work index	kWh/t	7.32	16.30	5.4-13.5	10.03	5.89	13.50
SAG power index	min	90.90	138.00	86.0-179.2	117.40	94.80	145.30
Comminution index	kWh/t	19.50	-	11.5-21.7	17.60	16.10	20.10
Modified ball mill work index	kWh/t	18.90	19.90	16.3-19.9	18.80	18.30	19.40
Axb*	-	50.00	-	26.9-45.7	37.50	31.30	42.60

Note: * Axb is a dimensionless testwork value

The typical ball load in the SAG mills is 15% to 18% by volume. The total mill loading is 28% and the rotational speed is 75% to 80% of critical speed. The SAG mill product has a top size of 85 mm, which discharges from the mill through a trommel screen with 9 mm openings. The oversize is screened and washed over a vibrating screen and reports to the pebble crusher circuit. Between 10% to 20% of the feed circulates from the SAG mills to the pebble crushers, depending on ore type and grate condition.

Undersize from the trommel screen and vibrating screen is combined and transferred to the ball mill feed distributors at an expected P_{80} of 2,400 µm. The washed pebbles are conveyed to a surge bin ahead of three cone crushers. Self-cleaning electromagnets on the conveying system protect the cone crushers from tramp metal and crushed pebbles are transferred to a surge bin before being fed proportionately to the SAG mill feed conveyors via belt feeders.

As part of the concentrator modifications, a new duty and standby pump will be installed at each SAG mill pump box to transfer slurry to the new ball mill discharge pump box. The new ball mill will operate in parallel with the four existing ball mills. The mills are charged with 65 mm forged steel balls, and typically operate with 33% ball charge volumes.

A variable-speed pump, installed at each ball mill discharge box, feeds a cluster of eight by 800 mm diameter Cavex cyclones. The projected cyclone overflow will contain 33% solids w/w at a target P_{80} of 140 µm to 160 µm.

Cyclone overflow streams from each circuit are sampled independently by Thermofisher MSA-type samplers for elemental content. The particle size distribution is measured automatically by particle size analyzers before the streams are combined in the flotation circuit feed. Cyclone underflow from each cluster is returned to its respective ball mill. Trunnion magnets remove ball chips from the ball mill discharge preventing a build-up of chips. A new pump, pump box and cyclone cluster and other equipment will be installed with the fifth ball mill.

17.4.3 Rougher flotation

For Phase 2, increased rougher flotation capacity will be provided by adding a fifth rougher flotation bank. The modification involves changing the existing feed distributor into a feed box and adding a new U-tube connected to three of the existing distributor discharge nozzles. The U-tube connects to a new symmetrical, five-way distributor which provides the required mixing and distribution to the five rougher banks. Total inflow of the distributor is planned to be 12,545 m^3/h.

The design of the fifth rougher bank is same as the existing 160 m^3 mechanical tank cells. Retention time in the rougher circuit is 25 minutes at design throughput rates.

Tailings from the new rougher bank will flow to the combined rougher tailings cross-launder at the end of the banks.

Rougher concentrate discharges into the combined concentrate launder, that feeds the regrind cyclone feed pump box.

17.4.4 Cleaner-scavenger flotation

Concentrate from the rougher flotation cells is reground in vertical tower mills before reporting to the first stage cleaner and cleaner-scavenger circuits.

Hugo North ore is low in pyrite and is liberated at a slightly coarser target regrind P_{80} of 40 µm compared to 35 µm for Southwest and 30 µm for the Central ores. The higher flow of material to be reground is offset by a finer rougher feed and lower hardness of the rougher concentrate. As a result, no additional regrind capacity is planned for Phase 2, and no additional equipment is required in the first cleaner and cleaner-scavenger flotation circuits.

When treating predominantly Hugo North ore, cleaner-scavenger concentrate will be directed to the column feed pump box. But the modifications will also allow the cleaner-scavenger concentrate to combine with rougher concentrate for regrinding, when treating open pit dominant ore.

17.4.5 Cleaner columns

Concentrate from the first stage cleaners-scavengers is pumped to column cells, which produce the final grade concentrate.

The column cleaner flotation circuit currently consists of four flotation column cells. The Phase 2 modification involves installing six new cells and associated ancillary equipment. The new cells will be identical to the existing cells. The average froth carrying capacity of the cells is 1.3 $t/h/m^2$ and average flow per column is 353 m^3/h. The additional six columns make use of a column tailing air sparging system with six new pumps installed.

The modifications will include the ability to direct the column cell tailings to the regrind circuit when processing predominantly Hugo North ore, or to the feed to the cleaner cells when processing mostly Oyut open pit ore.

17.4.6 Concentrate thickening

Final concentrate is currently thickened to 70% solids w/w in two 23 m diameter high rate concentrate thickeners. The Phase 2 modifications include installation of a third thickener. The new thickener has similar design specification with the existing thickeners. Each thickener has a design flow rate of 1,937 m^3/h and a unit area settling rate of 0.055 $t/h/m^2$. The existing two concentrate thickeners and storage tanks are enclosed within the concentrator building. The third thickener will be installed in an adjacent annex.

Thickened concentrate is pumped to existing agitated surge tanks ahead of the filtration process.

17.4.7 Concentrate dewatering and storage

Two stacked type concentrate filters, each with 24 plates and 144 m^2 filtration area, are currently installed. Each filter has a cycle time of 10.5 minutes at a rate of 0.723 $t/m^2/h$. Filtered cake has 8.5% moisture and a wet bulk density of 2.17 t/m^3.

The Phase 2 modifications include installation of two new 144 m^2 filters of similar design and capacity. The new filters will be mounted on an elevated platform to provide perimeter access and enough clearance for the gravity transfer of filter cake onto a belt feeder via an inlet surge chute. The concentrate is deposited on a conveyer that transports dewatered concentrate to the storage building.

17.4.8 Tailings handling

Tailings are currently thickened to 64% solids w/w in two 80 m diameter tailings thickeners. The thickener rakes are centrally driven and have a 35,000 m^3 emergency storage pond. Tailings are pumped approximately 310 m to the first of two booster pump stations. Each pump station contains a duplicate pump system (one operating, one standby) and includes a 20,000 m^3 emergency storage area. The tailings are pumped via twin 5 km long overland tailings lines to the TSF. The two lines normally run on duty and standby mode, but both lines can be run simultaneously when needed. There are four discharge points on the TSF with one point in use at any time. The discharge points are between 1.2 km and 2.7 km from the last booster station.

The studies supporting the Phase 2 modification process shows no material change to the properties of the flotation tailings or the TSF requirements.

17.4.9 Bagging Plant

The existing bagging plant has a capacity of 3,000 t/d. Concentrate production is expected to peak at 8,000 t/d during Phase 2. To ensure adequate catch-up capacity, the bagging plant capacity will be increased to 10,000 t/d. Bag capacity will remain at 2 t/bag and 20 bags loaded per truck. Planned concentrate moisture is planned at 8.5%, but within a range of 8-10%. Concentrate particle density is 4.2 t/m^3, with a P_{80} of 35-45 µm.

17.4.10 Raw water storage and distribution

Raw water from the bore field is currently piped to a storage lagoon near the process plant. The lagoon has a capacity of 350,000 m^3. Water from the lagoon is transferred to a raw water surge tank for distribution to potable water treatment systems and the concentrator. If the supply of water from the bore field were to be interrupted for a significant period, process water streams (such as column wash water, cooling water, gland seal water and reagent mixing water) can be supplied directly from the storage lagoon.

Potable water is produced by micro-filtration and chlorination. This is bottled on-site and distributed to personnel for use. Domestic water (showers, etc.) is produced by chlorinating raw bore water.

The bottom sections of the raw water storage tanks are reserved for firefighting. The various firewater mains are normally pressurised and have electric and backup diesel pumps if required.

As part of the Phase 2 modifications, an additional raw water (wash water) tank is proposed to supply the existing and new streams of gland seal water, filter wash water and column wash water.

17.4.11 Process water

Two process water ponds, each capable of storing 24 h of process water, are constructed adjacent to the concentrator. Process water consumption currently averages 11,882 m^3/h. This is planned to increase to 14,183 m^3/h for Phase 2. Water is primarily supplied from the tailing thickener overflow and TSF reclaim water, with make-up water being sourced from the existing raw water tank. One additional pump will be installed to increase the supply to the high-pressure process water circuit.

17.4.12 Air supply

Compressed air at 750 kPa, is currently provided from three compressor and dryer systems to two air receivers. Compressed air is distributed to the plant directly from the receiver outlet. To provide the additional compressed air required by the six new column cells, three additional air compressors and one air receiver will be installed. Air pressure to the existing and new column flotation air manifold is controlled by a pressure control valve. The planned capacity of new compressors is 5,000 m^3/h. Two compressors will be on duty with the third on standby.

17.4.13 Electrical wiring instrumentation and control

The Phase 2 modifications will involve installing new electrical switchgears, instrumentation, and control equipment. Where possible, new equipment will be similar to the existing equipment to minimise spare parts inventory and to retain familiarity for operations and maintenance teams. However, there will be opportunities to improve reliability and minimise cost by considering new equivalents and challenge existing design concepts.

17.4.14 Reagents

Quicklime required for pH control is received in bulk from regional Mongolian and Chinese suppliers and is pneumatically off-loaded into a silo that holds 4-6 weeks supply. Lime is slaked and the slurry metered to the plant from two ring mains. Each ring main consists of parallel lines that can operate on duty and standby modes.

Flotation reagent distribution is designed to allow flexibility in the reagent type used. Additional distribution pipelines are installed where needed.

Process and raw water monitoring programs are ongoing and water samples are collected on a weekly basis for detailed chemical analysis. Corrosion and scale formation are routinely monitored. Online water chemistry and scale formation is measured in real time. No change is planned to the water treatment chemical addition process as part of the Phase 2 modification.

The tailing thickener flocculant building is located adjacent to the flotation reagent building. The flocculants are delivered in dry form in 800 kg super sacks. No additional installations are planned for the tailings thickener flocculant section.

Concentrate thickener flocculant is delivered in 25 kg sacks and dumped manually into a metering hopper equipped with venturi type dosing system. Additional flocculent delivery equipment will be required for the new (3rd) concentrate thickener.

Grinding balls are delivered in trucks and dumped into storage bins. SAG mill balls are added via an automatic feeding system from a storage bin above the SAG mill feed conveyor. The ball mill ball feed system delivers balls onto a conveyor with gates to divert balls into the feed chute of each ball mill according to a timed sequence. The existing gated ball charging system conveyor will be extended to feed balls to the fifth ball mill.

Grinding balls for the regrind mills are loaded into buckets from the storage bin and charged to the mills by the bridge cranes.

Process plant usage rates for power, water, and key consumables varies with the ore types being processed. The projected average process plant consumption rates are summarised in Table 17.6.

Table 17.6 Average projected energy, water, and process plant consumables

Consumable	Unit	Forecast usage
Power	Kwh/t	26.2
Raw water	m^3/t	0.38
125 mm mill balls	Kg/t	0.36
75 mm mill balls	Kg/t	0.41
16 mm mill balls	Kg/t	0.10
Lime	Kg/t	0.86
Aerophine 3418A (main collector)	Kg/t	0.015

18 Project infrastructure

18.1 Introduction

Most surface infrastructure facilities that are required for the open pit, underground and concentrator operations have been constructed and are operational. The key infrastructure facilities supporting the Project are summarized in this section.

18.2 Power demand, distribution, and supply

18.2.1 Power demand

The estimated annual diversified peak power demand and the estimated power consumption per year for the Project over the next 20 years is shown in Table 18.1. The estimate is based on a combination of actual and predicted loads and load factors.

Table 18.1 Diversified peak power demand (MW) and energy consumption (GWh)

Area	Unit	Year									
		2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**
Central substation	MW	25	25	25	25	25	25	2	25	25	25
Concentrator substation	MW	118	118	136	136	136	136	136	136	136	136
Shaft farm substation	MW	43	45	50	55	59	64	68	69	69	69
Total peak demand	MW	187	188	211	216	219	224	228	230	230	230
Total energy	GWh	1,536	1,521	1,671	1,747	1,779	1,802	1,828	1,839	1,843	1,839
		Year									
		2030	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**
Central substation	MW	25	25	25	25	25	25	25	25	25	25
Concentrator substation	MW	136	136	136	136	136	136	136	136	136	136
Shaft farm substation	MW	69	69	69	69	69	69	69	64	58	43
Total peak demand	MW	230	230	230	230	230	230	227	224	219	204
Total energy	GWh	1,839	1,839	1,843	1,839	1,843	1,839	1,830	1,802	1,770	1,634

18.2.2 Main power supply

Oyu Tolgoi LLC has secured the power requirements for Oyu Tolgoi through the terms of the Investment Agreement and the subsequent agreements described in Section 4.4.2. Power for the Project is currently supplied with electricity from China in accordance with three agreements:

- Power Purchase Agreement for the Project between Oyu Tolgoi LLC, the Inner Mongolia Power International Corporation (IMPC), and the National Power Transmission Grid of Mongolia.
- Operation and Maintenance Agreement (O&M Agreement) between Oyu Tolgoi LLC and the IMPC.
- Dispatch Agreement between Oyu Tolgoi LLC and the IMPC.

Power is supplied via a 220 kV double-circuit transmission line from Inner Mongolia. Either circuit can supply approximately 400 MW, thus Oyu Tolgoi's load can be met entirely from one circuit. To date, the reliability of the electricity supply from IMPC has been very good, with no recorded full outage of the transmission line.

The IMPC funded the upgrade of the Inner Mongolia transmission system to facilitate the power supply to Oyu Tolgoi, and Oyu Tolgoi LLC funded part of an IMPC switching substation and the section of transmission line that connects the switching substation to the Mongolian border. As part of the O&M Agreement, Oyu Tolgoi pays IMPC to operate and maintain their equipment in Inner Mongolia. IMPC's capital cost of the transmission system upgrade and switching substation is recovered through the electricity tariff, but there is a requirement for Oyu Tolgoi to make a final payment for the undepreciated capital at the end of the term of the Power Purchase Agreement.

The section of transmission line that operates in Mongolia was built by Oyu Tolgoi LLC.

18.2.3 Emergency and standby power supply

The diesel power station at the Oyu Tolgoi site provides emergency and standby power in the event of loss of the main power supply. The power station comprises two plants, each with 20 MW capacity, connected to the site 35 kV grid. The emergency and standby loads include:

- Critical concentrator equipment (thickeners, gland seal water and pumps, etc.)
- The main communication and computer network systems
- Some heating systems
- Underground mine evacuation equipment, lighting, and critical ventilation
- Security facilities
- Fire pumps

Because of the unreliability of the existing generators, Oyu Tolgoi plans to replace the generators with self-contained air-cooled diesel generators that will be capable of load cycling to match the power demand.

Emergency power is also supplied by several dedicated generators located at the administration building and some other critical locations.

18.2.4 220 kV power distribution

Central substation

The 220 kV line delivering power to the Project connects to the central substation, approximately 500 m south of the concentrator. The central substation distributes to the various facilities at either 220 kV or 35 kV. The substation comprises an outdoor, double-bus 220 kV switchyard, two 51.5 MVA 220/35 kV transformers, and an indoor 35 kV substation.

Concentrator substation

The concentrator substation, just south of the concentrator building, receives 220 kV power from the central substation via twin 220 kV overhead transmission lines. The substation has an outdoor double-bus 220 kV switchyard, three 125 MVA 220/35 kV transformers, and an indoor 35 kV gas-insulated substation to supply the concentrator loads for grinding, conveying, flotation, and drying. This substation supplies two SAG mill cyclo-convertor drives (20 MW per drive), each equipped with power factor correction and harmonic filtering to suppress unwanted electrical noise and prevent harmful harmonic currents from affecting the system.

Shaft farm substation

A 220 kV switchyard and substation are located on surface, close to Shafts 2 and 5 (the shaft farm area). The shaft farm substation can supply all underground users. The shaft farm substation receives power from the central substation via twin 220 kV overhead transmission lines. The substation has an outdoor double-bus 220 kV switchyard, three 125 MVA 220/35 kV transformers, an indoor 35 kV gas insulated substation, and three 35/10.5 kV transformers to supply the mine loads and the infrastructure loads on the north and south ring mains. These include the incline conveyor, main and auxiliary hoists, ventilation fans, sinking stage pumps, compressors, and ancillaries and infrastructure buildings.

18.2.5 35 kV infrastructure power supply

The 35 kV infrastructure power distribution system comprises:

- Three 35 kV overhead power line circuits (north, south, and concentrator). The north and south circuits are fed from the shaft farm substation, the concentrator circuit is fed from the central substation.
- A 35 kV feed to the underground mine.
- Two overhead power lines, fed from the concentrator substation, supply the borefield and associated pump stations. The lines extend approximately 70 km to the north-east of the site. The power is stepped down to 6.3 kV at each pump station for transmission to the bore pump stations. The lines are strung on a single pole line to the last pump station. The two lines are isolated from each other during normal operation, but tie switches are installed at each substation to allow for power crossover, if required.
- A 35 kV line provides power to community loads at Khanbogd and Bayan Ovoo.

18.3 Site access

18.3.1 Airport

A permanent domestic airport has been constructed at Oyu Tolgoi to support the transportation of people and goods to the site from Ulaanbaatar. It also serves as the regional airport for Khanbogd. The airport is 11 km north of the Oyu Tolgoi camp area. It is a non-precision approach, visual flight rules facility. The surface is concrete, with a concrete apron at the terminal building. The runway has been aligned to the prevailing north-west–south-east wind direction to minimize crosswind conditions and facilitate optimal landing and take-off conditions. The design criteria are set to service commercial aircraft up to the Boeing 737-800 series aircraft.

18.3.2 Site access roads

All internal access roads are constructed of graded gravel. The road base is built on scarified/compacted existing ground where suitable. Where the ground surface is unsuitable for use as a wear course, it has been replaced with well-graded gravel and sandy fines. The top elevation of the shoulders of the gravel pavement surface is approximately the same level as the surrounding surface except at pipeline crossings. Side-drain ditches are provided parallel to the road for stormwater drainage.

Access to the borefield is by a gravel service road from the plant site, following the pipeline across the northern lease boundary to the borefield. Traffic loading for the borefield road is limited to light vehicles and occasionally heavy equipment and trucks for routine inspections and maintenance. The road is constructed to a Mongolian standard, which requires that topsoil is removed, and the road surface is levelled and compacted only. The road is formed with a cross-fall and table drains and has a gravel wear surface. The running surface is 3 m wide and the shoulders 1 m wide. Signage has been added as required.

18.3.3 Oyu Tolgoi – Gashuun Sukhait Road

The access road from Oyu Tolgoi to Gashuun Sukhait and the Mongolia to China border crossing has been upgraded. Approximately 19 km of the road are pending final construction to a fully paved standard. The Mongolian Government is considering a master plan for the strategic development of the precinct at the border crossing.

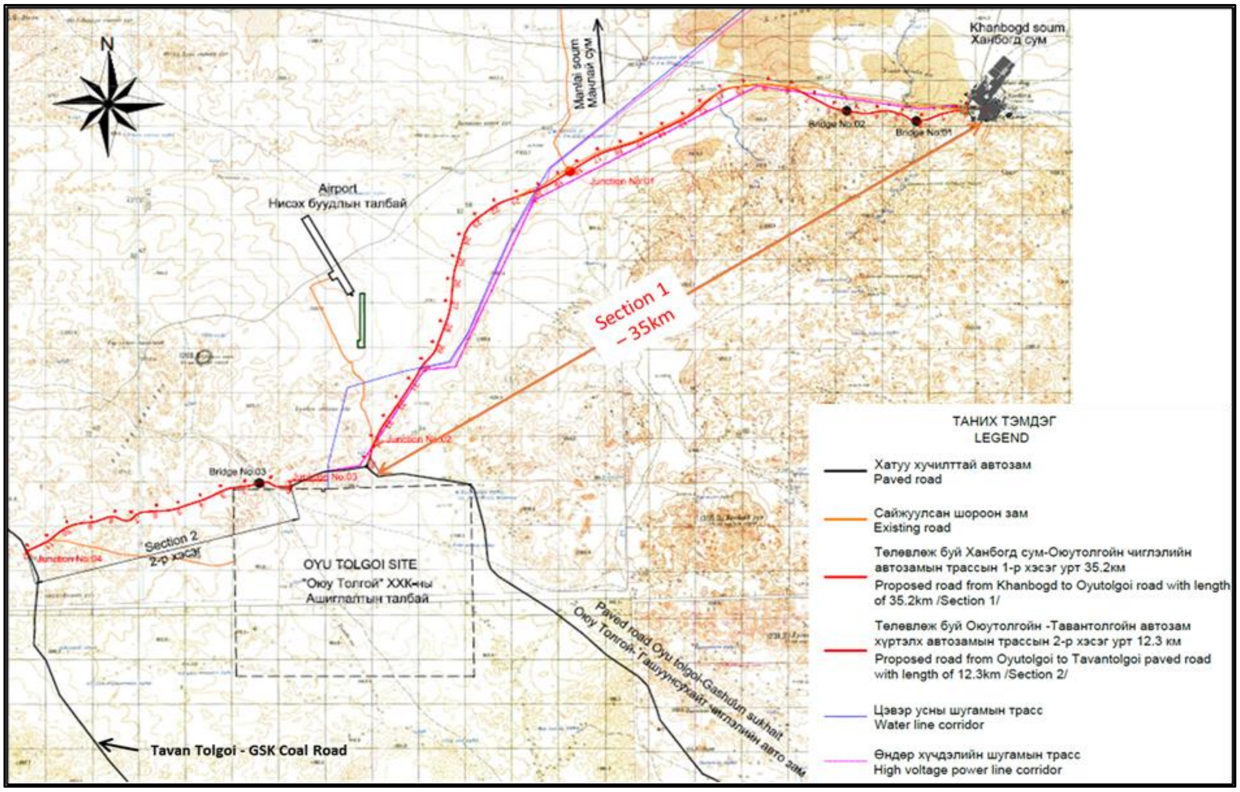
Concentrate is transported by road to the Jiayou Hua Fang terminal, 7 km beyond the border crossing. Concentrate bags are unloaded at Hua Fang, where Oyu Tolgoi has constructed a 100,000 m^2 laydown area. Bags are unloaded and reloaded using mobile gantry cranes.

A reasonable quality provincial road connects the border town of Ganqimaodao with the Jingzang Expressway via the towns of Hailiutu and Wuyuan. Overall, the routes are adequate for copper concentrate haulage.

18.3.4 Oyu Tolgoi – Khanbogd Road

The existing 35.1 km long gravel road between Oyu Tolgoi site and Khanbogd soum has been upgraded. The new road alignment, as shown in Figure 18.1, follows the existing road alignment. The road is an asphalt concrete construction and includes two reinforced concrete bridges, 65 m and 32 m in length along with four causeways totalling 400 m in length. Section 1 (35.1 km), between Oyu Tolgoi and Khanbogd, was completed in 2019 and Section 2 (12.1 km), between Oyu Tolgoi and the existing "coal road" between Tavan Tolgoi and Gashuun Shukait, is pending construction to a fully paved standard.

Figure 18.1 Oyu Tolgoi – Khanbogd Road



Source: Oyu Tolgoi LLC, Date, 23 July 2020

18.3.5 Railway access

The Trans-Mongolian Railway crosses the Mongolia-China border approximately 420 km east of Oyu Tolgoi, traversing the country from south-east to north-west through Ulaanbaatar to the border with Russia. There is currently no access from the Project site to the Mongolian railway network except along a 330 km desert trail north-east to Sainshand. At the Mongolian / Chinese border, the rail gauge changes from the Russian standard to the Chinese standard.

The Government of Mongolia may construct or facilitate construction and management of a railway in the vicinity of the Project. Oyu Tolgoi LLC will be consulted regarding the railway route. If constructed, the Government of Mongolia is obliged to make the railway available for use by Oyu Tolgoi on commercial and non-discriminatory terms.

A single-track heavy-haul railway from the Erdenes Tavan Tolgoi coal mine (approximately 150 km to the north-west of Oyu Tolgoi) to Gashuun Sukhait, ultimately to be interconnected with the Chinese rail network at Ganqimaodao. Once constructed, the rail line will pass within 12 km of Oyu Tolgoi and therefore represents an opportunity for eventual connection of Oyu Tolgoi to the rail network.

18.3.6 Port facilities

Oyu Tolgoi makes use of the Chinese Port of Tianjin, the largest port in northern China, some 150 km south-east of Beijing, to import freight from overseas. The port is open year-round and has no ice restrictions during winter. Road delivery from Tianjin is via Chinese highways connecting Tianjin to Wuyuan, about 1,050 km, from there along a state highway to Hailiutu, about 60 km, and then on to the China-Mongolia border crossing at Ganqimaodao-Gashuun Sukhait. This is the primary border crossing for both cargo and Chinese personnel immigration for the Project. Baotou, just east of Wuyuan, is the consolidation point for freight originating from China.

18.4 Mine site infrastructure

The entire site is surrounded by a mine lease perimeter fence with security gates at entrance / exit points. Any ongoing site development activities are generally within the disturbed area of the existing Oyu Tolgoi mine site.

18.4.1 Customs Bonded Zone and Marshalling Yard

A bonded yard with a security fenced area and administration building has been established at the Oyu Tolgoi site for import of equipment and material to the site. A secured customs bonded zone and marshalling yard has been added at the Oyu Tolgoi site. It serves as a marshalling yard to assemble convoys for the outbound concentrate fleet, a storage area for extra bags of concentrate, and a customs bonded zone approved by the Mongolian General Custom Administration. The marshalling yard will be expanded to address the increase in concentrate exports following ramp-up of underground production.

18.4.2 Accommodation strategy and camp management plan

Oyu Tolgoi has two on-site camps, Oyut and Manlai. The Manlai Camp is approximately 1 km south-east of Oyut. The camps have several accommodation options, ranging from single-bed rooms with an adjoining ablution facility, to rooms with four beds and non-adjoining dormitory-style ablution facilities. The capacity of the accommodation camps is summarized in Table 18.2.

Table 18.2 Accommodation inventory

Camp	Location	Beds	Expansion	Total
Oyut	On-site	1,533	5,500	7,033
Manlai	On-site	2,363	200	3,711
Total		**3,896**	**5,700**	**9,596**

18.4.3 Open-pit truck shop complex

The open-pit truck shop complex is approximately 1 km north-west of the primary crusher, within the maintenance complex, adjacent to the bonded customs storage area to the north-east and the main fuel storage facility to the south-east. It covers an area of 17.5 ha and incorporates outdoor facilities and four self-contained structural steel, pre-engineered buildings designed to accommodate the required facilities for repair, maintenance, and rebuild of the open-pit mining equipment. The complex includes buildings for the truck shop, washing shop, lubricant storage building, and welding and machine shop.

18.4.4 Central heating plant

The central heating plant was completed in 2012. Two new 29 MW units were installed in 2019. The coal-fired boiler provides hot water heating for the concentrator building, open-pit truck shop, construction and operations warehouses, administration building, Oyut and Manlai camps, electrical substations, and all other surface facilities, as well as mine air heating systems for Shafts 1, 2, and 3. Hot water from the plant is supplied and returned through a primary circulation loop to the various secondary circulation and heating loops, which are complete with dedicated hot water/glycol heat exchangers to provide heating to end users. The heat distribution system begins at the boiler house mechanical annex, where hot water is pumped to two heating distribution stations through pre-insulated pipelines. The pipe is buried most of the way to the distribution stations except near the beginning, where it crosses the river on a pipe rack. Water from the distribution stations is then circulated to heat exchangers at the end-user facilities for building heating in compliance with health and safety standards and regulations.

18.4.5 Waste disposal facilities

General waste generated by the Project is collected and disposed of in accordance with Mongolian and international laws. The waste management centre is a focal point of waste management practice at site. Principal features include a non-hazardous waste landfill, leachate treatment, and a waste incinerator / oil burner. Construction of a recycling and composting building is proposed.

18.4.6 Fuel storage

Diesel fuel is delivered to site by road tanker. The fuel is unloaded and stored in storage tank farms. The general vehicle fuel facility comprises two 50 kL gasoline fuel tanks and two 400 kL diesel fuel tanks. The open pit mine fleet fuel facility includes two 400 kL diesel fuel tanks and two 1,000 kL diesel fuel tanks. Four 50 kL diesel fuel storage tanks are provided for the diesel power stations, and storage tanks with a capacity of 72 kL are installed on surface at the shaft farm.

Current diesel fuel usage is approximate 240 kL per day. This will decrease to between 150 kL and 200 kL per day as production from Hugo North increases and the open pit operations are wound back.

18.4.7 Core storage facility

The core storage facility has gravel road access, an outdoor core storage area with compacted soil floor, and a 35 m by 24 m prefabricated steel building for core management facilities. The facility includes:

- Core logging work area.
- Saw room.
- Core test rooms.
- General storage room.
- Break room.
- Washroom facilities.

The existing facility meets the requirements of current and expected future operations.

18.4.8 Toyota workshop

Toyota has constructed a light-vehicle maintenance facility for contract maintenance of all light vehicles at the site.

18.4.9 Information and communications technology (ICT) systems

A state-of-the-art information, security, data, and voice communications system is installed to ensure that operational needs are met. A fibre-optic communications backbone extends throughout the mine site and the borefield, providing connectivity across administrative, open pit and underground activities. The following principal components support the surface concentrator, underground development, power distribution system, and operations camp:

- Distributed control system (DCS).
- Programmable logic controller (PLC) control systems.
- Electrical monitoring system.
- Local area network.
- Voice over internet protocol system.
- Security system, including closed-circuit television and access control system.
- Fire alarm system.
- Digital trunk radio system.
- Cable television for operations personnel entertainment.

18.4.10 Concrete batch plants

Two concrete batch plants are operational. One batch plant is rated for 120 m^3/h with an optimal rate of 90 m^3/h, which services the underground development requirement. The other batch plant, with an optimal rate of 40 m^3/h, is a backup for the larger plant.

Oyu Tolgoi LLC owns a fleet of 10 m^3 concrete mixer trucks. Any short-term mixer truck capacity is provided by contractors, as required.

18.4.11 Other support facilities and utilities

Other facilities include the warehouses, offices medical facilities, and fire station.

The operations warehouse is a 45 m by 180 m heated building adjacent to the construction warehouse. It provides 8,100 m^2 of storage for process equipment parts, spares, critical piping and valves. A new 6,600 m^2 heated warehouse, fitted with shelves, offices, loading-unloading areas, and a 50-tonne travelling crane will be commissioned to meet the underground mine requirements.

The existing surface medical and fire station infrastructure can service the construction and operational needs of the existing and future operations.

18.5 Water supply and distribution

18.5.1 Introduction

Water resource development in the South Gobi Region is part of the Mongolian national water resources strategy, and its management is embedded in national legislation and the institutional framework. Oyu Tolgoi LLC fully understands the importance of water in the South Gobi Region, and has implemented a wide range of measures to promote water conservation and to minimize the amount of water used by the Project.

18.5.2 Abstraction

The Government of Mongolia awarded a water utilization contract to Oyu Tolgoi LLC until 2040, which can be extended for 20-year periods beyond 2040, in accordance with the Law on Water. Oyu Tolgoi LLC is currently entitled to utilize water at a rate of 918 L/s.

Updated hydrogeological modelling of the Gunii Hooloi demonstrates that the aquifer can provide 1,475 L/s, at current drawdown conditions. The model indicates that, even after 40 years of extraction, the deep aquifer system will remain confined and is unlikely to impact on the streambed aquifers. Drawdown will be continuously monitored, and the aquifer model will be updated and refined as more data becomes available. As necessary, abstraction from the boreholes will be adjusted to optimize drawdown characteristics and protect the shallow groundwater resources.

