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BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

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SEMI-DETAILED GRAVITY SURVEY IN THE COMET-ROLLESTON AREA, QUEENSLAND

by

W.H. Oldham

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ABSTRACT

A semi-detailed gravity survey has been carried out over portion of "Authority to Prospect, No. 12P" in the Comet-Rolleston area, Queensland.

The results have made it possible to assign a new position to the axis of the Comet Anticline. The southern extension of the anticline is expected to contain a much thicker sequence of sedimentary rocks than that known near Comet. The thicker sequence may include lower Permian horizons considered favourable for oil generation and accumulation.

Additional gravity work is required to map the anticline in detail.

1. INTRODUCTION

In response to an application by Pacific Mining Ltd., a semi-detailed gravity survey was carried out by the Bureau of Mineral Resources over part of Authority to Prospect No. 12P, in the Comet-Rolleston region of Queensland. The surveyed area, about 150 miles west of Rockhampton, is bounded to the north by the Rockhampton-Emerald railway between Comet township and about 5 miles east of Blackwater, and to the south by the Springsure-Bauhinia Downs road between points 5 miles west and 9 miles east of Rolleston township.

Within the surveyed area there is a thick sequence of sedimentary rocks considered favourable for the production and accumulation of oil. The existence of the Comet Anticline was suggested by surface geological evidence and confirmed by a single seismic traverse done by the Bureau of Mineral Resources (Smith, 1951). It was hoped that a gravity survey would permit more detailed mapping of this anticline which might be a suitable structure for trapping oil or gas. Showings of oil and gas have been found by drilling at several sites south of the surveyed area.

The gravity party consisted of the writer and M.Byrne, who was employed as a survey hand and motor driver. Two landrovers and one trailer were used by the party, which left Melbourne on 12th October and returned on 20th December, 1956. In all, 139 gravity stations were read at intervals of about 1½ miles. Atlas gravimeter No. F21 was used for the first part of the survey but as its drift was irregular it was substituted by Worden gravimeter No.61. Stations were read in the order 1-3-1-3-1-2-3, 6-3-6-3-4-5-6 etc., so that the drift could be measured accurately. In addition, an Askania microbarometer was used for determining elevations and an Askania microbarograph and thermograph were kept in continuous operation at the base camp.

Mr. W.D. Mott of Brisbane, geological consultant to the company, arranged for some topographical surveying to be done in advance of the gravity survey. A private surveyor, N.W. Hyde, was engaged, and he sub-contracted part of the work to R.C. Wilkinson, another private surveyor.

2. GEOLOGY

The geology of the region is shown on Plate 1.

The surveyed area lies on the western side of the Bowen Syncline, an extensive feature trending south-south-east from near Bowen to the Roma-Chinchilla district. The syncline is bounded by Lower Palaeozoic metamorphic rocks which crop out about 50 miles west and 100 miles east of Comet.

Sedimentary rocks within the surveyed area are mainly of Permian age; these are overlain on its eastern boundary by rocks of Triassic age and in many other places by Tertiary laterite and basalt, and alluvium.

At Morella Well and Arcadia Well (Plate 1) andesite rock was reached at 4,400 and 6,000 feet respectively. This andesite is believed to be the same formation as the andesite which underlies marine Permian formations 100 miles east of Comet, and its age is considered to be Lower Permian. The thickness of andesite is not known but it was penetrated for 270 feet at Morella Well before drilling ceased. Reid's Dome No.1 Well (Plate 1) was drilled to 9,000 feet without encountering andesite; Webb (1956) considers, however, that the horizon of the Lower Permian andesite was not reached and

that andesite might have been revealed by deeper drilling. It seems probable that the andesite is a wide-spread if not continuous feature throughout the Bowen Syncline. The variable height of its upper surface may result either from erosion, faulting or folding.

Carboniferous formations crop out over a wide area to the west of the Bowen Syncline and to the east of the Syncline are outcrops of rocks of Carboniferous and Devonian age. Current literature on the geology of the district does not favour the idea that these formations extend far into the synclinal area; if they do, however, they can be expected to be compressed and metamorphosed sufficiently for their densities to be similar to that of andesite.

