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RECONNAISSANCE HELICOPTER GRAVITY SURVEY, W.A., 1971-72

by

A.R. Fraser

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SUMMARY

Between October 1971 and October 1972 the Bureau of Mineral Resources, Geology & Geophysics conducted a reconnaissance helicopter gravity survey over approximately one-third of Western Australia. The survey area covered a band 4° to 6° wide extending from the central west coast eastwards to the South Australian border and southwards to the Great Australian Bight. About 8300 new readings were made at a spacing of 11 kilometres over all or parts of fifty-eight 1:250 000 Sheets.

Thirteen gravity provinces are recognized, nine of which were partly defined from the results of previous gravity surveys. The gravity provinces are believed to correspond to tectonic divisions within the crystalline Precambrian Shield including its subsurface extension under the Officer and Eucla Basins, except in the southern Carnarvon Basin where to a large extent gravity relief apparently reflects variations in depth to basement.

A generally disturbed Bouguer anomaly contour pattern testifies to the structural complexity of the Yilgarn Block, local gravity highs and intervening low gravity areas respectively being associated with basic igneous masses and enclosing granitic gneisses. The gravity results indicate that the Yilgarn Block extends beyond its exposed limit to form the crystalline basement of the adjacent parts of the Officer and Bangemall Basins.

The central part of the Yilgarn Block is divided into two gravity provinces along a sinuous line extending between Norseman and Wiluna. In the western province, intense residual highs are disjointed and predominantly northerly trending, whereas in the eastern province, residual highs are longer, trend mainly north-northwest, and are of smaller amplitude and intensity. Gravity and geological evidence combined suggest that the boundary between the two provinces may be associated with a major Archaean unconformity separating a basement of older granites and greenstones exposed in the west from a younger greenstone sequence exposed in the east. Furthermore, the province boundary may coincide with the western limit of the main nickel province of the Yilgarn Block, as it passes just west of commercial deposits near Mount Keith, Sir Samuel, Agnew, and Widgiemooltha.

A regional Bouguer anomaly rise in the western part of the Yilgarn block as the Darling Fault is approached may be caused by a gradual increase in grade of metamorphism associated with an increasing abundance of basic dyke swarms.

The Yilgarn Block is bordered by several elongate gravity depressions. A depression west of the block correlates with the Coolcalalaya and Byro Basins of Phanerozoic sediments, but elsewhere the depressions extend wholly or partly across shield rocks and must therefore correspond to mass deficiencies within the Precambrian basement.

A narrow gravity ridge over the Fraser Range metamorphics continues with reduced intensity across the Officer Basin, and connects to a strong gravity ridge coincident with the Musgrave Block. The feature is believed to follow the partly buried southeast margin of the Yilgarn Block and may therefore be analogous to elongate gravity ridges surrounding the Pilbara and Kimberley Blocks. The latter have been interpreted as the expressions of Proterozoic mobile zones of dense metamorphic rocks.

An area of disturbed gravity pattern southeast of the Fraser Range metamorphics may correspond to a shield block buried beneath the Eucla Basin sediments. Low Bouguer anomaly values north and east of this block are attributed to low-density rocks forming the basement of the Eucla and Officer Basins.

Gravity results from the southern Carnarvon Basin support an earlier contention that gravity relief relates mainly to variations in depth to basement. Accordingly, elongate zones of relatively high Bouguer anomaly correspond to basement ridges, and areas of low Bouguer anomaly to basement troughs.

Continuity of minimum gravity level between the Byro Basin and the northern Perth Basin indicates that the Coolcalalaya and Byro Basins could be regarded as part of the Perth rather than the Carnarvon Basin. Gravity in conjunction with seismic results suggests that the basement of the Perth Basin may be of appreciably lower density than the basement of the Gascoyne Basin.

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1. INTRODUCTION

Between October 1971 and October 1972 the Bureau of Mineral Resources, Geology & Geophysics (BMR) extended the gravity coverage of Australia by conducting a reconnaissance helicopter survey which completed gravity coverage of Western Australia (Plate 1). The survey was conducted under contract by Wongela Geophysical Pty Ltd using the cell method, described by Hastie & Walker (1962), to establish an 11-k lometre grid of gravity stations over the survey area. Ties were made to permanently marked stations from previous BMR surveys in adjoining areas and from four previous private company surveys. The results of three of the private company surveys are incorporated in the preliminary Bouguer anomaly contour map (Plate 2).

The survey area covers parts of several regional geological units; these include six divisions of the Australian Precambrian Shield, and four sedimentary basins, namely, the Perth Basin, the Carnarvon Basin, the Eucla Basin, and the Officer Basin.

Topography within the area is dominated by the Great Western Plateau, an undulating peneplain whose height above sea level is generally in the range 400 to 600 metres. Vegetation is sparse over most of the plateau and rainfall varies from fair and regular in the west, to low and unreliable in the east. Survey operations were therefore only rarely disrupted by bad weather, rugged topography, or thick vegetation.

This report contains summaries of the geology of the area and of previous geophysical survey results, and a qualitative description and interpretation of major gravity features. A description of survey methods and lists of statistics are included as appendices. I. Zadoroznyj assisted in the review of the geology and previous geophysical results.

2. GEOLOGY

The survey area extends over a large part of the Australian Precambrian Shield, and parts of the Perth, Carnarvon, Officer, and Eucla Basins. These divisions are shown in Plate 3. Information on bore-holes in the sedimentary basins is given in Appendix 5.

Australian Precambrian Shield

This review of the geology is based on papers by Prider (1965, 1970), Wilson (1969) and McCall (1972). Information on rock ages is extracted from works by Wilson et al. (1960), Compston & Arriens (1968), and Arriens & Lambert (1969), and the names of tectonic units are those suggested by Daniels & Horwitz (1968).

The western part of the Australian Precambrian Shield contains the oldest known rocks in Australia. Granites and gneisses older than 3000 m.y. have been found in the northern and western parts of West Australian Shield and most of the extensive Archaean terrains are composed of rocks older than 2600 m.y. Geological reconnaissance and age dating have led to the division of the West Australian Shield into a number of geotectonic provinces, each of which is characterized by some uniformity of structure, age, or general rock type. The subdivisions that lie wholly or partly within the survey area are the Yilgarn Block, the Albany-Fraser Province, the Northampton Block, the Bangemall Basin, and the Gascoyne Block. These, together with the Musgrave Block of Central Australia, are described below.

Yilgarn Block. This block, one of the oldest parts of the shield, is characterized by linear north to northwest trending greenstone belts enclosed within a large expanse of granitic gneiss. The greenstone belts consist of complex associations of basic and ultrabasic volcanics and penecontemporaneous sills overlain conformably by clastic sediments and acid volcanics; they are intruded by massive granites. The block is intruded by easterly trending norite dykes of Archaean age in the eastern part and by Upper Proterozoic basic dyke swarms in the west.

The geotectonic pattern and lithology of the greenstone belts vary from east to west across the Yilgarn Block. The pronounced linearity of the greenstone belts in the eastern part of the block gives way to a less regular disposition in the west, and whereas ultrabasic volcanic and subvolcanic assemblages are found in the Eastern Goldfields area near Kalgoorlie, ultrabasics close to the western margin of the block tend to be serpentinized harzburgites and dunites of coarsely crystalline character. The greenstones near Mount Magnet are characterized by immense layered intrusions containing harzburgitic ultrabasic layers, in varying states of serpentinization.

The lithologic variation across the Yilgarn Block is reflected by the known distribution of nickel occurrences in Western Australia. All the important nickel deposits so far discovered are associated with the volcanics and shallow-level ultrabasic intrusives of the Eastern Goldfields; no substantial economic deposits have yet been found in association with the coarser-grained ultrabasics of the western half of the Yilgarn Block despite many promising sulphide shows.

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McCall (1972), suggests that the changes seen from east to west across the Yilgarn Block reflect progressively deeper levels laid bare by erosion, and that because of pressure controls on sulphide mineralization, important nickel deposits are confined to the relatively high crustal zone in the eastern part of the block.

Albany-Fraser Province. Along the south coast of the western part of Western Australia, Precambrian rocks strike east-northeast in marked discordance with the north-northwesterly trending structures in the adjoining Yilgarn Block. Farther east, the trend swings to northeast and the province is separated from the Yilgarn Block by the northeast trending Fraser Fault. Rocks within the province are of Proterozoic age and are therefore substantially younger than the Archaean rocks of the Yilgarn Block.

Only the eastern part of the province is of interest in the present survey. A linear belt of basic high-grade metamorphic rocks, parallel to and southeast of the Fraser Fault, and an associated gravity ridge of unusually large magnitude and intensity, appear to extend for some distance into the survey area. Wilson (1969) has studied the high-grade metamorphic rocks in the vicinity of Fraser Range, and describes them as 'basic pyroxene granulites derived from basalts, many of which appear to have been vesicular and pillowed'. The granulites at Fraser Range have been cut by a flat-lying olivine-gabbro sheet, the intrusion of which appears to have caused local destruction of the preferred crystallographic orientation of the granulites. Minor structures in the granulites suggest that the Fraser Fault is reverse and southeast dipping, with a strong sinistral transcurrent component moving the east block northwards. The tectonic history of the metamorphic belt is uncertain, but Arriens & Lambert (1969) have inferred from geochronological evidence that metamorphism took place as a sharp episodic event, or that there was a sudden termination to a prolonged metamorphic process. They conclude that the main geological alternatives consistent with these constraints are: (a) deposition of geosynclinal sediments, followed by orogenic deep-seated granulite-facies metamorphism, all within a few hundred million years, or (b) deep-seated and possibly prolonged rework ng under granulite-facies metamorphism of older crustal rocks, ending with rapid uplift.

Northampton Block. This is a comparatively narrow strip of crystalline Precambrian rocks forming an outlying part of the shield along the western margin of the northern Perth Basin. It consists of a folded complex of acid garnet granulites with minor basic bands of plagioclase-hornblende-pyroxene granulite. The rocks are believed to be the remains of greywackes which have been subjected to granulite-facies metamorphism. There is no sign of granitic igneous activity. The granulites, estimated to be 1000 million years old, are cut by a northeast trending dyke swarm.

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Bangemall Basin. The Bangemall Basin, north of the Yilgarn Block, is a trough that trends east to southeast and contains middle Proterozoic sediments and interbedded lavas. The sediments are possibly continuous with a thick Proterozoic section in the Officer Basin. The survey area covers only the southern part of the Bangemall Basin, where the presence of Archaean granite inliers suggest that the sediments form only a thin layer over predominantly granitic basement.

Gascoyne Block. The Gascoyne Block extends into the northwestern part of the survey area. It is younger than the Yilgarn Block and is made up mainly of granites and metamorphosed sediments and volcanics of probable lower Proterozoic age.

Musgrave Block. The western part of the Musgrave Block extends into the northeastern corner of the survey area. Proterozoic granites, high-grade metamorphic rocks, and basic dykes and sills are exposed in a few scattered inliers. The western part of the block is intruded by granite and by the Giles Complex, which consists of four main gabbroic sheets each intruded separately. Transecting the block is the northeast trending Giles Discontinuity thought by Horwitz et al, (1966) to be a transcurrent fault.

Perth Basin

The onshore part of the Perth Basin extends from the south coast of Western Australia 950 km to the north, varying in width from 15 to 90 km and covering an area of 54 000 square kilometres. Only the northern part of the basin lies within the survey area.

The eastern margin is the prominent Darling Fault which separates Precambrian basement from a thick half graben of sediments which in the deeper parts may exceed 10 km in thickness. A subsurface basement ridge, the Beagle Ridge, running south from the Greenough Block is considered to mark the western boundary of the onshore part of the northern Perth Basin. The boundary between the Perth and Carnarvon Basins is somewhat arbitrary but has generally been assumed to be in the vicinity of the Greenough Block. Significant movement of the Darling Fault began in the late Triassic and continued throughout the Jurassic and early Cretaceous. The magnitude of the steep gravity gradient which extends along the length of the Darling Fault indicates that the vertical throw is very large. This is confirmed from seismic evidence by Mathur (1973) who has computed the downthrow to be 7.5 km near Perth. This movement has resulted in a wedge of Palaeozoic and Mesozoic sediments, thickest in the east, with basement and sediments generally dipping east. The basin has a number of separate inner troughs and ridges which generally strike north.

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The northern Perth Basin is dominated by normal northerly trending faults usually along basement ridges; minor cross-faulting is also present. The fault pattern creates a complexity of fault blocks which may have controlled sedimentation throughout the Mesozoic. Anticlinal features in the region are therefore the result of draping of sediments over basement rises rather than compressional folding. A large north-northwest trending fault, the Urella Fault, is considered to form the eastern margin of a large trough, the Dandaragan Trough.

Carnarvon Basin

The Carnarvon Basin is an epicontinental basin of mainly Phanerozoic sediments extending on land from Onslow in the north to Geraldton in the south, and eastward from the coast for up to 200 kilometres. Recent sand and alluvium obscure the landward margin of the basin in the north, but centrally in the east the boundary is the junction between Palaeozoic sediments and Precambrian igneous and metamorphic rocks. The southern margin is the poorly-defined boundary between the Perth and Carnarvon Basins.

Early detailed geological investigations depicted the basin as a regional homocline of generally west-dipping Palaeozoic and Mesozoic sediments. Steeply-dipping contacts between Palaeozoic and Precambrian rocks were interpreted as faults or hinges resulting from stress in the basement, and the basin as a whole was considered to have evolved through large-scale tectonism (Condon, 1954). This view was modified after gravity, in conjunction with seismic and drilling evidence, suggested that the Precambrian basement surface is irregular, consisting of a number of relatively deep troughs separated by narrow sinuous ridges (Chamberlain, Dooley & Vale, 1954). Condon then (1956) proposed that most of the Palaeozoic/Precambrian contacts, originally described as faults, should be interpreted as depositional unconformities, and that the overall structure of the basin had been controlled by the pre-existing shape of the basement surface rather than by tectonism.

