

# Establishing a site specific mining geotechnical logging atlas

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*SRK Consulting, Vancouver*

**Why do we need a site specific geotechnical logging atlas?.....**



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# GEOTECHNICAL CORE LOGGING PROGRAMS

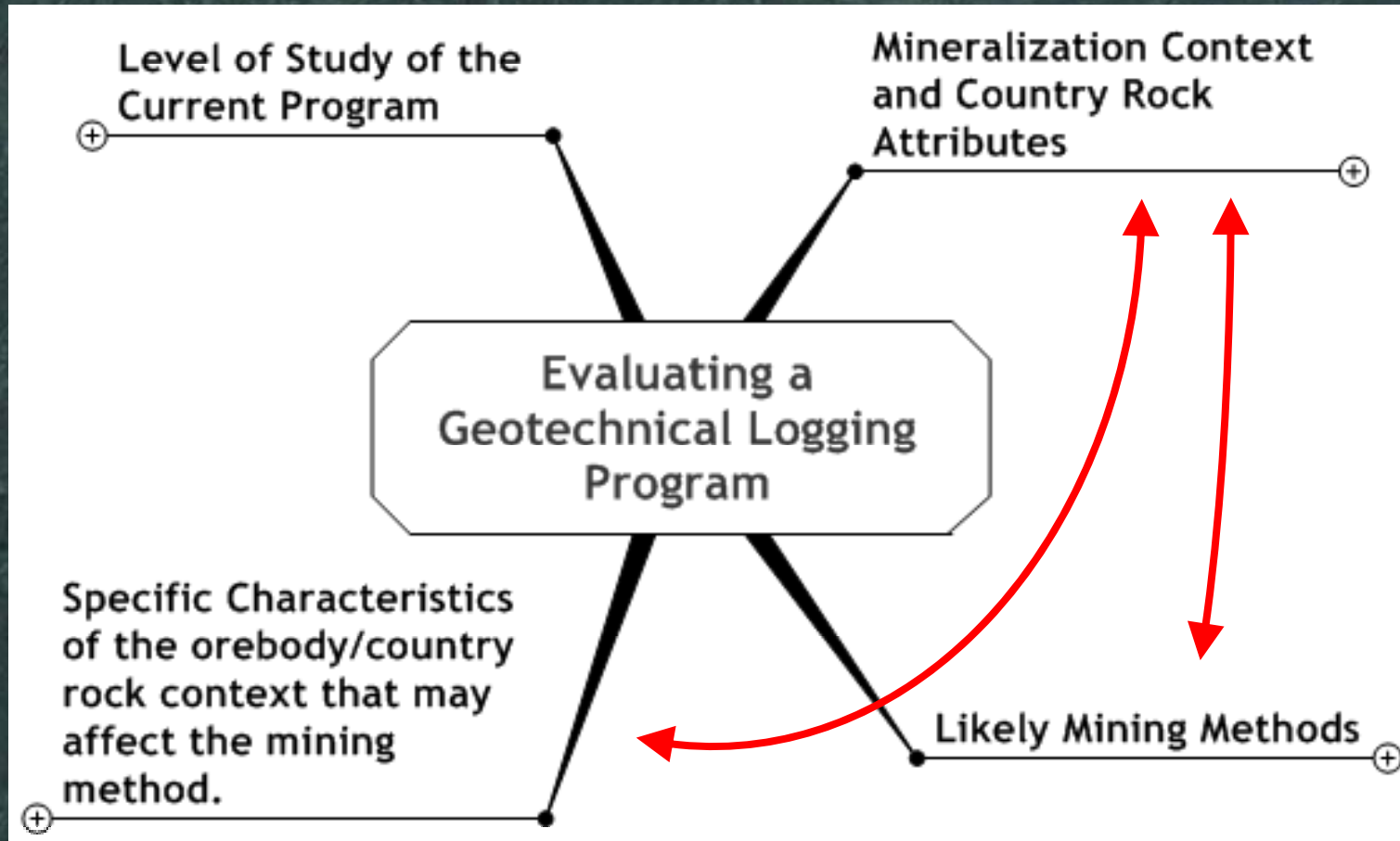
**Because sometimes it can be a little too laid back out there...**



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# IT'S REALLY A CONCEPT RATHER THAN JUST A DOCUMENT



# LEVEL OF STUDY OF THE CURRENT PROGRAM?

- *Early exploration targeting*
- *Scoping level*
- *Pre-feasibility*
- *Feasibility*
- *Ongoing mining program*

What is the business plan for the site?

Are you a junior or a major company?

The best time to produce an atlas is really just after the scoping study has been completed.



