GEOPEKO LIMITED

KING ISLAND

REPORT No. KI/73/3

ENGINEERING GEOLOGY OF THE DOLPHIN OREBODY

by

D. H. MOORE

ISG COORDINATES
REFER REPORT 70-0676

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CONTENTS

INTRODUCTION

This report arises from a request by King Island Scheelite Ltd. for information on the geology and rock stabilities in two particular areas of the Dolphin Orebody, the C lens hangingwall and a proposed 1:6.8 decline.

In combination with careful geological interpretation of the diamond drilling, it was hoped that indications of the stabilities of the various rock types to be encountered, and the location of zones of poor ground could be obtained.

Forty three diamond drill holes have been partly or completely logged for engineering purposes since 1970. The results of logging up to December 1972 have been discussed in a memo by P. Cottam in February 1973, and are summarised in this report. Data from the engineering logging of parts of each of the twenty seven diamond drill holes additionally logged for this study, including DDH 416, drilled to test the ground conditions of the first 200 metres of the 1:6.8 decline are presented.

In the engineering logging, note has been made of the fracture frequency, core loss, percentage of core less than 7.5 cm. in length, degree of weathering, and hardness. The effect of joint fillings has also been discussed.

Use has been made of Ege's (1968) method of calculating the relative stabilities of rocks. Comparisons are made with the Bold Head decline, King Island and the Climax Stock, Nevada, U.S.A.

SUMMARY

A study of rock stabilities near the proposed 1:6.8 decline, and in the hangingwall of C lens, Dolphin Orebody, was undertaken at the request of King Island Scheelite Ltd.

Analysis using Ege's (1968) Stability Index and joint frequencies revealed that B lens marble and C lens skarn were likely to be the most competent rock types in the decline, and the Upper metavolcanics and the B lens pyroxene hornfels the least competent.

The major rock type to be encountered by the decline is expected to be the B lens hornfels, which will probably need some rock bolting even where not intersected by faulting.

Poor ground is anticipated in the following zones; 97 - 110 metres, 150 - 210 metres, and from 310 metres, from the portal. The presence of some areas of fair stability are indicated within these zones.

A reduction of approximately 100 metres in the amount of unstable ground can be expected by repositioning the decline target 20 metres further to the west, and by a deviation eastwards of approximately 30 metres at about 150 metres from the portal.

Thirty eight diamond drill holes have penetrated C lens. Following Ege, 19 indicated either poor or incompetent hangingwall rocks, sixteen were classed as fair or good, and four had been split before they could be logged.

The "Wedge" area and the down-dip extensions of ore from the Open Cut appear to be the most stable areas. The southeastern quarter which contains over half the metal content of C lens appears to be the least stable.

Further evaluation of rock stabilities during the underground oreblocking program is recommended.

CONCLUSIONS

1. The stabilities of rock types to be encountered in the proposed 1:6.8 decline, in decreasing order are :-

B lens marble, C lens skarn.

B lens hornfels, Hangingwall biotite hornfels, Pyroxene garnet hornfels.

Upper metavolcanics, B lens pyroxene hornfels.

2. Approximately 270 metres or 50% of the proposed 1:6.8 decline is likely to be in rock classed by Ege (1968) as either poor or incompetent and, after Ege, is likely to need moderate to substantial support. Without the benefit of underground openings, it is very difficult to say whether close spaced rock bolting or steel sets would be required in these areas.

3. Approximately 75 metres of the bad ground could be reduced of possibly eliminated by repositioning the eastern end of the decline approximately 20 metres west onto section 6N.

4. A further reduction in poor ground could possibly be made by repositioning the decline northwards at about -75 metres RL. This may eliminate a section of Upper metavolcanics and the Dividing Fault., if present, would be crossed at a less oblique angle.

5. The stability of rocks to be encountered in the decline is expected to be less than that predicted by Ege's method, but greater than that seen in the Bold Head Decline, for equivalent Stability Indices. This is because Ege's Stability Index takes no account of the quantity or mineralogy of joint fillings, or whether the fractures are open or closed. At Bold Head, the joint filling of thick layers of chlorite substantially reduces the stability of the rocks. The effect of chlorite joint fillings is likely to be greatest in the B lens pyroxene hornfels, the Upper metavolcanics and in areas of high contrast in competency.

6. The major rock type found in the immediate hangingwall of C lens is likely to be Pyroxene garnet hornfels (pgh). In two areas, on section 1N and 7N, this has been faulted away so that Hangingwall biotite hornfels directly overlies the ore. The thickness of unmineralised Pyroxene garnet hornfels ranges from 1 to 11 metres. Above this the rock type will be Hangingwall biotite hornfels.

7. The stability of the C lens hangingwall is indicated as best in the "Wedge" area and worst in the south eastern quarter of the lens.

8. Throughout most of the body, it is indicated that the rocks will be stable enough to allow moderate sized stopes. Rock bolting will probably be required.

9. In the "Wedge" area less rock bolting or larger stopes may be possible, providing caution is exercised along the Wedge Fault and especially the Northern Fault.

10. The southeastern area may require a different stoping method as here the thickest ore with the best tonnage and grade in the mine is present below the worst hangingwall in the body.

11. None of the parameters used in this study take into account the quantity or mineralogy of a joint filling, or whether a joint is open or closed. It is known at Bold Head for example, that the highly chloritic joint planes in the Upper metavolcanics reduce the rock stability substantially. Stability Indices, joint counts, etc., can therefore only be a rough guide to what the stability of the rock in a given situation really is. The many different core sizes used in the drilling of the orebody have obscured this relationship even further.

12. The separate measurement of the Rock Quality Designator (R.Q.D.), that is the percentage of core longer than 10 cm., is unnecessary when Ege's Stability Index is also to be calculated. There is a close relationship between the R.Q.D. and the percentage of core greater than 7.5 cm. in length. The measurement of the Stability Index appears worthwhile, and future core logging for engineering purposes should be sufficiently detailed for this.

RECOMMENDATIONS

1. Consideration should be given to adjusting the target point of the proposed 1:6.8 decline at the -125 metre RL. approximately 20 metres west of the target proposed in May 1973. A deviation eastwards at the -75 metre RL. may also decrease the amount of poor ground to be encountered.

2. Careful consideration as to the most appropriate mining method be made in light of the indicated poor hangingwall conditions likely to be expected when mining C lens. Revaluation of the stability of the C lens hangingwall should be made after the completion of the decline and the oreblocking program on the body.

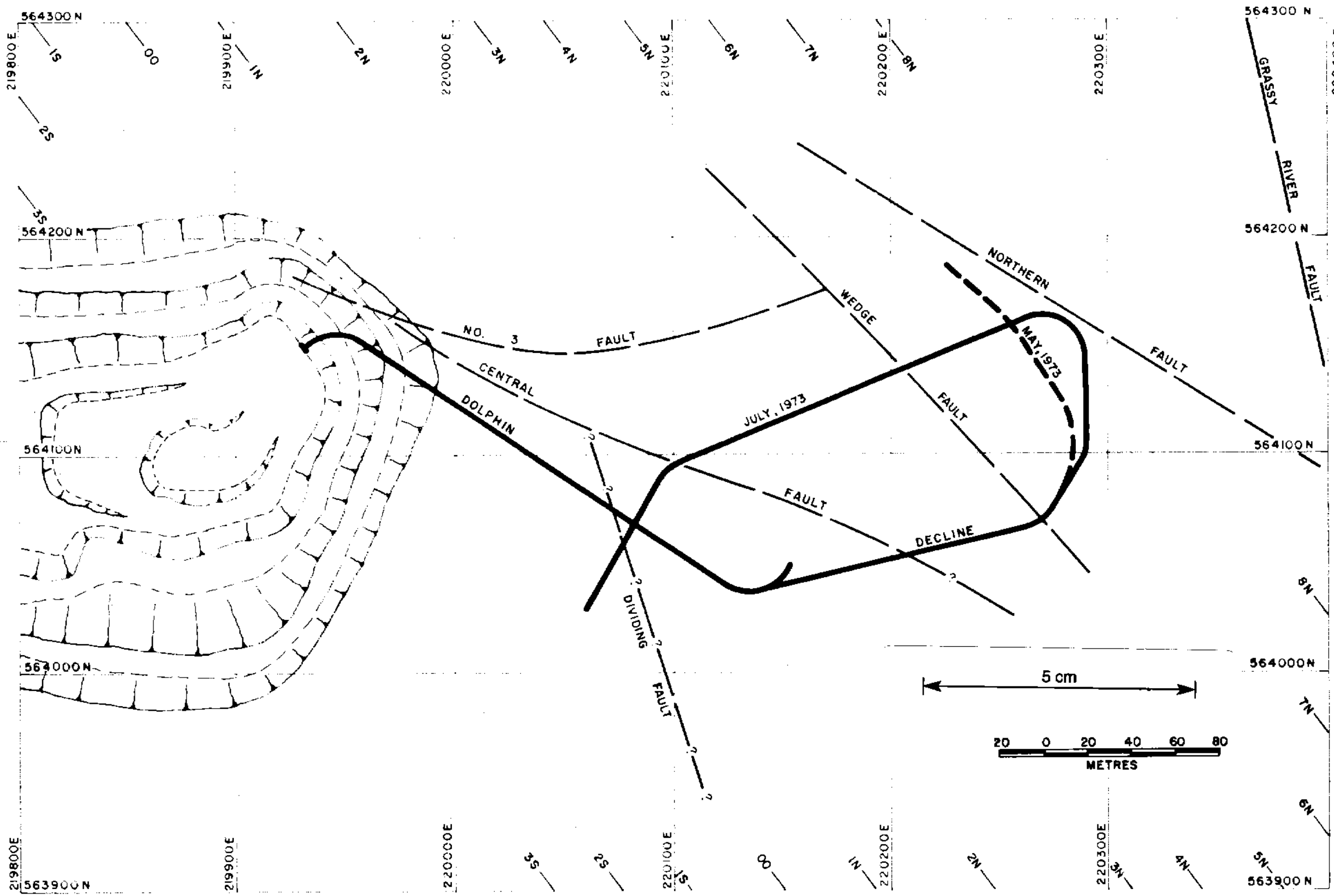
3. Comparison should be made with the stability conditions predicted in this report and those actually encountered. Only a continuing program of this type will enable sufficient knowledge to be built up so that prediction of rock stabilities will become closer to reality.