18.5.3 Raw water

The raw water supply system from the Gunii Hooloi aquifer was completed in 2012. The raw water supply system has a design capacity of 900 L/s. In 2018, raw water usage peaked at 630 L/s with an average annual usage rate of 460 L/s. Notably, 88% of the water used in the concentrator in 2018 was recycled.

Bores have been developed in two distinct areas of the Gunii Hooloi borefield, south-west and north-east. It is anticipated that the 10 water bores in the nearer, south-west part of the borefield provide approximately 30 L/s per bore (300 L/s in total) and that the 15 bores in the higher transmissivity, north-east part of the borefield will be able to provide another 40 L/s per bore (600 L/s in total). The design capacity of 900 L/s provides the ability to refill the emergency storage lagoons after emergency use, without affecting water availability to site.

Water from groups of individual bores accumulate into five centrally located collection tank pump stations, from which water is pumped into the main water line leading to the Oyu Tolgoi site. A break tank pump station decreases the line pressure to atmospheric pressure and provides the additional pumping energy to bring the water to the site.

Water is pumped into a 400,000 m^3 emergency storage lagoon (two cells of 200,000 m^3 each) situated on elevated ground approximately 5 km north of the Oyu Tolgoi site. The lagoon provides an approximately one-week emergency supply of water. Water is gravity-fed to the site through two pipelines from the two cells.

All equipment in the Gunii Hooloi borefield and pipeline is remotely controlled by the site DCS linked by redundant telecommunications networks. All equipment in the borefield is powered with electricity through a high-voltage transmission line routed adjacent to the pipeline, with power drops to each pump station and to the borefield. A light-duty access road runs along the pipeline to each pump station and bore.

18.5.4 Site water systems

Domestic water is only used for washing, shower, and eye-wash stations, and not for drinking. Raw water for domestic use is treated in the water treatment plant, then delivered to end users including the central heating plant, warehouse, open-pit truck shop, concentrator, primary crusher, 220 kV central substation, diesel power station, north gatehouse, operation camp, and administration building.

A water treatment and bottling plant treats raw water from the Gunii Hooloi borefield to drinking water (potable) standard. The potable water generated from raw water passes through dosing, multi-media and granular-activated carbon filtration, micro-filtration, reverse osmosis treatment, ultraviolet sterilization, and ozone disinfection prior to bottling and onward distribution. The total output of the treatment facility is 8 m^3/h. Treated potable water is passed to the water bottling line, with a capacity of 200 bottles per hour. Empty bottles are collected for sterilization and reuse.

The wastewater treatment plant is installed within the main camp area with a capacity for 8,000 equivalent people capacity. All sewage generated on site is either pumped directly to the plant or transported by truck from other areas of the site to an unloading bay. The treatment plant technology is mechanical biological activation using membrane bioreactor. Treatment consists of screening followed by nitrification and de-nitrification steps, biological treatment in a membrane bioreactor and finally, UV sterilization, chlorine disinfection and high-pressure sand filtering to render it suitable for discharge to the site TSF where it can be reclaimed into the concentrator circuit.

Excess sludge is dewatered and placed in transportation skips for onward disposal in the site waste management facility or for use in site composting activities.

A return water system is used to collect and transport mine water from Shaft 1 and Shaft 2, plus effluent from the central heating plant and other locations around the site to tailings storage.

Six fire pump stations provide high-pressure firewater system at site. The fire protection pump zones cover most of the on-site facilities. Remote on-site and off-site facilities are not connected to the high-pressure firewater system but rely on local manual fire protection. Fire detection and alarm systems are installed at key facilities and report to the mill area control room in the process plant or to the North Gatehouse, which is manned 24 hours a day.

Firewater systems are to be provided for the underground mine and associated maintenance and explosives storage areas. These systems are self-contained and serviced from the raw water distribution system via the shafts.

18.5.5 Water demand

A site water balance is maintained for the Project that identifies water supply, recovery loops and losses.

The total site design raw water demand ranges from 588–785 L/s, with an average of 628 L/s, at the planned production rate. More than 80% of the water used at the Project consists of recycled water.

Most water losses are from the TSF, primarily associated with interstitial water locked in the settled tailings, but also due to evaporation. Additional water losses result from dust control. Minor water losses relate to construction activities (e.g. concrete production), infrastructure maintenance (e.g. heating system make-up), and unrecoverable water from domestic water use.

As of December 2019, total metered water used was approximately 16 GL for domestic, concentrator and construction work. All water has been supplied from the production bores and wells of Gunii Hooloi groundwater aquifers (Table 18.3).

Table 18.3 Water use of Oyu Tolgoi LLC in 2019

Intended use	Water use (GL)	Explanation
Concentrator	13,7	Total amount of concentrator plant raw water supply from raw water pond
Domestic	0.5	Domestic water use amount is based on the data of water purification and packing factory of OT LLC
Dewatering water from open pit mining	0.1	Measured by guaranteed meter indicator installed at the dewatering facility in open pit mining
Other	1.6	Dust suppression, concrete production, underground mine development, boiler and heating system etc.
Total water use amount	**16.0**	

18.6 Tailing storage facility

18.6.1 Introduction

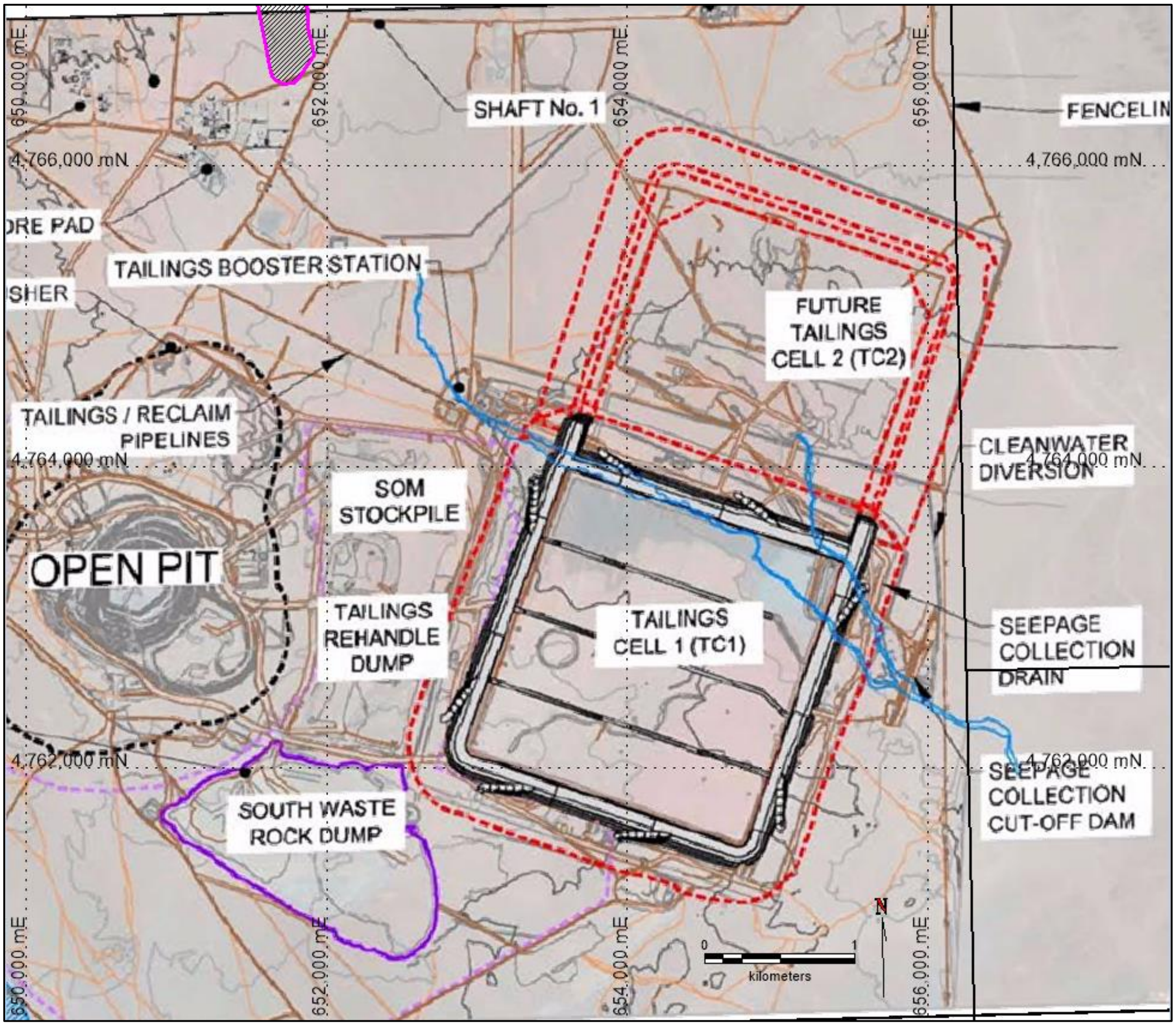
The TSF is located approximately 2 km east of the open pit and 5 km south-east of the process plant. The TSF design is based on deposition of conventional thickened tailings in several independent cells. The concept is for perimeter embankments for each cell to be raised in a staged process until the embankments reach their final design height. Additional cells will be added to the TSF as required over the life of the Project.

Tailing from the process plant are currently placed into the first cell (TC1). The cell measures approximately 2 km by 2 km and is separated into four sub-cells (A through D). A general plan view of TC1 and facility is shown in Figure 18.2.

As of 30 June 2019, about 213 Mt had been placed in TC1, which has a remaining capacity of approximately 176 Mt. The cell embankment has reached 50 m in height and is planned to reach its final height of 70 m in 2023. A second tailings cell (TC2) to the north of TC1 is planned to provide storage capacity for a further 360 Mt of tailings. The capacity of the TSF will need to be further increased for continuing mine operations after TC1 and TC2 are full. The plan is to construct up two more cells (TC3 and TC4) located east of TC1/TC2.

Tailings from the concentrator have an average solid content (by weight) of 60%. Tailings are spigoted from the west embankment into the sub-cells to promote water runoff toward the reclaim pond at the downstream corner for water recovery. Water is reclaimed from the pond by a floating barge and pumped back for re-use in the process plant.

Figure 18.2 General TSF arrangement of cell 1 and cell 2



Source: Prepared by AMC from information provided by Oyu Tolgoi, Date: 30 June 2020. Projection UTM (WGS84) Z48N.

18.6.2 Design studies

The design of the Oyu Tolgoi TSF has evolved since 2004, involving several studies and specialist consultants:

- 2004—Prefeasibility study by Knight Piesold (KP), with thickened tailings options by Golder.
- 2006—Feasibility study by Klohn Crippen Berger (KCB).
- 2007—Detailed design commenced by KCB.
- 2008—Interim report issued by KCB.
- 2010—Draft feasibility study by KCB.
- 2011—Final feasibility study by KCB (August 2011), material take-offs (October 2011), and detailed design of starter embankment by KCB (May 2011).

- 2013—Detailed design and quality control consulting responsibility to Golder. KCB retained for quality assurance reviews.
- 2014—Detailed design of first embankment raise completed by Golder. Independent Technical Review Team re-established to provide expertise oversight on ongoing design development, construction, and operations.

In 2015, Golder updated the feasibility study design for the planned ongoing development of TC1 and TC2 and prepared a supporting paper on TSF disposal options over the life of the mine. Key design improvements included:

- Downstream embankment construction method was changed from centreline/upstream to downstream to improve constructability and provide future flexibility.
- Widths of the key filter layers were optimized to reduce earthworks construction volumes, materials handling, and use of scarce sand and gravel.
- Steepened embankment exterior slopes are being evaluated based on a detailed review of instrumentation to date and rigorous geotechnical analysis that considers the development of strain and pore water pressures during embankment construction.

The improvements related to downstream embankment construction and reduced filter layer widths are supported and have been endorsed by an independent technical review team. The team also supports the strategy for optimizing exterior slopes, subject to ongoing characterization of the Cretaceous clay foundation.

Since 2015, Golder has issued annual raise design reports and updated design criteria and parameters for TC1, based on ongoing data collection and understanding.

18.6.3 Design criteria

TC1 was designed in accordance with the Australian National Committee on Large Dams (ANCOLD) design guidelines, based on a "High A" consequence classification. The design also complies with the Rio Tinto D5 Standard for Tailings and Water Storage Facilities.

Based on the ANCOLD guidelines and the "High-A" consequence classification, the following key design criteria were adopted for the TC1 design and operation:

- Floods—accommodate the 1-in-10,000 annual exceedance probability (AEP) 72-hour rainfall event.
- Contingency freeboard—to contain the 1-in-50 (2%) AEP wind wave run-up.
- Freeboard—additional freeboard of 0.5 m above the maximum operating level (MOL).
- Earthquake—operating basis earthquake (OBE) of a 475-year return period during operation and maximum design earthquake (MCE) of a 5,000-year return period for final height based on a M7 Richter Scale Earthquake at the Tavan Takhil Fault, located 18 km from the TSF.
- Geotechnical Stability—a factor of safety (FOS) exceeding 1.5 for "long-term drained, consolidated undrained and end of raise (loss of containment)"; a FOS exceeding 1.3 for "end of raise undrained (no loss of containment)"; and FOS between 1.0 to 1.2 for "post-seismic conditions".

Improvement of the TSF design and the tailings management strategy is ongoing.

18.6.4 Tailings characteristics

Golder conducted a tailings characterization campaign on TC1 in 2017 and recovered undisturbed tailings samples at different depths and locations.

The concentrator produces tailings with a relatively homogeneous grain size. Fines content ranges from 40% to 60% and is expected to stay within this range for the near future. The specific gravity of the tailings is tested regularly on site and is about 2.78.

Geochemical test work predicts that tailings from Central Oyu, the Wedge Zone, Hugo South, and Heruga will be strongly potentially acid forming (PAF). Non-acid-forming (NAF) tailings are predicted from Southwest Oyu and Hugo North.

The current thickener pumps tailings at density of about 60% solids, forming an average overall tailings beach slope of 0.65% after deposition.

Based on observations and surveys, the tailings form a hard crust as they dry and desiccate, which inhibits dust formation. After deposition, the tailings initially settled at about 1.5 t/m^3, while the TC1 overall density of the tailings is about 1.6 t/m^3.

18.6.5 Embankment borrow materials

TC1 embankment is constructed of locally sourced earth materials, which form the inner inclined clay core/filter layers, and of open pit mine waste rock, which forms the main embankment shell. The TC1 embankment is raised using a downstream method to ensure sufficient storage capacity for ongoing tailings deposition, plus adequate flood storage and freeboard. Every year, the main perimeter embankment is raised about 6.5 m.

Most of the embankment will be constructed of various mine waste rock materials, including:

- Oxide waste rock—this material acts as the processed filter zones between the fine tailings and the coarser waste. The oxide units are NAF and can be segregated for construction. The remaining oxide is classified as PAF and placed in waste rock storage.
- Sedimentary rock—this material is placed at the base of the downstream embankment shells and acts as a NAF filter and drainage system.
- Random waste rock—both NAF and PAF waste rock from the open pit are placed in the embankment shells of the TSF where water cannot come into contact with the PAF. NAF-only material will be used where these materials might be in contact with seepage.

The mine plan indicates that NAF rock types comprise about 30% (547 Mt) of the total waste rock to be produced. The timing and ability to effectively separate the NAF rock will affect the potential to use all of it for embankment construction. Dam zoning to incorporate some PAF rock into the dry sections of the embankment shells may be required. Oyu Tolgoi LLC has developed a draft strategy to identify and segregate waste products by chemistry and physical characteristics (gradation). All filter zones and the basal blanket layer will be constructed of NAF oxide and sedimentary rock units.

18.6.6 Future work

The ongoing and future work is planned for:

- Design of an external pond to manage excess water, often observed ponding outside the reclaim pond area. Managing this excess water externally will decrease the area prone to evaporation and provide better foundation condition for the reclaim dyke construction raises. By storing that excess water outside of TSF, features can be added to allow pumping of the water during the winter months, increasing reclaim to the concentrator.

- Assessment of foundation and hydrogeology long-term performance as input to the required TC1 batter slope closure design to guide upcoming year construction.
- TC1-TC2 transition plan.
- Final year deposition to better plan the final grading of tailings in TC1 prior to closure work.
- Reviews of various aspects to improve TC2 design, based on lessons learned from TC1. TC2 footprint may increase slightly towards the west and north, which will increase the life of TC2 by up to 15 years.

19 Market studies and contracts

19.1 Introduction

The Oyu Tolgoi Copper Concentrate Sales and Marketing group (CCSM) is responsible for all aspects of concentrate marketing and sales, including, updating product specifications, negotiating sales and logistics contracts, and analysing supply-and-demand trends in the Chinese and global markets. CCSM is supported by Rio Tinto's Copper Concentrate Sales and Marketing team.

Shipment of Oyu Tolgoi concentrates commenced in July 2013 and by January 2020 had reached a cumulative total of 4.6 Mt of concentrate. The logistics process remains stable with sales transacted at a 3rd party warehouse facility at Huafang in China, approximately 7 km from the China-Mongolia border. Here the customers pay for the copper concentrate by means of a letter of credit and take responsibility for delivery of the concentrate by truck or train to their respective smelters.

Efforts are continuing to explore markets outside China and to use different modes of transport, including direct delivery to customers or delivery to other bonded warehouses within China.

19.2 Product specification

The 2021-2040 concentrate specifications of Oyu Tolgoi concentrate are listed in Table 19.1 and Table 19.2. The specifications are regularly updated to match the planned production schedule. CCSM communicates and discusses any specification changes with Oyu Tolgoi customers.

During the initial years of production, concerns were raised by customers regarding grade variability and the high gold content of the concentrate. These concerns are expected to continue in the short term and are being addressed through smart scheduling and targeted placement, combined with active management of the product quality. Grade variability is expected to reduce significantly as production from Hugo North builds up, enabling higher-grade feed from the underground mine to be blended with ore from the open pit.

As underground production increases, the concentrate copper grade will increase to above 30%, making it more attractive to customers for blending with lower grade concentrates sourced from elsewhere. Gold content is also projected to decrease as underground production increases, making the concentrate more attractive to Chinese smelters.

Table 19.1 Specifications for major components of Oyu Tolgoi concentrate (2021-40)

Element	Unit	Average	Minimum	Maximum
Cu	%	28.3	22.3	35.7
Au	g/dmt	8.3	2.4	41.0
Ag	g/dmt	51.5	35.2	67.9
As	ppm	2,244	951	4,700
F	ppm	673	549	800
Cd/Pb/Hg	ppm	Under review	Under review	Under review
Moisture	%	8.0	6.0	10

Notes: Arsenic levels are managed to an internal limit of 4,700 ppm by either blending or internally recycling concentrate to meet the 5,000 ppm Chinese import limit.

Lead (Pb), cadmium (Cd) and mercury (Hg) specifications are currently under review.

Table 19.2 Specifications for major components of Oyu Tolgoi concentrate (5-year averages)

Major Elements	Unit	2021–25	2026–30	2031–35	2036–40
Cu	%	27.1	34.0	28.4	26.5
Au	g/dmt	12.9	8.8	5.9	3.4
Ag	g/dmt	51.6	63.9	50.8	42.0
As	ppm	2,501	1,635	1,717	2,105
F	ppm	664	677	645	687
Cd/Pb/Hg	ppm	Under review	Under review	Under review	Under review

Note: Lead (Pb), cadmium (Cd) and mercury (Hg) specifications are currently under review

Impurity limits

Impurity limits in concentrate smelted in China are issued jointly by the Ministry of Commerce and the Ministry of Environmental Protection. The mandatory standard, implemented in 2007, specifies the upper limits for impurities found in imported copper concentrate, as shown in Table 19.4. Copper concentrate with impurities content above these limits cannot be imported into China.

As indicated in Table 19.2, the arsenic (As) and fluorine (F) levels in the Oyu Tolgoi concentrate generally fall within Chinese national impurities limits. If there are any changes to these impurity limits, Oyu Tolgoi will take any necessary steps to ensure that the material produced complies with the requirements imposed by Chinese regulators. A detailed assessment and mitigation plan is underway to ensure this is achieved.

Table 19.3 Concentrate impurity limits impose by Chinese national regulators

Element	Upper limit (ppm)
As	5,000
Pb	60,000
F	1,000
Cd	500
Hg	100

Source: Chinese Standard GB 20424-2006

19.3 Supply-demand forecasts

The supply and demand information provided in this section has been summarized from the 2020 Feasibility Study, it contains forward-looking statements that are estimates based on information available at the time of preparing the 2020 Feasibility Study. Additionally, CCSM monitors key copper marketing trends and developments, including market forecasts available from Wood Mackenzie[17], which have contributed to this section. The supply and demand forecast does not reflect the impacts of the COVID-19 pandemic which are ongoing and continue to be assessed.

[17] Wood Mackenzie, Global Copper Long Term Outlook, July 2019

Copper supply-demand fundamentals are expected to remain solid, with the market in a slight deficit during 2019–20 and a moderate surplus from 2021. Demand in the next five years, is expected to increase, supported by growth in ex-China Asia, a modest expansion in China, and a recovery in developed markets (USA and Europe). Despite the strong gains observed in the last decade, there remains scope for further growth in emerging markets driven by continued urbanization, industrial and infrastructure upgrade, and rising household incomes in the medium-to-long term.

Supply is expected to remain constrained until 2021, when new production from committed projects are expected to enter the market, resulting in a temporary oversupply. Later in the decade, however, a supply gap is expected to open as output from existing operations declines due to falling grades and resource depletion. The pace at which new projects (particularly greenfield projects) can be brought online is slow because of remoteness, high altitudes, lower grades, high capital intensity, social and environmental requirements, and other risks associated with the development of large-scale copper projects.

Consistent with strong demand fundamentals, refined copper consumption is expected to increase. China is expected to continue to dominate this market, but with its share of refined consumption declining from a peak of 50% in 2019 to 46% by 2030.

Total copper smelting production capacity is expected to increase, with China forecast to see most of the growth in the next five years. Historically, raw material constraints have resulted in low utilization rates at smelters and have exacerbated competition for concentrate in China, which relies largely on imported feed. This trend is expected to continue.

Chinese smelting capacity is expected to continue to expand through 2030, with several identified greenfield and brownfield projects, and China is expected to add more smelting capacity than the rest of the world put together. As the smelter capacity growth outpaces mine supply growth and competition for concentrate intensifies, it is likely the Chinese smelting industry will see some consolidation.

19.4 Marketing plan

It is envisaged that the CCSM team will continue to oversee and execute all sales and marketing activities for Oyu Tolgoi LLC. A strategy has been developed by CCSM for marketing concentrate from Oyu Tolgoi that includes the following considerations:

- Customer attractiveness (financial situation, growth plans etc).
- Delivery point and terms.
- Freight costs (e.g. mine to customer versus port to customer).
- Precious metals recovery and payment.
- Length of contract.
- Percentage of off-take to smelters versus traders.
- Percentage on contract versus spot.
- Percentage sales to any one smelter.
- Number of customers for a given scale of operation.
- Management of concentrate quality and volume during commissioning and ramp-up.
- Alternate offshore logistics and costs.

In addition to the points listed above, the marketing strategy considers the contractual obligations of Oyu Tolgoi LLC under the Investment Agreement and the Concentrate and

Power Supply Agreement (dated 3 November 2012) concerning smelting capacity developed within Mongolia or Inner Mongolia. In the case of a smelter being built in Mongolia, contractual obligations require Oyu Tolgoi to provide concentrate for domestic smelting as a priority if requested by the Government of Mongolia and the terms should be mutually agreed. In the case of a smelter being built in Bayannoer, a city in western Inner Mongolia, contractual obligations will apply for supply of up to 25% of Oyu Tolgoi production at international terms no worse than those achieved elsewhere in the Chinese market. To date, no formal announcements have been made with regards to additional smelting capacity being built in Mongolia or in Bayannoer.

CCSM has established a customer database and conducts full marketing risk assessments each year, including contingency plans for customer default. Risk assessments are based on a number of factors, including contract value; Oyu Tolgoi's exposure to a single contract; customer reliability, competence, performance, reputation and loyalty; the customer's potential for increased future sales; their commitment to safe production and product use; the cost of transport to the smelter; and the customer's technical ability to maximize the value of by-products.

The current marketing plan places more than 60% of concentrates on term contracts and the balance on spot contracts tendered to smelters or traders. The spot component allows for management of the variations in annual production, market dynamics, support potential trials with new customers, or to support of other marketing activities. The plan also provides some flexibility on volume shipped.

The term of the current contracts ranges from one to five years, which helps to reduce contract renewal risk from contracts expiring at the same time.

The QP's believe that the marketing strategy developed by the CCSM team is reasonable and supports the concentrate marketing assumptions included in this Technical Report.

19.5 Current customers

Oyu Tolgoi currently has thirteen long-term contracts and several spot agreements. The arrangements differ between entities with respect to commercial terms and length of contract. Smelter customers are based in various provinces throughout China, while trader customers allow Oyu Tolgoi concentrate broad and far-reaching uptake across China's many smelters.

19.6 Smelter terms

Smelter terms assumed for this 2020 Technical Report are within industry norms and are based on CCSM's experience of selling Oyu Tolgoi concentrate, its assessment of the copper market, and the smelter terms typically used throughout the copper smelting industry. Payable metals in the copper concentrate are copper, gold, and silver.

19.7 Concentrate logistics

Concentrate is transported by truck from the mine to the Chinese border at Ganqimaodao. Until the bilateral border at Gashuun Sukhait – Ganqimaodao (GMD) obtains International Trade status, China is the only market that can be supplied via this border.

CCSM are responsible for the logistics strategy in China. Transportation from the mine to the bonded warehouse in China is the responsibility of Oyu Tolgoi Operations.

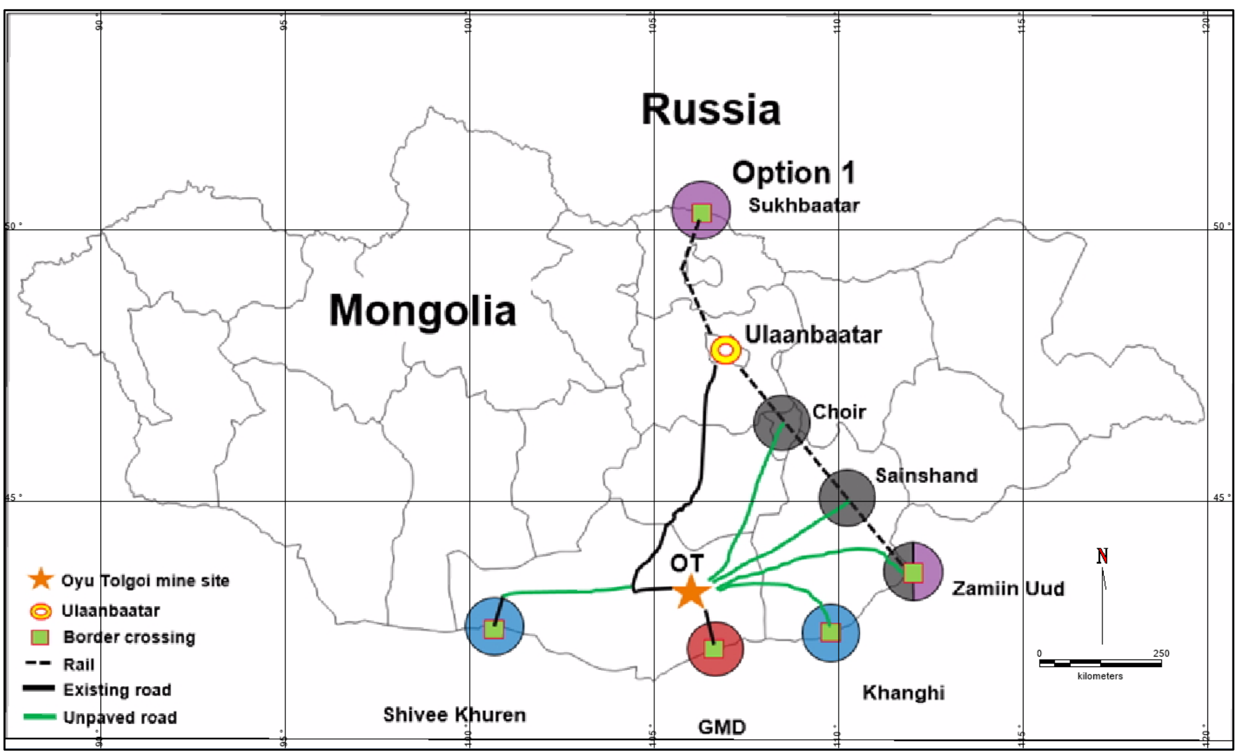
Sales to customers are currently completed on a "Deliver at Place" basis at the Huafung bonded warehouse. Customers are responsible for transportation within China, with compensation for transport costs provided through a freight differential price adjustment. Where it makes sense, customers are being transitioned to a direct delivery model, where Oyut Tolgoi pays for domestic transport in China and the freight differential is eliminated.

The existing bonded warehouse capacity is 93 kt of copper concentrate. Assuming there is no reduction in customs clearance time in China, generally between 14 to 21 days, capacity will need to increase to cope with increased concentrate production resulting from the higher-grade Hugo North ore. Surplus land is available for expansion at GMD, and a second 3rd party bonded warehouse has recently been registered in Linhe, 400 km from GMD.

Rail capacity in China is expected to be constrained for the next 5–10 years, leading to delivery delays and increased Chinese transport costs as concentrate volume grows. To secure downstream logistics capacity, Oyu Tolgoi LLC is pursuing an agreement with Shenhua Logistics to provide rail services to eastern China. Shenhua owns the largest private rail network in China, including the line to GMD.

Other transport options under investigation include a direct rail link to Oyu Tolgoi (subject to extension of the current GMD railway to the Tavan Tolgoi coalfields) and alternate border crossings (Figure 19.1). In conjunction with shorter customs clearance times at the border, this could reduce costs, mitigate transport risks, and significantly reduce delivery times.

Figure 19.1 Access to alternate border crossings



Source: Oyu Tolgoi LLC, June 2020. Projection WGS84 Lat/Long

19.8 Risks and opportunities

Action plans to mitigate identified risks have been developed by Oyu Tolgoi LLC and are being implemented. Risks are regularly reviewed, and mitigation measures and controls assessed through a risk management process.

The major risks in respect of product marketing and sales include:

- Variation or incomplete production forecasts may compromise strategic decision-making.
- Failure to meet contractual specifications (quality, volume, hazardous elements).
- Concentrate failing to meet Chinese import impurity limits (Table 19.4), including any future revisions to the limits.
- Concentrate may be classified as a hazardous/corrosive material.
- Market intel leakage to logistics provider.
- Bank acceptance of warehouse receipt as part of Letter of Credit opening process.
- Dependence on Chinese market.
- The impacts of COVID–19 on the concentrate market and the transport of concentrate to customers.

Three main opportunities have been identified:

- Alternate border crossings.
- Directly linking Oyu Tolgoi to customers by rail.
- Export ex-China via Tianjin or Vladivostok.

20 Environmental studies, permitting and social or community impact

20.1 Introduction

The operation's commitment to sound environmental and social planning is based on two important policies:

- TRQ's Statement of Values and Responsibilities, which declares its support for human rights, social justice, and sound environmental management, including the United Nations Universal Declaration of Human Rights (1948).
- Rio Tinto's Global Code of Business Conduct "The Way We Work" 2009, which defines the way Rio Tinto manages the economic, social, and environmental challenges of its global operations.

To meet its environmental and social obligations and commitments, Oyu Tolgoi LLC has completed a comprehensive Environmental and Social Impact Assessment (ESIA) for the Project. Oyu Tolgoi LLC has also implemented and audited health environmental management systems (EMS) that conform with the requirements of ISO 14001:2004.

Oyu Tolgoi LLC's environmental work for the Project is compliant with Mongolian regulatory requirements, internal policies and procedures, and external agreements. The environmental management plans for the Project are designed to ensure that key environmental factors are monitored and protected.

