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RECONNAISSANCE HELICOPTER GRAVITY SURVEY, CANNING BASIN, W.A., 1968

by

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SUMMARY

In 1968, the Bureau of Mineral Resources extended the reconnaissance helicopter gravity coverage of Australia by conducting a survey in northern Western Australia. The 'cell' method of flying was used to establish 2523 new gravity stations over all or parts of nineteen 1:250 000 map sheets, which cover an area roughly bounded by the 20th and 24th parallels and the 121st and 129th meridians. The survey completed the systematic gravity coverage of the Canning Basin, thus permitting full delineation to be made of gravity features which were only partly defined from previous work in the basin.

A broad gravity depression over the southern Canning Basin probably reflects the presence of thick sediments. Within this depression, local gravity minima indicate two possible basement troughs. The gravity depression is bounded on the north, southwest, and east by gravity ridges. The gravity ridge in the north is attributed to a basement ridge and/or sedimentary structure. The gravity ridge in the southwest correlates with the Proterozoic Paterson Province to the north, and with a basement ridge inferred from magnetic and seismic results to the south. This basement ridge may form the boundary between the Canning Basin and the mainly Proterozoic Officer Basin. The western flank of the gravity ridge in the east correlates with a basement rise interpreted from seismic and magneto-telluric evidence.

In the northeast of the survey area, in the marginal area between the Canning Basin and the Granites Tanami Block is a T-shaped gravity depression. The eastern-trending part of the depression may reflect low density basement rocks, but geologic and geophysical evidence suggest that its north-trending central part is due to a basement trough.

1. INTRODUCTION

During 1968 the Bureau of Mineral Resources (BMR) extended the helicopter gravity reconnaissance survey of Australia by conducting two surveys, one in southern Queensland and northern New South Wales (Darby, 1969), and another in Western Australia. Both surveys were conducted under contract to BMR by Wongela Geophysical Pty Ltd. This report describes the results over that part of the latter area (Plate 1) which falls within the Canning Basin. The western part of this area, over the Precambrian shield, is discussed in greater detail by Fraser (1974).

The survey in Western Australia was planned to cover the south-eastern part of the Canning Basin to investigate the major structural configuration of this part of the Basin. The survey completed the systematic gravity coverage of the Canning Basin. Several gravity surveys had been conducted previously within the survey area but this was the first systematic survey of the area.

Access throughout the area was difficult, being limited to a few rough bush tracks and old seismic traverse lines. Supplies generally had to be flown in from Alice Springs. Progress on the survey was slow owing to a high percentage (42%) of unserviceability of the helicopters and also to two extended periods of heavy rainfall which made travelling through the area impossible.

All survey methods and statistics are included in Appendices 1, 2, and 3 at the end of this report.

2. GEOLOGY AND PREVIOUS GEOPHYSICS

The geology of the survey area is illustrated in Plate 2. Stratigraphic sections penetrated by bore-holes are tabulated in Appendix 4. The locations of previous geophysical surveys are shown on Plates 3, 4, and 5. Magnetic intensity contours and interpreted depths to magnetic basement are shown on Plates 6 and 7 respectively.

Only a brief introduction to the geology is presented in this chapter. Detailed geological and geophysical information of relevance to the gravity interpretation is discussed in Chapter 3 in association with each gravity province. The main references for geology are papers by Veevers & Wells (1961) and Casey & Wells (1964). Rattigan (1967) and Smith (1968) discuss the structural patterns in the Canning Basin with special reference to the Fitzroy Trough.

The survey area covers the southern and eastern parts of the Canning Basin and the adjacent basin margins. Surface geology within the survey area largely consists of surficial Quaternary deposits discontinuously overlying subhorizontal Permian and Mesozoic strata. Lower Proterozoic metasediments and granites of the Arunta and Granites Tanami Blocks crop out in the east, and Lower Proterozoic metasediments and granites of the Paterson Province in the west of the survey area.

3. DISCUSSION OF GRAVITY RESULTS

Bouguer anomaly contours are shown on Plate 8 at a scale of 1:2 534 400. A rock density of 2.2 g/cm^3 was chosen for Bouguer corrections, in keeping with current BMR practice.

The contoured area has been divided into a number of regional gravity provinces. These cover large areas of fairly simple shape in which the gravity field is characterized by uniformity of contour trend and/or Bouguer anomaly level. Sub-divisions of a province are termed 'units'.

In naming these provinces and units, the descriptive terms 'high', 'low', 'ridge', 'shelf' and 'complex' have been used. The terms high and low describe areas in which the Bouguer anomaly level is greater or less respectively, than in surrounding areas. A ridge is an elongate high. Shelf and complex both refer to broad areas of intermediate Bouguer anomaly level, but the contour pattern of a complex is much more disturbed than that of a shelf. The names of provinces and units are generally derived from places names or the names of geographical features. Names used for features extending from previous survey areas into the present survey area have been retained.

The names of provinces and units totally or partly within the survey area are listed in Table 1.

TABLE 1. Gravity Provinces and Units

Province	Reference	Unit	Reference
Munro Regional Gravity Shelf	Darby & Vale, 1969	Joanna Gravity Ridge	Darby & Vale, 1969
South Canning Regional Gravity Low	Darby & Vale, 1969	Sahara Gravity Shelf Reeves Gravity Low	New New
Gibson Regional Gravity Low	Darby & Vale, 1969	Runton Gravity Low	Lonsdale & Flavelle, 1963
Anketell Regional Gravity Ridge	Darby & Vale, 1969	Paterson Gravity Ridge Warri Gravity Ridge	New Lonsdale & Flavelle, 1963.
Fitzroy Regional Gravity Complex	Darby & Vale, 1969	Broome Gravity Ridge	Darby & Vale, 1969
Cobb Regional Gravity Low	Darby & Vale, 1969		
Angas Regional Gravity High	New		
Papunya Regional Gravity Ridge	Darby & Vale, 1969		
Willowra Regional Gravity Ridge	Darby & Vale, 1969		
Pedestal Regional Gravity Low	Darby & Vale, 1969	Yam Gravity Low Moody Gravity Low Thornton Gravity Low	New New New
Tanami Regional Gravity Complex	Darby & Vale, 1969		

Munro Regional Gravity Shelf

This province, an area of moderate Bouguer anomaly variation, has been divided into three units. The southernmost unit, the Joanna Gravity Ridge, extends into the northwest corner of the survey area. It is an east-trending Bouguer anomaly ridge with several closed maxima where Bouguer anomalies exceed -20 mGal. The gravity ridge closely corresponds to a zone of high magnetic intensity (Plate 6). The gravity and magnetic features could be due to a dense and magnetically-active zone within the basement, a lateral density increase caused by sedimentary structure, or a high-standing basement ridge. Seismic results (Plates 9 and 10) (French Petroleum, 1967) indicate an anticlinal fold in the sediments coincident with the gravity ridge in northwest JOANNA SPRINGS* suggesting that the gravity ridge is at least partly caused by a basement ridge and/or raising of dense sediments in the core of the anticline.

South Canning Regional Gravity Low

The survey results indicate the full extent of this province which had previously been defined only in the north. The province is a broad area of relatively low Bouguer anomaly level and smooth gravity relief extending over the southwestern part of the Canning Basin including the Joanna Springs and Kidson Sub-basins. Within the survey area, the province is divided into two units on the basis of a difference in Bouguer anomaly level: the Sahara Gravity Shelf to the northwest, and the Reeves Gravity Low to the southeast.

Bouguer anomalies in the Sahara Gravity Shelf generally range from -30 to -40 mGal. Local depressions of 15 to 30 mGal relief occur in eastern JOANNA SPRINGS and central DUMMER. The surface geology consists of sand and salt lakes with occasional outcrops of Mesozoic sediments. Subsurface information from boreholes Kempfield No. 1 and Sahara No. 1 (Appendix 4) indicates a thickening of the sedimentary section to the south. This is supported by seismic evidence (French Petroleum Co., 1967). The magnetic contours (Plate 6) show a generally quiet pattern suggesting that a thick sedimentary section overlies magnetic basement.

* Throughout this report, capital letters will be used to denote the names of 1:250 000 Sheet areas.

Bouguer anomaly values within the unit are, on average, about 30 mGal lower than values in the bordering Anketell Regional Gravity Ridge to the west. This Bouguer anomaly difference could reflect either a sedimentary thickness change of 2000 to 3000 m between the two areas, or a regional change in basement density. The northern part of the Anketell Regional Gravity Ridge correlates with a Lower Proterozoic mobile zone (Fraser, 1974), known to be of higher density than the shield area immediately to the west. This implies that the decrease in Bouguer anomaly across the eastern boundary of the Anketell Regional Gravity Ridge is due to a decrease in basement density. However, the Phanerozoic sedimentary section thickens from zero in PATERSON RANGE to more than 2000 m at Sahara No. 1 in northwest SAHARA. Sedimentary thickening must therefore cause at least part of Bouguer anomaly decrease assuming that the sediments have a lower density than the basement.

The Reeves Gravity Low is a broad Bouguer anomaly depression covering the central part of the survey area. Bouguer anomalies are generally in the range -40 to -70 mGal. The most noteworthy features of the surface geology are scattered outcrops of Permian, Cretaceous, and undifferentiated Mesozoic sediments of the Canning Basin. No structures have been mapped at the surface. Two deep boreholes, Kidson No. 1 in southwest URAL, and Wilson Cliffs No. 1 in central northern WILSON (Appendix 4) have been drilled within the unit. Both indicate sedimentary thicknesses in excess of 3500 m. Kidson No. 1 bottomed in Lower Ordovician sediments after passing through thick Permian and Devonian sequences. Wilson Cliffs No. 1 bottomed in Cambrian or Upper Proterozoic sediments; Permian and Devonian sequences were much thinner than in Kidson No. 1.

Magnetic contours (Plate 6) show no well defined pattern, and anomalies are of small amplitude and randomly distributed. Magnetic basement contours (Plate 7) indicate a northwest-trending trough containing a 9000 m sedimentary sequence extending from central SAHARA to southeast URAL.

Limited seismic work has been conducted over the area of the unit (Plate 5). The results are illustrated in Plates 11 and 12. In URAL and MORRIS reflections dip mainly to the northeast into a northwest-trending trough, the Kidson Basin. The full horizontal extent of the trough was not determined as only one seismic traverse crossed the trough perpendicular to its strike. Basement depths range from 5000 m in central URAL down to 1000 m in northwest MORRIS close to the southern margin of trough. The southern margin trends northwest and appears to be fault-controlled at lower horizons. The northern margin is not defined but its strike appears to be easterly rather than northwesterly as in the south. A seismic survey in WILSON and RYAN (Plate 12) showed the dominant structural trend to be north-northeast with a general westerly dip steepening to the east. No reflectors deeper than 1000 m were observed. The results of a magneto-telluric survey (Plate 13) also indicate a north-northeasterly structural trend with westerly dip on WILSON and RYAN. A resistive basement depth of about 10 000 m was measured in southwest WILSON.