ACTION SHEET

1. Most of the work for this report had been completed when the design of the decline was amended to a 1:7 ramp to the -150m RL. (Aug. 1973).

The new design of the decline follows the previous design to approximately the -100m RL.

A memo to cover the expected ground conditions in the portion -100m to -150m RL. of the amended decline is expected to be completed by the end of Period 3.



Comparison of May and July, 1973 Declines

ACTION SHEET FIGURE I

TABLE 1.

COMPARISON BETWEEN STABILITY INDICES, THE CLIMAX STOCK AND BOLD HEAD UPPER VOLCANICS

STABILITY INDEX	JOINT FREQUENCY (J/M)	% CORE > 7.5 cm. IN LENGTH	CLIMAX STOCK	UPPER VOLCANICS, BOLD HEAD
< 8	< 8	> 95	Good rock; requires no support.	Rock bolting required.
8 - 12	8-16	85 - 95	Fair rock, requires occasional support; moderate overbreak.	
12 - 17	16 - 21	75 - 85	Poor rock; requires support much overbreak.	Steel sets required.
17 - ∞	> 21	< 75	Incompetent rock.	Closer spaced steel sets and some grouting required.

After Ege 1968 & Danielson (pers. comm.)

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TABLE 2.

ANTICIPATED ROCK STABILITY ALONG THE PROPOSED 1:6.8 DECLINE

DISTANCE FROM	TO	ROCK UNIT	APPROXIMATE No. J/M	PROBABLE ROCK STABILITY
0	63	C lens	7	Generally good. Poor approx. 26 to 29 due to minor fault.
63	82	Pyroxene garnet hornfels	5	Good.
82	97	Hangingwall biotite hornfels	7	Good.
97	109	Hangingwall biotite hornfels	20	Incompetent or poor. Possibly a fault zone.
109	131	B lens	10	Marbles good, pyroxene hornfels poor. Overall probably poor.
131	153	B lens hornfels	9	Good, decreasing to fair.
153	177	Upper metavolcanics	20	Poor, decreasing to incompetent as possible Dividing Fault (?) is approached.
177	210	B lens hornfels	15	Incompetent, grading to fair? away from possible Dividing Fault (?).
210	308	B lens hornfels	5	Good.
308	315	B lens hornfels	>10	Poor possibly to incompetent at fault.

(CONT.)

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TABLE 2. CONT.

ANTICIPATED ROCK STABILITY ALONG THE PROPOSED 1:6.8 DECLINE

DISTANCE FROM	DISTANCE TO	ROCK UNIT	APPROXIMATE No. J/M	PROBABLE ROCK STABILITY
315	335	B lens pyroxene hornfels	>10	Incompetent? to poor away from fault. May not be present in backs of Decline.
335	395	B lens hornfels	>10	Poor to imcompetent. Possibly isolated areas of fair rock before Wedge Fault.
395	434	B lens hornfels	15?	Fair to poor? Ground conditions largely unknown.
434	477	B lens	15?	Poor? Ground conditions largely unknown.
477	505	Hangingwall biotite hornfels	15	Fair to poor. Stability decreases as Northern Fault is approached.
505	516	Pyroxene Garnet Hornfels	17	Poor in the vicinity of the Northern Fault.
516	530	C lens skarn	18	Poor to incompetent? in the vicinity of the Northern Fault.

After Bujtor and Moore (1973).

156012

METHOD OF ANALYSIS

The method used for logging holes 400 to 415 inclusive, with the exception of holes 410 and 411, has been discussed in the memo by Cottam and Rogers (Feb. 1973). This method did not allow for the calculation of Deere's (1964) Rock Quality Designator (R.Q.D.) or Ege's (1968) Stability Index, both useful parameters for comparing similar rock types, and so was abandoned in later logging.

For this report the parameters noted were the number of fractures per metre, core loss, percentage of core less than 7.5 cm in length, fracture filling, and the angle of the fracture with respect to the core. These parameters were used to calculate Ege's Stability Index (J.R. Ege, 1968), using the formula

Stability Index = 0.1 (core loss) + fracture frequency per ft. + 0.1 (broken core) + weathering + hardness.

In almost all cases weathering was taken as 1 as all core logged was unweathered, and hardness as 2, hard. Results are listed in table 3.

Varying joint fillings, core sizes, coring methods, and the relative skills of different drillers are not taken into account, though all influence the relationship between the stability index and the actual stability of the rock. For this reason it is difficult to meaningfully compare stability indices from different rock types, or even from drilling programs on the same rock type where different equipment has been used.

. Table 1 shows a comparison between Ege's Stability Index, and the stabilities encountered at Bold Head, and in the Climax Stock, a granodiorite. It can be seen from the chart that the latter is approximately two classes more stable than the Upper Volcanics, with equivalent Stability Index. (No account of the size of openings at Bold Head or the Climax Stock have been considered here, the comparison then is indicative only.) The stability index of 7.0 of the B lens hornfels in DDH 416 is lower than the index for the other holes in the same stratigraphic unit, (table 3). This may be due to the former being cored in BQ whereas the latter in good ground was cored AXT.