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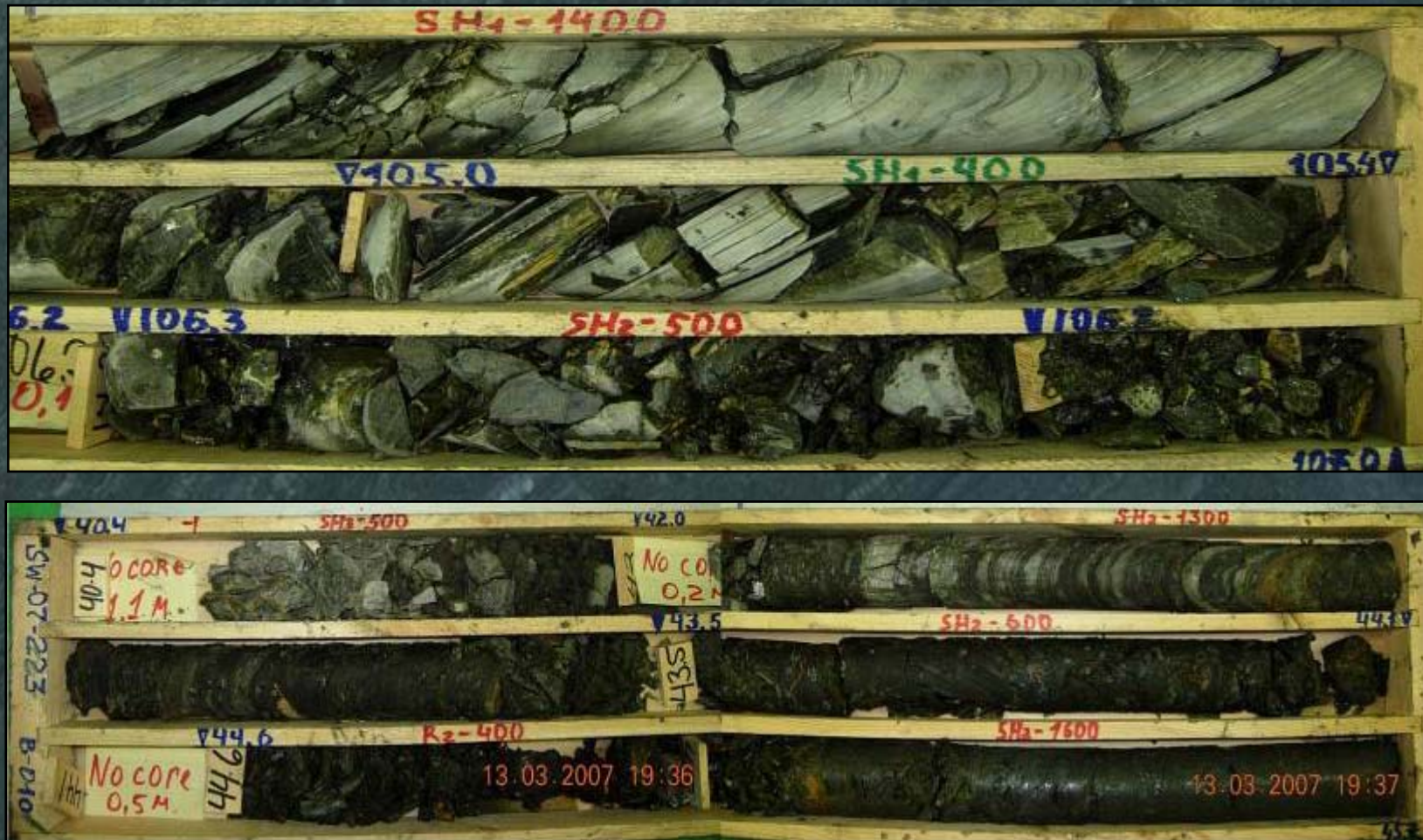
## MINERALIZATION CONTEXT

- *Orebody depth and geometric characteristics*
- *Orebody and country rock strength characteristics*
- *Hydrogeology and permafrost impacts*
- *Influence of the geological structures (faulting)*
- *Nature of the overlying country rock and overburden material (caving, mud rushes)*
- *Weathering/Alteration characteristics (kimberlites, porphyry)*





# LOGGING THIS TYPE OF ROCK MASS IS REALLY QUITE DIFFERENT TO .....



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# LOGGING THIS TYPE OF ROCK MASS



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## LIKELY MINING METHODS

- *Open pit only*
- *Open pit and underground transition*
- *Underground caving*
- *Underground self supported*
- *Underground supported*



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# SPECIFIC ROCK MASS CHARACTERISTICS AFFECTING THE MINING METHOD

Rock strength influences on rock mass performance

Alteration model vs lithological model  
(Density/Porosity effects)

## OUTLIER ROCK MASS TYPES:

Altered rock masses (e.g. epithermal, saprolitic, clay altered)

Heavily foliated (e.g. schist)