An examination of the gravity results in relation to seismic and magnetic evidence suggests that the Reeves Gravity Low corresponds to an area of thick sedimentary section. The decrease in basement depth from central URAL to northwest MORRIS, as indicated by seismic results, is accompanied by a 35 mGal regional increase in Bouguer anomaly. A local basement depression in southwest URAL and northwest MORRIS coincides with a local gravity depression. In WILSON and RYAN the eastern margin of the Reeves Gravity Low corresponds to the eastward rise of the basement indicated by both seismic and magneto-telluric evidence.

Assuming that variations in gravity level reflect variations in depth to basement the following inferences can be made. The basement trough in central URAL is a northwest-trending feature which ends in northwest URAL. The basement depression in the western parts of WILSON and RYAN is irregular in outline with a maximum depth in the northwest corner of WILSON. Basement depths in PERCIVAL and northern HELENA appear, from gravity evidence, to be substantially less than in the area to the south.

Gibson Regional Gravity Low

The southern part of this province was first defined and named by Lonsdale & Flavelle (1963). They divided the province into three units of which only the northernmost, the Runton Gravity Low, lies within the survey area. This unit is a broad west-northwest-trending gravity depression in which minimum Bouguer anomaly values are less than -70 mGal. It is bounded by a steep gradient in the north and east and gentler gradients elsewhere.

The geology over RUNTON and MORRIS has been described by Veevers & Wells (1961). The geology consists mainly of isolated outcrops of flat-lying Permian, Cretaceous, and undifferentiated Mesozoic sediments. The western edge of the Canning Basin is mapped as running southwards east of the western edge of RUNTON. In northwest RUNTON the basement rocks are mapped as Precambrian metamorphics and granites whereas farther south the basement is mapped as unmetamorphosed Proterozoic sediments.

At Woolnough Hills, near the southwest corner of MORRIS there is an apparent diapiric structure within the sediments. Veevers & Wells (1960) present evidence which favours this structure being a salt dome in preference to a laccolith or stock intrusion, a cryptovolcanic structure, or a buried hill. If this is so, the thickness of sediments in the area would be at least several thousand metres.

The magnetic contours and interpretation are shown on Plates 6 and 7. Over the area of the Runton Gravity Low the magnetic contours are relatively smooth and widely spaced indicating a deep magnetic basement overlain by thick non-magnetic sediments, or a shallow basement devoid of magnetic minerals. However the large size of the magnetically quiescent area possibly precludes the granitic basement hypothesis. The magnetic interpretation indicates some 8000 m of sediments overlying magnetic basement.

No seismic work has been done in the area of the gravity unit but a seismic reflection profile has been obtained from a traverse on the southern border of MADLEY (Turpie, 1967). This traverse is located in the centre of the Herbert Gravity Low (Lonsdale & Flavelle, 1963) which is similar in shape and amplitude to the feature under discussion. Reflection data suggest that the undisturbed sedimentary section is at least 13 000 m thick.

All available evidence suggests that the Runton Gravity Low is caused by a thick sequence of light, unmetamorphosed sediments. The steep Bouguer anomaly gradient separating the Anketell Regional Gravity Ridge from the Runton Gravity Depression passes south of the boundary between Precambrian metamorphics and younger unmetamorphosed sediments. The magnetic contour pattern also changes abruptly across this boundary from disturbed in the north to quiet in the south. The presence of thick sediments in southern MADLEY, as indicated by seismic results, and the possible existence of a salt dome south of MORRIS further support the view that low Bouguer anomalies are caused by thick sediments.

The predominant age of the sedimentary sequence is uncertain, but is probably Proterozoic. ?Proterozoic sediments crop out in western RUNTON (Veevers & Wells, 1961) where the amplitude of the gravity low is greatest. In Browne No. 1 (Hunt Oil Co., 1966) only 145 metres of Phanerozoic sediments were encountered above the ?Proterozoic Browne Evaporites. Browne No. 1 was located in southeast BROWNE within a gravity low.

If the Runton Gravity Low is caused mainly by thick Proterozoic sediments it is probably related to the Officer Basin rather than the Canning Basin. It would follow that the Anketell Regional Gravity Ridge, bordering the Runton Gravity Depression to the north and east, corresponds to the boundary between the two basins. This interpretation is in agreement with that of Lonsdale & Flavelle (1963).

Anketell Regional Gravity Ridge

This is an elongate gravity ridge of varying width and amplitude extending northwestwards from the Musgrave Block in central eastern Western Australia to and beyond the northwest coastline. It can be divided into two units; the Paterson Gravity Ridge in the north, a broad rectilinear feature of mainly positive Bouguer anomaly, and the Warri Gravity Ridge which is narrower, sinuous, and of lower Bouguer anomaly level. Parts of the province have previously been discussed by Flavelle & Goodspeed (1962), Lonsdale & Flavelle (1963) and Fraser (1974). The survey area covers the southern tip of the Paterson Gravity Ridge and the northern half of the Warri Gravity Ridge.

In the south of the province surface geology consists essentially of flat-lying Permian, Cretaceous, and undifferentiated sediments (Veevers & Wells, 1961). These sediments discontinuously overlie Lower Proterozoic metasediments and granites in the northern part of the province.

The magnetic contours (Plate 6) show a band of relatively high disturbance coincident with the gravity province. This indicates that sediments are thinner or that the basement is more magnetic than in areas to the northeast or southwest. Seismic results (Plate 11) indicate a shallowing of basement towards the Warri Gravity Ridge from the northeast.

Fraser (1974) has correlated the Paterson Gravity Ridge with the Paterson Province, a Proterozoic metamorphic belt bordering the Pilbara Block to the east. The continuity of gravity pattern between the Paterson and Warri Gravity Ridges suggests that the Paterson Province extends southeastward beyond its exposed part, under the Canning Basin. It would follow that high Bouguer anomalies in the Warri Gravity Ridge relate primarily to dense rocks within the basement. However seismic results (Plate 11) show that basement becomes shallower as the gravity ridge is approached from the northeast suggesting that a basement topographic rise may cause a component of the gravity ridge.

The marked reduction in the Bouguer anomaly level of the province in TABLETOP may reflect a rapid thickening of sedimentary cover to the southeast or a change in grade of metamorphism of the basement.

Fitzroy Regional Gravity Complex

This province is described and discussed in detail by Flavelle (in prep.). It consists of several elongate northwest trending gravity ridges and troughs. Of the five units defined, only the Broome Gravity Ridge extends into the survey area. This is a narrow slightly arcuate ridge on the southwest of the Fitzroy Regional Gravity Complex. Flavelle (op. cit.) attributes the gravity ridge to a zone of dense shallow basement and correlates its northern margin with the Fenton and Dampier Fault systems which mark the southwestern edge of the Fitzroy Trough.

The present survey results show that the Broome Gravity Ridge terminates rather abruptly in western CORNISH.

Cobb Regional Gravity Low

This is an intense arcuate gravity depression to the east of the Warri Gravity Ridge. Only the northern extremity of the province extends into the survey area. The province has been described and discussed in detail by Lonsdale & Flavelle (1963) who attribute low Bouguer anomaly values to thick sedimentary section.

Angas Regional Gravity High

This province was partly defined by Lonsdale & Flavelle (1963). It is an elongate north trending high of about 50 mGal amplitude extending from HELENA in the north to RYAN in the south.

The geology of the area is discussed by Veevers & Wells (1961), Casey & Wells (1964), and Smith (1968). Permian sediments of the Canning Basin cover most of the area of the province. These apparently overlie Proterozoic sediments which crop out in an elongate area several hundred kilometres long extending northeastwards from the southern end of the gravity province. Precambrian granitic inliers crop out in southwest WEBB.

Magnetic coverage over the gravity province (Plate 6) is not complete. However an isolated traverse in eastern WILSON indicates that the magnetic field becomes increasingly disturbed from west to east suggesting that the basement becomes shallower and/or more magnetic towards the gravity high. Seismic and magneto-telluric results (Plates 12 and 13) also indicate that basement becomes shallower as the gravity province is approached from the west.

The gravity high does not coincide with the Proterozoic outcrop and is therefore unlikely to be caused by a topographic high in the Proterozoic/Palaeozoic interface. Seismic, magnetic, and magneto-telluric evidence indicates a shallowing of basement as the gravity high is approached from the west. Although this implies that a basement ridge is the main cause of the gravity ridge, a basement inlier in southwest WEBB is not locally associated with high Bouguer anomalies. It is apparent therefore the gravity ridge cannot be interpreted in terms of basement topography alone; dense rocks within the basement may cause part of the gravity ridge.

The dominant easterly gravity trends associated with the basins and blocks of Central Australia are truncated by the Angas Regional Gravity High. This suggests that the eastern province boundary may correspond to the western boundary of the tectonic regime which dominates Central Australia.

Papunya Regional Gravity Ridge

This province, of which only the western tip lies within the survey area, has been described and discussed in detail by Whitworth (1970). It corresponds broadly to the southern Arunta Block of Precambrian metamorphic rocks. Within the survey area however, outcrops are restricted to isolated Proterozoic sedimentary and granitic inliers in WEBB and MACDONALD.

Willowra Regional Gravity Ridge

The survey area covers only the extreme western part of this province, which has previously been defined by Flavelle (1965) and Whitworth (1970). The province extends westwards from BARROW CREEK along a slightly arcuate path to STANSMORE. The Bouguer anomaly values reach 0 to +5 mGal to the east but within the survey area the maximum value is -5 mGal.

The geology is poorly known over most of the area of the province. However, the ridge has been correlated with outcropping metamorphic rocks of the Arunta Block in BARROW CREEK (Flavelle, op. cit.). The westward continuation of the ridge beyond this area may therefore reflect a subsurface continuation of dense metamorphic rocks in the basement.

A gravity low in southeast STANSMORE could be related to a granitic body within the metamorphic basement or to a thicker development of sediments.

Pedestal Regional Gravity Low

This province was originally defined by Whitworth (1970) as a gravity unit in southwestern THE GRANITES. The presencet survey reveals its full extent as a T-shaped gravity depression extending west from THE GRANITES to southeast CORNISH and south from southern LUCAS to northern WEBB. The province is bounded by relatively steep gradients except in the west. It is divided into three units, from east to west, the Yam Gravity Low, the Moody Gravity Low, and the Thornton Gravity Low.

The Yam Gravity Low, an east trending depression of irregular outline, encompasses outcrops of the Palaeozoic Lucas Beds, Upper and Lower Proterozoic sediments, and Proterozoic granitic inliers in south-western THE GRANITES and central LUCAS. The presence of granitic inliers within the unit suggests that the sediments do not attain a large thickness so that low Bouguer anomaly values probably reflect low-density basement rocks rather than thick sedimentary section.

