COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

PETROLEUM SEARCH SUBSIDY ACTS

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WIRA ANTICLINE GRAVITY SURVEY, PAPUA, 1959

BY

THE PAPUAN APINAIPI PETROLEUM COMPANY LIMITED

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COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

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Secretary: H. G. RAGGATT, C.B.E.

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FOREWORD.

In 1959 the Commonwealth Government enacted the Petroleum Search Subsidy Act 1959, under which companies proposing to drill for new stratigraphic information or to carry out either geophysical or bore-hole surveys in search of petroleum could be subsidised for the cost of drilling or of survey operations approved by the Minister for National Development.

The Bureau of Mineral Resources, Geology and Geophysics is required, on behalf of the Department of National Development, to examine the applications, maintain surveillance of the operations and in due course publish the results.

A gravity survey was carried out under the Petroleum Search Subsidy Act 1959 over the Wira Anticline of Papua by The Papuan Apinaipi Petroleum Company Limited. This Publication deals with that survey and contains the information furnished by The Papuan Apinaipi Petroleum Co. Ltd and edited in the Geophysical Branch of the Bureau of Mineral Resources. The final geophysical report was written by K.H. Morgan, Geologist, under the supervision of D.M. Traves, Chief Geologist, both of Mines Administration Pty Ltd. The methods of carrying out the gravity survey and the results obtained are presented in detail.

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ILLUSTRATIONS.