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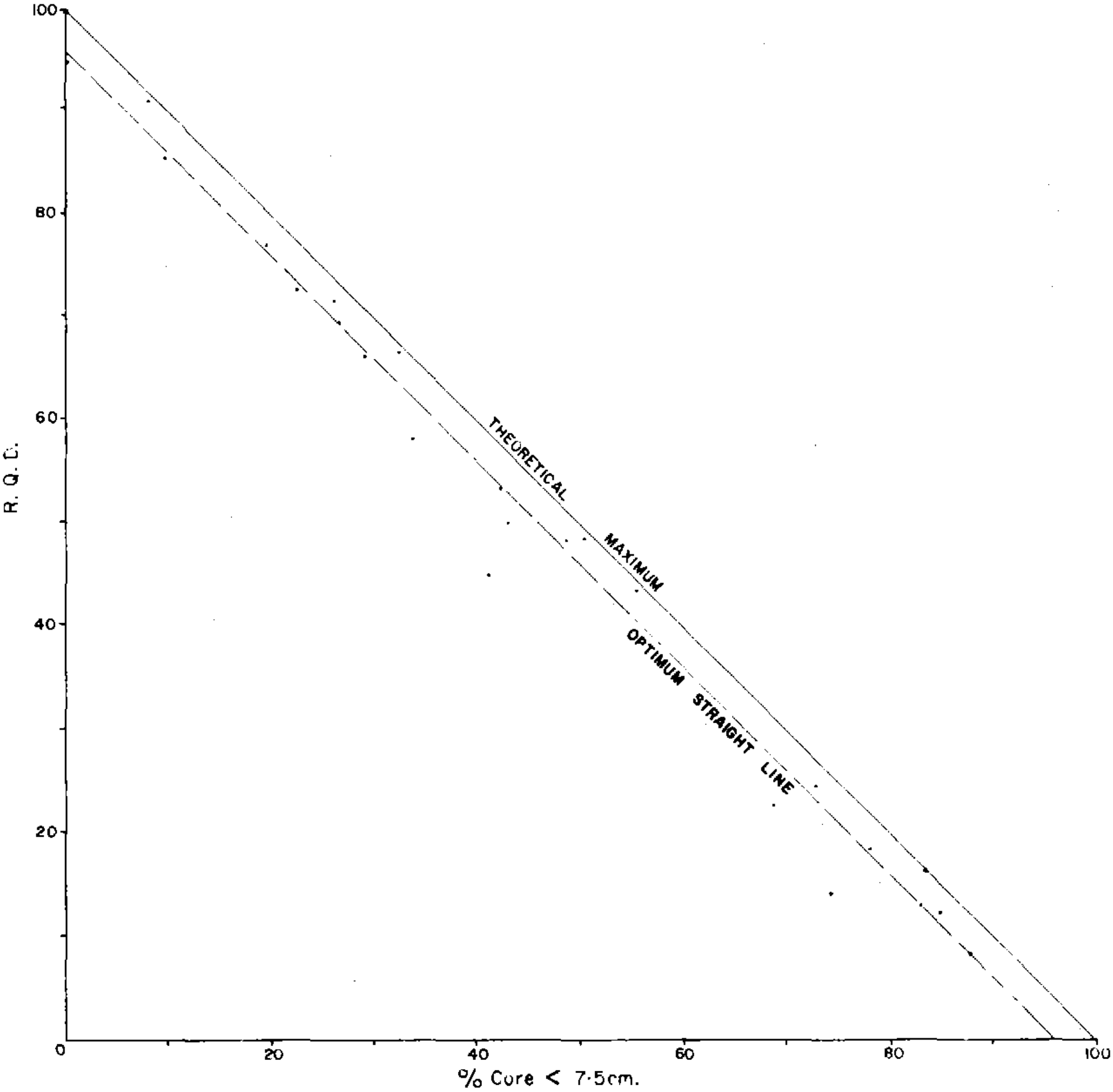
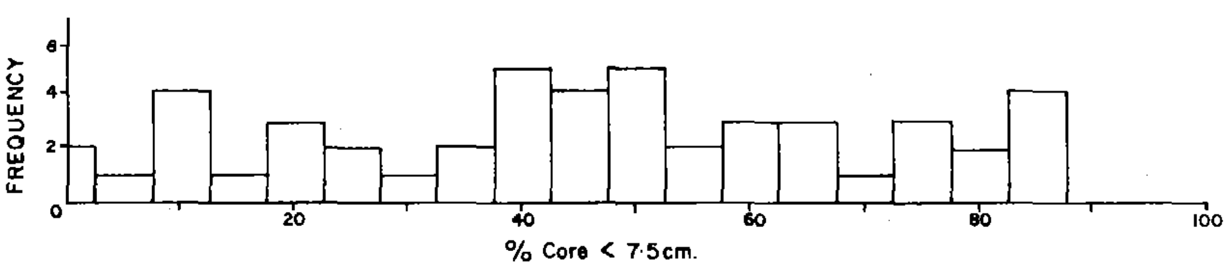


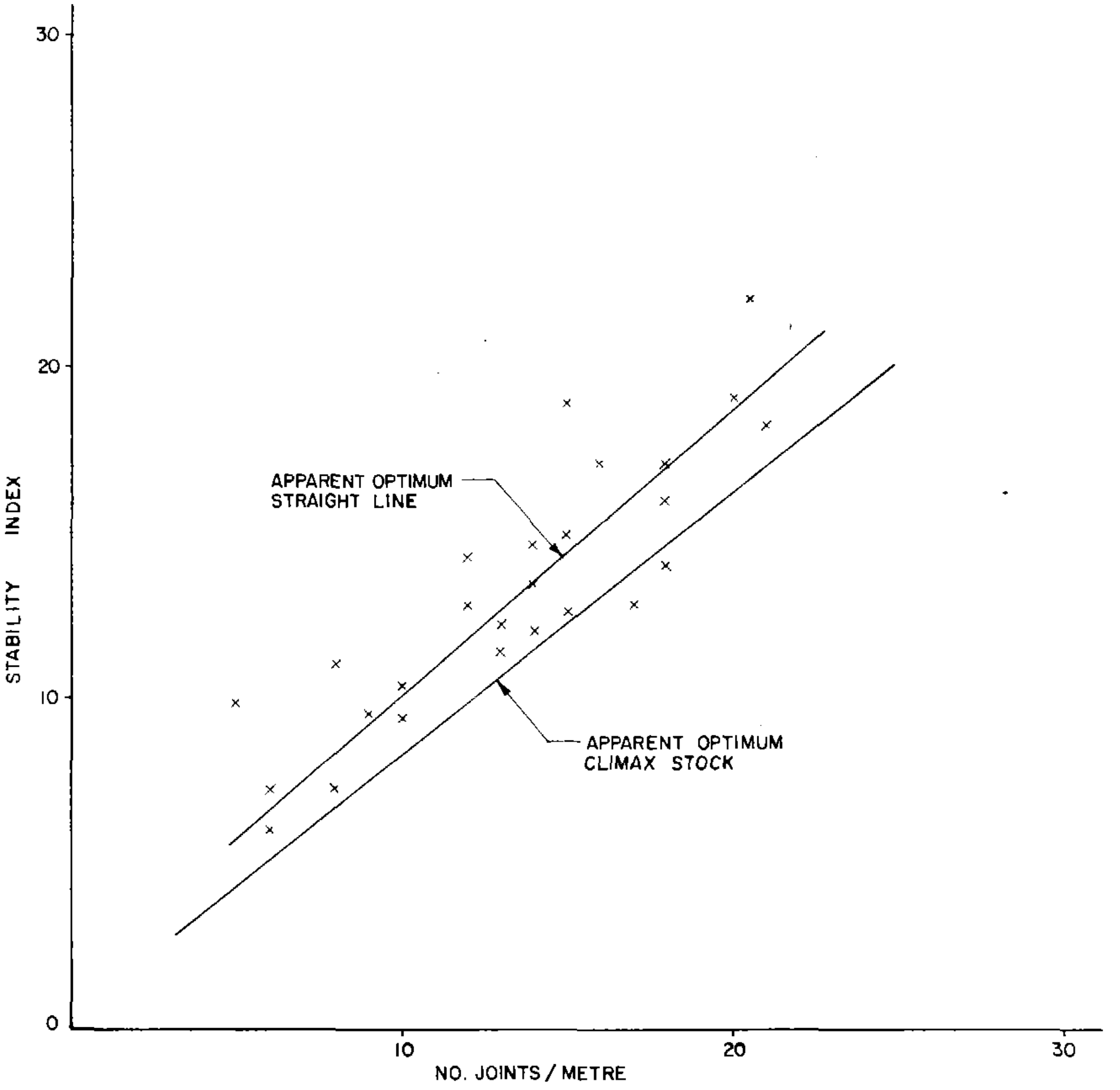
Plot of R.Q.D. Against % Core <7·5 cm.

Figure 1



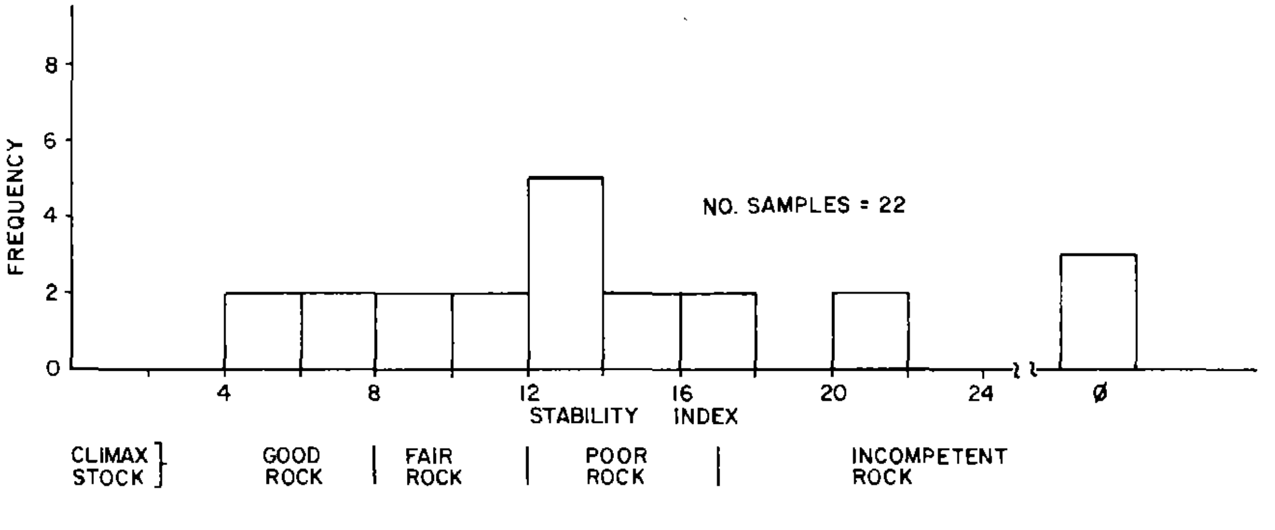
Histogram of % Core < 7·5cm.

