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AN INTERPRETATION OF REGIONAL GEOPHYSICAL DATA IN THE OLARY REGION, SOUTH AUSTRALIA

GEOLOGICAL SURVEY

by

A. MILLS

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SUMMARY

The area of study within the OLARY and CURNAMONA sheets, covers approximately 30,000 km^2 along the S.A./N.S.W. border, west of Broken Hill. This region has been extensively prospected for over 100 years for base metals, silver, gold, uranium, semi-precious stones and industrial minerals.

The Olary region is a crystalline basement block containing the Willyama Complex, of Early to Middle Proterozoic age, and is composed of metasedimentary and granitic terrains. To the south, this block is in faulted contact with Late Proterozoic Adelaidean sediments, while to the north it is covered by Adelaidean, Cambrian and Tertiary sediments.

Shallow pre-Adelaidean rocks extend as far north as Lake Frome along a major basement high, the Benagerie Ridge. In the south, this ridge is composed of Willyama Complex metasediments, whereas to the north it occurs in drillholes as porphyritic volcanics (200 m in Mudguard No. 1). Geochemically these volcanics are broadly equivalent to the Gawler Range Volcanics on the Stuart Shelf, (Giles and Teale, 1979b).

CURNAMONA contains various settings for mineral deposits. Through the centre of the area, outcropping and subcropping Willyama Complex offers an attractive target for base metal and uranium deposits. Large areas of essentially unexplored Willyama Complex lie along the northern and eastern margins of the Olary Block. The juxtaposition of Middle Proterozoic volcanics and a large sedimentary basin (Frome Embayment) in the north of the area offer targets for possible volcanogenic sedimentary ores. An Olympic Dam-type exploration model may be applicable as the Frome Embayment and Arrowie Basin has some structural, stratigraphic and geophysical similarities to the Stuart Shelf. In addition, several sedimentary uranium deposits are in Tertiary palaeochannels within CURNAMONA. Some exploration targets are outlined in the text.

The Bouguer gravity contours of the area indicate that the major density contrast lies within the Cambrian sediments between arenites and carbonates. Due to the generally thin nature of these carbonates, however, this density contrast may lie between the Cambrian and Adelaidean sequences.

The lack of major density contrasts between the Precambrian units is a major problem in the interpretation of the gravity data. The granite intrusions show a small negative contrast to the other rock. This is seen in the Bouguer gravity map, where large gravity lows are centred over areas of surface granites of Palaeozoic age.

The gravity data were collected on a 7 km square grid designed to delineate sedimentary basins. For this reason, the Bouguer gravity map is of limited use in the resolution of small density contrasts within the Olary Province. The major conclusions from this gravity information are:

(i) in the north it reflects areas of large granitic intrusions and to some extent Precambrian topography,

(ii) within the Willyama Complex it appears to be related to metamorphic grade, showing a regional gradient from the high grade Mutooroo area to the lower grade Kalabity area.

The original aeromagnetic coverage of CURNAMONA, flown along east-west lines at a height of 460 m with 1.6 km line spacing in the search for iron ore and sedimentary basins, gave poor resolution within shallow basement areas.

In the late seventies, the S.A. Dept. of Mines and Energy undertook a programme of detailed aeromagnetic coverage over areas of shallow magnetic basement. To resolve the strong northwest and northeast trends in the area, double grids were flown at an altitude of 100 m and at an average east-west spacing of 300 m and north-south spacing of 1.2 km. This data clearly defined strong northwest-southeast trends in the area, such as the McDonald and Outalpa Faults.

The magnetic data occasionally allow prediction of magnetic units by their fold patterns, as the Adelaidean is generally openly folded with east-west fold axes, whilst the Willyama Complex is more tightly folded with northeast fold axes a common occurrence.

The Benagerie Ridge has been shown to be up to 65 km wide, which is considerably wider than at first thought. The Ridge is composed of an eastern and a western zone of different magnetic character. The eastern zone is characterised by shallow (less than 100 m) narrow elongate anomalies with probable Willyama Complex fold styles. The western zone is more than 200 m deep and is characterised by circular, discontinuous anomalies with no folding apparent. Drilling by Mines Administration has intersected Middle Proterozoic volcanics in the western zone.

A detailed comparison of the geology of the centrally located Outalpa region shows that the Willyama Complex rocks contain both strongly magnetic (calc-silicates, ironstones) and non-magnetic (arenites and pelitic schists) units. The Adelaidean sediments are generally non-magnetic and the most magnetic unit is the Benda Siltstone and the basal Braemar Iron Formation. Although most of the Willyama Complex units show some degree of magnetism, the magnetite-quartzites, iron formations and calc-silicates are the strongest.

