APPENDIX 1-E

Underground Geotechnical Design

Red Mountain Project: Rock Geotechnical Feasibility Level Assessment

Prepared for

IDM Mining Ltd.

Prepared by

SRK Consulting (Canada) Inc.
2CI017.001
July 2017

Red Mountain Project: Rock Geotechnical Feasibility Level Assessment

July 2017

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List of Abbreviations

ATV – Acoustic Televiewer
AZ – Azimuth
CF – Conversion Factor
ELOS – Equivalent Linear Overbreak/Slough
ESR – Excavation Support Ratio
IRS – Intact Rock Strength
ISRM – International Society for Rock Mechanics
K – Horizontal to Vertical Stress Ratio
LiDAR – Light Detection and Ranging
OTV – Optical Televiewer
PLT – Point Load Test
RMR – Rock Mass Rating
RQD – Rock Quality Designation
SRF – Stress Reduction Factor
TCR – Total Core Recovery
UCS – Unconfined Compressive Strength
TCS – Triaxial Compressive Strength

1 Introduction

SRK conducted field investigations at the Red Mountain project site to characterize the structural and rock mass conditions, and undertook the appropriate analysis of the proposed underground mine and infrastructure design in support of a feasibility level study. The geotechnical assessment focused on the three primary ore bodies, namely Marc, AV, and JW, which were targeted during the 2016 drill program.

The interpreted geotechnical data was used to establish a three-dimensional structural model and representative geotechnical domains. These were used in stability assessments and to develop geotechnical design guidelines and support recommendations.

The Red Mountain gold deposit is located approximately 18 km east of the town of Stewart, British Columbia (Figure 1.1). Mine access is located at the top of a cirque, near the top of the mountain. The project is accessible by helicopter only.

The Project utilizes a mine-grid reference system, where the orientation of mine-grid north is 45º west of true north. This report will follow the same convention.

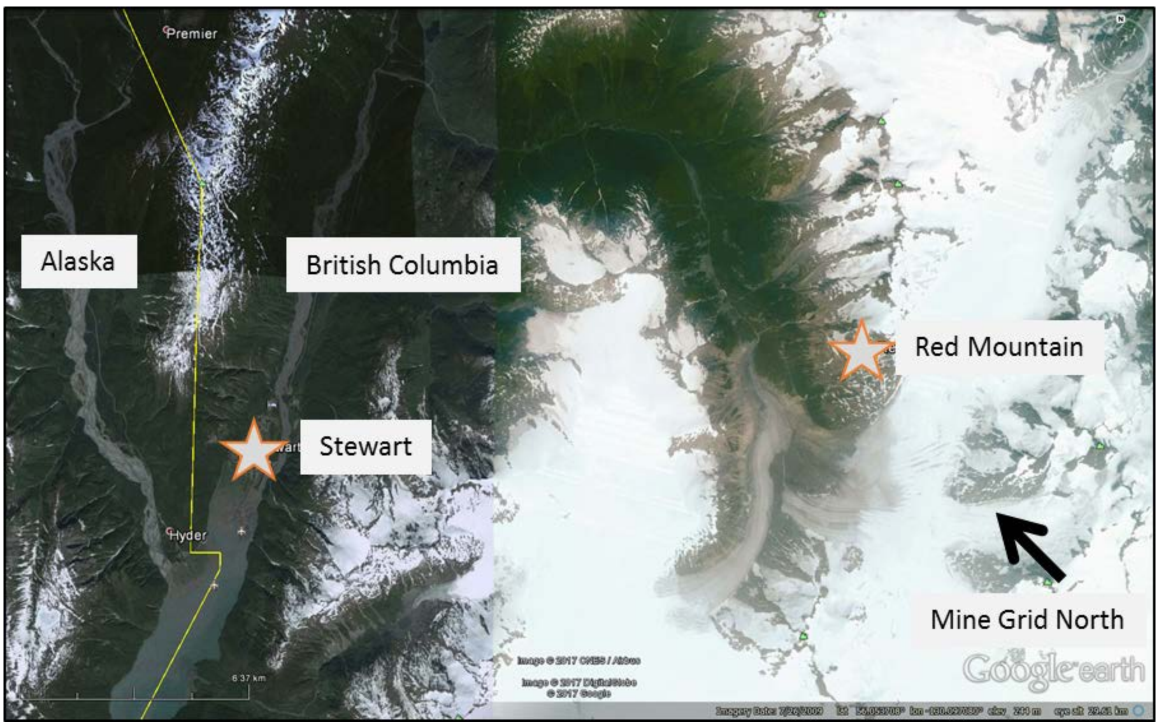

Figure 1.1: Project location.

To achieve the objectives of the study, a number of tasks were completed as described below. These tasks form the basis for the geotechnical report.

Project Background – The background geology and structural setting have been reviewed and considered during the geotechnical assessment.

Previous Work and Data Sources – Historical data relevant to the geotechnical study and previous assessments have been reviewed, and considered for the geotechnical study.

Development of Drilling Program – A geotechnical drilling program comprised of 11 drillholes was developed to assess the range of ground conditions and identify potential adverse fault structures. The geotechnical program was planned in conjunction with the resource infill drilling program and hydrogeological investigation. Downhole geophysical surveys were carried out on one drillhole to verify the orientation of discontinuity features.

Core Sampling and Testing – Field sampling and testing of core have been conducted for the determination of representative physical rock properties. The field testing was supplemented by laboratory testing including unconfined compressive strength tests (UCS) and triaxial compressive tests (TCS).

Structural Geology Study – A 3-dimensional fault model was created for the Red Mountain project. The model is based on the integration of underground mapping data, geotechnical core logging from the resource drilling program, and topographic LiDAR data with direct observations made by SRK during the site visits.

Hydrogeology Study – SRK completed a hydrogeological assessment of the Red Mountain project to develop a hydrogeological characterization of the proposed underground mine. This includes life-of-mine groundwater ingress to the underground workings and an assessment of the risks associated with groundwater in the context of the mine design.

Data Interpretation and Evaluation – SRK has undertaken a comprehensive geotechnical assessment based on the historical database, and newly acquired data from the geotechnical drilling program and underground mapping of all accessible areas. Geotechnical domains were selected for each mineralized zone, and representative geotechnical parameters have been allocated to each domain for application in geotechnical design.

Geotechnical and Ground Support Design – The proposed mining methods and layouts were evaluated to define practical and technically sound inputs to the mine design. The various aspects were assessed and geotechnical design recommendations provided to promote excavation stability, safety of people, and optimal extraction. Numerical modelling using the discrete boundary element code Map3D was used to evaluate the sequence and mine design.

2 Geological Description

Red Mountain is considered a porphyry-hosted, high-sulphidation gold/silver pyritic stockwork deposit. The deposit is located near the western margin of the Stikine terrain, which comprises Middle and Upper Triassic clastic rocks of the Stuhini Group, Lower and Middle Jurassic volcanic and clastic rocks of the Hazelton Group, and Upper Jurassic sedimentary rocks of the Bowser Lake Group (Figure 2.1).

Intrusive rocks in the Red Mountain region range in age from Late Triassic to Eocene. The Stikine plutonic suite comprise Late Triassic calc-alkaline intrusions that are coeval with the Stuhini Group, whereas Early to Middle Jurassic plutons are considered coeval with the Hazelton Group, with associated economic implications for gold mineralisation such as seen at Red Mountain. Eocene intrusions of the Coast Plutonic Complex occur to the west and south of Red Mountain and are associated with high-grade silver-lead-zinc occurrences.

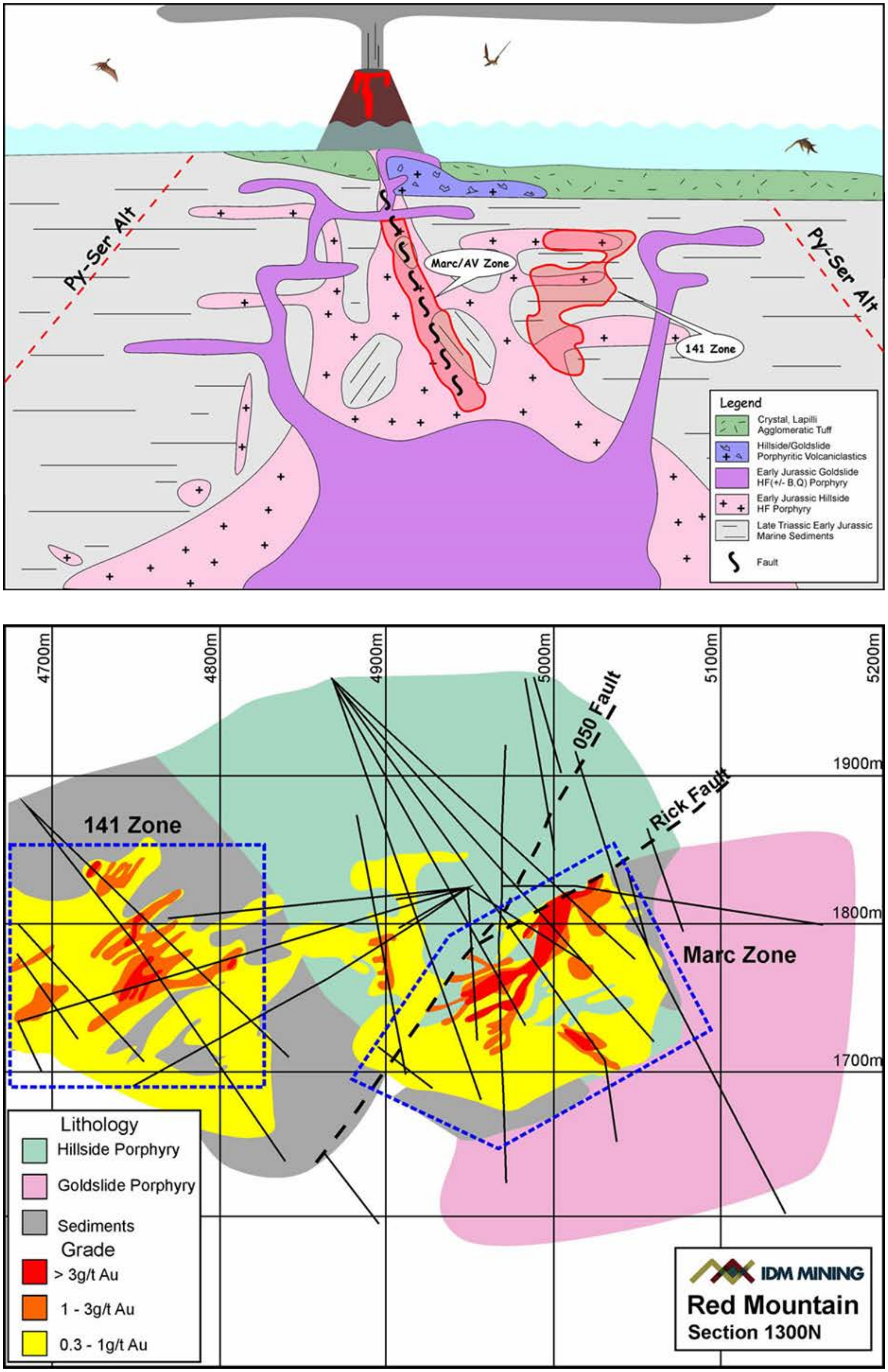

Figure 2.1: Conceptual geology of the Red Mountain deposit (from IDM Mining Ltd.).

The Red Mountain deposits lie at the core of the Bitter Creek antiform, a Cretaceous age, northwest-southeast trending structure that developed during deformation of the Stuhini, Hazelton and Bowser Lake groups from northeast-southwest directed regional stress.

Mineralised zones consist of crudely tabular, northwesterly trending and moderately to steeply southwesterly dipping gold and silver bearing iron sulphide stockworks. Pyrite is the predominant sulphide with pyrrhotite locally important. Stockwork zones are developed primarily within the Hillside porphyry and to a lesser extent in rafts of sedimentary and volcaniclastic rocks. Stockwork zones consist of pyrite micro-veins, coarse-grained pyrite veins, irregular coarse-grained pyrite masses and breccia matrix pyrite hosted in a pale, strongly sericite altered porphyry. Veins are very often heavily fractured or brecciated with infillings of fibrous quartz and calcite. Orientations of veins in the stockworks are variable; however, sets with northwesterly trends and moderate to steep northeasterly and southwesterly dips have been identified in underground workings.

Five major mineralized zones are currently recognised, the Marc, AV, JW, 141, and 132 zone. These typically consist of E-W trending and moderately to steeply west dipping gold bearing iron sulphide stockworks. Stockwork zones are developed primarily within Hillside porphyry, and to lesser extent, in rafts of sedimentary and volcaniclastic rocks. Current understanding is that the Marc and AV zones are mostly hosted in the Hillside porphyry whereas the 141 zone is hosted in sedimentary strata.

3 Data Sources and Quality

Geotechnical drilling and underground mapping from the 2016 field program formed the basis of the geotechnical interpretation. Historical geotechnical data stretching back to preliminary resource investigations (in the early 1990’s) were also considered during the geotechnical investigations and evaluations.

3.1 Historical Data

SRK reviewed the previous geotechnical evaluations and reports as provided by IDM Mining Ltd. (IDM). Historic relevant technical reporting and data sources include the following:

- Red Mountain Project – Underground Geomechanics Assessment, Klohn-Crippen Consultants Ltd., 1994. (KC, 1994a)
- Red Mountain Project – Hydrogeology Assessment, Klohn-Crippen Consultants Ltd., 1994. (KC, 1994b)
- Mine Feasibility Study, Bharti Engineering Associates Inc., 1994. (Bharti, 1994)
- Hydrologic Studies for Royal Oak Mines, Golder Associates, 1996. (Golder, 1996)
- Preliminary Economic Assessment – Red Mountain Gold Project, SRK Consulting, 2008. (SRK, 2008)

- Preliminary Economic Assessment – Red Mountain Gold Project, JDS Energy & Mining Inc., 2014. (JDS, 2014)

Geotechnical information extracted from these programs/studies and utilized in the current geotechnical study includes total core recovery (TCR) and rock quality designation (RQD) data from the 1993 drilling campaign (KC, 1994a). Underground structural mapping (KC, 1994a) was compared against oriented data collected during the 2016 FS investigation.

3.2 SRK 2016 Geotechnical Field Program

The 2016 geotechnical field program was campaigned with the resource drilling program (Figure 3.1). The program included detailed geotechnical core logging, underground geotechnical mapping, and laboratory testing. SRK staff were onsite for the greatest part of the field program, and were responsible to oversee the data collection, training, and quality assurance. Detailed geotechnical core logging was implemented for selected resource exploration drillholes as well, and was carried out by IDM under the supervision of SRK.

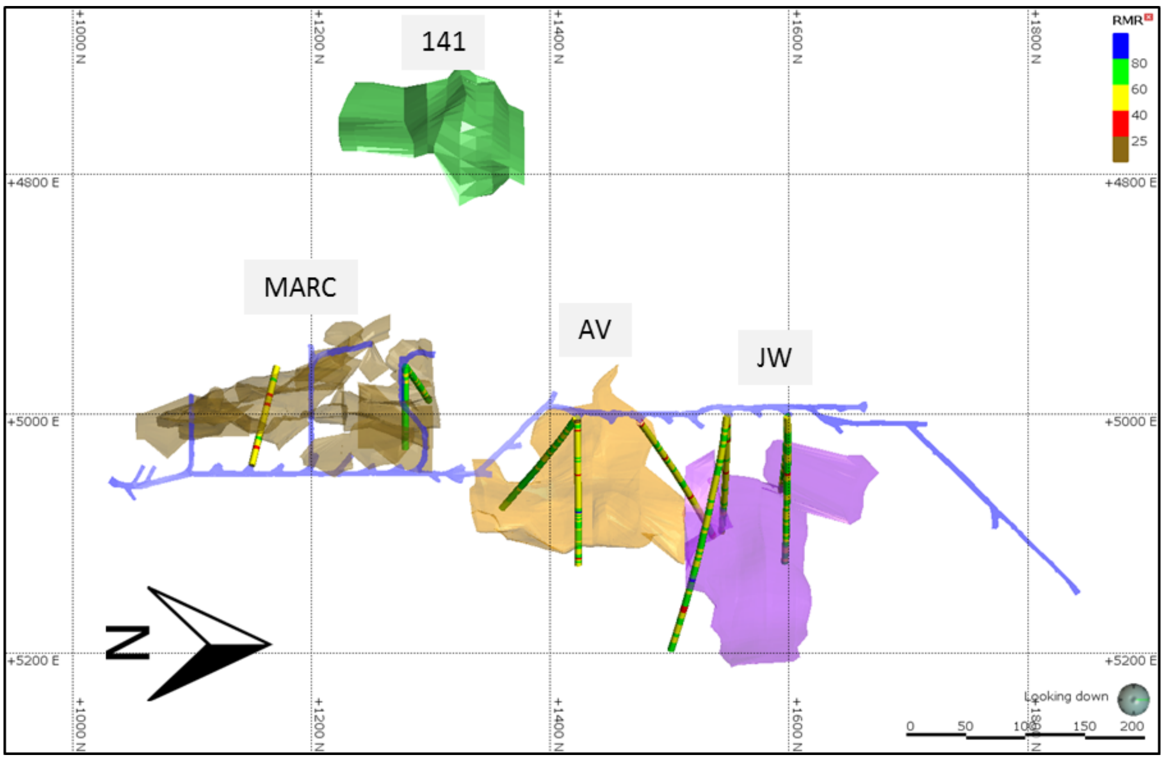

Figure 3.1 Drillholes logged for detailed geotechnical conditions in 2016. Mine north is referenced by the arrow.

The 2016 feasibility geotechnical data acquisition/investigation program included the following:

3.2.1 Geotechnical Core Logging

Eleven holes, Table 3.1, were drilled for a combined resource and geotechnical purpose. The recovered core was logged geotechnically prior to the geological logging and sampling. Joint orientation measurements were collected for five of these drillholes, however issues with the orientation tools (Reflex ACT II) prevented joint orientated data from being collected from all drillholes. One additional hole had oriented data collected with an acoustic televiewer. The holes selected for detailed geotechnical logging included three drillholes drilled into the Marc Zone, three into the AV Zone, and five drilled into JW Zone. No drilling intercepted the 141 Zone, and this zone was not assessed during these investigations. Drilling was primarily conducted in eastern or western (mine grid) trending orientations. Major faults were characterized by changing drillhole orientation to intersect these structures higher angles.

