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SAMATOSUM PROJECT

# PRELIMINARY ENGINEERING GEOLOGY, HYDROGEOLOGY AND ROCK MECHANICS ASSESSMENTS

## FOR THE

## PROPOSED UNDERGROUND MINE

Prepared by

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# 2. ENGINEERING GEOLOGY

## 2.1 GEOLOGY

### 2.1.1 Regional Geology

The site is located along the western flank of the Shuswap Metamorphic Complex, and is underlain by rocks of the Devonian or older Eagle Bay Formation. These rocks were complexly deformed and metamorphosed during the Jurassic-Cretaceous Columbian Orogeny. In general, a thick sequence of mafic pyroclastic rocks structurally overlies altered and metamorphosed sedimentary rocks which host the ore. Both stratigraphy and a well developed regional foliation strike about northwest and dip moderately to the northeast.

### 2.1.2 Lithology and Alteration

The main rock types and nomenclature are summarized in Table I. In general, the rocks may be divided into four groups on the basis of lithology, alteration and geotechnical parameters (see Section 2.3.3 below):

i) Mafic Pyroclastics and Related Rocks

These rocks include MFT, MLT and AMF and consist of dolomitized chloritic or sericitic tuffs and lapilli tuffs. They structurally overly the sedimentary rock and are themselves barren of ore. Much of the development access for the proposed mine will occur in these rocks.

ii) Silicified Sediments and Related Rocks

These rocks include SAG, AGM, SLS, QVS, QSX and MSX and consist of graphitic argillites, greywackes and other sediments, which are sometimes interbedded with dolomitized mafic pyroclastics, and which have been moderately to strongly silicified and/or quartz-carbonate veined. Sulphide mineralization and ore may occur within these rocks.

### iii) Sericitized Sediments and Related Rocks

These rocks include AS, SRT and AWE and generally consist of unaltered to strongly sericitized graphitic argillites, wackes, siltites, turbidites, chert and other sedimentary rocks. Pyritization and weak to moderate silicification may also occur, and these rocks may host ore.

### iv) Fault Zones

Fault zones consist of breccia and/or gouge filled zones which are commonly strongly graphitic, chloritized and/or sericitized. Lithologic distinctions are often difficult to determine; hence all fault zones are considered collectively. The ore blocks are displaced by cross-faults and bedding/foliation shears resulting from deformation of the relatively competent silicified ore zone and the incompetent sericitic wall rocks.

### 2.1.3 Ore Zone

As illustrated in plan in Fig. 1 and on the longitudinal projection in Fig. 2, the ore zone extends approximately 240m southeast from the existing pit slope, between about elevations 1273m and 1328m. Overall, the zone strikes about parallel to foliation, dips 20° to 30° to the northeast, and plunges slightly towards the southeast (i.e. into the slope). Minimum vertical distance from the top of the ore zone to the ground surface varies from zero at the pit face to about 190m.

The ore zone is considered to be an overturned synform, with the hanging wall limb locally sheared out. Most of the ore reserves are at or near the overthickened hinge area. The main orebody appears ovaloid to rectangular in cross section, and varies in dip length from about 8m to

45m, and in thickness from 2m to 12m. In cross section, the long axis of the main orebody is usually aligned subparallel to foliation (see Figs. 3 to 7). Along strike, the main orebody is deformed, interrupted or offset by several fault zones, resulting in considerable variation in shape and continuity.

In addition to the main orebody, several smaller, tabular to lens shaped orebodies have also been outlined. As illustrated in Figs. 3 to 7, these secondary orebodies commonly occur as vein-like or stratiform zones, either as up-dip extensions of the main orebody, or as independent zones stratigraphically above or below, and usually up-dip from, the main orebody. Thickness of these zones varies from less than 1m to about 3m, and continuity varies from about 3m to 14m along dip, and from about 5m to 30m along strike.

