M.D. HAMPTON

CYPRUS ANVIL MINING CORPORATION LTD.

GRUM DEPOSIT

PHASE TWO GEOTECHNICAL STUDIES

DRAFT REPORT

003129

December 1979

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11 December 1979

Cyprus Anvil Mining Corporation Ltd.
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Attention: Mr. P. Taggart

Dear Sirs:

We are pleased to submit our Draft Report for Phase Two Geotechnical Studies of the Grum Deposit. These studies were defined in our letter proposal of October 17 and authorized by yourselves in a telex of 18 October 1979. Modifications to the proposed scope of work were suggested in your telex of the 18 October 1979 and appropriate revisions agreed to in a telex reply of the same date.

Recommendations for further work detailed within this Draft Report pertain to the open pit rock walls. Additional geotechnical programs as outlined within our original proposal are still considered necessary to detailed mine planning. Programs required prior to stripping include:

- confirmation of design slope and location for overburden waste dumps of unconsolidated surficial deposits
- confirmation of design slopes for overburden excavations
- test pit excavations and additional drilling for waste dump and sedimentation pond location.

We trust this report meets your requirements at this time. Should you have any questions regarding the contents of this report please do not hesitate to call us at any time. It is anticipated that a joint meeting would be arranged during the period January 1 to 15, 1980 in order to receive your comments. A Final Report would then be issued shortly thereafter.

Yours very truly,

K.F. Randall

K.F. Randall
Regional Manager

DPM/mh

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SUMMARY

This report describes geotechnical investigations and resulting design parameters for the proposed open pit at the Grum deposit. Specific attention has been paid to the initial mining stage, as presently considered by the five year mine plan. The study consisted of:

1) Preparation of a conceptual geological model of discontinuities.

2) Field investigations including recovery of core for testing purposes and coordination of piezometer installations with Cyprus Anvil.

3) Laboratory investigations to establish physical properties of the phyllite in which the ore occurs. Particular emphasis was placed on determining foliation shear strength.

4) Analyses and preparation of design charts.

5) Application of the design charts using discontinuity orientations from the geological model to produce a preliminary pit design.

The drilling and laboratory results confirmed that the intact rock strengths are sufficiently high for stability of cut walls to be primarily dependent on foliation and fault characteristics. Jointing is a subordinate structural feature.

Two fundamentally different wall conditions have been identified. On the east side of the pit (N.E. and S.E. walls) foliation S_2 dips into the pit while on the west (N.W. and S.W. walls) foliation dips into the wall. Foliation dip is up to 70°W high on the east wall and decreases to some 33° or 34°W near the bottom of the pit.

Potential failure modes on the east side of the pit include plane translational failure on foliation and wedge failures bounded by foliation and faults.

In the absence of major discontinuities (foliation and faults) dipping into the west side of the pit, stability of the S.W. and N.W. walls is expected to be good. Toppling failure could occur if families of faults or joints exist dipping into the wall.

Preliminary design of the overall wall is based on kinematic considerations, that is not allowing potential slip surfaces to daylight on the face. Preliminary design parameters are summarized in the following table:

WALL	STRIKE[1]	SLOPES[2]	REMARKS
S.E.	045°	30 to 40°	Concave up
N.E.	315°	29 to 40°	Concave up
S.W.	315°	45°	
N.W.	045°	45°	

[1] Relative to true north

[2] Over all pit slope angles (rim to toe with benches but not including roads on east walls)

Benches can be 12 to 24 m high, although some loss of bench edges will occur for higher bench heights.

Dewatering or depressurization will be required to control piezometric pressures currently existing in the pit area. Similarly, good controlled blasting on final walls, particularly on the east side of the pit, is important with regard to pit wall stability.

Additional investigations are recommended in the following areas:

1) Preparation of a more detailed model of discontinuity orientations, including some field investigations. Confirmation of foliation strike and dip on the lower part of the east walls is particularly important.

2) Hydrogeological investigations to allow design of mine dewatering systems.

3) Testing of graphitic foliation surfaces.

4) Detailed analysis for slopes in deep surficial overburden southeast of Doal Lake. Unconsolidated materials in this area exhibit high pore pressures.

PART 1 - INTRODUCTION

Cyprus Anvil Mining Corporation commissioned Montreal Engineering Company, Limited to provide geotechnical recommendations pertaining to the proposed development of an open pit in the Grum deposit near Faro, Yukon Territory.

The Grum deposit is one of a series of stratabound lead zinc deposits approximately 190 km northeast of Whitehorse, Y.T. The deposit occurs on the southwest flank of the Anvil arch on the north side of the Tintina trench. The ore is contained within a variety of biotite, muscovite phyllites that are variably graphitic and calcareous. The deposit was formerly explored by Kerr Addison Mines Ltd. from whose work much of the detailed geological information incorporated in this study was taken. Cyprus Anvil Mining Corporation did not finalize its review of structural geology for the deposit prior to preparation of this report.

The current geotechnical study has been mostly based on conventional geotechnical considerations and concentrated on factors decisive for the pit slope design. The study primarily considered the initial phase of the mining, represented by a tentative outline of a five year pit as prepared by Canadian Mine Services.

Main objectives of the present pit stability study included clarification of the fundamental geotechnical aspects and behaviour of the rock mass pertaining to the development of geotechnical recommendations for input to mine planning. In order to achieve these objectives the following scope of work has been established:

1) To develop a conceptual geologic model of geotechnically important features in the Grum deposit.

2) To undertake field investigations including drilling of core to be used for testing purposes and coordination of piezometer installations with Cyprus Anvil.

3) To establish physical properties of representative rock types by laboratory testing.

4) To develop parametric design charts applicable to conditions at the Grum deposit.

The study was initiated on October 5, 1979. It included two phases:

1) Phase One - involved review of available geological information, discussions of geotechnical factors decisive for pit slope design and of technical aspects pertaining to necessary geotechnical investigations. The results were summarized in a report dated October 17, 1979.

2) Phase Two - involved office, field and laboratory work as previously formulated and these results together with geotechnical recommendations relative to mine planning are presented in this report.

Objectives of the Phase Two studies were discussed in meetings between Cyprus Anvil Corporation personnel and personnel representing Montreal Engineering Company, Limited on October 11 and 12, 1979.

Detailed review of geologic data obtained through previous exploration programs commenced in mid October 1979.

Drilling of one HQ and three NQ holes on the site was initiated later in October, 1979. Drilling was performed by Arctic Diamond Drilling Ltd. under contract to Cyprus Anvil. Mr. Dave Watkins provided liaison and drill inspection services.

Core logging for geotechnical purposes, on-site testing of core for index properties and sample selection was undertaken by Mr. D.S. Cavers commencing October 29, 1979. Mr. J. Mustard of Cyprus Anvil provided a lithological log of the core.

Preparation of the conceptual geological model by D.S. Cavers was greatly aided by discussions with Dr. D. Jennings of Cyprus Anvil Corporation. Following completion of rock testing in the laboratory, analysis commenced in mid November, 1979.

PART 2 - GEOLOGY AND HYDROGEOLOGY

2.1 Geomorphology and Surface Geology

Within the project mine and waste dump areas, topography is gently rolling. Steeper slopes exist within the Vangorda Creek valley approximately 1.5 km to the southeast. Regionally, the area slopes towards the Pelly River about 8 km to the southwest. Average elevation at the site is 1310 m, although in the surrounding region this exceeds 1980 m.

Surficial deposits within the area of the mine and waste dumps consist primarily of morainal and glaciofluvial deposits with a maximum thickness in excess of 100 m (Hole DL-1). These deposits include tills (heterogeneous mixtures of clay, silt, sand and gravels), uniform silts, sands and gravels.

Terrain analysis, including distribution of main surface deposit types, has been conducted in conjunction with previous studies and the results are contained in the Montreal Engineering Company Ltd. report dated 1975.

Pockets of permafrost exist in the general area. Previous investigations undertaken by Montreal Engineering have found occasional zones of segregated ice near sources of water supply. Hole DL-1 may have encountered permafrost conditions but no segregated ice was present in the limited amount of core which was recovered from the hole.

2.2 Bedrock Geology

Regionally, metamorphic rocks on the southwest flank of the Anvil arch include biotite muscovite schists, calc-silicate gneiss and biotite-muscovite phyllites. Mineralization in the currently mined Anvil pit occurs in the schist; however, the Grum deposit, and several other nearby deposits, occur within the phyllites.

Available cross-sections of the ore structure (produced by Kerr Addison Mines Ltd., 1976), indicate the overall structure of the Grum ore zone to be a broad syncline with dips ranging from 30° to 40° on the northwest limb. Structure on the south limb is more complex but a large "S" shaped fold apparently results in "overturning" of the zone. The deposit is cut by a number of faults which further contribute to the complexity of the structural geology. Deformation of the ore zone into the complex structure it now exhibits may have been a result of the D_2 period of deformation interacting with folds produced by an earlier D_1 phase.

Bleached phyllite which frequently surrounds the ore zone may have resulted from conditions prevailing during the original deposition of the sediments (Serola, 1975). Graphitic phyllites also occur, particularly on the footwall of the north limb of the deposit.

Currently, it is considered (Jennings, personal communication) that the suite of metamorphic rocks in which the deposits occur represents a quiet water miogeosynclinal accumulation of variably calcareous pelitic sediments. No genetic relationship between the ore zones and the Anvil Batholith to the north is apparent. Rather, it appears that the primary structural control on sulphide deposition is original bedding (S_o).

Regionally, some five periods of deformation and metamorphism appear to have taken place in addition to intrusion of the Anvil Batholith. The main foliation (S_2) has been folded by later metamorphic events into a broad synclinal structure with the Grum deposit located on the north limb. From a geotechnical point of view the S_2 foliation is the single most important feature affecting pit stability.

Within the future Grum open pit area foliation dips are generally west to southwest. The steepest dips (locally up to 70°) occur near the eastern perimeter of the proposed pit. Dips within the pit area average some 34° west; however, within the ore zone dips of up to 25° occur both to the west and east.

Foliation strike appears to be quite variable, particularly near the margin of the Anvil Batholith. Also, in some areas, it is probable that movement on faults has resulted in rotation of the foliation strike direction. On the basis of the conceptual geologic model discussed in Appendix "C", the average regional direction of foliation strike is 000° true[1].

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[1] All references to direction in this report are relative to true north Section lines (e.g. 62W) on the Grum deposit trend 044° true.

On a regional basis, important faults include the Tintina trench system, some 11 km to the south. On a smaller scale, the Doal Lake fault is an important feature some 1 km north of Doal Lake. Fault orientations within the pit area are discussed in greater detail in section 3.2 and in Appendix "C".

2.3 Surface Water and Groundwater

Doal Lake is the only significant surface water body within the proposed pit area. Surface drainage is generally northwest into Nose Creek or southeast into Vangorda Creek, however, there are no well established drainage courses within the site proper.

Currently available information indicates that the Pelly River valley southwest of the site represents a regional discharge zone. Recharge areas may include the site as well as terrain to the northeast. More groundwater information is required for the assessment of mine area position relative to regional groundwater system.

It is apparent that groundwater movement within the rock mass is governed by permeability of major discontinuities (i.e. faults, shear zones and joints). Consequently, the overall transmissibility and storage capacity of the rock mass within the pit area should be low.

Local groundwater conditions have been investigated by means of four P100 piezometers (manufactured by Petur Instruments Ltd.) installed at approximately 100 m depths in holes DL-1 to DL-4. Cyprus Anvil Corporation plans to install an additional four piezometers at shallower depths in the holes. Readings from the four piezometers installed to date are shown in Table I. Locations of the drill holes are shown in Plate 1. In the case of DL-1, the equivalent phreatic surface is above the ground surface (i.e. artesian condition) while in the other three holes, the surface is some 5 to 10 m below existing ground surface. It is expected that slightly higher readings might occur at other times of year.

Seepages observed during mining of the decline occurred largely within the ore zone from faults and fractures. Currently, the decline is flooded to the edge of

TABLE I

Pneumatic Piezometer Readings

Date	Hole No.	Elevation of Piezometer[3]		Reading	Equivalent Groundwater Elevation above Piezometer	
		(m)	(ft.)	p.s.i.	(m)	(ft.)
Oct. 25/79	DOAL LAKE[2] 1	73.8	242	108.5	76.4	250.6
Nov. 3/79	DOAL LAKE 1	73.8	242	106.5	75.0	246.0
	DOAL LAKE 2	56.8[1]	186.5[1]	64.0	45.0	147.8
	DOAL LAKE 3	97.5	320	123.5	87.0	285.3
	DOAL LAKE 4	59.1	194	75.0	52.8	173.3
Nov. 13/79	DOAL LAKE 1	73.8	242	110.0	77.4	254.1
	DOAL LAKE 2	56.8	186.5	64.0	45.0	147.8
	DOAL LAKE 3	97.5	320	125.0	88.0	288.8
	DOAL LAKE 4	59.1	194	77.0	54.2	177.9

[1] 60.5 m (198.5 ft.) down hole inclined 20°

[2] Abbreviated elsewhere as DL-1

[3] Relative to ground surface

the steel liner and water is overflowing (October, 1979) at a rate of some 0.5 l/sec. Installation of the shallow piezometers should give a clearer picture of local groundwater flow.

On the basis of current information it may be conjectured that through going discontinuities (faults, joints, etc.) have sufficient permeability and cross connections to reduce large piezometric pressure differences across the site. This is encouraging with regard to dewatering.

PART 3 - GEOTECHNICAL FACTORS

3.1 Pit Layout and Depth

The layout assumed for compilation of the structural geologic model was taken from the five year pit in the Canadian Mine Services drawing given to us in October. This proposed pit extends from sections 60 W to 80 W and from 35 S to approximately 14 N. The northeast wall of the pit intersects Doal Lake. At the end of five years, the northeast and southwest walls represent final pit walls. Eventually the pit would be extended beyond its five year boundaries both to the northwest and to the southeast.

For analytical purposes it was assumed that the pit would be approximately rectangular with walls striking 045° and 315° true.

3.2 Structural Features

Stability in the proposed Grum Pit will be predominantly governed by the properties of through going discontinuities and their orientation relative to the pit wall. Orientations of discontinuities within the pit area were examined during preparation of the conceptual geological model discussed in Appendix "C". Average orientations are summarized in Table II.

It should be appreciated that foliation dips were calculated from apparent dips on Kerr Addison sections using an assumed foliation strike. Variation in dip from the values given will occur. The data available from Kerr Addison's work probably justifies compilation of a more detailed model than that used here.

TABLE II

Average Orientations of Discontinuities

Feature	Location	Orientation[1] Strike/Dip
Foliation	East side of pit[2]	
	above 1203 m	000°/34°SW to 000°/70°SW
	1149 m -1203 m	000°/50°SW to 000°/60°SW
	1104 m -1149 m[3]	000°/34°SW to 000°/45°SW
Faults	Decline	266°/78°N
		236°/80°N
Joints	Decline	055°/90°

1 relative to true north

2 orientations change continuously with depth and the 1149 m level has been selected only as a convenient depth to divide the changing orientations.

3.3 Structure and Possible Failure Modes

On the northeast and southeast walls, stability will be largely governed by foliation and fault attitudes. Possible failure modes include wedge failures bounded by faults and foliation, and translational failure on foliation daylighting on the pit face.

On the northwest and southwest walls, foliation and faults dip into the wall which is favourable insofar as wall stability as concerned. Toppling failure could be a possibility if families of subparallel joints or faults exist dipping steeply into the wall. For all practical purposes the wall stability is governed by intact rock strength relative to stress conditions in the wall, by secondary discontinuities (joints, minor shear zones) dipping into the pit and by time dependant deterioration of the rock mass.

On the average, faults in the Grum deposit are relatively steeply dipping. However, faults 3 and 6[1], shown on maps in Appendix "C", are less steeply dipping, and

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[1] Fault numbers refer to numbers assigned by Kerr Addison Mines and appearing on their plans and sections.

if they daylight on planned pit walls, potential problems could result. Other comparitively gently dipping faults were mapped within the decline and their orientations appear on stereonets in Appendix "C". Unfortunately, there is little fault (or foliation) data beyond the perimeter of the proposed pit area. If faults dipping between approximately 20° and the slope of the wall daylight, translational failure could occur.

3.4 Rock Strength Parameters

Rock strength characteristics were established by means of direct shear and triaxial laboratory tests or estimated relative to other physical properties determined on selected rock specimens. Laboratory investigations and their results are detailed in Appendix "B".

Rock shear strength characteristics used in the analysis are shown in Table III.

TABLE III

Rock Shear Strength Characteristics

Discontinuity	Strength Parameters
Joints parallel to foliation	Ø = 19.5° [1]
	C = 850 psf [1]
	i = 6° [2]
Faults	Ø = 21° [3]
	C = 0

1 Estimated from laboratory testing. See Appendix "B"

2 Estimated from stereonet plot of surface foliation (Plate C-2). Forty percent of westerly dipping foliation surfaces lie within ±10° dip of the center. Four degrees was subtracted for the "smearing effect" of using a 1% counting circle.

3 Best estimate of fault strength on the basis of foliation strength, published data and previous experience in Anvil pit.

3.5 Groundwater Conditions

Only a qualitative evaluation of groundwater conditions during the mining operation is possible at present. The existing, relatively consistant, groundwater phreatic surface will be influenced by the pit excavation and gravitational drainage into the excavation will be introduced when pit walls intercept discontinuities controlling groundwater movement. Consequently, groundwater flow in the immediate vicinity of the pit will be modified (relative to existing regional conditions) and the phreatic surface depressed below its present level.

Since some discontinuities will not be intercepted and others may have low permeability, it is unlikely that all pit walls will be fully drained. Moreover, frost during the winter season may retard drainage and contribute to the build-up of pore-pressures behind certain wall segments. It is anticipated that non-homogeneous groundwater conditions, ranging from fully to a partly drained rock mass, will exist along the pit perimeter.

For the purpose of the stability analysis, both "dry" (no groundwater pressures) and "wet" conditions were assumed. In most cases, "wet" conditions considered that the phreatic surface within the rock mass intersected the bounding discontinuity in question half way up the slope. For each analysis, groundwater conditions are shown in detail on the relevant figure.

PART 4 - ANALYTICAL METHODS

4.1 Kinematic Analysis

For translational failure to occur, failure surfaces must daylight on the slope, thus freeing a portion of the rock mass which may potentially slide. Failure on discontinuities within the rock mass which do not daylight is kinematically not possible. The kinematics of failure thus allow a stable slope to be designed, even though a particular set of discontinuities is dipping at angles greater than the angle of friction (Ø), along the joint surface.

For this study, kinematic analyses were performed with the aid of stereonets. Applicable methods are given in Hoek and Bray (1977), Goodman (1976) and Goodman (1979).

4.2 Plane Failure Translational Analysis

Translational stability analyses were conducted using a card programmable pocket calculator (Hewlett-Packard

67). Translational stability on plane failure surfaces was analyzed using methods shown in Hoek and Brey (Chapter 7, 1977) together with a modified assumption regarding groundwater.

Important assumptions in the analysis include the following:

1) The failure mass is bounded by a plane discontinuity and an intersecting tension crack, both of which strike parallel to a plane slope face.

2) Moments are neglected and the factor of safety is given by the ratio of restraining forces to driving forces.

3) Hydrostatic water pressure conditions exist along the discontinuities bounding the slide mass.

4) Strength properties are defined by:

$$\tau = C + (\sigma - U) \tan(\phi + i) \qquad (1)$$

τ = shear stress

where C = cohesion

σ = normal stress

U = water pressure

ϕ = angle of friction along discontinuity

i = geometrical component of friction related to surface asperities.

With regard to point (1), the analysis was run for several tension crack configurations and the results plotted to find the lowest factor of safety. Tension cracks intersecting the slope face were not considered.

The assumption of hydrostatic water pressure conditions along the bounding surface(s) (point 3) requires that water discharge from the slope face be retarded, either by low permeability rock (due to low permeability perpendicular to the foliations), or by a frozen face in winter.

4.3 Sliding Wedge Analysis

Bray's short solution (Hoek and Bray, 1977, Appendix 2) was used to formulate a program to solve the stability of a wedge sliding on one or two intersecting planes. Assumptions include the following:

1) Bounding surfaces are plane and their intersection vector daylights on the slope.

2) Moments are neglected.

3) Shear strength of each surface is accounted for by equation 1.

4) No tension crack is present.

5) The factor of safety is defined with regard to the surface(s) which remain in contact during sliding.

6) Groundwater assumptions are similar to those for plane translation.

PART 5 - DESIGN CHARTS AND RECOMMENDATIONS

5.1 Types of Charts

Design charts have been produced for:

(1) Kinematically acceptable slopes with regard to translational sliding (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) Kinematically acceptable slopes with regard to toppling.

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

(4) Wedge failures formed by the two fault sets and the foliation dips above.

In applying the design charts it should be recognized that a great deal of engineering judgement may be required in assessing discontinuity orientations in order to produce meaningful slope designs.

5.2 Overall Pit Wall Stability

On the basis of currently available data, two fundamental structural domains were considered for the evaluation of overall pit walls. One domain, chiefly characterized by foliation dipping into the pit, encompasses the SE and NE walls of the 5-year pit. The second domain, involving foliation dipping into the walls, extends along the SW and NW pit walls.

5.2.1 SE and NE Walls

Overall wall stability on the southeast and northeast walls (striking 045° and 315° true, respectively) is governed by translational failure considerations. In this regard, it is apparent from Figures 8 to 18 that it will not be possible to design walls in excess of some 60 m in height if through going discontinuities daylight on the walls.

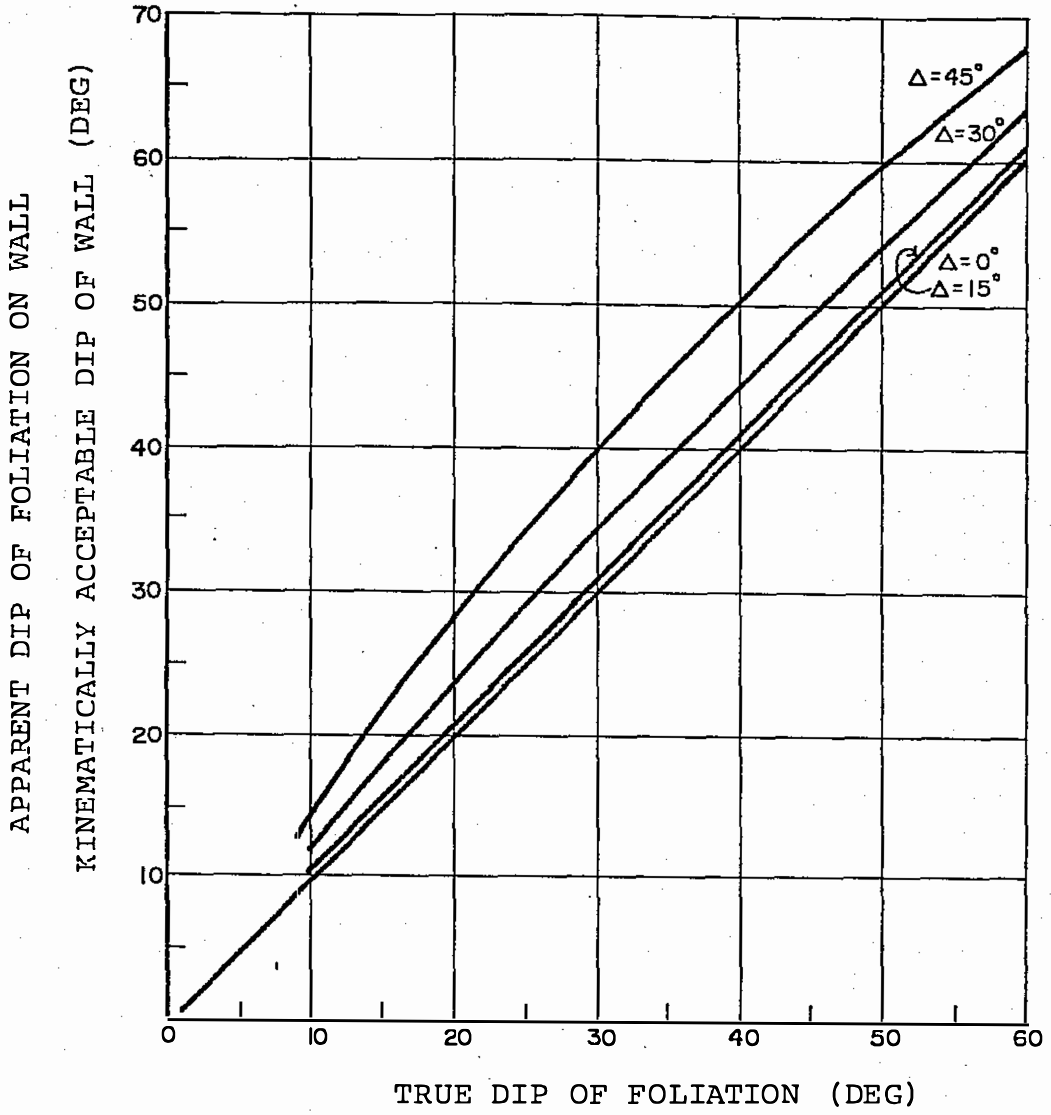
We therefore recommend designing the SE and NE walls according to kinematic considerations, i.e. excavating the wall at a suitable angle so that foliation and fault surfaces do not daylight.

It must be stressed that excavating a wall designed using kinematic methods requires careful and continuing mapping of discontinuity orientation since if the wall is excavated too steeply, and discontinuity surfaces daylight, failure may be triggered.

Figure 1 shows the limiting wall slopes for various angles between wall and foliation strike and for various foliation dips. Figures 2 and 3 show similar charts for wedges formed by faults and foliation. We recommend that the charts be used to determine average wall dip as follows:

Figure 1

1) Assess Δ, the angle between wall strike and foliation strike. If Δ is variable, the smaller value should be chosen.



NOTES

1) Δ = ANGLE BETWEEN WALL STRIKE AND FOLIATION STRIKE.
2) FOR FOLIATION DIPPING INTO MINE.
3) NO SAFETY FACTOR IS INCLUDED

FIGURE 1. KINEMATICALLY POSSIBLE FAILURE ON FOLIATION

2) Assess the true mean dip of foliation and subtract δ, a value measuring the dispersion in dips about the mean. On the basis of currently available data, we consider that δ should be at least 6°. For foliation dipping 34° on the northeast wall, it may be possible to reduce δ.

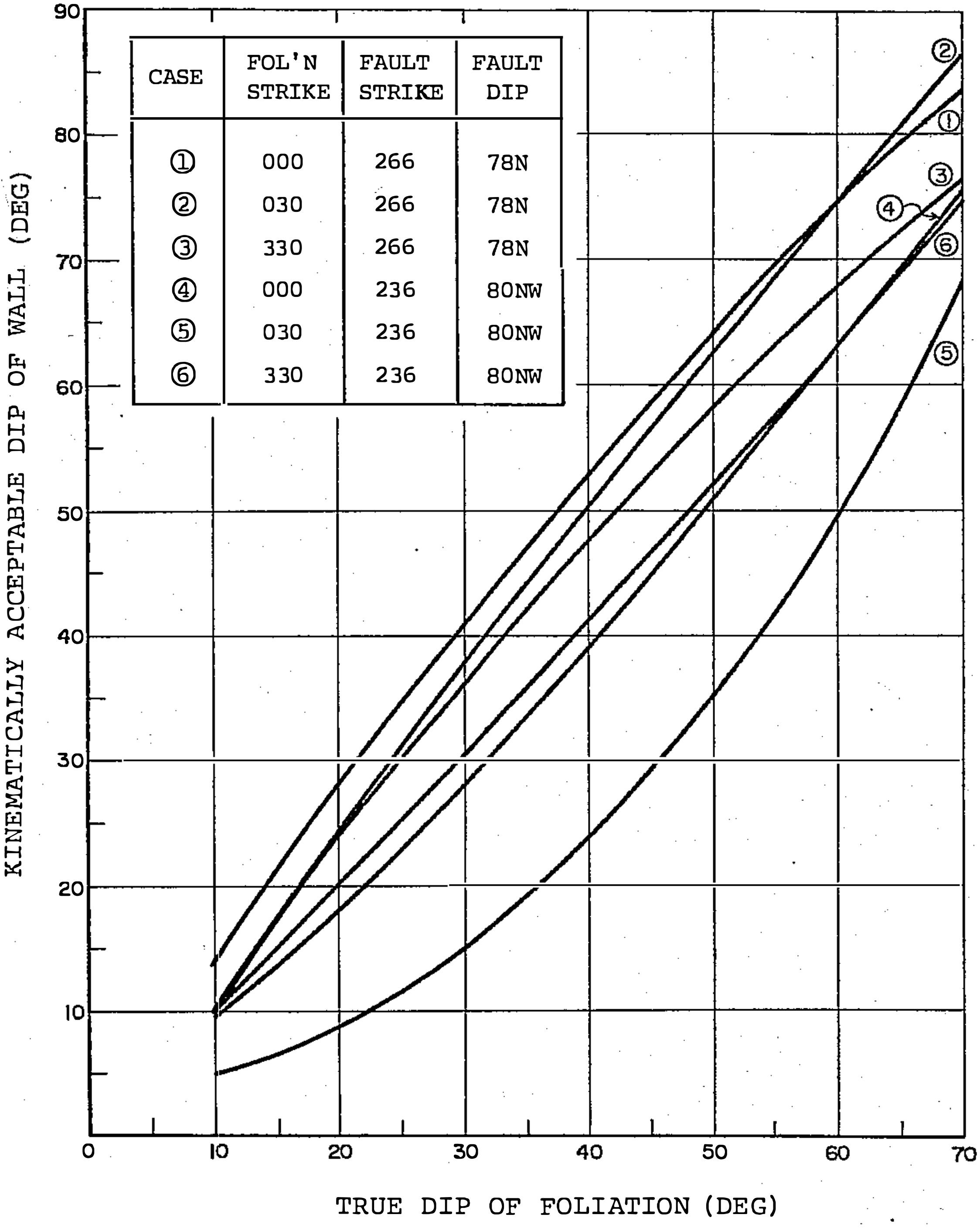
3) Using the values in points (1) and (2), find the kinematically acceptable dip of the wall on the "Y" axis.

<u>Figures 2 and 3</u>

1) Determine the applicable figure and that the assumptions made in deriving the figure are valid for the case in question.

2) Determine applicable foliation strike.

3) Find true mean dip of foliation minus δ as in (2) for Figure 1.

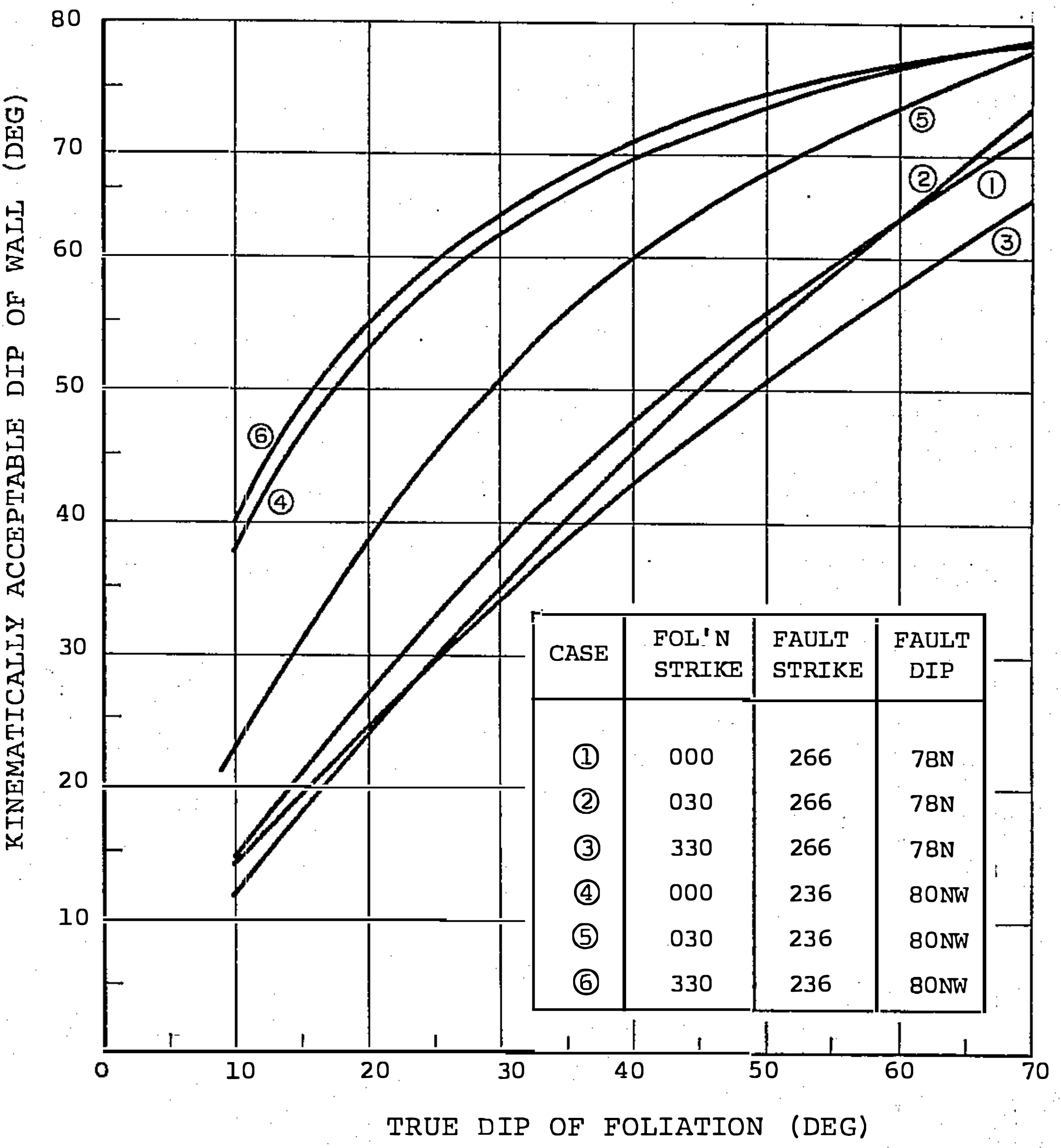


CASE	FOL'N STRIKE	FAULT STRIKE	FAULT DIP
①	000	266	78N
②	030	266	78N
③	330	266	78N
④	000	236	80NW
⑤	030	236	80NW
⑥	330	236	80NW

NOTES

1) STRIKE OF WALL IS 315° TRUE
2) NO SAFETY FACTOR IS INCLUDED

FIGURE 2. KINEMATICALLY POSSIBLE WEDGE FAILURE -- NE WALL



CASE	FOL'N STRIKE	FAULT STRIKE	FAULT DIP
①	000	266	78N
②	030	266	78N
③	330	266	78N
④	000	236	80NW
⑤	030	236	80NW
⑥	330	236	80NW

NOTES

1) SE WALL STRIKE IS 045° TRUE
2) NO SAFETY FACTOR IS INCLUDED

FIGURE 3. KINEMATICALLY POSSIBLE WEDGE FAILURE -- SE WALL

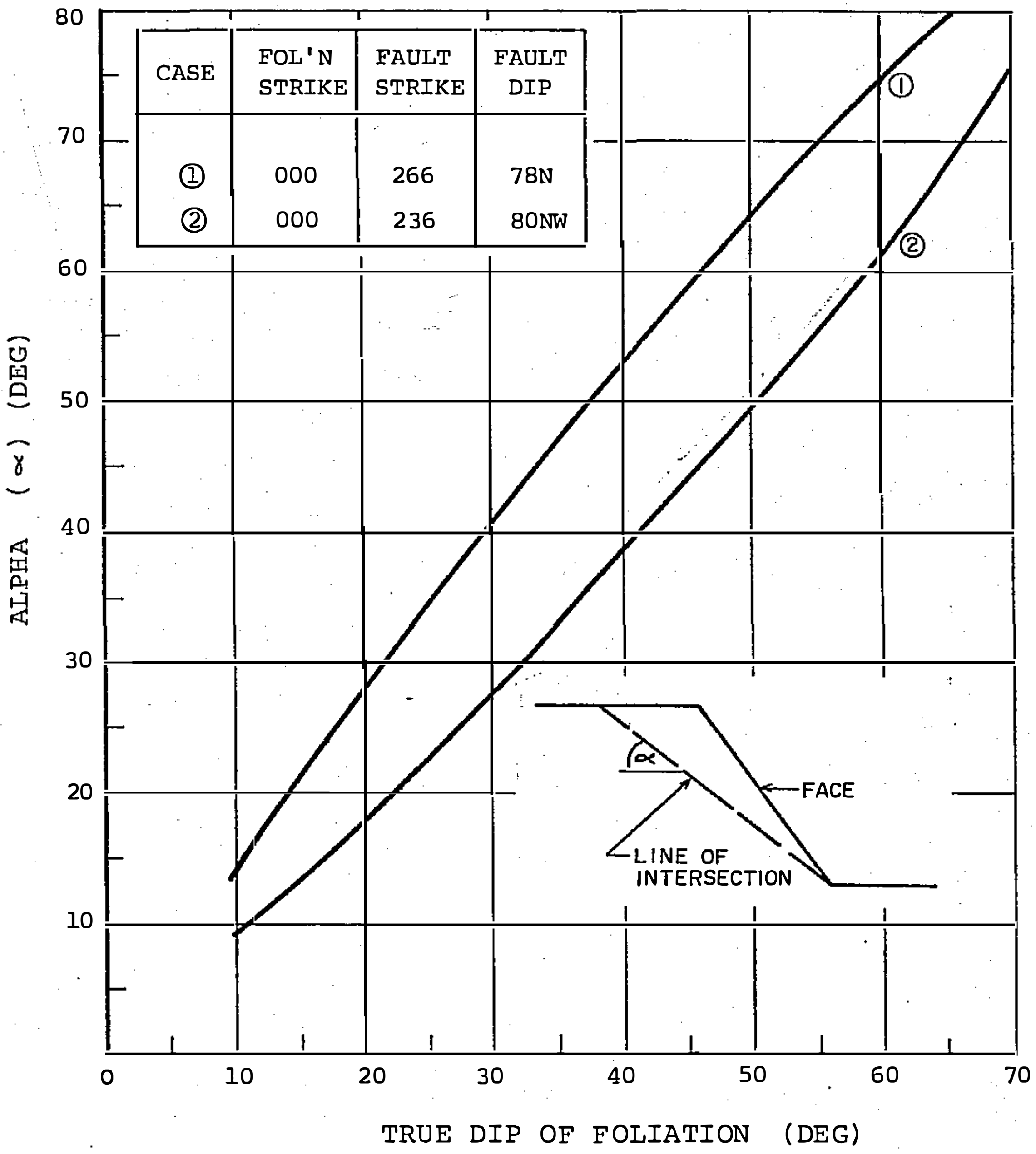
4) Determine the applicable fault set. In the absence of further information, we recommend that both fault sets be used and that the minimum wall dip be chosen.

5) Using the correct curve and the foliation dip calculated in (3) determine the applicable wall dip.

The applicable dip of the wall is the minimum of wall dips produced by Figure 1 and by Figure 2 or 3.

The corner between the northeast and southeast walls is critical with regard to stability since at some point wall strike will be parallel to foliation strike ($\Delta = 0°$). Ideally the corner should be made as sharp as possible to maximize the "arching" effect and to minimize the length of the transition zone. The dip of the wall in this zone should be checked using Figure 1 to ensure that foliation is not undercut.

