


CURRAGH RESOURCES INC.

Inter-Office Memorandum

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RE: **Geological observations bearing on geotechnical data for the Grum open pit**

**DATE: 10 07 1991**

Preface

This memo contains excerpts from a memo written in 1985 on Grum geotechnical features. It may provide a useful overview of structures at Grum. Much of the structural data presented from 1984 mapping is now superseded by pit wall exposures.

Introduction

For all areas of the Anvil District one of the major determinants of the stability of excavations in rock is the orientation of the dominant metamorphic cleavage or foliation (S_2). At the Grum deposit the orientation of the foliation is locally unknown because much of the bedrock surface is covered by thick overburden. There is however a body of evidence bearing on S_2 orientation available in the underground workings and on surface at the northwest end of the proposed pit. Another line of evidence is found in the structural style of the Anvil District which, though not site specific, provides a general guide to how reasonable assumptions are.

At Grum, assumptions must be made in the absence of specific data. This has been done in order to compile the structural model described in the Montreal Engineering Phase Two Geotechnical Report on Grum. It is the impression of

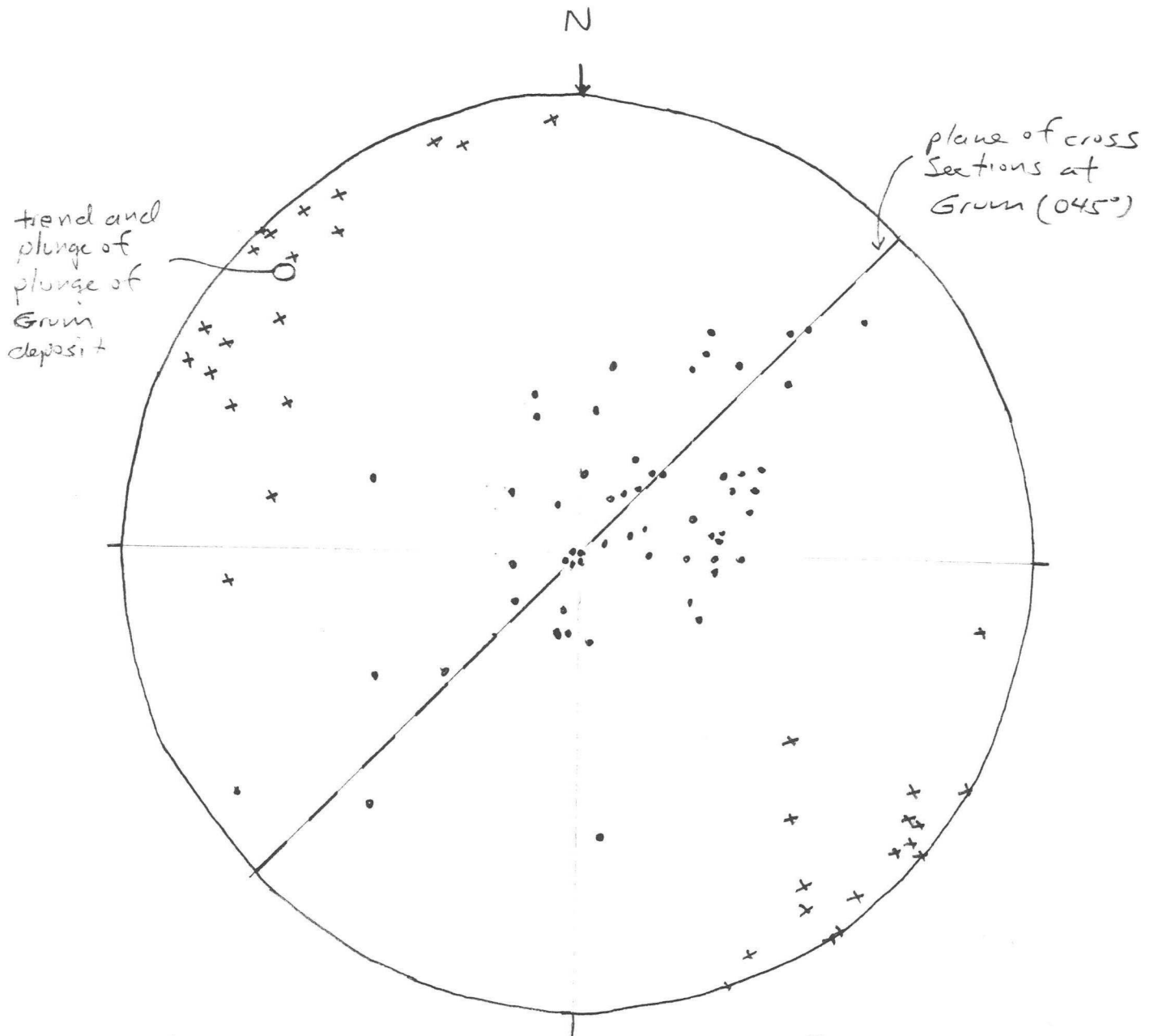
the author that the assumptions made, while conceivably correct, are not consistent with the usual structural style of the district. There are further assumptions that tend to systematically exaggerate the foliation dip on the order of 5° - 10°. This memo presents data gathered during the 1984 field season and re-examines old surface data in light of new structural interpretations of the Vangorda Plateau. This is a response to and reiteration of section 6.6.1 of the Montreal Engineering Report.

Regional Foliation Dip

The Vangorda Plateau portion of the Anvil District is characterized by shallow foliation dips that are generally toward the southwest but locally are thrown into broad open folds such that the dip can be shallow in any direction. Near faults and in areas of strong contrasts of ductility steeper dips are found but large domains of steep foliation dip have not been proven to exist. The stereonet of foliation attitudes from the vicinity of Grum presented in the Montreal Engineering report (plate C-2 of Appendix C) demonstrates this fact. Figure 1 of this memo is a modification of that stereonet which discards all but 58 of the 113 poles plotted on Plate C-3 since they are derived from domains that are not relevant to Grum (the mylonitic border of Anvil Batholith and the footwall sequence of the Tie Fault). This modification considerably lessens the prominent peak at 000/20W which is largely due to the schist sequence in the footwall of the Tie Fault. Figure 1 still demonstrates the overall low angle nature of the foliation when only phyllites of the Vangorda Plateau sequence are considered.