Figure 2



PLOT OF NUMBER OF JOINTS/METRE AGAINST STABILITY INDEX

FIGURE 3



HISTOGRAM OF C LENS HANGINGWALL STABILITY INDICES

FIGURE 4

On some holes the R.Q.D. (i.e. the percentage of core longer than 10 cm) was also measured. In most cases the function was approximately 5% smaller than the percentage of core longer than 7.5 cm, a parameter measured for the determination of the stability index. A plot of the two parameters (fig. 1) shows an approximate linear relationship. The percentages of core greater than 7.5 cm, recorded in table 3 may therefore be taken as about 5% larger than the R.Q.D. (after Deere).

The gap in values between R.Q.D's of 30 and 40 on figure 1 is probably just due to the few points used. No such gap exists in values of % core $<$ 7.5 cm in table 3, as can be seen from figure 2.

No estimate of stability was possible on split core. Thus large sections of B lens and the pyroxene garnet hornfels, and virtually all of C lens in the central sections of the orebody have not been considered in the study. Holes 400 to 415 have been drilled on the known margins of the orebody, and the only logging available is a histogram of the joints. It is possible that a bias may be present in the results presented in these areas but no estimation of the quantity or direction of the bias has been made.

In figure 7, averaging has been done over a distance of up to 10 metres away from the hangingwall of C lens. It is realised that the immediate 3 - 4 metres at the hangingwall will be of prime concern in stope design. However, if the open cut could be taken as a guide, most weaknesses are likely to be moderately to steeply dipping, and so it was thought that weaknesses logged up to 10 metres away from the proposed stope back would probably have a bearing on the stope strength in the vicinity of the drill hole.

RESULTS

Results of the present investigation are shown in table 3 and those of previous work are shown in table 4. In the latter only rock types relevant to the placement of the decline to - 125 m RL and the C lens hangingwall have been included. On table 3 all joint fillings not otherwise annotated are present in minor to very minor quantities. Because of the qualitative approach to fracture logging in previous studies it is not possible to give estimates of the degree and quantity of joint filling present for any of the holes on table 4.

Comparison of the results in table 3 with those in table 1 reveals that 23 of the 48 Stability Index values for all rock types in the vicinity of the decline (48%) have stability indices classed as poor or incompetent by Ege.

Comparison of the results in figure 6 and table 1 shows that 7 of the 13 diamond drill holes passing within 40 metres of the decline (excluding DDH 416) are classed by Ege as either poor or incompetent. DDH 416, drilled to test the first 200 metres of the decline showed two incompetent sections, from 78 to 87 metres and from 133 to 143 metres down the hole. From 143 to 168 metres the ground was classed as fair. Elsewhere it was good.

A similar comparison between tables 1 and 3 reveals that 12 of the 20 sections closest to the decline have stability indices classed as poor or incompetent. Four of the nine diamond drill holes logged containing B lens hornfels, the major rock type in the proposed decline, are similarly classed.

Comparison of tables 1 and 3 also shows that the percentage of core greater than 7.5 cm in length is much lower than would be expected for an equivalent Stability Index. The number of joints per metre is lower than predicted by Ege as can be seen in figure 3. It is thought that this is due to the predominance of fracturing parallel to the bedding and cleavage. They are the most prominent feature of the rocks and are generally at an angle greater than 75° to the drill holes, insuring maximum number of fractures intersected per metre of core drilled.

It is considered that rock stabilities at Bold Head fail to match Ege's predicted stabilities because of the abundance of chlorite on joint planes. Although chlorite is present on virtually all joint planes in Dolphin, the quantities present are, in general, much smaller (less than one tenth as much), and its influence can be expected to be less.

There are however three areas where the quantity of chlorite present on the fracture planes is sufficient to cause problems, they are :-

1. Upper meta-volcanics
2. B lens pyroxene hornfels
3. Contacts between rock types with a marked contrast in competency.

The Upper meta-volcanics usually display very well developed jointing, the surfaces very often being coated with a thick layer of chlorite, probably from the decomposition of pyroxenes and amphiboles. Calcite is often also present. Jointing frequency increases to the south - east, probably in response to the Grassy River Fault (Cottam 1972). Because of the similar quantity of chlorite present, and the same style of jointing as the Upper Volcanics at Bold Head, it seems reasonable to assume it will have a similar stability to them.

The B lens pyroxene hornfels, which is probably part volcanic in origin, (U. Buchard, 1972) is also chlorite rich, again from decomposition of mafic minerals. It is invariably more jointed than the interlayered marbles.

The increase in chlorite normally occurs over about 2 metres at the contacts between adjacent rock types. At marble pyroxene hornfels contacts, the frequency of joints was much higher, often up to 7 metres from the contact with the marble. It is probably caused by the varying competency of the rock units to folding and faulting. The contacts studied were usually those where there was quite a contrast in rock types. Chloritization of joint planes does not usually take place where there is little or no contrast in rock ductility or strength eg. the Pyroxene garnet hornfels - C lens skarn where the contact is gradational.

As the B lens marble-pyroxene hornfels is a unit made up of both stable marble and not so stable pyroxene rich hornfels and that unfavourable contact zones exist, then the suitability of the unit as a favourable host rock for a decline must be questioned.

Talc rarely occurs in the marbles and pyroxene hornfels of B lens and was not logged elsewhere in the sequence. Where present it will cause even more instability on joint surfaces because of its lubricant nature.

GEOLOGY OF THE PROPOSED DECLINE

This section is partly extracted from a memo by Bujtor and Moore (June 1973), and partly from the memo by Cottam (1972).

The rock types to be encountered in the proposed 1:6.8 decline are, in stratigraphic order :-

Upper metavolcanics

B lens hornfels

B lens (interbedded pyroxene hornfels and marble)

Hangingwall biotite hornfels

Pyroxene garnet hornfels

C lens skarn

The sequence dips shallowly southwards, the base of the volcanics dipping slightly steeper than the rest of the sequence. The structure is interpreted as a gentle south-plunging anticline with 1 orebody on one flank and Dolphin on the other. Faulting has complicated the picture throughout both bodies.

The geology and ground stability conditions along the proposed 1:6.8 decline are tabulated in table 2 and illustrated in figures 5 and 6.

Of the rock types encountered in the decline, it is anticipated that B lens marble, and C lens skarn are likely to provide the most stable conditions. However both are impractical hosts for the decline, the former because of its intercalated nature with poor rocks, and the latter because of proximity to ore. Of the remainder, the Hangingwall hornfels, pyroxene garnet hornfels and the B lens hornfels are the most stable although open and chloritised joints are present. Because of this it is considered likely that even in the better parts as indicated by DDH 416, this rock type will probably require some rock bolting, contrary to indications using Ege's method. On the other hand stabilities should be better than those in the Bold Head Decline. In both positions where the Hangingwall biotite hornfels will be present in the decline, the rock type will be faulted. The only stable ground indicated in the unit is likely to be from 82 to 97 metres from the decline portal.

The stability of the B lens marbles and pyroxene hornfels unit is difficult to predict. In two of the three positions where the decline is expected to intersect B lens, the unit will probably be represented by interbeds of the two rock types. It is doubtful that the marbles will be sufficiently competent to overcome the weakness of the pyroxene hornfels. At best small sections of the decline through B lens will be in stable ground. The third section of the decline in B lens, from 315 to 335 metres is unlikely to be very stable because of the absence of marble, and the probable association with faulting at that point.

Major geological limitations on the decline placement are to the north, quartzites and to the south volcanics. Both rock types are well known as unfavourable sites, the former because of extreme jointing and the latter because of the instability of the joint planes. Further important limitations are placed on the position of the decline by the presence of faulting and the position of the orebody. There are distinct indications that some advantage would be gained in moving the target point at -125 metres RL. some 20 metres west onto section 6N, adjusting the last 100 metres of the decline accordingly. Whilst the ground conditions in the area of 6N are not very well known, it is known that the core logged in holes 192 and 201 indicates more stable conditions than that logged in DDH 202 on 7N. If these ground conditions persist, an indicated reduction in the amount of poor ground of up to 75 metres could be made. Even if the rock stabilities are poor on 6N they are likely to be worse further east where the Northern Fault has more influence.

The stability of the Central Fault is largely unknown at present. DDH 184 appears to be largely unaffected. Visual inspection of DDH 183, which is interpreted to have intersected the fault, revealed two areas, approximately 20 metres each, of broken core. If the fault has not widely affected the rock stabilities, the section of the decline at approximately -75 metres RL. could be moved east so as to cross the possible Dividing Fault and the zone of volcanics over a shorter distance thus further eliminating bad ground.

GEOLOGY OF THE C LENS HANGINGWALL

The predominant hangingwall rock throughout the C lens is the pyroxene garnet hornfels. Approximately two thirds of the body has the rock type as the immediate hangingwall rock, and only on the northern parts of sections 1N, 3N and 7N is the rock type not present within 10 metres of the top of the orebody. On 1N it has probably been faulted out of the sequence in hole 425, and on 7N faulting may be the cause of the downwards movement of the ore of approximately 15 metres stratigraphically in hole 202. The reason for a 10 metre downwarp in the ore in hole 211 on 3N is not clear, but could be due to a local facies change in the original stratigraphic sequence. Where present the thickness of the unmineralized rock type varies from 1 to 11 metres.