In the absence of any positive evidence, the formations which underlie the andesite horizon within the Bowen Syncline can only be the subject of conjecture. The possibilities include the granite and metamorphic ("Lower Palaeozoic, Undifferentiated") formations which crop out on the western margin of the basin, and the Carboniferous and Devonian formations already mentioned. But in any case it is reasonable to assume that the density of such formations is substantially higher than the density of the sediments which are younger than the andesite (Lower Permian).

The Bureau's seismic traverse (page 1) indicated the presence of rock having a high seismic velocity (possibly andesite) at a depth of 2,200 feet, 4 miles east of Comet, at the crest of an anticlinal structure whose axis is directed roughly north-south. The gravity anomaly measured along this same traverse in the present survey is one that could arise solely from variations in thickness of the sedimentary rocks overlying the "high velocity" rock.

In order to be able to interpret the gravity anomalies it is necessary to make some assumptions about the rock types to be expected at depth within the surveyed area. For this purpose it is assumed that the "high velocity" rock 4 miles east of Comet is Lower Permian andesite and that this andesite, or older rocks of equal density, extends throughout the surveyed area. On the basis of this assumption, it follows that the gravity anomalies arise solely from variations in thickness of the sedimentary formations overlying the andesite or older rocks. For the purpose of this report the andesite or older rocks are considered to be the basement rocks.

The following table shows formations found within the Authority to Prospect and in nearby areas (Mott, 1955).

TABLE 1

STRATIGRAPHIC SEQUENCE.

Formation	Lithology	Facies	Thickness
TERTIARY	Laterites, lateritic basalts, young volcanics. Mainly basaltic flows.		
TRIASSIC Clematis Sandstone	Medium to coarse sandstone, conglomeratic in places. Stringers of siltstone. Sometimes conformable with Permian.	Non-marine	Up to 650' Average 400'

TABLE 1 (Continued)

Formation	Lithology	Facies	Thickness
PERMIAN			
Bandanna Formation	Clay shale overlying coarse calcareous sandstone to sandy limestone, grits, shales, bituminous coal and oil shale with plant remains and fossil wood.	Non-marine	From 1600' in south to 3000' in north.
Catherine Sandstone	Sandstone, often with carbonaceous matter. Conglomeratic and pebbly phases near Comet. Glacial pebbles and shells in one layer near Serocold.		From 400' in south to 1200' in north.
Ingelara Formation	Shales, marls, partly gypsiferous and carbonaceous sandstone, calcareous sandstone, calcareous sandstone with thin bands of limestone containing abundant marine fossils. Glacial erratics.	Marine	At Serocold and Consuelo ranges from 90' to 500'
Aldebaran Sandstone	Sandstone, often felspathic and sometimes micaceous. Some quartz pebbles and glacial beds. Occasional shales and leaf-bearing clays. Slight unconformity at base.		At Serocold and Consuelo ranges from 1600' to 2500'.
Cattle Creek Group	Shales, fine to medium sandstones, marls, marly limestones etc., with rich marine fauna. Glacial erratics.	Marine, perhaps fluvio-glacial in parts.	Probably between 500' and 2000'.

NOTE: Andesite rocks occur beneath the marine Permian rocks along the eastern margin of the Bowen Syncline.

3. REDUCTION OF RESULTS

A. Gravity Datum

Observed gravity values are based on the value 978.8397 cm/sec.^{2} established at Comet railway station by Narain in 1951 (Marshall and Narain, 1954). This figure, however, has been reduced to 978.8374 to bring it into agreement with the latest accepted figure of 979.6849 at the National Standards Laboratory gravity station, Sydney.

The scale values of both the gravimeters used in the survey have been carefully checked against pendulum stations over a wide range of gravity. By careful reading procedure and repetition of any doubtful intervals, the gravity observations were kept to a high order of accuracy. The largest error in closure was 0.13 mgal in a distance of 47 miles.

B. Bouguer Factor.

Bouguer anomalies were calculated using a factor corresponding to a density of 2.25 gm/cc for the near-surface rocks.