Figures 4 and 5 contain design charts for evaluation of possible failure modes governing the stability of

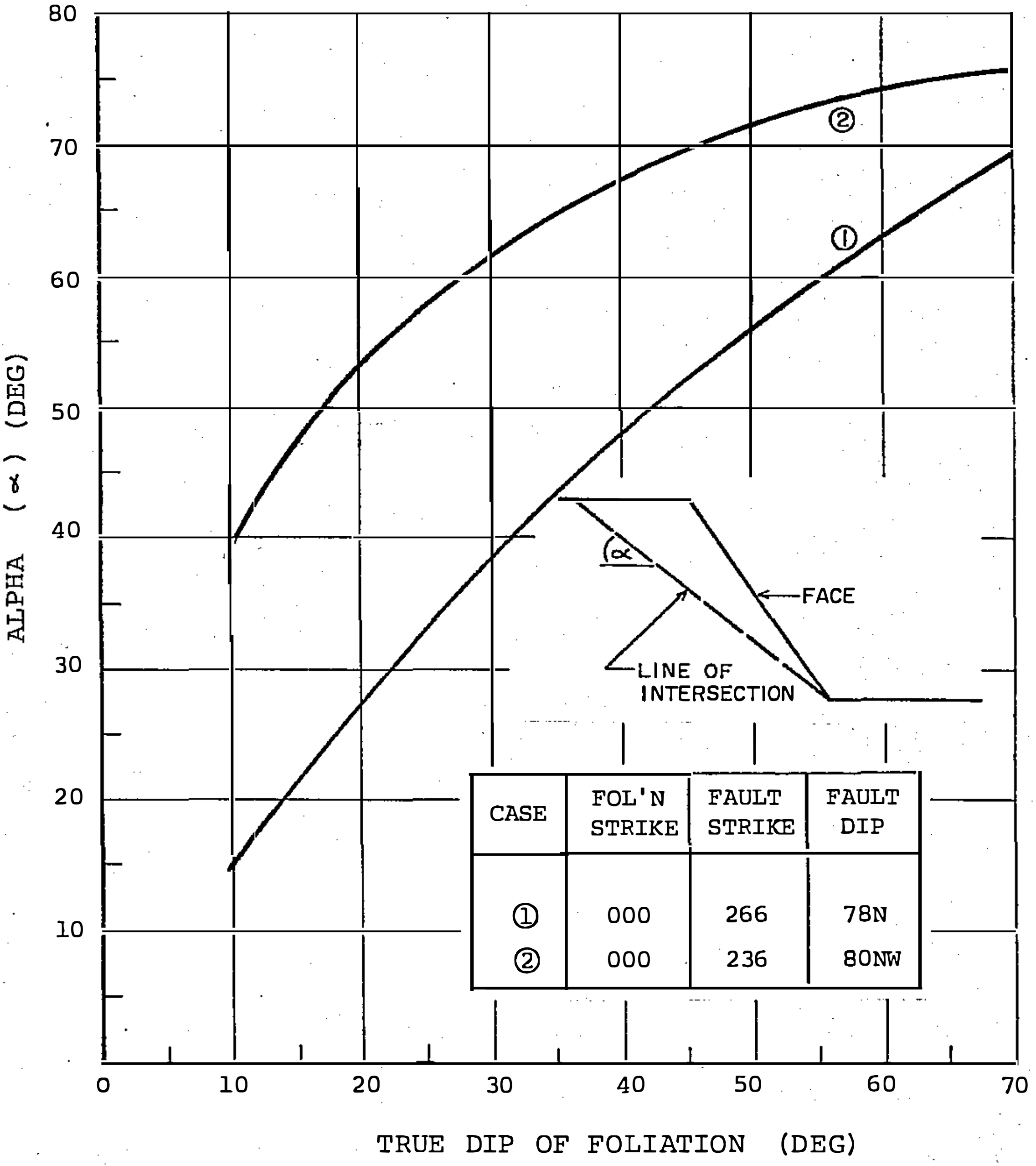


CASE	FOL'N STRIKE	FAULT STRIKE	FAULT DIP
①	000	266	78N
②	000	236	80NW

NOTES

1) ∝ IS THE APPARENT DIP OF THE INTERSECTION LINE OF THE WEDGE SEEN IN ELEVATION (SEE SKETCH)

FIGURE 4. APPARENT DIP OF WEDGE INTERSECTION LINE -- NE WALL (STRIKE 315°)



CASE	FOL'N STRIKE	FAULT STRIKE	FAULT DIP
①	000	266	78N
②	000	236	80NW

NOTES

1) ∝ IS THE APPARENT DIP OF THE INTERSECTION LINE OF THE WEDGE SEEN IN ELEVATION (SEE SKETCH)

FIGURE 5. APPARENT DIP OF WEDGE INTERSECTION LINE SE WALL

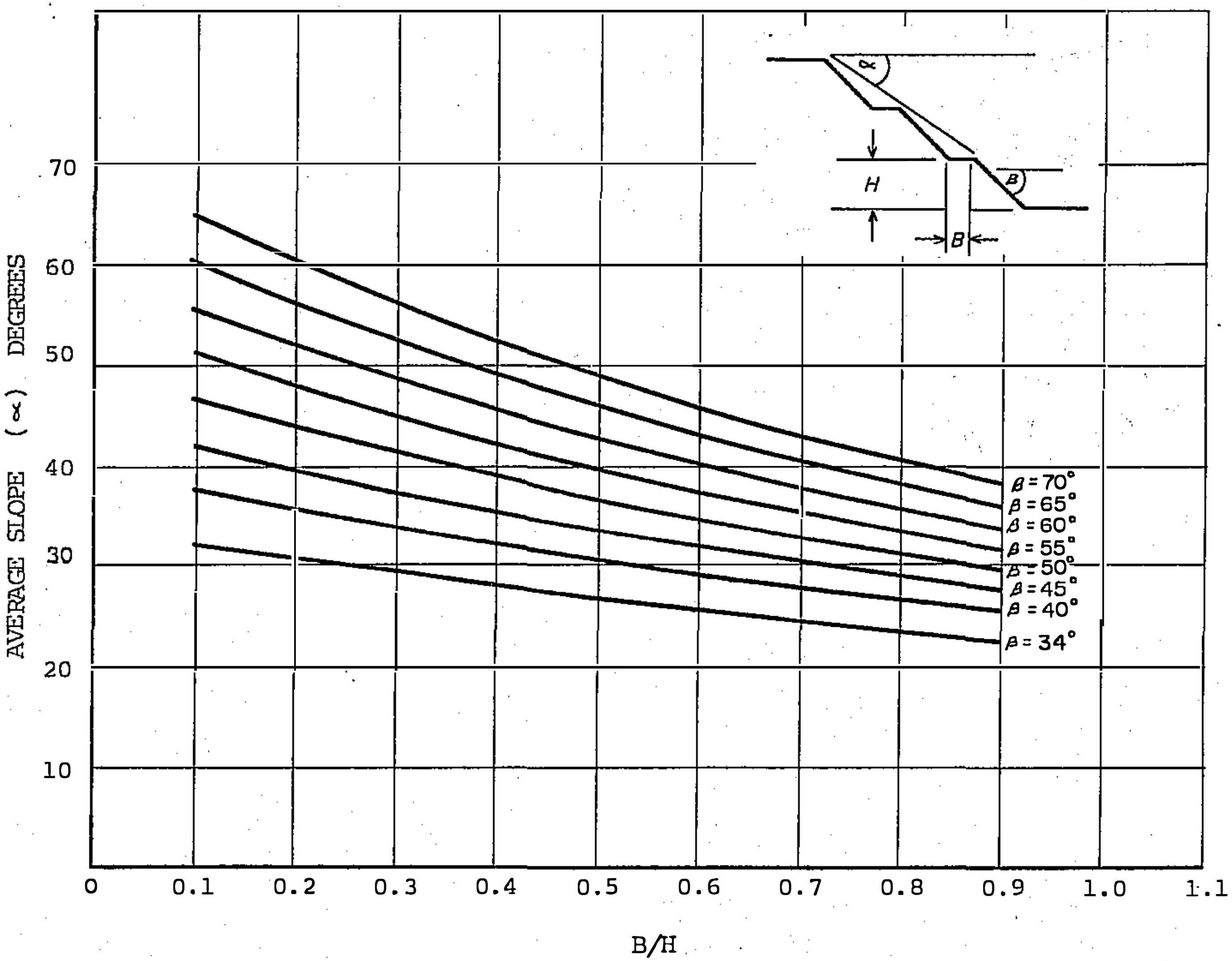


FIGURE 6. AVERAGE SLOPES FOR GIVEN BENCH WIDTH, HEIGHT AND BATTER

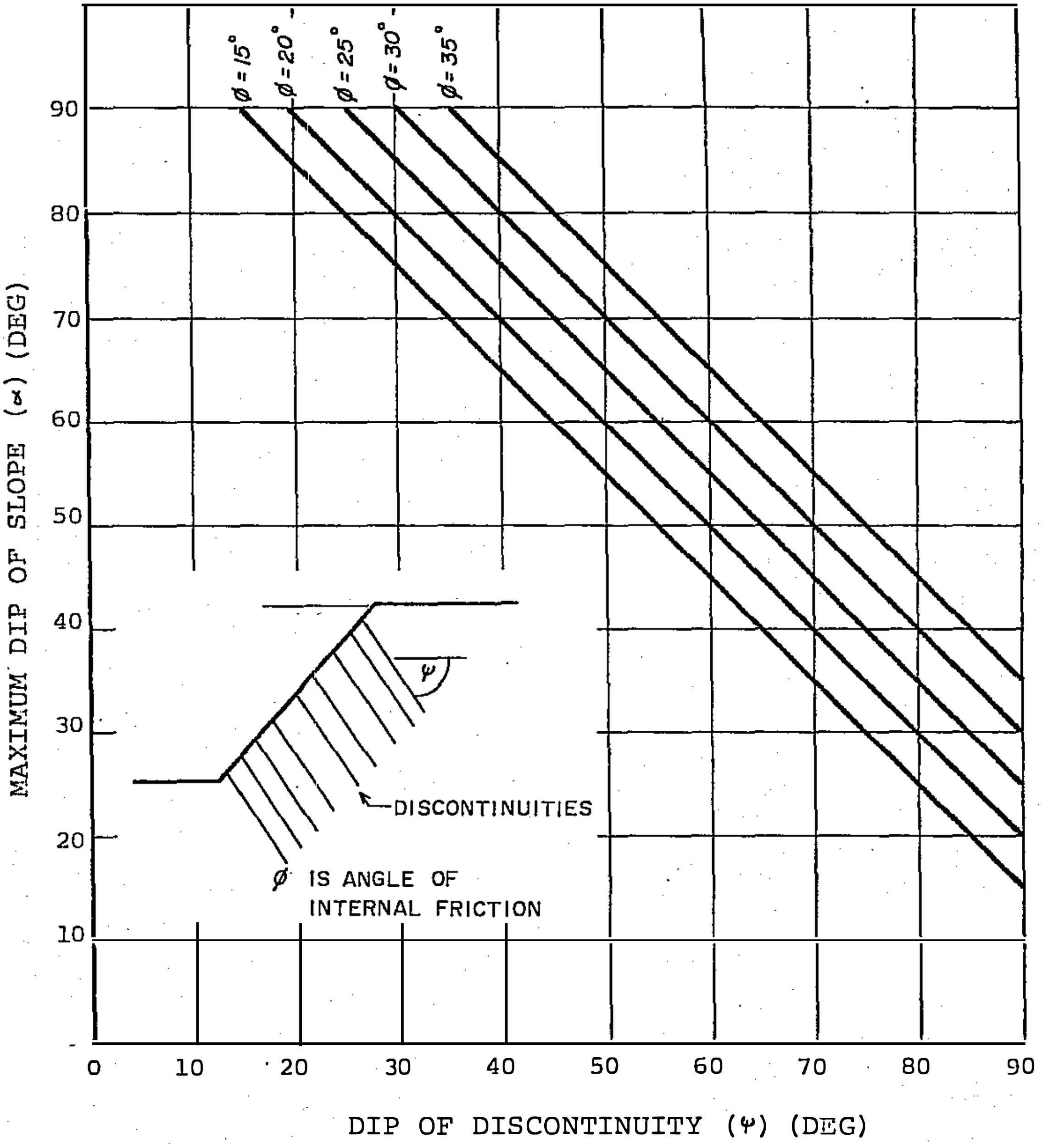
benches. Figure 6 allows calculation of overall slope, batter, bench width or bench height given the other three variables.

These charts (on Figures 4 to 6 inclusive) are recommended for the finalization of the pit wall design and their application is detailed in section 5.3 considering bench design.

5.2.2 SW and NW Walls

Both the foliation and fault sets inferred from the conceptual geologic model dip into the northwest and southwest walls rendering translational failure on these discontinuities kinematically impossible. It should be recognized, however, that there is little data available on the rock mass structure behind the proposed walls. Translational failure modes would be possible if faults exist dipping into the pit and daylighting on the proposed wall.

Toppling is a possible failure mode on these walls if families of subparallel discontinuities exist that dip into the wall. Figure 7 gives the kinematic conditions for



NOTES

1) ASSUMES C = O

2) ASSUMES DISCONTINUITYES DIP INTO WALL AND THAT OVERALL OR LOCAL WALL STRIKE AND DISCONTINUITY STRIKE DO NOT DIFFER BY MORE THAN ± 20°

FIGURE 7. KINEMATIC CONDITIONS FOR TOPPLING

toppling. This figure shows a necessary but not sufficient condition, since in addition there must be space for toppling to occur into. Necessary conditions for toppling include:

1) A family of discontinuities subparallel to each other dipping into the wall.

2) Strike of discontinuties and wall (or local parts of wall) should not differ by more than ±20°.

3) Space must exist for toppling to occur into.

It maybe seen from Figure 7 that if a steeply dipping fault set with $\phi = 21°$ is present, the limiting slope dip is low, approximately 25° for fault dip of 80°. There is currently insufficient information available to assess the possibility of toppling on these walls. In particular, more information on fault spacing would be required. If such information becomes available during mining, more detailed analyses can be undertaken.

Assuming for preliminary design purposes that toppling will not occur, we recommend maximum overall slopes on these walls of 45°. This recommendation considers the presence of secondary adversely oriented discontinuities and assumes that the wall is not constructed within the orebody where easterly foliation dips may occur. Within the ore zone, more gentle wall slopes, would be required for walls exceeding 30 m (100 ft.).

5.3 Stability of Benches

5.3.1 NE and SE Wall Benches

Design charts for benches on the northeast and southeast walls are contained on Figures 8 to 18. Table IV summarizes failure modes and conditions considered during analysis for each figure.

Critical failure modes northeast wall benches include:

a) translational failure on foliation, and
b) wedge failure on foliation and faults.

Critical failure modes on the southeast wall include:

a) translational failure on foliation, and

b) wedge failures on foliation and one fault set (266/78N). Wedge intersection lines for the other fault set (236°/80°N) have apparent dips greater than 64° in the dip direction of the bench faces for applicable ranges of dip and thus do not constitute an important set for analysis of bench face stability.

The analysis used to produce the foliation design charts (Figures 8 to 12) assumes that the foliation strike is parallel to the strike of the bench face. Since foliation will daylight on the bench faces, (bench faces will exceed kinematic angles given in Figure 1), a pseudo-wedge failure might be possible in some circumstances. This type of failure results in movement of a wedge shaped block bounded by foliation and by a tensile or shear crack. In our opinion, such failures are likely to be small unless severely shattered zones are encountered, or unless significant blasting damage occurs.

In certain areas (e.g. section 70W) zones of thick and extensive gouge are indicated on Kerr Addison sections. Benches in these areas cannot be expected to stand at more than the angle of repose of the material involved, say 30 to 34°.

Wedge failures beyond the limits calculated from the charts must be expected since foliation and fault dips and strikes may vary from mean orientations. In addition, faults are almost certainly present which differ significantly from the sets discussed in Appendix "C" and assumed during analysis.

5.3.1.1 Foliation Charts

Foliation design charts are intended for use in situations where the foliation strike is subparallel to the strike of the bench face (say, ±20°). Application is as follows:

1) Choose chart applicable to water conditions and foliation dip (Table IV).

2) Choose safety factor (we recommend 1.2 as a minimum).

3) Read off maximum bench height.

TABLE IV

Summary of Design Charts for Translational Failure Modes

Type	Foliation Dips	Faults	Groundwater	Slope Dips	Relevant Figures
Translational Failure	34°	No	Dry	38, 40, 45, 50, 60, 70°	8
	34°	No	Wet	38, 40, 45, 50, 60, 70°	9
	45°	No	Wet & Dry	50, 60, 70°	10
	50°	No	Wet & Dry	60, 70°	11
	60°	No	Wet & Dry	70°	12
Wedge Stability NE Wall	34°	Yes	Wet & Dry	50, 70°	13, 16
	45°	Yes	Wet & Dry	70°	14
	50°	Yes	Wet & Dry	70°	15, 16
	60°	Yes	Wet & Dry	70°	17
Wedge Stability SE Wall	34, 45, 50, 60°	One Set	Wet & Dry	70°	18

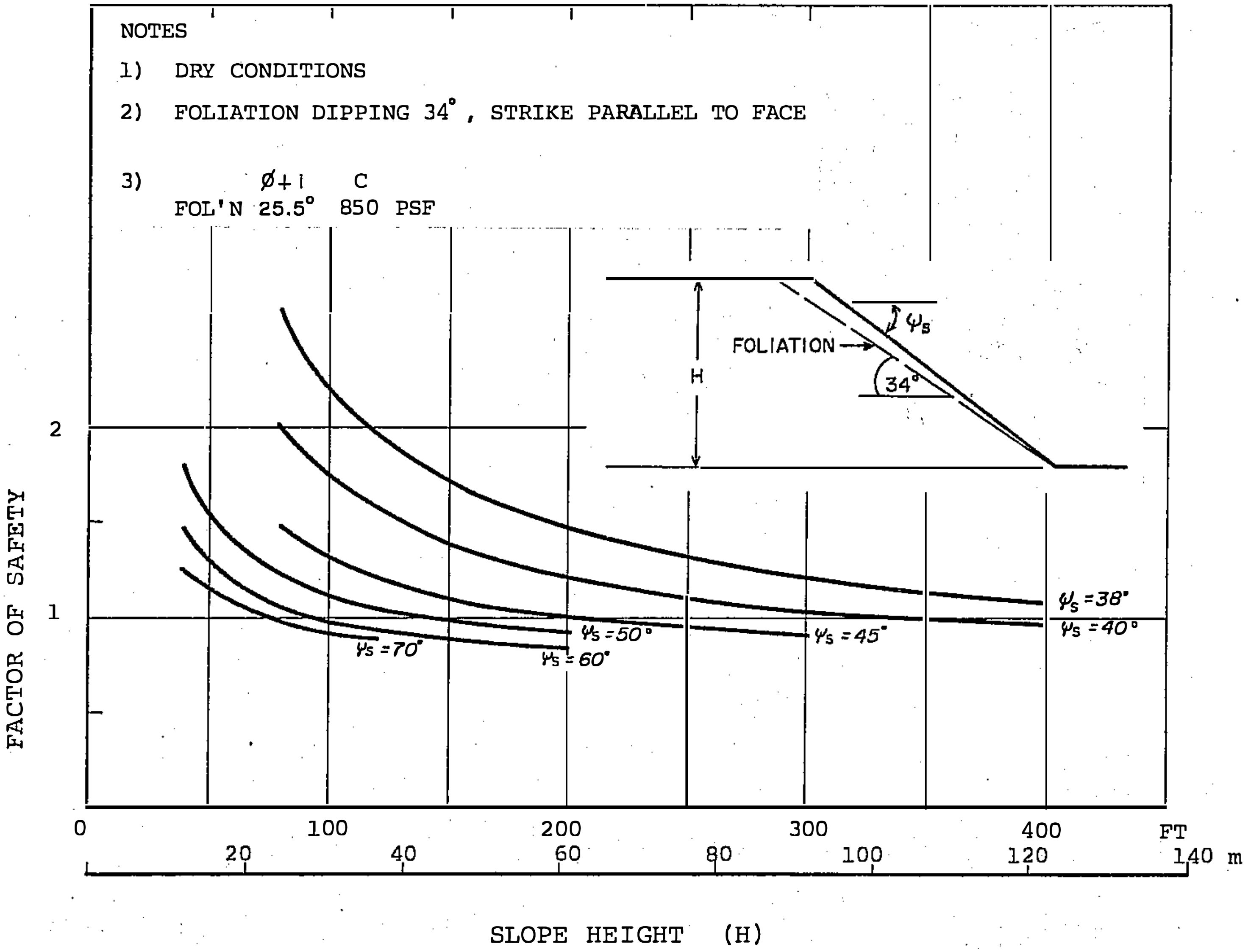
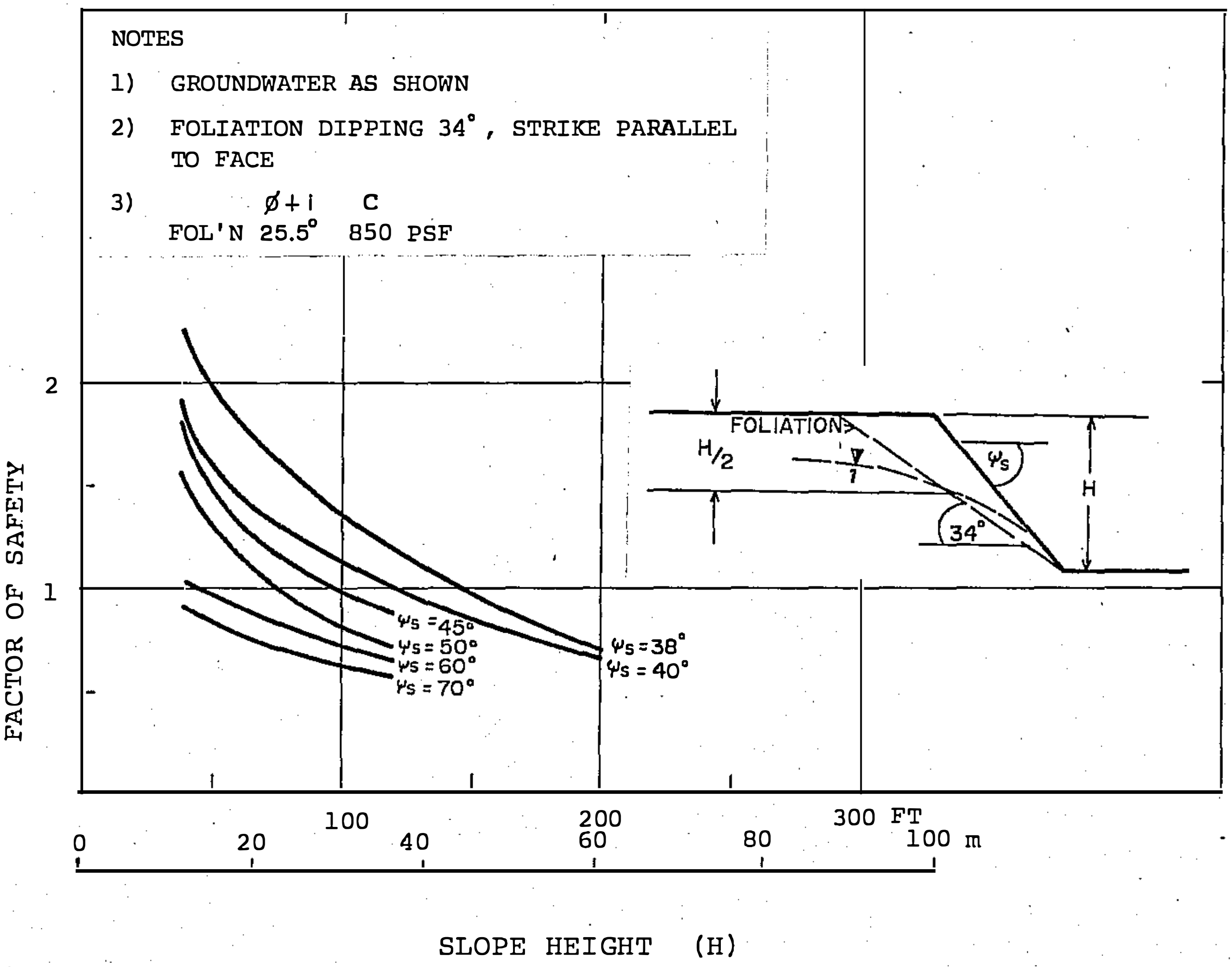


FIGURE 8. PLANE FAILURE ON FOLIATION - DRY, FOL DIP 34°


NOTES

1) GROUNDWATER AS SHOWN

2) FOLIATION DIPPING 34°, STRIKE PARALLEL TO FACE

3) FOL'N $\phi + i$ 25.5° C 850 PSF

FIGURE 9. PLANE FAILURE ON FOLIATION - WET, FOL'N DIP 34°

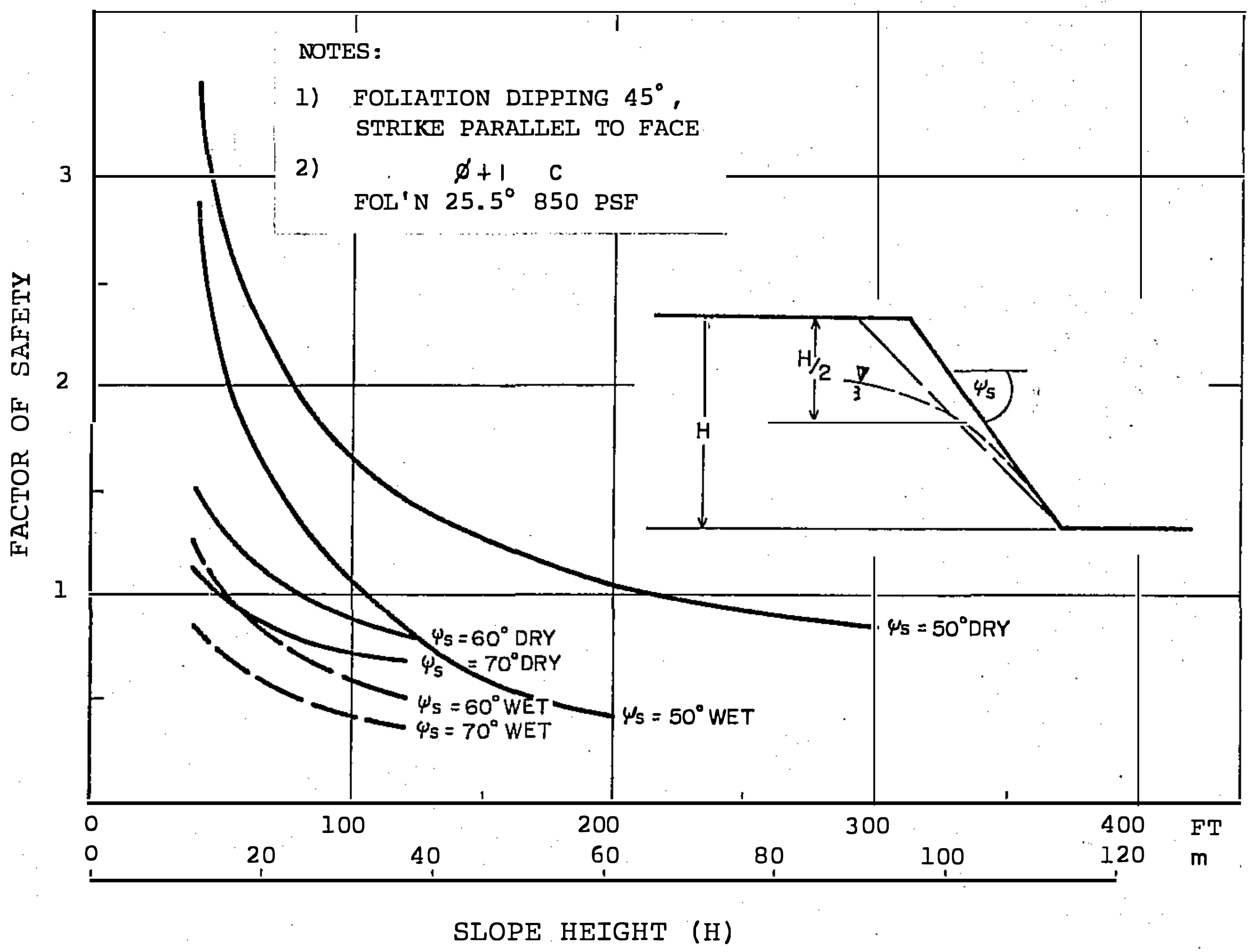
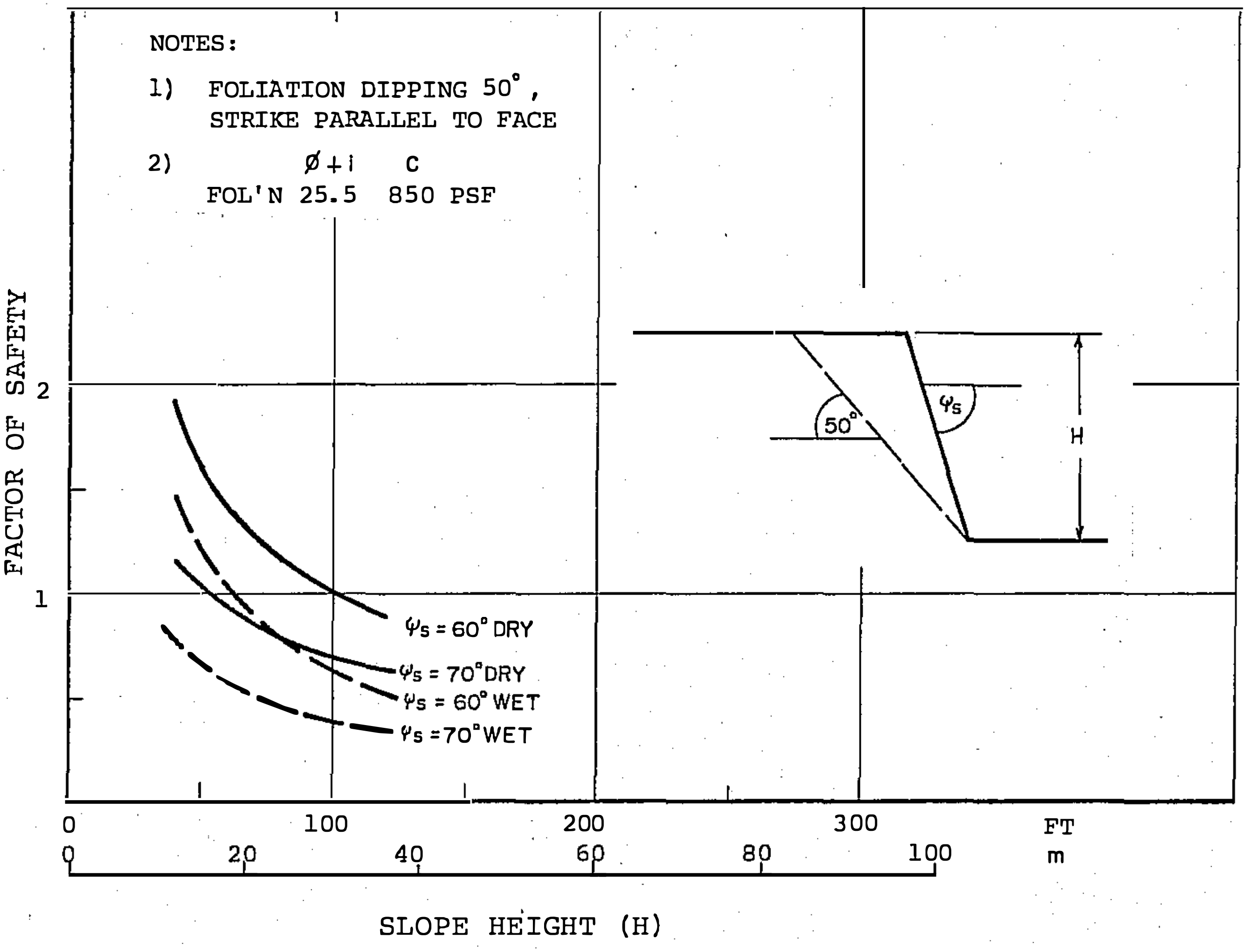


FIGURE 10. PLANE FAILURE ON FOLIATION - FOL'N DIP 45°


NOTES:

1) FOLIATION DIPPING 50°, STRIKE PARALLEL TO FACE

2) | | $\phi + i$ | C |
|---|---|---|
| FOL'N | 25.5 | 850 PSF |

FIGURE 11. PLANE FAILURE ON FOLIATION - FOL'N DIP 50°

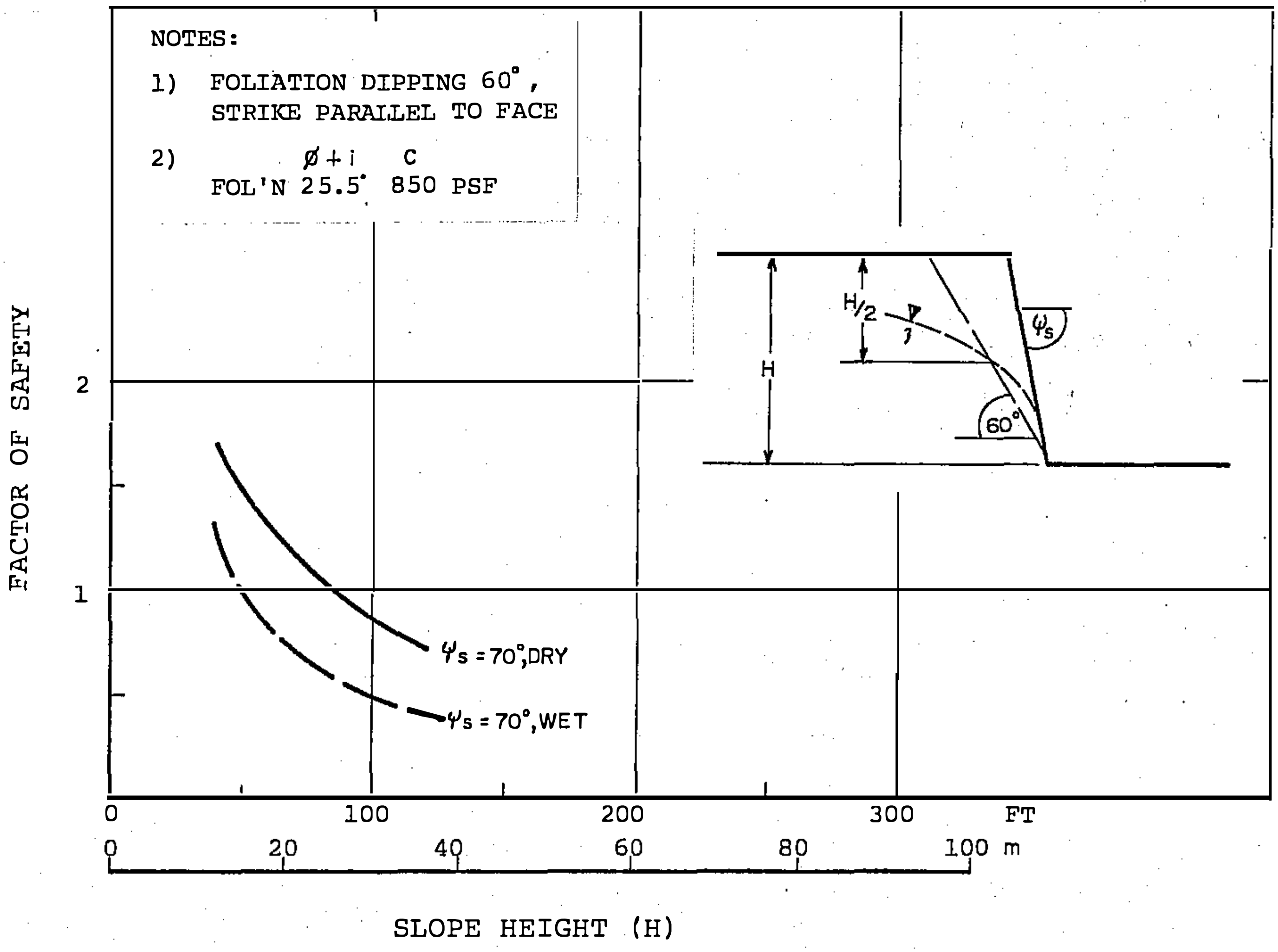
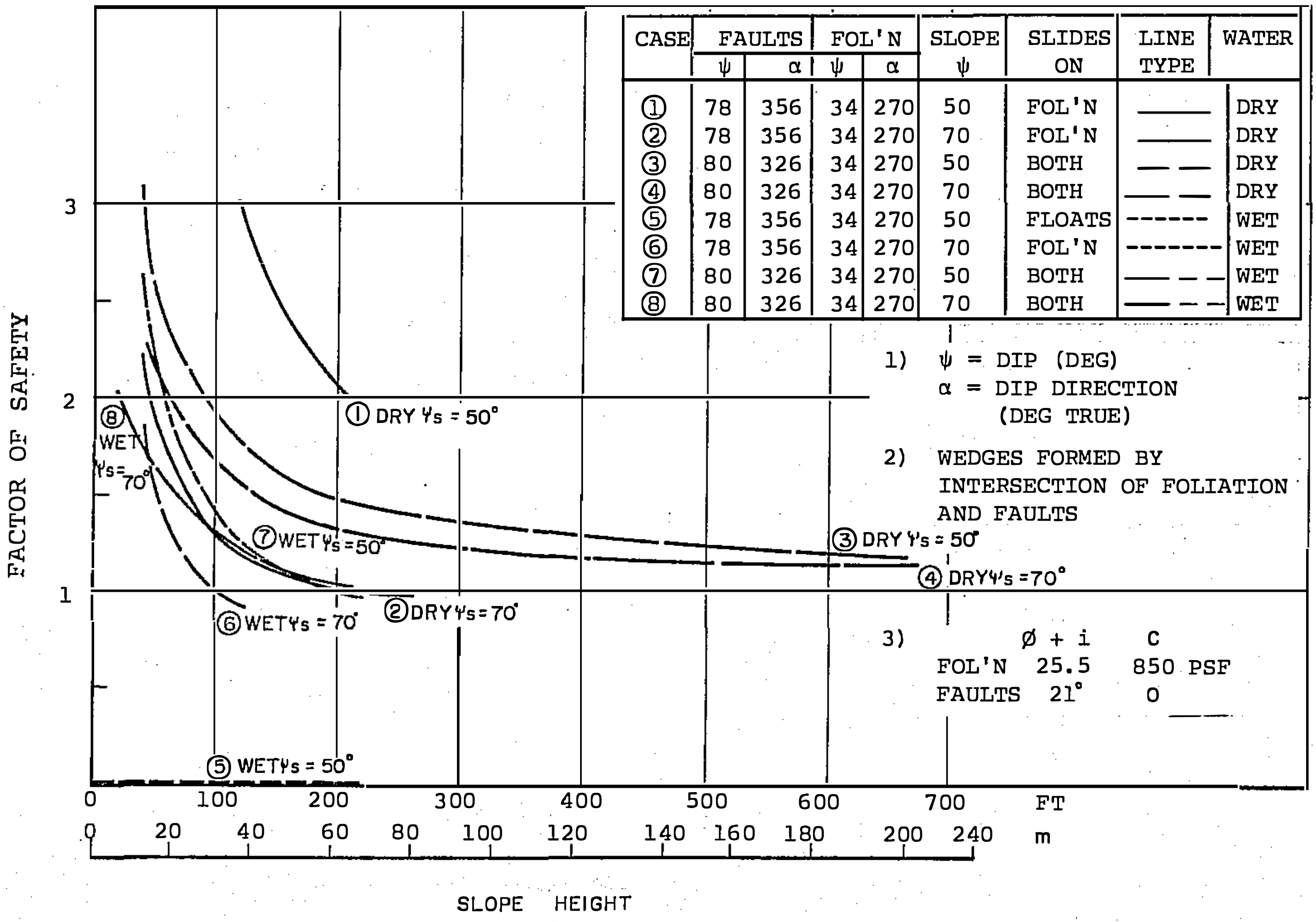


FIGURE 12. PLANE FAILURE ON FOLIATION - FOL'N DIP 60°



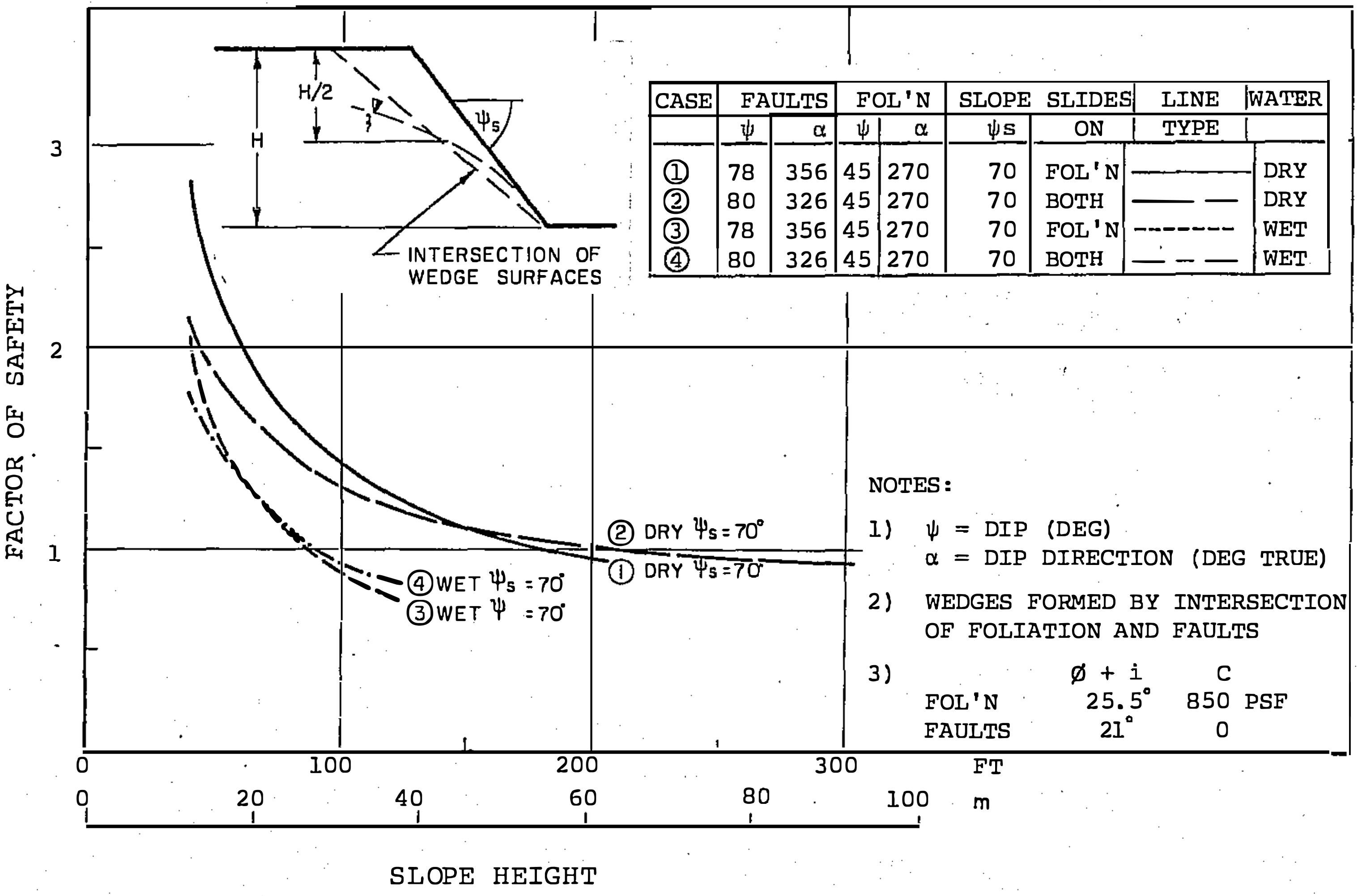
CASE	FAULTS		FOL'N		SLOPE	SLIDES ON	LINE TYPE	WATER
	ψ	α	ψ	α	ψ			
①	78	356	34	270	50	FOL'N	———	DRY
②	78	356	34	270	70	FOL'N	———	DRY
③	80	326	34	270	50	BOTH	— —	DRY
④	80	326	34	270	70	BOTH	—— —	DRY
⑤	78	356	34	270	50	FLOATS	------	WET
⑥	78	356	34	270	70	FOL'N	-------	WET
⑦	80	326	34	270	50	BOTH	—— — —	WET
⑧	80	326	34	270	70	BOTH	—— – –	WET

