

PRELIM REPORT ON PELESTER/WATERHOUSE  
ALBERTON - DAN RIVULET, MATHINA &  
MANGANA GOLDFIELDS  
STANNON. ENG. CO. PTY. LTD.

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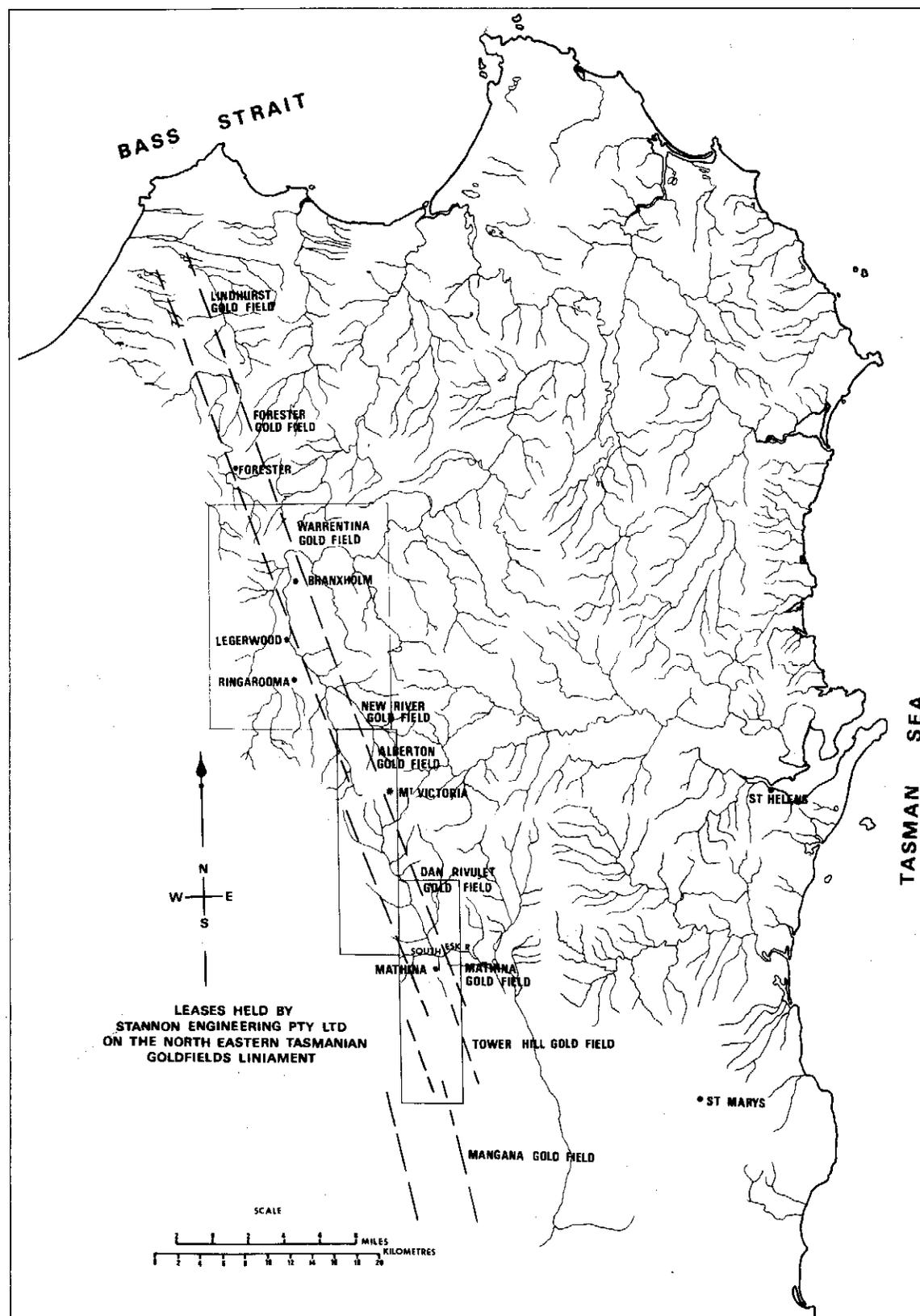
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**Preliminary Report  
on the Forester / Waterhouse  
Alberton - Dan Rivulet, Mathina  
& Mangana Goldfields**

**Confidential**  
Prepared by:  
**Stannon Engineering Company Pty. Ltd.**



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General Comments

### GENERAL COMMENTS

The project group is pleased to present this preliminary report to the Directors of Stannon Engineering Company Pty. Ltd. In the course of preparing this document the group undertook a rather comprehensive examination of all relevant historical material made available by the Tasmanian Mines Department. This activity was followed by a routine fieldwork programme designed to substantiate the records and assess the present condition and dimensions of the area under consideration.

At the outset, and indeed throughout this stage of the project, the group was amazed to find that an area once known as "the third productive goldfield in the Colony" was now completely ignored by the mining community – that the important fault-fissure lodes which exist in an unbroken 76 kilometer lineament remain untested to this day.

The Tasmanian holdings of Stannon Engineering Company Pty. Ltd. consist of three Exploration Licences which provide for the unbroken coverage of a 76 KM lineament which stretches from Forester in the North to Mtngana in the South. The area of interest along this lineament is approximately 3/5ths of a kilometer wide and contains some 200 "mines" having an average depth of 20/30 feet.

Taken one by one these shallow workings each have a recorded history which unless taken in context would be quite insignificant. However when considered collectively, such concentrated occurrence along a single lineament is indicative of the deep seated development of repeated gold bearing quartz veins and not simply a superficial phenomena. This circumstance can no longer be ignored.

It is ironic that, notwithstanding the repeated professional advice contained in the formal reports of Thureau, Nye, Twelvetrees, Blake, Reid, Loftus Hills, Hughes and others between 1898 and 1925, the hundreds of rugged individual prospectors and miners could not be made to understand that the real wealth of the area was beneath the inadequate holes they were digging – this despite the fact that the Golden Gate Mine at the Mathina end of the same lineament progressed to a depth of 2000 feet yielding over 263,000 ounces of gold at an overall average value of almost 1 oz. per ton. Gold bearing sulphides yielded 80 oz. per ton at the 1600 foot level.

Inasmuch as history itself and the recorded professional opinions of learned men have a direct bearing on the recommended programme of development, excerpts of documents held by the Tasmanian Mines Department are included in this report.

Throughout the research and fieldwork stages of this project we have been very conscious of the magnitude and potential of the entire area/s covered by Exploration Licence. There can be little doubt that the whole of this lineament will call for systematic exploration, development and exploitation for many years.

Having completed a great deal of research into the history of the area under consideration, the field party selected two locations for examination with a view to establishing a drilling site from which to test existing lodes at depth. These locations are:

1. The Ringarooma Mine located in the Alberton field, where the Rosalind, Gumsucker and Premier lodes were worked profitably over the years before it was discovered that the two substantial main lodes would intersect at depth. A winze was sunk for the purpose of locating and testing the intersection, but after driving some 130 feet the winze was abandoned only 32 feet short of its target. Apparently the Company had spent the bulk of its capital funds on ore dressing plant etc. and could no longer meet the operating costs involved in working some 390 feet below the outcrop. The final blow came with the destruction of the battery by fire and the site was abandoned.

The winze is now full of water following such a long period of inactivity. However, the surrounding area is very solid rock and it may be possible to remove the water and proceed (with safety) to drive through the remaining 32 feet or perhaps establish a platform from which a brief drilling programme can be undertaken.

2. The Mercury Mine consisting of lodes 1 and 2. The number one adit reached the main lode where considerable stoping took place and a winze was put down. At this upper level, the gold bearing quartz reef was some 134 feet long with an average thickness of about 8 inches. Eventually work ceased here in favour of the number two adit which located the reef at a lower level where extensive stoping occurred and good gold values recorded. A winze was sunk to 40 feet below adit level where the length of the reef was found to be 200 feet and its width had increased to over 4 feet. At this point, mine water could not be handled by the low capacity, hand operated pumps and the workings were abandoned.

An attempt was made to reach the lode via the new number three adit, but work was discontinued when funds were exhausted, leaving this tunnel short of its target.

N.B. The Directors attention is invited to the possibility of creating a small chamber in this tunnel for use as a drilling site. Alternatively the half completed tunnel could be driven to the lode and a relatively inexpensive mining operation established rather quickly.

**CONCLUSION (General)**

Based upon available technical data and recommendations which have persisted over the last half century as well as on the spot examination, the project group has selected the Mercury site as one which presents an outstanding opportunity to test the supposed deep seated nature of the known lode. The reef in question has been located, examined at depth and found to conform with its recorded characteristics. The immediate area has been mapped and detailed drawings of the main lode workings have been prepared for future use.

**CONCLUSIONS (Specific)**

1. Because of the great length of the lineament of gold bearing reefs (76 KM) of which the Alberton and Dan Rivulet fields comprise only a part and because of the proven depth of gold bearing quartz to the south of Mathina, it is a **certainty that the quartz lodes while they individually are relatively small bodies, are not a superficial feature but can be proven to depth with a repetitive occurrence.**
2. The shallow development programmes undertaken by the undercapitalized small local companies working these gold fields in the late 19th century have left them untested as to their full potential.
3. In the structural analysis of these fields, a possible model for other gold bearing quartz lodes along the lineament exists in the New Golden Gate Mine worked to 2000 feet below the surface and returning over 263,000 ozs. of gold just to the south of the Dan Rivulet field and the only mine sunk to this depth along the whole 76 KM of the lineament.
4. The extent and consistent mineralisation along this gold bearing lineament provides a good probability that other mines similar to the New Golden Gate Mine are to be found along the whole of its untested length including the Alberton and Dan Rivulet fields.
5. It should be mentioned that a continued high price structure for gold will probably be an important factor in any analysis and that future trends should be adequately explored. However, the size of the potential targets should make this area worth investigating over a considerable range of possible costs and pricing structures.

**RECOMMENDATIONS (General)**

After due consideration the project group recommends that an initial drilling programme be undertaken to intersect the principal lode at various depths from 200 feet to 600 feet below the number two adit level. This activity would represent the first attempt to confirm the repeated hypothesis that gold bearing lodes live to a depth of 2000 feet or more. A successful drilling programme would represent a major breakthrough and support our strong contention that there is more than one "Golden Gate" to be developed along this 76 kilometer lineament.

**RECOMMENDATIONS (Specific)**

1. The Alberton field could be tested by deep development and one or both of the two localities recommended by Loftus Hills, i.e. The Mercury Mine and the Ringarooma Mine. In the case of the Mercury Mine, the No. 3 level adit could be brought to completion in an initial testing programme of the No. 2 lode.
2. In the case of the Ringarooma Mine, the initial target would be to test the junction of the Premier and Rosalind-Gumsucker lodes.
3. A modern exploration programme could assess the 20 KM of outcrop of gold bearing quartz lodes with the purpose of locating the most suitable points at which to test the lineament by deep boring.

A possible approach to this could be –

Firstly to undertake a geochemical sampling programme. The gold in the quartz veins is known to be accompanied by arsenopyrite galena sphalerite and chalcopyrite. If soil samples were taken with a view to delineating say lead and copper anomalies associated with the quartz veins, then these anomalies could be further tested by suitable geophysical methods.

With the results obtained by both techniques suitable sites for drilling the lineament may be obtained. However, it would be important to field test these methods before the rigorous application to the complete lineament.

4. Development to depth could be preceded by drilling but must ultimately be tested by sinking.

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5. A rigorous decision methods analysis of the alternatives in organizing a programme to test and develop these fields to depth should be undertaken and all strategies, costs and eventualities, i.e. rewards, losses and risks involved, estimated in order to plan the optimum approach to develop this apparently forgotten area.

The Directors are encouraged to study the remainder of this report which includes reports submitted from time to time by men of stature. Their conclusions are consistent with our own. It is important to understand that Stannon Engineering Company is the first and only organisation to gain full control over the entire lineament offering hitherto impossible opportunities for comprehensive exploration and consolidated development.

Apart from the probable establishment of one or more mines, we wish to point out the existence of a large area of undisturbed alluvium which lends itself to testing and exploitation. The natural circumstances which have created this area are easily recognised.

We gratefully acknowledge the help and support of the Tasmanian Director of Mines and the ready assistance extended us by members of his department. Without such a high degree of cooperation, this preliminary report would have been impossible to compile.

#### THE MERCURY MINE — brief history and description

The Mercury Gold Mining Co. N.L. was started in 1883 and by 1885 two adits had been driven and the Mercury No. 1 and No. 2 lodes intersected and a 10 head battery erected. From 1883 to 1909, about 2150 ounces of gold were obtained from ore averaging about 17-18 dwts per ton. However, 2/3rds of this gold was won before December 1884. In this year, Thureau reported that development was not kept ahead of stoping and a change of management took place about 1885.

Little developmental work appears to have been done for the next ten years; at the end of this time the battery appears to have burnt down.

In 1897-1898, a low level adit was commenced but was only driven about 134 feet. The contractors did not finish this work as the ground was too hard. The logical development of this Mine would be to continue this No. 3 adit to intersect the No. 2 reef 90 feet below the No. 2 adit level.

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A winze was sunk about 40 feet below the No. 2 adit level near the southern end of the reef and a drive to the north-west continues from the bottom of the winze for 40 feet. Some stoping up to the No. 2 level has occurred. However, it was difficult to cope with water below the level of the No. 2 adit and the mine closed.

In 1933, another attempt was made to de-water the winze and some ore was mined returning about 14 dwts/ton from over ten tons of ore.

Two samples from the No. 2 lode were assayed in 1933 giving 13 grs. of gold, 19 grs. of silver and 19 dwts 2 grs. of gold and 3 dwt. 10 grs. of silver respectively.

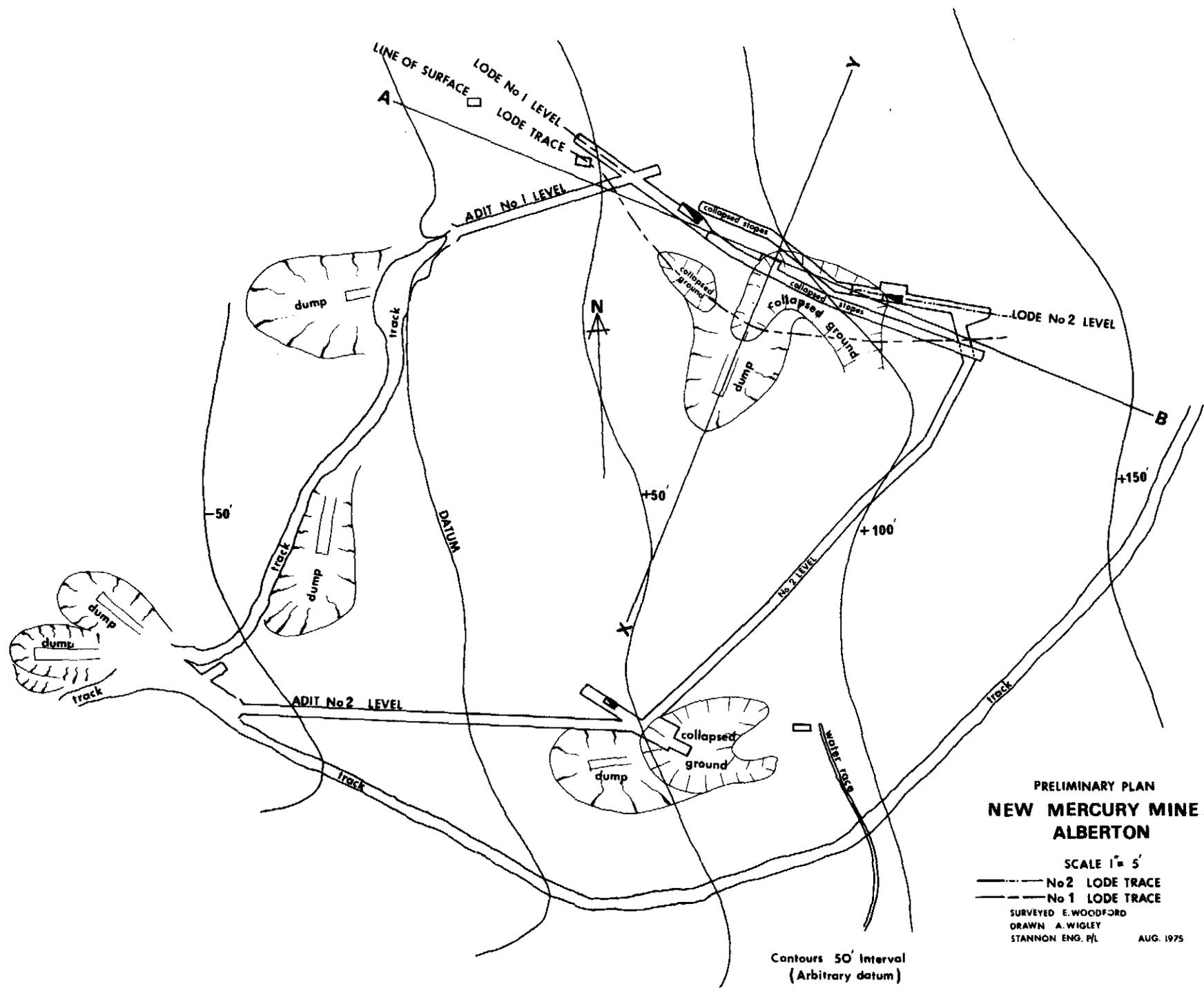
The Mercury No. 1 lode has a strike of 145 degrees and a dip of 45 degrees to the north-east. The width of this reef varied from 4 in. to 1 ft. 3 inches and the length was approximately 100 feet.

The Mercury No. 2 lode has a strike of 123 degrees and a dip of 80 degrees to the north-east. The width of this reef varies from 6 inches to approximately four feet.

This reef possesses a good wall on the north-eastern side. On the No. 2 level the reef channel reaches about 3 feet in width with 9 to 12 inches of quartz on the north-eastern side and irregular vein throughout the remaining two feet but becoming less numerous away from the wall. About half way along the length of the worked reef a bulge in the reef was caused by the intersection with a small branching reef.