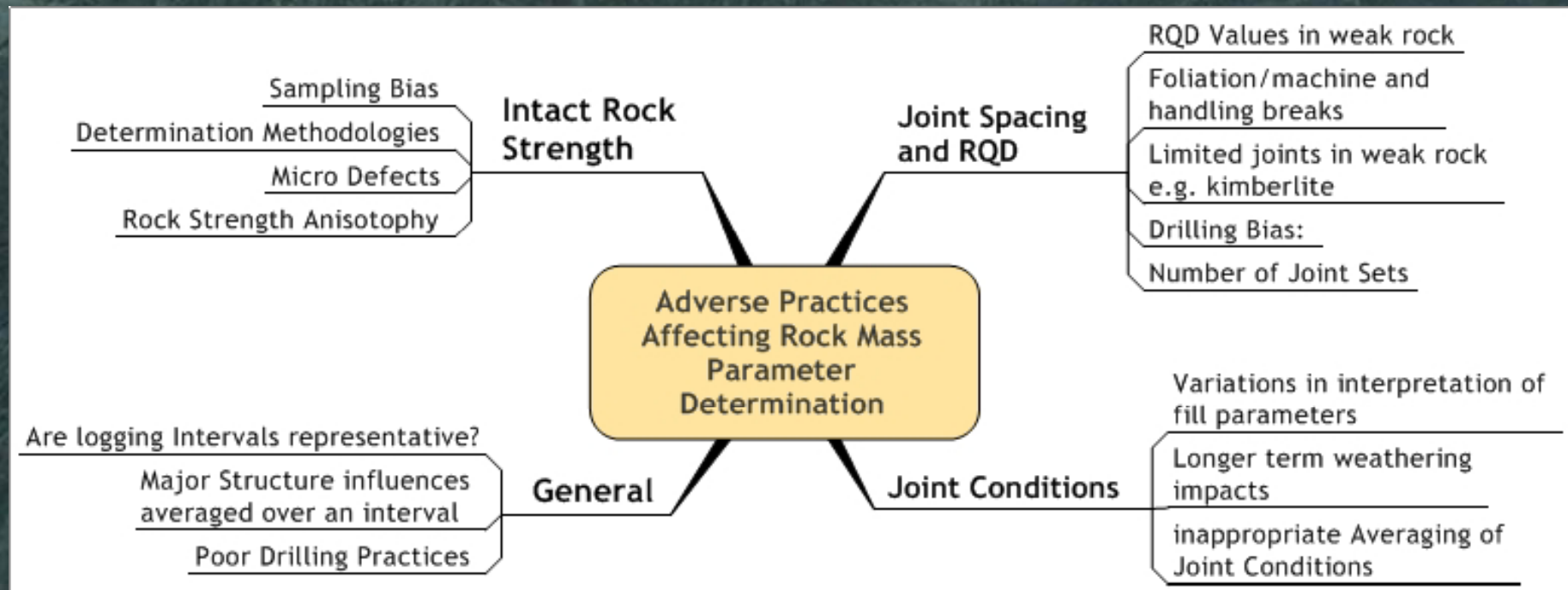
Low strength, ductile rock masses (e.g. evaporites, kimberlites)

Atypical (e.g. massive sulphides, karstic environments)



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# PRACTICES DURING CORE LOGGING THAT CAN AFFECT ROCK MASS PARAMETER DETERMINATIONS





# CREATE A GOOD ENVIRONMENT FOR DATA COLLECTION



Try and find the right people to do the job....



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# ELEMENTS OF A GOOD SITE SPECIFIC GEOTECHNICAL LOGGING ATLAS cont.