The Moody Gravity Low is a south-trending gravity depression bounded by steep gradients in its southern half. It extends over Permian sediments near the southeast margin of the Canning Basin. The steep gradients defining the east and west margins of the unit in the south partly coincide with faults. The gradient in the east corresponds to the Stansmore Fault where considerable down-to-the-west movement has occurred. One deep bore-hole has been drilled - Point Moody No. 1 in north-west STANSMORE - in which over 2000 m of mainly Permian sediments were encountered. Seismic results (Plate 12) (Australian Aquitaine Petroleum Pty Ltd, 1968a) indicate a sedimentary trough in western STANSMORE, within the area of the gravity unit. The above evidence suggests that the Moody Gravity Low corresponds to a local sedimentary trough within the Canning Basin. Assuming a density contrast of 0.3 gm/cm^3 between sediments and basin, the thickness of sediments would be at least 4000 m.

The Thornton Gravity Low is connected to the Moody Gravity Low by a gravity saddle across the northern end of the Angas Regional Gravity High. It is a shallow depression bounded by mainly northwest trending gradients. The unit extends over faulted Permian sediments, and like the Moody Gravity Low, may reflect a basement depression.

Tanami Regional Gravity Complex

This is an easterly elongated province characterized by high-intensity short-wavelength Bouguer anomaly features. Only the western part of the province lies in the survey area; the eastern part was defined by Whitworth (1970).

The province correlates broadly with the Granites Tanami Block (Geological Society of Australia, 1971) consisting of low-grade Proterozoic metasediments intruded by granite. A complex Bouguer anomaly field in northeast LUCAS indicates large and irregular density variations close to the surface. A northeast-trending low encompasses two Proterozoic outcrops in northeast LUCAS suggesting that a continuous granitic body underlies Proterozoic sediments. High Bouguer anomalies on the periphery of the gravity low probably reflect the presence of comparatively dense metamorphic rocks.

The western part of the gravity province lies in the area of the Canning Basin. This suggests that the Granites Tanami Block extends westward beyond its exposed limit as basement under the Canning Basin.

CONCLUSIONS

The survey results reveal the full extent of gravity provinces which were previously only partly defined from reconnaissance data, or defined from incomplete areal gravity coverage (Darby & Vale, 1969). The following conclusions were drawn from the analysis of the gravity results.

1. The Joanna Gravity Ridge extends into the northwest corner of the survey area. It coincides in part with an anticlinal closure mapped from seismic results and is therefore interpreted as representing a ridge in the basement of the Canning Basin.

2. The South Canning Regional Gravity Low extends centrally through the survey area as a broad depression in which Bouguer anomalies generally range from -30 to -70 mGal. Geophysical and borehole evidence suggest that low Bouguer anomalies reflect sedimentary section of the Canning Basin. Relatively deep basement troughs may be present in central URAL and western WILSON.

3. The northern part of the Gibson Regional Gravity Low occupies the southwest corner of the survey area. Geological and geophysical evidence suggest that low Bouguer anomalies are caused by thick development of Proterozoic sediments. If so, the province is probably related to the Office rather than the Canning Basin.

4. The survey results permit full definition of the Anketell Regional Gravity Ridge. The province is shown to be a continuous gravity ridge of varying width and amplitude extending northwestwards from the Musgrave Block in central eastern Western Australia to and beyond the coastline. Within the survey area, it corresponds to a basement rise which may represent the boundary between the Officer and Canning Basins. Variations in amplitude of the province are attributed to variations in thickness of sedimentary cover over the basement ridge and/or changes in grade of basement metamorphism.

5. The Angas Regional Gravity High is an elongate north-trending high in the east of the survey area. A gradient along its western margin corresponds to a basement rise. However, a basement inlier near the southern end of the province is not locally associated with high Bouguer anomaly values suggesting that a basement density increase

rather than a basement rise may be the main cause of the gravity high. The province truncates east-trending gravity ridges and troughs associated with blocks and basins in Central Australia. The eastern province margin may therefore delineate the western boundary of the tectonic regime which predominates in Central Australia.

6. A T-shaped gravity depression, the Pedestal Regional Gravity Low, is revealed in the northeast corner of the survey area. In the east of the province, the relation between gravity relief and surface geology indicates that low Bouguer anomalies may reflect low-density granitic basement rocks. Geological and geophysical evidence show that the north-trending central part of the province may be due to a basement depression.

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APPENDIX 1 Survey Statistics

Survey commenced	:	27 April 1968
Survey completed	:	25 September 1968
Total survey days	:	152
Total helicopter days	:	304
Days unserviceable	:	127
Pilot days off	:	6
Maintenance	:	0
Days off for weather	:	71
Loops	:	366
New readings	:	2523
Elapsed time (hrs - mins)	:	581 - 45
Flying time (hrs - mins)	:	391 - 11
Ferry time (hrs - mins)	:	113 - 30

The survey statistics are shown on a map sheet basis in Table 2.

TABLE 2 Map Sheet Statistics

Sheet	New Readings	Elapsed Time (hrs-mins)	Flying Time (hrs-mins)	Ferry Time (hrs-mins)	New Readings per Elapsed Hour	New Readings per Flying Hour	New Readings per Flying and Ferry Hour	New Readings per Elapsed and Ferry Hour	Loo
Cornish	165	35-30	22-12	4-51	4.6	7.4	6.1	4.1	24
Dummer	168	32-30	23-20	8-31	5.2	7.2	5.3	4.1	24
Gunanya	162	40-33	26-35	8-48	4.0	6.0	4.6	3.3	24
Helena	132	26-06	17-30	6-55	5.1	7.5	5.4	4.0	19
Joanna Springs	26	7-30	4-42	2-45	3.5	5.5	3.5	2.5	4
Lucas	144	30-26	21-42	4-41	4.8	6.7	5.5	4.2	18
Morris	110	22-58	16-02	4-31	4.8	6.9	5.3	4.0	16
Paterson Range	165	40-10	29-18	7-25	4.1	5.6	4.5	3.5	24
Percival	144	29-26	19-54	9-08	4.9	7.2	5.0	3.7	22
Rundall	166	40-01	28-15	4-50	4.2	5.9	5.0	3.7	24
Runton	164	41-50	27-30	7-10	3.9	6.0	4.7	3.3	24
Ryan	168	39-43	26-23	6-36	4.2	6.4	5.1	3.6	24
Sahara	51	14-10	9-10	2-55	3.6	5.5	4.2	2.2	9
Stansmore	94	17-22	11-43	6-49	5.4	7.9	5.0	3.8	12
Tabletop	158	37-04	25-12	7-10	4.3	6.3	4.9	3.6	23
Trainor	161	38-14	26-05	6-10	4.2	6.2	5.0	3.6	24
Ural	22	4-13	3-05	0-40	5.2	7.1	5.9	4.5	3
Webb	166	43-19	27-02	6-55	3.8	6.1	4.9	3.3	24
Wilson	157	40-40	25-31	6-40	3.9	6.2	4.9	3.3	24
Totals	2523	581-45	391-11	113-30	4.3	6.4	5.0	3.6	366

APPENDIX 2 Survey Personnel and Equipment

Staff

(Wongela Geophysical Pty Ltd)

Party Leader	-	L.N. Ingall
Chief Meter Reader	-	P. Youngs
Meter Readers	-	L.N. Ingall, A. Wright
Draughtsman	-	L. Spain

Base Readers from Messrs Spain, Read, Shaeffer, Dalitz, Shields, Henry, and Elliott.

Helicopter staff of 2 pilots and 2 engineers supplied by Helicopter Utilities Pty Ltd.

BMR Supervisor - F. Darby

Equipment

Worden gravity meters Nos 592 and 708

Mechanism microbarometers Nos 306, 318, 505, 506, 507, and 742

Helicopter

Two from Hillers UHE and UTB and Bells UTM and UTV.

Vehicles

3 Landrovers (4 x 4)

APPENDIX 3 Survey Procedure

Field Operations

The field operations were carried out by a private geophysical contractor, Wongela Geophysical Pty Ltd of Sydney, using methods adopted on previous BMR helicopter gravity surveys. All traversing was done by the cell method described by Hastie & Walker (1962).

Before the helicopter operation, the Survey Branch of the former Department of the Interior (now Department of Services and Property) established a network of optically-levelled and photo-identified elevation traverses. The bench marks on these traverses were elevation control stations for the survey, and an area enclosed by the traverses is called a segment. In the flying of the survey no loop was allowed to cross a segment boundary. This method of flying meant that each segment could be computed independently for elevation control.

Gravity control on the survey was maintained by tying to previously established accurate gravity stations termed 'Isogal' stations (Barlow, 1970), which have been established by multi-meter traversing. Previous BMR and private company gravity surveys were tied to but have not, as yet, been integrated with this survey.

Horizontal control was maintained by accurately pinpricking aerial photographs and by taking a 35-mm photograph of the station from 150 m, as a check on the original pinprick. The locations of gravity stations were plotted onto 1:250 000 photo-centre base maps.

Computing Procedure

The computing was conducted at Monash University on a CDC 3200 computer. For the barometric results each segment was computed three times:

1. With only one fixed elevation node. This is computed to determine the internal accuracy of the survey, and systematic errors are not taken into account.

2. With all of the fixed elevation nodes. This is computed to determine the external accuracy of the survey and to obtain the final station elevations for the computation of Bouguer anomalies. In this computation systematic errors are corrected, so that the external standard deviation of the adjustments is always higher than the internal standard deviation.

3. With half of the fixed elevation nodes. This is computed to determine the forecast standard derivation. Enough fixed points are included to eliminate systematic effects, and the difference between the true elevation and the measured elevation for the fixed nodes computed as free nodes is a good estimate of the accuracy of the heights in any segment.

For the gravity network, only steps 1 and 2 were carried out.

APPENDIX 4 Stratigraphic Sequences Encountered in Boreholes

The following table gives the stratigraphic sequences encountered in boreholes Sahara No. 1 (WAPET, 1964), Kempfield No. 1 (Total Exploration Australia Pty Ltd, 1968), Kidson No. 1 (WAPET, 1965c), Wilson Cliffs No. 1 (Australian Aquitaine Petroleum Pty Ltd, 1968c), and Point Moody No. 1 (Australian Aquaitaine Petroleum Pty Ltd, 1965b).