20.2 Regulatory framework

The Mongolian Constitution (1992) sets out the rights and freedoms of the people of Mongolia, including the right to a healthy and safe environment and protection against environmental pollution and ecological imbalance (Article 16.1.2). It also describes the system of government and allocates powers and responsibilities to each branch of government.

Mongolia has a comprehensive environmental protection framework with 22 environmental laws, 60 environmental regulations and procedures, and approximately 100 operational environmental standards that are applicable to the Project.

In general, national laws are administered and enforced by the central government. The Ministry of Environment and Tourism has legal authority for environmental protection legislation and regulations. The Ministry of Mining and Heavy Industry has legal authority for mining legislation and regulations. The central government delegates some powers to provincial (aimag) and regional (soum) levels.

Many of the environmental provisions contained in the Investment Agreement track the requirements of the Minerals Law and Water Law. Descriptions of how Oyu Tolgoi has implemented the environmental protection provisions of the Investment Agreement are provided in the ESIA. The ESIA also contains an overview of the applicable environmental laws, regulations, procedures, and standards.

20.3 Environmental and social impact assessment

The ESIA was publicly disclosed in August 2012 and identifies and assesses the potential environmental and social impacts of the Project, including cumulative impacts, focusing on key areas such as biodiversity, water resources, cultural heritage, and resettlement.

The ESIA also sets out measures to avoid, minimize, mitigate, and manage potential adverse impacts to acceptable levels established by Mongolian regulatory requirements and good international industry practice, as defined by the requirements of the Equator Principles, and the standards and policies of the International Finance Corporation, European Bank for Reconstruction and Development, and other financing institutions.

The ESIA is built upon an extensive body of studies, reports, and detailed environmental impact assessments (DEIAs).

The DEIAs provide baseline information for both social and environmental issues. They are structured using a core categorization of Mining and Processing, Transport and Infrastructure Corridor, Gunii Hooloi Water Supply, Coal Fired Power Plant, and Airport. DEIAs were also required to address new or updated facilities and requirements not covered under the broader categories.

All DEIAs are prepared and approved in accordance with Mongolian standards, but, although developed to meet international standards, they were not intended to address overarching IFC or EBRD social or environmental sustainability policies in a comprehensive manner

The ESIA and DEIAs prepared for Project design and development purposes and for Mongolian approvals have been prepared under the following laws:

- The Environmental Protection Law (1995).
- The Law on Environmental Impact Assessment (1998, amended 2001).
- The Minerals Law (2006).

The Project Area of Influence covered by the ESIA and related DEIAs is defined in Table 20.1. Summaries the key baseline studies and core DEIAs prepared for the Project is presented in Table 20.2. Summaries of supplementary DEIAs and studies are presented in Table 20.3.

Table 20.1 Project Area of Influence and scope of the ESIA

Term	Scope
Project Area of Influence	• Project elements defined as activities and facilities that are financed or over which the Project can exert control and influence through its design, impact management, and mitigation measures, including all Oyu Tolgoi facilities within the Oyu Tolgoi Property and surrounding 10 km buffer zone. • Local roads used regularly by the Project. • Communities that provide employees or services to Oyu Tolgoi • Local and regional transport network • Local services and utilities • Communities and community members that will be directly affected by the Project in ways that are foreseeable and within the reasonable control of the Project during construction, operations, and closure. • Communities and community members that may be directly affected by population influx. • Communities and herder households that may be affected by potential changes to local and regional groundwater supplies downstream of the Oyu Tolgoi site and along transportation corridors. • Project elements that may be transferred to third-party ownership in the future, such as the airport and Gashuun Sukhait border crossing facility.

Term	Scope
Potential future project elements	Although not directly addressed in the ESIA, certain potential future project elements were considered in the cumulative impact assessment, including potential expansion ob the Project to support increased ore throughput, and potential long-term project power supply
Potential extensions to scope	The ESIA estimated a project with a 27-year design life. However, it is anticipated that operations at Oyu Tolgoi will continue for a longer period that the 27-year design life and that extensions to the ESIA will be required.

Table 20.2 Baseline and core DEIA studies for the Project

EIA study title	Description	Date	Status
Environmental Baseline Study for Oyu Tolgoi Project	Covers geography, geological, hydrology, hydrogeology, soil, climate, air quality, flora and fauna, the socioeconomic status, and infrastructure of the Project site and surrounding areas.	2002	No approval required
Environmental Baseline Study for Town Planning	Covers geography, geological, hydrology, hydrogeology, soil, climate, air quality, flora and fauna, the socioeconomic status and infrastructure of potential development and interconnecting infrastructure areas for Khanbogd town developments.	2012	No approval required
Oyu Tolgoi Project EIA Volume I: Transport and Infrastructure Corridor from Oyu Tolgoi to Gashuun Sukhait	DEIA of the road and power line proposal from Gashuun Sukhait to Oyu Tolgoi. Provides approval for access through the South Gobi Strictly Protected Area. Several amendments have been undertaken to address changing alignments.	2004 2006 2010 2012	Approved Approved Approved Approved
Oyu Tolgoi Project EIA Volume II: Water Supply from the Gunii Hooloi Aquifer	DEIAs for the proposed aquifer and water supply system for the provision of a sustainable water supply to the Project. Several amendments have been completed to capture developments in the groundwater resource assessment and water supply pipeline design.	2004 2009 2010 2012	Approved Approved Approved Approved
Oyu Tolgoi Project Volume III: Oyu Tolgoi Mining and Processing Facilities	DEIA of the open pits, underground mine, concentrator, tailings and all facilities and support infrastructure located within the Oyu Tolgoi Property. The assessment was largely based on IDP05. It does however reflect the general permitting layout of May 2006. The maximum production rate was assumed as 85,000 t/d.	2006 2012	Approved Approved
Oyu Tolgoi Project Volume IV: Coal Fired Power Plant	EIA documentation drafted for a coal-fired power plant at the Oyu Tolgoi mine site. An amendment has been undertaken to reflect updates in design for three 150 MW generating units.	2006 2011	Not submitted Approved

Table 20.3 Updated list of DEIA reports for the Project

Project EIA component	Description	Date	Status
Fuel station facility	DEIA for the fuel facility built in 2004 within the Oyu Tolgoi Property. Amendment completed for extension of the fuel depot.	2005 2010	Approved Approved
Shaft 1	DEIA for Shaft #1, including headframe facilities, waste rock, and water disposal.	2005	Approved
Shaft 2	DEIA for Shaft #2, including headframe facilities, waste rock, and water disposal.	2006	Approved
Diesel power station	DEIA for the diesel power station located within the Mine License Area.	2007	Approved
Wastewater treatment plant	Supplementary DEIA for the construction camp wastewater treatment plant expansion to 4,000-person equivalent capacity.	2007	Approved

Project EIA component	Description	Date	Status
Quarry batch plant and Quarry	DEIA of hard rock quarry, concrete batching plant, and crusher located at the northern boundary of the Oyu Tolgoi Property.	2007	Approved
Airport	Construction projects for temporary and permanent airports have implemented.	2007 2011 2017 2018	Approved Approved Approved Approved
Chemicals	Covers the importation, storage, use, and disposal of chemicals. Amendments have been undertaken to update chemicals being used in construction, commissioning, and operation.	2008 2011 2012	Approved Approved Approved
Javkhlant Entrée LLC lease area	DEIA for future project facilities, infrastructure, and Heruga underground mine located within the southern Javkhlant-Entrée lease area.	2009	Approved
Shivee Tolgoi Entrée LLC lease area	DEIA for facilities, infrastructure, and portion of the Hugo Dummett underground mine located within the northern Shivee Tolgoi-Entrée lease area.	2009	Approved
Main fuel storage facility	DEIA for the main fuel storage facility within the Oyu Tolgoi Property.	2011	Approved
Undai River diversion DEIA	DEIA for diversion of the Undai River.	2011	Approved
Update of DEIA report of the construction and facilities in Shivee Tolgoi licensed area.	Project facilities, infrastructure, and construction on the Lease Area at Shivee Tolgoi.	2012	Approved
DEIA of Oyu Tolgoi LLC's construction of main facilities and infrastructure	This report includes new infrastructure and facilities in mine site.	2012	Approved
Oyu Tolgoi to Khanbogd power line	DEIA report of a 35 kW power line connecting Oyu Tolgoi to Khanbogd	2012	Approved
Waste management centre	Waste management centre were built with new technological solutions such as waste classified landfill, evaporation, and incineration	2014	Approved
DEIA report of Oyu Tolgoi TSF project	The report includes environmental issues related to the oyu Tolgoi concentrate thickener underflow.	2014	Approved
DEIA report of Tsagaan Khad to Oyu Tolgoi Road project	Environmental issues associated with a 18.6 km road construction activity connecting Tsagaan Khad to Gashuun Sukhait	2015	Approved
DEIA of 93.8 km paved road construction project connecting Khanbogd – Oyu Tolgoi – Javkhlant bag	The 35.1 km paved road between Khanbogd to Oyu Tolgoi was built and commissioned in 2018.	2016	Approved
DEIA of the use of Undai River sand deposit project	The diverted part of Undai river diversion was planned to be covered by mining waste rock stockpile and the sand from this part is planned to be used for mining construction activity before the stockpile is completed.	2018	Approved
DEIA on OT Hazardous Landfill	The facility was established to dispose of hazardous waste from the mine in an environmentally safe manner in accordance with the Waste Law revised in 2017 and following regulations.	2020	Approved
DEIA on OT Chemical Warehouse	Oyu Tolgoi chemical warehouse was established to store chemicals used in the concentrator and mining operations environmentally friendly manner and in accordance with relevant Mongolian Chemical Warehouse Standard.	2020	Approved

20.4 Management plans

Oyu Tolgoi LLC's various management plans set out how the Project will meet Oyu Tolgoi LLC standards and procedures to avoid, manage, mitigate, and offset operations-phase impacts and ensure Oyu Tolgoi LLC personnel and contractor compliance with the Project standards and Rio Tinto OHS standards.

Each management plan provides details of:

- Scope and relationship with other management plans.
- Roles and responsibilities for the implementation of the plan.
- Key interfaces with other management plans that relate to its implementation.
- Applicable national, lender, corporate and industry standards, and guidelines.
- Management, implementation, monitoring and verification controls and milestones.
- Key performance indicators (KPIs).

Below is a list of the area covered by the operational health, safety, environment, and community (HSEC) related management plans implemented at the Project:

- Environmental and Social Action Plan.
- Environmental and Social Management Plan.
- Atmospheric Emissions Management Plan.
- Biodiversity Management Plan.
- Community Health, Safety and Security Management Plan.
- Cultural Heritage Management Plan.
- Emergency Preparedness and Response Plan.
- Hazardous Materials and Non-Mineral Waste Management Plan.
- Land Disturbance Controlling and Rehabilitation Management Plan.
- Mine Closure Plan.
- Mineral Waste Management Plan.
- Noise and Vibration Management Plan.
- Resettlement Action Plan.
- Stakeholder Engagement Plan.
- In-Migration Management Plan.
- Pastureland and Livelihood Improvement Management Plan.
- Water Resources Management Plan.

20.5 Environmental and social baseline

The baseline assessment was prepared for Oyu Tolgoi LLC by Citrus by drawing upon the wide range of internal and independent studies that have been prepared for the Project since 2003. Baseline data available up to 2011 is incorporated in the 2012 ESIA.

Plans for ongoing data collection and studies are set out in the corresponding impact assessment chapters and management plans of the ESIA, as well as supplementary operational management and monitoring plans, to ensure baseline data continues to improve and that the results of ongoing monitoring and improved knowledge are integrated into updated and revised management plans and procedures.

The baseline chapters presented in the ESIA are, necessarily, a summary of an extensive body of research and assessment that has been ongoing over many years covering the biophysical environment and human environment. A brief outline of these studies is provided in the following sections.

20.5.1 Climate

The climatic conditions at Oyu Tolgoi are typically continental, with a cool spring and autumn, hot summers, and cold winters. Refer to Section 5.4 for descriptions of the prevailing temperature, humidity, solar radiation, rainfall, electrical activity, evaporation, and wind conditions at Oyu Tolgoi.

Climate change

Twelve different climate models were used to develop future climate change projections. In summary, climate change in the South Gobi region is considered to involve a steady increase in annual average temperature, a marginal increase in precipitation, and other seasonal variations in weather. Even though the precipitation is projected to increase, this is likely to occur as heavy rain or thunderstorm, which will decrease the water absorption in soil. This could reduce water availability, which could be significant to herders and wildlife, even at very low levels of change. With the existing sensitivities in relation to herder water supplies and, hence, herder wells, monitoring any decreases in overall annual precipitation will be of key interest to Oyu Tolgoi.

20.5.2 Air quality

For the purposes of monitoring the wide range of particulate and gaseous pollutants in the air, environmental parameters and providing reliable air quality information, four AQM 65 air quality monitoring stations were installed at the Oyu Tolgoi site in March 2017. These stations continuously measure common air pollutants including ozone (O_3), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon dioxide (CO_2), particulate matter (PM_{10}, $PM_{2.5}$, PM_1), and meteorological parameters such as rainfall, temperature, and humidity.

The Air quality standards have been developed based on the relevant Health, Safety, Environment and Community performance requirements and performance standards for the IFC, EBRD and Mongolian legislation. The EBRD applies European Union (EU) air quality and emission standards.

The results of the continuous observation for the last 2 years from these stations and monitoring data from previous years shows that the air quality indicators in the Project Area of Influence meet the acceptable level of air pollutant for most of the year. For example, the observation data for the last five years shows no trend of increasing or decreasing dust levels, the concentration of carbon monoxide (CO) is a tenth of the acceptable level (10 mg/m^3) of the standard, and the average hourly concentration level of sulfur dioxide (SO_2) varies between 0.002–0.015 mg/m^3, which is well below the acceptable level (0.35 mg/m^3) of the standard.

20.5.3 Noise

The baseline noise survey of the Project Area of Influence was conducted in 2010 by research team led by the professor of Aerophysics and Ecosystem of the University of Science and Technology, Mongolia. This baseline study concluded that the noise level within a 10 km radius of the Oyu Tolgoi mine site at any time during both day and night is below the level of adverse impact on human health. Noise level monitoring along the infrastructure lines and the airport also shows that Oyu Tolgoi mining operations meet the requirements of the standard for the noise level of 20–45 dB during the night and 20–58 dB during the day, respectively.

20.5.4 Vibration

Ground vibration surveys were conducted annually by researchers of the Research Centre for Astronomy and Geophysics of the Academy of Science, Mongolia until 2016. Eight seismograph stations were located at sensitive areas within a 35 km radius of the mine site and near the Khanbogd soum centre. The maximum amplitude of peak particle velocity ranged from 0.008 mm/s at the furthest station and up to 0.18 mm/s near to the blasting activities in the open pit. These values are much lower than the recommended maximum peak particle velocity level of 5 mm/s stated in the Australian and New Zealand Environment and Conservation Council guidelines (ANZECC 1990).

20.5.5 Landform and geology

Topography and landscape

There are no special protected areas within the Oyu Tolgoi Property, within the Gunii Khooloi valley, or along the transport corridor. Other than the surrounding mountains, the value of natural formations within this area is considered low.

Geology

There are no geologically sensitive areas within the Oyu Tolgoi Property or transport corridor. The overlying Recent–Quaternary sediments contain alluvial aquifers along ephemeral watercourses that the local herders rely on for domestic and stock water supplies. They also contain regional aquifers used as water sources by the local communities. The Project accesses the deeper Cretaceous Bayanshiree Formation (Gunii Khooloi basin) aquifer for its water supply, which is not currently exploited by other users in the Project Area of Influence.

Seismicity

The Oyu Tolgoi site is of low seismic risk, as is much of eastern Mongolia.

Topsoil

Gobi brown and saline soil, dominant in the Project Area of Influence, is generally poorly developed. Most of the Project Area of Influence has 10–30 cm layer of thin-layered topsoil with low humus content, with up to 70 cm topsoil in isolated surface depressions with valley reliefs. Vegetation cover is low, and some parts are covered with only rock debris. The top layer is loose, porous soil and, as it deepens, it becomes denser with higher content of rocks. This topsoil layer is prone to erosion, and there is increased risk of erosion in the areas of overgrazing and dirt roads. Dry weather condition, frequent strong winds, and occasional floods increase the risk of soil erosion in the area.

The topsoil is removed and preserved in specifically created stockpiles during the mine overburden removal operation. When the topsoil is reused, fertilizer is added to improve soil fertility and soil structures.

20.5.6 Surface water

There is no surface water in the Project Area of Influence, except for the ephemeral streams that flow along the dry streambeds in the summer only and few springs that appear around the edge of the Khanbogd granite massif. Hand-dug wells and springs along the dry streambed are the main source of water for local people, plants and wildlife. In general, the springs are relatively low yielding, with seasonal recharge dependent on the rainfalls and floods during the summer. The water quality of springs and hand-dug wells is relatively fresh as they fed by precipitation water and frequently engage in the natural water circulation.

20.5.7 Groundwater

Gunii Hooloi basin

Surface hydrogeological exploration drilling and pumping tests conducted by Oyu Tolgoi LLC between 2003 and 2007 identified the Gunii Hooloi aquifer as an industrial water source for the Project. In 2015, the total approved reserve of Gunii Hooloi groundwater deposit was upgraded to 918 L/s, including 184.6 L/s grade A, 613 L/s grade B, and 117.4 L/s grade C. Chemical testing and classification of Gunii Hooloi groundwater shows that, of the 28 operating wells, 17 are very hard, 8 are hard, and 3 are slightly hard. Mineralization is 2.1 to 5.8 times higher than the permissible level of the drinking water standard and is unsuitable for drinking.

Hand-dug wells in the region exploit small shallow aquifers along the riverbeds (dry streambeds), which are recharged by precipitation water. This water, which is used by herders, is fresher and significantly different in composition to the water extracted from the deeper Gunii Hooloi aquifer. No plants take nourishment from the groundwater along the Gunii Hooloi basin, which suggests that all vegetation in the area are nourished by seasonal rainfall.

Modelling and independent groundwater studies (Aquaterra, 2013) indicate that the Gunii Hooloi aquifer can be used for 40 years at a maximum of 1,475 L/s. These studies also indicate that there is limited potential for connection between the shallow streambed aquifers and the deeper Gunii Hooloi aquifer.

Mine area

An improved groundwater model is being developed for the mine site using well monitoring data. This model will assist with the assessment of dewatering in the open pit and underground mining impact area.

Local water supply

Water resource prospecting and exploration works on water supply for Khanbogd soum was funded by Oyu Tolgoi LLC in 2013–14. During the exploration, 41 boreholes were drilled and water was monitored in 12 boreholes. The total water reserve was estimated at 37 L/s or 3,200 m^3/d for the 20-year period and has been approved by the Mongolian Water Resources Board. The bulk water facility was built at a cost of US$6.9 million, and a reliable supply of clean drinking water to Khanbogd soum will be provided via the 6.6 km pipeline. The commencement of this facility's operation will be an important step in the development of infrastructure for Khanbogd soum. The facility was built with the capacity to provide potable water for 13,000 residents initially and designed for further expansion. The bulk water facility was handed over to Khanbogd soum on 18 April 2017.

20.5.8 Biodiversity

The Oyu Tolgoi Project Area of Influence belongs to the 16th region of Alashaa Gobi and 12th region of Dornogovi desert steppe from the vegetation geography of Mongolia. The Project Area of Influence belongs to the desert steppe, semi-desert and desert zone of the South Gobi ecosystem.

Terrestrial and aquatic flora and fauna

Numerous flora species classified as rare and very rare in the "red book" of Mongolia are found within the Project Area of Influence. The saxaul forest and *Ulmus pumila* grove that have grown along high moisture content dry streambed and lowlands are an important habitat for wildlife and birds. Nearly all vegetation in the region has some degree of significance in terms of ecosystem services to local communities, particularly as a source of forage for livestock.

The Project Area of Influence also has diverse fauna with populations of global conservation significance for several globally and nationally threatened species. Among these, the Asiatic wild ass or khulan, the goitered or black-tailed gazelle, the houbara bustard, and the saker falcon stand out. Many of the fauna demonstrate migratory or nomadic behaviour as a strategy for coping with such unpredictable weather and forage scarcity.

A few small nocturnal mammals have been recorded. Both wild and domesticated large herbivores are key elements of the regional ecosystems, and these depend on the ability to move freely across the landscape to track changing patterns of available forage plants.

There are no rivers, lakes, or ponds with permanent flow. Hence, there is no impact on aquatic biodiversity from the Project. One amphibian species is registered in this region. Reptiles, especially toad-headed agamas, are very common during the warm months and provide an important food resource for predatory birds and mammals.

Diverse bird assemblages are common, and the area supports important breeding populations of globally threatened species, particularly in the Galba Gobi Important Bird Area. Despite the general aridity of the region, artificial ponds constructed by the Project attract aquatic and migrant birds.

The survival of globally threatened fauna of the South Gobi and the Oyu Tolgoi Project Area of Influence will depend upon the sound development of natural resource extraction facilities and of transportation and electrical transmission infrastructure, as well as control of illegal hunting and competition with domesticated livestock for key water and forage resources.

Critical habitats and priority biodiversity features

A critical habitat assessment by The Biodiversity Consultancy and Fauna & Flora International in 2011 identified the habitats of Asiatic wild ass, Mongolian chesney, argali, goitered gazelle, and short-toed snake-eagle as critical habitats, as well as granite outcrop floral communities, and four ecosystem services: surface and groundwater regulation, livestock (pasture), biomass fuel, and fresh water.

In addition, Biodiversity Action Plans have identified three species of mammals (marbled polecat, Mongolian gazelle, and long-eared jerboa), eight birds (saker falcon, Pallas's sandgrouse, great bustard, houbara bustard, relict gull, Mongolian accentor, Mongolian ground jay, and yellow-breasted bunting), and three habitats (riverine elm trees, ephemeral lakes and pools, and tall saxaul forest) as having local or global significance.

The Oyu Tolgoi Project Area of Influence covers parts of two protected and designated areas that are priority biodiversity features: Small Gobi Strictly Protected Area and the Galba Gobi Important Bird Area. While the Small Gobi Strictly Protected Area is a legally protected area under Mongolian law, the resources allocated to its protection are low considering the size of the area and the needs for management, surveillance, enforcement, and monitoring. The

Galba Gobi Important Bird Area is recognized internationally as a designated area of high biodiversity value, but it has no legal status in Mongolia, and no management plans or monitoring programs are in place.

20.5.9 Land use

Mongolia is one of the least densely populated countries in the world. Of Mongolia's total population of approximately 3.29 million, 31.5% live in rural areas and are nomadic or semi-nomadic herders, and 68.5% occupy urban locations. Much of the land area is covered by steppe (open grassland), with mountains to the north and west and the Gobi Desert to the south. The South Gobi region constitutes approximately 22% of the total land area of the country and forms part of the international border with China.

Omnogovi aimag is the southernmost province in the South Gobi region bordering with China. The aimag has a total area of 165,400 km^2, most of which is grazing land (72%) used by livestock herders. The aimag also has several Special Protected Areas, including the Small Gobi A Strictly Protected Area in Khanbogd soum. The remaining land is made up of forest, water areas, residential areas, roads, and communications infrastructure. Khanbogd is the largest soum by area within the aimag.

Natural rangeland types in Omnogovi aimag include grass steppe, desert steppe, and desert. The latter two provide the most suitable habitat for camel, sheep, and goats, whereas grass steppe rangeland along the Chinese border provides suitable habitat for horses and cattle. Soils are generally thin and not suitable for arable crops. They are also friable and easily disturbed by vehicle traffic and sharp-hooved animals. Livestock production is still the main economic activity in Omnogovi aimag.

Khanbogd soum has a sparse and widely spread population. In 2019[18], Khanbogd soum had a population of approximately 8,700, of which approximately 15% are nomadic herders. The total area of land within Khanbogd soum is estimated at 1,496,000 ha, of which 1,176,164 ha is grazing land. Khanbogd soum is characterized by a desert steppe ecosystem of sparse and low-lying vegetation with minimal vegetation cover (<10%) and occasional trees around ephemeral and permanent spring areas. Within the desert steppe ecosystem, the grazing gradient shifts year by year according to rainfall, hence the pattern of pastureland use is seasonally variable. Rainfall is extremely low and is unpredictable.

Herder households establish winter camps and corrals to keep families and animals gathered in a shelter during colder periods. During summer and autumn when pastures grow, seasonal herders move their gers to good pasture. Water is a key pastureland resource and plays a major role in the location of the seasonal camps of herders within the soum. More than 90% of herders take water from hand-dug wells fed by shallow streambed aquifers. When no water is available from snow or from ephemeral or permanent springs, access to these wells is a critical factor for livestock production and human consumption.

20.5.10 Cultural heritage

The South Gobi Province of Mongolia is rich in archaeological heritage, including both physical artefacts, ritual sites, places of cultural or historical interest, and protected landscapes (referred to as "tangible heritage"). The region also has a rich tradition of rituals, ceremonies, folklore, music, handicrafts, and traditional knowledge (referred to as "intangible heritage").

[18] Estimate as last official census was in 2010.

The Mongolian Academy of Science, Institute of Archaeology (MASIA) has been extensively consulted on issues of cultural heritage compliance and protection.

Mine licence area

In 1998, a Mongolian geologist undertaking exploration work at Oyu Tolgoi unearthed Palaeolithic and Bronze Age stone tools. Subsequent investigation concluded that the tools were related to ancient mining from shallow pits to recover copper to produce bronze and jewellery. The discovery raised the awareness of the national archaeological community, which led to discovery of other sites of significance, including Turquoise Hill, after which the Project was originally named. These ancient workings are considered unique, as they are historically representative of early mining practices in the Gobi.

Two petroglyphs were found on the western boundary of the Oyu Tolgoi Property, in the far north-western corner. At this stage, no disturbance is envisaged, and appropriate mitigation measures will be developed as part of the Cultural Heritage Management System.

Two stone structures were also excavated in the northern sector of the Oyu Tolgoi Property. No human remains were found at these sites, and the report concluded that these were likely to be animal sacrifice sites associated with a religious ceremony. A letter from MASIA on 3 September 2002 advised they had no objection to the proposed mining development at Oyu Tolgoi nor excavation of these sites. The sites have been demarcated and artefacts removed to Ulaanbaatar.

Sacred sites

Javkhlant Mountain is 17 km from the Oyu Tolgoi Property and is one of the most significant features identified in the MASIA surveys. The mountain is a prominent landscape feature and holds cultural significance to the people of the soum. A large stone ovoo with a blue flag is located at the peak of Javkhlant with approximately 200 petroglyphs from the Neolithic to the Bronze Age. The long-term protection of the site is planned through cooperation between the local administration, MASIA, and Oyu Tolgoi LLC. The publication of the "Petroglyphs of Khanbogd" monograph was sponsored by Oyu Tolgoi LLC. Other sacred sites identified are typically locations in the landscape where mythical or historic events are believed to have taken place.

Within the Project Area of Influence, Oyu Tolgoi LLC has identified Oyu Tolgoi, Vandan Tolgoi Hills, and Bor Ovoo, as having significance to the community and requiring protection. A ceremony will be conducted with the community to consecrate the replacement for the Bor Ovoo spring when land use approval and construction at its final planned location are complete. A ground-breaking ceremony, including lamas and community members, was held for the opening of the new permanent airport site to "bless" the land.

Crafts and traditions

Twelve types of intangible heritage have been identified as significant for the residents of Omnogovi aimag and the Oyu Tolgoi Project Area of Influence, including metal smithing, urtiin duu singing, flour making, ger making, traditional games, traditional foods, and religious practices.

20.6 Environmental impacts and mitigation measures

20.6.1 Climate and air quality

Air quality standards

The Mongolian National Air Quality Standard (MNS 4585:2016) is intended for urban areas and is not considered applicable to a remote mining facility. As such, DEIAs prepared for the Project were not required to comply with this standard. In the absence of applicable national ambient air quality standards, the following ambient air quality standards have been adopted and are summarized in Table 20.4.

Table 20.4 EU ambient air quality standards

Parameter	Averaging period	EU ambient air quality standard[c] ($\mu g/m^3$)	Permitted no. of exceedances per year
Sulphur dioxide (SO_2)	1 hour 24 hours	350 125	24 3
Carbon monoxide (CO)	8 hours	10,000	NA
Nitrogen dioxide (NO_2)	1 hour Annual	200 40	18 NA
Ozone (O_3)	8 hours	120	25[d]
PM_{10}[a]	24 hours Annual	50 40	35 NA
$PM_{2.5}$[b]	Annual	25	NA
Lead	Annual	0.5	NA
Benzo[a]pyrene	Annual	0.001	NA

[a] PM_{10} denotes particulate matter less than 10 μm in diameter
[b] $PM_{2.5}$ denotes particulate matter less than 2.5 μm in diameter
[c] EU air quality requirements from Directive 2008/50/EC on ambient air quality
[d] 25 days per calendar year averaged over three years

Sensitive receptors

The Project Area of Influence is remote, and population density within 10 km of the Oyu Tolgoi Property is extremely low. There are currently no permanent residences within 10 km of the mine site. The following sites near the Project are considered sensitive receptors to emissions:

- Worker accommodation areas within the Oyu Tolgoi Property
- Nomadic summer camps outside the Oyu Tolgoi Property
- Winter herder shelters outside the Oyu Tolgoi Property

Mitigation measures and residual impacts

The potential impacts for air quality have been identified and assessed. No significant residual adverse impacts are anticipated after the proposed design enhancements and mitigation measures are implemented and impacts are monitored under the Air Quality Management Plan.

Greenhouse gas emissions

Several types of greenhouse gases (GHG) will be emitted from project-related activities. A high proportion of these emissions will be CO_2, and there could be some minor emissions of methane (CH_4) and nitrous oxide (N_2O). GHG monitoring and reduction programs are described in Section 20.7.3.

20.6.2 Noise and vibration

Sensitive receptors

Khanbogd, the nearest soum centre, is 45 km to the north-east of the Oyu Tolgoi Property and is not expected to be affected by noise during operations. Those receptors considered relevant to noise generated by the Project include:

- The worker accommodation facilities within the Oyu Tolgoi Property.
- Permanent winter herder camps outside the Oyu Tolgoi Property.
- Local population near activities related to the Project outside the Oyu Tolgoi Property.

Mitigation measures and residual impacts

The potential impacts for noise and vibration have been identified and assessed. No significant residual adverse impacts are anticipated after the proposed design enhancements and mitigation measures are implemented and impacts are monitored under the relevant management plan, including:

- Noise and Vibration Management Plan
- Transport Management Plan

20.6.3 Landform and geology

Actual and potential impacts

Actual and potential impacts on the topography, geology, and topsoil arising from the construction, operation, and closure of the Project include:

- Construction of mine infrastructure, including the TSF and waste rock dump areas.
- Impacts associated with open pit mining activities.
- Block caving mining activities and resulting surface subsidence zone.
- Creation of buildings and other structures, including camps and shaft headframes.
- Diversion of the Undai River and other ephemeral watercourses.
- Loss of topsoil from erosion by wind and water around earthworks, topsoil stockpiles, and restored areas.
- Potential subsidence impacts on the area overlying the Gunii Hooloi aquifer.

Mitigation measures and residual impacts

A "mitigation through design" approach has been adopted, which aims to prevent and mitigate, as far as practical, impacts on topography, landscape, geology, and topsoil. No significant residual adverse impacts are anticipated after the proposed design enhancements are implemented and impacts are monitored under the relevant management plan, including:

- Land Use Management Plan.
- Topsoil Management Plan.
- Transport Management Plan.
- Waste Rock Management Plan.
- Mine Closure and Reclamation Management Plan.
- Water Resources Management Plan.
- Hazardous Materials Management Plan.