Granites are moderately magnetic to non-magnetic and generally have associated magnetic aureoles.

The gravity data show the areas of granitic intrusion to be far more extensive than suggested by the magnetic data, implying that the plutons have often not fully intruded the Willyama Complex. The emplacment of these granites is strongly fault-controlled as evidenced by their polygonal shapes. Amphibolites in the Willyama Complex fall into two categories, of which the massive semiconcordant bodies are strongly magnetic whilst the metadolerites are non-magnetic. Two volcanic units appear in drillholes on the Benagerie Ridge. On the western side of the ridge they are strongly magnetic of possible intermediate to basic composition, whilst to the north they are weakly magnetic, possibly comprising of acid volcanics.

As most of CURNAMONA is concealed by Quaternary sediments, geophysics has been a major aid in compiling a tectonic framework. A depth to magnetic basement map was first compiled to define the Willyama Complex erosional surface. All anomalies attributed to Adelaidean ironstones or volcanics were ignored. The volcanic sources in the central western zone of the Benagerie Ridge were, however, included, as their nature was unknown.

The magnetic basement depth map shows the division of the Benagerie Ridge laterally and vertically into two zones divided by a trough-like feature apparently associated with the Namba Palaeochannel. It also shows the continuation of the MacDonald Shear and the deepening Arrowie Basin in the northwest.

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1. INTRODUCTION

In the Olary region (Figure 1), basement outcrop consists mainly of the strongly deformed, Pre-Adelaidean crystalline sequence of the Willyama Complex (Figure 2). To the south, these rocks are in faulted contact with Adelaidean sediments and to the north are onlapped by Adelaidean, Cambrian, Mesozoic and Tertiary sediments of the Frome Embayment and Arrowie Basin. Outcrop extends from northwest of Weekeroo Hill, east to the New South Wales border where isolated patches of outcrop indicate its continuation with the Broken Hill area.

Over the past hundred years, this region has been subjected to intensive prospecting for a variety of minerals; gold, silver, lead-zinc, copper, uranium, iron, as well as industrial minerals such as feldspar, beryl, mica, phosphates, andalusite, sillimanite, graphite, corundum, barite and fluorite.

In the early 1970's a decision by the Broken Hill Mining Managers' Association to intensify efforts to locate new areas of Broken Hill-type mineralisation marked the beginning of a new era of exploration in the Olary region. The South Australian Department of Mines and Energy contributed to this exploration programme by carrying out detailed airborne magnetic and radiometric surveys over the Willyama Block. Between 1975 and 1980, six low level surveys were flown for the Department, and combined with six surveys flown by mining companies, formed a composite map of the total magnetic intensity over the Willyama Complex and probable buried extensions to the north (Figure 3). Prior to these surveys, the area had been covered by poor quality regional and detailed aeromagnetic data flown by the BMR, between 1952 and 1962.

Regional gravity surveys were conducted by Delhi Australia Petroleum Ltd. (1964-65) over the northern half of CURNAMONA and the Bureau of Mineral Resources (1970), over OLARY and the southern half of CURNAMONA. The 7.2 km grid spacing renders this composite survey of limited use for detailed work, although regionally it is a useful supplement to the aeromagnetics.

In addition to these surveys, abundant geophysical information in company reports is held by the South Australian Department of Mines and Energy, are summarised in the Metallic Exploration Index Series for CURNAMONA and OLARY.

This report is a regional interpretation of the gravity and detailed aeromagnetic data and incorporates other detailed geophysical and geological work. The specific aims are to define the areal extent of, and depth to, near surface magnetic basement, to help to resolve the geological structures and to identify specific targets for further detailed geophysical exploration programmes.

2. GEOLOGY

The Precambrian rock exposures of the Olary Province fall into two distinct sequences. One is an older basement of schists, gneisses and granitoids, which forms part of the Early - Middle Proterozoic Willyama Complex (Mawson 1912), and extends from the Olary region of S.A. to the Broken Hill area of N.S.W. The other consists of younger Late Proterozoic sediments of the Adelaide Fold Belt, correlated with the Torrensian and Sturtian Series (Campana and King 1958), lying with marked unconformity on the folded basement sequence. The southern limit of the Province is marked by the east-north-east, Anabama-Redan Lineament, whilst to the north, all outcrop disappears beneath onlapping sequences of Cambrian (Arrowie Basin), Mesozoic (Frome Basin) and Tertiary (Tarkarooloo Basin) sediments.

