Report to:

AL-MASANE AL-KOBRA MINING COMPANY

PRELIMINARY GEOTECHNICAL REPORT ON THE AL-MASANE PROJECT

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JUNE 2008

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REVISION HISTORY

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1.0 INTRODUCTION

Al Masane Al Kobra Mining Co. (Al Masane) requested a geotechnical assessment be performed for the Al Masane project during the site visit on April 04 to 08 2008. Barnard Foo and Christopher Moreton, from Wardrop Engineering Inc. (Wardrop) performed a site visit accompanied by Veikko Koskela and Mohammed Salem of Al Masane.

During the site visit, there was a discussion with Veikko Koskela on site regarding the geologic conditions of Al Masane followed by underground mapping of two exploration drifts and six geotechnical logging of boreholes. The criterion for selection of the six boreholes was based on the surrounding geology, rock type, and approximate location to the proposed crown pillar and orebody.

It was observed that during the selection of the boreholes, the location of the boreholes only accomplished two of the three criteria stated – surrounding geology and rock type as boreholes intercepting the proposed Saadah crown pillar location were available. Detailed geotechnical data collection was not performed during the site visit in April 2008 due to time restrictions.

During the exploration drilling on site, both geotechnical and geological logging of the core were not performed. Currently there is no database pertaining to the rockmass conditions, classification, quality and geological information other than drillers' daily logs.

The geotechnical logging of the six boreholes, performed during the site visit, is an initial attempt to evaluate the rockmass conditions. The information gathered is only sufficient to initiate a preliminary geotechnical assessment of the crown pillar geometry and stope dimensioning indicated in the proposed scope of work.

Detailed geotechnical data collection is required to determine the ground conditions at depth for ground support and mine design, or for detailed engineering design purposes.

This report summarizes the observations made during the initial geotechnical core logging, and recommendations for crown pillar geometry and future geotechnical data collection plan for the Al Masane Project.

2.0 GEOTECHNICAL DATA COLLECTION

2.1 GEOTECHNICAL CORE LOGGING

Table 2.1 lists the boreholes evaluated for rockmass classification and the boreholes column information.

Table 2.1 Borehole Details

Borehole No.	Northing	Easting	Elevation	Collar Azimuth (°)	Dip (°)	Geotechnical Logging		Zone
			(m)			From (m)	To (m)	
WS 19	4993.00	5022.00	1622.1*	270	-30	0.0	48.3	Saadah/Wadi Saadah
WS 20	5055.00	5022.50	1625.4*	270	-30	0.0	100.1	Saadah/Wadi Saadah
AM 06	4752.91	4895.12	1514.47	93	-2	0.0	47.5	Saadah
AM 22	4995.92	4890.10	1517.05	75	-1	0.0	97.3	Saadah
AM 80	3375.00	4768.86	1521.24	90	-50	27.4	109.0	South Houra
AM 129	3734.15	4899.40	1520.80	270	44	0.0	74.4	North Houra
Note:	Coordinates on Mine grid not true north.			*Corrected Elevation				

Wardrop personnel conducted geotechnical data collection from the six drill holes. This logging commenced approximately 20 m in the hanging and foot wall of the ore zone. Representative samples of the rock types have been taken for point load testing. The samples can either be tested at Wardrop in Canada or by Al Masane on site.

Table 2.2 lists information pertaining to the samples and the table will be populated with testing results when performed. The updated table will be forwarded to Al Masane in a brief memorandum.

Table 2.2 Point Load Testing Samples*

Borehole No.	Box No.	From (m)	To (m)	Length (m)	Rock Type	Core Diameter D1	D2	De	P, Load (kN)	Is (50) (MPa)	UCS* (Mpa)
WS 19	2	15.07	15.25	0.18	Gossan						
WS 19	2	16.86	17	0.14	FV4						
WS 19	4	29.3	29.5	0.2	FV4						
WS 20	2	15.6	15.69	0.09	Gossan						
WS 20	2	16.64	16.79	0.15	Gossan						
WS 20	4	26.05	26.16	0.11	FV4						
WS 20	5	32.38	32.58	0.2	FV4						
WS 20	13	81.98	82.14	0.16	FV6						
WS 20	14	84.7	84.86	0.16	FV6						
AM 06	1	2.26	2.44	0.18	FV2						
AM 06	2	7.08	7.27	0.19	t/d						
AM 06	5	27.03	27.19	0.16	FV6						
AM 06	7	37.32	37.44	0.12	sh						
AM 06	8	43.54	43.7	0.16	FV2						
AM 22	2	15.8	16	0.2	FV3						
AM 22	15	82.61	82.91	0.3	FV4						
AM 22	20	110.02	110.34	0.32	FV2						
AM 80	10	60	60.33	0.33	FV1						
AM 80	16	95.78	95.85	0.07	t						
AM 80	16	95.85	95.91	0.06	t						
AM 80	16	95.91	96	0.09	t						
AM 80	16	96	96.1	0.1	t						
AM 80	16	94.53	94.68	0.15	t						
AM 129	1	8.16	8.29	0.13	FV6/ch						
AM 129	2	12.73	12.84	0.11	FV6/ch						
AM 129	4	23.7	23.88	0.18	FV6						
AM 129	12	73.42	73.65	0.23	FV4						
FV1	Rhyolite Porphry		FV6	Bedded Felsphatic Chert					Piston Area (m^2)		
FV2	Felsic Tuff and Crystal Tuff		ch	Chlorite					Rock Test PIL-7		
FV3	Laminated Cherty Rhyolite		sh	Black Shale					USC = (14+0.175*De)*Is(50) Hoek and Brown 1980		
FV4	Micaceous Felsic Tuff		t	Talc		****UCS results will be presented in a brief memorandum once testing is completed***					

2.2 Underground Geotechnical Mapping

Two areas of geotechnical mapping were performed underground at:

- Saadah Zone Exploration drift striking east at 4935 N
- South Houra Zone Exploration drift striking west at 3375 N

The mapping was performed approximately 20 m before and after of the ore zones. Details on the geotechnical mapping data are presented in Appendix A.

A total of 46 data points were gathered from the Saadah Zone and 13 data points were gathered from the South Houra Zone due to the limited time on site to perform all the geotechnical work. The stereographic plot is presented in Appendix A.

Both the drifts mapped can be observed to be relatively massive and mostly govern by foliation especially for Saadah Zone.

More data points are required to provide better statistical analysis to yield structurally control joint sets governing opening stabilities which can be obtained by underground geotechnical mapping campaign.

3.0 ROCKMASS CLASSIFICATION SYSTEM

The geotechnical data collected were classified with the use of Tunnelling Quality Index (Q) proposed by Barton, 1974, to allow the determination of rock mass quality, support estimation by Grimstad & Barton, 1993 and stope dimensioning by Stability Graph Analysis. The Q classification parameters are based on the block size, shear strength, and active stress.

Barton's Q is defined as:

$$Q = \left(\frac{RQD}{Jn}\right) x \left(\frac{Jr}{Ja}\right) x \left(\frac{Jw}{SRF}\right)$$

Where:

RQD/Jn is the Block Size
Jr/Ja is the Inter-block Strength
Jw/SRF is the Active Stress

RQD is the Rock Quality Designation
Jn is the Joint Set number
Jr is the Joint Roughness number
Ja is the Joint Alteration number
Jw is the Joint Water Reduction Factor
SRF is the Stress Reduction Factor.

The rockmass classification proposed by Barton to describe the rock conditions based on Q classification is defined in Table 3.1.

Table 3.1 Rockmass Quality Categories based on Q

Rockmass Quality	Range of Q
Exceptionally Poor	>0.01
Extremely Poor	0.01 to 0.1
Very Poor	0.1 to 1
Poor	1 to 4
Fair	4 to 10
Good	10 to 40
Very Good	40 to 100
Extremely Good	100 to 400
Exceptionally Good	400 to 1000

4.0 INTERPRETED GEOTECHNICAL CONDITIONS

4.1 SUMMARY OF GEOTECHNICAL OBSERVATIONS

A summary of the geotechnical logging of boreholes data is described in the following sections. For the purpose of initial geotechnical analysis at Al Masane, the Barton rockmass rating is simplified into six categories as indicated in Table 4.1. The factors for JW and SRF in the Tunnelling Quality Index for this investigation are set at 1.0, assuming that the joints have minor inflow of less than 5 L/min locally, or being dry within medium stress environments where joints are moderately clamped but not overly stressed.

Table 4.1 Simplified Rockmass Quality Categories Based on Q

Rockmass Quality	Range of Q
Very Poor	Less than 1
Poor	1 to 4
Fair	4 to 10
Good	10 to 40
Very Good	40 to 100
Extremely Good	Greater than 100

4.1.1 BOREHOLE WS 19

This borehole is located and drilled from the surface into Wadi Saadah. Logging was performed on the initial 48.3 m to identify the rockmass for the crown pillar. The initial 13.8 m of the borehole is broken and the remainder of the hole can be classified as Good to Extremely Good rockmass (Table 4.2).

4.1.2 BOREHOLE WS 20

Borehole WS 20 is located and drilled from surface into Wadi Saadah location. Logging was performed on the initial 100.1 m to identify the rockmass for the crown pillar. The initial 11.6 m of the borehole is broken and the remaining of the hole can be classified as Good to Extremely Good rockmass (Table 4.3).

4.1.3 BOREHOLE AM 06

This horizontal hole is drilled into the Saadah zone from the exploration drift. Logging was performed to 47.7 m to identify the rockmass in the hanging wall, ore zone and footwall. The core can be classified as Good to Extremely Good rockmass (Table 4.4).

4.1.4 BOREHOLE AM 22

Borehole AM22 is a horizontal hole drilled into the Saadah zone from the exploration drift. Logging was performed to 97.3 m to identify the rockmass in the hanging wall, ore zone and footwall. The core can be classified as Very Good to Extremely Good rockmass. Talcy shear was encountered at 75.45 to 75.70 m (0.25 m thick) and 76.5 to 76.59 m (0.09 m) (Table 4.5).

4.1.5 BOREHOLE AM 80

This downward dip borehole is drilled in the South Houra zones. Logging was performed from 27.4 m to 109.0 m to identify the rockmass in the hanging wall, ore zone and footwall. The core can be classified as Very Good to Extremely Good rockmass with talc from 93.33 to 97.0 m (3.67 m thick) (Table 4.6).

