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DEPARTMENT OF SUPPLY AND SHIPPING.

MINERAL RESOURCES SURVEY.

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GEOPHYSICAL SURVEY OF BARYULGIL ASBESTOS DEPOSITS, NEW SOUTH WALES.

BY

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DEPARTMENT OF SUPPLY AND SHIPPING.

MINERAL RESOURCES SURVEY BRANCH.

GEOPHYSICAL SURVEY OF BARYULGIL ASBESTOS DEPOSITS, NEW SOUTH WALES.

I. INTRODUCTION.

Baryulgil is situated about 52 miles north-west of Grafton on the Grafton-Tabulam road, and is a few miles east of the Clarence River. Asbestos has been mined by Asbestos Mines Ltd. from an open cut in portions 122 and 12 of the Parish of Yulgilbar, County of Drake. The open cut is covered by PML 6, and is about half a mile south of Baryulgil post office. There are few outcrops of rock in the immediate vicinity of the known deposits, and this renders geological interpretation of the area difficult. Because of this an extensive programme of development has recently been undertaken, by the company, including drilling, trenching, shaft-sinking and driving. The geophysical surveys made by Mineral Resources Survey were intended to assist the development, where possible, by outlining the probable extent of asbestos deposits, elucidating structural features associated with the deposits, and providing any information that would assist the geological interpretation of the area.

II. GEOLOGY.

A brief description of the geology of the area is given here. This was written after discussion with Messrs. J. S. Proud, Mining Consultant to Asbestos Mines Ltd., and L. C. Noakes, Geologist, Mineral Resources Survey.

The asbestos (chrysotile) deposits occur in a belt of serpentine which is believed to be about a mile wide, and trends approximately north and south. The serpentine is flanked on the west by granite and on the east by Jurassic sandstones which, however, lie uncomformably over the contact between the serpentine and older sediments. In many places the serpentine is covered by high-level gravels and alluvium which have obscured asbestos deposits and made them difficult to find by surface prospecting. Numerous narrow crush zones containing brecciated and silicified rocks occur in the serpentine in some areas adjacent to the granite contact. Such crush zones have been observed to the west and north of the present open cut. The serpentine is intruded in places by dolerite in the form of dykes and small irregular bodies. To the south of the open cut is a basic sill of microdiorite striking approximately east and west.

Along the contact between the serpentine and the granite there occurs a narrow belt of more basic rocks including gabbro and some hybrid material. The basic rocks are probably differentiates of the magma from which the granite was derived.

Chrysotile asbestos occurs in fissures in the serpentine and in the richest portions may constitute up to 7 or 8% of the rock. The chrysotile fibres run approximately transverse to the veins whose width rarely exceeds one or two inches. Magnetite occurs scattered throughout the serpentine.

Serpentine is an alteration product of ultrabasic rocks containing olivine, e.g. peridotite, dunite, etc. Chrysotile is identical in chemical composition and in many of its physical properties with serpentine, the latter being a massive form containing some impurities.

Chrysotile asbestos is usually found as veins occupying fractures in rock which has been completely serpentinised. Many deposits of chrysotile occur in serpentine adjacent to acid intrusions, and this has given rise to the theory that complete serpentinisation and formation of chrysotile are, in many places, due to hydrothermal alteration by solutions emanating from acid intrusions. However, it is probable that partial serpentinisation occurs in many other basic rocks either as a result of deuteric action during late stages of solidification of the magma or as a result of subsequent dynamic metamorphism, but chrysotile asbestos is almost invariably restricted to a serpentine in which the alteration is complete.

The geology of the area is shown in the plan prepared by Mr. Noakes, plates 1 and 2. Known asbestos occurrences are marked so that they can be correlated with the geophysical results on plate 4.

III. NATURE OF THE PROBLEM.

Because of the scarcity of outcrops mentioned above, surface geological mapping was found to be difficult, and it was thought that geophysical methods might be of some assistance in planning the opening up of the area.

The geophysical survey was carried out with three objects in view, viz:-

1. To search for any physical features associated with asbestos deposits which might assist in locating extensions of known deposits, or in finding new deposits.

2. To determine the boundaries of the serpentine belt at places where the contacts are covered.

3. To determine the depth of gravel overlying the serpentine at certain points.

In regard to the first object, as chrysotile is essentially the same substance as serpentine, it is not possible to detect the presence of chrysotile in serpentine directly by geophysical methods unless the deposits have associated with them a mineral such as magnetite which would render them sufficiently different from their surroundings to permit detection. It has been found in the Baryulgil area that asbestos deposits occur in zones of complete serpentinization; barren zones are only partially serpentinized. Olivine usually contains some iron in the ferrous state, and during serpentinisation much of this iron is believed to be oxidized to magnetite (Fe_2O_3); many analyses from other deposits show a greater ratio of Fe_2O_3 to FeO in serpentinized rock than in unaltered rock. It is not known whether this condition holds at Baryulgil. If it does, it should be possible to detect areas of more complete serpentinization and hence possible asbestos-bearing areas, by their magnetic effect.

