GEOPHYSICAL SURVEY OF HAMPTON PLAINS AREAS, COOLGARDIE, W.A.

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GEOPHYSICAL SURVEY

OF

HAMPTON PLAINS AREAS, COOLGARDIE, W.A.

BY

J.C. DOOLEY, W.A.L. FORSYTH AND L.A. RICHARDSON

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PLANS

GEOPHYSICAL SURVEY OF HAMPTON PLAINS AREAS, COOLGARDIE, WA.

I. INTRODUCTION

During recent years officers of the Geological Survey of Western Australia have been actively engaged on regional and detailed mapping of the greenstone series at Coolgardie. As a result of this work certain cross-fold structures regarded as favourable for the localisation of gold ore have been discovered and it is advocated that prospecting should be intensified over areas where these conditions exist. Some success has already resulted from such guidance.

In September 1946 Mr. Ellis, Government Geologist, suggested the use of geophysics as a possible means of further localising areas for prospecting on soil covered parts, where geological mapping is not able to accurately locate the position of the particular structural conditions concerned. He mentioned one specific problem involving the tracing of a certain greenstone contact through an extensive soil covered part, to fix its intersection with the axis of a known cross-fold.

A geophysical survey at Wiluna in 1938[1] demonstrated the ability of geophysics to trace certain greenstone beds due to their varying magnetite content and the Coolgardie problem was a like one, with promise of success providing the greenstone beds concerned exhibited favourable magnetic properties.

On the 18th September the writer visited the area and discussed the matter further with R.S. Matheson of the Western Australia Geological Survey who was in charge of the geological survey party operating in the Coolgardie district. It was apparent that due to the existence of extensive soil covered areas there was much scope for geophysics on the field providing the magnetic characteristics of the beds concerned were favourable.

A geophysical test traverse was made across certain known greenstone contacts near Zadows workings. The results were a little disappointing but inadequate to determine the full possibilities. In October it was found practicable to undertake field operations on a scale sufficient to test the possibilities further and this work was commenced on 22nd October by Mr. J.C. Dooley, Geophysicist, assisted by Mr. W.A.L. Forsyth, Geophysical trainee. Due to the Bureau's work commitments elsewhere Mr. Dooley was able to spend only one week on this work, during which time the survey was launched and a programme of work prepared based on the results obtained. Mr. Forsyth then continued the survey until December 18th, alone apart from inspection visits by the writer on 29th November to 3rd December and 12th December.

The necessary geological co-operation in the work was provided by Messrs. Matheson and Ward who also assisted materially in field arrangements necessary for the conduct of the survey.

II. GEOLOGY AND NATURE OF THE PROBLEM

The accompanying plan shows the regional geology of the area as supplied by the Western Australia Geological Survey. Briefly stated the geological aspects of importance to the geophysical work are given below.

The greenstone beds comprising ultra-basics, basic lavas and amphibolite, all highly metamorphosed, have been mapped by Messrs. Matheson and Ward as shown on the accompanying plan. It is understood that these beds dip steeply to the east. The crossfolds whose axes are also shown on the plan are believed to have produced conditions specially favourable for gold deposition and intense prospecting in a narrow zone along these axes is recommended by the geologists. For further details concerning factors favourable for gold deposition, the reader is referred to

the GEOLOGICAL MAP OF THE HAMPTON GROUP by the Geological Survey of Western Australia published in 1946.

The significance of the accepted crossfold influence on gold deposition is well illustrated by the following reasoning used in establishing the first geophysical problem that this survey was concerned with.

The contact between the amphibolite and the easterly basic lava (Lava II) is considered to be a favourable horizon for gold deposition because at the 3 mile Hill there is a large low-grade ore body in or adjacent to this contact. It follows from the cross-fold hypothesis, that this horizon should be prospected in the vicinity of a cross-fold axis because conditions are likely to be more favourable for gold deposition there than at the 3 mile Hill.

Geological mapping revealed that the intersection of this horizon with the axis of Tindall's Cross-fold was on a soil covered area. The problem for geophysics was therefore to fix the position of this intersection and if successful the geologists would be prepared to recommend exploration by diamond drilling. This problem was made Project 1 and the results are described in the following section of this report.

After taking Project 1 to a certain stage and following discussions with Mr. Matheson, Project 2 was undertaken with the object of examining further certain anomalies that had been found in the metamorphosed ultrabasics near "The Surprise" lease and to endeavour to trace the trend of the ultrabasic beds and "The Surprise" auriferous belt across the alluviated area to the south. It was intended to carry the work easterly to "The Barbara" area but time did not permit this to be done.

III. RESULTS OF THE SURVEY

The accompanying plan shows the position of all geophysical traverses and the accompanying profile sheets show all results in the form of profiles. The results of the second project are shown also on the plan in the form of geomagnetic contours.

(i) Project 1

This was commenced with a test traverse under known conditions at the 3 mile Hill across the amphibolite and on the two flanking basic lava flows. The results are shown in the profile for Test Traverse 2 (Profiles Sheet 1). It will be seen that the intensity values over the greater part of the amphibolite are substantially the same as those on the basic lava flow on the east (lava I). However, within the amphibolite and near to its northern edge there is a pronounced anomaly, the principal part of which could be due to a narrow dyke-like bed of strongly magnetic material. It was considered that if this anomaly was found to be a common feature of this horizon in the amphibolite bed it would serve as a magnetic marked by means of which the eastern edge of the amphibolite could be approximately located in other parts of the area.

Operations were then commenced in the vicinity of Tindall's cross-fold with Traverse 00. The results are shown in profile form on Profiles Sheet 2. It was considered that the anomaly centred at about 5450N on Traverse 00 may be comparable with the anomaly referred to on Test Traverse 2 and if so, the amphibolite-lava II contact could be placed a little to the east of this anomaly. Other traverses at 100E, 200E etc. up to 1000E were then surveyed to follow this suspected near-contact anomaly but no similar one was found on any of these traverses, and at the part where it would be expected to occur the profiles are irregularly disturbed. The results are shown in the form of profiles on Profiles Sheets 2 and 3.

Traverses 1300E and 1400E were then made in a position closer to the assumed position of the cross-fold axis and the results were of similar type to those on traverses 00 to 1000E.

The complete results at this stage were examined by the writer and it was concluded that the irregularities in the profiles were largely due to superficial deposits viz. soil and/or lateritic material rich in magnetite. This assumption is supported by the fact that the relatively quiet part of the profiles, centred at about 6000N on traverses 00 to 1000E, occurs over the small area of amphibolite outcrop where superficial deposits are of negligible thickness. However, it was considered that the anomaly centred at 00/5450N was a possible exception and its likeness in form to the 3 Mile Hill anomaly was regarded as a feature of possible significance.

To gain additional information for use in the interpretation of the results described above, Test Traverse 3 was made across the assumed position of the amphibolite - lava II contact at a part intermediate between the 3 Mile Hill Traverse and Traverse 00. The results are shown on Profiles Sheet 1. No pronounced anomaly of the 3 Mile Hill type was found. It may be concluded therefore that the 3 Mile Hill anomaly is not a consistent feature of the amphibolite - lava II contact environment and consequently the diagnostic value of the anomaly at 00/5450N as an indicator of the position of this contact is considerably reduced.

The site of Test Traverse 2 was then examined and it was found that some of the ore in the low-grade mine there exhibited appreciable magnetic properties. The ore in question is actually a mineralised amphibolite (?) and the magnetisation is probably largely due to the pyrrhotite content. A specimen was secured for mineragraphic examination. It is believed that this ore material may be responsible for the pronounced anomaly on Test Traverse 2 because no other material was found on the surface in the vicinity which on testing showed sufficient magnetisation to produce an anomaly of the required order.

On studying the complete results the conclusions reached were as follows.

(a) The anomaly centred at 00/5450N may be due to a bed comparable with the one responsible for the anomaly found on Test traverse 2. The two anomalies have features in common. If so the amphibolite - lava II contact might be placed at 00/5860N which point is displaced from the anomaly a distance of similar order to the corresponding displacement on Test Traverse 2. At this point there is also some suggestion of a contact anomaly in the profile.

(b) The identification of strong magnetic properties in specimens of the ore material from 3 Mile Hill is of twofold interest. Firstly it provides scope for geophysics in tracing the extent of this ore body and secondly the existence of like material may be postulated to account for the anomaly centred at 00/5450N. The likelihood of this being the case is somewhat reduced by the fact that the anomaly at 00/5450N does not maintain its form even as far easterly as Traverse 100E but its place on this traverse is taken by disturbed conditions which appear to be more likely due to superficial material rather than to a deposit of the type postulated above.