Age	Formation	Sahara No. 1 Thickness (m)	Kempfield No. 1 Thickness (m)	Kidson No. 1 Thickness (m)	Wilson Cliffs No. 1 Thickness (m)	Point Moody No. 1 Thickness (m)
Quaternary		7.3	12.5	13.4	12.2	12.2
U. Jur.	Alexander	35.0	36.0			
U. Jur.	Wallal		50.6			
Undiff. Mes.				194.1	169.2	
Perm.	Liveringa			77.1		
Perm.	Noonkanbah	227.1	54.6	310.9	192.0	335.3
Perm.	Poole Sandstone	75.3	21.3	135.0	205.7	312.4
Perm.	Grant	569.4	383.7	835.2	387.7	1230.5
Perm./ Carb.	Anderson					160.9 +
M. Dev.	Mellinjerie Limestone	196.6	157.6	266.4	127.4	
L. Dev.	Tandalgoo Red Beds	598.9	394.7	733.0	684.3	
L. Dev.	Caribuddy	393.5 +	65.8 +	1709.3	754.4	
L. Ord.	Goldwyer			133.5	314.6	
L. Ord.				18.6 +	655.9	
Camb/U. Prot.					76.8	
Camb/U. Prot					142.0	
Total depths (m)		2103.1	1176.8	4426.5	3722.2	2051.3

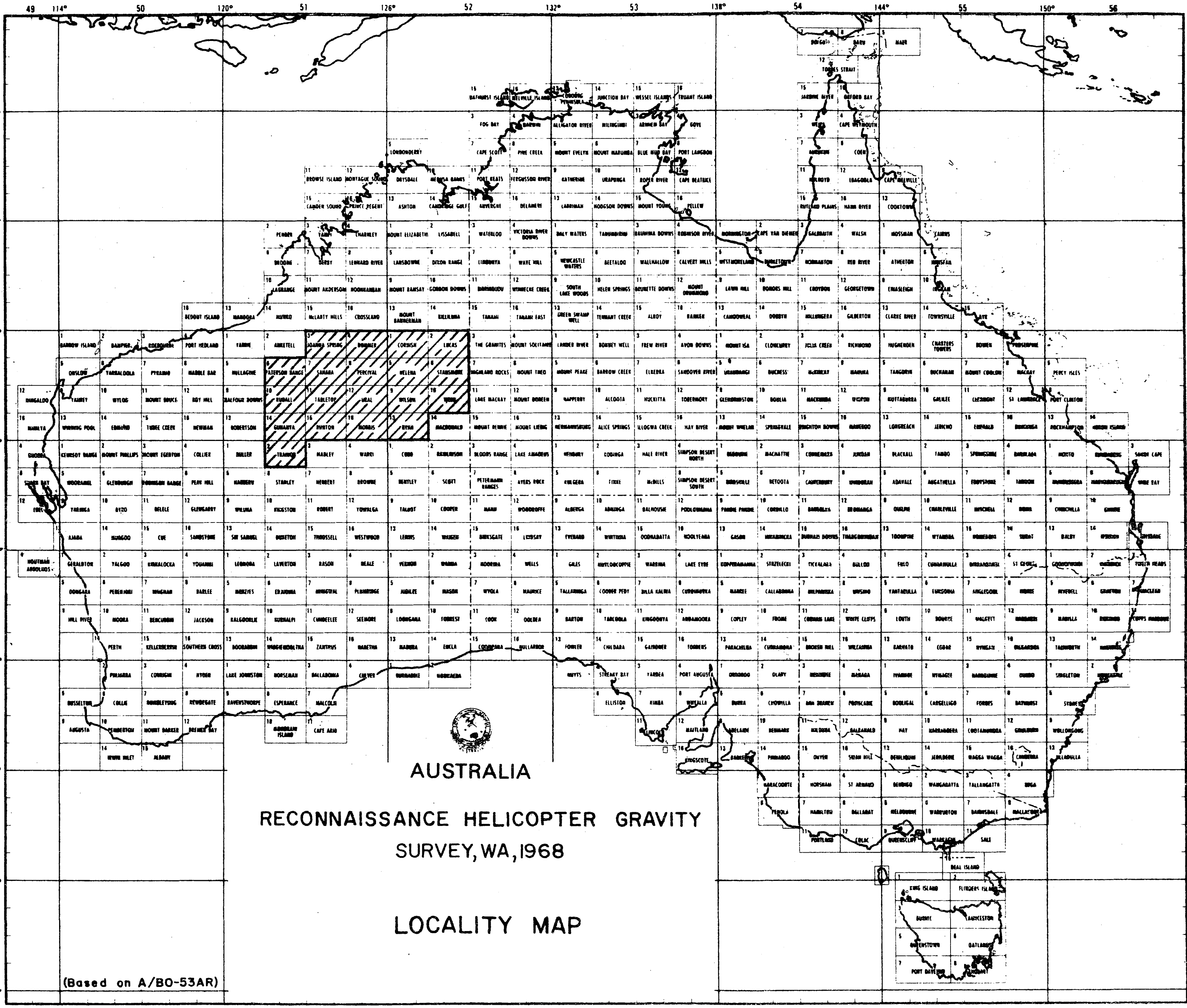
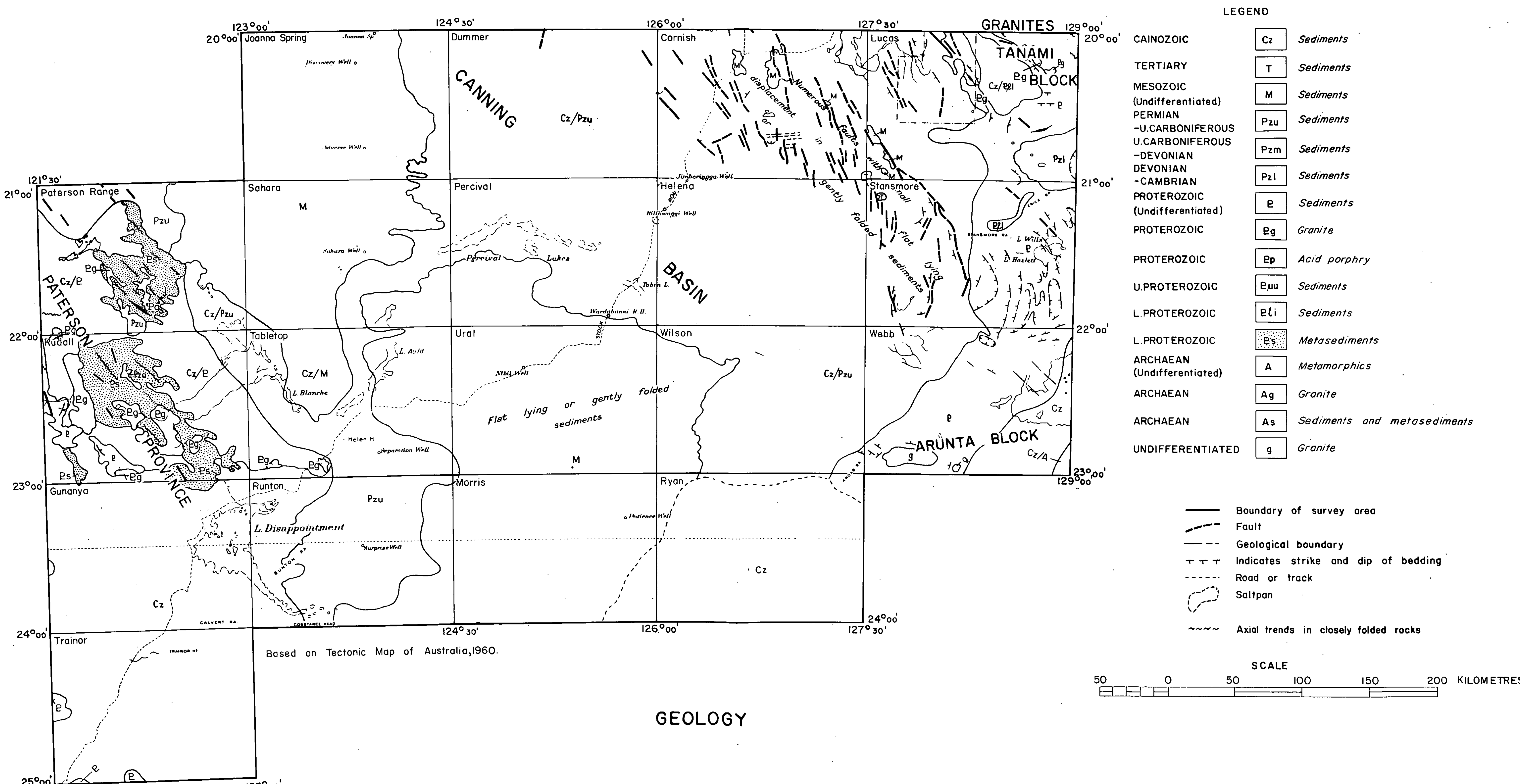

AUSTRALIA
RECONNAISSANCE HELICOPTER GRAVITY
SURVEY, WA, 1968
LOCALITY MAP
(Based on A/BO-53AR)

PLATE 1

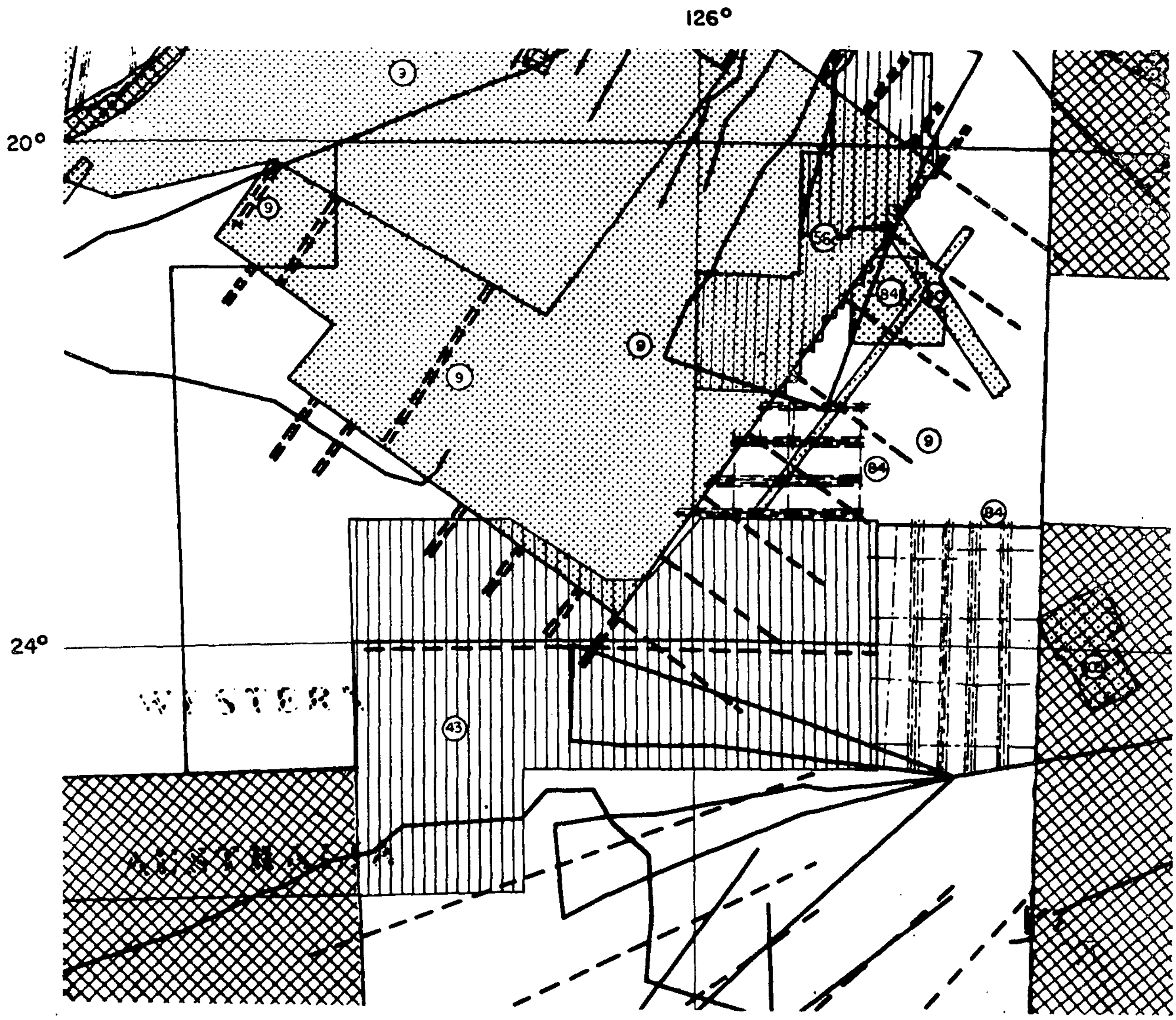
PLATE 2



Based on Tectonic Map of Australia, 1960.