It is possible that the deposits have been localised in the serpentine by geological structures that could be mapped by geophysical methods, and in this way it might be possible to predict the occurrence of asbestos elsewhere in the serpentine. Chrysotile occurs at Baryulgil in a series of tension cracks adjoining minor shear planes. Rock of commercial grade occurs where these shears are numerous, and prospecting to date appears to indicate that the deposits consist of lenticular masses separated by serpentine in which no shearing, or shearing to only a minor degree, has been developed. It was thought possible that the localisation of the shearing was due to physical differences in the serpentine which a geophysical survey might reveal. It should be emphasised, however, that apart from the relation mentioned above between the shears and occurrences of veins of chrysotile, little was known at the time of the survey of the structures, if any, which controlled the occurrence. It was realised, therefore, that the possibility of geophysical methods being successfully applied to the elucidation of the structure was slight and would depend on the methods revealing pronounced physical differences which could be related to structures in the rocks and which in turn could be related to the chrysotile occurrences.

IV. METHODS USED.

Three geophysical methods were used - magnetic, potential ratio, and resistivity depth probe. The maghetic and potential ratio methods were used for the first two objects listed above, while the resistivity method was used for the third. A brief description of each method is given below.

(a) Magnetic Method.

A Watts' Vertical Variometer was used for the magnetic survey. This consists essentially of a delicate magnetic balance, which is supported on knife-edges, and oriented in the magnetic east-west direction. Any variation in the earth's vertical magnetic field causes a deflection of the balance which is read on a scale magnified by an eyepiece. The earth's vertical magnetic field is anomalous above any magnetic material, usually being more intense.

(b) Potential Ratio Method.

The essence of this method is the application of an external electric field to the ground; the resulting distribution of potential is then investigated.

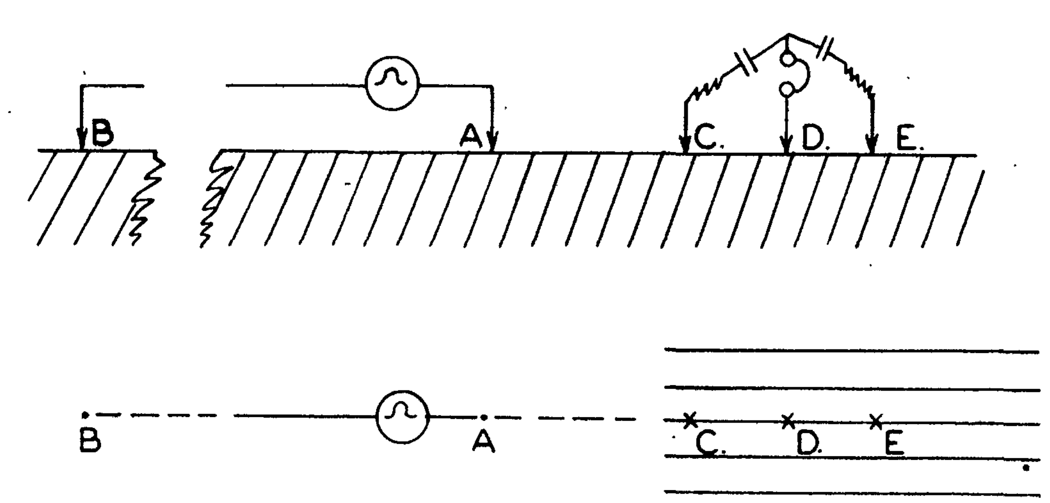

FIGURE I.

Current from a 500 c.p.s. generator is supplied to the earth through two electrodes A and B, (See fig. 1.) which are about 3,000 ft. apart. A series of parallel traverses is pegged out approximately in line with AB, and working away from the electrode A.

Contact is made with the ground at three points C, D and E along one of these traverses (CD= DE). The ratiometer, essentially an A.C. bridge, is used to measure the ratio of the potential drop from D to E to the potential drop from C to D. The whole arrangement C D E is moved along the traverse so that the "front" interval DE now becomes the "rear" interval; thus on each traverse a series of ratios is measured. In ground of uniform resisivity these ratios decrease with increasing distance from A; this is known as the normal variation. Each ratio is multiplied by the reciprocal of the normal ratio for its distance from A; then any departure from unity in the ratios indicates a change of resistivity in the ground.

The potential gradient at the centre of any interval can be calculated by multiplying the gradient for the previous interval by the ratio for the two intervals; thus if a value is assumed for the potential gradient of the first interval, relative values for all the subsequent intervals can be calculated from the ratios observed. Any variation in potential gradient indicates an anomaly; an increase in potential gradient represents a change to a body of higher resistivity, while over a conducting body a decrease in the gradient would be found. A more detailed description is given by Horvath (1936).

(c) Resistivity (Depth Probe) Method.

Four electrodes A, B, C, D, (Fig. 2) are placed in the ground at equal spacings (AB = BC = CD = a). A reversible direct current of known strength is supplied to the ground

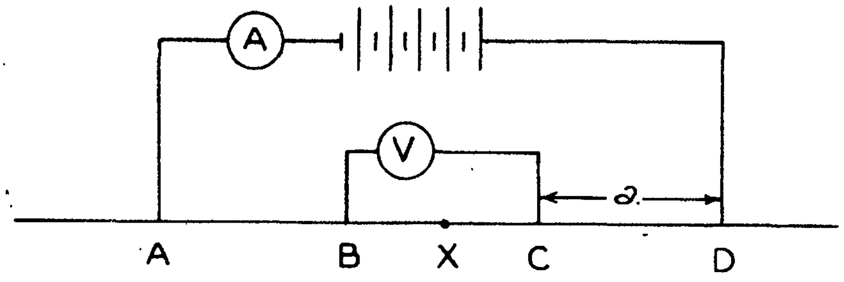

FIGURE 2

from batteries through the electrodes A and D. The resulting voltage across the inner electrodes B and C is then measured by a D.C. potentiometer. From this voltage and the current, the "apparent" resistivity of the earth, corresponding to the electrode separation 'a' can be calculated. For very small electrode separations, this is equal to the true resistivity of the surface layer; as 'a' is increased, the effect of layers at depth becomes important.