Concerning the distribution of the Willyama Complex in the Olary area, Forbes and Pitt (1980) comment:

> "A complex of curved, branching shears determines the distribution of the Willyama Complex: as a consequence of this shear system and probable block-tilting, individual fault-blocks or inliers are bounded to the west or southwest by shears, and to the east or northeast by the unconformably overlying Adelaidean sequence. The Willyama Complex in South Australia is therefore composed of a number of semi-isolated blocks, many of which are further broken up by east-west shears. Individual metamorphic sequences for each of these blocks may be erected with fair confidence. However, the definition of a regional sequence is considerably more subjective, complicated by block-to-block correlations, and both metamorphic and original sedimentary facies changes"

2.1 Stratigraphy

Talbot (1967) erected the first detailed stratigraphic succession for the Early & Mid. Proterozoic Willyama Complex in South Australia in describing a small area at Weekeroo. He made two simplifying assumptions:

> ..."that the units recognised in the Willyama Complex reflect original sedimentary units and that the central antiform is in fact an anticline...".

To the six mappable units proposed by Talbot, a seventh, named 'anatexites' was added by Pitt (1971) in his report on Plumbago (1:63,360 sheet area).

Although Talbot's sequence of units is specifically applicable only to the Weekeroo area, many of his lithotypes may be recognised throughout the Willyama Complex in South Australia. Recent correlation studies (Pitt, pers. comm.), indicate that Talbot's sequence is not directly recognisable due to metamorphic variations. Thick sequences of migmatites and units such as iron formations and calc-silicate beds, for instance, are absent at Weekeroo. The overall Willyama Complex sequence, therefore, incorporates Talbot's sequence but is not identical. Talbot's units for the Weekeroo area are described below to help resolve the causes of magnetic patterns.

2.1.1 Willyama Complex

Anatexites

This term was first used informally to describe a large body of foliated, sometimes porphyritic granitoid gneisses in the Plumbago H.S. area. These rocks host the cobalt, nickel, copper deposit of the Ethiudna Mine. Some magnetite is often found in surrounding rocks.

Leucogneiss

This unit, exposed only in the Weekeroo area, forms the lowermost unit of the sequence. It consists of leucocratic gneisses and minor schists.

Migmatitic Schist

Structurally overlying the leucogneiss is this invariably schistose, quartz-feldspar-mica unit injected by pegmatitic schlieren. Contained within this unit are two, 25 m thick bands of calc-silicates, which have known mineralisation association in the Ethiudna area. Ubiquitous tourmaline and garnet are present with possibly common, disseminated magnetite.

Granitoid Gneiss

This is a poorly layered, medium to fine grained, leucocratic equigranular rock of metamorphic origin and granitoid appearance.

Layered Gneisses and Schists

Originally mapped in the Weekeroo area, this unit also outcrops to the northeast in the Outalpa area. In contrast with the non-layered nature of the previous unit, it is layered on all scales. Consisting predominantly of layered quartz-rich schists, gneisses and migmatites, there are also bands dominated by quartzites exhibiting regular lamination, along which have developed laminae of hematite and magnetite, up to a few millimetres thick. In places, this becomes quite a distinctive feature and the magnetite-hematite laminae may be thick and close enough together to form locally bedded iron formations, such as in the Ameroo Hill area, and in the stratigraphically equivalent horizon in the Koolka and Billeroo areas.

Mica Schists

A gradational boundary with the underlying gneisses leads into a sequence of fairly homogeneous silvery to bronze coloured, even grained mica schists. Magnetic minerals are generally absent from this unit, but in some complex structural areas, such as that just south of Cathedral Rock, where adjacent or underlying B.I.F's and pyritic and magnetitic orthoquartzite occur in biotite-feldspar gneisses and quartzites (Pitt pers. comm.), interpretation of the magnetic data may be complicated.

Bedded Mica Schist

This unit is a red-brown weathered sandy granofels, grading with increasing mica content into a sandy mica schist. Occasional clean bedded quartzite beds are present. This unit is intruded by large pegmatites. As it outcrops only in the Weekeroo area, it is not known whether or not it lies conformably on the underlying mica schists.

In addition to Talbot's sequence, the area is complicated by a series of calc-silicate beds, and is cross-cut by pegmatites and amphibolites.