The generation of revenues, employment opportunities, and community services from conversion of geological resource and sale of processed ore/concentrate was identified as a major positive impact on soum residents, residents of Omnogovi, and the Mongolian Government.

20.6.4 Water resources

Actual and Potential impacts

Based on an appraisal of the baseline conditions and sensitivities discussed in the ESIA, actual and potential impacts on surface water and groundwater arising from the construction, operation, and closure of the Project include:

- Impacts on surface water systems, including the diversion of ephemeral watercourses and ephemeral and permanent springs in the Oyu Tolgoi Property. These impacts could affect water quantity or the length of time an ephemeral watercourse sustains surface or groundwater flows over the course of a year.
- Impacts on the ground surface associated with mining operations and dewatering of the aquifers in and immediately around the Oyu Tolgoi Property.
- Potential contamination from construction of mine infrastructure, including the TSF and waste rock dump areas.
- Impacts of dewatering the Gunii Hooloi aquifer, including potential for subsidence.

Mitigation measures and residual impacts

A "mitigation through design" approach has been adopted, which aims to prevent and mitigate, as far as practically possible, impacts on water resources. Groundwater abstraction will have an unavoidable residual impact on the Gunii Hooloi groundwater resource, which will be mitigated by ensuring that the plant operates efficiently to minimize water use and by maximizing the recycling and reuse of water. No other significant residual adverse impacts are anticipated after the proposed design enhancements are implemented and impacts are monitored under the relevant management plan, including:

- Water Resources Management Plan.
- Hazardous Materials Management & Waste Management Plan.
- Environmental Protection Plan.
- Tailings Management Plan.
- Mine Closure and Reclamation Management Plan.

Oyu Tolgoi will also take a proactive approach to any issues that arise with herder wells and take responsibility for assisting them to rectify any issue and restore their water supplies, if necessary. All such works will be intended to restore the same level of supply and not notably increase the herders' supply, thus ensuring that the current balance between herd numbers and pasture stresses is not negatively affected.

20.6.5 Biodiversity

Summary of impacts

In 2011, Oyu Tolgoi implemented a Rapid Biodiversity Assessment as part of the risk assessment process for impacts on various identified biodiversity features. The risks were categorized as critical, high, medium, and low. The critical and high-risk impacts identified in the Rapid Biodiversity Assessment are listed in Table 20.5. Priority biodiversity features that require connectivity of the landscape to support their populations include:

- Species that might avoid Project infrastructure.
- Species of birds that could suffer mortality from collision or electrocution.
- Species that could be subjected to increased levels of hunting or collecting.
- Species that are susceptible to indirect loss of habitat around Project infrastructure.
- Species that could be affected by increased populations of natural predators.

Table 20.5 Priority biodiversity features at critical and high risk from potential Project impacts

Feature	Impact	Likelihood	Consequence	Risk
Asiatic wild ass, goitered gazelle	Indirect habitat loss due to avoidance of infrastructure	Likely	Serious	Critical
Asiatic wild ass	Indirect mortality from hunting facilitated by increased access	Possible	Major	Critical
Argali, goitered gazelle, saker falcon, houbara bustard, tall saxaul forest	Indirect mortality from hunting and collecting facilitated by increased access	Possible	Serious	High
Argali, houbara bustard	Indirect habitat loss due to avoidance of infrastructure	Likely	Medium	High
Great bustard, houbara bustard, saker falcon	Direct mortality from collision with and electrocution by power transmission lines	Almost Certain / Likely	Medium	High
Mongolian chesney, Asiatic wild ass, goitered gazelle, houbara bustard, Mongolian ground jay	Direct habitat loss under infrastructure	Almost Certain	Medium	High
Houbara bustard, Mongolian ground jay	Indirect mortality from increased predation rates	Likely	Medium	High

Impacts rated by the Rapid Biodiversity Assessment process as moderate to low risk, on specific biodiversity features, generally relate to non-priority status species. Mitigation options for low to moderate risks are also addressed by the mitigation options proposed for critical and high-risk issues.

Biodiversity offset strategy

The Project has committed to a goal of net positive impact on biodiversity. As such, residual impacts on priority biodiversity features will be offset to achieve this goal. The Rapid Biodiversity Assessment program implemented in 2011 included the preparation of a biodiversity offset strategy for the Project that outlined what was considered at the time to be necessary to achieve net positive impact for priority biodiversity. This strategy is based on wide technical consultation and aims to demonstrate the technical feasibility of achieving a net positive impact on biodiversity.

Mitigation measures and residual impacts

Mitigation actions have been developed for all potential critical and high-risk impacts to priority biodiversity features and priority ecosystem services, which are described in relevant management plans, including:

- Water Resources Management Plan.

- Atmospheric Emissions Management Plan.
- Land Disturbance Control and Rehabilitation Plan.
- Non-Mineral Waste Management Plan.
- Hazardous Materials Management Plan.

The Project will have unavoidable residual impacts on biodiversity. Residual impacts are predicted for 15 priority biodiversity features, two ecosystems, and three priority habitats known or likely to occur in the Project Area of Influence. Residual impacts include direct habitat loss, indirect habitat loss, and increased mortality from increased hunting, increased collecting, collisions with vehicles and power lines, and increased numbers of natural predators. Conservation of the Asiatic wild ass is recognized as the highest priority for the Project, given the international importance of the Southern Gobi region to this rapidly declining, globally endangered species and the residual impacts of the Project it is likely to impose.

20.6.6 Land use and displacement

Potential impacts

Oyu Tolgoi LLC will require approximately 11,347 hectares (ha) of land to construct and operate the mine and ancillary facilities. This includes land for the Oyu Tolgoi Property that was granted in 2009 and additional land required for the TSF, concentrator, airport, Gunii Hooloi borefield and water pipeline, and transport-infrastructure corridor between Oyu Tolgoi and Gashuun Sukhait (Table 20.6).

Land will also be temporarily disturbed during the construction phase for activities such as the installation of worker construction camps, excavation of borrow pits, and soil stripping along the water pipeline and transmission line corridors.

Mitigation measures and residual impacts

In 2003, when it became apparent that advanced evaluation of the Project would occur, it became necessary to resettle ten herder households from the Oyu Tolgoi Property and a surrounding residential exclusion zone. Accordingly, legally constituted resettlement agreements were concluded with each of the ten households in 2004. In 2011, when construction of processing facilities and ancillary infrastructure commenced, a further 89 herder households were recognised as being negatively impacted by the Project. Economic displacement compensation agreements were agreed with each of these households, and to meet lender compliance requirements and embed commitments into Oyu Tolgoi's management system, a Resettlement Action Plan was prepared in 2011, updated in each of 2013 and 2015.

Evaluation of the Resettlement Action Plan by an independent party, conducted in 2018, concluded that livelihoods of the affected herder families are fully restored except for five families with water dependencies. Oyu Tolgoi LLC is currently working with these families and implementing individual household livelihood improvement plans

Table 20.6 Summary of Project land requirements

Land requirements	Component	Area (ha)
Mine licence area[a]	Original licence area	8,489.1
	TSF additional area	64.8
	Concentrator load-out	18.4
Airport sites	Permanent airport	230.0
Water supply pipeline	Pipeline land limit area	2,457.0
TVET building in KB	Local vocational training school in KHB	1.0
Digital Radio Tower	Digital radio tower	0.06
Big Ger	Meeting camp	12.0
New areas requesting land use permits		
Transportation	Parking area	3.33
35 kV OHPL to Khanbumbat	Power transmission line of Khanbumbat aiport	23.55
New Permanent Marshalling Yard	Marshalling Yard - 2	47.60
Total		**11,346.83**

a) Some further land is required in addition to the original Oyu Tolgoi Property to accommodate the tailings storage facility, concentrator, and batch plant. Oyu Tolgoi LLC has sought permission for these additional land requirements and received approved by the soum governing body.

20.6.7 Cultural heritage

Oyu Tolgoi LLC seeks to “design out” impacts to archaeological heritage. Wherever possible, changes have been made to the location of fixed elements of the Project and the design of linear features, such as the roads and the water pipeline, in consideration of archaeological findings.

Many of the impacts on cultural heritage have already been realized in relation to land disturbance, topsoil stripping, and construction of new access roads and associated borrow pits. Existing and possible future impacts include:

- Physical loss of tangible heritage from physical land disturbance.
- Indirect disturbance of tangible heritage through the operation of construction vehicles and machinery, operations vehicles, dust deposition, and vibration effects.
- Damage or deliberate disturbance of heritage by Project workers or incomers to the region.
- Loss of intangible heritage over time as the patterns of work, kinship, worship, and sources of income change.

Potential for further impacts on archaeological and palaeontological sites is expected to be low because the scale and intensity of additional earthworks and engineering activities will be low during the operations and decommissioning phases (compared with the construction phase). However, some levelling, landscaping, contouring, and other land-based activities do have the potential to result in further minor archaeological impacts. Should these activities remain within the existing disturbance footprint, no significant impacts are expected. Nevertheless, predicted changes to traditions and the traditional way of life are considered long-term effects.

20.7 Environmental, social and cultural heritage management

Oyu Tolgoi LLC's Health, Safety, Environment and Community (HSEC) Policy affirms its commitment to protecting the environment and to safeguarding the health, safety and welfare of people affected by the Project including employees, contractors, and communities. The Oyu Tolgoi LLC is dedicated to performing its duties in a safe, sustainable, and environmentally responsible manner.

20.7.1 HSEC Management System

Oyu Tolgoi LLC has developed a comprehensive HSEC Management System. Accountability for compliance sits with line management, with support and technical expertise provided by HSEC resources.

The HSEC Management System is designed on the principle of continual improvement. It adopts the "Plan, Do, Check and Review" methodology and comprises 17 discrete elements for implementation.

Monitoring of compliance is undertaken, wherever possible, through current processes that are established and aligned to the specific requirements of each element.

Evaluation of compliance with each HSEC Management System element is ongoing, with formal internal review undertaken annually, and as well as external review/audit processes that includes up to three reviews per year through project financing processes.

20.7.2 Cultural Heritage Management System

The Cultural Heritage Management System describes methods to effectively identify, map, document, and protect any archaeological resources that may be encountered during the life of the Project. The objectives of the Cultural Heritage Management System are to:

- Outline the legal obligations/project standards regarding the protection of cultural heritage.
- Identify the actual and potential sources of impact on both tangible and intangible heritage.
- Establish effective plans, programs, and procedures for managing archaeological sites and cultural assets, including potential chance finds during construction and operations.
- Define roles and responsibilities.
- Define monitoring and reporting procedures.
- Define training requirements.

The Cultural Heritage Management System has several mitigation and management controls, including:

- Conducting surveys or an appropriate level of archaeological and/or paleontological investigation by the Institute of Academy and Institute of Palaeontology of Mongolian Academy of Science prior to land disturbance.
- Informing the relevant institutes in writing before undertaking any planned excavations, mining, or acquisition of land disturbance permits.
- Following established excavation, retrieval, and recording procedures in the event of chance finds.

20.7.3 Environmental and community programs

Biodiversity monitoring programs

Oyu Tolgoi LLC also works with international non-government agencies (NGOs), consultants and university researchers to achieve a net positive impact on biodiversity of the mine area. The annual biodiversity monitoring programs provide information to assess the effectiveness of the mitigation strategies that have been incorporated into the Oyu Tolgoi LLC operational management plans.

The Core Biodiversity Monitoring Program has progressed well in 2019 with a ground ungulate population survey covering around 79,000 km^2 area of the South Gobi region. The 2019 survey results indicated a significant increase in ungulate populations, specifically khulan and goitered gazelles. Favorable weather conditions and the Oyu Tolgoi LLC's conservation efforts through the biodiversity offset program have contributed to this excellent outcome.

Oyu Tolgoi LLC has implemented several biodiversity offsetting projects that contribute to moving towards a net positive impact on biodiversity and ecosystem services in the region. An example is the anti-poaching project, including implementation of the Spatial Monitoring and Reporting Tool software package, and khulan carcass assessments. Other offset projects include powerline insulation to reduce bird mortality, development of sustainable cashmere, and modification of railroad fencing to lower the impact on fauna.

There were several significant achievements in the offsetting projects in 2019, including:

- The success of the Spatial Monitoring and Reporting Tool system has enabled the Government of Mongolia to develop a working group that is examining the expansion of the system into other protected areas in Mongolia.
- The development of sustainable cashmere underwent a restructure to improve long-term viability and to ensure its success.
- The railroad fence project pilot saw the successful removal of two sections of the railroad fence, totalling 1,200 metres.
- Through a stakeholder consultation workshop, the biodiversity team gained significant input from local government officials on goals, gaining support to continue these programs.

Greenhouse gas emission monitoring and reduction programs

Oyu Tolgoi LLC has been measuring monthly GHG emissions since 2012 and completes an annual GHG workbook. Performance for the year ended 31 December 2019 was 2.38 tonnes CO_2 equivalent per unit product against an annual target of 1.96 tonnes CO_2 equivalent per unit product. These emissions include both direct (from activities related to the Project) and indirect emissions (from generation of purchased energy). The emission targets and actual from 2014 to 2020 are shown in Table 20.7.

Table 20.7 Greenhouse gas emissions

	2014	2015	2016	2017	2018	2019	2020
Emissions intensity target (tonnes CO_2-e per unit of production)	–	1.90	1.76	2.46	2.12	1.96	2.75
Emissions intensity actual (tonnes CO_2-e per unit of production)	2.40	1.85	1.70	2.18	2.06	2.38	–

Total emissions actual (tonnes CO_2-e)	1,353,130	1,463,002	1,428,626	1,572,355	1,514,205	1,596287	–

Notes: (1) The emissions intensity per tonne of product reflects the tonnes of metal produced and are impacted by variability of the grade of the ore mined, which is a function of the orebody. 2020 is anticipated to be a lower-than-average grade year and the emissions intensity target reflects this (2) All figures exclude the underground development Project emissions.

Oyu Tolgoi LLC has implemented numerous programs and activities aimed at reducing its GHG emissions and to save energy, including:

- Discontinuing diesel generators at the training centre (2015), mine camp and site facilities (2017-18), and Khanbumbat airport (2018).
- Installation of walkway lighting powered by solar energy (34 sections installed in 2019).
- Installation of runtime management equipment on air conditioners (30% reduction in energy).

Community programs

Oyu Tolgoi continues to have a positive impact on the communities surrounding the mine, especially Khanbogd, Manlai, Bayan-Ovoo and Dalanzadgad soums. In Khanbogd, the partnership with Oyu Tolgoi LLC led to the connection of the town to a permanent power supply; funding for new educational and healthcare facilities; sealing of local roads; social welfare programs; a new water supply system with capacity to support 13,000 residents; and construction of a 35.1 km sealed road between Oyu Tolgoi and Khanbogd, which opened in early 2019. In 2019, Oyu Tolgoi LLC also reached an agreement with local herders, made possible by the strong commitment of Oyu Tolgoi LLC's management and the extensive engagement by the company's Communities Team.

In addition to the above achievements, Oyu Tolgoi LLC makes an annual contribution of US$5 million to the Gobi Oyu Development Support Fund, a separate fund that supports sustainable community development. Since its creation in September 2015, the Development Support Fund has invested US$27 million in 197 sustainable development projects and programs, which have resulted in the creation of more than 391 permanent jobs, benefits to over 390,000 community members, including scholarships for 187 students, among many other achievements. Examples of projects implemented through the Development Support Fund include:

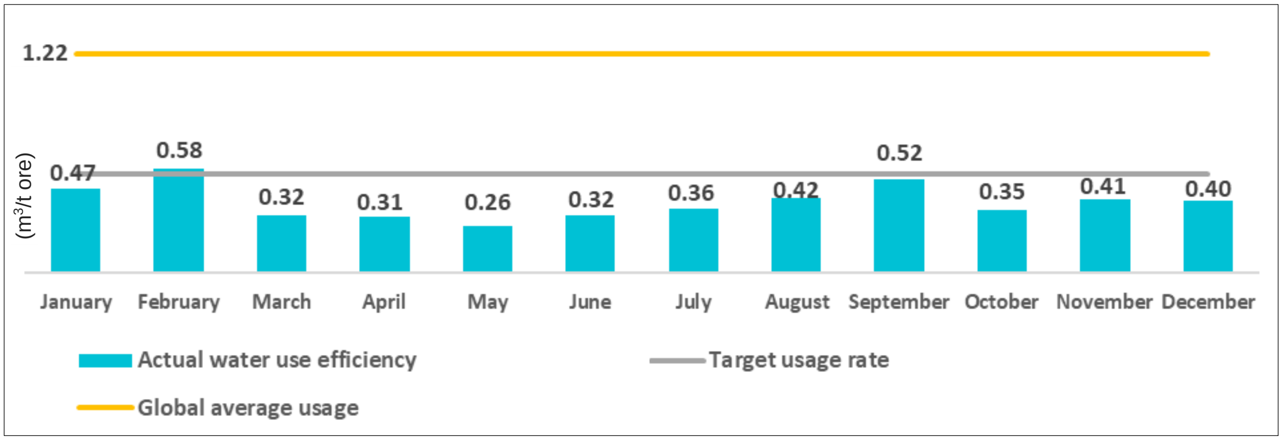
- Construction of a school and kindergartens.
- Construction of a health care centre in Mandal-Oyoo soum.
- Construction of a new museum in Umnugobi aimag and provision of required equipment.
- Co-funding of an integrated health care program for Umnugobi aimag women and youth.
- Co-funding of a three-year program to support small to mid-sized business.
- Construction of a heating plant in Manlai soum.
- Gobi grove in Manlai soum.
- Development of a flood prevention dam in Khanbogd soum.
- Implementation of a disinfection program assistance and over 5,000 winter shelters across Umnugobi aimag.
- Introduction of three high output breeds of camel and creation of a local brand of cashmere.
- Protection of 42 historical sites with education of local rangers.

To update the community knowledge base, Oyut Tolgoi LLC completed the 2018 Umnugobi socioeconomic and environmental baseline study update with the National Statistical Office and UNFPA. The study provides insights on key social trends and changes in the local community in last 10 years.

20.7.4 Water management

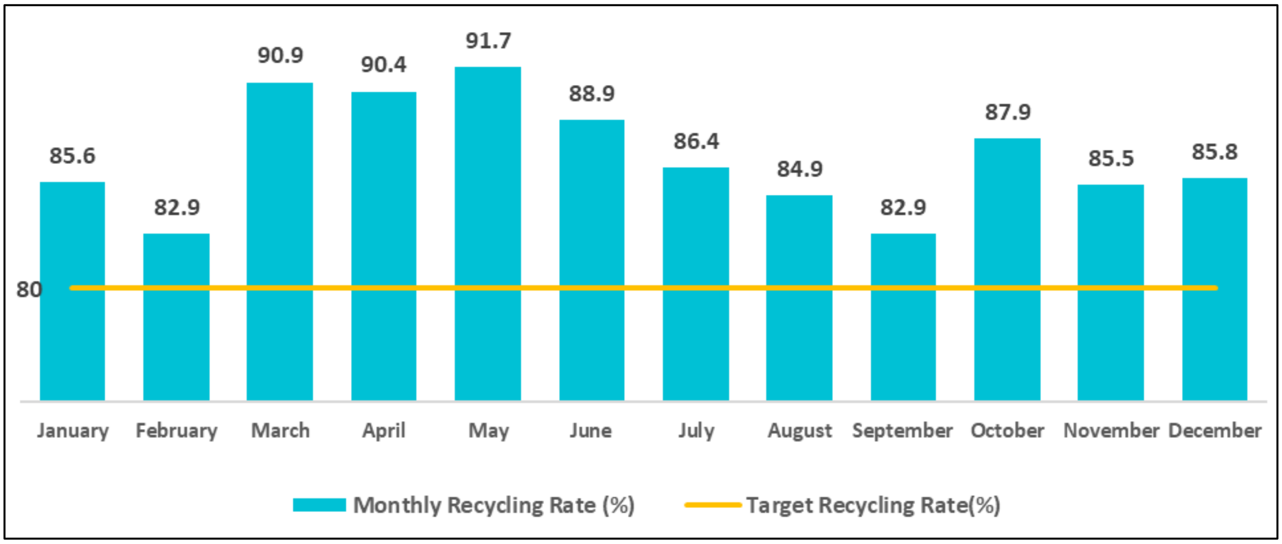
Oyu Tolgoi is one of the most water-efficient mines in the world with average water use of 0.39 cubic metres of water per tonne of ore processed in 2019 (Figure 20.1). The water used by Oyu Tolgoi comes from a deep and saline aquifer and has no impact on drinkable water in the region. In 2019, water used by Oyu Tolgoi was continuously recycled at an average rate of 87.2% (Figure 20.2). An independent water audit is undertaken every five years, with the last audit completed in 2016. Compliance with water management and conservation policies, standards and legislation in 2019 was ensured through diverse processes including inspections from the Government of Mongolia as well as local community field verifications.

Figure 20.1 Raw water use in 2019



Source: Oyu Tolgoi LLC, June 2020.

Figure 20.2 Water recycling rate in 2019



Source: Oyu Tolgoi LLC, June 2020.

Recent achievements in water management include:

- 41 exploration water bores sealed and rehabilitated.
- 77 new herder wells created.
- Shoreline cleaning events for local water sources.
- Enhancement of three natural springs in Khanbogd soum.

Minimizing water use throughout all the operational aspects has been a key focus during mine planning and design. Examples of water conservation planning include:

- Reuse of cooling water.
- High-efficiency tailings thickeners.
- High-efficiency TSF reclaim.
- 100% mine water recovery.
- 100% treated wastewater reuse.
- 100% truck wash water reuse.
- Lagoon floating cover.
- Selection of low or zero water use equipment.

Ongoing attention to water conservation will be maintained through the continuous review of key performance indicators for water use and implementation of additional water conservation measures.

Ongoing work programs for developing water resources include:

- Updated hydrogeological model of Gunii Hooloi water resource based on monitoring response of operation.
- Clarification of aquifer reserve approval for the eastern part of the Khanbogd water resource.

20.7.5 Waste management

Mineral waste

Oyu Tolgoi LLC stores mineralized waste in tailings storage facilities, which are engineered structures designed to minimise impact on the local environment. TSF C1 has been in use since 2013 and is currently 49 m high. In 2019, 40 million dry cubic metres were pumped to the TSF, meeting the anticipated level rise of 6 m. The TSF uses the downstream method of wall construction. The last independent review of the facility was carried out in February 2019.

Oyu Tolgoi LLC's tailings risk is managed with three levels of assurance to monitor and reduce risk. The first level of assurance is based on the work of site teams and processes, the second level of assurance is provided by TRQ, Rio Tinto with their in-house specialists providing technical reviews and monitoring the application of Rio Tinto's global standards, and the third level of assurance is provided by regular external reviews of the facility against the Australian National Committee On Large Dams (ANCOLD) framework.

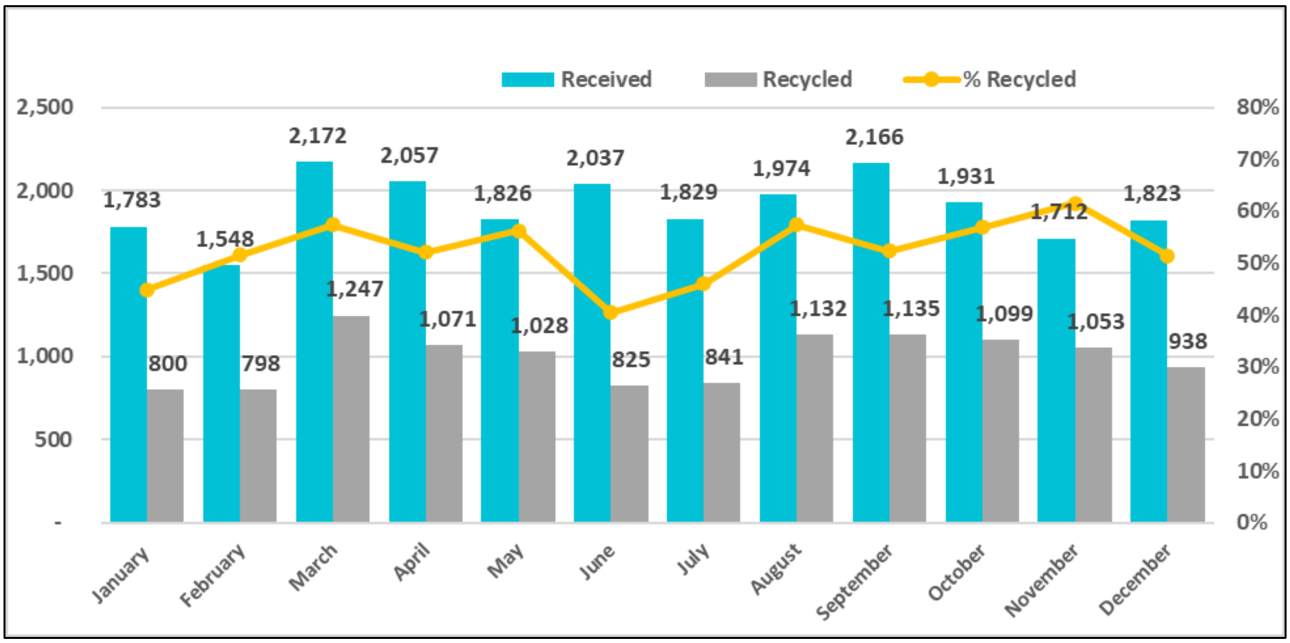
Oyu Tolgoi LLC's tailings standard is consistent with the International Council on Mining and Metals position statement on TSF governance.

Non-mineral waste

As result of the development of the underground, the quantity of non-mineral waste generated at Oyu Tolgoi has significantly increased. For the past two years, Oyu Tolgoi LLC has focused on continuous improvement of non-mineral waste management through the development of the long-term non-mineral waste management strategy and the reduction of the waste that goes to the waste management centre by improving the ability to reuse and recycle waste materials and segregating waste in the work areas. As a result of these activities:

- In 2019, 54% of total waste was diverted from the waste management centre by reuse and recycling (Figure 20.3).
- Since 2016, the quantity of landfill waste has decreased by 49%, to 3.4 kg per person per day in 2019.
- Over 2,250 m^3 of wood was reused in cooperation with the local Red Cross Primary Committee.

Figure 20.3 Non mineral waste tonnes received and recycled from the waste management centre in 2019



Source: Oyu Tolgoi LLC, June 2020.

20.8 Progressive rehabilitation and closure planning

Progressive rehabilitation and planning for closure is a critical and integral part of the business process and demonstrates a commitment to sustainable development. Progressive rehabilitation involves the continuous technical and biological rehabilitation of disturbed areas following completion of works activities. Closure planning involves the development of strategies to avoid or mitigate potential environmental and social impacts associated with closure to the extent that is financially appropriate.

20.8.1 Progressive rehabilitation and planning

Oyu Tolgoi LLC's progressive rehabilitation planning adheres to all related Mongolian laws and regulations and industry best practices as stated in IFC and EBRD performance standards and the Rio Tinto closure standard.

Progressive reclamation will be performed on any areas of the mine site where it is deemed practical to do so and with consideration of the need to preserve future mine expansion options. Disturbed areas that are no longer used in the active operation will be physically and biologically rehabilitated concurrently with ongoing mining operations, as far as practicable.

Significant progressive rehabilitation works have been done for the rehabilitation of disturbed land following the completion of construction works, including:

- Historically used temporary airport.
- Historically used borrow pits and quarries used to support construction activities.
- Land disturbed by installation of underground pipelines.
- Land disturbed by drilling activities.
- Historically used tracks and access roads.
- Other areas disturbed during construction.

By the end of the 2019, 1,663 ha of land had been progressively rehabilitated out of a total of 6,036 ha of land affected by the mining operation. Physical and biological rehabilitation phases have been fully completed on 466 ha.

The company will also pursue opportunities for local communities and herder groups to participate in the implementation of progressive rehabilitation measures that could result in economic benefits and capacity development for those involved.

Technical rehabilitation

By the end of 2019, Oyu Tolgoi LLC had successfully completed the technical rehabilitation of a total area of 1,661.3 ha which were handed back to local government.

Biological rehabilitation

To support biological rehabilitation, a 4 ha plant nursery has been established on the outskirts of Khanbogd soum centre, where seed collection and preparation, shrub and tree propagation, and rare plant research activities are undertaken. By the end of 2019, Oyu Tolgoi LLC had completed the biological rehabilitation for total area of 466 ha of which 53 ha of land was associated with off-site construction works, such as road construction.

In 2019, 1.34 ha of landscaping was completed in the Oyut camp, Mazaalai mess hall, North gate, and Khanbumbat airport. Oyu Tolgoi LLC also conducted a 1,500 tree planting campaign in Khanbogd. During the "open day" event, about 1000 saplings were given to local communities in Dalanzadgad.

20.8.2 Closure planning

The Mine Closure and Reclamation Management Plan, prepared by AMEC Americas Limited in 2012 and updated in 2014 (AMEC Environmental & Infrastructure, 2014), documents the outcomes of an order-of-magnitude closure study conducted with the following objectives:

- Compliance with relevant Mongolian national standards.

- Compliance with relevant international guidelines and directives.
- Documentation of closure vision, objectives, and targets.
- Early development of strategies to meet closure objectives and targets.
- Early identification of likely site-specific closure issues and assessment of risks.
- Identification of action items that should be conducted to manage and mitigate risks and enable efficient and effective closure methods and technologies in the future.
- Preparation of a preliminary closure schedule based on current information.
- Estimation of costs associated with the closure, developed to an intended accuracy of an order-of-magnitude study.
- Development of a multidisciplinary information resource.

The main supporting infrastructure and facilities at the site that are addressed in the closure plan include:

- The Southern Oyu open pit mine and the Hugo North Level 1 underground mine and subsidence area.
- Underground and open pit infrastructure and equipment.
- Materials handling and processing facilities.
- Offices, truck shops, camps, and warehouses.
- Accommodation facilities.
- Waste management facilities.
- Standby diesel generators.
- Power distribution lines both on and off site.
- Access roads on and off site.
- Groundwater supply system from the off-site Gunii Hooloi borefield.
- Water treatment and distribution facilities.
- Water diversion structure (Undai River diversion dam and channel).
- Waste rock dumps and TSF.

Certain features of the mine will create permanent changes to the landscape that cannot be fully remedied through reclamation. The closure plan ensures that, where possible, these disturbed areas are physically and chemically stable to limit ecological impacts to the surrounding water, air, and land.

The proposed timeframe for implementing community and socioeconomic initiatives with regard to mine closure would span a period of about 15 years, beginning five years before closure, continuing through the estimated five years of mine closure and reclamation, and ending five years into the post-closure phase. The cost of mine closure is summarized in Section 21.

20.8.3 Post-closure monitoring

The site will be extensively monitored during the closure and post-closure phases of the mine, to characterize both physical and chemical stability of the Oyu Tolgoi Property and the environmental impact of the Project.

21 Capital and operating costs

21.1 Introduction

This section provides a summary of the capital and operating cost estimates for developing and operating the Project as envisaged in the 2020 Feasibility Study. The cost estimates include the remaining capital required to complete the Project and to mine and process the Mineral Reserves reported in Section 15 of this 2020 Technical Report.

The forecast costs exclude the potential impacts arising from the COVID-19 pandemic, as the duration of the pandemic and the impact on costs is currently unknown.

Oyu Tolgoi is being developed in two phases (Phase 1 and Phase 2). Phase 1 involved development of the Oyut open pit, and construction of the Oyu Tolgoi concentrator and associated infrastructure. Capital expenditure on Phase 1 (the Phase 1 capital) is complete except for $24 million planned to be spent during 2020 and 2021 to complete outstanding road works.

Phase 2, which is ongoing, involves development of the Hugo North underground mine, modifying the concentrator, and expanding the site infrastructure.