In the "depth probe" method, the electrode system is maintained symmetrically about a central point X, while 'a' is increased. This method is suitable for determinations of depths of contacts in horizontally stratified layers. The logarithm of apparent resistivity is plotted against log a, and the depth to a horizontal contact can be estimated by comparison with standard curves. These are for a two-layer case, and being plotted with a double logarithmic scale, their shape is independent of the depth of contact and the resistivity of the top layer. A set of two-layer standard curves is drawn for different ratios of the resistivities of the two layers. The standard curve which most nearly fits the curve to be interpreted is superimposed upon it. The position of the origin of the standard curve then determines the depth of the contact and the resistivities of the layers. For multilayer cases, sections of the curve to be interpreted are fitted by a series of two layer curves. A detailed description of the method of interpretation is given by R. F. Thyer (1944).

V. ANALYSIS OF OPERATIONS.

The survey was carried out during August and September, 1945. The management made field assistants available as required from the mine employees.

The magnetic survey covered about 150 acres. Traverses were made every 200 ft., with readings at 25 ft. intervals. More intensive work was done in an area of about 30 acres in the immediate vicinity of the open cut; in this area traverses were made every

50 ft.

Traverses with the potential ratiometer extended over a distance of about 29,000 feet. They were done in groups of three E-W traverses, 50 feet apart, each group being about 400 feet from the next. In addition, two pairs of traverses were run past the open cut in a N.E. - S.W. direction, one pair being to the N.W., and the other to the S.E. of the open cut.

Depth measurements by the resistivity method were made at six points.

A grid system which had been pegged out by the company around the mine workings was used as the basis of the co-ordinate system. The co-ordinates run magnetic N - S and E - W respectively.

VI. RESULTS OF THE SURVEY.

(a) Magnetic.

The results of the detailed magnetic work around the open cut are shown in the form of a contour map on plate 3. The contours represent lines of equal magnetic vertical intensity, and are drawn at intervals of 250 gammas. It will be seen that the area is considerably disturbed magnetically; however, the variations are too local to permit of any general interpretation. The most prominent features are the highly magnetic area to the west of the cut, and the zone of low values to the east, striking north and south.

East-west traverses at 200 feet intervals from 800N to 3200S were made, and the results plotted in the form of profiles. A contour plan of this area was prepared by smoothing these profiles to eliminate local variations. This plan (plate 4) which has contour lines at intervals of 500 gammas, is intended to show any regional magnetic variation. The high areas on this plan do not show any particular correlation with known asbestos occurrences. There are two zones of low readings, approximately parallel and striking roughly N.E. - S.W. One runs through about 1000S/1400W and 800N/0; the other from about 3000S/200W through 1200S/1200E.

The traverse 1000S which is shown on plate 5 was extended westwards past the granite contact. The values obtained over the granite are comparable with those in the low zones mentioned, and this suggests the possibility of granite at shallow depth under these zones.

The E - W traverse through the zero point was extended eastwards to about 10,000 feet in an endeavour to locate the eastern boundary of the serpentine belt, which is here obscured by gravel. No change in vertical magnetic intensity which dould be interpreted as a contact between the serpentine and the rocks which form its eastern boundary was observed. Vertical intensities commenced to rise at about 6000 feet east near the first outcrop of Jurassic sandstone, and rose steadily eastwards due presumably to an increase in thickness of the sandstone in this direction.

(b) Potential Ratio.

On the first traverses that were carried out, outcrops of brecciated and silicified rock (crush zones) were found at several places where high readings were obtained. It was thought therefore that the high spots would, in general, correspond to the narrow crush zones intersecting the serpentine. If these crush zones were found to conform to some general pattern, the occurrence of asbestos might show some relation to them. The traverses are shown on plate 6, where the logarithms of the potential gradients are plotted. The high spots are marked on the plan on plate 4, but do not appear to fit into any definite pattern. Although it is possible that more traverses between the present ones would elucidate such a pattern, it seems probable that the individual zones do not extend far, and are irregular in occurrence.

(c) Resistivity.

Determinations were made of the depth of the gravel overlying the serpentine at six points. The apparent resistivity curves are shown on plate 7, with the most probable depths to the serpentine and upper and lower limits of possible interpretations. The problem becomes a three layer one, as the surface soil has a high resistivity of the order of 10^5 ohm-cm.; whereas at a small depth the gravel, containing much clay, has a low resistivity of about 2×10^3 ohm-cm. The resistivity of the serpentine is of the order of 3×10^4 ohm-cm. Standard curves have for the most part been fitted to the lower portion of the curves only, as the top interface is not important although it renders interpretation more difficult.

A shaft sunk subsequently at 1100S/400E revealed serpentine at a depth of 18 feet, which is within the limits of the interpretation given at this point. However, the most probable interpretation was 23 feet; thus it appears that the interpretations given at other points may err in giving too great a depth to the serpentine contact.

VII. SUMMARY AND CONCLUSIONS.

The high magnetic readings must correspond to higher magnetite content of the rocks. There is not enough geological information available to state whether this can be related to the degree of serpentinization of the rock or to the asbestos deposits. Some low readings may represent acid intrusive bodies, which may be related to asbestos formation; but at present no definite conclusions can be reached on this point.