(c) The widespread extent of intensely disturbed conditions due to superficial deposits makes it difficult to interpret the results in respect of the small-scale features found on some profiles. For instance at the point 100E/5000N the profile suggests the presence of a contact between beds of differing magnetic characteristics. It is not easy, however, to detect a corresponding feature in all the other profiles. Using a number of doubtful points of this nature, the position of a possible contact is shown on the accompanying plan. At first sight it appears likely that this

suspected contact might be that between the amphibolite and lava I but this assumption conflicts with known geology. It seems that if there is a contact in this position it must be within the known amphibolite bed which after all may consist of two or more separate beds differing in magnetic characteristics in these parts. There are fine, medium and coarse-grained types of amphibolite.

(d) The gradual change in intensity on Test Traverse 3 centred at 1000N may be due to the existence of a rock contact at about that point. It seems that the most reasonable interpretation avoiding confliction with known geology, is that such a contact is one within the amphibolite similar to the one mentioned above.

(e) On available information it was considered that no interpretation of consequence other than that given above could be satisfactorily made from the results on Traverses 00 to 1400E. Additional features of some interest but of unknown origin and significance are the small scale anomalies, apparent after smoothing the profiles, showing a local increase of intensity which is presumably not due to superficial deposits. Such an anomaly is the one centred at 500E/5500N.

(f) It was considered that the layout of work on Project 1 was well chosen for the purpose of the survey and that the work completed has provided data of important specific and general interest. It was believed that the position of the amphibolite - lave II contact, if not at 00/5860N, is probably within the area covered and there seemed to be no need to extend the traverses further northerly. In any case such extensions would probably encounter magnetic irregularity due to superficial deposits.

At this stage in the operations it was decided to spend the remaining time available on Project 2, the results of which are described below.

(ii) Project 2.

The results of Test Traverse 1 and Traverse 00 of Project 1 showed that some appreciable but irregular anomalies were associated with the metamorphosed ultrabasics. It was decided to examine these further to learn more of their nature and possible usefullness by means of a reconnaissance survey on "The Surprise" area. The survey had the additional objective of tracing the trend of the ultrabasic beds southerly across the alluviated area to the south.

Preliminary work on this project was completed by W.A.L. Forsyth and the writer on December 2nd when some widely spaced traverses were made between Trav.00 of Project 1 and the southern boundary of G.M.L. 341. Anomalies were found which seemed to correlate well with the one at 00/600N and on this basis the particular bed responsible was traced easterly, then southerly, to give a trend conforming with the known trend of the ultrabasics-lava I contact and of the porphyry bodies in and adjacent to the known auriferous zone. At this stage Mr. Forsyth was left to continue the project while the writer carried out a geophysical survey at Bullfinch. Mr. Forsyth's results were examined by the writer on December 12th and arrangements were made for the survey to be terminated for the time being on December 18th.

The results of this survey are shown in the form of profiles on Profiles Sheets 4 and 5 and as geomagnetic contours on the plan.

On the completion of some traverses between those first made on December 2nd it was found that the correlation of anomaly from traverse to traverse was not clear-cut and that a more detailed survey was therefore needed to satisfactorily achieve the objects of the survey. However, as available time and manpower was short, the survey was continued in reconnaissance fashion.

As the work proceeded southerly the results became more complex and over the alluviated area intense shallow-seated anomalies

were found to be common. Consequently the correlation basis from traverse to traverse and the location of traverses required became less obvious. It is believed that in spite of these difficulties the work completed by Mr. Forsyth was skillfully planned, well suited to the circumstances and adequate for immediate requirements.

In the analysis of the results the profiles were first smoothed where necessary (in some cases very severely) to separate the shallow-seated effects from the deep-seated effects. The dotted lines on the profiles show the smoothed parts, which have been used along with the unsmoothed part of the profiles in preparing the geomagnetic contours shown on the accompanying plan.

From the anomaly distribution portrayed by these contours it is believed that the trend of the strongly magnetic ultrabasic bed, or beds responsible is generally established. The definition of same is subject to the limitations imposed by the reconnaissance nature of the survey and the severity of the smoothing used. The axis lines of the anomalies show a winding course which may be due to crumpling of the bed responsible, to irregular magnetite distribution in the bed or to the presence of separate beds of irregular form. In this connection it should be noted that the profiles contain much more detail than is apparent from the contours. However, due to the wide separation between traverses these detailed features cannot be used to give any significant interpretation.

It is believed that the intense and irregular anomalies are due to superficial deposits of soil or lateritic material. A trench on the alluviated area reveals a bed of concretionary ironstone gravel at shallow depth which exhibits strong magnetic properties and which is probably a feature of the greater part of the alluviated area.

The conclusions reached from a study of the results described are summarised below.

(a) The zone of strong anomaly detected in the metamorphosed ultrabasics has been traced for a distance of 1½ miles in a manner adequate to indicate its general characteristics. The trend of the zone in the part north of the alluviated area is in general agreement with the known trend of the ultrabasics-lava I contact and of the porphyry bodies associated with "The Surprise" auriferous zone.

(b) On the basis of the agreement mentioned above the anomaly zone may be regarded as a strike feature of the ultrabasics and used to determine, by inference, the position of the ultrabasics-lava I contact. This has been done with the result as shown on the accompanying plan.

(c) The strong anomaly measured in certain parts of the zone point to the existence of magnetic properties of exceptionally high magnitude for rocks of the class concerned. The conclusion is of course that the magnetite content of these rocks is very high in certain parts. It is possible that a high pyrrhotite content is partly responsible and if so there may be some associated gold mineralisation of importance present in the anomaly bodies.

(d) The intense and irregular anomalies found on the soil and alluviated areas are believed to be mainly due to magnetite in the soil and in the laterite ironstone gravel found occurring at a shallow depth. It is not easy on all profiles to separate the effects of this superficial material from those of the deeper-seated rocks which in some parts seem also to produce a fair measure of irregularity. This is well illustrated on Traverse R where it is considered that the smoothing applied has gone further than the main purpose.

(iii) Regional Aspects

With the exception of Test Traverse 1 all traverse profiles are plotted on a common datum. This datum has been referred to the Coolgardie Absolute Station by a series of connections which show that the profile datum represents a vertical force value 70 gammas numerically more than the value at the Absolute Station at any given time.

The absolute value of the magnetic elements were observed on 7th August, 1944, at the Coolgardie Absolute Station and the mean-of-day results are given below.

Declination	00°	12'.7W
Inclination	64°	11'.5S
Hor. Intensity	25143 gammas.	

A study of the profiles shows that there exists some regional anomaly in the vertical force as evidenced by the large difference between the absolute values of that element on the undisturbed parts of Test Traverses 2 & 3. This difference gives a N-S gradient in the vertical force of approximately 100 gammas per mile. The normal gradient in these parts is approximately 13 gammas per mile. It is possible that this regional anomaly is related to a basement-rock configuration and it is further possible that a widespread survey of regional features may reveal the existence of some correlation between their distribution and that of gold deposition as indicated by the position of the principal gold mines.

IV. CONCLUSIONS

The problems confronting geophysical surveys of the kind described in this report are primarily concerned with the structural behaviour of the greenstone beds. These have been geologically mapped in a regional sense using certain differentiation criteria of somewhat inconspicuous nature and obvious in the first instance to few persons other than the geologists responsible for the mapping. The interpretation of the mapping in terms of ore-occurrence leads to the use of geophysics for the purpose of accurately locating the position of certain selected favourable structural conditions affecting the greenstone.

The geophysical work completed at Coolgardie to date has provided sufficient information concerning the magnetic character of certain greenstone beds to show that there is scope for the application of geophysics as an aid to geological structural mapping on the area. Furthermore it may be expected that such surveys will produce some evidence of geological detail not revealed by the regional geological mapping nor perhaps by any practicable form of detailed geological mapping. Some of this detail may be found to have important significance in connection with gold mineralisation.

The use of the magnetic method of geophysical survey, which is the only one tried at Coolgardie to date, will probably be found unsuitable for certain problems on most of the soil and alluvium covered areas. This is due to the common occurrence in these parts of strongly magnetic superficial deposits, the effects of which will often be found to mask small scale effects of the greenstone beds. However, in the case of large scale effects of the greenstone, such as was found in the ultrabasics (Project 2), it will be possible to do useful work in spite of the effects from superficial material.