GEOLOGY

PLATE 3



Based on G350-38

KEY TO SURVEYS

TRAVERSE
AREA
SURVEYED BY BMR

AREA
TRAVERSES
SURVEYED BY OTHER ORGANIZATIONS

(9) South Canning aeromagnetic survey (WAPET, 1962)

(43) Gibson Desert aeromagnetic survey (Union Oil Devel. Corp., 1965)

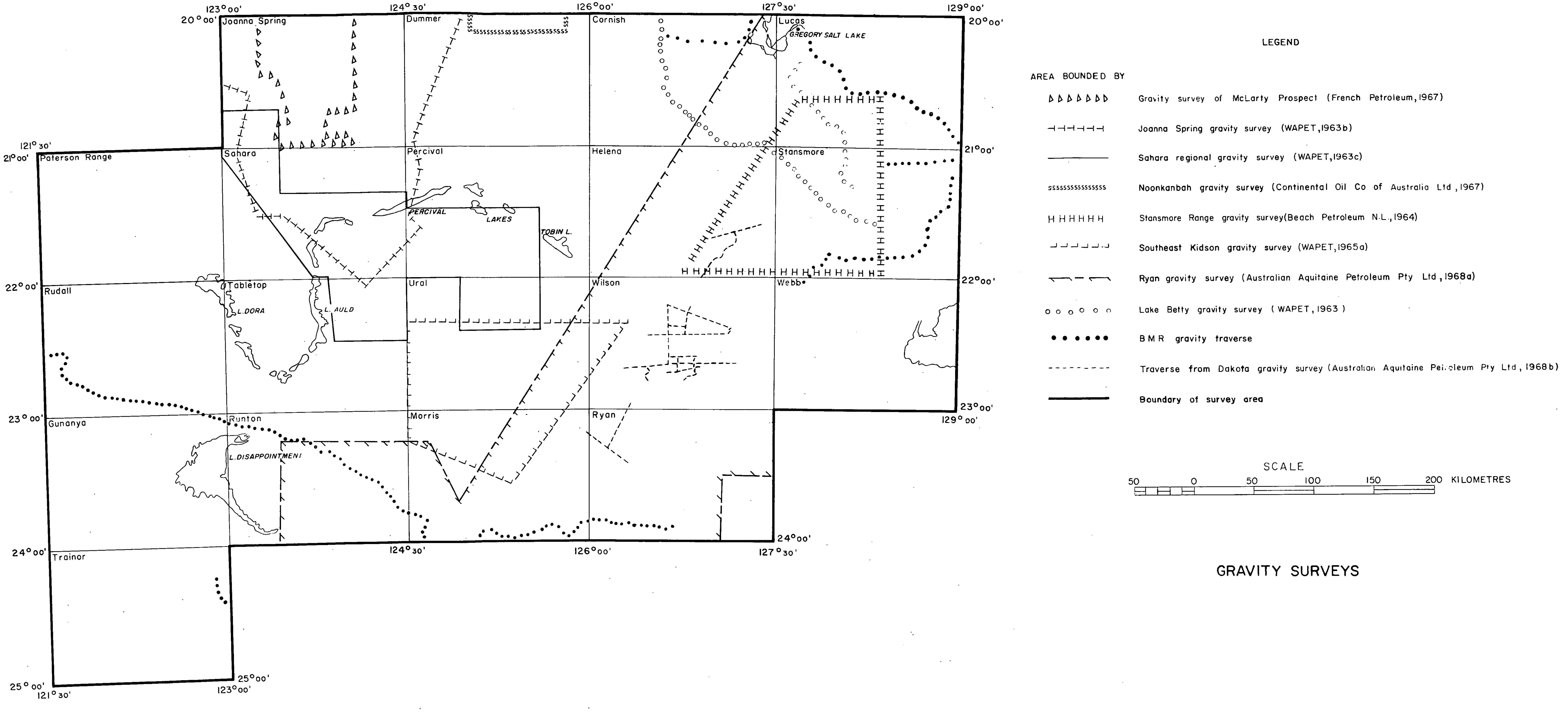
(80) Stansmore Range aeromagnetic survey (Hackathorn, 1963)

(84) Pollock Hills aeromagnetic survey (Australian Aquitaine Petroleum Pty Ltd, 1965a)

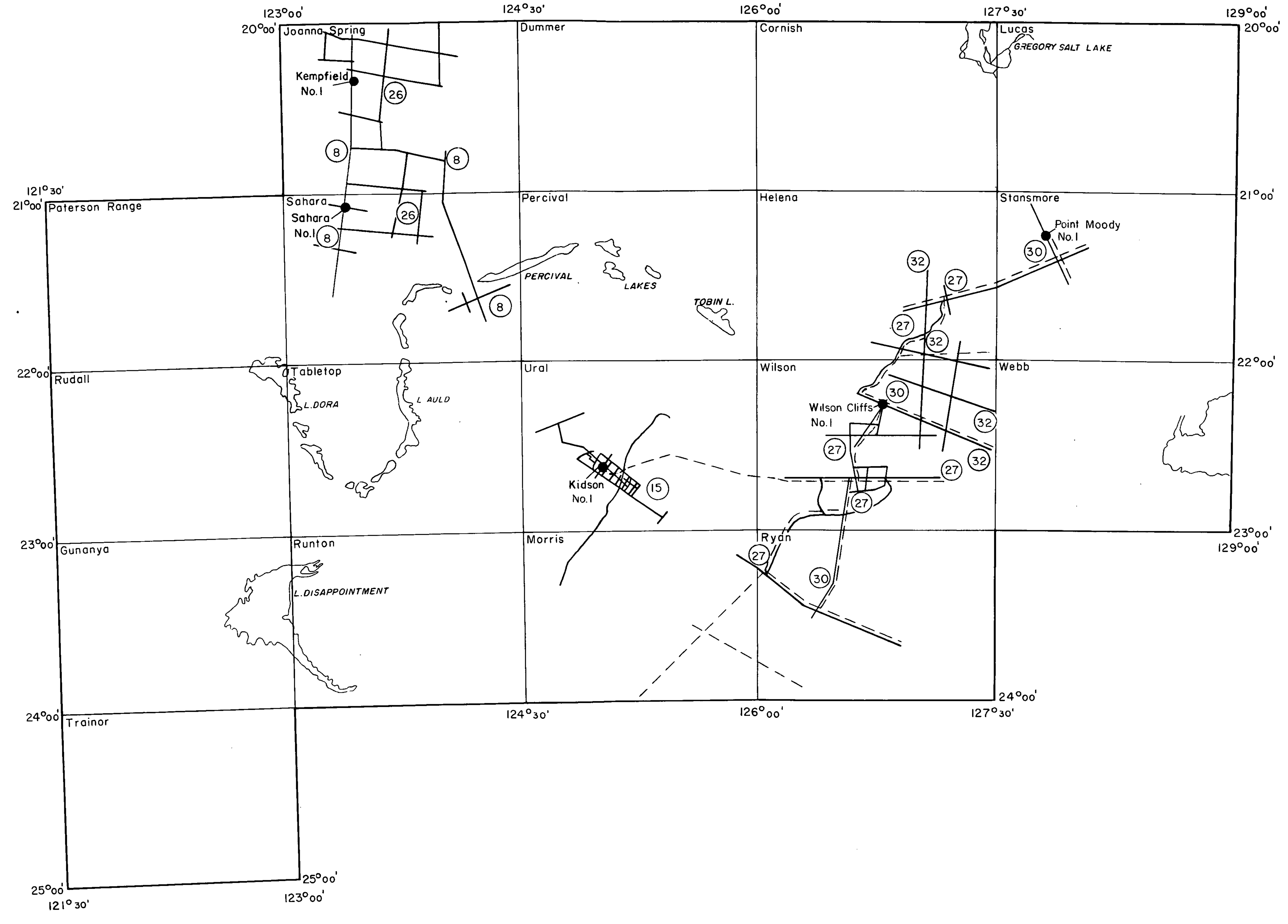
(56) Billiluna — Helena aeromagnetic survey (Mines Administration Pty Ltd, 1972)

AEROMAGNETIC SURVEYS

100 0 100 200 300 400 km



GRAVITY SURVEYS



KEY TO SEISMIC SURVEY

(8) Sahara seismic reconnaissance survey (WAPET, 1963 a)

(15) Southeast Kidson seismic survey (WAPET, 1965 b)

(26) Reflection/refraction seismograph survey of McLarty Prospect (French Petroleum, 1967)

(27) Dakota seismic survey (Australian Aquitaine Petroleum Pty Ltd, 1967)

(30) Ryan seismic survey (Australian Aquitaine Petroleum Pty Ltd, 1968 a)

(32) Contention Heights seismic refraction survey (Australian Aquitaine Petroleum Pty Ltd, 1969)

SYMBOLS

Seismic traverse

Terry Range magnetic-telluric survey (Australian Aquitaine Petroleum Pty Ltd, 1968 b)