Narrow crush zones may be located with the ratiometer; however the work done so far has not revealed that they occur in any marked structural pattern and their relation, if any, to asbestos formation remains obscure. If additional exploratory work should reveal that these crush zones are intimately associated with the asbestos occurrences, and that mapping them would lead to disclosure of additional asbestos deposits, further electrical prospecting would be justified.

In the light of present geological knowledge of the area, none of the geophysical results can be related either directly or indirectly to asbestos occurrences, and consequently no testing as a result of the survey is recommended. However, it is possible that as the systematic testing of the asbestos deposits proceeds, geological information so gained might lead to a proper understanding of the results of the magnetic survey and may even lead to them being usefully employed in the search for additional asbestos areas.

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Thyer, R. F. (1944) Preliminary Geophysical Survey of Morwell Brown Coal Field, Victoria. Commonwealth Mineral Resources Survey Report No. 1944/41.

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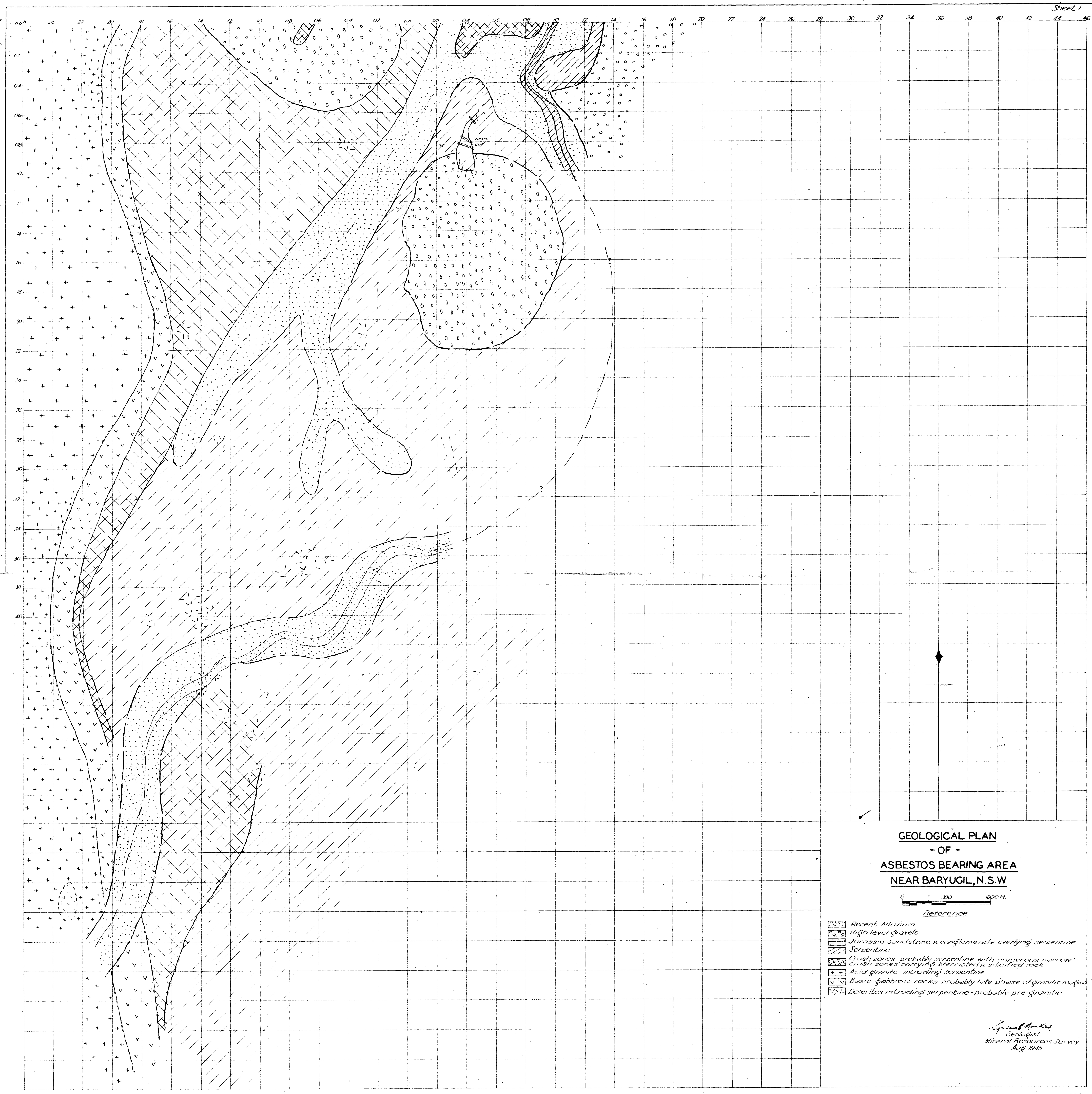
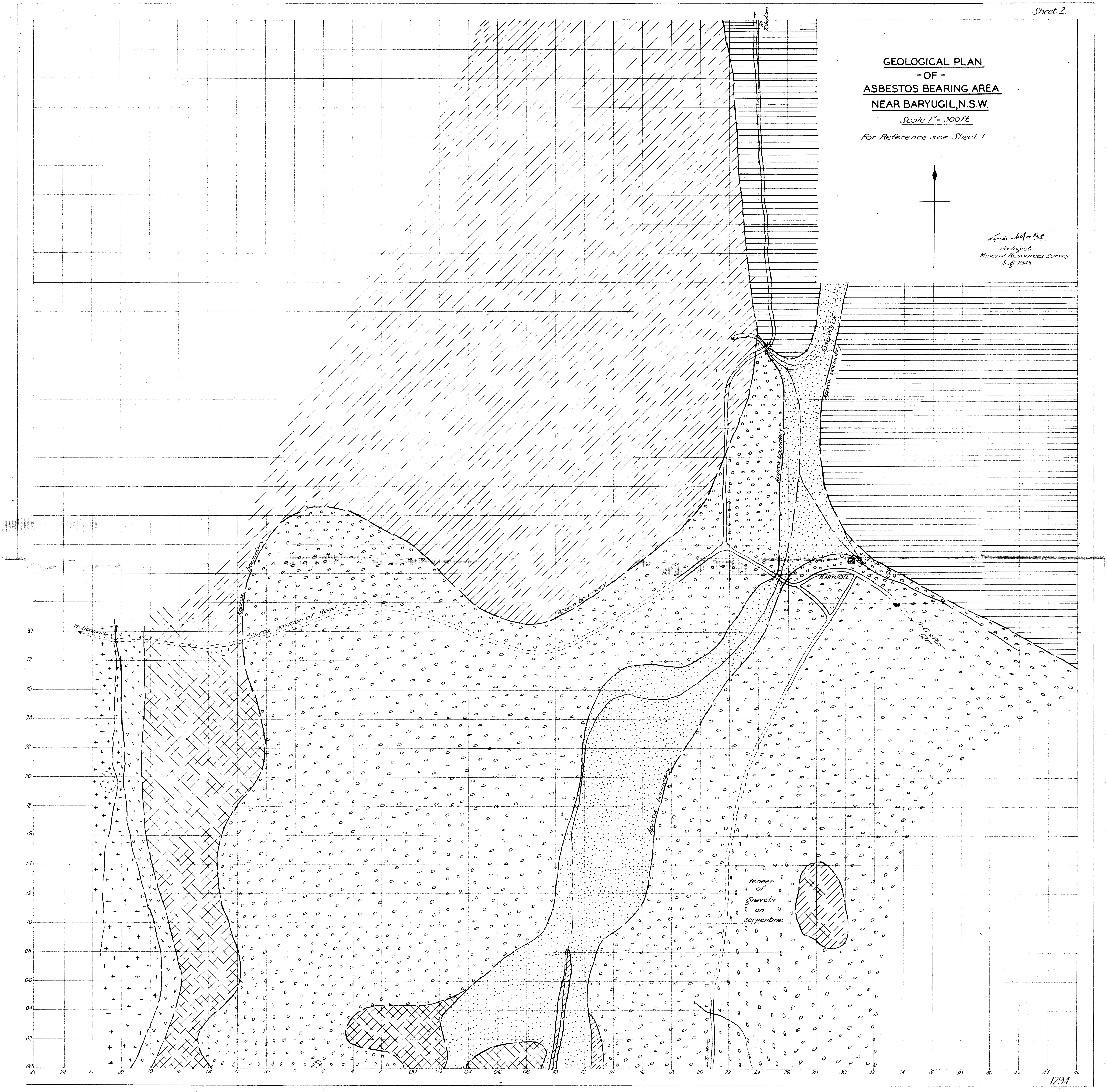
20th May, 1946.