The remaining capital required to complete Phase 2 (the Phase 2 capital) includes all expenditure from January 1, 2021 required to design, develop, and construct the Hugo North mine. This includes the pre-production development and construction work needed to complete the necessary facilities to bring the mine into production and allow it to produce at a nameplate capacity of 33 Mtpa.

For the purposes of the estimate, Capital Expenditure includes:

- All Panel 0 development required to be completed prior to first drawbell is considered capital.
- Panel 1 and Panel 2 and other mine development to support cave ramp up to the quantity classified in the 2016 Feasibility Study as development capital.
- Capital expenditure also includes specialized contractor construction of facilities (e.g., crushers, conveyors, production ore passes, internal ventilation raises) scheduled after production starts. This is known as the 'CAPEX tail' which starts after first drawbell and continues until the completion of crusher two.

Sustaining capital includes capital expenditure required to increase production from Hugo North and then sustain the Oyu Tolgoi operation at its design capacity. It includes ongoing capital (such as mobile equipment purchases) for the Oyut open pit, the Hugo North operation, the concentrator operation, site infrastructure and administration facilities. Sustaining capital is also required to construct the additional tailings storage capacity in the form of ongoing embankment lifts for TC1 and construction of tailings TC2.

For Hugo North, sustaining capital includes all lateral development, undercutting and drawbell construction activities, which are over and above that required to achieve Sustainable Production. A portion of development in Panels 1 and 2, which is planned to be carried out prior to the start of Sustainable Production, is also included in sustaining capital.

Costs, which are incurred during the Hugo North commissioning phase, that are necessary for successful commissioning of these new assets, are treated as capital expenditure.

For Hugo North, costs incurred after the commencement of Sustainable Production are capitalized to the extent, they are expected to give rise to a future economic benefit. Where this is not the case, they are not capitalized. Such production and processing costs would include mucking ore from the block cave, trucking, crushing, conveying or hoisting the ore to surface, delivering it to the concentrator or ore stockpile as well as costs for the concentrator, Project infrastructure, and G&A.

21.1.1 Currency and exchange rates

Where necessary to convert pricing of goods and services to US$, prevailing exchange rates at the time, the spend was incurred have been used for past expenditure. As applicable, the exchange rates outlined in Table 21.1 have been used in developing the future cost estimates.

Table 21.1 Currency conversion rates

Currency	Unit / US$ range
Mongolian Tugrik (MNT)	2,618 – 2,757
Chinese Yuan (RMB)	6.82 – 7.06
Canadian Dollar (CAD)	0.76 – 0.80

21.1.2 Major commodity pricing

Commodity prices used for cost estimation are based on current pricing or supply estimates from Oyu Tolgoi (refer to Section 22.4.2 for further detail).

Mongolian value added tax (VAT) is calculated at 10% of all costs including subcontracted labour, material, equipment, off-shore services, and indirect costs. Direct labour is not subject to VAT. Duties are calculated as 5% of the value of imported materials and equipment including freight.

21.1.3 Contingency

An amount of contingency has been provided in the estimate to cover the anticipated variances between the specific values given in the base estimate and the final Project cost so that the total estimated Project cost represents the probabilistic mean or Expected Value. This value represents a central estimate as per industry best practice. It is expected that all contingency monies will be spent in the execution of the Project.

Contingency is not intended to cover changes to the Project scope but to provide an allowance for the inaccuracies and specific risks inherent in the estimating process. The contingency is an estimate of the allowances required for inaccuracies and risks in the estimate process, but the actual inaccuracies and costs for the Project scope may turn out to be higher than the contingency.

A contingency budget of approximately 15% is included within the capital cost to complete. Contingency of approximately 6% to 7% has been allocated to underground operating costs and sustaining capital costs.

21.2 Development Capital

The actual and forecast development capital expenditures for Phase 2 are summarized by year in Table 21.2. A breakdown of the major cost areas for the Phase 2 capital is shown in Table 21.3. Costs presented in this Section are reported in 100% Project basis.

The forecast development capital expenditure estimate targets an accuracy of ±20% (excluding impacts of COVID-19) in line with Mongolian regulatory requirements. The estimate is subject to further study and assessment as part of Oyu Tolgoi LLC's ongoing cost estimation and project management processes, including preparation of a definitive estimate and on-going studies for Panels 1 and 2.

The current forecast development capital includes contingency and escalation but excludes interest costs during construction. The base date for the cost estimates is the first quarter (Qtr1) 2020, and the cost estimates are expressed in nominal terms.

Actual capital expenditure on Phase 2 from 1 January 2015 until 31 December 2019 was approximately $3.4 billion, and a further $3.4 billion (including 2020 development capital spend of $1.2 billion[19]) is forecast to be required to complete the Phase 2 scope of work.

The scope of the remaining capital program includes:

- All remaining shaft construction and commissioning work including installation of the associated permanent ventilation equipment.
- The construction of all facilities required to crush and transfer ore from Sustainable Production in Panel 0 to the concentrator, including Crusher 1 and the conveyor to surface system.
- All Panel 0 development required to be completed prior to Sustainable Production.
- Construction and maintenance of temporary construction facilities to support ongoing construction activities after the start of Sustainable Production.
- Carrying out the modifications to the Oyu Tolgoi concentrator.
- Completing any remaining additions or modifications to the Project infrastructure required to enable Hugo North Lift 1 to meet its planned production rate of 33 Mtpa.

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[19] As the base date for the cost estimates is Qtr1 2020, this amount excludes any impacts of Covid-19. As a result, it differs from TRQ's 2020 underground capital guidance, which was revised to a range of $1.0 billion to $1.1 billion in its May 13, 2020 press release.

Table 21.2 Summary of planned Phase 2 Development Capital expenditure by year

Year	Phase 2 ($ billion)
Spent to from 1 January 2015 to 31 December 2019	3.4
2020	1.2
2021	1.0
2022	0.6
2023	0.4
2024	0.2
2025	0.0
Total	**6.8**

Note: Amounts are rounded and exclude any impacts of Covid-19 and are subject to further study and assessment as part of Oyu Tolgoi LLC's cost and schedule estimation update which is expected later in 2020; they are expressed in nominal terms and are inclusive of any applicable taxes.

Table 21.3 Phase 2 Development Capital by area

Description	Spent from 1 January 2015 to 31 December 2019 ($ billion)	Forecast to complete from 1 January 2020 ($ billion)	Total Phase 2 ($ billion)
Underground mine (Hugo North Lift 1)	1.4	1.3	2.7
Site development	0.0	0.0	0.0
Concentrator Modifications	0.0	0.2	0.2
Utilities and ancillaries	0.1	0.0	0.1
Offsite facilities	0.1	0.1	0.2
Subtotal direct costs	**1.6**	**1.6**	**3.2**
Indirect costs	0.8	0.7	1.4
Owner's costs, escalation, growth, forex, contingency	1.0	1.2	2.2
Subtotal – indirect costs	**1.8**	**1.8**	**3.6**
Total	**3.4**	**3.4**	**6.8**

Note: Amounts are rounded and exclude any impacts of Covid-19 and are subject to further study and assessment as part of Oyu Tolgoi LLC's cost and schedule estimation update which is expected later in 2020; they are expressed in nominal terms and are inclusive of any applicable taxes.

21.2.1 Development Capital for shafts

The remaining expenditure on shafts is for the ongoing construction of Shaft 3 and Shaft 4. The estimate has been prepared by Worley, an internationally recognized EPCM company, based on the awarded contract for shaft construction. An industry standard work breakdown structure methodology has been used to estimate and control Project expenditure.

21.2.2 Underground mine Development Capital

The scope of work covered in the Underground Mine capital estimate includes two separate areas; underground development and underground construction.

Underground development includes all horizontal and vertical development (excluding shafts), all mass excavations (crusher chambers, workshops, etc.) plus draw point and haul road construction. Shaft operation and waste rock handling during the construction period is also included.

Underground construction includes the design and construction of all underground permanent facilities including crushers, conveyors, ventilation, power, communication systems, workshops, offices and supporting utilities. Any associated surface construction activities are also included, such as the mine dry and overland conveyors and supporting utilities.

The estimate for underground development has been prepared by Oyu Tolgoi LLC using:

- Deswik Scheduling[20] — a package for scheduling quantities of mine development, undercutting and other mining activities, including quantities for ground support, explosives, and equipment usage hours.
- PCBC software for estimating and scheduling production tonnages and grades.
- Arena® simulation used by Labrecque Technologies to develop the equipment hours and fleet count for the production mobile equipment.

Estimates of the tonnage of material produced by lateral development include a 10 % to 15% factor to allow for overbreak, which is related to the anticipated ground conditions. Fuel consumption rates were estimated from vendor data and load factors. Material wastage factors for shotcrete rebound, over-drill and re-drill allowances and other similar factors are included.

The underground construction cost estimate to complete the remaining underground facilities was prepared by underground mine estimation team using Pronamics Expert Estimator, and Worley using Worley Est6, and Microsoft Excel, with PRISM software used to populate the actuals to date. Actuals and the estimated cost to complete were consolidated in Excel for consistency and reporting.

21.2.3 Concentrator modifications

The scope of work for the Concentrator Modifications is described in Section 17. The estimate has been prepared by Worley in accordance with the project work breakdown structure.

21.2.4 Utilities, ancillaries, and offsite facilities

The scope of the infrastructure and utilities cost estimate includes an expansion of the central heating plant by installation of two 29 MW coal-fired boilers, camp and warehouse capacity expansion, extensions of other existing utilities and associated engineering and support services. The estimate has been prepared by Worley.

21.2.5 Indirect and EPCM costs

Indirect costs include the cost of EPCM services covering the project management of the surface and underground facilities by the EPCM contractor(s) but excludes management of the underground development activities. The services provided include engineering management, project control, contracts administration, materials and construction management, and no-load commissioning. Other works include the design and construction of a new site concrete batch plant and construction of a warehouse to store parts for the

[20] Software using widely in the mining industry for scheduling mine development activities

service of underground mobile equipment. The estimate has been prepared by Oyu Tolgoi LLC and Worley.

21.2.6 Owner’s Costs

Owners cost have been prepared by Oyu Tolgoi LLC and include the following:

- Overall program management of the complete Phase 2 works.
- Government permit applications.
- Customs / border management.
- Construction insurances.
- Interface management with the Oyu Tolgoi’s Operations Group.
- Overall engineering and construction management of the underground lateral and vertical development, including underground mass excavations and shaft-sinking.

21.3 Sustaining Capital

The total sustaining capital estimate over the life of the Project from 1 January 2021 is summarised in Table 21.4. The estimate has been prepared by Oyu Tolgoi LLC. Sustaining capital costs are expressed in 2020 US dollars based on fixed exchange rates. The costs are un-escalated.

Table 21.4 Total sustaining capital estimate

Description	Total ($ billion)
Open Pit	0.8
Hugo North Lift 1	2.7
Concentrator	0.1
Tailings	0.8
Infrastructure	0.3
Other	0.2
Sub-total	**5.0**
VAT & Duties	0.5
Total	**5.5**

21.3.1 Open pit

Sustaining capital for replacement of the open pit equipment (trucks, shovels, drills, etc.) at the end of their useful life is estimated at 43% of the open pit sustaining capital over the life of the Project. The scheduled replacement hours for the major equipment is shown in Table 21.5.

Table 21.5 Open pit major equipment life

Unit	Life (hours)
55 m^3 Electric Shovel	95,000
34 m^3 Hydraulic Shovel	55,000
18 m^3 Loader	55,000
290 t Truck	120,000
Drills	53,000

In addition to the sustaining capital for equipment replacement, approximately 48% of open pit sustaining capital is allocated for the replacement of major equipment components based on the life cycle of each major component, such as haul truck engines and undercarriage changes for production shovels. Minor equipment replacement and upgrades such as lighting plant, cable tower, and specialty maintenance equipment is also included.

21.3.2 Hugo North

Sustaining capital costs for Hugo North include all lateral and vertical development, undercutting, and drawbell construction activities, over and above that required to achieve Sustainable Production. A portion of development in Panels 1 and 2 that is planned to be carried out prior to the start of Sustainable Production is also included in sustaining capital.

The cost estimate has been prepared by Oyu Tolgoi LLC in a similar manner and using the same software that was used to estimate the underground development capital cost.

21.3.3 Concentrator

Process plant sustaining capital is allocated to replace fixed plant equipment after it has reached the end of its useful life. Annual sustaining capital expenditure for the concentrator has been estimated by Oyu Tolgoi LLC based on 0.5% per annum of the initial direct capital cost of building the concentrator.

21.3.4 Tailings storage facility

Potentially acid forming mine waste is used in the construction of the embankment structure of the TSF. Of the total quantity of embankment material, 78% is composed of mine waste that will be placed by the mine mobile equipment fleet (trucks and dozers). The cost of hauling this material to the TSF is included in the open pit operating cost estimate. Overhaul[21], placing, contouring, and compacting the material is included in the sustaining capital estimate for the TSF. Other construction materials required for tailings dam construction are included in the TSF construction sustaining capital estimate.

21.3.5 Infrastructure

The infrastructure operating cost estimate covers the costs required to maintain the site infrastructure which includes:

- Replacement of communication and information technology equipment at a rate of 10% per annum of initial capital value.
- Refurbishment/replacement of the central heating plant boiler.

[21] Overhaul is the additional haulage distance required to transfer waste to the TSF father than to the waste storage area.

- Refurbishment of process and non-process buildings approximately every 10 years.
- Green energy production including energy from waste products at the waste management center and small size solar power plants.
- Camp area development including new laundry facility, gym expansion and indoor/ recreation centres.
- New marshalling yard construction.
- Equipment replacement.

21.3.6 Other

Other sustaining capital costs include costs to replace vehicles, equipment including communication and information technology equipment, refurbish buildings, any green energy initiatives as well as those other items expected to give rise to a future economic benefit not separately categorized above.

21.4 Operating costs

The total operating cost over the life of the Project from 1 January 2021 onwards are summarised in Table 21.6. Operating costs are un-escalated and are expressed in real 2020 US dollars based on fixed exchange rates.

Table 21.6 Operating cost summary

Description	Total ($ billion)
Open Pit[22]	3.5
Hugo North	3.4
Concentrator	7.7
Infrastructure	2.5
G&A, including exploration & evaluation and technical support costs	2.3
Sub-total	**19.4**
VAT & Duties	1.8
Total	**21.1**

The operating costs have been estimated by Oyu Tolgoi LLC and are based on the fixed exchange rates listed in Table 21.1 The estimates include all expenses required to operate and maintain the open pit mine, the underground mine, the concentrator, and the Project support activities. The following are excluded from the operating cost estimates

- Escalation.
- Financing costs.
- Royalties.
- Selling costs.

The estimates are built up on the fundamental principle of centrality, giving them an equal probability of upside and downside. The cost estimate for the open pit includes an adjustment for deferred stripping.

[22] Excludes costs associated with deferred stripping of $1.3 billion (pre-tax) which are capitalised

21.4.1 Open pit

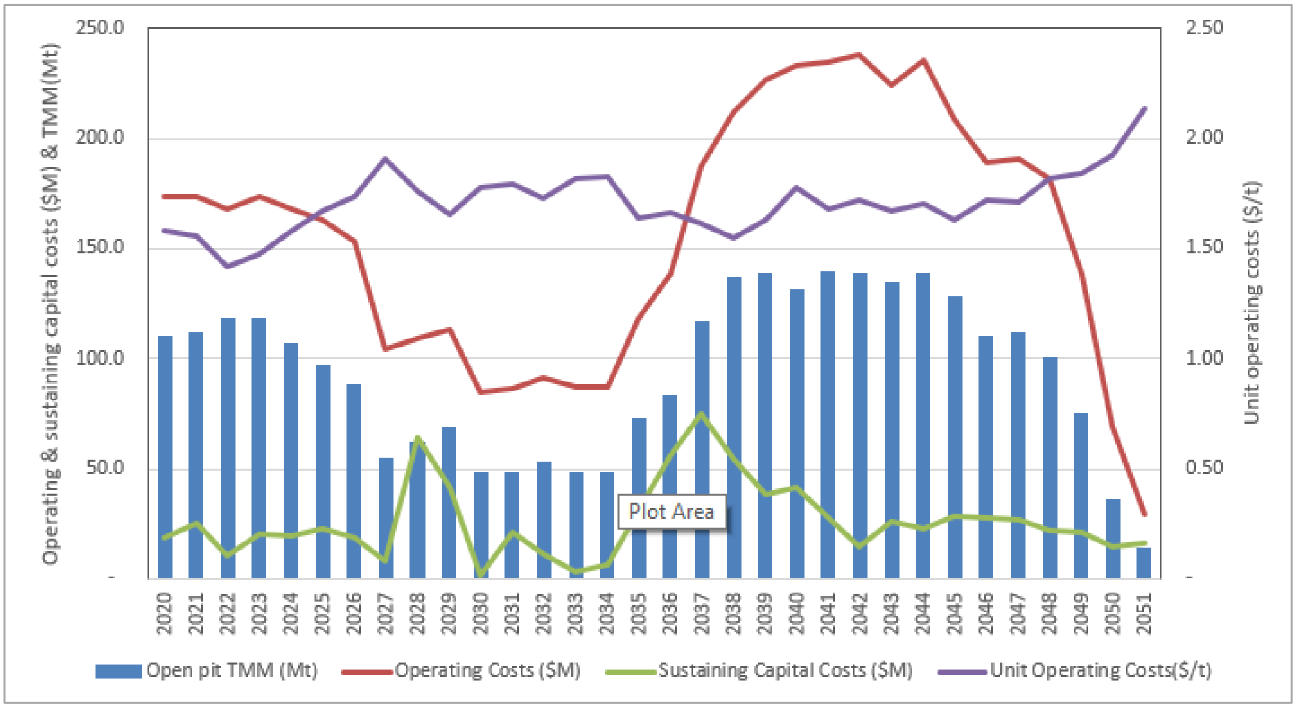
Open pit costs include costs associated with drilling, blasting, loading, and hauling of ore and waste. They include operating and maintenance labour, consumables such as diesel, explosives, equipment spare parts, and general materials. They also include the cost of mine management and support services.

Figure 21.1 shows the planned annual total material movement for the open pit, together with the estimated operating costs and sustaining capital costs.

Truck haulage costs (the most significant mining cost) increase as the pit deepens and haulage distances increase. As underground production increases, open pit production decreases and haulage costs and truck numbers decrease. The number of large haul trucks decreases from 30 in 2025 to 14 in 2030. From 2035 onwards, truck numbers increase to a maximum of 50 trucks in 2042 as underground ore from Hugo North Lift 1 is depleted, open pit ore tonnages increase, and the pit deepens. Truck numbers and operating costs then decrease as the open pit approaches completion.

Diesel fuel costs are based on equipment fuel consumption rates per operating hour. The large trucks and diesel shovels have an average consumption rate of 243 litres and 376 litres per hour, respectively.

Figure 21.1 Open pit annual ore production, operating and sustaining capital costs



Note: Total Material Movement (TMM). Source: AMC from TRQ data. Date 4 August 2020

21.4.2 Hugo North underground

The operating costs for Hugo North include the cost of mine management and support, mine production, and support services.

Standard labour rates based on existing agreements, combined with estimates of future workforce requirements have been used to estimate labour costs. Workforce requirements are based on either a fixed requirement (i.e., 1 hoist person on duty, 2 electricians on duty, etc.) or on fixed crew sizes developed from the activities required to achieve production requirements.

Maintenance labour includes the mechanical and electrical crews required to maintain the fixed plant and the mobile equipment fleet.

Mine management costs include management, technical services groups, finance, administration, safety, human resources and training. Costs are estimated from workforce tables and organization charts.

Unit prices for fuel, drill consumables, explosives, ground support materials, and shotcrete are derived from a combination of actual job-site prices, current budget-level quotes, or recent quotes for similar materials.

The consumption of materials is driven by the activities required to achieve the planned production schedule, e.g. tonnes of ore mucked, metres drilled, and tonnes blasted. Usage rates are based on current operating experience where available, or from vendor-supplied data and benchmarking. Allowances are included in the usage rates for shotcrete rebound, over-drill and re-drill and for other loss or wastage.

Estimates for the cost of excavation re-support are included in the operating cost estimate based on the anticipated frequency of drawpoint repair and the cost of labour and materials.

Equipment operating costs are built up from first principles using vendor supplied information and verified against actual performance, when available or against typical industry benchmark values. A similar approach is used to estimate mobile equipment maintenance cost.

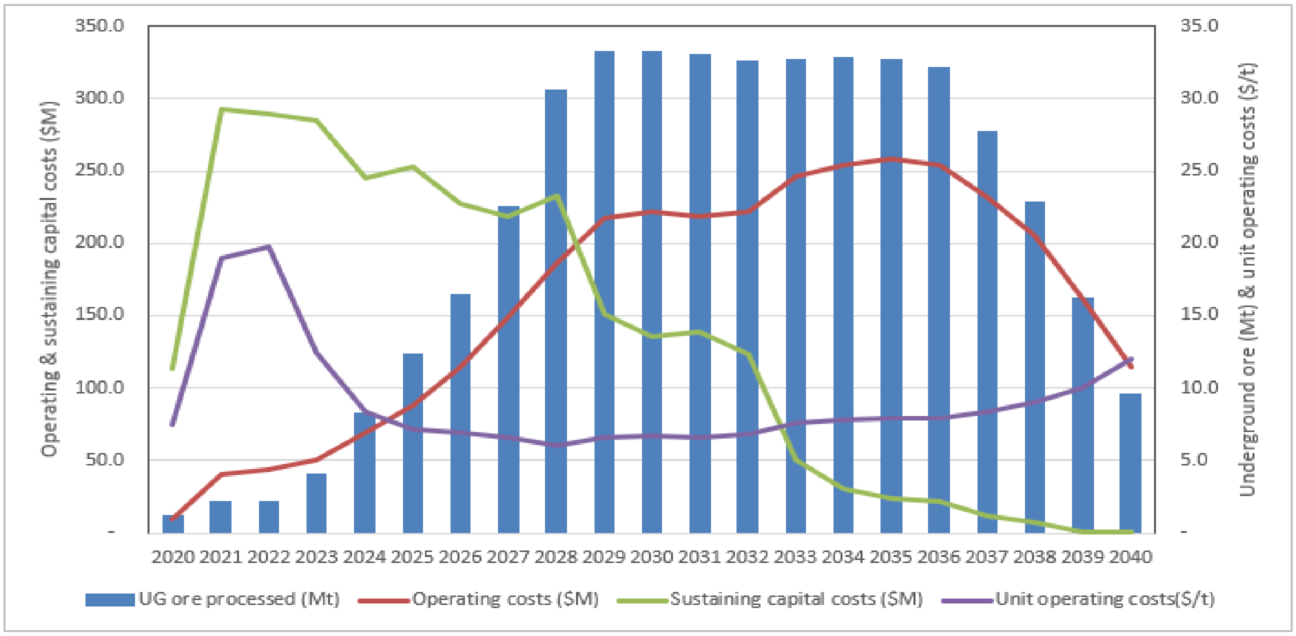
Maintenance costs for fixed equipment, such as pumps, compressors, fans, and air-handling units are developed from an electrical and mechanical equipment lists. The fixed costs incorporate the replacement of each type of equipment or component, based on an assumed operating life.

The costs of maintaining materials handling equipment including crushers, ore bins, truck loading chutes, and conveyor transfer points is based on tonnage throughput and expected wear rates. The cost of ore pass and grizzly maintenance includes one replacement set of ore pass liners per 5 Mt of ore throughput. Conveyor costs are based on operating hours, the number and length of belts, and the expected replacement frequency of system components.

Electrical power represents approximately 15% of the mine operational and sustaining capital costs. Ventilation, ore crushing, conveying and hoisting are the main consuming activities. The electrical loads were calculated by the electrical engineers based on the forecast loads over time from an engineered load schedule.

A graph showing planned annual ore tonnage processed and estimated operating costs for Hugo North is shown in Figure 21.2. The graph also shows the sustaining capital for Hugo North.

Figure 21.2 Annual LOM underground mine production and operating costs



Source: AMC from TRQ data. Date 4 August 2020.

21.4.3 Concentrator operating costs

The concentrator operating costs were developed by the Oyu Tolgoi LLC based on the 2019 actuals or 2020 contracted unit costs for most consumables.

The annual Phase 2 concentrator operating costs are not expected to differ significantly from Phase 1.

The operating costs include additional personnel required once the concentrator has been modified to process higher grade Hugo North Lift 1 ore. VAT and duties are included in the estimate on a weighted average basis, and no contingency was applied.

The concentrator electrical load includes all equipment and ancillaries in the concentrator buildings and the primary crushing, overland conveying, tailings pumping, water reclaim, and seepage control areas. Power consumption is estimated at 1,037 GWh (126 MW average load per mill operating hour) through 2022, increasing thereafter to 1,151 GWh (140 MW average load per mill operating hour) as harder underground ore is milled.

Grinding media consumption is based on kg/t ore milled by direct reference to Phase 1 operating data. When processing Hugo North ore, grinding media consumption is escalated by 20% from that required to process the Southwest ore type due to its higher abrasion index. Grinding media consumption estimates for the different ore types is shown in Table 21.7.

Table 21.7 Grinding media consumption by ore type

Grinding line and media load	Hugo North	Southwest	Central Ores
SAG milling, 125 mm steel balls (kg/t)	0.47	0.42	0.33
Ball milling, 75 mm steel balls (kg/t)	0.54	0.40	0.30
Regrind, 17 mm steel balls (kg/kWh)	0.127	0.058	0.10

The concentrator and TSF workforce, is based upon a review of actual labour levels. Personnel numbers increase in 2024 due to the concentrator modifications and remain constant for the life of mine until 2044 when production starts to decline.

The costs of maintenance materials are based upon the zero-based budgeting, reviewed against 2019 actual operating cost data. Maintenance materials, including mill and crusher liners, wear plates, and the regular maintenance spares required in the normal course of operation, are budgeted on an annual basis. The annual maintenance cost includes allowances for items such as screen decks and panels, cyclone parts, pump internals, flotation cell impellors / stators, bearings, and fixed plant lubricants.

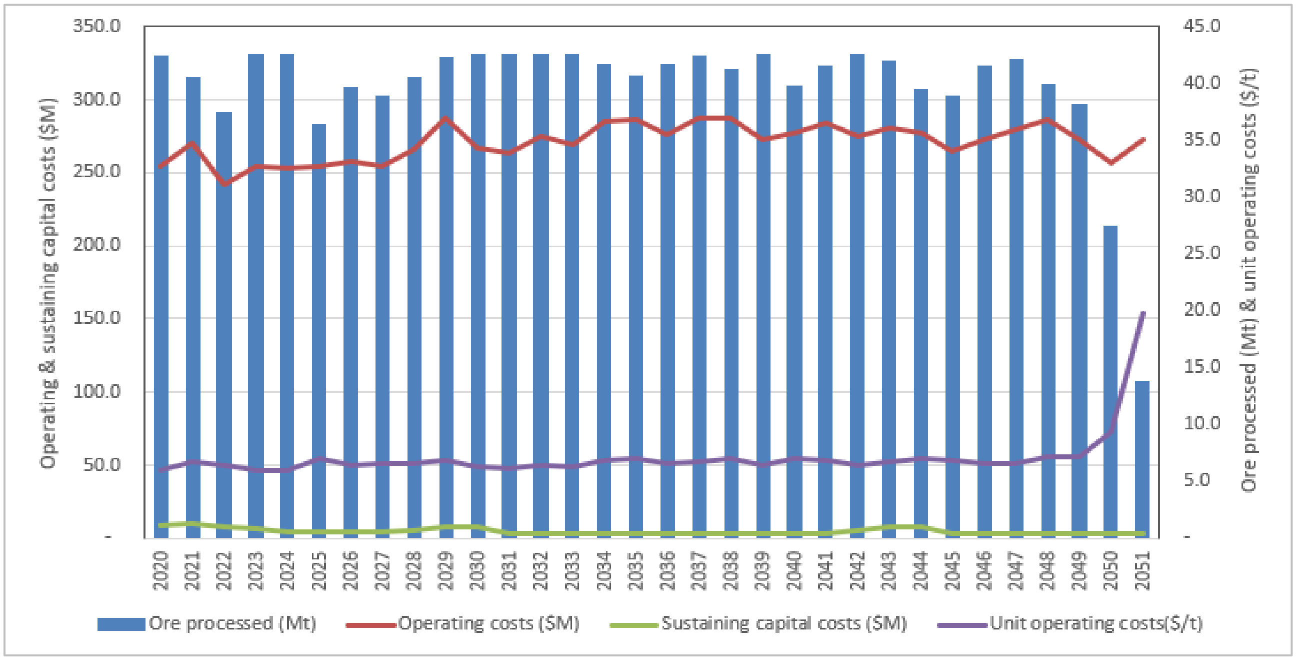
Reagent additions are based on operating data for Southwest and Central ore types and have been estimated for Hugo North ores proportional to contained copper metal. Reagent costs are based on current pricing. Tailings flocculant consumption is based on historical average and assumed to be the same for all ore types. Concentrate flocculant usage is calculated in proportion to concentrate produced. Other water treatment chemical dosing rates are based on historical averages.

The cost of external services is included in the estimate. This includes, the major contract for the assay laboratory, maintenance and processing related professional services and services for outsourced functions such as industrial clean-up.

The current industrial water price applicable to Oyu Tolgoi of 0.366 $\$/m^3$ is used with a concentrator consumption rate of 0.36 m^3/t dry ore processed to estimate water costs for the concentrator. The assumed long-term water consumption is representative of current and future plant performance.

Tailings operating costs are included in concentrator operating costs. The annual concentrator operating costs and tonnes of ore milled by year are shown in Figure 21.3.

Figure 21.3 Concentrator costs and ore milled by year for the LOM



Source: AMC from TRQ data. Date: 8 August 2020.

21.4.4 Infrastructure operating costs

The infrastructure operating cost estimate covers the costs of maintaining and operating the site infrastructure and services. The cost estimate is based on historical estimates wherever possible and relevant. The main facilities covered by the cost estimate includes:

- The central heating plant.
- The raw water supply from the borefields including the water treatment and bottling plant.
- Camp services, including security.
- Warehousing, inbound, and outbound logistics.
- Asset management.
- Health, safety, and environment.
- The mining heavy equipment facility.
- Other building maintenance, including the waste management centre and waste-water treatment plant.
- Electrical utilities other than the power plant.
- The light vehicle facility.
- Mechanical and maintenance services.
- The airport and charter flights between Ulaanbaatar and Oyu Tolgoi site.
- Operation’s support area including office of Operation’s Director.

21.4.5 G&A costs

The G&A costs encompass those not directly attributable to mining or processing, or to the maintenance of infrastructure facilities. It also includes the general and administrative departments principally operating from the company’s Ulaanbaatar offices. Each area contains several functional departments that have been grouped according to the organizational structure adopted by Oyu Tolgoi LLC.

G&A operating costs by department are provided in Table 21.8.

Table 21.8 General and administrative operating costs (inclusive of VAT)[23]

Department	**Total ($ billion)**
Communities	0.2
External affairs and communications	0.1
Finance and commercial	0.4
HSE security and communities	0.3
Information technology	0.4
Legal	0.1
Office of CEO	0.1
People and organizations	0.3
Procurement	0.2
Transformation and integration	0.1
Construction and engineering	0.1
Total	**2.3**

The G&A costs are based on a projection of the comprehensive two-year look-ahead budget prepared by Oyu Tolgol LLC. The budget plan is updated and reforecast based on actual performance and near-term commitments. Data from two-year plan has been used as the basis for the forward projection of costs for the life of the Project as envisaged in the 2020 Feasibility Study.

21.4.6 Mine Closure

The total projected cost of closure of the Oyu Tolgoi mine site is $1.3 billion. The costs are summarized in Table 21.9. All costs are expressed in 2020 US dollars with no allowances for escalation.