Calc-Silicates

Campana and King (1958) noted that many of the mineral deposits of the Olary Province are confined to distinctive epidote and garnet ± tremolite ± diopside ± carbonate rocks. All occurrences of this calc-silicate group were correlated to the sequence in the Ethiudna Mine area. Talbot (1967), however pointed out that the calc-silicates lay within the schist sequence in all localities, except at the type section, where they lie in an isolated gneissic terrain of unknown 'stratigraphic' position. Due to the apparent difference in occurrence and appearance, Talbot suggested the discontinuation of the term 'Ethiudna Calc-silicates Group'. Pitt (pers. comm.) from recent studies suggests that a broad zone within the stratigraphic succession, hosting several levels of calc-silicates, occurs regionally. Another complicating factor is that the Ethiudna mine area seems to have been more highly metamorphosed than adjacent areas, suggesting that the gneisses in that area may correlate with schists in other areas (Pitt, pers. comm.). In some areas this unit has a very high magnetite content.

Pegmatites

Thoughout the basement area, the rocks are invaded by pegmatite swarms, showing at times conformable contacts with the metasediments, often following a more quartzitic or arkosic horizon, suggesting a metasomatic origin. This, however, is not the general rule, and in places long pegmatite dykes crosscut the whole metasedimentary succession at a high angle. These pegmatites show varying amounts of accessory magnetite. In some areas, such as Bimbowrie-Boolcoomata, the pegmatites are of economic importance and deserve careful attention.

Amphibolites

This group consists of a suite of basic rocks which are exclusively associated with the crystalline basement, but show wide variations in composition, mode of occurrence, and origin. Earlier workers (Campana and King, 1958) interpreted the presence of both ortho- and para-amphibolites.

The para-amphibolites are preferably termed calc-silicate formations (Pitt, pers. comm.) and as they have been discussed above, only ortho-amphibolites are considered here; they consist of three types:

1) Discordant meta-dolerite dykes often showing well preserved igneous textures (as described by Talbot 1967, p. 51) and range in width from 2-20 m and are up to 2 km long.
2) Three large (750 m wide, by 2 km long) discordant bodies at Weekeroo (Cobb and Morris, 1970). These display relict igneous textures, contain pyroxenes, have probable pillow structures and have extensive soda metasomatism and brecciation textures. They contain magnetite-rich layers with ilmenite or titanomagnetite and are regarded by Pitt as being of extrusive basic volcanic origin.
3) Concordant amphibolites of the Mutooroo area, which may correlate with similar rocks in the Broken Hill area. Campana and King (1958) regarded these as para-amphibolites, i.e. metasedimentary, but they are now regarded as of igneous origin; possibly sills or basic tuffs (Pitt, pers. comm.). They are generally 10-40 m wide, have a strike length of several kilometres, and contain magnetite.

Following Talbot's work in the Weekeroo area, Pitt (1980) recognised three distinct domains in the Olary region:

(1) granitic Crocker Well-Ethiudna Hill area.

(2) Old Boolcoomata (Weekeroo-Olary) area (Figure 4).

(3) Mutooroo area.

A metamorphic sequence defined for the Old Boolcoomata area (similar to Talbot's) may be applied to the Ethiudna area, but not at Mutooroo where a small group of unrelated rock types were mapped. Here the rocks are of notably higher grade and similar lithologies to those at Broken Hill are recorded.

2.1.2 Adelaidean System

The crystalline basement rocks of the Willyama Complex are unconformably overlain by the well bedded, thick and generally little altered beds of the Adelaidean System, consisting in the Olary area of basal conglomerates, magnesitic carbonates, slates and phyllitic slates and quartzites of the Burra Group, and diamictites, various pebbly quarzites and siltstones, and minor dolomites of the lower part of the Umberatana Group.

Except for the Benda Siltstone (Forbes, 1970), which hosts the Braemar iron formation facies, the Adelaidean sediments are iron-poor, especially in comparison with the underlying Willyama Complex, in which hematite is an ubiquitous accessory.

2.2 Structure

Berry *et al*, (1978) in a study of the Outalpa area have interpreted five deformations of the Olary Province, of which the first three were pre-Adelaidean. The first deformation occurred in the Early Proterozoic and gave rise to a mid-amphibolite grade metamorphism, the first of four recognised metamorphic events. This was followed by a weak deformation giving rise to open folding which probably coincides with the beginning of retrogressive metamorphism. The third deformation is largely responsible for the overall distribution of rock types within the Willyama Complex. Large scale folds were formed, plunging to the northeast with associated foliations trending northeast to east-northeast. The majority of the amphibolite dykes were intruded after this phase of deformation.