Sheet 1
open cut
GEOLOGICAL PLAN
- OF -
ASBESTOS BEARING AREA
NEAR BARYUGIL, N.S.W
0 300 600 Ft
Reference
Recent Alluvium
High level gravels
Jurassic sandstone & conglomerate overlying serpentine
Serpentine
Crush zones - probably serpentine with numerous narrow crush zones carrying brecciated & silicified rock
Acid granite - intruding serpentine
Basic gabbroic rocks - probably late phase of granitic magma
Dolerites intruding serpentine - probably pre granitic
Geologist
Mineral Resources Survey
Aug 1945



Sheet 2.
GEOLOGICAL PLAN
-OF-
ASBESTOS BEARING AREA
NEAR BARYUGIL, N.S.W.
Scale 1" = 300ft.
For Reference see Sheet 1.
Geologist
Mineral Resources Survey
Aug. 1945
To Tabulam
Joseph's Ck
Approx boundary
BARYUGIL
To Grafton
To Lionsville
Approx position of Road
Veneer of Gravels on serpentine
To Mine
1294

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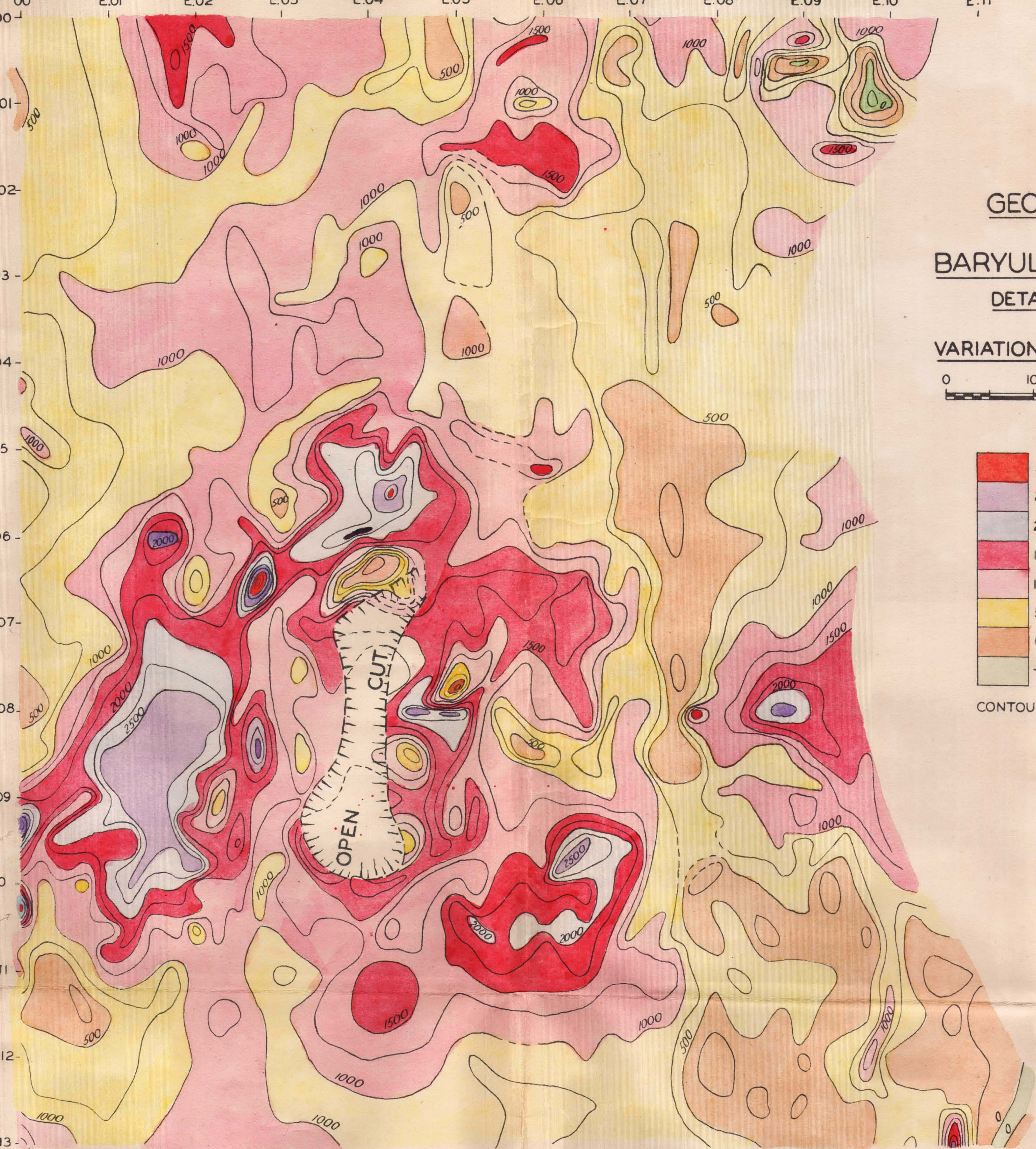

GEOPHYSICAL SURVEY
-OF-
BARYULGIL ASBESTOS DEPOSIT

DETAILED CONTOUR PLAN
SHOWING
VARIATION IN VERTICAL MAGNETIC INTENSITY

0 100 200 300 400 FT.

REFERENCE

3000 - 3750 GAMMAS
2500 - 3000 "
2000 - 2500 "
1500 - 2000 "
1000 - 1500 "
500 - 1000 "
0 - 500 "
-500 - 0 "

CONTOUR LINES AT INTERVALS OF 250 GAMMAS

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Jan 1946

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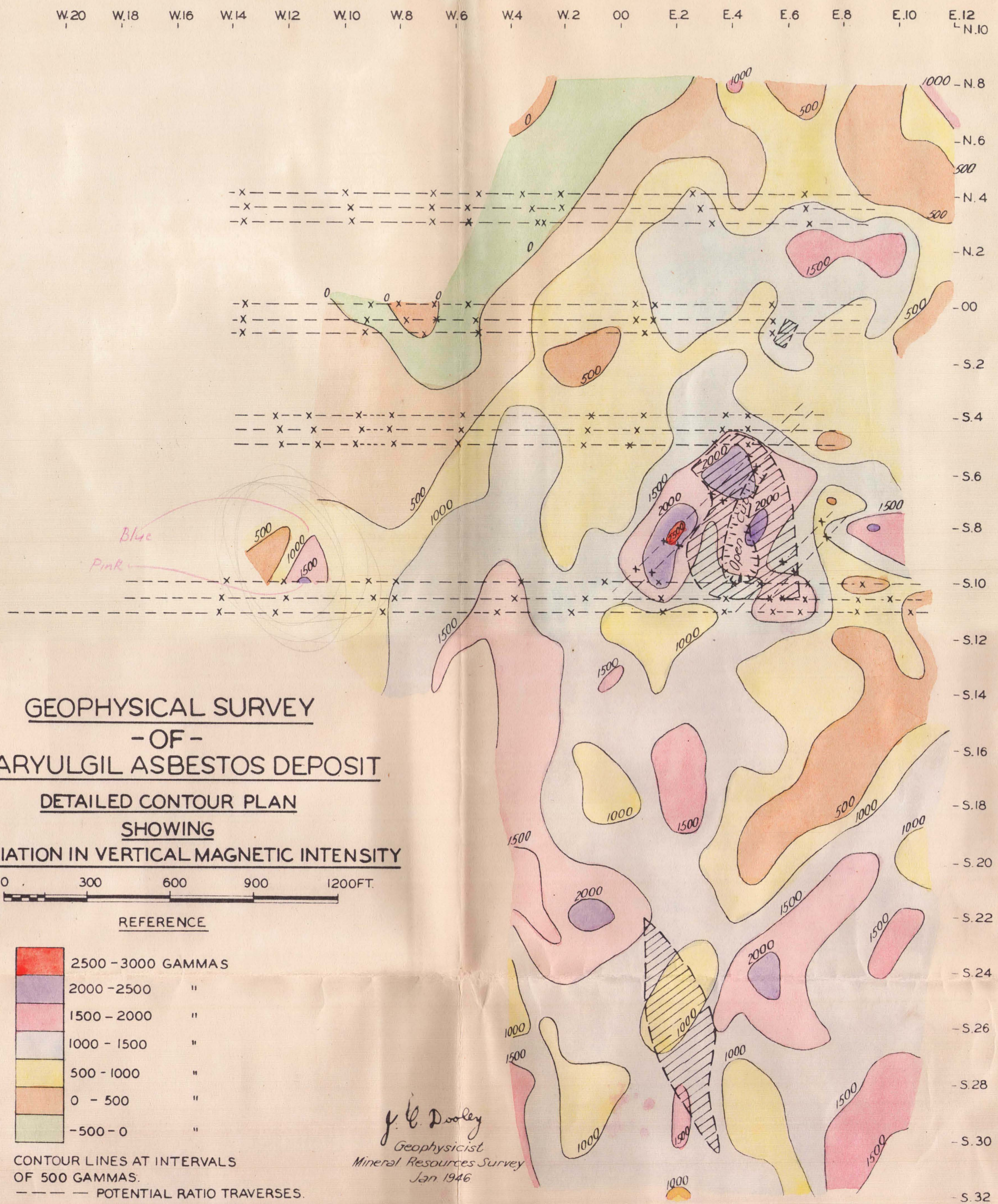
PLATE 4.