The No. 2 reef has been mined along a length of 134 feet in the upper level and has been stated to be over 200 feet long in the lower level. The workings associated with the winze on the No. 2 level showed the No. 2 lode to be making about 4 feet in width and returning good gold values.

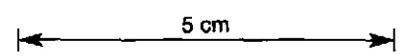
This mine has a poor development history in that the money won from early mining was not applied to developing it to test its full potential by continuing the No. 3 adit and other work to test the mine potential at depth.

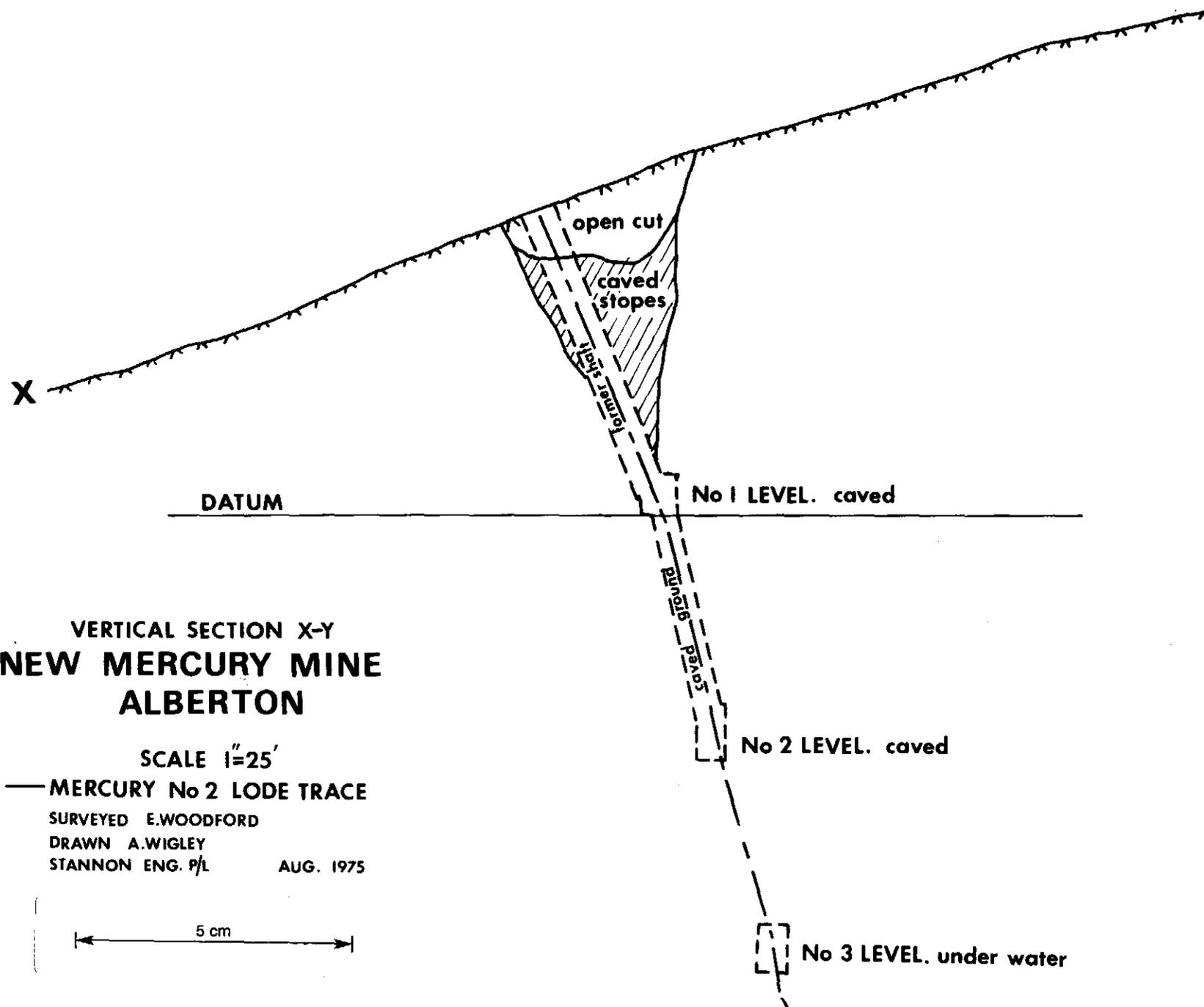


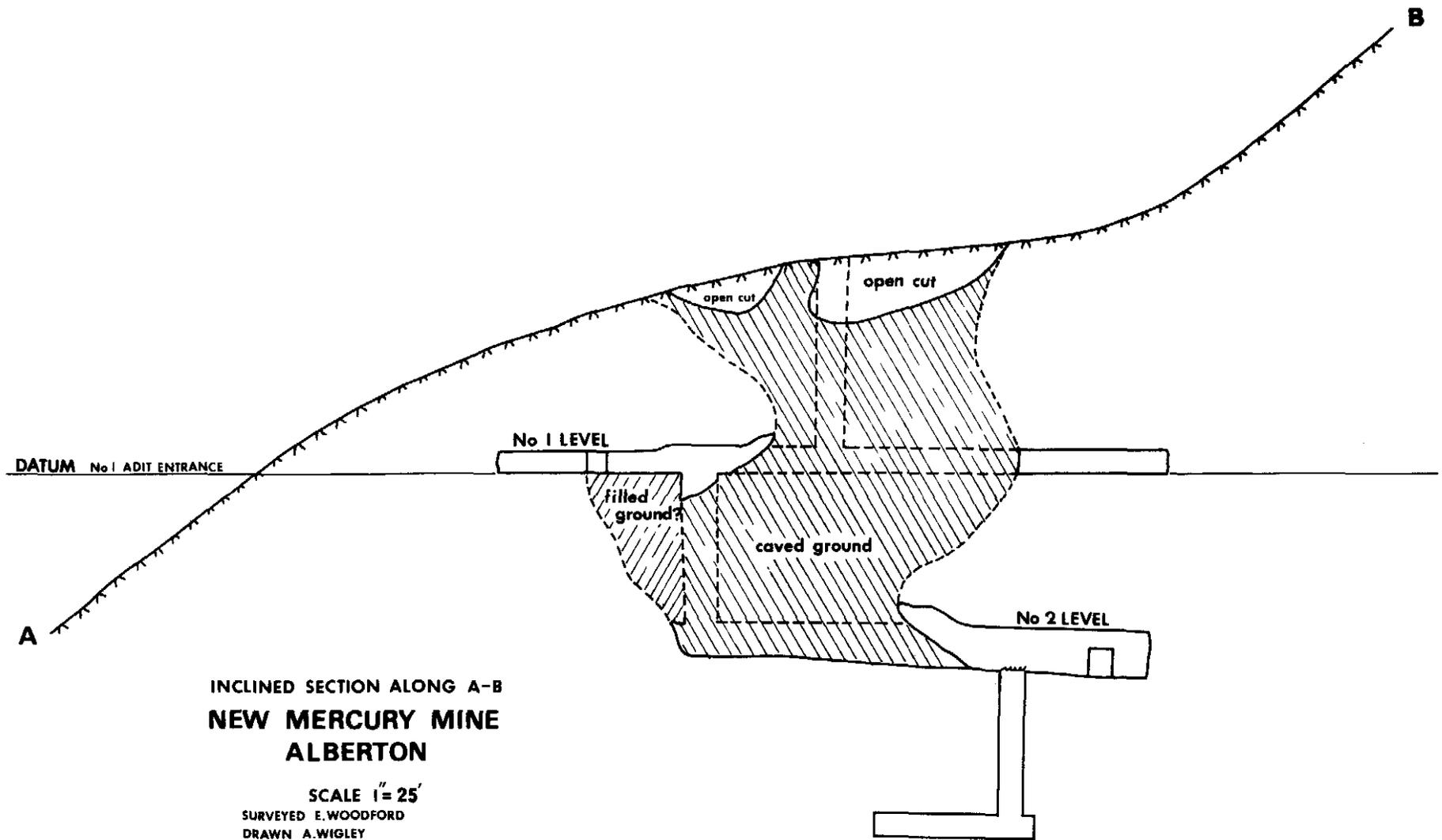
PRELIMINARY PLAN  
**NEW MERCURY MINE**  
**ALBERTON**

SCALE 1" = 5'  
 - - - - - No 2 LODE TRACE  
 ———— No 1 LODE TRACE  
 SURVEYED E. WOODFORD  
 DRAWN A. WIGLEY  
 STANNON ENG. P/L AUG. 1975

Contours 50' Interval  
 (Arbitrary datum)

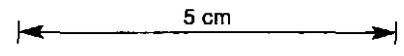


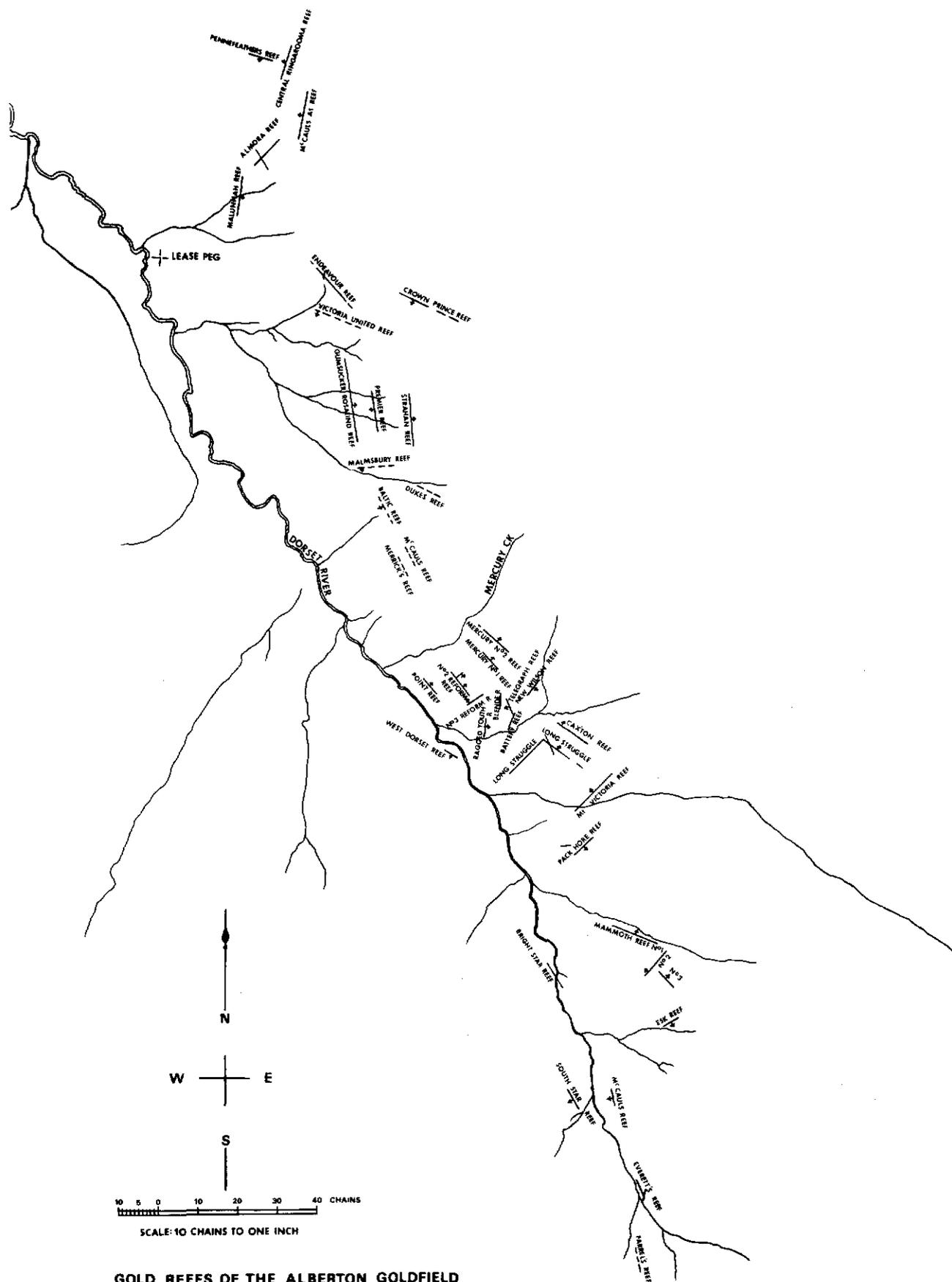




**INCLINED SECTION ALONG A-B  
NEW MERCURY MINE  
ALBERTON**

SCALE 1" = 25'  
SURVEYED E. WOODFORD  
DRAWN A. WIGLEY  
STANNON ENG. P/L AUG. 1975





**THE ALBERTON GOLDFIELD (General)**

This field was first discovered in the early 1880s, and is located about fourteen kilometers from the railway station at Legerwood adjacent to one of the richest farming districts in Tasmania.

The gold quartz lodes occur on the western slope of a ridge springing from the north-western side of Mt. Victoria in a topography that has sponsored adit mining.

The host rocks for the quartz lodes are the Mathina beds, and the general geological map of Tasmania indicates the gross relationships of these lodes to the granitic rocks of the Blue Tiers batholith. The sandstones and slates of the Mathina beds lie in a comparatively deep trough like depression in the batholithic roof with the goldfield lineation running conformably with the axis of this trough.

In the Alberton field the gold quartz lodes are confined to a narrow belt approximately 3/5ths KM in width and approximately 8 KM long. The gold bearing belt does not cease at this length. In the North it is covered by basalt and aluvium in the south it continues as the goldfields of the Dan Rivulet.

Within the Alberton field which covers about 26% of our holdings, at least 100 lodes have been located, not all of which have been mined. Those that have been mines have only been tested to an average depth of some 20/30 feet.

The lodes discovered near the surface are relatively short and rather narrow bodies of quartz varying in length from several hundreds of feet to some which are a few tens of feet long.

**MINERALOGY OF THE QUARTZ LODES**

While there is some variation in the mineralogy of individual reefs within these fields, there is a mineralogy common to this field and to the lineament as a whole. In addition to gold, the quartz reefs contain small amounts of arsenopyrite, pyrite, chalcocopyrite, sphalerite and galena. The arsenopyrite and pyrite are the most abundant sulphides.

The gold occurs as fine free gold and also accompanying sulphides and included within them. This led Hughes to surmise that the gold was of two generations. Firstly that associated with the sulphides was contemporaneous with the quartz and secondly a later influx of free gold from solutions that found their way through pre-existing fractures within the lodes. The ore shoots generally dip steeply to the south and the source of the gold was therefore probably deep and to the south.

The arsenopyrite is really the characteristic mineral of the quartz veins within these fields. While it may be absent from some lodes, in others it is very highly developed. Those lodes with the highest concentrations of arsenopyrite seem to have negligible free gold contents. However in some lodes the appearance of arsenopyrite as a lode constituent coincided in general with an increase in the free gold content, e.g. at the Ringarooma mine.

Galena is a very important mineral component in the quartz vein although it is by no means always present. The reason for its importance is that with only one exception its presence within a vein accompanies a high gold content. The exception is Cash's Lode. In all other lodes where Galena occurs the gold content is appreciable especially at the Mercury Mine. In the gold bearing lodes the Galena occurs as very small disseminated crystals and aggregates giving the quartz a dark bluish black tinge. Free gold occurs in the blue-black quartz but a portion of the total gold content is contained within the Galena itself as disseminated free gold.

Sphalerite is less plentiful than Galena but is also accompanied by a higher gold content and contributes to the dark colour of the blue-black gold rich quartz so typical of the Mercury group. Carbonate minerals such as ankerite also occur in small amounts within the lodes. Chalcopyrite if present can also indicate high gold values but is relatively rare.

#### **STRUCTURAL GEOLOGY OF THE QUARTZ VEINS**

The quartz veins are rather narrow tubular ore bodies. Extremes occur from well defined lodes of several hundreds of feet in length to lodes which are a few tens of feet long. These are generally clean and well defined sometimes one wall being well defined and the other wall irregular with spurry penetrations into the wall rock. The veins are essentially cavity filling deposits accompanied in some localities with minor replacement. The cavities are essentially joints and faults along which there has been only minor movement related to the folding of the Mathina beds. But this does not explain the restricted linear occurrence of the belt of gold bearing quartz lodes. There are a number of veins that are not well defined. They have no well defined walls; they are not persistent in any direction and there is a general inconsistency in the amount of gold they contain.

In general the veins contain ore shoots of different kinds.

- (1) Those shoots that form at the intersection of two veins.
- (2) Those shoots which form in a flexure or change of dip of a vein.

Wall rock controlled shoots do not occur in these fields as the gold may be present regardless of whether the wall rock is slate, quartzite or any intermediate variation between these two. Ore shoots formed by secondary enrichment from downward percolating surface waters do not seem to have occurred in these fields either. In general, the rich ore shoots are steeply deepening to the south (within the quartz veins).

There is no evidence of any major post mineral faulting in these areas and only minor displacement of the veins in the mines has been observed. *The veins may terminate by pinching out. They may also terminate by feathering into a number of minor veins which eventually die out.*

A third type of termination is against crossheads, i.e. a well defined plane at which both the cavity and the quartz end abruptly. **The veins being relatively small are repeated parallel to one another and the system of more than one vein will continue down to great depth.** An essential to the development to this field is the expensive business of locating a system of veins extending to depth from the surface exposure of one or two veins. For example, at the New Golden Gate Mine an adit driven to intercept one vein found three more and the subsequent sinking of a shaft found 2 more lodes. *The location of the rich ore shoots within the vein systems is the next important target of development.*

In the Gumsucker-Rosalind lode of the Ringarooma Mine and the Mercury No. 1 and No. 2 lodes of the Mercury Mine, the veins are not simple fissure fillings but are characterized by an abundance of black slate occurring as inconstant bands or as irregular blobs within the veins. These veins resemble the laminated quartz veins described at Bendigo in Victoria and are thought to be due to the mineralizing solutions exerting great pressure on the walls of a relatively narrow fissure and enlarging what was originally a number of small cracks or cleavages.