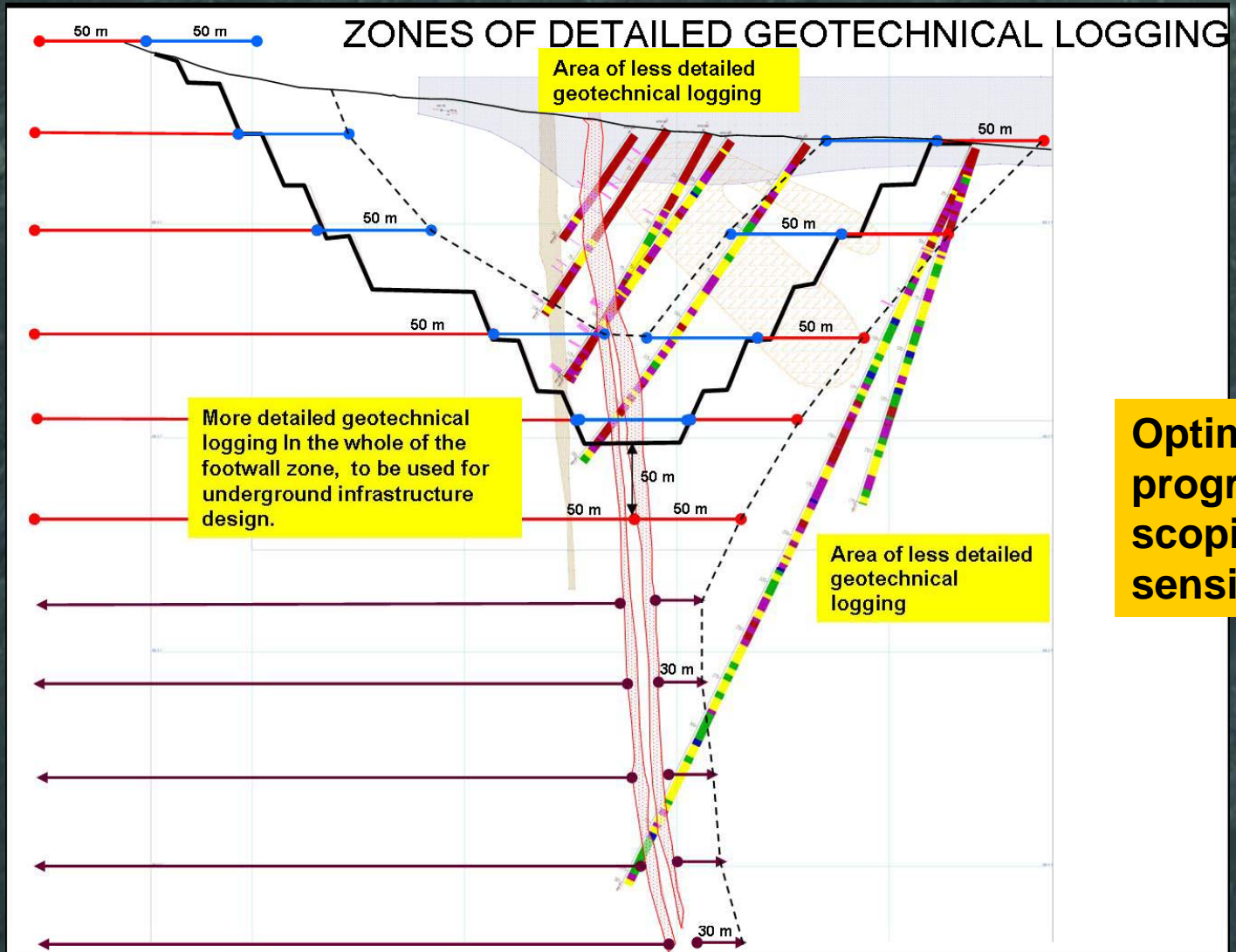
- *Geotechnical Program Context and Objectives*
- *Data Capture Practices*
- *General Logging Process Definition*
- *Photography Guidelines*
- *Geotechnical Feature Reference Slides*



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## GEOTECHNICAL PROGRAM CONTEXT AND OBJECTIVES



## Optimise your program based on scoping sensitivities

### SELECTION OF GEOTECHNICAL DOMAINS



**DOMAIN 1:** FGAB, IRS=R 4, moderate – high FF /m, moderate joint conditions.

**DOMAIN 2:** Fault zone, IRS=R1 (dominant), very high FF /m with poor joint conditions.

**DOMAIN 3:** FGAB, IRS=R 4, moderate FF /m, moderate joint conditions.

*Domain changes most commonly correspond to changes in structure, intact rock strength (IRS), lithology and alteration.*



# SITE JOINT CHARACTERISTICS

## ATLAS SLIDE EXAMPLES

### SMALL SCALE ROUGHNESS

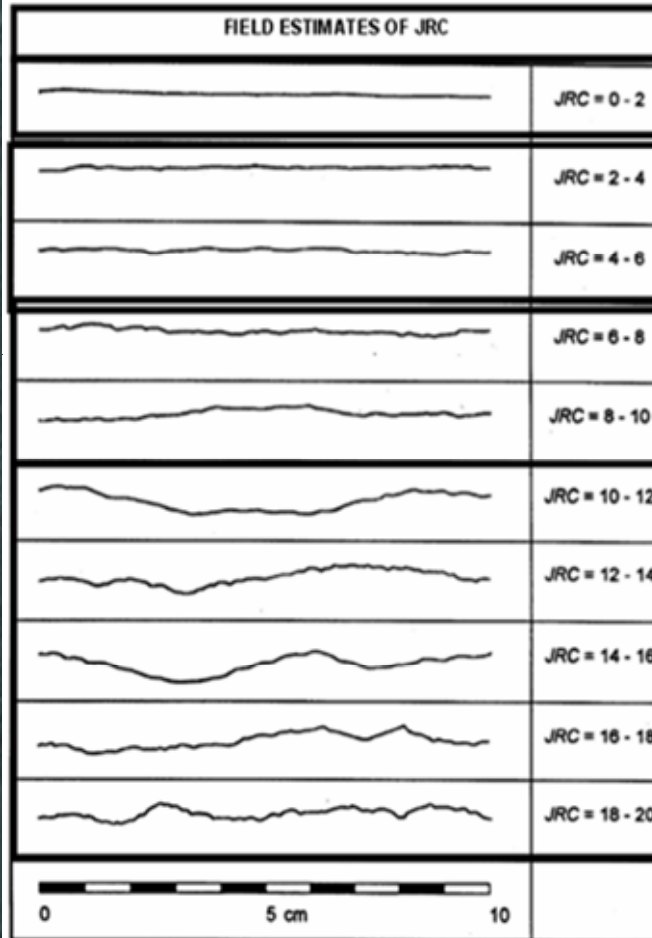


Figure 4.2: Roughness profiles and corresponding JRC values (After Barton and Choubey 1977)