Foliation in the Underground Workings

Foliation poles measured underground at Grum were plotted on Plate C-3 of the Montreal report. The latter plot is remarkably similar to Figure 1 with poles tending to fall on a girdle close to the plane of the Grum cross sections and on a peak corresponding to a strike a little more northwesterly than 000 (160° to 170°). In general the measured dips underground are so low and so variable that



trend and
plunge of
plunge of
Grum
deposit +

plane of cross
sections at
Grum (045°)

- S₂ pole
- x L₂ lineation

FIGURE 1

Limits on data are:

- a) Vangorda ck on SE
- b) Batholith contact on NNE
- c) Tie Fault on NW
- d) a line parallel to and 7000' SW of the centerline of Grum deposit

D₂ structural elements
from northwest Vangorda
Plateau portion of sheet F6
(1979 data)

it is difficult to think of an average foliation strike for Grum on the basis of a stereonet analysis alone.

A somewhat different analysis of foliation dips underground can be made by attempting to draw highly generalized form lines for the S² foliation (note that to do this analysis I have examined the geology of the walls of the cross cuts as portrayed by Kerr Addition and overruled some plotted foliation attitudes as being inconsistent with the walls or the breast). The results of this analysis (Figure 2) show that two major domains exist with the domain boundary at about 2N. Southwest of 2N, foliation dips are nearly always toward the southwest about 10° to 30° (the average strike is about 140° and dip direction 230°). Northwest of 2N the dips are more variable but there is a strong component dipping gently to the northeast (average strike about 125° and dip direction 035°) and a tendency to reverse back to a southwest dip at about 7N. This gentle warp in the foliation is apparent on all the Grum cross sections and the mapped cross cuts.

1984 Work on Surface Foliations

Figure 3 is a map of the area of the proposed Grum pit [Note: the pit proposed by Cyprus Anvil] showing the foliations measured during the 1984 field season. Considerable attention was paid to this area and several new areas of outcrop were found and measured. The results show the foliation defines a fairly smooth arc with a poorly defined change in foliation attitude at about 3N. Southwest of that line dips are to the southwest with an average strike of about 140° (Figure 4), this is the surface extension of the domain southwest of 2N in the subsurface. To the northeast dips are toward the northwest with a slight tendency to dip north (Figures 3 and 4), this is presumably the surface expression of the dip reversal in the subsurface. There is a rather remarkable antithetic correlation between foliation dip and the proposed pit walls so that foliation tends to dip into both the southwest and northwest walls (Figure 3). If this situation persists to depth then these walls can be kept steep as presently planned. Indications are that this is the case.