The cause of the latter is believed to be the presence of magnetite in the soil and in lateritic material commonly found at shallow depth on thickly alluviated areas. This lateritic material is believed to be of more recent origin than the widespread laterite sheet found in many of the goldfields. At Coolgardie the latter is found only on the higher ground, apparently as residuals. The investigations of Dr. Dorothy Carroll on the soils of W.A. goldfields

show that magnetite is common and occurs in appreciable quantities in goldfields soil. In a report by Prof. E. de C. Clarke entitled "The Past and Present Physiography of Western Australia" dated September 1934, it is stated that "Miss Carroll has accumulated a large number of observations on the formation of new minerals, such as leucoxene and magnetite by weathering". To date the writer has not had access to any published account of this weathering process but efforts will be made to learn more of Dr. Carroll's findings because the superficial occurrence of magnetite on the W.A. goldfields and in other parts of Australia is of vital importance to any operations which include precise land-magnetic observations. The existence of magnetite in the superficial deposits mentioned above is postulated on the basis only of the intensity of the magnetic properties exhibited by the material concerned and not on any mineralogical determinations. Indeed the postulation is believed to be somewhat contrary to accepted beliefs that the iron content of lateritic material is in the form of iron hydroxide. Combined mineralogical and geophysical research is needed to relate the mineralogical constituents with the magnetic properties. The principal magnetisation exhibited is commonly found to be in the form of remanent magnetisation.

The following recommendations are made :-

(a) A geological examination aided by shallow exploration, if necessary, in the vicinity of 00/5860 N to test the validity of the suggestion that the amphibolite-lava II contact is located there.

(b) The anomaly centred at 00/5450 N should be tested. However, the case does not seem strong enough at this stage to recommend diamond drilling and additional geophysical work should be completed, particularly on the westerly side of Traverse 00, before a site is selected for deep testing.

(c) Steps should be taken to determine the nature of the material responsible for the strong anomalies found in the ultrabasics. Diamond drilling to the depth of the sulphide zone may be desirable. A vertical drill hole at the point midway along the southern boundary of G.M.L.410 would be well placed for the abovementioned purpose.

The results of the testing outlined above may have considerable influence on the subject of scope for the magnetic method of geophysical survey at Coolgardie. In any case it is believed that the work to date has shown that the scope is considerable and it is believed that the work should be continued.

It is possible that the gravity method could be successfully used in tracing the greenstone beds and if so the troubles produced by the strongly magnetic superficial deposits would be avoided. However, it seems unlikely that the greenstones concerned would exhibit sufficient gravity differences to make the use of this method practicable.

It is particularly desirable that any extensive programme of geophysical work undertaken at Coolgardie should have the continuous co-operation of geologists on the problems concerned as was the case with the surveys described in this report.

REFERENCES

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L.A. Richardson

(L.A. RICHARDSON),
Superintending Geophysicist.

MELBOURNE,
14th March, 1947.

COOLGARDIE GEOPHYSICAL SURVEY

PLAN OF AREA SHOWING

GEOPHYSICAL TRAVERSES,

PRINCIPAL RESULTS OF SURVEY,

AND

GEOLOGY BY GEOL. SURVEY OF W.A.

Geophysical work by J.C. Dooley, A.L. Forsyth & L.A. Richardson

SCALE IN CHAINS

10 0 10 20 30 40

Possible position of Amphibolite - Lava II contact

Line showing position of geophysical features suggesting presence of rock contact

LEGEND

Geophysical

Traverses thus TRAV. B

Geomagnetic Vertical Intensity Contours thus 400 γ

Geological

Metamorphosed ultrabasics thus

Basic lava flows "

Amphibolite "

Porphyry "

Laterite "

Alluvium "

L.A. Richardson 24/1/47

Position of Ultrabasics - Lava I contact as suggested by geophysical survey

Ultrabasics - Lava I contact shown here by 1946 Geological mapping. L.A.R. 22/5/47

LOCALITY PLAN

Showing Area of Survey, Positions of Test Traverses and General Geological Features.