C. Station Elevations.

Station elevations were adjusted to agree with known elevations above sea level at two Main Roads Department bench marks (near Comet and near Blackwater) and a Queensland State Datum peg (QG 133) at Rolleston. The elevations were measured for most of the area by stadia levelling, in some parts by barometric levelling, and in some parts by both methods. Neither method is very precise but in those parts where both methods were used the agreement was generally fairly good. Discrepancies were greatest in the elevation interval between pegs A2 and 41, over which the two methods differed by 15 feet. Final values were adopted by giving equal weight to the barometric and stadia values over those sections of the traverses where the two methods were used, and accepting the mean value as correct for the section. This left small errors in closure on to bench marks and these errors were distributed over the remaining sections of the traverses. The over-all accuracy is almost certainly within ± 10 feet and the station-to-station accuracy probably within ± 1 foot.

Elevations were calculated from the microbarometer readings in the following steps:-

(i) Field barometer readings were corrected for instrument temperature and converted to pressure in mm of mercury.

(ii) Microbarograph charts were scaled for temperature and pressure at times corresponding to the field barometer readings.

(iii) Microbarograph scalings were converted to pressure in mm of mercury and corrected for instrument temperature.

(iv) Field barometer pressures were corrected for diurnal variation (barograph pressure) and expressed in terms of pressure difference between adjacent stations.

(v) Pressure differences were corrected for atmospheric temperature - assumed to be the same as the field barometer temperature. In this step it was also assumed that the relative humidity was 40 per cent.

(vi) Pressure differences were converted to height differences in feet by using a conversion factor of -37.1 ft. per mm of mercury, which is an average figure for the limited range of elevations encountered.

D. Topographical Mapping.

Most of the stations were surveyed by stadia traversing. The positions of some of these pegs and of all pegs not surveyed by stadia were marked carefully on airphotos and transferred to airphoto mosaics at a scale of 1" = ½ mile. The mosaics, which are accurately compiled from slotted template assemblies, were later reduced photographically to a scale of 1" = 2 miles. The stadia readings were converted to latitudes and departures and the traverses plotted at a scale of 1" = ½ mile. This plot also was reduced photographically to 1" = 2 miles, the scale of

the final map which was drawn as a compromise between the stadia traverse plot and the positions of pegs as shown by the airphoto mosaics.

Latitudes of the pegs were scaled from the final map. Although the map is not highly accurate, the inaccuracies appear to be in an east-west rather than a north-south direction. The maximum over-all inaccuracy is almost certainly within 1,000 feet but the maximum error accumulated between adjacent stations is much less.

4. DISCUSSION OF GRAVITY ANOMALIES

A. General comment.

The Bouguer anomaly contour plan (plate 2) shows some large areas where no gravity values were read; this is due to the rough inaccessible nature of the region and the short time available for the survey.

Contouring of gravity anomalies was begun in those parts where gravity stations were spaced closely enough to indicate clearly the anomaly trends. Contours in the parts with little or no gravity control were then interpolated, using the theory that the simplest contour patterns are most likely to be correct.

It may be taken for granted that a more detailed survey would reveal many minor irregularities in the contour pattern. It is believed, however, that the major features of the plan closely approximate true conditions, and the following discussion is based on this assumption.

The principal features of the Bouguer anomaly plan are:-

(1) A zone of high gravity anomalies which appears to trend south-east through station A4 ($3\frac{1}{2}$ miles east of Comet) and veer south-west, passing between stations 53 and 56. More traverses crossing its axis are required to determine its position accurately. This is referred to later as the gravity "high".

(2) A zone of low gravity anomalies in the area enclosed by Laleham, Humboldt and Somerby properties, referred to later as the gravity "low".

Tentative closures are drawn on the southern part of the gravity "high", but additional gravity stations are needed to justify these closures. The feature might extend much further in both directions. The feature is shown as being separated into two maxima, but additional stations would be required for confirmation. The general trend, however, remains clear.

The lowest anomaly values are in the north-east, where the thickness of sediments in the Bowen Syncline is increasing progressively in that direction and where W.D.Mott's geological plan shows a small local synclinal structure (marked on plate 3).

The contour plan suggests that the "Tertiary lateritic basalt" and "young volcanic" formations are not of sufficient thickness to have any important effect on gravity values.