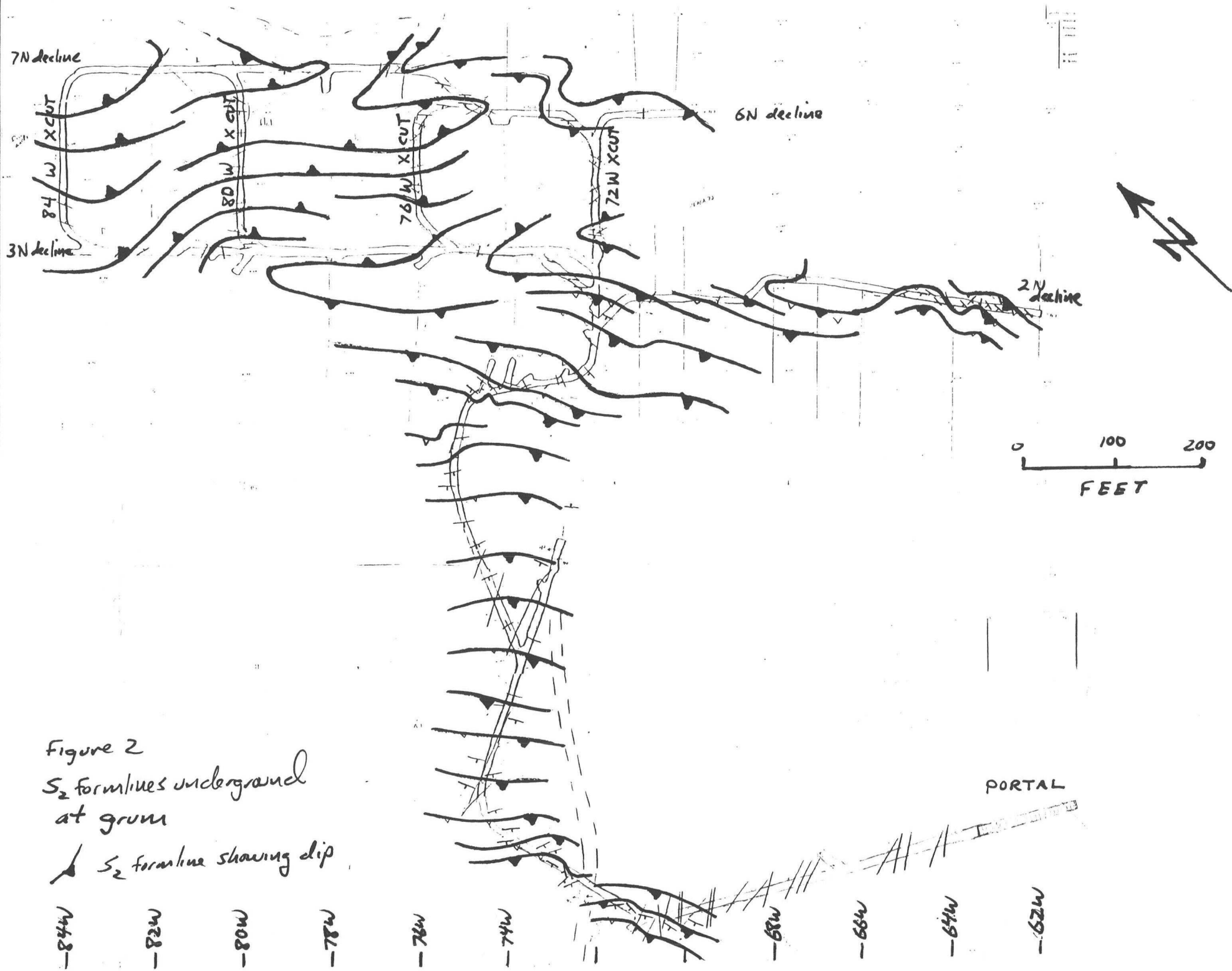


Figure 2
 S_2 formlines underground
 at ground

▲ S_2 formline showing dip

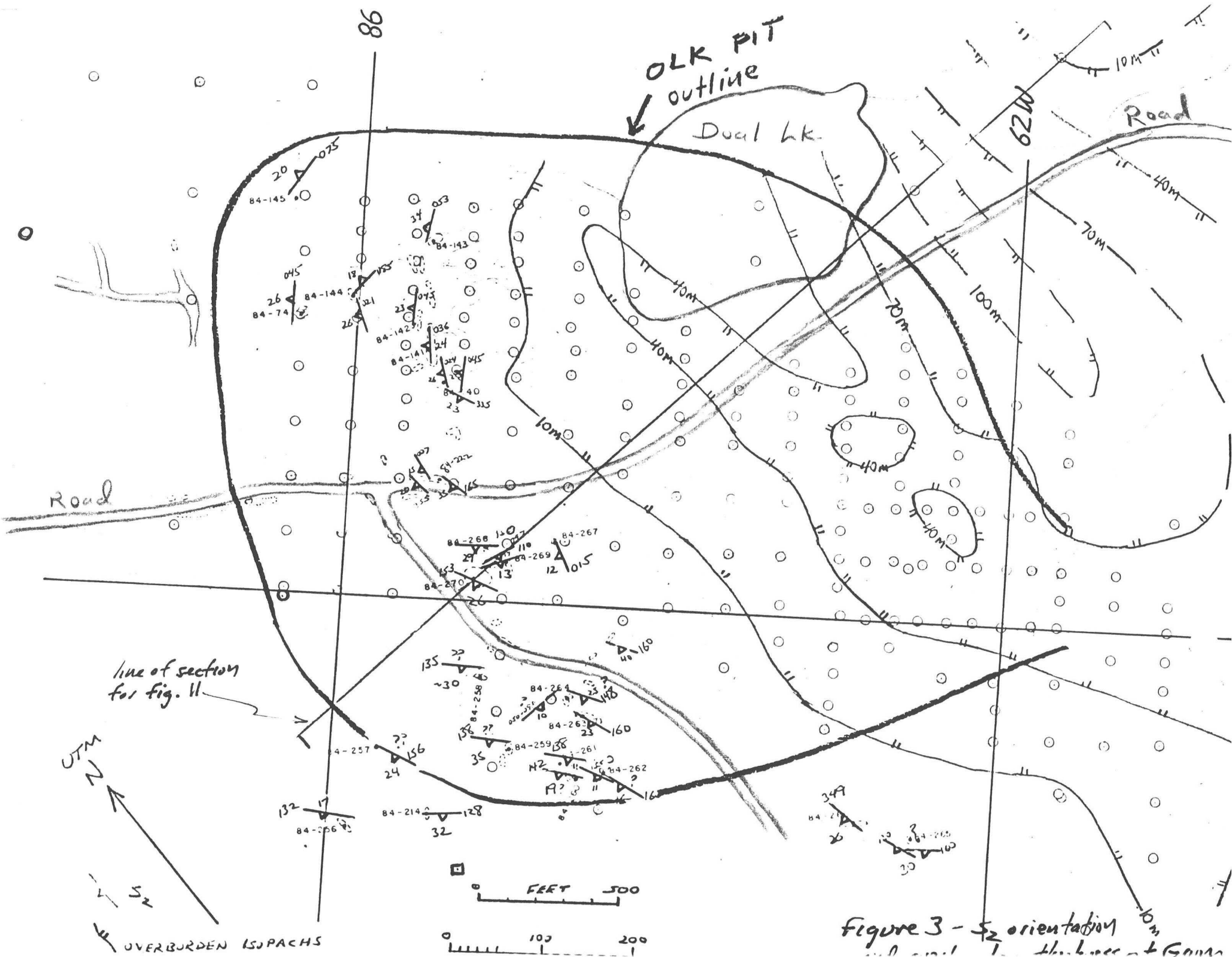
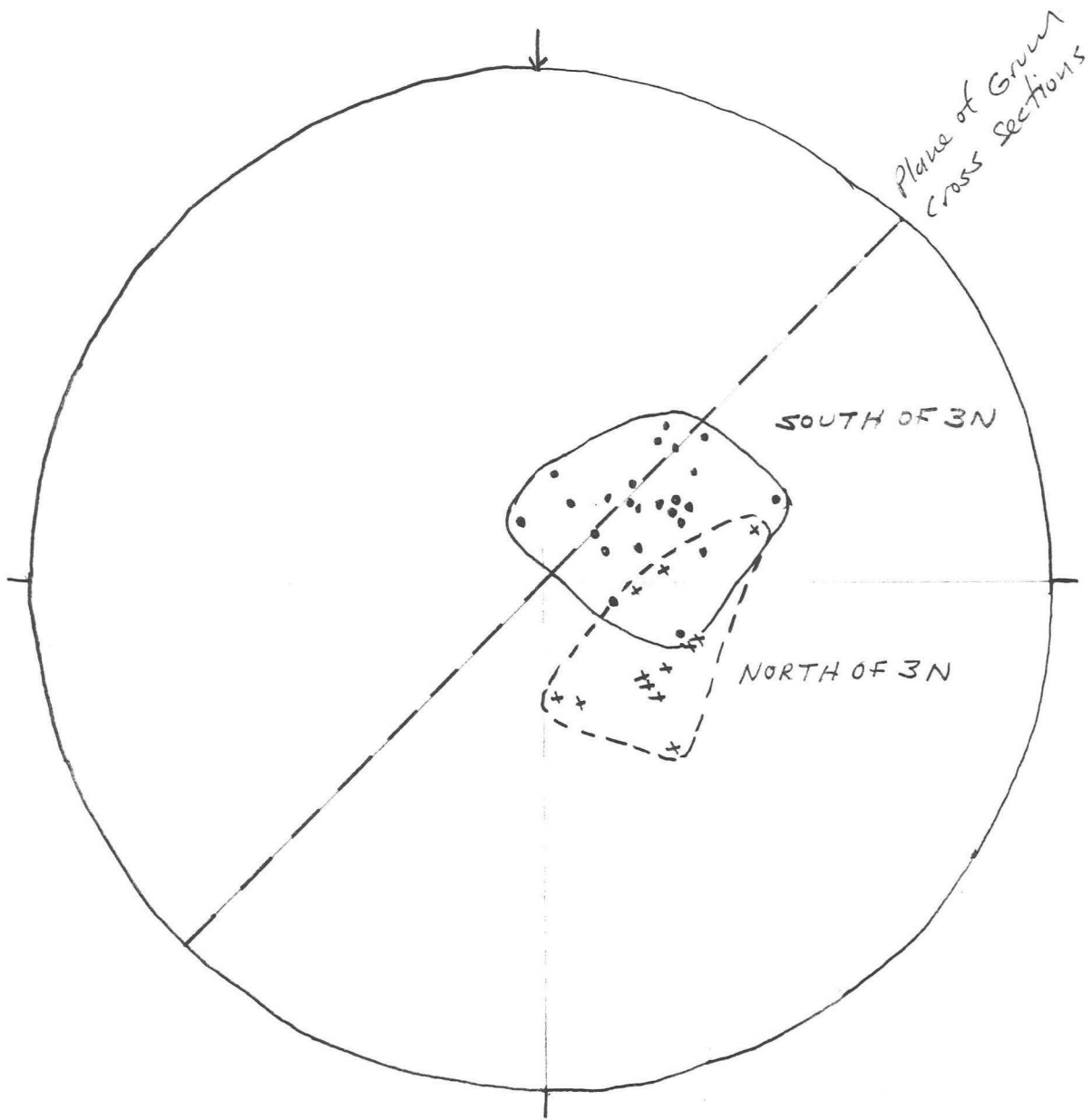