Scale: 1 inch = 80 chains

COOLGARDIE

Railway

LAVA II

LAVA I

TEST TRAVERSE 2

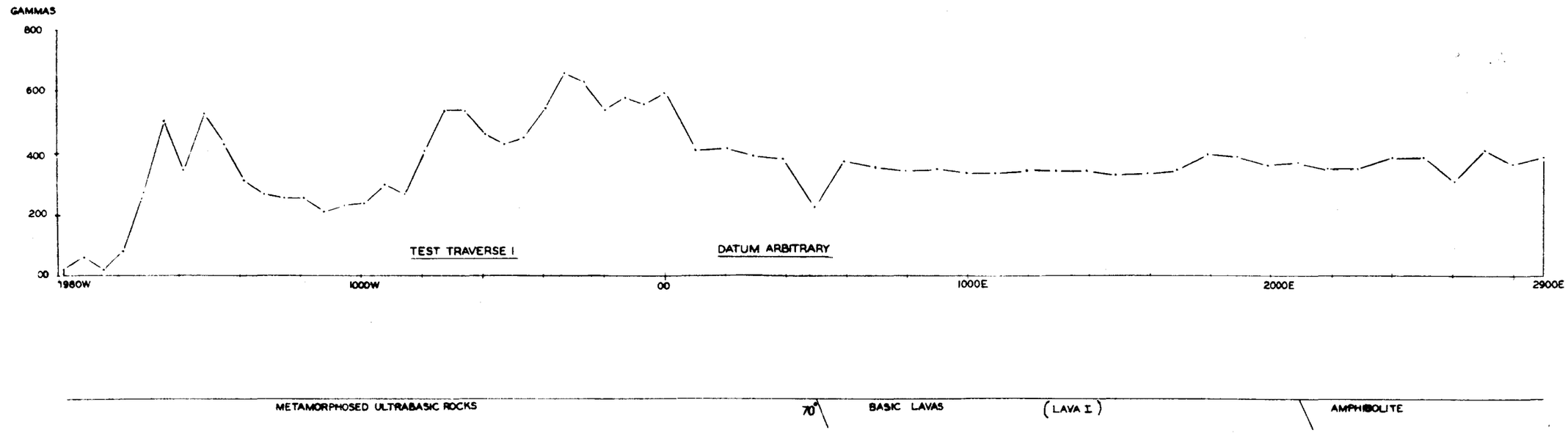
TEST TRAVERSE 3

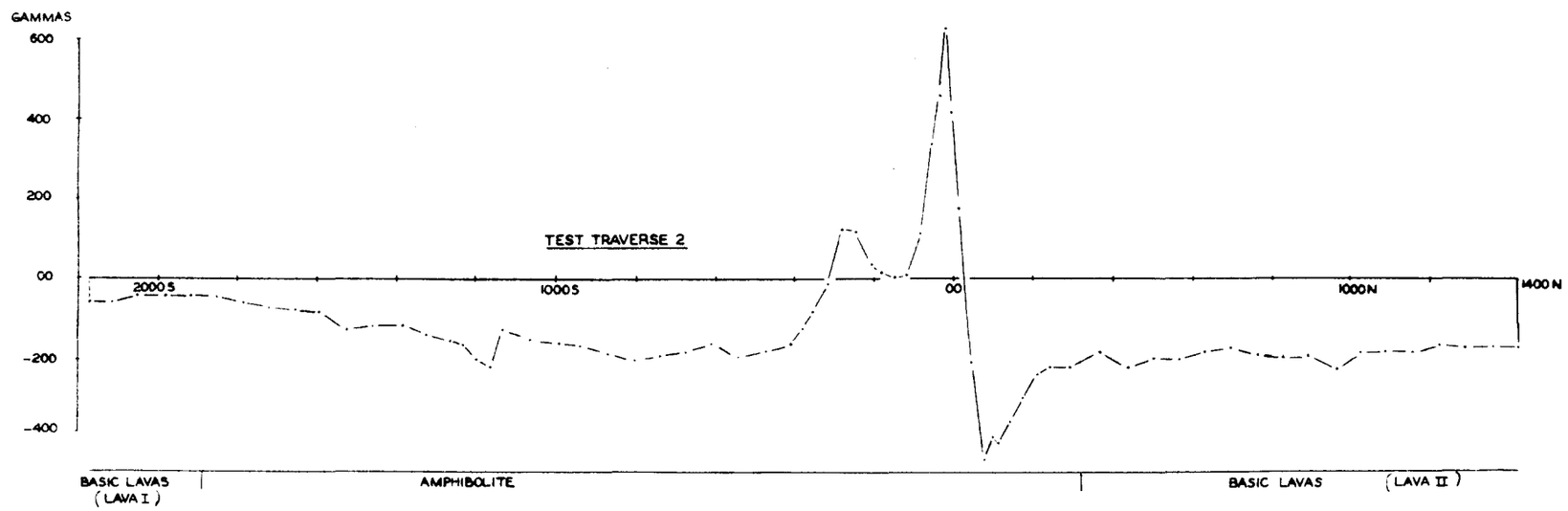
TEST TRAVERSE 1

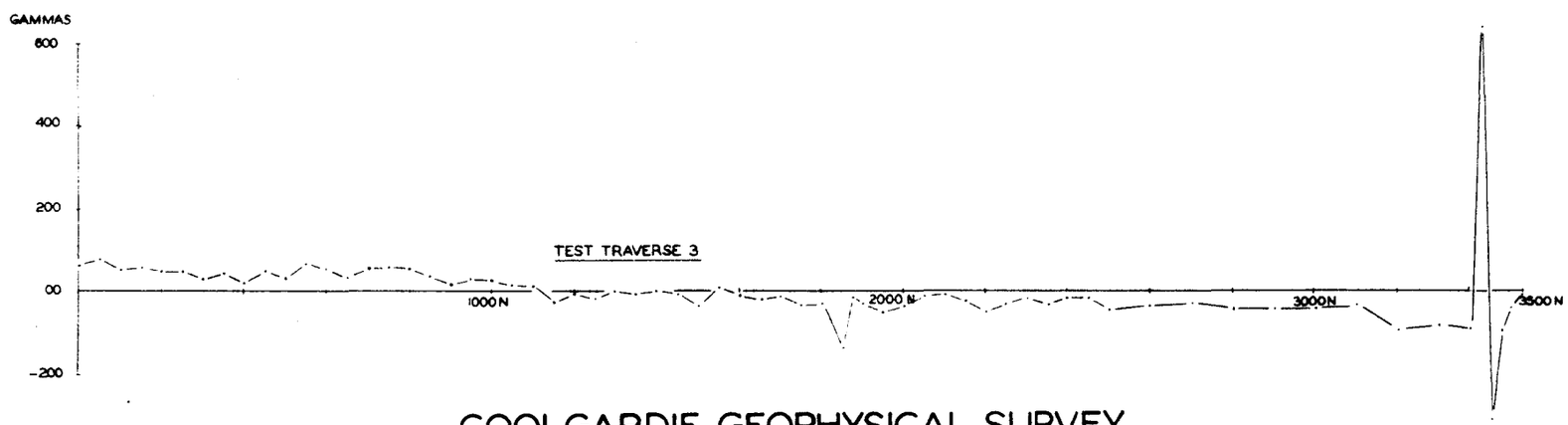
SMILE HILL

CROSSFOLD AXIS

Approximate outline of area examined by reconnaissance survey





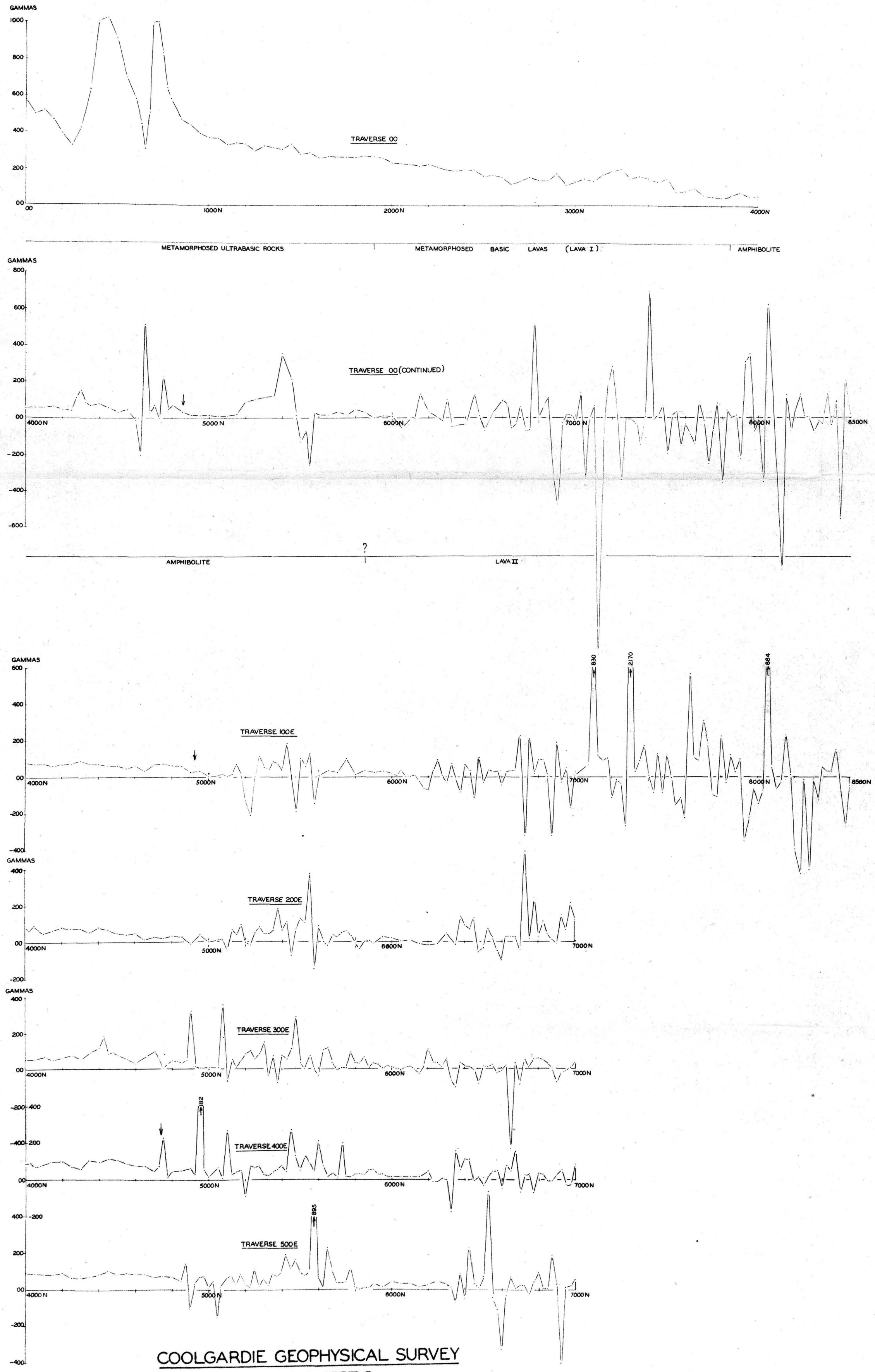


COOLGARDIE GEOPHYSICAL SURVEY

PROFILES SHEET I.

0 200 400 600FT.

0 200 400 600 GAMMAS



COOLGARDIE GEOPHYSICAL SURVEY

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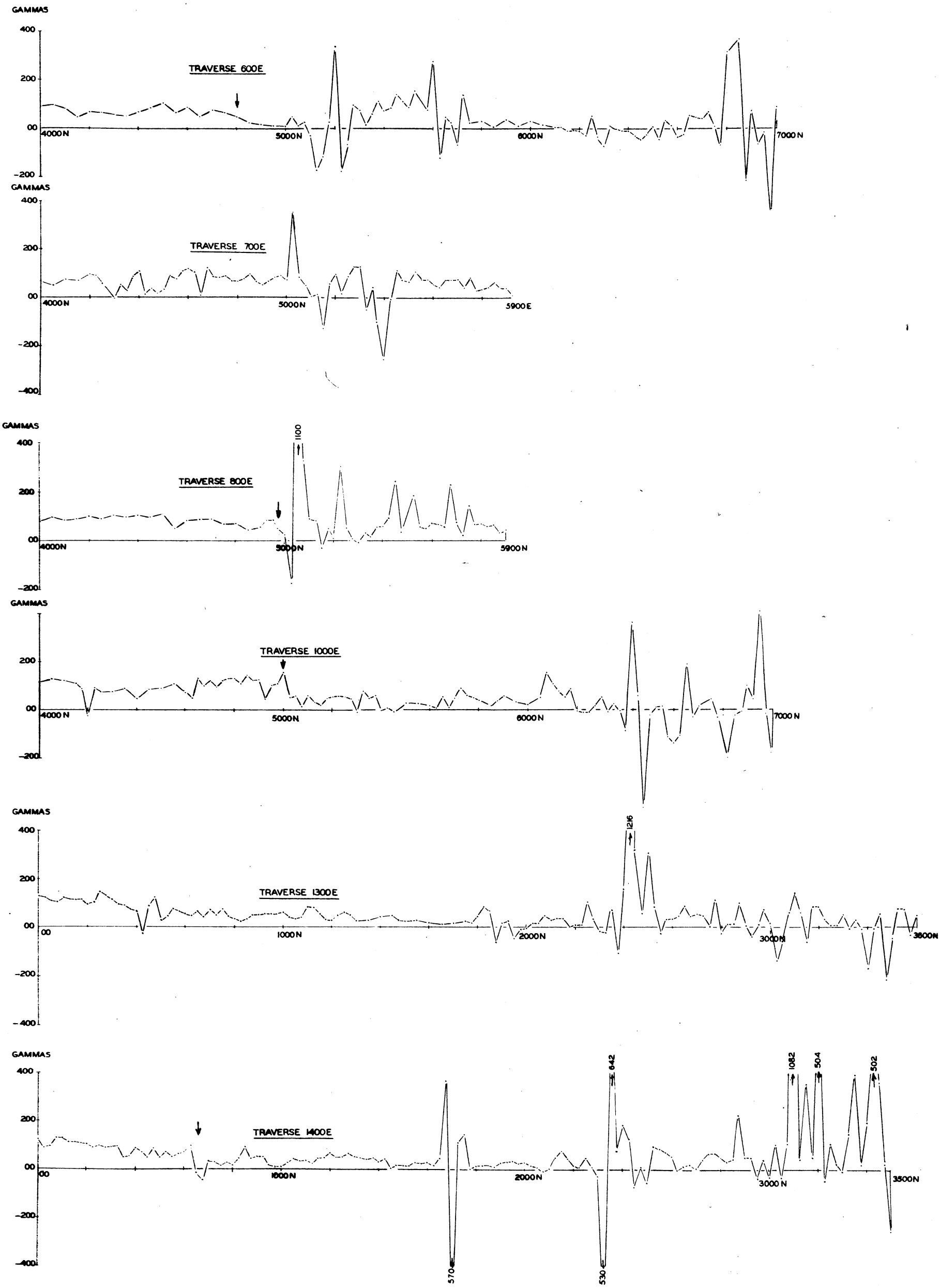
RECORD 1947/9.