GEOPHYSICAL SURVEY
- OF -
BARYULGIL ASBESTOS DEPOSIT

DETAILED CONTOUR PLAN
SHOWING
VARIATION IN VERTICAL MAGNETIC INTENSITY

0 300 600 900 1200FT.

REFERENCE

2500 - 3000 GAMMAS	
2000 - 2500	"
1500 - 2000	"
1000 - 1500	"
500 - 1000	"
0 - 500	"
-500 - 0	"

CONTOUR LINES AT INTERVALS OF 500 GAMMAS.

— — — — POTENTIAL RATIO TRAVERSES.

x---x x " RATIOMETER HIGH SPOTS

ASBESTOS OCCURRENCES.

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Jan 1946

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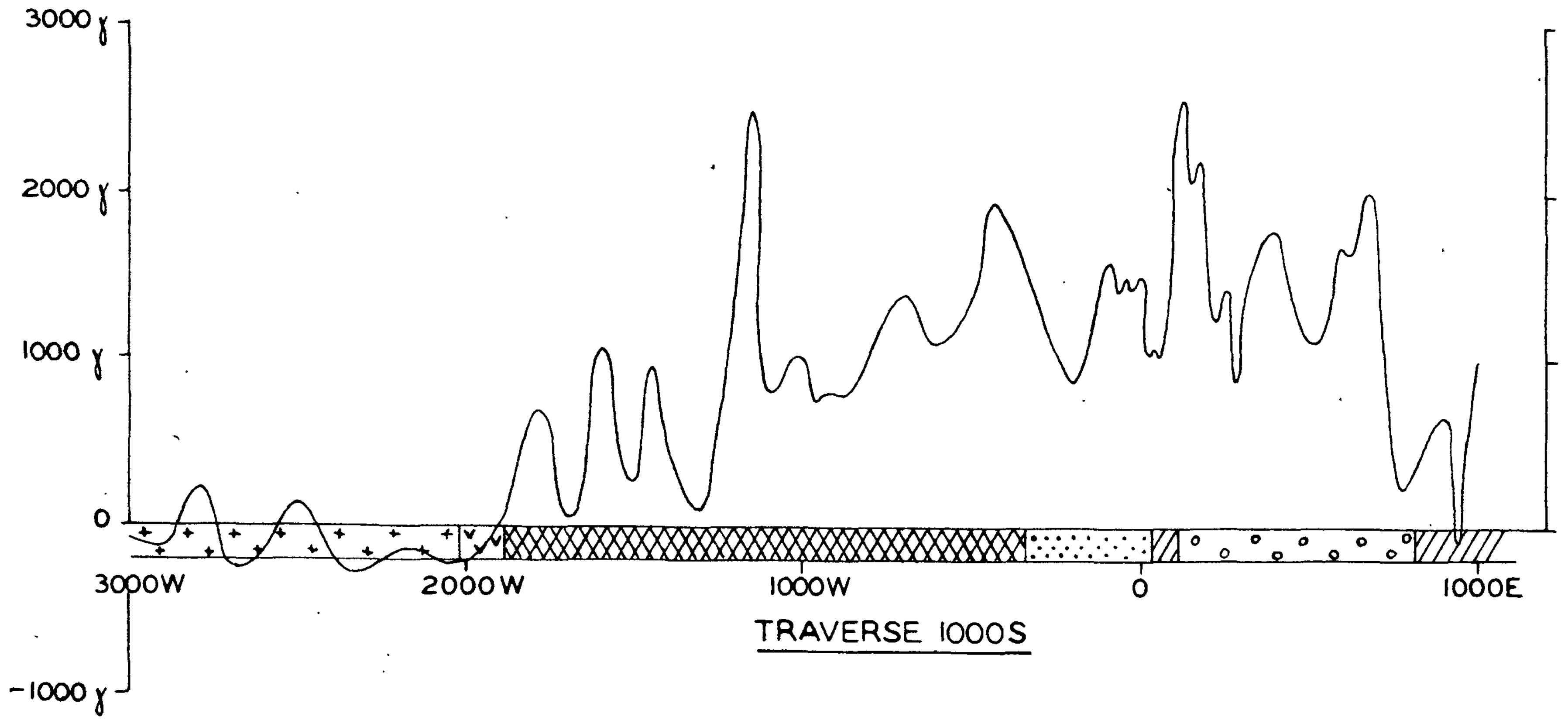