Table 3.1: Summary of geotechnical drillholes drilled during 2016 field campaign.

Hole ID	Easting	Northing	Elevation	Final Depth	Dip	Azimuth	Drillhole Size
U16-1179	5043.133	1150.132	1849.105	96	-28	284	HQ
U16-1194*	5004.757	1422.631	1795.22	128.5	-18	90	HQ
U16-1195*	5003.413	1422.695	1794.473	124	-64	90	NQ2
U16-1198*	5006.491	1474.764	1784.943	193.5	-55	55	HQ
U16-1201	5002.204	1548.442	1771.176	165	-53	93	NQ2
U16-1202	5002.217	1547.908	1771.889	229.5	-28	104	HQ
U16-1204*	4960.407	1278.703	1820.611	70.5	-60	55	HQ
U16-1205*	4961.253	1278.729	1821.26	73.5	-21	90	HQ
U16-1208	5002.209	1598.565	1761.158	166.5	-68	95	NQ2
U16-1209	5002.465	1598.545	1761.93	160.5	-41	90.5	HQ
U16-1216	5003.724	1421.637	1794.418	138	-45	130	HQ

*Orientated holes.

Core from these holes were logged geotechnically to characterize the rock mass per the RMR_{90} (Laubscher, 1990) and Q (Barton, 1989) rock mass classification systems. The rock mass properties were established for the hanging wall, orebody and footwall of the three primary mineralized zones. The resource wireframes and latest mine design (2016 Preliminary Economic Assessment, mine design from JDS on June 17, 2017) were used to determine the extent of the mineable portion of the mineralized zones.

Under the supervision of SRK staff, IDM geologists carried out detailed geotechnical logging in order to characterize the rock mass using the rock mass rating methodology after RMR_{90} (Laubscher, 1990) and Q (Barton, 1989). A geotechnical core logging manual was provided (Appendix C). The following information was collected at the IDM core shed in order to provide input parameters to the two systems:

- **Core recovery:** total core recovery (TCR), solid core recovery (SCR), rock quality designation (RQD);
- **Intact rock strength:** based on empirical ISRM guidelines for testing the strength of strong and weak rock sections within drill run;

- **Fracture count by type:** natural, natural and fabric-parallel, cemented, mechanical;
- **Intensity and strength of micro-defects**;
- **Discontinuity surface characteristics:** roughness, alteration, aperture, and infilling per drilled run;
- **Oriented discontinuities:** depth and orientation (alpha and beta angles) of each discontinuity; and
- **Major structures:** depth, length and recovered material properties.

During the geotechnical drill core logging, QA/QC was managed by a SRK staff on site. Core logging was reviewed daily, with adjustments to the logging made as necessary. Regular visits to the drill rigs were required to monitor quality of orientation marks and address any identified issues. SRK staff were not on-site to supervise logging of holes U16-1198 and U16-1216, but a detailed data review was performed before integrating the measurements. The data has been compiled as part of Appendix A and strip logs are available in Appendix B.

3.2.2 Geophysical Survey

One drillhole (U16-113 in the Marc zone) was partially surveyed using a downhole geophysical tool (acoustic televiewer) to collect orientation data of geological features. Additional surveys were planned but hole instability and blocked collars limited the number of available holes. Data delivered from DGI is available as Appendix D.

3.2.3 Field and Laboratory Strength Testing

Field strength testing was undertaken on the drill core from the 11 selected geotechnical drillholes. Both empirically based ISRM strength testing and point load index testing (PLT) was performed on every logged run to determine the intact rock strength (IRS).

Core samples were selected from the mineralized zones and surrounding rock mass. Samples were collected within 5 – 10 m of the proposed stope hangingwalls, within the ore zone (if permitted by site geologists), and the footwall of the mineralized zones (~5 m from the footwall limit). The core samples were shipped to Queens University for unconfined and triaxial compressive strength tests (Appendix I). Unconfined shear stress, shear stress under confinement, Young's modulus, and Poisson's ratio were collected by the lab.

The 38 samples collected for unconfined and triaxial compression testing were predominantly from igneous rock units. The 29 unconfined strength test (UCS) provided 25 valid results. Nine samples selected for triaxial testing (8 of which were valid), which provided rock confined strengths. Correlation factors between the point load test results and the UCS test results were established and applied to calibrate the point load test data.

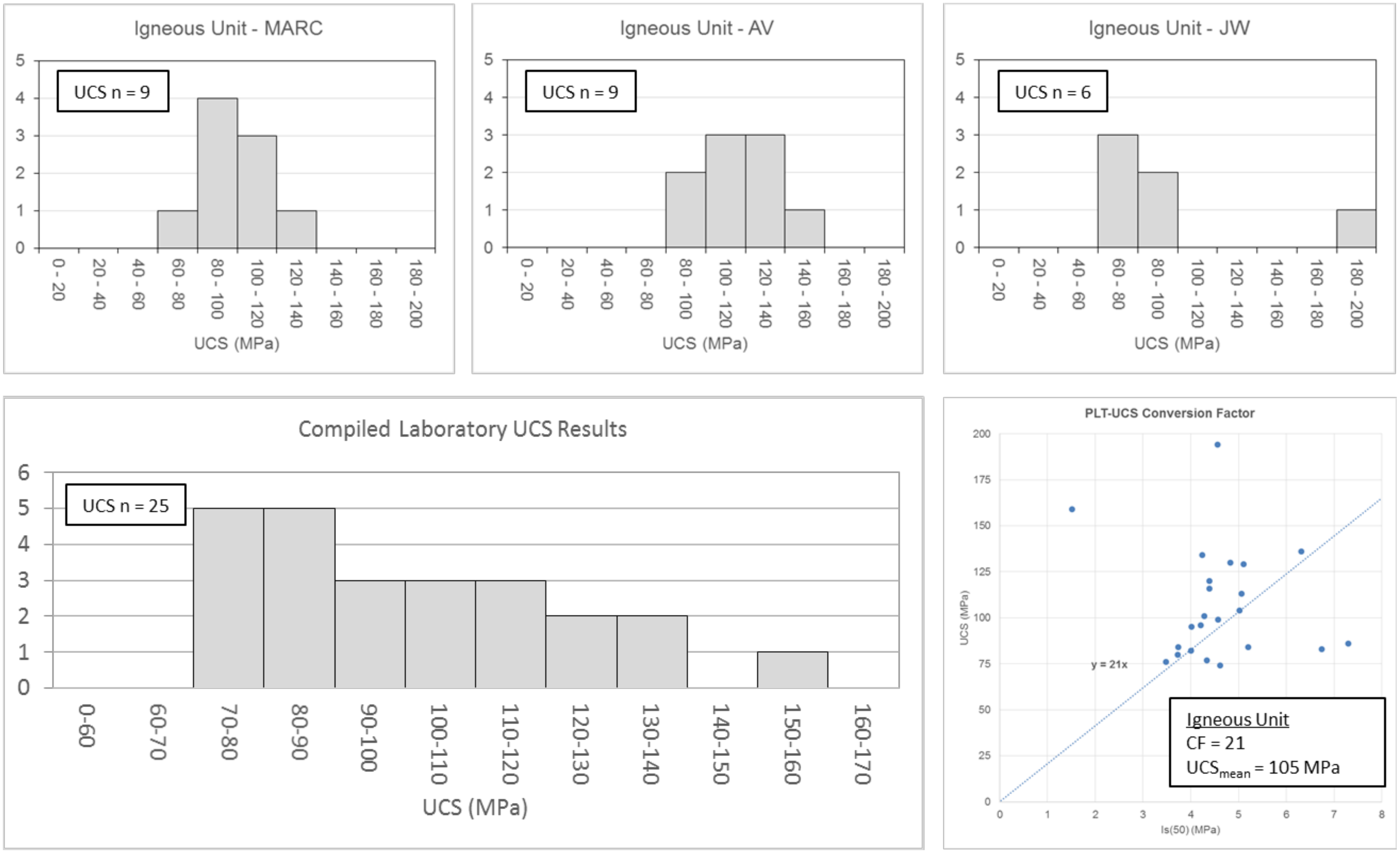

Figure 3.2: Summary of UCS results by ore body (upper row), compiled lab testing (bottom left), and correlation to PLT values (bottom right).

3.2.4 Core Photograph Re-logging

SRK was supplied the lithological data and core box photographs for all the drillholes completed in the 2016 drilling program. Photo geotechnical re-logging was conducted on the remaining resource holes to supplement the geotechnical data collected from the 11 geotechnical holes. Drill intervals that intersected MARC, AV, and JV zones were reviewed to establish the rock mass condition, presence of structures, and variability. A qualitative rating system (1 to 5) was assigned to each 3.0 m drill run based on the condition of the drill core. The rating system was established whereby representative geotechnical parameters would be applied. Figure 3.3 illustrates examples of the core photo logging and the associated rock mass conditions. This data was used to assess the rock mass condition in the hanging wall, orebody, and footwall, and were used to help establish the geotechnical domain model.

Table 3.2: Rating System Applied to the Core Photo Logging.

Core Photo Logging Rating	Description
1	Solid core, RQD >90%
2	Slightly broken core, RQD 70-90%
3	Moderately broken core, RQD 50-70%
4	Heavily broken core, RQD 25-50%
5	Completely broken or lost core, RQD 0-25%

Additionally, major structures were characterized to improve the understanding of the location, frequency and characteristics of the structures. The logging scheme for structures is qualitative and based on characterizing the fault zone and extents of damage.

Table 3.3: Descriptions of Structural Feature Class

Class	Description
1	Core of the fault often showing gouge-breccia infill.
2	Fault damage zone consisting of heavily fractured and disintegrated rock. Evidence of slickenlines may be present on joint planes.
3	Distal damage in core. Rock has minor fracturing, and fabric planes have been activated.
4	Class 4 is used to indicate that a structure may exist, but the evidence from the core is unclear; the observed damage could be related tectonism, or drilling

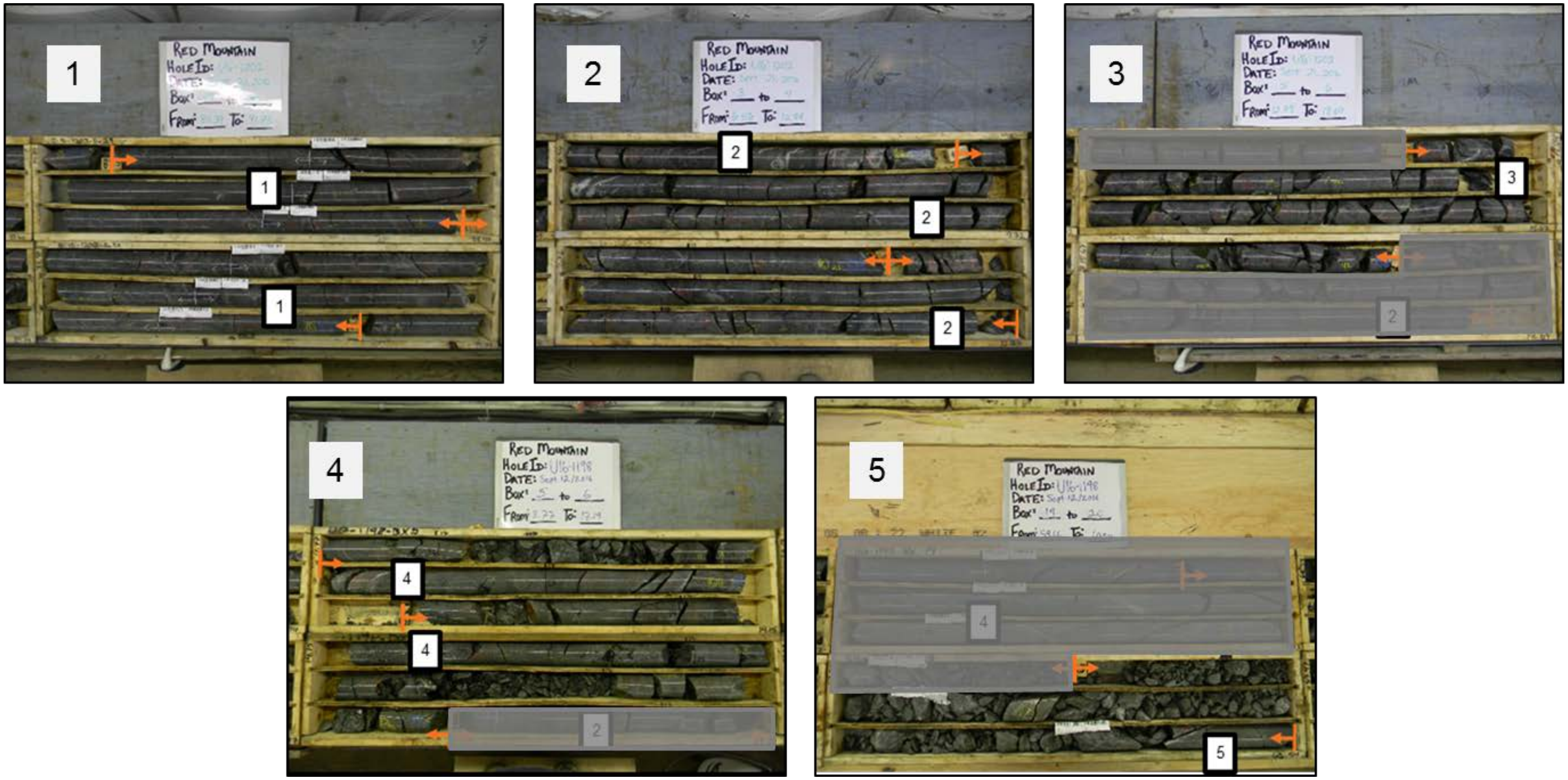

Figure 3.3: Core box photo examples of qualitative photo logging rating scheme.

3.2.5 Underground Mapping

Accessible areas of the existing underground excavations (approximately 875 m) were mapped to supplement rock mass and structural discontinuity data collected through geotechnical core logging. Detailed structural mapping was conducted during these efforts, and fault timing relationships and orientations were assessed. IDM provided SRK with the surveyed positions of each marked major mapped fault. Positions of the mapped structures (Figure 3.4) were provided in Mine grid.

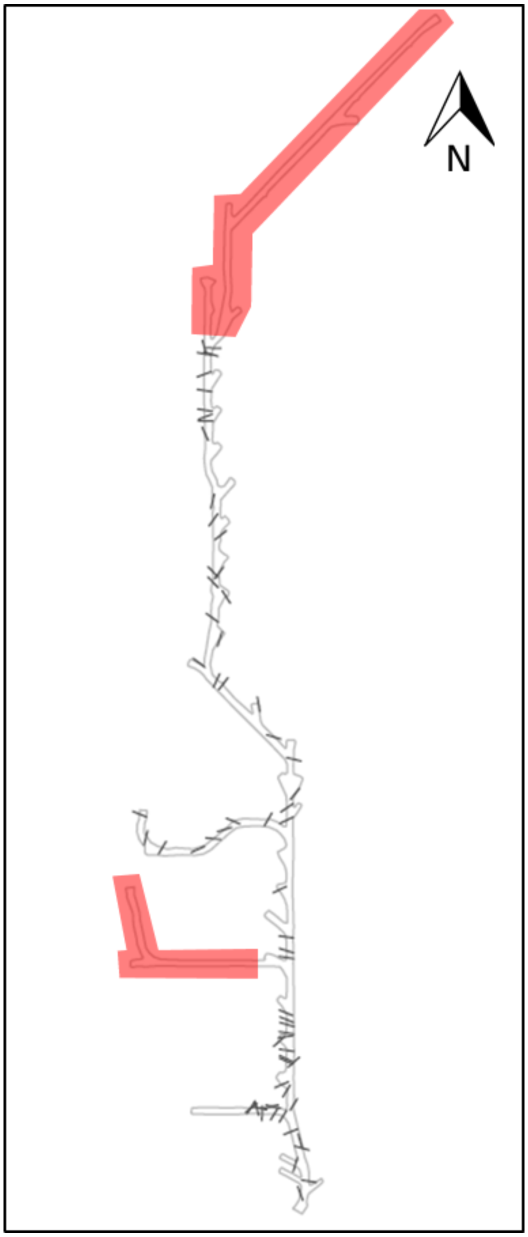

Figure 3.4: Major structures mapped in the underground decline. Red highlighted areas were inaccessible.

Underground geotechnical mapping was used to assess the rock mass, throughout the accessible areas of the existing decline. The mapping data is considered most relevant within Marc Zone where the decline passes close to the mineralized zone. The decline is further removed from the AV and JW Zones which decreases the confidence in the mapping being representative of the immediate stoping areas. The data was still included in the geotechnical assessment, but used at a lower confidence.

4 Structural Geology

4.1 Relevant Regional Tectonic History

The tectonic history of northwestern British Columbia in the Red Mountain area is summarized as follows (IDM 2014):

200 Ma (Early Jurassic) –Subduction on the eastern edge of Stikinia produces an oceanic magmatic arc in which the Red Mountain gold deposits are formed. Stikinia remains separated from the North American continent by the Cache Creek oceanic crust.

170 Ma (Middle Jurassic) – The Stikinia terrain is docked with North America, and Cache Creek oceanic rocks in the east are thrust onto the Stikine terrain by back-thrusting. A lack of intrusive rocks suggests there is no active subduction immediately west of Stikinia at this time.

145 Ma (Early Cretaceous) – The Alexandria terrain docks with the Stikine terrain, initiation of the Skeena fold belt and deformation of the Stuhini, Hazelton and Bowser Lake groups.

65 Ma (End of Cretaceous) – Deformation of Stikine terrain rocks is complete with folded and doubly plunging structural culminations. The Red Mountain deposits have been rotated from a vertical (?) orientation to a westerly dipping, northerly plunging orientation in the eastern limb of the Bitter Creek antiform. The Alexandria terrain is intruded by plutons of the Coast Plutonic Complex.

20 Ma (Miocene) – Extension along north-northwest and northeast trends forming large- and small-scale structures. Locally at Red Mountain this tectonic event has been equated to the formation of the Rick Fault and other property scale faults, offsetting the mineralised zones.

Brittle faulting is prevalent throughout all rock units. Previous work (e.g. Rhys et al., 1995) recognized two phases of faulting: 1) a set of north to NNW dipping faults that offset mineralized zones, and 2) NE dipping faults. Both groups are moderate to steeply dipping and the latter group was noted by Rhys et al (1995) to contain more gouge and have broader alteration envelopes than the former.