## HISTORY – ALBERTON GOLDFIELD REPORTS

The first reports were written by Mr. G. Thureau in 1883 and in 1884. These reports gave the general position and character of the lodes.

Next Mr. W.H. Twelvetrees reported on the field in 1900. In his general comments, Twelvetrees stated that: "The short and rather tricky makes of gold-bearing quartz have often proved too much for the limited resources of prospectors; money too has not always been wisely expended, and this in a field where more than ordinary managerial skill is requisite, has contributed to frequent failures, and the consequent disappointment of investors. Owing to this, the field has not been taken in hand by the public to the extent it really deserves and the only companies which are now working there on a decent scale are the Ringarooma and the Central Ringarooma, both under one mining management".

Twelvetrees terminated his report on the Alberton field saying, "With the fair yield of gold in the past" (worth about 50,000 pounds sterling in 1900) "it deserves a bright future. At the present time it ranks as the third productive goldfield in the Colony, and if the Ringarooma Company can secure the introduction of capital to work their important properties on an adequate scale, the whole district will most likely enjoy a considerable revival, and some of the other claims will be restarted, and fresh discoveries made. The frequency of good gold contents in the courses of quartz is highly suggestive of further good shoots still undiscovered; and the trifling depth attained by the shafts makes a despairing policy quite ridiculous. I feel sanguine that a goldfield will sooner or later be found below the present workings, but success, I think will largely depend upon the discretion with which the work is taken in hand. Small claims must be amalgamated, and properties worked on rather a large scale with more than one string to their bow".

In 1923 Mr. Loftus Hills as a government Geologist, reported on the goldfield and stated: "During the course of activities of the Ringarooma Company, many properties were worked by them on a limited scale and parcels of quartz of various sizes obtained and carted to their central battery. In this way many lodes had a testing on a limited scale which would have otherwise been neglected, but in most cases such testing was far from sufficient to give a correct idea of the value of the lode.

With the cessation of operations of the Ringarooma Company which coincided with the burning down of the battery, the whole field sank into a dormant and almost deserted state. The four main companies which had operated up to that time had experienced a similar career – The Ringarooma, Mt. Victoria, Long Struggle and Mercury companies and their failures gave the field such a bad name that it has been neglected by investors until quite recently. The impression had become general that the lodes were either of no value at all or were payable or barely payable down to water level but no further.

A group of miners remained on the field however, and in groups of two or more worked many of the lodes during the twenty years following on the burning of the Ringarooma battery. In this way several men made a living following rich shoots of ore and crushing their output in small batteries. This continued up to the year 1919 when Mr. S. Wallace, after carrying out some prospecting work, succeeded in interesting Mainland capitalists in the field.

As a result the Ringarooma United Company has been formed and the group of lodes in the neighbourhood of and including the Old Ringarooma Gold Mining Company's lodes, have been acquired by them and preparations have been started for comprehensive exploratory work.

Recently also a local group subscribed some capital for working the Long Struggle lodes. The old policy of constructing a battery in the early stages of development was repeated here with the result that funds ran out before either the exploratory work of the Main adit level or the battery itself was completed.

The renewed attention to the field which developed during the last two or three years is evidenced by the number of leases taken up and the exploratory work although on a rather limited scale carried out by the Miners Dream, Forest King and other small companies and syndicates. To give the field such a testing as will definitely establish its value, however calls for more than repetition of the policy and practices which only brought about the failures in the past. History tends to repeat itself but it would be a great pity if the lessons to be learnt from the past history of the Mt. Victoria field were not thoroughly grasped and applied in the design of future operations".

"The total amount of capital invested in the field up to date cannot be ascertained but the total output of gold from the field (before 1923) is approximately 60,000 pounds sterling equivalent to 15,000 oz. of gold. Roughly this corresponds to about 30,000 tons of lode material. No less than six batteries have been in operation in the field to deal with this output. It is thus obvious that battery construction and therefore expenditure on batteries has been out of all proportion to mining operations. The lesson to be learnt is perfectly clear".

In addition, Loftus Hills reached the following definite conclusions with regard to the Mt. Victoria Goldfield including both the Alberton and Dan Rivulet fields.

- " (1) Of the 100 lodes either partially worked or merely located some are of no economic importance while others possess characteristics which indicate an appreciable potential value.

- (2) The lodes of greatest permanent value are structurally distinguishable from those which are non persistent in depth. These more valuable lodes are the fault-fissure lodes.
- (3) The fault-fissure lodes on the geological evidence may be expected to persist in general to appreciable depths of at least 2000 ft.
- (4) The maximum depth reached up to the present in mining operations on this field is 390 feet below the outcrop". (At the Ringarooma Mine)".
- (5) The absence in most of the lodes of long shoots of payable quartz in the direction of the strike of the lodes at the surface, demands as an essential to the success and stability of mining operations that deep sinking should be the primary undertaking in the revival of the field.
- (6) Much capital has been uselessly expended in the erection of batteries to the comparative neglect of exploratory work.
- (7) Neighbouring lodes which could be most economically worked by one organization have been attacked by two or more companies which duplicated or triplicated expenditure on equipment and ultimately failed without accomplishing very much when amalgamation of interests would have permitted far more efficient operations.
- (8) Without exception the mining ventures on the field have been undercapitalized".

Loftus Hills then went on to say that:

"Consideration of these conclusions results in the conviction that the development of the Mt. Victoria goldfield demands the following procedure.

It being clear that the future of the field depends on the value and extent of the gold quartz lode below the level yet reached, it follows that the expenditure of whatever capital is available for the field should be concentrated on deep sinking. Further, it is apparent that such expenditure on sinking and exploring the lodes at a depth should be concentrated on a few carefully selected spots. Indiscriminate sinking must only reproduce the unfavourable opinion in regard to the field which resulted from the previous misdirected operations. On the results of the sinking at carefully selected points the future of the field wholly depends.

If such exploratory and development work demonstrates the existence to appreciable depths of lodes possessing dimensions and values which can be used as the basis of a successful mining enterprise, then the future of the field will be assured and sinking could then be undertaken at other points where the geological factors are favourable.

Since the future of the field depends on the results of such deep sinking, it is very important that the location of such testing should be carried out where the greatest chances of success lie. On the geological evidence the two localities which stand out prominently as giving justification for expenditure in this direction are the **Gumsucker-Rosalind Group at the Ringarooma Mine** and the **Mercury No. 1 and No. 2 Group at the Old Mercury Mine**. It so happens that at both of these localities winzes have been sunk to about 65 and 45 feet respectively below the lowest adit level. In both cases this work could be utilized in connection with more comprehensive sinking campaigns. As a matter of fact the winze of the Old Ringarooma Company is now being used in this way in connection with the operations of the Ringarooma United Company. In both this mine and the Mercury, **the lodes look better than at the upper levels, being well defined and strong bodies of quartz, 5 feet and 4 feet respectively. The appearance of these lodes at this depth certainly justifies an active campaign of sinking.**

**It cannot be too strongly urged that all capital now available should be utilized in sinking at these two points".**

Two years later in 1925, Mr. A. McIntosh Reid, a Government Geologist, wrote a report on the Properties of the Ringarooma Gold Mining Company.

It would appear from Mr. Reid's report, that **the advice of Loftus Hills had been largely ignored**. That doubts occurred as to the advisability of testing the mine to depth. That ore was only being mined from extensions of the existing workings. That the battery of 10 stamping heads was to be enlarged to 20 stamping heads and other expensive surface plant commissioned without sufficient ore being proven to justify this expenditure.

About this time or shortly afterwards, work ceased on this mine without the winze being completed to test the intersection of the two main lodes. It is interesting to observe that after driving this winze over 130 feet all work was terminated only some 32 feet short of this vital target which if reached would have proved the possibility of ore at depth.

Similar reports were written for the Mercury, Forest King and other mines between the years 1923-1933.

In 1933 Messrs. Nye and Blake, working for the Tasmanian Mines Department, made careful surveys of all the main lodes and workings in the Alberton field and prepared a series of maps showing these. Since 1933, a small amount of development work, mainly at the Long Struggle, Mt. Victoria and New River Mines has occurred, however no report exists of this work.

In 1952, Mr. Terence D. Hughes, as a Government Geologist, again reported on the Alberton field. He opened his report with the following remarks:-

"Ever since 1883 when gold was first produced at Alberton, it has been confidently expected that this field would develop into Tasmania's foremost gold producer, but although many small rich shoots in a number of vein systems have been worked, this promise has never been fulfilled. However, this is probably due to the weak policy of development undertaken by the operating companies and in a field such as this, a strong developmental policy should be more important than the immediate stoping of rich shoots".

Hughes summarized the main points of his report as follows:-

- (1) The area occupied by the majority of reefs is about 50 chains in width and extends south from the New River Alluvium through to Mathina. This is a sheer zone striking  $160^{\circ}$  and located on the Western limb of a major anticline and roughly parallel to its axis.
- (2) The quartz reefs are mainly of the fault fissure type and strike either North-West or North-East. Sometimes the same reef will continue through openings in both these directions giving a zig-sag course.
- (3) The greatest intensity of the quartz reefs is where the cross folding is most pronounced, i.e. in the vicinity of the Forest King-Ringarooma, the Mercury - Long Struggle - Mt. Victoria and the Central-New River systems of reefs.
- (4) Post Mineral faulting is of no great magnitude.
- (5) The reefs are mainly quartz carrying fine gold and gold contained in sulphide minerals.
- (6) This gold is of two generations, that in sulphides and a later intrusion of free gold.

- (7) The character of the country rock does not seem to have influenced the precipitation of the gold as shoots are found in hard quartzite and fissile slate.
- (8) Surface enrichment has not taken place but sometimes due to weathering of the sulphide minerals near the surface and their breakdown, the gold contained in these is liberated and the amount of easily obtaining free gold is increased.
- (9) The ore shoots are not as a rule large and often the bottom of a shoot is located near the present surface; but they are very numerous.
- (10) The ore shoots normally dip to the south.
- (11) The value of the shoots is not governed by the width of quartz but can be better located in well defined lodes.
- (12) In any mining operation, a vigorous policy of driving and cross-cutting should keep well ahead of stoping so that neighbouring shoots may be defined.
- (13) **The ultimate depth of the gold bearing quartz should be at least a couple of thousand feet as the granite should underlie this area at a great depth.** Mining operations to date have rarely been carried to three hundred feet below the outcrop.
- (14) Any policy of development should aim at:
  - (a) The limiting of re-shoots already known such as the one on the Rosalind lode cut by the shaft from the Lower Ringarooma Mine adit and the one on the Mercury lode cut by the lower winze; both of these workings are stated to be in payable gold.
  - (b) The location of new shoots in existing reefs by drilling south of the workings on the Long Struggle, Mercury, Ringarooma, Forest King or Victoria systems of reefs, and at a greater depth than these workings. The sites of any possible drills should be carefully chosen and surveyed.
- (15) Large areas of alluvial ground, both Tertiary leads and more shallow Recent deposits should contain alluvial gold in payable amounts and would be worth investigating".

#### **THE DAN RIVULET GOLDFIELD — (General)**

This field is located about 12 miles north of Mathina and continues south along the valley of the Dan Rivulet to the Township of Mathina.

The gold quartz lodes occur in at least three different sets of fractures in sandstones and shales of the Mathina Beds and as at Alberton, the reefs are structurally controlled.

The gross relationship of the lodes to the adjacent granitic rock of the Blue tiers batholic are indicated on the Geological map of Tasmania and this field is really a southern extension of the Alberton field connecting it with the gold quartz reefs of Mathina.

Numerous reefs have been located by prospecting, of which about 25 have been mined in the past. There is relatively easy access to these lodes up the valley of the Dan Rivulet.

Past mining practice is one of robbing the reefs without due concern for future development. Consequently very few mines have been carried down below 100 ft. from the surface despite the fact that the field yielded good gold values and despite its proximity to Mathina and the New Golden Gate Mine.

#### **HISTORY — DAN RIVULET GOLDFIELD REPORTS**

The history of this field is similar to that of the Alberton field and was discovered about the same time.

G. Thureau outlined the general position of the reefs in his **1883** and **1884** reports and also gave a general description of the character of the lodes.

In **1904**, Mr. W.H. Twelvetrees reported on the Dan Rivulet Goldfield.

The following is an extract from Twelvetrees report.

“The shoots of auriferous quartz in this field are sometimes of considerable length, though shorter shoots are very common. It is a familiar axiom that a long shoot is likely to descend to a good depth, but the converse is not always true. It does not follow that a short shoot will always give out at a shallow depth. It is possible, too, that a shoot, short at the surface, may expand at a lower level. At all events, it is good mining to follow auriferous quartz down.

The field is now languishing as a result of past indiscretions. Inadequate provision of capital led to mining being stopped in many cases, just when continuance of the work was most highly necessary. It also gave rise to what in Germany is called "Raubbau", a significant and useful term, for which we have no equivalent in English. It denotes that the stone has been torn out of the mine as if by robbers, the best quartz rooted out in all directions without any regard to economy, safety or appearances. The Americans call it "coyoting". The old unfilled stopes and meandering unsupported excavations which I saw in some of the mines were illustrations of this practice.

Work done so far has been at quite shallow depths, mostly between the grass roots and 100 ft. below; in one instance 140 feet has been worked, but no serious attempt has been made to go down on the shoots of stone.

A distinct defect in the mining done is that far too little use has been made of crosscutting. The structure of the field indicates a frequent occurrence of parallel reefs or quartz filled gashes and some of these it may be expected will not come to surface. Accordingly, if there is no crosscutting such reefs may be missed altogether. Of course, the neglect of exploratory and dead work has been largely due to want of adequate funds in initiating the several enterprises.

As several reefs have been found payable for limited distances at shallow depths below the outcrops, the area lends itself to the inception of small undertakings, which if ill financed can never be expected to last long, while at the same time a good deal of gold has been extracted at little cost. Considerable quantities could no doubt still be won by small parties in different parts of the field if crushing facilities were handy. In several of the mines a large proportion of concentrates would be obtained from the mineralized stone. If state batteries are ever established in Tasmania, this district would be one of the most suitable for a trial.

The future of the field, however, rests with the application of adequate capital and skill to the systematic development of the reefs at a depth".

In 1923, Loftus Hills reported on this Goldfield along with the Alberton field. However, not much additional developmental work was indicated as having been attempted by this report.

Mr. T.D. Hughes reported on the Dan Rivulet Goldfield in 1947 for the Tasmanian Geological Survey.

The condition of this field has remained little changed to the present day and has been adequately summarized by Hughes as follows:

"The Dan Rivulet Goldfield is one which has received a great deal of superficial attention but very little in the way of organized mine development. **Every square mile has been vigorously prospected thousands of shallow trenches dug, many adits driven and shallow shafts sunk, but seldom have the depths exceeded a hundred feet or so. It must not be supposed that this is because the ore shoots do not persist at depth.** Indeed only a mile to the south of this area lies the New Golden Gate Mine, once Tasmania's most important Gold Mine, 2000 ft. in depth and producer of over 250,000 oz. of gold. **This is a field where exploration has been succeeded by exploitation rather than by development.** Dozens of Companies with impressive names but very limited capital have commenced operations, grabbed all the ore in sight near the surface with no regard to economy or safety and then faded into oblivion. Little money has been invested in any one mine and consequently, there has been little return. Thus the field has quite unwarrantedly gained a bad name".

Mr. V. Threader has also investigated this field as part of the continuous line of goldfields called the Waterhouse goldfields in his M.Sc. Thesis 1967.

In addition to these general reports on the Goldfield as a whole, there are a number of smaller unpublished reports on individual mines within the field. These include:-

- (1) R.F. Finucane, 1932 — A Report on the Hinemoa Mine.
- (2) Q.J. Henderson, 1936 — Departmental Report on Recent Prospecting Operations in the Vicinity of Lady Havelock and Larandah Mines.
- (3) P.B. Nye, 1941 — City of Melbourne Mine.
- (4) P.B. Nye, 1941 — O'Brien's Mine Dan Rivulet.

All of these reports support Hughes' general conclusions as to the lack of proper development within the field and to the paucity of gold left near the surface.

**SUMMARY**

During the years which followed the sinking of the first shaft in the field, hundreds if not thousands of men examined in detail every foot of our lease area/s. Hundreds of shafts were sunk, thousands of feet of tunnels were dug in a massive, protracted effort to discover the untold number of gold bearing quartz reefs which abound. Of prime importance is the fact that some records have been handed down to us – records which provide a storehouse of information. The collective efforts of these pioneers constitute an exploration programme of immense proportions – one which would not be contemplated much less undertaken by any modern company.

As the history of these Tasmanian goldfields is brought into focus, we are able to see clearly the basic reasons which contributed to failure after failure. Apart from examples of individual greed, misspent funds, lack of capital, etc., the single outstanding circumstance which brought about collapse was the proliferation of small lease holdings. Human and capital resources were duplicated many times over and exhausted accordingly. Stannon Engineering is the only company to ever control the entire lineament by virtue of its three lease areas. The many advantages which apply are self evident.

It has been our purpose to condense history to workable proportions and so encourage meaningful conclusions. The extent to which we are able to build upon the experiences of others will be determined in due course. We look upon the Golden Gate as a "yardstick" by which the balance can be measured. We respect the repeated professional advice of Twelvetrees, Nye, Loftus Hills, Blake, Thureau, Reid, Hughes and others whose collective skill and judgement pointed the way to the true wealth of the area. We are eager to carry out the orderly development of our lease area in a manner which will do credit not only to the Company itself, but to others who may be invited to participate from time to time.

With proper management, adequate finance and the intelligent use of modern equipment and techniques, this forgotten area may yet realise the expectation that it would become Tasmania's foremost gold producer.