COOLGARDIE GEOPHYSICAL SURVEY
PROFILES SHEET 3.

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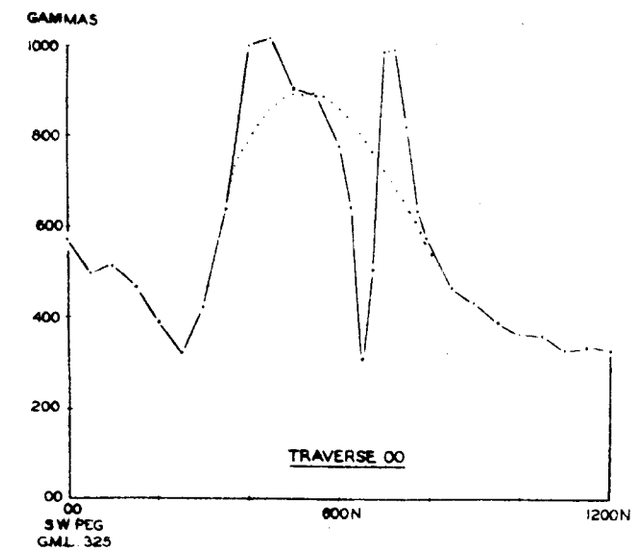
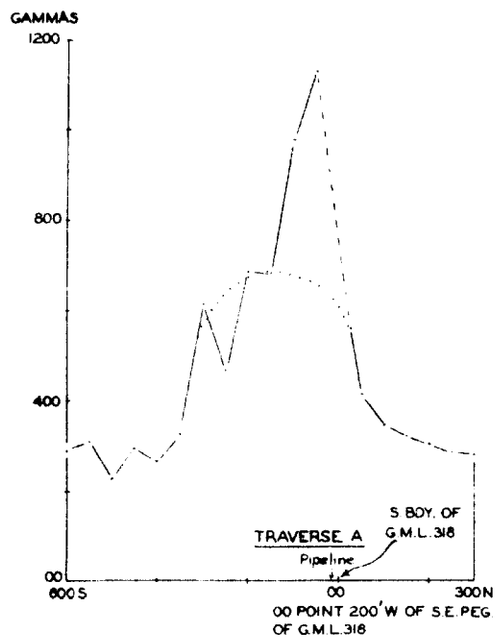
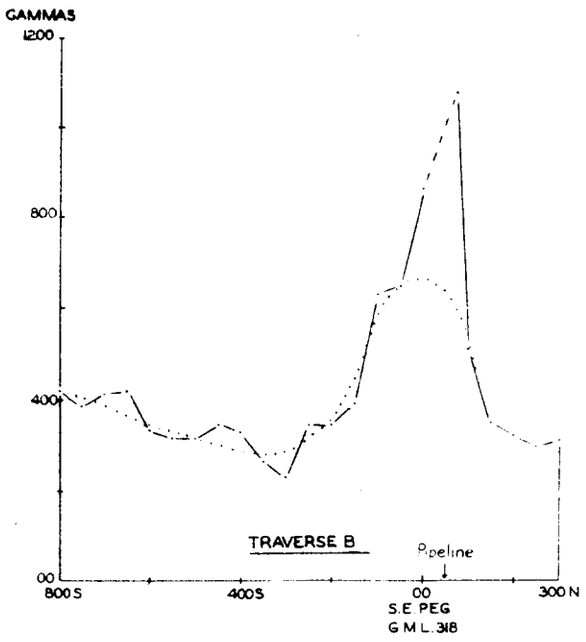
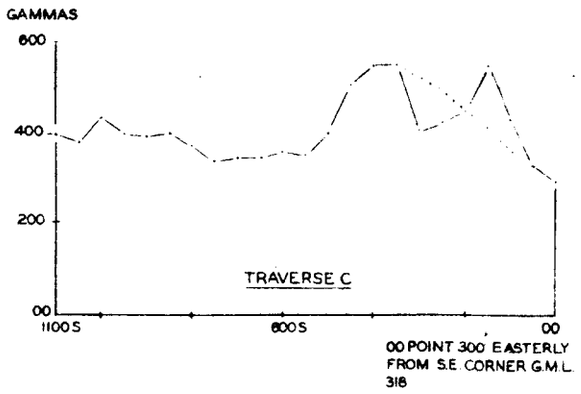
0 200 400 600 GAMMAS