4.2 3-Dimensional Structural Model

During the September site visit, a total of 4 full days were spent mapping the underground structures, between the 27th September and 30th September, 2016. All accessible major structures within the underground workings were mapped and marked with spray paint.

Structures were photographed and observations were recorded. These included the following: fault orientation, fault width, fault fill, fault kinematics (if possible), estimate of fault persistence, fault damage zone width. Also recorded was a qualitative water flow value for each of the structures mapped (SRK classification scheme between 1 and 6). A Total of 68 structures were mapped and marked (R1 to R68) (Figure 4.1). Note that the scope of work was limited to mapping the underground major structures only and no surface structural mapping was done given the time constraints.

Once the major structures were mapped, the dominant joint patterns between each of the major structures were then recorded to establish any changes in joint pattern within the respective major structures blocks and used to establish geotechnical domain boundaries.

All fault and joint orientations were measured as strike and dip using the right-hand rule and to magnetic North. Data were then corrected to True North (+19º declination). Note: All fault readings in this section are given to true north orientations. The compiled fault data and relevant report are available as Appendix E.

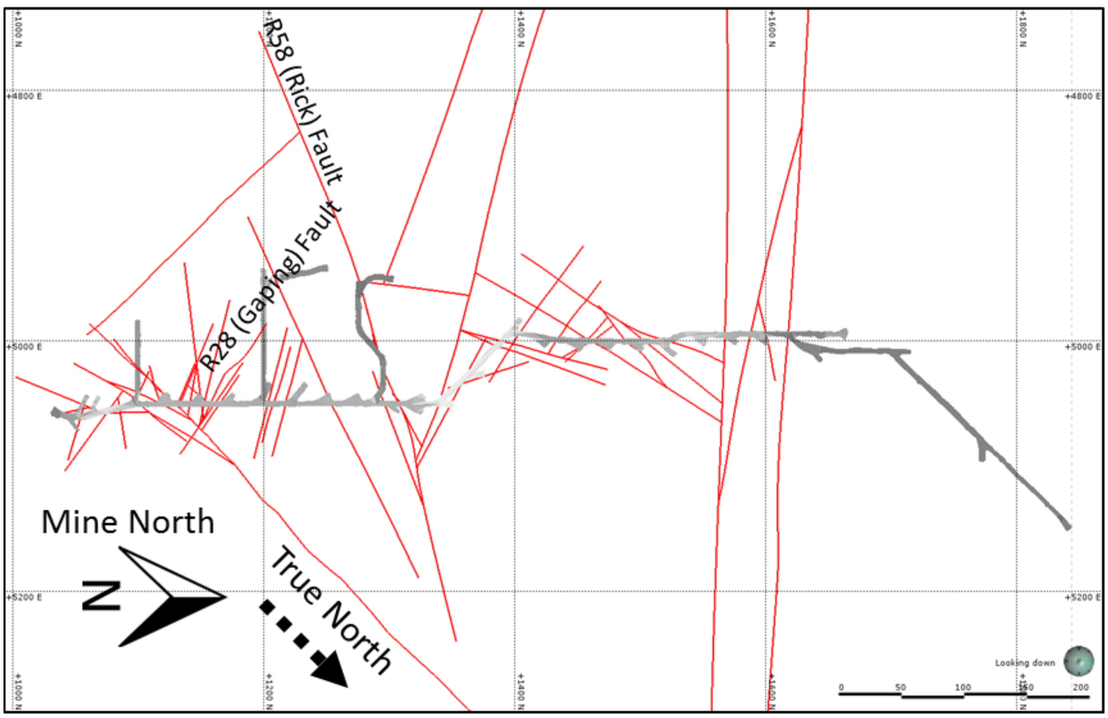

Figure 4.1 Plan section through existing infrastructure of 2017 structural model. Faults offsetting mineralization are labelled. Mine grid north and true north are referenced.

A three-dimensional structural model was developed for the deposit. The model was built from detailed underground mapping, surface LIDAR review and lineament analysis, and drillhole intercept data including historic and new geotechnical logging data. The data is referenced here to true north (as opposed to mine north) and strike (right hand rule). Three dominant trends were found for the deposit:

- **NE set**: This is the dominant fault set. Faults may dip to the SE or NW. This orientation is also the dominant orientation noted by IDM which offsets the mineralisation. This trend includes the Rick Fault (R58) and Gaping Fault (R28). These faults are moderately to steeply dipping and characterised by significant strike slip offsets. The main body of the Goldslide porphyry also has this orientation.
- **NNW set:** This corresponds to the orientation of minor Goldslide porphyry dyke offshoots and regional fold axes.
- **NNE set:** Mostly steeply easterly dipping structures. The trend well represented regionally by the Steward Valley, the Sutton Glacier and the main axis of the Cambria Ice Sheet.

Subordinate orientations included the following:

- **NE conjugate set:** These faults have the same trend as the main NE set but dip to the SE.
- **NE steep set:** This set strikes 033 and dips steeply to the SE.
- **EW set:** This set dips moderately to the south.
- **NW set:** This set dips moderately to the NE. Regionally this trend is represented by the Bitter Creek trend.

4.3 Impact of Structures on Mining

The brittle structures modelled by SRK are expected to adversely impact the mining (Figure 4.2). Faults intersecting stopes or other excavations will increase the unplanned dilution and are a risk to stope stability. Marc Zone is expected to be affected by adverse structures the most, and these have been highlighted within the geotechnical domains.

Damage zones for these faults are not expected to exceed 2.0 – 3.0 m throughout the deposit. The largest risk is in the formation of large blocks that may increase unplanned dilution and result in increased secondary blasting requirements. The ground support recommendations are expected to be sufficient to manage risks within the infrastructure and man-entry excavations. Ground support is not currently planned for the hangingwalls of stopes where these structures will daylight, but the implication on stability of these will need to be assessed on exposure.

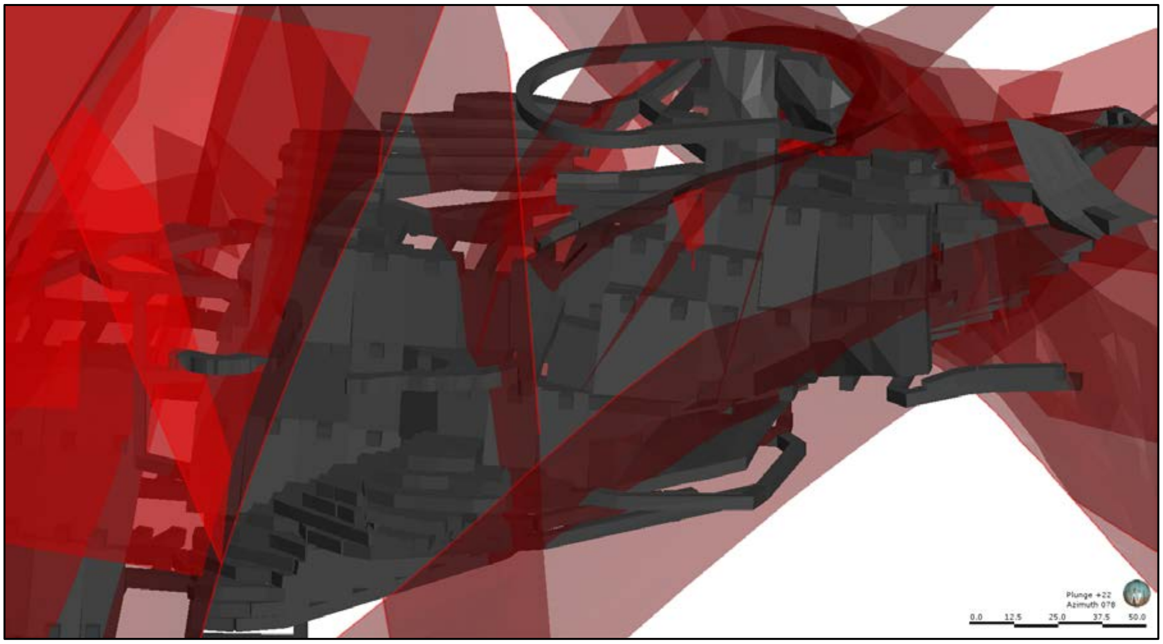

Figure 4.2: Isometric view to ENE of Marc zone illustrating faults crosscutting planned stoping.

4.4 Structural Domains

Three individual structural domains were identified based on joint set orientation and the impact on kinematic analysis (Table 4.1). Data collected through underground mapping, oriented core logging, and the televiewer survey indicated similar joint patterns across the project, with local rotation of some features. The domains are bound by the offsetting faults (R3 and R58 (RICK fault)) and correspond with the mineralized zones (Figure 4.3). Limited mapping exposure and orientated drilling of the JW structural domain restricted the interpretation. It is recommended that further orientated drilling be undertaken within the JW zone to verify joint orientations.

Four joint sets have been identified within each structural domain. Three sub-vertical sets and a flat dipping set are expected across the deposit. From the underground mapping, the joints were identified as having large-scale waviness. Maximum joint persistence was identified from the underground mapping as approximately five metres, with the majority of the joint persistence ranging from 1 – 3m. A summary of all available oriented data including mapping interpretations is available as Appendix F.

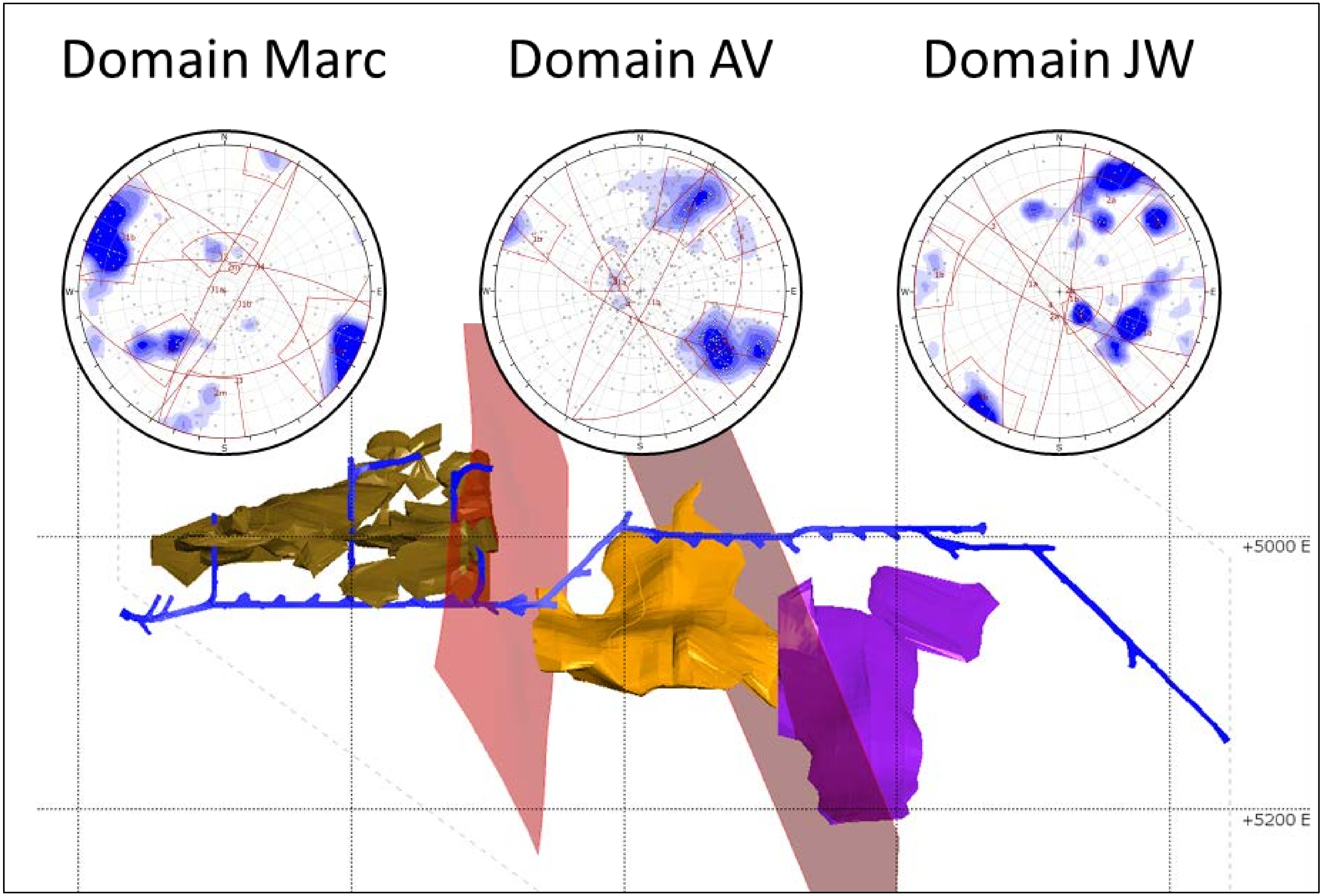

Figure 4.3: Red Mountain Structural Domains based on underground mapping and orientated drilling results.

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Table 4.1: Summary of joint sets per structural domain.

Marc Zone

Joint Set	Dip	Dip Range	Dip Direction	Dip Dir. Range	Confidence	Sources
J1a	75	+/- 15	300	+/- 25	High	Mapping data, televiewer, oriented drill core. Well represented across entire deposit.
J1b	75	+/- 15	120	+/- 25	High	Opposite dip direction of subvertical J1a.
J2	75	+/- 15	5	+/- 15	High	Mapping data, oriented drill core. Weak representation in televiewer data due to orientation bias.
J3	30	+/- 15	175	+/- 40	High	Mapping data, televiewer, oriented drill core. Present across entire deposit.
J4	60	+/- 15	45	+/- 20	Moderate	Oriented core data, some mapping data.

AV Zone

Joint Set	Dip	Dip Range	Dip Direction	Dip Dir. Range	Confidence	Sources
J1a	70	+/- 20	300	+/- 20	High	Mapping data, oriented drill core. Well represented across entire deposit.
J1b	80	+/- 10	120	+/- 20	High	Opposite dip direction of subvertical J1a.
J2	70	+15/-25	210	+/- 15	High	Mapping data, oriented drill core.
J3	25	+/- 15	120	+/- 15	High	Mapping data, oriented drill core. Present across entire deposit.
J4	80	+10/-15	240	+/- 40	Moderate	Oriented core data, some mapping data.

JW Zone

Joint Set	Dip	Dip Range	Dip Direction	Dip Dir. Range	Confidence	Sources
J1a	70	+/- 20	295	+/- 30	Moderate	Mapping data, oriented drill core. May be shallower dip than in AV and MARC.
J1b	80	+/- 10	115	+/- 30	Moderate	Opposite dip direction of subvertical J1a.
J2a	75	+15/-20	205	+/- 20	High	Mapping data, oriented drill core.
J2b	85	+5/-10	25	+/- 20	High	Opposite dip direction of subvertical J2a.
J3	20	+/- 10	315	+/- 40	Moderate	Mapping data, oriented drill core. Present across entire deposit.
J4	80	+/- 10	235	+/- 10	Low	Oriented core data, some mapping data.

4.5 In-Situ Stress

A brief literature review revealed that no in-situ stress measurements are available for the project site. The deposit is located within a mountain, adjacent to two valleys including the Cambria icefield. Stresses will either be cut-off due to the valleys, or maintained through the mountain (Figure 4.4).

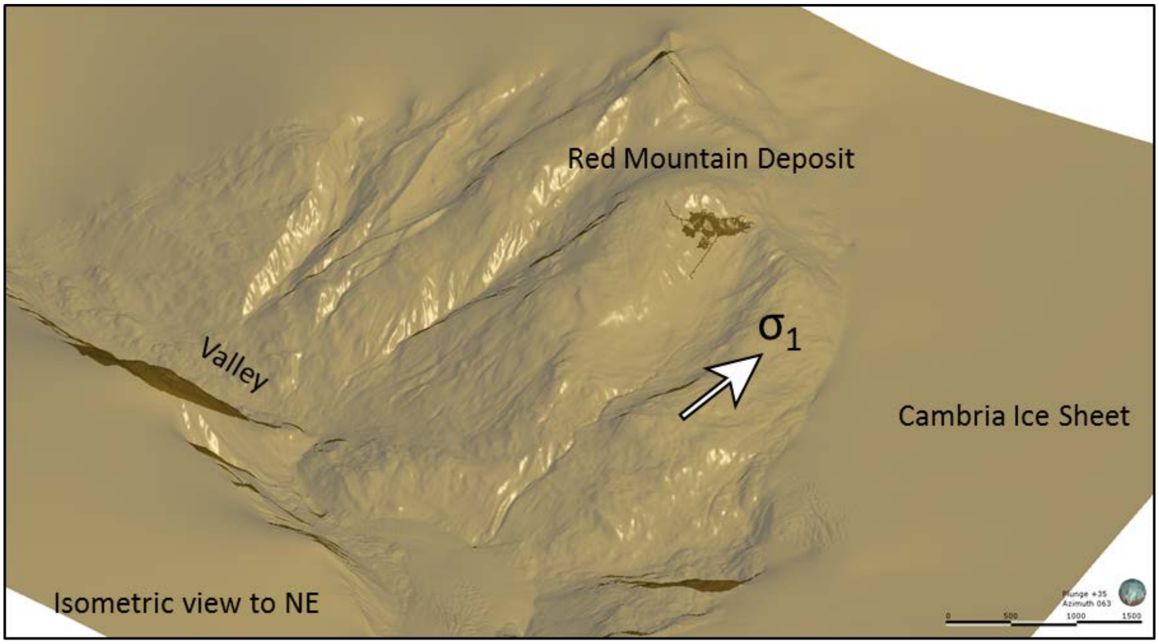


Figure 4.4: Regional principle stress orientation (105°) with reference to the orebody and surrounding topography.

Stress orientations were determined from the World Stress Map (Heidbach et al, 2014) while magnitudes have been estimated from typical Canadian Shield stress conditions (Table 4.2). Lithostatic stress has been assumed as the base case to determine the stress magnitudes. A sensitivity analysis was performed on the stress conditions using the numerical modelling for both higher stress and isotropic stress conditions.

Table 4.2: Principle stress ratios and orientations relative to the mine grid

Stress	Trend	Plunge	K Ratio
σ_1	105°	0°	1.5
σ_2	195°	0°	1.5
σ_3	0°	90°	1

5 Hydrogeology

5.1 Field Program

Between 1990 and 2016, a number of technical hydrogeological field programs were carried out in support of exploration and permitting. The field methods included drillhole drilling and logging, installation and development of monitoring wells, hydraulic conductivity testing (packer tests and slug tests), measurements of groundwater levels, and measurements of inflow rates and pressure heads during dewatering events of the decline.