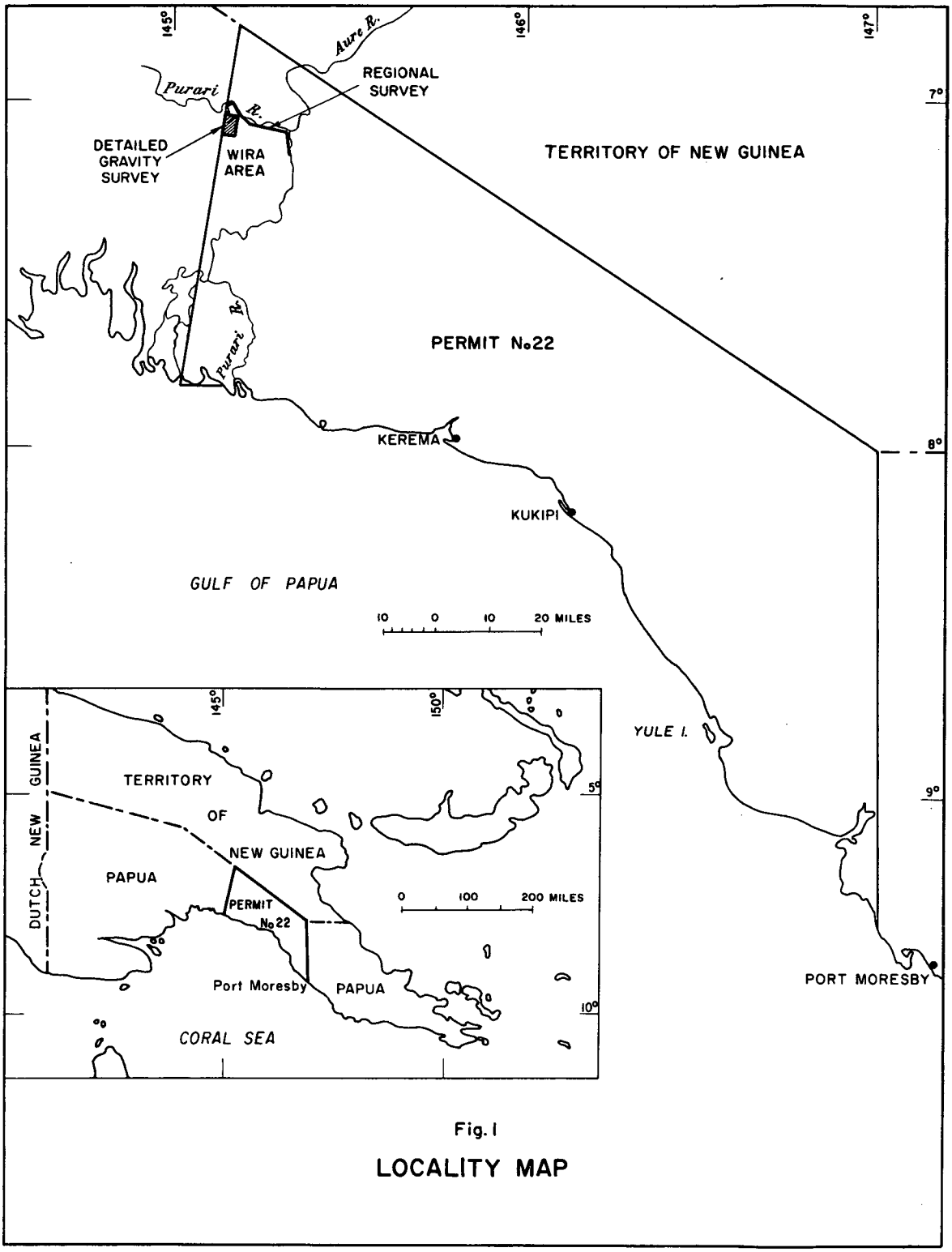

Fig. 1

LOCALITY MAP

ABSTRACT.

This report describes two gravity surveys conducted by Mines Administration Pty Ltd for The Papuan Apinaipi Petroleum Co. Ltd during the period June 1959 to October 1959. The purpose of the first survey, a detailed gravity survey over the Wira Anticline, was to confirm closure in the Wira Culmination and to obtain information on the possibility of limestone occurring in the sediments below the culmination. The other survey, a regional gravity traverse from the Wira Anticline down the Purari River, was expected to extend the gravitational trends shown in the Purari area by a previous survey.

No gravity anomaly was established that could be correlated with the surface geological structure of the Wira Anticline. The results indicate that the largest negative anomaly occurs east of the Purari River, below the Aure Scarp. Starkey has drawn similar conclusions from his gravity work which was carried out southwards along the Purari and Vailala Rivers in 1958.

1. INTRODUCTION.

The Wira area (see Figure 1) is situated in the north-western corner of Permit 22, Papua, and has an approximate geographical position of Latitude 07° 06' S, Longitude 145° 07' E. Two gravity surveys were carried out in this area by Mines Administration Pty Ltd for The Papuan Apinaipi Petroleum Co. Ltd during the period June 1959 to October 1959. One was a detailed gravity survey over the Wira Anticline and the other a regional gravity traverse from the Wira Anticline down the Purari River.

The survey party consisted of K. H. Morgan (geologist) and N. Bailey (field assistant). Gravity reductions were made by J. E. Burbury. Assistance in the tie-in to the gravity value at the regional station was given by L. J. Starkey.

2. OBJECTIVES OF THE GRAVITY SURVEY.

Detailed geological mapping in the Wira Creek area in 1959 indicated a small surface culmination on the Wira Anticline, a north-east trending fold between the Pide and Mena Basins. It was thought that high density limestone rocks may have formed early in the folding history on this structural divide between the two basins and that such limestone may be present at moderately shallow depth below the Wira Culmination. Considerable density contrast would be expected between limestone and the exposed argillaceous sediments. However, later regional traverses indicated that the culmination is contained within a fault slice along the Mena Fault, and was probably formed by differential movements along the boundary faults.

The objectives of the detailed gravity survey were to confirm closure in the Wira Culmination and to obtain information on the possibility of limestone in the sediments below the culmination. The regional gravity traverses were expected to extend the gravitational trends of the Purari area shown by L. J. Starkey (1958) in the Mines Administration Pty Ltd unpublished report No. Papua /22/47 "Gravity investigations Purari-Vailala region, Permit 22".

3. SUMMARY OF REGIONAL GEOLOGY.

(a) Stratigraphy.

I. Cretaceous:- 1600+feet of Lower Cretaceous shale which has been measured in the Kereru Range area and in the Wana Well, may underlie the Wira area.

500 feet of Middle Cretaceous rock is indicated in the Paw Creek area west of the Eri Anticline in a 1:100,000 map, by S.W. Carey (1942). This map is printed in an unpublished Oil Search Report LJ "Report on the geology of the area between the Lower Purari and Vailala Rivers". The Middle Cretaceous rocks are thought to be in a more arenaceous facies than the Lower Cretaceous shale.

II. Eocene:- 500 feet of Eocene radiolarian claystone recorded in the Kereru Range area may also extend to the subsurface in the Wira area, and Eocene limestone about 700 feet thick is exposed on the upthrow side of the Aure Fault. Eocene limestone also crops out on the upthrow side of the Pio Fault in Tevi Creek.