B. Gravity "high".

The axis of the gravity "high" feature passes almost exactly through the crest of the Comet Anticline at a point 4 miles east of Comet where the anticline was confirmed by seismic survey. The direction of the gravity "high" appears to differ appreciably, however, from the direction previously assumed for the anticline (Mott, 1955). It must be remembered that the anticline had been plotted from rather scanty geological evidence, and it may reasonably be accepted that the gravity "high" outlines the axis of the anticline. The anticline, as indicated by the gravity results, swings sharply to the south-west where it enters a region covered by alluvial deposits and basaltic flows.

As mentioned earlier, the depth to andesite rock at the crest of the anticline 4 miles east of Comet (near station A4) is accepted as about 2,200 feet. The densities of rocks in the area are not accurately known but it has been assumed that the average density of the sedimentary rocks deeper than 2,200 feet but overlying the andesite or older rock is between 2.4 and 2.5, and that of the andesite or older rock about 2.7. The density contrast between sedimentary rocks and andesite or older rock is, therefore, probably between 0.2 and 0.3.

At station A4, the gravity anomaly is +4.3 mgal. At station 53 the anomaly is -0.8 mgal, a decrease of 5.1 mgal. The thickening of lighter sedimentary rocks required to produce this decrease would be 2,000 feet if the contrast is 0.2, and 1,330 feet if the contrast is 0.3. At station 53, therefore, andesite or older rock should be found at a depth between 3,500 and 4,200 feet.

The values calculated here are based on the assumption that the thickening or thinning of sedimentary rocks may be represented by a thin horizontal sheet of infinite extent. The gravity effect of such a sheet is approximately $4.07 \times \pi \sigma t$ mgal, where

σ is the density contrast (in gm/cc), and

t is the thickness of the sheet.

The assumption is not strictly correct, but is justifiable in this case as the drilling information is scanty and the Bouguer anomalies are subject to appreciable error because of inaccuracies in determination of the elevations and latitudes of the gravity stations.

Plate 3 shows a theoretical geological section A - A. The depth to andesite or older rock has been calculated from the formula given above. It must be borne in mind that there could be large errors in the dips and thicknesses shown for the various sedimentary formations. However, it is felt that the section gives a general indication of actual conditions.

C. Gravity "low".

Within the gravity "low" area, between Toprain Hill and Shotover Creek, Shell (Queensland) Development Pty.Ltd. had previously drilled nine shallow holes which located a very slight anticlinal structure, the axis of which almost coincides with that of the gravity "low". The drilling information suggested that this might be a continuation of the Comet Anticline. Over an anticline in sedimentary rocks

lighter than the basement rocks, one would expect a gravity maximum rather than a minimum. It is postulated, therefore, that this gentle anticlinal structure is a surface feature only, and that at greater depth the folding is synclinal. Similar occurrences have been proved in other parts of Australia.

Using similar assumptions to those used for station 53, the thickness of sedimentary rocks at the centre of this zone of low gravity should be between 7,500 and 10,200 feet.

5. CONCLUSIONS AND RECOMMENDATIONS

A gravity "high" which is believed to coincide with the axis of the Comet Anticline has been traced over a distance of about 30 miles. Additional gravity traverses would be required to plot its position more accurately, to locate extensions of the feature northward or southward, and to confirm possible gravity closures along the structure. Such closures might indicate anticlinal structures; such structures are favourable for the accumulation of oil or gas if other conditions are also favourable.

The present survey does not allow possible drilling targets to be suggested. It seems likely, however, that the gravity "high" (and therefore the anticline) persists into a region where the sedimentary sequence is much thicker than that immediately east of Comet. The thicker sedimentary sequence might be expected to include the older Permian horizons, particularly the "Cattle Creek Group".