5.2 Impact to Mining

Based on the hydrogeological assessment of the mine site conducted by SRK in 2017 (Mine Area Hydrogeology, SRK, 2017) the majority of mine inflows will come from intersection of or connection to faults or areas of broken ground through open joints. Inflows are predicted to be relatively low, reaching an annual average rate of about 3,810 m^3/d in Year 2 and then decreasing from this point onward to about 2,640 m^3/d (i.e., Base Case), while under more conservative assumptions (i.e., Upper Case), predictions were respectively 6,400 m^3/d and 4,400 m^3/d. Inflows of this magnitude are not expected to impact geotechnical assessments or mining conditions, except in very localised areas. Seasonal water inflows into structurally complex stoping areas could complicate mining and backfill operations.

Dewatering of the underground mine will be achieved using gravity, where possible, via the lower access ramp. Pumping will be used, as needed, to assure positive dewatering in decline headings, and to route water to settling sumps and holding ponds prior to discharge or further treatment, as required. At mine closure, the ventilation shafts, adits, and portals will be sealed to limit the potential for direct mine water discharge to surface waters, and limit the ingress of oxygen; the groundwater system is then expected to return to baseline conditions.

6 Rock Mass Model

6.1 Geotechnical Domains

A thorough evaluation of geotechnical parameters, laboratory strength testing, kinematic, empirical and numerical analyses has been conducted to support the underground mine design. Most of the mineralization is located in the igneous unit but all the units have similar geotechnical properties. No distinction was made based on lithology during the geotechnical assessment due to the similarity in geotechnical properties.

The geotechnical evaluation focused on the rock mass forming the orebodies as well as the immediate hangingwall and footwall. The orebodies were individually assessed on the rock mass condition from drilling data and underground mapping from the field program, and the interpreted structural model. Majority of the rock mass is interpreted to be in Fair to Good ground, with poorer ground conditions expected in the region near the surface and at fault intersection areas. Data collected during the underground mapping was used to supplement the drillhole data.

Longhole open stoping has been selected as the primary mining method, with cut-and-fill or drift-and-fill being applied in the narrower areas, flatter dipping sections, and areas with a weaker rock mass. Four geotechnical domains were derived based on the defined geotechnical conditions and expected performance of open stopes. The domaining approach considered stope stability/performance, unplanned dilution and support requirements:

- **Green Domain:** The most competent rock mass (RQD: > 95%, RMR: 60 - 65) with no prominent brittle structures likely to affect stope stability. This domain is suitable for open stoping with a primary-secondary sequence.
- **Yellow Domain:** Comprised of fair rock mass conditions (RQD: 80% - 95%, RMR: 55 - 60) not affected by structures. Increased dilution is expected compared to the Green Domain. Open stoping with a primary-secondary sequence will be appropriate within this domain.
- **Pink Domain:** This domain is similar to the Yellow in terms of the global rock mass conditions (RQD: 80% - 95%, RMR: 55 - 60) but faults are expected to impact stope stability and overall performance. Open stoping on a primary-primary sequence is achievable with the necessary support to address the more challenging ground conditions around faults.
- **Red Domain:** The poorest ground conditions (RQD: 20% - 60%, RMR: 25 - 55) are found in the crown pillar near surface which is also associated with faults. Longhole stoping is not recommended within the Red Domain. Cut-and-fill or drift-and-fill mining with the appropriate support are the recommended mining methods. The range of parameters is broad within the Red domain, and represents better quality rock between the fault zones.

Geotechnical domains, Marc (Figure 6.1), AV and JW (Figure 6.2), were defined for each of the three ore bodies considering the geotechnical data, core photographs, structural model, and recommended mining methods. Using the geotechnical data collected in the field and underground mapping data. The domaining of the orebody considers the photo logging data at the orebody boundaries and within the ore zone, and the underground mapping data was used in determining domain boundaries for the Marc zone. No geotechnical data was available for the 141 zone; geotechnical domains were not defined for this zone. The mine design was based on the geotechnical recommendations for the Yellow Domain in the AV and JW Zones.

The geotechnical domains were evaluated based on the mineralized zone solids. Drillhole intercepts of the hanging wall, footwall, and mineralized zone were classified using core box photos, and a representative category assigned. These representative categories were assessed against the geotechnical logging data to determine RMR_{90} and representative Q' parameters. The Q' parameters were quantified based on a range of RQD values, dominant joint condition properties (Jr and Ja), and a Jn value was assigned based on the structural interpretation. Representative rock mass properties (Table 6.1) were derived for each of the geotechnical domains. The 3-dimensional solids and associated core photograph interpretations are available as part of Appendix G.

The 3-D fault model was used to assess the extents of brittle structures, which were used to define the extents of the Pink domain. Assessments of all three domains (hangingwall (H), orebody (O), and footwall (F)) were combined to form a representative mining practical geotechnical domain.

Table 6.1: Rock mass parameters for each geotechnical domain.

Geotech Domain	Photo Rating	IRS_{eng}	RQD	Jn	Jr	Ja	Q'	RMR_{90}
Green	1	105	95	6	2	2-4	7.9-15.8	60-65
Yellow	2	105	80	9	2	2-4	4.4-8.9	55-60
Pink	3							
Red	4-5	50	20-60	9-15	1-2	3-4	0.1-4.4	25-55

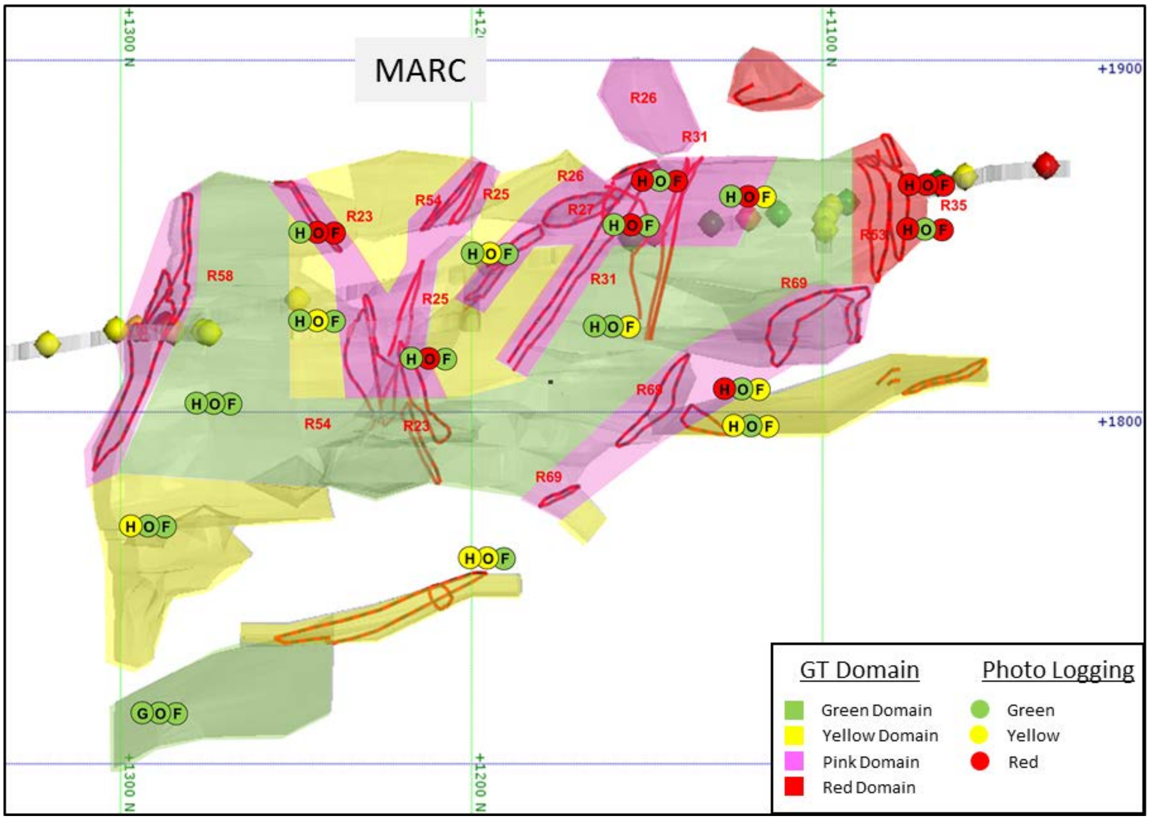


Figure 6.1 Geotechnical domains within the Marc zone (hangingwall (H), orebody (O), and footwall (F)).

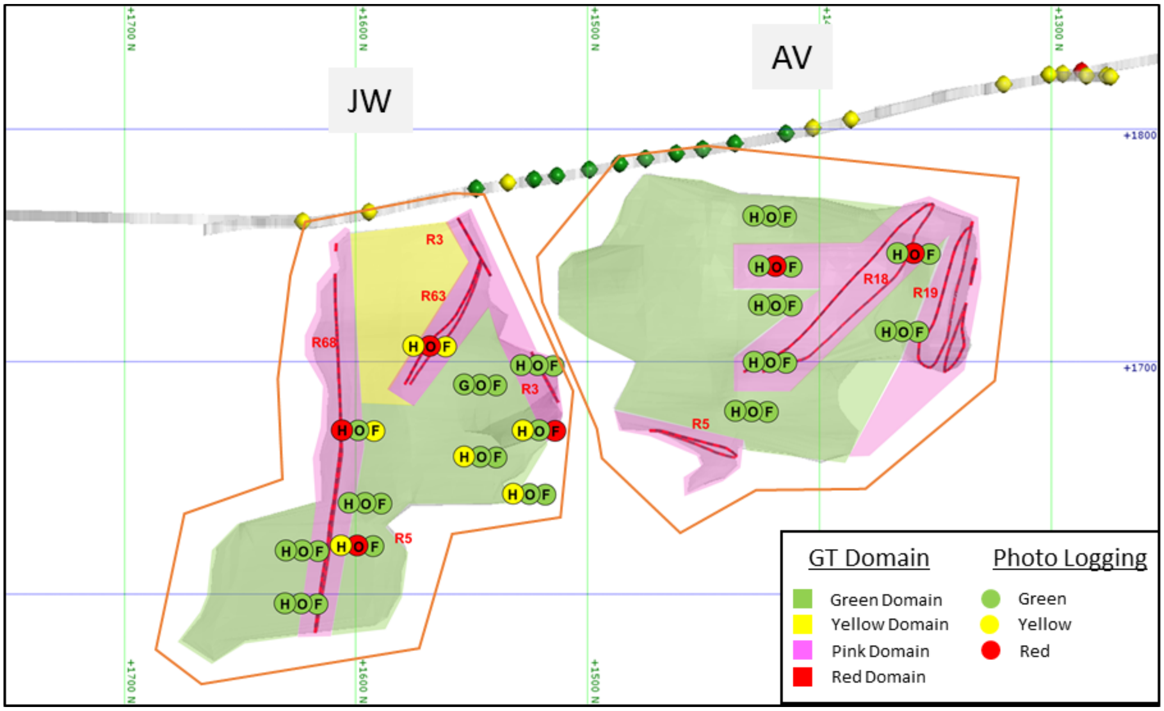


Figure 6.2 Geotechnical domains for the JW (left) and AV (right) zones (hangingwall (H), orebody (O), and footwall (F)).

6.2 Orebody Geometry

The orebodies vary in dip from sub-vertical to less than 55° dip (with a minimum of 30° dip). This influences the mine design as the flatter dipping sections will be planned as cut/drift-and-fill type excavations. Steeper orebody geometries are suitable for longhole stoping across the deposit. The thickness of the orebodies varies throughout, and a combination of transverse/longitudinal stoping methods will be required.

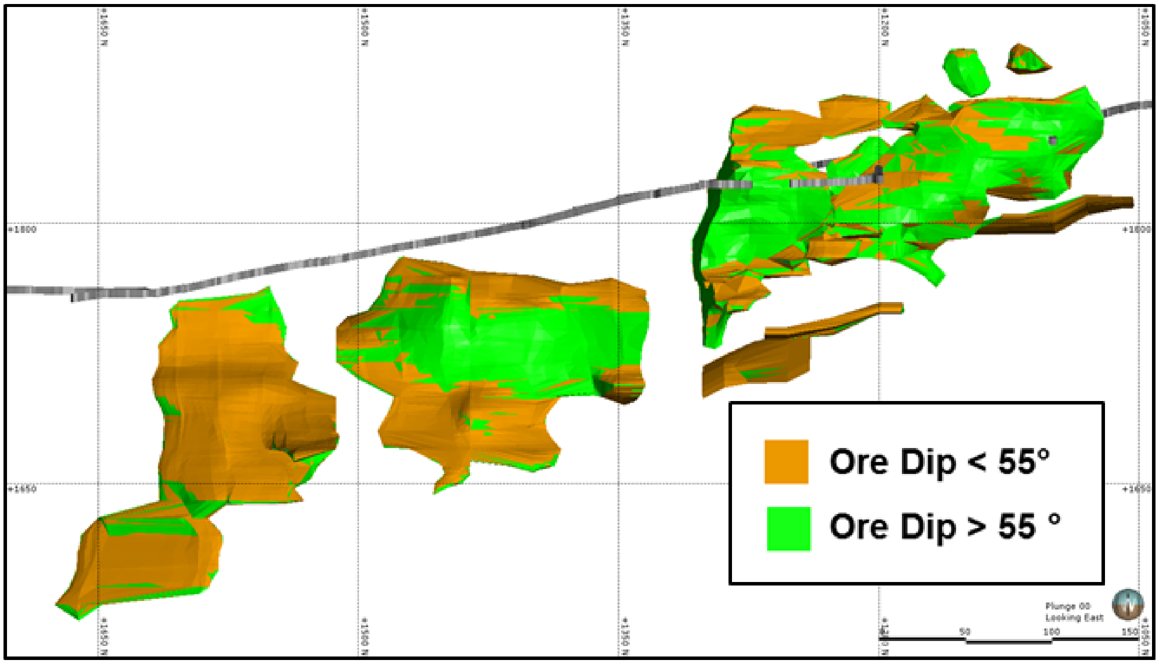


Figure 6.3: Hangingwall orebody dip. Colors illustrate areas where hanging wall dip is greater and less than 55º.

7 Geotechnical Design

The design of underground excavations benefit from a number of well-established, empirical and semi-empirical rules. These rules enable approximations to be made of the expected mining conditions and support requirements based on a detailed description of the rock mass. The design involves two steps:

1. The rock mass condition is related to a pre-defined classification system (Section 6).
2. The expected performance of the underground openings is predicted using an empirically derived correlation between the rock mass quality, joint orientation and excavation geometry/dimensions.

The design recommendations derived from the empirical relationships are adjusted to account for variability within the domains, expected excavation performance and engineering judgement.

The four domains as described in Section 6 are expected to be similar across the deposit. Faults and broken ground within these domains are expected to influence mining conditions, and have been accounted for during the geotechnical design.

7.1 Excavation Design

7.1.1 Man-Entry Excavations

The development and production excavations requiring man entry have been assessed using the critical span curve after Ouchi et al (2004). The design spans (4 – 10 m) fall within the stable to potentially stable region for the Green, Yellow, and Pink domains. This suggests that the excavations are expected to be stable with typical ground support. The Red domain consists of weaker rock mass intersected by faults. The design spans (4 – 8 m) are expected to be potentially unstable to unstable which will necessitate additional ground support and adjustments to the mining sequence to maintain excavation stability (Figure 7.1).

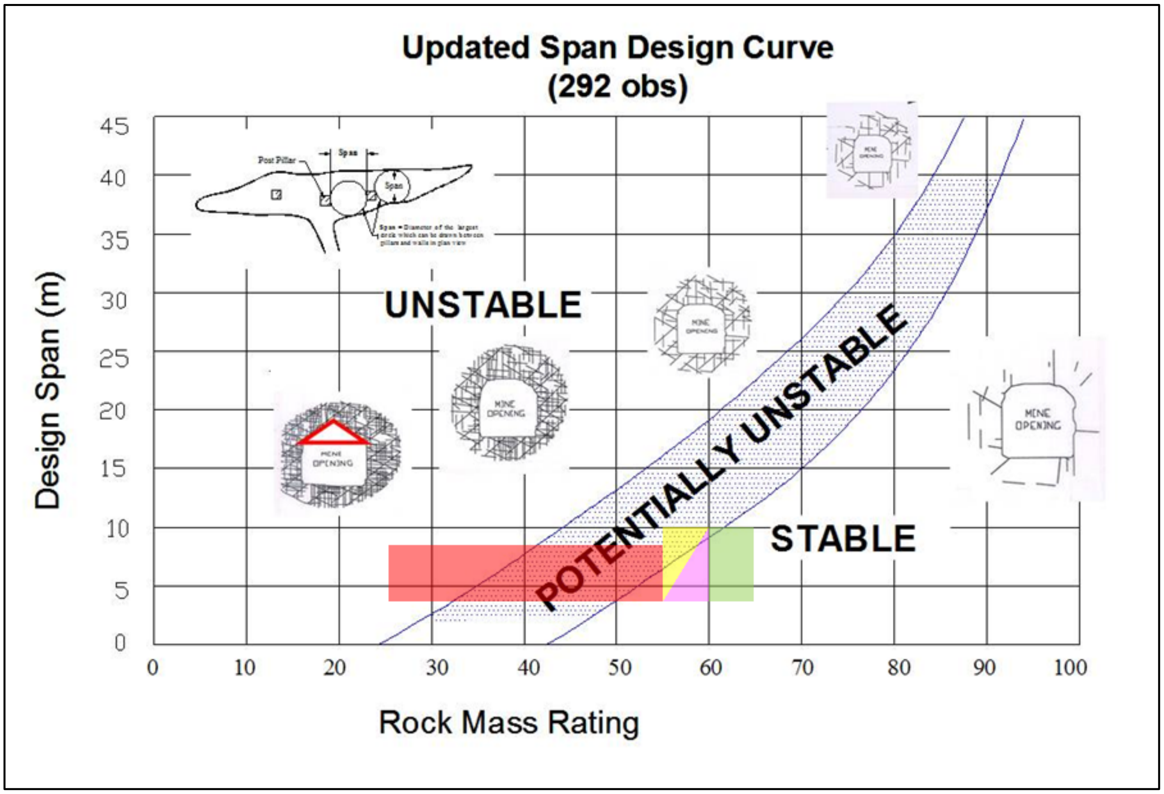


Figure 7.1: Ouchi et al. (2004) Critical Span Curve with excavation spans and geotechnical domains overlain.

