ATTACHMENT A

Golder 2004. Project No. 03-1117-0029. Technical Memorandum - Open Pit Slope Design Recommendations, Fortune Minerals Limited, Gold-Bismuth-Cobalt Project. November 2004.

TECHNICAL MEMORANDUM

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TO: Fortune Minerals **DATE:** November 3, 2004

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RE: **OPEN PIT SLOPE DESIGN RECOMMENDATIONS**
FORTUNE MINERALS LIMITED
NICO GOLD-BISMUTH-COBALT PROJECT

1.0 INTRODUCTION

Enclosed are summaries of structural fabric assessments and rock slope stability analysis results and recommended bench configurations for Fortune Minerals Nico deposit pit slopes based on oriented core and surface mapping data. The purpose of these input parameters is to allow for a bankable feasibility study ultimate pit shell to be generated for the purpose of mine planning. The revised open pit configuration should be reviewed by Golder once generated. Slope design recommendations are presented on Table 4.

2.0 BOREHOLE RECORDS

Records of geotechnically logged drillholes and oriented core data from the 2003 geotechnical investigation are presented in the 2003 Draft Factual Report submitted to Fortune. Borehole logs from previous investigations are presented in the July 1999 report by Golder titled “A Review of Geotechnical Data and Recommendations for Pit Slope Design Configurations, Nico Deposit.”

3.0 DEPOSIT GEOLOGY

The following description is taken from a recent CIM paper (Goad, et. al, 1998). The Nico deposit is situated in the Snare Group sedimentary rocks that comprise a 3 to 5 km wide succession of siltstone, impure dolomite, sub-arkosic wacke and arenite. These strata are interpreted to dip 50° to 80° towards 030°. The Snare Group sedimentary rocks are uncomformably overlain by the Faber Lake Group volcanics.

These rocks dip 20° to 50° towards 020° and are made up of a succession of rhyolite to rhyodacite tuffs, flows and minor volcaniclastics. The sedimentary and volcanic rocks of the Nico deposit are intruded by early quartz feldspar porphyritic dykes emplaced parallel to the strike of the Snare Group and later quartz porphyritic dykes emplaced parallel to the Faber Lake Group. A series of late northeast trending (040°) transverse fault intersects both Snare and Faber Group rocks. Major northeast trending (070°) regional faults and associated quartz veins have also been identified. The mineralization consists of several closely stacked stratabound, irregular, sulphide bearing lenses in altered siltstone and subarkosic wacke units. Mineralization is found in the sedimentary rock units that have been subject to “Black Rock Alteration”. The unit is referred to as Black Rock Ironstone.

The metasedimentary rocks are Palaeozoic in age.

The surface morphology of the deposit area is dominated by hills that correspond to the volcanic rock outcrop. The exposed mineralization (termed the bowl zone) is located in a small valley flanked by hills comprised of mixed volcanic, intrusive and metasedimentary rocks.

4.0 ENGINEERING GEOLOGY

The four main geotechnical rock types at the Fortune site are described below:

TABLE 1: Geotechnical Units

Rock Type (from oldest to youngest)	Typical Rock Strength	Typical Number of Joint Sets	Significant Exposures in Proposed Mine Workings
Footwall Siltstone • Light grey, fresh, fine grained • Bedded • Dip 40-50 ° to the NE	R5-R6, Very strong to Extremely strong rock	2 to 3 smooth to rough, planar	Non-mineralized. • Host rock for bulk sample portal and decline (underground ramp). • Footwall on a limited number of underground panels. • Limited exposure on proposed Ultimate Slopes