Borehole

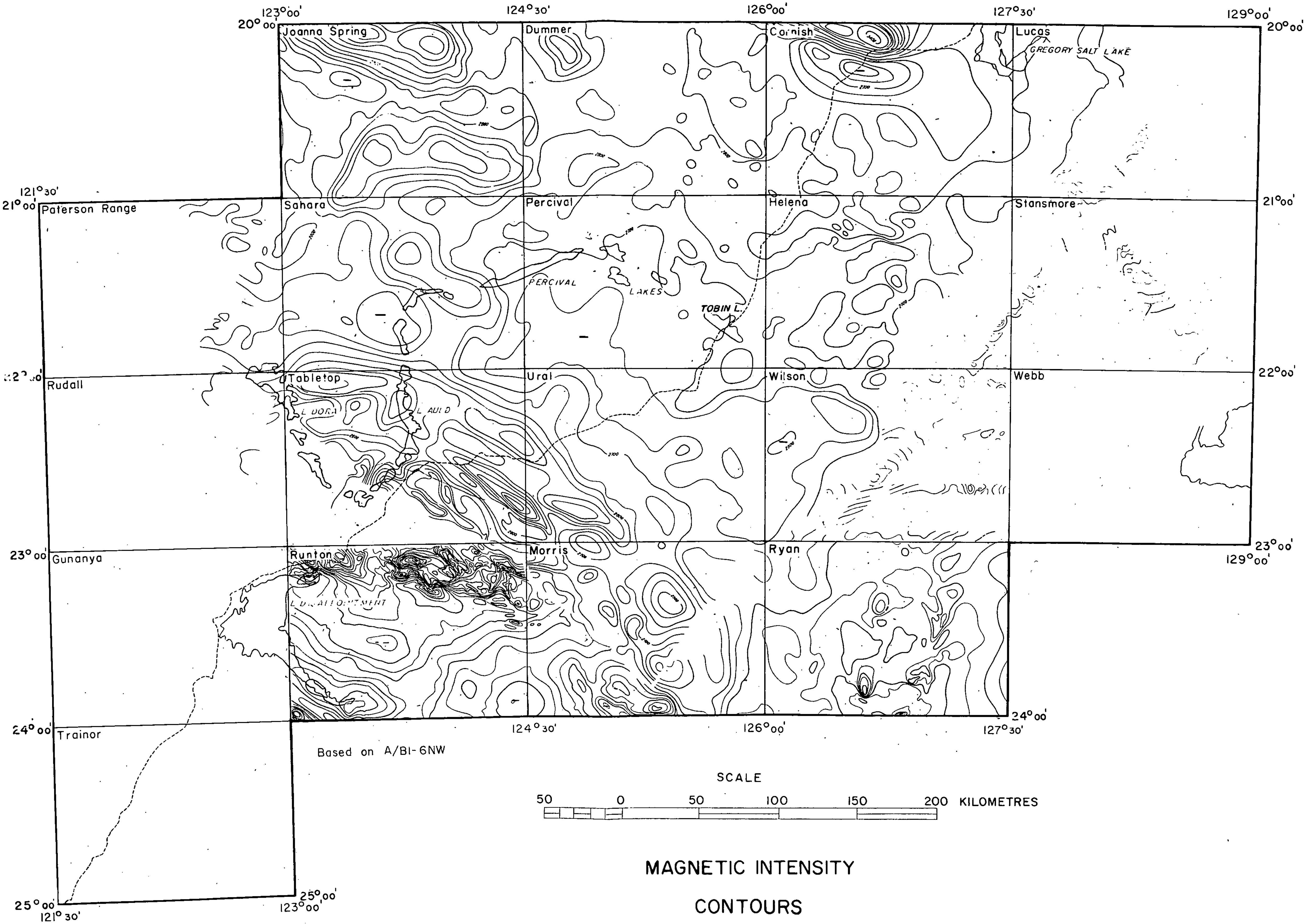
Boundary of survey area

SCALE

50 0 50 100 150 200 KILOMETRES

SEISMIC SURVEYS, MAGNETO-TELLURIC SURVEY AND BOREHOLES

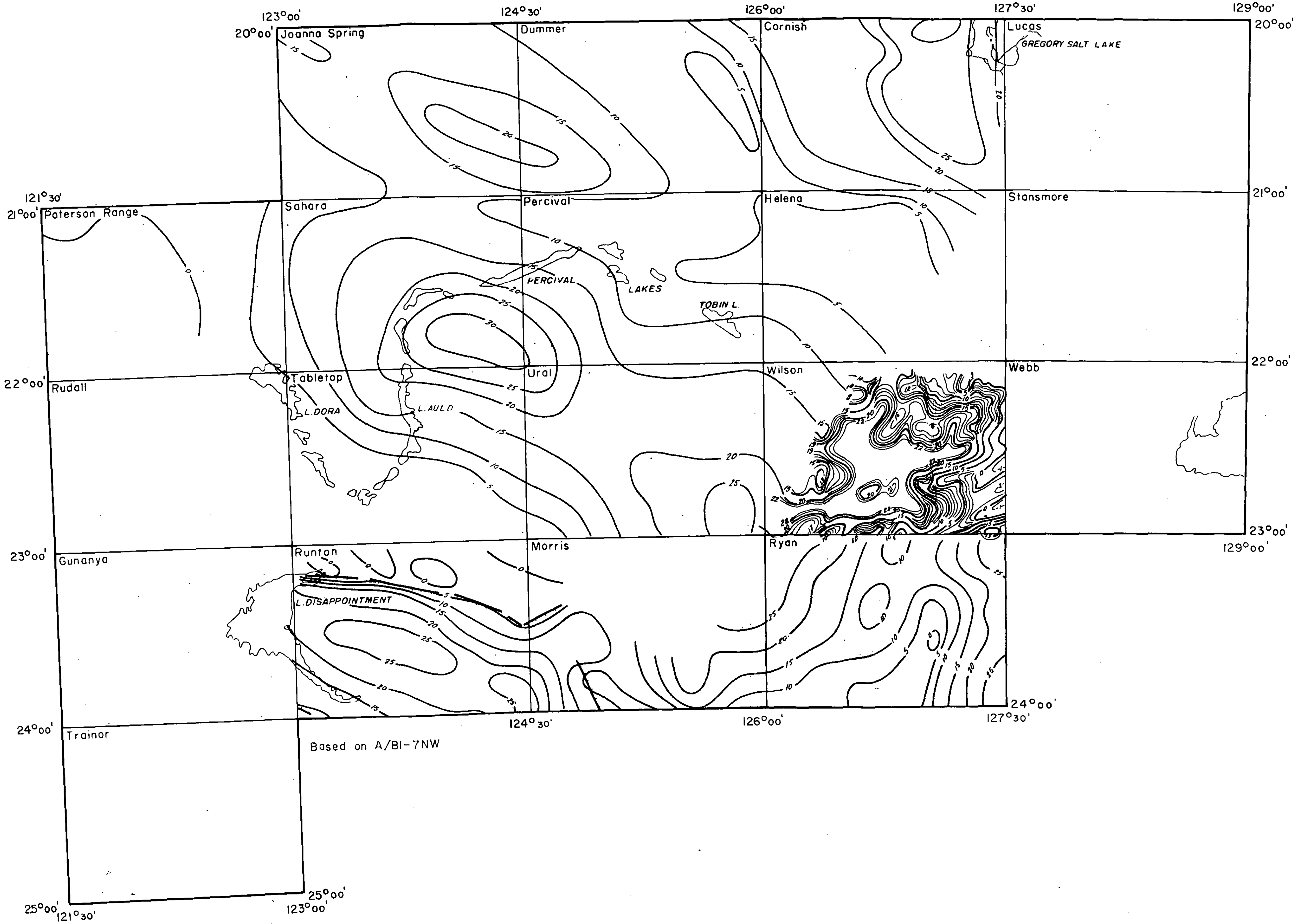
PLATE 6



MAGNETIC INTENSITY CONTOURS

RECORD No. 1969/37

WA/B2-79



LEGEND

Boundary of survey area

25 Contour

Depths in thousands of feet

SCALE

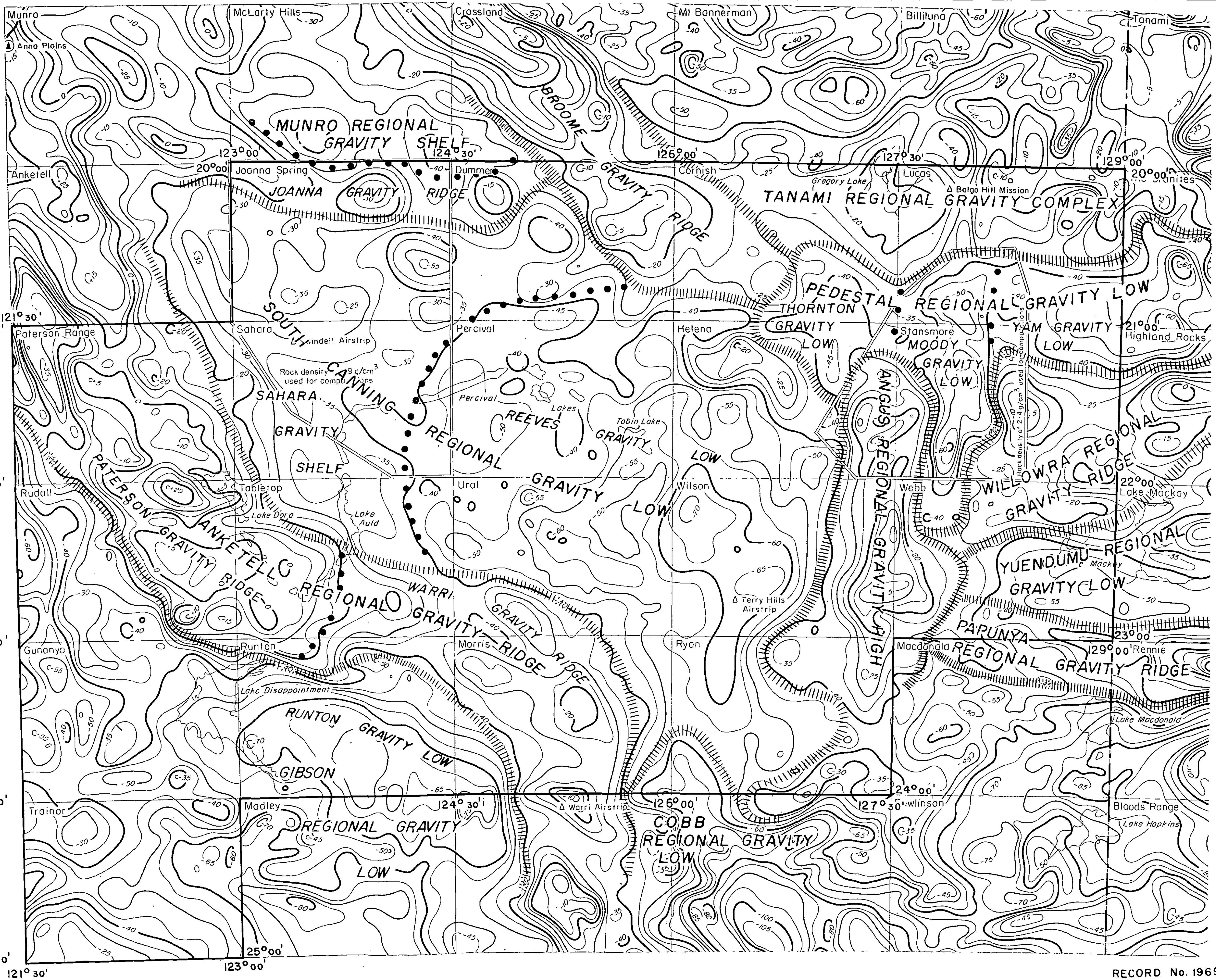
50 0 50 100 150 200 KILOMETRES

MAGNETIC BASEMENT CONTOURS