1) ψ = DIP (DEG)
α = DIP DIRECTION
(DEG TRUE)

2) WEDGES FORMED BY INTERSECTION OF FOLIATION AND FAULTS

3)	$\phi + i$	C
FOL'N	25.5	850 PSF
FAULTS	21°	0

FIGURE 13. WEDGE STABILITY - FOLIATION DIP = 34°
NE WALL



CASE	FAULTS		FOL'N		SLOPE	SLIDES	LINE	WATER
	ψ	α	ψ	α	ψs	ON	TYPE	
①	78	356	45	270	70	FOL'N	———	DRY
②	80	326	45	270	70	BOTH	—— —	DRY
③	78	356	45	270	70	FOL'N	-------	WET
④	80	326	45	270	70	BOTH	—·— —	WET

NOTES:

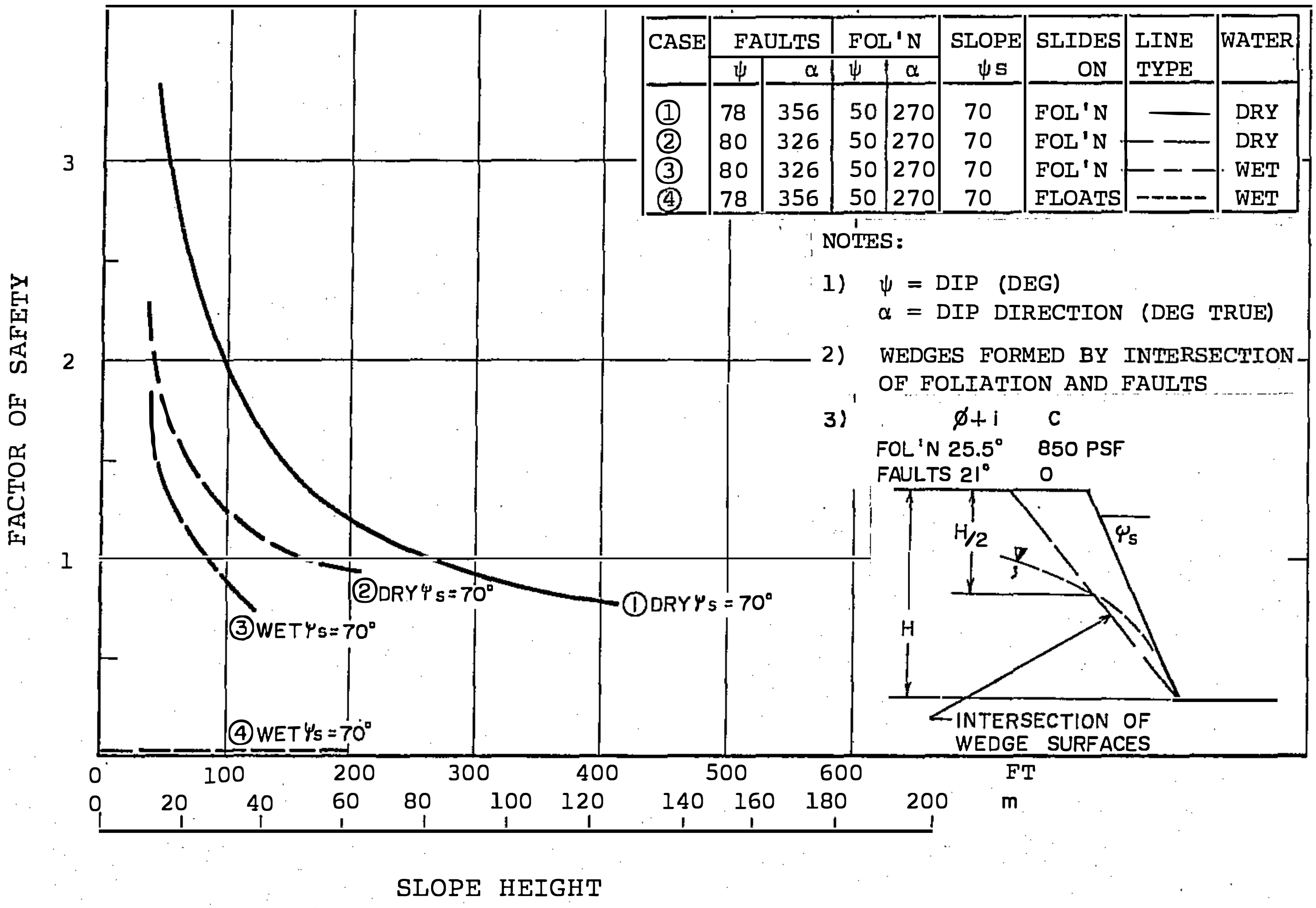
1) ψ = DIP (DEG)
α = DIP DIRECTION (DEG TRUE)

2) WEDGES FORMED BY INTERSECTION OF FOLIATION AND FAULTS

3)

	Ø + i	C
FOL'N	25.5°	850 PSF
FAULTS	21°	0

FIGURE 14. WEDGE STABILITY - FOLIATION DIP 45°
NE WALL



CASE	FAULTS		FOL'N		SLOPE	SLIDES	LINE	WATER
	ψ	α	ψ	α	ψs	ON	TYPE	
①	78	356	50	270	70	FOL'N	———	DRY
②	80	326	50	270	70	FOL'N	— ——	DRY
③	80	326	50	270	70	FOL'N	— — —	WET
④	78	356	50	270	70	FLOATS	------	WET

NOTES:

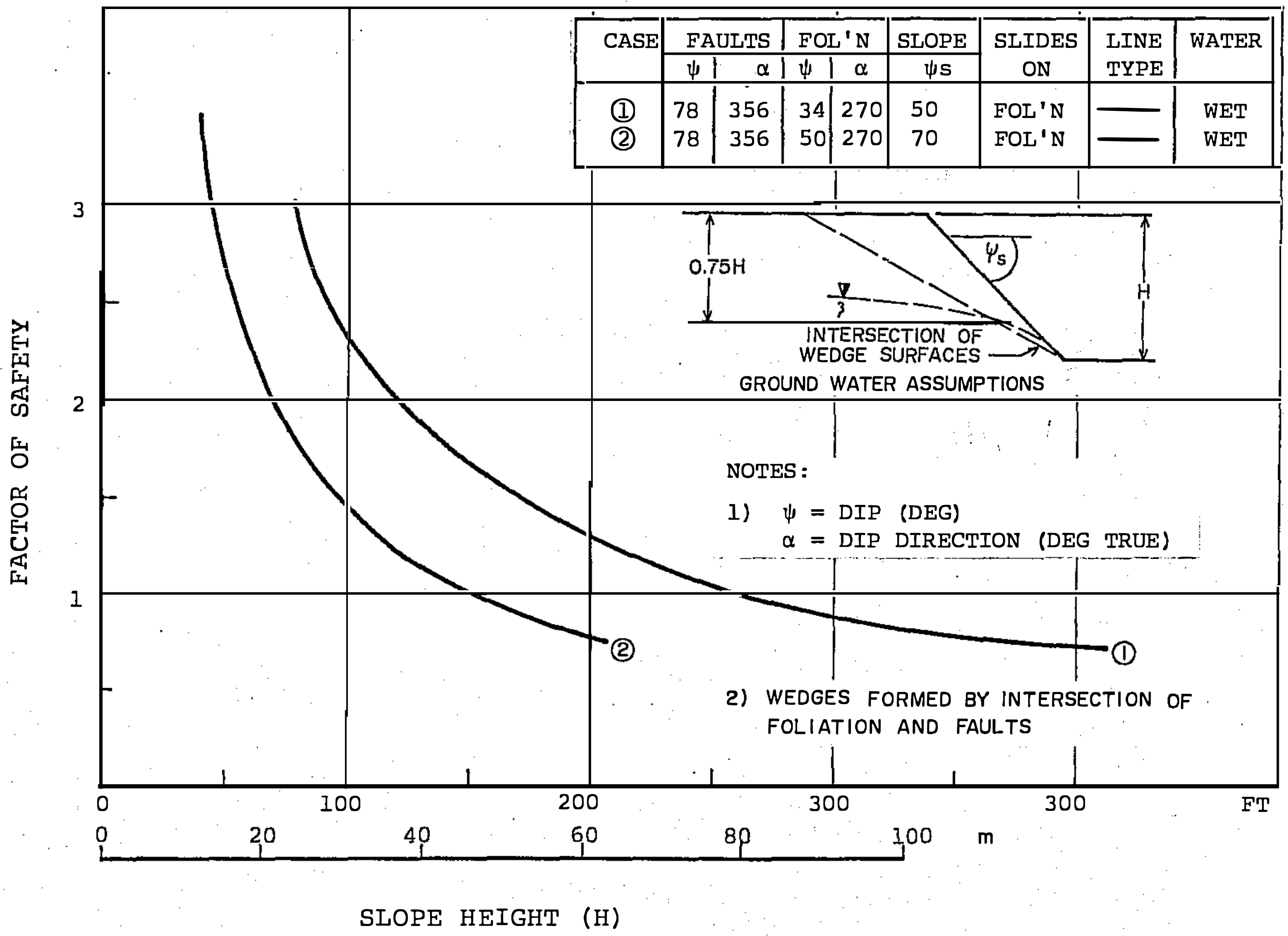
1) ψ = DIP (DEG)
α = DIP DIRECTION (DEG TRUE)

2) WEDGES FORMED BY INTERSECTION OF FOLIATION AND FAULTS

3)

	Ø+i	C
FOL'N	25.5°	850 PSF
FAULTS	21°	0

FIGURE 15. WEDGE STABILITY - FOLIATION DIP = 50°
N.E. WALL



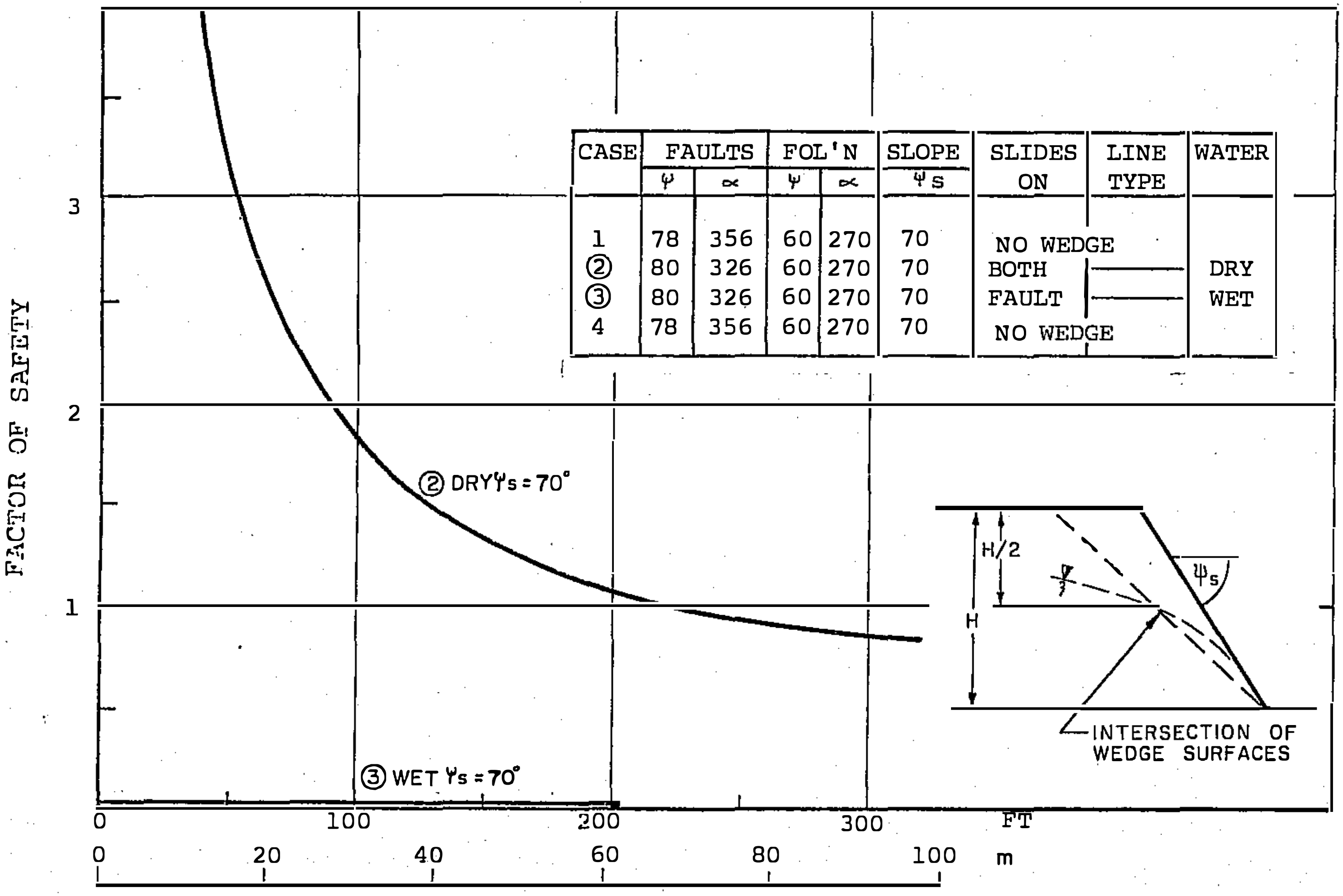
CASE	FAULTS		FOL'N		SLOPE	SLIDES	LINE	WATER
	ψ	α	ψ	α	ψs	ON	TYPE	
①	78	356	34	270	50	FOL'N	——	WET
②	78	356	50	270	70	FOL'N	——	WET

NOTES:

1) ψ = DIP (DEG)
α = DIP DIRECTION (DEG TRUE)

2) WEDGES FORMED BY INTERSECTION OF FOLIATION AND FAULTS

FIGURE 16. WEDGE STABILITY, LOW GROUNDWATER; FOR 34° AND 50° FOLIATION
NE WALL

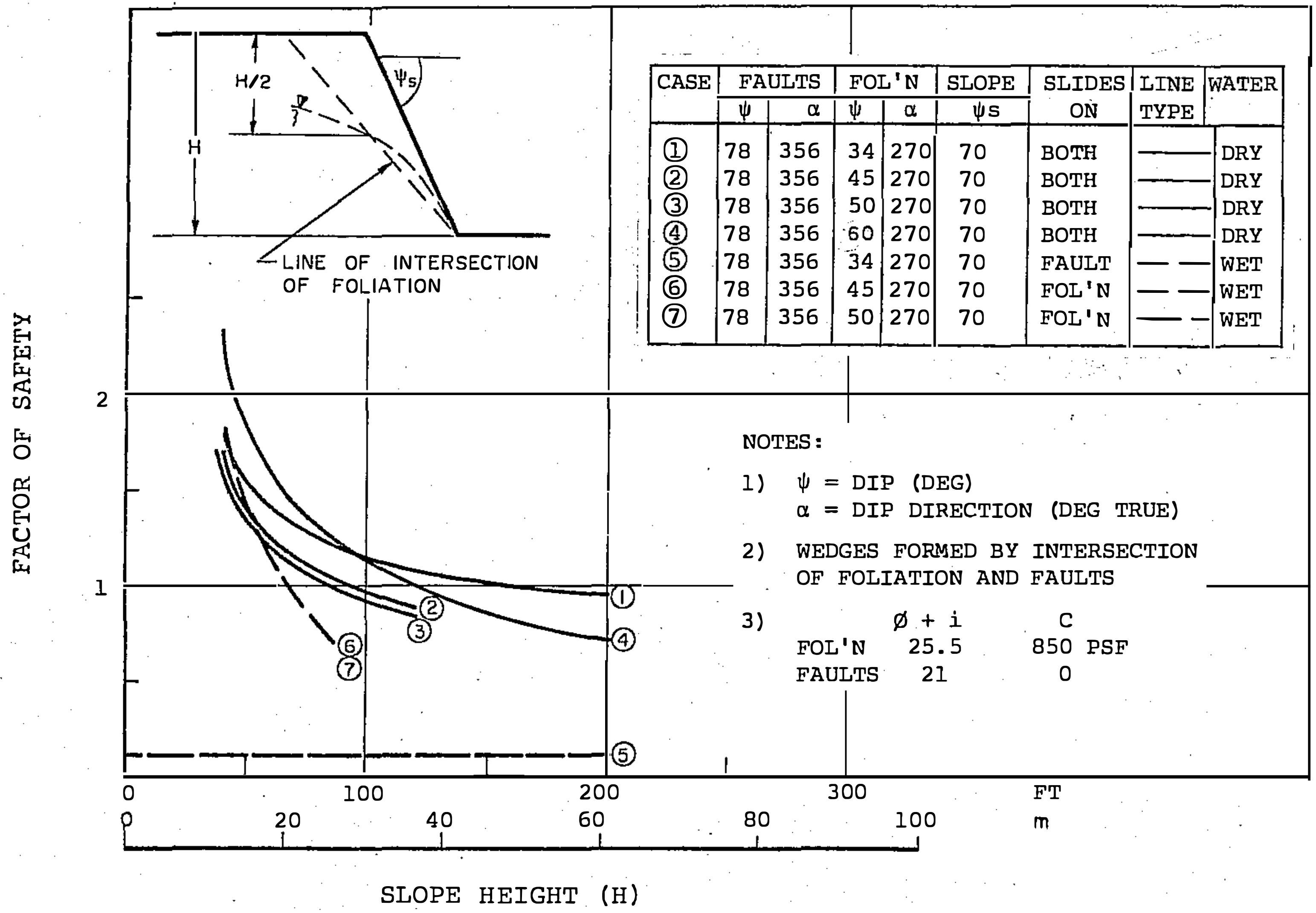


CASE	FAULTS		FOL'N		SLOPE	SLIDES ON	LINE TYPE	WATER
	ψ	∝	ψ	∝	ψs			
1	78	356	60	270	70	NO WEDGE		
②	80	326	60	270	70	BOTH	———	DRY
③	80	326	60	270	70	FAULT	———	WET
4	78	356	60	270	70	NO WEDGE		

NOTE: "NO WEDGE" IMPLIES THAT WEDGE DOES NOT DAYLIGHT.

FIGURE 17 WEDGE STABILITY - FOLIATION DIP 60°

NE WALL



CASE	FAULTS		FOL'N		SLOPE	SLIDES	LINE	WATER
	ψ	α	ψ	α	ψs	ON	TYPE	
①	78	356	34	270	70	BOTH	———	DRY
②	78	356	45	270	70	BOTH	———	DRY
③	78	356	50	270	70	BOTH	———	DRY
④	78	356	60	270	70	BOTH	———	DRY
⑤	78	356	34	270	70	FAULT	— —	WET
⑥	78	356	45	270	70	FOL'N	— —	WET
⑦	78	356	50	270	70	FOL'N	—— —	WET

NOTES:

1) ψ = DIP (DEG)
α = DIP DIRECTION (DEG TRUE)

2) WEDGES FORMED BY INTERSECTION OF FOLIATION AND FAULTS

3)

	Ø + i	C
FOL'N	25.5	850 PSF
FAULTS	21	0

FIGURE 18. WEDGE STABILITY - S.E. WALL

In many cases, the geotechnically possible bench height may exceed the bench height to which it is possible to safely scale. Other considerations in bench design may include ore control, and the minimum width required for cleaning.

5.3.1.2 Wedge Charts

The assumptions made in deriving the design charts are shown on each figure. These assumptions (particularly wall and fault orientations) must be applicable to the particular situation involved.

Steps in application of the wedge charts are as follows:

1) With regard to wall orientation, fault set, foliation dip and water conditions, choose applicable chart from Figures 13 to 18.

2) Choose a factor of safety (we recommend a minimum of 1.2).

3) Determine bench height. Normally several conditions (e.g. more than one fault set) may be applicable to one bench. Customarily, the minimum bench height would be chosen. If loss of the outer bench edge is acceptable, bench height may be adjusted upward from the minimum.

The impact of a wedge failure on a bench is shown by Figures 4 and 5 which give the apparent dip of the wedge intersection vector (α). Alpha represents the batter slope to which wedge failures may occur. In some circumstances loss of a portion of the bench face may be acceptable or even unavoidable. Foliation dip used in Figures 4 and 5 should be reduced by δ (measure of disperion of dips) as discussed for translational failures on foliation.

5.3.2 NW and SW Wall Benches

In the absence of translational or toppling failures (see Section 5.2.2) major instabilities are not expected on the northwest and southwest walls. In these areas bench configuration would be influenced by the overall pit wall geometry, mining procedures and subordinate structural features. It is our judgement that maximum bench heights in the range of 12 to 24 m (40 to 80 ft.) may be considered.

5.4 Application of Charts to Conceptual Model of Geology

The design charts discussed in sections 5.1 to 5.3 and our conceptual geological model have been used to produce preliminary pit design parameters. Should actual structural conditions in the perimeter walls or their major segments substantially deviate from those in the conceptual geologic model, these design parameters would be invalidated. In this respect, the governing structural features (section 3.2) are faults and foliation.

Table V summarizes preliminary wall angles. Where a range of slope angles are shown on Table V, they correspond to ranges of dips existing within the wall zone involved.

In deriving the slope values shown on Table V, foliation dip dispersion values (δ) were assumed to be as low as 3° below 1149 m and approximately 10 to 12° or higher

TABLE V

Preliminary Wall Slopes

Wall	Foliation Dips	Recommended Wall Angle	Bench Height/ Batter	Batter Angle of Potential Wedge Failures	Remarks
NE Wall Strike 315° True					
Above 1203 m[2]	34° to 70°W	35 to 40°	12 m/70°	-	Shallower foliation dips or strikes of 015 to 030° are unfavourable and would reduce slopes
1149 - 1203 m	50° to 60°W	35 to 40°	12 m/70°	-	
1104 - 1149 m[1]	34° to 45°W	29 to 32°	12 m/70°	50°	
SE Wall Strike 045° True					
Above 1203 m[2]	34° to 70°W	40°	12 m/70°	-	Depending on final locatio of wall, fault 6 could affect stability. Analysi assumes fault does not daylight
1149 - 1203 m	50° to 60°W	40°	12 m/70°	-	
1104 - 1149 m	34° to 45°W	30 to 32°	12 m/70°	50°	
SW and NW Wall Strike 315° and 045° True	variable into wall	45°	12 m/70°	-	Assumes that walls are not constructed in ore zone, where shallower slopes might be required

[1] $\delta = 3°$ should be confirmed prior to mining

[2] If extensive areas of foliation dips of 34° dip occur, shallower wall angles will be required

above 1149 m. Below 1149 m, dips appear to be somewhat more consistant than at higher elevations and therefore δ on the northeast wall was reduced to 3°. As a minimum, detailed investigations of core logs and core are required to substantiate this figure. Higher values of δ would result in flatter slopes (for example, δ = 6° requires slopes of 27°). Due to the economic importance of slopes near the toe of the wall it may be justified to undertake additional investigations to confirm the correct value of foliation dip and strike in these areas.

Higher values of δ were used above 1149 m because of apparently greater variation in foliation attitude where steep foliation dips occur. In this area, consistent steeply dipping foliation with consistent strike would permit steepening the wall.

The figures shown on Table V do not make any provision for haul roads. Haul roads on the SE or NE walls would require flatter average slopes to maintain kinematic stability. (No portion of the slope can exceed the inclination for kinematic stability without locally undercutting foliation or wedges).

PART 6 - ADDITIONAL CONSIDERATIONS

6.1 Dewatering

Our assessment of groundwater conditions and results of stability analyses indicate that some form of dewatering or depressurization will be required. The design of a dewatering system should be based on more detailed groundwater information than is currently available. This information may be obtained during the pre-mining stage and augmented as mining progresses. Consequently, modifications of the general dewatering system to deal with specific problem areas will be possible.

We would expect that the ore zone and through going faults represent the most important aquifers. High pressures which may exist along foliation joints may be generated by small quantities of water but these pressures must also be relieved.

Dewatering or depressurization systems might include one or more of the following elements:

(1) Pumping from the decline. The decline has a large surface area within the ore zone; however, due to its location, it may be relatively ineffective with respect to the northeast and southeast walls. In order to facilitate drainage of the southeast and northeast walls auxilary drifts could be driven and relief drains drilled to intercept aquifers on the east side of the proposed pit.

(2) Pumping from deep wells located outside the pit.

(3) Pumping from wells drilled directionally from within the pit. This option has the advantage of shorter drill holes compared to point (2). Disadvantages include possible disturbance to the wells by mining and by any slope movements or rock fall.

(4) Inclined holes drilled from benches in the pit.

Water pumped from drainage systems may require treatment prior to being discharged into local waterbodies.

6.2 Surface Water

Surface water should not be permitted to drain into the pit or to seep into ground adjacent to pit walls. Diversion measures may include collector drains, ditches around the pit crest and dikes or dams to divert surface flow.

Doal Lake should be drained and water diversion measures implemented so that drainage into Doal Lake basin does not flow into the pit. Prior to draining Doal Lake, it might prove economically attractive to dredge some of the unconsolidated sediments underlying and adjacent to the lake, rather than excavating these materials after draining the lake.

Benches configuration should encourage natural drainage of surface water since ponding may result in seepage into discontinuities behind the wall.

6.3 Blasting

Controlled blasting is recommended to reduce disturbance to the slope and to avoid loss of cohesion on foliation surfaces. Present experience in the Anvil Pit may provide useful information, however, a variety of patterns and charging methods should be tried in the Grum pit to maximize fragmentation while minimising disturbance to the slope.

Due to numerous discontinuities within the rock mass, uniform fragmentation may be a problem. Adjacent to final walls it may be necessary to accept reduced fragmentation quality and the possible necessity for secondary breaking, in order to minimize damage to the rock mass.

6.4 Monitoring and Mapping

Slopes exceeding approxiamtely 30 m high should be monitored to detect possible movement in both horizontal and vertical directions. For general monitoring, electronic distance measuring equipment combined with a one second automatic vertically indexing theodolite is adequate. Depending on conditions and lengths of sight lines, accuracies in the order of a few millimeters may be achieved. If movement of a portion of the slope is detected, additional monitoring methods may be installed to provide more comprehensive information than available from EDM.

Surveys should be referenced to hubs permanently installed well beyond the pit perimeter. Instrument stations should provide for relocation of the instrument to within ± 1 mm. Depending on the EDM equipment chosen and on access to the pit wall, wall stations may be relocatable glass prisms, permanently mounted glass prisms, truck reflectors or Scotchlite (products similar to the latter are manufactured under other trade names).

Porewater pressures around the pit should be monitored, preferably using fast acting (e.g. pneumatic type) piezometers. As well as installations outside the pit perimeter, temporary installations in air track holes may be used to monitor conditons immediately behind the pit face.

Bench faces should be geoligically mapped as mining proceeds, in order to check that assumptions of discontinuity orientation used in design remain valid. During mapping, particular attention should be paid to discontinuity orientation and distribution. Line mapping techniques or similar methods should preferably be used to obtain statistically valid samples.

6.5 Slopes in Unconsolidated Materials

Detailed analysis of slopes in deep unconsolidated overburden near Doal Lake will be required. Available data indicates that overburden depths to 100 m coupled with high pore pressures exist in this area.

6.6 Future Investigations

6.6.1 Geologic Model

Considerable scope exists for improving the geologic model, especially on the northeast and southeast walls. In particular it may be possible to improve estimates of foliation orientation (both strike and dip) by reanalysing Kerr Addison's basic data from boreholes and the decline.

Surface mapping of the area after preproduction stripping will provide additional data. Drilling of oriented core (using a triple barrel orienting core barrel) can provide important information on the two east walls, especially with regard to foliation strike.

Of particular importance in assessing discontinuity attitude relative to wall design is foliation and fault attitude on the lower portions of the northeast and southeast walls. In particular, δ on the NE wall has been reduced to 3° for foliation dips of 34° near the toe. Confirmation of foliation strike and dip, and fault attitude if possible, will result in increased design confidence in this area.

6.6.2 Laboratory Testing

HQ core recovered from hole DL-2 contained mostly serricitic foliation surfaces with only a few graphitic surfaces that were suitable for testing. Within the rock mass as a whole, graphitic surfaces appear to be at least as important as serricitic surfaces. If further investigations result in good quality graphitic surface being available, they should be tested in order to confirm the foliation strength parameters chosen for the analysis.

Laboratory testing of fault gouge samples recovered during the recent field program is currently underway to confirm the estimated strength parameters for faults.

6.6.3 Groundwater

Detailed investigations should be undertaken to establish basic hydrogeological characteristics of the rock mass including permeability, and regional and local flow regimes.

Pump tests using the decline and deep wells could provide a great deal of information regarding practical dewatering problems.

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Hoek, E. and Bray, J.W. (1977): Rock Slope Engineering, Revised Second Edition, the Inst. of Min. and Met., London, 402 p.

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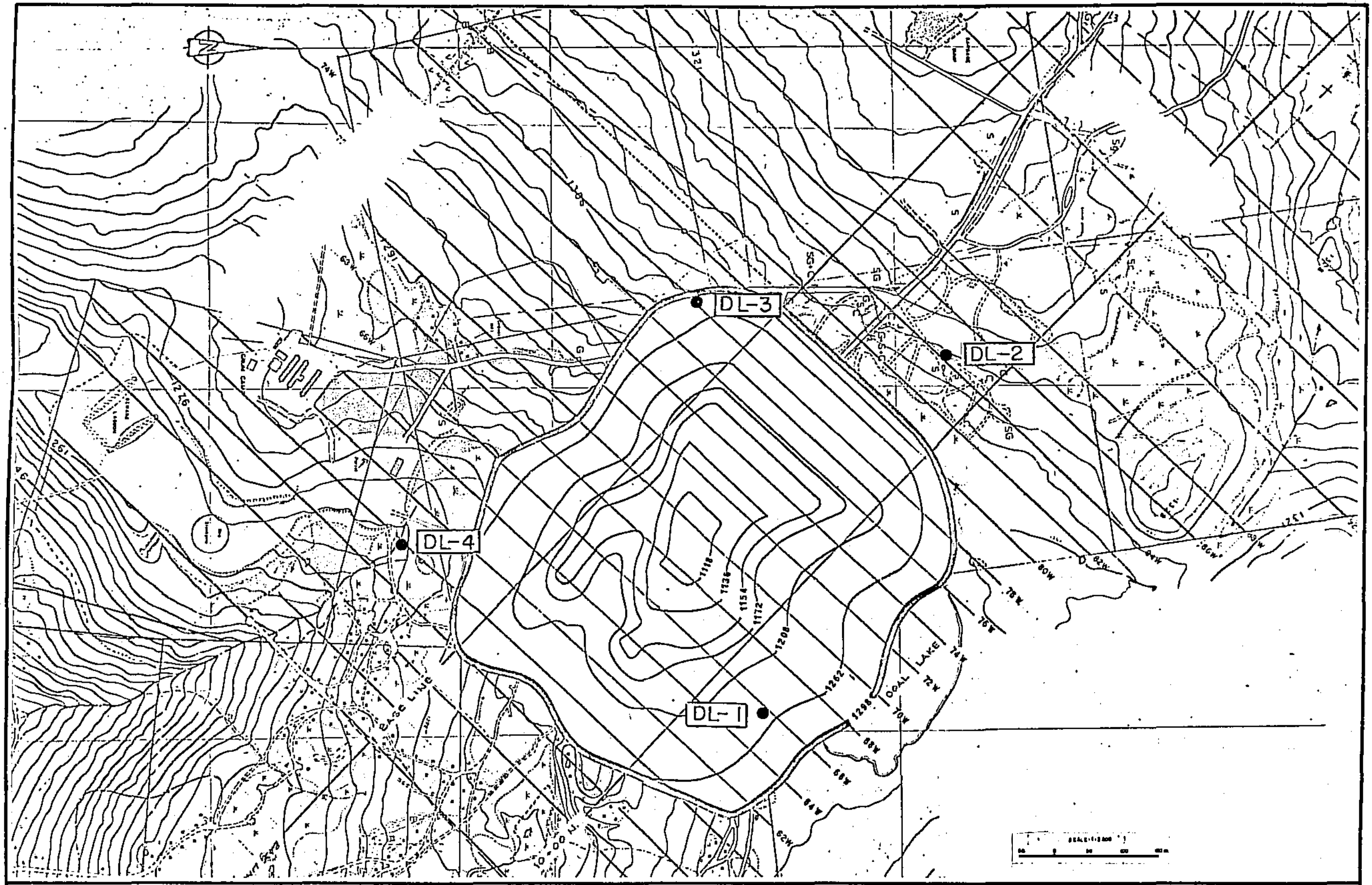

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GRUM DEPOSIT
CANADIAN MINE SERVICES LTD.
PIT AT END OF FIVE YEARS

Q 2160-002

PLATE I

HT10 - 79/05

APPENDIX A

LOGS

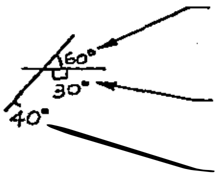
LEGEND

Samples

B1	Bag sample 1
S1	Shear sample 1
M4	Density sample 4
G1	Gouge sample 1

Symbols

F2:38° Angle between S_2 foliation and core axis is 38°



angle between strike of foliation and joint strike looking down core

foliation attitude assuming hole vertical

joint attitude assuming hole vertical

I_{S50}	Point load test perpendicular to foliation
I_{S50}	Point load test parallel to foliation

LITHOLOGICAL CODE USED BY CYPRUS ANVIL MINING CORPORATION

5A	Variably calcareous graphitic phyllite
5B	Calcareous muscovite chlorite ± biotite phyllite
5C	Metabasite
5D	Laminarly banded, variably calcareous, chloritc phyllite, tuffaceous
1	Siliceous
2	Carbonaceous
3	Calcareous (white mica envelope)
4	Altered pyritic (white mica envelope)
5	Banded/laminated
6	Non-calcareous
7	Tuffaceous
8	Chloritic
9	Sulfide bearing
0	Normal
0Q0	Bull Quartz

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LITHOLOGIC LOG

PROJECT: GRUM DEPOSIT

Borehole DL-1 | Date of Drilling Oct./79 | Job No. 02160-002
Location 66W, 13.2N, East of Doal L.
Surface Elevation | Top of Casing Elevation
Drilling Contractor | Rig Longyear 38 D.D.

DEPTH metres	SOIL SYMBOL	DESCRIPTION	DRILLING AND INSTRUMENTATION
? to 127'		? to 127' TILL, very hard, numerous pebbles to 4 cm, boulder to 10 cm (Granodiorite), some clay, silt and sand. 5.6 ft of core.	123-124' sample B-1
267 -304		3 Runs - 12.5 ft of core	
		267-296.5' SILT, slightly clayey, few rusty zones, powdery	267-269 sample B-2
		296.5.2966 CLAY, grey, hard, laminated, dry, low plastic	296.5-296.6 sample B-3
		296.6-304 SILT, as above with 17 cm boulder at 303.5'	
? to 315'		? to 315' SILT, as above	
315 -321		315-321' TILL, hard, numerous pebbles, frozen, occassional specks of ice.	
321 -326		321-326' Only weathered chunks of granodiorite recovered	
		NOTE: All core is frozen but this may have occurred after recovery. No segregated ice was seen except 315-321'.	

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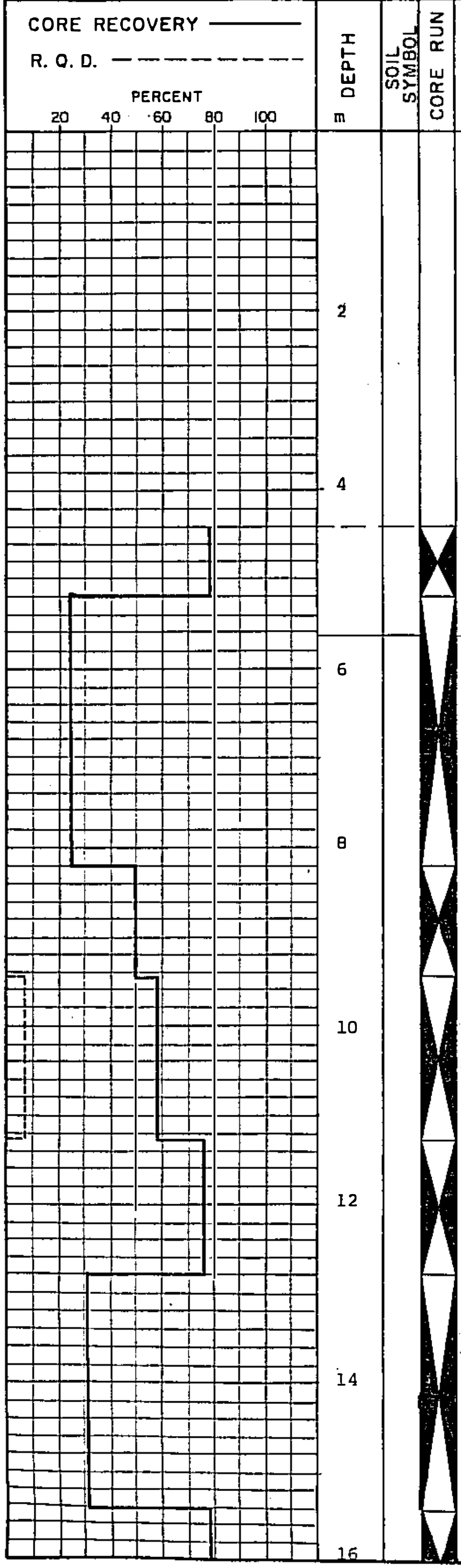
ROCK CORE LOG

PROJECT GRUM DEPOSIT

HOLE LOCATION SECTION 80W BETWEEN A 104 and A 20, HOLE INCLINED 20° FROM VERT TO GRID 230°

LOGGED BY	CHECKED	DATE OF INVESTIGATION	JOB NUMBER	HOLE
DSC/JM	DSC	Oct. 29-30, 79	02160	DL-2



WEATHERING (W)	STRENGTH (S)	DESCRIPTION	REMARKS
		0 - 4.4 m Triconed: 0 - 2.3 m Glacial overburden 2.3 - 4.4 m Vangorda fm.	
MW.		5D3 Phyllite, tuffaceous, calcareous, chloritic, banded	F2: 38 to 85° 5m: I_{s50} = 0 I_{s50} = 8.5 MPa
FW		5B0 Phyllite, calcareous, chloritic, some muscovite, locally interbedded 5D0	6m: $I_{s50//}$ = 1.45 MPa $I_{s50\perp}$ = 4.5 MPa F2: 56° F2 = 62° 9m: $I_{s50\perp}$ =1.05 MPa F2: 65° F2: 80° M7: 13.9 m

PAGE 1 OF 7

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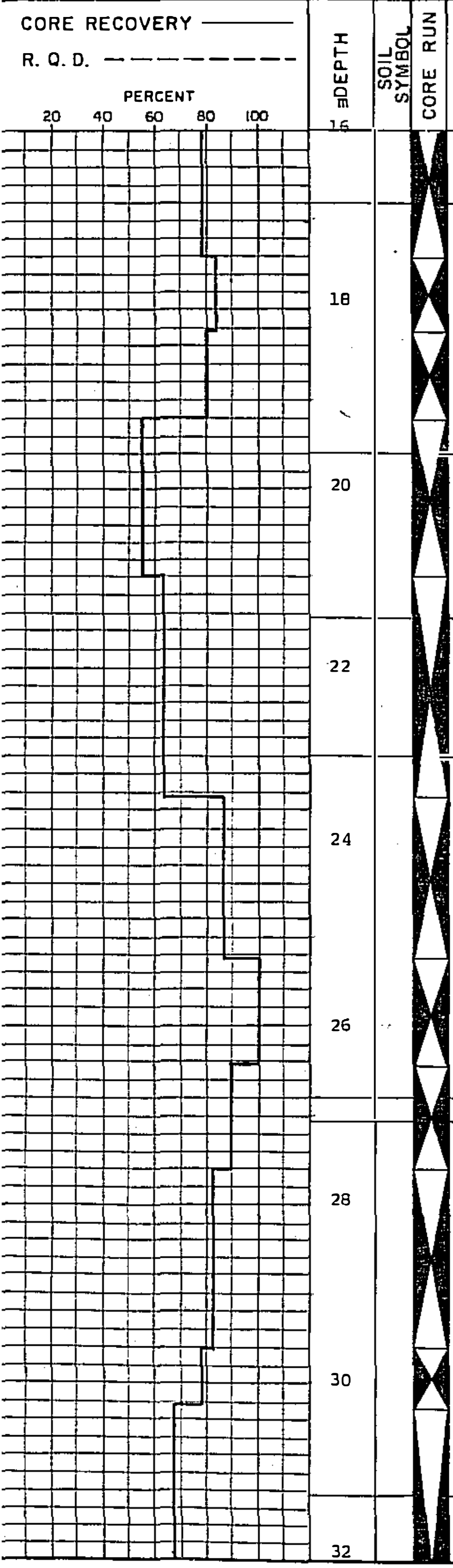
ROCK CORE LOG

PROJECT GRUM DEPOSIT

HOLE LOCATION SECTION 80W BETWEEN A 104 and A 20, HOLE INCLINED 20° FROM VERT TO GRID 230°

LOGGED BY DSC /JM | CHECKED DSC | DATE OF INVESTIGATION Oct. 29-30, 79 | JOB NUMBER 02160 | HOLE DL-2

CORE RECOVERY ———
R. Q. D. – – – – – –



WEATHERING (W)	STRENGTH (S)	DESCRIPTION	REMARKS
		As Above	16.5 m: $I_{s50\perp}$ = 1.45 MPa
		5D3 Phyllite, tuffaceous, calcareous, chloritic, banded. Locally 5B0, few thin quartz veins.	F2: 62-65°
		5B0 Phyllite, calcareous, chloritic, some muscovite, minor interbedded 5D3	F2: 70-73° 21m: $I_{s50\perp}$ = 6.8 MPa
		5D3 Phyllite, tuffaceous, calcareous, chloritic, banded	F2: 46-57°
		5B0 As above 40% interbedded 5D3	23.8m: Sample S1 F2: 49° 25.35m Sample S2 F2: 60° Foliation Strongly developed. Some powdery sericite on surfaces. F2: 50-55°
		GOUGE	
		5D3 As above. Local quartz stringers	28.4m: Sample S3 F2: 65°
		See following page	

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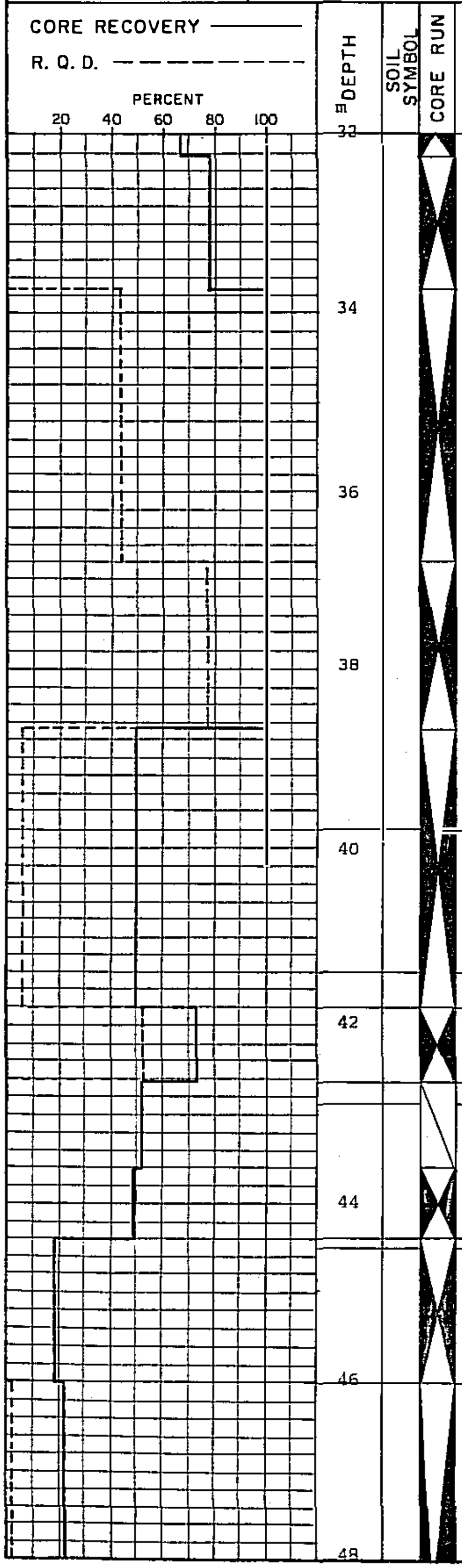
ROCK CORE LOG

PROJECT: GRUM DEPOSIT

HOLE LOCATION: SECTION 80W BETWEEN A 104 and A 20. HOLE INCLINED 20° FROM VERT TO GRID 230°

LOGGED BY	CHECKED	DATE OF INVESTIGATION	JOB NUMBER	HOLE
DSC /JM	DSC	Oct. 29-30, 79	Q2160	DL-2



WEATHERING (W)	STRENGTH (S)	DESCRIPTION	REMARKS
		5D0 Phyllite, laminarly banded, tuffaceous chloritic, calcareous	F2: 58° 36.2 m: $I_{s50\perp}$ = 10.5 MPa Foliation poorly defined, some folding. F2: 46-50° 38.6 m: $I_{s50\perp}$ = 5.9 MPa Foliation better defined, some powdery sericite.
		0Q0 Quartz	F2: 64°
		5B0 Phyllite, as 20m	
		5D3 Phyllite, as at 22 m	
		Gouge and sand, disturbed during drilling.	
		5D3 Phyllite as above. Badly shattered.	F2: 64°
		Gouge and sand	
		5D3 Phyllite as above. Broken.	
		Gouge and sand. Some core apparently ground during drilling.	G1: Intact sample of fault gouge. G2: Sand, probably ground in barrel.