**Stannon Engineering Company Pty. Ltd.**

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**A Brief Appraisal of Geophysical  
Exploratory Methods**

**A BRIEF APPRAISAL OF GEOPHYSICAL  
EXPLORATORY METHODS**

**INTRODUCTION**

In the selection of an appropriate geophysical method, there are several problems to consider. An analysis must be made in the first instance to determine the best method(s) for the environment; and secondly, to determine the optimum point and line spacing.

A selection of the best method relates to considerations of,

- a) the physical properties of the rocks,
- b) the topography and climate,
- c) the objectivity of the survey, (e.g. can the pertinent structural controls be detected?)
- d) the required information regarding the sub-surface (e.g. the type(s) of anomalies associated with the geological environment).

Concurrent usage of two or more methods has the advantages of economy, i.e. cuts down on overall costs; and also partially negates the uncertainties inherent in the interpretation of the field data.

For favourable optimal point and line spacings, a balance should be obtained between,

- a) the amount of detail, and information, sought, and
- b) the element of acceptable risk of non-detection.

The optimum point ('distance between observation points') must be adjusted to the 'anticipated' depth of the feature, viz. narrow features tend to give 'narrow anomalies', whereas broad features give 'broad anomalies'. The response to be obtained from narrow reefs can be enhanced by traversing obliquely to the regional strike of the reef system, providing that a maximum angle of 30° from the 'normal' is observed.

In most cases, observations on geophysical data will not yield information about features whose depth is much greater than the distance between observation points. For the 'artificial field methods' (e.g. resistivity) the depth of exploration can be controlled; for the 'natural field methods' (e.g. magnetics) such depth control is not possible.

### THE PHYSICAL PROPERTIES OF THE ROCKS

The physical properties of rocks and minerals exhibit great variability (anisotropic effects), dependent on,

- a) pressure
- b) temperature
- c) moisture condition
- mineral { d) grain size
- e) texture
- f) distribution of constituent minerals
- g) pore space and arrangement
- h) age and tectonic evolution.

Many empirical expressions have been derived to relate these, but they are only significant in a statistical sense.

However it is necessary to have some indication of the physical properties of the rocks to estimate the *proportion of the 'response' expected*. To test the effectiveness of the method(s) to be used, and to evaluate the 'background' value of the field or non-mineralised rock, both actual property values, and contrast values, (i.e.  $P_2 - P_1$ ) are used.

The following table lists some pertinent properties relative to the goldfield areas of N.E. Tasmania.

ROCK TYPE	DENSITY (wet) (gm/cm <sup>3</sup> )	MAGNETIC VOLUME SUSCEPTIBILITY k.10 <sup>6</sup> (S.I.)	ELECTRICAL RESISTIVITY (ρ.ohm-m)	ELECTROCHEM POLARISABILITY (ρξ)
SANDSTONE	2.1 – 2.7	35 – 950	100 – 5.10 <sup>3</sup>	0.9
SHALE	2.1 – 2.6		1 – 10 <sup>3</sup>	
SILTSTONE	2.2 – 2.4		10 <sup>4</sup>	0.081 – 0.92
BASALT	2.9 – 3.1	2.5.10 <sup>2</sup> – 10.5.10 <sup>4</sup>	10 <sup>2</sup> – 10 <sup>4</sup>	
DOLERITE	2.8 – 3.3	3.8.10 <sup>2</sup> – 8.8.10 <sup>4</sup>		
GRANITE	2.5 – 2.8	10 – 5.10 <sup>4</sup>	10 <sup>3</sup> – 2.10 <sup>4</sup>	0.03 – 0.57
QUARTZ	2.65		10 <sup>12</sup> – 2.10 <sup>14</sup>	
PYRITE	4.9 – 5.1	35 – 60	10 <sup>-5</sup> – 1	
STIBNITE	4.64		10 <sup>5</sup> – 10 <sup>12</sup>	
CHALCOPYRITE	4.25	375 – 1500	3.10 <sup>-5</sup> – 5.10 <sup>-2</sup>	
ARSENOPYRITE	5.9 – 6.2	1690 – 2960	10 <sup>-4</sup> – 10	

(source Parasnis 1971).

*assumes massive  
homog. etc.  
measured on small  
samples*

The associated mineralisation, pyrite, stibnite, chalcopyrite and arsenopyrite, which occurs with the gold is not in sufficient concentration to appreciably affect the geophysical response. The main criteria is the property contrast between the quartz veins and the country rock, as tabulated below.

ROCK ASSOCIATION	DENSITY CONTRAST	SUSCEPTIBILITY CONTRAST (MAG.)	RESISTIVITY CONTRAST
QUARTZ/SANDSTONE	0 – 0.5		10 <sup>10</sup> – 10 <sup>11</sup>
QUARTZ/SHALE	0 – 0.5		10 <sup>9</sup> – 10 <sup>11</sup>
QUARTZ/SILTSTONE	0.2 – 0.4		10 <sup>8</sup> – 10 <sup>10</sup>
QUARTZ/BASALT	0.2 – 0.4		c.10 <sup>10</sup>
QUARTZ/DOLERITE	0.1 – 0.6		—
QUARTZ/GRANITE	0 – 0.2		10 <sup>8</sup> – 10 <sup>11</sup>

*never as great as this  
quite unrealistic*

**ENVIRONMENTAL FACTORS (Topography and Climate)**

With the exception of seismic work, applied geophysics is ideally suited to flat or gently undulating terrain, and areas of thin overburden cover. In areas of rugged relief there is often considerable uncertainty with respect to the various correction factors that need to be applied. Penetration through thick overburden is difficult, and it is often found that the 'response' of the feature sought generally lies within the 'errors' of measurement.

The North Eastern part of Tasmania lies within what could be generally called a temperate climatic zone. The area is rugged, wet, cool, and generally well vegetated, with minimal weathering (viz. weathering barely keeps ahead of erosion). This type of locale is amenable to most methods, any handicaps imposed are purely physiographic.

*on Mathinna rocks?*

**THE OBJECTIVITY OF THE SURVEY: SUB-SURFACE INFORMATION**

In the reduction and interpretation of geophysical data, simplicity is assumed in respect of both geological structure and 'physical' behaviour. This means that no unique solution is obtainable, with the exception of seismic data, and modelling techniques are freely used. However the relative merits of any method can be predicted for a given environment. For example consider the following relationships.

The anomaly formulae for a spherical body in the subsurface are,

- GRAVITY  $\Delta g = (4/3 \cdot \pi \cdot G) (R^3) (\rho_2 - \rho_1) z/r^3$
- MAGNETIC  $\Delta H = (H_0) (R^3) \left( \frac{\mu_2 - \mu_1}{\mu_2 + 2\mu_1} \right) \left( \frac{2x^2 - z^2 - y^2}{r^5} i + 3xyj + 3xzk \right)$
- RESISTIVITY  $\Delta E = (E_0) (R^3) \left( \frac{\sigma_2 - \sigma_1}{\sigma_2 + 2\sigma_1} \right)$  "
- E.M.  $\Delta H = (H_0) (R^3) \left( \frac{M - iN}{r^3} \right)$  "
- I.P.  $\Delta f(\Delta E) = (E_0) (R^3) \left( \Delta f \frac{\sigma_2 - \sigma_1}{\sigma_2 + 2\sigma_1} \right)$  "

=	R =	F.	S.	P.	G.
	Response	Inducing Field	Size	Physical Property Contrast	Geometry

*don't need formulae to know when by depth*

From these formulae it can be seen that the magnetic, gravity, E.R. and I.P. methods are all volume dependent; E.M. is dependent only on the area of the inhomogeneity relative to the source.

For a value of  $P = 1$  (unity, or saturation; maximum value), then theoretically, both magnetic and resistivity methods give the same percentage anomaly for a spherical source. In regard to E.M.,  $P$  has a maximum value of  $\frac{1}{2}$ , whereas for I.P., it varies from  $\frac{1}{2}$  for  $\sigma_2 \gg \sigma_1$  to 2, for  $\sigma_2 \ll \sigma_1$ .

With figures available for physical property contrasts, it is possible to predict the maximum anomaly to be expected for spherical targets at any depth of burial.

The problem then relates to an evaluation of response relative to noise. Noise, basically is of three types,

- a) instrument noise -- generally this is much lower than the other two
- b) disturbance field noise -- tides, telluric currents etc.
- c) terrain noise = geologic noise + topographic noise + location noise.

No geophysicist knows the limiting depth of exploration since the terrain noise varies from location to location. Educated guesses suggest the following values for terrain noise,

0.05 m.gals	for	GRAVITY
25 $\gamma$		MAGNETICS
5% of 1 <sup>ary</sup> field		RESISTIVITY
2% of dip angle or, )		E.M.
3.5% of 1 <sup>ary</sup> field )		I.P.
2% of frequency effect		

*very lucky unless fully corrected. usually after 50%*

Hence, given  $P$ , and noise effects, the maximum depth and 'size of response' for any method and shape criteria can be evaluated: this leads to an evaluation with respect to a risk/cost analysis.

**OPTIMAL POINT AND LINE SPACING**

Line spacing depends on the strike length (known or assumed) of the sub-surface feature; the problem then is one of simple continuous geometric probabilities.

If  $L$  = length of the unknown feature  
 $S$  = line spacing

The probability  $P$ , that at least one set of lines crosses the feature is,

$$P = \frac{2L}{\pi S} \quad \text{for } S \geq L$$

$$P = \left( \frac{2L}{\pi S} \left( 1 - \left\{ 1 - \frac{S^2}{L^2} \right\}^{1/2} \right) \right) + \frac{2}{\pi} \cos^{-1} \frac{S}{L}$$

for  $S \leq L$ .

As an illustration, consider,

i) if  $S = 100$  m, and  $L = 20$  m, the probability of detection is,

$$P = \frac{2 \cdot 20}{\pi \cdot 100} = 0.13 \quad \text{or } 13\% \text{ probability}$$

ii) if  $L = 100$  m, and  $S = 20$  m, the probability of detection is,

$$P = \frac{2 \cdot 100}{\pi \cdot 20} \left( 1 - \left\{ 1 - \frac{20^2}{100^2} \right\}^{1/2} \right) + \frac{2}{\pi} \cos^{-1} \frac{20}{100}$$

$$= 0.974 = 97\% \text{ probability of detection.}$$

#### RESPONSE

The general form of the response equation can be written,

$$R = F (P_2 - P_1) \iint \frac{\Delta V}{r^n}$$

$R$  = response

$P_2 - P_1$  = physical property contrast

$F$  = inducing field

$\Delta V$  = portion of volume measured

$r$  = distance from observation to centre of body

$n$  = integer (= function of method used).

**CONCLUSIONS**

Using the physical property contrast data, we can determine the response of the various methods. The property contrasts are given below.

	Gold in quartz veins associated with					
MAGNETIC	SANDSTONE	SHALE	SILTSTONE	BASALT	DOLERITE	GRANITE
$\frac{\mu_2 - \mu_1}{\mu_2 + 2\mu_1}$	0.1 - 0.5	0.1 - 0.5	0.1 - 0.5	0.9	0.9	0.6 - 0.8
GRAVITY						
$\rho_2 - \rho_1$	0.2	0.2	0.3	0.3	0.4	0.1
RESISTIVITY						
$\frac{\sigma_2 - \sigma_1}{\sigma_2 + 2\sigma_1}$	0.9	0.9	0.8	0.8	0.8	0.8
E.M. M - iN	0	0.1	0.1	0.3	0.3	0.2

I.P.

$$\Delta f \frac{\sigma_2 - \sigma_1}{\sigma_2 + 2\sigma_1} \quad \text{In this situation, very close to zero.}$$

The general form of the response equation is,

$$R = F (P_2 - P_1) \iint \frac{\Delta V}{r^n} \quad \text{where we assume,}$$

- a) the source of the "measurable effect" is at the centre of the body
- b)  $\Delta V = f(r')$ ;  $r'$  = length parameter of the body
- c)  $P_2 - P_1 = \text{constant}$  for the specified conditions

Considering only the two dimensional case, where  $\Delta V = x.r'^2$  then three cases are possible, i.e.

- i)  $r' > r$  i.e. sample size greater than the distance to the observations viz. the measurements are within the body.
- ii)  $r' < r$  - normal case, if  $r' \ll r$ ,  $x r'^2 \rightarrow 0$ ,  $\therefore R \propto F (P_2 - P_1) \frac{1}{r^n}$

This is the condition where the sample size is insignificant with respect to the analysis.

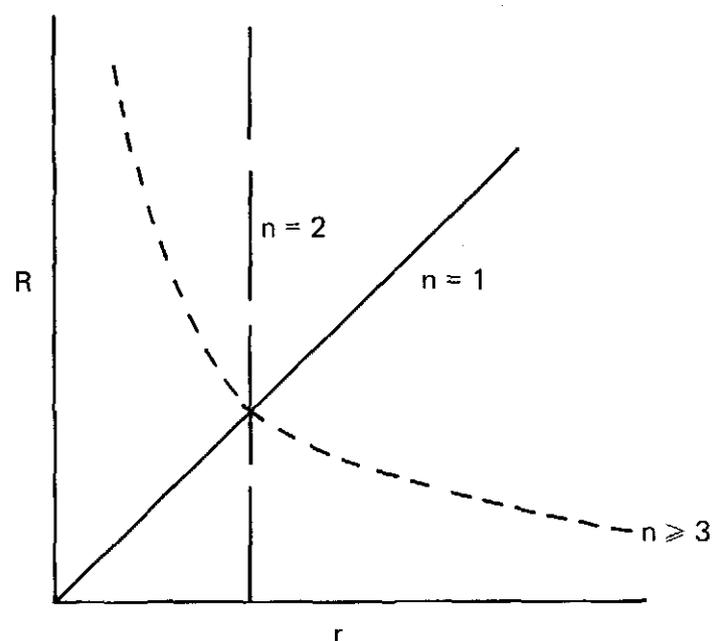
iii)  $r' = r$  — a special case of ii).

Therefore,  $r' \leq r$  for significant results, and  $r'$  must be expressed in terms of  $r$ .

If we further assume that  $r'$  is expressible in terms of  $r$  then  $\Delta V = x \cdot r^2$

Hence for a constant inducing field, and providing the physical property contrast is constant, the response  $R$  is definable as,

$$R \propto x \cdot r^{2-n}$$



For,

i)  $n \leq 0$ , not considered

ii)  $1 \leq n \leq 2$  — a very sensitive arrangement

iii)  $n \geq 3$ , the sensitivity is totally dependent on values of  $x$  and  $(P_2 - P_1)$

Thus  $R$  is definable by  $r$ , if a mapping function can be found for  $\Delta V$  in terms of  $r$ .

Using Greenspan's function,

$$x = a \cos \beta + c \cos 3\beta$$

$$y = b \sin \beta - c \sin 3\beta$$

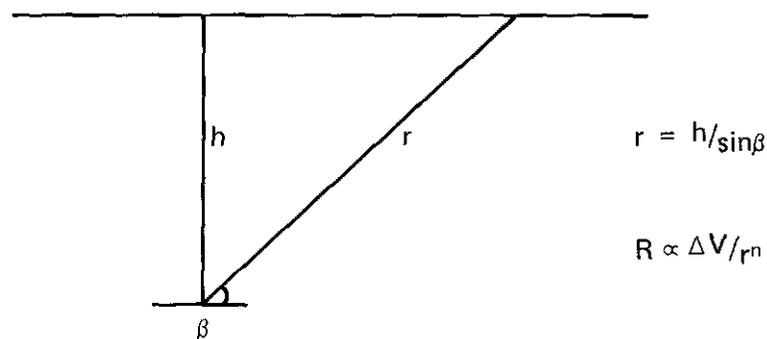
For a two dimensional case, the area of the inhomogeneity is

$$\text{Area (A)} = 4 \int_0^{\pi/2} y \cdot dx.$$

$$= \pi (ab - 3c^2)$$

Areas		a	b	c	Area (units <sup>2</sup> )
Type					
CIRCLE		1	1	0	$\pi$
ELLIPSE	2:1	2	1	0	$2\pi$
	4:1	4	1	0	$4\pi$
	8:1	8	1	0	$8\pi$
OVALOID	2:1	2.1	1.1	-0.1	$2.28\pi$
	4:1	4.19	1.19	-0.19	$4.9\pi$
SQUARE (side axes)	1:1	1	1	-0.14	$0.94\pi$
	1:1 (side 45° to axes)	1	1	+0.14	$0.94\pi$

As a first approximation the formulation is not greatly in error if we simply use circles or ellipses as our basic shape format.



In geophysics, commonly  $n = 2$  or  $4$ , although occasionally it may be  $1$  or  $3$ .