The two final deformations are associated with the Early Palaeozoic Delamerian Orogeny, the final major tectonic episode in the region. As a consequence of this episode, Adelaidean rocks were folded and metamorphosed to greenschist facies and pre-Adelaidean rocks were further retrograded.

Although not reflected in the stratigraphy, an epeirogenic Tertiary event gave rise to block faulted horst and graben structures.

2.3 Metamorphic Zones

Three distinct areas within the Olary Subdomain are recognised on metamorphic, lithological and deformational grounds. The Mutooroo area is of notably higher grade (upper amphibolite to granulite facies) than the other two. The Old Boolcoomata area is generally more mobilised and gneissic than the less penetratively deformed Kalabity area. Grades of deformation and metamorphism can vary along folds from limb to limb resulting in schistose, gneissic or migmatoid variants of any particular unit or sequence of units. In the Olary Subdomain the iron formations are present in both higher and lower grade regions, i.e. metamorphic overprinting of later deformations transgresses the earlier formed structures.

Tectonic events in the Willyama Domain continued through to Delamerian times. Adelaidean rocks resting on the Willyama Complex are moderately deformed and show large thickness changes across faults believed to be extensions of retrograde schist zones. Some retrograde schist zones may have been intermittently reactivated from the time of the third deformation through the Delamerian Orogeny. Consequently, the final development of a stable craton in the Willyama area did not take place until ca. 490 Ma.

2.4 Mineralisation

Two metallogenic epochs have been recognised within the Olary Province, which may be genetically related to the tectonic history.

2.4.1 Proterozoic Metallogenic Epoch

The older mineralisation of the basement is featured by high temperature deposits of pegmatitic and pyrometasomatic-type related to the granitisation and granite emplacements, which took place at the end of the Proterozoic orogeny. The former include most, if not all of the uranium and rare earth occurrences; the latter include the copper-cobalt-tungsten deposits. Industrial mineral deposits such as feldspar, beryl, mica, phosphates, andalusite, sillimanite, graphite and corundum, form a third group restricted to the Willyama Complex, mostly in pegmatites.

2.4.2 Early Palaeozoic Epoch

The second epoch, which affected both basement and Adelaidean cover rocks, is characterised by numerous low temperature invading siliceous veins carrying gold, silver-lead and traces of copper and cobalt. These deposits were generally introduced along bedding or cleavage in structural openings.

The Anabama Granite is the only granite associated with this epoch in the Olary area though others do occur in the southern end of the Mt. Lofty-Olary arc.

2.4.3 Sedimentary Deposits

A second category embraces the banded iron formations and the Tertiary uranium deposits. The iron formations occur in the Willyama basement metasediments and in the Adelaidean Benda Siltstone, (Braemar iron formation facies).

2.5 Summary

From the known geology facts, the major magnetic responses are from the Willyama Complex. Disseminated magnetite, ilmenite, hematite and other ferruginous minerals, along with disseminated sulphides such as pyrite, and cobalt and nickel concentrations, all add to some degree the basement's magnetic relief. The basement's magnetic fabric reflects the magnetic units distribution overprinted by the structural history of the area.

This is further complicated by the presences of the Braemer iron formation facies in Olary.

3. INTERPRETATION OF THE OLARY AND CURNAMONA REGIONAL BOUGUER GRAVITY MAPS

The Bouguer gravity maps of OLARY and CURNAMONA were compiled by Gerdes (1975 and 1980), from readings at about 7 km spacing by the S.A.D.M.E. in 1972, Wongela Geophysical Pty. Ltd. on behalf of Delhi Petroleum Pty Ltd. in 1964-65 and the Bureau of Mineral Resources in 1970. The Bouguer gravity values were adjusted for latitude and elevation obtained by barometric levelling referred to S.A. Dept. of Lands Bench Marks. For the Bouguer gravity maps of OLARY and CURNAMONA, densities of 2.67 t/m^3 and 2.2 t/m^3 were chosen to correspond to the basement metasediments and the Tertiary sediments respectively. For this report, CURNAMONA was recalculated at a density of 2.67 t/m^3 to aid in the interpretation of the southern area of outcropping basement.

3.1 Data Quality

The grid spacing of data stations acts as a spatial filter so that with a 7 km spacing, these data are mainly of value in the determination of large scale structures such as basins, and large zones of contrasting density, such as granite intrusions and zones of differing metamorphic grade and bulk lithology.

