COMMONWEALTH OF AUSTRALIA

MINISTRY OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES,
GEOLOGY AND GEOPHYSICS

RECORD 1951/23

PRELIMINARY REPORT ON
SEISMIC SURVEY AT
ROMA, QUEENSLAND

by

J. C. DOOLEY

COMMONWEALTH OF AUSTRALIA
MINISTRY OF NATIONAL DEVELOPMENT
BUREAU OF MINERAL RESOURCES,
GEOLOGY AND GEOPHYSICS

RECORD 1951/23

PRELIMINARY REPORT ON SEISMIC SURVEY AT ROMA, QUEENSLAND

by

J. C. DOOLEY

CONTENTS

PLATES.

PRELIMINARY REPORT ON SEISMIC SURVEY, ROMA, QUEENSLAND

INTRODUCTION:

A seismic survey was carried out near Roma during 1949-50, being part of a geophysical programme to search for structures likely to be significant for oil exploration. This programme was undertaken by the Bureau of Mineral Resources, Geology and Geophysics at the joint request of the Queensland Government and four associated oil companies, viz.; Roma Blocks Oil Co. N.L., Roma North Oil Company N.L., Kalimna Oil Co. N.L., and Australian Oil Development Company, N.L. As preparation and publication of the final report on the survey may take some months it is desired to present briefly the main results in the form of a preliminary report.

The first phase of the geophysical work at Roma comprised gravity and magnetic surveys, the results of which were presented in Bulletin No. 18. The residual gravity pattern revealed two possible structural high closures. The object of the seismic survey was to prove or disprove the existence of these structures, and to obtain more detail concerning them if proved.

FIELD PROCEDURE.

The equipment used was a Heiland 12-channel electrical recording seismograph designed for reflection work. A Failing F750 mobile drilling plant was used for the shot-holes which were generally drilled to a depth of about 80 feet. Traverses were generally laid out as straight lines, although small departures were made in places to avoid scrub and other obstructions. Shot-points were laid out at quarter-mile intervals. Twelve geophones were spaced at 100 ft. intervals between any adjacent pair of shot-points, each end of the geophone spread being 110 ft. from the adjacent shot-point. Each geophone spread was used to record shots from both ends of the spread.

Some shots were fired above the surface of the ground by the method developed by Dr. Thomas Poulter (1950). This method was tried partly for experimental purposes, but some Poulter records were used to confirm the results of the conventional method in critical places.

REDUCTION OF RESULTS

In general the quality of the reflections obtained was poor, but good reflections were obtained in some parts of the area. Reliable correlations between reflections could not be followed over any considerable distance along the traverses. The results were therefore treated by the dip method, i.e. the dips of all reflections recorded were calculated, and the average dip of the reflections within a certain depth range was assigned to a phantom horizon at the centre of the range. The phantom horizon was built up by integrating these average dips from point to point along the traverse.

The near-surface velocities required for calculating the surface corrections were estimated from

(1) the uphole times recorded from shots fired at various depths in the holes;

(2) the velocities measured from the first refraction breaks on the reflection records; and

(3) the velocities measured from special weathering shots, which were fired at the surface with the geophones spaced closer to the shot-point than for the regular shots.

/2..

The near-surface velocities so obtained varied considerably over the area and the corrections were calculated accordingly. The observed reflection time was corrected to the time at a datum level of 900 ft. above sea-level which is about 200 ft. below the average surface level. The corrected time should represent the time from shot to geophone if both were at the datum level.

The dip of a reflecting bed corresponding to any particular reflection was calculated from the step-out, i.e. the change in the times recorded for that reflection by the geophones from one end of the spread to the other. The step-out was measured in milliseconds per thousand feet by calculating the slope of the line which would give the best fit to the times recorded by the twelve geophones when plotted as a function of their distance from the shot-point. A special least-square circular slide rule was used for this operation.

Two corrections were applied to this step-out. The first one, for changes in surface conditions across the spread, was calculated from the difference in the datum correction at each end of the spread. The second was for normal step-out, i.e. the step-out which would be recorded if the reflector had zero dip. This was calculated by a statistical method. A large number of fair to good correlating pairs of reflections from interlocking records was selected from all parts of the area. (Interlocking records are recorded by the same geophone spread from shots fired at each end of the spread). The normal step-outs for such a pair of reflections are equal in magnitude but opposite in sign. If the dip is the same for both records, dip and surface effects increase the magnitude of the step-out on one record, and decrease it on the other. Thus the normal step-out is the average of the two recorded step-outs, disregarding sign. Normal step-outs calculated thus were plotted against observed times, and a smooth curve was drawn to give the best fit. The curve was used for the normal step-out corrections, and also for calculating the distribution of velocity with depth.

A refraction spread was shot from shot-points 36 and 40 in order to determine the velocity distribution, and its results agree fairly well with those of the normal step-out curve, but the depth penetration was less. The velocity distribution was required for converting corrected reflection time to depth, and for converting corrected step-out to dip. Profiles showing the calculated positions and dips of the reflectors were plotted along each traverse. All reflections were graded according to the system suggested by Gaby (1947), for certainty of existence and accuracy of dip. Plate 2 shows a portion of Traverse A with the reflectors plotted in profile.