III. Oligocene/Miocene:-

(i) Oligocene-Lower Miocene. ("Kereruan" stage)

About 700 feet of "Kereruan" limestone occurs in the Kereru Range area and 800 feet of foraminiferal limestone, probably "Kereruan", has been measured in Tseri Creek.

(ii) Lower Miocene ("Taurian")

1,500 feet of Lower Miocene calcareous orbulina rocks has been measured in the Puri area and the basal part of a 1500 foot section of a grey argillaceous limestone in Tseri Creek may be of the same age.

(iii) Middle Miocene ("Ivorian")

Approximately 500 feet of marly rock is recorded overlying the "Taurian" limestone in the Puri area, and at least 4000 feet of thinly bedded calcareous sandstone, siltstone, mudstone, and foraminiferal limestone measured on the Eri Anticline is from lower Upper Miocene to upper Middle Miocene age.

(iv) Upper Miocene ("Muruan")

5500 feet of Upper Miocene mudstone with minor sandstone, siltstone, and calcareous intervals was measured by previous workers in the Puri-Pide area.

The following threefold division of the Upper Miocene in the Wira area is now recognised:

a lower arenaceous section of thickness greater than 2000 feet, the basal part of which extends into Middle Miocene, followed upwards by,

6000 feet of grey mudstone with minor carbonaceous, calcareous sandstone and siltstone intervals. This unit includes calcareous sandstone beds which are of value as marker beds in photo interpretation and field work.

An upper 2000 feet of interbedded sandstone and mudstone.

(b) Structure.

The area lies on the western margin of the Aure Trough and is complexly folded and probably thrust faulted. The following tectonic provinces, modified after Carey (unpublished report, 1942) are recognised:

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* Footnote by the Bureau of Mineral Resources:
The stage names "Kereruan", "Taurian", "Ivorian" and "Muruan" refer to time-rock subdivisions of the Miocene of western Papua, used by Australasian Petroleum Co. Pty Ltd.

(i) Purari Quaternary Depression - This forms the south-western edge of the Papuan Geosyncline which laps on to the Australian Shelf.

(ii) Synclinal Zone, which includes the following zones nominated by Carey:

1. Folded belt including the Orloli Anticline.
2. Faulted anticlinorium with the Kuku Fault the main structure.
3. Synclinal basins including the Pide, Mena and Kuku Basins.
4. A faulted anticlinorium of which the Bevan Fault is the principal structure.
5. Aure - Ekiere Fault System.

The Wira anticlinal ridge can be considered continuous with Zone (4).

4. DESCRIPTION OF METHOD AND EQUIPMENT.

A Hilger and Watts No. 1 microptic theodolite was used for the detailed topographical survey, a Wild (TO) compass theodolite for regional traverses on land, and an altimeter for height control of regional traverses on the Purari River.

Heavy and almost continuous rainfall in July and August made theodolite surveying and gravity meter reading extremely trying. Survey instruments had to be frequently dismantled to eliminate condensed water. It was found that the switch and battery circuit on the Worden meter was useless in extremely wet, humid conditions. The switch would short on touch and had to be dismantled and dried at every station. The life of the small batteries was very short and when they were wet they gave out a very weak current. To continue the survey, the switch battery system was completely removed and larger 1.5 volt waterproof torch-batteries were coupled in a reliable circuit.

A topographic base was established over the Wira Anticline using the stadia method. Backsight-foresight and instrument check methods were used. The accuracy in feet is estimated as within $0.5\sqrt{m}$ for vertical closure and within $10\sqrt{m}$ for horizontal closure, where m is the length of the traverse in miles. Rapid stadia method was used to tie the survey to the Mid-Purari Astrofix which was established by Oil Search Ltd a little upstream from the mouth of Hou Creek on the Purari River, and this served as a base for the regional gravity survey. Accuracy is probably about 15 to 25 feet per mile horizontal closure and 1 foot per mile vertical closure. This survey was tied at intervals to the compass chain survey carried out previously to tie the Wira geological survey to the Purari River base.

Forty gravity stations were established at approximately 1500-foot intervals in the detailed survey and sixteen stations at 2-mile intervals in the regional survey. A leap-frogging technique was adopted for reading the gravity meter and closure was made within two hours.