Rock Type (from oldest to youngest)	Typical Rock Strength	Typical Number of Joint Sets	Significant Exposures in Proposed Mine Workings
Black Rock Ironstone (metasedimentary rock) • Dip 40-50 ° to the NE • Banded *Note that this unit is also referred to as Schist in previous reports.*	R3-R4 Medium strong to strong rock	2 to 3 smooth to rough, planar	Mineralized (including sulphides and magnetite). Significantly heavier than other rock types. Arseno-pyrite banding prevalent. • Footwall and hanging wall for most ultimate pit slopes. • Footwall, hanging wall, roof and backs of most underground panels.
Greywacke (metasedimentary rock) • Dip 40-50 ° to the NE • Bedded	R5-R6 Very strong to Extremely strong rock	2 to 3 smooth and planar	Non-mineralized. • Overlies the Black Rock Altered Ironstone (schist) • Also occurs as un-mineralized zones within the Ironstone
Volcanics Rhyolite that is highly potassium feldspar altered, which colours the rock red.	R5-R6 Extremely strong rock	3-4 smooth to rough, planar	Mineralized (but not economic). • Overlies the Greywacke as a discontinuous cap. • Will be exposed on some open pit slopes, mainly upper benches of the hanging wall • Observed to be highly fractured at surface.
Dykes	R5-R6 Extremely strong rock	3-4 smooth to rough, planar	Sub-vertical intrusions that cross-cut the host rocks. • Potential exposures both on proposed ultimate pits and underground openings

Key drillholes, the site exploration grid, the June 2004 ultimate pit shell (which will be revised base on the recommendations in this memorandum and on market prices for base metals) and the Fortune geological model are shown in plan and section on Figures 1 through 25.

Note that while the Black Rock Ironstone is termed a schist in exploration and geological logs, in geotechnical terms the unit does not have a strong, closely spaced foliation that behaves as a preferred plane of weakness. Rather the unit is massive, with distinctive bands of arseno-pyrite mineralization within the host black rock metasedimentary rock. Field observations and uniaxial strength testing verify that the banding alignment (foliation) is not a preferred plane of weakness.

4.1 Hydrogeological Conditions

In 2003, Golder monitored the diamond drilling of three drillholes intersecting the main rock types, logged the core geotechnically and performed constant pressure hydraulic conductivity tests at selected intervals using both single and double packer assemblies. A total of twenty packer tests were performed; eighteen in the metasedimentary rocks and two in the volcanic cap rock.

During drilling, water returns appeared to be about 100% within the metasedimentary rocks (Footwall siltstone, Black Rock Ironstone and Greywacke). Hydraulic conductivity test results agreed with this observation, indicating low hydraulic conductivity, ranging from 10^{-8} m/s to 10^{-10} m/s. Two 6.5 metre packer intervals, one at top of rock and one at depth intercepted zones with hydraulic conductivity slightly higher, 10^{-7} m/s.

Water returns during drilling through the near surface volcanic cap rock were low to zero percent. Returns only occurred in the lower portion of this unit, near its contact with the underlying Black Rock. Water level monitoring in completed boreholes indicate that static water levels are at or near the e base of this unit. The two packer tests at the base of this unit intercepted the highest hydraulic conductivity intervals of the twenty tests, 10^{-6}m/s and higher.

Packer test and static water level monitoring results are presented in the Factual Report. The 2003 Draft Factual Report will be updated to include data collected in 2004.

4.2 Faults within the Mine Footprint

Surface fault traces mapped by Fortune geologists are shown on Figures 1 and 2. Faults are typically healed to slightly broken at surface. Fault zones interpreted at depth are based on displaced geological or mineralization features. While some zones of broken core / low RQD are reported, these do not necessarily correspond to the locations of inferred faults in the borehole records.

4.3 Structural Fabric

Structural fabric data was obtained from nine oriented core holes (six drillholes logged by Golder-trained Fortune geologists, three logged by Golder in 2003) and from surface mapping carried out by Fortune in 1996-1997 and 1997-1998. The results of the detailed review of lower hemisphere, equal area projections of discontinuity populations obtained from both oriented core and surface mapping are summarized below.

Lower hemisphere, equal area projections of the oriented core data collected by Golder in 2003 and the 1996-1997 surface mapping data collected by Fortune are presented on Figures A1 to A5.

4.3.1 Overview

The main rock type to be exposed in ultimate pit slopes (hanging wall and footwall) will be Black Rock Ironstone. Review of the available information suggests that there is a consistent structural fabric within this unit, characterized by moderate to widely spaced joints dipping parallel to and orthogonal to the Siltstone / Black Rock Ironstone contact, which dips to the northeast at about 40-45°.