### JOINT ROUGHNESS (JRC)



# ELEMENTS OF A GOOD SITE SPECIFIC GEOTECHNICAL LOGGING ATLAS

- *Logging Parameter Definitions*
- *Major Structures*
- *Core orientation procedures*
- *Logged Boxes Reference Slides*
- *Geotechnical Testing*
- *Sampling Procedures*



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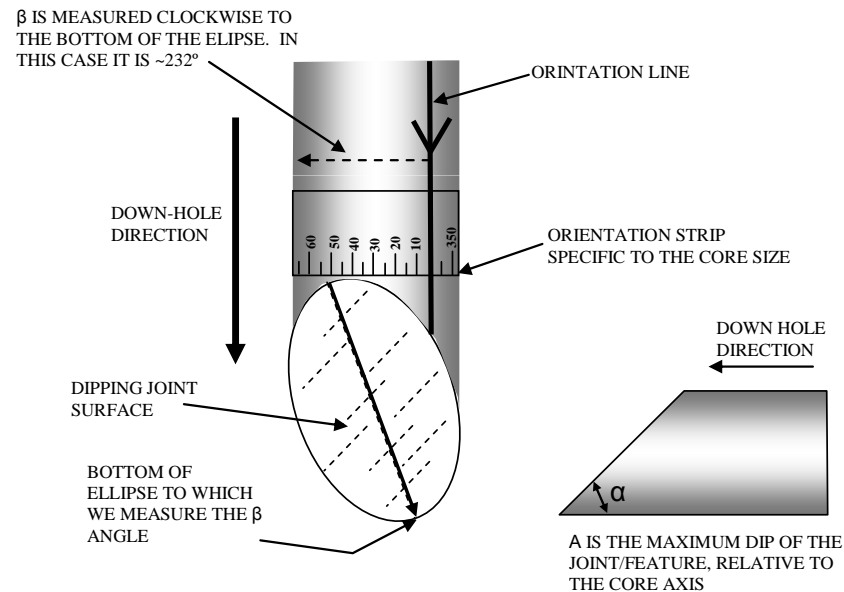
## CORE ORIENTATION

Measuring of the required orientation parameters is accomplished using a graduated strip and a carpenters angle.

Alpha angle ( $\alpha$ ): the carpenter angle is used to measure the maximum dip ( $\alpha$ ) of the feature relative to the core axis.

Beta angle ( $\beta$ ): The plastic calibrated strip is placed with the "0" on the orientation line of the same piece of core and the tape is wrapped clockwise around the core so that the 360° point returns to the orientation line. The angle ( $\beta$ ) is then measured, clockwise, to the bottom of the ellipse.

IN THIS CONVENTION, ONLY THE UPPER PART OF THE FEATURE IS USED FOR THE MEASUREMENT.



## REFERENCE LOGGED BOXES

## ATLAS SLIDE EXAMPLES



➤ *This looks difficult to do, but the core has been extensively disrupted by a combination of handling at the rig, transportation and then again at the logging shack site. If handled correctly at the site and geotech logged there, it will be fairly easy.*

➤ The rock has some joints, cemented joints (closed and open by drilling) and has been broken up by drilling and handling. The cemented joints and fractures need to be removed from the open joint count.