3.2 Density Data

In the B.M.R. report on the 1970 gravity survey which covers OLARY and the southern half of CURNAMONA, Tucker and Brown (1973) included a comprehensive discussion of the density data, in which they suggested the following average density ranges for the lithologies present.

Granitic intrusions	2.65-2.70 t/m^3
Adelaidean sediments	2.68-2.73 t/m^3
Metamorphic basement	2.55-2.79 t/m^3

(see Appendix A for additional data)

Their data shows an overlap in density ranges for all the major lithologies in the area. Thus any gravity based model must necessarily be complicated. Density variations within an area are often a reflection of metamorphism, as this leads to compaction of grains, expulsion of water and hence an increased density. Pitt (1980) noted ..."the fact that a particular unit, representing a certain stratigraphic level, may be variably schistose, gneissic or even migmatitic, depending on the degree of mobilisation or metamorphism".

Figure 5 shows a summary of density measurements and that the major density contrast lies within the Cambrian section between the limestones and arenites. The major units within the Precambrian basement have a similar density, except for those in the Mutooroo area. No data from this area are presented, but the continuity into the Broken Hill Block (both magnetically and gravitationally) suggests that the density ranges for these two areas are the same. Tucker and Brown (1973) quote densities of up to 3.15 t/m^3 in the Broken Hill area.

They also noted that the Phanerozoic sediments of the Frome Embayment and Murray Basin have little effect on the Bouguer gravity pattern. This fact was borne out in several areas during model studies, as the calculated gravitational effect of the known thickness of sediments accounted for only a small portion of the observed anomaly.

However, stratigraphic drilling by Delhi Petroleum Ltd along the southern edge of Lake Frome (Figure 6) showed a large wedge of Cambrian sediments (Arrowie Basin) below the Frome Embayment which must strongly affect the regional gravity gradient.

3.3 Interpretation

The area was first divided into zones of consistent gravitational character (Figure 7) as follows:

Zone type	Character
A	large negative
B	small negative
C	large positive
D	complex zone
E	trough-like

3.3.1 Regional Gradient

The regional gradient slopes from east to west; steeply at first, then levelling out to a value of around -140 μ Galileos. The general north-south trend of the contour lines lies at high angle to both the east-west elongation of the Olary basement complex, and the major northeast and northwest trends in the area, as reflected in structural elements and photo-lineaments. An exception is the Mingary/Mutooroo area where contours parallel a major northwest trending fault between the Olary and Broken Hill magnetic zones (Section 4.3). To the west of this, the contours elongate in apparent response to the rocks in the OMZ4 (Section 4.4). As previously mentioned, there is a noticeable metamorphic gradient from the high grade Mutooroo area (upper amphibolite to granulite facies), through the Old Boolcoomata area (lower amphibolite facies), to the least penetratively deformed Kalabity area (lower amphibolite facies). In the Broken Hill area, Binns (1964) deduced that the grade of metamorphism increased from northwest to southeast, and this was reaffirmed by Phillips, 1977.

The regional gravity gradient appears to reflect the metamorphic grade, decreasing from the high grade metamorphics in the Broken Hill and Mutooroo areas, across the central Olary Block (which has a density similar to the Adelaidean sediments).

3.3.2 Anomalous Zones

3.3.2.1 Type A Zones

These zones are characterised by large gravitational lows, indicative of low density granitic rocks.

Zone A1, a large zone extends along the western side of CURNAMONA is dominated by a -300 μGalileo, low centred over the Curnamona H.S. with two weaker lobes to the north. The major low is directly attributable to a granite batholith which outcrops in the Crocker's Well and Mt. Victor areas, while drillhole data extends the known occurrence further north.

The two lobes, north of the main anomaly, are less intense, and probably coincide with deeper granitic sources. Cambrian sediments are the only moderately low density sediments in the area which are possibly thick enough to cause these anomalies, but Lake Frome DDH 1, 2 and 3 indicate a thick undisturbed

Cambrian sequence dipping gently westwards reaching a maximum thickness along the eastern edge of the Flinders Ranges. If these anomalies were due to Cambrian sediments, they should increase in intensity to the west, not decrease.

Zone A2, a tightly confined negative zone is caused by the Anabama Granite. The very steep gradients on the southeast, southwest and northeast sides of the anomaly and the truncated contour pattern, are suggestive of fault control. Three faults paralleling the dominant trends were proposed by Gerdes (1973) after a detailed gravity study. While modelling this anomaly, Tucker and Brown (1973) proposed a vertical southeast boundary to account for the steep gradient which exactly parallels the Anabama fault zone.