Figure 3 - S_2 orientation
 and soil thickness at Goun



- Poles to S_2 south of 3N
- x Poles to S_2 north of 3N

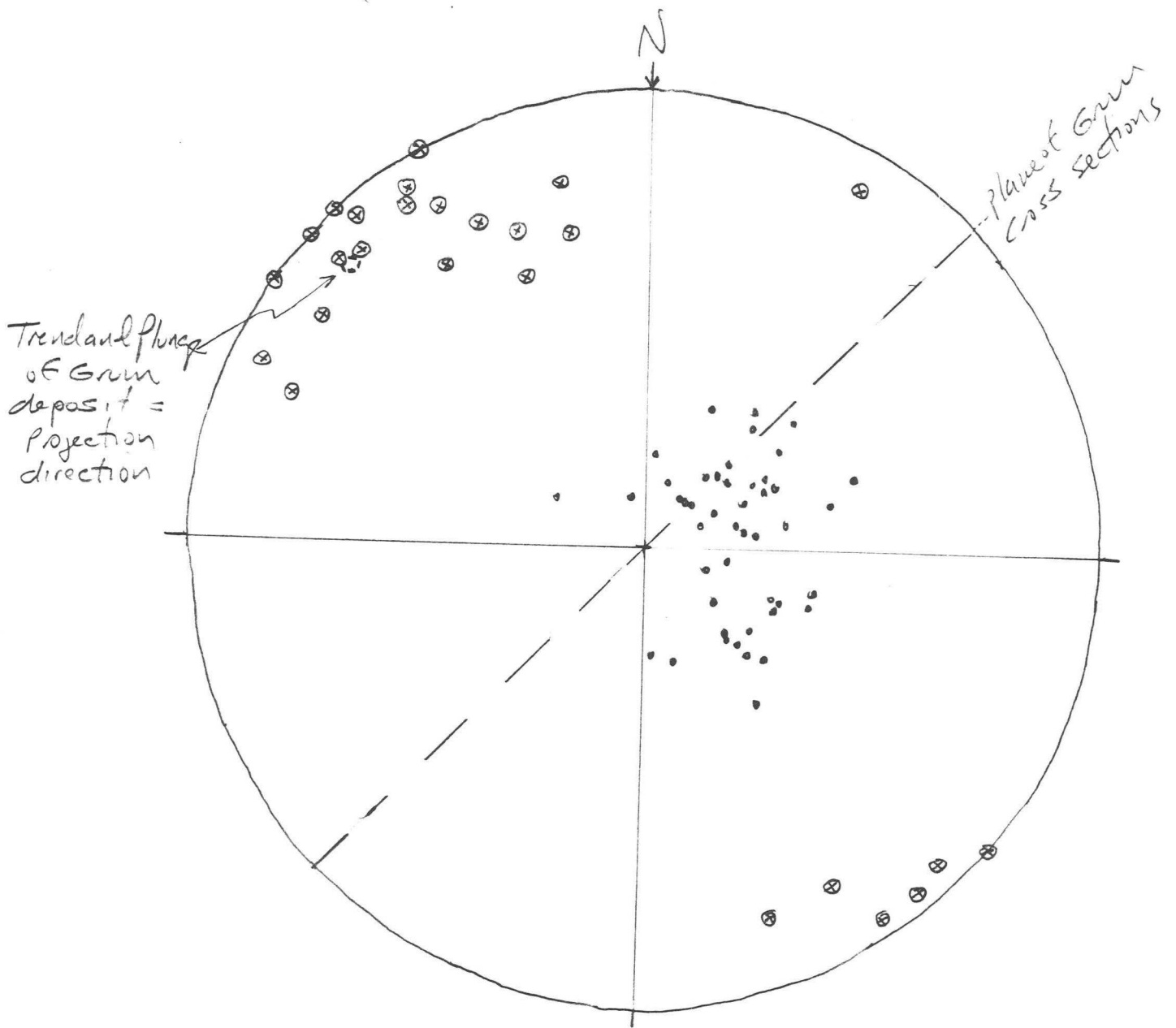
Figure 4
 S_2 poles measured in
 the immediate vicinity
 of Groom during
 1984