The Black Rock Ironstone unit is banded, and the peak orientation of discontinuities associated with the banding (foliation joints) is slightly steeper, dip 50°, than the contact dip between the Footwall Siltstone and the Black Rock Ironstone. The spacing with which these banding / strata sub-parallel joints occur is moderate to wide (e.g. 0.5 m to 1.0m) in the oriented core: at drillhole 03-282, about 50 features with this orientation were intercepted over a borehole length of over about 210 metres. Similarly, at drillhole 03-283, about 190 features were intercepted over about 270 metres. See Table 2 for details of the peak orientations of discontinuity features.

The structural fabric within the volcanic cap rock, which will have limited exposures on upper benches of the ultimate pit slopes (no more than 20m vertically) is distinct from the underlying metasedimentary rocks. The volcanic rocks are blocky, with sub-vertical and sub-horizontal joint sets. They lack the footwall parallel bedding / foliation set prevalent in the metasedimentary rocks. See Table 3.

4.3.2 Metasedimentary Rocks

The nine (9) oriented core holes and surface mapping data indicate similar and consistent discontinuity population sets within the Siltstone, the Black Rock Altered Ironstone and Greywacke metasedimentary rocks. Peak orientations that parallel the footwall strike or the faults mapped by Fortune (Figures 1 and 2) and are considered most likely to be potentially continuous at the bench to multi-bench scale are labelled F1 to F3. The remaining peaks, considered more likely to be discontinuous at the bench to multi-bench scale are labelled J1 to J4. Potentially continuous discontinuities are of most concern with respect to control of multi-bench scale slope stability. A full set of stereonets will be presented in the Factual Report. A selection is presented on Figures B1 to B9.

Orientation Bias

All core orientation data was obtained from geotechnically logged exploration or in-fill definition drillholes with southwest azimuths and, as such, have potentially not intercepted possible discontinuity sets dipping to the southwest (parallel to the drillholes). Those discontinuities, if they exist and were continuous and persistent, would control the slope configurations on the hanging wall of the open pit or could combine to form underground wedges. This ***possible*** footwall perpendicular "cross-joint" set is labelled J4 for purpose of these discussions.

The surface mapping data collected by Fortune in 1996 and 1997 agrees with the oriented core data, in that it captures the same set distributions as the oriented core, but also suggests, by the limited number of poles intercepted, that the J4 is set poorly developed and discontinuous. Additional surface mapping collected by Fortune in 1998 generated a similar distribution of peak orientations. Stereonets of surface mapping data will be presented in the Factual Report.

TABLE 2: Peak Orientations of Discontinuity Populations in the Metasedimentary Rocks

Set ID	Dip / Dip Direction	Joint Set Description	% / Number
F1	50 / 026	parallel to sub-parallel to footwall	5.8 / 16
F2	78 / 023	sub-vertical sets striking parallel to the footwall,	2.2 / 6
F3	60 / 081	sub-vertical set striking perpendicular to the footwall.	2.2 / 6
J4	55 / 210	set dipping into footwall ***(based on surface mapping only)***	1.5 / 2
J3	15 / 207	Prevalent sub-horizontal set	3.4 / 10
J2	79 / 204	Minor joint set	2.2 / 6
J1	88 / 156	Minor joint set	2.2 / 6

Notes:
1. Sets in bold, **F1 to F3**, are considered most likely to be potentially continuous.
2. Because of the uniformity of oriented core hole azimuths and consistency of data in coreholes and surface mapping, the peak orientations above were selected from a single borehole, 03-282, which was considered representative of the metasedimentary rock structural fabric for purposes of this assessment. Set J4, based on surface mapping, was added for completeness.
3. %/ Number generally refers to the pole concentration at the peak orientation of the set based on a 1% counting circle on a lower hemisphere equal area stereonet. For Set J4, this is based on a surface mapping database of 87 poles from 1997. For the remaining sets, the percent and number are based on O3-282 data, which had 284 poles.

Volcanics

The altered Rhyolite cap rock and the intrusive dykes have a different structural fabric. Jointing in these rocks is characterized by steep sub-vertical sets and orthogonal, sub-horizontal sets, and the absences of the footwall parallel discontinuity set observed in the metasediments.