Owing to the smallness of the dips generally encountered and the lack of consistency of the reflections, the profiles of the reflectors did not give any clear structural picture. The next step was to calculate the phantom horizons, thus combining the information from the reflections into such a form that the most probable structural trends could be studied more readily. Two horizons were chosen - one at about 2,500 feet depth, the other at about 4,500 feet. Starting with either of these depths, the average dip of the reflections recorded in a zone extending 750 feet above and below the horizon was calculated at every 250 feet along the traverse. In determining the average, weight was given to the reflections according to their grade.

Doubtful reflections with a dip contrary to the general trend were ignored. The rise or fall in the phantom horizon was calculated from the average dip. The depth zone in which the reflection dips were averaged was centred at the phantom horizon, not at a fixed depth. The phantom horizons are shown on Plate 2 in relation to the reflections for a portion of traverse A.

The depth of the phantom horizons at the shot-points were plotted as contour plans (Plates 3 and 4). A phantom horizon of course does not represent a real bed at a known depth. In order that it should have any meaning at all, it must be assumed that the reflecting beds in the corresponding zone are mostly conformable. If this is so, the phantom horizon contours should represent the structural features of any bed within that zone. For this reason the contours on Plates 3 and 4 have not been numbered in terms of absolute depth, but in terms of relative depth in feet below a reference point at shot-point 12. Since the contours are numbered in terms of depth and not height, low or negative values represent high points.

In the lower zone, although 4,500 feet was chosen as the depth to the centre of the zone at shot-point 12, nearly all the lower zone reflections used are above the phantom horizon through that point. Thus the lower phantom horizon should be regarded as representing the structural features in a zone above 4,500 feet, rather than in a zone centred at 4,500 feet.

Misclosures occurred when the phantom horizons were calculated around closed loops formed by sections of the traverses. These errors were distributed around the loops before contouring. In estimating the probable errors in the results, the size of the misclosures was an important consideration.

Contour plans of the total surface corrections and the elevations of the shot-points were drawn. The purpose of these was to see if there was any obvious correlation (direct or reverse) between the phantom horizons and the corrections. Such a correlation might suggest that the features in the phantom horizons were caused by under-correction or over-correction for elevation or weathering. No general correlation was apparent, although the elevation contours show a high trend in the neighbourhood of the high contour closure of the phantom horizons.

DISCUSSION OF RESULTS.

Plates (3) and (4) illustrate the contours obtained on the two phantom horizons. The outlines of the gravity closures are shown with the contours. Cardboard models were made showing the contours on each horizon in relief with an exaggerated vertical scale. These were photographed and are shown on Plates (5) and (6).

The reflections from the upper zone are more consistent and reliable than those from the lower zone. There are a few places where no reflections or doubtful reflections only were recorded from the upper zone, but generally speaking two or three usable reflections occur in this part of the record. From the lower zone, good reflections are comparatively few, and several gaps occur for two or three shot-holes where no reliable reflections were recorded from that zone. Thus the upper horizon may be regarded as providing a reasonably continuous picture, but the lower horizon is based on rather sketchy information.

The contours on both horizons show a high closure in the southern part of the area, coinciding approximately with the gravity high in that part of the area. On the upper horizon, there is a closure of about 70 feet, on the lower horizon it is about 150 feet.

/4..

As the survey progressed, it was realized that the best chance of a high closure was in the southern part of the area. There was a suggestion of a high near the intersection of traverses B and C, in the region of the northern gravity feature; however, the reflections east and south from the shot-point 44 were weak, and the contours do not appear to close in that area. It was decided that further work should be confined to the area south of traverse D in order to confirm whether there is a southern high closure. Extra traverses were run in this area, and existing traverses were checked at critical places by re-shooting at a greater depth and by the Poulter method. This extra work reduced the probable errors in the vicinity of the closure.

A detailed analysis of the probable errors in the results in this part of the area has not yet been made. However a preliminary estimate shows that the probable errors approach the order of magnitude of the closures given above. Since the seismic method is thus at the limit of its resolution in this part of the area, there must be some uncertainty concerning the reality of the structural high and the closure associated with it. Due weight must of course be given to the fact that the structural high indicated by the seismic method agrees in position with that indicated by the gravity method.

The high closure on the lower horizon is in much the same position as the one on the upper horizon but is of greater magnitude. The dips recorded on the lower horizon are generally steeper than those on the upper horizon, and comparatively steep dips in opposite directions are found close together in some places. The tendency of the lower horizon to follow and exaggerate some of the trends of the upper horizon suggests that multiple reflections may be included in the lower zone. However the tendency is compatible with a comparatively rugged basement topography whose features are impressed in a milder form on the sediments by compaction folding. The possibility of multiple reflections being present has not yet been fully investigated. However some reflections which were recorded from apparent depths of over 5,000 ft. are probably multiples, as this is considerably deeper than the basement as recorded in the bores at Roma township, Block 16, Warooby, and Blythdale.