7.1.2 Production Excavations

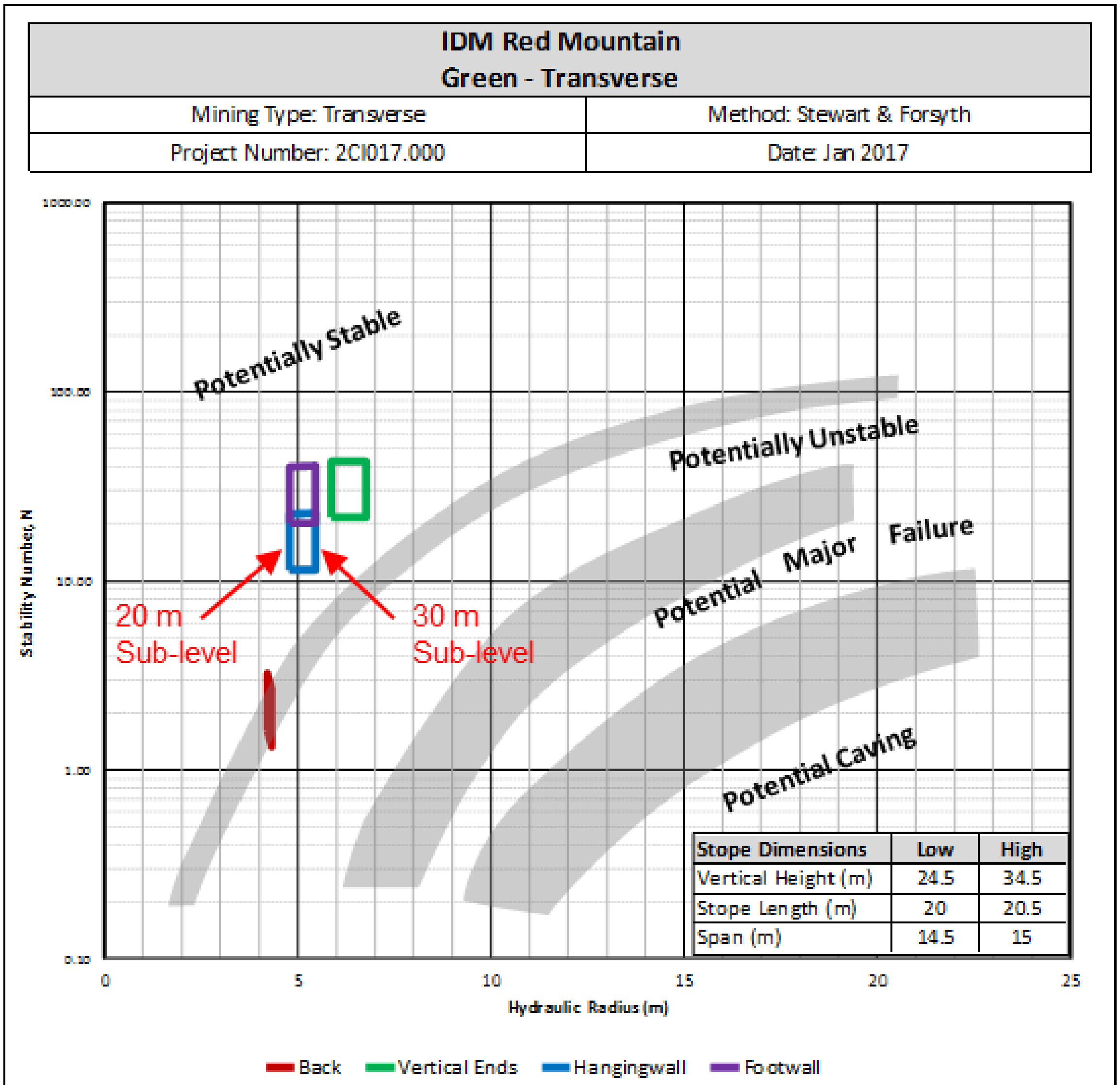
Longhole stope design (no man-entry) was completed using the modified Mathews stability curve after Stewart and Forsyth (1995). The stope design was constrained by practical mining limitations and assessed based on stability and dilution. A range of sub-level spacing's and strike dimensions were considered while the orebody thickness dictated the third dimension. Transverse stoping was considered for the wider (>10 m) part of the orebody with narrow zones to be mined using a longitudinal stoping method. The inputs to the empirical charts are derived from Q’ values for the different domains, with adjustment factors that consider orebody orientation, induced stress, critical joint orientations, and the IRS.

A Factor: The A-factor is used to account for induced stress in the investigated stope surface. The stresses can be estimated through numerical analyses of induced stresses at the stope boundaries, or through strength versus stress adjustment. For this study, the latter approach has been used. The moderate to high intact rock strength and low induced stress result in a favorable A-factor value for all surfaces and less favorable in the back. The hanging wall and footwall are usually in tension which imply that the surfaces will not undergo stress induced failure. The lack of confining stress will however allow for the mobilization of blocks therefore decreasing stability. The influence of a tensile zone is not accurately considered by the empirical stope design tools in jointed/foliated rock.

B Factor: The B-factor considers the orientation of the most critical structure relative to the stope walls, which could be a joint set, bedding planes, or foliation. Structurally controlled failures are observed to occur when joints form a shallow angle with the stope surface, however, two or more joint sets are needed to form rock blocks. The joint sets interpreted from drill core and underground mapping at Red Mountain result in low B-factor values, which implies that joint orientations will adversely affect stope stability.

C-factor: The C-factor considers the mode of failure based on the dip of the investigated surface from the horizontal. The horizontal back of a stope is considered unfavorable. The orientation of the mineralized zones (dip ranging between 40° and 70°) results in unfavorable conditions for the HW but the FW benefits from the flatter dip. The dip of the HW implies that the gravity will have a much greater influence compared to vertical surfaces which are more favorable.

Geotechnical design recommendations were derived for the three main zones (Marc, AV and JW) based on the geotechnical domains, structural domains, and assumed stress conditions. A summary of the recommended stope dimensions and anticipated dilution are presented in Table 7.1 (Marc) and Table 7.2 (AV and JW). Figure 7.2 presents the empirical stope design graph for the Green Domain in the Marc Zone. A compilation of the stope design graphs from the Stewart and Forsyth (1995) analysis are available as part of Appendix H.



	Q'		UCS	A		B	C	Hydraulic Radius, HR	
	Low	High	(MPa)	Small	Large			Small	Large
Back	7.9	13.8	105	0.60	0.50	0.34	1.00	4.20	4.33
Vertical Ends	7.9	13.8	105	1.00	1.00	0.34	8.00	3.86	6.77
Hangingwall	7.9	13.8	105	0.92	0.93	0.35	4.50	4.79	5.43
Footwall	7.9	13.8	105	0.92	0.93	0.35	8.00	4.79	5.43

Figure 7.2: Example of empirical stope stability analysis for transverse stoping in the Green domain.

The stope design options are considered realistic and practical. The driving force behind the stope design is the stability and amount of unplanned over break or dilution. Increasing sub-level spacing has the greatest impact on stability and unplanned dilution. The findings of the stope stability assessment concluded that:

- Overhand open stoping is recommended for the Green, Yellow and Pink domains based on the 25 m sublevel spacing (floor to floor). Stope length, width and mining sequence should be based on the ground conditions in the various geotechnical domains:

  - Longitudinal stopes length and width should be limited to 20 m and 10 m respectively.
  - Transverse stopes in the Green and Yellow domains could be mined on a primary-secondary sequence. Stope width (15 m primary and 10 m secondary) was based on stope stability and dilution. Stope length is based on the orebody width but individual stopes should not exceed 20 m.
  - The Pink domain contains faults that will impact stability and dilution. Transverse stopes (15 m wide) should be mined on a primary-primary (end slicing) sequence to manage stability. Increased ground support, including cable bolting, will be required to manage stability around the fault damage zones. Dilution is expected to be similar to the Yellow domain, however the fault interactions with the stope pose a risk of additional unplanned dilution (i.e. large wedges).
- Open stoping mining methods are considered high risk in the Red domain. This domain is more suited to a cut-and-fill/drift-and-fill mining method.

Table 7.1: Stope design: MARC Zone.

		Transverse (Primary)	Transverse (Secondary)	Longitudinal
Sub-level spacing		**25 m**	**25 m**	**25 m**
Yellow Domain	Stope Width	15	10	10
	Stope Height	29	29	29
	Stope Length	20	20	20
Green Domain	Stope Width	15	10	10
	Stope Height	29	29	29
	Stope Length	20	20	25

Table 7.2: Stope design: AV and JW Zones.

		Transverse (Primary)	Transverse (Secondary)	Longitudinal
Sub-level spacing		**25 m**	**25 m**	**25 m**
Yellow Domain	Stope Width	15	10	10
	Stope Height	29	29	29
	Stope Length	20	20	20
Green Domain	Stope Width	15	10	10
	Stope Height	29	29	29
	Stope Length	20	20	25

7.2 Kinematic Wedge Assessment

The small-scale structures (joints, discontinuities, or persistent rock fabric) contribute to the stability of underground excavations. The rock mass is made up of an interlocking matrix of discrete blocks, with block size controlled by fracture orientation and persistence. When exposed in an excavation these structures may interact in adverse ways, leading to the formation of wedges than can impact dilution within production excavations and pose a risk to safety within development.

Joint set orientations were based on the drilling, mapping, and televiewer data collected in 2016. The potential risk of unstable wedges forming around the excavations was analyzed using Rocscience's UNWEDGE software. The evaluation was based on the known joint orientations, typical excavation orientations and excavation dimensions. The software does not consider curvilinear surfaces, and the results of the analysis are therefore considered conservative.

UNWEDGE was used to evaluated the stability of stopes within Marc and AV zones. No stoping is planned with the JW zone. The formation of unstable wedges within the stopes will have a significant impact on stope performance and dilution. Vertical stopes within Marc, and steep stopes (~75°) within the AV zone are the most likely to be affected by unstable wedges (Figure 7.3). These wedges will potentially form in the HW of the longhole stopes and increase the expected dilution (equivalent linear overbreak) by 0.2 m and 0.1 m for the Marc and AV zones respectively.

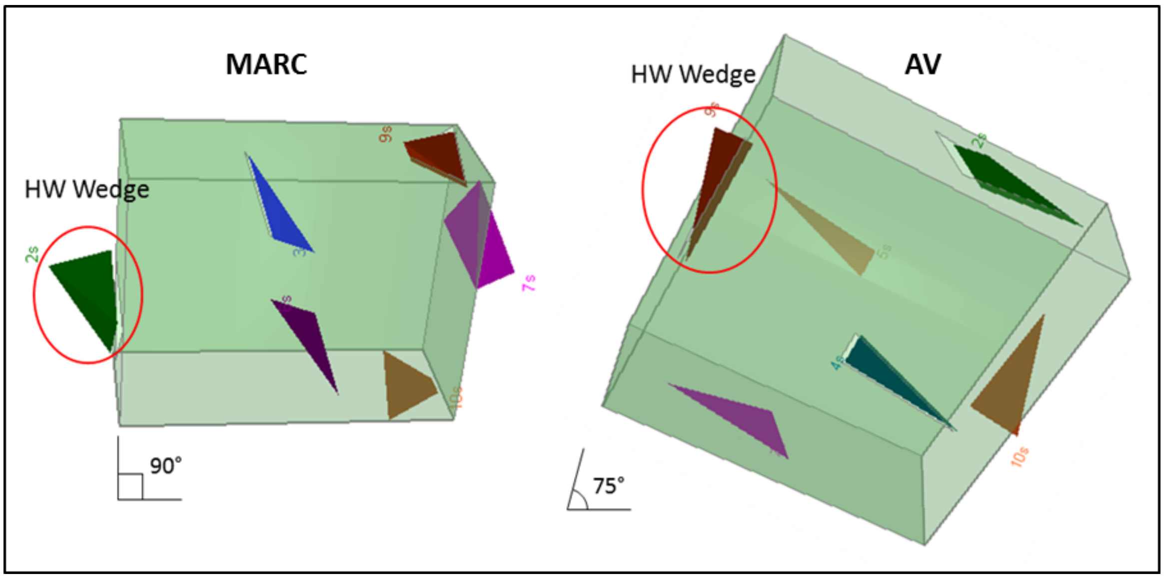


Figure 7.3: Critical wedge formation within Marc and AV zones.

The stability of all major man-entry excavations was analyzed and the recommended ground support would be sufficient to stabilize potential wedges.

7.3 Dilution

The mineralized zone is not defined by discrete structures and dilution from both the hanging wall and footwall will be influenced by the ground conditions, joint orientation and stress state. The level of unplanned dilution (ELOS - Equivalent Linear Over break/Sloughing) is expected to vary between the various mineralized zones due to the difference in joint orientation, depth below surface and structural complexity. Empirical estimates and bench marking have been used to determine the combined unplanned dilution (equivalent linear overbreak, Figure 7.4) for the different geotechnical domains and orebodies (Marc, Table; AV and JW zones, Table 7.4).

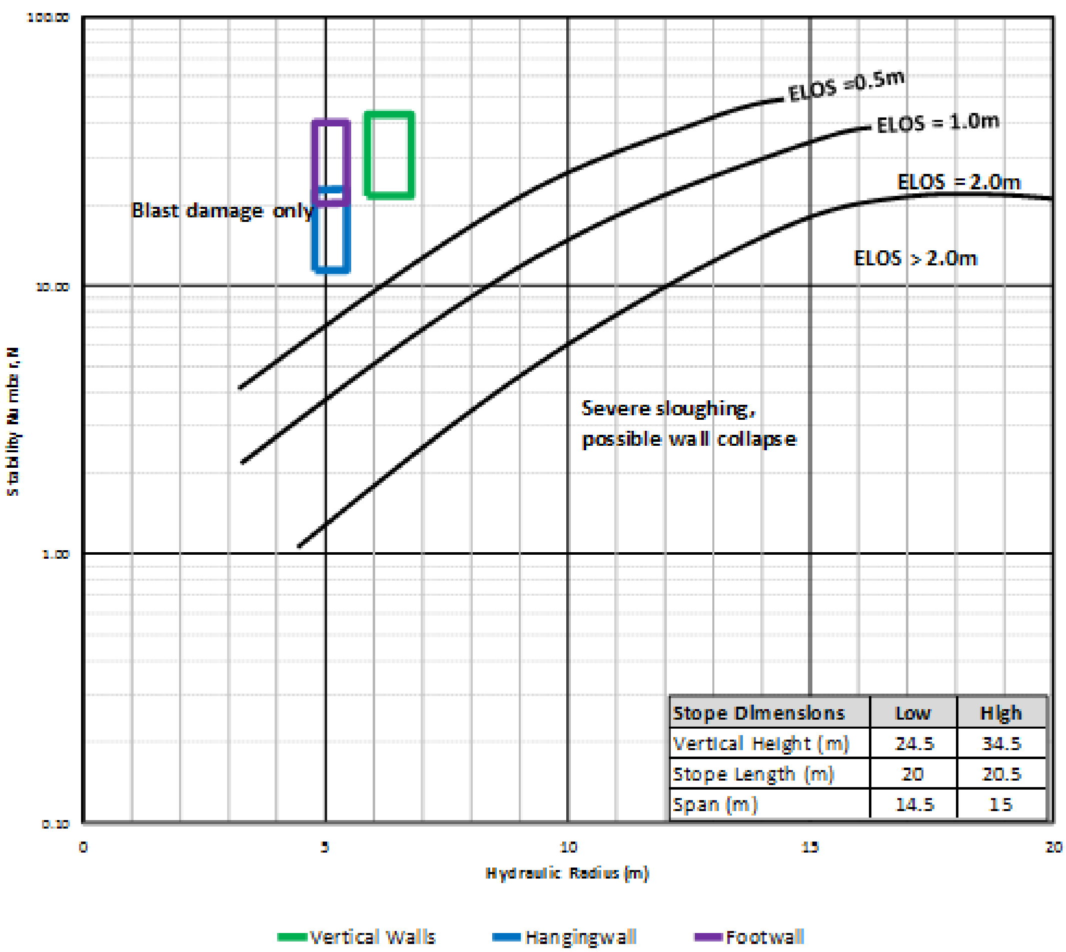
Table 7.3: Dilution assessment for Marc zone.

		Transverse (Primary)	Transverse (Secondary)	Longitudinal
Sub-level spacing		**25 m**	**25 m**	**25 m**
Yellow Domain	HW Dilution	0.45	0.6	0.7
	FW Dilution	0.35	0.35	0.45
	Total Dilution	**0.8**	**0.95**	**1.15**
Green Domain	HW Dilution	0.35	0.45	0.5
	FW Dilution	0.2	0.3	0.35
	Total Dilution	**0.55**	**0.75**	**0.85**

Table 7.4: Dilution assessment for AV and JW zones.

		Transverse (Primary)	Transverse (Secondary)	Longitudinal
Sub-level spacing		**25 m**	**25 m**	**25 m**
Yellow Domain	HW Dilution	0.8	0.9	0.7
	FW Dilution	0.45	0.5	0.45
	Total Dilution	**1.25**	**1.4**	**1.15**
Green Domain	HW Dilution	0.45	0.55	0.5
	FW Dilution	0.35	0.35	0.35
	Total Dilution	**0.8**	**0.9**	**0.85**

IDM Red Mountain Green - Transverse	
Mining Type: Transverse	Method: ELOS
Project Number: 2CI017.000	Date: Jan 2017



	Q'		UCS	A		B	C	Hydraulic Radius, HR	
	Low	High	(MPa)	Small	Large			Small	Large
Back	7.9	15.8	105	0.60	0.50	0.34	1.00	4.20	4.33
Vertical Ends	7.9	15.8	105	1.00	1.00	0.34	8.00	5.86	6.77
Hangingwall	7.9	15.8	105	0.92	0.93	0.35	4.50	4.79	5.43
Footwall	7.9	15.8	105	0.92	0.93	0.35	8.00	4.79	5.43

Figure 7.4: Example of empirical dilution assessments for transverse stoping in the Green

7.3.1 Longhole Open Stoping Benchmarking

The empirical dilution estimate for the deposit was compared against unplanned dilution (planned and achieved) from other operations and studies within the SRK database. The benchmarking study was completed to compare the empirical estimates for Red Mountain against achieved results for similar mines. Dilution values are reported using the ELOS metric to enable direct comparison (Figure 7.5).