4.1.6 BOREHOLE AM 129

This upward dip borehole is drilled in the North Houra zones. Logging was performed from 0.0 m to 74.4 m to identify the rockmass in the hanging wall, ore zone and footwall. The initial 6.1 m of the core is mechanically broken. The core can be classified as Good to Extremely Good rockmass with broken core at 18.6 to 19.00 m (0.4 m thick) (Table 4.7).

Table 4.2 Hole ID 19 (Saadah)

DEPTH	FROM	Length (m)	Dip w.r.t Core Axis	RQD	Jn (L)	Jn(U)	Jr(L)	Jr(U)	Ja(L)	Ja(U)	Q' (L)	Q' (U)	Percentage	Rating For Q'(L)	Zone	Remarks
0.0	13.8	13.8	N/A										28.5%		FW	Overburden ??
13.8	16.1	2.36	38-40	25	2	2	3	3	2	2	19	19	4.9%	Good	FW	
16.1	17.8	1.7	38-40	50	2	2	3	3	2	2	38	38	3.5%	Good	FW	
17.8	23.8	5.99	38-40	50	2	2	3	3	2	2	38	38	12.4%	Good	FW	
23.8	31.0	7.2	N/A	74	2	2	3	3	0.75	1	111	148	14.9%	Extremely Good	ORE	Core Split 30-50 m
31.0	37.4	6.44	38-40	25	2	2	3	3	1	1	38	38	13.3%	Good	ORE	
37.4	48.3	10.9	N/A	75	1	1	4	4	1	1	300	300	22.5%	Extremely Good	ORE	

Table 4.3 Hole ID 20 (Sadaah)

DEPTH	FROM	Length (m)	Dip w.r.t Core Axis	RQD	Jn (L)	Jn(U)	Jr(L)	Jr(U)	Ja(L)	Ja(U)	Q' (L)	Q' (U)	Percentage	Rating For Q'(L)	Zone	Remarks
0.0	11.6	11.6	48-50	50	2	3	3	4	2	2	25	50	11.6%	Good	FW	Broken, Overburden ??
11.6	18.6	7	45-50	25	2	2	3	4	2	2	19	25	7.0%	Good	FW	
18.6	24.9	6.3	45-50	45	2	2	2	3	0.75	1	45	90	6.3%	Very Good	FW	
24.9	30.6	5.69	55-60	95	1	2	3	4	0.75	1	143	507	5.7%	Extremely Good	FW	
30.6	36.3	5.67	45-50	75	2	2	2	3	0.75	1	75	150	5.7%	Very Good	ORE	Split 35.94-36.26 m
36.3	41.9	5.68	55	95	1	1	4	4	0.75	1	380	507	5.7%	Extremely Good	ORE	
41.9	47.2	5.23	55	95	1	1	4	4	0.75	1	380	507	5.2%	Extremely Good	ORE	Broken @ 41.94-42.17 m & 42.41-42.49 m
47.2	59.4	12.21		95	1	1	4	4	0.75	1	380	507	12.2%	Extremely Good	ORE	Core Split
59.4	77.2	17.82	45-50	95	1	1	4	4	0.75	1	380	507	17.8%	Extremely Good	ORE	Core Split
77.2	82.6	5.43	45-50	85	1	1	3	4	0.75	1	255	453	5.4%	Extremely Good	HW	Core Split till 78.45 m
82.6	100.1	17.44	48-52	95	1	2	2	3	0.75	1	95	380	17.4%	Very Good	HW	

Table 4.4 Hole AM 06 (Sadaah)

DEPTH	FROM	Length (m)	Dip w.r.t Core Axis	RQD	Jn (L)	Jn(U)	Jr(L)	Jr(U)	Ja(L)	Ja(U)	Q' (L)	Q' (U)	Percentage	Rating For Q'(L)	Zone	Remarks
0.0	1.5	1.5		90	1	2	2	3	0.75	1	90	360	3.6%	Very Good	HW	
1.5	3.0	1.5	35	90	1	2	2	3	0.75	1	90	360	3.6%	Very Good	HW	
3.0	4.5	1.5	35	90	1	2	3	3	2	2	68	135	3.6%	Very Good	HW	
4.5	6.0	1.5		90	1	1	3	3	0.75	1	270	360	3.6%	Extremely Good	HW	
6.0	7.5	1.5		90	1	1	3	3	0.75	1	270	360	3.6%	Extremely Good	HW	
7.5	12.0	4.5		90	1	1	3	4	0.75	1	270	480	10.8%	Extremely Good	HW	
12.0	17.8	5.82		90	1	1	3	4	0.75	1	270	480	14.0%	Extremely Good	HW	
17.8	23.8	5.98												Poor	Ore	Core Split
23.8	29.2	5.4		90	1	1	2	3	0.75	1	180	360	13.0%	Extremely Good	FW	
29.2	30.4	1.24		90	1	1	2	3	0.75	1	180	360	3.0%	Extremely Good	FW	
30.4	41.1	10.65		90	1	1	2	3	0.75	1	180	360	25.7%	Extremely Good	FW	
41.1	47.5	6.41		90	1	1	2	3	0.75	1	180	360	15.4%	Extremely Good	FW	

Table 4.5 Hole AM 22 (Sadaah)

DEPTH	FROM	Length (m)	Dip w.r.t Core Axis	RQD	Jn (L)	Jn(U)	Jr(L)	Jr(U)	Ja(L)	Ja(U)	Q' (L)	Q' (U)	Percentage	Rating For Q'(L)	Zone	Remarks
0.0	23.4	23.4	65-70	90	2	2	2	3	0.75	1	90	180	24.0%	Very Good	HW	
23.4	63.1	39.72	55-60	90	2	2	3	4	0.75	1	135	240	40.8%	Extremely Good	ORE	
63.1	97.3	34.27	65-70	95	2	2	3	4	0.75	1	143	253	35.2%	Extremely Good	FW	Shear (Talcy) @ 75.45-75.7 m & 76.5-76.59 m

Table 4.6 Hole AM 80 (Houra)

DEPTH	FROM	Length (m)	Dip w.r.t Core Axis	RQD	Jn (L)	Jn(U)	Jr(L)	Jr(U)	Ja(L)	Ja(U)	Q' (L)	Q' (U)	Percentage	Rating For Q'(L)	Zone	Remarks
27.4	35.4	8.1	55-60	80	2	2	3	4	0.75	1	120	213	9.9%	Extremely Good	FW	
35.4	41.4	5.97	55-60	65	2	2	2	3	0.75	1	65	130	7.3%	Very Good	FW	
41.4	47.2	5.78	50-55	95	2	2	2	3	0.75	1	95	190	7.1%	Very Good	ORE	Split @ 41.4-43.47 m
47.2	53.1	5.93	55	90	1	1	4	4	0.75	1	360	480	7.3%	Extremely Good	ORE	
53.1	60.4	7.3	60	95	1	1	4	4	0.75	1	380	507	8.9%	Extremely Good	ORE	
60.4	66.5	6.11	50-58	95	1	2	2	3	0.75	1	95	380	7.5%	Very Good	ORE	
66.5	72.4	5.88	50-55	75	2	2	2	3	0.75	1	75	150	7.2%	Very Good	HW	
72.4	90.3	17.92	50-55	80	2	2	3	4	0.75	1	120	213	22.0%	Extremely Good	ORE	Split @ 74.12 m
90.3	109.0	18.66	65-70	80	2	2	2	3	0.75	1	80	160	22.9%	Very Good	HW	Talc 93.33-97.0 m

Table 4.7 Hole AM 129 (North Houra)

DEPTH	FROM	Length (m)	Dip w.r.t Core Axis	RQD	Jn (L)	Jn(U)	Jr(L)	Jr(U)	Ja(L)	Ja(U)	Q' (L)	Q' (U)	Percentage	Rating For Q'(L)	Zone	Remarks
0.0	6.1	6.1														Mechanical Breaks
6.1	8.8	2.7	65-72	70	2	2	2	3	0.75	1	70	140	4.0%	Very Good	HW	
8.8	12.1	3.3	58-62	75	2	2	2	3	0.75	1	75	150	4.8%	Very Good	HW	
12.1	14.8	2.7	52-58	70	2	2	1.5	2	0.75	1	53	93	4.0%	Very Good	HW	
14.8	18.3	3.5	58-62	85	2	2	1.5	2	0.75	1	64	113	5.1%	Very Good	HW	
18.3	21.0	2.7	50-55	45	2	2	1.5	2	0.75	1	34	60	4.0%	Good	HW	Broken @ 18.6-19.00 m
21.0	33.5	12.5	55	55	2	2	1.5	2	0.75	1	41	73	18.3%	Very Good	HW	
33.5	39.3	5.8	68-72	90	2	2	3	4	0.75	1	135	240	8.5%	Extremely Good	ORE	Core Split
39.3	60.0	20.7	40-45	80	2	2	3	4	0.75	1	120	213	30.3%	Extremely Good	ORE	Core Split
60.0	74.4	14.4	38	85	2	2	1.5	2	0.75	1	64	113	21.1%	Very Good	FW	

4.2 Preliminary Geotechnical Data Collection Results

4.2.1 Rockmass Classification Conclusions (Underground Mapping)

Underground mapping indicated that the rockmass is massive with one joint set and a random set. Wedge failures underground were observed due to the opening dimension and joint set orientation. This does not seem to occur at all the drift intersections observed underground. Spot bolting and cable bolting is recommended to increase safety in drift intersections and underground openings as mining progresses.

4.2.2 Rockmass Classification Conclusions (Boreholes)

The rockmass logged for the six boreholes indicated that the rockmass is competent with rockmass classification ranging from Good to Extremely Good ground. The talc encountered in the core and from underground mapping is not subjected to shearing or deformation. Additional on-site geotechnical data collection through underground mapping during the development stage and core logging is required to ensure that the rock types and geotechnical domain are addressed.

The talc is likely weaker than the surrounding rockmass and will induce additional dilution during mining adjacent to this unit. The strength of talc will be determined once point load testing results are available.

5.0 STOPE DIMENSIONING

Open stope dimensioning can be empirically estimated with the use of the Stability Graph. The stability graph developed based on more than 350 case histories collected from Canadian mines by Potvin, 1988; Potvin and Milne, 1992; and Bawden, 1993; accounts for key factors influencing open stope design. These key factors includes information on rockmass strength and stresses surrounding the opening, the dominating joint structure with respect to the excavation surface, the influence of gravity on the stability of the excavation face and stope size.