Stratigraphically, according to Reeves' (1947) classification, the reflecting beds of the upper zone should be near the bottom of the Walloon series (Jurassic) or the top of the Bundamba series (Triassic). The reflections from the lower zone should come from the basement or near basement rocks. As mentioned above, it has not been possible to correlate reflections from either zone over any great distance. Also, several reflections are generally found close together, and their quality and relative prominence varies along the traverse. This makes it impossible to identify any single outstanding layer which could be correlated with some geological horizon, and which could be picked up again after a gap in the seismic correlations. Thus each phantom horizon is drawn from the average dips of various layers which are assumed to be conformable , although the characteristics which make the layers good or bad reflectors apparently change gradually along the traverses. This typical vagueness is characteristic of the Walloon series, which lacks beds with definite and persistent characteristics which could be used for detailed geological surface mapping. Similarly, attempts to correlate between bores, even where they are close together, usually fail because the bore-logs do not show the same sequence of rocks in different bores. The basement surface, consisting in some places of deeply weathered granite and in other places of metamorphic rocks could not be expected to give consistent reflections throughout the area, though probably some lower zone reflections are from the basement surface.

The reflections from the upper zone generally show consistent dips, but those from the lower zone are more erratic. This seems reasonable when it is considered that the lower zone could give rise to a mixture of reflections, possibly from Upper or Middle Triassic sediments (between which, according to Reeves, (1947) there is a slight unconformity), from the basement surface, from metamorphic beds within the basement in some areas, and multiple reflections from higher zones. Possibly, reflections from all these sources are present in the records of various parts of the area.

Traverses were extended to the bores at Warooby and at Block 16 (see plates 3 and 4). The basement surface at Block 16 is about 240 feet higher than at Warooby. The contact between the Walloon series and the Bundamba series (after Reeves (1947) is about 220 feet higher at Block 16 than at Warooby. The two seismic phantom horizons show a rise of about 40 feet from Warooby to the Block 16 bores, and there is therefore a discrepancy of about 200 feet. The above discussion indicates that no definite correlation between the lower phantom horizon and the basement surface can be expected. It might be expected however that the upper phantom horizon would correlate fairly well with the Walloon and Bundamba series, which according to Reeves (1947) are conformable. But the seismic tie between the bores is about 10 miles long, and includes some bad records, and about four miles of unclosed traverses. Under the circumstances an error of 200 feet is quite possible.

Other high features are shown by the seismic results, and some of them may warrant further investigation. The steep rise on the upper phantom horizon on traverse F between shot-points 128 and 129 is based on very doubtful evidence and is probably of little significance. However, the horizons rise towards Warooby bore and towards the Block 16 bores, and at the south-east end of Traverse C. The work done to date does not indicate whether there is any likelihood of the contours closing in these places.

In the final report, it is proposed to discuss the following points in greater detail:-

1. Methods of reduction of results and estimation of probable errors.

2. Presentation of cross-sections showing all reflections recorded.

3. Average departure from conformability of the reflections from which the phantom horizons were calculated, and possible revision of the zones used.

4. Possibility of multiple reflections.

5. Analysis of the Poulter records and comparison with the conventional method.

CONCLUSIONS.

The seismic survey has indicated a possible closed structural high centred approximately at a point whose co-ordinates on the military grid system are 167000E and 1698000N on the Roma 4 mile sheet. The closure of the feature appears to be about 70 feet on the upper phantom horizon and about 150 feet on the lower phantom horizon. Since these figures are scarcely greater than the estimated probable errors there must be some uncertainty concerning the reality of the structural high and the amount of closure associated with it. The areal extent of the feature is approximately three square miles. Both seismic phantom horizons show the feature in approximately the same position and this agrees well with the high feature shown by the residual gravity pattern. While the seismic evidence for the feature is poor, the agreement between the gravity and seismic results increases the probability that the feature is real. The results are compatible with a basement high feature and a corresponding folding of the overlying sediments, although of course the presence of this type of structure is not definitely indicated. It is impossible to determine the apex of the feature accurately from the seismic results, because of the low dips and the mediocre quality of the reflections.

If a structure such as that indicated above exists it could serve as an oil-trap under favourable conditions. The next step in the exploration programme is a close study by the companies concerned of this report together with the geological and other factors associated with the possible structure and the testing of it prior to a final decision regarding a drilling campaign. It is pointed out that the preparation of a final report on the results of the seismic survey is now in progress and may modify the conclusions submitted in this preliminary report.