Figure 5 shows the results of measurement of S_2 and L_2 for the area around Grum. It is analogous to Figure 1 but draws data from a smaller area. Note that on this stereonet and the underground map (Figure 2) the average foliation strike is close to 000° but that is not a common direction for individual measurements.

Steep foliation along the East Walls

The foliation dip in the northeast pit walls is the most difficult issue and it is these areas where overburden cover is greatest and data is least. Certainly where the walls are in thick overburden the pit slopes will have to be kept shallow. Dewatering of the overburden must be considered as this will have a substantial effect on stability as the Montreal report points out. In the bedrock it is these areas where the foliation dips predicted by Montreal Engineering looks most suspicious to me. Dips of up to 70° are predicted (see plates C-13-C-15) as a result of manipulating the foliation angles measured and displayed by Kerr Addison geologist on cross sections.

There are two points to be made here. First the assumption has been made that the foliation angles plotted by Kerr geologists on section were apparent dips. This is not the case. Sirola stated on page 11 of Kerr Addison's 1977 Mineral Inventory Report that foliation was plotted numerically, while the meaning of this statement maybe unclear, checking their logs against the sections shows that the measured core angle was simply plotted directly in relation to the apparent drill hole trajectory on section. By assuming a strike of 000° and using the plotted dips on section with the assumption that they are apparent dips one arrives at a "true" dip that is too large. Figure 6 and Table 1 of this memo show that the magnitude of this overestimate is 0° to about 10° depending on the local geometry. Consequently the dips plotted on plates C-13 to C-15 should not be accepted uncritically. Of greater importance of course is possibility that the 000° strike is not applicable. Reference to the foliation charts for the northeast and southeast walls shows that this is not necessarily good news since the statement