The stability graph design procedure is based on the calculation of two factors, the Modified Stability Number (N') representing the ability of the rockmass to stand up under given conditions and the Shape Factor (S) or hydraulic ratio, which accounts for the stope size.

5.1 THE MODIFIED STABILITY NUMBER, N

The modified stability number, N' is based on the Barton’s Tunnelling Index (Q) with alteration to the active stress factor (Jw/SRF) on Q. The conditions in most underground mining environment are relatively dry, thus the Jw factor is considered to be 1.0. The Stress Reduction Factor (SRF) is set to 1.0 for moderate stress environment where moderate clamping of the joints are expected, but not overly stressed.

This alteration yields the Modified Tunnelling Index (Q') where:

$$Q' = \left(\frac{RQD}{Jn}\right) x \left(\frac{Jr}{Ja}\right)$$

Therefore, the tunnelling quality index (Q) for this geotechnical investigation is equivalent to the modified tunnelling quality index (Q').

The modified stability number (N') consisted of:

N' = Q' x A x B x C

Where:

Q' is the modified tunnelling quality index
A is the rock stress factor

B is the joint orientation adjustment factor
C is the gravity adjustment factor.

The shape factor or commonly known as the hydraulic radius, for the stope surface under consideration is computed as follows:

$$S = \frac{\text{Area (sq. m)}}{\text{Perimeter (m)}} = \frac{\text{w x h}}{2(\text{w} + \text{h})}$$

Where,

W is the width of stope in metres
H is the height or length of stope in metres.

The method proposed by the stability graph is based on Canadian case histories. This provides preliminary guideline for open stope dimensioning. Modifications of its parameters are required to reflect the site conditions at Al Masane and as detailed geotechnical data is available. Back analysis on the stope performance is essential to alter the parameters to suit the underground conditions.

5.2 STABILITY GRAPH ANALYSES

Error! Reference source not found. shows the modified Stability numbers to empirically estimate stope dimension. The average dip of the Saadah ore body for longhole mining is reported to be at 75-85°.

An estimated "A" factor of 1.0 is for intact rock greater that the induced strength and where the hanging wall is at relaxation during mining.

The "B" factor accounts for the joint orientation with respect to the stope surface. Since limited information of the major joint set or the dominant set is not readily available other than the information from underground mapping, a value of 0.3 is assigned.

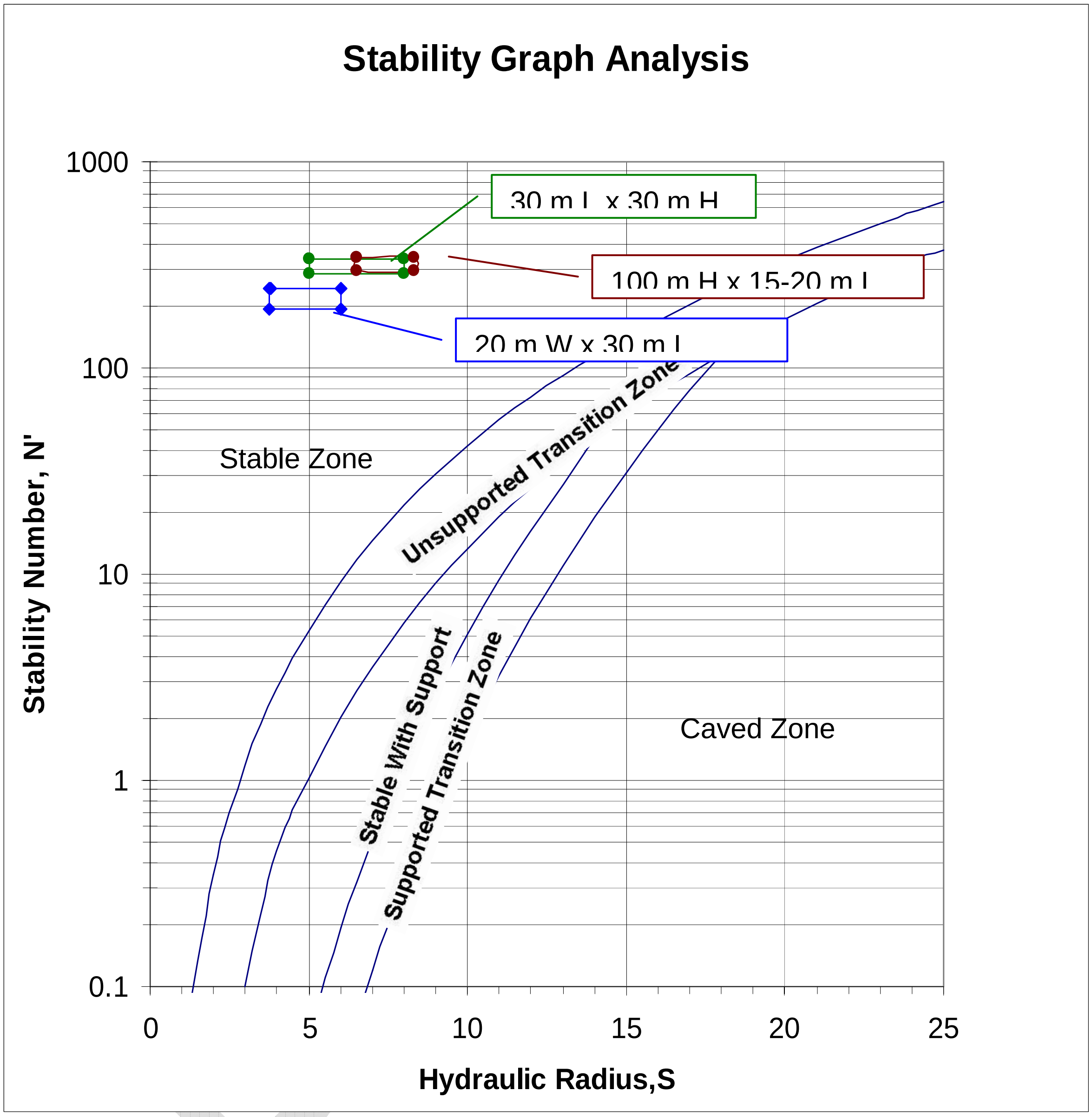
Since the hanging wall is steeply dipping at 75-85°, the gravity adjustment factor C for the stope will likely be induced by gravity. Thus, at 75-85° stope inclination the "C" factor will yield a value of 6.5 for the hanging wall and 2 for the back.

The rockmass tunnelling index is good to very good to extremely ground conditions for Q' ranging 175-180 for the wall and the A, B, and C factors remain constant, indicated in **Error! Not a valid bookmark self-reference.**

Table 5.1 Stope Dimension and Stability Numbers (N')

	Dimension (m)				Q'		A	B	C	Stability Number, N'		Stope
	Strike	Width	Height	S	HW	FW				HW	FW	
Walls	20		15	4.3	177	173	1.0	0.3	6.5	345.15	337.35	**Stable**
			20	5.0	177	173	1.0	0.3	6.5	345.15	337.35	
			25	5.6	177	173	1.0	0.3	6.5	345.15	337.35	
			30	6.0	177	173	1.0	0.3	6.5	345.15	337.35	
			35	6.4	177	173	1.0	0.3	6.5	345.15	337.35	
	25		15	4.7	177	173	1.0	0.3	6.5	345.15	337.35	**Stable**
			20	5.6	177	173	1.0	0.3	6.5	345.15	337.35	
			25	6.3	177	173	1.0	0.3	6.5	345.15	337.35	
			30	6.8	177	173	1.0	0.3	6.5	345.15	337.35	
			35	7.3	177	173	1.0	0.3	6.5	345.15	337.35	
	30		15	5.0	177	173	1.0	0.3	6.5	345.15	337.35	**Stable**
			20	6.0	177	173	1.0	0.3	6.5	345.15	337.35	
			25	6.8	177	173	1.0	0.3	6.5	345.15	337.35	
			30	7.5	177	173	1.0	0.3	6.5	345.15	337.35	
			35	8.1	177	173	1.0	0.3	6.5	345.15	337.35	
	25		15	4.7	177	173	1.0	0.3	6.5	345.15	337.35	**Stable**
			20	5.6	177	173	1.0	0.3	6.5	345.15	337.35	
			25	6.3	177	173	1.0	0.3	6.5	345.15	337.35	
			30	6.8	177	173	1.0	0.3	6.5	345.15	337.35	
			100	10.0	177	173	1.0	0.3	6.5	345.15	337.35	
Roof / Back	20	5		2.0	242		1.0	0.3	2	145.2		**Stable**
		10		3.3	242		1.0	0.3	2	145.2		
		15		4.3	242		1.0	0.3	2	145.2		
		20		5.0	242		1.0	0.3	2	145.2		
	25	5		2.1	242		1.0	0.3	2	145.2		**Stable**
		10		3.6	242		1.0	0.3	2	145.2		
		15		4.7	242		1.0	0.3	2	145.2		
		20		5.6	242		1.0	0.3	2	145.2		
	30	5		2.1	242		1.0	0.3	2	145.2		**Stable**
		10		3.8	242		1.0	0.3	2	145.2		
		15		5.0	242		1.0	0.3	2	145.2		
		20		6.0	242		1.0	0.3	2	145.2		
					242		1.0	0.3	2	145.2		
Narrow Vein	15	3	100	6.5	177	173	1.0	0.3	6.5	345.15	337.35	**Stable**
	20	3	100	8.3	177	173	1.0	0.3	6.5	345.15	337.35	

Figure 5.1 Masane Stability Graph Analysis



A stope with a strike length of 30 m x 30 m high yields a hanging wall shape factor or hydraulic radius of 7.5 and narrow vein stope with dimension of 15-20 m L by 100 m height at 8.3 hydraulic radius, indicate that the stope is stable under the rock mass condition estimated.

“The hanging wall rocks are talcose however, and are not likely to stand for long periods without some support” (Watts, Griffis and McOuat Limited, July 13, 1994). Watts, Griffis and McQuat also suggested residual pillars to be left during mining operations which limits the overall extraction to 80%.

The height of the stope is controlled by the contact regularity and hanging wall stability. Thus at the current stage the stope dimension is suggested not to exceed the maximum dimension until detail geotechnical data is available to support the rock mass quality.