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ROCK CORE LOG

PROJECT GRUM DEPOSIT

HOLE LOCATION SECTION 80W BETWEEN A 104 and A 20, HOLE INCLINED 20° FROM VERT TO GRID 230°

LOGGED BY DSC/JM

CHECKED DSC

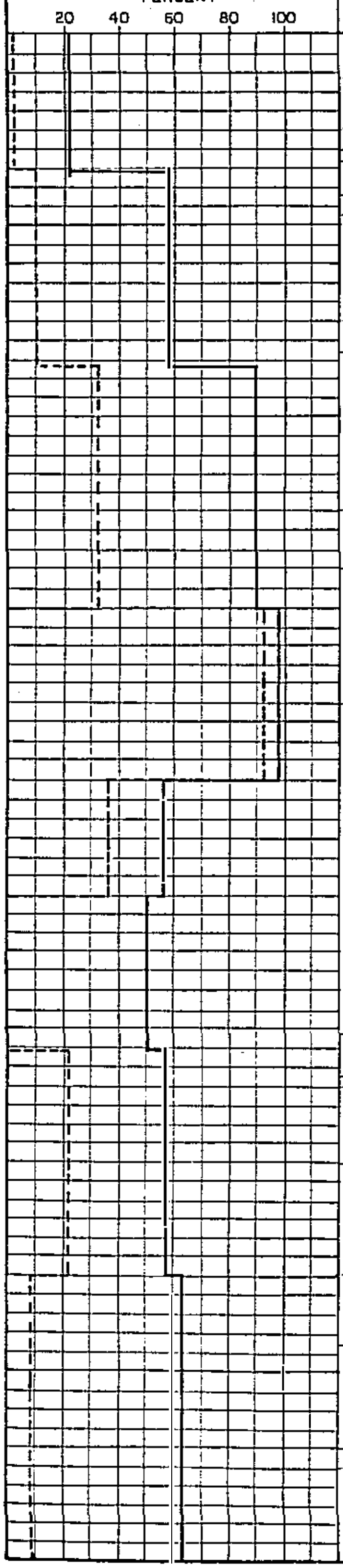
DATE OF INVESTIGATION Oct. 29-30, 79

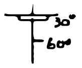
JOB NUMBER 02160

HOLE DL-2

CORE RECOVERY ———

R. Q. D. — — — — —



DEPTH	SOIL SYMBOL	CORE RUN	WEATHERING (W)	STRENGTH (S)	DESCRIPTION	REMARKS
48					As above	
					5A9 Phyllite, graphitic, calcareous, suphide bearing.	F2: 50°
					Quartz	
					5A9 as above	F2: Variable 0-60° Sheared and folded
					Quartz	49.6m: Sample S4
50					5A9: Phyllite, graphitic, calcareous, sulphide bearing.	51.7m: Joint, planar, rough, SW 
52					5D3: Phyllite, tuffaceous. calcareous, chloritic, banded	
54 56 58					5B2: Phyllite, calcareous, graphitic, with muscovite and chlorite	54.25m:S5, slightly graphitic foliation. F2: 65° 55.7-55.9 m; Clay and gouge on foliation Point loads as follows: 54.4m: $I_{s50\perp} = 5.8$ MPa 55.1m: $I_{s50\perp} =2.7$ MPa 55.3m: $I_{s50\perp} =2.6$ MPa 57.0m: $I_{s50\perp} = 3.2$ MPa 58.4m: S-6
					Quartz	
					5B2 As above	Thin gouge at 59.8 m and 60 m
60					5D3 Phyllite, tuffaceous, calcareous, chloritic, banded	61.7 to 62.8 m: Badly fragmented, split parrallel foliation. F2: 70°
62					5B0: Phyllite, calcareous with muscovite and chlorite	
					5D0 Some 5B0. Only chips recovered.	F2: 64° Some graphitic partings
64						

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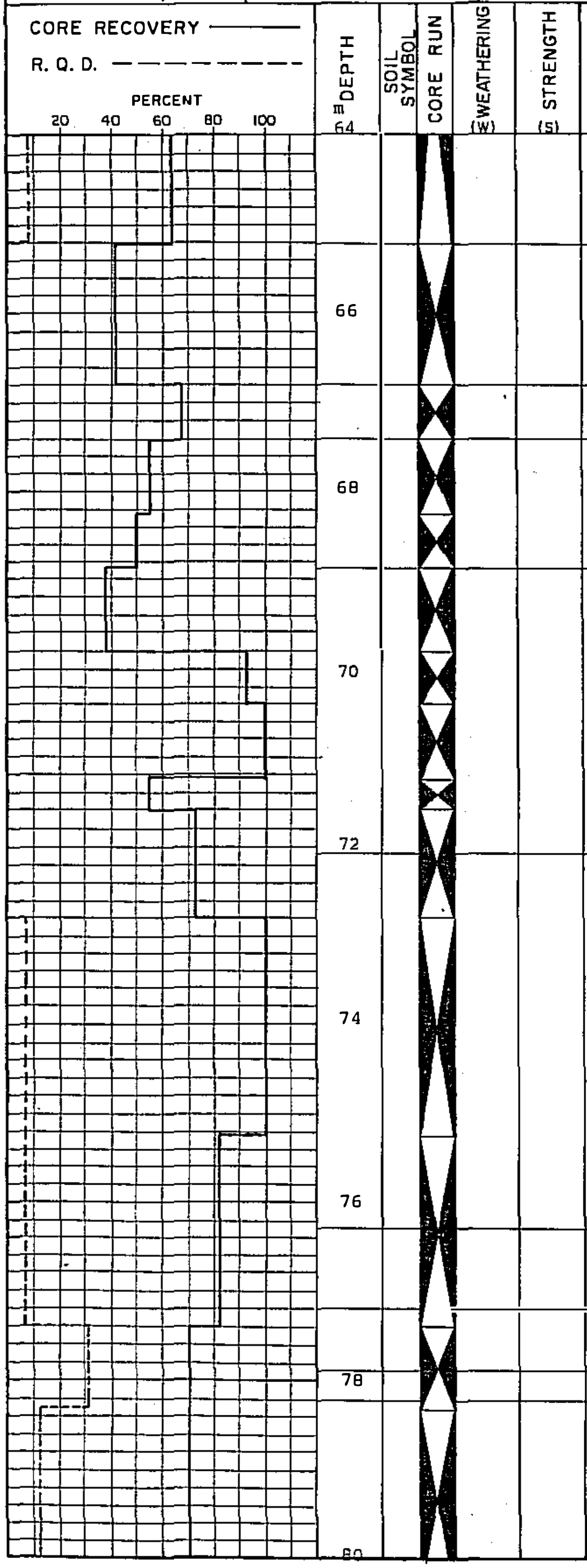
ROCK CORE LOG

PROJECT GRUM DEPOSIT

HOLE LOCATION SECTION 80W BETWEEN A 104 and A20, HOLE INCLINED 20° FROM VERT TO GRID 230°

LOGGED BY DSC/JM	CHECKED DSC	DATE OF INVESTIGATION Oct. 29-30, 79	JOB NUMBER Q2160	HOLE DL-2



DESCRIPTION	REMARKS
As above	
SAND. Core ground in barrel.	
5B/5D/0Q0 Chips, lithology not known	
5D0 Only chips recovered	
Sand.Ground core	71.4m: $I_{s50\perp}$ = 3.7 MPa
5B0 Phyllite, calcareous, chlorite, with muscovite 5D0 Phyllite, laminarly banded, tuffaceous, chloritic. calcareous	Broken core 73.5m: M3 74.35m: 58 74.4 m: 57 F2: 80° 75.2m: M4
Ground Core.	
5B0 as above	77.7m: S9 serricitic foliation F2: 85°
0Q0 Quartz	
5B0 as Above	80.65m: $I_{s50\perp}$ =5.5 MPa 80.7 m: G3: Not long enough for intact test.

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ROCK CORE LOG

PROJECT GRUM DEPOSIT

HOLE LOCATION SECTION 80W BETWEEN A 104 and A 20, HOLE INCLINED 20° FROM VERT TO GRID 230°

LOGGED BY DSC /JM

CHECKED DSC

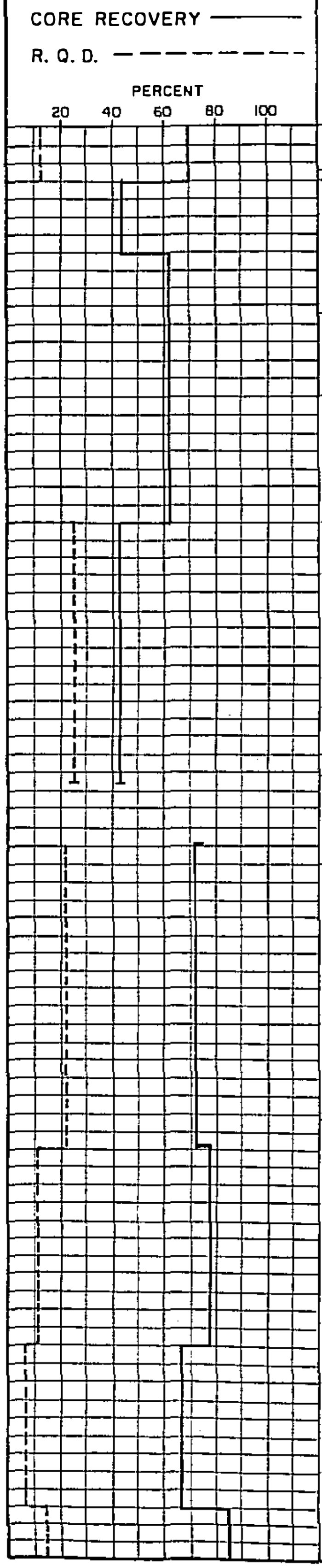
DATE OF INVESTIGATION Oct. 29-30, 79

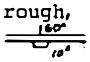
JOB NUMBER 02160

HOLE DL-2

CORE RECOVERY ————

R. Q. D. — — — — —



DEPTH m	SOIL SYMBOL	CORE RUN	WEATHERING (W)	STRENGTH (S)	DESCRIPTION	REMARKS
80					As above	
					Gouge	
82						
84					580 As above	83.8m: I_{s50_L} = 0.9 MPa
86			FW – MW		5D0 Phyllite, laminarly banded, tuffaceous, chloritic, calcareous	85.4m: G4, Mod. weath. sheared phyllite G4A Intact G4B Disturbed 87.6 m: I_{s50_L} = 7.2 MPa
			FW		5B0 Phyllite, calcareous, chloritic, some muscovite, few gouge zones	87.7m JNT, Planar, rough, faintly weath. 
88					Gouge	86.7m G5 Sheared phyllite 87.1m G6 and G7 Good samples of gouge.
90					5D0 As above 89.3m: s11 Serricitic Foliation 91.5m: s12 Serricitic Foliation 90.9m: G8 Good Gouge Sample Foliation varies from 55 to 90°	89.3m: $I_{s50\perp}$ = 6.5 MPa 90.9m: G9
					Gouge	
92 94 96					5D0 Phyllite, banded, tuffaceous, grey	88.3m: I_{s50_L} = 3.8 MPa F2: 60° 92.4m: I_{s50_L} = 4.8 MPa 95.3m: M1 95.5m: S13 Serricitic Foliation 97.5m: S15 97.7m: $I_{s50\perp}$= 5.9 MPa 98.2M: $I_{s50\perp}$= 6.8 MPa 99.6m: Rusty coating on foliation surface F2: 40°

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ROCK CORE LOG

PROJECT GRUM DEPOSIT

HOLE LOCATION SECTION 80W BETWEEN A 104 and A 20, HOLE INCLINED 20° FROM VERT TO GRID 230°

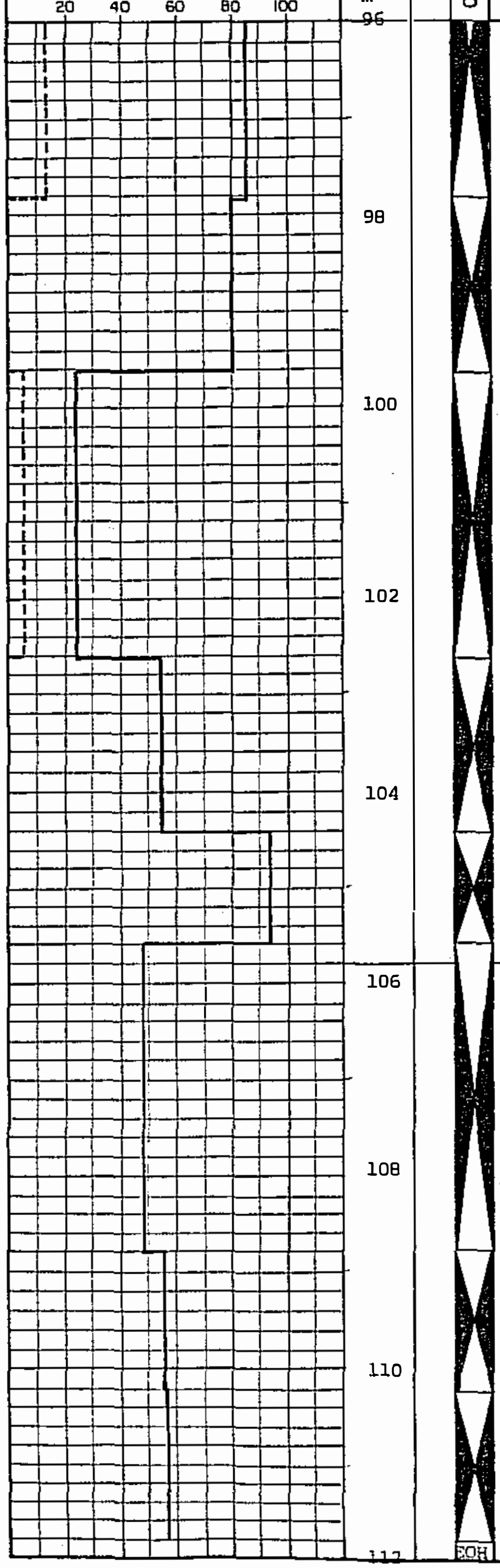
LOGGED BY DSC/JM	CHECKED DSC	DATE OF INVESTIGATION OCT. 29-30, 1979	JOB NUMBER 02160	HOLE DL-2

CORE RECOVERY ——————

R. Q. D. — — — — — —

PERCENT

DEPTH m | SOIL SYMBOL | CORE RUN | WEATHERING (W) | STRENGTH (S)



DESCRIPTION	REMARKS
5DO con't	99.5m: M5 99.6m: S16 Serricite Foliation 100.7m: Joint rough, angle to axis = 90°, calcite filled 102.3 - 102.7m Joint, rough, angle to core axis = 90° 102.3m: $I_{s50\perp}$ = 0.41MPa (poor break) 104.2m: $I_{s50\perp}$ = 5.8 MPa 104.5m: M6 F2 = 70° F2 = 65°
NOTE: Lithology logged by Jim Mustard of Cypruss Anvil.	109.8m: G9 Good sample 109.9m: Gouge, angle to core = 70° 111.3m: Joint, slickensided, foliation variable, joint crosscuts foliation, angle to core = 58° Sample S17 111.5m: M8

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ROCK CORE LOG

PROJECT GRUM DEPOSIT

HOLE LOCATION 3.1S, 78W

LOGGED BY DSC
CHECKED DSC
DATE OF INVESTIGATION Oct. 1979
JOB NUMBER Q2160
HOLE DL-3

CORE RECOVERY ————
R. Q. D. – – – – –

PERCENT 20 40 60 80 100	DEPTH m	SOIL SYMBOL	CORE RUN	WEATHERING (W)	STRENGTH (S)	DESCRIPTION	REMARKS
						This hole was logged for lithology by Jim Mustard of Cyprus Anvil. Selected intervals were logged geotechnically.	
	2						
						0 - 6.9 m Triconed	
	4						
	6						
						Scale Change	
	6						
						5B2	
	8						
						5D3	
	10					5B0, interbedded 5D0	
						5C0	
	12					5B0, Fuschite: 12.3 - 12.5 m	
	14						

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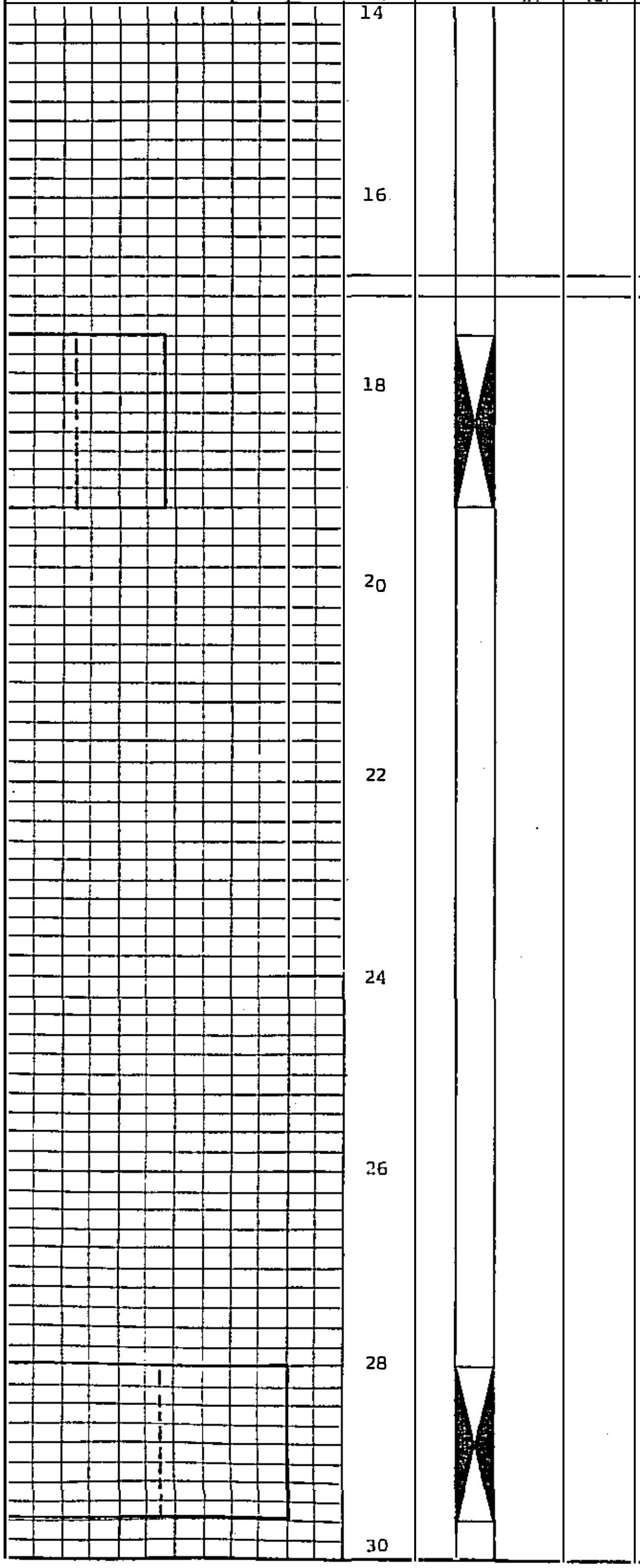
ROCK CORE LOG

PROJECT GRUM DEPOSIT

HOLE LOCATION 3.1S, 78W

LOGGED BY DSC | CHECKED | DATE OF INVESTIGATION Oct./79 | JOB NUMBER Q2160 | HOLE DL-3

CORE RECOVERY ———
R. Q. D. - - - - - -
PERCENT



DEPTH m	DESCRIPTION	REMARKS
14		
16		
	5CO	
	5BO Phyllite, calcareous, graphitic with muscovite	
18		18.3 m: $I_{s50\perp}$ = 21.8 MPa
20		
22		
		23.4 m: U20
24		
26		
28		28.5 m: $I_{s50\perp}$ = 13.2 MPa 28.5 m: $I_{s50\parallel}$ = 22.4 MPa F2 = 90° 28.9 m: joint, calcite filled, angle to core = 45°
30		

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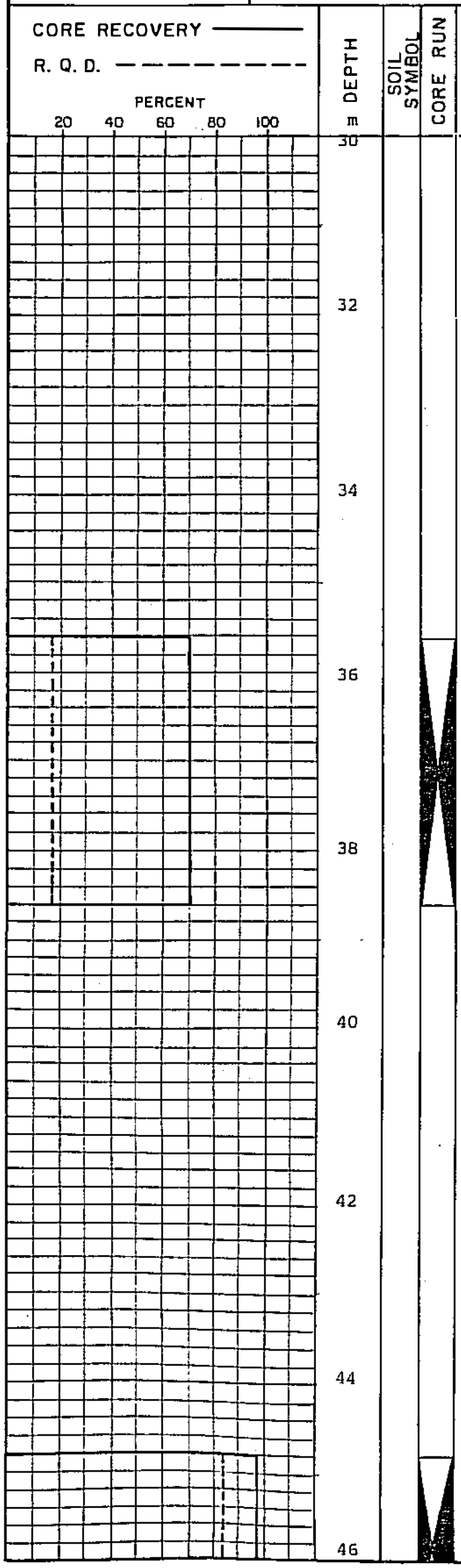
ROCK CORE LOG

PROJECT GRUM DEPOSIT

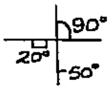
HOLE LOCATION 3.1S, 78W

LOGGED BY DSC
CHECKED
DATE OF INVESTIGATION Oct./79
JOB NUMBER Q2160
HOLE DL-3

CORE RECOVERY ————
R. Q. D. – – – – – – – – –



DEPTH m	DESCRIPTION	REMARKS
30	5B0 as above	30.1 m: U21 30.2 m: U22 30.7 m: U23
37.2		37.2 m: $I_{s50}\perp$ = 23.9MPA
44.9		44.9 m: joint planar rough, assuming hole vertical:



45 m: $I_{s50}\perp$ = 7.1 MPa
45 m: $I_{s50}\perp$ = 29.8 MPa

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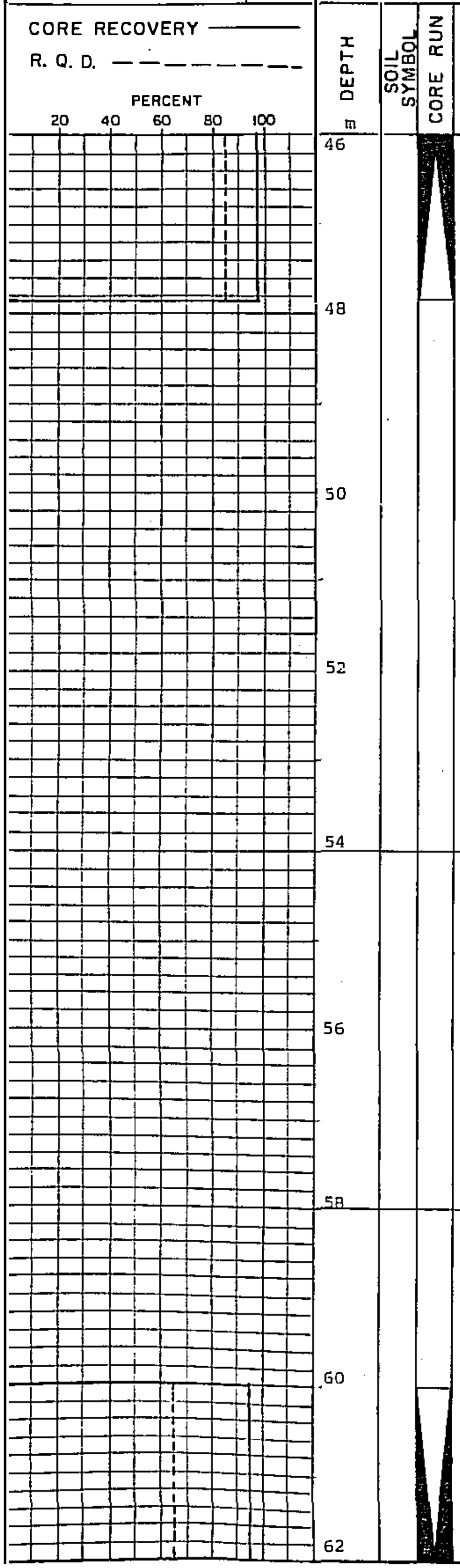
ROCK CORE LOG

PROJECT GRUM DEPOSIT

HOLE LOCATION

LOGGED BY DSC
CHECKED
DATE OF INVESTIGATION Oct./79
JOB NUMBER Q2160
HOLE DL-3



DEPTH m	WEATHERING (W)	STRENGTH (S)	DESCRIPTION	REMARKS
46			5B0 as above	45.3 m :U24
54			5A0, locally 5B4, phyllite, calcareous, very graphitic	55.0 m: U25
58			5B0 as above	Shiny graphitic partings 60.0 m: $I_{s50\perp}$ = 12.3 MPa 62.0 m: $I_{s50\perp}$ = 27.9 MPa

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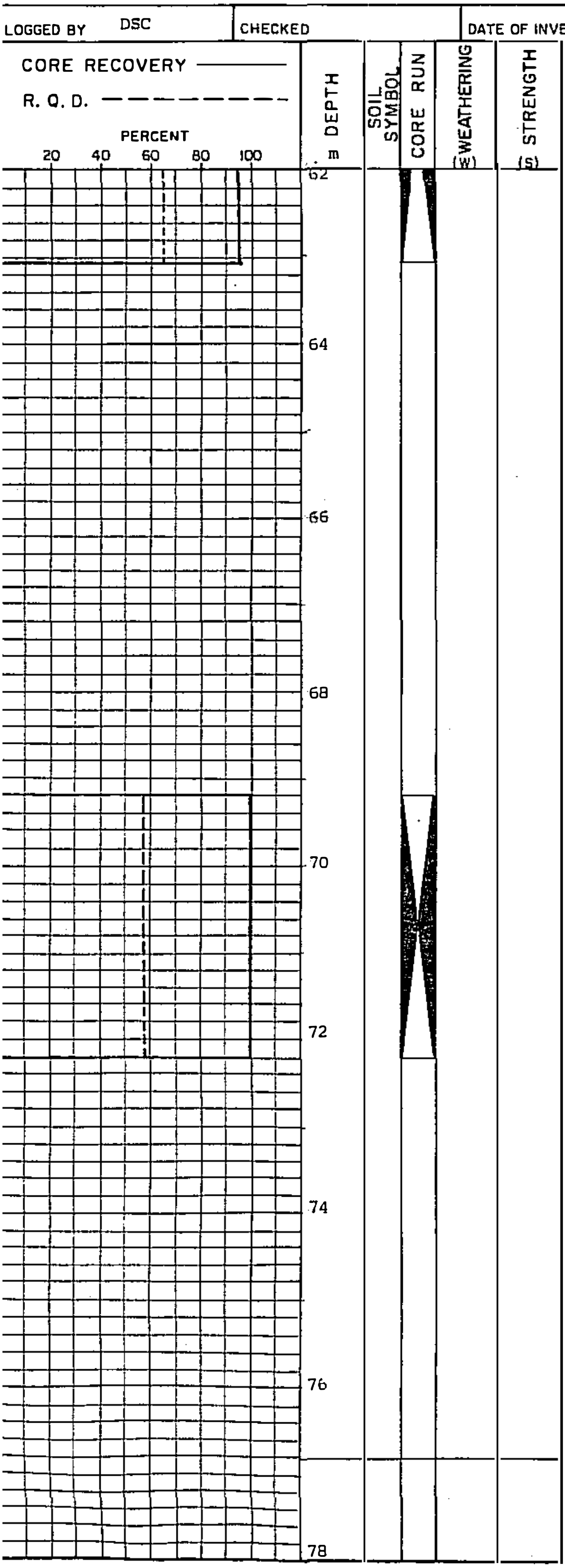
ROCK CORE LOG

PROJECT GRUM DEPOSIT

HOLE LOCATION 3.1S, 78W

LOGGED BY DSC | CHECKED | DATE OF INVESTIGATION Oct./79 | JOB NUMBER 02160 | HOLE DL-3



DESCRIPTION	REMARKS
5B0 as above	
	63.0 m: $I_{s50\perp}$ = 44.8
	67.6 m: U26 67.9 m: U27 67.8 m: U28
	70.55 m: $I_{s50\perp}$ = 10 MPa
	71.8 m: $I_{s50\perp}$ = 17.6 MPa
5A0 phyllite, calcareous graphitic, quartz veins. Local interbeds of 5D3 and 5B2.	

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ROCK CORE LOG

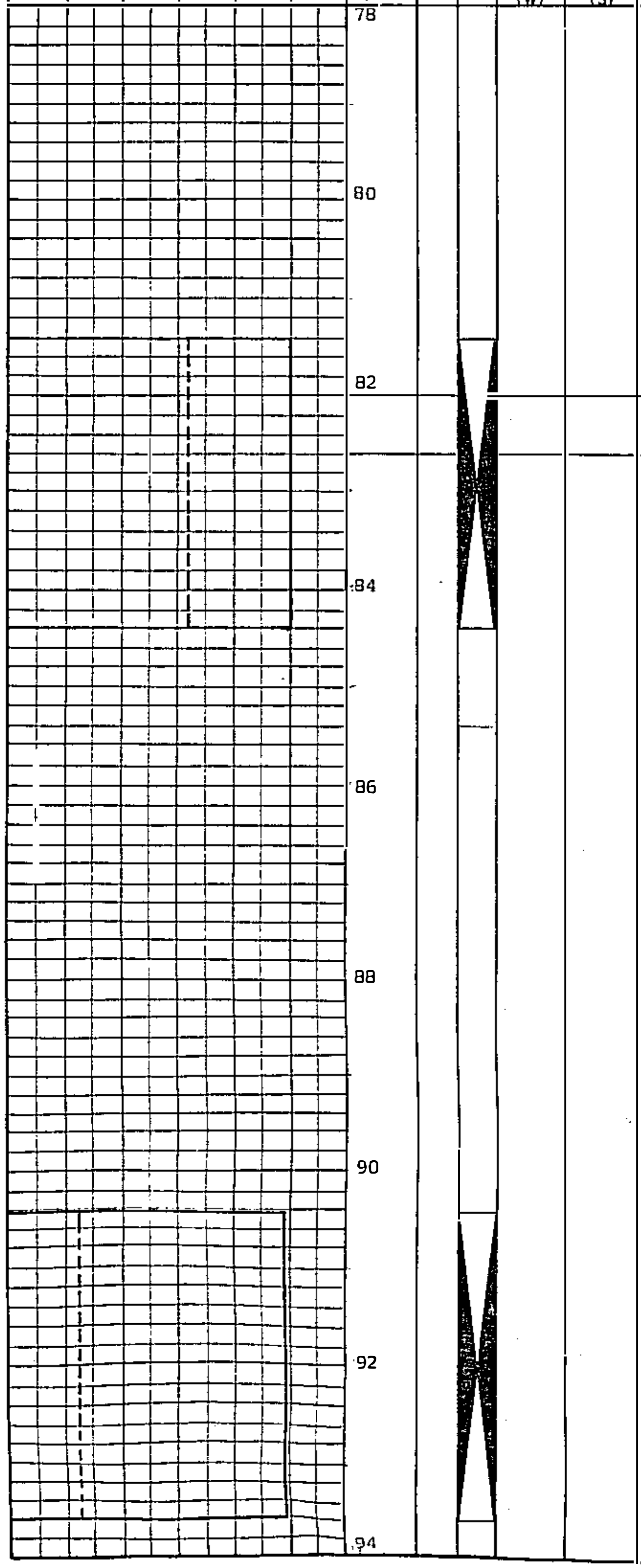
PROJECT GRUM DEPOSIT

HOLE LOCATION

LOGGED BY DSC	CHECKED	DATE OF INVESTIGATION Oct./79	JOB NUMBER 02160	HOLE DL-3

CORE RECOVERY ———
R. Q. D. - - - - -
PERCENT

DEPTH m	SOIL SYMBOL	CORE RUN	WEATHERING (W)	STRENGTH (S)	DESCRIPTION	REMARKS



DESCRIPTION

5A0 as above

5D1 phyllite, laminarly banded, calcareous, chloritic, tuffaceous, siliceous

5A0 phyllite, calcareous, graphitic, locally 5B2, some pyrite in S1 fold hinges.

REMARKS

81.8 m: $I_{s50\perp}$ = 8.5 MPa

82.4 m: $I_{s50\perp}$ = 21.8 MPa.

82.7 m: $I_{s50\perp}$ = 23.7 MPa

82.75-82.95 m: joint, irregular calcite and epidote filled, angle to CA = 0°.

87.8 m: U29

F2 = 90°

90.6: joint, planar rough, angle to CA = 48°

92.8: joint, planar rough, 1 mm calcite infilling, angle to core axis = 0°

90.6 m: $I_{s50\perp}$ = 6.9 MPa

91.0 m: $I_{s50\perp}$ = 10.7 MPa

92.0 m: $I_{s50\perp}$ = 9.2 MPa

93.4 m: $I_{s50\perp}$ = 23.9 MPa.

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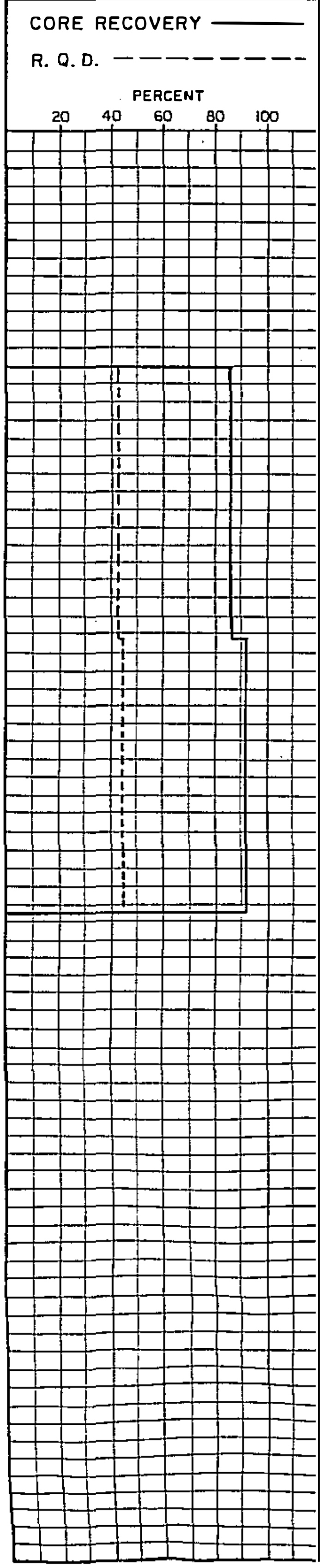
ROCK CORE LOG

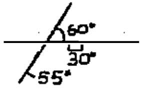
PROJECT GRUM DEPOSIT

HOLE LOCATION 3.1S, 78W

LOGGED BY DSC	CHECKED	DATE OF INVESTIGATION Oct./79	JOB NUMBER Q2160	HOLE DL-3



DEPTH m	SOIL SYMBOL	CORE RUN	WEATHERING (W)	STRENGTH (S)	DESCRIPTION	REMARKS
94					5A0 as above	
					Gouge in 5A	U30A Gouge U30B Gouge U30C Gouge U30D Gouge
96					5B6 phyllite, muscovite and chlorite	
					5D6 phyllite, laminarly banded, chloritic, tuffaceous	
98					5D1, phyllite, as above, calcareous, siliceous	98.5–98.75: joints (3) parallel to foliation, planar to curved, smooth, some serricite and chlorite, some powdery gouge (<1 mm) angle to CA = 55° to 30° 98.5 $I_{s50\perp}$ = 17.9 MPa 98.8: joint, planar smooth, some talcy infilling
					5C0 metabasite	
					5D6 as above	
100					5C0 metabasite, some interbedded 5D	
102					5B6 as above	
					End of Hole at 102.7 m	
104						



APPENDIX B

LABORATORY ROCK TESTING

APPENDIX B

LABORATORY ROCK TESTING

PART 1 - INTRODUCTION

Laboratory testing was carried out on NQ and HQ core samples secured from drill holes at the Grum deposit (Holes DL-2 and DL-3) and at the Vangorda deposit (Hole V-27-R). Core from the HQ hole (DL-2) was used mainly for direct shear tests. Due to the low quality core recovered from hole DL-2, unconfined compressive strength samples were secured from hole DL-3 (NQ core) and triaxial samples from both DL-3 and V-27-R. According to Mr. J. Mustard of Cyprus Anvil, core selected from the Vangorda hole is similar to predominant rock types at the Grum deposit.