Aeromagnetic and seismic surveys have subsequently confirmed that the Carnarvon Basin consists of several sub-basins separated by basement ridges (Forsyth, 1960; Spence, 1961, 1962; Bow & Turpie, 1964). The main ridge, the Ajana-Wandagee Ridge, divides the onshore part of the basin meridionally and separates the Gascoyne Basin to the west, from the Coolcalalaya, Byro, Merlinleigh, and Bidgemia Basins to the east (Condon, 1965-1968). The Byro, Merlinleigh, and Bidgemia Basins are separated from each other by partly exposed basement ridges.

The Ajana-Wandagee Ridge appears to have influenced the distribution of Mesozoic sediments in the southern Carnarvon Basin. The north-plunging Gascoyne Basin, west of the ridge, contains thick sequences of Tertiary, Cretaceous, Jurassic, and older sediments, whereas the Merlinleigh, Byro, and Coolcalalaya Basins to the east contain sediments no younger than Permian except for a discontinuous Tertiary cover. Silurian sediments outcropping in the south of the Carnarvon Basin probably underlie younger sequences on both sides of the Ajana-Wandagee Ridge.

Officer Basin

This account is based on a report by Jackson (1971).

The Officer Basin is a deep, elongate structural depression covering an area of about 345 000 km^2, about three-fifths of which is in Western Australia. It is an intracratonic basin, bounded by the Yilgarn Block and the Median Belt in the west, the Musgrave Block in the north and northeast, the Gawler Block in the southeast, and the Eucla Basin in the south. Jackson correlates the Proterozoic sediments in the Officer Basin with Proterozoic sediments in the Bangemall Basin and infers that the two basins may be continuous.

Owing to lack of geological information, the boundaries of the basin are generally poorly defined, even where not obscured by Recent deposits. The sediments overlie a Precambrian basement which in most areas consists of igneous or metamorphic rock. Geophysical investigations indicate that the basin is asymmetrical in section with its deepest part lying close to its northern boundaries; from here the basin gradually shallows southwards.

There is a significant difference in sedimentary section between the western and eastern parts of the basin. Geological and geophysical investigations suggest that the Officer Basin in Western Australia is composed of a Proterozoic sequence 5500 m thick capped by a thin veneer of Palaeozoic and Mesozoic rocks. Five shallow holes drilled in the search for petroleum by Hunt Oil Company in 1965-66 all entered rocks believed to be of Proterozoic age at depths less than 450 m. The Officer Basin in Western Australia is therefore considered to be composed mainly of Proterozoic rocks. In contrast, Krieg (1969) describes the eastern Officer Basin of South Australia as being composed of a Palaeozoic sequence 4000 m thick overlying a Proterozoic sequence only 900 m thick. A deep stratigraphic well in the eastern Officer Basin (Munyarai No. 1) drilled by Continental Oil Company of Australia Limited (1969), penetrated 2890 m of sediments no older than Silurian.

Eucla Basin

This account is derived largely from a report by Lowry (in prep.).

The Eucla Basin is a large arcuate basin covering about 176 000 km^2 onshore and up to 120 000 km^2 offshore. In Western Australia it occupies about 133 000 km^2 onshore and more than 50 000 km^2 offshore. It is bounded to the west by the Albany-Fraser Province, to the east by the Gawler Block, and to the north by the Officer Basin. The southern boundary is on the continental shelf in the Great Australian Bight and has not yet been delineated. Most of the basin is occupied by a Tertiary limestone plateau that slopes gently seawards from an altitude of about 240 metres in the north to 60 to 120 metres in the south. The plateau grades northwards into the Great Victoria Desert, and in the south terminates abruptly in wavecut limestone cliffs. The uniformity of the limestone succession largely accounts for the featureless nature of the Nullarbor Plain.

The basin is thought to have been formed by subsidence of parts of the Australian Shield. It is unusually shallow for a basin of such large areal extent; the average onshore thickness is considered to be less than 600 metres. Lowry (op. cit.) notes that the Eucla Basin is a good example of an epeirogenic basin as it lies on the edge of a continent, has no volcanics, shows virtually no folding or faulting, and has an extremely low ratio of maximum depth to area. Tectonic deformation has been very mild consisting only of gentle downwarping in the Cretaceous, Eocene, and Lower Miocene followed by uplift, slight tilting, and minor faulting.

Boreholes in widely separated parts of the Eucla Basin in Western Australia have encountered crystalline basement rocks at depths less than 600 metres. Analyses of core samples from these boreholes suggest that the basement is composed of Precambrian granite and gneiss similar to those along the southeast margin of the Yilgarn Block (Peers & Trendall, 1967).

3. PREVIOUS GEOPHYSICAL RESULTS

Numerous geophysical surveys have been made within the survey area by BMR, the Geological Survey of Western Australia, mining companies, and oil exploration companies. Consideration is given only to those surveys from which information is readily available and which could have some bearing on regional gravity interpretation. Those surveys are listed in Appendix 4. Their locations are shown in Plates 4, 5, and 6. The major results are as follows:

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Gravity surveys

Previous gravity surveys have been conducted in the Perth and Carnarvon Basins by BMR, West Australian Petroleum Pty Ltd, and Barewa Oil and Mining N.L., over part of the Officer Basin by Hunt Oil Company, and across the Eucla Basin by BMR. Gravity, in association with magnetics, has helped to define the margins and internal structures of the Perth and Carnarvon Basins. A broad low gravity feature in the Officer Basin was presumed to be the expression of a thick sedimentary section. Gravity relief in the Eucla Basin was attributed mainly to basement density variations (Gunson & Van der Linden, 1956).

Magnetic surveys

Most of the regional aeromagnetic surveys in the survey area have been carried out by BMR. Coverage of the whole of the Carnarvon Basin was obtained from 1956 to 1961, and in 1957 the Perth Basin south of Geraldton was surveyed. From the results of these surveys, contours of depth to magnetic basement were drawn, and faults, basement ridges, and troughs in the two basins were delineated. Offshore aeromagnetic surveys, carried out west of the northern Perth Basin by West Australian Petroleum Pty Ltd, and west of the Carnarvon Basin by Tasman Oil Pty Ltd, defined a number of troughs and ridges.

BMR aeromagnetic surveys also cover a number of adjoining 1:250 000 Sheet areas in the Yilgarn Block. These areas are: BARLEE, MENZIES, EDJUDINA, LEONORA, LAVERTON, SIR SAMUEL, DUKETON, SANDSTONE, YOUANMI, BELELE, CUE, KIRKALOCKA, BYRO, MURGOO, YALGOO, GLENGARRY, WILUNA, and KINGSTON. Magnetic contours are closely related to structures in the greenstone belts as magnetite-rich banded iron formations are interbedded with the clastic sediments and layered intrusions of which the greenstone belts are composed. The contour maps indicate a predominant north-northwesterly trend and a subsidiary easterly trend; the latter has been attributed to basic dykes occupying fissures produced by easterly cross-folding.

A small land magnetic survey by Hunt Oil Company in western NEALE helped to resolve the source of a large gravity anomaly observed during an earlier gravity survey by Hunt Oil Company. The gravity and magnetic features were attributed to a fault-bounded basement platform capped by dense sedimentary rocks.

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Seismic surveys

Numerous seismic surveys have been carried out in the four main sedimentary basins within the survey area, in the search for structures favourable for the accumulation of hydrocarbons. They have ranged from reconnaissance and experimental to detailed. The data quality has often been poor, necessitating the use of multiple coverage and other techniques.

Most of the subsidized seismic surveys in the Perth and Carnarvon Basins have covered small areas, and have only minor relevance to regional gravity interpretation. They indicate that the southern Carnarvon Basin and northern Perth Basin are complexly faulted, the majority of anticlinal closures being associated with faulting. A BMR seismic survey in 1963 covered three sub-basins of the south Carnarvon Basin. The following general conclusions were obtained from two unpublished reports of this survey.

1. The western part of the Gascoyne Basin may contain up to 5 km of Silurian and Ordovician sandstone and limestone (Bow & Turpie, 1964)
2. The Byro Basin contains up to 3 km of sediments including at least 1 km of Permian. The predominant structure is a north to northeast trending syncline extending to a depth of 3 km, flanked by two anticlinal structures which are probably associated with basement ridges (Turpie, 1964)
3. The Coolcalalaya Basin contains about 3 km of sediments (Bow & Turpie, 1964)
4. The Ajana-Wandagee Ridge is overlain by sediments 1 to 2 km thick and may represent the westward limit of Permian deposition (Bow & Turpie, 1964).

Hunt Oil Company conducted four seismic surveys in the western Officer Basin in 1963-65. A good reflector was mapped over most of the survey areas, while another reflector, about 0.5 sec below and unconformable with the first, was also mapped in YOWALGA and LENNIS. The upper reflector is believed to correlate with a basalt layer interbedded with clastic sediments.

Two marine surveys in the offshore part of the Eucla Basin were carried out for Tenneco Australia Incorporated in 1967. Data quality was poor in areas where sediments were absent, but improved as the sedimentary section thickened. The surveys revealed the offshore part of the basin to have an average section of only about 1000 metres. Two troughs were indicated with sediments up to 2000 metres thick. The sediments are notable for their lack of prospective features; even sedimentary drapes over topographic basement highs appear to be absent.

4. DISCUSSION OF GRAVITY RESULTS

Bouguer anomaly contours are shown in Plate 2. Survey statistics, personnel, equipment, and procedure are given in Appendixes 1-3. In keeping with current BMR practice a rock density of 2.2 g/cm^3 was chosen for computing Bouguer corrections. This density is intermediate between values adopted for gravity surveys over sedimentary basins, and values adopted for surveys of hardrock areas. Discontinuities of contours with those of previous surveys tied to, are therefore minimized.

No attempt has been made to apply terrain or isostatic corrections to the Bouguer anomalies. The former are not considered necessary since the terrain is flat or undulating over almost the entire survey area, while computation of isostatic corrections would involve doubtful assumptions about the matter in which isostatic compensation is achieved.

The contoured area has been divided into a number of regional gravity provinces to assist in interpretation. Gravity provinces cover large areas of fairly simple shape in which the gravity field is characterized by uniformity with respect to contour trend, Bouguer anomaly level, or degree of contour disturbance. Where appropriate, provinces are subdivided into units, which are similar to provinces but generally occupy smaller areas.

Provinces are named after geographical features or towns. Some provinces have already been named as they extend into areas covered by previous gravity surveys. The names of all provinces wholly or partly within the survey area are listed in Table 1.

The geological Map of Western Australia, 1966, has been used in correlating the gravity features with outcropping rock units.

TABLE 1. GRAVITY PROVINCES

Province Name	Named After	Gravity Survey in which province first defined	Reference
Gascoyne Regional Gravity Complex	River	1969b	Fraser, 1973b
Perth Regional Gravity Low	City	Perth Basin, 1951-2, 1969a	Thyer & Everingham, 1956; Fraser 1973a
Erabiddy Regional Gravity Platform	Range	New	
Teano Regional Gravity Trough	Range	1969b	Fraser, 1973b
Austin Regional Gravity Complex	Lake	New	
Carey Regional Gravity Complex	Lake	New	
Ashburton Regional Gravity Ridge	Range	1969b	Fraser, 1973b
Yeo Regional Gravity Shelf	Lake	New	
Rason Regional Gravity Depression	Lake	1962; 1969a	Lonsdale & Flavelle, 1963 Fraser, 1973a Old name: Dundas Regional Gravity Depression (to the south) Gibson Gravity Depression (to the north)
Fraser Regional Gravity Ridge	Range	1969a	Fraser, 1973a
Blackstone Regional Gravity Plateau	Range	1962	Lonsdale & Flavelle, 1963
Eyre Regional Gravity Complex	Hamlet	1969a	Fraser, 1973a Old name: Gambanga Regional Gravity Low
Wanna Regional Gravity Depression	Lakes	1970	Pettifer, 1973 Old name: Officer Regional Gravity Depression

Gravity provinces

Each gravity province is discussed in relation to geology, previous geophysical results and tectonic setting.

Gascoyne Regional Gravity Complex. The northern part of this province was defined by Fraser (1973b). It is characterized by high-amplitude medium-wavelength variations in Bouguer anomaly and a general northerly trend of contour.

Within the present survey area, the province is bounded in the east by gradients towards lower Bouguer anomaly areas, while its southern and western boundaries lie beyond the coastline and will remain undefined until gravity results from the continental shelf are available. The main features are a strong positive north-trending gravity spur in the south of the province, and two broad depressions farther north. The northerly prolongation of the spur is a narrow ridge of elevated Bouguer anomalies which can be traced over the entire length of the province. The ridge bifurcates in eastern WOORAMEL and the divergent limbs partly enclose the easternmost of the two gravity depressions. The province can be divided into three units (Plate 2). Unit I is the gravity spur and its northerly extension; Unit II is broad depression west of Unit I; and Unit III is the depression partly enclosed by the bifurcate part of Unit I.

Chamberlain et al. (1954) have interpreted the results of regional gravity traverses over the central part of the province. Their main conclusion is that gravity relief relates principally to variations in sedimentary thickness rather than to lateral changes of basement density. Corrobarative evidence for this is provided by the results of both the present and past surveys and is as follows:

1. Along the eastern margin of Unit III, Bouguer anomaly values rise towards the east as Precambrian outcrop is approached.

2. Precambrian inliers are associated with gravity maxima. This is particularly noticeable in the south of Unit I, where a closed Bouguer anomaly maximum exceeding +50 mGal coincides with a large exposure of Precambrian metamorphics. Local gravity maxima are also associated with Precambrian inliers in the western part of GLENBURGH and near the junction of KENNEDY RANGE and MOUNT PHILLIPS.