Elsewhere, biotite hornfels, actinolite hornfels, marble and unmineralized skarn form the hangingwall of the body. The latter two are more common near the Open Cut. Further away from the Open Cut the Hangingwall biotite hornfels sequence is the ubiquitous rock type.

Comments on the stability of the hangingwall (see figures 7 and 8) can only be regarded as generalisations because of the incompleteness of the geological information. It can be considered certain that more faults are present than have so far been located. Others such as the Wedge Fault and that through DDH 408 are known only in one area. Only after a DDH ore blocking program and geological mapping of the openings will the true nature of the orebody and hangingwall be known.

Interpretation of logging of the core of the hangingwall rocks has been complicated by the fact that four different core sizes and both wireline and standard core barrels have been used. These fall into three groups :-

1. DDH 167 was drilled with EXT equipment.

2. DDH 169 to DDH 211 was drilled with AXT equipment except in broken ground where AQ was used.

3. DDH 400 to 425 were all drilled with BQ equipment.

Core breakage and recoveries will be quite different for each of the three groups and so the various stability indices should not strictly be compared without a compensating factor. Such treatment would however go beyond the scope of the present study.

No diamond drill holes with numbers lower than 208 have been surveyed. On those holes that have been surveyed, the trend is generally, but not exclusively to the west. This is probably the reason for the apparent discrepancy between DDH's 199 and 209. Where "fair" and "incompetent" ground are shown to be within 12 metres of each other.

Fourteen out of twenty small cored (AXT, AQ or EXT) drill holes, and five out of fourteen large (BQ) cored drill holes suggest poor or incompetent hangingwall rocks, according to stability indices. Even though only a small sample of thirty four holes is available, a low number for statistical analysis, it appears that at least one third and possibly more than two thirds of the C lens hangingwall may be in ground that should be classed as either poor or incompetent. A histogram of stability indices (fig. 4) shows a fairly even distribution apart from a peak between 12 and 14.

Another problem is that the contact between pyroxene garnet hornfels and hangingwall hornfels is a site for increased chlorite on joint planes. It is not nearly as pronounced as that around B lens but joint planes are often slick with chlorite, or else open. The Stability Index may therefore be an optimistic indication of the conditions likely to be encountered.

For discussion purposes it is convenient to break the body up into 5 blocks, as can be seen on figs. 7 and 8, and review each one separately. They are :-

1. Down-dip ore extensions from the Open Cut. The eastern margin is taken as the Dividing Fault(?).

2. The block bounded by the Dividing Fault(?), the Central Fault and 220220E.

3. Bounded by No. 3 Fault, the Wedge Fault, the Central Fault and the decline.

4. East of 220220E and south of both 564080 and the decline.

5. The Wedge Block, with block 4 as the southern limit.

Though the selection of these zones is largely arbitrary, it is considered that the selection of different boundaries would not radically alter the interpretation.

1. The stabilities seen in the Open Cut are probably as good a guide as joint counts, and Stability Indices measured on drill core. DDH 167 gave very poor results. This could be due to the small core size (EXT) used, which may have depressed the core recovery by as much as 50% in places when compared with results obtained in similar ground using BQ equipment.

Both experience in the Open Cut and stability parameters seem to indicate that there should not be great geological problems associated with mining ore close to the pit. Rock bolting is likely to be needed, but with conservative stope design no more expensive means of support seem likely to be needed. Further from the Open Cut the ore becomes very thin and probably stringy and unlikely to be mined.

2. Block 2 contains little known ore apart from the eastern margins north of about 563930N. Stability parameters within the block generally indicate fair rock or better, although DDH 209, just outside the block indicates incompetent ground.

The Dividing Fault, if present, will probably have no effect on mining as there is little ore in the area. The immediate vicinity to the Central Fault will probably prove quite troublesome. The effect of the fault, on DDH 183 is about 40 metres of core (20 metres true width) with S.I. estimated at greater than 15.

3. Block 3 is the most intensively drilled area in the orebody. Even here no definite pattern in the structural parameters could be seen. Stability indices range from 6 to ϕ although 5 of the 9 holes fall in Ege's poor range. Three of the remaining holes are in quite stable ground and the final one is classed as incompetent.

Visual inspection of core close to the No. 3 Fault in DDHs 188,184 and 211 suggested very poor to incompetent rock up to 15 metres away from the contact with quartzites. The Wedge Fault is only inferred south of the No. 3 Fault, but either cuts the ore in DDHs 189 and 200, or passes below the ends of the drill holes. There is 10 metres of high core loss in DDH200 just below the C lens hangingwall; if this is the Wedge Fault, then the problem zone is likely to be only a few metres wide.

4. Block 4 contains about half the ore resource of C lens. Most of it is below the -150 metre RL. It has been penetisted by only seven diamond drill holes, although another five DDHs 199,209,403,404, and 407 are sufficiently close to aid in analysis. Most of the drilling in the block has been done using BQ equipment.

Three of the seven drill holes inside the block indicate an incompetent hangingwall, and three of the remainder suggest poor ground. Only one hole inside the block DDH 401, is in good, stable rock. However three of the five holes just outside the block indicate fair hangingwall conditions, a fourth, good stability and the fifth, incompetent ground. Even allowing for these holes it is clear that this block, the profitable extraction of which is highly desirable for the profitability of the whole mine, has the poorest hangingwall conditions of the five areas.

It is considered that this is probably due to the proximity of the Grassy River Fault, a major tectonic feature in the area. There are however other faults which may also influence rock stabilities. The Wedge Fault and the Central Fault may both go through the block, although their positions in this area are at present unknown. DDH 408 encountered a reverse fault with an apparent vertical throw of approximately 60 metres. No other trace of this fault is known. The detailed geology of the block is poorly known and it will require considerable definition.

Ore thickness in the block is generally greater than that found anywhere else in the mine, ranging up to 55 metres true width in DDH 400 and 50 metres in DDH 203A. Unfortunately the hangingwall conditions in both holes are extremely poor. Only in the south western corner of the block does mineralization appear too thin to justify mining.

It appears likely that only very cautious mining methods are going to be successful. However as approximately 2.7 million tonnes at about 1.2% WO_3 are involved, the reward for success is high.

5. Block 5, in general, does not appear likely to cause too many problems. All of the 7 drill holes in the block with the exception of DDH 202 indicate either fair or good hangingwall stability.

The only geological problem areas are likely to be the fault zones either side of the block. The Wedge Fault however appears to have little influence on the mine series rocks adjacent to it, the largest zone noted being only 3 metres in DDH 414. The Northern Fault has a wider margin of disruption being up to 8 metres in DDH 415. DDH 202 has been disrupted right from 40 metres to the end of the hole, with possibly a splinter fault moving the ore section down about 15 metres from below the pyroxene garnet hornfels.

156025

The south eastern corner offers room for further exploration, although the ground would be expected to become less stable as the Grassy River Fault is approached.

GEOPEKO LTD.

PROJECT GEOLOGIST ... D.M. MOORE
GEOLOGIST.

SUPERVISED .... M.C. ROGERS
SENIOR GEOLOGIST.

ACKNOWLEDGEMENT

Particular acknowledgement is made of the work of G. Bujtor, who contributed figure 5 and helped in the preparation of figure 6, and whose geological interpretation largely forms the basis of this report.

156027

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Legend:

- Upper meta-volcanics
- B Lens hornfels
- B Lens marble
- B Lens ore (cut-off 0·25 % WO_3)
- B Lens pyroxene hornfels
- Hangingwall biotite hornfels
- P. G. H. (pyroxene garnet hornfels)
- C Lens ore (cut-off 0·25 % WO_3)
- Older volcanics

v	Upper meta-volcanics	pgh	Pyroxene garnet hornfels
bh	Biotite hornfels	gh	Garnet hornfels (–skarn)
bah	Biotite actinolite hornfels	gph	Garnet pyroxene hornfels
ah	Actinolite hornfels	ov	Older volcanics
ph	Pyroxene hornfels	q	Quartzite
ch	Calcite hornfels (marble)		

- Poor ground
- Fault, showing relative movement
- Degree of uncertainty in fault position
- Mineralization $< 0·25\% WO_3$