In addition to the testing summarized in this appendix, a point load testing machine was transported to the site and used for index testing during core logging. These results are shown on the core logs in Appendix A.

Laboratory testing was conducted in Hardy Associates (1978) Ltd. Calgary laboratory under the supervision of D.S. Cavers, P.Eng. and A.H. Overend, P.Eng. Testing was carried out using generally accepted methods as shown in Table 1. Individual tests are discussed in greater detail in the following sections.

TABLE I

TESTING STANDARDS

Direct Shear Test:	ISRM[1] (1974), Part 2.
Density:	ISRM[2] (1972), Part I.
Compressive Strength:	ISRM[3] (1972).
Triaxial Tests:	Samples were prepared as for the compressive test. The step triaxial joint test was carried out as suggested in Goodman (1976) and analyzed using Goodman's equations corrected by D.S. Cavers.

[1] International Society for Rock Mechanics (ISRM), Commission on Standardization of Laboratory and Field Tests, (1974): Suggested Methods for Determining Shear Strength.

[2] ISRM (1972): Part 1, Suggested Methods for Determining Water Content, Porosity, Density, Absorption and Related Properties. Prepared by J.A. Franklin.

[3] ISRM (1972): Doc. No. 1, Suggested Methods for Determining the Uniaxial Compressive Strength of Rock Materials and the Point Load Strength Index.

Goodman, R.E. (1976): Methods of Geological Engineering in Discontinuious Rocks, West. Publ. Co., St. Paul.

PART 2 - DIRECT SHEAR TESTING

Tests were run on pre-broken foliation surfaces in HQ core. Specimens selected for testing had planar foliation surfaces cutting the core at angles of 40 to 60°. Each half of the specimen was cast in high strength grout using special jigs and molds and then mounted in a Hoeck type direct shear machine.

In the machine, normal and shear stresses (relative to the foliation plane) are applied hydraulically. The test consists of measuring shear stress and displacement while maintaining constant normal stress.

Each sample was subjected to several increasing normal stresses, producing a strength envelope for the specimen. Plates B-1 and B-2 summarize results for sericitic (fine grained micas) and graphitic surfaces. Plates B-3 to B-10 contain plots of detailed test results for each sample.

Results of the test are fairly consistent. One interesting result is that at normal stresses in excess of

2 MPa (290 psi) there is a tendency for phi (the angle of friction) to increase. The reason for this is not known, but may reflect a breaking down of the surface resulting in a stronger quartz-feldspathic rock behind the foliation surface influencing the results. Since normal stresses on possible failure planes in the pit are much less than 2 MPa (290 psi) this effect was not included in design calculations.

For design purposes, the limiting strength envelope (shown on Plate B-1) was assumed to have Ø = 19.5° and C = 6 psi (41.4 kPa).

PART 3 - TRIAXIAL TESTING

Triaxial tests were run in a Hoeck type rock triaxial cell. Two individual tests were undertaken:

1) Strength tests on foliation involving breaking intact foliation planes under different confining pressures.

2) Step triaxial joint tests involving shearing already broken foliation surface under different stress considerations.

Due to core quality problems, insufficient triaxial specimens were available. In addition, several otherwise usable specimens broke while their ends were being surface ground in preparation for testing.

Results of strength testing on intact foliation are shown on Plate B-11. The strength envelope plotted through the three Mohr's circles is not regarded as trustworthy since sample U28, which had a relatively high strength, broke on a rough foliation surface. Foliation surfaces in the other two samples were plane and shiny.

The step triaxial test on sample T-1 (Plate B-12) gave good results. In interpretting the test it is necessary to assume a value for K, the coefficient of friction between the rock specimen and platten. Our best estimate for K is 0.1. K = 0 represents a maximum limiting strength envelope. A few points which plot off the curve are probably the result of temporary misalignment of the foliation surfaces during the test.

Up to normal stresses of 2.5 MPa (363 psi) the results are consistant with data from the direct shear tests. Above 2.5 MPa, there is a tendancy for the strength envelope to be curved. This result is often seen in high pressure joint testing and is a result of shearing through slight asperities on the foliation surface rather than the riding over them. In addition, there may be some buildup of gouge on the surface.

PART 4 - COMPRESSIVE STRENGTH AND DENSITY

Unconfined compressive strength tests results are shown in Table II. These test results confirm the point load testing results and indicate that the strength of the rock, when failing across the foliation, is moderately high.

Table III shows results of density and poroxity tests on selected specimens. For design purposes, the bulk density was assumed to be 26.7 KN/m^3 (170 pcf).

TABLE II

UNCONFINED COMPRESSIVE STRENGTH TEST RESULTS

SAMPLE NO.	H/W[1] RATIO	COMPRESSIVE STRENGTH (psi)	FAILURE DESCRIPTION	HOLE	DEPTH
U21	1.85	6,618	Wedge - cutting across sericitic foliation planes and intact rock.	DL-3	30.1 m
U23	1.93	4,746	Wedge - cutting across sericitic foliation planes and intact rock.	DL-3	30.7 m
U24	1.95	2,645	Wedge - along a sericitic foliation surface.	DL-3	45.3 m
U26	1.96	12,605	Wedge - cutting across graphitic foliation planes and intact rock.	DL-3	67.6 m

Continued

U27	2.02	12,101	Longitudinal splitting through intact rock.	DL-3	67.9 m
U28	2.04	10,942	Wedge - cutting across graphitic foliation planes and intact rock.	DL-3	67.8 m

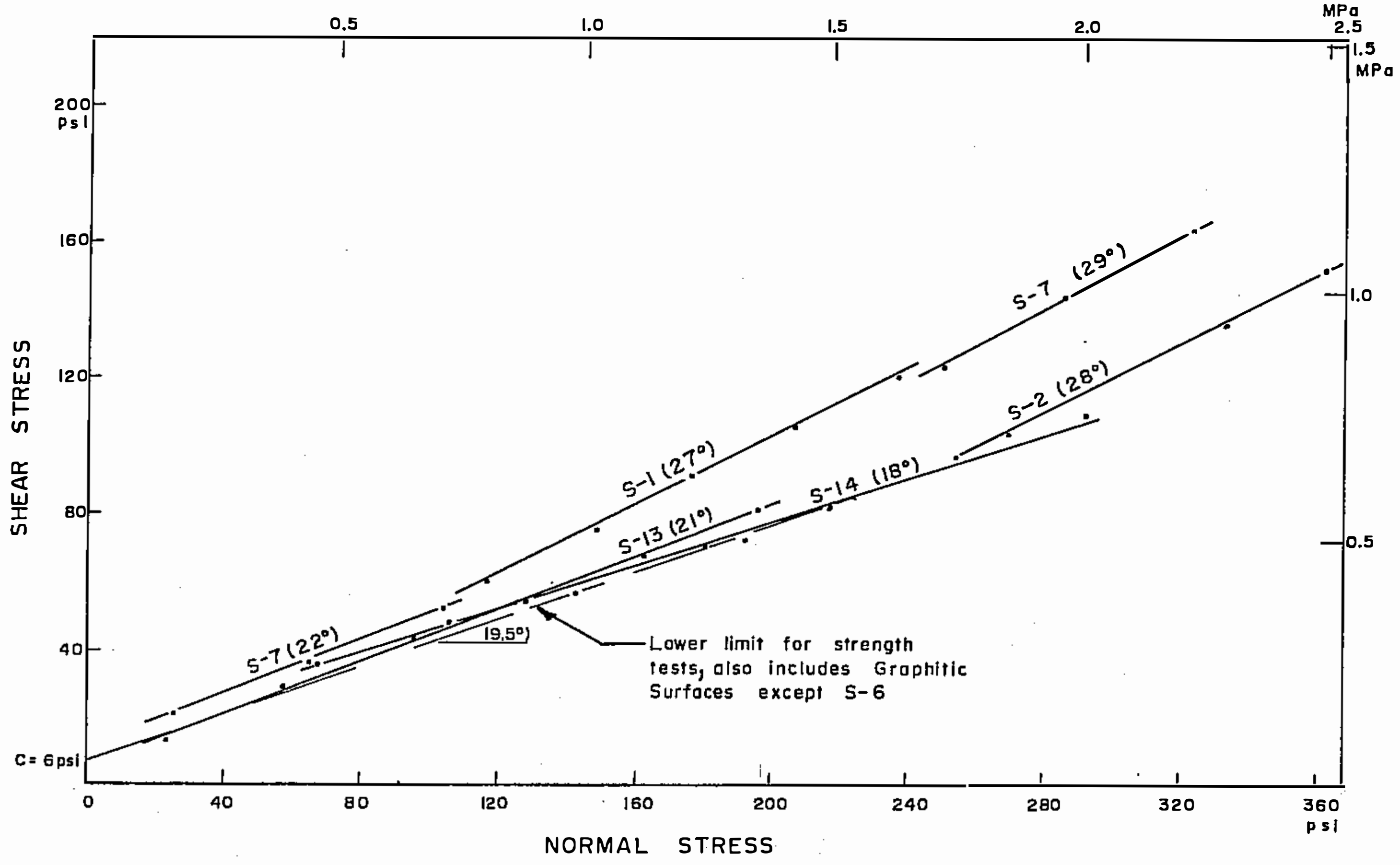
[1] Height/width ratio

TABLE III

DENSITY AND POROSITY TEST RESULTS

SAMPLE NO.	"IN-SITU" DENSITY pcf (kN/m^3)	DRY DENSITY pcf (kN/m^3)	SATURATED DENSITY pcf (kN/m^3)	POROSITY (%)	HOLE	DEPTH
M1	170.2 (26.7)	169.1 (26.6)	171.2 (26.9)	3.3	DL-3	95.3 m
M2	169.1 (26.6)	168.3 (26.4)	169.8 (26.7)	2.5	DL-3	55.3 m
M3	171.9 (27.0)	171.1 (26.9)	172.3 (27.1)	1.9	DL-3	73.5 m
M4	169.9 (26.7)	169.3 (26.6)	170.3 (26.8)	1.6	DL-3	75.2 m
M5	170.3 (26.8)	169.9 (26.7)	170.6 (26.8)	1.0	DL-3	99.5 m
M6	168.5 (26.5)	167.5 (26.3)	169.3 (26.6)	2.7	DL-3	104.5 m
M7	169.6 (26.6)	169.4 (26.6)	170.6 (26.8)	1.9	DL-3	13.9 m
M8	170.4 (26.8)	169.5 (26.6)	170.8 (26.8)	2.5	DL-3	111.5 m

[1] As recieved in laboratory



Lower limit for strength tests, also includes Graphitic Surfaces except S-6

REFERENCES

SCALE AS SHOWN
DATE NOV. 1979
MADE M.L.
CHKD. D.C.
APPD. D.C.

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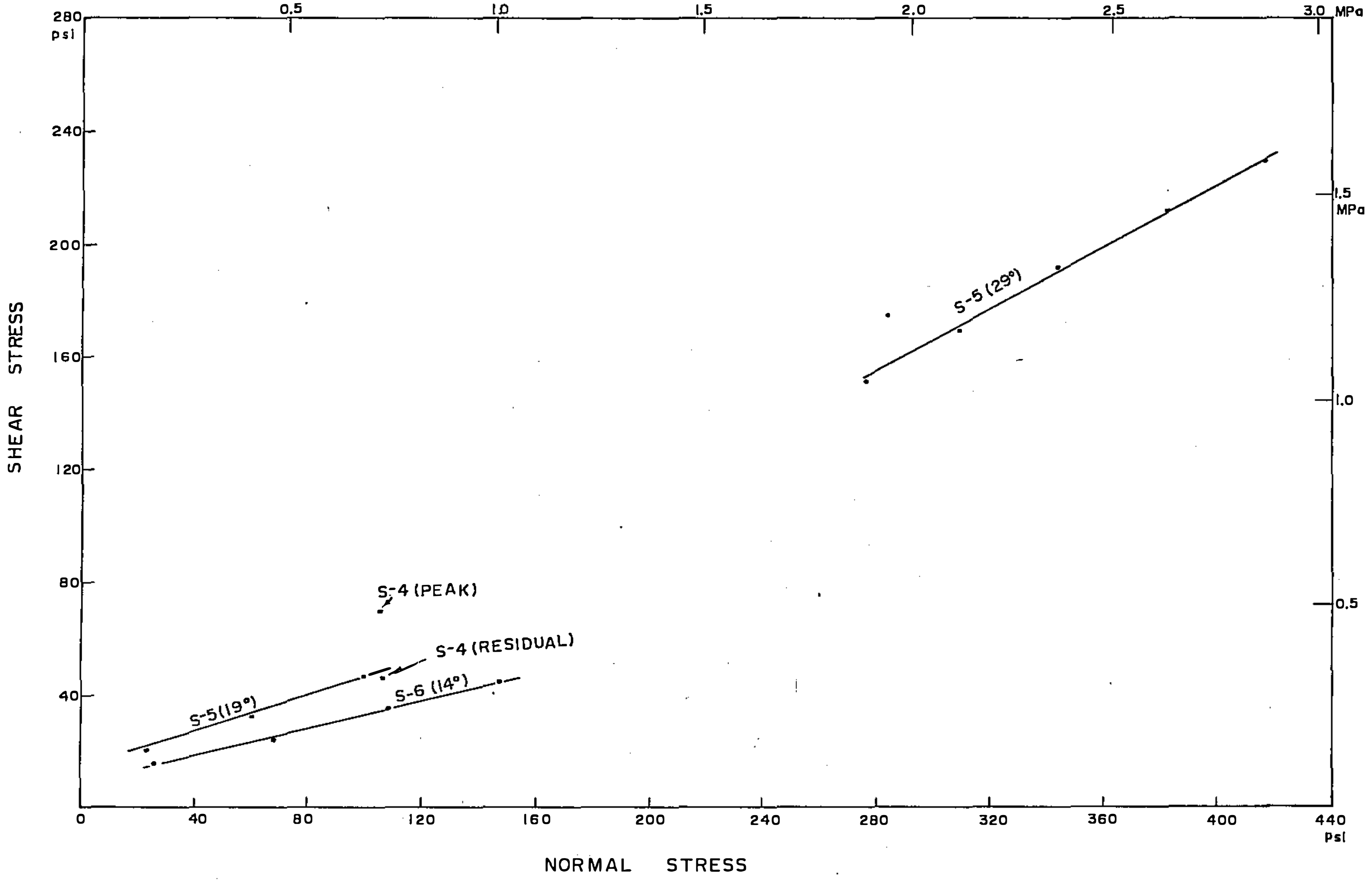
GRUM DEPOSIT
SUMMARY OF
SERICITIC SURFACES

No. Q2160-002

PLATE - B-1

HT14 . 79/05



REFERENCES

SCALE AS SHOWN
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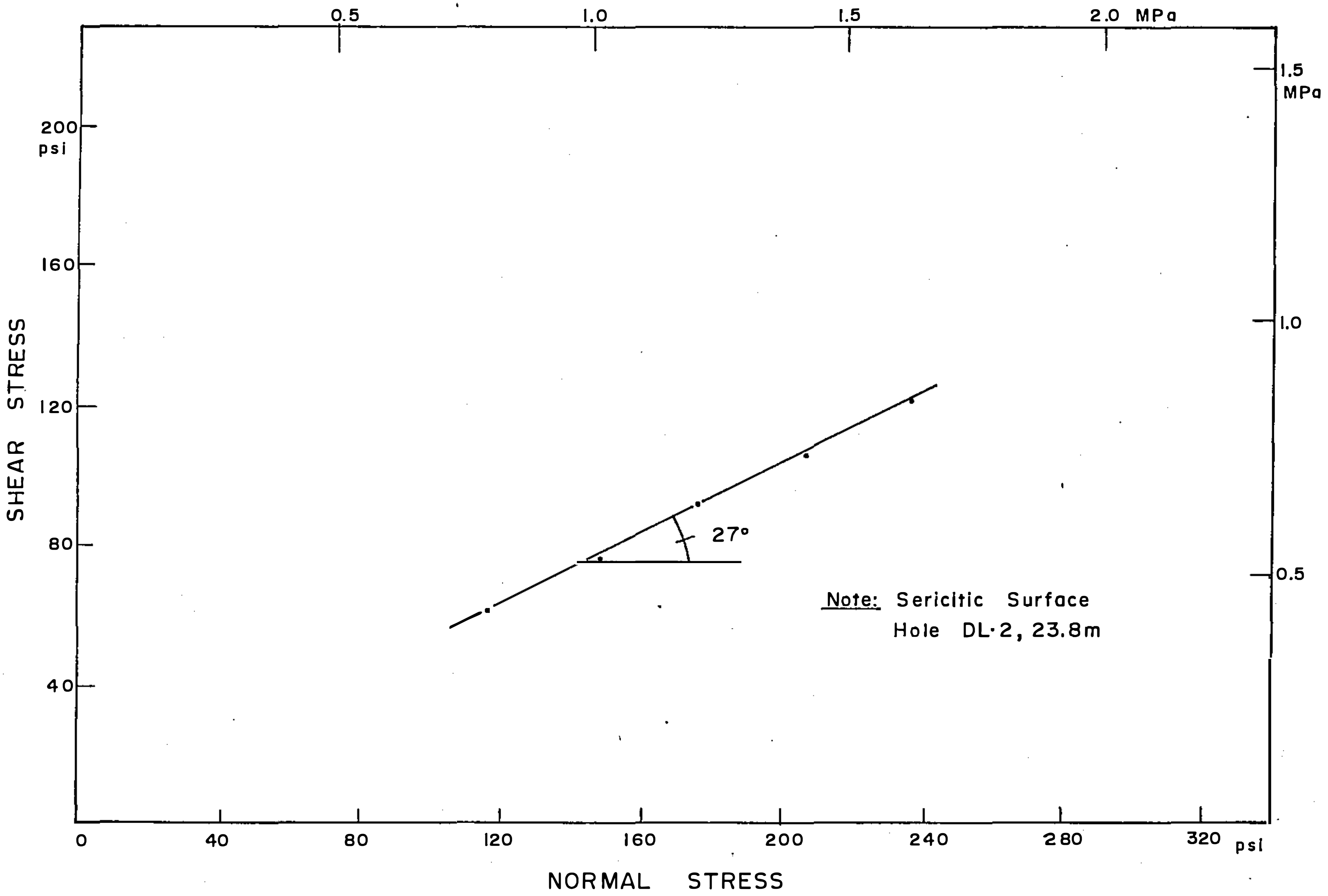
GRUM DEPOSIT
SUMMARY OF
GRAPHITIC SURFACES

No. Q2160-002

PLATE - B-2

HT14 - 79/05



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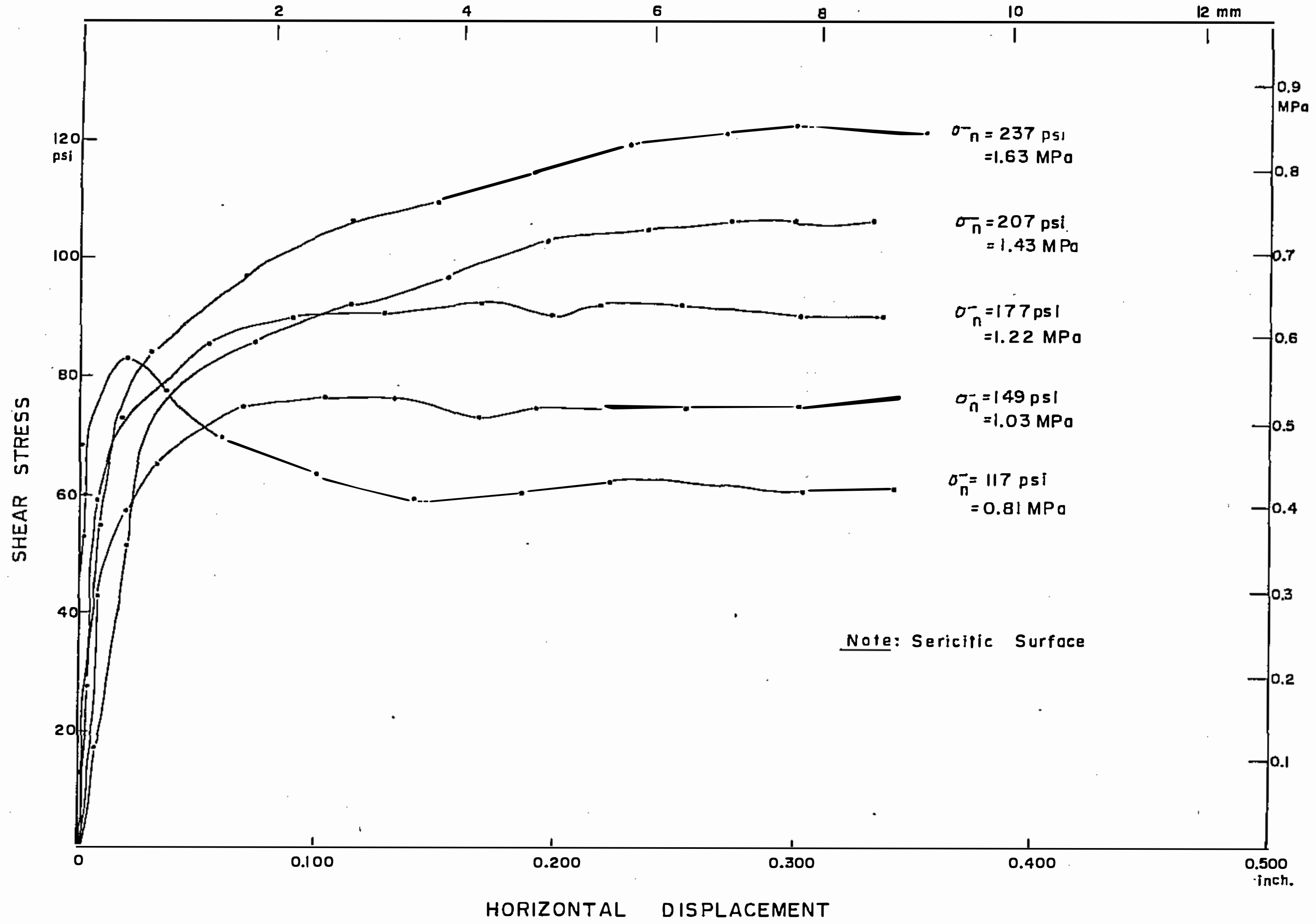
GRUM DEPOSIT
DIRECT SHEAR TEST
SAMPLE S-1

Q2160-002

PLATE-83A

HT10-79/05



REFERENCES

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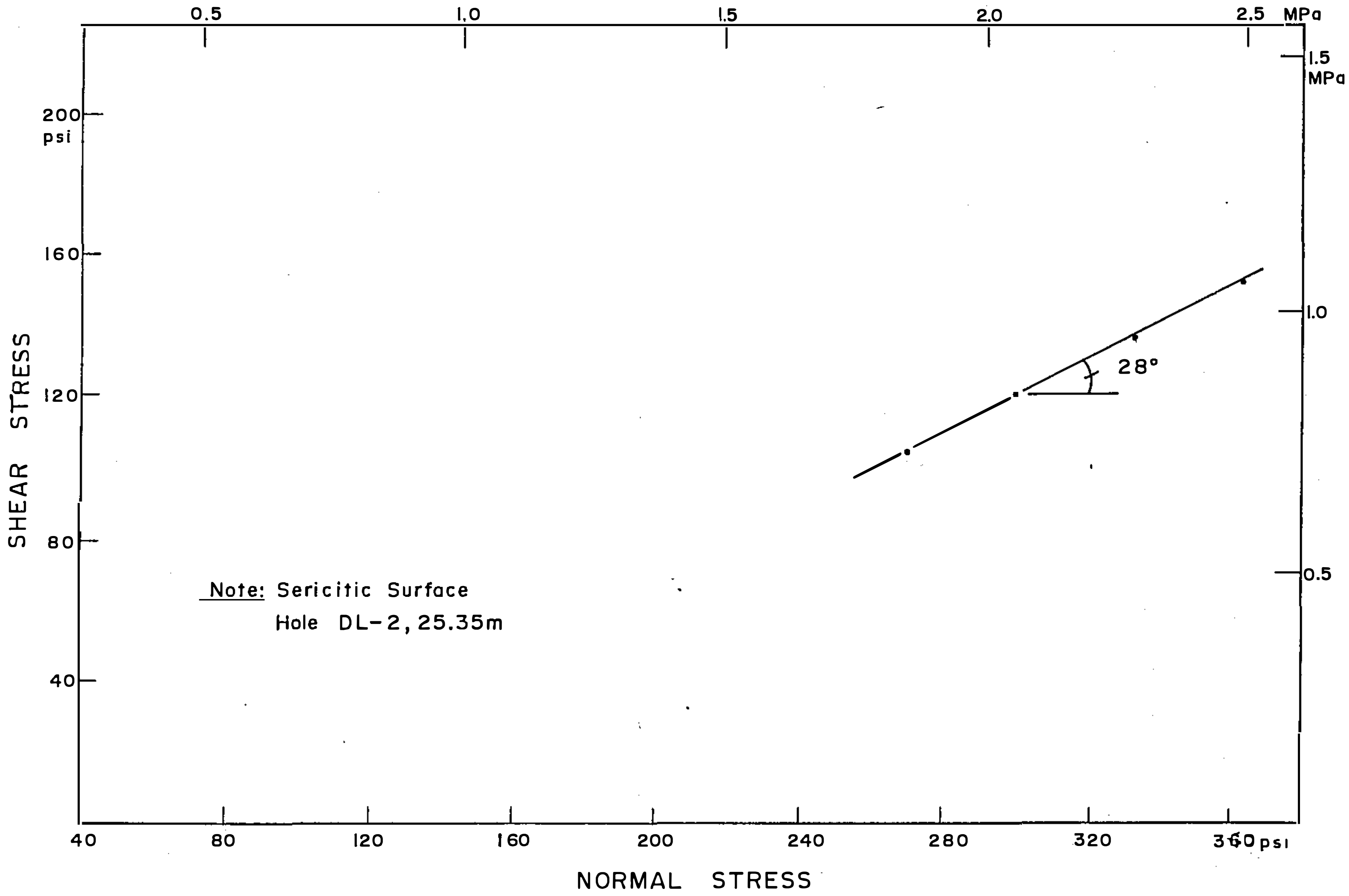
GRUM DEPOSIT
DIRECT SHEAR TEST
SAMPLE S-1

No. Q 2160-002

PLATE-B38

HT14 . 79/05



Note: Sericitic Surface
Hole DL-2, 25.35m

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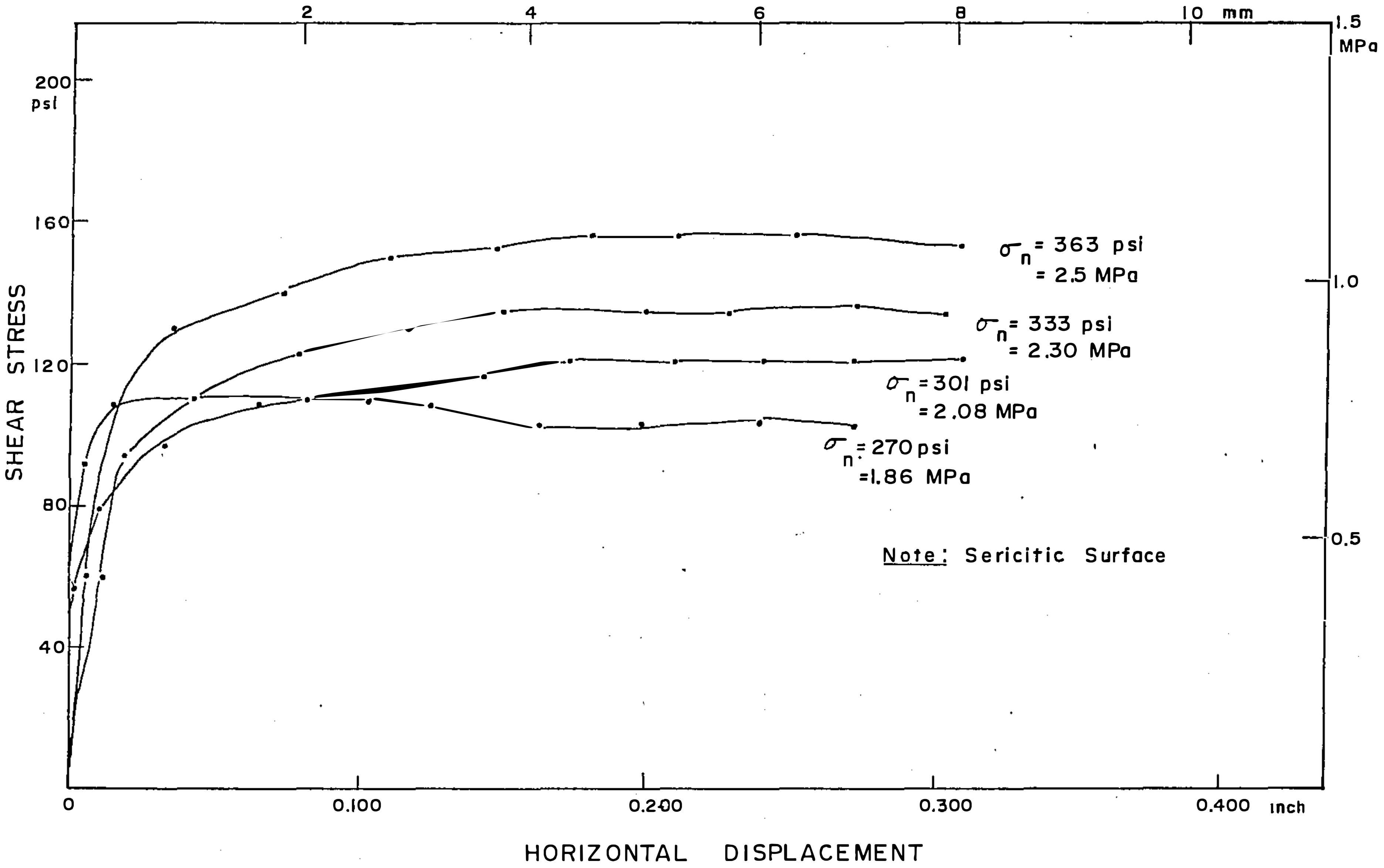
GRUM DEPOSIT
DIRECT SHEAR TEST
SAMPLE S-2

0 2160-002

PLATE -B-4A

HT10 - 79/05



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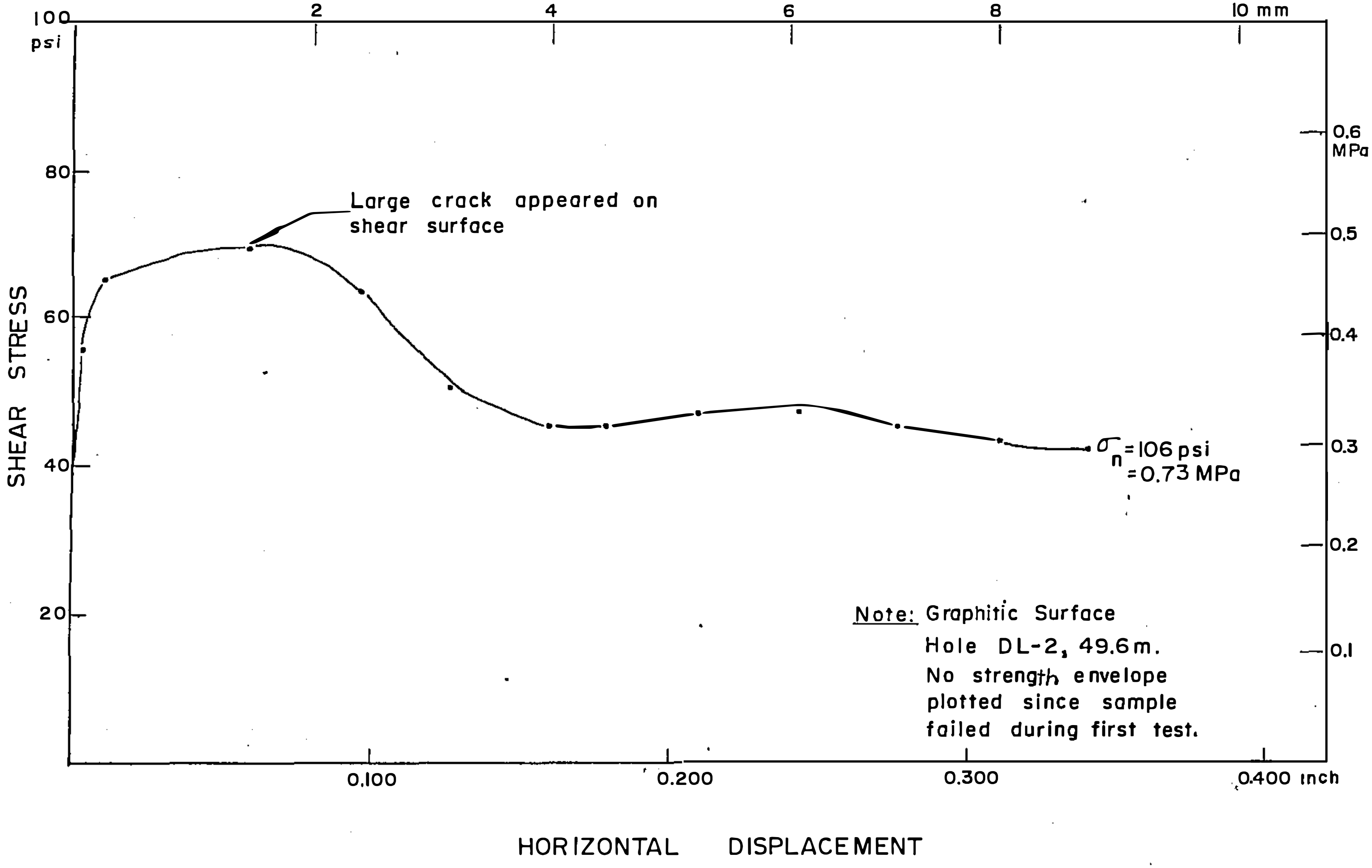
GRUM DEPOSIT
DIRECT SHEAR TEST
SAMPLE S-2

Q 2160-002

PLATE-B-4B

HT10-79/05



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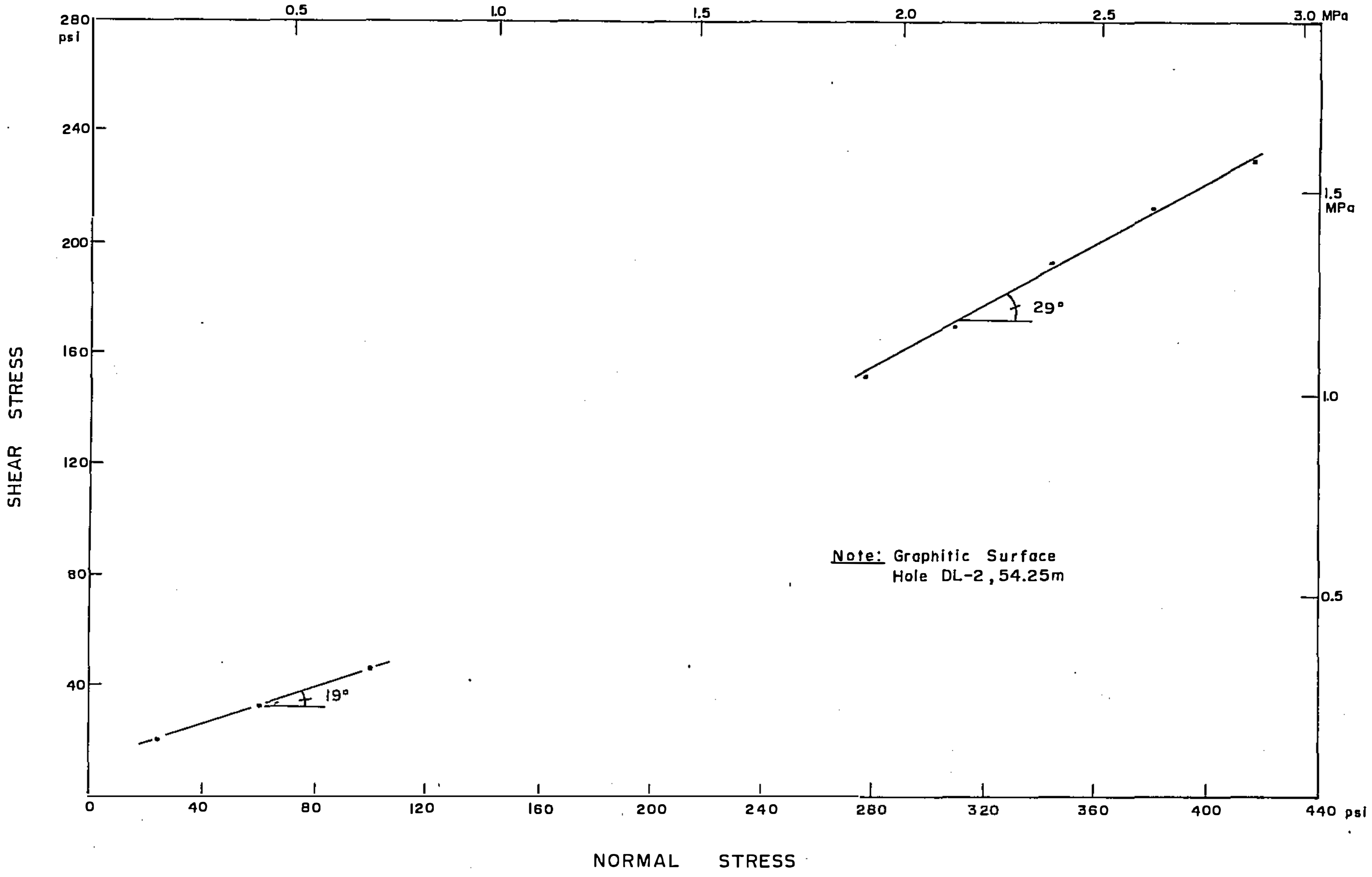
GRUM DEPOSIT
DIRECT SHEAR TEST
SAMPLE S-4

02160-002

PLATE B-5

HT10 - 79/05



REFERENCES

SCALE AS SHOWN
DATE NOV. 1979
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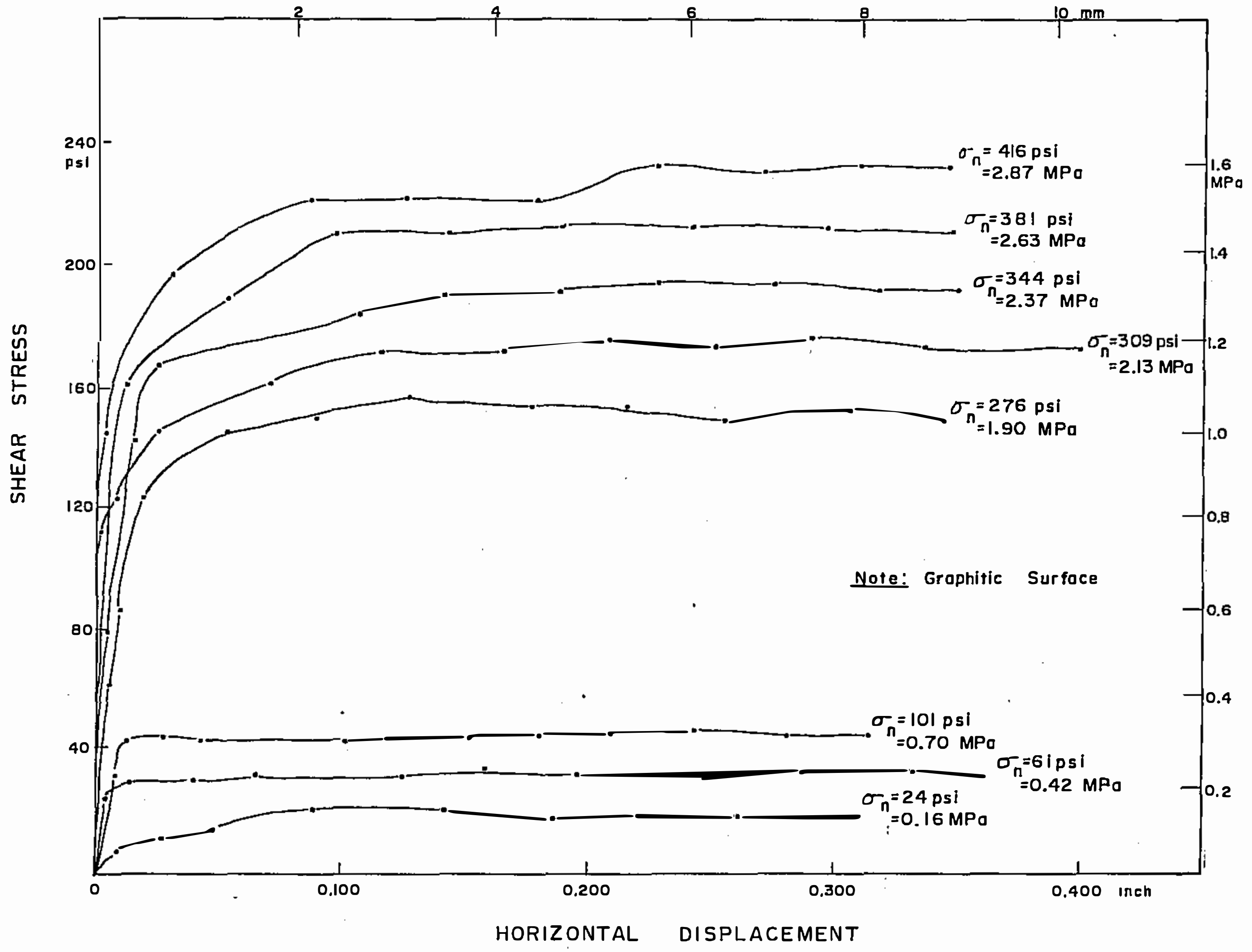
GRUM DEPOSIT
DIRECT SHEAR TEST
SAMPLE S-5