3. Low gravity features, similar in shape, area, and amplitude to Units II and III, are absent over the shield rocks immediately adjacent to the sediment-covered area.

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The assumption of uniform basement density under the sediment-covered area led Chamberlain et al. to interpret gravity depressions and ridges as the expressions of sedimentary troughs and basement ridges respectively. This interpretation was subsequently vindicated by reflection seismic evidence (Bow & Turpie, 1964) which showed that sediments are 5000 metres thick in the southern Gascoyne Basin but only 2000 metres thick over the basement ridge to the east, where Bouguer anomaly values are about 25 mGal higher. The required density contrast between basement and sediments to produce this difference in Bouguer anomaly level is calculated to be about 0.2 g/cm^3 assuming that the vertical relief of the basement ridge is small compared to its transverse horizontal extent.

Units I, II, and III relate to structural features most of which were defined from the results of the earlier gravity survey. Unit I of high Bouguer anomaly covers the Northampton Block and its subsurface northerly extension, the Ajana-Wandagee Ridge. Units II and III of low Bouguer anomaly correspond to relatively deep sedimentary troughs, the Gascoyne and Merlinleigh Basins respectively.

Perth Regional Gravity Low. Only the northern part of this province lies within the survey area. The southern part was first recognized and described by Thyer & Everingham (1956) from results of regional gravity traverses. The province is a narrow, elongate, north-trending trough, of strongly negative Bouguer anomalies, bounded to the east and west by steep gradients. It extends as a continuous feature between AUGUSTA in the south and GLENBURGH in the north, where it terminates against a gravity saddle.

The province is the combined gravity expression of the Perth, Coolcalalaya and Byro Basins. The steep gradient along its eastern margin coincides with the fault zone separating basin sediments from exposed shield rocks to the east. The continuity of minimum gravity level across supposed inter-basin boundaries suggests that the Coolcalalaya and Byro Basins could be regarded as sub-basins of the Perth rather than the Carnarvon Basin.

Within the present survey limits, the province can be divided into three units, each of which corresponds to a sub-basin of the Perth Basin. Exceptionally low Bouguer anomaly values in Unit I may relate to thick sediments of the Dandaragan Trough, which is one of the deepest parts of the Perth Basin. A steep gradient, defining the eastern margin of the unit in the south, follows the Urella Fault, not the Darling Fault, confirming previous indications that the vertical throw of the Urella Fault exceeds that of the Darling Fault in this area. The steep gradient diverges eastwards from the Urella Fault in the north of the unit and rejoins the Darling Fault.

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The province becomes narrower to the north, and Unit II is a tenuous, steep-sided gravity trough flanked on both sides by positive anomaly zones. The unit is correlated with the Coolcalalaya Basin of predominantly Palaeozoic sediments. Gradients are steepest along the eastern unit margin, where the basin wall is probably the near-vertical Darling Fault plane. To the west, gentler gradients appear to reflect a gradual shallowing of the basin floor from the deepest part of the basin, close to the Darling Fault zone, towards outcropping or near-surface Pre-cambrian rocks.

Depth to basement in the Coolcalalaya Basin has been estimated from seismic results to be 3000 to 4000 metres (Bow & Turpie, 1964). Paradoxically, this is 1000 to 2000 metres shallower than the adjacent part of the Gascoyne Basin, where the Bouguer anomaly level is about 30 mGal higher. Two alternative explanations are offered:

1. The overall density of sediments is lower in the Coolcalalaya Basin than in the Gascoyne Basin.

2. The density of the basement is lower under the Coolcalalaya Basin than under the Gascoyne Basin.

If the basement was of the same density under both the Gascoyne and Coolcalalaya Basins, then the bulk density of sediments in the Gascoyne Basin would have to be 0.2 to 0.3 g/cm^3 greater than in the Coolcalalaya Basin, in order to produce the observed gravity level difference (basement/sediment density contrast in the Gascoyne Basin is taken as 0.2 g/cm^3). As this seems unlikely on geological grounds, the second alternative is favoured. A basement density contrast between the two basins of 0.2 g/cm^3 extending to a depth of 10 km, would produce a gravity level difference of the right order of magnitude. The density contrast between intrusive granite and high-grade metamorphic rock could conceivably be 0.2 g/cm^3. Considerations of the gravity field over the Precambrian shield give further support to the second alternative. The Yilgarn Block is rimmed on its southern, southeastern, and northern margins by elongate gravity depressions. These must be associated with mass deficient Precambrian rocks as they extend across large tracts of the exposed shield and in some areas correlate with outcropping granite. As the Perth Basin, like the elongate gravity depressions, is peripheral to the Yilgarn Block, the Precambrian basement beneath the basin may conceivably be of unusually low density. It is pertinent that the Perth Regional Gravity Depression swings eastwards at its northern end and appears to wrap around the northwest corner of the Yilgarn Block. It then connects across a gravity saddle to a major peripheral gravity depression over Precambrian rocks. The foregoing considerations suggest that negative anomalies over the Perth Basin may be only partly attributable to light Phanerozoic sediments and that a component of the gravity trough relates to low-density rocks within the Precambrian basement.

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Unit III, the northernmost unit of the Perth Regional Gravity Low, can be correlated with the Byro Basin. It is a northeast trending gravity depression, wider than Unit II and bounded to the northwest and southeast by steep gradients. These gradients are associated with faults which form the boundaries of the Byro Basin. Continuity of contour trend between Unit II and III indicates that the Coolcalalaya and Byro Basins are connected and are not separated by a basement ridge as inferred by Condon (1965). The total Bouguer anomaly change across each of the two units is about the same, suggesting that the Coolcalalaya and Byro Basins are of approximately equal depth. This agrees with seismic evidence, which shows that the thickness of sediments in the two basins is about 3 km (Bow & Turpie, 1964; Turpie, 1964).

<u>Erabiddy Regional Gravity Platform.</u> This is a newly-defined province adjacent to and east of the Perth Regional Gravity Depression. It is characterized by a comparatively high Bouguer anomaly level, north to northeasterly contour trends, and fairly gentle gravity relief. Bouguer anomalies decrease from positive in the west to about -35 mGal at the eastern province boundary.

The province extends over the northwestern part of the Yilgarn Block and overlying Middle Proterozoic metasediments. In the west, elongate Bouguer anomaly maxima parallel to the margins of the Coolcalalaya and Byro Basins approximately coincide with elongate outcrops of Middle Proterozoic metasediments. The gradual rise in Bouguer anomaly from east to west across the province could relate to an increasing abundance of basic dyke swarms and/or to an increase in grade of metamorphism. Isostatic effects may also contribute to the Bouguer anomaly rise in view of the proximity of the province to the continental margin.

Apart from the narrow residual highs along the western province boundary, there is only one local gravity feature of amplitude greater than 10 mGal. This is a gravity high in northern MURGOO which coincides with an Archaean basic igneous outcrop.

Teano Regional Gravity Trough. The northern part of this province was first defined by Fraser (1973b). It is a broad east-trending gravity trough bounded by fairly steep gradients in the south and gentler gradients in the north. The province is separated from the Gascoyne Regional Gravity Complex to the west by a gravity ridge but connects across a saddle to the Perth Regional Gravity Low. In the east the province becomes narrower and appears to terminate in the northwest corner of NABBERU.

The province flanks the northern part of the Yilgarn Block, and extends over the southern part of the Gascoyne Block and overlying sediments of the Bangemall Basin. Gravity contour trends are not associated with any exposed geological contacts, which suggests that the source of the gravity depression is deep-seated. The province is one of several which lie around the periphery of the Yilgarn Block. The depressions extend parallel to major gravity ridges corresponding to Proterozoic mobile zones, and may therefore be associated with Proterozoic tectonic activity.

Austin Regional Gravity Complex. This is a newly-defined province whose relief is characterized by elongate residual highs, mainly north trending, superimposed on a gravity surface which shows a regional north-easterly decrease from -40 mGal in the southwest, to -80 mGal in the northeast of the province. The province abuts the Teano Regional Gravity Trough to the north, and the Erabiddy Regional Gravity Platform to the west; it extends southwards into the area surveyed in 1969 but does not correspond to any previously-defined province.

The province covers a large area of the western part of the Yilgarn Block. Residual highs can generally be correlated with greenstone outcrops; the low Bouguer anomaly areas between the residual highs correspond to granite or gneiss. The regional Bouguer anomaly decrease to the northeast across the province has no evident surface cause and it may relate to a change of the deep crust, such as crustal thickening, or to a change in the average composition or grade of metamorphism of rocks.

A predominant northerly trend, apparent in the Bouguer anomaly contours, is not reflected in the outcrop pattern of the greenstones in this area. The geological map (Plate 3) shows that north-northwesterly trends of the greenstones, prevalent in the eastern part of the Yilgarn Block, are also present in the area covered by the Austin Regional Gravity Complex. But a detailed examination of the relation between gravity contours and regional geology reveals that parts of greenstone outcrops elongated in north-northwesterly direction (e.g. in SANDSTONE, YOUANMI, and BARLEE) have no associated gravity expression. This indicates either that geological mapping is inaccurate, or that the greenstone belts with a north-northwesterly orientation are surficial or of small density contrast with the enclosing rocks.

Carey Regional Gravity Complex. This province is characterized by elongate north to northwest trending residual highs and lows. The residual highs are longer, have a different overall trend, and are of smaller amplitude and intensity than residual highs in the Austin Regional Gravity Complex, and it is on these criteria that the two provinces are differentiated. The southern part of the province lies within the area surveyed in 1969,

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where it includes a broad region of disturbed Bouguer anomaly extending north-northwestwards across KALGOORLIE, KURNALPI, and WIDGIEMOOLTHA. The western province boundary extends parallel to a line of gravity highs which can be traced with varying degrees of confidence from Norseman to north of Wiluna. The eastern province boundary is less clearly definable, but is drawn so as to separate the province from an area of more quiescent gravity field to the east.

Residual gravity highs and intervening areas of low Bouguer anomaly are respectively associated with greenstone belts and enclosing granitic gneisses. Many high gravity features are not precisely coextensive with greenstone outcrop, indicating that the greenstone bodies may vary appreciably in depth or density from place to place. High grade metamorphic rocks shown on the 1966 Geological Map of Western Australia in western LEONORA and elsewhere in the province have no perceptible gravity expression and must therefore have a density close to the average for this area of the shield.

Correlations between the gravity results and surface geology are difficult in the north of the province, where the Archaean rocks are largely obscured by Middle Proterozoic sediments and volcanics of the Bangemall Basin. A large triangular gravity high occupying the northwest corner of the province is coextensive with a Proterozoic outlier, suggesting that the Proterozoic sequence is either denser than granite and of fairly substantial thickness, or is underlain by dense Archaean greenstone. The depth to magnetic basement in the northeast of GLENGARRY, within the area of high gravity, has been estimated to be about 600 m (Lambourn, 1972). Proterozoic section of this depth could only contribute about 4 mGal to gravity relief assuming that its bulk density was 0.15 g/cm^3 greater than the underlying Archaean basement. But the Proterozoic/Archaean contact is associated with consistent Bouguer anomaly gradients, and the shape and areal extent of the high gravity feature are unlike those of the gravity highs produced by the greenstone belts farther south. It may therefore be logical to interpret the triangular gravity high as the expression of Proterozoic section, a local maximum in the southwestern part being caused by underlying greenstone. The Proterozoic section would have to contain dense basic volcanics and be substantially thicker overall than 600 m as estimated in northern GLENGARRY. If the section does contain layered basic volcanics, then the measured magnetic basement could be much shallower than Archaean basement and the depth estimate of 600 m would be a misleadingly small value for the total depth of the section.

Parts of the Bangemall Basin cover most of NABBERU, THROSSELL, and KINGSTON in the northeastern part of the province. The depth to magnetic basement has been estimated at 200 to 600 m in central KINGSTON and 2200 m m in northeast KINGSTON (Lambourn, 1972). In spite of this considerable variation in thickness of the Proterozoic section, gravity relief is attributed mainly to lateral density changes in the basement. This is suggested by the similarity of gravity pattern between the Proterozoic-covered area and the Archaean granite/greenstone terrain farther south, the continuity of gravity trends across the Proterozoic/Archaean boundary, and the approximate coincidence of the southern part of a gravity high on KINGSTON with a greenstone outcrop south of and adjacent to the Proterozoic sediments.

Comparison between the Austin Regional Gravity Complex and the Carey Regional Gravity Complex. The contrast in gravity pattern between the Austin Regional Gravity Complex and the Carey Regional Gravity Complex relates essentially to differences of geometry and density contrast of the greenstone belts between the eastern and western parts of the Yilgarn Block. These differences are summarized as follows:

1. The greenstone belts in the western Yilgarn Block are of greater density contrast with surrounding granites and gneisses than are the greenstone belts in the eastern Yilgarn Block.

2. The greenstone belts in the west are generally elongated in a northerly direction whereas the eastern greenstone belts are aligned along north to northwest axes.

3. The western greenstone belts are short and disjointed compared with the longer, more linear belts in the east.

Recent geologic evidence is significant with respect to the gravity province division. At Jones Creek (SIR SAMUEL), very close to the boundary between the two gravity provinces, Durney (1972) has mapped a major unconformity in the Archean, in which a granitic conglomerate at the base of a younger greenstone succession (exposed to the east) rests with angular discordance on older granite and greenstone (exposed to the west). The strike of the unconformity, although mapped over only a small north-south distance, is parallel to a line of gravity highs along the western margin of the Carey Regional Gravity Complex. It is suggested that this line of gravity highs corresponds to the westernmost of a series of younger greenstone belts in the Eastern Goldfields, and that the boundary between the Austin Regional Gravity Complex and the Carey Regional Gravity Complex approximately coincides with a major unconformity separating older, lower-level greenstones to the west, from younger volcanic and subvolcanic greenstones in the east.