From above then,

$$R \propto \frac{\pi (ab - 3c^2)}{\left(\frac{h}{\sin\beta}\right)^n}$$

For circles and ellipses,  $c = 0$ , then

$$R \propto \frac{\pi \cdot ab}{\left(\frac{h}{\sin\beta}\right)^n}$$

Consider two cases,

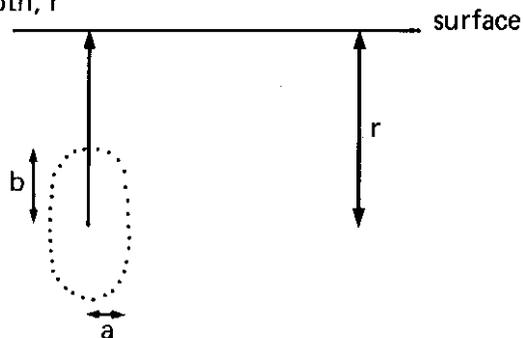
- i) Response is measured at a point directly above the centre of the body, then  $r = h$ , and  $\sin\beta = 1$ .  
This is the position of maximum response, then

$$R = \frac{(P_2 - P_1) \cdot \pi \cdot ab}{r^n}$$

- ii) The response is measured at any point excepting the position of maximum response, then

$$R = \frac{(P_2 - P_1) \cdot \pi \cdot ab}{(h/\sin\beta)^n}$$

Using the concept of a 20:1, 40:1 and 80:1 ellipse, we can compute the relative merits of each method with respect to units of depth,  $r$



Example,

$$r = 2b$$

$$a = b/2$$

## RESULTS

## Values of R for n = 2

	a = 1 b = 20a	a = 1 b = 40a	a = 1 b = 80a
1	62.83 P	125.6 P	251.3 P
2	15.72 P	31.4 P	62.9 P
3	6.98 P	13.96 P	27.9 P
4	3.9 P	7.8 P	15.7 P
5	2.5 P	5.04 P	10.1 P
6	1.75 P	3.49 P	6.98 P
7	1.28 P	2.56 P	5.13 P
8	0.98 P	1.96 P	3.93 P
9	0.78 P	1.55 P	3.10 P
10	0.63 P	1.26 P	2.51 P

## Values of R for n = 4

	a = 1 b = 20a	a = 1 b = 40a	a = 1 b = 80 a
1	62.83 P	125.6 P	251.3 P
2	3.92 P	7.8 P	15.7 P
3	0.78 P	1.55 P	3.1 P
4	0.25 P	0.49 P	0.98 P
5	0.1 P	0.2 P	0.4 P
6	0.05 P	0.1 P	0.2 P
7	0.03 P	0.5 P	0.1 P
8	0.015 P	0.03 P	0.06 P
9	0.0096 P	0.019 P	0.038 P
10	0.006 P	0.012 P	0.025 P

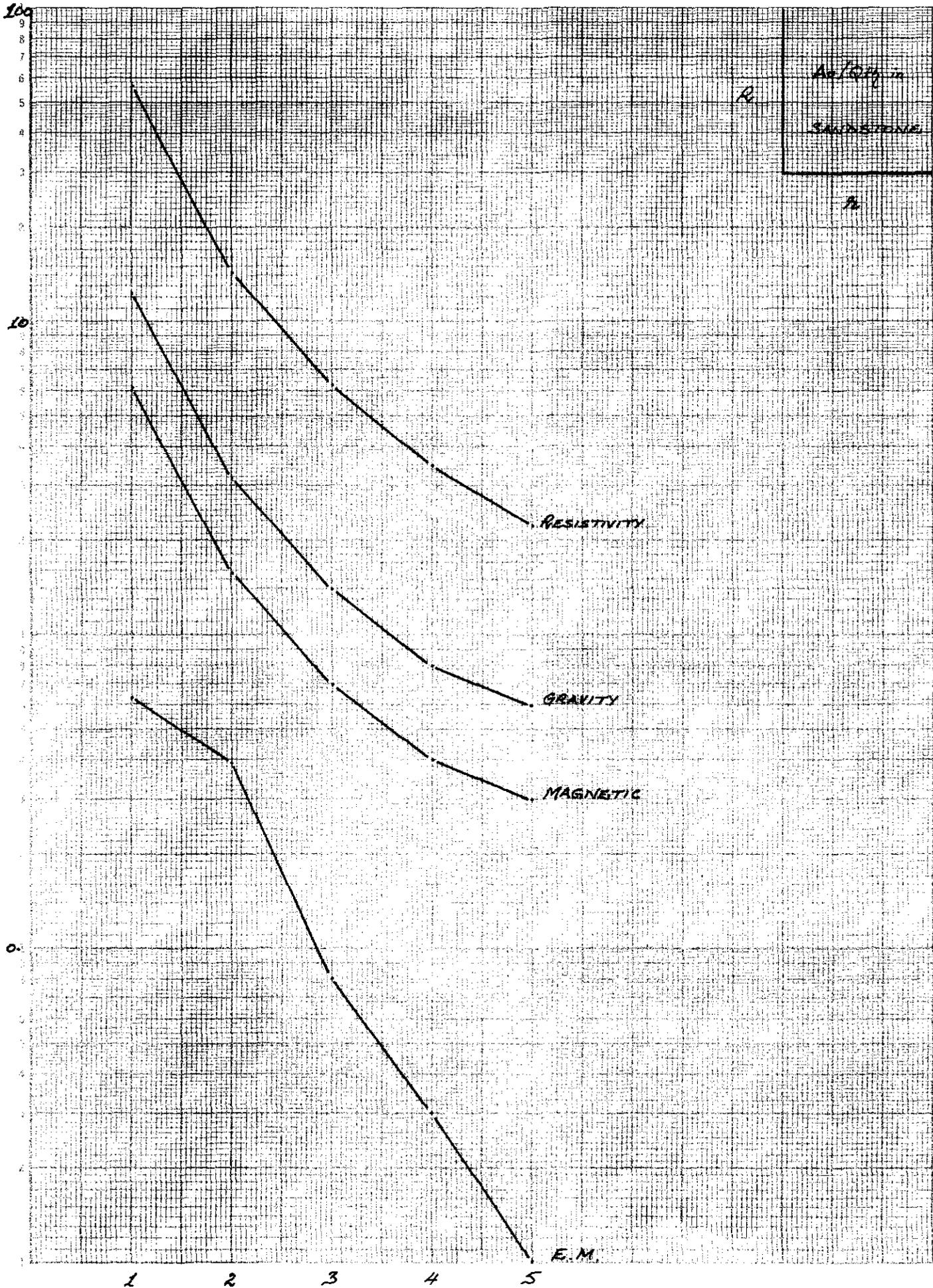
Using values of  $r = 1$  to 5 inclusive, the response values are, for  $a = 1$ ,  $b = 20a$ ,

		GOLD in quartz, host rock is,						
		SANDSTONE	SHALE	SILTSTONE	BASALT	DOLERITE	GRANITE	
MAGNETIC	= 1	6.2	6.2	6.2	56.5	56.5	50.1	
	2	1.6	1.6	1.6	14.1	14.1	12.6	
	3	0.7	0.7	0.7	6.3	6.3	5.6	
	4	0.4	0.4	0.4	3.5	3.5	3.1	
	5	0.3	0.3	0.3	2.3	2.3	2.0	
GRAVITY	1	12.4	12.4	18.6	18.6	24.8	6.2	
	2	3.2	3.2	4.8	4.8	6.4	1.6	
	3	1.4	1.4	2.1	2.1	2.8	0.7	
	4	0.8	0.8	1.2	1.2	1.6	0.4	
	5	0.6	0.6	0.9	0.9	1.2	0.3	
RESISTIVITY	1	56.6	56.6	50.3	50.3	50.3	50.3	
	2	14.15	14.15	12.6	12.6	12.6	12.6	
	3	6.3	6.3	5.6	5.6	5.6	5.6	
	4	3.5	3.5	3.1	3.1	3.1	3.1	
	5	2.25	2.25	2.0	2.0	2.0	2.0	
E.	1	0	0.63	0.63	1.89	1.89	1.26	
M.	2	0	0.39	0.39	1.17	1.17	1.78	
	3	0	0.08	0.08	0.24	0.24	0.16	
	4	0	0.03	0.03	0.09	0.09	0.06	
	5	0	0.01	0.01	0.03	0.03	0.02	

The results are plotted below.

To determine values for  $b = 40a$  or  $80a$ , simply multiply the above values by 4, 8, etc.

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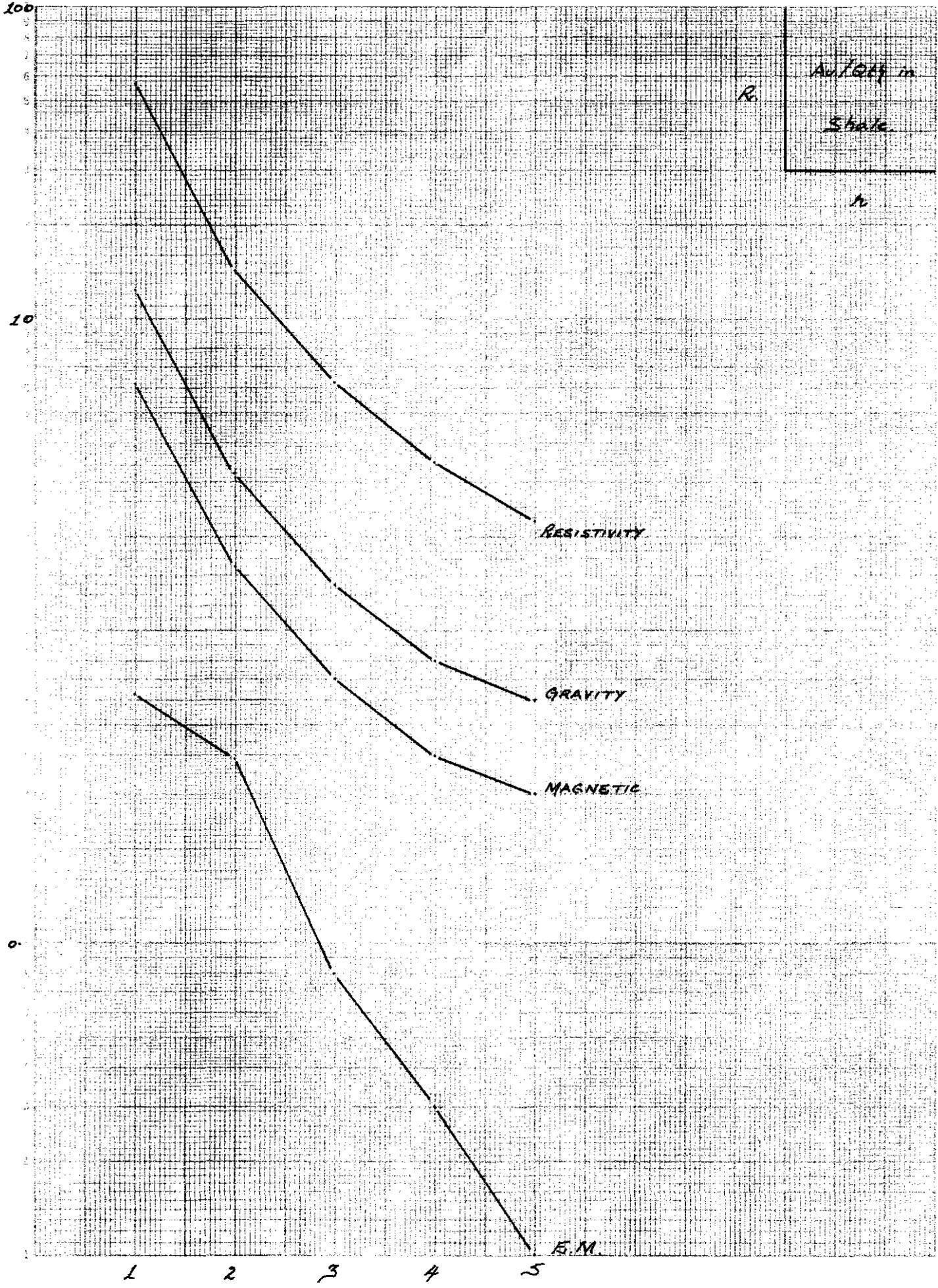


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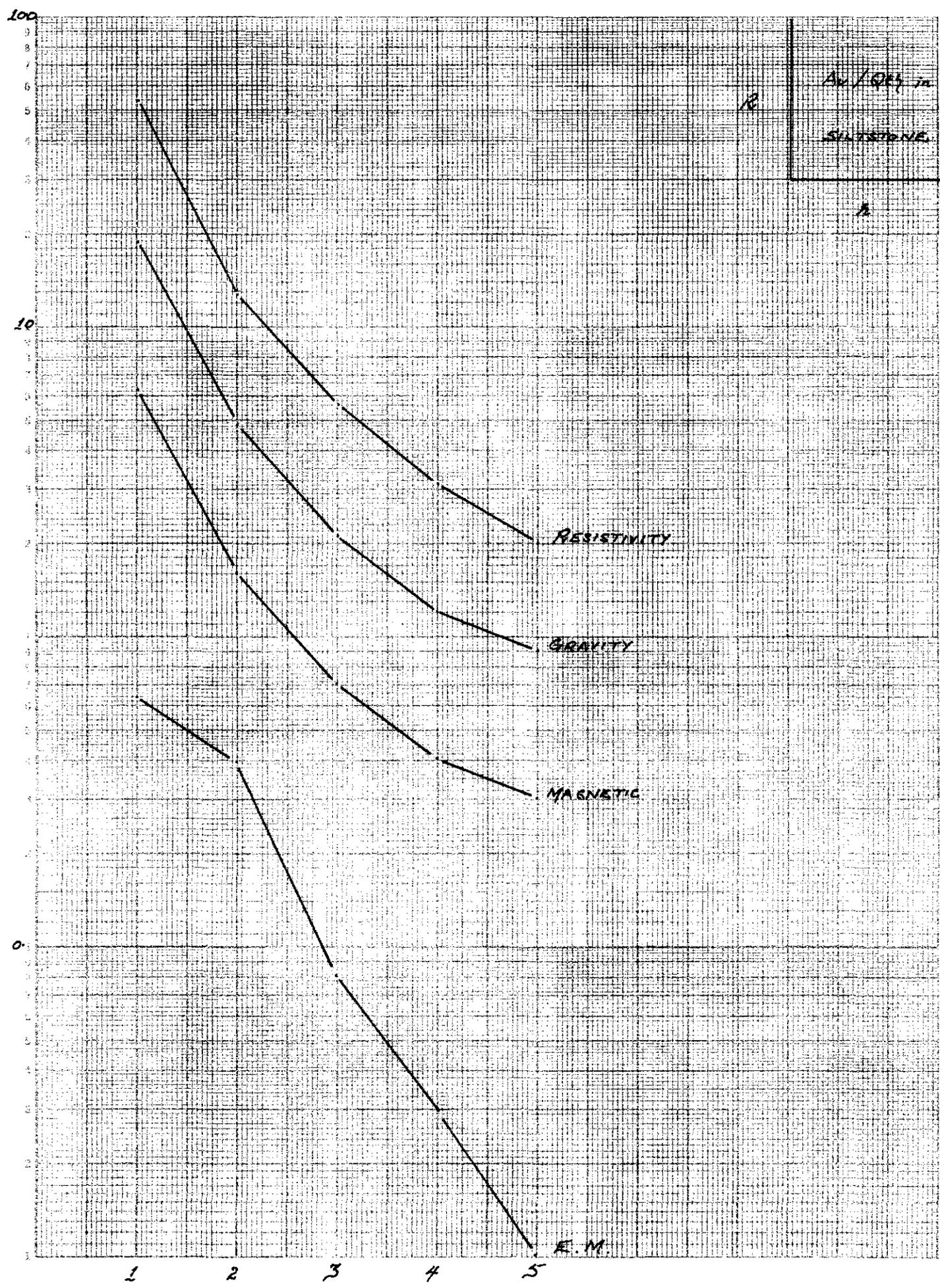
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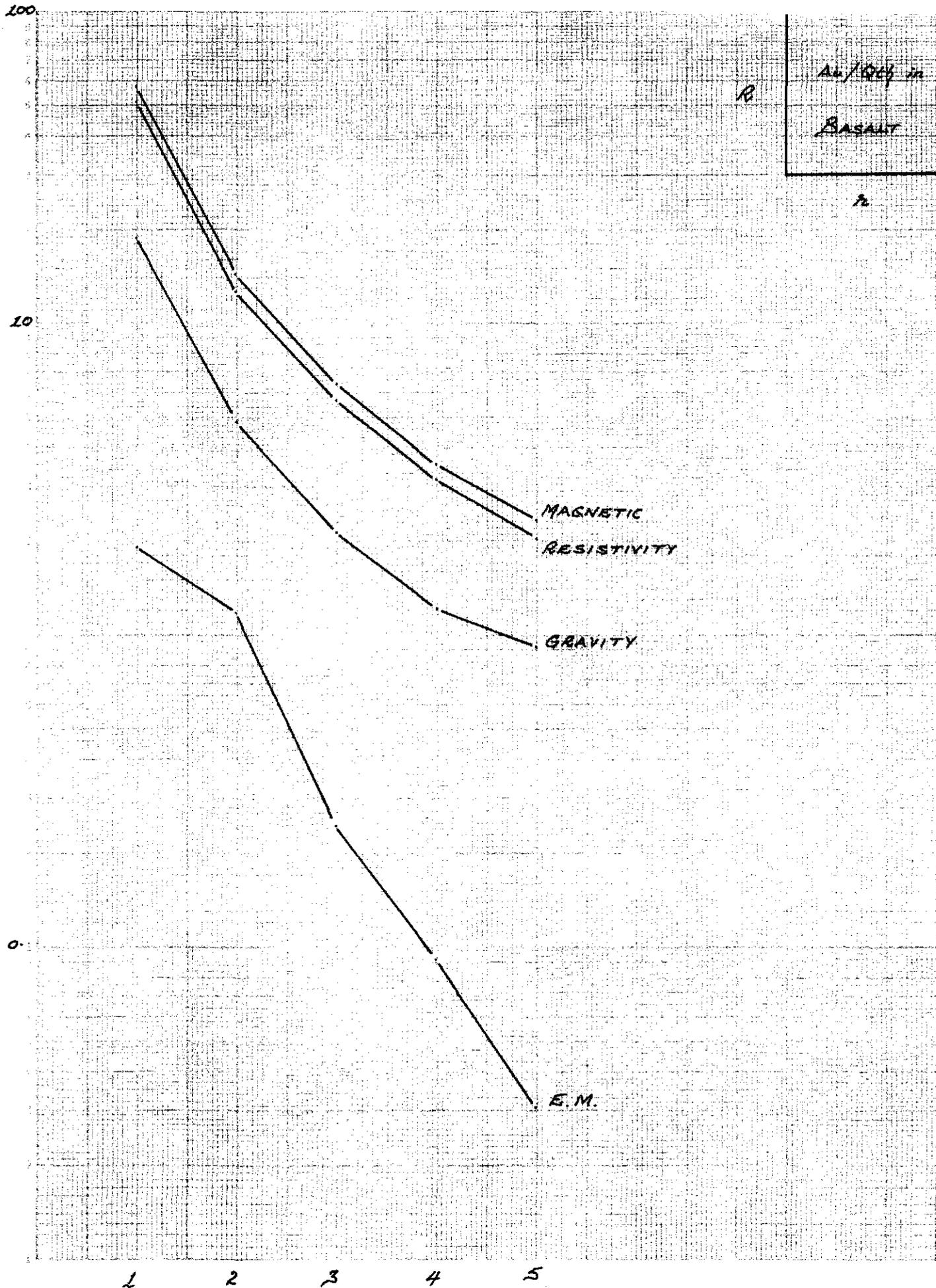
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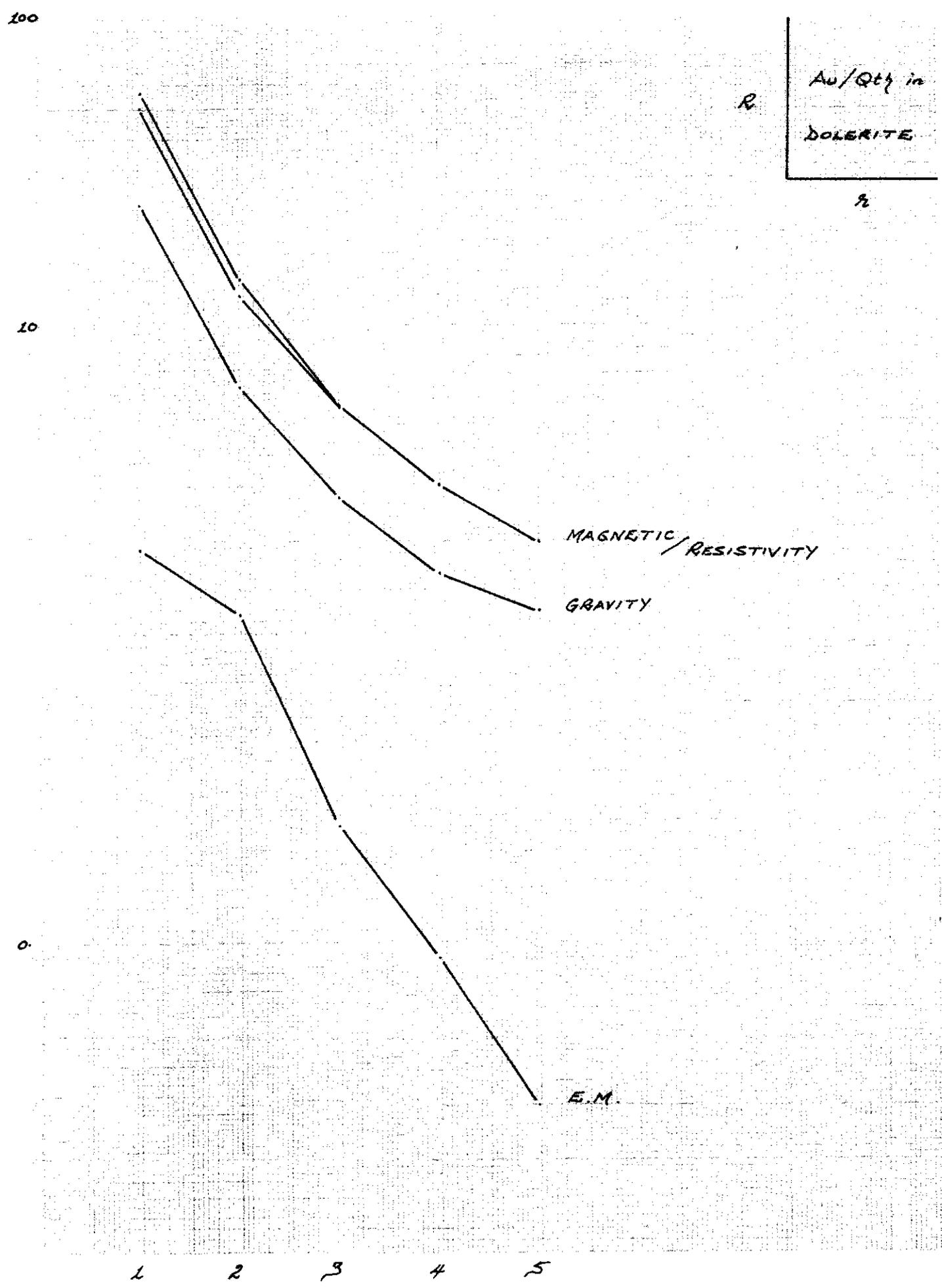
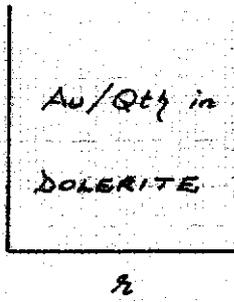