TABLE 3: Peak Orientations of Discontinuity Populations in the Volcanic Cap Rock (Potassium Feldspar Altered Rhyolite)

Set ID	Dip / Dip Direction	Set Description	% / Number
R1	16 / 105	*Peak orientations of Flat Sets (dips < 38 degrees)*	8.0 / 4
R2	37 / 083		8.0 / 4
R3	75 / 220	Steep set with strike sub-parallel to Footwall	3.4 / 2
R4	76 / 349	Sets R4 and R5 are orthogonal.	5.8 / 3
R5	84 / 071		4.6 / 3

Notes:
1. Sets in bold, R1 to R3, are considered most likely to be potentially continuous based on prevalence and / or fault and contact trends.
2. Because of the uniformity of oriented core hole azimuths and consistency of data in coreholes and surface mapping, the peak orientations above were selected from a single borehole, 03-282, which was considered representative of the cap rock structural fabric for purposes of this assessment
3. %/ Number refers to the pole concentration at the peak orientation of the set based on a 1% counting circle on a lower hemisphere equal area stereonet.

5.0 KINEMATIC ASSESSMENT

The kinematic assessments indicate that bench configurations on some wall orientations will be controlled by potential planes and wedges involving structures assumed to be potentially continuous because they parallel the regional interpreted fault trends. For purposes of this assessment, a shear strength of phi=30 ° and cohesion of c=0 was assigned to all discontinuities. This strength is considered conservative given the variability of joint surface character. Joint surfaces showed minimal surface alteration.

Results of the kinematic assessment are summarized on Figure 26, based on the oriented core discontinuity data from the sedimentary rock intercepted in borehole 03-282, on which Set J4 has been added.

6.0 SLOPE DESIGN RECOMMENDATIONS

The following are the slope design recommendations for Ultimate Pit slopes in rock, presented by wall dip direction for the three design sectors.

6.1 Ultimate Rock Slopes by Design Sector

Bench geometries were developed assuming adequate dewatering of the rock slopes will have been achieved due to exposure and blasting. Should observations on initial benches indicate that enhanced depressurization is required, horizontal drains should be considered.

TABLE 4: Nico Open Pit Slope Design Recommendations

Slope Dip Direction	Rock Type	Maximum Vertical Bench Separation (m)	Bench Face Angle °	Minimum Berm Width (m)	Maximum Inter-ramp Angle (°)
020° to 030° FOOTWALL	Metasedimentary Rock	15m	75	8.5	**50°** [1,2]
	Volcanic Cap Rock[3]	15m	75	8.5	**50°**
200° to 210° HANGINGWALL	Metasedimentary Rock	15m 20m	75 75	8.0 9.0	**51°** [4,5] to **54°** [4,5]
	Volcanic Cap Rock[3]	15m	75	8.0	**51°**
ENDWALLS	All rock types	15m	75	8..5	**50**[6]

Notes:
1. Actual Inter-ramp and overall slopes on the footwall slope will most often be less than 50 degrees, controlled by the local dip of the stratabound mineralization zones (see cross-sections) and placement of ramps.
2. Bench face angle controlled by set potential for planar failures involving set F2, dip 78°, inter-ramp slope angle controlled by set F1 (foliation), mean dip 50°.
3. Some slopes will expose significant amounts of volcanic rocks on upper benches. While the kinematics indicate that the structural fabric in the volcanic rocks is more favourable and that steeper slopes could be achieved, surface exposures are blocky and broken, and ravelling can be expected on excavated slopes. For this reason a steeper design for slopes in volcanics is not presented. Initial operating experience with volcanic slopes will determine whether ravelling will require modified blasting practices or shallower inter-ramp angle.
4. Bench face angle on the hanging wall will controlled by potential for planar failures involving set J2 (dip 79°). Inter-ramp angle on the hanging wall controlled by potential for planar instability involving set J4 (dip 55°). Should the F2-J2 wedge be prevalent (plunge 51°) the inter-ramp angle will require flattening from 54° to 51°.

The hanging wall slope design is considered aggressive. It is recommended that in order to optimize the hanging wall design, ramps be placed on the footwall, which will be mined at the flatter angles conforming to the dip of the stratabound mineralization zones.

5. Potential for toppling failure, particularly on the hanging wall, is not considered a control on bench design given the moderate to wide spacing of joints. Localized toppling instabilities may still occur. Should toppling failure be problematic, a mid-bench catch-berm may be required.

6. Potential wedge F1-F3, plunge 50° will control slope design on southeast dipping endwalls. Northwest dipping endwalls have been assigned the same recommended configuration for consistency.

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