- S_2 poles
- ⊗ L_2

Figure 5

Poles to S_2
& L_2 lineations

all domains Near the
Gmm Deposit

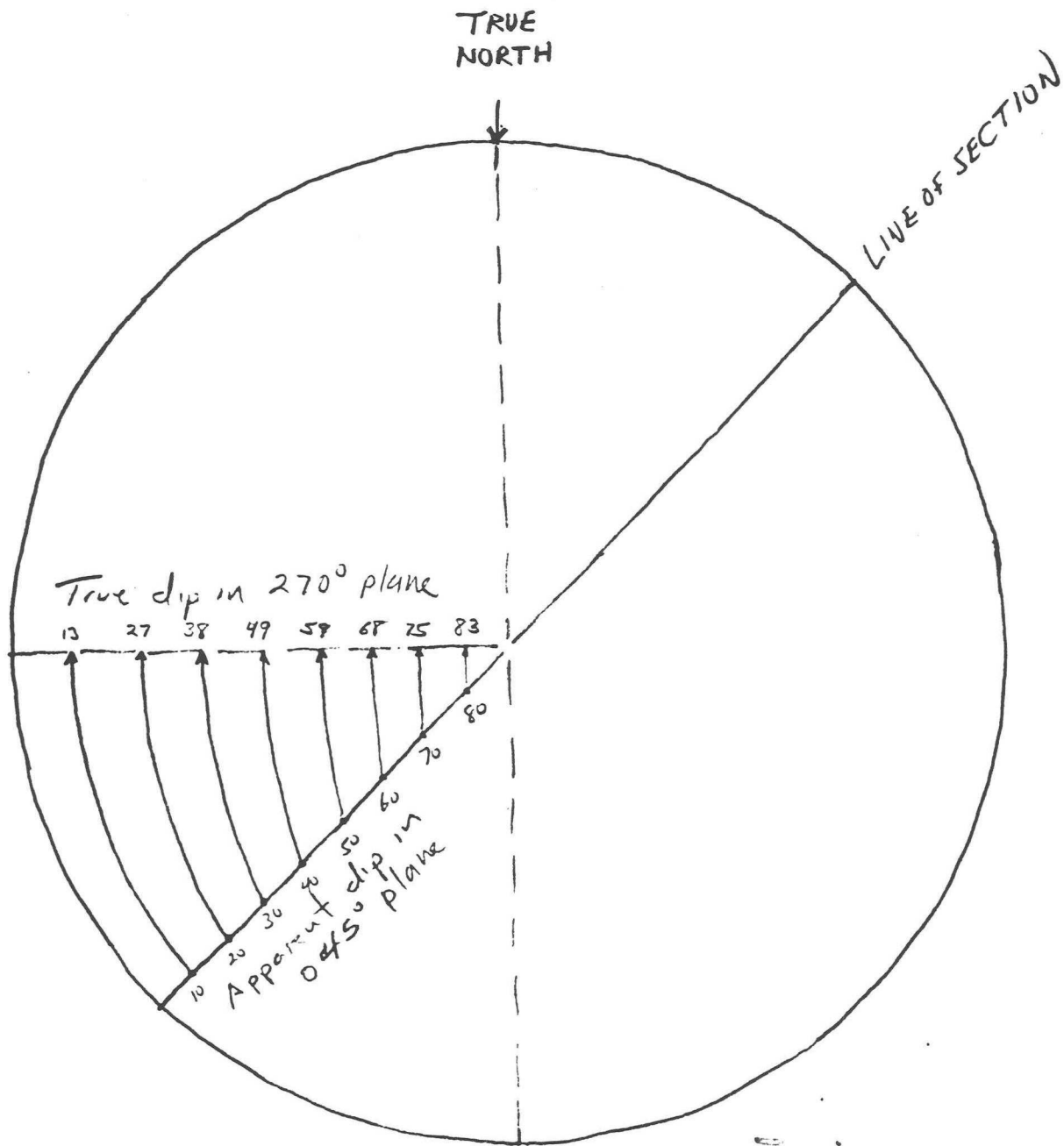


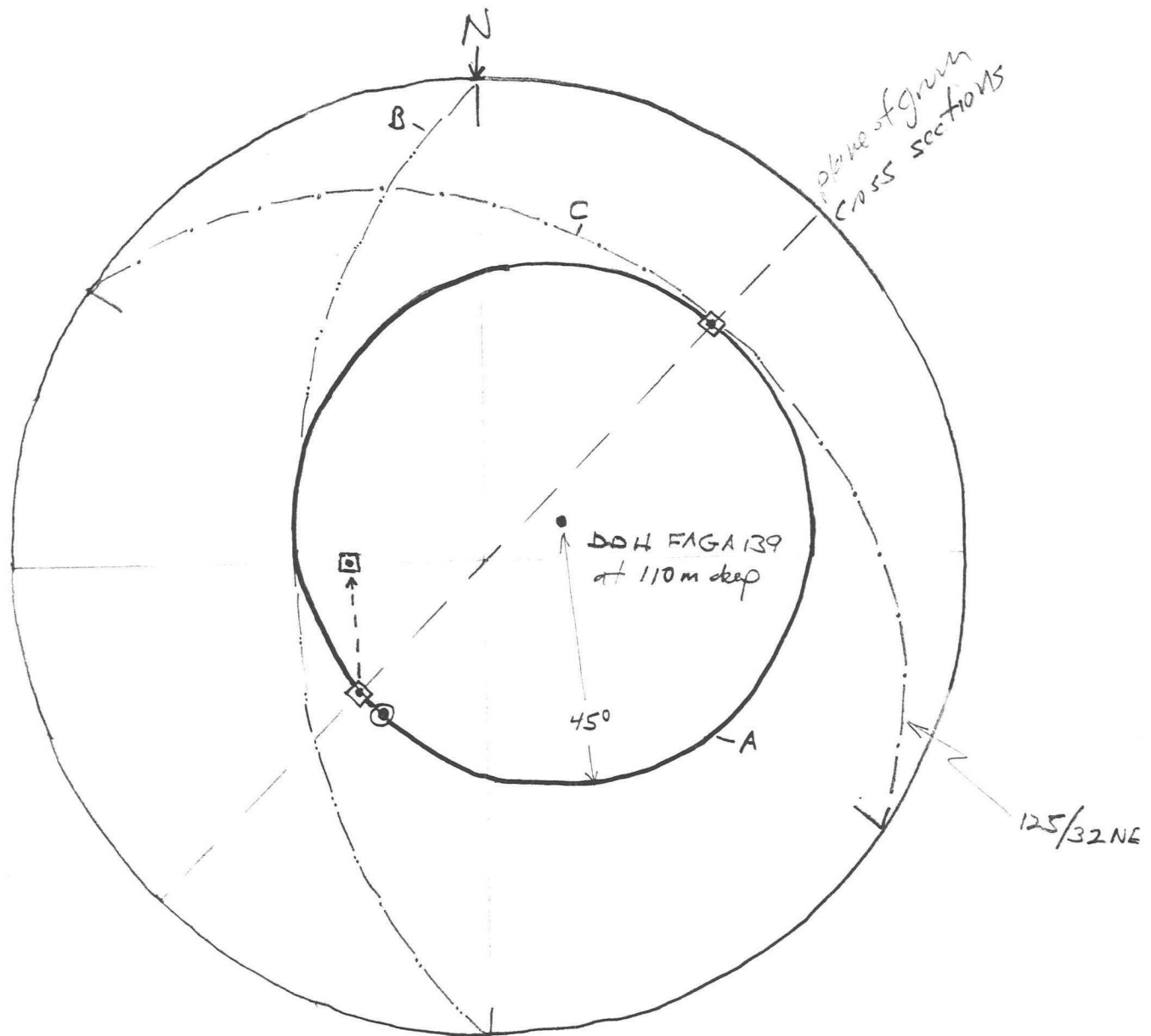
Figure 5.
 Stereonet showing the
 result of assuming
 plotted S_2 in plane of
 section is an apparent
 dip

TABLE 1. Amount of exaggeration of dip that results from the assumption that the dips on section are apparent dips and the the strike is north - south

apparent dip on a section at 045 degrees	true dip if plane strikes 000 and dips west	exaggeration of dip that results
0	0	0
10	13	3
20	27	7
30	38	8
40	49	9
50	59	9
60	68	8
70	75	5
80	83	3
90	90	0

is made that shallower dips will mean less stability (footnote 2 of Table V). The extent to which this generalization is valid is uncertain since there must come a point when stability starts to increase as dip decreases. If dips are 20° then increased stability may set in especially if there is waviness in the foliation resulting in a lower sheet dip (thus my concern over a small increase to dips thought to be in the 15° to 30° range).