Regional gravity stations on the Purari River were positioned from air photos. Relative position is known from these to within 200 feet. The height control was by altimeter, using altimeters for establishing a diurnal curve, and the expected accuracy was $\pm$ 15 feet. However, since readings were taken with reference to the level of the Purari River, and the river has a gentle gradient of approximately 1.5 feet per mile, the accuracy of each reading is improved to $\pm$ 10 feet.

The regional traverse was plotted on a slotted template compilation at airphoto scale (approximately 1:40,000) and reduced to a standard scale.

The gravity survey was carried out using Worden gravity meter No. 216. Its sensitivity as determined at the time of manufacture was 0.09095 milligals (mgal)/scale division. This meter was checked against calibration stations in Brisbane prior to the survey. The differences in scale divisions determined between Mines Administration Pty Limited basement station and the trigonometrical station on Mt. Coot-tha were :-

23rd May 1959	-	655.4
13th October 1959	-	655.6

These checks were made prior to the establishment of a standard calibration range in Brisbane by the Bureau of Mineral Resources (*).

Meter drift throughout the survey was normal. The detailed gravity survey on the Wira Anticline was tied by a regional traverse to the Mid-Purari Astrofix. The detailed gravity survey was then extended down the Purari River to 4 miles below the Tsubu Junction and tied to the regional gravity survey, Station 20 (see Plate 2), made by Starkey in 1958. Station 20 is, in turn, tied to the station established by the Bureau of Mineral Resources at Jackson Aerodrome, Port Moresby.

Gravity stations on the Wira Anticline were marked by a 2" x 2" x 12" wooden peg and the number blazed on a suitable tree. Regional stations were made at easily identifiable landmarks at approximately 2-mile intervals.

5. REDUCTION OF RESULTS.

Gravity meter readings were converted to milligals (using the manufacturer's sensitivity of 0.09095 milligals per scale division), to obtain observed gravity values. Latitude corrections were determined from the formula based on the International Ellipsoid.

Although most of the surface mudstones have a density of 1.9 g/c.c, rocks below the surface are more calcareous, and the average density has been estimated as 2.0 g/c.c. This gives the value for the Bouguer correction factor of 0.06854 mgal/ft which was used throughout the survey.

(*) Footnote by the Bureau of Mineral Resources:

The gravity interval between the stations used for calibrating the Worden gravity meter No. 216 was subsequently (January 1960) determined by the Bureau of Mineral Resources as 59.15 mgals. (Stations M.A.1 and B.C.S.2). This leads to a mean sensitivity of 0.09024 mgal/scale division.

Terrain corrections were not considered necessary for the results of the regional gravity survey but, for the results of the detailed gravity survey, terrain corrections were made from a contour map. The contour map was prepared for this purpose by using the gravity base traverse, additional stadia topographic shots, and data from the detailed compass, chain, and abney-level survey carried out during the geological survey prior to the gravity survey. The maximum terrain correction applied was 0.26 milligals.

The accuracy of the survey can be estimated by considering the respective accuracies of the gravity observations, the latitude correction, and the elevation and terrain corrections. These are estimated to be respectively 0.05, 0.02, 0.07 and 0.02 milligals for the detailed survey and 0.05, 0.04 and 0.70 milligals for the regional traverse.

These give estimated values for the errors of :-

0.09 milligals for the detailed gravity survey.

0.70 milligals for the regional gravity traverse.

6. INTERPRETATION AND CONCLUSIONS.

Presentation of Results.

The results of the survey have been plotted on two sheets. Plate 1 shows the Bouguer gravity values, at a contour interval of 1 milligal, plotted over the Wira Anticline. Plate 2 shows the Bouguer gravity values for the regional gravity traverse. No attempt has been made to contour the Bouguer values for the regional traverse until an assessment can be made of all previous work available.

A "Table of Principal Facts" has been filed in the Bureau of Mineral Resources, Geology and Geophysics, and is available for future reference.

Wira Anticline Detailed Gravity Survey.

Gravity closure was not determined for the geological culmination. The main feature of the Bouguer gravity map is a regional gradient from south-west to north-east over which the Bouguer values drop irregularly through 9 milligals in approximately 2 miles. The main irregularity in the gradient occurs as a nose around Traverse O where a marked flattening of the gradient is present. On the east and north side of this flattening, a very steep gradient occurs over approximately 1000 feet. This gradient is steepest on the eastern side where Bouguer values drop 5 milligals in approximately 1000 feet. A small gravity low occurs around Station V9 in the southern part of the area.