➤ **IRS: R4 0 0 Broken Zone: 0.1 m**

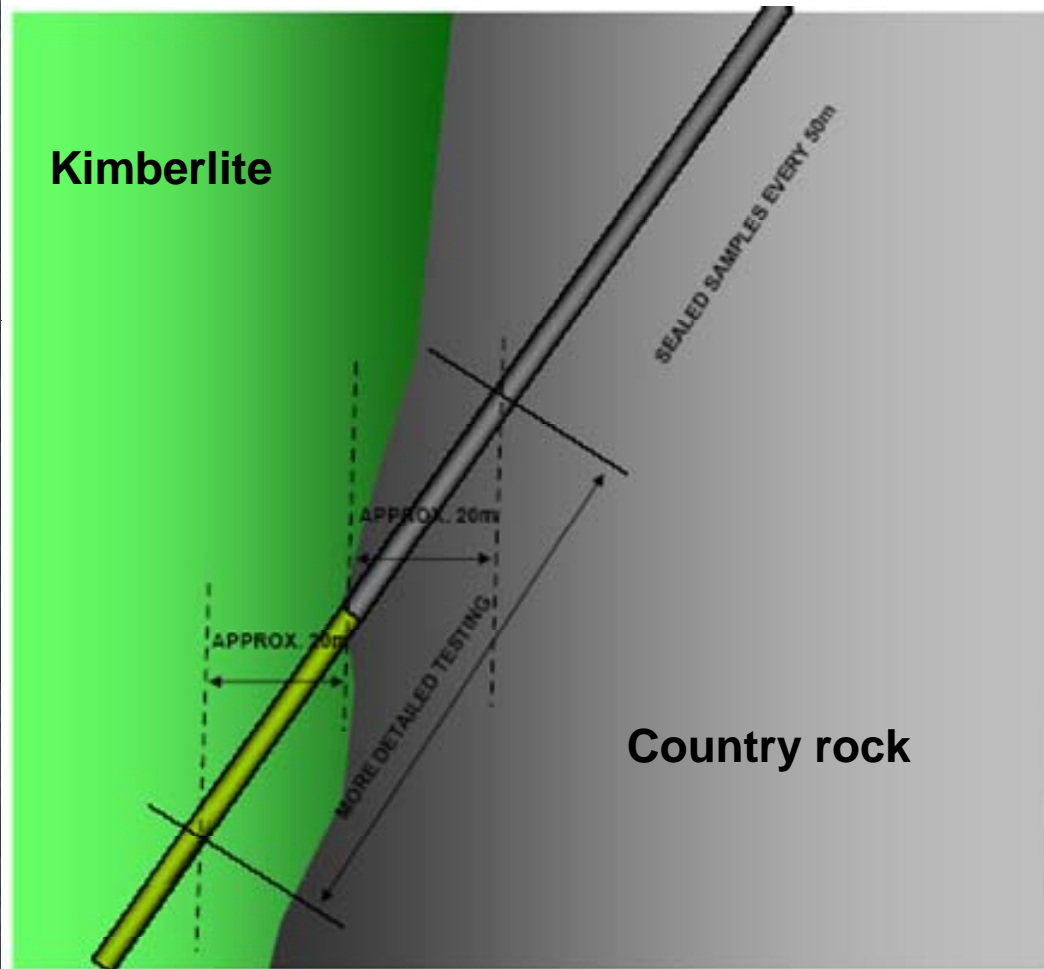
➤ **Number of open joints: 12 (marked and counted) + 4 = 16, Cemented Joints: 8 Strength of fill: 2**



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### Sampling Rationale



- A significant sample database currently exists for Gahcho Kue.
- To avoid redundancy, standard country rock will only be sampled every 50 m.
- This program will concentrate sampling efforts on the contact zone. The following slide explains this sampling frequency.
- Kimberlite will be sampled for UCS, weathering (field test) and slake/durability (lab test) every 30 m or per change in lithology.

# CASE STUDIES: SITE SPECIFIC GEOTECHNICAL LOGGING

Ekati Diamond Mine – Alteration

Quimsacocha Gold Project –  
Alteration and Defects

Voisey's Bay Nickel Project –  
Defects and Strength



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## EKATI CASE STUDY: Kimberlite Alteration

- Rockmass alteration was identified as a dominating factor affecting the rockmass.
- Within the Koala pipe, kimberlite rock strength is inherently tied to clay alteration.
- By recording alteration intensity it was possible to model weaker zones in 3D models.
- To aid logging staff, photos and descriptions of alteration levels were added to a site-specific logging manual.



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# EKATI CASE STUDY: Kimberlite Alteration

Deposit Type: Diamondiferous kimberlite pipes (typical geometry)

Critical Rock Mass Characteristics: Rock strength related to retrograde hydrothermal clay alteration (breakdown of olivine to clay minerals (incl. serpentine))