It is at this point where the second issue must be discussed. That is that foliation angles are measured relative to drill holes that are not necessarily vertical nor on section. It is this correction for drill hole deviation that can be most significant at Grum and it is likely that the areas of steep dip predicted in the pit have their origin here. A typical area of suspicious steep dip is at 10 north on section 66W on level plan 1203m (Plate C-13). The drill hole that is the source of data here is FAGA139. At the point in question the foliation angle measured is 45° , when plotted on section this translates to a dip of 58° and when "corrected" for apparent dip this becomes the 69° shown on Plate C-13. Figure 7 shows the orientation of the drill hole, the cross section and a small circle that represents the cone that is the locus of all possible poles to the foliation. Because this is a special case (of 45° angle between the foliation pole and drill hole) the small circle also is a close approximation to the locus of all possible dip directions for the foliation. This figure shows that the true dip for the 270° (i.e. the assume 000° strike) direction is 57° , it also shows that a number of alternate solutions for the foliation dip exist. Underground mapping shows that northeast dips do occur thus this possibility should be considered, if the generalized dip direction for the domain north of 2N is used here the resultant dip is 32° to the northeast. If this is the cause of the several very steep foliation dips predicted by Montreal Engineering for the northeast and southeast pit walls then it is possible that there is actually a fairly well developed component of northeast dips there. Once the slight exaggeration of southwest dip is removed and the possibility of a slight waviness to the northeast is added in the situation could be somewhat



A) small circle representing the cone of all possible poles to S_2 and approximately all possible dip directions

□ Two possible solutions for S_2 dip direction if dipping in plane of sections - Kerr plotted the one with southwest dip - the dotted line shows the exaggeration of the dip if an apparent dip is assumed.

Figure 7

B) great circle showing actual S_2 plane if strike is 060° and dip is to west

C) great circle showing S_2 if average dip direction for S_2 in underground N of $2N$ is assumed. \odot is its pole.

more hopeful than we are anticipating.

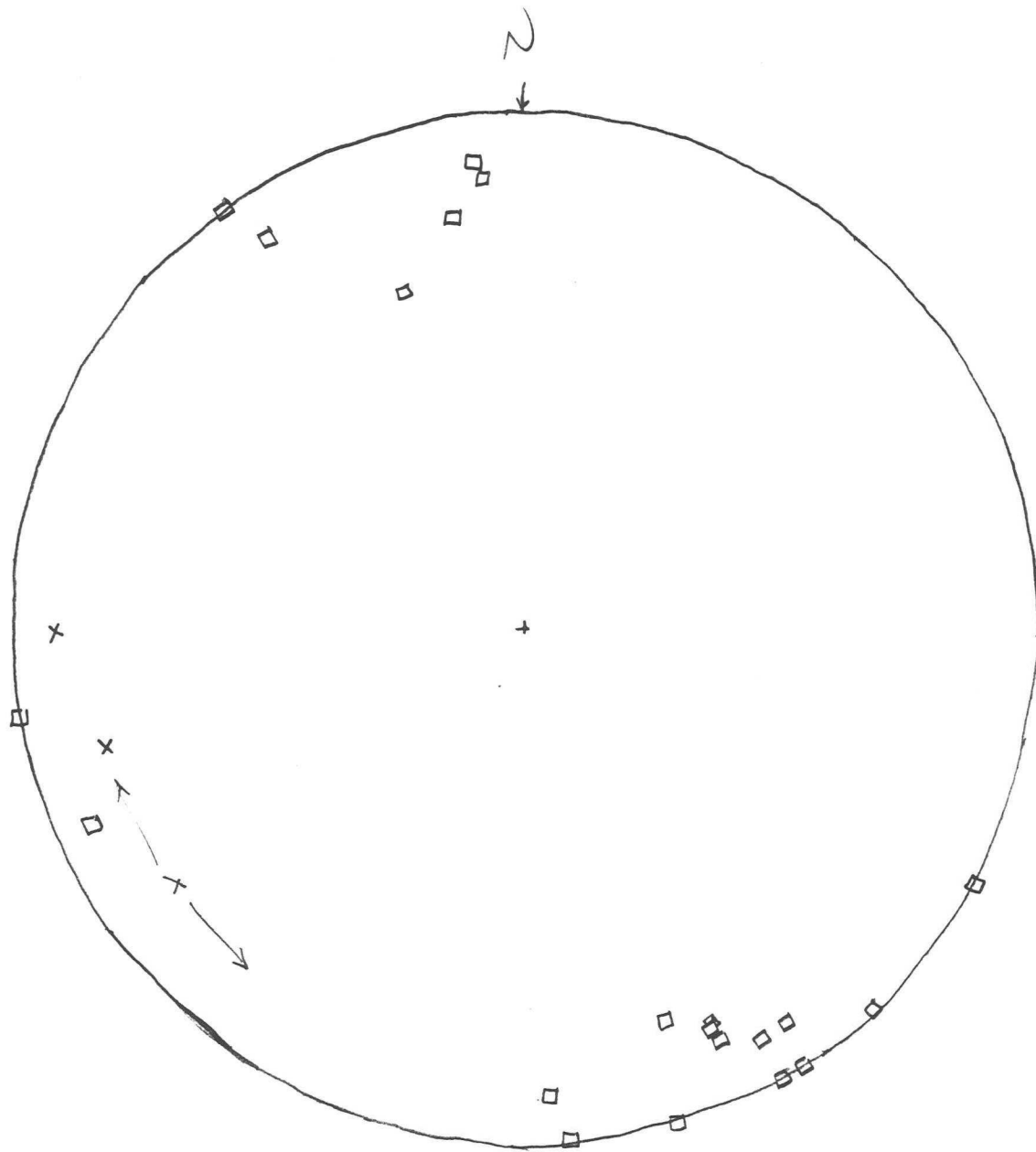
Moderate Angle Faults

Faults with moderate dips are an important component of the overall structural style of the Vangorda Plateau and the Grum deposit. Preliminary indications are that a major gouge marked fault zone will be found in the northeast wall. The fault is expected to be striking north-south and dipping 40° to the west. If the foliation is dipping to the southwest there may be problems with 3D wedge failures. As the structural interpretation of Grum progresses more data on this structure will become available. A larger fault (the Doal Lake Fault) of similar nature and orientation truncates the Grum deposit at its east end. Current [note: as of 1984] pit designs do not include this area but a large pit intended to take the upright panel may encounter stability problems due to this structure [note: the current CRI pit does take in the upright panel]. Similarly oriented faults were pointed out to be present in the Montreal report (page C-6).