No. Q 2160-002

PLATE B-6A

HT14 - 79/05



REFERENCES

SCALE AS SHOWN
DATE NOV, 1979
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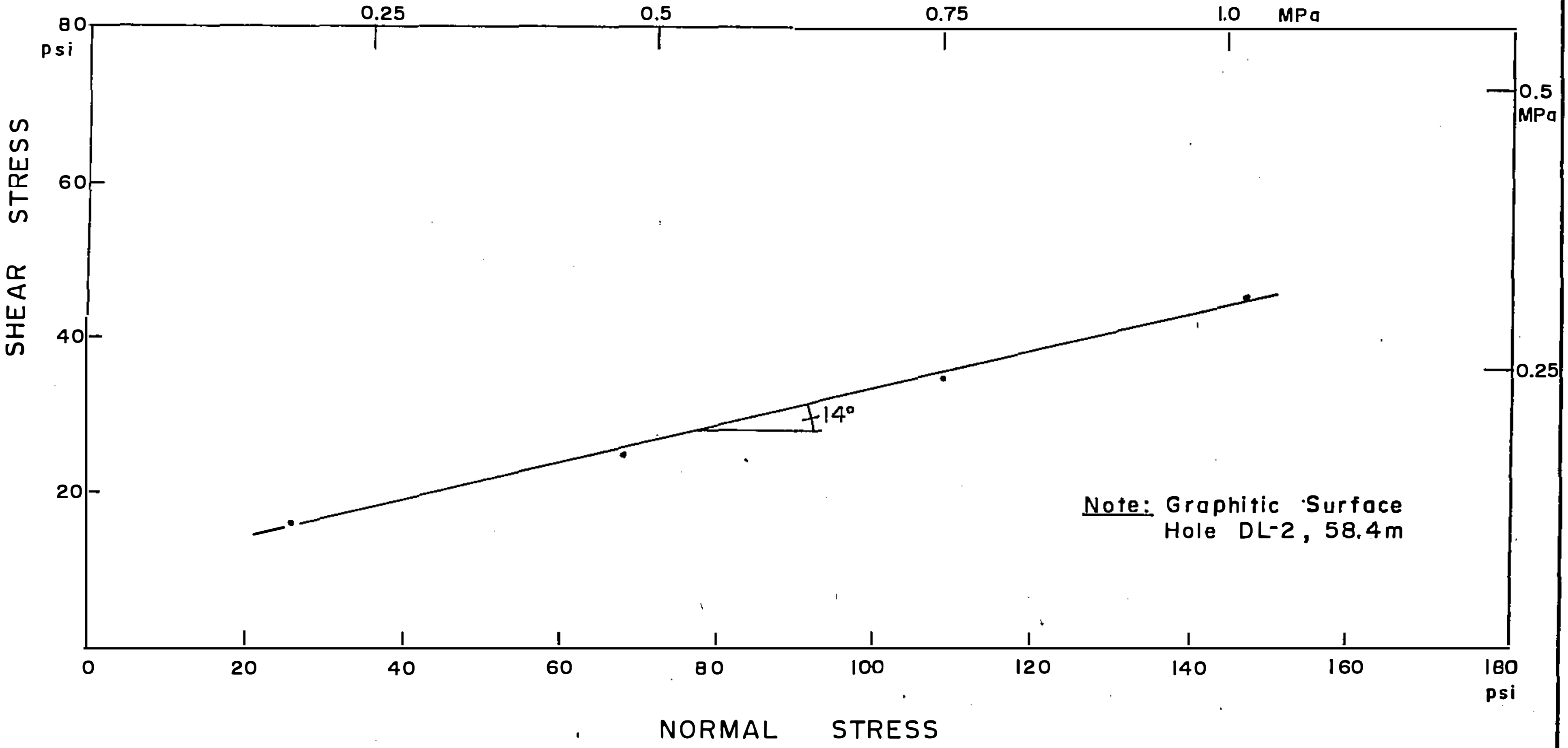
GRUM DEPOSIT
DIRECT SHEAR TEST
SAMPLE S-5

No. Q 2160-002
PLATE B-6B

HT14 - 79/05



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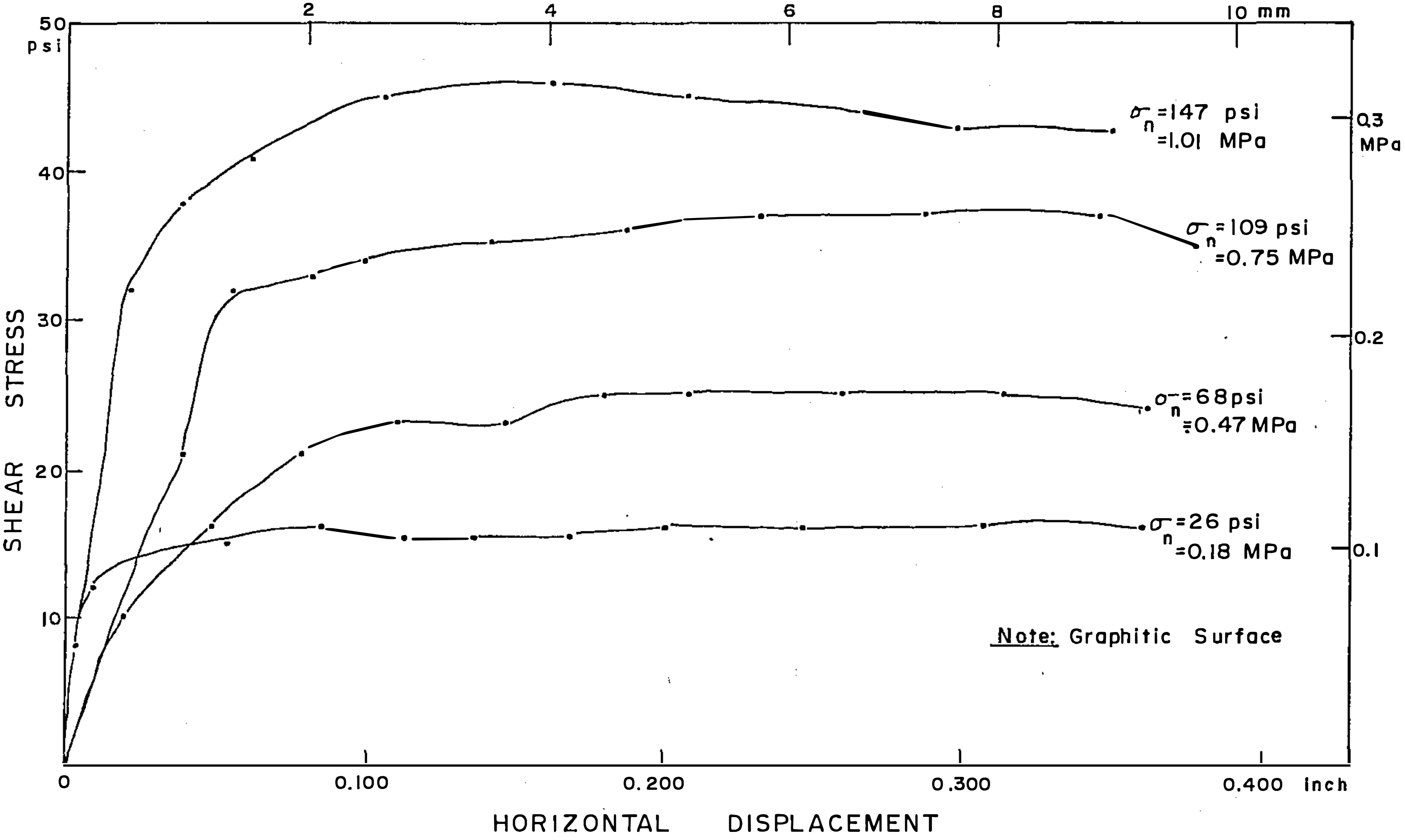
DRUM DEPOSIT
DIRECT SHEAR TEST
SAMPLE S-6

Q 2160-002

PLATE B-7A



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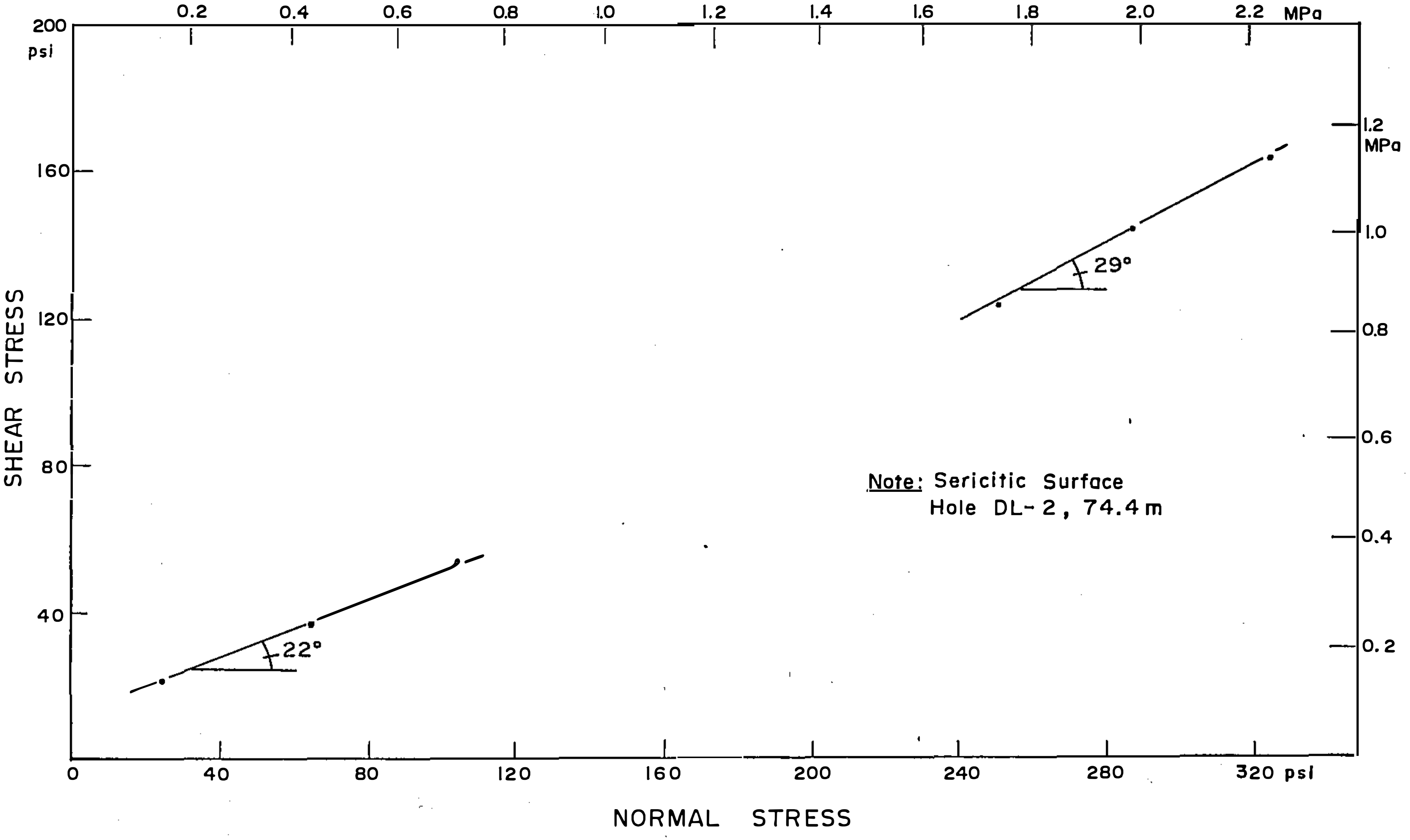
GRUM DEPOSIT
DIRECT SHEAR TEST
SAMPLE S-6

Q2160-002

PLATE B-78

HT10, 79/0



Note: Sericitic Surface
Hole DL-2, 74.4 m

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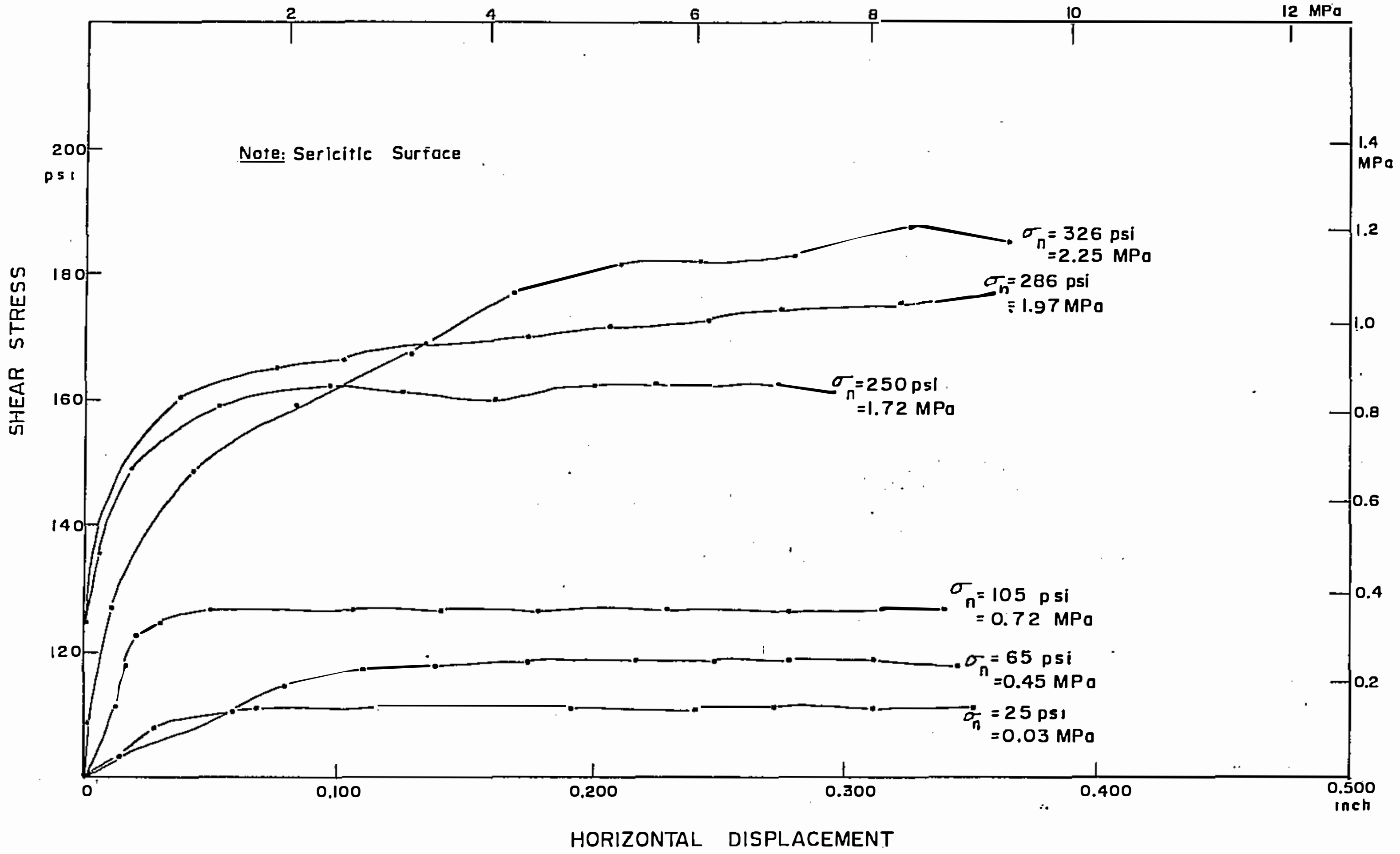
GRUM DEPOSIT
DIRECT SHEAR TEST
SAMPLE S-7

Q2160-002

PLATE B-BA

HT10



REFERENCES

SCALE AS SHOWN
DATE NOV, 1979
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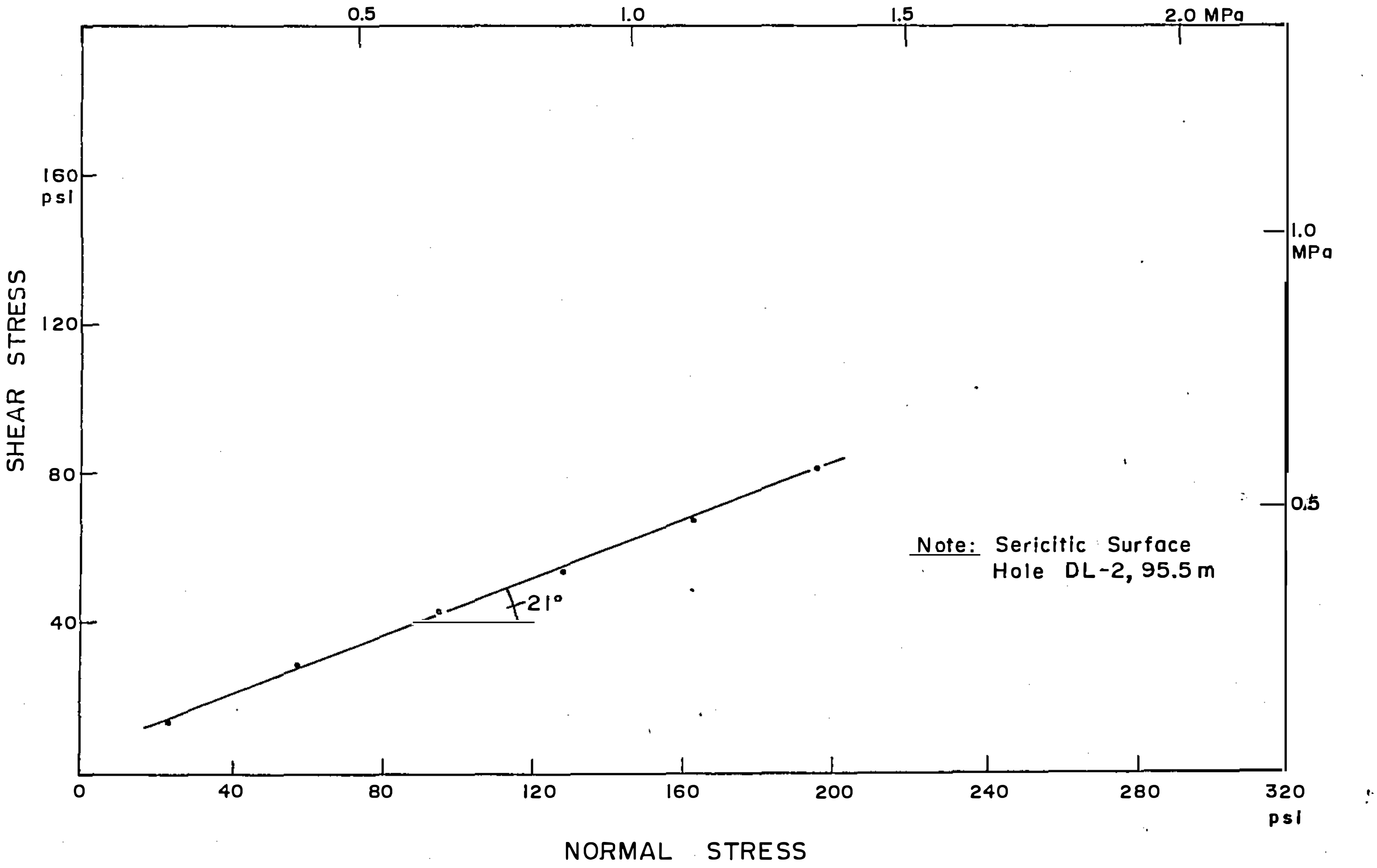
GRUM DEPOSIT
DIRECT SHEAR TEST
SAMPLE S-7

No. Q-2160-002
PLATE B-88

HT14 - 70/06



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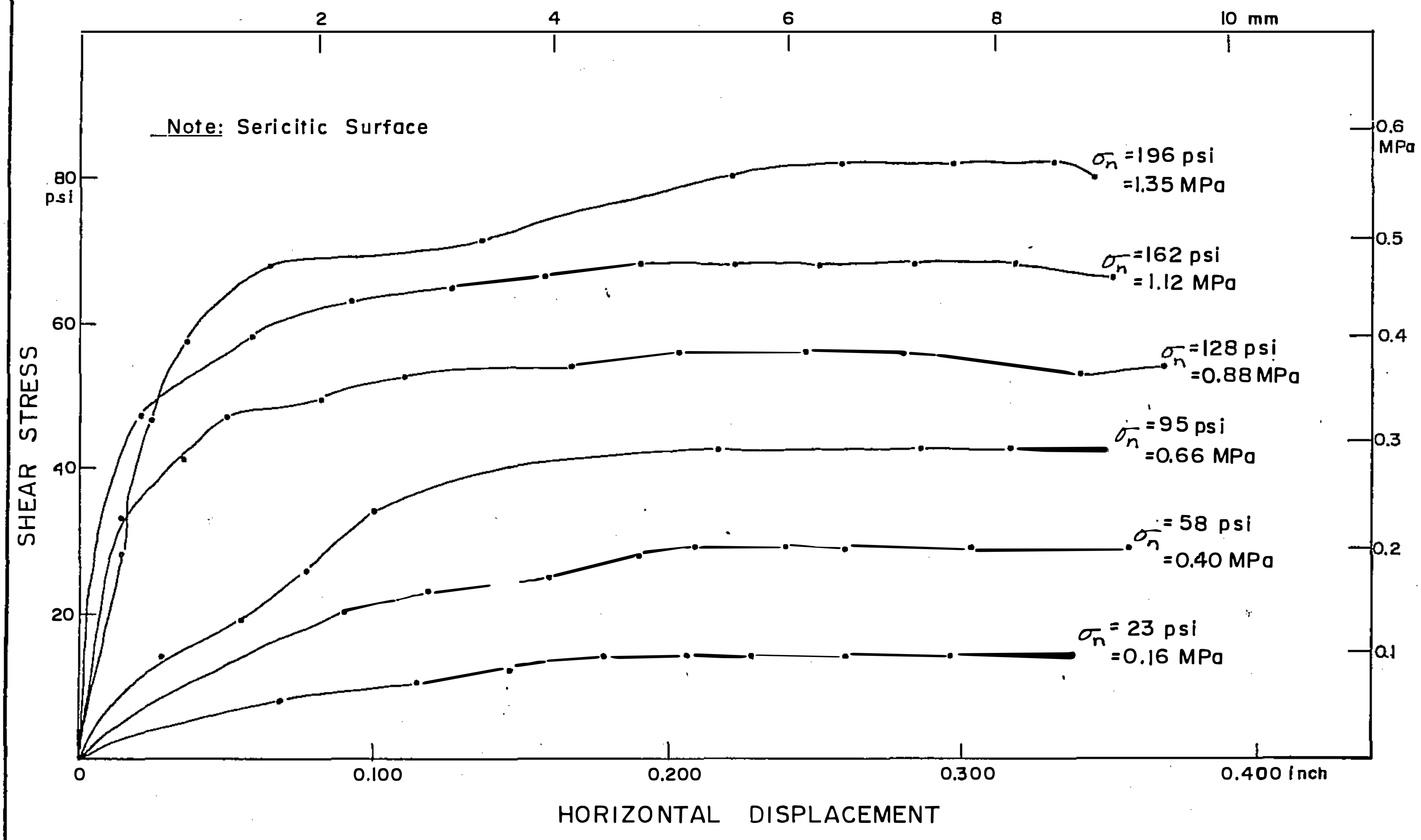
GRUM DEPOSIT
DIRECT SHEAR TEST
SAMPLE S-13

Q-2160-002

PLATE B-9A



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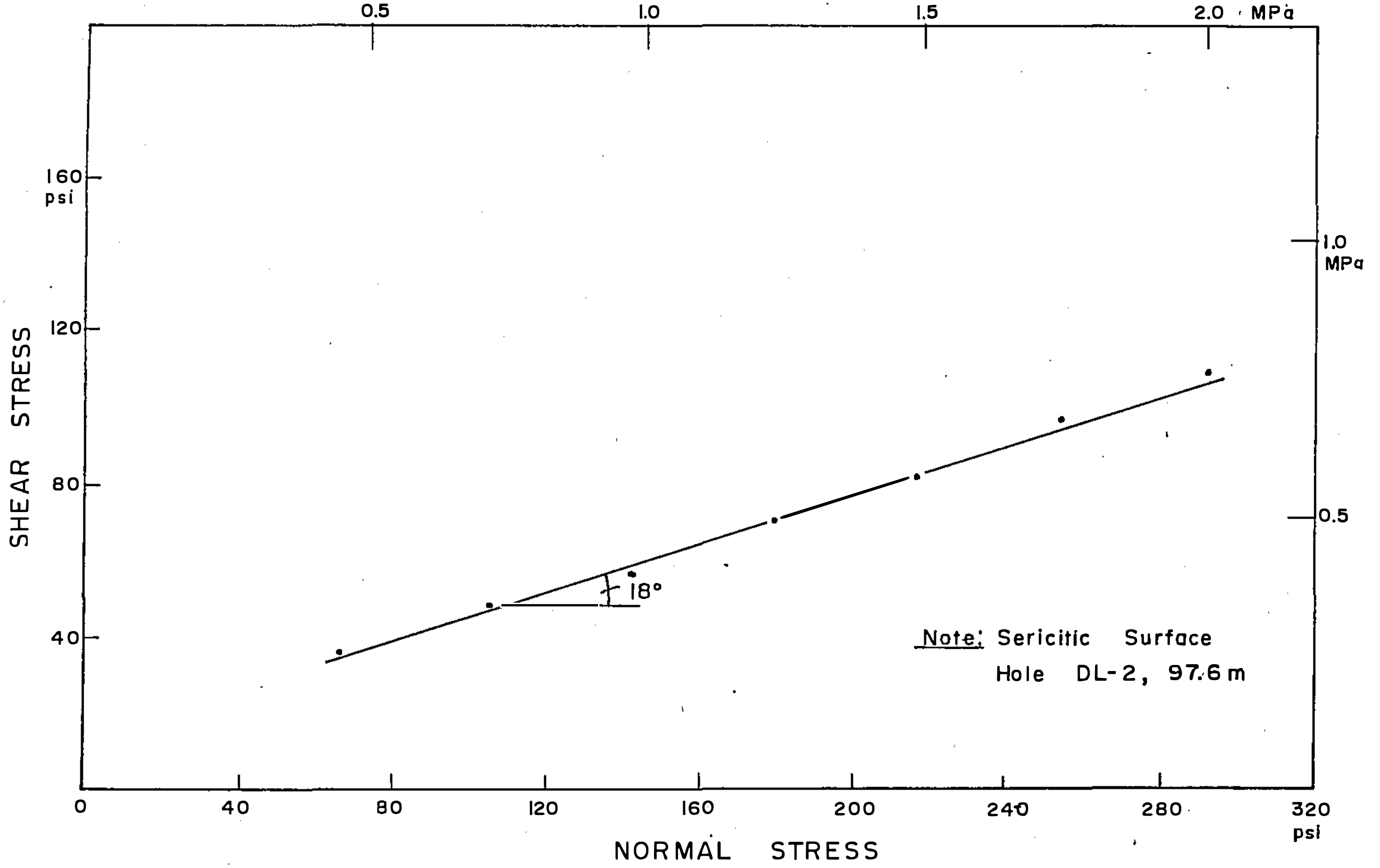
GRUM DEPOSIT
DIRECT SHEAR TEST
SAMPLE S-13

Q 2160-002

PLATE B-98



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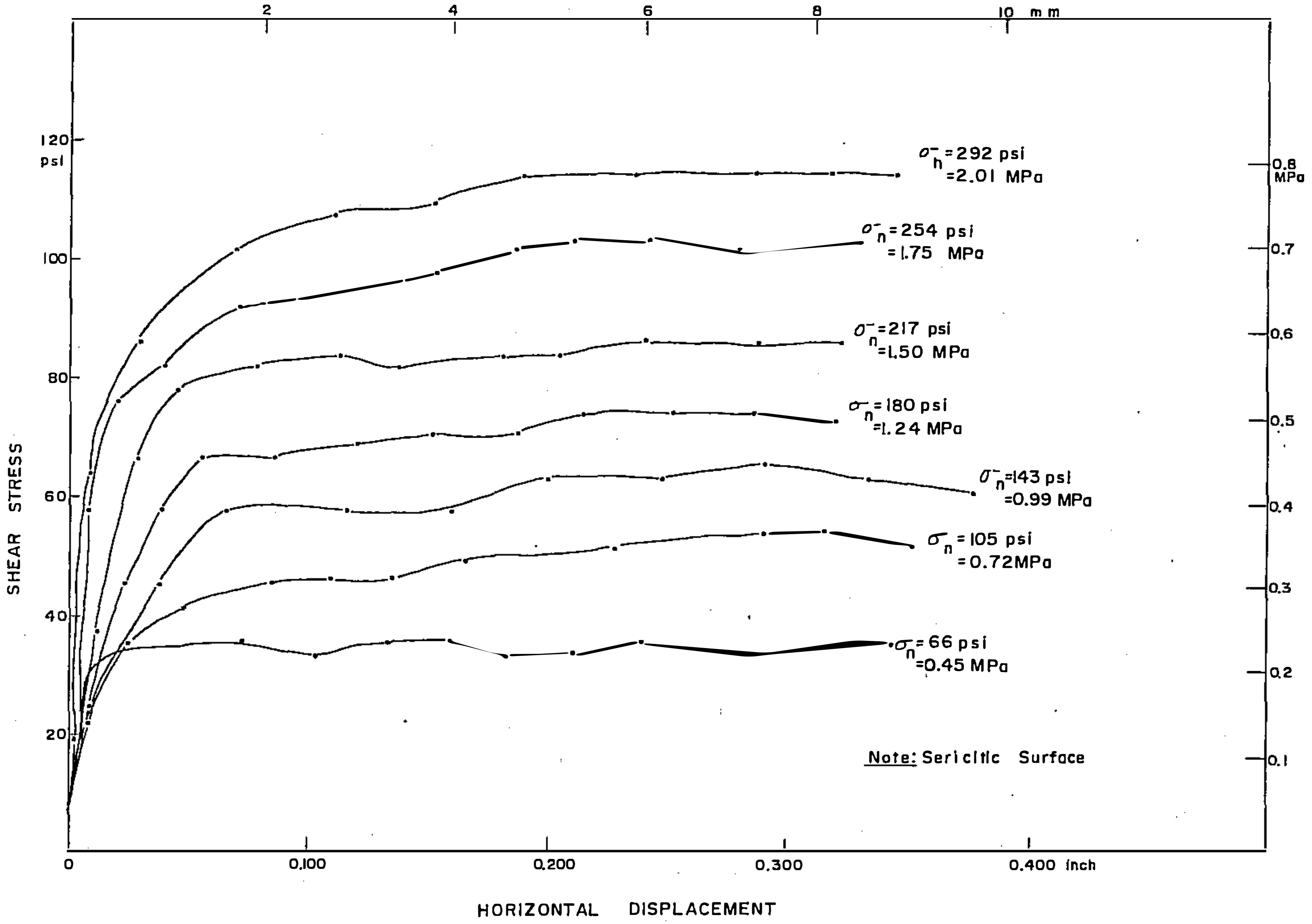
GRUM DEPOSIT
DIRECT SHEAR TEST
SAMPLE S-14

Q2160-002

PLATE B-10A

HT1



REFERENCES

SCALE AS SHOWN
DATE NOV, 1979
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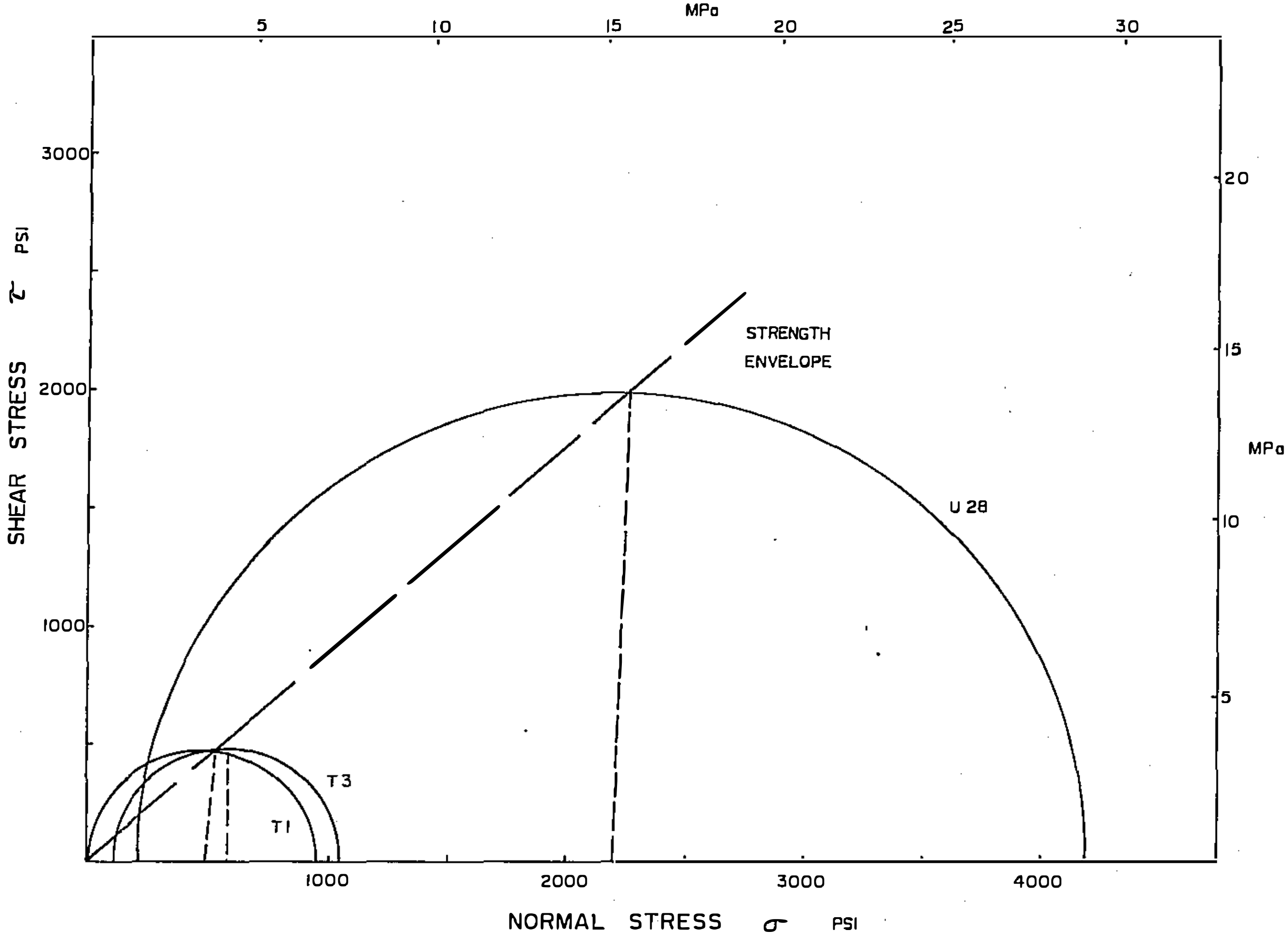
GRUM DEPOSIT
DIRECT SHEAR TEST
SAMPLE S-14

No. Q 2160-002
PLAT



NOTES:

1) PLOT IS PRESENTED FOR INFORMATION ONLY AND IS NOT BELIEVED TO TRULY REPRESENT THE PROPERTIES OF INTACT FOLIATION.

2) T-1, HOLE V-27-R, 43.9 m
T-3, HOLE V-27-R, 45.1 m
U-28, HOLE DL-3, 67.8 m

ALL CORE NQ.

3) T-1 AND T-5:
GRAPHITIC SURFACES, PLANAR.
T-1 BROKE ON FOLIATION IN MIDDLE OF SAMPLE,
T-3 BROKE ON FOLIATION WITH BREAK EXTENDING INTO PLATTEN.

4) U-28 BROKE ON ROUGH WAVY FOLIATION SURFACE EXTENDING INTO PLATTEN.

REVISIONS

REFERENCES

SCALE As Noted
DATE Dec. 4 / 79
MADE J R
CHKD.
APPD.

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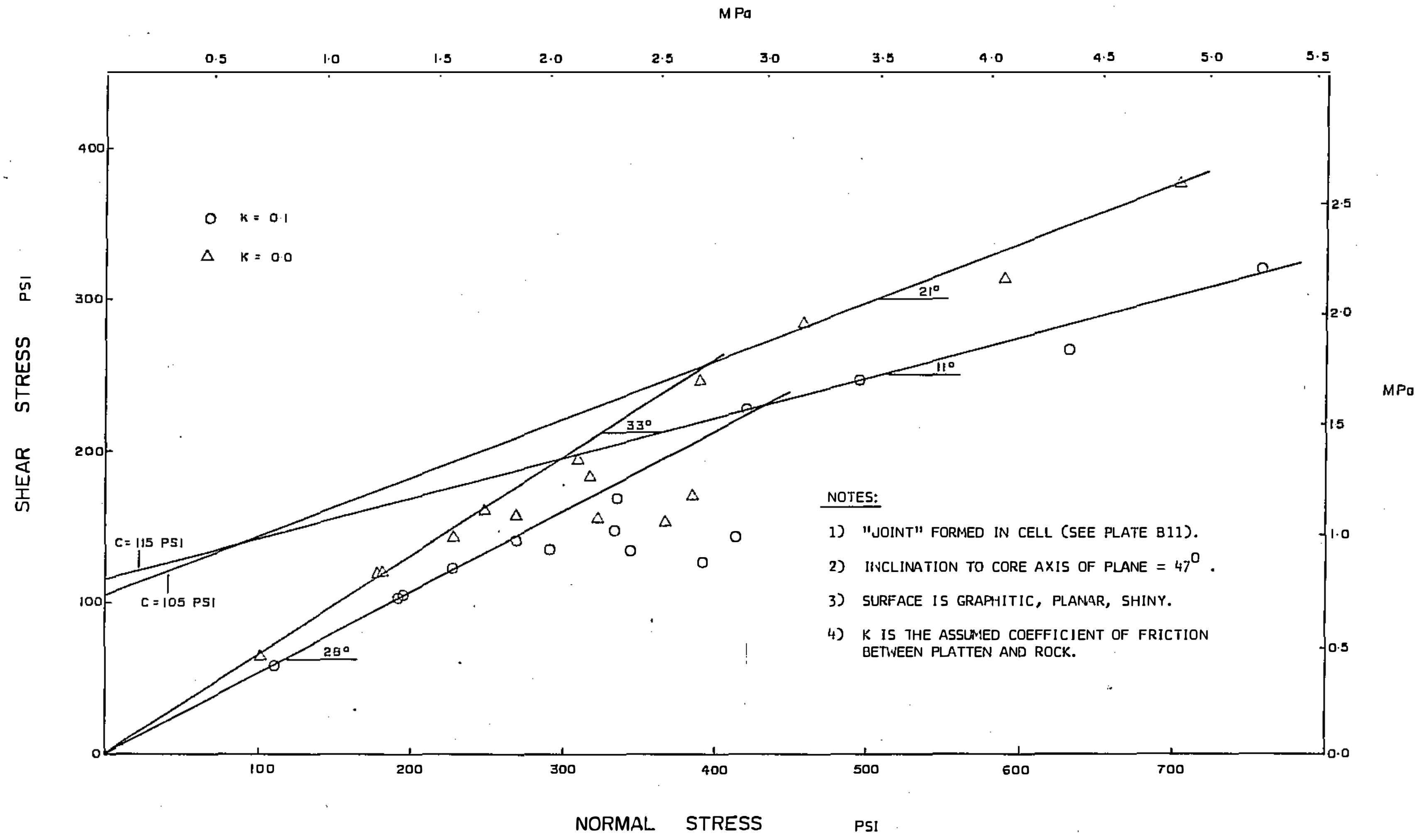
GRUM DEPOSIT
TRIAXIAL TEST ON INTACT

No. Q 2160-002



NOTES:

1) "JOINT" FORMED IN CELL (SEE PLATE B11).
2) INCLINATION TO CORE AXIS OF PLANE = 47^0 .
3) SURFACE IS GRAPHITIC, PLANAR, SHINY.
4) K IS THE ASSUMED COEFFICIENT OF FRICTION BETWEEN PLATTEN AND ROCK.

REVISIONS	REFERENCES	SCALE As Noted DATE Dec. 5 / 79 MADE J R CHKD. APPD.	**HARDY ASSOCIATES (1978) LTD.** CONSULTING ENGINEERING & PROFESSIONAL SERVICES	GRUM DEPOSIT STEP TRIAXIAL TEST **No.** Q 2160–002

APPENDIX C

GEOLOGIC MODEL

APPENDIX C

GEOLOGIC MODEL

PART 1 - INTRODUCTION

A preliminary model of geologic structure in the Grum deposit was prepared from data provided by Cyprus Anvil Mining Corporation. The purpose of constructing the model was twofold:

1) To determine what failure modes should be analyzed in the preparation of design charts and to determine the applicable range of discontinuity orientations.

2) To allow application of the design charts to produce a preliminary pit design.

The following tasks were undertaken during compilation of the model:

1) Logs of diamond drill holes along three sections in the pit area (64W, 72W and 80W) were examined in detail.

2) Underground geologic mapping of foliation, faults and joints in the decline was plotted on computer produced stereonets. Data was taken from Kerr Addison Mines Ltd.'s. "Geological Plan in Plane of the Underground Workings", 1977, east and west sheets.

3) Surface foliation data was plotted on computer generated steronets. Surface data was taken from Cyprus Anvil Mining Corporation's D_2-Post D_2 Structural Overlay, revised to 1978, sheet F-6. Data was taken from a rectangular area around the Grum deposit bounded on the northeast by a line extending 24,000 ft southeast and a second line extending 14,000 ft S.W. forming the southeast side. The area is bounded by Vangorda Creek to the southwest and the edge of the map sheet to the northwest.