REFERENCES

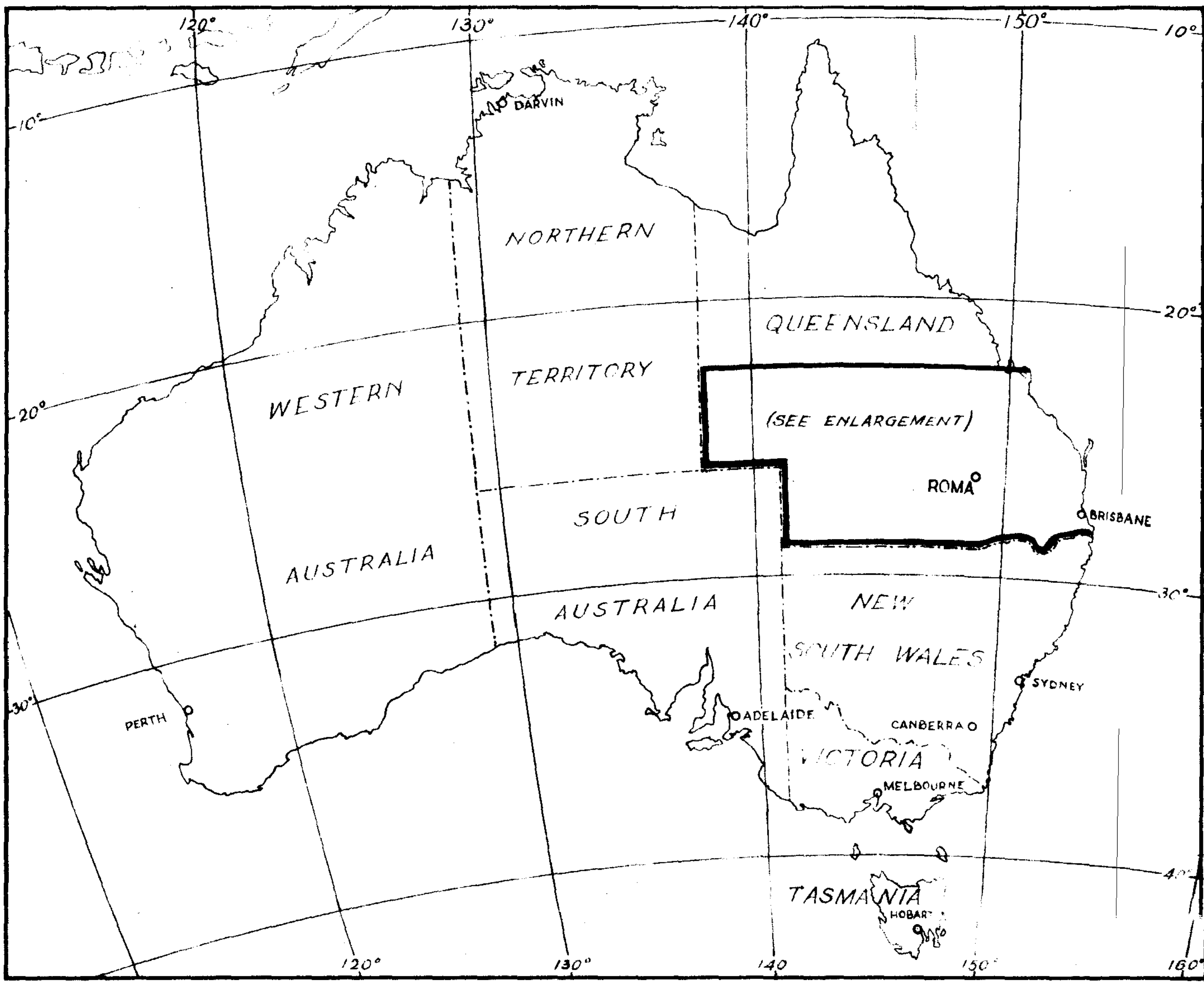
DOOLEY, J.C., 1950. Gravity and Magnetic Reconnaissance, Roma District, Queensland. Bur. Min. Resources, Bull. No. 18.

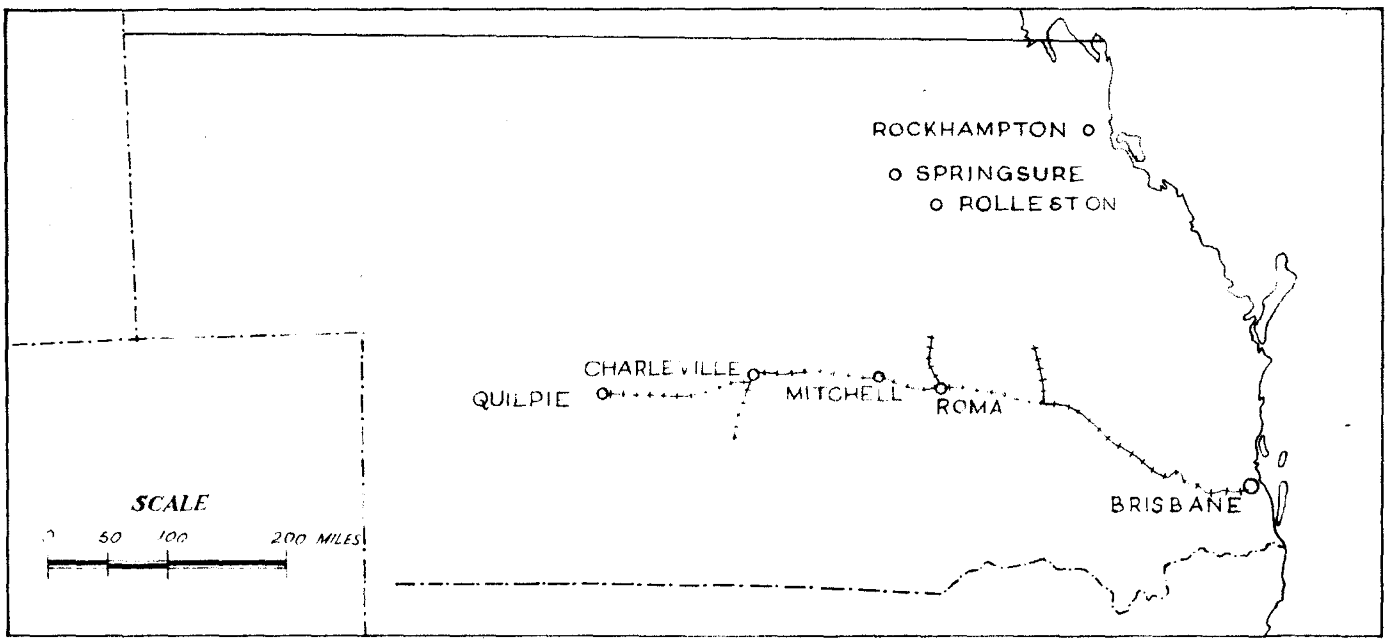
GABY, PHIL. P., 1947. Grading System for Seismic Reflections and Correlations. Geophysics, 12 (4), 590 - 617.