6.0 CROWN PILLAR ASSESSMENT

The West Saadah ore body subcrops directly beneath Wadi Saadah based on WGM's report (July 1996). The mining method at Al Masane involves both longhole stoping, and Cut and Fill. The wider section of the ore body will be mined with longhole stoping and the thinner section will be mined either by Cut and Fill or Alimak stoping. Table 6.1 lists average ore widths to suggested mining methods for Al Masane.

Table 6.1 Average Stope Dimensions

Mining Methods*	Average Width (m)
Alimak Mining	Less than 3
Cut-and-fill	3-5
Longhole Stoping	5-25
Note: Suggested Mining Methods. Requires additional costs analysis.	

Three approaches were made to determine crown pillar configuration:

- Empirical Approaches by Carter, and Hoek and Brown
- Numerical Modelling - CPillar

6.1 EMPIRICAL METHODS

6.1.1 CARTER'S CROWN PILLAR STABILITY ANALYSIS

The method proposed by Carter is being used for dimensioning of new crown pillars and assessing stability of abandoned mines' crown pillar.

The "scaled crown span" concept demonstrates the stability of the pillar depends on geometry for any given rock quality: Span, thickness and rockmass weight to be most critical.

The database covers more than 100 case records from the original 1989/1990 database of 200 case records which includes more than 42 documented failures.

The "Scaled Crown Span", C_s is defined as:

$$C_S = S\left[\frac{\rho}{t(1+S_R)(1-0.4Cos(\phi))}\right]^{0.5}$$

Where:

S = span of pillar (m)

t = thickness of pillar (m)

ρ = rockmass specific gravity (tonnes/m3)

SR = (Crown pillar span, S/Crown pillar strike length, L)

Ø = dip of ore body

The crown pillar stability analysis design parameters and results based on methodology proposed by Carter are presented below (Table 6.2 and **Error! Reference source not found.**).

Table 6.2 Crown Pillar Stability Design Parameters and Result

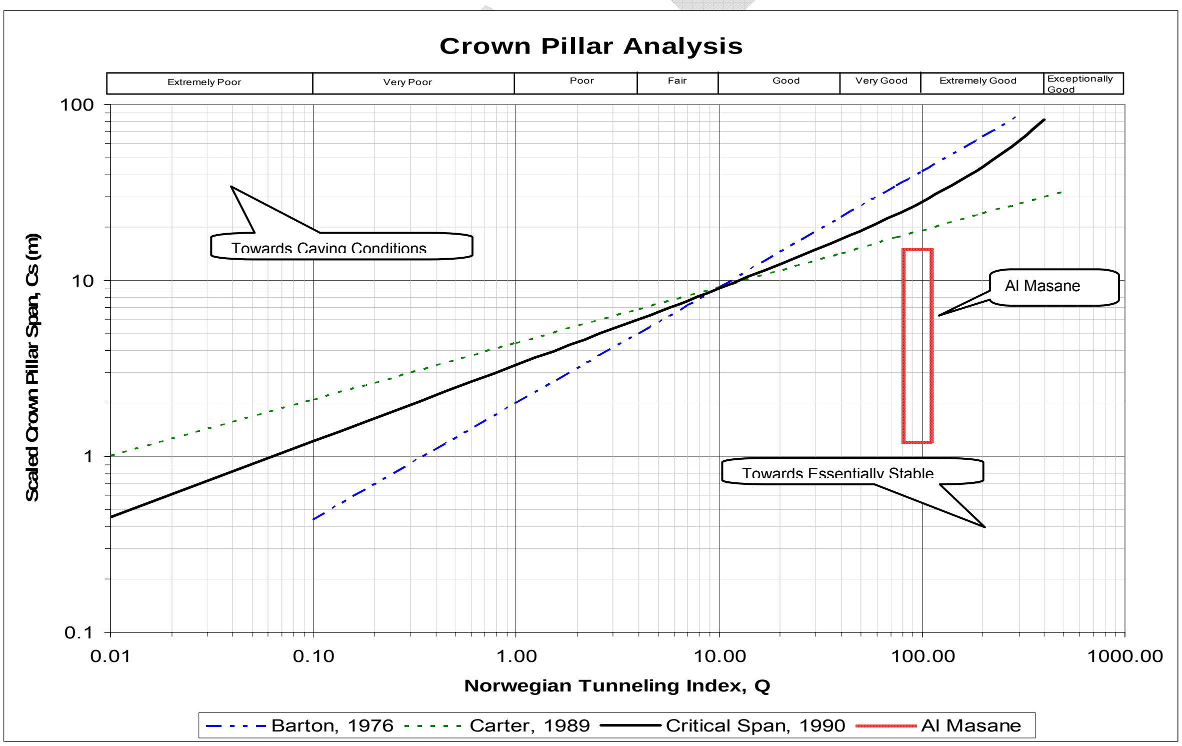
Tunnelling Quality Index			
Description	**Min**	**Max**	**Comments**
Modified Q'	173.00	177.00	Foot & Hangingwall Values
Jw (Medium)	114.18	116.82	Jw = 0.66 (1-2.5 kgf/cm Water Pressure)
Jw (Large)	86.50	88.50	Jw = 0.55 (2.5-10.0 kgf/cm Water Pressure)
Design (Q)	80	110	
Note: Q' = Modified Q, Jw = Joint Water Reduction Factor			
Crown Pillar Dimension			
Description	**Min.**	**Max.**	**Units**
Span	3	25	m
Thickness	10	25	m
Strike		200	m (Estimated-WGM Geological Map 1515 L)
Density		3.7	t/m^3
Dip		75	°
Note: Density and Dip from WGM, July 13,1994			
Crown Pillar Stability Analysis			
Description	**Min.**	**Max.**	**Comments**
Scaled Span, C_S	1.21	15.14	Stable ($C_S < S_c$)
Q (Critical)	0.10	34.58	
Critical Span, S_c	24.66	29.67	Critical Span Limit based on Design Q (The Span of the Pillar limit for widest scaled span value for Unsupported Ground in relation to Q is approximately 30 m for the Q of 34.58

Table 6.3 lists the Scaled Crown Span, Cs, for variable crown pillar span and thickness.

Table 6.3 Scaled Crown Pillar Span with Variable Span and Thickness

Design Q (min.)	**80**	**80**	**80**	**80**	**80**	**80**	**80**	**80**	**80**	**80**
Span, S (m)	**3.0**	**5.0**	**8.0**	**10.0**	**12.0**	**15.0**	**18.0**	**20.0**	**22.0**	**25.0**
Thickness, T (m)	1.5	2.5	4.0	5.0	6.0	7.5	9.0	10.0	11.0	12.5
Cs @ S/T = 0.5	4.9	6.4	8.1	9.0	9.9	11.0	12.1	12.8	13.4	14.3
Thickness, T (m)	3.0	5.0	8.0	10.0	12.0	15.0	18.0	20.0	22.0	25.0
Cs @ S/T = 1.0	3.5	4.5	5.6	6.3	6.8	7.6	8.3	8.7	9.0	9.58
Thickness, T (m)	3.6	6.0	9.6	12.0	14.4	18.0	21.6	24.0	26.4	30.0
Cs @ S/T = 1.2	3.2	4.1	5.1	5.7	6.2	6.9	7.5	7.9	8.3	8.7
Thickness, T (m)	4.5	7.5	12.0	15.0	18.0	22.5	27.0	30.0	33.0	37.5
Cs @ S/T = 1.5	2.9	3.7	4.6	5.1	5.6	6.2	6.7	7.1	7.4	7.8
Thickness, T (m)	6.0	10.0	16.0	20.0	24.0	30.0	36.0	40.0	44.0	50.0
Cs @ S/T = 2.0	2.5	3.2	4.0	4.4	4.8	5.4	5.8	6.1	6.4	6.8

Figure 6.1 Crown Pillar Analysis



Crown Pillar Stability Analysis Parameters

Tunnelling Quality Index

The Joint Water Reduction factor for Tunnelling Quality Index parameter was included in the crown stability analysis. Thus, the Modified Tunnelling Quality (Q') index quoted in the Stability Graph Analysis (Section 5.1) is multiplied by a factor of 0.5 and 0.66 yielding design values (Design Q) of 80-100. This is to account for groundwater (Joint Water Reduction Factor, Jw) and maintaining the Stress Reduction Factor (SRF) of 1.

Crown Pillar Dimension Parameter

The crown pillar is estimated to be 200 m strike length with span ranging from 3-25 m dipping at 75°.

RESULTS: CARTER'S CROWN PILLAR STABILITY ANALYSIS

The crown pillar is estimated to be stable for span (m)/thickness (m) ranging from 3:10 to 25:25 for Design Q values of 80-100. The ground conditions will have to deteriorate to a critical value of Q = 0.1 (Extremely Poor ground) for 3 m spans, and Q = 34.58 (Good ground) for 25 m spans, before a potentially unstable condition is reached. For smaller spans this level of deterioration does not appear likely. In larger spans than the span/thickness ratio prescribed, the level of deterioration is possible, and stabilization will be required.

For a crown pillar span of 25 m W by 25 m thick:

Crown pillar Scaled Span, $C_S = 15.14 < $ Critical Span, $S_C = 29.67$; Stable

The crown pillar is considered stable.

The Critical Span of the pillar limit for widest stable scaled span value for unsupported ground in relation to Q is approximately 30 m.

During development or production blasting, the stopes have to be excavated allowing the crown pillar to have a gradual tapering thickness versus the span. The determination of crown pillar dimension proposed by Carter considers the rockmass quality, geometry and database on stable geometries and failures. This methodology does not incorporate factor of safety.

6.1.2 HOEK AND BROWN EMPIRICAL PILLAR DESIGN

The crown pillar dimension estimation proposed by Carter did not take into consideration pillar strength. To address this, Hoek and Brown relationship for pillar strength and pillar shape was used to examine the pillar dimension.

The pillar strength can be determined with Hoek and Brown Criterion:

$$\sigma_1 = \sigma_3 + \sqrt{m\sigma_c\sigma_3 + s\sigma_c^2}$$

Where

m and *s* are rockmass constant

σ_C and σ_3 are axial and confining effective principal stresses.

For pillar strength estimation, σ_3 is equated to 0, yielding only uniaxial confining stress conditions.