GEOPEKO LIMITED
KING ISLAND GROUP

156028

SCALE: 1 : 500

No. KG2-93

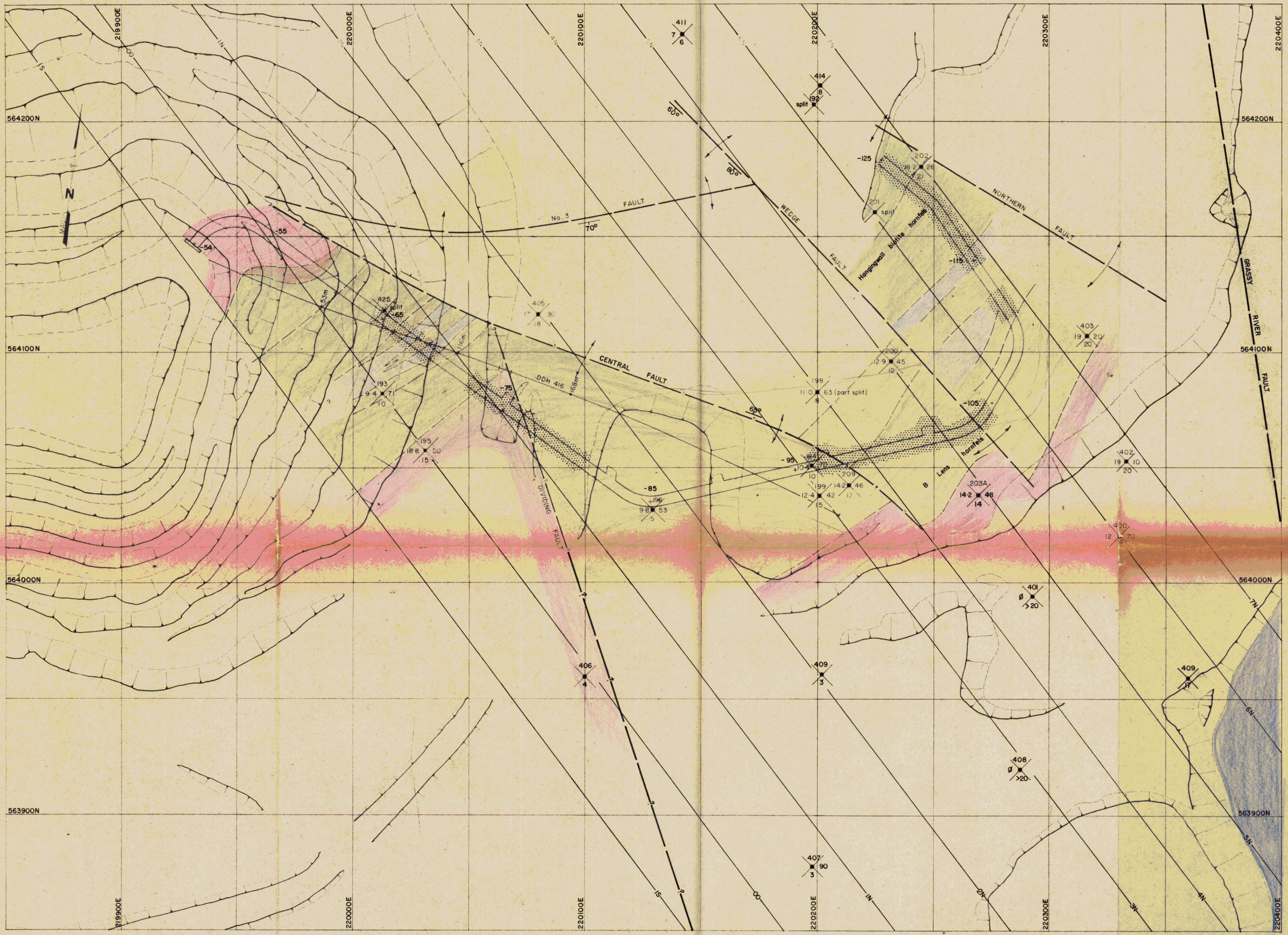
DATE: JUNE, 1973
GEOLOGIST: G.J.B.
DRAWN: R.F.
CHECKED: M.C.R.

DOLPHIN MINE

5 cm

GEOLOGICAL SECTION ALONG THE PROFILE OF THE PROPOSED DECLINE

FIG. 5



ISG REFER REPORT 70-0676

93-3462

Legend

v	Upper meta-volcanics
bh	Biotite ± actinolite hornfels
ph	B lens pyroxene hornfels
ch	B lens marble
pgh	Pyroxene garnet hornfels
gh	C lens skarn

Fault

Uncertainty in fault position

Poor ground

-105 FLOOR R.L OF DECLINE

STABILITY INDEX — DDH No. — % CORE > 7·5cm LONG — No. JOINTS/M

CORE LOGGING LIMITS 2·5m. ABOVE AND BELOW DECLINE R.L.

53m METERAGE DOWN DDH 416

NOTE:

1. DECLINE POSITION AS AT MAY 10, 1973.
2. 400 SERIES VALUES APPROXIMATE
3. THE END OF DDH 416 IS 9·0m. BELOW THE FLOOR OF THE DECLINE.

DDH 416 RESULTS:

FROM	TO	ROCK TYPE	J/M	% CORE > 7·5cm.	S.I.
0m	16m	gh	7·8	93	6·2
16	53	pgh	4·4	95	4·8
53	78	bh	7·4	92	6·2
78	87	bh	19·0	28	17·2
87	116	ph-ch	7·2	84	6·8
116	133	bh	8·6	89	6·8
133	143	bh-v?	>20	26	19 to Ø
143	168	bh	14·3	78	9·5
168	295	bh	4·2	95	4·8

GEOPEKO LIMITED
KING ISLAND GROUP

156029

SCALE: 1:1000

No. KG2-100

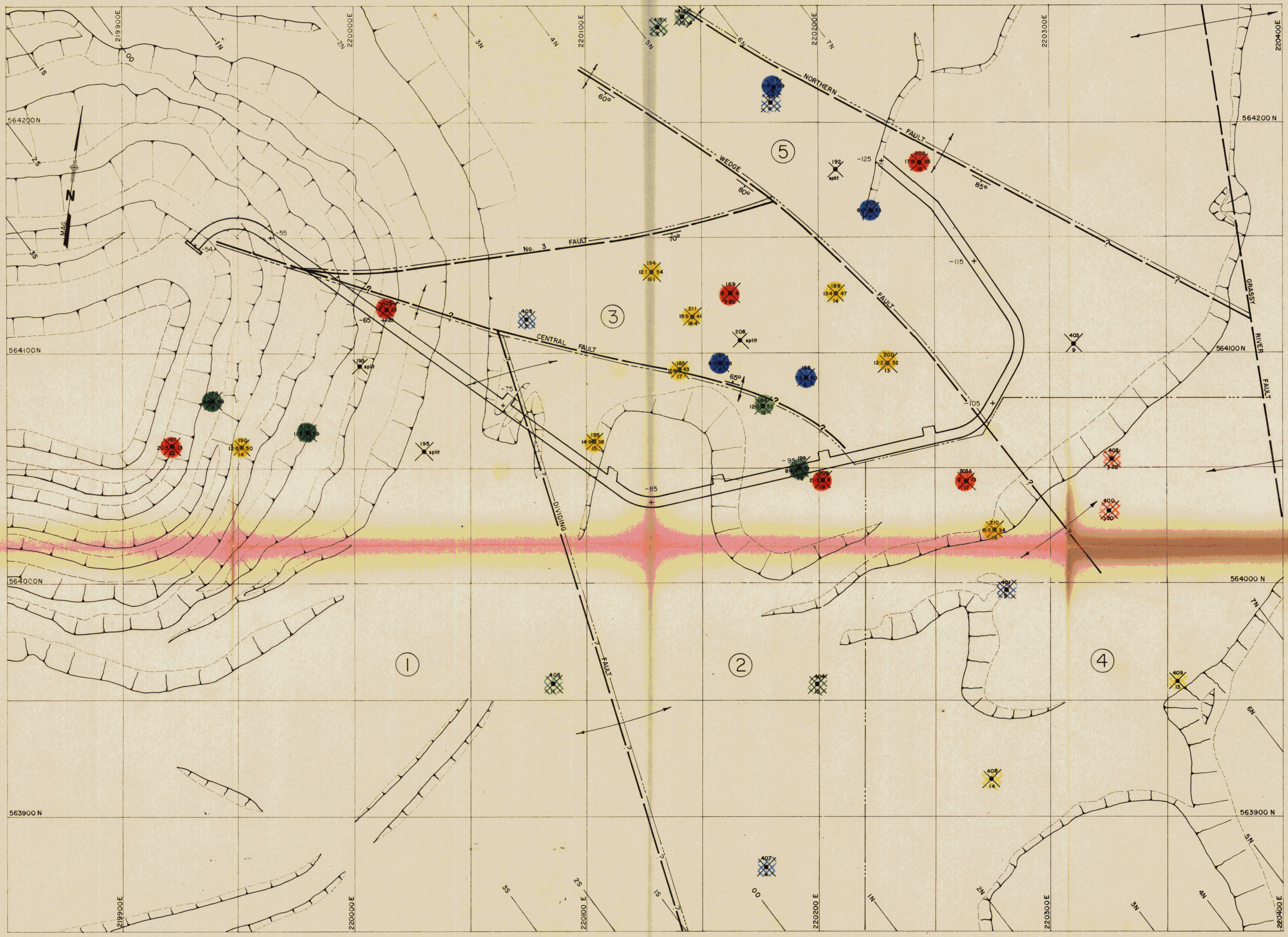
DATE: MAY, 1973
GEOLOGIST G.J.B. D.H.M.
DRAWN R.F.
CHECKED M.C.R.