The following interpretations are possible :-

(a) The north-west trend of the Bouguer contours follows the structural trend of the Aure Trough.

(b) The flattening of the regional gradient in the centre of the area could have some relation to the Wira Anticline ridge.

However, the main development of this feature is to the east of the geological structure and its trend is eastwards away from the north-east surface geological trend.
A residual gravity culmination would be offset to the east of the geological surface culmination and have a pronounced eastward trend.

The steep gravity gradient associated with the flattening of regional gradient is likely to be an expression of a fault downthrown to the east. The 5-milligal drop in 1000 feet near Stations L8 to L13 could represent a fault with a minimum vertical displacement of approximately 1000 feet. A fault with a downthrown side to the east, as shown on Plate 1, was deduced from surface mapping. However, the trend of the steep gravity gradient shows no resemblance to that of the mapped fault.

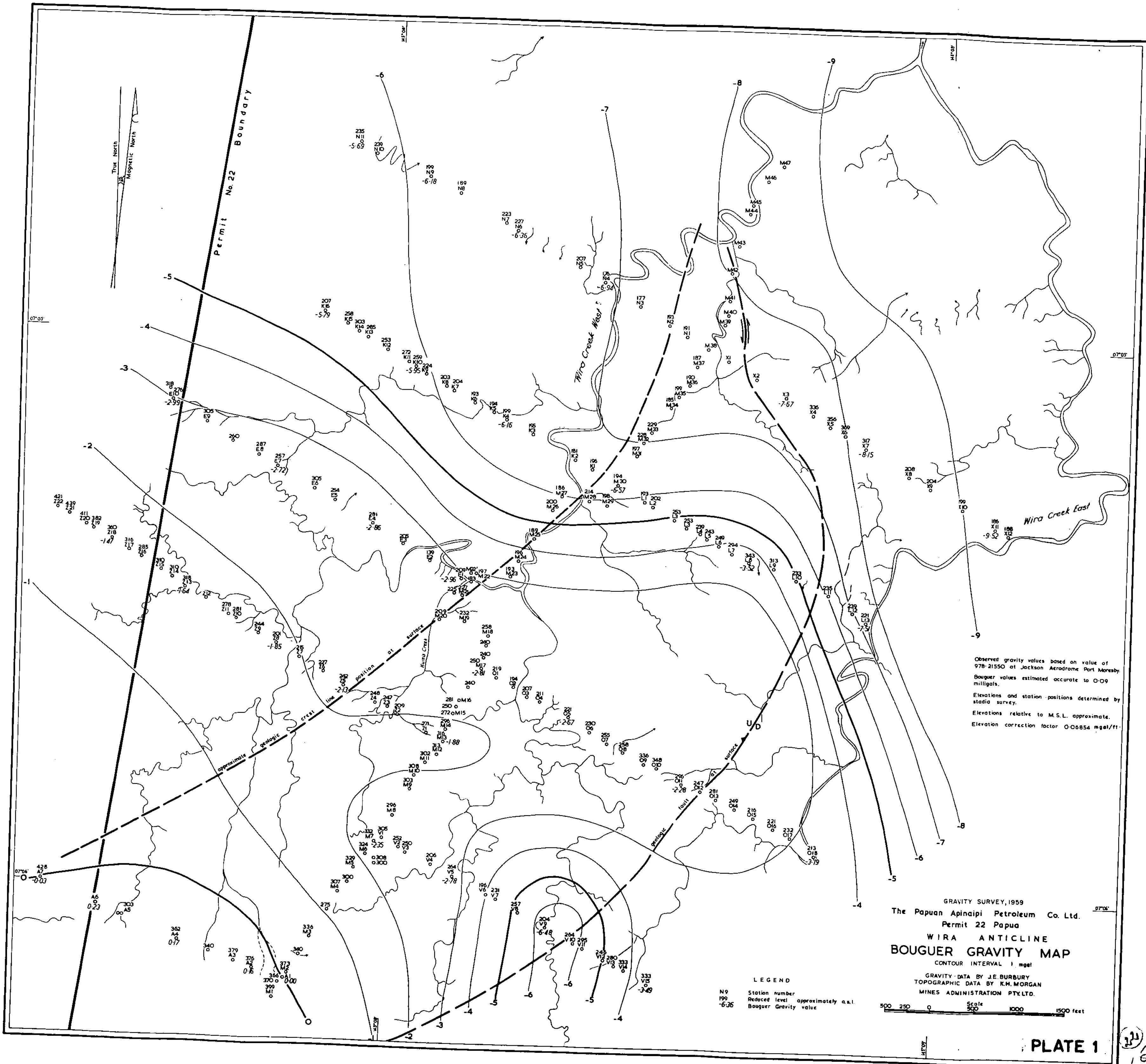
No depth estimation was attempted for the following reasons:-