Zone A3, a northeast to north trending elongate zone extending across Mulyungarie, is marked by two well defined lows and a suggestion of a third at its northern extremity. Resistivity and drilling over the largest anomaly confirmed granite at a depth of about 25 m near Mundaerno Hill. The non-magnetic nature of this area is consistent with a non-magnetic granite source. The angular contour pattern of the central anomaly indicates that this intrusion is fault-controlled (OMZ 3b, Figure 16).

Zone A4, a small gravity low in central CURNAMONA is an intense negative anomaly with a north-south elongation. Drill data from E.L. 89 by Southern Ventures Pty Ltd, showed Cretaceous sediments at around 120 m in this area. A non-magnetic circular feature, centred about 4 km south of the centre of zone A4, is interpreted as a granite intrusion. The angularity of the boundaries of zone A4 and the coincidence with magnetic boundaries within the Benagerie magnetic zone (Section 4.3.3) imply that the emplacement of this granitic body was strongly fault controlled.

3.3.2.2 Type B Zones

These zones are characterised by minor gravity lows, which are defined by sufficient data and therefore considered real features.

Zone B1, situated on the eastern side of Kalabity, is probably due to granitic rocks. Its magnetic signature is consistent with this interpretaion.

Zone B2, lying just south of B1, is of similar dimensions to B1 though less intense. Although there is some granite outcrop on its southern edge, it does not have a coincident magnetic anomaly indicative of granite.

Zone B3, on the southwestern side of Lake Charles, a small negative is centred in an open ended, easterly trending gravity low area. This gravity feature lies across an undisturbed area of north-south steep magnetic gradient (the boundary between the Kalabity and Benagerie Magnetic Zones is defined later). The northern edge of B3 coincides with a major LANDSAT lineament which also runs along the northern edge of C3 and between the two northern lobes of A1. There is no reflection of this gravity feature in the magnetics.

The source must be an intrabasement density contrast, as drilling in the area (Callen, 1981) shows no appreciable thickness of sediments to account for it.

Zone B4, is covered by few data points, all of which coincide with isolated granitic outcrops on Olary and Kalabity. This feature may not be real, as these outcrops may not be from the same body. Magnetically the area is complex and not indicative of a single granite mass.

Zone B5, is a small gravity depression, controlled by two gravity stations on a tongue of Adelaidean sediments in Olary. It is probably real, reflecting a minor density contrast between the Adelaidean sediments and the surrounding Willyama Complex metasediments.

3.3.2.3 Type C Zones

These zones are large, elongate, positive gravity features.

Zone C1, is part of a major arcuate tectonic region, which extends from the northeast corner of CURNAMONA, through Broken Hill to Lake Alexandrina in the south where it apparently terminates against a major north-northeast tectonic lineament. The Anabama-Redan lineament zone divides C1 into two. To the south, this feature closely parallels the western margin of the Murray Basin, suggesting that it reflects a basement rise onto which the sediments onlapped. Through CHOWILLA this region is bounded to the north by the Anabama Fault Zone and south by the Hamley Fault.

The Mutooroo area in southeast Mingary lies in the southernmost corner of the northern section of C1. The continuity of this zone through the Broken Hill Block, and the similarities between rock types, suggest that the density range of 2.67-3.15 t/m^3 quoted for the Broken Hill area (Tucker, 1972) is applicable in Mutooroo. The higher density of this area relative to the rest of the Olary Block is consistent with the an increased metamorphic grade. The coincidence of the northwest boundary of this zone with the major boundary between the Olary and Mutooroo magnetic zones (Section 4.3), implies a distinct difference between the basement rocks of the Olary and Broken Hill Blocks. Although outcrop in the area is poor, concordant amphibolites occur frequently within C1, whereas north of the major northeast lineament which bounds the zone, they are totally absent.

Zone C2, an 's' shaped gravity high composed of two subparallel north-northeast sections, extends along the eastern border of CURNAMONA. These two zones are separated by a weak subparallel arcuate gravity low which coincides with the non-magnetic Kalabity Magnetic Zone, considered as a trough containing Adealidean sediments. This gravity low's amplitude increases from zero in the south, where it terminates against a major northwest magnetic and gravity lineation, to about -30 µGalileos in the north. This reflects the general N-S thickening of the sedimentary sequence.

The crest of the southern gravity high within C2 coincides with a Precambrian high based on drilling and resistivity survey interpretations. Drill hole data has confirmed Willyama Complex rocks at a depth of 546.5 m beneath Adelaidean and Cambrian sediments.