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The contention that the gravity province boundary is the locus of a major geologic change is supported by the known distribution of important mineral occurrences in the Yilgarn Block. The boundary between the Austin Regional Gravity Complex and the Carey Regional Gravity Complex quite closely delineates the western boundary of the main nickel province in Western Australia, passing just west of deposits at Mount Keith, Mount Sir Samuel, Agnew, and Widgiemooltha.

Several alternative tectonic processes could explain the present mass distribution, as deduced from gravity, in the Eastern Goldfields. Of these, two are suggested which could have resulted in a major unconformity between the Eastern Goldfields and the area to the west:

1. Downwarping of the eastern part of the Yilgarn Block along a hinge and deposition of thick younger greenstone sequences unconformably on the older basement, followed by isoclinal folding of the sequences along north to northwesterly axes.

2. Welding of alternately volcanic-rich and sediment-rich belts on to the margin of a pre-existing cratonic nucleus (the western part of the Yilgarn Block) by a process of lateral accretion.

Ashburton Regional Gravity Ridge. Only the southeastern tip of this province extends into the survey area. The province has been described and discussed by Fraser (1973b) and will not be considered here.

Yeo Regional Gravity Shelf. This province is characterized by fairly flat gravity relief with Bouguer anomaly values generally ranging between -40 and -60 mGal. No consistent contour trends are obvious, and in this respect the province contrasts with the Carey Regional Gravity Complex to the west, where trends are north-northwesterly, and the northeast-trending Rason Regional Gravity Depression to the east. A short distance north of the survey area the province appears to terminate against the Gibson Gravity Depression (Lonsdale & Flavelle, 1963) while to the south the province is terminated at the junction of the Carey Regional Gravity Complex and the Rason Regional Gravity Depression, close to the southern survey boundary. The most noteworthy local gravity features are a north-northwesterly elongated residual high on RASON, and a broad east-trending high on THROSSELL which swings round to a northerly direction in western WESTWOOD and extends to southwestern BROWNE.

The province extends over the eastern part of the exposed Yilgarn Block, and Proterozoic, Permian, and Tertiary sediments of the Officer Basin. Contour trends are continuous across the shield/sediments boundary, indicating that the sediments form only a thin layer, or are of small density contrast with the underlying basement. The residual high on RASON is conformable in trend and shape with the highs in the greenstone area to the west, so the feature probably corresponds to a basic igneous body in the basement. The broad east-trending high on THROSSELL is of different orientation from the gravity features associated with the greenstone belts and is therefore considered unlikely to have an intra-basement source. The feature could relate to either a basement topographic rise or a dense inrusive body such as a basic sill or dyke interbedded with, or cutting across, sediments. A more precise interpretation of the gravity feature may be possible when the results of recent seismic and gravity surveys in the area, conducted after the present survey, are interpreted (Harrison & Zadoroznyj, in prep.).

Rason Regional Gravity Depression. Only the central part of this province lies within the survey area. Its southern part, previously termed the Dundas Regional Gravity Depression, was defined by Fraser, (1973a), and its northern part lies in an area surveyed in 1962 (Lonsdale & Flavelle, 1963). The province is a broad gravity trough of variable width and intensity, which can be traced from northwest ESPERANCE along a northeasterly path to TALBOT, where it swings to a northwesterly direction and terminates north of the survey area against the Ashburton Regional Gravity Ridge.

Although the province extends across the Officer Basin, low Bouguer anomaly values are considered to reflect a mass deficient zone within the basement rather than thick sediments. This is suggested by the following observations:

1. The province is most clearly definable south of the survey area, where Precambrian rocks are exposed.

2. The province bears no relation spatially to the known shape and structure of the Officer Basin.

3. The Bangemall Basin is not associated with a gravity depression, suggesting that the Proterozoic sediments have a bulk density close to the basement average. The Officer Basin is believed to have a thick Proterozoic section which is continuous with the Bangemall Basin sedimentary section.

4. The province is part of an almost continuous ring of gravity depressions circumscribing the Yilgarn Block. With the exception of the Perth Regional Gravity Low, these depressions all extend over Precambrian rocks.

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The province is similar in tectonic setting to the Teano Regional Gravity Trough. It extends parallel to the gravity expression of a Proterozoic mobile belt and may therefore be associated with Proterozoic teconic activity.

Fraser Regional Gravity Ridge. The southern half of this province was defined by Fraser (1973a). The province is an elongate gravity ridge of varying width and amplitude, extending northeastwards between the south coast near Esperance and the western part of the Musgrave Block.

Except for a few scattered Precambrian inliers in PLUMRIDGE and NEALE, the province, within the survey area, is wholly coextensive with Officer Basin sediments. Although these mask the source of high Bouguer anomalies, it can be inferred that gravity relief relates mainly to basement density variations, as high Bouguer anomalies in the Fraser Range area are clearly associated with the dense, gabbro-intruded basic granulites exposed southeast of the Fraser Fault.

There is a marked reduction in intensity and Bouguer anomaly level of the province between PLUMRIDGE and TALBOT. While this is mainly attributable to a general decrease in basement density, the relatively light Officer Basin sediments could also have an attenuating effect on gravity relief. A residual high in NEALE and VERNON is similar in trend, shape, and area to a high in PLUMRIDGE, but its peak Bouguer anomaly value is about 35 mGal lower. Assuming that the sources of the two highs can be approximated by identical infinite horizontal cylinders of density contrast 0.3 g/cm^3 with the enclosing basement, and 0.5 g/cm^3 with the sedimentary cover, and that the cylinder corresponding to the anomaly in PLUMRIDGE is tangential to the surface, the depth to basement in eastern NEALE is calculated to be about 2 km.

The province appears to follow the partly buried southeastern margin of the Yilgarn Block, and may therefore have similar tectonic significance to elongated gravity ridges which girdle the Pilbara and Kimberley Blocks. These have been correlated with Proterozoic mobile zones containing dense metamorphic rocks (Whitworth, 1970; Fraser, 1973b). Mobile belt activity southeast of the Yilgarn Block may have influenced geological development in the western part of the Musgrave Block. This is implied by the continuity of the gravity contour pattern between the Fraser Range area and the western Musgrave Block, the presence in both areas of post-tectonic gabbroic sheet intrusions, and the approximate colinearity of the Fraser Fault and Giles Discontinuity.

<u>Blackstone Regional Gravity Plateau</u>. The northern part of this province was first defined and named by Lonsdale & Flavelle (1963). The province occupies the northeast corner of the survey area and is an intense, narrow, east-trending gravity ridge, with several peaks exceeding +40 mGal.

It is broadly coextensive with the Musgrave Block, and high Bouguer anomalies can be attributed to the gabbro-intruded metamorphic rocks of which the block is predominantly composed.

<u>Eyre Regional Gravity Complex</u>. This province adjoins the Fraser Regional Gravity Ridge to the southeast, and the Wanna Regional Gravity Depression to the south and west. The Gambanga Regional Gravity Low, defined by Fraser (1973 a), forms its western part, and to the south the province extends beyond the coastline. Four units can be defined within the province: Units I and II in the west are broad northeast-trending depressions; Unit III in the south of the province is an irregularly-shaped gravity high whose northwesterly prolongation is sharply truncated by the Fraser Regional Gravity Ridge; Unit IV is a gravity complex with several intense residual highs trending north to northeast.

Except for the southwest of the province, where granitic rocks crop out, the basement is covered everywhere by the thin Tertiary and Cretaceous sediments of the Eucla Basin. For this reason, the interpretation of gravity features is conjectural and depends largely on comparisons with gravity relief in areas of exposed basement. Units I and II run parallel to the Fraser Regional Gravity Ridge and could therefore, like the Rason Regional Gravity Depression, be related to Proterozoic tectonic activity. Unit III corresponds to an area of dense and probably metamorphosed basement although the regional increase in Bouguer anomaly towards the coastline may relate partly to a transition from continental to oceanic-type crust. The contour pattern in Unit IV resembles that over the greenstone/whitestone terrains of the Yilgarn and Pilbara Blocks. The intense residual highs may therefore correspond to small basic igneous bodies enclosed within gneissic basement.

The shape of the province, and its overall contour pattern, suggest that it may be the expression of a shield block, perhaps of Archaean age, which is welded onto the southeast margin of the Yilgarn Block.

<u>Wanna Regional Gravity Depression</u>. This province is a large depression in which the Bouguer anomaly level is fairly uniformly in the range -60 to -90 mGal. Its northern part is continuous with the Officer Regional Gravity Depression in South Australia (Pettifer, 1973). Relief is broad and gentle within the province, but a steep gradient forms its western boundary in the south.

Although sediments of the Eucla and Officer Basins crop out over the province, low Bouguer anomalies are probably due to light granitic basement, certainly in the south where a borehole near Forrest encountered biotite granite at a depth of only about 300 metres (Maitland, 1915; Peers & Trendall, 1967). Since the Bouguer anomaly level is uniformly low between Forrest and the northern part of the province, it is likely that the province as a whole corresponds to an area of predominently low-density basement. The only effect of the Officer Basin sediments may be to attenuate the gravity expressions of local mass anomalies in the basement, therefore causing flattish gravity relief.

5. CONCLUSIONS

The following general conclusions are made on the basis of the gravity results:

1. In the southern Carnarvon Basin, gravity relief probably reflects variations in depth to basement. Gravity depressions and ridges are interpreted respectively as the expressions of sub-basins and basement ridges of the Carnarvon Basin.

2. The gravity expression of the Perth Basin is continuous with those of the Coolcalalaya and Byro Basins, indicating that the latter could be regarded as sub-basins of the Perth rather than Carnarvon Basin.

3. The gravity profile across the Coolcalalaya Basin suggests that the basin floor dips gently east towards a steep wall bounding the basin in the east.

4. Vertical throw across the Urella Fault probably exceeds that across the Darling Fault in the area where the two faults are parallel.

5. Rocks underlying the Perth Basin sediments may be of appreciably lower density than those under the Gascoyne Basin sediments.

6. A gradual rise in Bouguer anomaly across the western Yilgarn Block as the Darling Fault is approached from the east may relate to deep crustal changes, to an increase in grade of metamorphism, or to an increasing abundance of basic dyke swarms.

7. Extensive gravity depressions along the northern end eastern margins of the Yilgarn Block have no obvious surface cause and must relate to deep crustal mass deficiencies. Their approximate parallelism to elongate gravity ridges, the expressions of Proterozoic mobile belts, suggests that the mass deficient zones are related to Proterozoic activity.

8. The central part of the Yilgarn Block is divided into two gravity provinces along a sinuous line extending from Norseman to north of Wiluna. In the western province, intense residual highs are disjointed and mainly north-trending, whereas in the eastern province, residual highs are longer, have a predominant north-northwesterly trend, and are of smaller amplitude and intensity. The contrast in contour pattern between the two gravity provinces reflects a regional geometric difference of the greenstone belts in the two sides of the Yilgarn Block. Geological and gravity evidence combined suggest that a major unconformity, close to and parallel to the boundary between the gravity provinces, separates younger greenstone sequences of the Eastern Goldfields from older greenstones and granites to the west.

9. The boundary between the eastern and western gravity provinces quite closely delineates the known westward limit of the main nickel province of the Yilgarn Block, passing just west of deposits near Mount Keith, Mount Sir Samuel, Agnew, and Widgiemooltha.

10. A narrow gravity ridge over the Fraser Range metamorphics continues with reduced intensity across the Officer Basin, and joins up with an intense gravity ridge over the Musgrave Block. The feature apparently follows the partly buried southeastern margin of the Yilgarn Block and is therefore analogous to elongate gravity ridges bordering the Pilbara and Kimberley Blocks. The latter have been interpreted as the expressions of Proterozoic mobile zones of dense metamorphic rocks.

11. A well-defined area of disturbed gravity contour pattern to the southeast of the Fraser Range metamorphic belt may correspond to a shield block which is almost totally buried beneath the Eucla Basin sediments.

12. Low Bouguer anomalies in an area extending from the Musgrave Block southwards to the Great Australian Bight are attributed mainly to low-density rocks within the basement of the Officer and Eucla Basins.

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Note: Additional abbreviated references for previous geophysical and borehole surveys, not specifically referred to in the text, are given in Appendixes 4 and 5.

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APPENDIX 1: SURVEY STATISTICS

The following statistics refer to the initial coverage of the survey area and do not take account of follow-up work.