Based on an estimated uniaxial compressive strength (UCS) for Saadah of 150-200 MPa, the pillar strength is estimated at 63.2 MPa with Hoek and Brown Criterion for very good quality rockmass (Table 6.4). The estimation of rock strength for Saadah ore will be confirmed when test results are available from point load testing.

RESULTS: HOEK AND BROWN CROWN PILLAR DIMENSION ANALYSIS

Figure 6.2 relates the pillar strength as a function of the pillar dimension. The nomenclature for pillar dimension on Hoek and Brown pillar graph is:

- Pillar width is perpendicular to the direction of principal stress.

In this case the pillar width on the graph represents crown pillar thickness. For crown pillar strength over unaxial compressive strength (UCS) of 0.32 for good quality rockmass, the ratio of pillar thickness to span is 0.9. This concludes that a span of 25 m requires a thickness of 22.5 m (Table 6.4).

This approximates to the value determined by Carter's Crown pillar stability analysis. The limiting factor to this graph is the interpolation for the variable rockmass quality at pillar width/height less than 0.3.

Thus Very Good Quality rockmass is not consider for Al Masane with the use of Hoek and Brown's graph for pillar width/height less than 0.3 because of the accuracy in the database generating the graph and information gathered from core logging.

Figure 6.2 Hoek and Brown Pillar Dimension to Strength Estimate

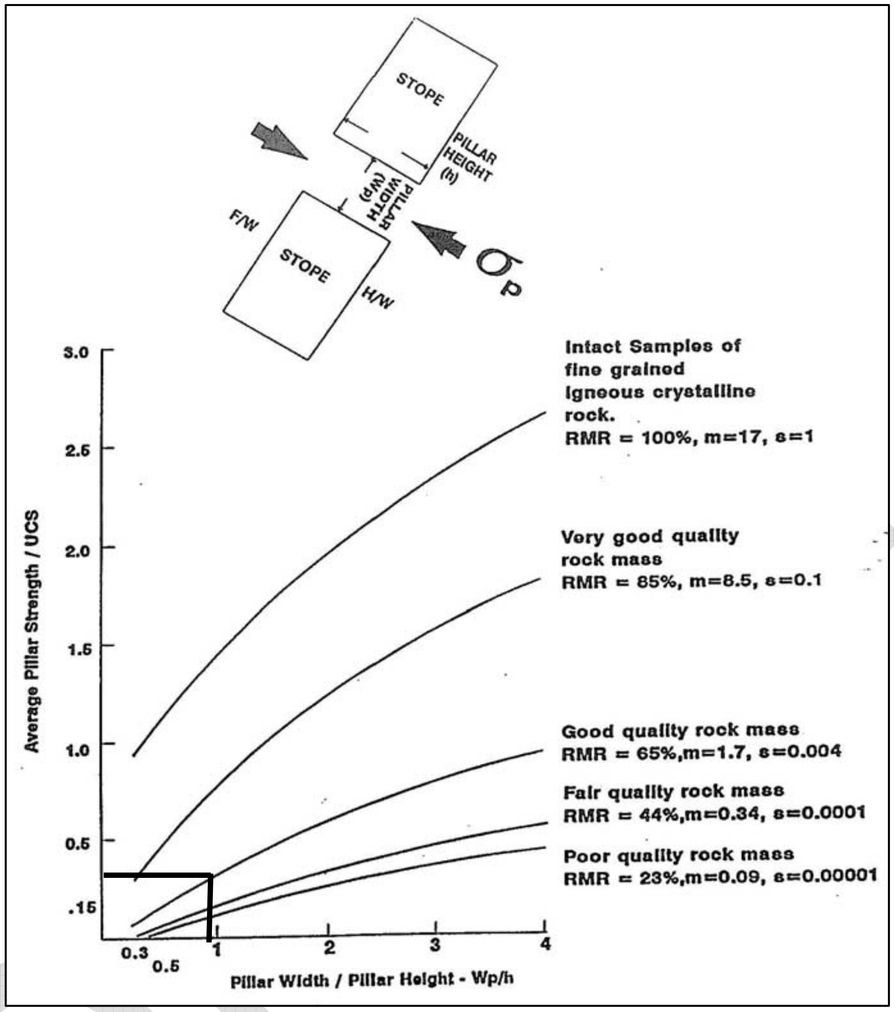


Table 6.4 Hoek and Brown Empirical Pillar Dimension Estimate Values

Description	Min	Max
Q	80.00	100.00
RMR	83.44	85.45
σ_C	150.0 MPa	200.0 MPa
m	1.70	8.50
s	0.004	0.100
Estimated Pillar Strength	9.49 MPa	63.25 MPa
Pillar Strength/UCS	0.063	0.316
Pillar Span	3.0	25.0
Pillar Thickness	2.7	22.5
Thickness/Span	0.9	0.9

6.2 NUMERICAL ANALYSIS

6.2.1 CPILLAR ANALYSIS METHOD

Stability of surface crown pillar was analysed by CPillar. The pillar stability is assessed by methods: Rigid or Elastic and Voussoir. The analysis performed on Al Masane is Rigid since the failure modes and main assumptions for this analysis are:

- Any span to thickness ratio
- Low to medium or confining stress
- Simple “falling block” analysis

An overburden thickness of 3 m has been used for the model and the presence of groundwater is also modelled with water level estimated at 2.0 m above overburden (Figure 6.3). Results from the analysis (Table 6.5) indicated that pillar span to thickness of 25/25 yields a factor of safety (FOS) at 1.8 and 1.75 for permeable conditions.

Hoek recommended factor of safety in excess of 1.5 for pillars acting as permanent support.

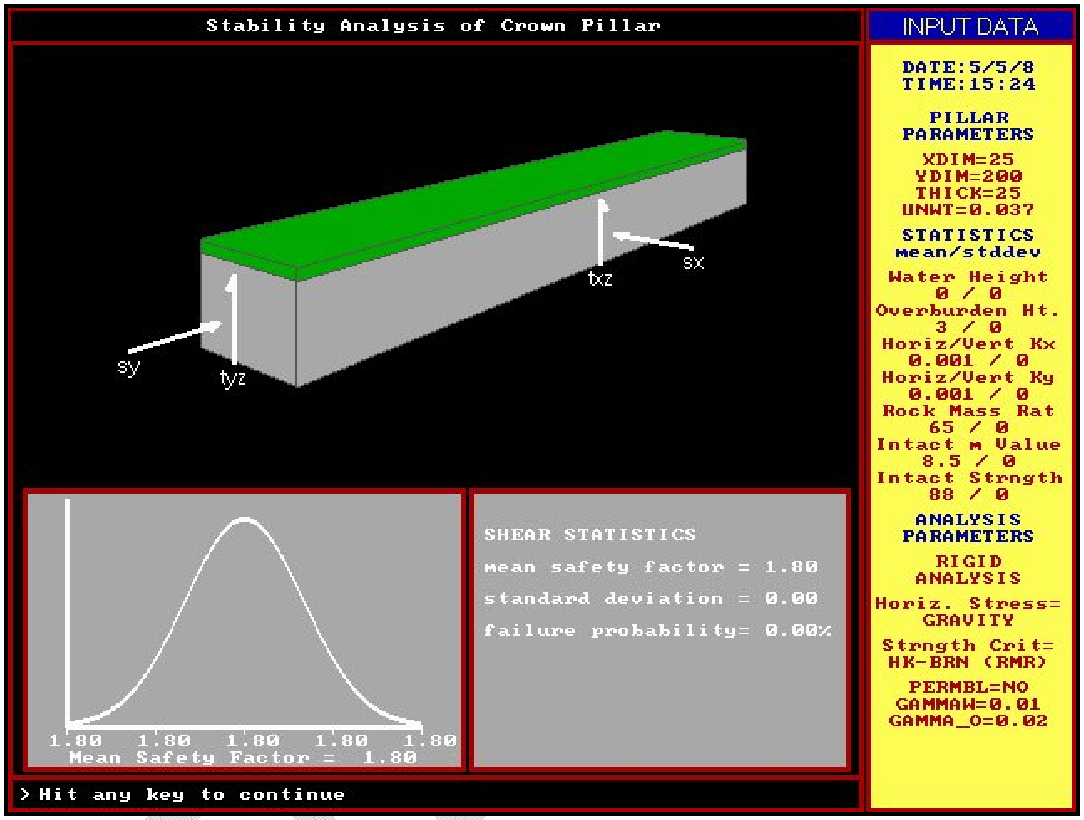
Generally some caving of the unsupported crown pillar will occur during the life of mine and the depth of failure in the back (roof) is usually restricted to one half the excavation span.

Based on this theory, if the back were to cave to approximately 12 m or span/thickness ratio of 2.5, the FOS is at 1.7 and 1.68 (permeable condition).

Table 6.5 Al Masane CPillar Analysis Results

Span/thick	Pillar Dimension			Estimated	Permeability	Water Level (m)	Rigid Analysis (FOS)
	Span	Thickness	Length	Overburden			
0.30	3	10	200	3	No		12.39
	3	10	200	3	Yes	2	11.58
2.50	25	10	200	3	No		1.65
	25	10	200	3	Yes	2	1.54
2.00	25	12.5	200	3	No		1.70
	25	12.5	200	3	Yes	2	1.68
1.67	25	15	200	3	No		1.73
	25	15	200	3	Yes	2	1.65
1.25	25	20	200	3	No		1.77
	25	20	200	3	Yes	2	1.71
1.00	25	25	200	3	No		1.80
	25	25	200	3	Yes	2	1.75

Figure 6.3 Stability Analysis of Crown Pillar



7.0 BACKFILL REQUIREMENTS

Backfill is required in order to mine the ore body with unsupported and supported mining methods. Unsupported mining methods such as Cut and fill will require classified mine tailings, waste or surface rock to be placed in the excavated sill before a consecutive lift can be mined. Consolidated fill is required for longhole stoping to maintain stability of the excavated stope and as dilution control during mining.

Strategically located rib and sill pillars have to be designed in the mine plan to with geotechnical and reserve parameters. A detail investigation is required to determine types of fill material for Al Masane.

8.0 OBSERVATION UNDERGROUND

The following are general observations made during the underground mine visit.

8.1 INTERSECTION REQUIRES CABLE BOLTING

Underground excavation requires cable bolts to provide additional support to wedge formation on the back. Wedge formations were observed at the ramp access to the north-south exploration drift and east-west to north-south exploration drift.