6. REFERENCES

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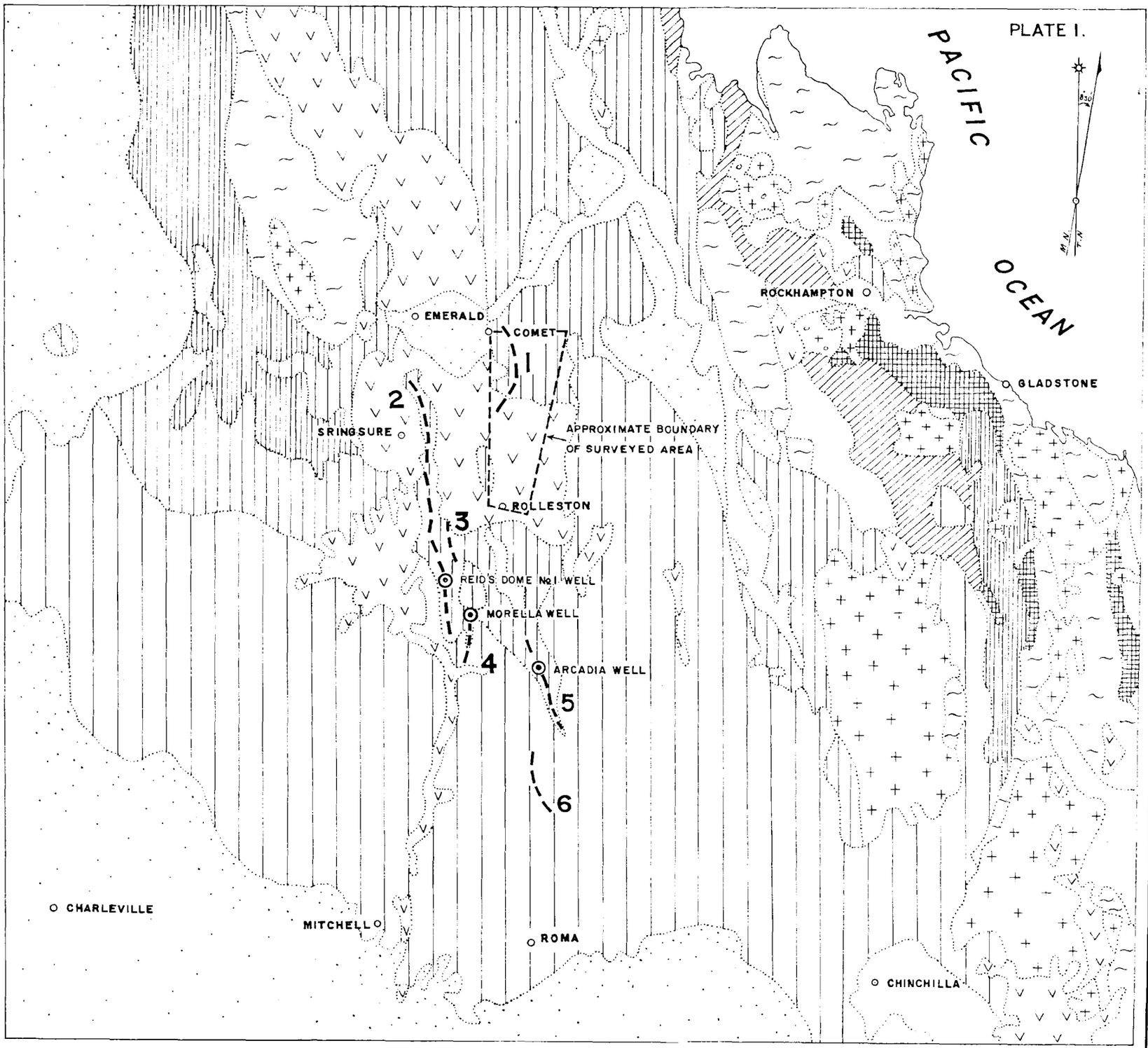
PLATE I.



LEGEND

	QUATERNARY ALLUVIUM		UPPER PALAEOZOIC, UNDIFFERENTIATED
	TERTIARY VOLCANICS, MAINLY BASALT		DEVONIAN
	OTHER TERTIARY		LOWER PALAEOZOIC, UNDIFFERENTIATED
	MESOZOIC		GRANITE, ETC.
	PERMIAN		SERPENTINE
	CARBONIFEROUS		AXIS OF ANTICLINE (SEE FOOTNOTE)
1	COMET ANTICLINE	4	MORELLA ANTICLINE
2	SEROCOLD ANTICLINE	5	ARCADIA DOME
3	CONSUELO ANTICLINE	6	HUTTON DOME

NOTE: COMET ANTICLINE BASED ON GRAVITY RESULTS. OTHERS AFTER E.A. WEBB, 1956 AND SHELL (QUEENSLAND) DEVELOPMENT PTY. LTD. REPORT 1940-1951.