Figure 8 shows the results of measurement of close spaced joints to wide spaced fracture cleavage in phyllites around the Grum deposit (1984 data). These poles fit well with those measured underground and show that the joints measured in ore do apply to rocks outside the ore. This direction is very widely developed throughout the Vangorda Plateau. Other joint directions occur but they are more local; nonetheless they can be the significant controls on rock breakage.

Overburden east of the Grum Deposit

Figure 3 shows overburden thickness isopaches. As is apparent from that map there is a buried valley to the east of the Grum deposit. The valley runs north-south and appears to be controlled by the soft, highly gouged phyllites of the Doal Lake Fault Zone. The east side of this valley, from the available evidence, is quite steep and slopes toward Grum at an angle of 25°. Figure 9 shows this valley in relation to the approximate Olk Pit limit. Incrementally larger pits designed to mine the upright panel and other sulphide horizons will encounter increasing thicknesses of overburden. It does not appear likely that the



□ poles
 x axes

Figure 8

poles to close spaced joints
 to wide spaced fracture
 cleavage & axes of kinks
 related to them

GROND - all domains

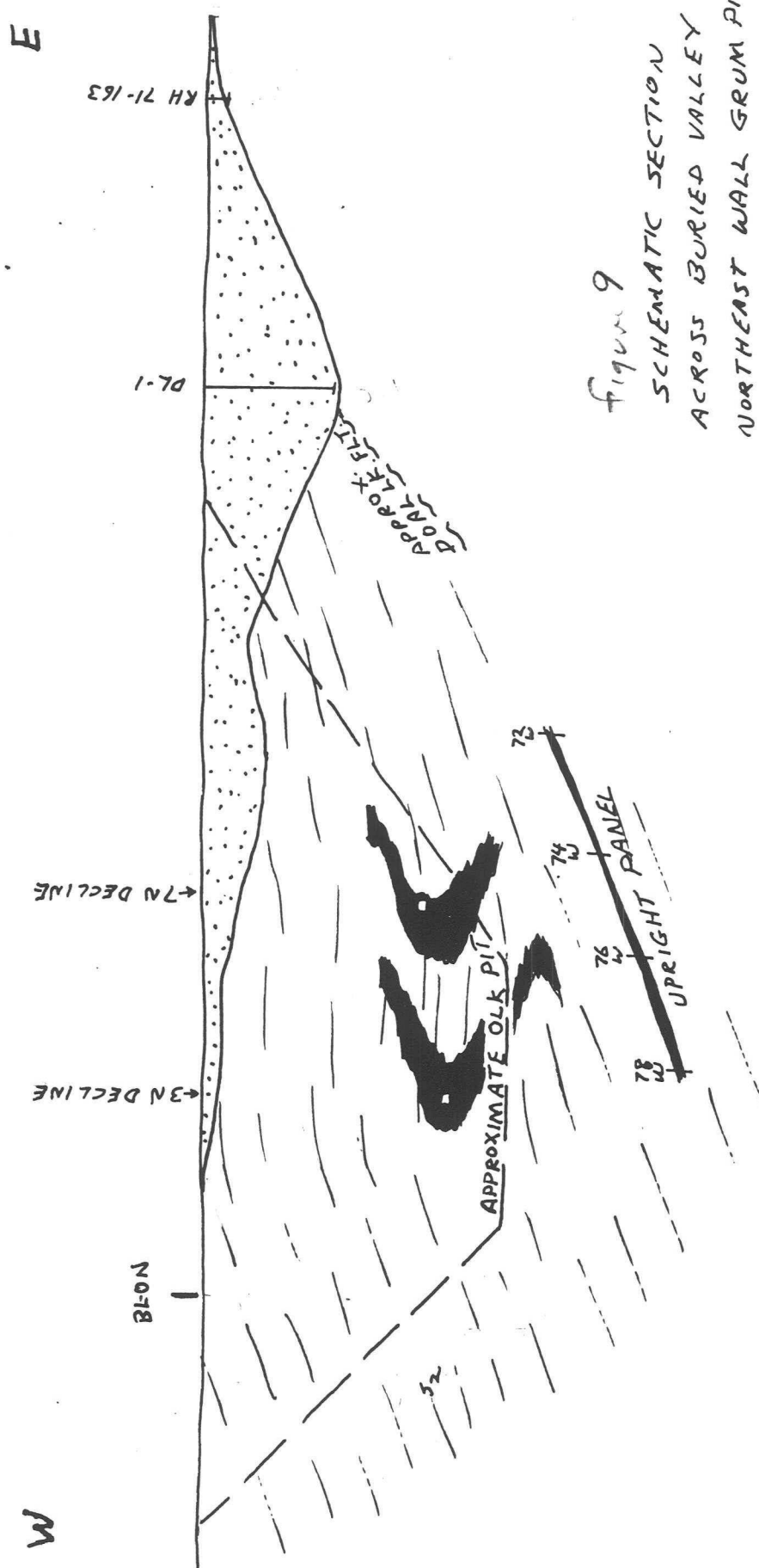


Figure 9
 SCHEMATIC SECTION
 ACROSS BURIED VALLEY
 NORTHEAST WALL GRUMP PIT
 1:5000

Note: BEDROCK GEOLOGY IS
 HIGHLY SCHEMATIC

west sloping sub-overburden surface will ever daylight in the pit but sufficiently large proposed pits may have problems with failure on this plane.

Recommendations

Structural mapping of the Grum Pit walls must be ongoing in order to provide a basis for analysis of drill hole data.

The sorts of analysis of foliation dip undertaken here should be extended. Since shallower dips may be expected than the 24° minimum currently studied, foliation charts for lower dips should be derived for the northeast and southeast walls. Since foliation waviness may occur along these walls, Q-sums analysis of the foliation should be undertaken.

A geotechnical engineer should examine the date for Grum in close co-operation with a project geologist. Most of what is said here was previously mentioned in the recommendations of the phase two geotechnical report. The other recommendations of the Montreal Engineering report should also thus be enacted or examined at the earliest practical date.