## 2.2 STRUCTURAL GEOLOGY

### 2.2.1 Geologic Structural Analysis

The engineering behaviour of a rock mass is often influenced by orientation and characteristics of discontinuities within the rock mass. Extrapolation of stability analysis results, and hence design criteria, is valid only within zones where the geologic structural characteristics are similar. Zones with consistent, similar geologic structure are called Structural Domains.

To assess the distribution of discontinuity orientations, geologic structural mapping data collected in the existing exploration workings was analyzed using lower hemisphere equal area projections. Initially, separate projections were prepared for data collected within mafic pyroclastics and related rocks, and within sediments and related rocks. In addition, separate projections were prepared for joints, faults and foliation. Lower hemisphere equal area projections of each of the rock and discontinuity types are given in Appendix A.

Although only limited data is available, particularly in sediments and related rocks, comparison of the projections in Appendix A indicates that relatively little difference in the overall distribution of discontinuities occurs between the main rock types. Hence, for preliminary assessment purposes, the ore zone and surrounding rock mass are considered to occur within one structural domain.

### 2.2.2 Discontinuity Sets

Fig. 8 is a lower hemisphere projection of all geologic structural mapping data from the existing exploration workings. Based on this projection, it appears that at least two well developed discontinuity sets occur within the rock mass (i.e. Foliation and Discontinuity Set C). Figure 9 is a similar projection based on a considerably larger data base obtained from mapping of the Phase 2 pit benches (Piteau Associates, 1990). Both Foliation and Discontinuity Set C are also well represented in Fig. 9, and peak orientations of these sets are closely comparable between the two data sources.

Foliation, including foliation joints and foliation shears, strikes about N60°W and dips moderately to the northeast. Foliation joints are commonly chlorite or sericite coated, and spacing between natural joints in the exploration workings varied from about 0.1m to 0.8m in mafic pyroclastics and related rocks, and from about 0.05m to 0.5m in sediments and related rocks.

Discontinuity Set C strikes northeast and dips moderately to steeply to the southeast. This set consists primarily of joints, although a few shears with similar orientations were also mapped.

In addition to Foliation and Discontinuity Set C, two other moderately developed sets (i.e. Discontinuity Sets A and B) are apparent in Fig. 9. A few discontinuities with similar orientations to Sets A and B were also mapped in the exploration workings, although too few were mapped to reliably determine peak orientations of these sets based on underground mapping data alone. Based on surface mapping data, Discontinuity Set A strikes about N10°W and Discontinuity Set B strikes about N20°E. Both sets dip steeply to subvertical to the west, and both are represented by joints and faults.

## 2.3 ROCK STRENGTH AND COMPETENCY

### 2.3.1 Intact Rock Strength

Hardness classification conducted in conjunction with geotechnical core logging (see Section 2.3.3 below) indicates that mafic pyroclastics and silicified sediments are the strongest rocks, classifying as R2 to R3 (i.e. soft to average rock), which may be roughly correlated to an unconfined compressive strength (UCS) in the range 7 to 56 MPa (see Appendix B). Point Load Index testing of core samples of mafic pyroclastics and related rocks conducted for a previous study (Piteau Associates, 1988a) indicated an approximate UCS in the range 12 to 250 MPa, depending on degree of alteration and direction of testing (i.e. parallel or perpendicular to foliation).

Sericitized sediments and related rocks and rock fragments contained within fault zones classified as R1 to R2 (i.e. very soft to soft rock), with an equivalent UCS in the range 0.7 to 28 MPa. Point Load Index testing previously conducted on lightly altered sediments (previously referred to as muddy tuff) indicated an approximate UCS of about 16 MPa.

### 2.3.2 Discontinuity Shear Strength

Based on results of previous direct shear testing (Piteau Associates, 1988a), and examination of discontinuity conditions in core and in the exploration workings, friction angles of 25° and 30° to 35°, with no cohesion, are considered appropriate for foliation joints and cross joints in unaltered rocks, respectively. Where sericite, chlorite or other clay alteration occurs on joints (foliation or cross joints), or in fault zones containing appreciable gouge, friction angles of 20° or lower, with no cohesion, are considered appropriate.