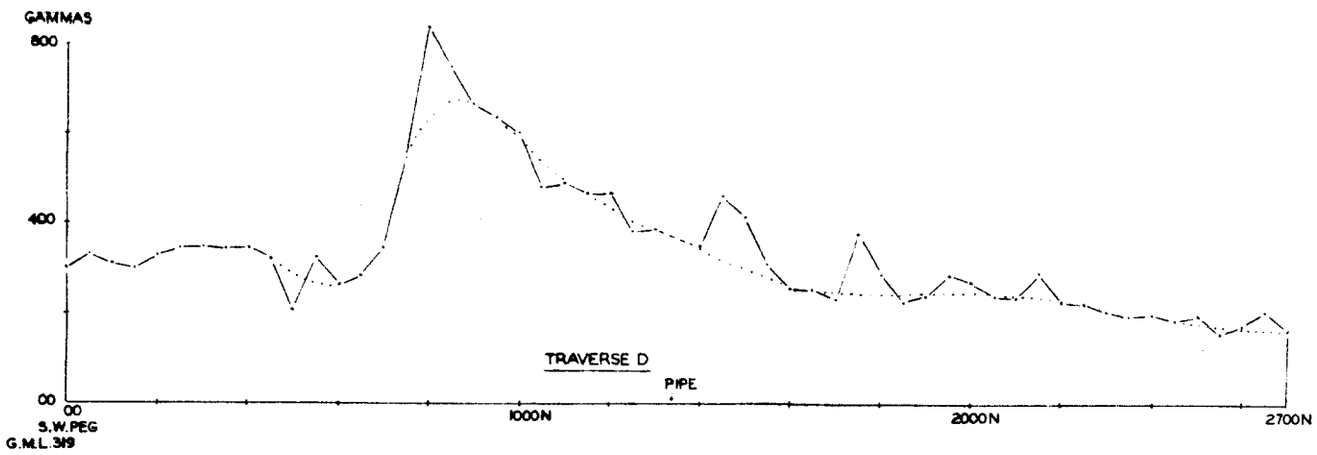
RECORD 1947/9

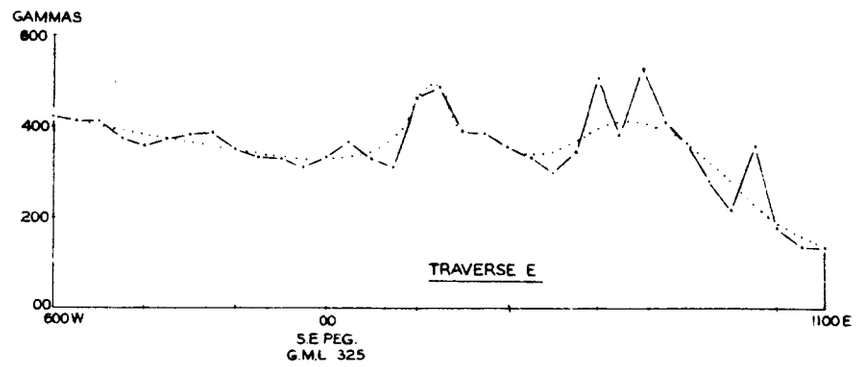


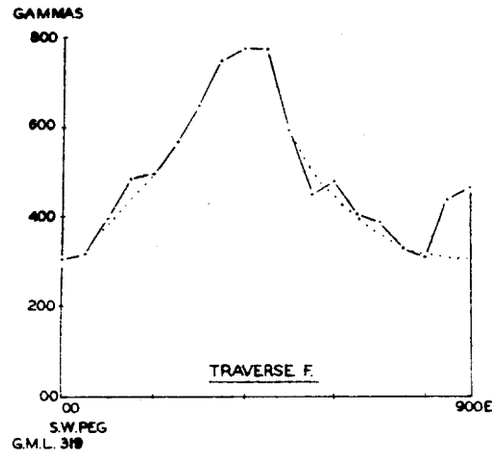


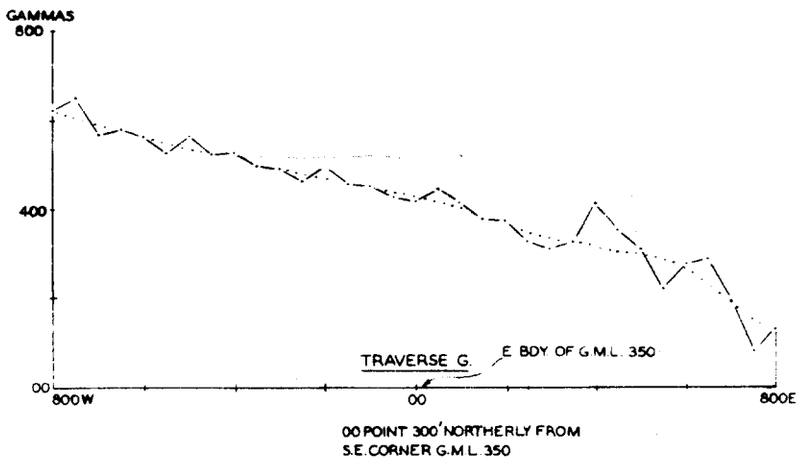


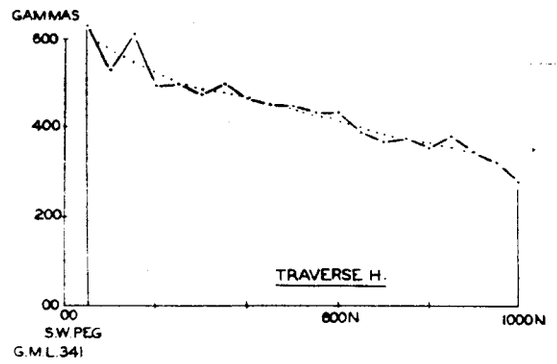


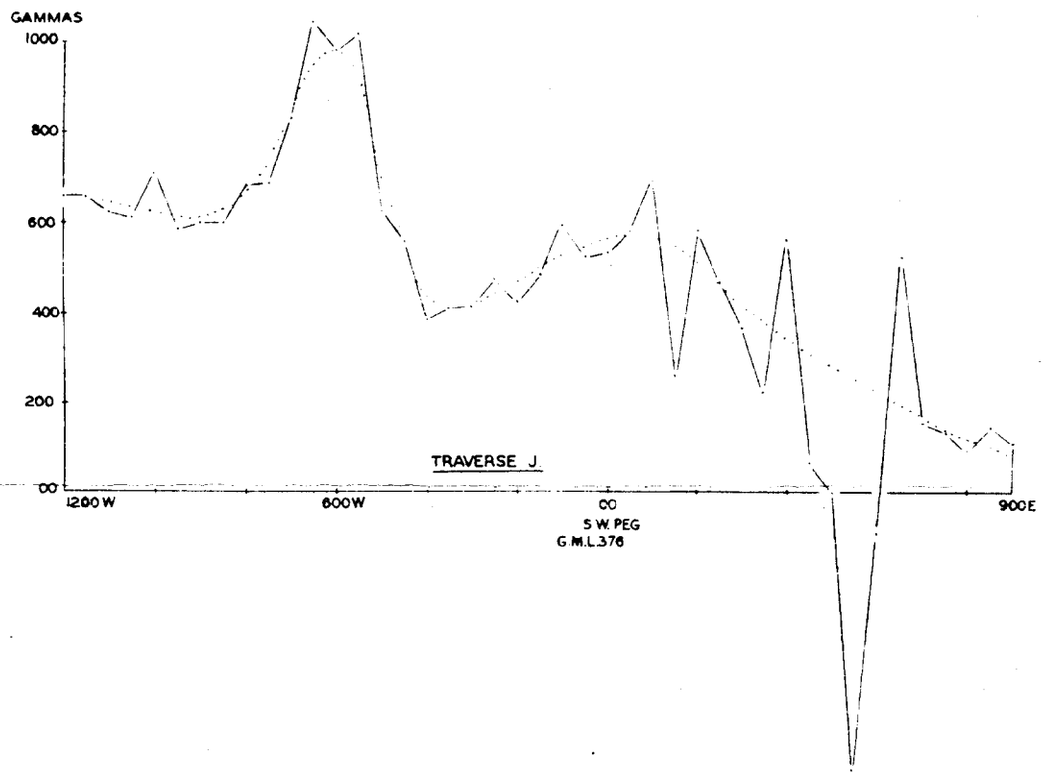