Survey commenced	:	12 October 1971
Survey completed	:	2 July 1972
Total survey days	:	237
Total helicopter days available	:	208
Days unserviceable	:	7
Pilot days off	:	18
Days lost during maintenance	:	17
Days lost during bad weather	:	2
Loops flown	:	1180
New readings	:	8046
Flying time	:	1460.95 hours
Ferry time	:	211.55 hours

1:250 000 Sheet Name	New Readings	Flying Hours	Ferry Hours	Loops
Ajana	102	19.15	3.35	14
Barlee	157	34.50	3.30	24
Belele	159	31.15	5.05	24
Burnabbie	46	7.15	-	6
Byro	159	30.45	5.00	24
Cooper	134	20.20	2.25	19
Culver	111	16.25	1.35	15
Cue	158	30.00	4.05	24
Dongara	49	9.30	0.30	6
Duketon	158	29.10	5.05	24
Edjudina	162	26.55	3.50	24
Eucla	123	19.30	2.45	18
Forrest	130	19.55	1.50	17
Geraldton	96	17.10	1.30	13
Glenburgh	161	30.30	4.20	24
Glengarry	163	31.00	4.10	24
Jubilee	159	24.35	3.05	24
Kennedy Range	171	31.10	2.20	24
Kingston	158	29.10	7.25	24
Kirkalocka	161	32.00	3.15	24
Laverton	161	29.15	2.20	24
Lennis	114	23.10	4.20	16
Leonora	159	27.55	3.50	24
Loongana	157	24.50	3.15	24
Madura	159	25.40	2.40	24
Mason	130	20.10	4.25	18
Menzies	162	28.40	3.45	24
Minigwal	160	25.25	6.50	24

1:250 000 Sheet Name	New Readings	Flying Hours	Ferry Hours	Loops
Mount Phillips	169	30.55	2.50	24
Murgoo	160	30.20	3.25	24
Nabberu	180	34.15	4.05	24
Naretha	160	26.20	3.45	24
Neale	162	32.50	3.05	24
Ninghan	158	24.10	4.00	24
Noonaera	15	2.25	0.15	2
Peak Hill	168	32.55	3.05	24
Perenjori	162	31.10	3.25	24
Plumridge	156	25.20	3.40	24
Quobba	61	12.10	0.40	11
Rason	162	30.20	7.10	24
Robert	158	31.45	10.45	24
Robinson Range	160	30.40	3.40	24
Sandstone	158	30.00	3.45	24
Seemore	157	24.20	3.05	24
Sir Samuel	157	28.30	5.25	24
Stanley	173	33.40	4.50	24
Talbot	98	19.45	2.30	12
Throssell	159	30.50	5.45	24
Vernon	162	33.00	4.20	24
Waigen	122	23.50	12.20	15
Wanna	129	26.45	5.55	19
Westwood	130	26.20	4.00	18
Wiluna	166	31.55	3.15	24
Wooramel	56	10.40	0.50	8
Yalgoo	162	29.15	4.05	24

1:250 000 Sheet Name	New Readings	Flying Hours	Ferry Hours	Loops
Yaringa	39	8.25	2.00	8
Youanmi	159	29.30	4.05	24
Yowalga	69	13.30	4.30	9

Follow-up work within the survey area was carried out between 17 and 30 October 1972. A total of 247 new readings were made in checking and further delineating small anomalies in the preliminary contours. One or more follow-up loops were flown on the following 1:250 000 areas: Ajana, Barlee, Belele, Cue, Dongara, Edjudina, Forrest, Glengarry, Kingston, Kirkalocka, Laverton, Lennis, Loongana, Madura, Mason, Menzies, Minigwal, Mount Phillips, Ninghan, Perenjori, Rason, Robert, Seemore, Sir Samuel, Throssell, Yalgoo, Youanmi. The contours (Plate 2) have been amended where necessary, to conform with the results of follow-up work.

APPENDIX 2: SURVEY PERSONNEL AND EQUIPMENT

Staff

Contractor	:	Wongela Geophysical Pty Ltd
Party Leader	:	L.N. Ingall
Meter Readers	:	B. Riddler, L.N. Ingall
Draughtsman	:	L. Spain
Base Readers	:	Messrs Jackson, Hockley, Simms
Helicopter Staff	:	2 pilots and an engineer
BMR Supervisors	:	A.R. Fraser and I. Zadoroznyj

Equipment

2 Worden gravity meters (Nos. W592 and W708)

4 'Mechanism' microbarometers

1 Wet and dry bulb thermometer

Helicopters

Bell 47G3B-1, VH-AHO

Jetranger, VH-AHV

Vehicles

3 Landrovers

APPENDIX 3: SURVEY PROCEDURE

Field operations

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

Prior to the helicopter gravity operation, the Survey Branch of the former Department of the Interior optically levelled and photo-identified a network of elevation traverses. The benchmarks on these traverses were elevation control stations for the survey, and an area enclosed by the traverses is called a segment. The segmentation of the survey is shown in Plate 7. 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 as far as elevation control was concerned.

Gravity control on the survey was maintained by tying to previously established accurate gravity stations termed 'Isogal stations' (Barlow, in prep.).

Horizontal control was maintained by accurately pinpricking aerial photographs and plotting station locations on 1:250 000 photo-centre base maps.

Computing procedure

The results were computed at Monash University using 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 segment, 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 segment 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 deviation. Enough fixed points are included to eliminate systematic errors, and the difference between the true elevation and measured elevation at the 'unfixed fixed' 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.

The internal, external, and forecast network adjustments are shown in the following table. The internal and external standard deviations are the standard deviations of the least-squares adjustments to legs in the network. The forecast standard deviation is the standard deviation of differences between true and measured elevations for those fixed nodes which were computed as free nodes, as in 3.

Network adjustments

Segment	Elevation (metres)							Gravity (mGal)			
	Internal Network		External Network		Forecast Network			Internal Network		External Networ	
	S.D.	Max. adj.	S.D.	Max. adj.	S.D.	Max. adj.	Max. adj. S.D.	S.D.	Max. adj.	S.D.	Max. adj.
A	1.45	5.04	2.09	6.25	1.65	4.88	3.0	0.06	0.42	0.06	0.42
B	1.43	5.65	1.92	5.55	1.37	4.27	3.1	0.05	0.20	0.05	0.20
C	0.94	2.37	1.73	5.80	1.71	3.05	1.7	0.03	0.13	0.03	0.13
D	1.50	5.13	2.15	9.73	1.92	4.26	2.2	0.04	0.12	0.04	0.12
E	1.35	4.22	1.71	5.28	1.34	4.26	3.1	0.04	0.12	0.04	0.12
F	1.04	3.95	1.86	4.86	1.49	3.66	2.4	0.05	0.20	0.05	0.20
G	1.58	4.29	2.46	7.40	2.29	5.79	2.5	0.03	0.09	0.03	0.09
H	1.77	5.08	2.24	7.22	3.54	9.45	2.6	0.03	0.10	0.03	0.10
I	1.48	6.30	2.20	8.74	1.89	6.10	3.2	0.04	0.14	0.04	0.14
J	1.79	5.78	2.54	7.21	2.47	6.40	2.5	0.03	0.09	0.03	0.09
K	1.42	4.37	2.71	8.43	2.71	6.10	2.2	0.03	0.09	0.05	0.18
L	1.42	3.46	2.42	7.72	1.59	3.66	2.3	0.03	0.10	0.03	0.10

APPENDIX 4: LISTS OF PREVIOUS GEOPHYSICAL SURVEYS WITHIN THE SURVEY AREA

GRAVITY SURVEYS

NAME OF REPORT	BASIN	OPERATOR	REFERENCE
Dongara-Mullewa gravity survey	Perth	West Aust. Petrol. Pty Ltd	BMR subsidy File 62/1925
Eganu gravity survey	Perth	West Aust. Petrol. Pty Ltd	BMR subsidy File 62/1933
Lennis-Breaden gravity survey	Officer	Hunt Oil Co.	BMR subsidy File 64/4800
Geraldton gravity survey	Perth	West Aust. Petrol. Pty Ltd	BMR subsidy File 67/4827
Murchison-Gascoyne grav. survey	Carnar-von	Barewa Oil & Mining N.L.	BMR subsidy File 70/326
Regional gravity traverses across the Eucla Basin, 1954-55	Eucla	BMR	Gunson & van der Linden, 1955
Geophysical exploration in the Carnarvon (N.W.) Basin	Carnar-von	BMR	Chamberlain, Dooley, & Vale, 1954
Gravity survey of the Perth Basin	Perth	BMR	Thyer, & Everingham, 1956

MAGNETIC SURVEYS

Offshore West Beagle aeromagnetic survey	West Aust. Petrol. Pty Ltd	BMR subsidy File 69/3050
Neale Junction land magnetic survey	Hunt Oil Co.	BMR subsidy File 65/4617
West Carnarvon aeromagnetic survey	Tasman Oil Pty. Ltd.	BMR subsidy File 65/4615
Preliminary report on airborne surveys (scintillograph and magnetometer) of Geraldton-Onslow Region, W.A., 1956	BMR	Parkinson, W.D., BMR Record 1957/9

MAGNETIC SURVEYS (continued)

NAME	OPERATOR	REFERENCE
Carnarvon Basin airborne magnetic and radiometric survey, W.A. 1959	BMR	Forsyth, 1960
Perth Basin aeromagnetic survey, W.A., 1957	BMR	Quilty, J.H., BMR Record 1963/74
Carnarvon Basin airborne magnetic and radiometric survey, W.A., 1959	BMR	Spence, 1961
Rawlinson Range/Young Range aeromagnetic reconnaissance survey, W.A., 1960	BMR	Goodeve, P.E., BMR Record 1961/137
Carnarvon Basin airborne magnetic and radiometric survey, W.A., 1961	BMR	Spence, 1962
Maps showing the result of an airborne magnetic and radiometric survey of the Barlee 1:250 000 area W.A., 1957	BMR	Geophysical Branch BMR Record 1965/28
Menzies and Leonora airborne magnetic and radiometric survey, W.A., 1964	BMR	Young, G.A., & Tipper, D.B. BMR Record 1966/15
Laverton-Edjudina airborne magnetic and radiometric survey, W.A., 1966	BMR	Tipper, D.B., BMR Record 1967/65
Sir Samuel/Duketon airborne magnetic and radiometric survey, W.A., 1967	BMR	Shelley, E.P., & Waller, D.R., BMR Record 1967/136
Sandstone-Youanmi airborne magnetic and radiometric survey, W.A., 1968	BMR	Gerdes, R.A., Young, G.A., Cameron, B.F., & Beattie, R.D., BMR Record 1970/2
Airborne magnetic and radiometric survey of Belele, Cue, Kirkalocka, and the eastern part of Byro, Murgoo and Yalgoo 1:250 000 sheet areas, W.A., 1969	BMR	Waller, D.R., & Beattie, R.D. BMR Record 1971/28

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SEISMIC SURVEYS

NAME	BASIN	OPERATOR	COVERAGE (km)	REFERENCE
Pelsart (marine) seismic survey	Perth-Carnarvon	West Aust. Petrol. Pty Ltd	505	BMR subsidy File 69/3014
Turtle Dove (marine) seismic survey	Perth-Carnarvon	West Aust. Petrol. Pty Ltd	379	BMR subsidy File 68/3000
Beagle (marine) seismic survey	Perth	West Aust. Petrol. Pty Ltd	267 (58 refract)	BMR subsidy File 68/3038
Offshore Eucla Basin R.2 (marine) seismic survey	Eucla	Tenneco Aust. Inc.	1197	BMR subsidy File 67/11195
Yowalga seismic survey	Officer	Hunt Oil Co.	478	BMR subsidy File 65/4579
North Lennis seismic survey	Officer	Hunt Oil Co.	251	BMR subsidy File 65/11033
Snag Island (marine) seismic survey	Perth	French Pet. Co. (Aust) Pty Ltd	45	BMR subsidy File 65/11043
Podooloo seismic survey	Perth	French Pet. Co. (Aust) Pty Ltd	76	BMR subsidy File 65/11010
Athamo seismic and gravity survey	Perth	French Pet. Co. (Aust) Pty Ltd	410	BMR subsidy File 65/11060
Geraldton seismic survey	Carnarvon	West Aust. Petrol Pty Ltd	48	BMR subsidy File 67/11146
Abrolhos D-I (marine) seismic survey	Carnarvon	B.P. Pet. Dev. (Aust) Pty Ltd	200	BMR subsidy File 66/11127
Zeewyk Channel (marine) seismic survey	Carnarvon	B.P. Pet. Dev. (Aust) Pty Ltd	98	BMR subsidy File 66/11112
Abrolhos (marine) seismic survey	Carnarvon	B.P. Pet. Dev. (Aust) Pty Ltd	1224	BMR subsidy File 65/4592
West Carnarvon (marine) seismic survey	Carnarvon	Canadian Superior Oil (Aust) Pty Ltd	2218	BMR subsidy File 66/11089
West Gnarraloo (marine) seismic survey	Carnarvon	Canadian Superior Oil (Aust) Pty Ltd	885	BMR subsidy File 67/11158

Ballythanna Hill seismic survey	Carnarvon	Continental Oil Co. of Australia	153	BMR subsidy File 65/11049
Merlinleigh anticline seismic survey	Carnarvon	West Aust. Petrol. Pty Ltd	18	BMR subsidy File 66/11075
Shark Bay (marine) seismic survey	Carnarvon	Continental Oil Co. of Australia	257	BMR subsidy File 64/4551
Yalbalgo-Yaringa seismic survey	Carnarvon	Continental Oil Co. of Australia	502	BMR subsidy File 65/11021
Kennedy Seismic survey	Carnarvon	West Aust. Petrol. Pty Ltd	29	BMR subsidy File 65/11038
Quail Anticline seismic survey	Carnarvon	West Aust. Petrol. Pty Ltd	177	BMR subsidy File 62/1622
Wooramel seismic survey	Carnarvon	Continental Oil Co. of Australia	965	BMR subsidy File 64/4545
Hyde Soak seismic survey	Carnarvon	Continental Oil Co. of Australia	64 (45 refract)	BMR subsidy File 64/4538
Wicherina seismic survey	Perth-Carnarvon	West Aust. Petrol. Pty Ltd	459 (600 refract)	BMR subsidy File 62/1651
Dongara seismic survey	Perth-Carnarvon	West Aust. Petrol. Pty Ltd	63	BMR subsidy File 63/1507
Warradong seismic survey	Perth-	West Aust. Petrol. Pty Ltd	55	BMR subsidy File 62/1590
Woolamulla South seismic survey	Perth	West Aust. Petrol. Pty Ltd	92	BMR subsidy File 62/1627
Hill River/Dongara seismic survey	Perth	West Aust. Petrol. Pty Ltd	275	BMR subsidy File 62/1534
Woodada seismic survey	Perth	French Pet. Co. (Aust) Pty Ltd	211 (356 refract)	BMR subsidy File 64/4547
Eneabba seismic survey	Perth	West Aust. Petrol. Pty Ltd	241	BMR subsidy File 62/1541
Babbagoola seismic survey	Officer	Hunt Oil Co.	55	BMR subsidy File 63/1551
Warburton seismic survey	Officer	Hunt Oil Co.	132 (142 refract)	BMR subsidy File 64/4516

Irwin seismic survey	Perth-Carnarvon	West Aust. Petrol. Pty Ltd	43 (34 refract)	BMR subsidy File 64/4511
Geelvink Channel seismic survey	Carnarvon	B.P. Pet. Dev. (Aust) Pty Ltd	1435 (470 processed)	BMR subsidy File 70/241
Southern Carnarvon Basin seismic survey W.A., 1963 (Traverse A, Tamala-Narryer Area)	Carnarvon	BMR		Bow, & Turpie, 1964
Southern Carnarvon Basin seismic survey, W.A., 1963 (Traverse B - Byro Basin)	Carnarvon	BMR		Turpie, 1964

APPENDIX 5: BOREHOLES WITHIN THE SURVEY AREA AND AGE SEQUENCES ENCOUNTERED

Boreholes

Numerous boreholes have been drilled within the survey area, including both test bores for minerals in the Precambrian shield and stratigraphic wells in the sedimentary basins. The results of borehole surveys in the shield area are not available for publication. Boreholes in sedimentary basins have been confined mainly to the Perth and Carnarvon Basins, where thick Phanerozoic sediments and a relative abundance of potential structural traps for hydrocarbons have attracted the attention of a number of oil exploration companies. Stratigraphic sections from these bores have added greatly to geological knowledge of the two basins. Phanerozoic sediments are shallow and structurally featureless in the Eucla and Officer Basin, and drilling activity has been correspondingly small. Yowalga No. 2 in the western Officer Basin encountered Proterozoic sediments at about 600 metres, and the few bores drilled in the onshore Eucla Basin have generally encountered Precambrian basement at depths less than 600 metres.