The cost estimate is based on the remediation activities described in Section 20.

[23] Excludes exploration and evaluation and technical support costs

Table 21.9 Project closure cost estimate

Cost Item	Cost estimate ($ billion)
Direct costs	
Demolition and removal of permanent facilities	0.37
Rehabilitation and revegetation, treatment, and disposal of hazardous waste	0.34
human resources	0.03
Community	0.03
Post-closure monitoring and other obligations	0.02
Subtotal direct costs	0.79
Indirect costs	
Closure support facilities	0.07
Closure management (EPCM) services	0.06
Owner’s costs incl. 10% VAT	0.13
Subtotal indirect costs	0.26
Contingency (25%)	0.26
Total closure cost	**1.31**

The estimate has been prepared using quantities and installation hours from existing capital cost estimates and the closure plan. Original hours to install or construct most of the surface infrastructure facilities have been factored at 20% of original hours to represent demolition-type activities. No residual or salvage values are included.

The main closure cost components for the physical scope of works include, but are not limited to, the following:

- Demolition and removal of permanent facilities – Includes all rehabilitation related to the open pit mine, the underground mine, and associated infrastructure, such as offices and other buildings, processing plant, mobile and fixed equipment, access roads, water supply facilities, water and wastewater treatment and management facilities, power supply, etc.
- Rehabilitation and revegetation – Mainly comprises the costs associated with the closure and rehabilitation of waste rock dumps (27% of costs) and the tailings storage facility (73% of the costs), inclusive of removal of tailings and water management equipment, regrading, and revegetation.
- Treatment and disposal of hazardous wastes – Includes oils, lubricants, reagents, refrigerants, coolants, and other materials.
- Human Resources – covers the cost of redundancies, redeployment, and retraining of the workforce at the end of the mine life, including the costs related to planning and preparation of such activities.

The estimate for closure costs has an expected accuracy of ±30%.

22 Economic analysis

22.1 Forward-looking information

The economic analysis presented in this section contains forward-looking information about mineral reserve estimates, commodity prices, exchange rates, proposed mine production plans and cash flows, projected recovery rates, operating costs, capital expenditures, project schedule, mine life, head grades, payback, NPV and IRR. The results of the economic analysis are subject to several known and unknown risks, uncertainties and other factors that may cause actual results to differ materially from those presented here. The reader is referred to the section titled "Important Notice" at the beginning of this Technical Report.

22.2 Introduction and summary

This section provides an economic analysis of the Project. A summary of the production and financial results are shown in Table 22.1. Cash flows prior to 2021 are considered sunk for the purpose of this economic evaluation. Accordingly, all cash expenditures prior to 1 January 2021 have been excluded.

The results of the economic analysis of the Oyu Tolgoi Mineral Reserves is an after-tax net present value at a real discount rate of 8% (NPV8) of $10.0 billion. The analysis also exhibits an unlevered after-tax IRR of around 46% and a payback period of around six years (including interest and similar costs on the existing project finance facility) for the remaining capital expenditure to be spent from 1 January 2021.

Table 22.1 Production and financial evaluation summary from 1 January 2021[1, 2, 3, 4, 5]

Description	Units	Value (life of Project)
Material processed	Bt	1.2
Copper (Cu) head grade	%	0.82
Gold (Au) head grade	g/t	0.30
Silver (Ag) head grade	g/t	1.89
Cu in concentrate	Mt (Billion lb)	8.8 (19.5)
Au in concentrate	Moz	8.4
Ag in concentrate	Moz	51.7
Concentrate	Mt	31.1
Payable Cu	Mt (Billion lb)	8.5 (18.8)
Payable Au	Moz	8.0
Payable Ag	Moz	46.5
Mine life[6]	years	31
Development capital[7]	$ billions (nominal)	2.3
Development capital[7]	$ billion (real)	2.2
Payback period[8]	years	6
Internal Rate of Return (unlevered, after tax)[9]	%	46%
NPV8 (after tax)[10]	$ billion	10.0

Notes:

1. Cost estimates prepared in 2020 real terms.
2. The financial analysis uses the Mineral Reserves reported in Section 15. The estimate of Mineral Reserves may be materially affected by environmental, permitting, legal, title, sociopolitical, marketing, or other relevant issues including risks set forth in 2019 AIF and other filings made with Canadian securities regulatory authorities and available at www.sedar.com. These updated estimates differ from those reported in the 2019

AIF and reflect incorporation of changes in the Hugo North Panel 0 design and incorporated into this 2020 Technical Report.

3. The financial analysis uses long-term metal prices of 3.03 $/lb copper, 1,474 $/oz gold, and 17.85 $/oz silver. The analysis was calculated with assumptions for smelter refining and treatment charges, deductions, and payment terms, concentrate transport, metallurgical recoveries, and royalties.
4. Mine life is calculated from 1 January 2021 and only reflects Mineral Reserves.
5. Economic analysis is calculated as of 1 January 2021 and excludes development capital spend up to 31 December 2020 (refer to Section 21). Underground project spend includes development capital and VAT and excludes capitalized interest. Development capital is presented in nominal terms for convenience in agreeing amounts to Section 21.
6. Payback period is calculated from 1 January 2021 and is rounded to years. Payback is calculated on undiscounted real cash flows including the interest and similar charges associated with the in-place project finance facility.
7. IRR is the discount rate that makes the net present value of all net cash flows after tax from Mineral Reserves equal to zero, calculated at 1 January 2021, based on expected net cash flows after tax from and after that date.
8. NPV8 is the net present value of Mineral Reserves at a discount rate of 8% for all years, calculated at 1 January 2021, based on expected cash flows from and after that date.

22.3 Methodology used

The financial evaluation is based on a discounted cash flow (DCF) model on a constant US dollar ($) basis (real basis) as at 1 January 2021. Refer to Section 21 for the methodology and basis for how the forecast development capital, sustaining capital and operating costs were estimated.

The DCF approach involves projecting yearly estimated revenues (net of realization charges, which include government royalties, treatment and refining charges, freight costs and penalties) and subtracting yearly estimated cash outflows such as operating costs (for example mining, processing, tailings, G&A and infrastructure costs) development capital costs, sustaining capital costs, taxes, closure costs and working capital movements to obtain the estimated annual net cash flow after tax. All net cash flow after tax is presented on a pre-finance basis. These net cash flows after tax are discounted back to the valuation date using a real, after tax discount rate of 8% and then summed to determine the net present value (NPV8) of the Project.

The discount rate represents an estimate of the rate the market would apply having regard to the time value of money and the risks specific to the asset for which the future cash flow estimates have not been adjusted. The model assumes that all net cash flows after tax are discounted in the middle of each year.

As the DCF model was constructed on a real basis, none of the inputs or variables were inflated. For discounting purposes, 1 January 2021 is the first period (valuation date). The benefit of physical equipment acquired as a result of prior expenditures and any associated remaining depreciable balance for calculating income taxes has been incorporated in the evaluation. The primary outputs of the analysis are NPV8, IRR, payback period, and net cash flow after tax, all on a pre-finance, 100% project basis (except payback period, which also incorporates interest and similar charges on the existing project finance facility). Any impacts on operations and underground development related to the COVID-19 pandemic as well as the uncertain duration and severity of the COVID-19 pandemic and the economic, commercial, and financial consequences thereof have not been incorporated into the economic analysis.

Cash flows prior to 2021 are considered sunk for the purpose of this economic evaluation. Accordingly, all cash expenditures prior to 1 January 2021 have been excluded.

A sensitivity analysis was performed (Section 22.6) to assess the impact of variations in discount rate (Table 22.6), metal prices (Table 22.7), head grades, total capital cost, development capital cost, and operating cost (Table 22.8).

22.4 Financial model parameters and key assumptions

The financial model is based on the Mineral Reserves reported in Section 15, the mine plan in Section 16, the recovery plan in Section 17, infrastructure assumptions in Section 18, the marketing assumptions in Section 19, social, permitting and environmental considerations in Section 20 and the capital and operating costs in Section 21.

22.4.1 Project life

The DCF analysis is based on a 31-year Project life (2021–2051) derived from the Mineral Reserves and mine plan described in Sections 15 and 16 respectively.

22.4.2 Economic Assumptions

The key economic assumptions for the analysis are shown in Table 22.2.

Metal prices are based on TRQ’s price forecasts of commodity prices, which assume that short term observable market prices will revert to TRQ’s assessment of the long-term price, generally over a period of three to five years. These long-term forecast commodity prices are derived from industry analysts’ consensus (drawn from a pool of leading international financial institutions) published as at 30 June 2020.

Smelter terms used in the analysis are as reported in Section 19.5. Treatment and refining charges were selected from internally prepared forecasts and assessed for reasonability against proprietary research by TRQ’s financial advisors. Treatment and refining charges form part of the deductions made in determining net revenue (other deductions include freight charges, penalty charges and royalties).

Table 22.2 Assumed metal prices and smelting and refining charges

Parameter	Unit	2021	2022	2023	Long-term financial analysis assumptions
Cu price	$/lb	2.67	2.80	2.88	3.03
Au price	$/oz	1,694	1,616	1,549	1,474
Ag price	$/oz	17.64	17.55	17.40	17.85
Treatment charges	$/dmt concentrate	67.37	79.24	91.12	91.12
Cu refining charge	$/lb	0.07	0.08	0.09	0.09
Au refining charge	$/oz	4.50	4.50	4.50	4.50

22.4.3 Royalties

Oyu Tolgoi is subject to a 5% royalty payable to the Government of Mongolia on a gross sales value basis (i.e. no deductions from sales for realization costs including, but not limited to, treatment charges and refining charges, freight differentials, penalties and / or payables). This royalty is stabilized and governed by the Investment Agreement (see Section 4.4).

The Underground Development Plan specifies the international markets in which specific prices are to be used in determining sales values to calculate the mineral royalties payable, as referenced and published in Metals Daily, for the day of shipment, as follows:

- Copper - the average monthly price determined by the London Metal Exchange Copper Grade A Settlement quotation.
- Gold - the London Bullion Market Association Final Gold quotations.
- Silver – the London Bullion Market Association Spot Silver quotations.

The Underground Development Plan sets out provisions if these market-pricing mechanisms cease to be available (see Section 4.4 of this report). Please note royalties are one of the deductions made in determining net revenue.

22.4.4 Operating, sustaining capital and development capital costs

Development capital, sustaining capital, operating costs, and closure costs included in this economic analysis are discussed in Section 21. Section 21 presents the methodology and basis for estimating development capital on a nominal basis. The development capital has been adjusted to real terms for the purpose of the economic analysis.

22.4.5 Power

Oyu Tolgoi LLC currently sources its power under an agreement with the Inner Mongolia Power International Cooperation Company Ltd. (IMPIC), via the Mongolian National Power Transmission Grid (NPTG) authority. This agreement is due to expire in 2023 Oyu Tolgoi LLC is preparing to negotiate the extension of its current arrangement with IMPIC/NPTG, as well as the terms of a new power purchase agreement with the Government with respect to a state owned power plant. Under the Power Source Framework Agreement, as amended (see Section 4.4), both Oyu Tolgoi LLC and Government of Mongolia have agreed to work towards securing an extension of the IMPIC/NPTG arrangement by 1 March 2021 and to reach agreement on a power purchase agreement for SOPP by 31 March 2021. Power costs reflect the assumed outcome of negotiations with IMPIC/NPTG and the Government of Mongolia respectively.

22.4.6 Working Capital

Changes in working capital are based on expected changes in accounts receivable, accounts payable, and inventory, as follows:

- Accounts receivable are assumed 95% to be received on delivery to the warehouse at the Chinese-Mongolian border with the remaining 5% received after 60 days.
- Accounts payable are based on 40-day End of Accumulation Payment (EAOP) terms for operating costs and sustaining capital costs.
- All saleable material produced in a period is assumed to be sold in that same period. For material and supplies inventory, yearly values are based on a percentage of non-services procurement spending, which is approximately 10% of operating costs including sustaining capital.

22.4.7 Taxation

Under the terms of the Investment Agreement, several forms of taxation have been identified as stabilized for the term of the agreement at the rates and bases applicable at the date of the agreement. The taxes and fees payable to the Government of Mongolia, and their rates, include:

- Corporate income tax: 25%.
- Value added tax: 10%.
- Customs duties: 5%.

Additional discussion can be found in Section 4.4.

The analysis does not include any potential withholding tax for the repatriation of dividends or interest charges outside of the country. Interest charges from shareholder loans and project financing are not included in the operating and capital costs but are allowed for in the calculation of tax. Additionally:

- In accordance with the Investment Agreement, Oyu Tolgoi LLC is not subject to an excess profits tax or any similar windfall tax.
- The copper concentrate does not qualify as a "finished product" for VAT purposes; as such, Oyu Tolgoi LLC is unable to claim back any associated credits / refunds.
- The IA allows for the tax loss carry-forward period in relation to Corporate Income Tax losses of eight years and that tax losses can be applied to offset 100% of taxable income.
- Customs duty of 5% is payable on all imported goods and associated inbound logistics costs incurred outside of Mongolia, including ocean freight, air freight, and land transportation.
- Several other non-stabilized taxes and levies will affect Oyu Tolgoi LLC. Examples include social security obligations, work placement fees, car registration taxes, royalties on the use of sand and gravel, and water levies. However, in accordance with Investment Agreement, Oyu Tolgoi LLC is not subject to any new taxes that came into effect after 6 October 2009.
- The Investment Agreement provides the depreciation rates applicable to different asset classes that have a useful life exceeding one year.

22.4.8 Management services payment

A Management Services Payment based generally on 3% of development capital costs and 6% of operating and sustaining capital costs during production is payable by Oyu Tolgoi LLC to the management team, who may in turn direct payment to TRQ or a member of the Rio Tinto group. Refer to Section 4.4 of this report for the Underground Development Plan which discusses the Management Services Payment and the relevant costs.

22.5 Results summary

The 2020 Technical Report mining production statistics and financial results are summarized in Table 22.3 and Table 22.5. The development and sustaining capital expenditures are summarized in Table 22.4.

The economic analysis indicates a NPV8 of US$10.0 billion as at 1 January 2021 and an IRR of approximately 46%. The payback period is approximately six years. For the analysis, all cash flows prior to 1 January 2021 are considered sunk.

Table 22.3 Production and cash flow results

Category	Units	Total			Annual Average		
		First 5 years	First 10 years	Project life	First 5 years	First 10 years	Project Life
Processing							
Total ore processed	Mt	199	403	1,228	40	40	40
Head grade - Cu	%	0.67	1.04	0.82	0.67	1.04	0.82
Head grade - Au	g/t	0.38	0.40	0.30	0.38	0.40	0.30
Head grade - Ag	g/t	1.7	2.4	1.9	1.7	2.4	1.9
Production							
Recovery - Cu	%	85	89	88	85	89	88
Recovery - Au	%	71	74	71	71	74	71
Recovery - Ag	%	64	74	69	64	74	69
Concentrate	Mt	4.2	12	31	0.8	1.2	1.0
Cu in concentrate	Mt	1.1	3.7	8.8	0.23	0.37	0.29
Cu in concentrate	Billion lb	2.5	8.3	19	0.50	0.83	0.63
Au in concentrate	Moz	1.7	3.9	8.4	0.35	0.39	0.27
Ag in concentrate	Moz	6.9	23	52	1.4	2.3	1.7
Cu Concentrate grade	%	27	32	28	27	32	28
Au Concentrate grade	g/t	13	10	8.4	13	10	8.4
Ag Concentrate grade	g/t	52	60	52	52	60	52
Payable metal							
Cu payable metal	Mt	1.1	3.6	8.5	0.22	0.36	0.27
Cu payable metal	Billion lb	2.4	8.0	19	0.48	0.80	0.61
Au payable metal	Moz	1.7	3.8	8.0	0.34	0.38	0.26
Ag payable metal	Moz	6.2	20	46	1.2	2.0	1.5
Financial Summary							
Net revenue	$ billion	8.3	25.4	58.1	1.7	2.5	1.9
Operating surplus before tax	$ billion	4.0	17.0	34.1	0.8	1.7	1.1
Net cash flow after tax	$ billion	(0.4)	10.8	22.9	(0.1)	1.1	0.7
Cash costs							
C1 Cash Costs (total)	$ billion	2.5	5.4	18.9	0.5	0.5	0.6
C1 Cash Costs (unit)	$/lb	0.99	0.65	0.97	0.99	0.65	0.97

Table 22.4 Capital expenditure and financial results

Category	Units	Project life
Capital Expenditure		
Development Capital	$ billion	2.2
Sustaining Capital	$ billion	5.5
Total	$ billion	7.8
Financial Results		
Net Present Value (8%)	$ billion	10.0
Internal Rate of Return	%	46
Payback	Years	6

22.5.1 Cash costs

C1 cash cost[24] (total and per pound of copper produced), presented in Table 22.3 and Table 22.5, is a metric representing the cash cost and per unit cash cost of extracting and processing the principal metal product, copper, to a condition in which it may be delivered to customers, net of gold and silver credits from concentrates sold. This metric is provided in order to support peer group comparability and to provide investors and other stakeholders with additional information about the underlying cash costs of the Oyu Tolgoi mine and the impact of gold and silver credits on the operation's cost structure. C1 cash costs are relevant to understanding the Project's operating profitability and ability to generate cash flow. When calculating costs associated with producing a pound of copper, gold and silver revenues are deducted, as the production cost is reduced by selling these products.

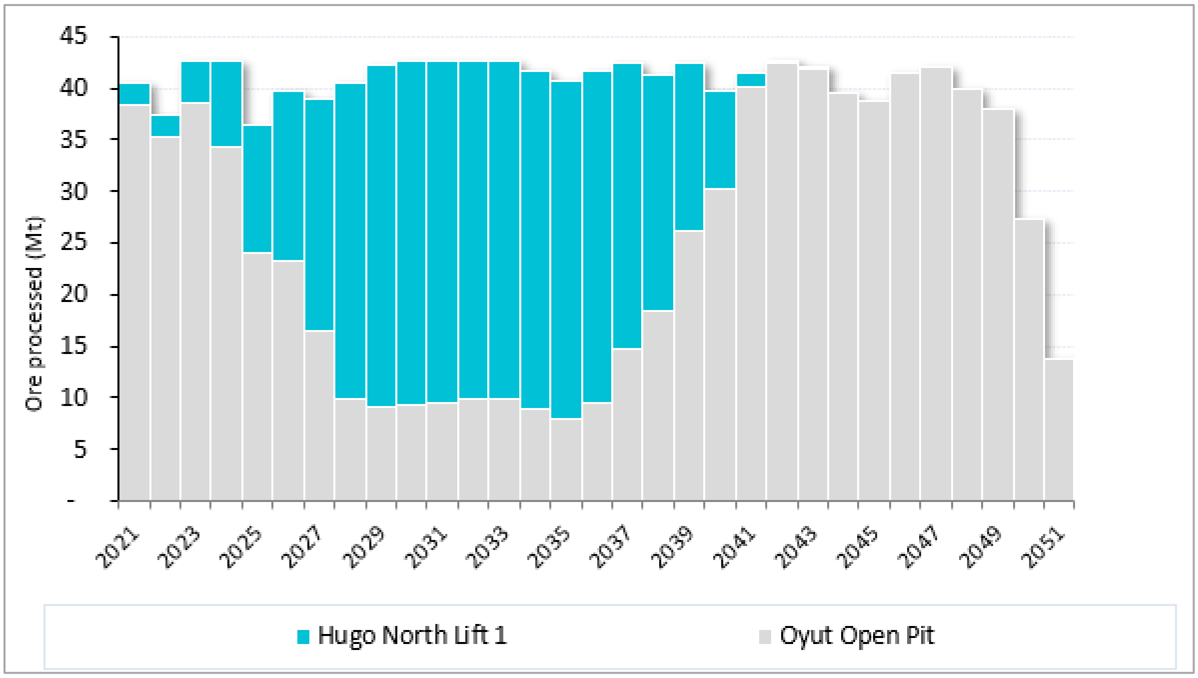
22.5.2 Contained metal production and cash flow

Figure 22.1 presents the ore processed by source, annually over the Project life, and Figure 22.2 presents the copper contained in concentrate (before payability factors are applied) by source, annually over the Project Life. Hugo North Lift 1 ultimately provides most of the copper produced while the Oyut pit supplies most of the ore to be processed.

Figure 22.3 presents the concentrate production profile along with contained copper and gold production annually over the mine life, and Figure 22.4 presents the Project net cash flows after tax annually as well as on a cumulative basis.

[24] C1 cash costs are a non-GAAP (Generally Accepted Accounting Principles) measure (i.e. not defined by International Financial Reporting Standards (IFRS)). It is presented in order to provide investors and other stakeholders with an additional understanding of performance and operations at the Oyu Tolgoi mine and is not intended to be used in isolation form, or as a replacement for, measures prepared in accordance with IFRS

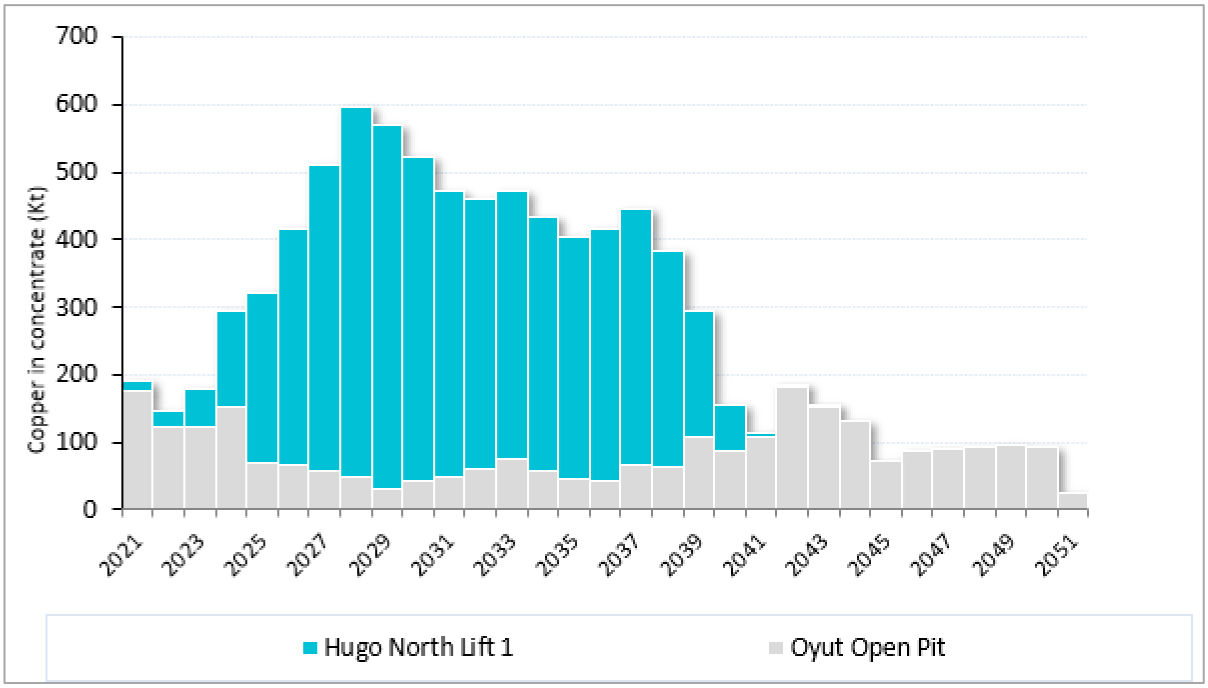
Figure 22.1 Ore processed by ore source



Source: AMC from TRQ data. Date: 8 August 2020.

Note: Amounts are rounded and exclude any impacts of Covid-19 and are subject to further study and assessment as part of Oyu Tolgoi LLC's cost and schedule estimation update which is expected later in 2020 and subject to further study and analysis on Panels 1 and 2.

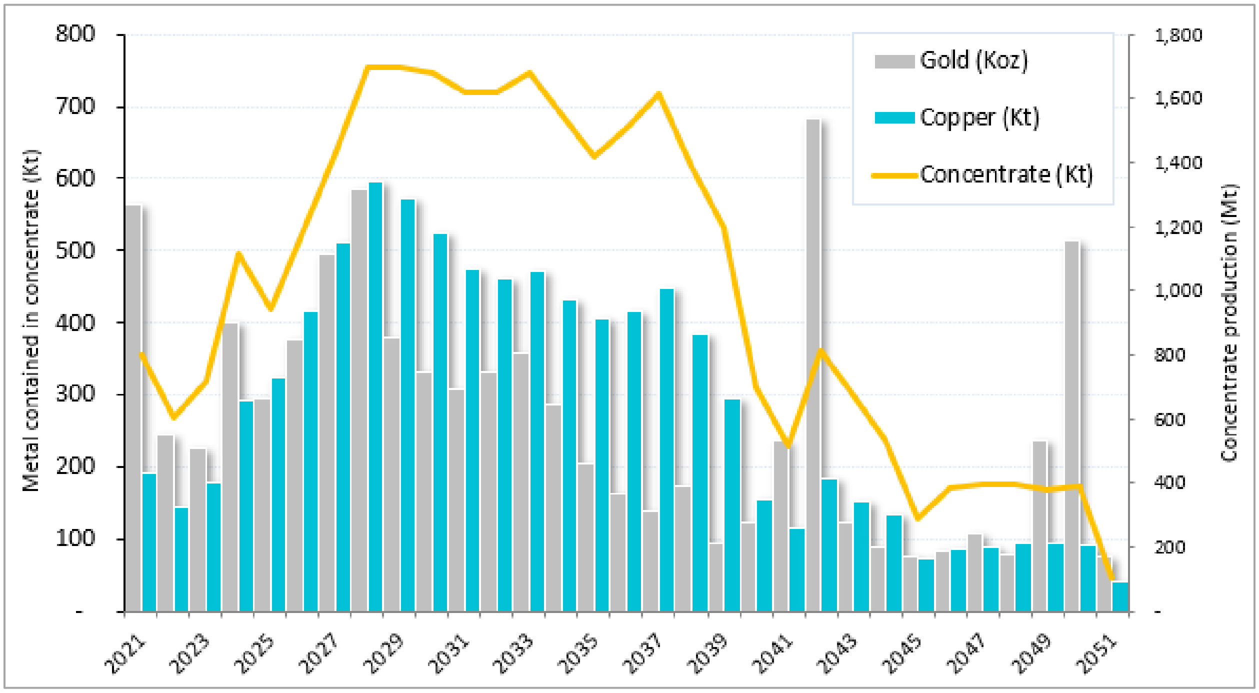
Figure 22.2 Copper in concentrate by ore source



Source: AMC from TRQ data. Date: 8 August 2020.

Note: Amounts are rounded and exclude any impacts of Covid-19 and are subject to further study and assessment as part of Oyu Tolgoi LLC's cost and schedule estimation update which is expected later in 2020 and subject to further study and analysis on Panels 1 and 2.

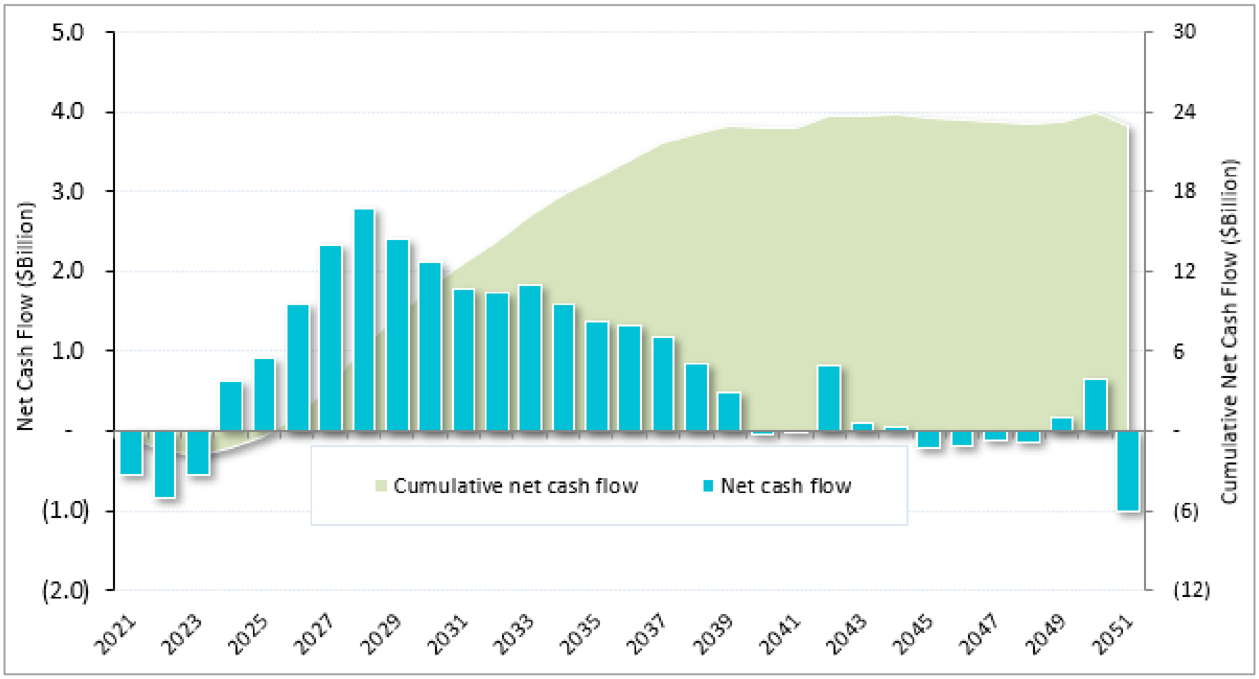
Figure 22.3 Concentrate production and contained metal in concentrate



Source: AMC from TRQ data. Date: 8 August 2020.

Note: Amounts are rounded and exclude any impacts of Covid-19 and are subject to further study and assessment as part of Oyu Tolgoi LLC's cost and schedule estimation update which is expected later in 2020 and subject to further study and analysis on Panels 1 and 2.

Figure 22.4 Cumulative cash flow



Source: AMC from TRQ data. Date: 8 August 2020.

Note: Amounts are rounded and exclude any impacts of Covid-19 and are subject to further study and assessment as part of Oyu Tolgoi LLC's cost and schedule estimation update which is expected later in 2020 and subject to further study and analysis on Panels 1 and 2.