DOLPHIN MINE

5 cm

ENGINEERING GEOLOGY OF PROPOSED DECLINE PLAN PROJECTION

FIG. 6



93-3462

Legend

v	Upper meta-volcanics
bh	Biotite ± actinolite hornfels
ph	B lens pyroxene hornfels
ch	B lens marble
pgh	Pyroxene garnet hornfels
gh	C lens skarn

Fault

Uncertainty in fault position

-105 FLOOR R.L. OF DECLINE

STABILITY INDEX / DDH No. / % CORE > 7·5cm. LONG / No. JOINTS/M.

(FOR UP TO 10m. INTO HANGINGWALL)

(2) BLOCKS WITHIN OREBODY

BLOCK BOUNDARY

NOTE:

1. DECLINE POSITION AS AT MAY 10, 1973.
2. PARAMETERS FOR 400 SERIES DDH's APPROXIMATE

GROUND STABILITY CONDITIONS

	HOLES CORED BQ	HOLES CORED A or E
GOOD		
FAIR		
POOR		
INCOMPETENT		

(AFTER EGE, 1968)

DATE: JULY, 1973

GEOLOGIST: D.H.M.

DRAWN: R.F.

CHECKED: M.C.R.

GEOPEKO LIMITED

KING ISLAND GROUP

156030

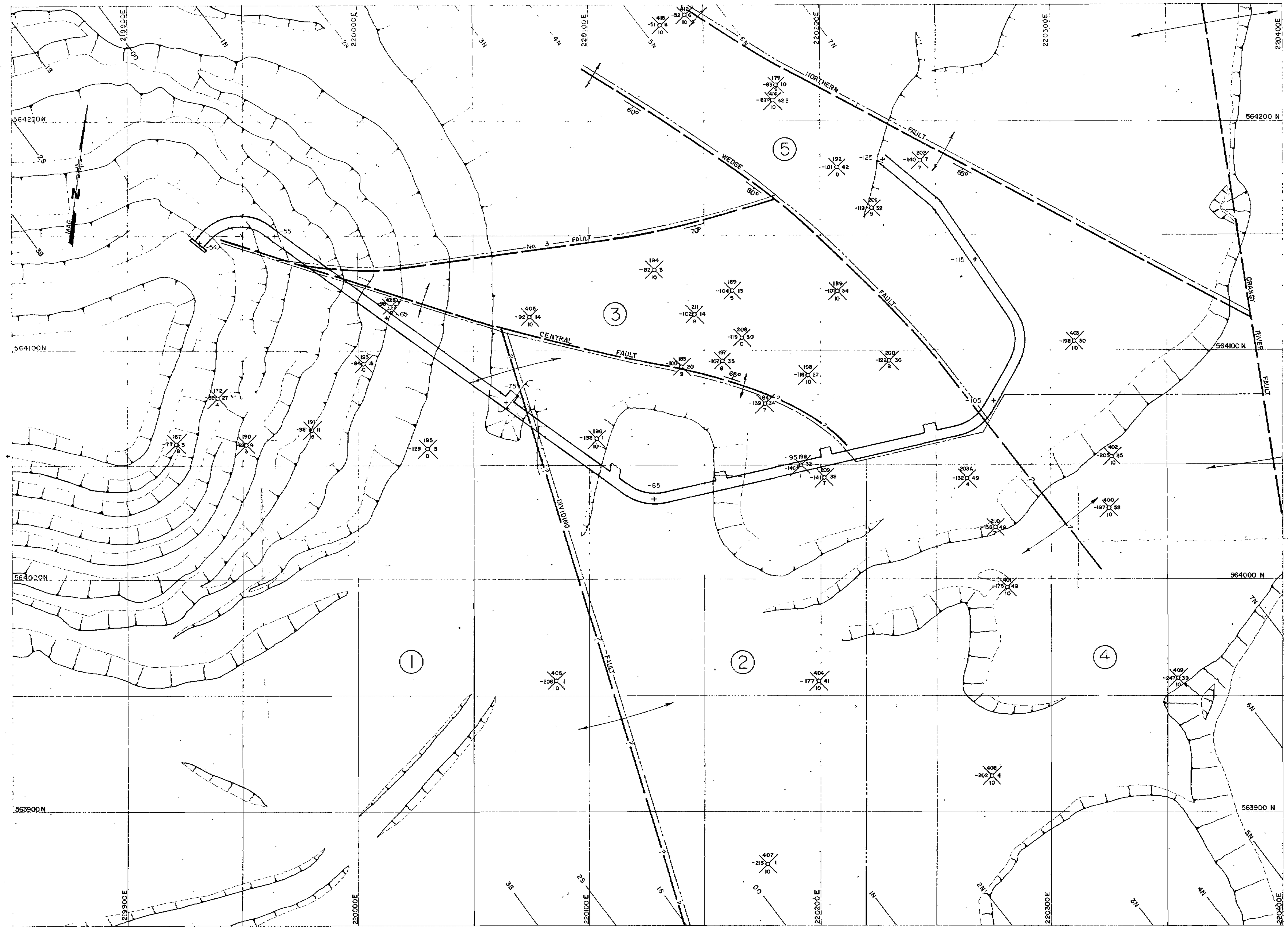
SCALE: 1 : 1000

No. KG2-101

5 cm

DOLPHIN MINE
C LENS HANGINGWALL
PLAN PROJECTION
ROCK STRENGTH PARAMETERS

FIG. 7



ISG REFER REPORT 70-0676

93-3462

Legend

v	Upper meta-volcanics
bh	Biotite ± actinolite hornfels
ph	B lens pyroxene hornfels
ch	B lens marble
pgh	Pyroxene garnet hornfels
gh	C lens skarn
	Fault
	Uncertainty in fault position

-105 FLOOR R.L. OF DECLINE

DDH No. — HANGINGWALL R.L. — TOTAL ORE THICKNESS (metres) — HANGINGWALL THICKNESS AVERAGED (metres)

(2) BLOCKS WITHIN OREBODY

BLOCK BOUNDARY

NOTE:
1. DECLINE POSITION AS AT MAY 10, 1973.

GEOPEKO LIMITED 156031
KING ISLAND GROUP

No. KG2-102

SCALE: 1:1000

5 cm

DATE: JULY, 1973
GEOLOGIST: D.H.M.
DRAWN: R.F.
CHECKED: M.C.R.

DOLPHIN MINE
MISCELLANEOUS PARAMETERS
PLAN PROJECTION

FIG.8

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Table: 3
ENGINEERING GEOLOGY OF THE DOLPHIN OREBODY
SUMMARY OF DETAILED STRUCTURAL CORE LOGGING