REEVES, Frank, 1947. Geology of Roma district, Queensland, Australia. Bull. Amer. Assoc. Petrol. Geol., 31 (8), 1341-71.

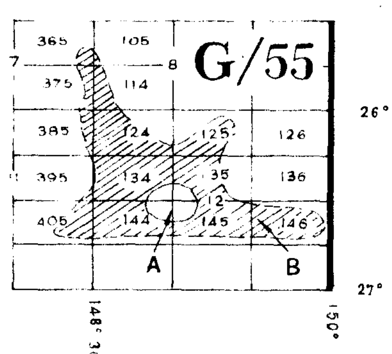
POULTER, Thos. C., 1950. The Poulter Method of Geophysical Exploration. Geophysics, 15 (2), 181-207.

PLATE I





REFERENCE TO ROYAL AUST. SVY. CPS. MAPS



A Area covered by Seismic Survey

B Area covered by Gravity & Magnetic Survey

GEOPHYSICAL SURVEY AT ROMA, QLD.

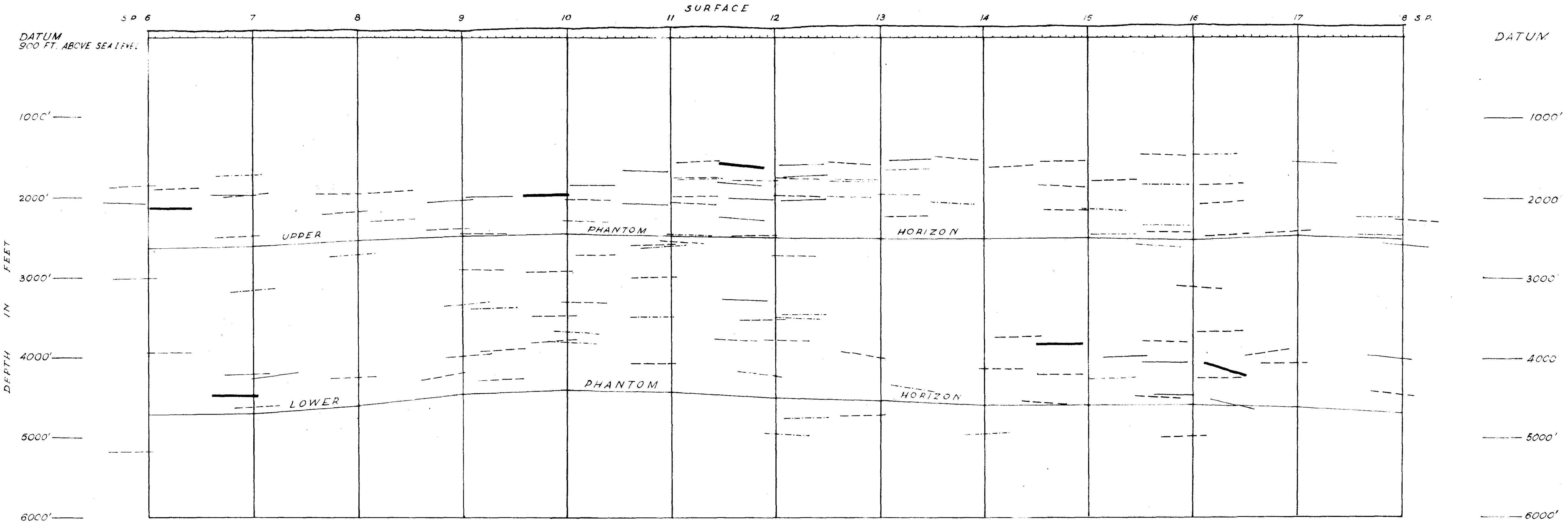
LOCALITY SKETCH OF SURVEY AREA

J. C. Dooley
GEOPHYSICIST

G 38-19

Geophysical Section, Bureau of Mineral Resources Geology and Geophysics

PLATE 2

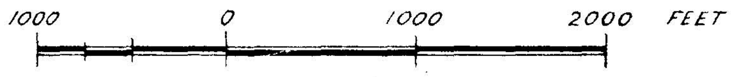


GEOPHYSICAL SURVEY AT ROMA QUEENSLAND

ROMA SEISMIC REFLECTION SURVEY

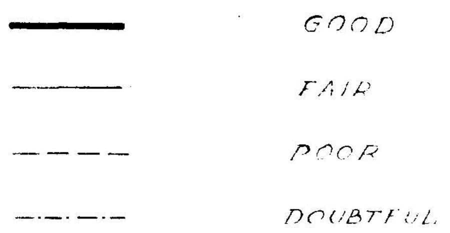
SECTION SHOWING PORTION OF TRAVERSE A ILLUSTRATING REFLECTIONS AND PHANTOM HORIZONS