Intersections generate greater spans and expose the back to the wedge formation when the correct joint sets angle intercept. It is critical to design ground support for the dead weight of the wedge formed in terms of breaking load and bond strength associated with the embedded bolt length.

Figure 8.1 Wedge Failure Close to Pump Station

8.2 PORTAL

Approximately 15-20 m from the portal into the ramp requires fibre reinforced shotcrete if screens are not incorporated to the current bolting system. Screens can be attached to the current support with push plates.

Shotcrete provides additional support for loose material occurring in between the current spot bolting. The shotcrete improves the safety of the excavation during traffic transiting in the operation stage.

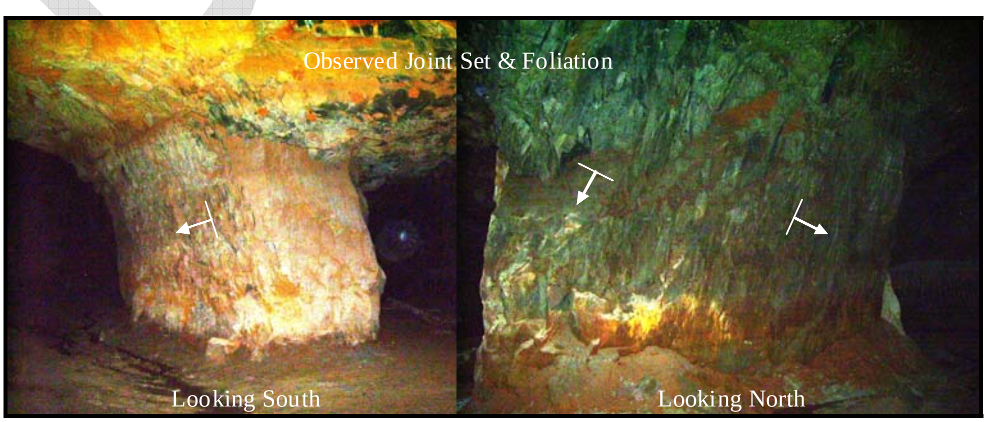
Proper scaling of loose and complete wash down of the area is essential to ensure good adhesion of the shotcrete.

Figure 8.2 Mine Portal

8.3 PILLAR REQUIRES REINFORCEMENT

Time dependant pillar deterioration can be observed in the intersection pillar located between the ramp and north-south exploration. Increased pillar confinement by reinforcement followed by intersection cable bolting is essential to increase safety of the area before mining commences.

Figure 8.3 Pillar (Between Ramp and North-South Exploration Drift)



8.4 GROUND WATER

The source of water infiltration into underground excavation is observed from two sources:

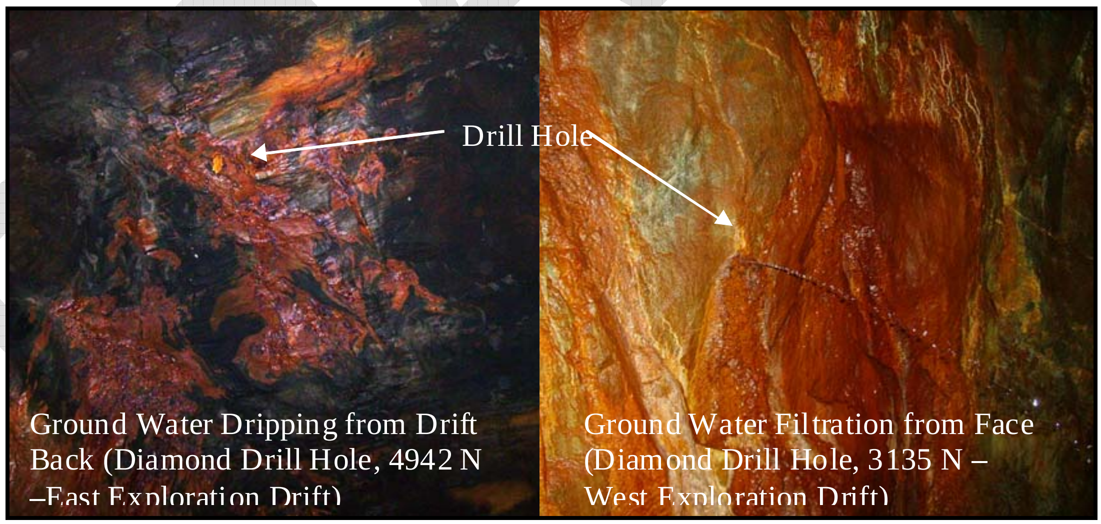
- Unplugged or ungrouted diamond drill boreholes – observed in the majority of boreholes
- Infiltration from surrounding openings and ramp-portal area.

The location of all surface, underground and future drill holes is recommend to be plugged with cement slurry to reduce direct filtration of ground water into underground excavation. This reduces the amount of pumping capacity and requirements during mining operations.

Open diamond drill holes can present hazards when blasting and also introduce water into back-filled areas within stopes, washing out backfill and introducing backfill and stope instability.

Groundwater sources must be identified, and de-watering or grouting programs via drilling can be accomplished to drain or seal off these aquifers and de-pressurize areas that may cause stability issues.

Figure 8.4 Ground Water Filtration



9.0 CONCLUSIONS AND RECOMMENDATIONS

9.1 ROCKMASS INTERPRETATION

Underground mapping indicated massive rockmass with one joint set to random. A total of 46 data points were gathered from the Saadah Zone and 13 data points were South Houra due to limited time on site to perform all the geotechnical work.

Both the drifts mapped can be observed to be relatively massive and mostly govern by foliation especially for Saadah Zone.

Wedge failures underground were observed due to the opening dimension and joint set orientation. This does not appear to occur on all the intersections observed underground. Spot bolting and cable bolting is recommended to increase safety in underground openings as mining progresses.

The rockmass logged for the six boreholes indicated that the rockmass in competent with rockmass classification ranging from Good to Extremely Good ground. The talc encountered in the core and from underground mapping is not subjected to shearing or deformation processes.

The talc altered rock is weaker than the surrounding rockmass and will induce additional dilution during mining adjacent to this unit. Al Masane's talc is a product of alteration through geological processes, rather than a tectonically derived event. The strength of talc at Al Masane will be confirmed when confirmation from Point Load Test result is being performed.

Additional on-site geotechnical data collection through underground mapping during the development stage and core logging is required to ensure that the rock types and geotechnical domains are addressed. This will provide more data points for statistical analysis yielding structurally control joint sets governing opening stabilities.

9.2 STOPE STABILITY ANALYSIS

Stope strike length of 30 m x 30 m high with hydraulic radius of 7.5 and narrow vein stope with of 15-20 m L x 100 m height at 8.3 hydraulic radius, indicate that the stope is stable under the rockmass condition estimated based on open stope non-man entry analysis.

The hanging wall is reported to be talcose and may require additional support.

Additional geotechnical investigation and ground support analysis is required for man-entry into narrow vein mining with Alimak.

The height of the stope is controlled by the contact regularity and hanging wall stability.

Thus at the current stage the stope dimension is suggested not to exceed the maximum dimension until detail geotechnical data is available to support the rockmass quality and economic analysis considering the dilution with contact irregularity.

9.3 Crown Pillar Analysis

Based on the empirical and numerical analyses maximum crown pillar span of 25 m with a thickness of 25 m is stable with a factor of 1.80 (CPillar Analysis). Hoek and Brown recommended the permanent pillar to have a safety factor exceeding 1.5. The CPillar analysis was performed under dry and impermeable conditions and in both conditions, exceeding Hoek's recommendation for permanent pillar design.

The crown pillar thickness is recommended to have a gradual tapered in thickness with respect to the width of the ore body. The maximum width of the crown pillar for this analysis is 25 m with a thickness of 25 m, to a minimum width of 3 m x 10 m thick. The strike length of the Saadah ore body is estimated at 200 m for this analysis. To achieve gradual tapering thickness for the crown pillar, the stope height can be increase to the decrease in ore width.

The crown pillar span to thickness ratio is estimated to be greater than 1.0 because unravelling of the unsupported pillar is expected and generally restricted to one half the excavation span. For maximum span of 25 m, the thickness of the pillar is set at 25 m taking into consideration that the pillar will unravel at some extent. At span/thickness of 2.0 (span at 25 m and thickness of 12.5 m) the factor of safety is at 1.70 based on CPillar analysis for dry condition and 1.68 for permeable conditions. This exceeds recommendation suggested by Hoek for permanent pillar design.

Hydrogelogical investigation is recommended to provide details on the groundwater conditions and the effect on crown pillar, general mine stability and pumping requirement.

Constant surveying and monitoring of the crown pillar is recommended to understand the extent of possible pillar unravelling. This will assist in determining prevention measures for mine design and future recovery of the pillar.

9.4 GROUND CONTROL

A ground control program has to be implemented at the mine in the early stages to assist and address mine design and safety issues.

9.5 GROUND WATER

Location of all surface, underground and future drill holes is recommend to be plugged with cement slurry to reduce direct filtration of ground water into underground excavation. Observation of ground water filtration into the mine can be best observed during the flooding of the Wadi.

Additional hydrogeolgical investigation is required to determine the presence of groundwater other than the water derived from surface or Wadi. A program of grouting current and all future boreholes should be instituted to reduce the amount of water filtration, and to reduce safety risks from future blasting.

9.6 CLOSURE

The geotechnical logging of the six boreholes, performed during the site visit, is an initial attempt to evaluate the rockmass conditions. The information gathered is only sufficient to initiate preliminary geotechnical assessments of the crown pillar geometry and stope dimensioning indicated in the proposed scope of work.

Detailed geotechnical data collection is required to determine the ground conditions at depth for ground support and mine design, or for detailed engineering design purposes. The following data should be collected in order of priority:

- Initial site rock strength determination by Point Load Testing
- Detail geotechnical data collection from available, future core and mapping
- Uniaxial and triaxial testing data
- Oriented core measurements
- Regional stress testing.

This report summarizes the observations made during the initial geotechnical core logging and recommendations for crown pillar geometry and the future geotechnical management plan for the Al Masane Project.