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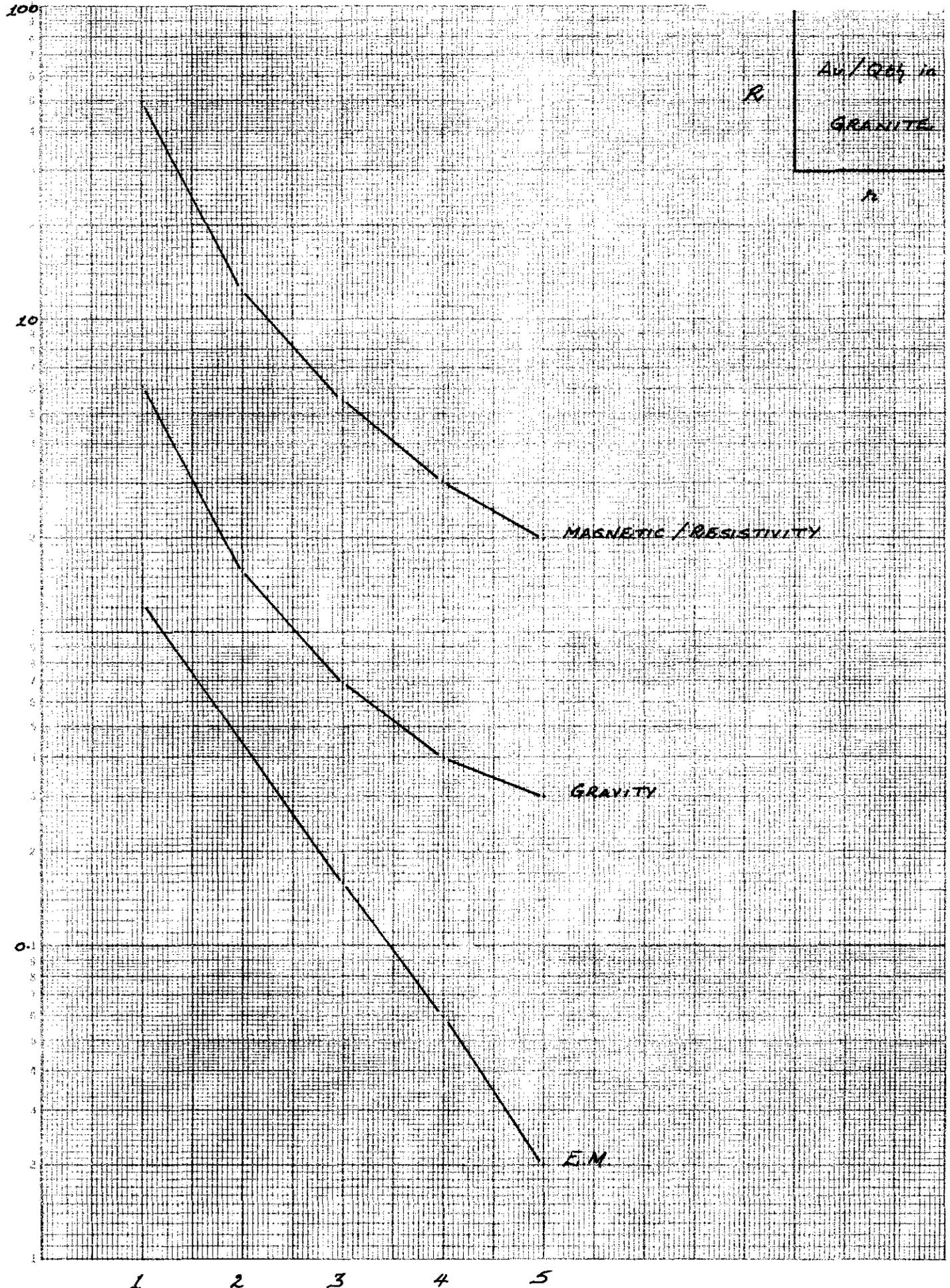
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**The Financial Evaluation of Mineral Deposits  
(A Computer Method Using Both Sensitivity And  
Probabilistic Analysis Methods)**

**THE FINANCIAL EVALUATION OF MINERAL DEPOSITS  
(A COMPUTER METHOD USING BOTH SENSITIVITY AND  
PROBABILISTIC ANALYSIS METHODS)**

**INTRODUCTION**

A computer programme developed by Bennett, Thompson, Quiring and Toland, U.S.G.S. (1970, circular 8495) has been adapted to run on the Cyber 72 computer at R.M.I.T. This programme performs both sensitivity and probabilistic financial analyses of mineral prospects and mines.

The discounted-cash-flow rate of return is the basic criterion to select a mining system, processing method, and production rates at varying costs, grades, recovery and prices. Probabilistic techniques are generally more relevant to these types of analyses since they more realistically indicate the risk involved due to the uncertainties inherent in the data.

Meaningful evaluations can, and should, be made at all stages of the development of a prospect; from initial exploration right through to the production phases. For any financial analysis however, it is necessary to make some estimate of,

- (a) physical parameters defining the deposit
- (b) reserves - (real and sometimes imagined)
- (c) grade - (quality of reserves)
- (d) relevant mining and processing methods
- (e) production rates
- (f) recovery rates
- (g) market price (including fluctuations)
- (h) capital investment requirements
- (i) operating costs (actual and anticipated).

The degree of accuracy attained relates to the definitiveness of the obtained data.

The complete project evaluation procedure is shown below;

#### PROJECT EVALUATION PROCEDURE

1. Assemble characteristics defining Deposit
- ↓
2. Assemble Information of Project Economics
- ↓
3. Rank Applicable Mining Methods
- ↓
4. Assess Basic Beneficiation Methods and Process Variations
- ↓
5. Choose Appropriate Costing Method
- ↓
6. Select Production Rates
- ↓
7. Develop Cost Estimates for the above
- ↓
8. Compute Return for Beneficiation Alternatives
- ↓
9. Select Beneficiation Method
- ↓
10. Compute Return for Alternative Mining Methods
- ↓
11. Select a Mine System
- ↓
12. Select Optimum Production Rate
- ↓
13. Conduct Sensitivity Analysis
- ↓
14. Conduct Probabilistic Analysis
- ↓
15. Evaluate Feasibility of Project.

The parameters associated with the above flow chart are enumerated below.

1. **CHARACTER OF DEPOSIT**

These parameters should be defined during the exploration programme, and the data here determined will influence the selection of appropriate mining and processing methods. The information should include:-

(a) **Geology of deposit**

Type, grade, and uniformity of mineralisation.  
Amount and classification of reserves.  
Physical characteristics of ore and waste.

(b) **Geometry of deposit(s)**

Size, shape, attitude and depth.

(c) **Geography**

Location and climate.

2. **PROJECT ECONOMICS**

The data pertinent to the economic evaluation can be classified as;

(a) **price projections of recoverable mineral(s)**

(b) **demand projections of recoverable mineral(s) including both competition from overseas and interstate markets and substitutes**

(c) **location of markets**

(d) **marketable form of product**

(e) **tax information: local, state, federal.**

**3/4. MINING AND BENEFICIATION METHODS**

The problems here relate to the development and assessment of particular mine systems and variants; and to the relative applicability and recovery related to beneficiation methods. Recovery is governed by the mineralogic composition of the ore, and the processing and comminution methods used.

**5. COSTING METHODOLOGY**

The (D.C.F.) rate of return is used as the criterion to evaluate the viability of a prospect, mine or investment. This rate of return can also be used to select the appropriate mining and beneficiation methods to yield the greatest profit. Actual costing methodology relates to the need of accuracy and the detail of the data available. Estimates should be made at all stages of development.

**6. SELECTION OF PRODUCTION RATE**

The "best" rate can be determined from the D.C.F. analysis. However, the production rate not only depends on the physical characteristics of the deposit, but relates to the parameters of processing method, plant design, technological advances, volume and stability and competitiveness of markets.

**7. DEVELOP COST ESTIMATES TO MINE AND PROCESS ORE AT SELECTED PRODUCTION RATES**

The capital investment and operating cost requirements relate to,

(a) Mining

Development and system variation.  
Mining phases,

and

(b) Beneficiation

Basic method, and variants.  
Beneficiation phases.

Using the rate of return criterion, the unsuitable choices are discarded, and mathematical expressions derived, and curves plotted, for estimated costs versus production rates.

#### 8/9/10/11 SELECTION OF MINING AND BENEFICIATION ALTERNATES

The rate of return is calculated for alternate beneficiation and mining methods at selected production rates and estimated recovery rates. A comparison of return rates are made on total and incremental investment (the appropriate rate depends on company policy).

#### 12. SELECT OPTIMUM PRODUCTION RATE

The production rate chosen reflects the company goals; the election may be to maximise profits or to take acceptable profits considering future alternate investments and continuity of corporate entity.

If a maximum rate of return is not indicated, the cost curves must be recomputed to estimate investment and operating cost at differing production rates.

#### 13. SENSITIVITY ANALYSIS

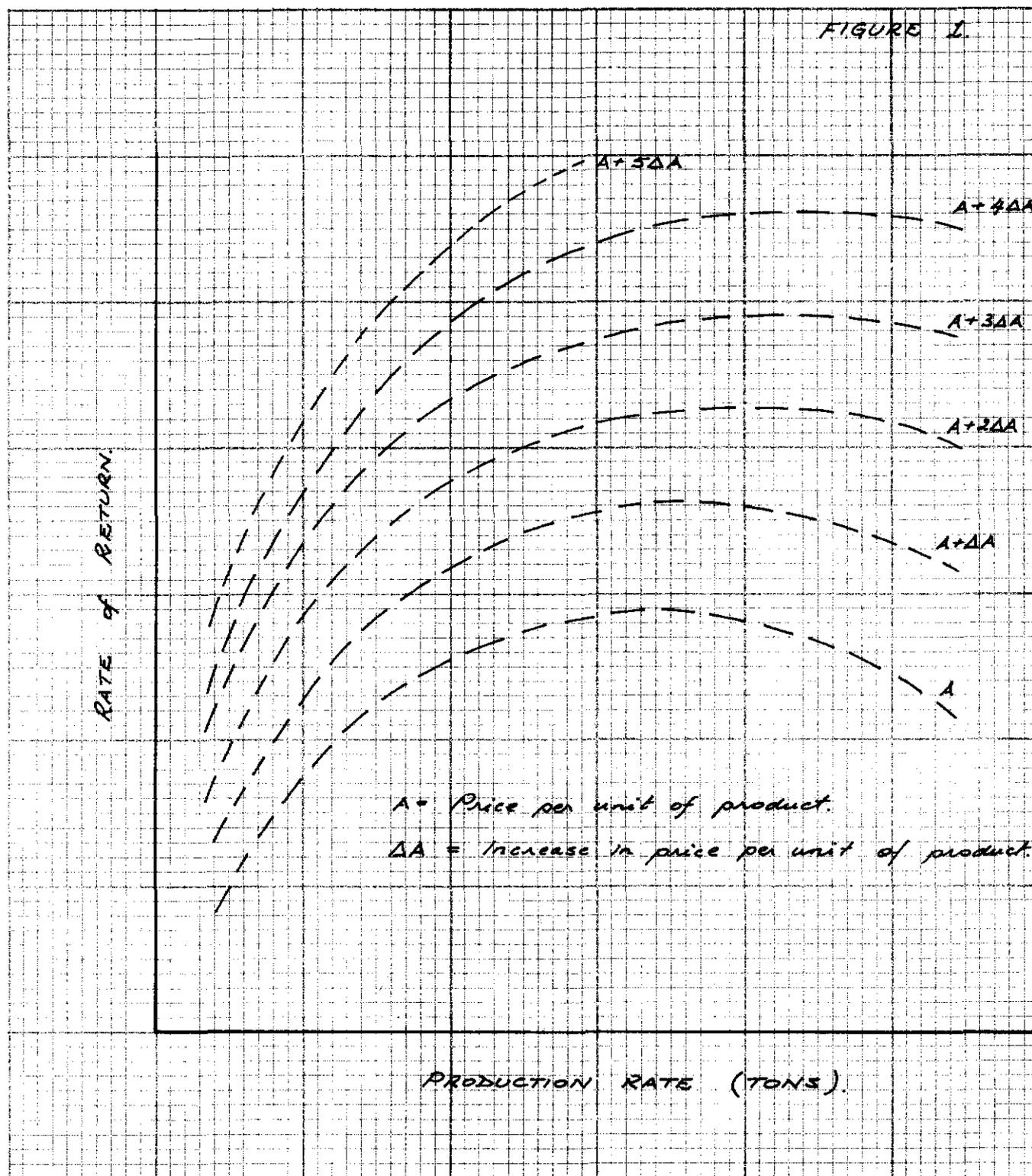
A single value (point estimate) is assigned to each of the critical parameters. Uncertainties or risks, can be determined by varying one or all of the values and making successive calculations. This is useful in that it shows the overall effect that a point estimate has upon the feasibility of the project, and indicates the areas where greater accuracy is required. Figure 1 shows the effect that changes in a single parameter may have on the rate of return.