SCALE

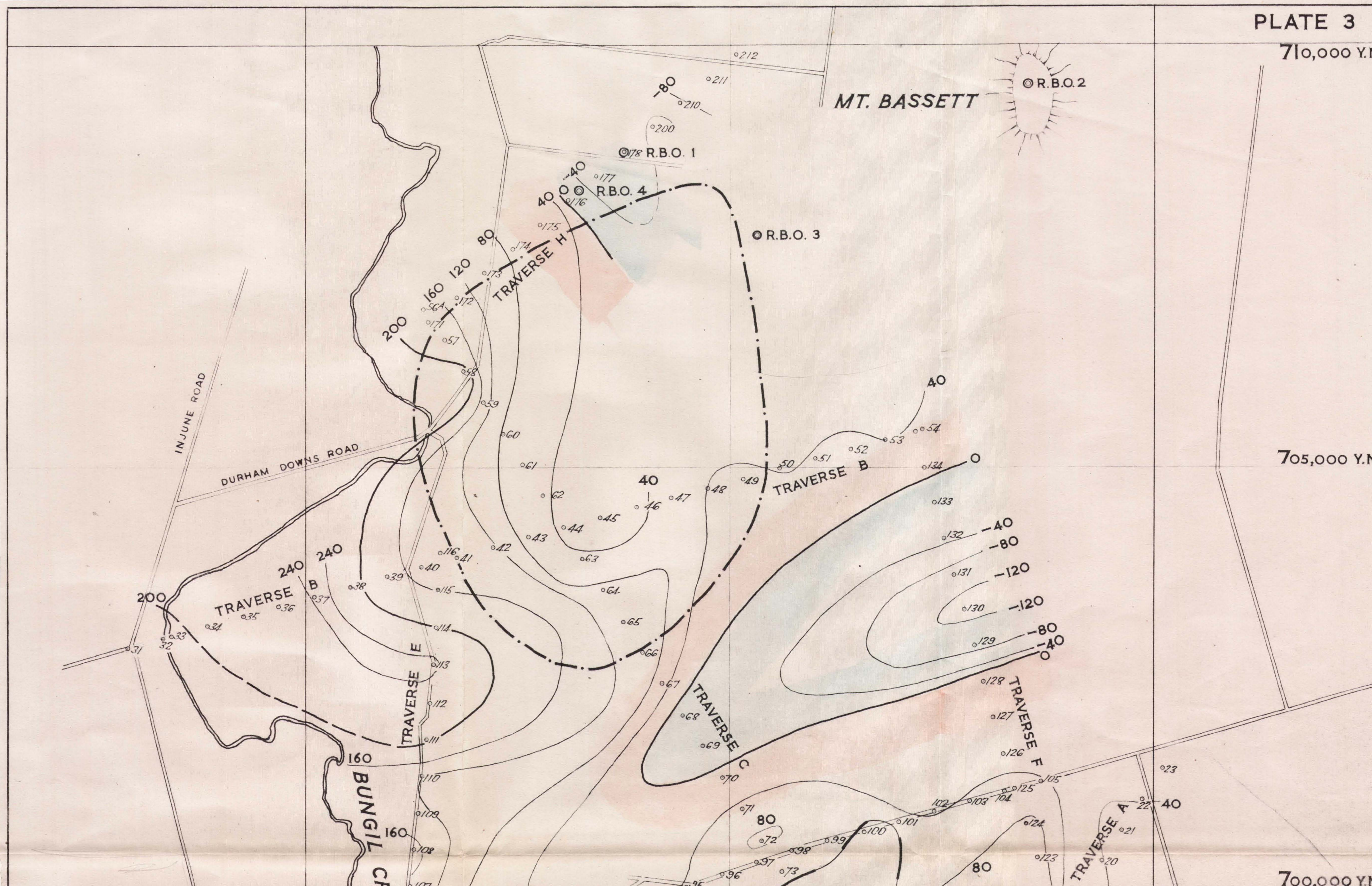


J. C. Dooley
GEOPHYSICIST

KEY TO REFLECTION GRADING



G 38 – 20



GEOPHYSICAL SURVEY AT ROMA QUEENSLAND

ROMA SEISMIC REFLECTION SURVEY

UPPER PHANTOM HORIZON CONTOURS

CONTOUR INTERVAL 40'

ORIGIN– 2500' BELOW DATUM 900'

AREAS OF HIGH CONTOURS OUTLINED IN BLUE.
AREAS OF LOW CONTOURS OUTLINED IN RED.

CO-ORDINATE REFERENCE TO ROYAL AUSTRALIAN SURVEY CORPS 10,000 YARD MILITARY GRID.

- OUTLINE OF GRAVITY RESIDUAL HIGH CLOSURE
- OUTLINE OF SEISMIC HIGH CLOSURES
- RAILWAYS
- BORES

MILES 1 0·25 0·5 0·75 0 1 MILES
SCALE

J. C. Lonley
GEOPHYSICIST

REFERENCE TO HOSPITAL HILL BORES

A –	R.O.C. NO. 2
B –	R.O.C. NO. 1
C –	TOWN NO. 1
D –	TOWN NO. 2
E –	TOWN NO. 3
F –	R.O.C. NO. 3
G –	LANDER NO. 4

G38–21

PLATE 4

REFERENCE TO HOSPITAL HILL BORES.