HOLE No.	VOLCANICS				B LENS HORNFELS				B LENS MAFIC HORNFELS				B LENS MARBLE				HANGINGWALL BIOTITE HORNFELS				PYROXENE GARNET HORNFELS				REMARKS
	J/M	% CORE >7·5cm.	S.I.	JOINT FILLINGS	J/M	% CORE >7·5cm.	S.I.	JOINT FILLINGS	J/M	% CORE >7·5cm.	S.I.	JOINT FILLINGS	J/M	% CORE >7·5cm.	S.I.	JOINT FILLINGS	J/M	% CORE >7·5cm.	S.I.	JOINT FILLINGS	J/M	% CORE >7·5cm.	S.I.	JOINT FILLINGS	
167																	21·2	16·7	19·8	CALCITE CLAY	20·0	0	ø	CALCITE	DRILLED EXT , PYROXENE GARNET HORNFELS OVER 1·0m.
169													>20·0	20·0	ø	CHLORITE PYRITE	>20·0	6·0	ø	CHLORITE CALCITE PYRITE					B LENS MARBLE OVER 2·0m.
172																	8·9	75·7	8·7	CHLORITE CALCITE OPEN					
179																	8·7	91·3	6·6	CHLORITE CALCITE GYPSUM PYRITE OPEN					
183																	19·5	43·0	14·8	ABUNDANT CHLORITE MINOR CALCITE PYRITE	12·8	71·8	10·2	ABUNDANT CHLORITE MINOR PYRITE CALCITE	
184					11·2	55·0	12·7	CHLORITE IRON OXIDES PYRITE	15·5	30·0	16·2	CHLORITE IRON OXIDES PYRITE	6·6	90·0	6·9	CALCITE CLAY GYPSUM	12·7	50·0	12·4	CHLORITE CALCITE PYRITE GYPSUM	14·1	40·0	13·3	CHLORITE PYRITE CLAY	
189																	14·3	47·7	13·4	MODERATE CHLORITE MINOR CALCITE CLAY PYRITE					
190																	13·3	54·0	12·9	CALCITE CLAY CHLORITE CLINOHUMITE					
191																	13·0	59·4	11·3	CHLORITE CLAY PYRITE CALCITE					ACTINOLITE HORNFELS OCCURING BELOW THE PYROXENE GARNET HORNFELS.
192									12·0	60·0	9·8	MODERATE CHLORITE CALCITE CLAY PYRITE					8·7	64·0	9·1	CHLORITE CLAY PYRITE IRON OXIDES					B LENS MAFIC HORNFELS OVER 2m.
193									13·1	37·1	10·9	CHLORITE PYRITE CALCITE QUARTZ					7·5	71·0	8·5	CHLORITE					UPPER 11·0m. VERY BIOTITE RICH AND MAY BE PART OF UPPER BIOTITE HORNFELS.
194																	16·1	54·0	12·1	MODERATE CHLORITE MINOR CALCITE PYRITE					
195	18·3	12·5	20·8	CHLORITE CALCITE CLAY PYRITE	7·7	25·6	9·6	CALCITE CHLORITE CLAY PYRITE																	UPPER BIOTITE HORNFELS IS PYROXENE RICH IN PART.
196	12·0	20·0	14·7	CHLORITE PYRITE IRON OXIDES	10·0	48·7	11·9	CHLORITE CALCITE IRON OXIDES CALCITE CLAY	12·7	37·5	13·4	CHLORITE PYRITE CALCITE	8·1	85·0	6·7	CALCITE ABUNDANT CHLORITE 131-135m. TALC	10·6	50·7	12·8	CHLORITE PYRITE CALCITE CLAY	16·6	37·0	15·3	CHLORITE CLAY CALCITE GYPSUM PYRITE	
197																	7·3	83·3	6·9	CLAY CHLORITE CALCITE OPEN	6·3	87·0	6·3	CHLORITE CALCITE PYRITE	
198	7·5	70·0	8·5	CHLORITE CLAY	10·0	53·9	11·9	CHLORITE PYRITE CALCITE CLAY	8·0	62·5	13·4	CHLORITE PYRITE CALCITE					7·2	82·2	7·4	CHLORITE PYRITE	12·0	60·0	11·1	CHLORITE PYRITE	MARBLES NOT REPRESENTED IN HOLE.
199	8·7	77·6	9·0	CHLORITE PYRITE CLAY	12·9	51·8	12·5	CHLORITE CALCITE CLAY PYRITE	10·9	66·6	10·7	CLAY CHLORITE CALCITE PYRITE	2·0	100·0	3·6	CALCITE					10·0	78·0	8·3	CALCITE CHLORITE	B LENS MARBLE OVER 1·0m. HANGINGWALL BIOTITE HORNFELS NOT REPRESENTED.
200					19·8	15·5	20·7	CHLORITE CALCITE PYRITE CLAY	12·0	45·0	13·0	ABUNDANT CHLORITE					12·2	57·6	17·6	CHLORITE CLAY CALCITE PYRITE					B LENS MAFIC HORNFELS OVER 2·0m. HOLE VERY CLOSE TO WEDGE FAULT.
201					10·8	67·2	10·3	CHLORITE CALCITE PYRITE	16·8	53·0	13·5	CHLORITE CALCITE					6·8	90·8	6·1	CALCITE CHLORITE PYRITE	8·0	100·0	5·5	ABUNDANT CHLORITE PYRITE	B LENS MAFIC HORNFELS OVER 2·0m. PYROXENE GARNET HORNFELS OVER 1·0m.
202																	17·8	39·5	16·9	ABUNDANT CHLORITE MINOR CALCITE CLAY	16·4	33·0	16·8	ABUNDANT CHLORITE MINOR CLAY	HOLE BADLY FAULTED. MAJOR DISTURBANCES IN SEQUENCE.
203A	13·6	47·6	14·2														16·1	26·5	19·9	ABUNDANT CHLORITE MINOR PYRITE CALCITE					B LENS ROCKS NOT REPRESENTED.
208																	7·4	84·1	7·1	CHLORITE OPEN CALCITE PYRITE					
209	8·8	77·0	8·2	CHLORITE CALCITE PYRITE	10·3	58·3	12·0	CALCITE PYRITE CHLORITE	18·0	22·3	17·9	CHLORITE PYRITE CALCITE					19·2	17·4	19·2	CHLORITE PYRITE CALCITE	14·0	17·0	19·6	CHLORITE PYRITE	B LENS MARBLE NOT REPRESENTED.
210																	15·6	34·0	16·5	CHLORITE CALCITE PYRITE OPEN					
211																	18·4	41·0	15·9	CHLORITE PYRITE CLAY OPEN					
416	>20·0	27·2	ø	CHLORITE CALCITE PYRITE	7·9	90·3	7·0	CHLORITE PYRITE CALCITE	8·0	80·5	7·5	CHLORITE CALCITE PYRITE TALC, CLAY	4·0	92·3	5·0	CALCITE CHLORITE CLAY	8·2	75·0	8·5	CHLORITE PYRITE CLAY CALCITE, TALC	14·4	95·4	4·8	CHLORITE PYRITE CALCITE	VOLCANICS DOUBTFUL, VERY CLOSE TO A FAULT. DRILLED BQ
425					18·8	50·0	14·7	MODERATE CHLORITE PYRITE CALCITE									>20	28·7	ø	ABUNDANT CHLORITE MINOR CLAY PYRITE CALCITE					DRILLED BQ

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Table: 4
ENGINEERING GEOLOGY OF THE DOLPHIN OREBODY
SUMMARY OF GENERALIZED ENGINEERING CORE LOGGING

D.D.H. No.	VOLCANICS		B LENS HORNFELS		B LENS PYROXENE HORNFELS		B LENS MARBLE		HANGINGWALL HORNFELS		PYROXENE GARNET HORNFELS		C LENS SKARN		QUARTZITE		REMARKS
	Joints / Metre	Joint Filling	Joints / Metre	Joint Filling	Joints / Metre	Joint Filling	Joints / Metre	Joint Filling	Joints / Metre	Joint Filling	Joints / Metre	Joint Filling	Joints / Metre	Joint Filling	Joints / Metre	Joint Filling	
400	10 - >20	CHLORITE	10 - >20	CHLORITE	8 - >20	CALCITE CHLORITE	8 - >20	CALCITE	>20	CHLORITE	8 - 20	CALCITE CHLORITE	2 - 8	CALCITE			
401	4 - >20								2 - 10	CALCITE	4 - 8	CALCITE	0 - 4	CALCITE			
402	10 - >20	CHLORITE	4 - >20	QUARTZ	8 - 20	CALCITE CHLORITE	2 - 8	CALCITE	10 - 20	CALCITE	4 - 8	CALCITE	2 - 8	CHLORITE			
403	8 - >20	CHLORITE CLAY CALCITE	8 - >20	CLAY	2 - >20	CHLORITE CLAY CALCITE	2 - 4	CALCITE	4 - >20	CLAY	8 - 10	CLAY	4 - 8	CALCITE			
404	4 - 10	CHLORITE	4 - 10		4 - 10		4 - 10		4 - 10		10 - 20		2 - 4				
405			4 - 8	CLAY	2 - 10		2 - 4		4 - 10	CHLORITE	2 - 4		2 - 4	CALCITE	10 - 20		
406	2 - 10	CHLORITE	4 - 8	CLAY OPEN	2 - 8	CHLORITE	2 - 8	CALCITE	4 - 10	OPEN CLAY	2 - 8		2 - 4				
407	2 - 4	CHLORITE	4 - 10	OPEN					2 - 8	OPEN CALCITE	2 - 4		2 - 4				
408	8 - 20	CHLORITE							2 - >20	CLAY CALCITE	2 - > 20	CHLORITE CALCITE	2 - >20	CHLORITE CALCITE CLAY			
409	10 - >20	CHLORITE							8 - >20	CHLORITE CLAY	10 - >20	CHLORITE CLAY	2 - 10	CHLORITE CLAY			
410															8 - 20 ?		
411									5 - 10	MOST OPEN	0 - 5	CHLORITE	0 - 5		15 - >30		
412					0 - 20	CLAY CHLORITE CALCITE			10 - >20	CHLORITE	8 - 10	CALCITE	4 - 8	CALCITE	10 - >20	CALCITE CLAY PYRITE	
414									4 - 20	CHLORITE CALCITE	0 - 8		4 - 20	CHLORITE CALCITE PYRITE	8 - >20	CHLORITE CALCITE CLAY	
415									0 - 20	CHLORITE CALCITE	2 - 8	CHLORITE CALCITE PYRITE	2 - >20	CHLORITE PYRITE CALCITE	8 - >20	CHLORITE CLAY PYRITE	
																	AFTER COTTAM AND ROGERS (1973)