APPENDIX A

WARDROP

GEOTECHNICAL DATA MAPPING SHEET

Date: Apr 05 2005 Project No: **Al Masane - 8869001.00** Mapper: B.Foo

Mapping Type:

Bedrock:
Description

Jv=No of Jnts/m: Survey Info:
RQD=115-3.3*Jv:

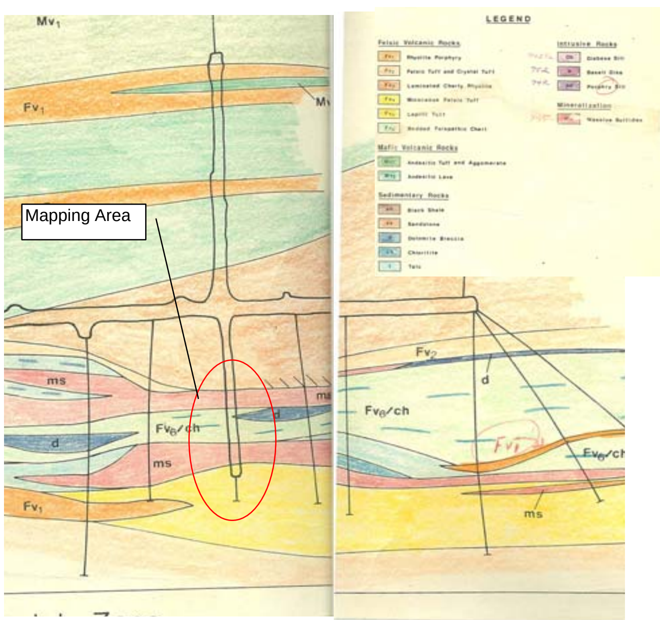
Comments: Saadah Zone

Declination :

LINE SURVEY INFORMATION

Line No	Line Trend	Line Plunge	Initial East	Initial North	Initial Elev	Length Line

Section\Plan



Line No.	Distance	Dip	*Strike	Feature Type	Continuity (m)	Spacing (m)	Infilling	Aperture	Shape	Roughness	Termination 1	Termination 2	Weather State	Strength	Water
1	0	90	92	JN	4		CL	VT	ST	RO	RC	FC	W1	R5-6	1
	4	77	70	JN	0.1-0.15	1.5	CL	VT	ST	RO	IR	FC	W1	R5-6	1
	4	30	70	JN	2.5	2	CL	VT	ST	RO	AJ	IR	W1	R5-6	1
	5	80	270	JN	4	3	CL	VT	ST	RO	RC	FC	W1	R5-6	1
	5	82	170	BD	4		CL	VT	ST/PL	RO	RC	FC	W1	R5-6	1
	5.5	88	140	BD	4	0.1-0.15	CL	VT	ST/PL	RO	RC	FC	W1	R5-6	1
	5.6	88	140	BD	5	0.1-0.16	CL	VT	ST/PL	RO	RC	FC	W2	R5-6	1
	5.7	88	140	BD	6	0.1-0.17	CL	VT	ST/PL	RO	RC	FC	W3	R5-6	1
	5.8	88	140	BD	7	0.1-0.18	CL	VT	ST/PL	RO	RC	FC	W4	R5-6	1
	5.9	88	140	BD	8	0.1-0.19	CL	VT	ST/PL	RO	RC	FC	W5	R5-6	1
	6	88	140	BD	9	0.1-0.20	CL	VT	ST/PL	RO	RC	FC	W6	R5-6	1
	6.1	88	140	BD	10	0.1-0.21	CL	VT	ST/PL	RO	RC	FC	W7	R5-6	1
	6.2	88	140	BD	11	0.1-0.22	CL	VT	ST/PL	RO	RC	FC	W8	R5-6	1
	6.3	88	140	BD	12	0.1-0.23	CL	VT	ST/PL	RO	RC	FC	W9	R5-6	1
	6.4	88	140	BD	13	0.1-0.24	CL	VT	ST/PL	RO	RC	FC	W10	R5-6	1
	6.5	88	140	BD	14	0.1-0.25	CL	VT	ST/PL	RO	RC	FC	W11	R5-6	1
	6.6	88	140	BD	15	0.1-0.26	CL	VT	ST/PL	RO	RC	FC	W12	R5-6	1
	6.7	88	140	BD	16	0.1-0.27	CL	VT	ST/PL	RO	RC	FC	W13	R5-6	1
	6.8	88	140	BD	17	0.1-0.28	CL	VT	ST/PL	RO	RC	FC	W14	R5-6	1
	6.9	88	140	BD	18	0.1-0.29	CL	VT	ST/PL	RO	RC	FC	W15	R5-6	1
	7	88	140	BD	19	0.1-0.30	CL	VT	ST/PL	RO	RC	FC	W16	R5-6	1
	7.1	88	140	BD	20	0.1-0.31	CL	VT	ST/PL	RO	RC	FC	W17	R5-6	1
	7.2	88	140	BD	21	0.1-0.32	CL	VT	ST/PL	RO	RC	FC	W18	R5-6	1
	7.3	88	140	BD	22	0.1-0.33	CL	VT	ST/PL	RO	RC	FC	W19	R5-6	1
	7.4	88	140	BD	23	0.1-0.34	CL	VT	ST/PL	RO	RC	FC	W20	R5-6	1
	7.5	88	140	BD	24	0.1-0.35	CL	VT	ST/PL	RO	RC	FC	W21	R5-6	1
	7.6	88	140	BD	25	0.1-0.36	CL	VT	ST/PL	RO	RC	FC	W22	R5-6	1
	7.7	88	140	BD	26	0.1-0.37	CL	VT	ST/PL	RO	RC	FC	W23	R5-6	1
	7.8	88	140	BD	27	0.1-0.38	CL	VT	ST/PL	RO	RC	FC	W24	R5-6	1
	7.9	88	140	BD	28	0.1-0.39	CL	VT	ST/PL	RO	RC	FC	W25	R5-6	1
	8	88	140	BD	29	0.1-0.40	CL	VT	ST/PL	RO	RC	FC	W26	R5-6	1
	9	70	60	JN	4	0.5	CL	VT	ST	RO	RC	FC	W1	R5-6	1
	9.2	78	91	JN	4	0.5	CL	VT	ST	RO	RC	FC	W1	R5-6	1
	9.3	72	160	BD	4	5	CH	TI	PL	RO	RC	FC	W1	R5-6	1
	10	70	194	BD	4	0.1-0.15	CL	VT	ST/PL	RO	RC	FC	W1	R5-6	1
	10.5	30	90	JN	0.5	0.5-1	CL	VT	ST	RO	AJ	AJ	W1	R5-6	1
	11	70	180	SH	4	0.2-0.5	TL	VT/IT	UN	SL	RC	FC	W1	R4	1
	11-20			ME											
	17			ME											3-4
	20	80	350	BD	4	0.01	CL	VT	UN	RO	RC	FC	W1	R5-6	1
	23	80	380	JN	4	1	TL	IT	ST/UN	SM/RO	RC	FC	W1	R5-6	1
	25	88	340	SH	4	0.8 Thic.	TL	IT	UN	SM	RC	FC	W2-3	R4	1
	32	48	340	BD	4	0.2-0.5	TL	VT/IT	PL	SM/RO	RC	FC	W2-3	R4	3
At Pt 60	35	38	60	JN	1-1.5	0.3	CL	VT	ST	RO	IR	IR	W2-3	R5-6	3
	35	38	60	JN	1-1.6	1.3	CL	VT	ST	RO	IR	IR	W2-3	R5-6	3
	35	38	60	JN	1-1.7	2.3	CL	VT	ST	RO	IR	IR	W2-3	R5-6	3
	35	38	60	JN	1-1.8	3.3	CL	VT	ST	RO	IR	IR	W2-3	R5-6	3
	35	38	60	JN	1-1.9	4.3	CL	VT	ST	RO	IR	IR	W2-3	R5-6	3
	37	65	160	BD	4	2	CL	VT	ST	RO	RC	FC	W2	R5-6	1

Type
FL: Fault Zone
SH:Shear
JN:Joint
VN:Vein
BD:Bedding
CO:Contact
FO:Foliation
CJ:Conjugate
ME: Massive

Continuity and Spacing

<1cm	1-2m
1-2cm	2-5m
2-5cm	5-10m
5-10cm	10-20m
10-15cm	20-50m
15-50cm	50-100m
50-100cm	>100m

Infilling
CL:Clean
GO:Gouge
BR:Broken Rock
SU:Sulphides
CH:Chlorite
QZ:Quartz
CA:Calcite
CH:Chlorite
TL:Talc
EP:Epidote

Aperture
VT:Very tight <.1mm
TI:Tight .1-.25mm
PO:Part Open .25-.5
OP:Open .5-2.5mm
MW:Mod Wide 2.5-10mm
WD:>10mm
VW:Very Wide 1-10cm

Shape
PL=Planar
UN=Undulating
ST=Stepped
CU=Curved

Roughness
SL:Slickensided
SM:Smooth
RO:Rough
VR: Very Rough

Water
1:Dry
2:Dry, Stained
3:Damp
4:Drops
5:Contiuous Flow

Weathering
W0:Industrial Stain
W1: Fresh
W2:Slightly weathered
W3:Mod weathered
W4:Highly weathered
W5:Completely Weathered
W6:Residual Soil