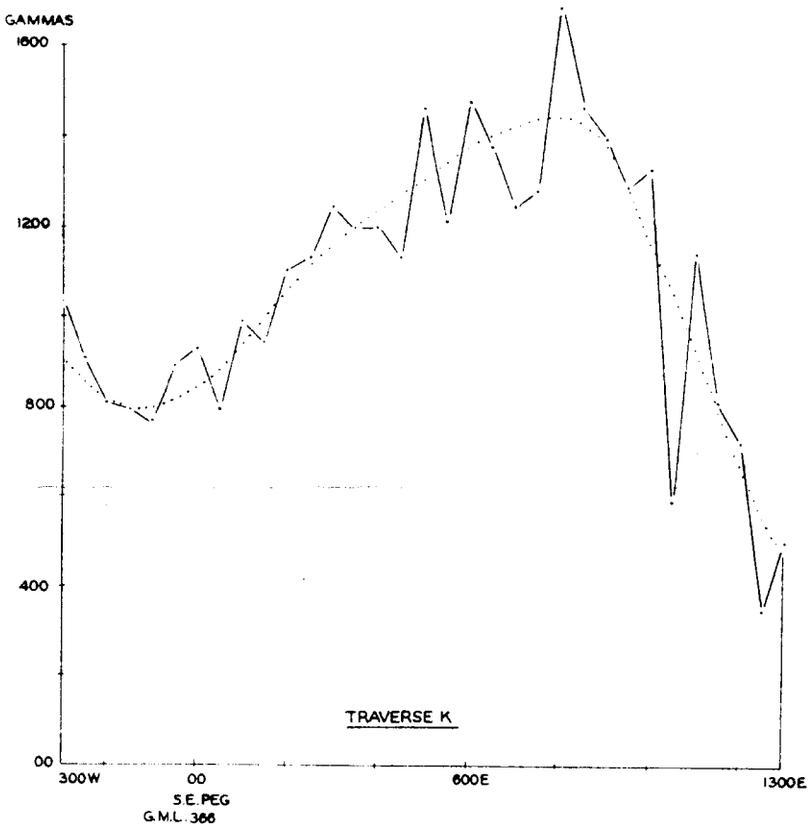


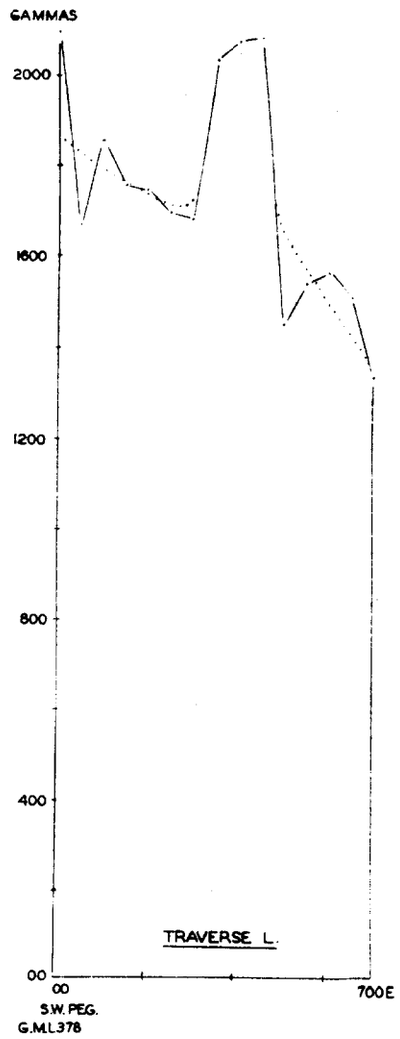








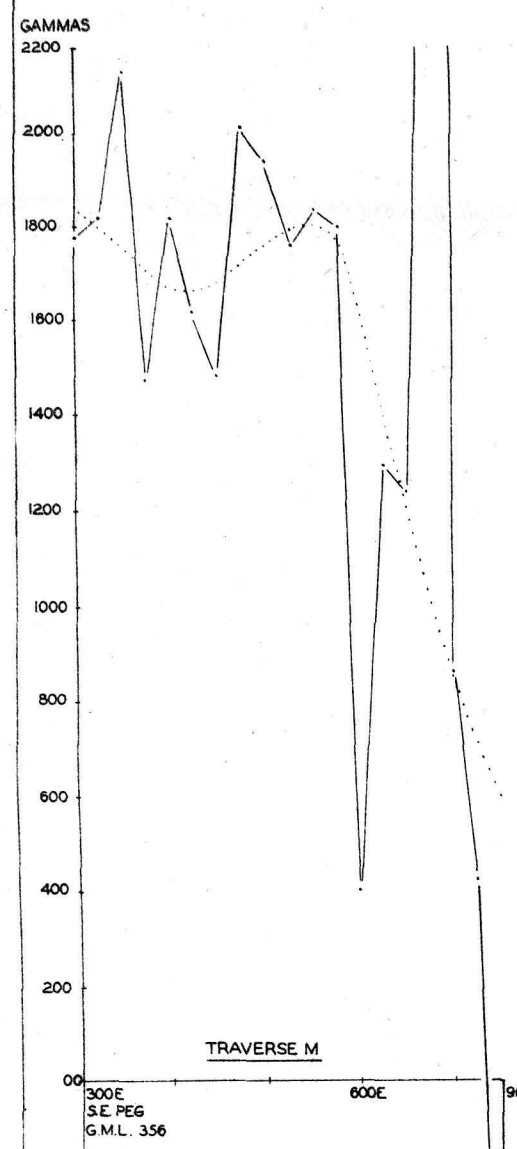


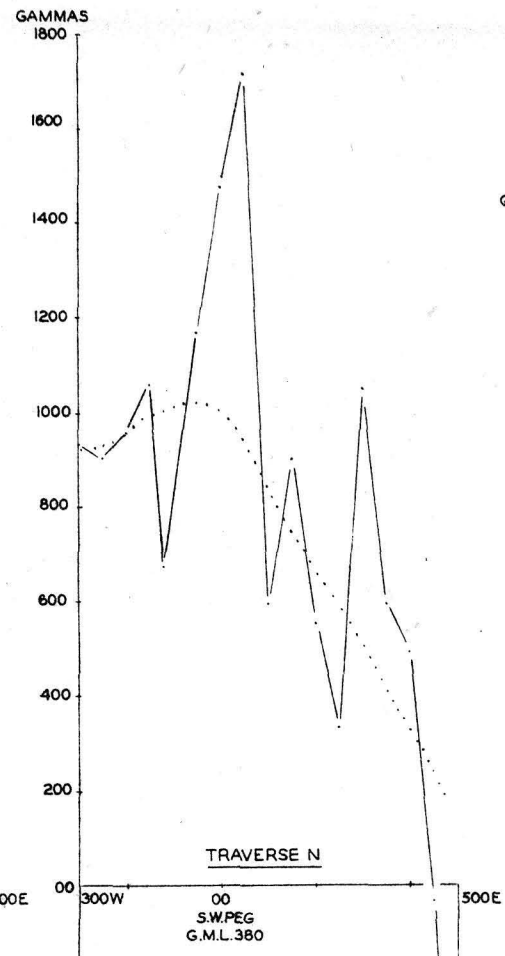


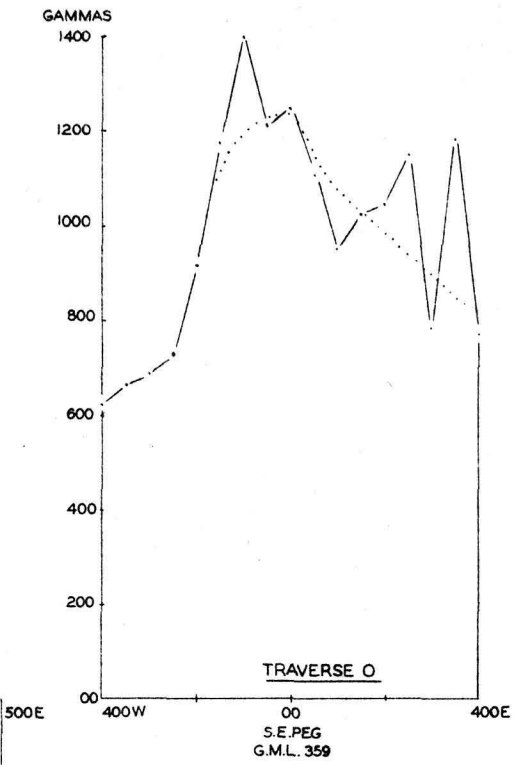
COOLGARDIE GEOPHYSICAL SURVEY

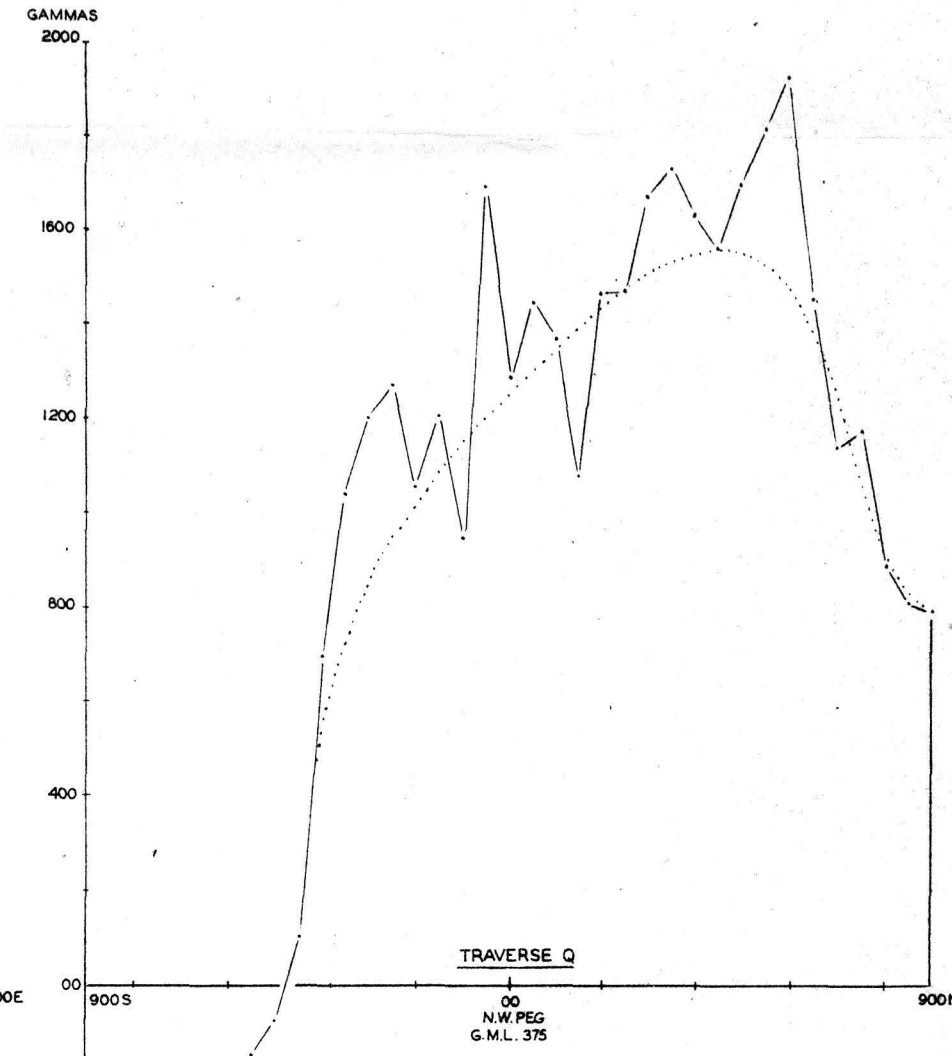
PROFILES SHEET 4.