A — R.O.C. NO. 2.
B — R.O.C. NO. 1
C — TOWN NO. 1
D — TOWN NO. 2.
E — TOWN NO. 3.
F — R.O.C. NO. 3.
G — LANDER NO. 4.

—·— OUTLINE OF GRAVITY RESIDUAL HIGH CLOSURE
— — OUTLINE OF SEISMIC HIGH CLOSURES
—+— RAILWAYS
◎ BORES

GEOPHYSICAL SURVEY AT ROMA QUEENSLAND

SEISMIC REFLECTION SURVEY

LOWER PHANTOM HORIZON CONTOURS

CONTOUR INTERVAL 40'

ORIGIN:— 4500' BELOW DATUM 900'

1 ¼ ½ ¾ 0 1 MILES

SCALE.

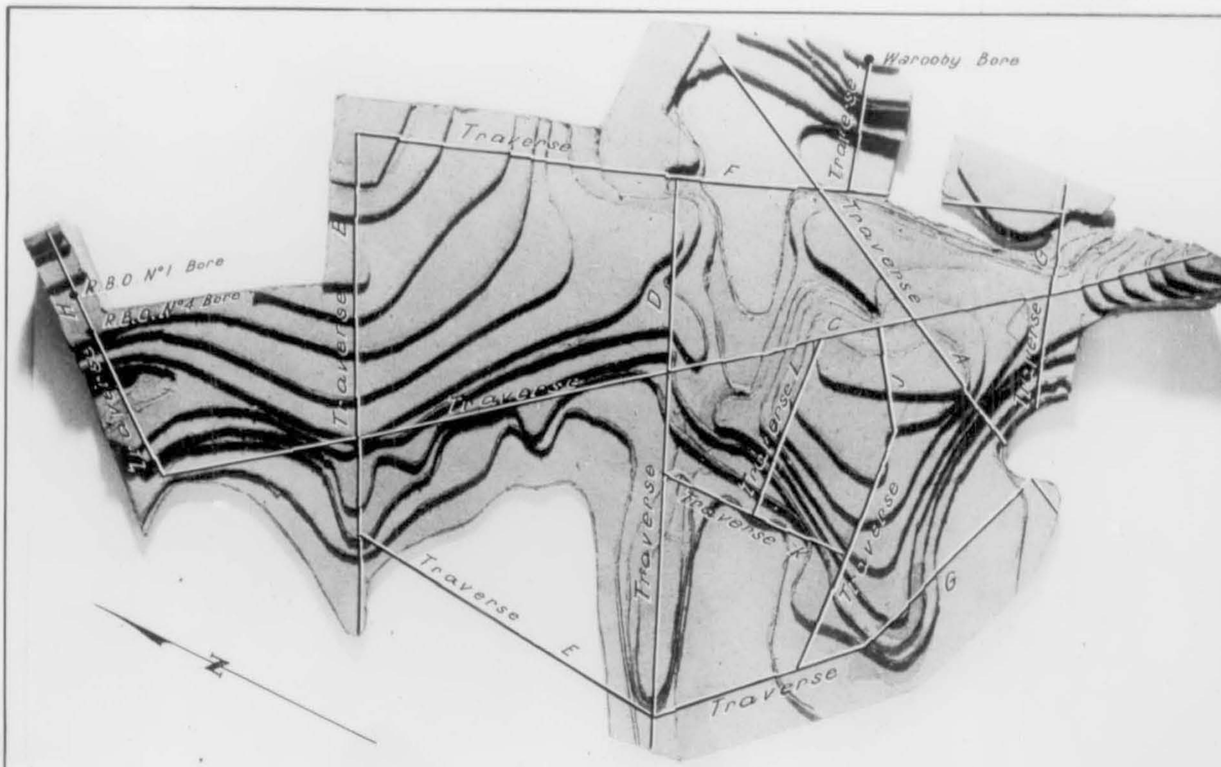
CO-ORDINATE REFERENCE TO ROYAL AUSTRALIAN SURVEY CORPS 10,000 YARD MILITARY GRID.

AREAS OF HIGH CONTOURS OUTLINED IN BLUE.
AREAS OF LOW CONTOURS OUTLINED IN RED.