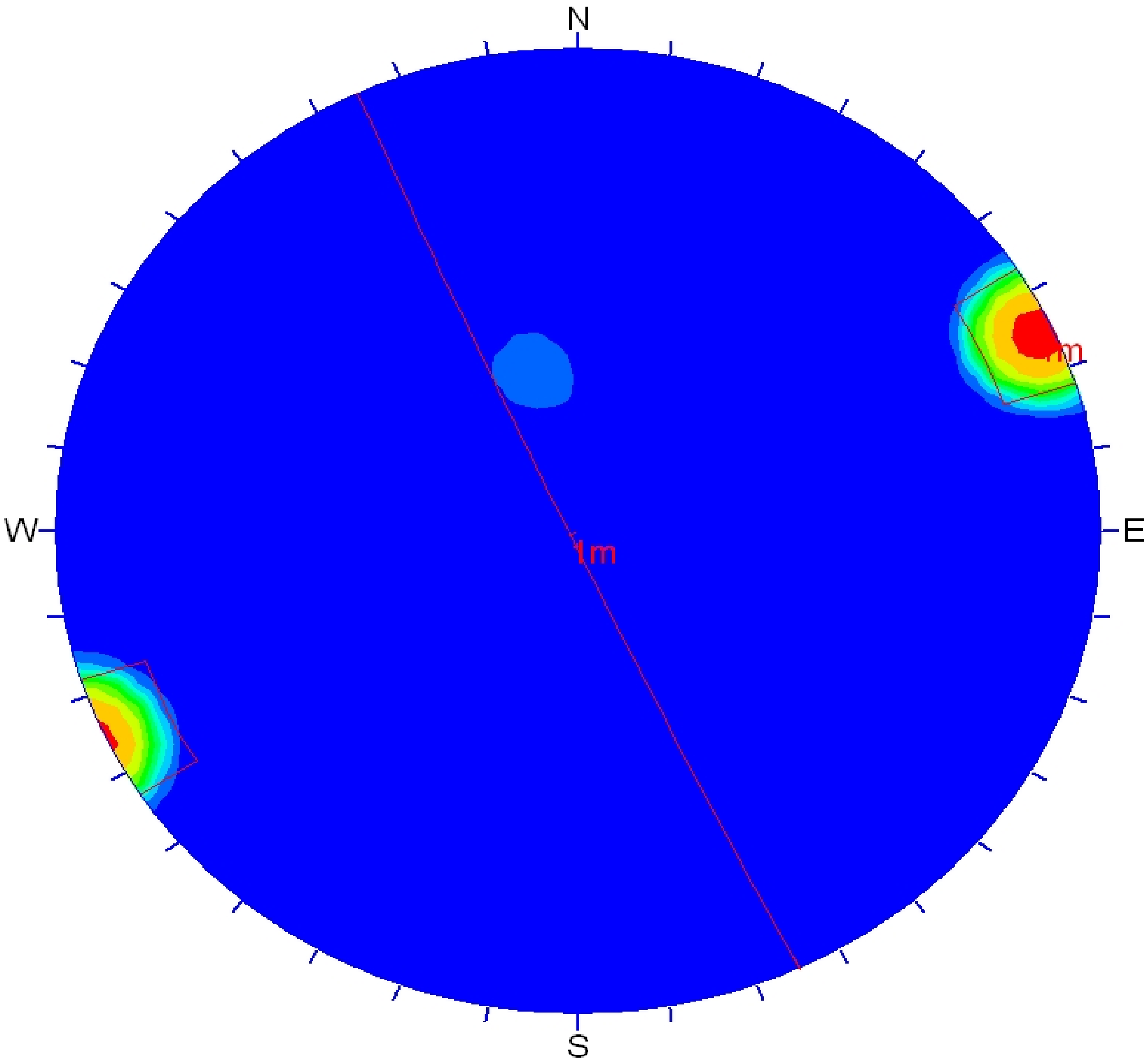
Strength
R0:Extremely weak -Indented by thumbnail
R1:Very weak - Peeled by pocket knife
R2: Weak - Peeled with pocket knife is difficult
R3:Med - Knife not peel\fracture with hammer one blow
R4:Strong - Breaks with more than one hammer blow
R5:V.Strong - Requires many hammer blows to fracture
R6:Ext Strong >250MPa - Chipped by hammer blow

Termination/Ends
AJ:Another Joint
IR:Intact Rock
FC:Floor Censored
RC:Roof Censored
W0:Industrial Stain

ENDS:0, 1 or 2

Note: * Strike Not Corrected For Declination

Stereographic Analysis For Al Masane Underground Mapping Data - Saadah Zone



Orientations

ID		Dip / Direction
1	m	88 / 245

Equal Angle
Lower Hemisphere
46 Poles
46 Entries

WARDROP

GEOTECHNICAL DATA MAPPING SHEET

Date: Apr 05 2005 Project No: **Al Masane - 8869001.00** Mapper: B.Foo

Mapping Type:

Bedrock:
Description

Jv=No of Jnts/m:
RQD=115-3.3*Jv:

Survey Info:

Comments: South Houra Zone

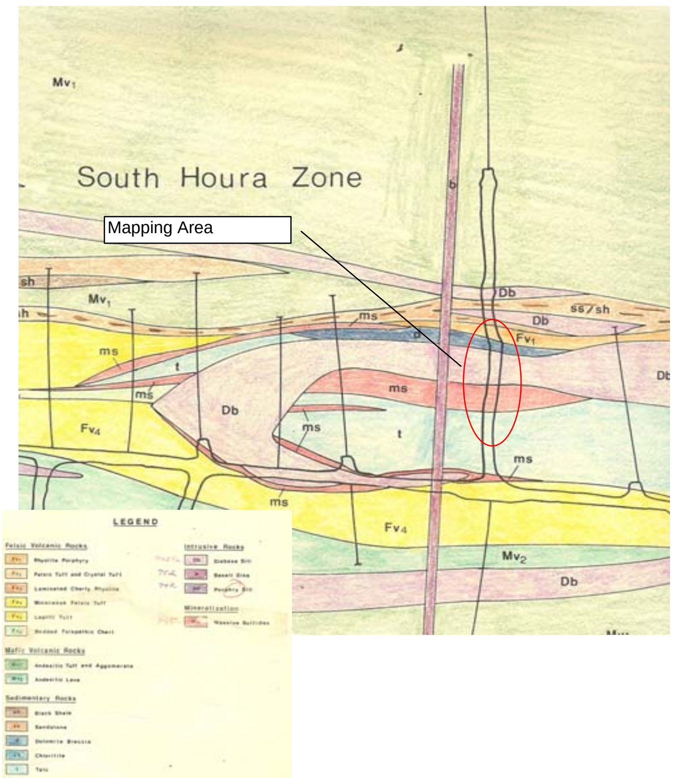
Declination :

LINE SURVEY INFORMATION

Line No	Line Trend	Line Plunge	Initial East	Initial North	Initial Elev	Length Line

Line No.	Distance	Dip	*Strike	Feature Type	Continuity (m	Spacing (m)	Infilling	Aperture	Shape	Roughness	Termination 1	Termination 2	Weather State	Strength	Water
1	20	88	170	BD	4	0.2-0.5	TL	VT	UN	SM-RC	RC	FC	W2	R3-4	1
	Bands of talc with some sulphide. Bedding is mostly massive														
	25	70	160	BD	4	0.2-0.5	TL	VT	UN	SM-RC	RC	FC	W2	R3-4	1
	30	60	70	JN	3	0.4	TL	VT	PL	SM-RC	RC	FC	W2	R3-4	1
	30	60	50	JN	3	0.4	TL	VT	PL	SM-RC	RC	FC	W2	R3-4	1
	30	60	50	JN	3	0.4	TL	VT	PL	SM-RC	RC	FC	W2	R3-4	1
	32	60	170	BD	4	1	TL	VT	PL	SM-RC	RC	FC	W2	R3-4	1
	33	60	170	BD	4		TL	VT	PL	SM-RC	RC	FC	W2	R3-4	1
Random	39	38	80	JN	3		CL	VT	ST	RO	AJ	AJ	W2	R4-5	1
Random	45	90	180	BD	4	0.2-0.5	CL	VT	ST	RO	RC	FC	W2	R5	1
	52	65	220	JN	8	2.5	QZ	VT	UN	RO	RC	FC	W2	R5	1
	58	80	245	JN	6	3	QZ	VT	UN	RO	RC	FC	W2	R5	1
	58.5	70	190	JN	4		QZ	VT	UN	RO	RC	FC	W1	R5	1
	60	80	160	Contac	4	2	CL	VT	PL	RO	RC	FC	W1	R5	1

Section\Plan



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BD:Bedding
CO:Contact
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ME: Massive

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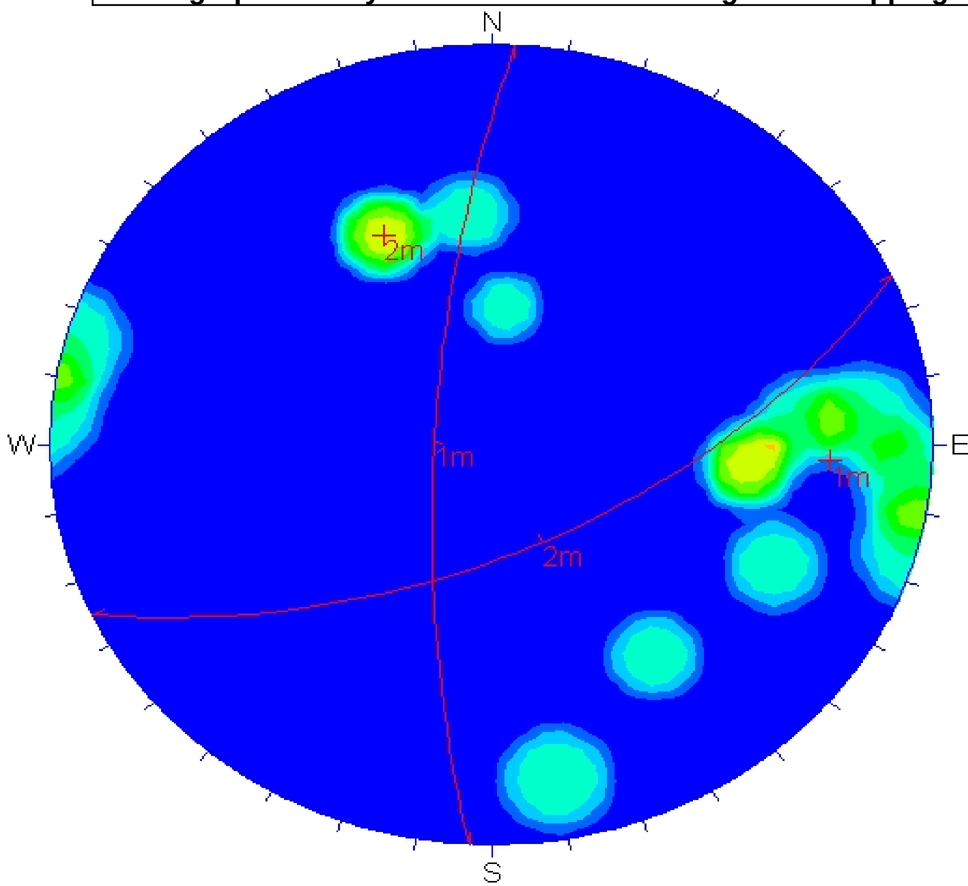
Stereographic Analysis For Al Masane Underground Mapping Data - South Houra Zone



Orientations

ID		Dip / Direction
1	m	75 / 273
2	m	60 / 155

Equal Angle
Lower Hemisphere
13 Poles
13 Entries