Data was collected from 17 properties, yielding 30 reference points of which 23 are related to some form of longhole open stoping (LHOS) method (bench and fill, multiple sub-level stoping, sub-level stoping). The remaining reference points relate to man-entry mining methods. 11 of the 23 LHOS reference points are from transverse layouts. Because of the nature of how overbreak or dilution data is collected, calculated and reported, several assumptions have been made in order to present the data for comparison to Red Mountain.

- Dilution estimates were typically provided as percentages and have been converted to an ELOS estimate.
- The source of the dilution (back, sidewalls) was not specified. For ELOS estimate all dilution was assumed to have reported from the sidewalls of the stope.
- Ore loss due to blasting layout and stope geometry was not considered in the ELOS calculation.

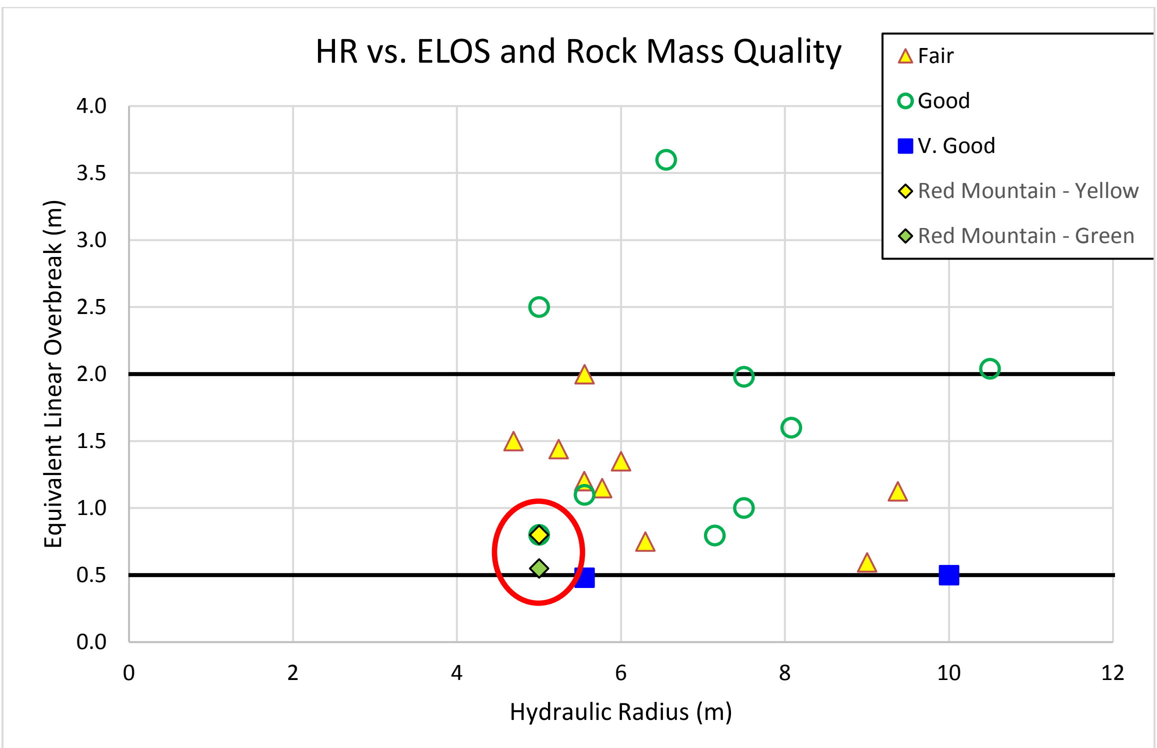


Figure 7.5: Dilution benchmarking comparing estimated dilution for Red Mountain against other operations (planned and actual).

7.4 Cement Rock Fill

The selected mining methods, longhole open stoping and cut-and-fill / drift-and-fill requires backfill to achieve the planned extraction and manage stability. Cement rock fill (CRF) will be used in all longitudinal stopes and primary transverse stopes as well as the primaries in drift-and-fill areas. Geotechnical considerations don't require CRF in secondary stopes and cut-and-fill mining provided that the fill won't be exposed by future mining.

CRF strength (UCS > 2 MPa) was based on benchmarking from similar operations and the requirement that it remains stable for the maximum exposed span (20 m) and a sublevel height of 25 m. No underhand mining or sill mining is planned which eliminates the need to work underneath previously placed backfill.

7.5 Excavation Interaction and Sequence Evaluation

Numerical modelling was conducted using the 3-dimension elastic boundary element code Map3D to assess the interaction between planned excavations based on the proposed mining sequence. The evaluation of the induced stresses around production and development excavations provides an understanding of stress interaction and expected level of damage that may occur during mining.

7.5.1 Sequence

The current mining design is based on an overhand longhole open stoping in the wider and steeper areas with overhand drift-and-fill/cut-and-fill mining being used in the narrower and flatter areas. Longhole open stoping is limited to the AV and Marc Zones, and drift-and-fill/cut-and-fill will be used in all three mineralized zones.

Long Hole Open Stoping

The adopted primary-primary sequence broadly entails a sequence that commences at the bottom and middle of the stoping area expanding upwards and outwards (Figure 7.6). This method minimizes backfill exposure to one vertical wall but requires cement rock fill in most stopes. Uncemented fill can be used in the final stopes which will not be exposed during subsequent mining. The sequence is beneficial interim of stope stability due to the reduced length of the unsupported hanging wall and footwall.

Drift-and-Fill / Cut-and-Fill

Overhand drift-and-fill and cut-and-fill mining is planned to extract the narrower and flat portions of the deposit. This includes the JW Zone and smaller sections of the Marc and AV Zones. The mining will begin at the bottom of the mining block and progressing upwards. Drift-and-fill mining in the Marc zone will occur in close proximity to previously mined and backfilled longhole stopes as illustrated in Figure 7.6.

Overall Production Sequence

The longhole open stoping is the primary focus of the production and the stopes are mostly extracted prior to the drift-and-fill/cut-and-fill mining. The mining was sequenced in such a way that it doesn't close on previously mined excavation. There are however areas where the drift-and-fill mining is planned in close proximity to the previously mined longhole stopes.

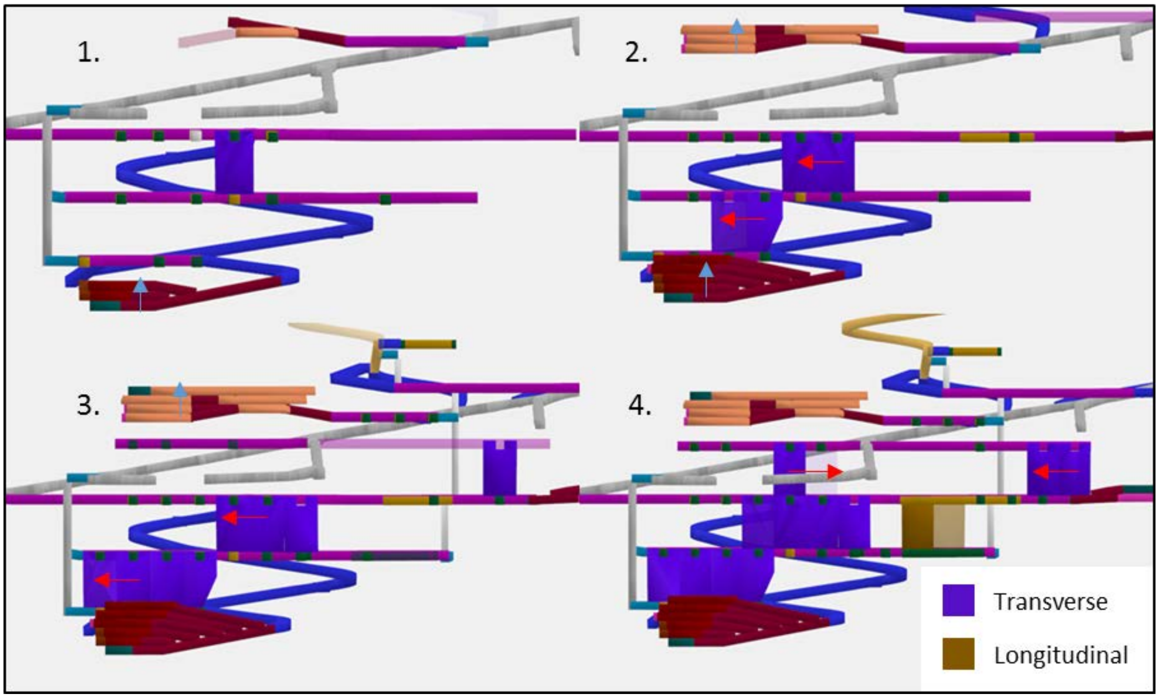


Figure 7.6: Sequence example of Marc zone showing drift-and-fill and longhole stoping.

7.5.2 Numerical Modelling

The mine design (dated June 17, 2017) and mining sequence (dated May 5, 2017) was used to assess the overall mining sequence and excavation interaction in a 3-dimensional numerical model (Map3D). The entire proposed mine was modeled in steps to assess the excavation performance and interaction during the mine life.

The stress used for the model assumed gravitational loading and K ratios of 1.5:1.5:1, with the principal horizontal stress oriented at 105º (mine grid). A stress datum was used at the bottom of the JW zone, with stress magnitudes interpreted from the K ratios and gravitational loading relative to the top of the mountain. This allows the topography to be better represented and act as a free surface during modelling. A stress gradient of 0.0281*K MPa/m was assumed to establish the pre-mining stress. Sensitivity analyses were run to simulate high stress (K of 2.0: 1.5: 1.0), and isotropic stress (K of 1.0: 1.0: 1.0).

Two material properties were used during modelling to simulate the 3 mining stages. The three stages simulated include the base material (intact rock), the excavation (void), and the backfill. Hoek-Brown parameters were used for intact rock, whereas Mohr-Coulomb was applied to the backfill. Laboratory testing data and geotechnical rock mass classification data was used to determine the rock mass material properties applied in the numerical modelling (Table 7.5). Backfill properties were based on bench marking as no laboratory testing data is available.

Table 7.5: Modelling parameters for Red Mountain.

	Rock	Backfill
UCS (MPa)	105	2
Ei (GPa)	24.9	500
v	0.14	0.30
GSI	60	N/A
mi	16	N/A

Longhole Open Stoping

Longhole open stoping will be conducted in the Marc and AV zones. The flat dip of the JW zone mineralization made it unsuitable for longhole open stoping at this time. The adopted primary-primary sequence attempts to eliminate diminishing pillars, with only one example within the Marc zone where stoping will close upon a pillar (Figure 7.7).

The mine is in a relatively low stressed environment and no zones of excessively high stress are expected around the open stopes. The risk related to mining induced seismicity is considered low. Stope performance is expected to perform as predicted.

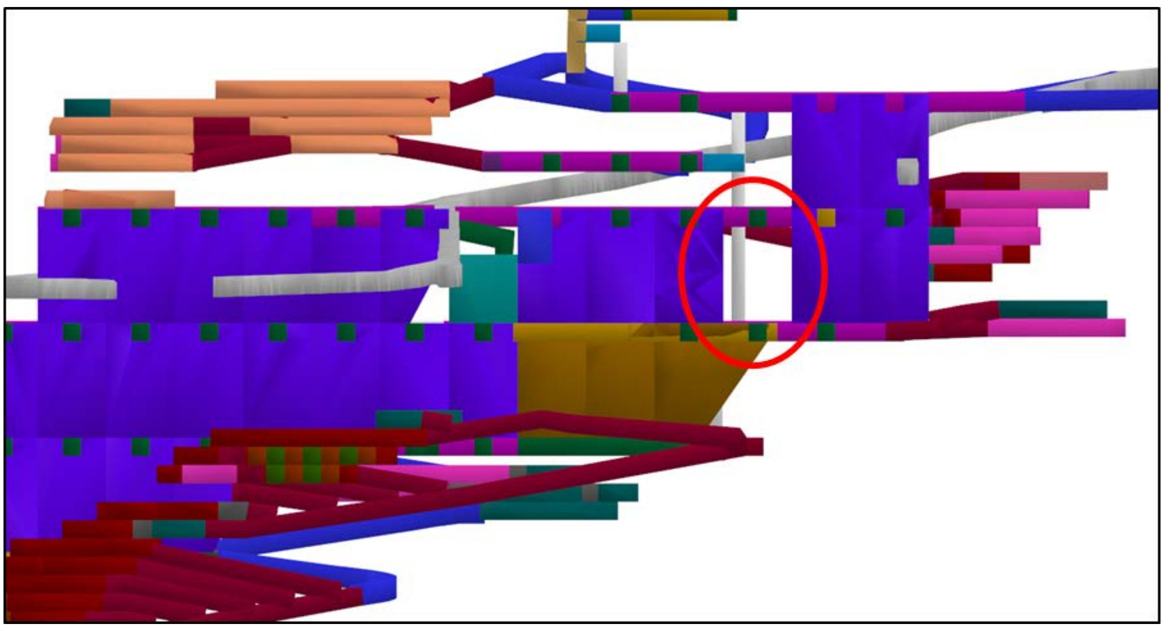


Figure 7.7: Diminishing pillar within Marc zone. Image shows the diminishing pillar prior to extraction (red circle)

Drift and-Fill / Cut-and-Fill

No mining induced stress issues are anticipated in around the drift-and-fill areas in AV and JW zones. In the AV zone a portion of the drift-and-fill mining is planned in close proximity to longhole stopes. The drift-and-fill excavations are mined before the stopes, and no mining induced stress issues are expected to occur as a result.

In the Marc zone, longhole stopes will be extracted before the drift-and-fill excavations at the base of the deposit. This will result in high stress concentrations in the drift-and-fill mining that may impact the rock mass performance negatively (Figure 7.8). This interaction requires CRF in the associated longholes stopes to mitigate the risk of backfill mobilization should the excavations intersect. Stress damage and weaker rock mass conditions around the affected drift-and-fill areas may require additional support.

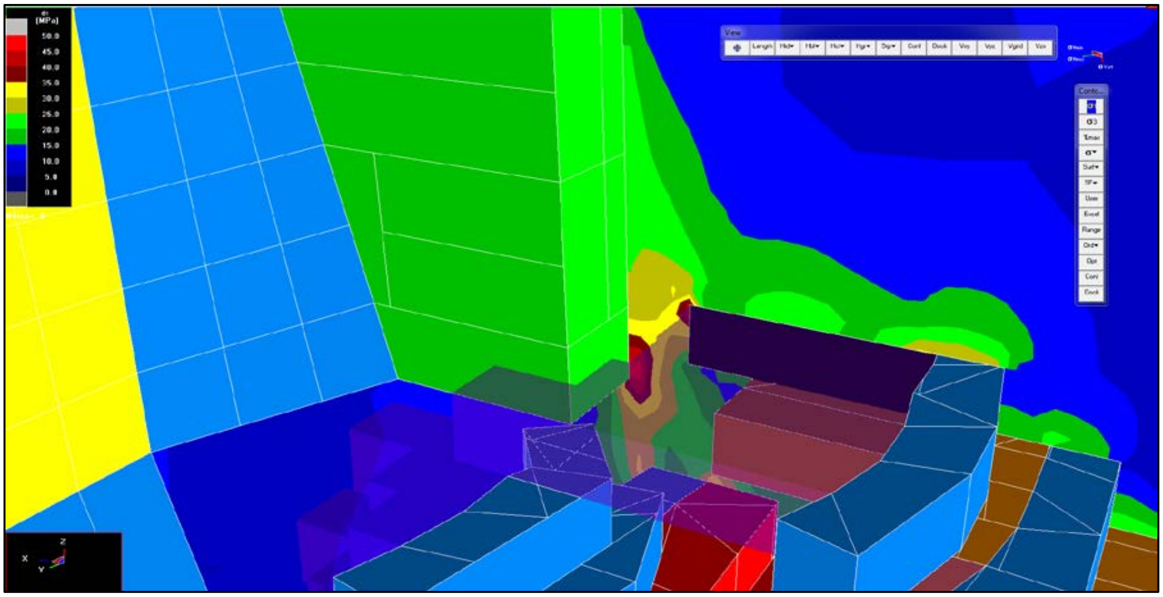


Figure 7.8: Stoping interaction with drift-and-fill excavations in Marc zone.

A sill pillar will be left in the JW zone between the lower and upper areas. The ore body will be mined from the bottom up, and mining induced stresses in this pillar are expected to be elevated but are not expected to impact mining. This pillar will not be recovered.

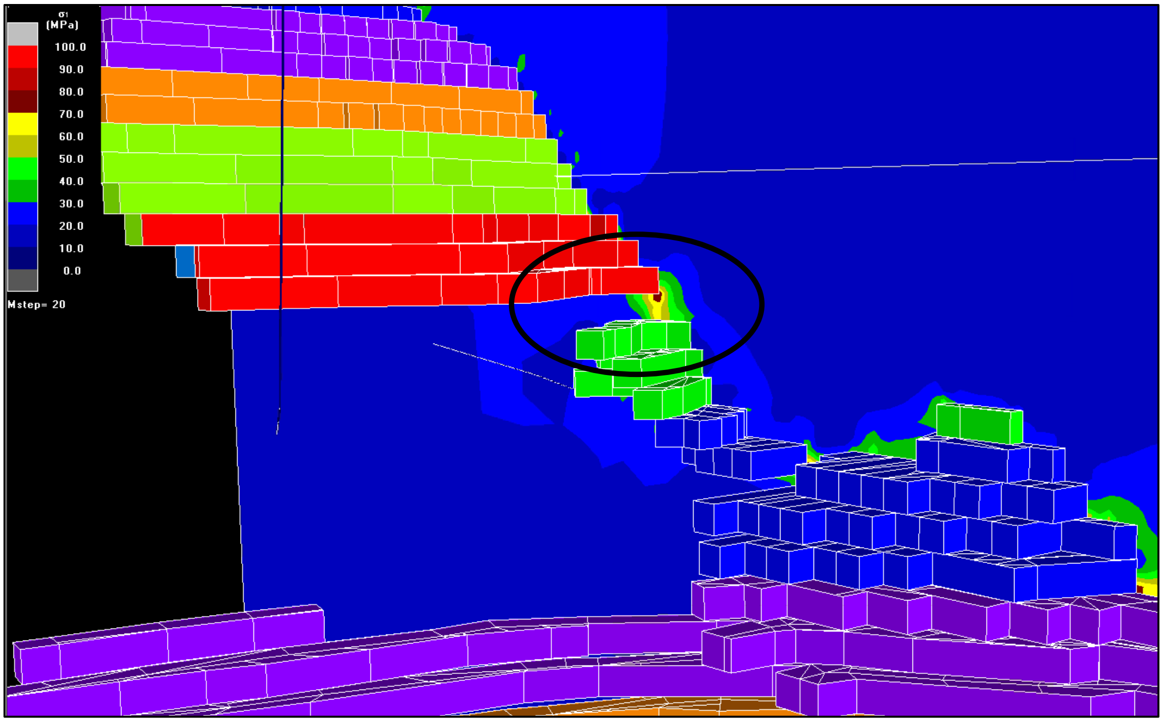


Figure 7.9: Sill pillar in the JW zone (black circle) will be left in place and not recovered.