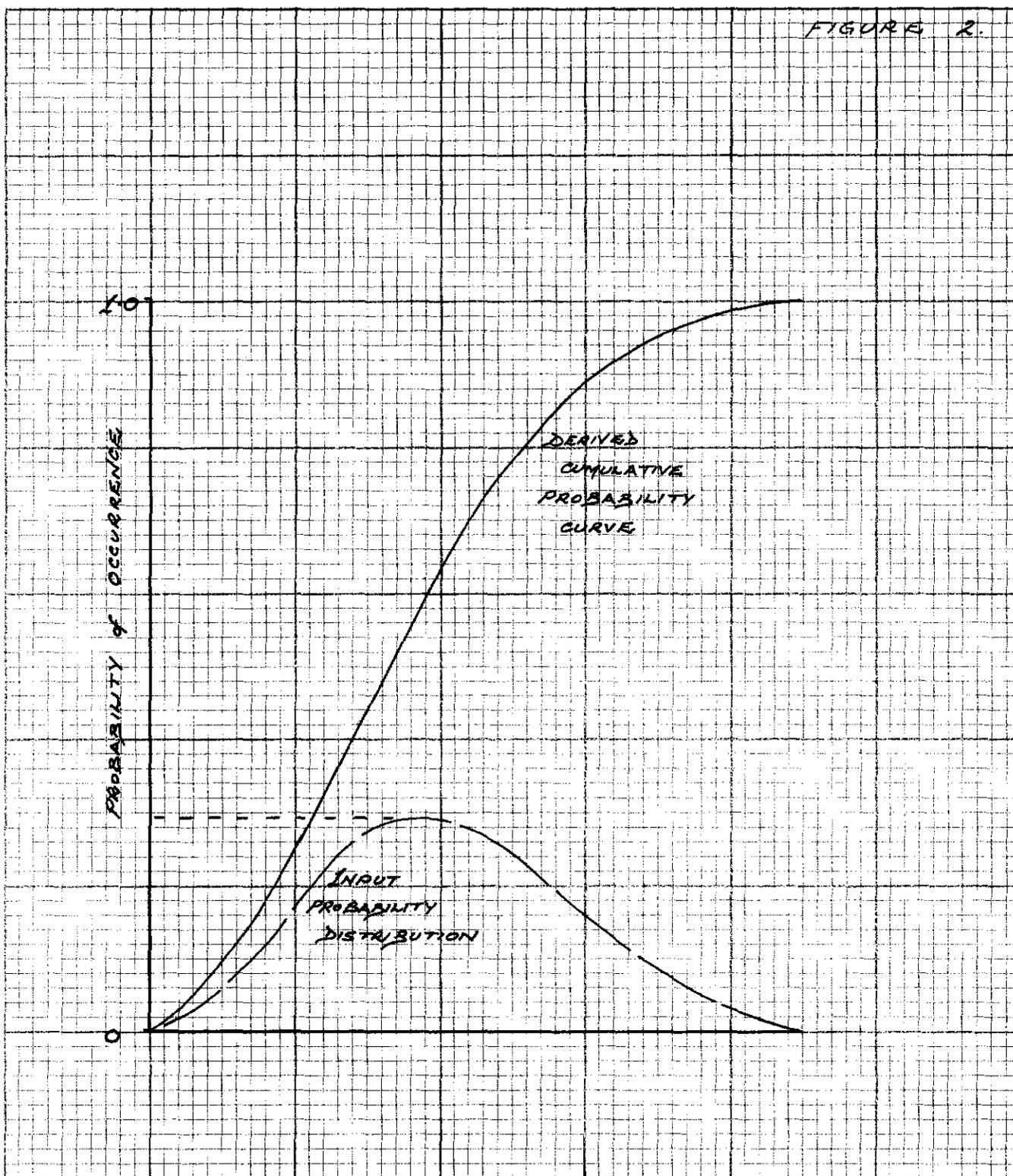
#### 14. PROBABILISTIC ANALYSIS

A better method of taking account of the uncertainty of data is by means of risk or probability analyses. Instead of a point estimate, each parameter is determined by maximum and minimum values and estimations of the "most probable", and the probability of occurrence for each parameter is given. For cash flow analysis, the probability distribution of the rates of return is computed. The probability of a particular rate of return provides a measure of the risk involved.

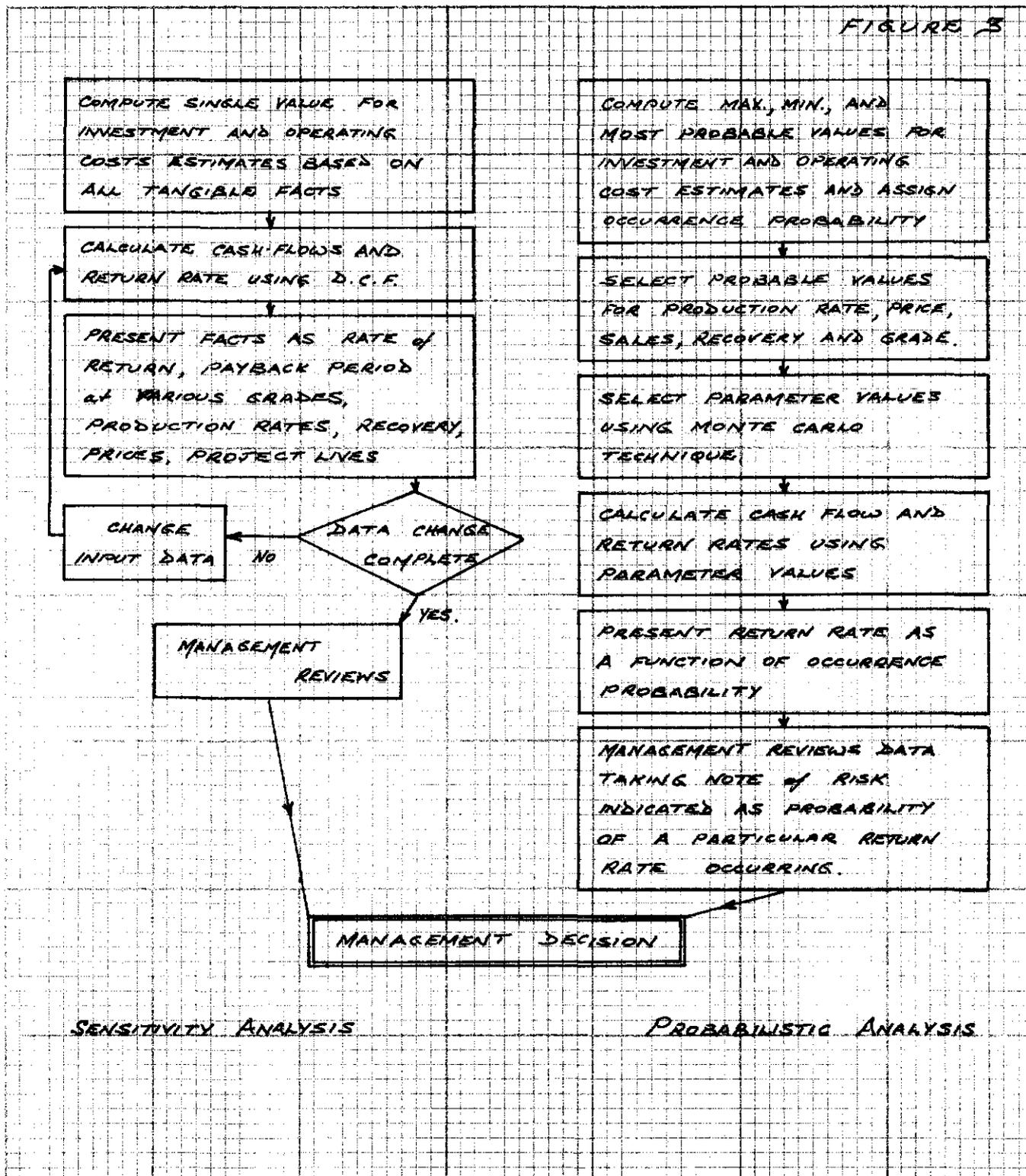
The relationship of input probability distribution and the derived cumulative probability curve is shown in figure 2.

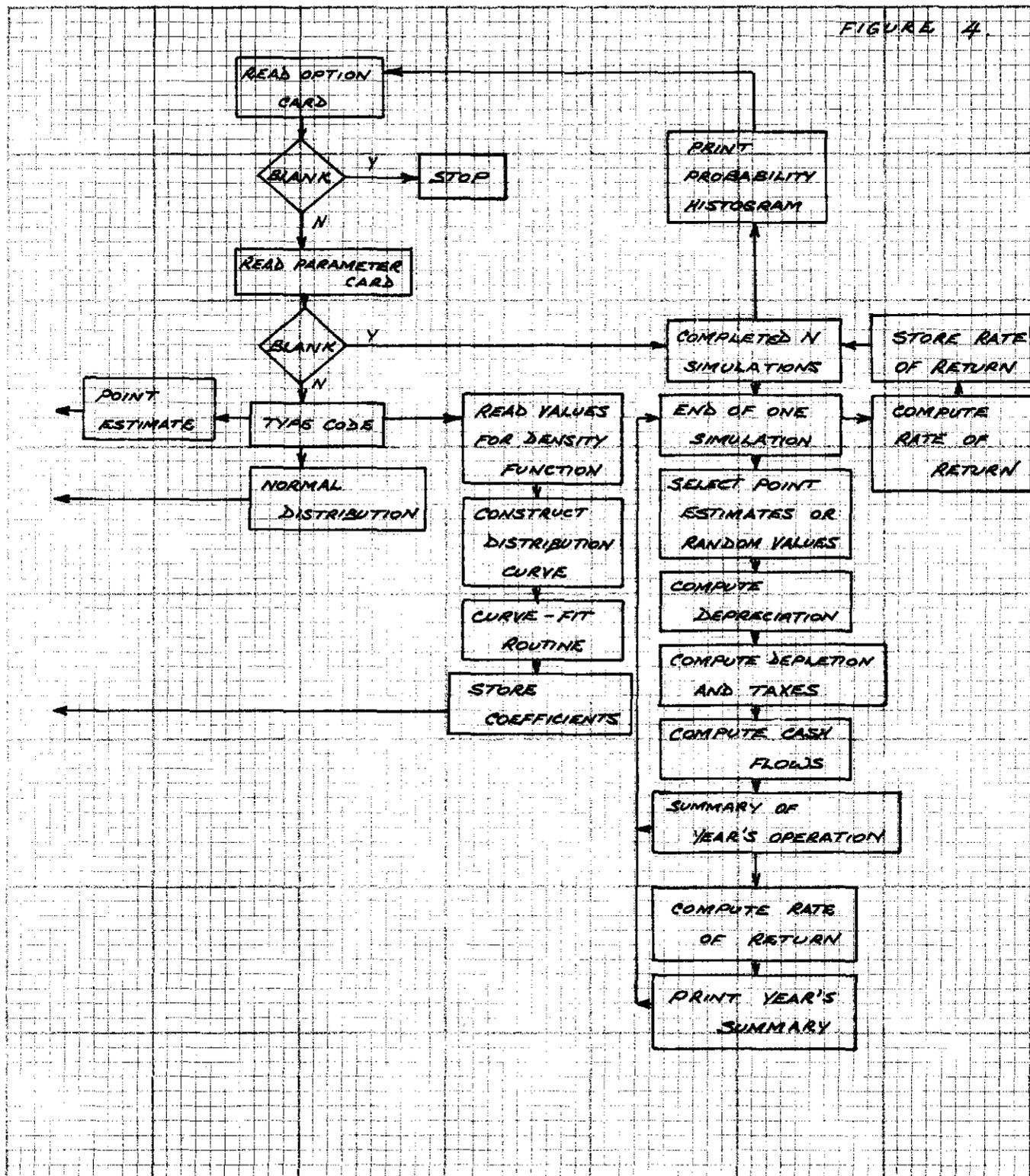
The generalised computer flow diagrams are shown in figures 3 and 4.





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## MINERAL PROSPECT EVALUATION GUIDE

### A. SULPHIDE DEPOSITS

Various graphical solutions are easily prepared for the 'economic evaluation' of ore deposits; the main criterion of decision making being company policy. General solutions of the type included here provide a quick method of determining the **minimum** tonnage/grade combination to provide a viable deposit, but are in no way meant to preclude final feasibility studies.

The assumptions made in this analysis are listed below:

- (1) Ore tonnage: 12 cu. ft.  $\bar{=}$  1 long ton.
  - (2) Required realisable values per ton of ore is shown in Table A.
  - (3) Realisable values per pound of metal is shown in Table B.
- N.B. Realisable value = current market price – (freight + smelting + refining) costs.
- (4) Recovery = 80% metal.
  - (5) Life = 10 years: determines capital and production costs.
  - (6) A D.C.F. (discounted cash flow) of approximately 15% is taken as acceptable.

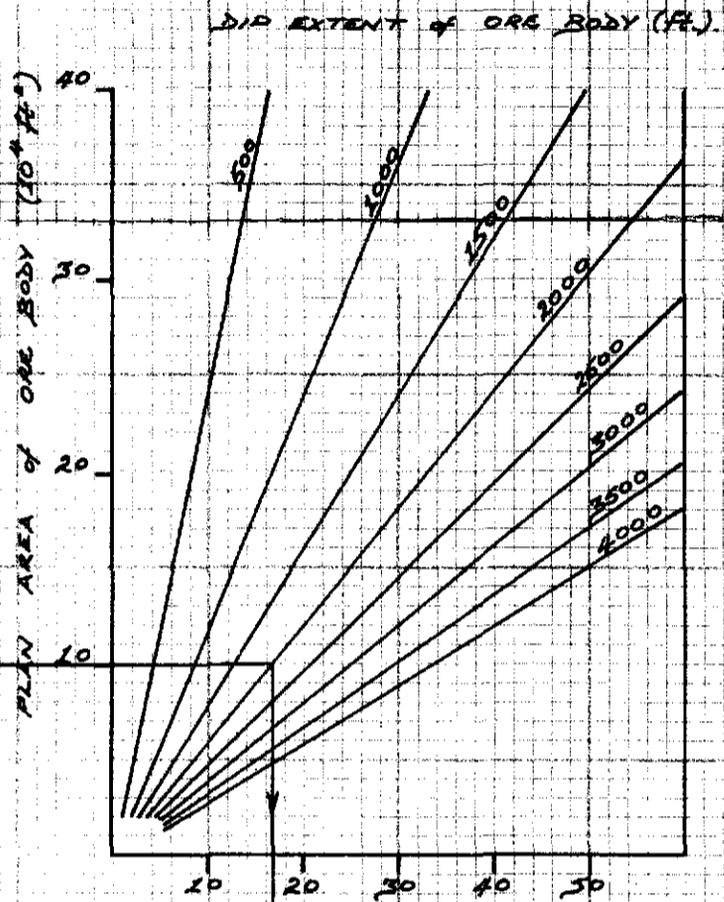
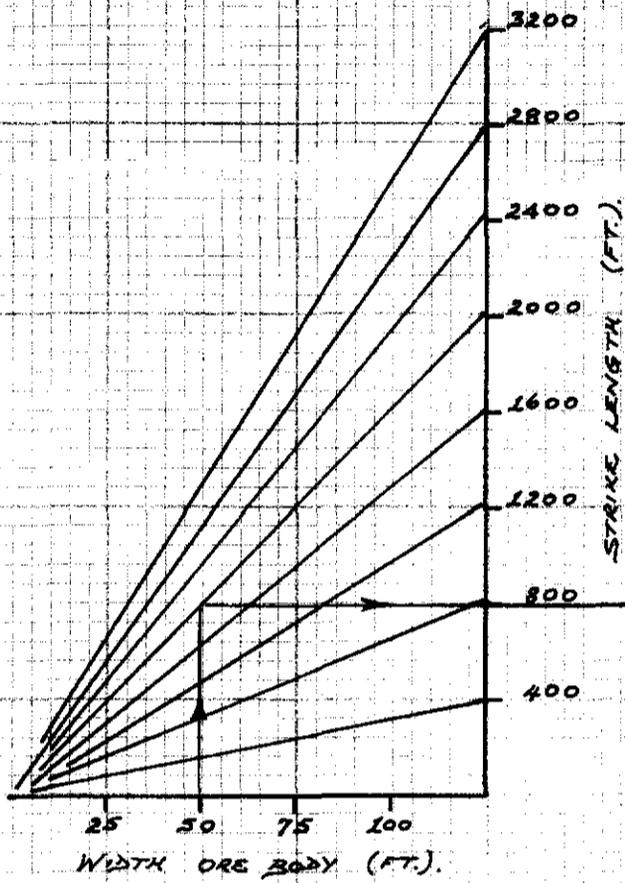
Monomineralic deposits are rare so for the purposes of calculating grades for multimineral deposits, the following procedure is given.

- (i) Obtain required realisable value per ton of ore from graphs (take account of any precious metal credit).
- (ii) Obtain equivalent grade of one of the metals from graph, using the appropriate realisable value per pound of metal marketed.
- (iii) Use an algebraic solution of the form
 

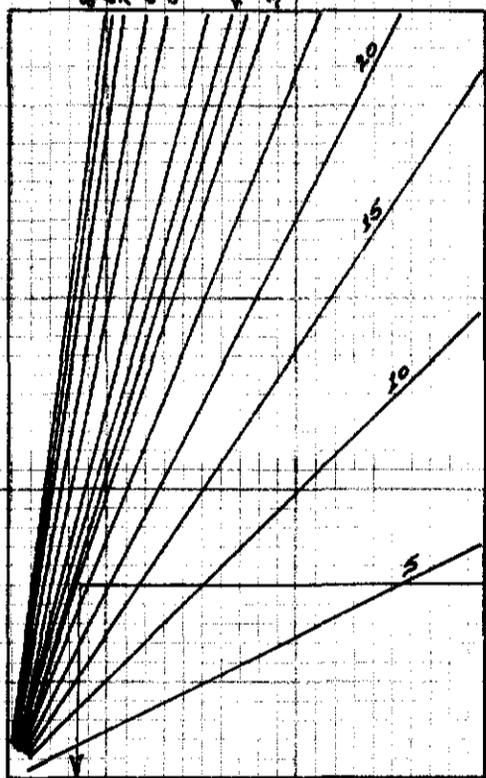
Y	=	0.79 x + 0.29 bx
y	=	required realisable value per ton of ore.
x	=	lbs of metal 1. recovered.
b	=	grade of metal 2. expressed in form of fraction of metal 1.