COMET-ROLLESTON 1956 GRAVITY SURVEY
GEOLOGY & MAJOR STRUCTURAL FEATURES

SCALE IN MILES

40 20 0 40 80 120

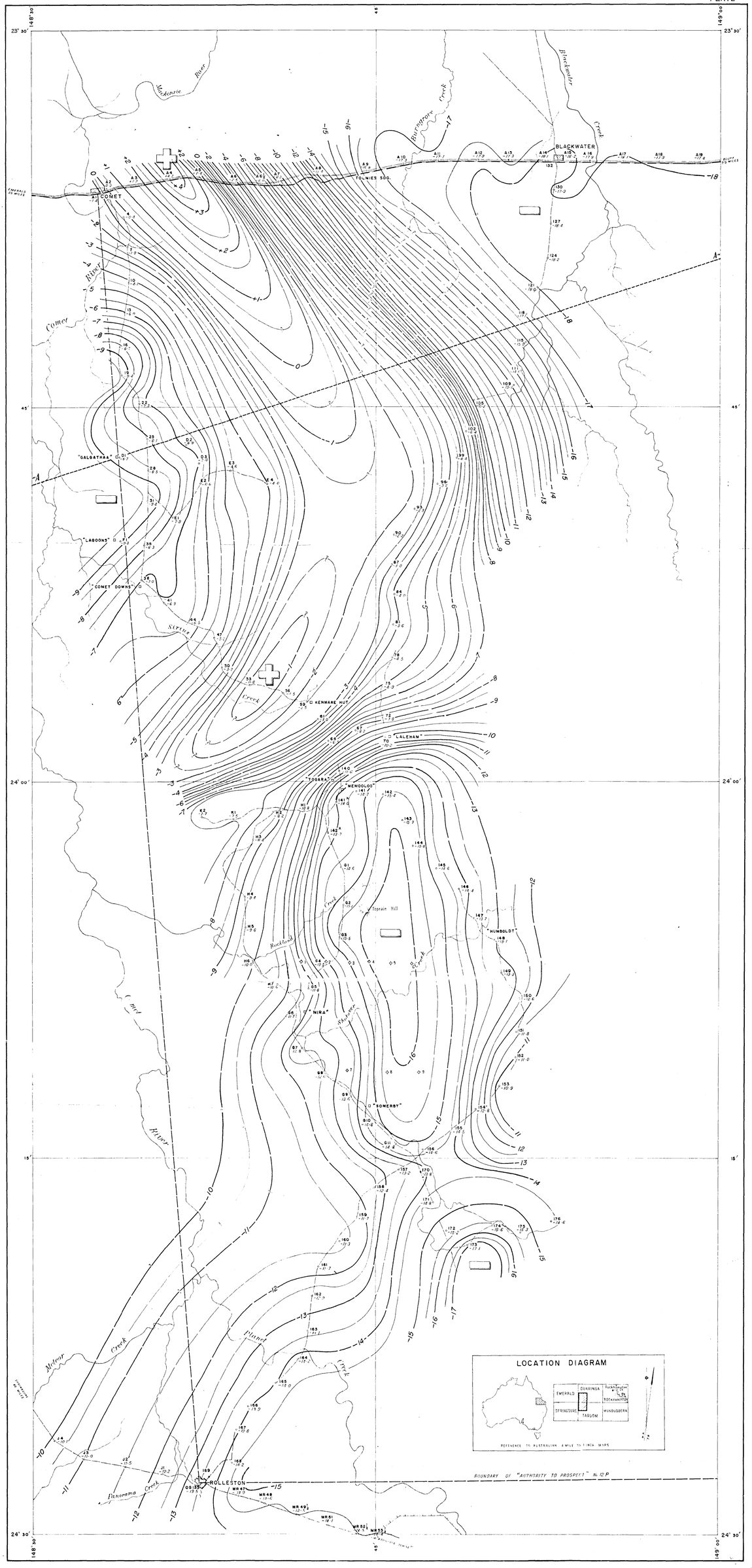
Hugh Oldham

GEOPHYSICIST

REFER TO GEOLOGICAL MAP OF QUEENSLAND, 1953.