RECORD No. 1969/37

WA/B2-80

PLATE 8



LEGEND

IIIIIIIII Gravity province boundary

• • • Gravity unit boundary

—— Boundary of survey area

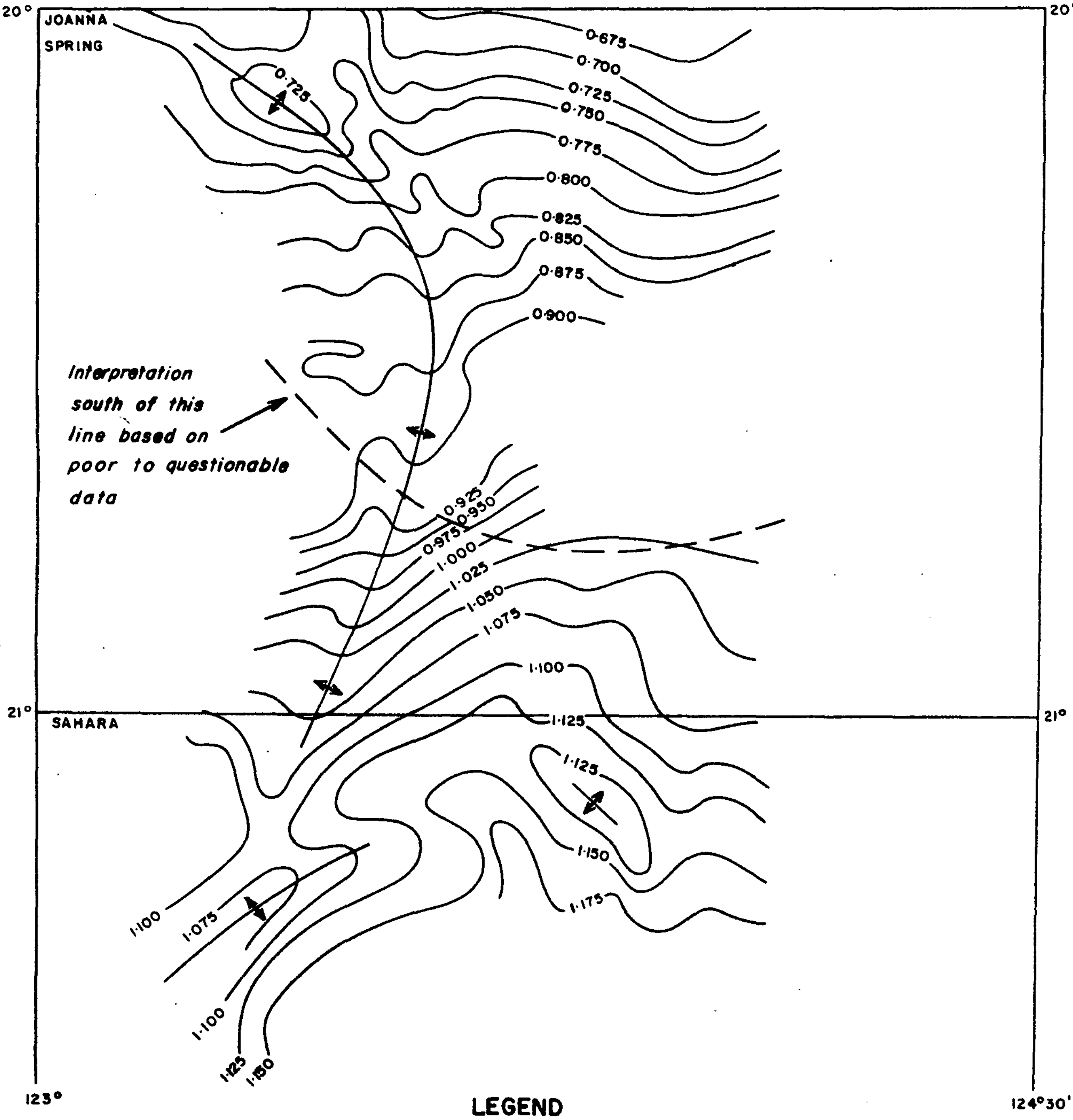
50 0 50 100 150 200 KILOMETRES

BOUGUER ANOMALIES AND GRAVITY FEATURES

Based on A/B2-50 NW

RECORD No. 1969/37

WA/B2-81



LEGEND

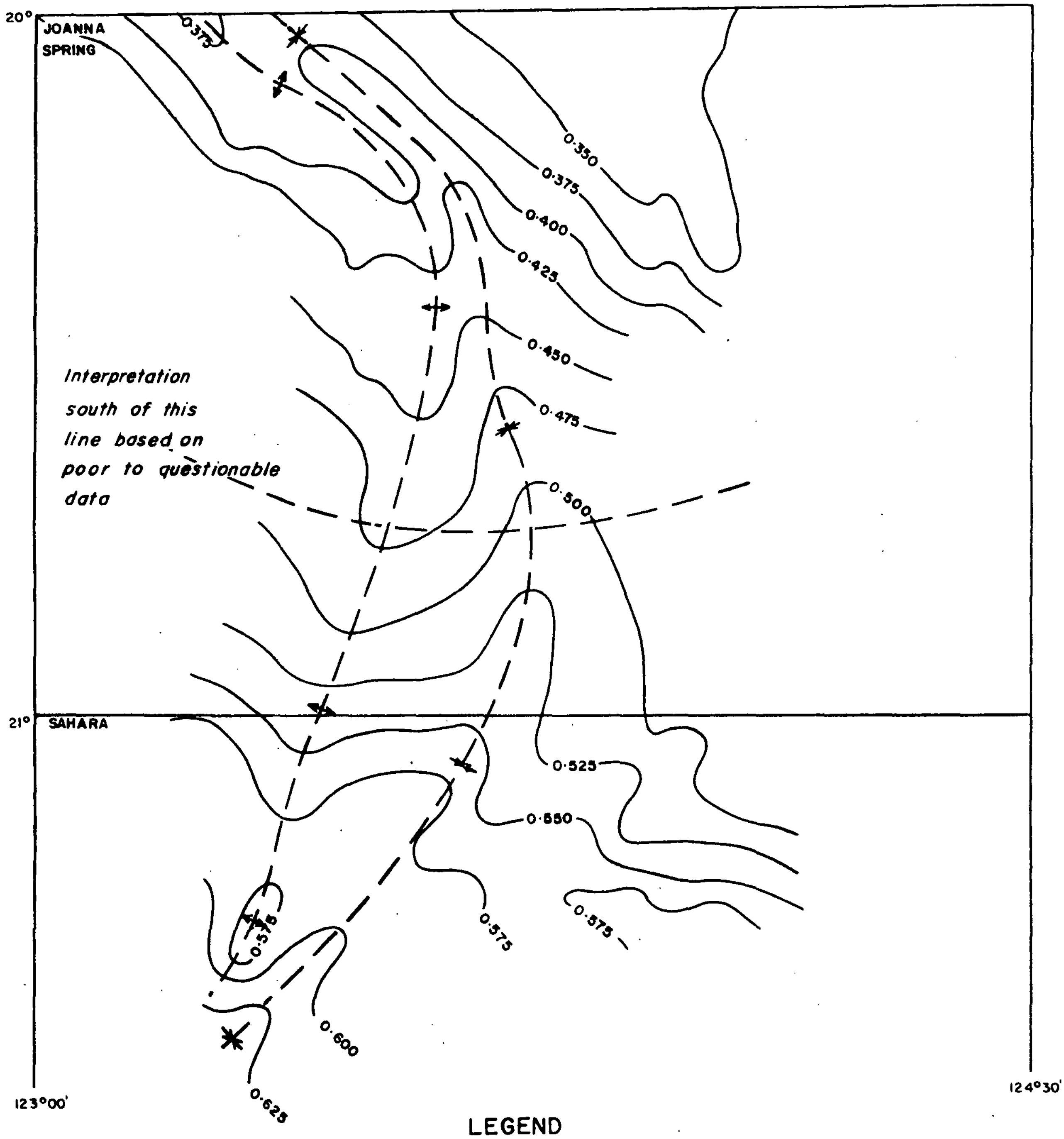
1·10 Contour

Anticlinal axis

CONTOUR OF HORIZON 'C', McLARTY PROSPECT (FRENCH PETROLEUM, 1967)