The age sequences encountered in boreholes are given in the following table. Borehole locations are shown in Plate 5.

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List of Boreholes within the Survey Area and Age Sequences Encountered

NAME	BASIN	OPERATOR	LAT. LONG.	T.D. (metres)	ROCK AGES	THICK-NESS (metres)	REFERENCE
Wandagee No. 1	Carnarvon	West Aust. Petrol.	22°53'15"	1073	Quaternary	8	BMR Subsidy File
		Pty Ltd	114°23'51"		Cretaceous	169	62/1215
					Upper Devonian	98	
					Silurian	533	
					Sil/Ordovician?	262+	
Quail No. 1	Carnarvon	West Aust. Petrol.	23°57'04"	3580	Quaternary	5	BMR Subsidy File
		Pty Ltd	114°29'57"		Permian	589	63/1010
					Carboniferous	2118	
					Devonian	629	
					Silurian	499+	
Abbarwardoo No. 1	Perth-Carnarvon	West Aust. Petrol.	28°35'10"	600	Quaternary	2	BMR Subsidy File
		Pty Ltd	115°09'35"		Jurassic	21	62/1222
					Triassic?	34	
					Permian	544+	
Wicherina No. 1	Perth	West Aust. Petrol.	28°49'53"	1686	Quaternary	4	BMR Subsidy File
		Pty Ltd	115°14'19"		Cretaceous	15	63/1056
					Jurassic	262	
					Triassic	91	
					Permian	1314+	

Mungarra No. 1	Perth	West Aust. Petrol. Pty Ltd	28°51'02" 115°06'55"	609	Quaternary Jurassic Triassic Permian	2 221 30 357	BMR Subsidy File 64/4105
Yardarino No. 1	Perth	West Aust. Petrol. Pty Ltd	29°13'13" 115°03'10"	2377	Quaternary Jurassic Triassic Permian	9 1867 345 93+	BMR Subsidy File 64/4035
Jurien No. 1	Perth	West Aust. Petrol. Pty Ltd	30°08'40" 115°02'54"	1026	Quaternary Triassic Permian Precambrian	24 247 751 48	BMR Subsidy File 62/1110
Woolamulla No. 1	Perth	West Aust. Petrol. Pty Ltd	30°01'24" 115°11'28"	2811	Quaternary Triassic Permian Precambrian	4 1228 1541 39+	BMR Subsidy File 62/1127
Eganu No. 1	Perth	West Aust. Petrol. Pty Ltd	29°59'05" 115°49'35"	600	Quaternary Jurassic	5 539+	BMR Subsidy File 62/1221
Hill River No. 1	Perth	West Aust. Petrol. Pty Ltd	30°16' 115°18'	579	Jurassic	579+	BMR Subsidy File 62/1402
Gingin No. 1	Perth	West Aust. Petrol. Pty Ltd	31°08'32" 115°49'35"	4544	Quaternary Cretaceous Jurassic	35 1072 3432+	BMR Subsidy File 64/4121

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Gambanga No. 1	Eucla	Exoil Co.	32°16' 124°50'	391	Recent Miocene Eocene Santonian Albian Aptian Archaean	2 32 172 168 11 6 1+	BMR Subsidy File 62/1052
Eyre No. 1	Eucla	Exoil Co.	32°07' 126°58'	524	Recent Pleistocene Miocene Eocene Santonian/Aptian Archaean	2 12 2 287 219 3+	BMR Subsidy File 62/1053
Kennedy Range No. 1	Carnarvon	West Aust. Petrol. Pty Ltd	24°29'45" 114°59'27"	2227	Permian	2227+	BMR Subsidy File 66/4235
Yaringa No. 1	Carnarvon	Continental Oil Co. of Australia	26°03'58" 114°21'35"	2288	Cretaceous Jurassic Silurian/Ord? Ordovician	141 709 671 762+	BMR Subsidy File 66/4215
Donkey Creek No. 1	Perth	French Pet. Co. (Aust) Pty Ltd	29°37'35" 115°17'25"	3853	Cretaceous Jurassic Triassic	1810 1552 491+	BMR Subsidy File 66/4223
Cadda No. 1	Perth	French Pet. Co. (Aust) Pty Ltd	30°20'15" 115°12'48"	2795	Quaternary Jurassic Triassic Permian Precambrian	2 166 1864 707 52+	BMR Subsidy File 65/4164

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Gun Island No. 1	Perth	B.P. Pet. Dev. (Aust) Pty Ltd	28°53'30.11" 113°51'27.0"	3725	Quaternary Tertiary Cretaceous Jurassic	126 259 516 2817	BMR Subsidy File 68/2015
Quinns Rock No. 1	Perth	West Aust. Petrol. Pty Ltd	31°48'01" 115°30'52"	2209	Tertiary Cretaceous Jurassic	292 431 1280	BMR Subsidy File 68/2046
Eneabba No. 1	Perth	West Aust. Petrol. Pty Ltd	29°34'14" 115°19'56"	4179	Quaternary Cretaceous Jurassic Triassic	9 1694 1271 1202	BMR Subsidy File 62/1076
Yowalga No. 2	Officer	Hunt Oil Co.	26°10'12" 125°58'00"	989	Recent Jurassic Permian Upper Proterozoic	4 87 312 582+	BMR Subsidy File 66/4191

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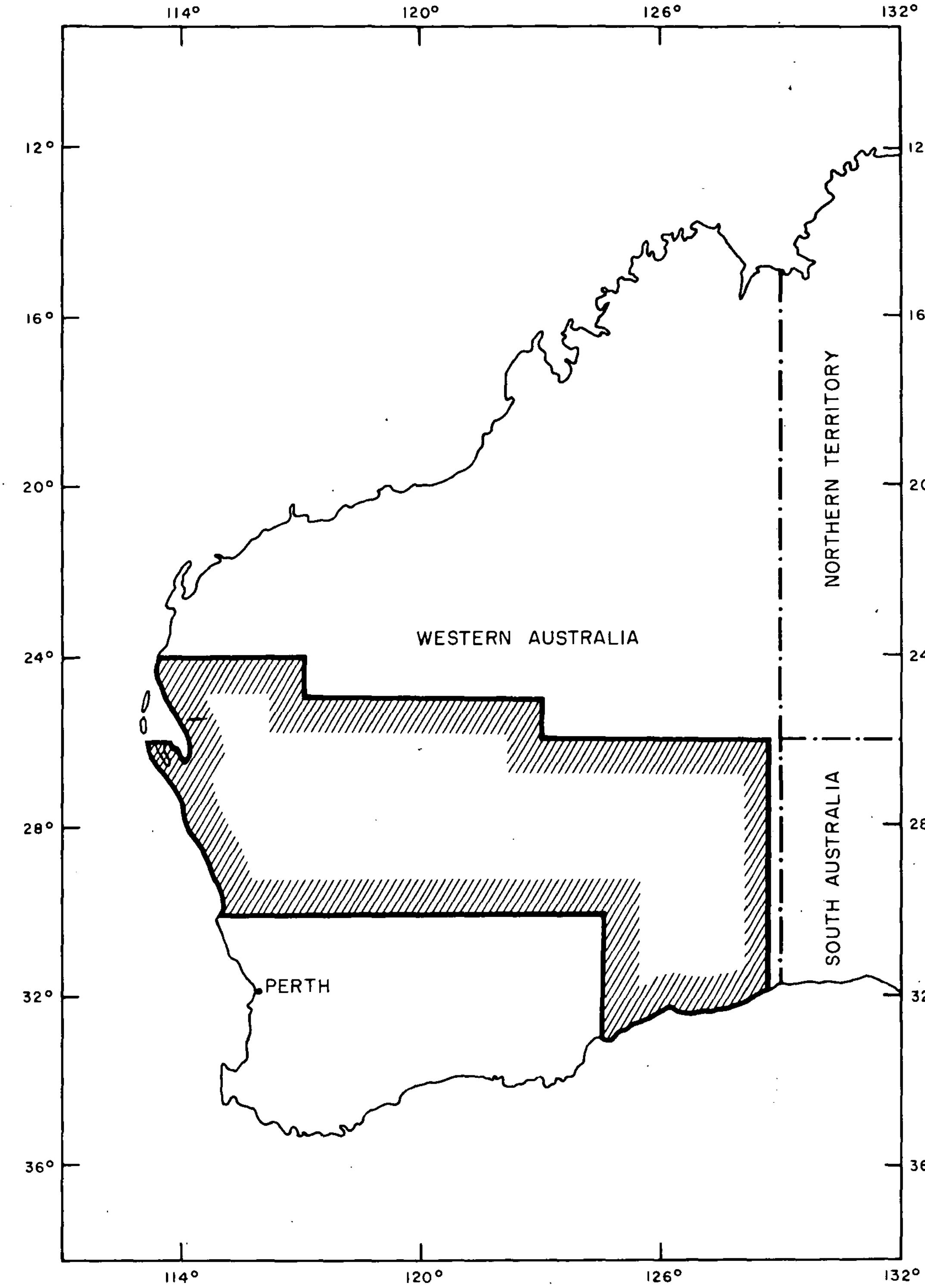
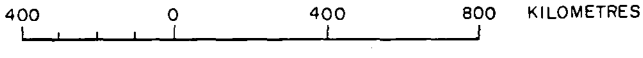
PLATE I