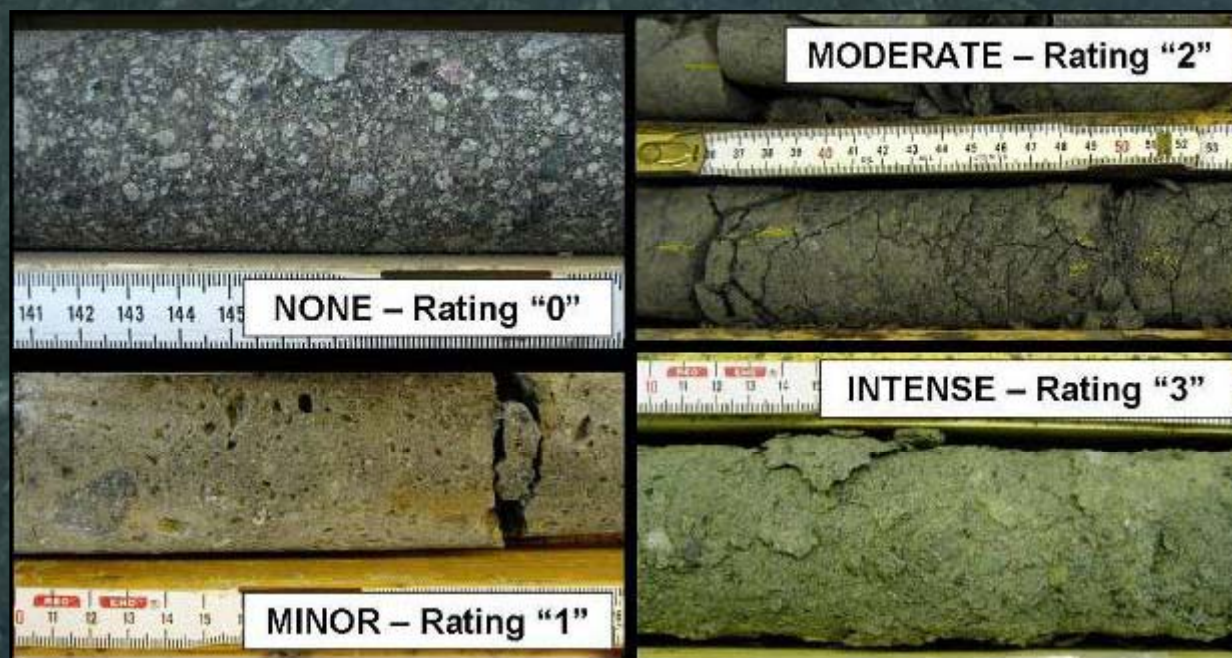
Logging Specific Practices: Recording of (clay) alteration intensity:

None (rating “0”)

Minor (rating “1”)

Moderate (rating “2”)

Intense (rating “3”)



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## QUIMSACOCHA CASE STUDY: Alteration and Defects

- The rockmass at IAMGOLD's Quimsacocha project is characterized by zoned alteration assemblages.
- Logging of alteration type and intensity (e.g. kaolinite – moderate) were incorporated to the geotechnical logging methodology.
- Micro-defects are also recorded for each geotechnical domain (veinlets, brecciation, and dissolution). Both intensity (none, minor, moderate and intense) and strength are recorded.
- To aid logging staff, photos and descriptions of alteration levels were added to a site-specific logging manual.



# QUIMSACOA CASE STUDY: Alteration and Defects

Deposit Type: Epithermal gold deposit (quartz-breccia hosted)

Critical Rock Mass Characteristics: Rock strength variability related to alteration assemblages and microdefects (breakdown of olivine to clay minerals (incl. serpentine))

Logging Specific Practices: Recording of alteration type and intensity and microdefect intensity and strength:

ALTERATION (type with intensity)							
SILICIFICATION	ALUNITE	PHYLITIC	DICKITE	KAOLINITE	ILLITE	SMECTITE	CHLORITE
				1	1		
	3						
	3						
		1		1			
		1					
			1	1			
			1	1			
				1			
		1		1			
		2	1				
		1					

MICRODEFECTS - QUANTITY	
CODE	DESCRIPTION
0	NONE
1	MINOR
2	MODERATE
3	HEAVY

DROP TEST - CJ/DEFECTS	
CODE	CATEGORY
0	STRONG (NEVER BREAKS)
1	MODERATE (SOMETIMES BREAKS)
2	WEAK (ALWAYS BREAKS)



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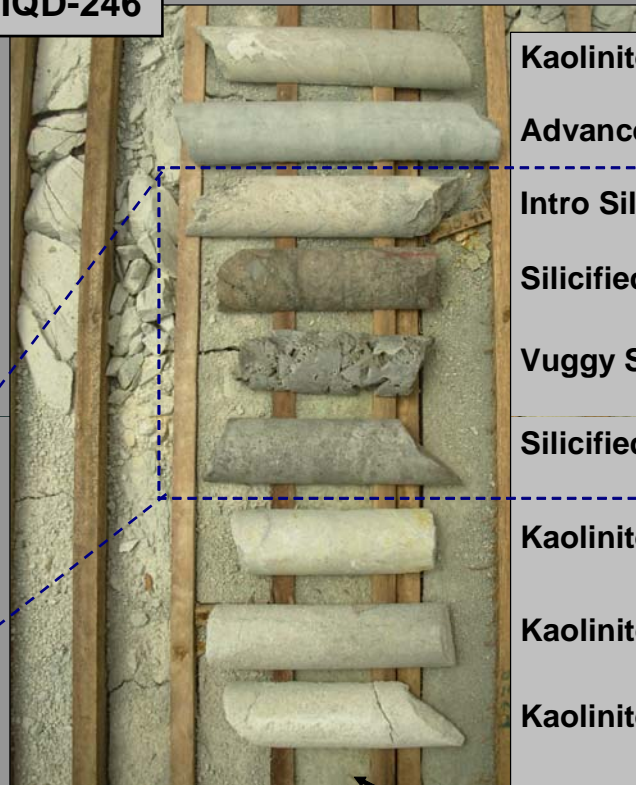
# QUIMSACOCHA CASE STUDY: Alteration and Defects