10 0 10 20 30 km

Contour Interval: 25 milliseconds of one-way reflection time



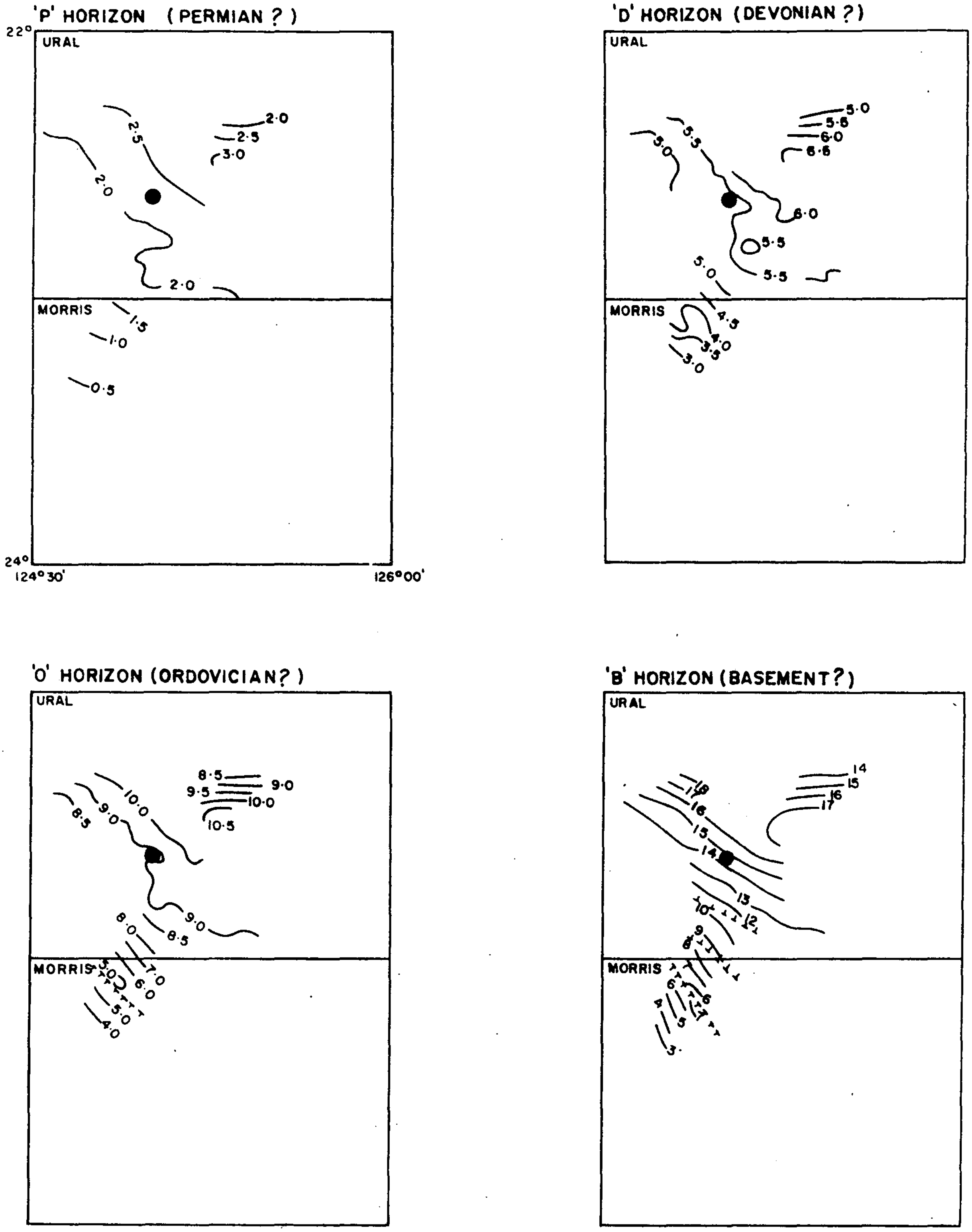
LEGEND

0·6 Contour
Anticlinal Axis
Synclinal Axis

CONTOURS OF CARRIBUDY FORMATION, McLARTY PROSPECT
(FRENCH PETROLEUM, 1967)

10 0 10 20 30 kilometres

Contour Interval: 25 milliseconds of one-way reflection time



LEGEND

9·0 Depth Contour
⊥⊥⊥ Fault
● Borehole (Kidson No. 1)

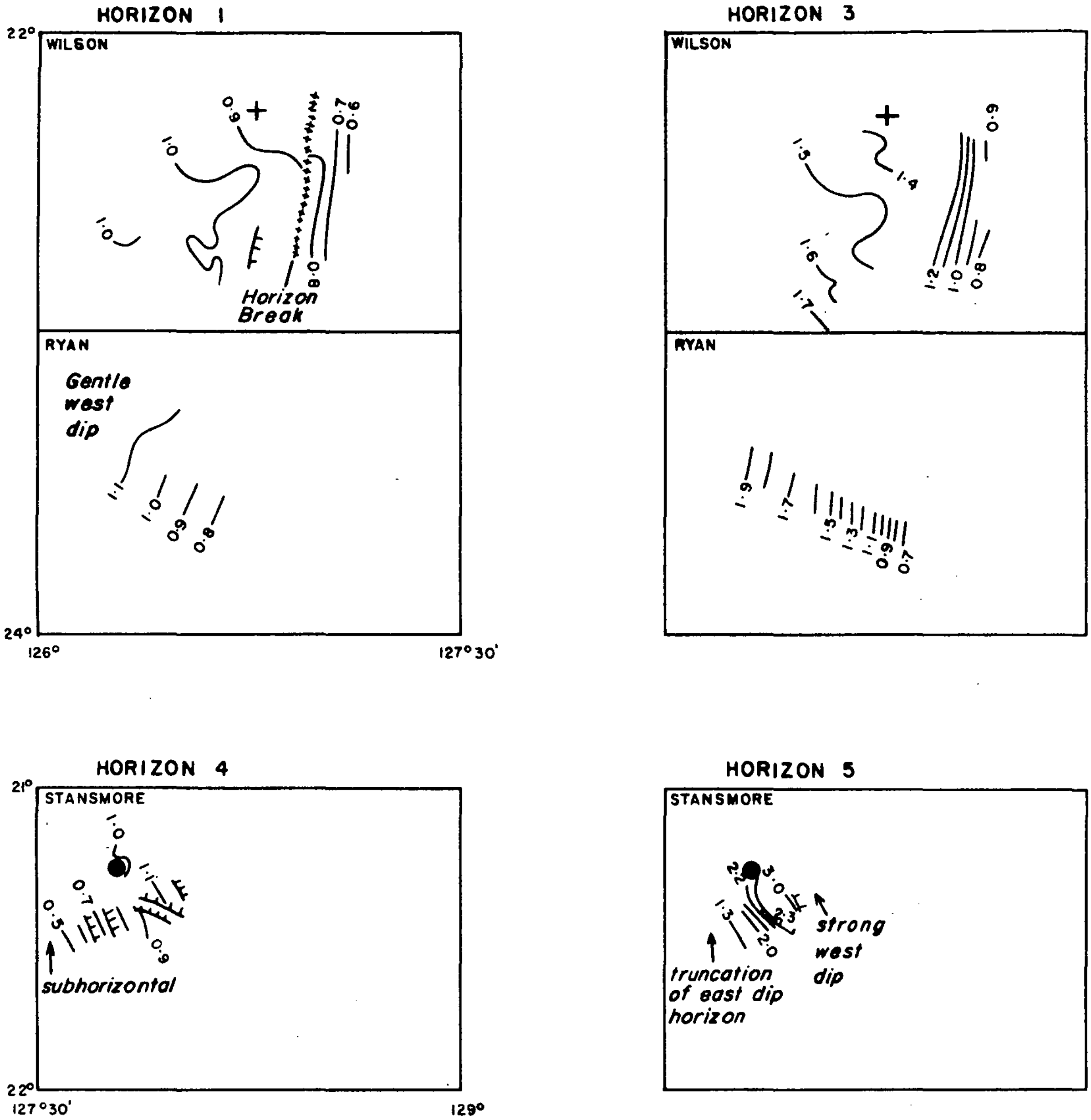
SEISMIC REFLECTION RESULTS, URAL AND MORRIS

1:250 000 AREAS (WAPET, 1965b)

50 0 50 100 kilometres

Depths are in thousands of feet below sea level

PLATE 12



LEGEND

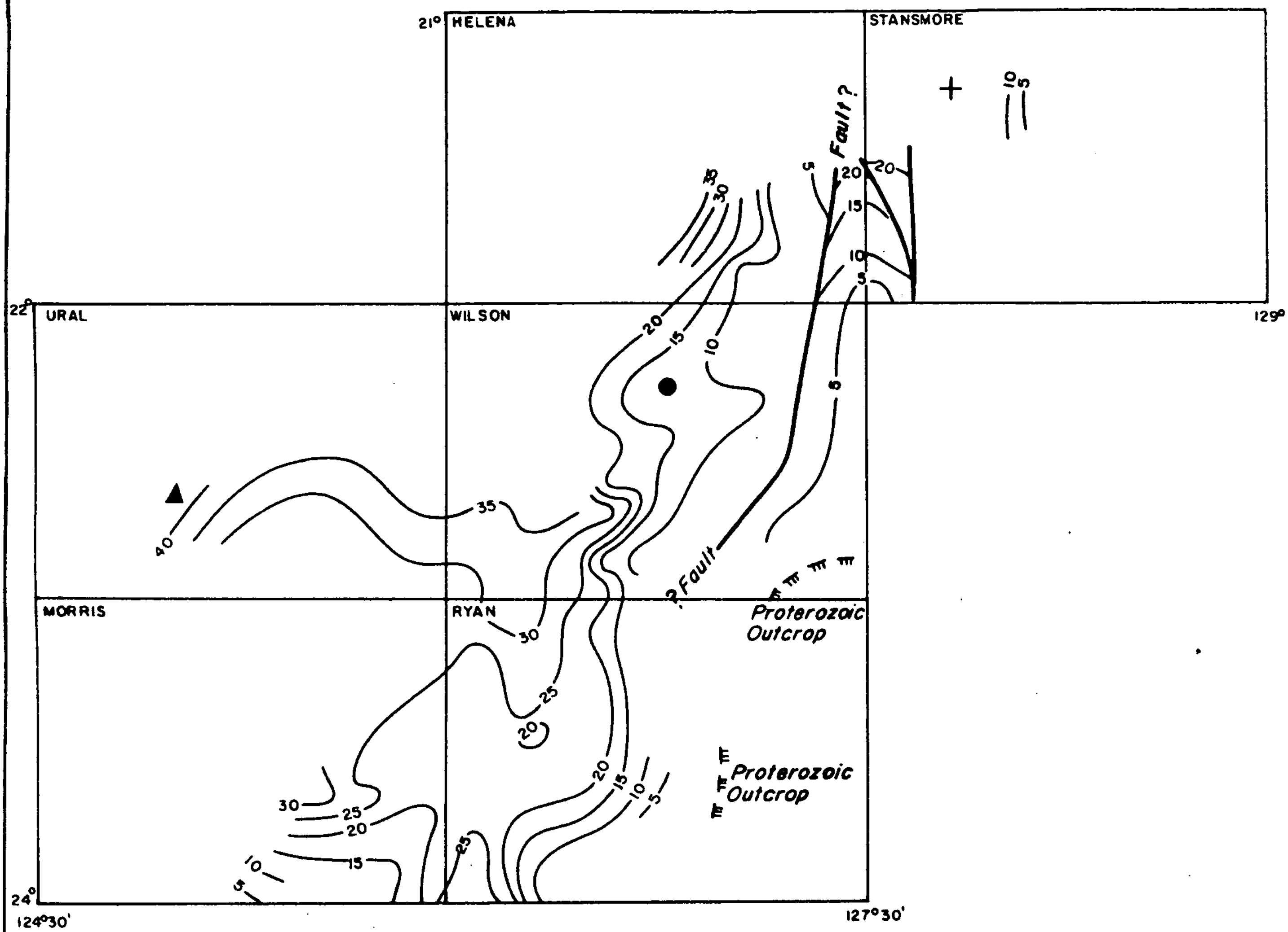
Contour
Fault
Borehole (Wilson Cliffs No.1)
Borehole (Point Moody No.1)

SEISMIC REFLECTION RESULTS, WILSON, RYAN, AND STANSMORE 1:250 000 SHEET AREAS

(Australian Aquitaine Petroleum Pty Ltd, 1968a)

50 0 50 100 km

Contour values in seconds of two-way time



LEGEND

20	Contour
	Fault
	Boundary of Proterozoic outcrop
+	Borehole(Point Moody No. 1)
●	Borehole(Wilson Cliffs No. 1)
▲	Borehole(Kidson No. 1)

TENTATIVE RESISTIVITY BASEMENT MAP
(AUSTRALIAN AQUITAINE PETROLEUM PTY. LTD., 1968b)

50 0 50 100 kilometres

Contour interval: 5000 feet