4) Using the plot of surface foliation data, the average foliation strike was estimated to be 000° true. This figure was used to calculate true foliation dips from apparent dips shown on Kerr Addison geologic sections for the Grum area. Similarly, fault strike on Kerr Addison geologic plans for different elevations was used to calculate true fault dip.

6) Geologic data was compiled on three plans at different elevations.

PART 2 - SUMMARY OF MODEL

Throughgoing discontinuities include faults, joints and foliation. Stereonet plots of orientation of these features in the decline and of surface foliation appear on Plates C-2 to C-11. The data used to generate the stereonets is shown on Plates C-1A to C-1H. Plate C-1I gives the meaning of symbols appearing on the stereonet. Plate C-12 shows a schematic plan of the decline layout and the zones used for plotting the stereonets. Division of the decline into zones was based on the orientation and direction of dip of foliation.

Average orientations of features are shown in Table I.

TABLE I

AVERAGE ORIENTATIONS OF DISCONTINUITIES

FEATURE	ORIENTATION[1] STRIKE/DIP	LOCATION
Foliation (S2)	000/17° W.	Surface
Foliation (S2)	350/9° W.	Decline Zones 1, 2 and 3
Faults	266/78° N.	Decline Zones 1, 2 and 3

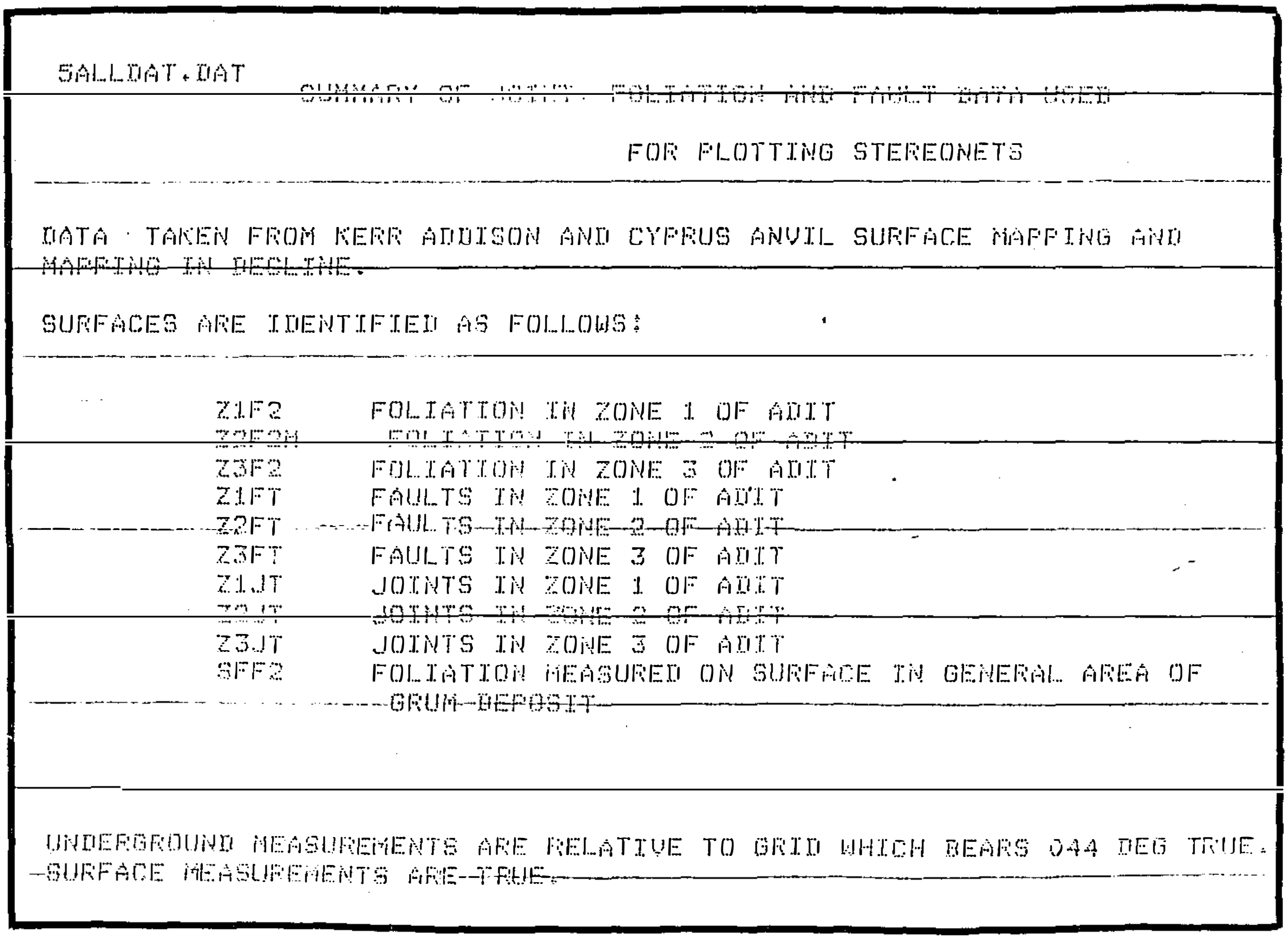
Faults	236/80 N.W.	Decline Zones 1, 2 and 3
Joints	055/90°	Decline zones 1, 2 and 3

[1] Orientations are relative to true north.

Orientations of faults from the decline were assumed to be valid for the S.E. and N.E. pit walls and were used directly in the wedge analyses. As indicated previously, surface foliation strike was used to calculate true dip from available Kerr Addison sections. Joint data was not used in the analysis since most joints measured in the decline occur within the ore zone and it is probably unrealistic to extrapolate this data to walls outside the ore zone.

The geologic model adopted is shown schematically on Plates C-13 to C-15. In general, foliation dips are to the west except in the ore zone where dips to the east also occur. Foliation orientation implies that failure on the N.E. and S.E. walls could potentially occur along foliation. On these walls, foliation dips are generally steepest near the top of the wall (up to 70°) and decrease to 33° or 34° near the bottom of the wall.

Major throughgoing faults shown on Plates C-13 to C-15 are taken from Kerr Addison maps which apparently omit smaller faults unimportant to the geology of the ore zone but which could possibly have geotechnical importance. Most of the faults shown by Kerr Addison on their geologic plans are relatively steeply dipping; however, it is apparent from stereonet plots of decline fault data (Plates C-8 to C-10) that more shallowly dipping features do occur. Unfortunately, insufficient data is available to allow a statistically valid estimate of shallow dipping fault orientations to be made.



5ALLDAT.DAT ~~SUMMARY OF JOINT, FOLIATION AND FAULT DATA USED~~

FOR PLOTTING STEREONETS

DATA TAKEN FROM KERR ADDISON AND CYPRUS ANVIL SURFACE MAPPING AND ~~MAPPING IN DECLINE.~~

SURFACES ARE IDENTIFIED AS FOLLOWS:

Z1F2	FOLIATION IN ZONE 1 OF ADIT
~~Z2F2M~~	~~FOLIATION IN ZONE 2 OF ADIT~~
Z3F2	FOLIATION IN ZONE 3 OF ADIT
Z1FT	FAULTS IN ZONE 1 OF ADIT
~~Z2FT~~	~~FAULTS IN ZONE 2 OF ADIT~~
Z3FT	FAULTS IN ZONE 3 OF ADIT
Z1JT	JOINTS IN ZONE 1 OF ADIT
~~Z2JT~~	~~JOINTS IN ZONE 2 OF ADIT~~
Z3JT	JOINTS IN ZONE 3 OF ADIT
SFF2	FOLIATION MEASURED ON SURFACE IN GENERAL AREA OF ~~GRUM DEPOSIT~~

UNDERGROUND MEASUREMENTS ARE RELATIVE TO GRID WHICH BEARS 044 DEG TRUE. ~~SURFACE MEASUREMENTS ARE TRUE.~~

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GRUM DEPOSIT
SUMMARY OF JOINT, FOLIATION AND FAULT DATA FOR STEREONET PLOTTING

Q2160-002

Plate C-1A

CODE	STRIKE	DIP
DATA:		
Z1JT	010.0	85.0 W
Z1JT	359.0	85.0 E
Z1JT	014.0	85.0 E
Z1JT	000.0	80.0 E
Z1JT	185.0	90.0 E
~~Z1JT~~	~~187.0~~	~~90.0 E~~
Z1JT	208.0	70.0 W
Z1JT	211.0	70.0 E
Z1JT	007.0	90.0 W
Z1JT	352.0	90.0 W
Z1JT	357.0	75.0 E
~~Z1JT~~	~~348.0~~	~~75.0 E~~
Z1JT	356.0	70.0 E
Z1JT	170.0	90.0 E
Z1JT	351.0	60.0 W
Z2JT	206.0	90.0 W
Z2JT	206.0	90.0 W
~~Z2JT~~	~~056.0~~	~~90.0 W~~
Z2JT	016.0	90.0 W
Z2JT	067.0	70.0 SE
Z2JT	112.0	70.0 NE
Z2JT	185.0	80.0 W
Z2JT	198.0	70.0 E
Z3JT	358.0	85.0 E
Z3JT	042.0	90.0 S
Z3JT	018.0	90.0 W
Z3JT	024.0	60.0 SE
Z3JT	014.0	90.0 W
Z3JT	176.0	80.0 W
~~Z3JT~~	~~352.0~~	~~90.0 E~~
Z3JT	014.0	90.0 W
Z3JT	008.0	90.0 W
Z3JT	355.0	90.0 W
Z3JT	007.0	90.0 W
Z3JT	349.0	80.0 E
~~Z3JT~~	~~012.0~~	~~0.90 W~~
Z3JT	173.0	70.0 E
Z3JT	010.0	80.0 E
Z3JT	017.0	90.0 E
Z3JT	016.0	90.0 E
Z3JT	200.0	60.0 E
~~Z3JT~~	~~153.0~~	~~60.0 E~~
Z3JT	005.0	90.0 E
Z3JT	002.0	90.0 E
~~Z3JT~~	~~002.0~~	~~90.0 E~~
Z3JT	297.0	01.0 SW

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GRUM DEPOSIT
SUMMARY OF JOINT, FOLIATION AND FAULT DATA FOR STEREONET PLOTTING

Q2160-002

PlateC-1B

CODE	STRIKE	DIP
Z1F2	116.0	10.0 N
Z1F2	[illegible]	10.0 N
Z1F2	035.0	25.0 W
Z1F2	053.0	30.0 NW
~~Z1F2~~	~~172.0~~	~~90.0 W~~
Z1F2	203.0	30.0 W
Z1F2	234.0	30.0 W
Z1F2	[illegible]	25.0 W
Z1F2	088.0	40.0 N
Z1F2	090.0	10.0 N
~~Z1F2~~	~~088.0~~	~~10.0 N~~
Z1F2	86.0	15.0 N
Z1F2	077.0	30.0 N
Z1F2	[illegible]	30.0 N
Z1F2	101.0	25.0 N
Z1F2	103.0	20.0 N
~~Z1F1~~	~~090.0~~	~~30.0 N~~
Z1F2	076.0	45.0 N
Z1F2	097.0	35.0 N
Z1F2	[illegible]	35.0 N
Z1F2	129.0	20.0 N
Z1F2	133.0	45.0 SW
~~Z1F2~~	~~028.0~~	~~22.0 SE~~
Z1F2	235.0	10.0 SW
Z1F2	099.0	40.0 S
Z1F2	084.0	70.0 S
Z2F2	105.0	15.0 S
Z2F2	025.0	05.0 W
~~Z2F2~~	~~321.0~~	~~35.0 SW~~
Z2F2	129.0	20.0 SW
Z2F2	127.0	50.0 SW
Z2F2	115.0	20.0 SW
Z2F2	057.0	25.0 NW
Z2F2	093.0	20.0 S
~~Z2F2~~	~~065.0~~	~~30.0 NW~~
Z2F2	050.0	10.0 SE
Z2F2	000.0	00.0 E
Z2F2	125.0	25.0 NE
Z2F2	124.0	15.0 NE
Z2F2	206.0	10.0 SE
Z2F2	062.0	05.0 SE
Z2F2	012.0	10.0 W
Z2F2	130.0	10.0 SW
Z2F2	[illegible]	40.0 SW
Z2F2	100.0	75.0 S
Z2F2	160.0	10.0 W
~~Z2F2~~	~~149.0~~	~~50.0 SW~~
Z2F2	140.0	65.0 SW
Z2F2	038.0	50.0 SE
Z2F2	184.0	10.0 W
Z2F2	127.0	20.0 SW
Z2F2	149.0	10.0 SW

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

GRUM DEPOSIT
SUMMARY OF JOINT, FOLIATION AND
FAULT DATA FOR STEREONET PLOTTING

Q2160-002

Plate C-1

HT09 - 79/05

CODE	STRIKE	DIP
~~Z2F2~~	~~126.5~~	~~45.0 SW~~
Z3F2	023.0	10.0 W
Z3F2	306.0	10.0 SW
~~Z3F2~~	~~092.0~~	~~05.0 S~~
Z3F2	082.0	01.0 S
Z3F2	058.0	10.0 N
~~Z3F2~~	~~293.0~~	~~20.0 SW~~
Z3F2	232.0	30.0 NW
Z3F2	049.0	15.0 N
~~Z3F2~~	~~019.0~~	~~10.0 W~~
Z3F2	080.0	30.0 S
Z3F2	285.0	10.0 S
~~Z3F2~~	~~178.0~~	~~50.0 W~~
Z3F2	278.0	20.0 S
Z3F2	091.0	30.0 S
~~Z3F2~~	~~090.0~~	~~75.0 S~~
Z3F2	092.0	30.0 S
Z3F2	097.0	10.0 S
~~Z3F2~~	~~359.0~~	~~20.0 W~~
Z3F2	273.0	30.0 S
Z3F2	358.0	01.0 E
Z1F2	116.0	10.0 N
~~Z1F2~~	~~106.0~~	~~10.0 N~~
Z1F2	035.0	25.0 W
Z1F2	053.0	30.0 NW
~~Z1F2~~	~~172.0~~	~~90.0 W~~
Z1F2	203.0	30.0 W
Z1F2	234.0	30.0 W
~~Z1F2~~	~~169.0~~	~~25.0 W~~
Z1F2	088.0	40.0 N
Z1F2	090.0	10.0 N
~~Z1F2~~	~~088.0~~	~~10.0 N~~
Z1F2	86.0	15.0 N
Z1F2	077.0	30.0 N
~~Z1F2~~	~~100.0~~	~~30.0 N~~
Z1F2	101.0	25.0 N
Z1F2	103.0	20.0 N
~~Z1F1~~	~~090.0~~	~~30.0 N~~
Z1F2	076.0	45.0 N
Z1F2	097.0	35.0 N
~~Z1F2~~	~~100.0~~	~~35.0 N~~
Z1F2	129.0	20.0 N
Z1F2	133.0	45.0 SW
~~Z1F2~~	~~028.0~~	~~22.0 SE~~
Z1F2	235.0	10.0 SW
Z1F2	099.0	40.0 S
~~Z1F2~~	~~084.0~~	~~90.0 S~~
Z2F2	105.0	15.0 S
Z2F2	025.0	05.0 W
Z2F2	321.0	35.0 SW

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

GRUM DEPOSIT

SUMMARY OF JOINT, FOLIATION AND FAULT DATA FOR STEREONET PLOTTING

Q2160-002

Plate C-1D

CODE	STRIKE	DIP
Z2F2	129.0	20.0 SW
Z2F2	127.0	50.0 SW
Z2F2	115.0	20.0 SW
Z2F2	057.0	25.0 NW
Z2F2	093.0	20.0 S
~~Z2F2~~	~~065.0~~	~~30.0 NW~~
Z2F2	050.0	10.0 SE
Z2F2	000.0	00.0 E
Z2F2	125.0	25.0 NE
Z2F2	124.0	15.0 NE
Z2F2	206.0	10.0 SE
~~Z2F2~~	~~062.0~~	~~05.0 SE~~
Z2F2	012.0	10.0 W
Z2F2	130.0	10.0 SW
Z2F2	118.0	40.0 SW
Z2F2	100.0	75.0 S
Z2F2	160.0	10.0 W
~~Z2F2~~	~~149.0~~	~~50.0 SW~~
Z2F2	140.0	65.0 SW
Z2F2	038.0	50.0 SE
Z2F2	184.0	10.0 W
Z2F2	127.0	20.0 SW
Z2F2	149.0	10.0 SW
~~Z2F2~~	~~126.5~~	~~45.0 SW~~
Z3F2	023.0	10.0 W
Z3F2	306.0	10.0 SW
Z3F2	092.0	05.0 S
Z3F2	082.0	01.0 S
Z3F2	058.0	10.0 N
~~Z3F2~~	~~293.0~~	~~20.0 SW~~
Z3F2	232.0	30.0 NW
Z3F2	049.0	15.0 N
Z3F2	019.0	10.0 W
Z3F2	080.0	30.0 S
Z3F2	285.0	10.0 S
~~Z3F2~~	~~178.0~~	~~50.0 W~~
Z3F2	278.0	20.0 S
Z3F2	091.0	30.0 S
Z3F2	070.0	75.0 S
Z3F2	092.0	30.0 S
Z3F2	097.0	10.0 S
~~Z3F2~~	~~359.0~~	~~20.0 W~~
Z3F2	273.0	30.0 S
Z3F2	358.0	01.0 E

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

GRUM DEPOSIT
SUMMARY OF JOINT, FOLIATION AND
FAULT DATA FOR STEREONET PLOTTING

Q2160-002

Plate C-1E

CODE	STRIKE	DIP
SFF2	175.0	18.0 W
SFF2	185.0	14.0 E
SFF2	010.0	12.0 W
SFF2	007.0	15.0 W
SFF2	173.0	36.0 W
SFF2	150.0	34.0 SW
SFF2	119.0	30.0 S
SFF2	000.0	32.0 W
SFF2	003.0	35.0 SW
SFF2	137.0	25.0 S
SFF2	025.0	12.0 E
SFF2	170.0	18.0 NE
SFF2	022.0	53.0 E
SFF2	090.0	25.0 S
SFF2	135.0	15.0 S
SFF2	120.0	20.0 S
SFF2	000.0	00.0 E
SFF2	125.0	14.0 S
SFF2	075.0	26.0 S
SFF2	000.0	00.0 E
SFF2	100.0	14.0 N
SFF2	000.0	00.0 E
SFF2	175.0	12.0 SW
SFF2	020.0	22.0 W
SFF2	075.0	30.0 SE
SFF2	130.0	46.0 S
SFF2	115.0	46.0 S
SFF2	127.0	46.0 S
SFF2	134.0	37.0 S
SFF2	110.0	34.0 S
SFF2	120.0	46.0 S
SFF2	108.0	32.0 S
SFF2	080.0	15.0 N
SFF2	100.0	14.0 N
SFF2	070.0	10.0 SE
SFF2	075.0	30.0 S
SFF2	164.0	32.0 SW
SFF2	140.0	50.0 SW
SFF2	020.0	22.0 W
SFF2	170.0	24.0 W
SFF2	097.0	26.0 S
SFF2	005.0	25.0 W
SFF2	158.0	34.0 SW
SFF2	172.0	25.0 SW
SFF2	057.0	22.0 W
SFF2	015.0	35.0 W
SFF2	090.0	42.0 S
SFF2	030.0	26.0 W
SFF2	030.0	26.0 W
SFF2	175.0	43.0 W

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

GRUM DEPOSIT

SUMMARY OF JOINT, FOLIATION AND FAULT DATA FOR STEREONET PLOTTING

Q2160-002

Plate C-1F

CODE	STRIKE	DIP
SFF2	165.0	25.0 W
SFF2	143.0	30.0 SW
SFF2	170.0	40.0 SW
SFF2	170.0	25.0 SW
~~SFF2~~	~~180.0~~	~~10.0 W~~
SFF2	165.0	22.0 W
SFF2	015.0	20.0 W
SFF2	015.0	15.0 W
SFF2	028.0	07.0 W
SFF2	010.0	17.0 W
~~SFF2~~	~~007.0~~	~~15.0 W~~
SFF2	180.0	15.0 W
SFF2	180.0	20.0 W
SFF2	150.0	30.0 SW
SFF2	022.0	06.0 W
SFF2	006.0	20.0 W
~~SFF2~~	~~000.0~~	~~27.0 W~~
SFF2	150.0	43.0 NE
SFF2	120.0	60.0 NE
SFF2	150.0	20.0 NE
SFF2	105.0	30.0 N
SFF2	125.0	64.0 S
~~SFF2~~	~~115.0~~	~~39.0 S~~
SFF2	128.0	56.0 S
SFF2	154.0	37.0 S
SFF2	140.0	32.0 N
SFF2	129.0	55.0 S
SFF2	090.0	15.0 S
~~SFF2~~	~~100.0~~	~~35.0 S~~
SFF2	140.0	70.0 S
SFF2	145.0	80.0 S
SFF2	135.0	57.0 S
SFF2	130.0	60.0 N
SFF2	145.0	14.0 N
SFF2	160.0	22.0 S
SFF2	000.0	20.0 W
SFF2	150.0	05.0 W
SFF2	120.0	12.0 S
SFF2	156.0	13.0 S
SFF2	000.0	30.0 W

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

GRUM DEPOSIT
SUMMARY OF JOINT, FOLIATION AND FAULT DATA FOR STEREONET PLOTTING

Q2160-002

Plate C-1G

CODE	STRIKE	DIP
~~SFF2~~	~~020.0~~	~~40.0 E~~
SFF2	085.0	50.0 N
SFF2	086.0	25.0 N
~~SFF2~~	~~098.0~~	~~13.0 N~~
SFF2	128.0	38.0 N
SFF2	060.0	22.0 NW
~~SFF2~~	~~122.0~~	~~44.0 S~~
SFF2	155.0	10.0 S
SFF2	121.0	40.0 S
~~SFF2~~	~~150.0~~	~~30.0 SW~~
SFF2	152.0	33.0 N
SFF2	158.0	34.0 SW
~~SFF2~~	~~090.0~~	~~42.0 S~~
SFF2	135.0	26.0 SW
SFF2	130.0	31.0 SW
~~SFF2~~	~~135.0~~	~~22.0 SW~~
SFF2	150.0	32.0 SW
SFF2	150.0	35.0 SW
~~SFF2~~	~~035.0~~	~~37.0 W~~
SFF2	135.0	24.0 SW
SFF2	040.0	18.0 W
~~SFF2~~	~~004.0~~	~~47.0 W~~
SFF2	020.0	10.0 W

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

GRUM DEPOSIT
SUMMARY OF JOINT, FOLIATION AND
FAULT DATA FOR STEREONET PLOTTING
Q2160-002
Plate C-1H

SYMBOL	PERCENT RANGE	
1	1	2
2	2	3
3	3	4
4	4	5
5	5	6
6	6	7
7	7	8
8	8	9
9	9	10
A	10	11
B	11	12
C	12	13
D	13	14
E	14	15
F	15	16
G	16	17
H	17	18
I	18	19
J	19	20
K	20	21
L	21	22
M	22	23
N	23	24
O	24	25
P	25	26
Q	26	27
R	27	28
S	28	29
T	29	30
U	30	31
V	31	32
W	32	33
X	33	34
Y	34	35
Z	35 AND GREATER	

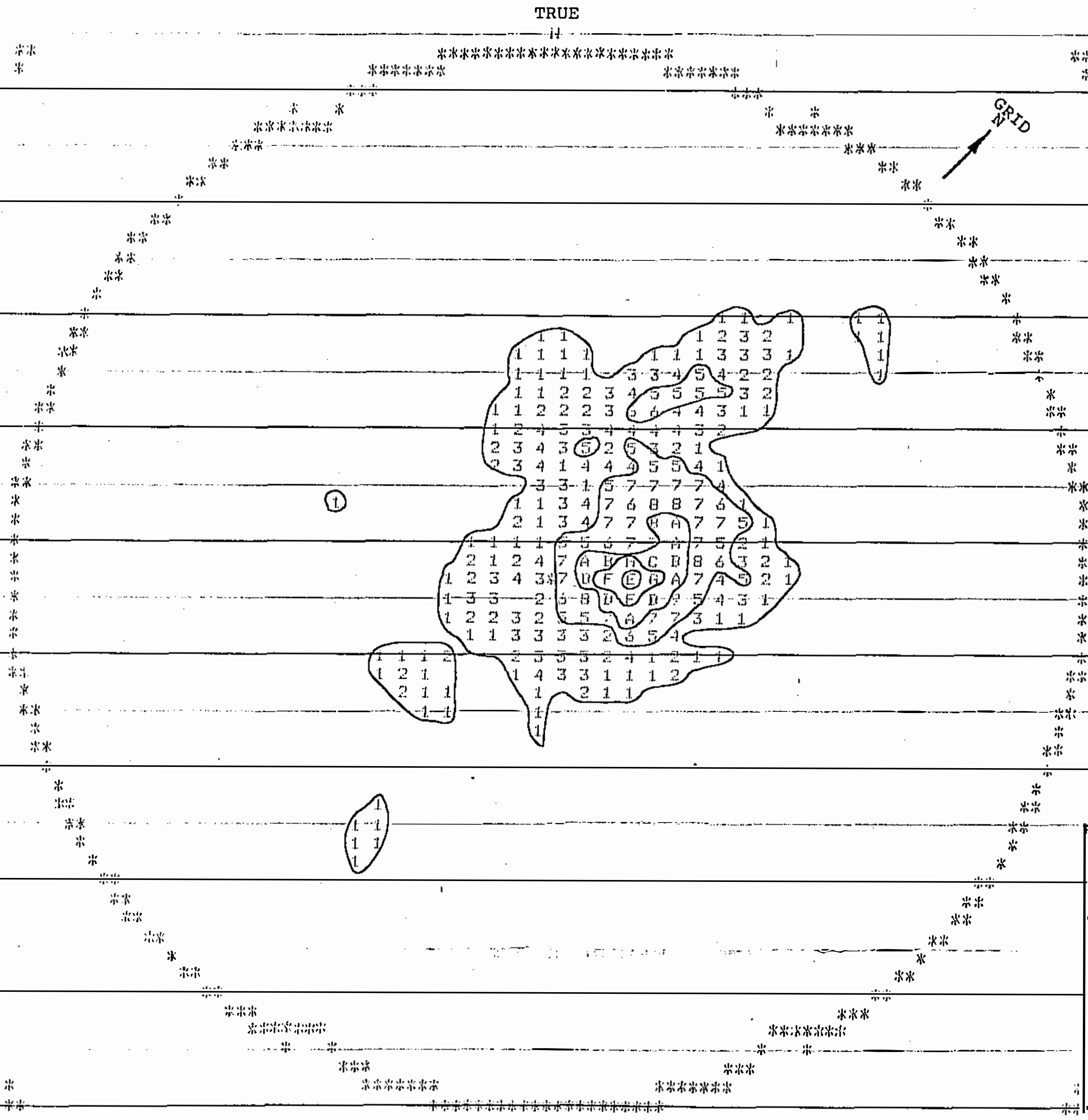
R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRUM DEPOSIT

MEANING OF SYMBOLS ON STEREONET

Q2160-002

Plate C-1I



NOTES:

1) Poles to planes on the lower hemisphere (WULFF NET) contoured with a 1% counting circle.

2) No Terzaghi correction applied.

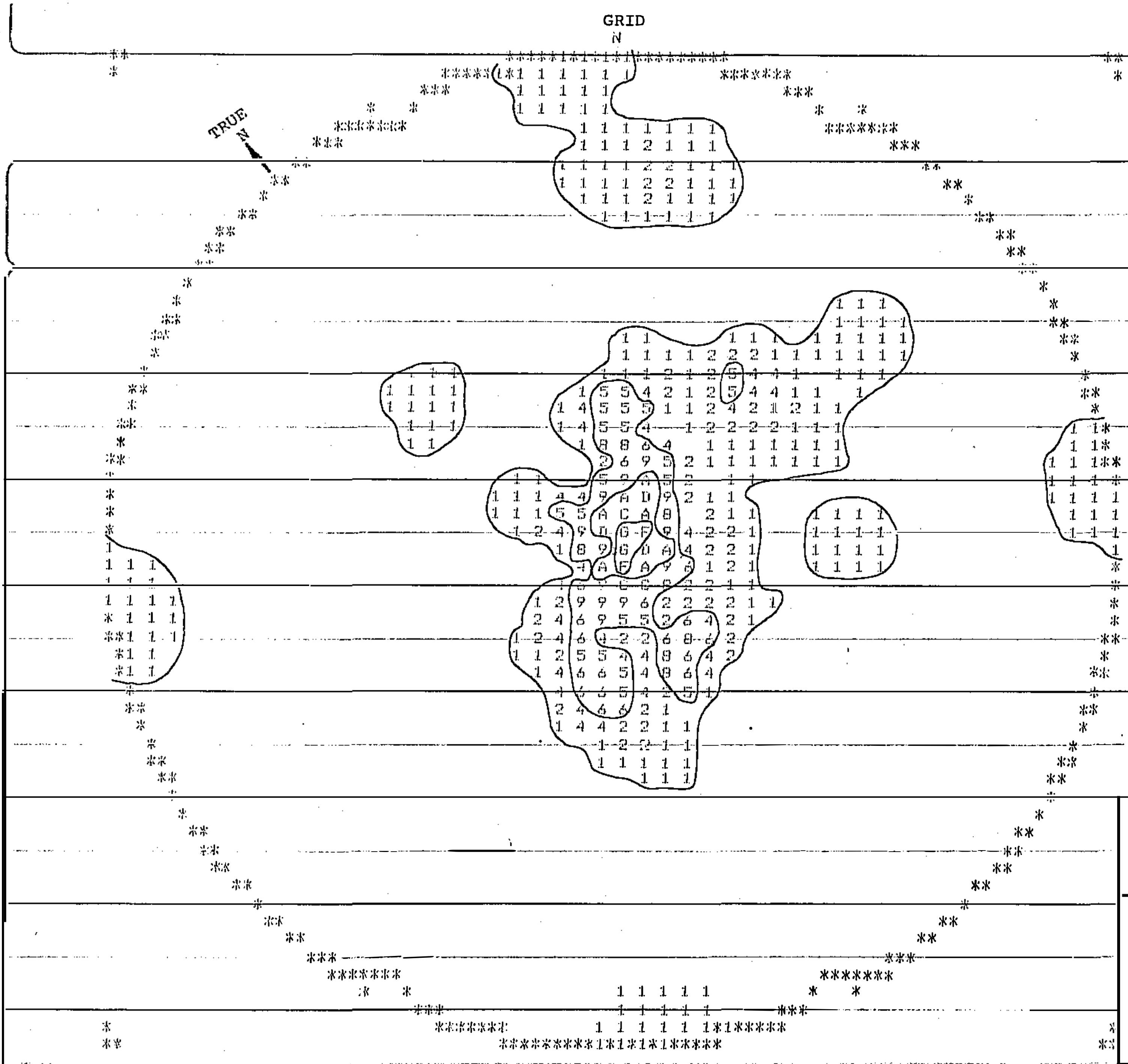
HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

GRUM DEPOSIT

CONTOURED STEREONET OF SURFACE FOLIATION NEAR GRUM DEPOSIT

Q2160-002

PLATE C-2



NOTES:

1) Poles to planes on the lower hemisphere (WULFF NET) contoured with a 1% counting circle.

2) No Terzaghi correction applied.

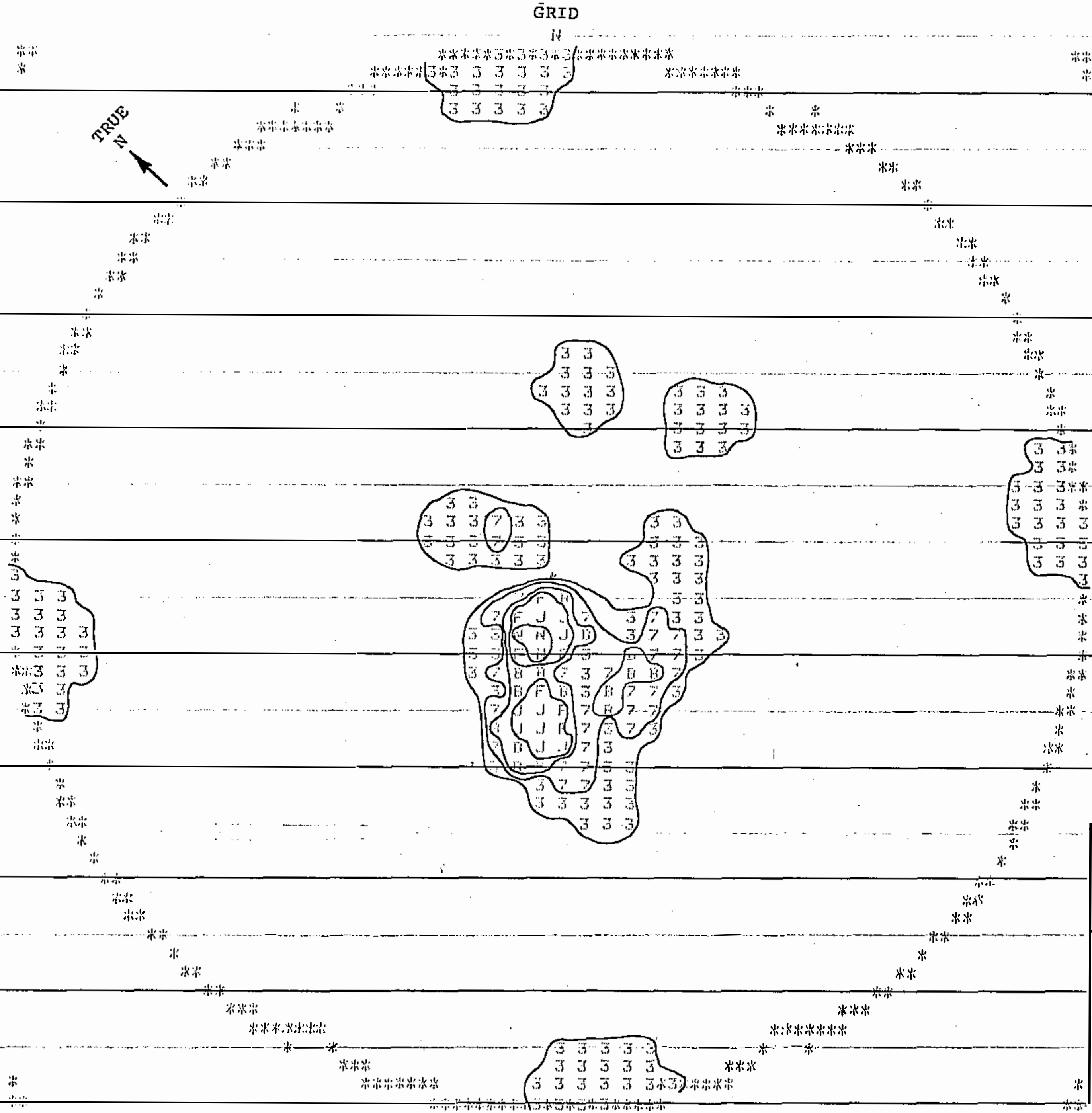
HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

GRUM DEPOSIT

CONTOURED STEREONET OF FOLIATION IN DECLINE ZONES 1, 2 AND 3

Q2160-002

PLATE C-3



NOTES:

1) Poles to planes on the lower hemisphere (WULFF NET) contoured with a 1% counting circle.

2) No Terzaghi correction applied.

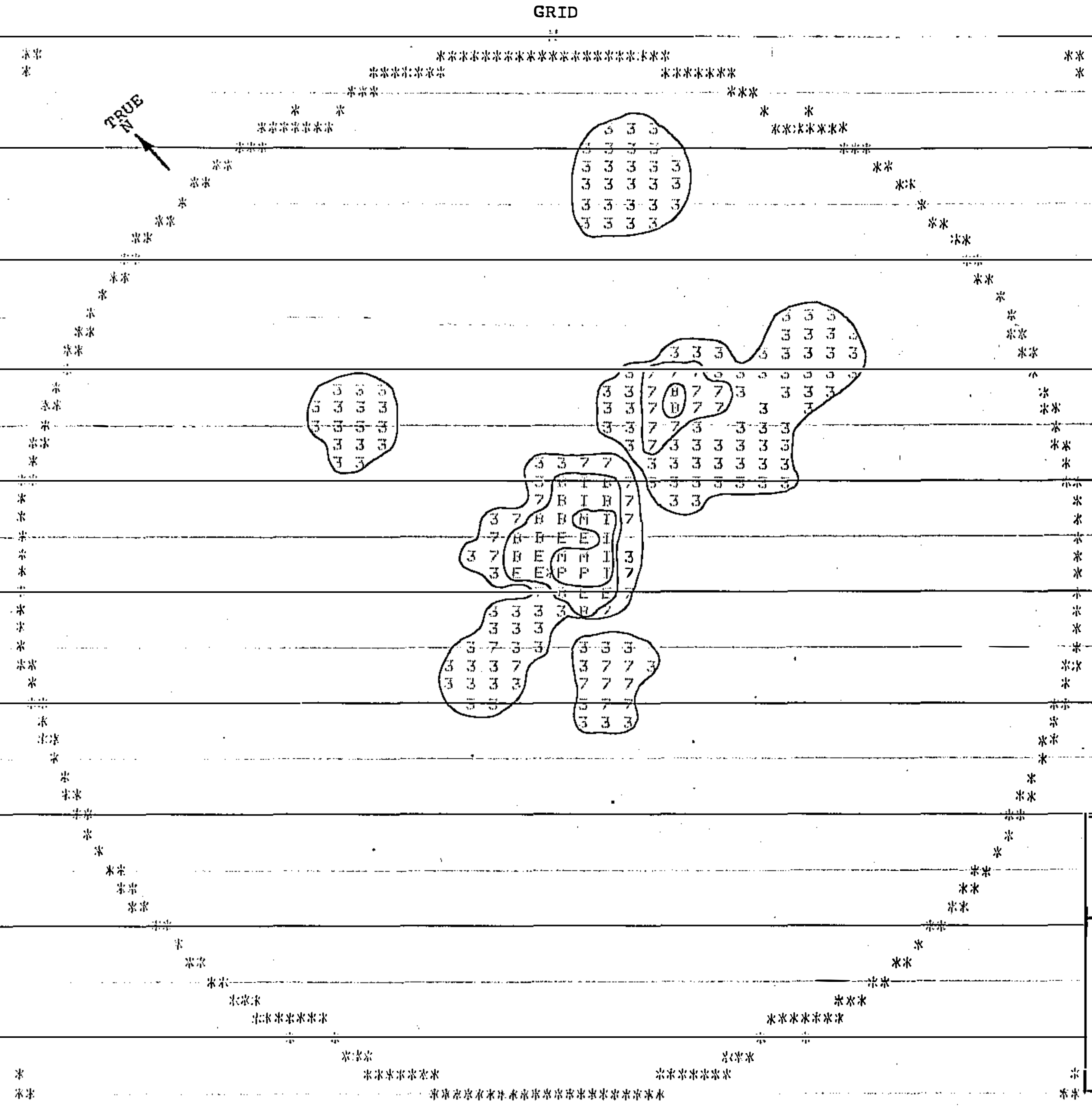
HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

GRUM DEPOSIT

CONTOURED STEREONET OF
FOLIATION IN DECLINE ZONE 1

Q2160-002

PLATE C-4



NOTES:

1) Poles to planes on the lower hemisphere (WULFF NET) contoured with a 1% counting circle.

2) No Terzaghi correction applied.

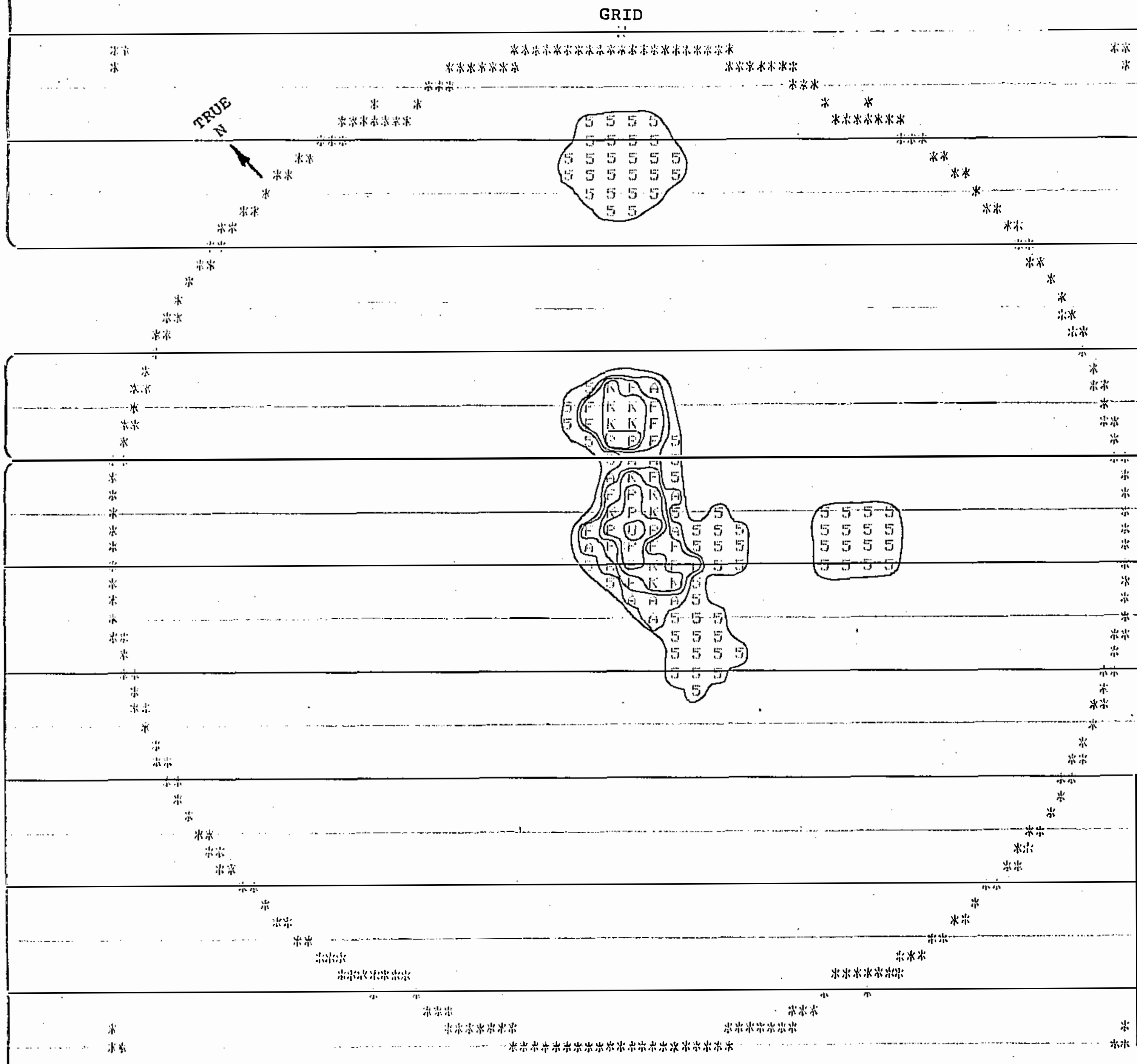
HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

GRUM DEPOSIT

CONTOURED STEREONET OF
FOLIATION IN DECLINE ZONE 2

Q2160-002

PLATE C-5



NOTES:

1) poles to planes on the lower hemisphere (WULFF NET) contoured with a 1% counting circle.