(i) Regional geological traverses indicate that a sharp density contrast between pure limestone and non-calcareous rocks is unlikely.

(ii) No gravity anomaly was established that could be correlated with the surface geological structure of the Wira Anticline.

Regional Gravity Traverse.

The north-east gradient observed in the area of the detailed survey continues eastward with Bouguer values dropping from − 6.2 mgal in the Wira area to − 26.8 mgal at Station 11 below the Purari - Tsubu River junction. A general north-north-west to north trend is indicated along the Aure Scarp (Stations 10 to 12). A north-west trend is probable in the centre of the regional traverse. The results indicate that the largest negative anomaly occurs east of the Purari River, below the Aure Scarp. Starkey has drawn similar conclusions from his gravity work which was carried out southwards along the Purari and Vailala Rivers.


True North
Magnetic North
Permit No. 22 Boundary
Wira Creek West
Wira Creek East
Kuma Creek
approximate geologic crest line position at surface
geologic fault at surface
U
D
Observed gravity values based on value of 978·21550 at Jackson Aerodrome Port Moresby.
Bouguer values estimated accurate to 0·09 milligals.
Elevations and station positions determined by stadia survey.
Elevations relative to M.S.L. approximate.
Elevation correction factor 0·06854 mgal/ft·
GRAVITY SURVEY, 1959
The Papuan Apinaipi Petroleum Co. Ltd.
Permit 22 Papua
WIRA ANTICLINE
BOUGUER GRAVITY MAP
CONTOUR INTERVAL 1 mgal
GRAVITY DATA BY J.E. BURBURY
TOPOGRAPHIC DATA BY K.H. MORGAN
MINES ADMINISTRATION PTY. LTD.
LEGEND
N9 Station number
199 Reduced level approximately a.s.l.
-6·36 Bouguer Gravity value
Scale
500 250 0 500 1000 1500 feet
07°05'
07°06'
PLATE 1

GRAVITY SURVEY, 1959

The Papuan Apinaipi Petroleum Co. Ltd.

Permit 22 Papua

WIRA - PURARI AREA

REGIONAL GRAVITY TRAVERSE

K.H. MORGAN

MINES ADMINISTRATION PTY. LTD.

Scale

1 3/4 1/2 1/4 0 1 miles

Observed gravity values based on value of 978·21550 at Jackson Aerodrome Port Moresby.

Bouguer Gravity values estimated accurate to 0·71 milligals.

Elevations determined by altimeter survey and relative to M.S.L. approximate.

Station positions plotted on photo mosaic.

Elevation correction factor 0·06854 mgal/ft

LEGEND

9 Station number

-22·0 Bouguer Gravity value (mgal)

Eri River

UU Creek

2 o -8·8

3 o -9·3

1 o -9·3

4 o -11·6

PURARI RIVER

Mid Purari Astrofix

Base o -9·6

Lat. 07° 02' 24·2" S

Long. 145° 07' 47·4" E

d1 o -7·7

Howi Creek

5 o -14·4

6 o -17·1

Baha Creek

Mid River

Taeri River

7 o -18·6

Eri Creek

d2 o -6·2

Wira West

d3 o -6·9

Wira East

8 o -22·3

Sia Creek

9 o -22·0

Aure or Tsubu River

10 o -24·5

Wharo Creek

PURARI RIVER

11 o -26·8

12 o -26·6

Iava Creek

(Starkey 1958)

20 o -26·5

True North

Magnetic North

145°10'

145°15'

145°20'

07°00'

07°02'

07°04'

07°06'

PLATE 2