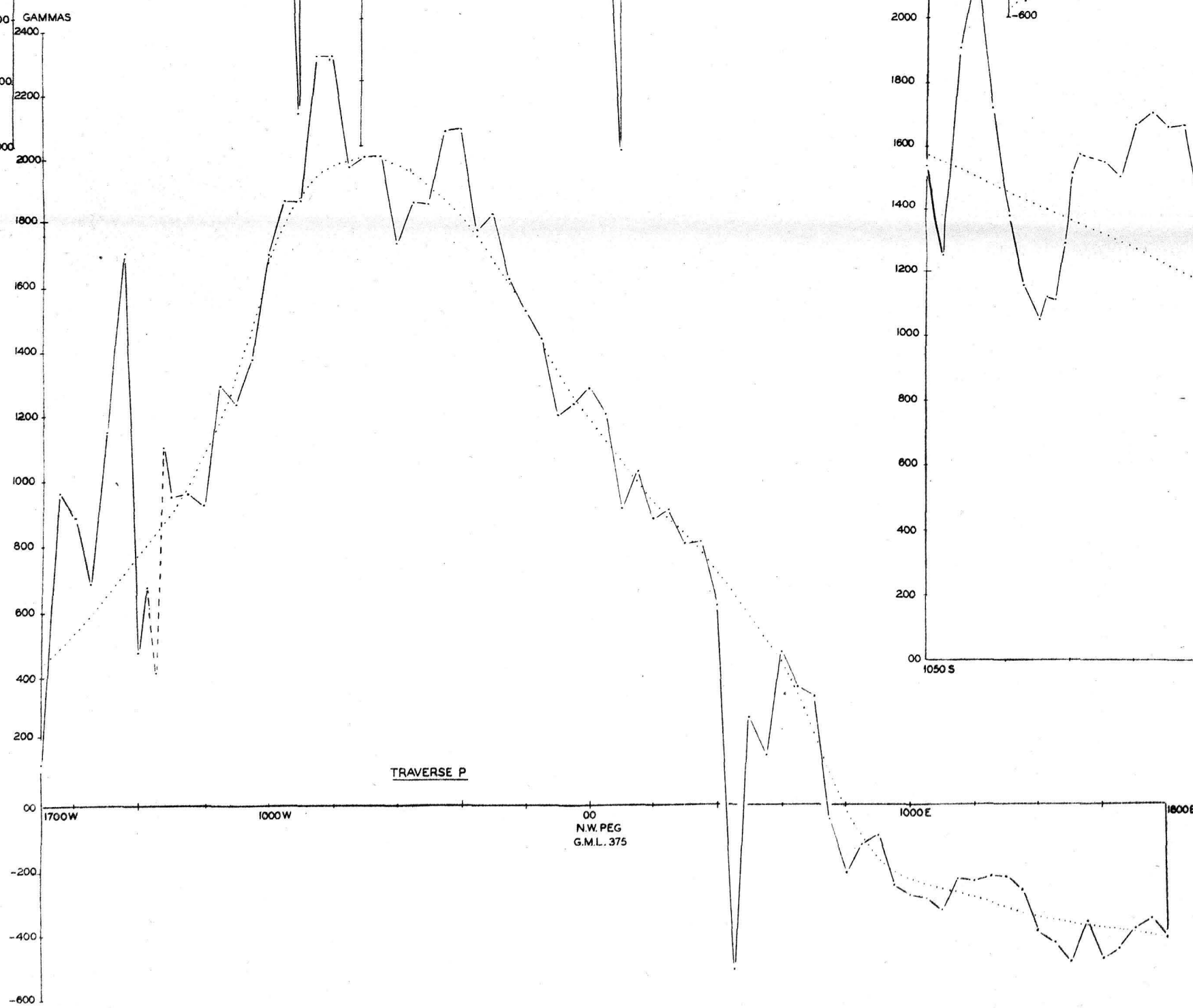
0 200 400 600FT.
0 200 400 600GAMMAS

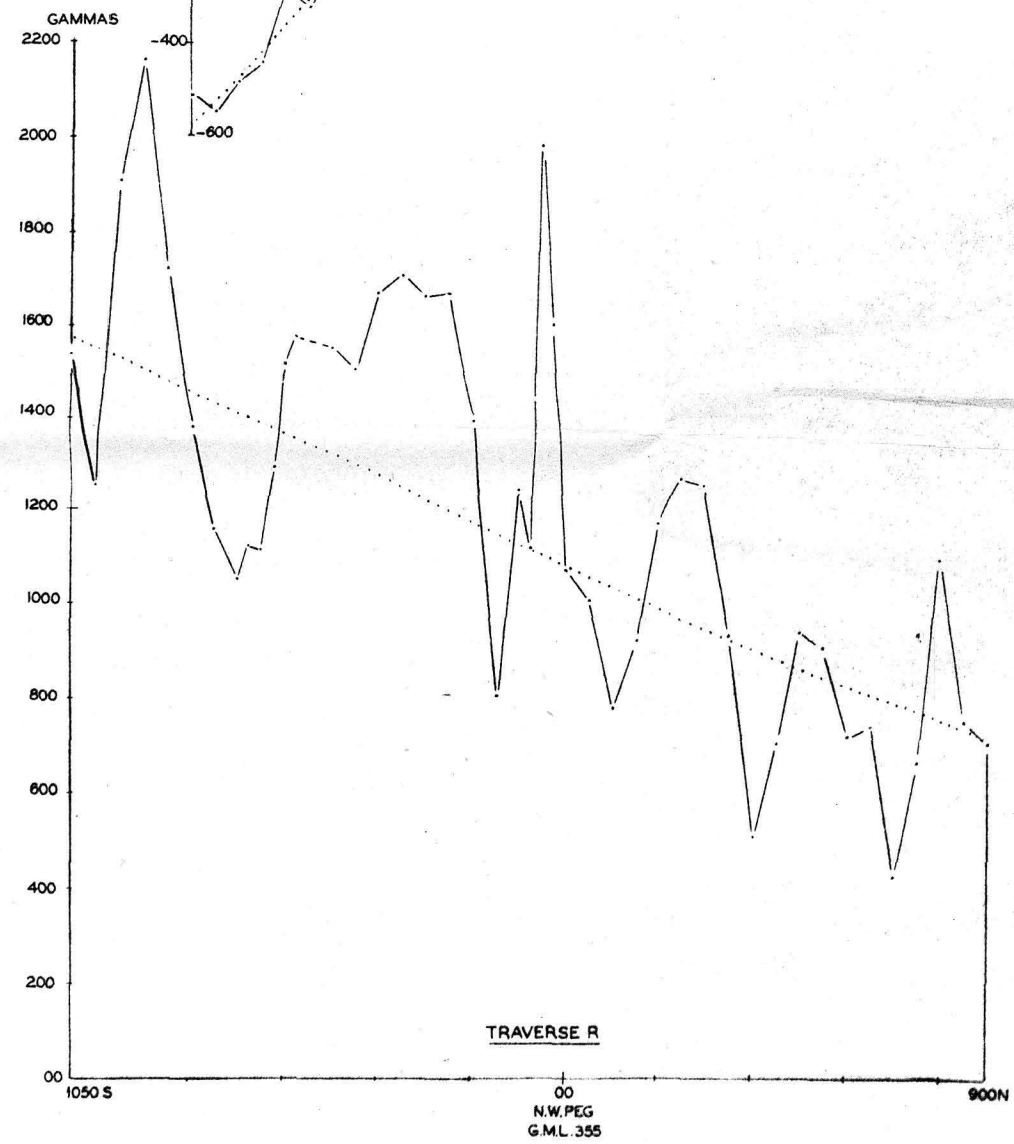












COOLGARDIE GEOPHYSICAL SURVEY
PROFILES SHEET 5

0 200 400 600 FT.
0 200 400 600 GAMMAS

RECORD 1947/9