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# HARDY ASSOCIATES (1978) LTD.

CONSULTING ENGINEERING & PROFESSIONAL SERVICES

Q2160-002

File No.

satisfact with raw data
extrapolating data beyond perimeter of pit.

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November 30, 1979

Montreal Engineering Ltd.,
1199 West Pender Street,
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Attention: Mr. P. Mahoney, P.Eng.

Dear Sirs:

Re: Grum Deposit

Progress on work for the Grum deposit is summarized very briefly below. These results are preliminary and based on following assumptions and data:

1.0 GROUNDWATER

Four piezometers installed by Cyprus-Anvil show piezometric pressures equivalent to a phreatic surface very close to the existing ground surface.

2.0 GEOLOGIC MODEL

All directions in the following are referenced to true north. West section lines (e.g. 62W) trend 044° true.

Foliation is very variable but average strike of surface measurements is 000° true. True dips in NE and SE wall areas are as follows:

borehole deflection?
foliations ∠'s

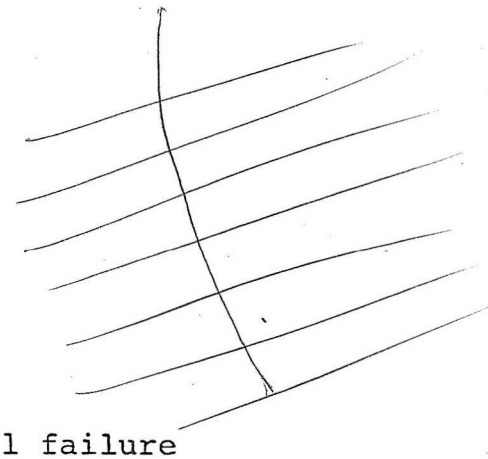
a) above 1203 m: 34° to 70° SW, steeper dips predominate

b) 1149 m - 1203 m: 50° to 60° SW

c) 1104 - 1149 m: 34° to 45° SW

d) Faults in decline average:

266°/78° N
236°/~~89°~~ 80 N



## 3.0 ANALYSIS

### 3.1 Assumptions

1) Failure modes are translational failure on foliation and wedges, the latter formed by intersection of foliation and faults.

2) Strength data for foliation:

$\phi$ Phi = 19.5°
c = 850 psf
i = 6°

i is the geometrical component of friction.

3) Assumed strength for faults

PHI = 21°
c = 0

4) Groundwater conditions assumed included (a) dry, (b) phreatic surface half way up slope or bench and (c) phreatic surface at top of slope.

5) Pit location was taken from Canadian Mine Services drawing given to us in October.

average foliation & used?

Design charts (factor of safety vs slope height) were produced for:

1) Kinematically acceptable slopes (i.e. not allowing wedges or foliation to daylight on slope). Since both foliation and faults are relatively steeply dipping, kinematic criteria will govern stability of the overall slope.

2) Translational failure on foliation (dips 34, 45, 50, 60°, both wet and dry).

3) Wedge failures formed by the two fault sets and foliation dips in no. (2).

Preliminary summary of the design charts and assuming conditions as defined for the geologic model yields the following design:

3.2 NE Wall (strike 315 deg. true)

3.2.1 Overall Wall

a) above 1149 m: 35 to 40° is kinematically acceptable. - more work required

* b) below 1149 m: 29 to 32° (corresponding to true foliation dips of 35 to 40°).

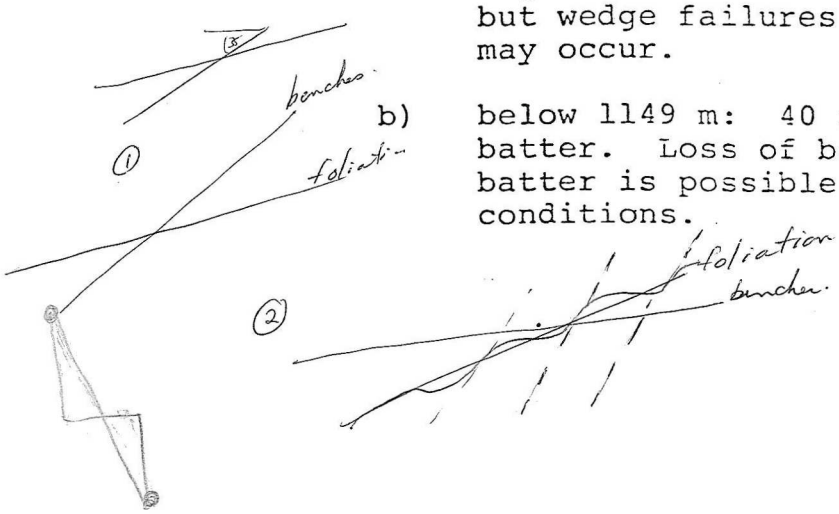
variation from mean dip assumed 60°.

Any tendency for shallower foliation dips than given in geologic model or for strikes of 015 to 030° is unfavourable and would reduce above angles.

3.2.2 Benches

a) above 1149 m: 40 ft benches can have batter angles 60 to 70°. 80 ft benches are possible but wedge failures back to a batter of 50° may occur.

b) below 1149 m: 40 ft benches with 60 to 70° batter. Loss of bench edge back to 50 to 55° batter is possible under anything but dry conditions.



3.3 SE Wall (strike 045)

A major fault occurs (No. 6 on Kerr-Addison maps) but does not daylight on Canadian Mine Services Pit. No fault data is available behind the wall.

3.3.1 Overall Wall

a) above 1149 m: 40° is acceptable kinematically.

b) below 1149 m: Kinematically acceptable dips are 30 to 32°, the range depending on foliation dips.

3.3.2 Benches

a) above 1149 m: 40 ft with 60 to 70° batter. 80 ft is possible but wedge failures back to 55° batter will occur.

b) below 1149 m: as above but both 40 and 80 ft benches may have wedge failures back to 50° batter.

The following applies to both NE and SE walls:

1) Wedge failures more extensive than those noted above will undoubtedly occur on faults or joints differing in orientation from those assumed.

2) Zones of extensive and thick gouge or shattered rock (e.g. section 70 W) will not support benches with batter angles higher than the angle of repose, say 30 to 34°.

3) Controlled blasting will be required to avoid loss of cohesion on foliation surfaces. Bench design requires maintenance of this cohesion.

4) Lowering of groundwater pressures by dewatering is necessary.

5) The transition zone between NE and SE walls is critical for bench stability and should be as short as possible. Ideally a fairly sharp corner should be used.

6) Detailed pit design will require that a more detailed geologic model be prepared.

3.4 SW Wall (strike 135 deg. true)

40-45° Slope 4H B. Cavers.

On this wall fault 3 (numbered on Kerr Addison maps) may cause stability problems on upper portions of the slope. On limited portions of the slope wedges are possible between faults 3 and 7.

3.5 NW Wall (strike 45 deg. true)

40-45°.

No major stability problems are expected except that if families of subparallel faults exist dipping steeply into wall, toppling failure is possible.

All of the above information was taken from the design charts using extrapolated information from geologic model, which in itself is extrapolated from available data. All of the design recommendations must be treated with caution.

If we can provide further information prior to the draft report being available, please contact us at your convenience.

Yours truly,

HARDY ASSOCIATES (1978) LTD.

Per: D. S. Cavers

D. S. Cavers, M.Eng., P.Eng.

DSC/baw