TABLE A. REQUIRED REALISABLE VALUES.

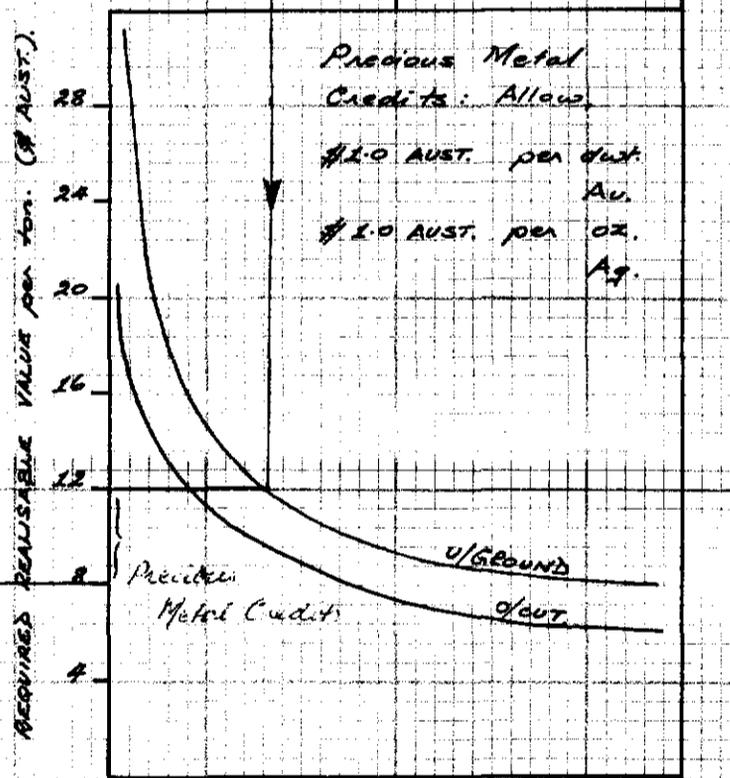
Formula line representation; unit size of production assume a straight	SIZE OF PLANT (TENS/HR.)	ANNUAL TONNAGE.	ORE RESERVE 106 TONS	CAPITAL REQUIRED		ANNUAL REQ. @ 30% D.C.F.		ANNUAL TRIMABLE REVENUE (\$/MILL)		ANNUAL COSTS		REVENUE REQUIRED		ANNUAL REQ. CASH FLOW
				#/TON DAILY	# MILL	NET PROFIT. (\$ MILL)	ANNUAL TRIMABLE REVENUE (\$/MILL)	#/TON	\$/MILL	\$/MILL YR.	#/TON			
Formula line representation; unit size of production assume a straight	500	0.15	1.5	12000	6.0	0.6	0.97	0	8.0	1.2	2.77	18.5	1.57	
								U	20.0	3.0	4.57	20.5		
	1000	0.3	3.0	10000	10.0	1.0	1.62	0	6.5	1.95	4.57	15.2	2.62	
								U	14.0	4.2	6.82	22.7		
	2000	0.6	6.0	8000	16.0	1.6	2.58	0	6.0	3.6	7.78	13.0	4.18	
								U	11.5	6.9	11.08	18.5		
	4000	1.2	12.0	6250	25.0	2.5	4.03	0	4.8	5.76	12.29	10.3	6.53	
								U	8.0	9.6	16.13	13.5		
	6000	1.5	15.0	6000	30.0	3.0	4.84	0	4.0	6.0	13.84	9.3	7.84	
								U	6.5	9.75	17.59	11.7		
	10000	3.0	30.0	4700	47.0	4.7	7.57	0	3.5	10.5	22.77	7.6	12.27	
								U	6.0	18.0	30.27	10.0		



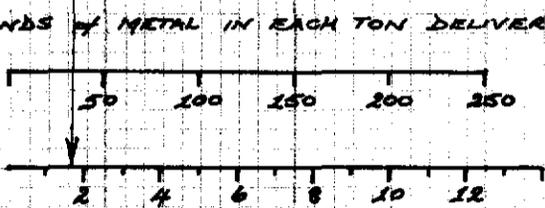
REALISABLE VALUE per lb of METAL MARKETED (CENTS)



ORE TREATMENT RATE (10<sup>3</sup> tons/day)



POUNDS of METAL IN EACH TON DELIVERED at MILL (80% RECOVERY)



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**MINERAL PROSPECT AND EVALUATION GUIDE****B. GOLD DEPOSITS**

The purpose of this report is to provide a rapid method for determining the priorities for exploration of individual prospects.

The assumptions used are listed below;

- (a) Gold price – U.S. \$100 per troy ounce.
- (b) No by-product credits.
- (c) A minimum cash flow net of taxes and depreciation \$1.0 Mill.
- (d) Company interest – 100%.
- (e) Capital investment amortised over 10 years.
- (f) A return of capital of not less than 15% on a D.C.F. basis.
- (g) The gold ore is essentially free milling.

It should be noted that these tonnage/grade figures are guidelines only and do not preclude a consideration of each prospect on its own merit. No allowance is made in terms of remoteness of localities.

**OPEN-CUT MINING**

The assumptions used are,

- (a) Ore treatment rates of 1000, 2000, and 3000 tons/day.
- (b) Waste-ore ratios (W:O) of 2:1, 4: and 8:1 for each treatment rate.
- (c) Mining costs of 20-50 cents per ton of material.
- (d) Mill costs \$1.50 to \$2.00 per ton of ore.

- (e) Mill recovery 90% of in situ values.
- (f) Overheads = 30% of mining and milling costs.
- (g) Capital costs range from \$5000 to \$12,000 per daily ton of ore treatment capacity.

#### **UNDERGROUND MINING**

The assumptions are,

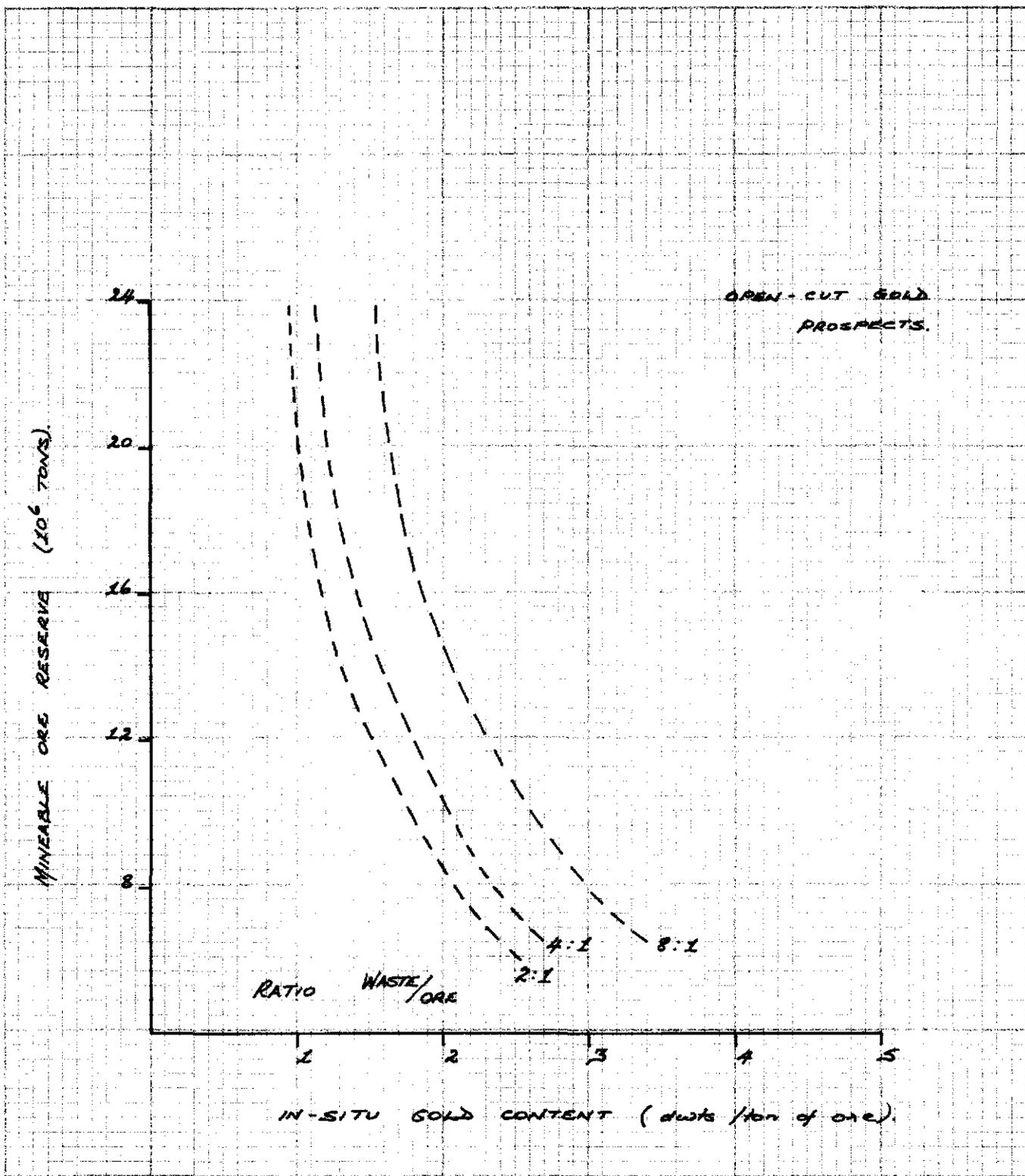
- (a) Ore treatment rates of 500, 1000, 2000 and 3000 tons per day.
- (b) Ore mining costs in the range of \$4 – \$10 / ton of ore.
- (c) Milling costs in the range of \$1.50 to \$2.50 per ton.
- (d) Mill recovery of 80% of the in-situ value.
- (e) Overheads = 20% of mining and milling costs.
- (f) Capital costs in the range of \$7000 to \$15,000 per daily ton of ore treatment capacity.

#### **CHARACTERISTICS OF FREE MILLING GOLD ORES**

Free milling gold ores generally possess the following characteristics;

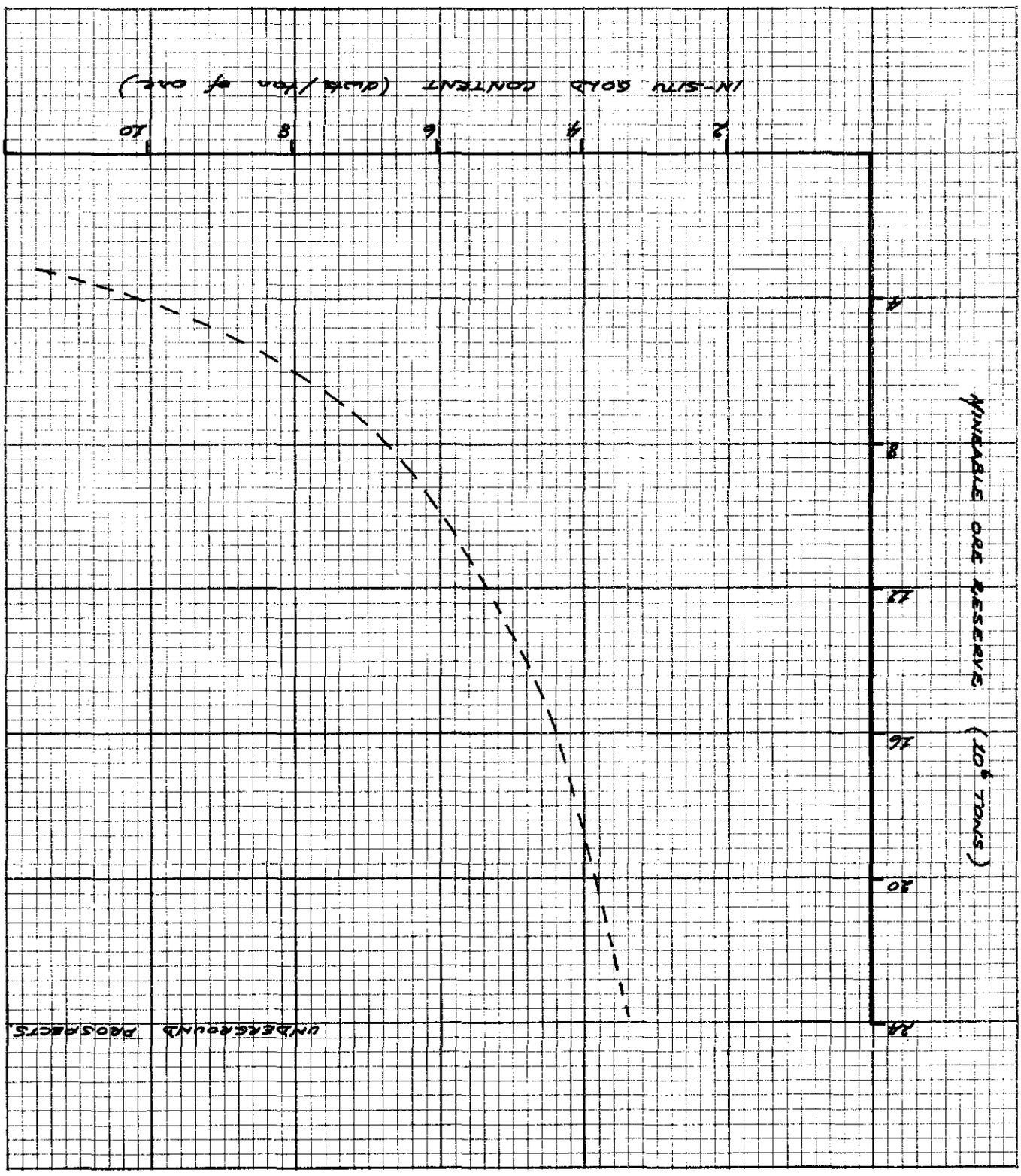
- (1) The gold is relatively coarse and amalgable.
- (2) The sulphide content is low and non-arsenical.
- (3) Oxidised compounds of bismuth and antimony are absent.
- (4) The gangue is free from any clayey, graphitic or talcy constituents.

Such ores allow about 50-70% gold recovery by amalgamation and gravity concentration at < 50 mesh. Tailings of course require cyanidation. The ore is said to be refractory as it diverges from the above characteristics: costs naturally rise as the ore is more difficult to extract.

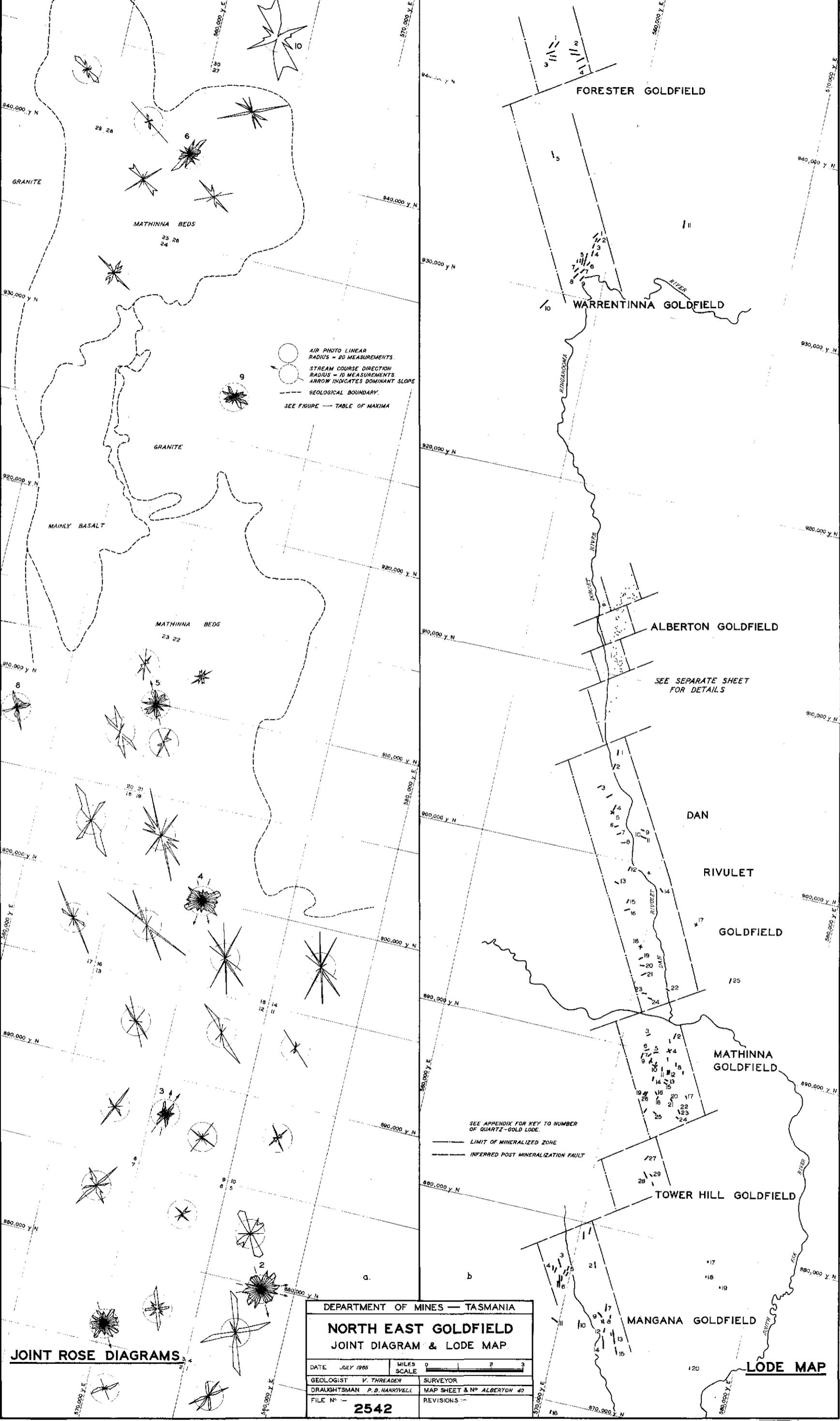


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