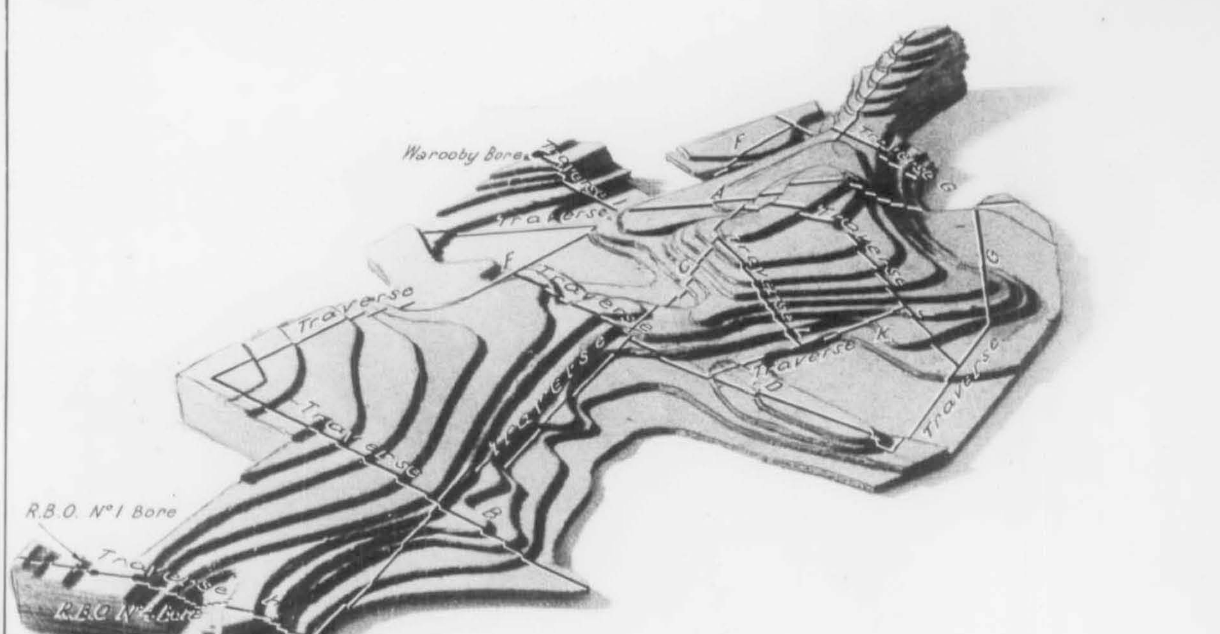
J. C. Dooley
GEOPHYSICIST

G38-22.

PLATE 5



VERTICAL VIEW



OBLIQUE VIEW

SEISMIC SURVEY AT ROMA, QUEENSLAND.

PHOTOGRAPHS OF RELIEF MODEL SHOWING

CONTOURS ON LOWER PHANTOM HORIZON

APPROXIMATE DEPTH 4500 FEET

VERTICAL VIEW SCALE

0 1 2 MILES

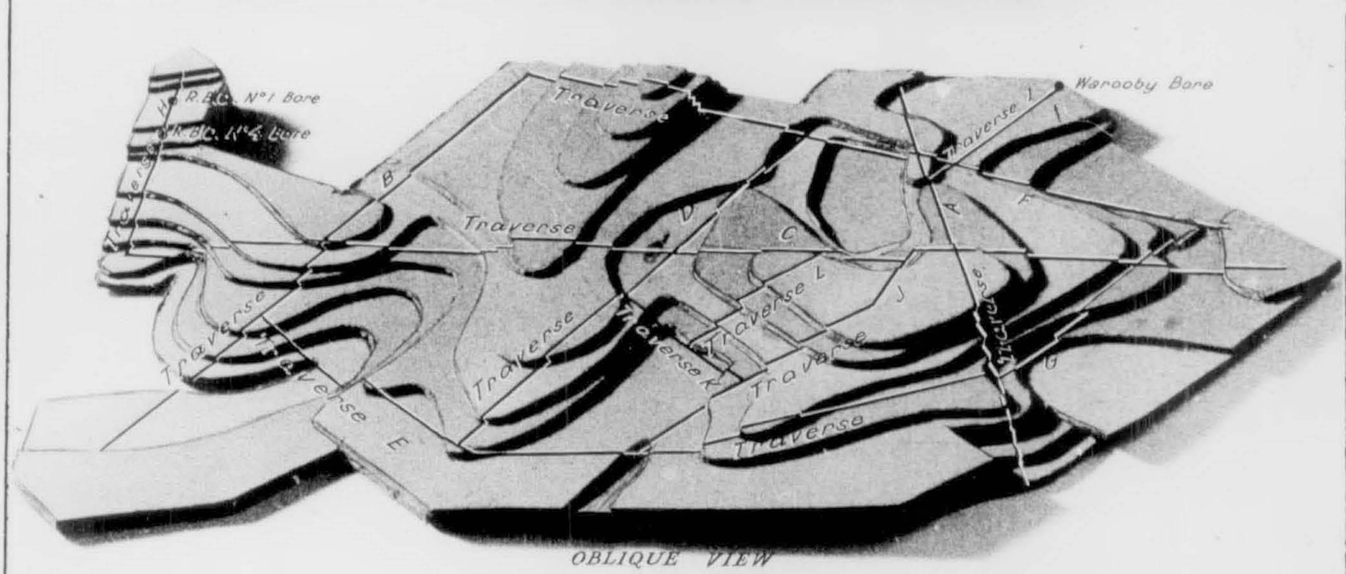
CONTOUR INTERVAL 40 FEET

G38-23

GEOPHYSICAL SECTION   BUREAU OF MINERAL RESOURCES GEOLOGY AND GEOPHYSICS

PLATE 6

VERTICAL VIEW



OBLIQUE VIEW

SEISMIC SURVEY AT ROMA, QUEENSLAND.

PHOTOGRAPHS OF RELIEF MODEL SHOWING

CONTOURS ON UPPER PHANTOM HORIZON

APPROXIMATE DEPTH 2500 FEET

VERTICAL VIEW SCALE

0 1 2 MILES

CONTOUR INTERVAL 40 FEET

G 38 - 24

GEOPHYSICAL SECTION BUREAU OF MINERAL RESOURCES GEOLOGY AND GEOPHYSICS