Infrastructure

Infrastructure design at Red Mountain is efficient, with close spacing of development, ramps, and stoping/drift-and-fill mining. Several areas were analysed to assess the impact of mining on the infrastructure excavations:

- Existing decline:

  Mining in the Marc zone is expected to result in stress changes around the current decline. Lower confinement and increase tension in back may lead to ravelling in the unsupported excavation. For this reason, it will be recommended that this main access be pre-supported pre-production mining.

- Planned ramp from lower portal to Marc/AV Zones (Figure 7.10):

  Stoping will approach the ramp but a 20 m standoff is maintained. The stoping will elevate stress around the ramp, but is expected to be supportable with the designed ground support.

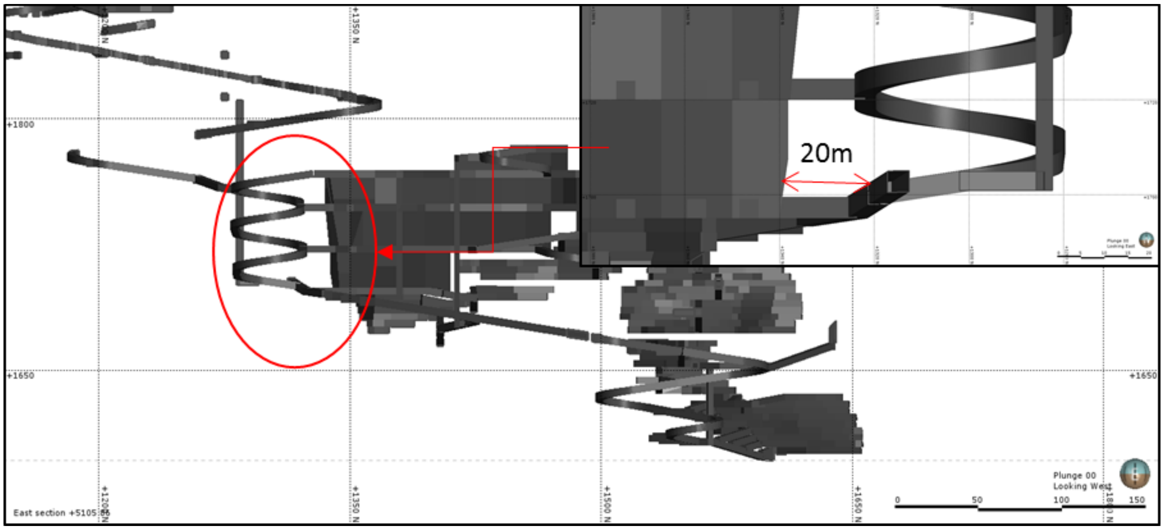


Figure 7.10: Planned ramp between Marc and AV zones.

7.6 Crown Pillar Assessment

Mineralization in the Marc zone extends near surface in the vicinity of the existing portal. The two areas of the out cropping or near surface resources is referred to as the Upper Crown and Lower Crown (Figure 7.11).

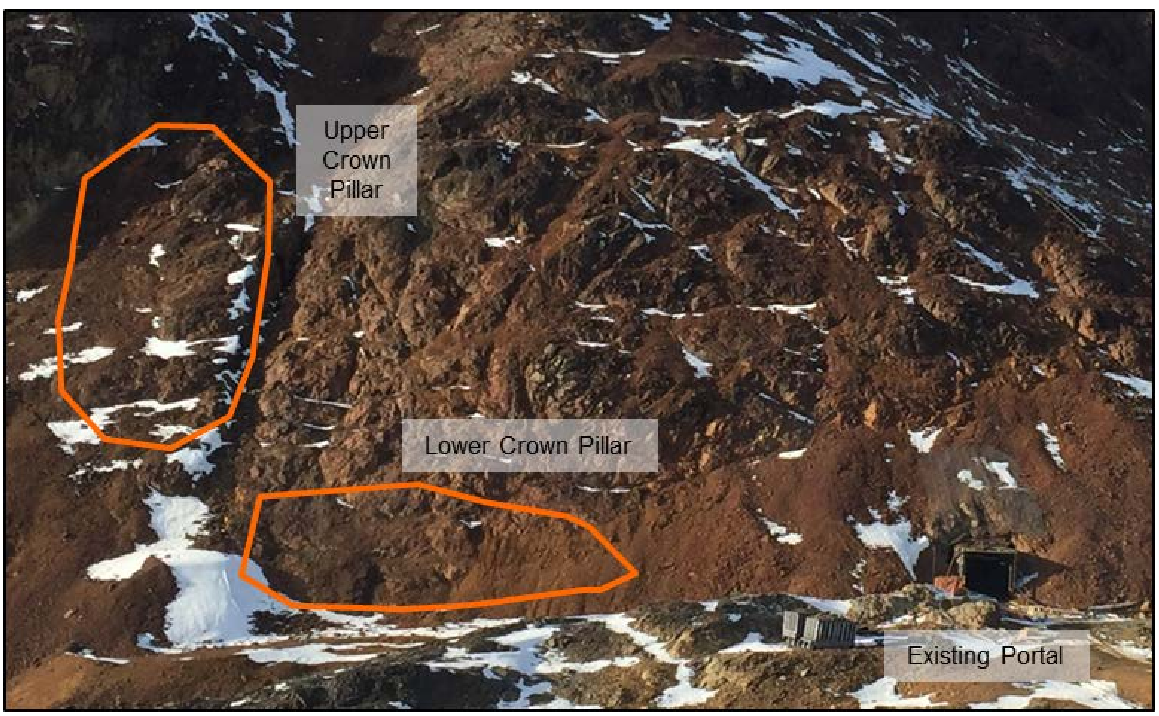


Figure 7.11: Location of the Upper and Lower Crown Pillars.

A combination of drift-and-fill and longhole stoping will be used to mine in close proximity to surface resulting in a thin crown pillar. The planned drift-and-fill excavations have a minimum crown pillar thickness of 12.5 m, and longhole stoping will create a 20 m thick crown pillar as shown in Figure 7.13. The span across these excavations range from 4.0 to 7.0 m for the drift-and-fill areas, while the back of the open stopes are limited to 4.0 m. Mining drift-and-fill in the Red Domain will require that excavations be limited to a maximum of a 4.0 m span. Primary excavations should filled with CRF prior to widening the span.

The Scaled Crown Pillar method (Carter, 2004) was used to assess the crown pillar stability. The empirical method uses the RQD, geometry of the planned excavations, and crown pillar thickness to evaluate the stability. The crown pillars are located in the Red domain which is characterized by weaker and broken rock (RQD: 20 – 60 and RMR_{90}: 25 - 55). The crown pillar plots within Classes A to C (Figure 7.12), which represents to limited stand-up time. Long-term crown pillar stability will require tight filling of the drift-and-fill and long-hole excavations with CRF.

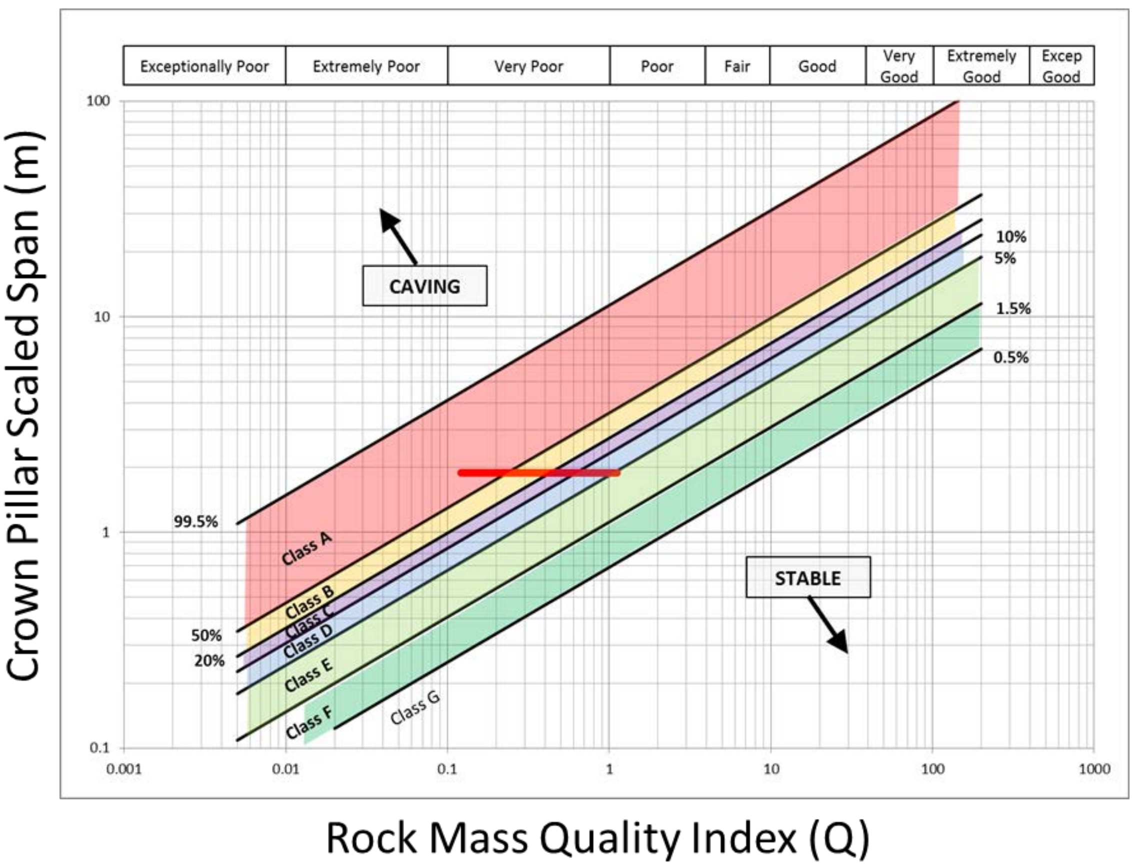


Figure 7.12: Carter's Scaled Span Crown Pillar Evaluation for an 11.5m thick crown pillar with expected range of geotechnical conditions.

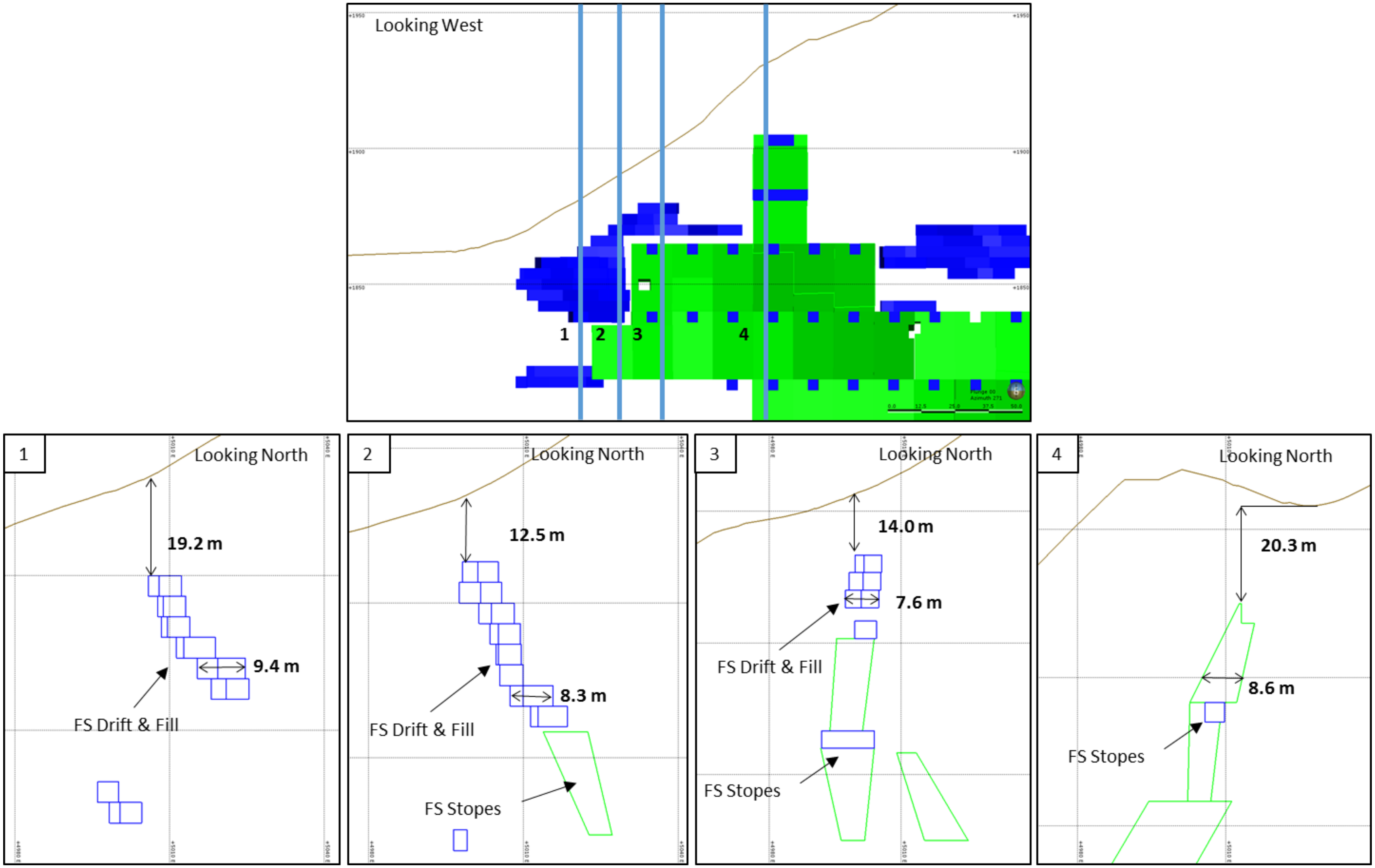


Figure 7.13: Crown pillar dimensions within the Marc zone.

Additional extraction of the upper and lower crown pillars are planned at the end of the Marc Zone mining (upper crown) and at the end of mine life (lower crown) as shown in Figure 7.14. The lower crown will be excavated as a portal (Location 1) and will be established during the early stages of the project to provide a second access to the underground workings and for ventilation purpose. Further extraction of the shallow mineralization from surface through these crown pillars will increase the exposure and thin the crown pillar around the second decline. The stability of the final slopes and open excavations have not been evaluated.

The upper crown (Location 2) is not easily accessible from surface and will be mined from underground. Longhole mining (uppers) of the upper crown is expected to daylight on surface creating an unsupported gloryhole.

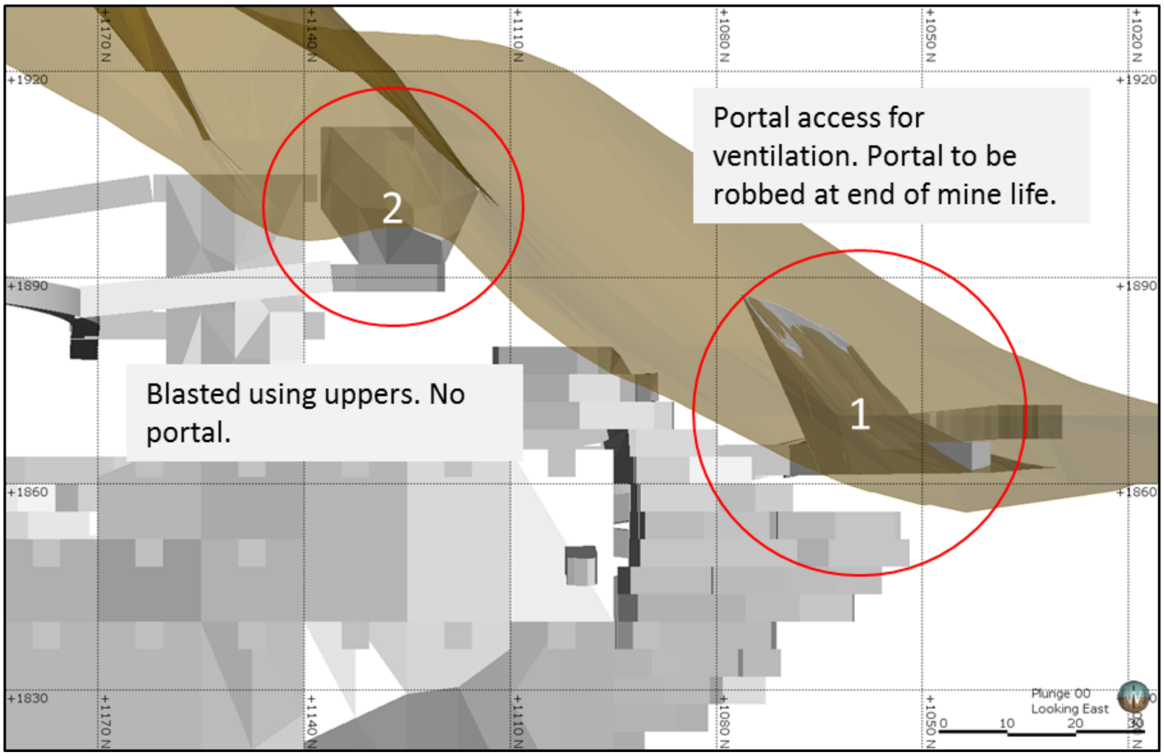


Figure 7.14: Portal near Marc zone called the lower crown (1) and the location of the upper crown (2). Gloryhole mining will be undertaken at both locations. Topography is overlain to show approximate geometry.

7.7 Ground Support Design

The ground support requirements have been evaluated for the planned development and production excavations in each of the geotechnical domains using empirical design charts (i.e. Grimstad and Barton (1993)) and experience from similar operations. The empirical support requirements were adjusted based on expected conditions during mining. Spans exceeding the planned dimensions will require a case by case assessment and adjustment to the support specifications. Table 7.6 contains the support recommendations for development, longhole open stopes and cut-and-fill/drift-and-fill.