GEOPHYSICAL SECTION, BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS F55/B2-27

(Ex G229-3)



LEGEND

- Gravity station
- 165 " " number
- -12·2 " " value
- (Uncertain contours shown broken)
- Bore hole (position approximate)
- Gravity high anomaly
- " low "

SCALE IN MILES

2 0 2 4 6 8

CONTOUR INTERVAL 0·5 MILLIGAL

Hugh Aldham
GEOPHYSICIST

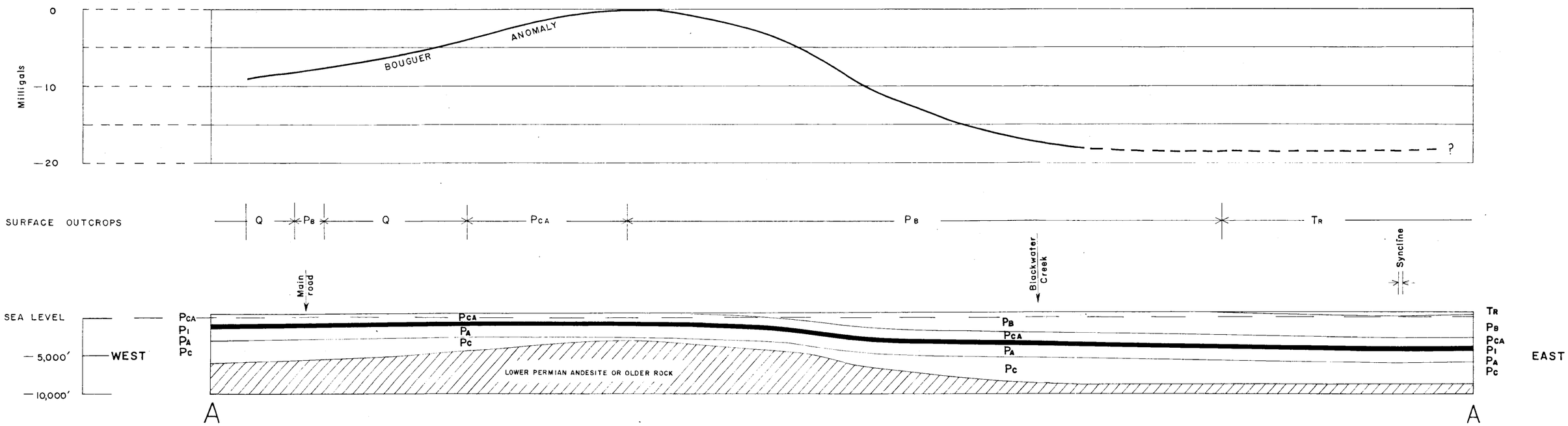
REVISED NOV. 1957.

SEMI-DETAILED GRAVITY SURVEY (1956), COMET – ROLLESTON AREA, QLD.

BOUGUER ANOMALY MAP

(AUTHORITY TO PROSPECT No 12P)

Geophysical Section, Bureau of Mineral Resources, Geology and Geophysics F55/B2-29 (EX G229-5)



LEGEND

	Q	ALLUVIUM
TRIASSIC	TR	CLENATIS SANDSTONE
PERMIAN	PB	BANDANNA FORMATION
"	PCA	CATHERINE SANDSTONE
"	PI	INGELARA FORMATION
"	PA	ALDEBARAN SANDSTONE
"	PC	CATTLE CREEK GROUP

DEPTH TO BASEMENT IS INFERRED FROM BOUGUER ANOMALY.

GEOLOGICAL INFORMATION FROM "GEOLOGY OF AUTHORITY TO PROSPECT NO. 12P" BY W.D. MOTT, 1955.

HORIZONTAL SCALE IN MILES

2 1 0 2 4 6 8 10

VERTICAL SCALES AS SHOWN

SEMI-DETAILED GRAVITY SURVEY (1956), COMET-ROLLESTON AREA, QLD.

BOUGUER ANOMALY AND GENERALISED GEOLOGICAL SECTION A-A

Hugh Oldham
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