### 2.3.3 Geotechnical Core Logging

Geotechnical logging was conducted on approximately 4000m of BTW (i.e. 38mm dia.) core from 58 diamond drillholes. Parameters recorded included RQD, Hardness, Degree of Breakage, Degree of Alteration, rock type, foliation dip, frequency of clay-coated foliation joints and type of clay alteration. A complete description of the geotechnical core logging parameters is given in Appendix B.

Results of the geotechnical core logging are summarized by rock type in Table II. Results in Table II indicate that mafic pyroclastics and silicified sediments and related rocks are similar in overall competency, and are the most competent of all the rocks logged. Sericitized sediments appear to be slightly less competent, and predictably, fault zones tend to be the least competent.

### 2.3.4 Rock Mass Quality

In addition to general assessments of rock mass competency based on rock type, geotechnical core logging data was used to develop a three dimensional model of rock mass quality throughout the zone. Information regarding the distribution of areas of relatively good vs poor rock mass quality is important in assessing likely rock mass behaviour and possible support requirements in various areas of the mine.

To simplify the model, each of five key geotechnical parameters derived from the core was rated on a scale of 0 to 4, with 0 representing the worst or least favourable condition, and 4 representing the best or most favourable condition. Rock Mass Quality was then defined as the sum of the individual ratings for each of the parameters, with a possible variation from 0 to a maximum of 20. As a further simplification, five descriptive categories of Rock Mass Quality, ranging from very poor to very good were defined, based on the total numerical rating. Numerical ratings for each of the key geotechnical parameters and for each of the five categories of Rock Mass Quality are summarized in Table III.

Rock Mass Quality ratings for each core run of each drillhole were plotted on geotechnical cross sections spaced at 10m to 20m intervals along the full length of the zone. To assist in visualizing zones of contrasting Rock Mass Quality, different symbols were assigned to each of the five categories defined in Table III. Finally, zones of similar Rock Mass Quality were identified and contoured on each section. Typical geotechnical cross sections illustrating Rock Mass Quality are given in Figs. 3 to 7.

Examination of the typical geotechnical cross sections in Figs. 3 to 7 indicates that zones of very poor to poor rock mass quality are often (but not exclusively) related to fault zones and strongly sericitized rocks. Zones of fair to good Rock Mass Quality are often associated with mafic pyroclastics or strongly silicified rocks.

Typical Rock Mass Quality ratings were also prepared for each of the basic rock types, based on the average geotechnical parameters shown in Table II. The results are summarized on the left side of Table II. Mafic pyroclastics, silicified sediments and related rocks rate on average as fair quality rocks. Sericitized sediments and related rocks rate on average as poor quality rocks, and fault zones rate as very poor quality rocks.

### 2.3.5 Rock Mass Classification

General rock mass quality can also be assessed using a number of "universal" classification schemes. Such classifications provide a method for comparing local rock mass conditions with conditions and experience at other mining operations and underground excavations. Comparisons based on rock mass classification are commonly used to provide a preliminary evaluation of design parameters, such as expected standup time, allowable unsupported spans, support requirements for different spans and applications, etc.

Preliminary rock mass classification was carried out in the exploration workings using the NGI Tunnelling Quality Index (Q), developed by Barton et al (1974) and the CSIR Rock Mass Rating (RMR), developed by Bieniawski (1976). A total of 18 locations in the workings were thus classified, representing the range of rock types and rock mass conditions exposed in the workings. Results are summarized in Fig. 10 and indicate that most rocks exposed in the workings classify as poor, according to NGI. According to CSIR, mafic pyroclastics and related rocks classify as fair to good, and sericitized sediments and related rocks classify as poor to fair. Fault zones classify as extremely poor and poor, according to NGI and CSIR, respectively.

### 2.3.6 In Situ Stress

In situ stress measurements were not conducted for this study; however, no evidence of high vertical or horizontal stress was observed in any of the exploration workings, in the adjacent open pit, or in the nearby Rea Gold exploration adit. For preliminary assessments, we have assumed that the principal in situ stress is vertical, and results directly from the vertical rock load.