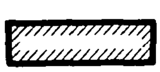


RECCONNAISSANCE HELICOPTER GRAVITY SURVEY, WA, 1971/72

LOCALITY MAP



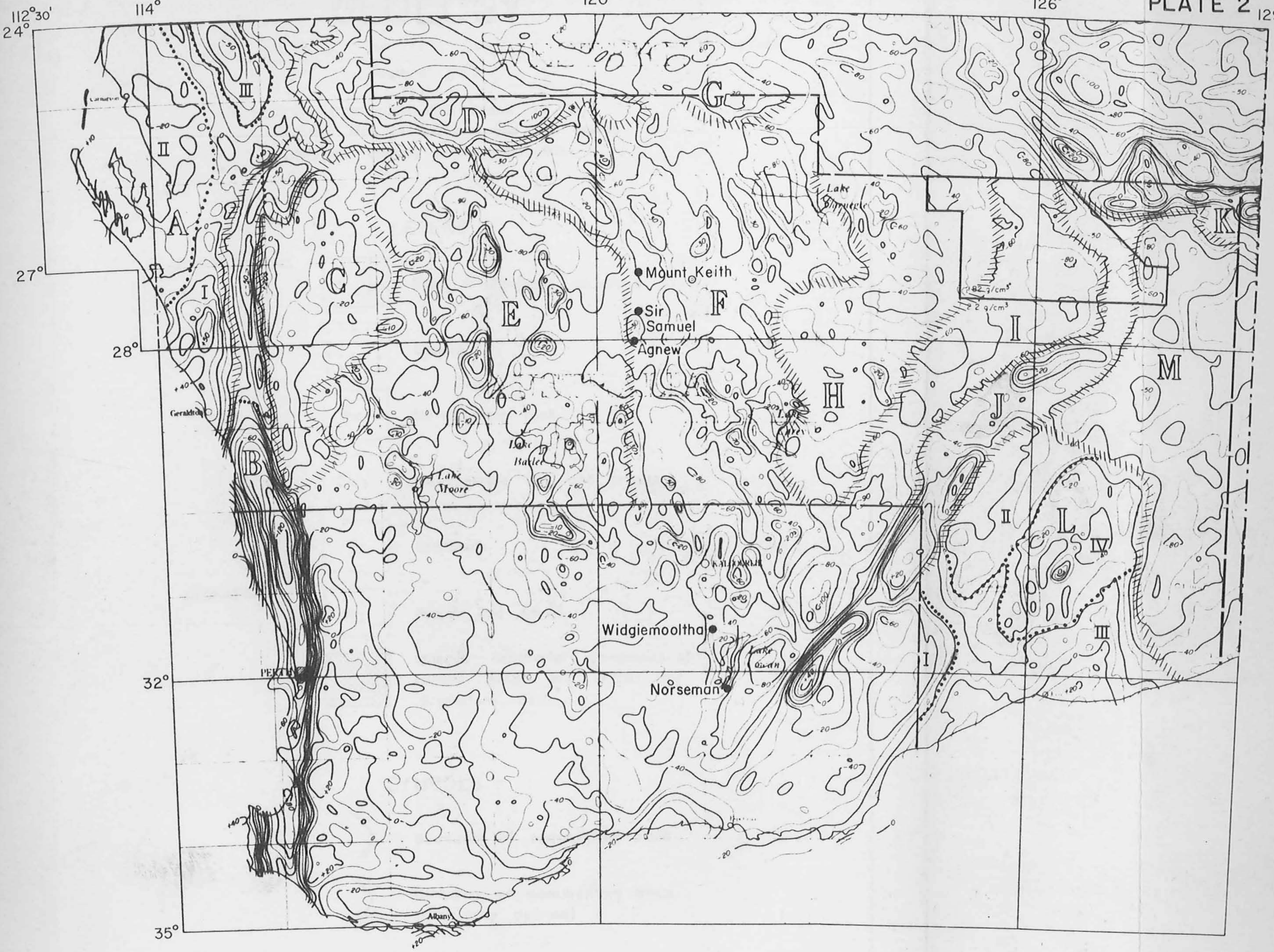
50



To accompany Record No 1973/130

WA/B2· 42A

PLATE 2



SYMBOLS

//// Province boundary

E Province

····· Unit boundary

II Unit

● City, town or named place

– – Boundary of survey area

PROVINCE NAMES

A Gascoyne Regional Gravity Complex

B Perth Regional Gravity Depression

C Erabiddy Regional Gravity Platform

D Teano Regional Gravity Trough

E Austin Regional Gravity Complex

F Carey Regional Gravity Complex

G Ashburton Regional Gravity Ridge

H Yeo Regional Gravity Shelf

I Rason Regional Gravity Depression

J Fraser Regional Gravity Ridge

K Blackstone Regional Gravity Plateau

L Eyre Regional Gravity Complex

M Wanna Regional Gravity Depression

BOUGUER ANOMALY CONTOURS AND GRAVITY PROVINCES

100 0 100 200 KMS

Note A density of 2·2 g/cm^3 was used for Bouguer corrections

Contour interval: 10 milligals

To accompany Record No 1973/130

WA/B2-66

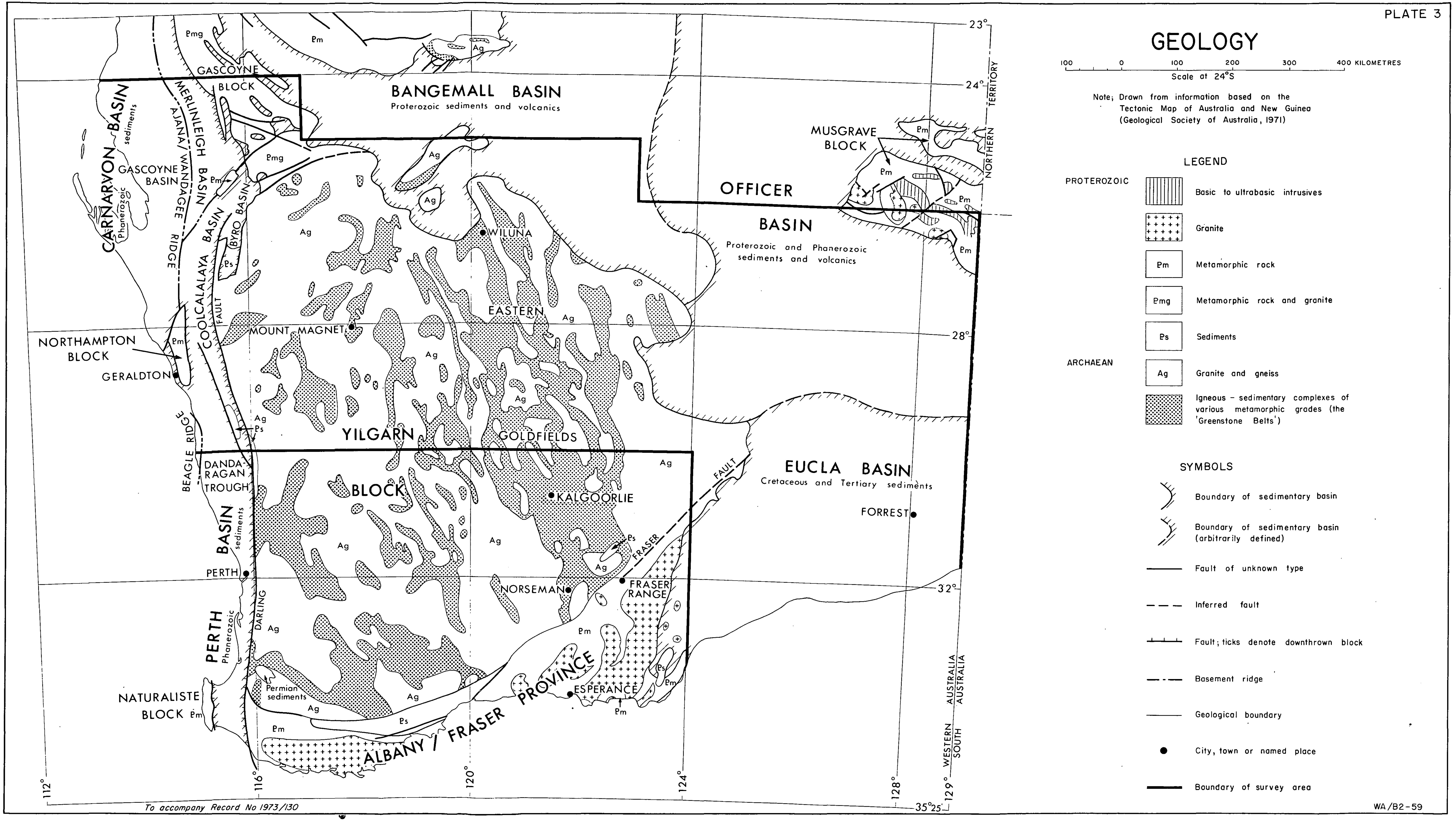
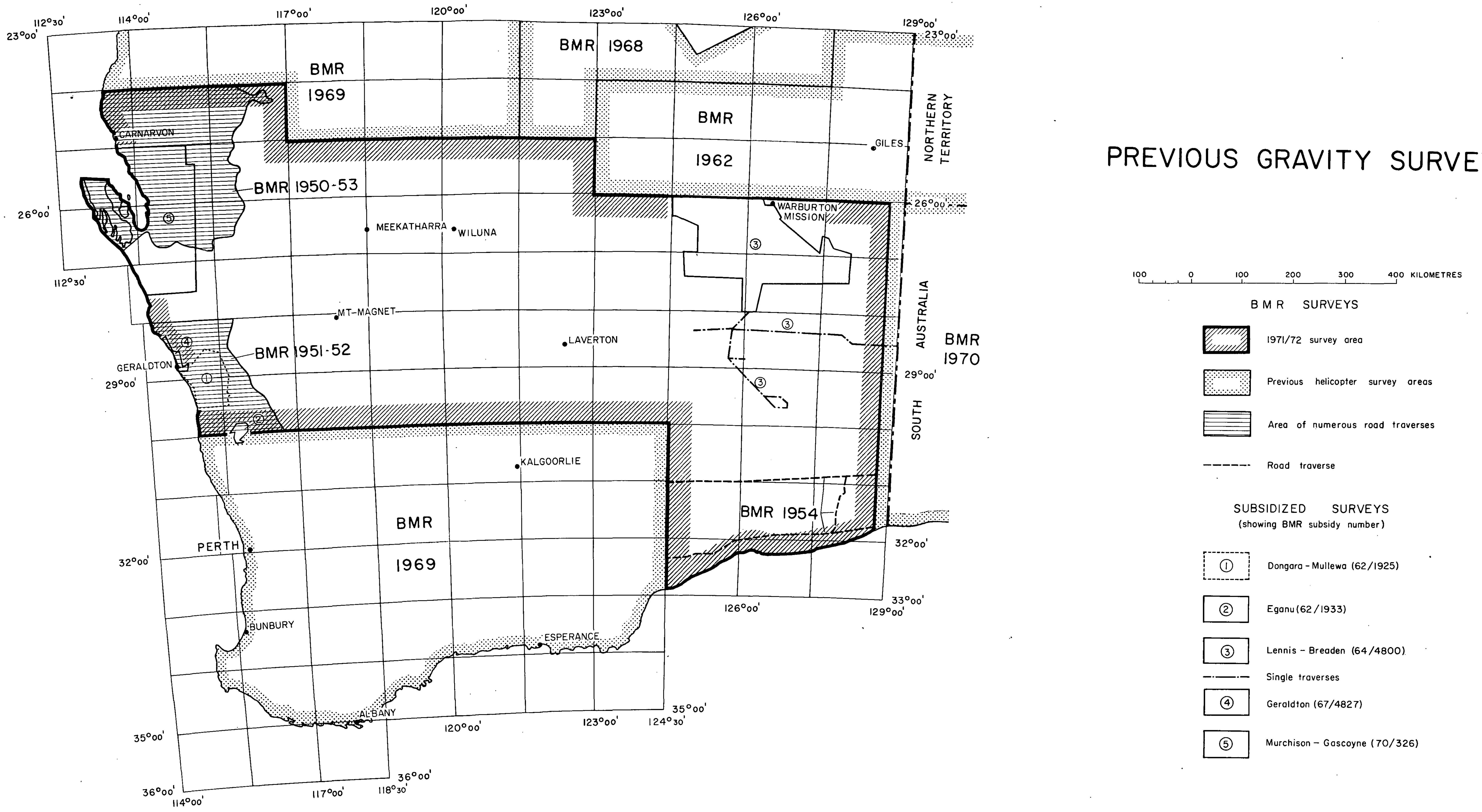


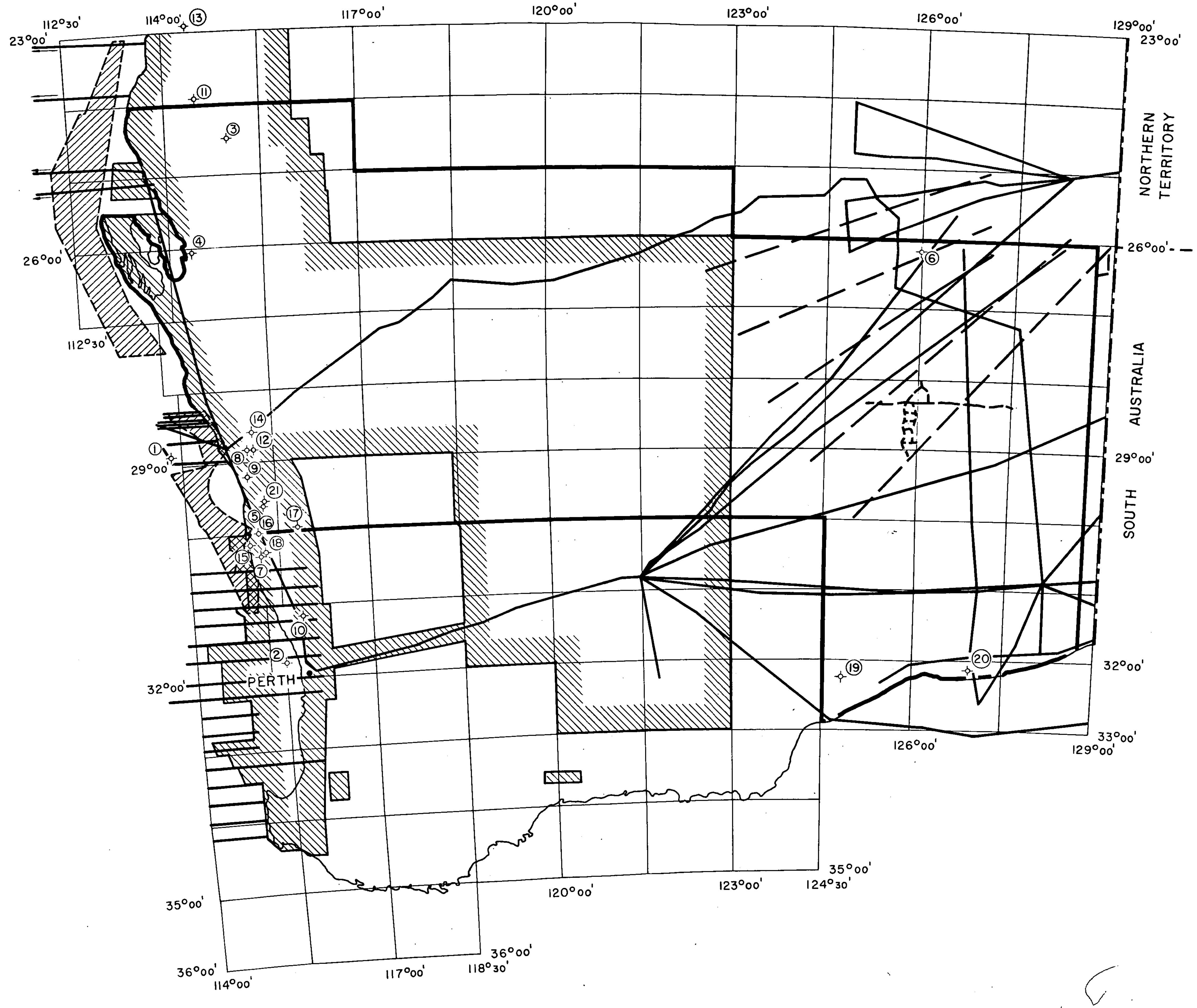
PLATE 3
GEOLOGY
100 0 100 200 300 400 KILOMETRES
Scale at 24°S
Note; Drawn from information based on the Tectonic Map of Australia and New Guinea (Geological Society of Australia, 1971)
LEGEND
PROTEROZOIC
Basic to ultrabasic intrusives
Granite
Pm Metamorphic rock
Pmg Metamorphic rock and granite
Ps Sediments
ARCHAEAN
Ag Granite and gneiss
Igneous - sedimentary complexes of various metamorphic grades (the 'Greenstone Belts')
SYMBOLS
Boundary of sedimentary basin
Boundary of sedimentary basin (arbitrarily defined)
Fault of unknown type
Inferred fault
Fault; ticks denote downthrown block
Basement ridge
Geological boundary
City, town or named place
Boundary of survey area
BANGEMALL BASIN
Proterozoic sediments and volcanics
GASCOYNE BLOCK
CARNARVON BASIN
sediments
Phanerozoic
GASCOYNE BASIN
MERLINLEIGH BASIN
AJANA/WANDAGEE RIDGE
COOLCALALAYA BASIN
BYRO BASIN
FAULT
MUSGRAVE BLOCK
OFFICER BASIN
Proterozoic and Phanerozoic sediments and volcanics
NORTHERN TERRITORY
WILUNA
EASTERN
MOUNT MAGNET
NORTHAMPTON BLOCK
GERALDTON
YILGARN
GOLDFIELDS
BLOCK
KALGOORLIE
EUCLA BASIN
Cretaceous and Tertiary sediments
FORREST
BEAGLE RIDGE
DANDARAGAN TROUGH
BASIN
sediments
PERTH
NORSEMAN
FRASER RANGE
FRASER FAULT
PERTH BASIN
Phanerozoic
DARLING
NATURALISTE BLOCK
Permian sediments
ALBANY / FRASER PROVINCE
ESPERANCE
WESTERN AUSTRALIA
SOUTH AUSTRALIA
23°
24°
28°
32°
35°25'
112°
116°
120°
124°
128°
129°
To accompany Record No 1973/130
WA/B2-59