Table 22.5 Statement of cash flows (100% project basis)

	Units	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036
Operating Summary																	
Ore milled	Mt	40	37	43	43	36	40	39	40	42	43	43	43	43	42	41	42
Cu Grade	%	0.57%	0.48%	0.52%	0.82%	0.98%	1.16%	1.43%	1.60%	1.49%	1.36%	1.24%	1.21%	1.25%	1.16%	1.09%	1.11%
Au Grade	g/t	0.59	0.30	0.25	0.41	0.34	0.39	0.51	0.57	0.36	0.32	0.30	0.32	0.35	0.29	0.21	0.17
Ag Grade	g/t	1.5	1.4	1.4	1.9	2.4	2.6	3.0	3.4	3.2	2.9	2.7	2.6	2.6	2.4	2.4	2.2
Cu Recovery	%	84%	81%	80%	84%	90%	91%	92%	92%	91%	90%	90%	89%	89%	89%	92%	90%
Au Recovery	%	74%	67%	65%	72%	74%	75%	77%	79%	78%	76%	75%	75%	75%	74%	74%	70%
Ag Recovery	%	59%	55%	59%	67%	72%	76%	80%	81%	80%	79%	77%	76%	75%	75%	72%	74%
Concentrate Sold	Mt	0.8	0.6	0.7	1.1	0.9	1.2	1.4	1.7	1.7	1.7	1.6	1.6	1.7	1.5	1.4	1.5
Cu Grade in Concentrate	%	24%	24%	25%	26%	34%	35%	36%	35%	34%	31%	29%	28%	28%	28%	29%	28%
Au Grade in Concentrate	g/t	22.0	12.5	9.8	11.2	9.8	9.9	10.8	10.7	6.9	6.1	5.9	6.4	6.6	5.8	4.5	3.4
Ag Grade in Concentrate	g/t	44	46	48	48	68	66	65	66	65	59	55	52	50	48	49	45
Recoverable Cu in Concentrate	Mt	0.19	0.14	0.18	0.29	0.32	0.42	0.51	0.60	0.57	0.52	0.47	0.46	0.47	0.43	0.40	0.41
Recoverable Au in Concentrate	Moz	0.56	0.24	0.23	0.40	0.30	0.38	0.50	0.58	0.38	0.33	0.31	0.33	0.36	0.29	0.21	0.16
Recoverable Ag in Concentrate	Moz	1.1	0.9	1.1	1.7	2.1	2.5	3.0	3.6	3.5	3.2	2.9	2.7	2.7	2.4	2.2	2.2
Payable Cu in Concentrate	**Mt**	**0.18**	**0.14**	**0.17**	**0.28**	**0.31**	**0.40**	**0.49**	**0.58**	**0.55**	**0.51**	**0.46**	**0.44**	**0.46**	**0.42**	**0.39**	**0.40**
Payable Cu in Concentrate	**Billion lb**	**0.41**	**0.31**	**0.38**	**0.62**	**0.69**	**0.89**	**1.09**	**1.27**	**1.22**	**1.12**	**1.01**	**0.98**	**1.00**	**0.92**	**0.86**	**0.88**
Payable Au in Concentrate	**Moz**	**0.55**	**0.24**	**0.22**	**0.39**	**0.28**	**0.36**	**0.48**	**0.57**	**0.36**	**0.32**	**0.29**	**0.31**	**0.34**	**0.27**	**0.19**	**0.15**
Payable Ag in Concentrate	**Moz**	**1.0**	**0.8**	**1.0**	**1.6**	**1.8**	**2.3**	**2.7**	**3.2**	**3.2**	**2.9**	**2.6**	**2.4**	**2.4**	**2.2**	**2.0**	**2.0**
Gross Revenue	$ millions	2,031	1,254	1,439	2,482	2,533	3,265	4,050	4,739	4,272	3,895	3,530	3,474	3,588	3,221	2,928	2,931
Realization Costs[1]	$ millions	269	202	243	397	376	480	587	691	662	630	587	581	601	548	502	521
Net Sales Revenue	$ millions	1,763	1,052	1,196	2,084	2,157	2,785	3,463	4,048	3,611	3,265	2,943	2,893	2,986	2,673	2,425	2,410
Site Operating Costs																	
Mining	$ millions	186	204	221	179	214	234	228	209	256	271	270	272	300	289	276	248
Processing and Tailings	$ millions	258	255	265	288	266	263	265	259	276	277	266	278	278	264	251	257
Infrastructure	$ millions	99	101	103	102	94	92	91	91	92	92	92	92	92	92	89	90
G&A and Other	$ millions	98	95	94	94	92	85	85	85	85	85	82	82	82	82	82	82
Total Site Operating Costs		**641**	**655**	**683**	**663**	**665**	**675**	**669**	**645**	**708**	**724**	**709**	**724**	**752**	**726**	**698**	**677**
C1 Cash Costs	*$/lb*	*0.13*	*1.82*	*1.76*	*0.79*	*0.88*	*0.63*	*0.39*	*0.27*	*0.58*	*0.70*	*0.79*	*0.82*	*0.82*	*0.92*	*1.00*	*1.02*
Operating Cash Flow before Indirect Costs and Tax	$ millions	1,121	396	514	1,421	1,492	2,110	2,794	3,403	2,902	2,541	2,234	2,169	2,234	1,947	1,727	1,733
Indirect Costs[2]	$ millions	201	187	195	180	169	166	150	155	166	173	190	215	233	205	169	145
Operating Cash Flow before tax	$ millions	920	210	319	1,242	1,323	1,944	2,644	3,248	2,736	2,368	2,044	1,954	2,002	1,742	1,558	1,588
Income Tax	$ millions	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Operating Cash Flow after tax	$ millions	**920**	**210**	**319**	**1,242**	**1,323**	**1,944**	**2,644**	**3,248**	**2,736**	**2,368**	**2,044**	**1,954**	**2,002**	**1,742**	**1,558**	**1,588**
Capital Expenditure[3]																	
Development Capital	$ millions	1,015	591	421	215	20	-	-	-	-	-	-	-	-	-	-	-
Sustaining Capital	$ millions	437	437	449	346	356	321	298	388	253	206	227	194	151	89	100	128
Deferred Stripping Costs	$ millions	31	8	3	64	41	37	23	90	77	35	34	40	32	53	96	145
Total Capital Expenditure	$ millions	**1,483**	**1,035**	**873**	**625**	**417**	**358**	**321**	**478**	**330**	**240**	**260**	**234**	**183**	**142**	**196**	**273**
Working Capital	$ millions	(10)	7	(1)	(3)	1	(4)	(4)	(7)	3	3	1	(0)	(2)	3	1	(2)
Closure[4]	$ millions	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Subtotal	$ millions	(10)	7	(1)	(3)	1	(4)	(4)	(7)	3	3	1	(0)	(2)	3	1	(2)
Net Cash Flow After Tax[5]	$ millions	**(553)**	**(833)**	**(553)**	**620**	**904**	**1,589**	**2,327**	**2,777**	**2,403**	**2,125**	**1,783**	**1,720**	**1,820**	**1,597**	**1,362**	**1,316**

	Units	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	Total
Operating Summary																	
Ore milled	Mt	42	41	42	40	41	43	42	39	39	41	42	40	38	27	14	**1,228**
Cu Grade	%	1.17%	1.03%	0.79%	0.45%	0.36%	0.55%	0.46%	0.40%	0.25%	0.29%	0.29%	0.31%	0.32%	0.42%	0.25%	**0.82%**
Au Grade	g/t	0.15	0.19	0.11	0.15	0.26	0.68	0.17	0.12	0.12	0.12	0.14	0.12	0.29	0.77	0.12	**0.30**
Ag Grade	g/t	2.3	2.1	1.6	1.1	1.1	1.3	1.3	1.1	0.9	0.9	1.07	0.95	1.11	1.34	0.95	**1.89**
Cu Recovery	%	90%	90%	88%	86%	76%	79%	78%	83%	74%	73%	73%	76%	79%	80%	74%	**88%**
Au Recovery	%	68%	69%	60%	63%	67%	74%	55%	56%	50%	51%	54%	50%	67%	76%	49%	**71%**
Ag Recovery	%	73%	73%	64%	56%	53%	62%	48%	44%	44%	46%	49%	44%	51%	64%	43%	**69%**
Concentrate Sold	Mt	1.6	1.4	1.2	0.7	0.5	0.8	0.7	0.5	0.3	0.4	0.4	0.4	0.4	0.4	0.2	**31**
Cu Grade in Concentrate	%	28%	28%	25%	22%	22%	23%	22%	25%	25%	23%	23%	24%	25%	24%	24%	**28%**
Au Grade in Concentrate	g/t	2.7	3.9	2.4	5.5	14.3	26.1	5.7	5.2	8.2	6.7	8.3	6.1	19.5	41.0	13.3	**8.4**
Ag Grade in Concentrate	g/t	43	46	36	35	46	42	38	37	56	47	55.5	42.5	57.5	60.4	50.1	**52**
Recoverable Cu in Concentrate	Mt	0.45	0.38	0.30	0.15	0.11	0.18	0.15	0.13	0.07	0.09	0.09	0.09	0.09	0.09	0.04	**8.8**
Recoverable Au in Concentrate	Moz	0.14	0.17	0.09	0.12	0.24	0.68	0.12	0.09	0.08	0.08	0.11	0.08	0.24	0.51	0.08	**8.4**
Recoverable Ag in Concentrate	Moz	2.3	2.0	1.4	0.8	0.7	1.1	0.8	0.6	0.5	0.6	0.7	0.5	0.7	0.8	0.3	**52**
Payable Cu in Concentrate	**Mt**	**0.43**	**0.37**	**0.28**	**0.15**	**0.11**	**0.18**	**0.14**	**0.13**	**0.07**	**0.08**	**0.09**	**0.09**	**0.09**	**0.09**	**0.04**	**8.5**
Payable Cu in Concentrate	**Billion lb**	**0.95**	**0.82**	**0.63**	**0.33**	**0.24**	**0.39**	**0.32**	**0.28**	**0.15**	**0.18**	**0.19**	**0.20**	**0.20**	**0.19**	**0.09**	**19**
Payable Au in Concentrate	**Moz**	**0.12**	**0.16**	**0.08**	**0.12**	**0.23**	**0.67**	**0.12**	**0.08**	**0.07**	**0.08**	**0.10**	**0.07**	**0.23**	**0.50**	**0.07**	**8.0**
Payable Ag in Concentrate	**Moz**	**2.0**	**1.8**	**1.2**	**0.7**	**0.7**	**1.0**	**0.7**	**0.6**	**0.5**	**0.5**	**0.6**	**0.5**	**0.6**	**0.7**	**0.3**	**46**
Gross Revenue	$ millions	3,093	2,743	2,041	1,174	1,074	2,171	1,151	986	577	675	730	718	958	1,338	383	**69,446**
Realization Costs[1]	$ millions	558	484	396	224	178	309	222	184	99	128	134	134	142	166	62	**11,299**
Net Sales Revenue	$ millions	2,535	2,259	1,646	950	897	1,861	929	802	478	547	596	584	816	1,173	321	**58,147**
Site Operating Costs																	
Mining	$ millions	289	219	361	342	287	282	235	235	21	164	134	181	138	69	29	**6,844**
Processing and Tailings	$ millions	248	253	249	239	247	252	258	245	228	246	238	246	228	169	119	**7,730**
Infrastructure	$ millions	90	89	92	88	88	88	54	54	54	54	54	54	54	54	54	**2,525**
G&A and Other	$ millions	82	82	79	78	78	78	46	46	46	46	46	46	46	46	46	**2,279**
Total Site Operating Costs		**709**	**644**	**781**	**746**	**699**	**698**	**594**	**580**	**350**	**510**	**472**	**527**	**466**	**338**	**248**	**19,377**
C1 Cash Costs	*$/lb*	*1.05*	*1.01*	*1.65*	*2.53*	*2.41*	*0.07*	*2.06*	*2.35*	*2.44*	*3.06*	*2.57*	*2.95*	*1.44*	*(1.21)*	*3.09*	***0.97***
Operating Cash Flow before Indirect Costs and Tax	$ millions	1,826	1,615	864	203	198	1,163	335	222	128	37	124	57	349	834	73	**38,769**
Indirect Costs[2]	$ millions	152	142	150	142	132	130	117	112	84	103	98	104	91	69	110	**4,636**
Operating Cash Flow before tax	$ millions	1,675	1,474	714	61	66	1,033	218	110	44	(67)	26	(47)	258	765	(37)	**34,133**
Income Tax	$ millions	216	313	128	-	-	166	19	-	-	-	-	-	-	29	-	**870**
Operating Cash Flow after tax	$ millions	**1,459**	**1,160**	**586**	**61**	**66**	**868**	**199**	**110**	**44**	**(67)**	**26**	**(47)**	**258**	**736**	**(37)**	**33,263**
Capital Expenditure[3]																	
Development Capital	$ millions	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**2,262**
Sustaining Capital	$ millions	160	122	85	95	78	60	108	62	61	71	71	62	47	42	38	**5,543**
Deferred Stripping Costs	$ millions	131	206	21	-	-	-	-	-	207	28	62	-	-	-	-	**1,462**
Total Capital Expenditure	$ millions	**291**	**328**	**106**	**95**	**78**	**60**	**108**	**62**	**268**	**98**	**133**	**62**	**47**	**42**	**38**	**9,266**
Working Capital	$ millions	(4)	2	5	7	2	(7)	6	2	3	(2)	(0)	(0)	0	1	18	**19**
Closure[4]	$ millions	-	-	-	-	-	-	-	-	-	28	23	36	36	55	926	**1,104**
Subtotal	$ millions	(4)	2	5	7	2	(7)	6	2	3	26	22	36	36	56	944	**1,123**
Net Cash Flow After Tax[5]	$ millions	**1,171**	**830**	**475**	**(41)**	**(14)**	**814**	**85**	**46**	**(227)**	**(192)**	**(130)**	**(145)**	**175**	**638**	**(1,019)**	**22,873**

Notes to Table 22.5 Cash Flow:

1. Realization costs are inclusive of Government royalties, treatment and refining charges freight costs and penalties
2. Indirect costs are inclusive of operating cost VAT, management fees, property taxes and other fees
3. Capital expenditure is presented inclusive of associated VAT. Total capital in nominal terms is $2.3 billion in nominal terms as presented in Section 21.
4. Closure costs incurred after the period of analysis (2051) are presented on a present value basis in 2051.
5. Net cash flow after tax is exclusive of any expenses related to financing
6. Net cash flow after tax is presented on a pre-finance basis. TRQ's disclosed incremental funding requirement of $3.6 billion incorporates principal repayments of $1.9 billion and interest and similar charges of $1.1 billion. Refer the TRQ's 16 July 2020 press release.
7. Totals and subtotals may not sum due to rounding.
8. Amounts are rounded and exclude any impacts of Covid-19 and are subject to further study and assessment as part of Oyu Tolgoi LLC's cost and schedule estimation update which is expected later in 2020 and subject to further study and analysis on Panels 1 and 2.

22.6 Sensitivity Analysis

A sensitivity analysis has been carried out to assess the impact of the following assumptions on the after tax NPV and IRR:

- Discount rate.
- Commodity prices (Cu and Au).
- Head grade (Cu and Au).
- Total capital.
- Development capital.
- Operating costs.

The sensitivity of the Project after-tax NPV to various discount rates is shown in Table 22.6.

Table 22.6 Discount rate sensitivity

Discount rate (%)	After tax ($ billion)
Undiscounted	23.9
5	13.6
6	12.3
7	11.1
8	10.0
9	9.0
10	8.2
11	7.4
12	6.7

The sensitivity of the financial results to a range of copper and gold prices, is shown in Table 22.7 and Table 22.8. The following price sensitivities are run with the copper and gold price of each scenario as constant in all years.

Table 22.7 Sensitivity of after-tax NPV to changes in metal price

Copper price	Gold price						
	$900/oz	$1,100/oz	$1,300/oz	$1,500/oz	$1,700/oz	$1,900/oz	$2,100/oz
$2.00/lb	0.36	1.05	1.74	2.42	3.11	3.80	4.48
$2.25/lb	2.30	2.98	3.67	4.36	5.05	5.73	6.42
$2.50/lb	4.23	4.92	5.61	6.29	6.98	7.67	8.35
$2.75/lb	6.17	6.85	7.54	8.23	8.92	9.53	10.11
$3.00/lb	8.10	8.78	9.38	9.97	10.62	11.16	11.76

$3.25/lb	9.82	10.42	11.01	11.62	12.21	12.76	13.35
$3.50/lb	11.48	12.07	12.64	13.21	13.78	14.40	14.93

Long-term silver price of 17.85 $/oz assumed for all cases.

Table 22.8 Sensitivity of after-tax IRR to changes in metal price

Copper price	Gold price						
	$900/oz	**$1,100/oz**	**$1,300/oz**	**$1,500/oz**	**$1,700/oz**	**$1,900/oz**	**$2,100/oz**
$2.00/lb	10	13	16	19	22	25	29
$2.25/lb	17	20	23	26	29	32	36
$2.50/lb	23	26	29	32	36	40	45
$2.75/lb	29	32	36	39	44	48	55
$3.00/lb	35	39	42	47	52	59	67
$3.25/lb	42	46	50	56	62	71	83
$3.50/lb	49	53	59	66	76	89	110

Long-term silver price of 17.85 $/oz assumed for all cases.

Table 22.9 presents sensitivities on an after-tax basis for NPV8 and Table 22.10 presents sensitivities on an after-tax basis for IRR for a range of key inputs. It provides copper and gold sensitivities where only the long-term price is impacted for each. It also presents the impact of other key sensitivities (e.g. head-grade for copper and gold as well as various cost categories).

Table 22.9 NPV8 sensitivities

Item	Item Sensitivity Range				
Long-term copper price ($/lb) After tax NPV8 ($ billions)	2.80 8.7	2.90 9.3	3.03 10.0	3.10 10.4	3.20 11.0
Longterm gold price ($/oz) After tax NPV8 ($ billions)	1,275 9.6	1,375 9.8	1,473 10.0	1,575 10.2	1,675 10.4
Copper grade (± %) After tax NPV8 ($ billions)	-20% 5.5	-10% 7.9	0% 10.0	+10% 12.0	+20% 13.8
Gold grade (± %) After tax NPV8 ($ billions)	-20% 9.1	-10% 9.5	0% 10.0	+10% 10.5	+20% 10.9
Operating cost (± %) After tax NPV8 ($ billions)	-20% 11.6	-10% 10.8	0% 10.0	+10% 9.2	+20% 8.3
Capital cost (± %) After tax NPV8 ($ billions)	-20% 10.9	-10% 10.5	0% 10.0	+10% 9.5	+20% 9.1
Expansion capital (± %) After tax NPV8 ($ billions)	-20% 10.4	-10% 10.2	0% 10.0	+10% 9.8	+20% 9.6

Table 22.10 IRR sensitivities

Item	Item Sensitivity Range				
Longterm copper price ($/lb) **After tax IRR (%)**	**2.80** **42%**	**2.90** **44%**	**3.03** **46%**	**3.10** **47%**	**3.20** **49%**
Longterm gold price ($/oz) **After tax IRR (%)**	**1,275** **44%**	**1,375** **45%**	**1,473** **46%**	**1,575** **47%**	**1,675** **47%**
Copper grade (± %) **After tax IRR (%)**	**-20%** **29%**	**-10%** **37%**	**0%** **46%**	**+10%** **56%**	**+20%** **67%**
Gold grade (± %) **After tax IRR (%)**	**-20%** **39%**	**-10%** **42%**	**0%** **46%**	**+10%** **50%**	**+20%** **54%**
Operating cost (± %) **After tax IRR (%)**	**-20%** **58%**	**-10%** **51%**	**0%** **46%**	**+10%** **41%**	**+20%** **37%**
Capital cost (± %) **After tax IRR (%)**	**-20%** **64%**	**-10%** **53%**	**0%** **46%**	**+10%** **40%**	**+20%** **36%**
Expansion capital (± %) **After tax IRR (%)**	**-20%** **54%**	**-10%** **50%**	**0%** **46%**	**+10%** **43%**	**+20%** **40%**

23 Adjacent properties

No adjacent properties are significant to the Oyu Tolgoi Project.

24 Other relevant data and information

24.1 Oyu Tolgoi Mineral Resource potential

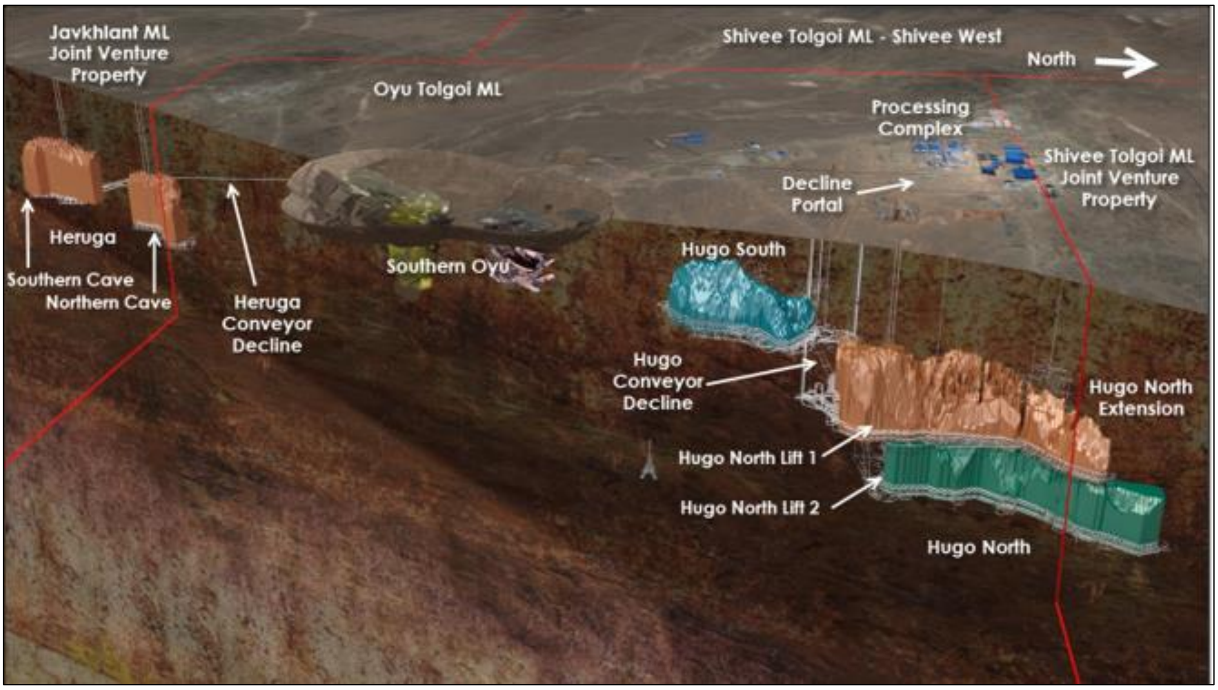
Significant Mineral Resources have been identified on the five mining licences that make up the Project that have not been converted to mineral reserves. These include the part of the Hugo North deposit not included in the Lift 1 mining plan, the Hugo South deposit, the Heruga deposit, and the part of the Oyut deposit below the open pit. The Mineral Resource estimates for these deposits are reported in Section 14.

The Mineral Resources within these deposits are almost entirely classified as Inferred Mineral Resources, thus there is significant uncertainty about their geological and geotechnical properties and the economic and legal feasibility of their exploitation. There is no assurance that Inferred Mineral Resources will ever be upgraded to a higher resource classification or converted to Mineral Reserves.

Plans have been developed for further exploration and evaluation of these Mineral Resources and concepts for their development have been envisaged by Oyu Tolgoi LLC. The following sections describe these development concepts.

The conceptual arrangements that are preliminary in nature for developing the Oyu Tolgoi Mineral Resources are shown in Figure 24.1.

Figure 24.1 Concepts for developing Oyu Tolgoi Mineral Resources

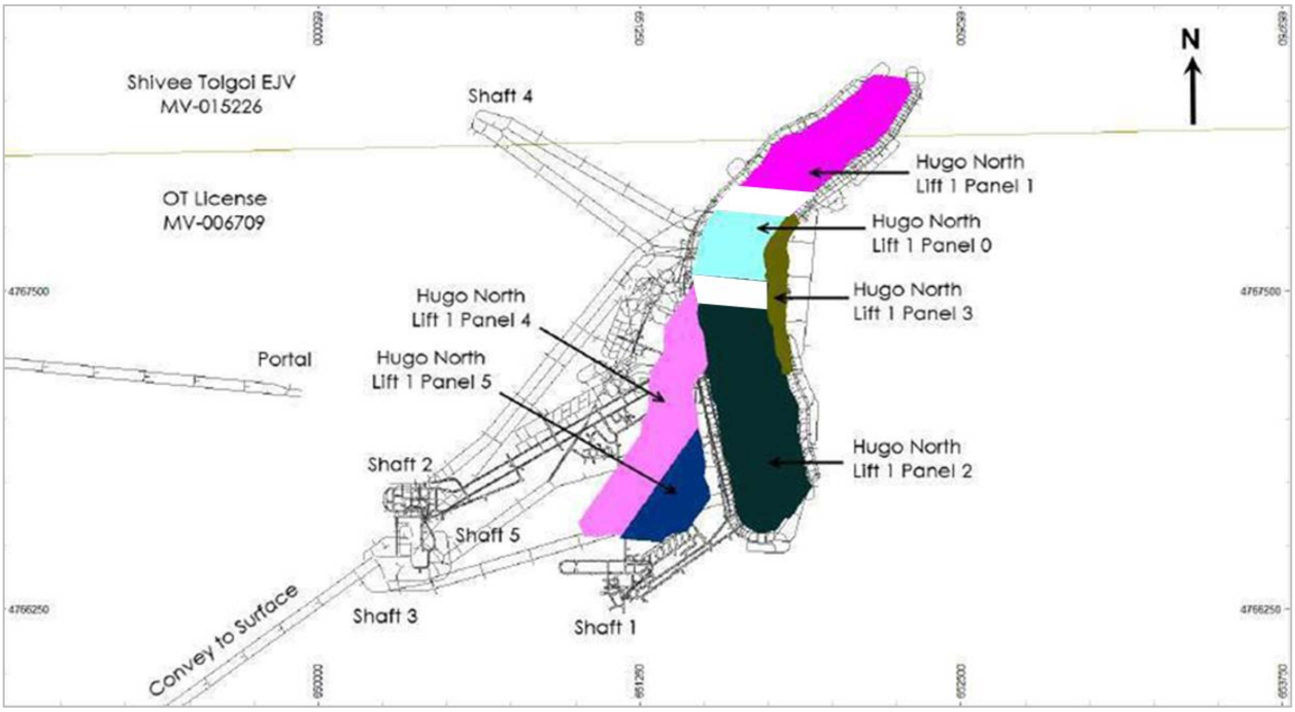


Source: 2020 Feasibility Study Date: 23 July 2020
Note: Pillars on Hugo North Lift 1 are not shown

24.1.1 Hugo North Lift 1 extensions

There may be potential at Hugo North to develop three low-grade panels (Panels 3, 4, and 5) on the same elevation as Lift 1. The relative positions of these conceptual panels are shown in Figure 24.2. Panel 3 would be a narrow panel on the eastern side of Panels 0 to 2. Mining of Panel 3 would need to be completed before the underlying Hugo North Lift 2 area could be mined. Panels 4 and 5 are located on the western side of Lift 1. If developed, the panels would be able to use the Lift 1 materials handling and support infrastructure.

Figure 24.2 Conceptual arrangement of for mining Panels 3, 4, and 5 at Hugo North



Source: 2016 Technical Report. Date: October 2016.
Note: The layout for mining Hugo North Panels 3, 4, and 5 are conceptual in nature

24.1.2 Hugo North Lift 2

Hugo North Lift 2 would be the vertical continuation of the high-grade core of the Hugo North deposit. Three possible extraction level elevations have been considered for Lift 2: 300 m, 400 m, and 500 m below Lift 1. Studies indicate that the preferred extraction level would be 400 m below Lift 1, approximately 1,700 m below surface.

The conceptual arrangement for mining the Hugo North Lift 2 area is shown in Figure 24.3. Access to the Lift 2 mining area is anticipated to be via a decline system from Lift 1, an extension to Shaft 4, and internal ventilation shafts or raises to provide ventilation. Ore would be crushed, and then conveyed to surface via a two-leg extension to the Lift 1 incline conveyor system. It is envisaged that Hugo North Lift 2 could be mined at a similar production rate to Lift 1.

24.1.3 Hugo South

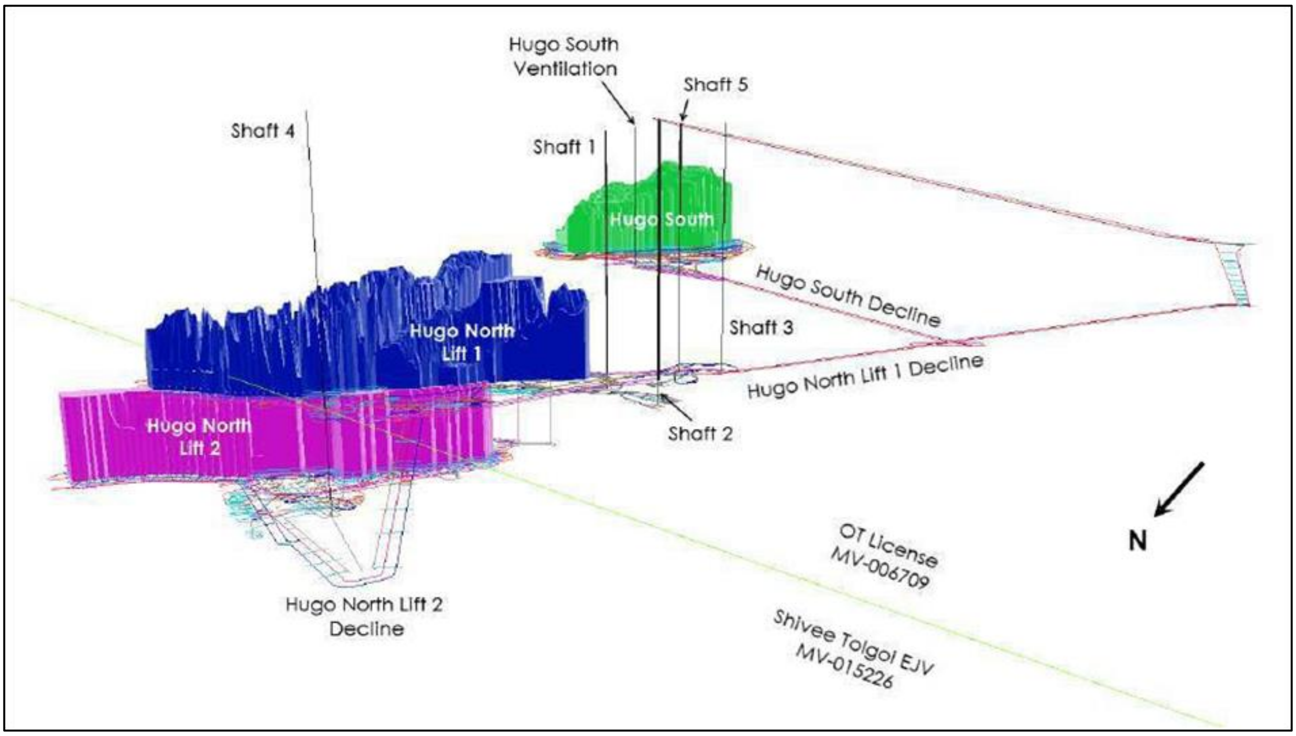
It is envisaged that the Hugo South could be mined using a similar caving method to that proposed for Hugo North. The conceptual arrangement for mining the Hugo South deposit is shown in Figure 24.3.

The approximate elevation of the extraction level for Hugo South could be 520 m RL, approximately 650 m below surface. It is envisaged that Hugo South could be mined in four caving panels, with an average height of draw of 300 m.

A 1.5 km long conveyor would be required to transfer material onto the Lift 1 incline conveyor system. A drive parallel to the conveyor would provide the primary access to the mining area. A single exhaust shaft would be required to support the initial construction effort. In the longer term, parallel lateral ventilation drives connecting Hugo South with Shafts 3 and 5 could provide the remaining ventilation capacity as production from Hugo North ramps down.

It is envisaged that material from Hugo South could be processed in the Oyu Tolgoi concentrator.