## IRS LEGEND (with MPa ranges)

R0	Extremely Weak	Indented by Thumb nail	0.25 - 1.0
R1	Very Weak	Crumbles under firm blow of geologic hammer pick, peeled by pocket knife	1.0 - 5.0
R2	Weak	Shallow indentation under firm blow of pick end of geologic hammer	5.0 - 25
R3	Medium Strong	Fractured with single firm blow of geologic hammer	25 - 50
R4	Strong	Requires more than one blow of hammer to fracture	50 - 100
R5	Very Strong	Requires many blows of hammer to fracture	100 - 250
R6	Extremely Strong	Can only be chipped with strong blows of hammer	> 250

\* International Society for Rock Mechanics

## IQD-246



Kaolinite 118.9m **R2**

Advanced Argillic 134.0m **R3/ R2**

Intro Silicified 149.5m **R4**

Silicified 164.5m **R5**

Vuggy Silicified 169.6m **R5/R4**

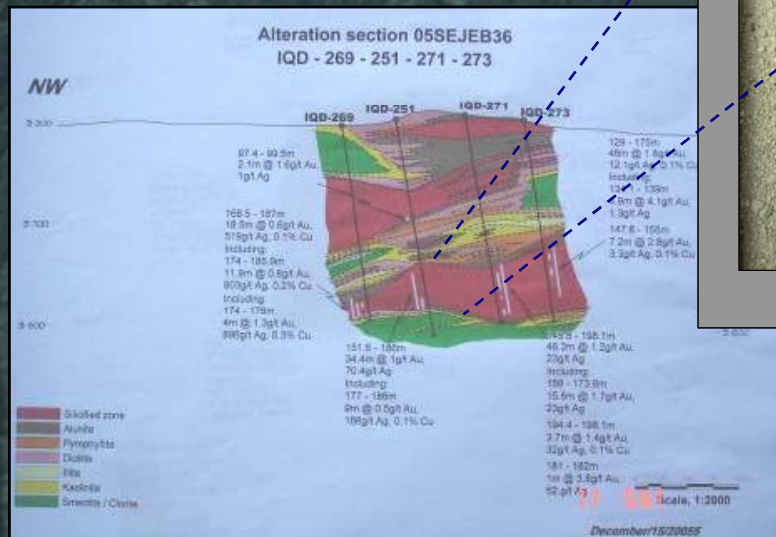
Silicified (orezone) 205.8m **R5**

Kaolinite 213.9m **R2**

Kaolinite - Illite 217.7m **R2**

Kaolinite - Illite 230.8m **R1**

Smectite 238.0m **R0** (in core box)



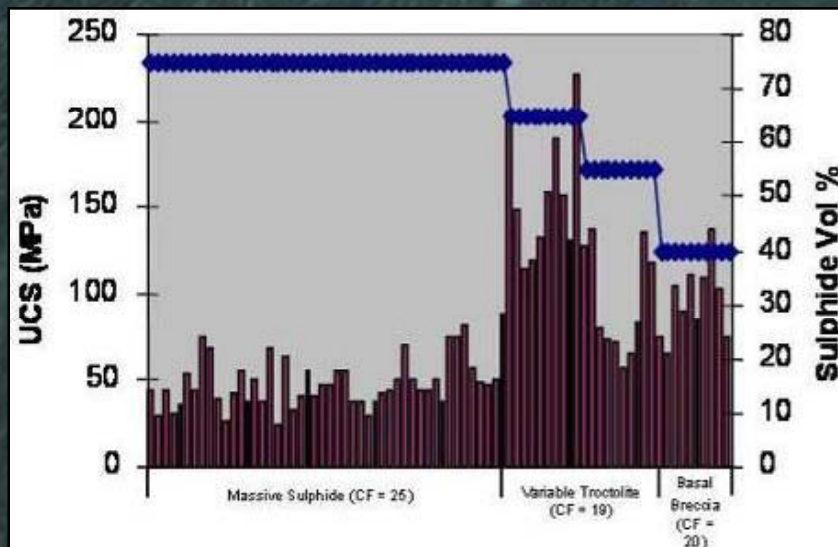
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# VOISEY'S BAY NICKEL DEPOSIT: Defects/IRS



Deposit Type: Massive and disseminated sulphides (igneous host)

Critical Rock Mass Characteristics:  
Rockmass-weakening defects present within orebody



Logging Specific Practices:  
Classification of defect intensity and strength with enhanced strength testing (point load, laboratory UCS/TCS)



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# Is a 70 RMR a 70 RMR? Thursday's Question



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## IN CONCLUSION

The benefits of a good geotechnical atlas are:

- A focused cost effective program, customized, more focused geotechnical data gathering program than a general 'blanket' approach.
- The collection of the right parameters – both geological and geotechnical
- Consistent good data sets from informed loggers



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