PREVIOUS GRAVITY SURVEYS



(Based on WA/BO-12) *To accompany Record No 1973/130*

WA/B2-45



MAGNETIC SURVEYS AND BOREHOLES

100 0 100 200 400 KILOMETRES

LEGEND

- Boundary of gravity survey area
- Private company magnetic traverse
- Area surveyed by private companies
- City, town or named place
- BMR aeromagnetic traverse
- Area surveyed by BMR
- Borehole

BOREHOLES

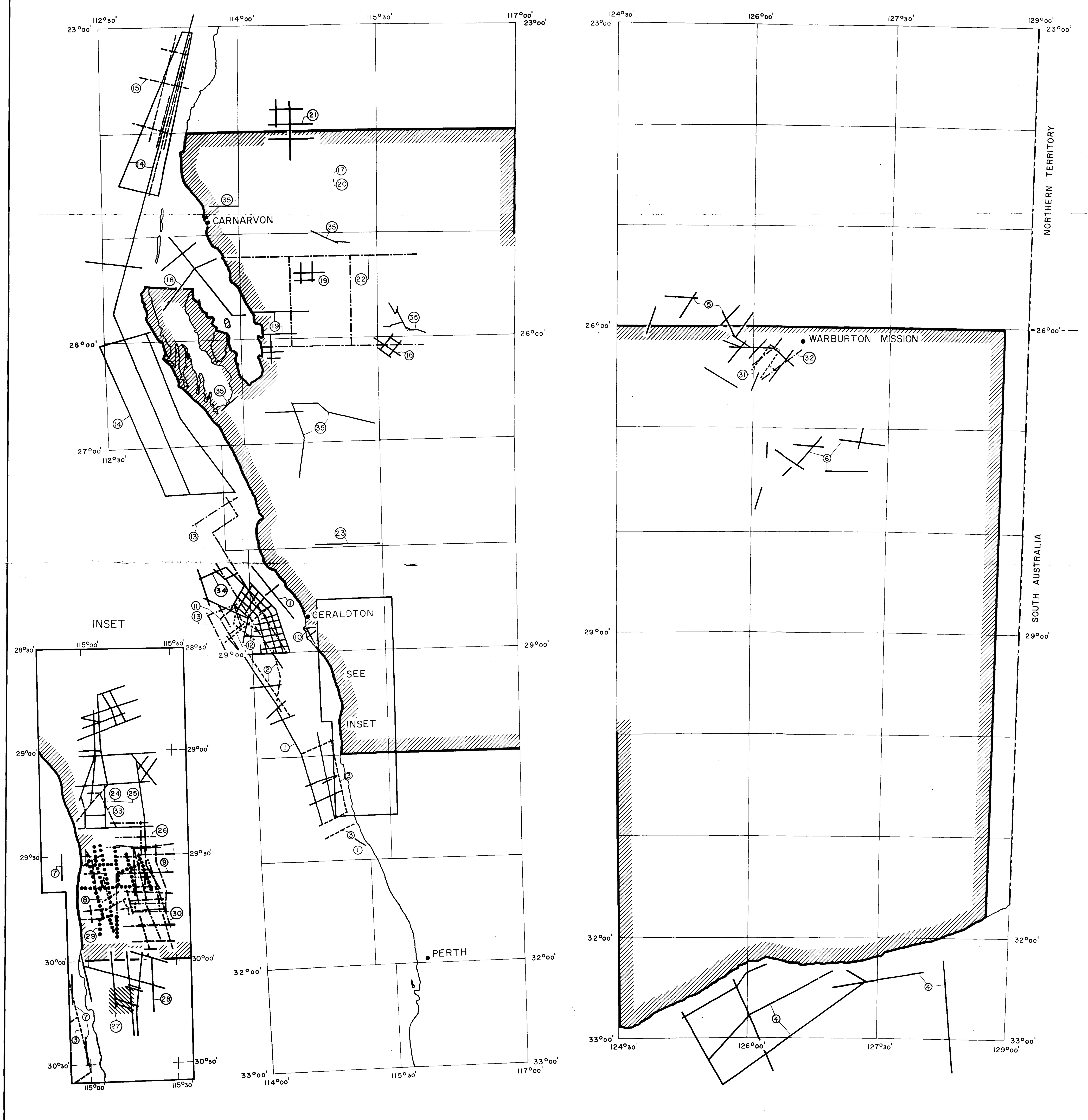
(Showing BMR subsidy file number)

1. Gun Island No. 1 (68/2015)
2. Quinn's Rock No.1 (68/2046)
3. Kennedy Range No. 1 (66/4235)
4. Yaringa No. 1 (66/4215)
5. Donkey Creek No. 1 (66/4223)
6. Yowalga No. 2 (66/4191)
7. Cadda No. 1 (65/4164)
8. Mungarra No. 1 (64/4105)
9. Yardarino No. 1 (64/4035)
10. Gingin No. 1 (64/4121)
11. Quail No. 1 (63/1010)
12. Wicherina No. 1 (63/1056)
13. Wandagee No. 1 (62/1215)
14. Abbarwardoo No. 1 (62/1222)
15. Jurien No. 1 (62/1110)
16. Woolmulla No. 1 (62/1127)
17. Eganu No. 1 (62/1221)
18. Hill River No. 1 (62/1402)
19. Gambanga No. 1 (62/1052)
20. Eyre No. 1 (62/1053)
21. Eneabba No. 1 (62/1076)

(Based on WA/BO-12) *To accompany Record No 1973/130*

WA/B2-46

PREVIOUS SEISMIC SURVEYS



SCALE

100 0 100 200 KILOMETRES

INSET SCALE

50 0 50 100 KILOMETRES

LEGEND

- City, town or named place
- Boundary of survey

SESMIC SURVEYS

(Showing BMR subsidy file number)

1 Pelsari (marine)(69/3014) ✳

2 Turtle Dove (marine)(68/3000) ✳

3 Beagle (marine) (68/3038) ✳

4 Offshore Eucla Basin R 2 (marine)(67/11195) ✳

5 Yowalga (65/4579)

6 North Lennis (65/11033)

7 Snag Island (marine)(65/11043)

8 Podooloo Area (65/11010)

9 Athamo (65/11060) ✳

10 Geraldton (67/11146)

11 Abrolhos D-1 (marine)(66/11127) ✳

12 Zeewyk Channel (marine)(66/11112) ✳

13 Abrolhos (marine) (65/4592) ✳

14 West Carnarvon (marine)(66/11089) ✳

15 West Gnarraloo (marine)(67/11158) ✳

16 Ballythana Hill (65/11049)

17 Merlinleigh Anticline (66/11075)

18 Shark Bay (marine) (64/4551)

19 Yalbalgo–Yaringa (65/11021) ✳

20 Kennedy (65/11038)

21 Quail Anticline (62/1622)

22 Wooramel (64/4545) ✳

23 Hyde Soak (64/4538)

24 Wicherina (62/1651)

25 Dongara (63/1507)

26 Warradong (62/1590)

27 Woolmulla South (62/1627) (survey area)

28 Hill River–Dongara (62/1534)

29 Woodada (64/4547) ✳

30 Eneabba (62/1541) ✳

31 Babbagoola (63/1551)

32 Warburton (64/4516)

33 Irwin (64/4511)

34 Geelvink Channel (marine)(70/241) ✳

35 Southern Carnarvon Basin 1963/64 (BMR) ✳

NOTE ✳ All individual traverses are not shown. The generalized position of the survey only is indicated. This plate does not show the locations of unsubsidized seismic surveys.

LOCATION DIAGRAM

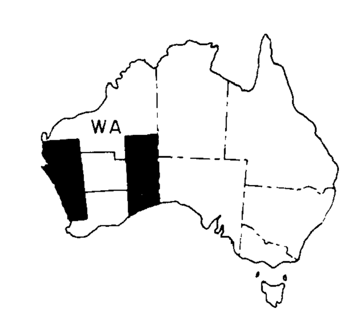
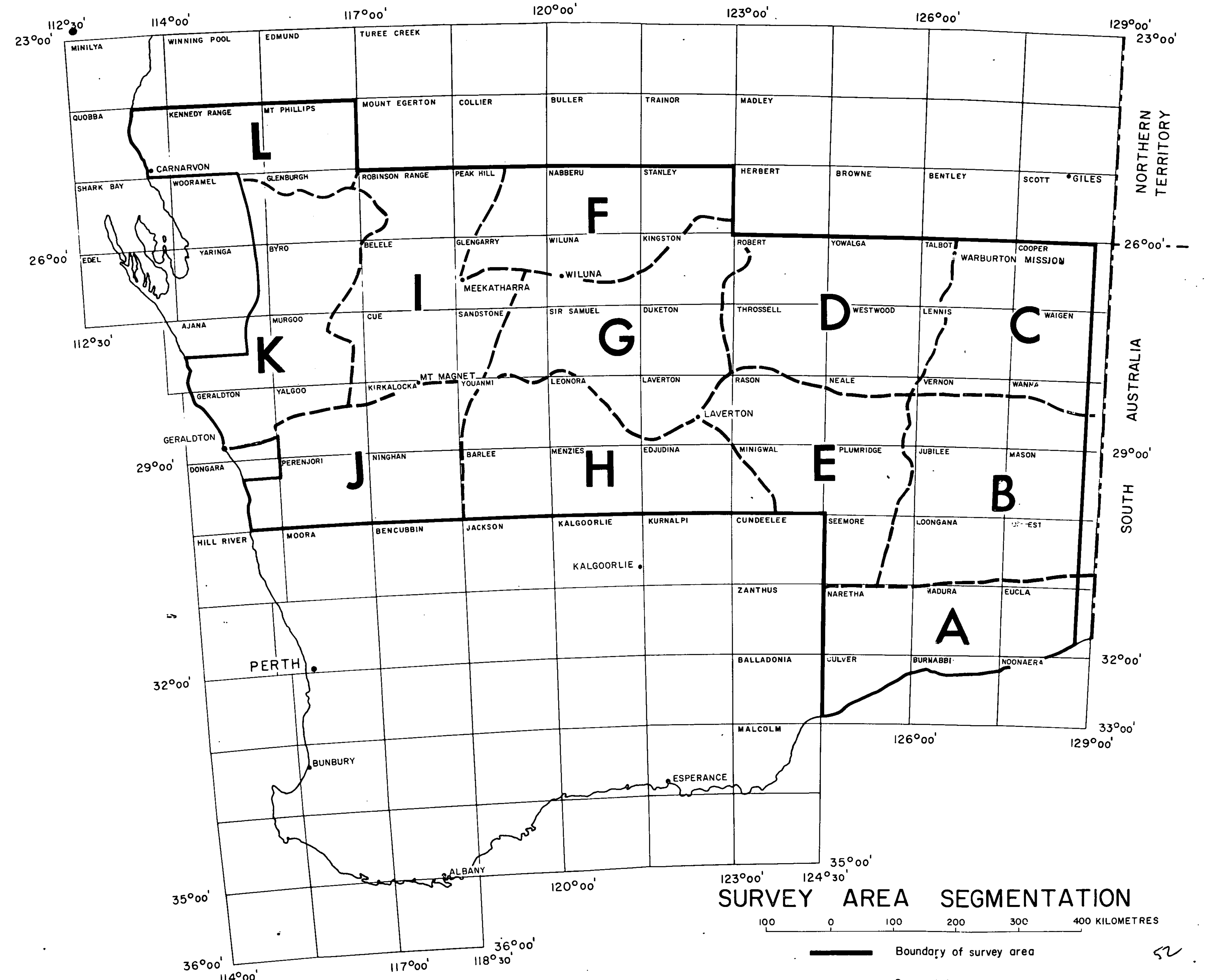


PLATE 7



SURVEY AREA SEGMENTATION

100 0 100 200 300 400 KILOMETRES

Boundary of survey area

Segment boundary

City, town or named place

52

(Based on WA/BO-12) *To accompany Record No 1973/130*

WA/B2-48