Table 7.6: Detailed support recommendations by geotechnical domain.

Excavation	Dimension		Design Comment and Ground Support Recommendation
Transverse Stope	25 m sub-level spacing (floor to floor) **Primary Stopes:** 15 mW x 20 mL **Secondary Stopes:** 10 mW x 20 mL		**Green Domain Support:** 1.8 m resin rebar on 1.5 m x 1.5 m spacing. Welded wire mesh installed down to shoulder. 6.0 m cable bolts on 2.0 m within the ring (6 cables per ring) and 3.0 m between rings.
			Yellow Domain Support: 1.8 m resin rebar on 1.2 m x 1.2 m spacing. Welded wire mesh installed down to shoulder. 6.0 m cable bolts on 2.0 m within the ring (6 cables per ring) and 2.5 m between rings.
			Pink Domain Support: 2.1 m resin rebar on 1.2 m x 1.2 m spacing. Welded wire mesh installed down to grade line. 6.0 m cable bolts on 2.0 m within the ring (6 cables per ring) and 2.5 m between rings. Shotcrete will be required through fault zones.
Longitudinal Stope	25 m sub-level spacing (floor to floor) **Green:** maximum 10 mW x 25 mL **Yellow:** maximum 10mW x 20 mL		**Green Domain Support:** 1.8 m resin rebar on 1.5 m x 1.5 m spacing. Welded wire mesh installed down to shoulder. Span 6.0 - 10 m: 4.0 m cable bolts on 2.0 m within the ring (6 cables per ring) and 3.0 m between rings.
			Yellow Domain Support: 1.8 m resin rebar on 1.2 m x 1.2 m spacing. Welded wire mesh installed down to shoulder. Span 6.0 - 10 m: 4.0 m cable bolts on 2.0 m within the ring (6 cables per ring) and 2.5 m between rings.
			Pink Domain Support: 2.1 m resin rebar on 1.2 m x 1.2 m spacing. Welded wire mesh installed down to grade line. Span 6.0 - 10 m: 4.0 m cable bolts on 2.0 m within the ring (6 cables per ring) and 2.5 m between rings. Shotcrete will be required through fault zones.
Overhand Cut -and-Fill, Drift-and-Fill, Crosscuts	4.0 m x 4.0 m, flat back style		**Green Domain:** 1.8 m resin rebar on 1.5 m x 1.5 m spacing
			Yellow Domain: 1.8 m resin rebar on 1.5 m x 1.5 m spacing
			Pink Domain: 2.1 m resin rebar 1.2 m x 1.2 m spacing. Welded wire mesh installed down to shoulder. Cable bolts around faults.
			Red Domain: 2.1 m plastic coated swellex on 1.2 m x 1.2 m spacing. Welded wire mesh and 50 mm shotcrete down to 0.5 m from the floor
	Wider span (6-8 m)		**Green Domain:** 1.8 m resin rebar on 1.5 m x 1.5 m spacing
			Yellow Domain: 1.8 m resin rebar on 1.5 m x 1.5 m spacing. Welded wire mesh installed down to shoulder
			Pink Domain: 2.1 m resin rebar on 1.2 m x 1.2 m spacing. Welded wire mesh installed down to shoulder. Cable bolts around faults.
			Red Domain: Exposed span should be limited to 4.0 m. Fill first drift with CRF before mining the second.
	Wider span (8 - 10 m)		**Green Domain:** 1.8 m resin rebar on 1.5 m x 1.5 m spacing. 4.0 m cable bolts on 3.0 m x 3.0 m spacing
			Yellow Domain: 1.8 m resin rebar on 1.5 m x 1.5 m spacing. Welded wire mesh installed down to shoulder. 4.0 m cable bolts on 3.0 m x 3.0 m spacing
			Pink Domain: 2.1 m resin rebar on 1.2 m x 1.2 m spacing. Welded wire mesh installed down to shoulder. 4.0 m cable bolts on 2.0 m x 2.0 m spacing
			Red Domain: Not applicable
	3-Way Intersections		**Green Domain:** 2.1 m resin rebar on 1.5 m x 1.5 m spacing
			Yellow Domain: 2.1 m resin rebar on 1.5 m x 1.5 m spacing. Welded wire mesh installed down to shoulder
			Pink Domain: 2.1 m resin rebar on 1.2 m x 1.2 m spacing. Welded wire mesh installed down to shoulder. 4.0 m cable bolts on 2.0 m x 2.0 m spacing
			Red Domain: Not applicable
	4-Way Intersections		**Green Domain:** 2.1 m resin rebar on 1.5 m x 1.5 m spacing
			Yellow Domain: 2.1 m resin rebar on 1.5 m x 1.5 m spacing. Welded wire mesh installed down to shoulder
			Pink Domain: 2.1 m resin rebar on 1.2 m x 1.2 m spacing. Welded wire mesh installed down to shoulder. 4.0 m cable bolts on 2.0 m x 2.0 m spacing
			Red Domain: Not applicable
	Crosscuts		**Green Domain:** 1.8 m bolts (possibly split sets) on 1.5 m x 1.5 m spacing
			Yellow Domain: 1.8 m bolts (possibly split sets) on 1.5 m x 1.5 m spacing
			Pink Domain: 2.1 m bolts (possibly split sets) 1.2 m x 1.2 m spacing. Welded wire mesh installed down to shoulder. Cable bolts around faults.
			Red Domain: Not applicable
Ramp and Footwall Drifts	4.5 m x 4.5 m, arched		**Green Domain:** 1.8 m resin rebar on 1.5 m x 1.5 m spacing. Welded wire mesh installed down to shoulder
			Yellow Domain: 1.8 m resin rebar on 1.5 m x 1.5 m spacing. Welded wire mesh installed down to shoulder
			Pink Domain: 1.8 m resin rebar on 1.2 m x 1.2 m spacing. Welded wire mesh installed down to grade line. Cable bolts around faults.
			Red Domain: 2.1 m plastic coated swellex on 1.2 m x 1.2 m spacing. Welded wire mesh and 50 mm shotcrete down to 0.5 m from the floor

7.8 Mine Access

The feasibility study mine design includes the addition of a lower portal and a second upper portal. The lower portal will be located approximately 700m to the west and down slope of the current portal and will be used to haul ore to the processing facilities and for dewatering. The second upper portal (the lower crown), located adjacent to the current portal, will be developed for an alternative access and ventilation (Figure 7.15).

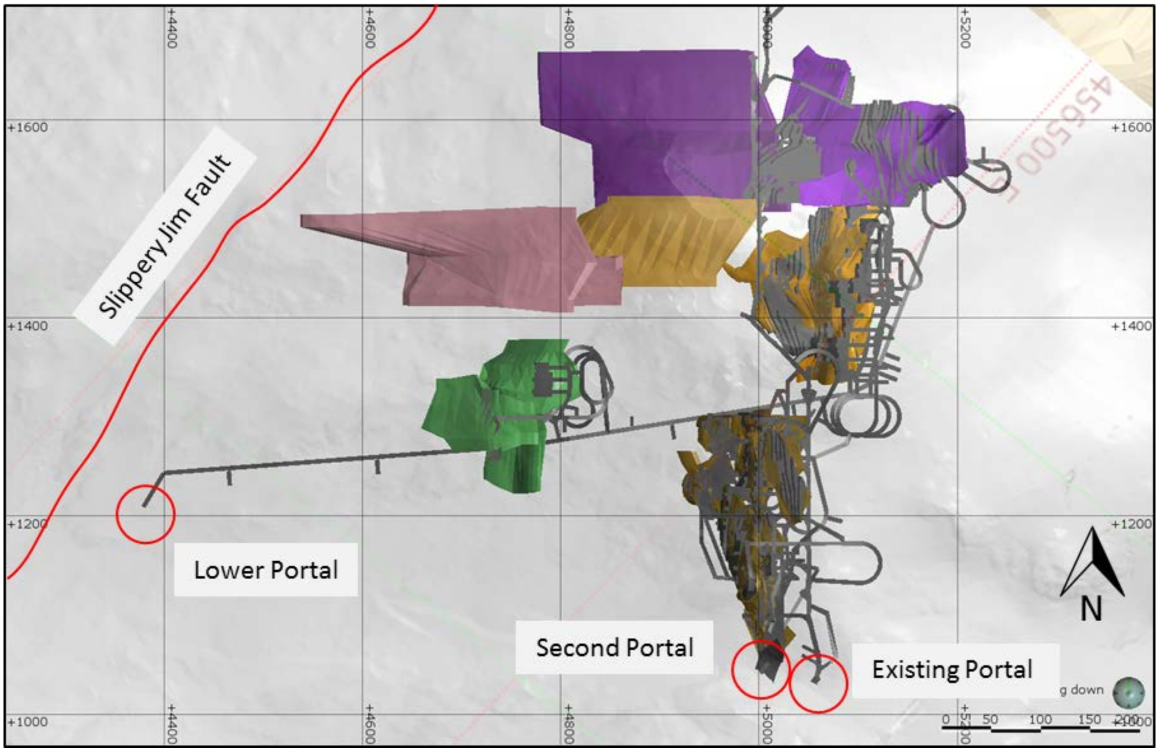


Figure 7.15: Plan view of existing and planned portals, with mine plan, mineralized solids, and the Slippery Jim fault.

No detailed geotechnical data is available for either proposed portal locations and the ground conditions were assumed to be similar to the upper portal (Red domain) once the talus is removed. No detailed structural interpretation exists at the lower portal location, but there is a large regional fault (Slippery Jim) to the west of the proposed site. Conceptual design recommendations were provided but are preliminary pending further investigation. SRK is not aware that a geotechnical hazard assessment has been completed for the proposed portal location for rockfall and avalanche risks (Figure 7.16). This will need to be completed to establish the final location.

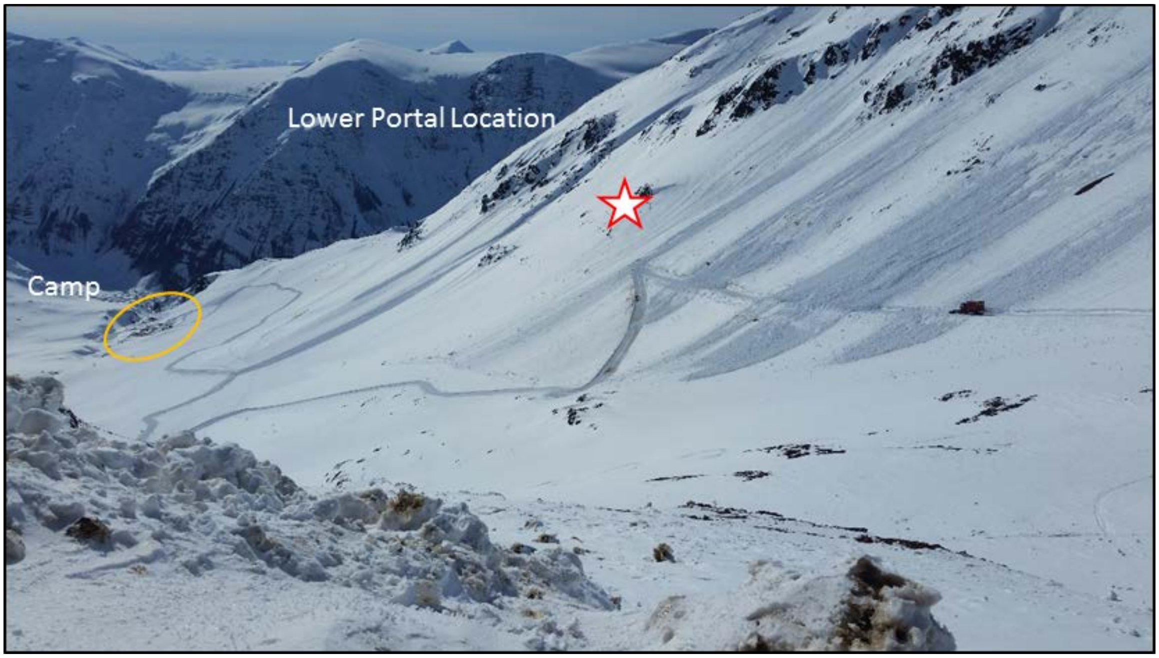


Figure 7.16: Lower portal location. Avalanche tracks are visible along mountain side.

The second upper portal is planned near the existing decline (Figure 7.15). No detailed geotechnical data is available for the proposed location but the conditions are assumed to the similar to the existing portal due to the proximal location. Design recommendations are preliminary and should be verified through further investigation.

7.8.1 Portal Design

Portal design is conceptual lacking detailed drilling or geotechnical data at either of the proposed locations. Preliminary design requires clearing talus from the slope, or excavation of talus to a stable slope angle and/or supported. The suitability of talus as a road bed should also be considered. The portal design (Figure 7.17) is modelled after the existing portal.

The portals (4.5m x 4.5m, with an arched back) should be excavated with at least 5 m competent rock above the back and rockfall protection must be included in the design. Ground support around the portal should include:

- 2.4m resin rebar @ 1m spacing with chain-link
- 6m cable bolts @ 2m spacing (2 rows above portal)
- Sidewalls in rock cut to 45º and cleared of talus
- Face angle cut to 70º, with a minimum of 5 m of competent rock above portal entrance
- Solid structure to be installed outside the portal (minimum 3 m) and for first 3 m into the decline to mitigate rockfall risk from the slope above the portal. This can be a timber structure like existing portal, or segmented steel (Armtec)

- Portal will be designed to accommodate frame for rockfall protection

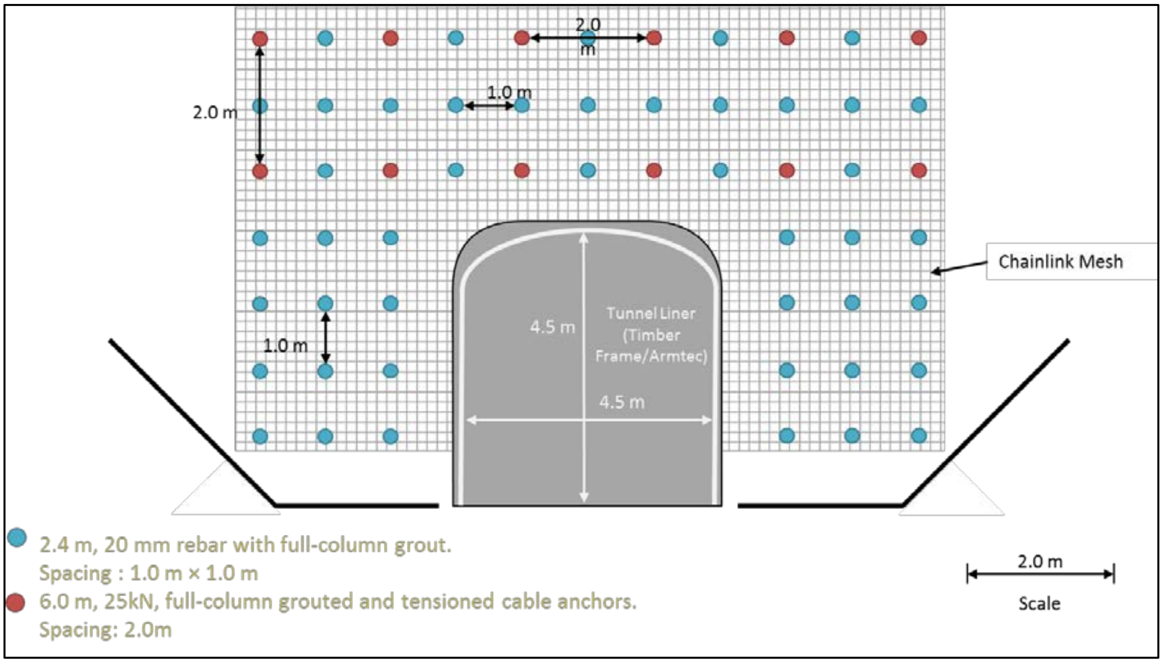


Figure 7.17: Conceptual portal support design.

8 Conclusions and Recommendations

SRK undertook field investigations designed to characterize the rock geotechnical conditions, and provide appropriate analysis of the data for use in underground mine and infrastructure design, in support of the feasibility study.

- Based on the geotechnical assessment, the orebody has been sub-divided into four geotechnical domains. Three domains are considered suitable for longhole open stoping and the fourth requires drift-and-fill or cut-and-fill mining. Geotechnical design recommendations were derived based on rock mass conditions and in situ stress levels.

- A three-dimensional structural model was created for the deposit from underground mapping, core logging data, and core photo review. The brittle structures are expected to have some impact on the planned mining and they form the boundaries between the three ore bodies (Marc, AV and JW).

- Dilution (ELOS) from the longhole open stopes is expected to range between 0.55 and 1.4 m depending on the domain and rock mass conditions and stope dimensions.

- Based on the current mine design, the crown pillar is expected to be temporarily stable. Long-term stability will require installation of the recommend support and tight filling of the excavations with CRF.

- Inflows are predicted to be relatively low, reaching an annual average rate of about 3,810 m^3/d in Year 2 and then decreasing from this point onward to about 2,640 m^3/d (i.e., Base Case), while under more conservative assumptions (i.e., Upper Case), predictions were respectively 6,400 m^3/d and 4,400 m^3/d. Seasonal water inflows into stoping areas could complicate mining and backfill operations in faulted areas.
- The support design is based on a range of ground conditions (geotechnical domains) and specific spans which should be maintained. Additional support requirements are required in the existing accesses due to stress changes related to production stoping.

9 Risks and Opportunities

Risks identified during the geotechnical assessment include:

- JW has minimal intersections for oriented core data, underground mapping, and detailed geotechnical logging. The mining design is based on cut-and-fill mining due to the shallow dip of the deposit, which decreases the risk relative to a longhole stoping scenario.
- No geotechnical data was collected in the 141 zone and was not assessed for this investigation.
- Limited geotechnical data exists at the crown pillar.
- Rock mass and geohazard risk exists around the lower portal location where no information is currently available.

Opportunities to improve understanding of the deposit include:

- Improved understanding of the regional structural geology will improve understanding of the deposit and assist in exploration targeting.
- Collection of geotechnical data for the 141 zone to validate the mine design.

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All data used as source material plus the text, tables, figures, and attachments of this document have been reviewed and prepared in accordance with generally accepted professional engineering and environmental practices.

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