GEOPHYSICAL SURVEY OF BARYULGIL ASBESTOS DEPOSITS

MAGNETIC TRAVERSES SHOWING VERTICAL FIELD INTENSITY

FOR GEOLOGICAL LEGEND SEE PLATE I.

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Jan. 1946.

GEOPHYSICAL SURVEY
-OF-
BARYULGIL ASBESTOS DEPOSITS

TRAVERSES SHOWING LOGS OF POTENTIAL GRADIENTS

VERTICAL SCALE 1" = 0·5

HOR. SCALE 1" = 100 FT.

FOR GEOLOGICAL LEGEND SEE PLATE I.

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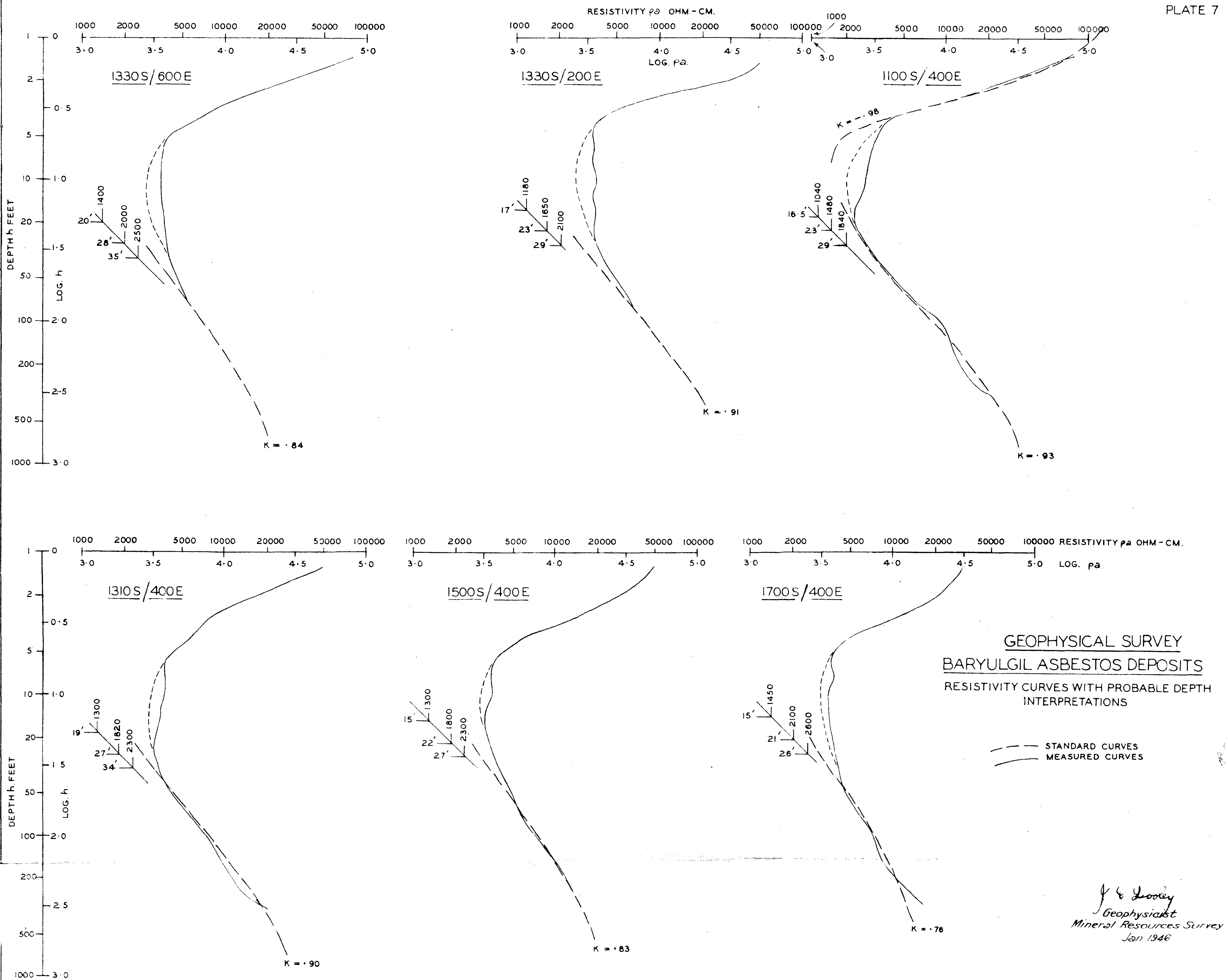
Jan 1946

PLATE 7



GEOPHYSICAL SURVEY

BARYULGIL ASBESTOS DEPOSITS

RESISTIVITY CURVES WITH PROBABLE DEPTH INTERPRETATIONS

STANDARD CURVES
MEASURED CURVES

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Jan 1946

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