2) No Terzaghi correction applied.

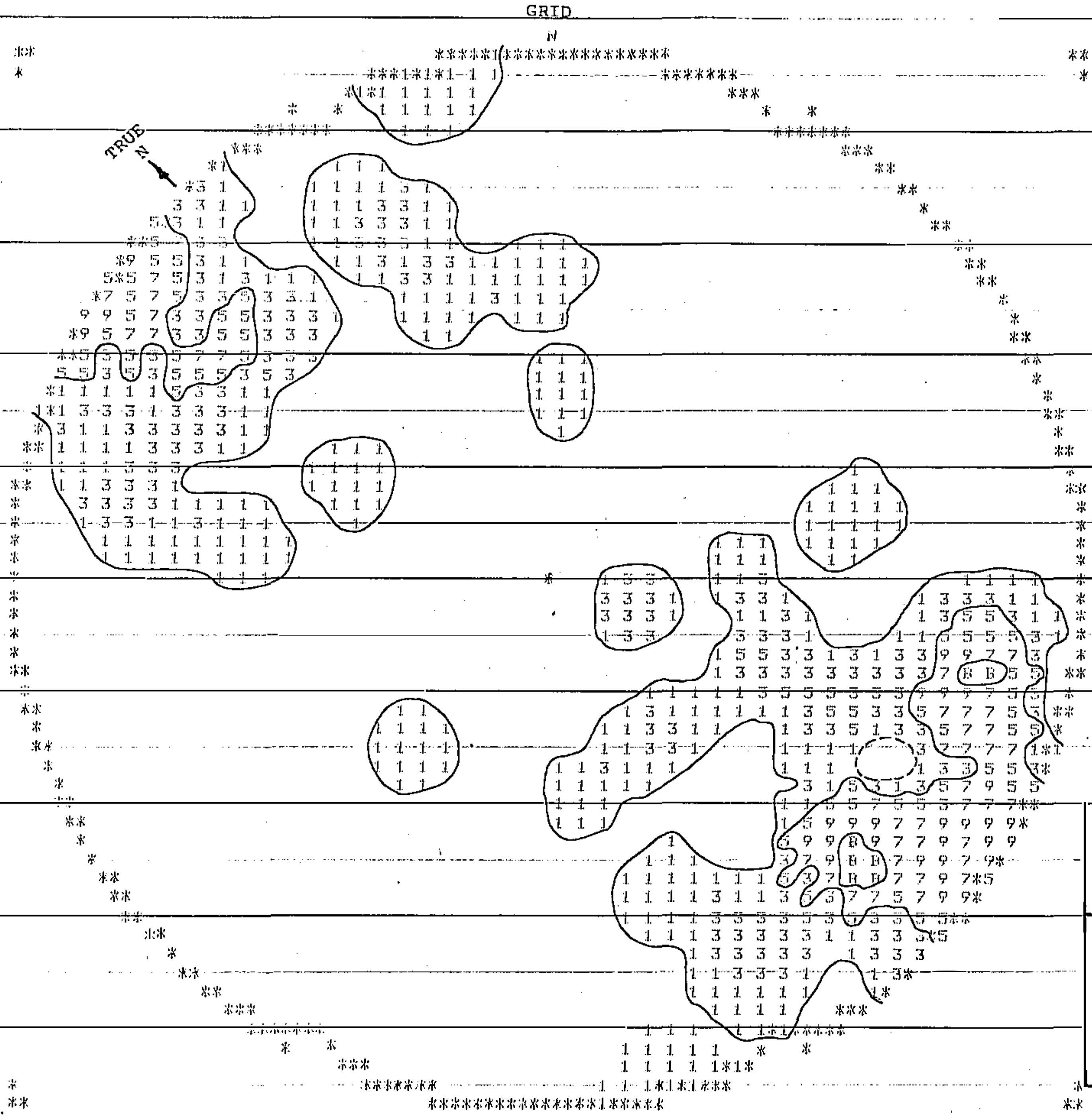
HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

GRUM DEPOSIT

CONTOURED STEREONET OF
FOLIATION IN DECLINE ZONE 3

Q2160-002

PLATE C-6



NOTES:

1) Poles to planes on the lower hemisphere (WULFF NET) contoured with a 1% counting circle.

2) No Terzaghi correction applied.

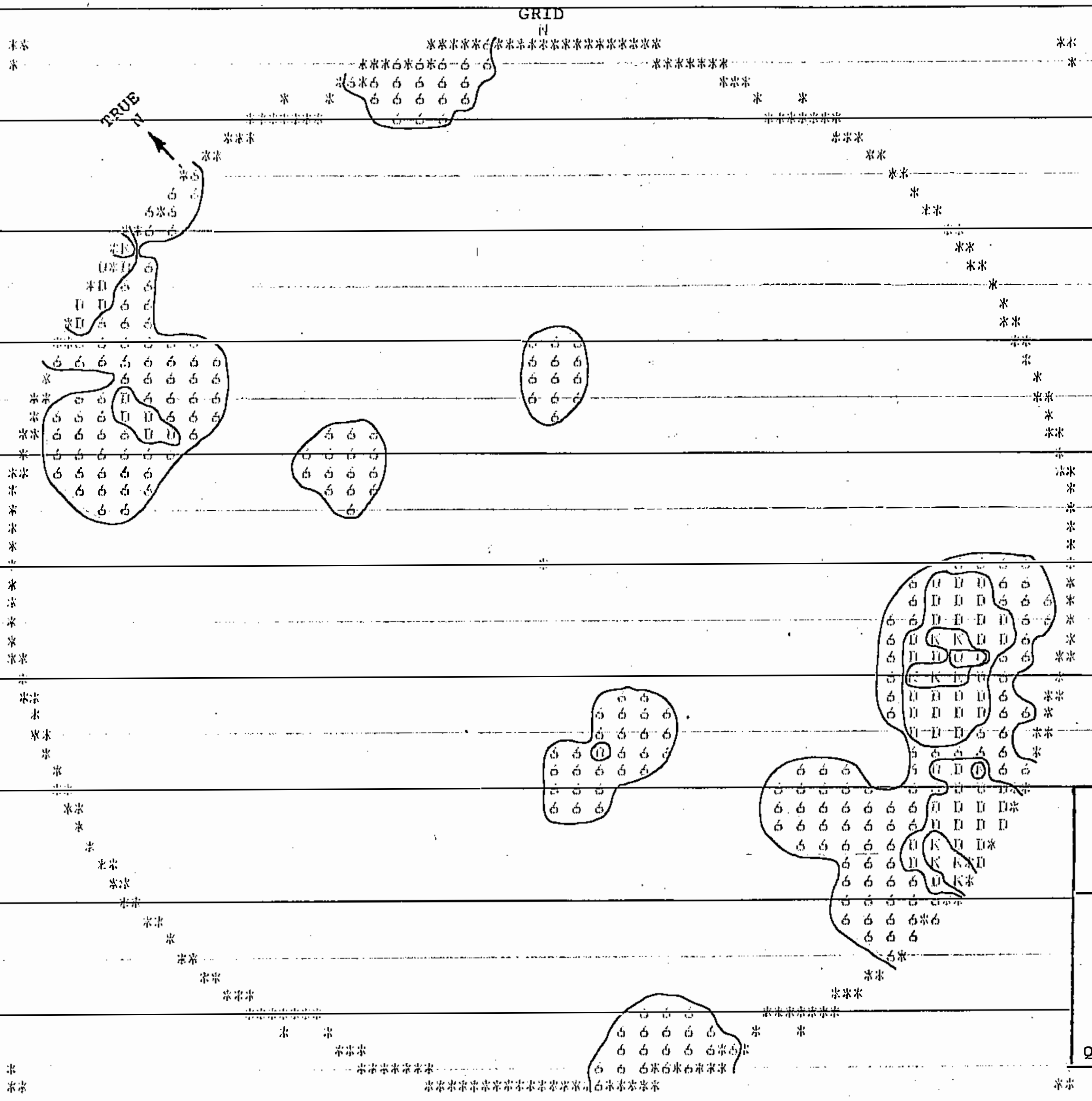
HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

GRUM DEPOSIT

CONTOURED STEREONET OF FAULTS IN DECLINE ZONES 1, 2 AND 3

Q2160-002

PLATE C-7



NOTES:

1) Poles to planes on the lower hemisphere (WULFF NET) contoured with a 1% counting circle.

2) No Terzaghi correction applied.

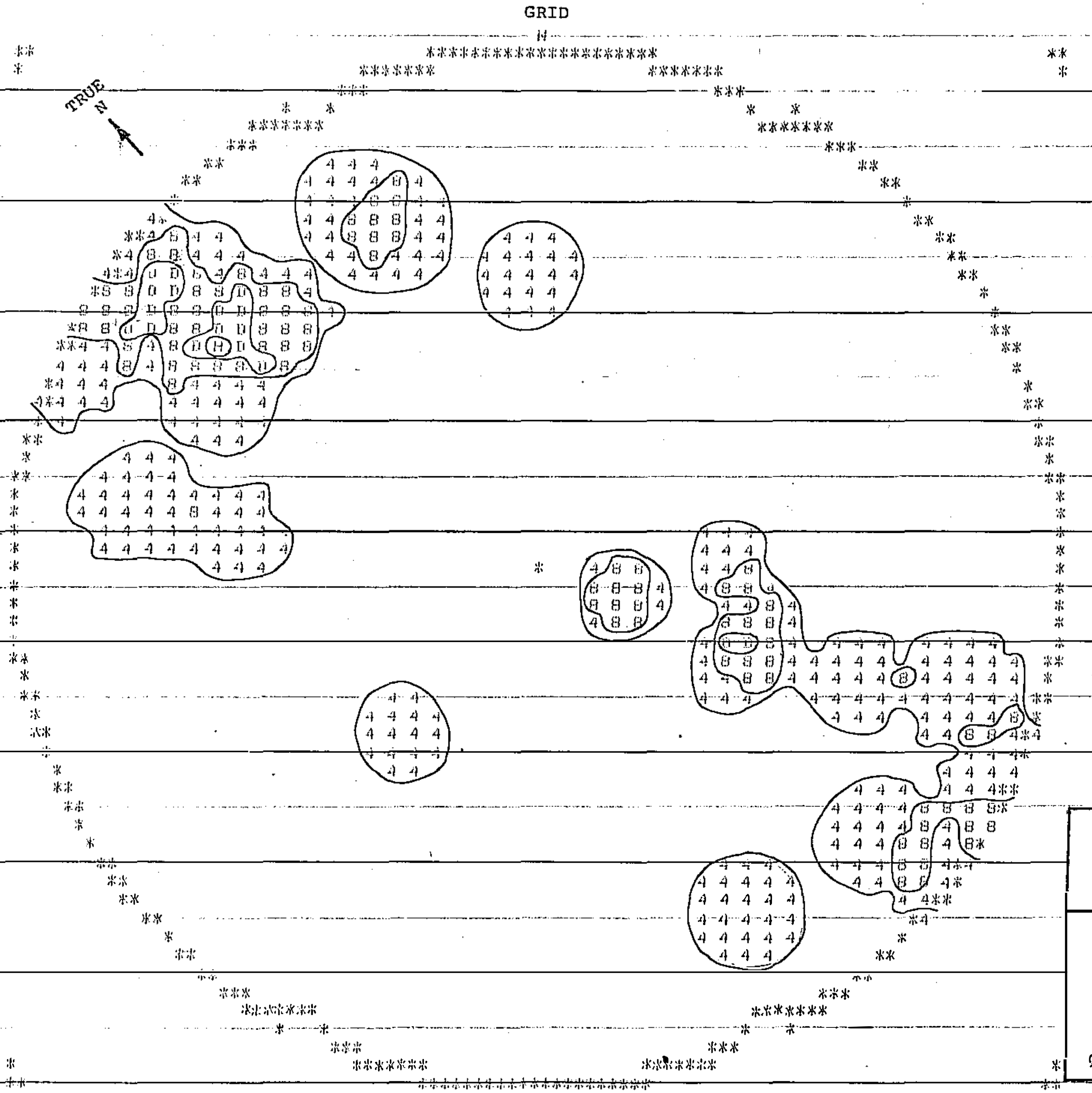
HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

GRUM DEPOSIT

CONTOURED STEREONET OF
FAULTS IN DECLINE ZONE 1

Q2160-002

Plate C-8



NOTES:

1) Poles to planes on the lower hemisphere (WULFF NET) contoured with a 1% counting circle.
2) No Terzaghi correction applied.

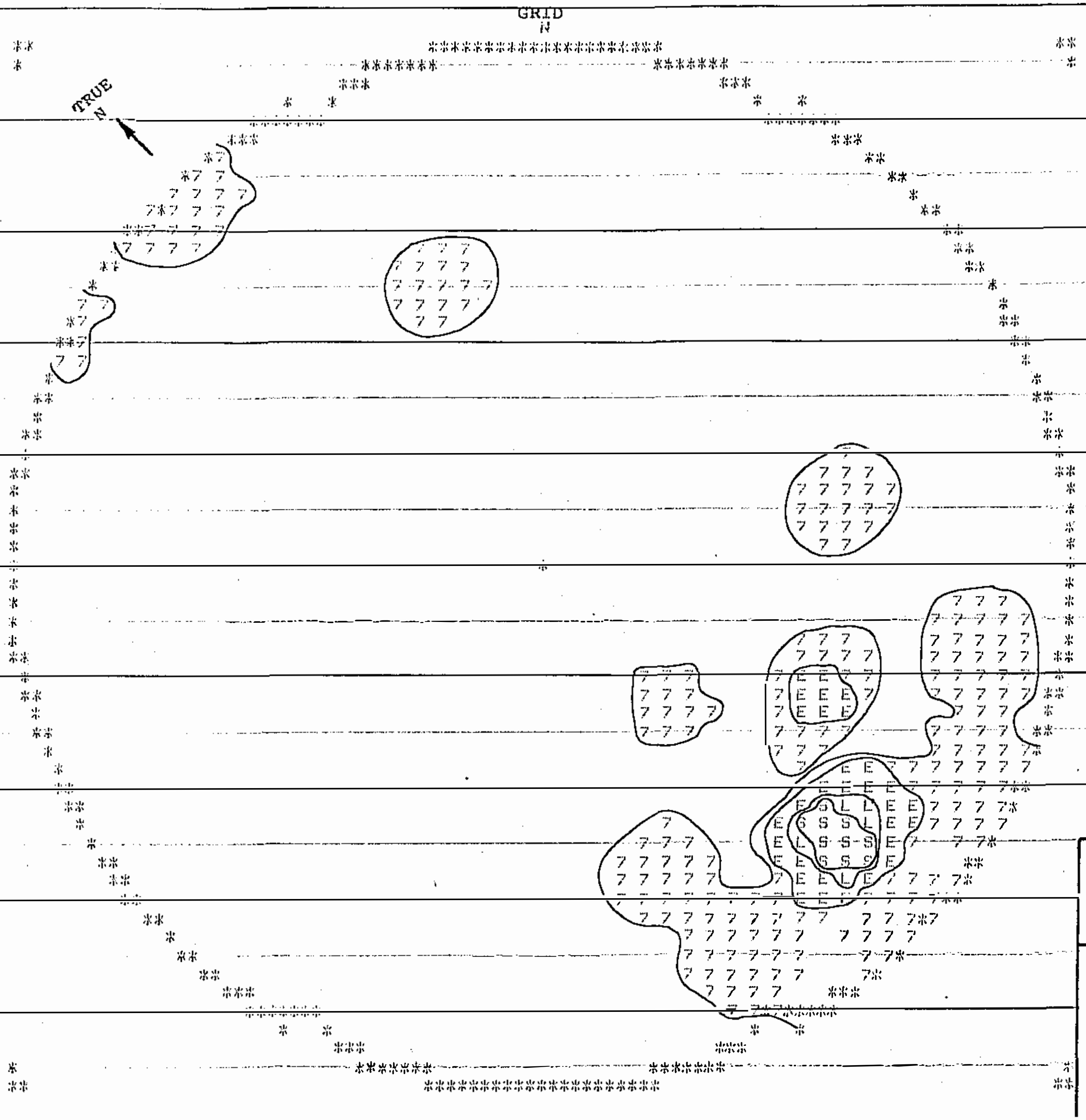
HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

GRUM DEPOSIT

CONTOURED STEREONET OF FAULTS IN DECLINE ZONE 2

Q2160-002

PLATE C-9



NOTES:

1) Poles to planes on the lower hemisphere (WULFF NET) contoured with a 1% counting circle.

2) No Terzaghi correction applied.

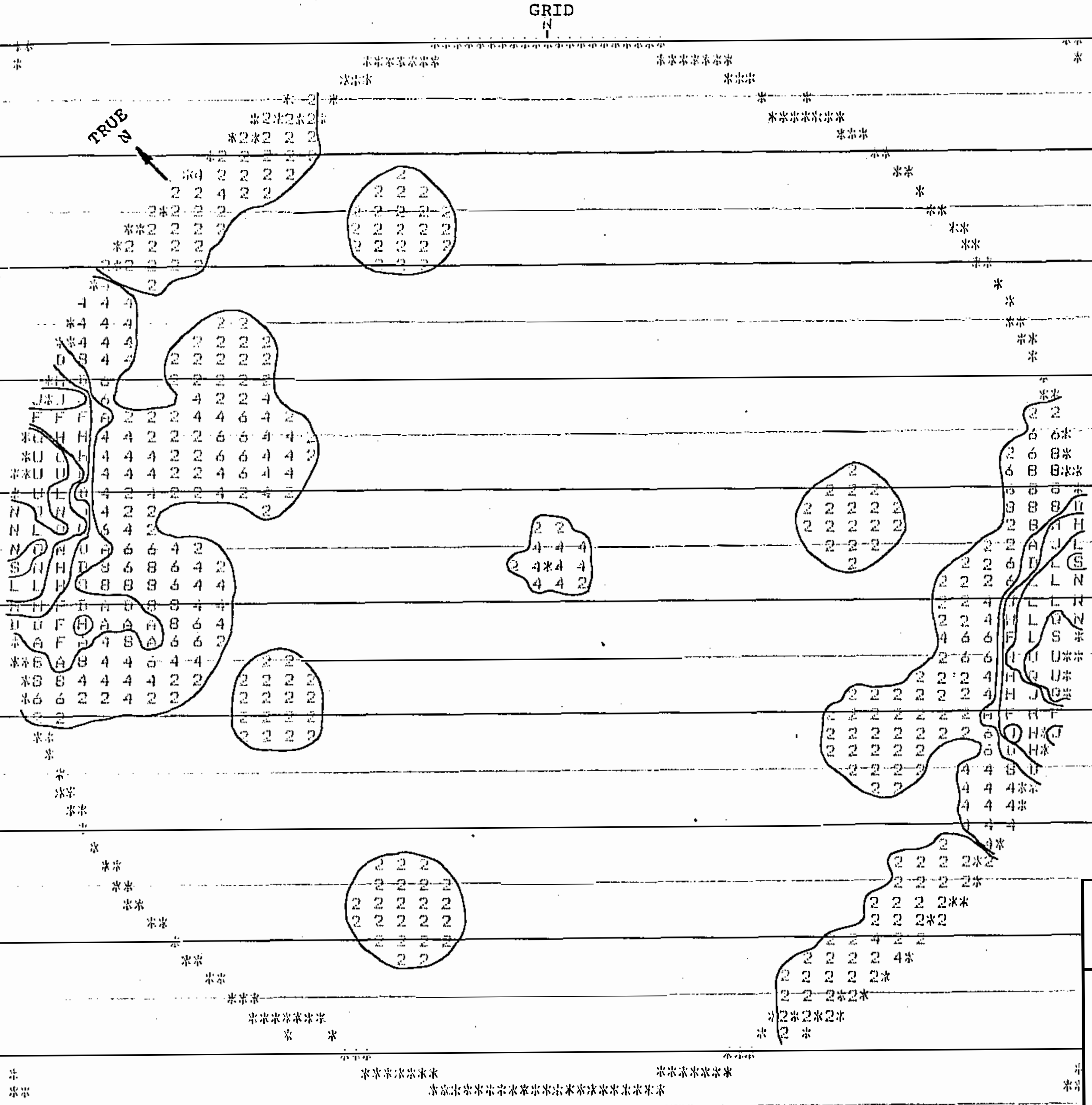
HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

GRUM DEPOSIT

CONTOURED STEREONET OF
FAULTS IN DECLINE ZONE 3

02160-002

PLATE C-10



NOTES:

1) Poles to planes on the lower hemisphere (WULFF NET) contoured with a 1% counting circle.

2) No Terzaghi correction applied.

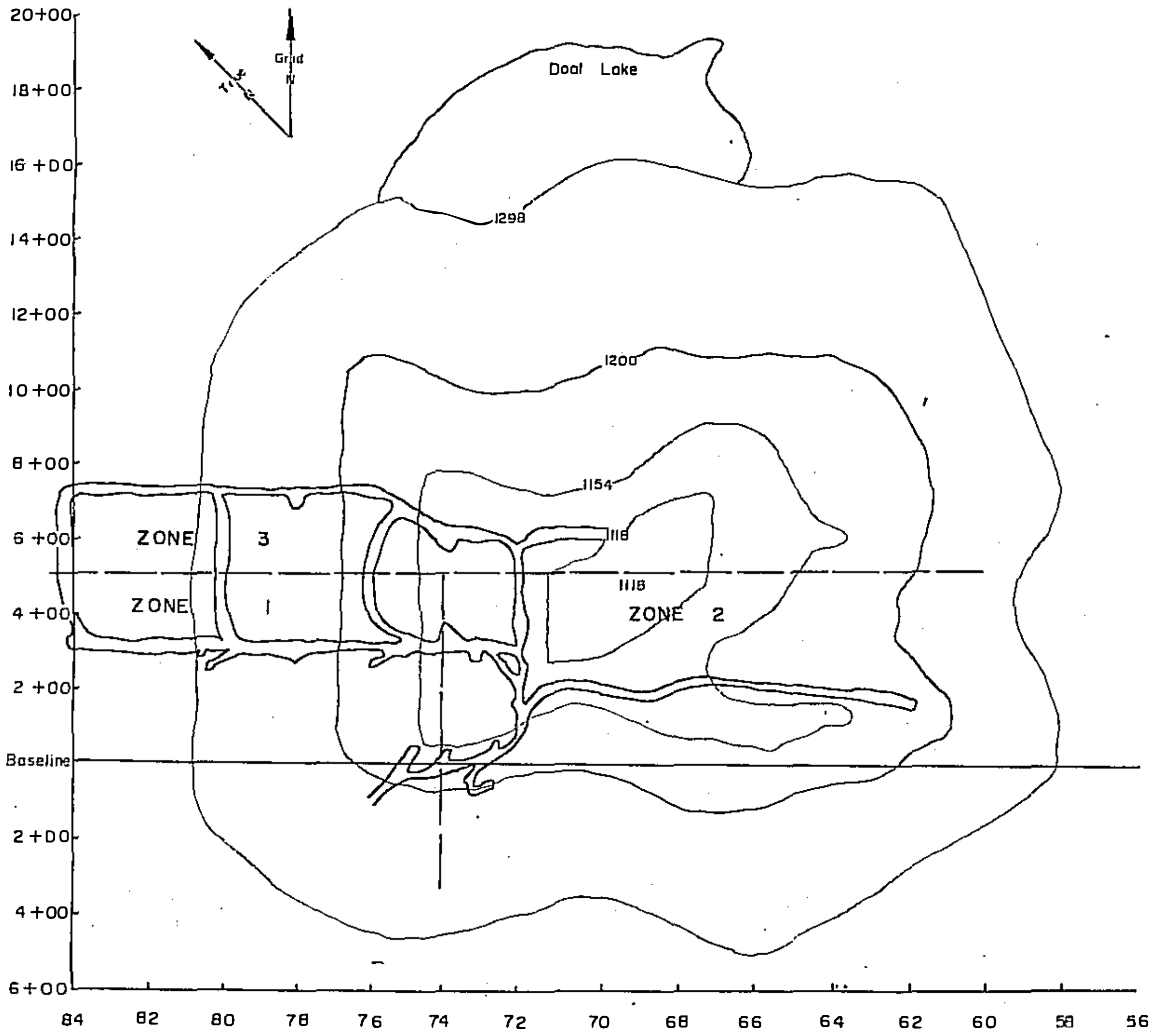
HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

GRUM DEPOSIT

CONTOURED STEREONET OF
JOINTS IN DECLINE
ZONES 1, 2 AND 3

Q2160-002

PLATE C-11



NOTES:

1) FROM GEOLOGICAL PLAN IN PLANE OF UNDERGROUND WORKINGS, KERR ADDISON MINES LTD., PLATES 1 AND 2.

2) ZONES 1, 2 AND 3 REFER TO ZONES USED FOR PLOTTING STEREONETS OF UNDERGROUND DATA.

3) BENCH LEVELS 1136, 1172 AND 1262 m HAVE BEEN OMITTED FOR CLARITY.

4) PIT DETAILS FROM CANADIAN MINE SERVICES PLAN.

0 100 200 m

SECTION LINES ARE IN HUNDREDS OF FEET. CONTOURS ARE IN METERS.

REVISIONS

REFERENCES

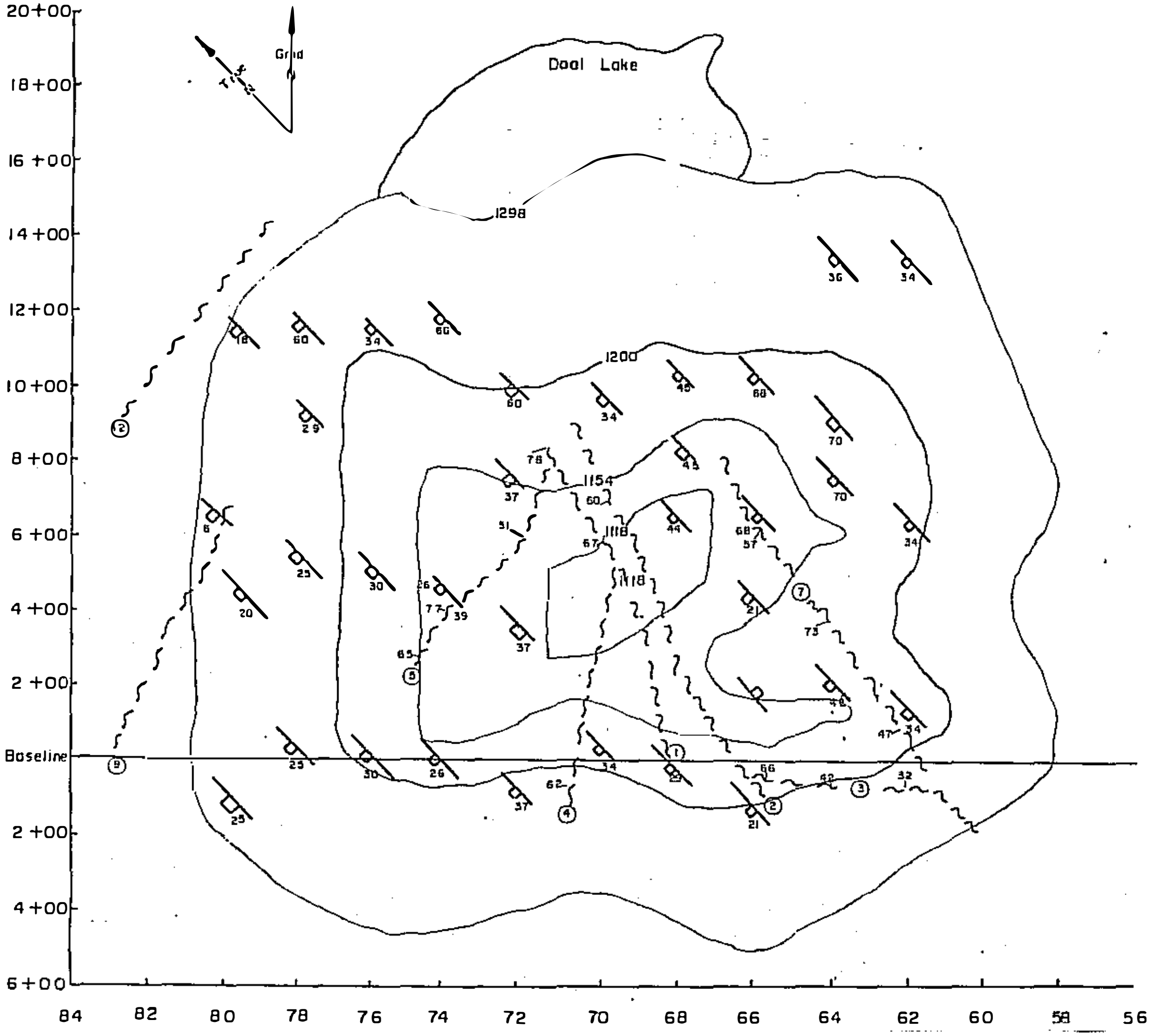
SCALE As Noted
DATE Dec. 4 /79
MADE J R
CHKD.
APPD.

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

GRUM DEPOSIT
SCHEMATIC LAYOUT OF
DECLINE AND CROSSCUTS

No. Q 2160-002 Plate C-12

HT14 · 79/05



NOTES:

1) FAULT STRIKE FROM KERR ADDISON GEOLOGICAL PLANS – 1203 M.

2) FOLIATION STRIKE IS PREDOMINANT STRIKE OF FOLIATION DATA FROM SURFACE AND UNDERGROUND DATA.

3) DIPS WERE CALCULATED FROM APPARENT DIPS ON RELEVANT KERR ADDISON GEOLOGICAL SECTIONS.

4) DATA CONTAINED ON THESE PLANS SHOULD BE USED WITH CAUTION DUE TO THE CALCULATIONS AND EXTRAPOLATIONS REQUIRED.

5) BENCH LEVELS 1136, 1172 AND 1262 M HAVE BEEN OMITTED FOR CLARITY.

6) PIT DETAILS FROM CANADIAN MINE SERVICES PLAN.

0 100 200m

SECTION LINES ARE IN HUNDREDS OF FEET. CONTOURS ARE IN METERS.

REVISIONS

REFERENCES

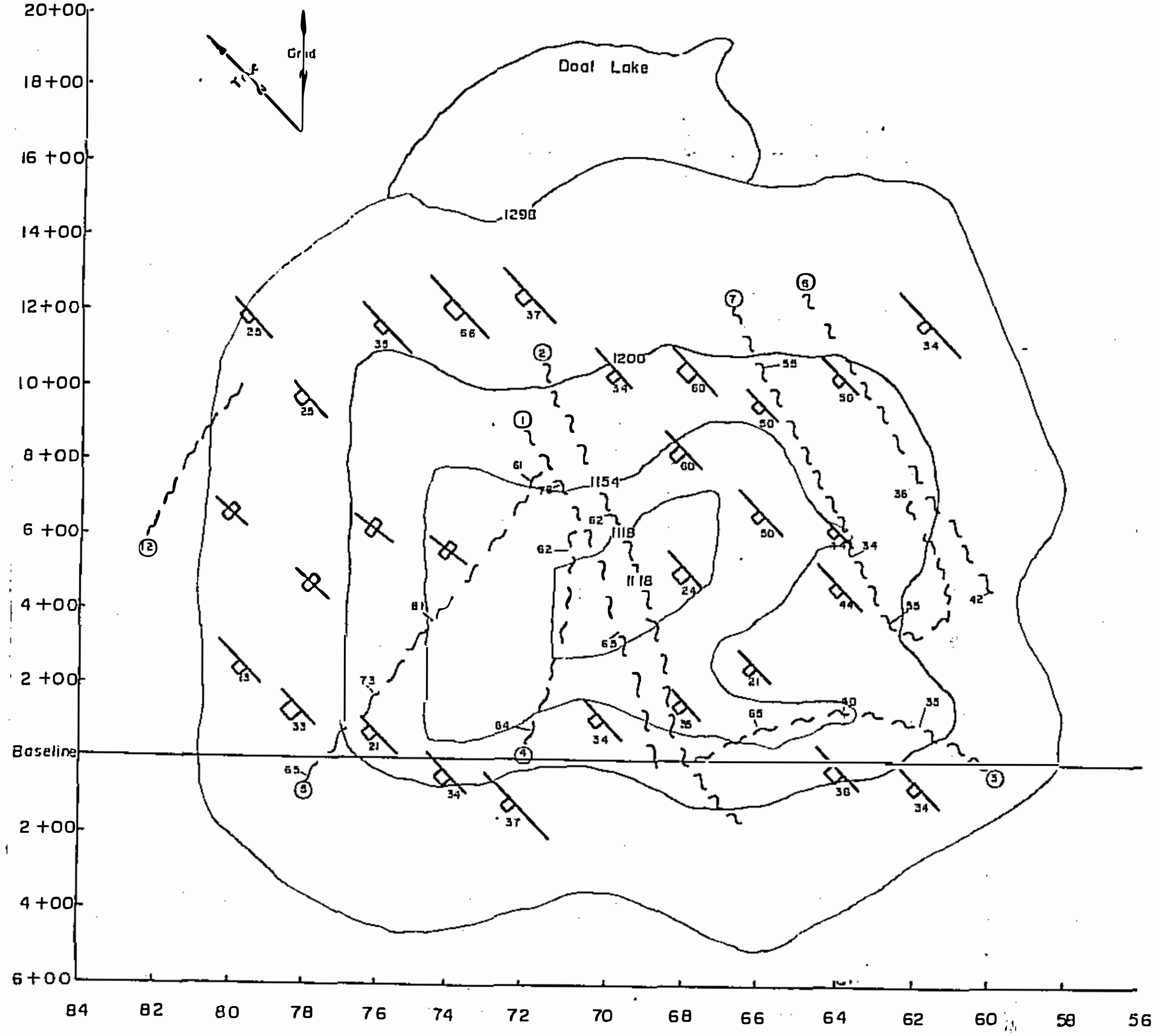
SCALE As Noted
DATE Dec. 5 / 79
MADE JR
CHKD.
APPD.

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

GRUM DEPOSIT
GEOLOGIC MODEL – 1203 m

No. Q 2160–002
Plate C –13

HT14 · 78/85



NOTES:

1) FAULT STRIKE FROM KERR ADDISON GEOLOGICAL PLANS - 1149 m

2) FOLIATION STRIKE IS PREDOMINANT STRIKE OF FOLIATION DATA FROM SURFACE AND UNDERGROUND DATA.

3) DIPS WERE CALCULATED FROM APPARENT DIPS ON RELEVANT KERR ADDISSON GEOLOGICAL SECTIONS.

4) DATA CONTAINED ON THESE PLANS SHOULD BE USED WITH CAUTION DUE TO THE CALCULATIONS AND EXTRAPOLATIONS REQUIRED.

5) BENCH LEVELS 1136, 1172 AND 1262 m HAVE BEEN OMITTED FOR CLARITY.

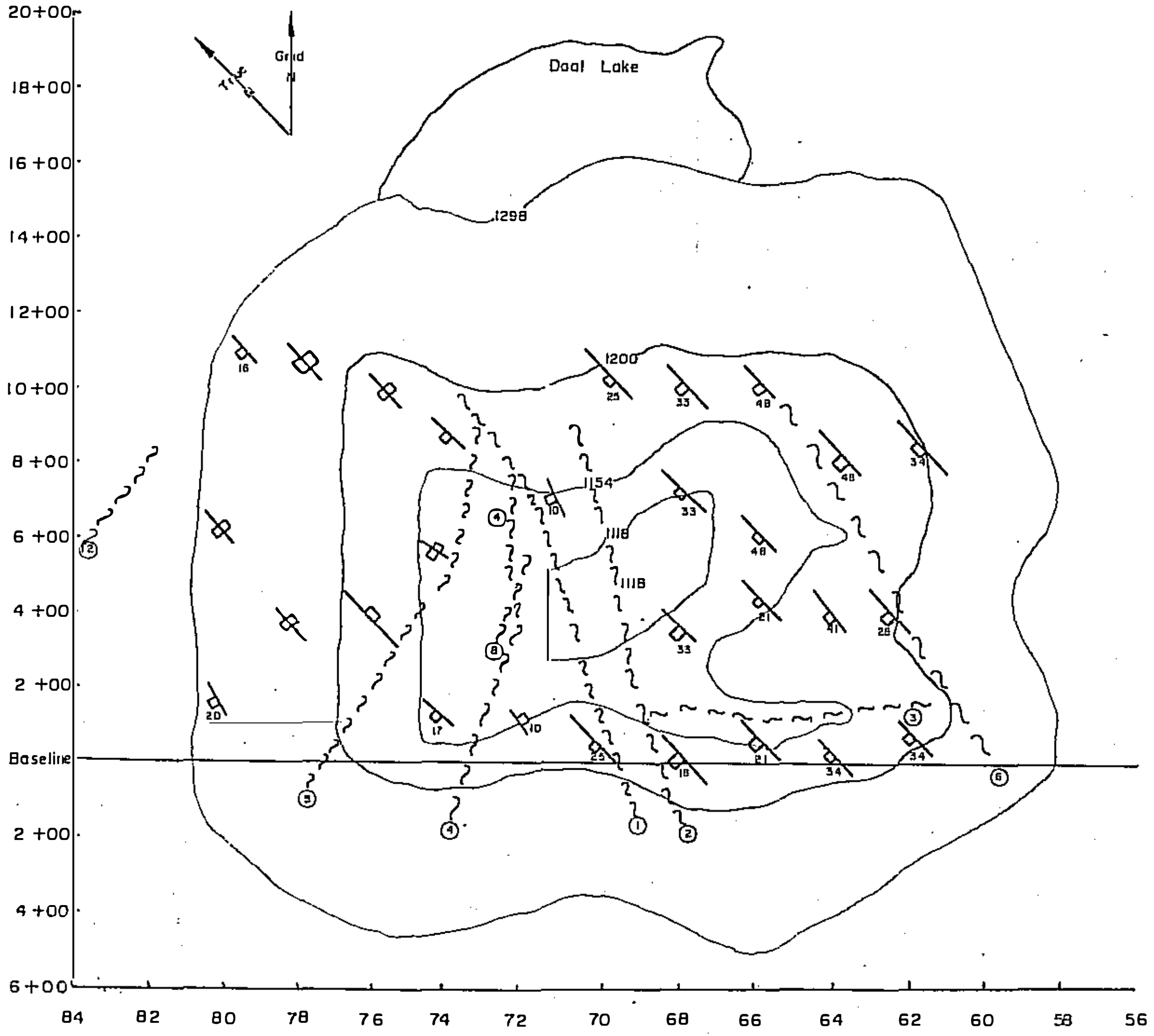
6) PIT DETAILS FROM CANADIAN MINE SERVICES PLAN.

0 100 200m

SECTION LINES ARE IN HUNDREDS
OF FEET. CONTOURS ARE IN METERS.

REVISIONS	REFERENCES			
		SCALE As Noted DATE Dec. 5 / 79 MADE JR CHKD. APPD.	**HARDY ASSOCIATES (1978) LTD.** CONSULTING ENGINEERING & PROFESSIONAL SERVICES	GRUM DEPOSIT GEOLOGIC MODEL — 1149 m **No.** Q 2160-002 Plate C-14

HT14 · 79/05



NOTES:

1) FAULT STRIKE FROM KERR ADDISON GEOLOGICAL PLANS – 1104 m

2) FOLIATION STRIKE IS PREDOMINANT STRIKE OF FOLIATION DATA FROM SURFACE AND UNDERGROUND DATA.

3) DIPS WERE CALCULATED FROM APPARENT DIPS ON RELEVANT KERR ADDISON GEOLOGICAL SECTIONS.

4) DATA CONTAINED ON THESE PLANS SHOULD BE USED WITH CAUTION DUE TO THE CALCULATIONS AND EXTRAPOLATIONS REQUIRED.

5) BENCH LEVELS 1136, 1172 AND 1262 m HAVE BEEN OMITTED FOR CLARITY.

6) PIT DETAILS FROM CANADIAN MINE SERVICES PLAN.

0 100 200 m

SECTION LINES ARE IN HUNDREDS OF FEET. CONTOURS ARE IN METERS.

REVISIONS	REFERENCES	SCALE As Noted DATE Dec.4 / 79 MADE J R CHKD. APPD.	**HARDY ASSOCIATES (1978) LTD.** CONSULTING ENGINEERING & PROFESSIONAL SERVICES	GRUM DEPOSIT GEOLOGIC MODEL – 1104 m No. Q 2160–002 Plate C–15

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