Figure 24.3 Conceptual arrangements for developing Hugo North and Hugo South deposits



Source: 2016 Technical Report. Date October 2016.
Note: The layout for mining Lift 2 and Hugo South are conceptual in nature. Pillars on Hugo North Lift 1 are not shown

24.1.4 Heruga

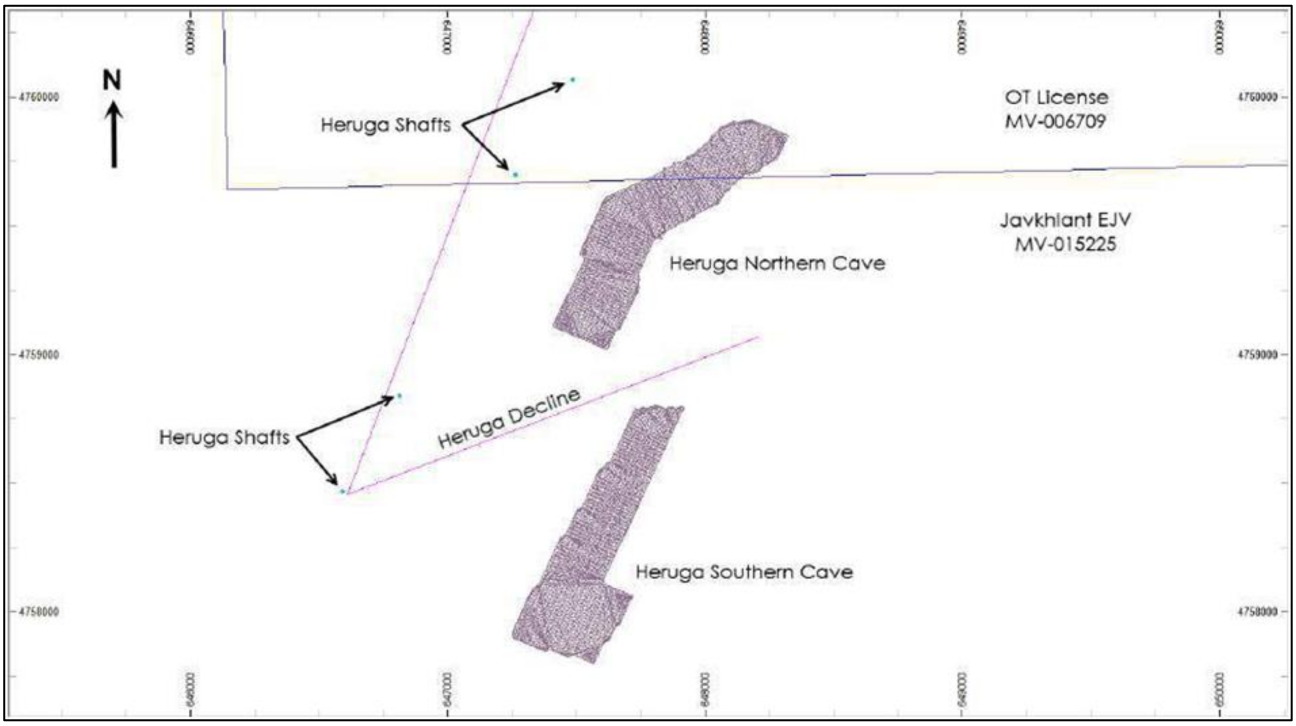
The top of the Heruga Mineral Resource is approximately 500 m below surface and considered too deep for open-pit mining. The deposit is low grade and has a large extent and could potentially be mined using similar caving methods to Hugo North Lift 1.

The Heruga deposit contains molybdenum as a secondary metal that could possibly be recovered to a molybdenum concentrate by adding a molybdenum recovery circuit to the Oyu Tolgoi concentrator. Heruga mineralization is harder than the Hugo North mineralization, which will require modification to the concentrator comminution circuit to achieve the same throughput rate as Hugo North Lift 1 ore.

It is envisaged that the Heruga deposit could be mined in two separate caving areas: a northern cave and a southern cave (Figure 24.1). The northern cave would have a footprint elevation at approximately 350 m RL (820 m below surface). The footprint of the southern cave would be at about -20 m RL (1,200 m below surface). Individual underground crushing and associated infrastructure including ventilation shafts would be required for each caving area with a shared conveying system to surface.

The conceptual arrangement for mining the Heruga deposit is shown in Figure 24.4.

Figure 24.4 Conceptual arrangement for mining the Heruga deposit



Source: 2016 Technical Report. Date October 2016.
Note: The layout for mining Heruga are conceptual in nature.

24.1.5 Oyut deposit

The Oyut deposit has four target areas for potential underground mining beneath the planned open pit. The Oyut deposit extends at depth beneath the planned open pit and may be amenable to extraction via underground mining methods.

24.1.6 Conceptual development sequence

Several scheduling and sequencing scenarios exist for developing the Oyu Tolgoi Mineral Resources. The deposits could be mined and processed through the Oyu Tolgoi concentrator in a sequence that prioritizes the higher-grade deposits.

An alternative development scenario would be to increase the capacity of the Oyu Tolgoi concentrator and, where technically and economically possible, mine some deposits in parallel. In both scenarios, the grade of material mined would progressively decrease as the higher-grade deposits are depleted.

Further work will be required in future to investigate the most appropriate scenario for developing the Mineral Resources at Oyu Tolgoi that have not yet been converted to mineral reserves.

25 Interpretation and conclusions

25.1 Summary of relevant results

25.1.1 Overview

The initial investment decision to construct Phase 1 of Oyu Tolgoi was made in 2010. Phase 1 consisted of developing the Oyut open pit mine, concentrator and supporting infrastructure. These facilities are complete, and first concentrate was exported from Phase 1 of the Project in October 2013. Phase 1 mining and processing operations are ongoing and are meeting or exceeding the performance objectives of the initial investment decision, with industry leading productivity from haul truck and other performance metrics.

Part of the initial investment decision included continued investment on Phase 2, the development of the Hugo North Lift 1 underground mine and modifying the concentrator and Project infrastructure to enable simultaneous processing of ore from Oyut open pit and Hugo North underground mine. The decision to resume Phase 2 was made in 2016, and the Hugo North underground mine development is now at an advanced stage, with actual expenditure of over US$3.4 billion to 31 December 2019, and with a further $3.4 billion forecast to be required to complete the Phase 2 scope of the underground capital works. The completed work includes commissioning of Shaft 2, which incorporates one of the world's largest production winders.

The Oyu Tolgoi Project is in a remote area of Mongolia which has necessitated the establishment of supporting infrastructure including power connection to the grid, water supply, all-weather airport, and accommodation camp. The surface infrastructure to support the Phase 1 operation is complete. Only minor additions to the infrastructure facilities are required in Phase 2, and establishment of these is well advanced.

25.1.2 Agreements and permits

TRQ's interest in the Project is held through its 66% interest in Oyu Tolgoi LLC, which together with Entrée LLC holds the Oyu Tolgoi mining licences on which the Project is being developed. The mining licences provide rights to the holders to explore, develop mining infrastructure, and conduct mining operations at Oyu Tolgoi. The three Oyu Tolgoi mining licences have 30-year terms from 23 December 2003, the Shivee Tolgoi Licence and the Javkhlant Licence each have 20-year terms from 27 October 2009. Each of the five mining licences has two 20-year extensions.

TRQ has entered into agreements with the Government of Mongolia, Rio Tinto, and other parties in respect of the development and operation of the Project.

Activities related to the Project must be carried out in accordance with these agreements and the laws of Mongolia. As of the date of this 2020 Technical Report, material permits and authorizations necessary to develop and operate the Project have been obtained.

25.1.3 Oyut open pit

The Oyut open pit is a low-grade copper gold open pit operation with a current production rate of approximately 40 Mtpa and a planned remaining overall waste to ore strip ratio of 2.3 to 1. Mining is carried out using conventional drill, blast, load, and haul methods and is conducted 24 hours per day, 365 days per year.

Mining has proceeded generally in accordance with the mine plan developed in 2012 and as reported in the 2016 Technical Report, However, the pit phase design and sequence has been updated since 2012 and now represent a more optimised approach to mining.

The current production rate from the Oyut open pit is planned to continue until 2023, after which it will be progressively reduced as production increases from Hugo North underground. Open pit mining will then continue in parallel with Hugo North Lift 1 until the Mineral Reserves in Lift 1 are depleted. Production from the Oyut open pit will then be increased to meet mill capacity until open pit mining and recovery of the associated stockpiles is complete.

25.1.4 Hugo North development

The Lift 1 Panels are designed to extract the high-grade core of the Hugo North deposit and the Mineral Resources therein have been converted to a Mineral Reserve. The extraction level for Lift 1 is approximately 1,300 m below surface. Concepts have been developed for a potential further extraction level, Lift 2, about 400 m below Lift 1.

Inferred Mineral Resources associated with Lift 2, and some lower grade Inferred Mineral Resources above the Lift 1 footprint elevation, have not yet been sufficiently explored and evaluated to convert them to Mineral Reserves. Mineral Resources are not Mineral Reserves and do not have demonstrated economic viability. As mining and more detailed exploration from surface and underground drill sites continues, upgrading the Mineral Resource classifications in Lift 2 and in the lower grade areas above the Lift 1 elevation is envisaged.

A total of five shafts are planned to access the Hugo North Deposit and of these, three shafts have been completed (two for access and one for exhaust ventilation). Construction of the final two ventilation shafts (Shaft 3 intake ventilation and Shaft 4 exhaust ventilation) has commenced. A decline conveyor system from surface to the underground crushing system is being developed. Two underground crushers are planned to crush ore from Lift 1. One crusher (Crusher 1) is under construction. Construction of the second crusher (Crusher 2), which will be required as production from Lift 1 increases, is yet to commence.

Production operations are planned to commence in Panel 0 and progress into Panel 2 and later into Panel 1. Development of Panel 0 is well advanced with development ongoing on the extraction, undercut, and apex levels.

Development of Panel 0, combined with detailed geotechnical drilling and analysis, has identified greater structural complexity in Panel 0 than was originally anticipated in the 2016 Feasibility Study. The increased structural complexity has necessitated the redesign of aspects of Panel 0 and Lift 1 to increase confidence in the planned performance of the caving operation. The redesign includes leaving two 120 m wide pillars, one separating Panel 0 from Panel 1 and a second separating Panel 0 from Panel 2.

The redesign of Panel 0 includes relocating ore passes, ventilation raises, and access crosscuts that are critical to the successful operation of Panel 0 from their original positions to more secure positions within the two pillars. Several other changes have also been made to the design and sequencing of Panel 0 to reduce the impact of the more complex structural environment now known to exist in Panel 0.

Had the mining of Panel 0 progressed as envisaged in the 2016 Feasibility Study, a large part of the Mineral Reserves in Panel 0 may not have been recoverable and the planned production rate from the panel may not have been achievable. The delays associated with managing the difficult mining conditions in Panel 0 could have also slowed the development of Panels 1 and 2.

The pillars between the three panels provide the opportunity to optimise the design of Panels 1 and 2 to best suit the geology, geotechnical characteristics, and economic return of each panel. Work is ongoing to extend the detailed geotechnical drilling and structural investigations into Panels 1 and 2, and by the end of 2021, the planned data collection program for these panels will be complete and studies well advanced. Studies are also ongoing to evaluate design options for Panels 1 and 2 and into methods for recovering mineral resources within the pillars. These studies are investigating the possibility of changing the footprint elevation of Panels 1 and 2 to optimise the value of the Project.

An iterative process has been used to develop the key completion dates for the underground project. Construction activities, such as conveyor installations, are linked to the excavation schedule to determine dates when construction sites become available. In turn, construction durations and completion dates are feedback into the excavation schedules.

Key completion dates were initially estimated by deterministic scheduling methods using scheduling software. The deterministic schedules were then subjected to a semi-quantitative risk analysis (SQRA) process to assess the probability of the dates being achieved. The SQRA analysis generally extended the key deterministic milestone dates by approximately five months.

Subject to any delays arising from the COVID-19 pandemic, Sustainable Production is expected to occur in February 2023, followed by a six-year production build up to a maximum underground production rate of 33 Mtpa.

25.1.5 Oyu Tolgoi concentrator

The Oyu Tolgoi concentrator uses conventional crushing, grinding, and froth flotation technology. The Phase 1 concentrator had an initial nameplate capacity of 32 Mtpa. Annual throughput has progressively increased as a result of operating experience and minor plant modifications such that annual production rates exceeding 40 Mtpa have been achieved.

Because of its higher grade, ore from Hugo North will be fed to the concentrator in preference to ore from the Oyut open pit. Mining from the open pit will continue in parallel with Hugo North Lift 1 to keep the Oyu Tolgoi concentrator operating at its maximum capacity.

Modifications to the concentrator (Phase 2) to process the combined production from the Hugo North and Oyut deposits required installation of an additional ball mill, additional rougher and cleaner flotation equipment, and additional concentrate thickening, filtering, and handling facilities.

The concentrator currently produces copper concentrate with a grade of approximately 22% from the Oyut open pit. Copper recovery and concentrate grades are forecast to increase as production increases from Hugo North where the mineralization is more favourable to achieving higher recoveries and to the production of higher-grade concentrates (above 30% Cu), making it more attractive to customers for blending with lower grade concentrates sourced from elsewhere.

The copper concentrate, which contains significant gold credits, is sold to smelters in China on commercial terms that are generally consistent with the international trade in copper concentrates.

25.1.6 Infrastructure

Most surface infrastructure facilities that are required for the open pit, underground and concentrator operations have been constructed and are operational.

25.1.7 Capital and operating costs

Capital expenditure on Phase 1 is complete except for a requirement to complete minor outstanding road works.

The remaining capital required to complete Phase 2 includes all expenditure from 1 January 2021 required to design, develop, and construct the permanent facilities required to bring the Hugo North mine into production.

Actual capital expenditure on Phase 2 from 1 January 2015 until 31 December 2019 was approximately \$3.4 billion, and a further \$3.4 billion (including 2020 development capital expenditure of \$1.2 billion[25]) is forecast to be required to complete the Phase 2 scope of work.

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[25] As the base date for the cost estimates is Qtr1 2020, this amount excludes any impacts of Covid-19. As a result, it differs from TRQ's 2020 underground capital guidance, which was revised to a range of \$1.0 billion to \$1.1 billion in its May 13, 2020 press release.

The total sustaining capital estimate over the life of the Project from 1 January 2021 is estimated at $5.5 billion, expressed in 2020 US dollars based on fixed exchange rates. The costs are un-escalated.

25.1.8 Economic performance

The results of the economic analysis of the Oyu Tolgoi Mineral Reserves is an after-tax net present value at a discount rate of 8% (NPV8) of $10.0 billion. The analysis also exhibits an after-tax IRR of around 46% and a payback period of around six years (including interest and similar costs on the existing project finance facility). The analysis is assessed as at 1 January 2021. The analysis demonstrates the mineral reserves to be value generative with respect to the remaining required capital investment and the underlying assumptions discussed in Section 22.

The sensitivity analysis showed the project is most sensitive to the change in copper prices and copper head-grade. This analysis show that the project is also highly sensitive to the change in gold prices and gold head-grade. Finally, the analysis indicated the project is only moderately sensitivity to changes in operating costs, development capital and total capital costs (sustaining and development capital costs combined).

25.1.9 Development of undeveloped mineral resources.

Since filing the 2016 Technical Report, the primary focus of Oyu Tolgoi LLC has been to develop the mineral reserves of Lift 1 (Panels 0, 1, and 2). No substantive work has been carried out to upgrade or further evaluate the Inferred Mineral Resources at Hugo North, Hugo South or Heruga.

25.2 Risks

Due to its nature and location, the Project is subject to many legal, commercial, and political risks associated with the agreements with Rio Tinto, the sovereign government of Mongolia, and other entities. Although, as of the date of this 2020 Technical Report, all material permits and authorizations have been obtained for the work being carried out at Oyu Tolgoi, there is a risk that delays in granting future permits required to develop or operate some aspects of the Project may delay overall Project completion.

The key technical risks to the Project are summarised in the following sections.

25.2.1 Oyut open pit performance

The Oyut open pit has a good performance history but faces similar risks to those risks faced by other well-established open pit mining operations. Approximately 40% of the Oyut open pit Mineral Reserve has a Proven Mineral Reserve classification, and the risk that the open pit will not perform as envisaged is low.

25.2.2 Oyu Tolgoi concentrator performance

Oyu Tolgoi concentrator has an established history of improving metallurgical performance but faces similar risks to those risks faced by other similar well-established concentrators. The mineralogy and forecast metallurgical response of the Hugo North mineral reserves has been comprehensively investigated and the planned modifications to the concentrator involves installation of similar equipment to that already installed and operational. The risk that the concentrator will not perform as envisaged when processing the planned blend of ore from the open pit and underground mining operations is low. The risk is further mitigated by the slow build-up in ore feed to the concentrator from Hugo North, which provides ample time to adjust plant operations to optimise metallurgical performance.

25.2.3 Hugo North Mineral Reserve estimate

There is a risk that despite a conservative estimate of the premature loss of drawpoints in areas of Panel 0 affected by the lower fault splay and the premature closure of other drawpoints, the impact of faulting on rock mass strength could be more significant, and mining induced stress levels higher than expected. Ore recovery could therefore be less than anticipated.

There is a risk that detailed geotechnical drilling into Panels 1 and 2 may reveal more complex fault structures than has currently been interpreted This may require design of additional pillars in Lift 1. This risk could be mitigated by the results of the ongoing studies to optimise the design of Panels 1 and 2 and recovering mineral resources in the Panel 0 pillars.

Modifying factors applied within the PCBC modeling process may not adequately reflect the actual cave propagation process or the actual movement of rock within caved muck pile. The Probable rather than Proven classification applied to the Mineral Reserve estimate reflects this uncertainty. The consequence could be that dilution from low-grade or unmineralized material enters drawpoints earlier than expected causing their premature closure.

25.2.4 Hugo North underground mine development

The main technical risks to the development of the Hugo North underground mine relate to the timing and cost of completing the development work and achieving the planned production build-up. These risks are summarised below.

- The start of undercutting in Panel 0 depends on commissioning Crusher 1 and the associated materials handling system to Shaft 2. COVID-19 related delays in progressing aspects of the construction of Crusher 1 and the materials handling system could delay the start of undercutting and the start of Sustainable Production.
- In addition to the need to commission the Crusher 1 materials handling system, the dates for commencing undercutting and drawbell blasting for Panel 0 are determined by the rate at which the extraction, undercut, apex, and haulage levels can be developed. The dates are also dependent on the timely construction of the drawpoints, ore passes, and truck loading chutes. These development and construction activities are closely integrated. There is a risk that localised poor ground conditions could delay critical activities. This risk has been partly mitigated by relocation of the ore passes and by simplifying the ore pass design. The application of a semi-quantitative risk analysis (SQRA) process to assess the probability of achieving the key dates also mitigates the risk that the key dates will not be achieved.
- Although reasonable allowances have been made in the development scheduling process for difficult to manage ground conditions, the undercutting and drawbell construction process in Panel 0 may be delayed if rock mass conditions and mining induced stress levels are more challenging than expected. This risk can be mitigated by careful monitoring of rock mass conditions as development progresses and by contingency planning. Plans are in place to install a comprehensive rock mass monitoring system, including a seismic system, to minimise the risk to personnel and to the operation.
- COVID-19 related delays to sinking activities in Shafts 3 and 4, are unlikely to adversely impact the key milestone dates for Panel 0, but could impact the ability to extend the footprint development into Panels 1 and 2 because of limited ventilation until these shafts are commissioned.
- There is a risk that the production build-up in Panels 1 and 2 will be slowed if geotechnical conditions in the initial undercutting area of these Panels is less favourable than is currently anticipated. Geotechnical drilling is being carried out to better understand this risk and develop mitigation strategies.
- Because of COVID-19 related delays or other unforeseen factors, there is a risk that the capital estimate to complete the Phase 2 underground development scope of work will be higher than forecast.

- There is a risk that sustaining capital and operating costs for the Hugo North underground operation will be higher than estimated due to geotechnical related risk associated with high stress and faulting. This may increase the cost of ground support and of rehabilitating drawpoints, extraction drives, ore passes, and other footprint related excavations. However, the risk of sustaining capital and operating costs being significantly higher than estimated is mitigated by the allowances for geotechnical risk related costs included in the estimate and by an established history of actual mining labour, materials, and equipment costs developed during the construction period since 2016.
- Power costs represent a significant portion of the operating costs for both the concentrator and the underground mine. Because agreements relating to the cost of the long-term power supply to the Project have yet to be finalised, there is a risk that future power costs will be higher than estimated.
- Forecast operating costs for open pit mining and for concentrator operations are based on seven years of actual operating experience and thus estimates of the required quantities of labour, fuel, explosives, and spare parts etc have a much lower uncertainty than would be the case when estimating quantities from first principles for a new project. However, the residual risk of increases to labour and commodity prices still exists.

25.3 Impact of technical and cost risks in the economic viability of the Project

The technical risks relating to the Hugo North underground mine described above could result in increases in development capital, sustaining capital, and operating costs. However, as indicated by the economic analysis in Section 22, the impact of the reasonably foreseeable cost increases that might result from these risks and uncertainties do not affect the potential economic viability of the Project.

The sensitivity analysis in Section 22.6 indicates that the Project NPV is most sensitive to changes in copper prices and copper head-grade, and to a lesser extent to changes in gold prices and gold head-grade. However, the NPV of the Project remains strongly positive at lowest long-term metal prices used in the sensitivity analysis.

26 Recommendations

This section provides an overview of the main work program recommended for the Project. Many of the programs are ongoing, and their cost is included in the development capital and operational budgets.

26.1 Open pit mining

The following work is recommended relating to the Oyut open pit:

- Continue geotechnical data gathering and investigations into the potential for steepening the pit walls.

26.2 Underground mining

The following work is recommended relating to the Hugo North underground project:

- Update the Hugo North project development and construction schedule, and the remaining capital expenditure estimate to increase confidence in the accuracy of the forecast Project completion date and cost estimate.
- Carry out further detailed implementation planning for Panel 0 to reduce construction schedule and operational risks. This includes simulation work to sequence and schedule development and production activities focusing on interaction and congestion management.
- Implement the planned real-time cave monitoring program prior to start of undercutting to monitor the ground reaction from undercut initiation. Proceed with preparation for installing equipment to acquire high-quality seismic data from Hugo North Lift 1.
- Investigate methods to increase the performance of construction activities associated with the installation of Crusher 1 and the associate materials handling system and sinking of Shafts 3 and 4. Construction of these facilities is currently being delayed by COVID-19 restrictions and are likely to be on the critical path.
- 72 km of drilling in Hugo North Panels 1 and 2 is planned of which 30 km has been approved for geotechnical assessments of Lift 1 at a cost of $20 million. The objective of the study is to apply the lessons learned from Panel 0 to the remainder of the footprint, considering the updated geological and geotechnical information acquired from the drilling program.
- Continue to investigate design options for Panels 1 and 2 using the learnings from redesign of Panel 0 and the additional geotechnical data collected from the further drilling program. The studies should include options for optimising the elevation of the Panels 1 and 2 footprints and methods for recovering mineral resources in the pillars.
- Carry out exploration drilling from surface and underground drill sites focused on upgrading the Mineral Resource classifications in Lift 2 and in the lower grade areas above the Lift 1 footprint elevation.
- Continue on-going assessments of methods to reduce impacts of COVID-19 on critical path development projects including use of remote visualisation for specific technical tasks and options for in-country habitation for critical staff and contractors.

26.3 Oyu Tolgoi concentrator

The following work is recommended relating to the Oyu Tolgoi concentrator and is envisaged to be covered by the Operations budget:

- Testwork on samples from the open pit and Hugo North should continue to confirm the proposed flowsheet and specifications for upgrading the Oyu Tolgoi concentrator. This includes further testing and evaluation to confirm the need for a third concentrate thickener.

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Certificate of Author

I, Michael Jeremy Thomas, Higher National Diploma (Mining), of Brisbane, Queensland, Australia, do hereby certify that:

- This certificate applies to the technical report titled “Oyu Tolgoi 2020 Technical Report”, with an effective date of 30 June 2020, (the “Technical Report”) prepared for Turquoise Hill Resources Ltd. (“the Issuer”);
- I am currently employed as a Principal Mining Consultant with AMC Consultants Pty Ltd with an office at Level 21, 179 Turbot Street, Brisbane, Queensland, Australia;
- I graduated from Glamorgan Polytechnic, United Kingdom in 1973 with a Higher National Diploma (Mining). I am a Fellow and a Chartered Professional in good standing of the Australasian Institute of Mining (110904).
- My professional mining experience included 47 years in various roles in the mining industry, including over 10 years operating, designing, and evaluating mines using caving mining methods similar those proposed for the Oyu Tolgoi project.
- I have read the definition of "qualified person" set out in National Instrument 43-101 – *Standards of Disclosure for Mineral Projects* (NI 43-101) and certify that by reason of my education, affiliation with a professional association (as defined in NI 43-101) and past relevant work experience, I fulfil the requirements to be a "qualified person" for the purposes of NI 43-101;
- I have not visited the Oyu Tolgoi Project;
- I am responsible for Sections 1 (co-author), 2, 3, 5, 12.2, 12.3, 13, 15, 16, 17, 18 (except 18.6), 19, 20, 24, 25, 26 (co-author), of the Technical Report;
- I am independent of the Issuer applying all of the tests in Section 1.5 of NI 43-101;
- I have not had prior involvement with the property that is the subject of the Technical Report;
- I have read NI 43-101, and the parts of the Technical Report for which I am responsible have been prepared in compliance with NI 43-101 and Form 43-101F1;

As of the effective date of the Technical Report and the date of this certificate, to the best of my knowledge, information and belief, the parts of the Technical Report for which I am responsible contain all scientific and technical information that is required to be disclosed to make the Technical Report not misleading.

Effective Date: 30 June 2020
Signing Date: 28 August 2020

”Michael Thomas” [signed and sealed]
Michael Thomas, Higher National Diploma (Mining), FAusIMM (CP)

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Certificate of Author

I, Roderick David Carlson, BSc, MSc., of Brisbane, Queensland, Australia, do hereby certify that:

- I am currently employed as a Principal Consultant with AMC Consultants Pty Ltd with an office at Level 21, 179 Turbot Street, Brisbane, Queensland, Australia;
- This certificate applies to the technical report titled “Oyu Tolgoi 2020 Technical Report”, with an effective date of 30 June 2020, (the “Technical Report”) prepared for Turquoise Hill Resources Ltd. (“the Issuer”);
- I am a graduate of University of Canberra in Canberra, Australia (Bachelors of Science (Geology) in 1987) and University of Western Australia (Masters of Science (Ore Deposit Geology and Evaluation) in 1998). I am a member and registered professional geologist in good standing of the Australian Institute of Geoscientists (RPGeo License #10,122), and a member of the Australasian Institute of Mining and Metallurgy. I have experience in sampling, QA/QC, resource estimation and porphyry copper-gold deposit styles.
- I have read the definition of "qualified person" set out in National Instrument 43-101 – *Standards of Disclosure for Mineral Projects* (NI 43-101) and certify that by reason of my education, affiliation with a professional association (as defined in NI 43-101) and past relevant work experience, I fulfil the requirements to be a "qualified person" for the purposes of NI 43-101;
- I have not visited the Oyu Tolgoi Project;
- I am responsible for Sections 1 (co-author), 4, 7, 8, 9, 10, 11, 12 (co-author), 14 (co-author), and 27 of the Technical Report;
- I am independent of the Issuer applying all of the tests in Section 1.5 of NI 43-101;
- I have not had prior involvement with the property that is the subject of the Technical Report;
- I have read NI 43-101, and the parts of the Technical Report for which I am responsible have been prepared in compliance with NI 43-101 and Form 43-101F1;

As of the effective date of the Technical Report and the date of this certificate, to the best of my knowledge, information and belief, the parts of the Technical Report for which I am responsible contain all scientific and technical information that is required to be disclosed to make the Technical Report not misleading.

Effective Date: 30 June 2020
Signing Date: 28 August 2020

”Roderick Carlson” [signed and sealed]

Roderick Carlson, BSc, MSc, MAIG (RPGeo Mining and Exploration), MAusIMM

TURQUOISE HILL

Certificate of Author

I, Jo-Anne Dudley, B.E. Mining (Hons), Grad Cert (Technology Management) of Brisbane, Queensland, Australia, do hereby certify that:

- I am currently employed as a Chief Operating Officer at Turquoise Hill Resources Ltd. (the "Issuer") with an office at Suite 3680, 1 Place Ville-Marie, Montreal, Quebec, Canada, H3B 3P2;
- This certificate applies to the technical report titled "Oyu Tolgoi 2020 Technical Report", with an effective date of 30 June 2020, (the "Technical Report") prepared for the Issuer;
- I am a graduate of University of New South Wales in Sydney, Australia (Bachelors of Engineering (Mining) in 1994) and Deakin University (Graduate Certificate (Technology Management) in 2000). I am a Chartered Professional and member in good standing of the Australasian Institute of Mining and Metallurgy (FAusIMM (CP), Member 110635) and a Registered Professional Engineer in Queensland (RPEQ 15627). I have experience porphyry copper-gold deposit mineral reserve estimation and reconciliation as well as underground, caving and open pit mining.
- I have read the definition of "qualified person" set out in National Instrument 43-101 – *Standards of Disclosure for Mineral Projects* (NI 43-101) and certify that by reason of my education, affiliation with a professional association (as defined in NI 43-101) and past relevant work experience, I fulfil the requirements to be a "qualified person" for the purposes of NI 43-101;
- I have visited the Oyu Tolgoi Project in January 2019, March 2019, July 2019 and 24 September 2019;
- I am responsible for Sections 6, 12.1, 18.6, 21, 22 and 26 (co-author);
- I am not independent of the Issuer applying the tests in Section 1.5 of NI 43-101;
- I have have been involved with the Oyu Tolgoi Project since January 2010 in my previous roles as Manager Mine Design, Senior Manager Strategic Mine and Resources planning of **Rio Tinto Limited** and in my current role as Chief Operating Officer of the Issuer;
- I have read NI 43-101, and the parts of the Technical Report for which I am responsible have been prepared in compliance with NI 43-101 and Form 43-101F1;

As of the effective date of the Technical Report and the date of this certificate, to the best of my knowledge, information and belief, the parts of the Technical Report for which I am responsible contain all scientific and technical information that is required to be disclosed to make the Technical Report not misleading.

Effective Date: 30 June 2020
Signing Date: 28 August 2020

"Jo-Anne Dudley" [signed and sealed]

Jo-Anne Dudley, B.E. (Mining), FAusIMM (CP), RPEQ 15627.

TURQUOISE HILL

Certificate of Author

I, Racquel Mae Kolkert, BSc, Hons., of Brisbane, Queensland, Australia, do hereby certify that:

- This certificate applies to the technical report titled “Oyu Tolgoi 2020 Technical Report”, with an effective date of 30 June 2020, (the “Technical Report”) prepared for Turquoise Hill Resources Ltd. (“the Issuer”);
- I am currently employed as Director of Resources and Exploration for the Issuer;
- I graduated from the University of Tasmania, Australia in 1988 with a Bachelor of Science and First Class Honours (Geology). I am a registered member (CP) in good standing of the Australasian Institute of Mining and Metallurgy (No. 113101);
- My experience includes 21 years in mine geology, exploration and resource estimation, including over 10 years in the evaluation and mining of porphyry deposits.
- I have read the definition of "qualified person" set out in National Instrument 43-101 – *Standards of Disclosure for Mineral Projects* (NI 43-101) and certify that by reason of my education, affiliation with a professional association (as defined in NI 43-101) and past relevant work experience, I fulfil the requirements to be a "qualified person" for the purposes of NI 43-101;
- I have not visited the Oyu Tolgoi Project;
- I am responsible for the following sections of this Technical Report; Sections 1 (co-author), 14 (co-author) and 23 of the Technical Report;
- I am not independent of the Issuer applying the tests in Section 1.5 of NI 43-101;
- I have not had prior involvement with the property that is the subject of the Technical Report;
- I have read NI 43-101, and the parts of the Technical Report for which I am responsible have been prepared in compliance with NI 43-101 and Form 43-101F1;

As of the effective date of the Technical Report and the date of this certificate, to the best of my knowledge, information and belief, the parts of the Technical Report for which I am responsible contain all scientific and technical information that is required to be disclosed to make the Technical Report not misleading.

Effective Date: 30 June 2020
Signing Date: 28 August 2020

”*Racquel Kolkert” [signed and sealed]*

Racquel Kolkert, BSc (Hons), MAusIMM (CP)

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