The northern gravity high lies well within the non-magnetic Kalabity Magnetic Zone, so that the source rocks of this anomaly may not be Willyama Complex, unless they are totally non-magnetic like the pelitic schists, (Section 4.1.3.4). The distribution of Willyama Complex rocks within outcrop areas shows a strong mixing of rock types, which is inconsistent with the Kalabity Magnetic Zone being due to a single rock type. Possibly the northern half of this anomaly is due to Broken Hill-type basement at depth, as it extends across the border into the northern reaches of the

Broken Hill Block. Several semi-detailed gravity traverses should help relate the gravity more closely to the aeromagnetics and possibly solve this problem.

Zone C3, a gravity high located in the southwest of Benagerie is apparently associated with the basement rocks of the western half of the Benagerie Ridge, which lies within the Benagerie Magnetic Zone, (Section 4.3). A weak gravity low between -10 and -20 μGalileos, south of C3 shows good correlation with a non-magnetic zone within the Benagerie Magnetic Zone. As this non-magnetic zone is 4 km wide, it is not well defined by the gravity data. A detailed gravity survey is required to clarify this correlation, and similar features with the aeromagnetic data.

3.3.2.4 Type D Zones

These zones are composed of several small amplitude anomalies defined by very few data points, and requires further gravity stations for better resolution.

Zone D1, is a zone of marginally higher density, and coincides with two synclines of Ulupa Siltstone, which are separated by an anticline along which the Barrier Highway is located. This high is thought to reflect Delamerian fold structures.

Zone D2, is a reflection of the Weekeroo Inlier, which the data spacing is too coarse to resolve.

Zone D3, covering the southern half of Yunta, consists of three small highs. The contour lines do not follow the geology because of data spacing, but indicate a zone of high density tillites, banded iron formations and iron rich siltstones.

3.3.2.5 Type E Zones

These are elongate low zones in which the anomaly patterns are suggestive of trough-like features, striking parallel to the dominant northeast and northwest structural framework of the area.

Zone E1, elongated in a northeasterly direction cutting across Oakvale, the contour pattern suggests a pair of parallel major northeast faults and down-thrown to the south. The aeromagnetic data indicates similar features. To explain fully the gravity contour pattern, it was assumed that the down-thrown blocks are tilted northwest and that the whole system was then plunged to the southwest, as are many folds in the area. Erosion was then thought to have planed down the area leaving a shallow bilobal valley. Subsequent subsidence saw the basin infilled with Tertiary sediments (Figure 8). Drilling by Tricentrol Aust. Ltd. along the fault zone shows two major faults down-thrown some 25 m to the southeast and tilting to the north.

The computed gravitational effect of this model could only account for a minor part of the observed anomaly, thus indicating a low density zone below the basin in the fault zone. A weathered zone was considered initially, then a broad porous shear zone. For the weathered zone model, a density contrast of $-0.4\ t/m^3$ was chosen, giving a depth of weathering of around 500 m. Although this fault zone would be expected to be more deeply weathered than surrounding areas, a weathered depth of 500 m seems unrealistic. A significantly larger density contrast to compensate for a shallower depth of weathering is also considered most improbable. The second model assumes that the faults mark a major shear zone in which the rocks have been substantially crushed creating a large pore space volume. Although this zone may extend to great depths, the porosity will close at a maximum depth of about 500 m due to pressure (Barnett, per. comm.). Taking this as the maximum depth of fracturing, the anomaly can be accounted for by a minimum porosity of 2.4%.

It seems probable that factors from both these models add to produce the observed anomaly, viz. weathering and porosity due to fracturing.

Zone E2, a rectangular low, which is elongated northwest across the northwest corner of Lake Charles, is surrounded on three sides by C2. The pattern of the contours suggest a basin, with a possible truncation along the northwest end. Drilling and resistivity data in the area (Kerr 1966) have shown Tertiary sand channels at depths of 100-130 m underlain by Cretaceous sediments. The aeromagnetic patterns show an increased depth to magnetic basement parallel to and centred over this gravity feature.

To account for the mass deficiency of E2, a basin of Tertiary, Cretaceous, Cambrian and Adelaidean sediments is proposed. As with E1, only part of the anomaly could be explained, indicating an intrabasement density contrast.

3.3.3 Summary

In general, gravity data delineates a zone of high grade metamorphic basement along the S.A./N.S.W. border, being part of the Broken Hill Block. A major northeast lineament north of Mutooroo divides this basement from the less dense Olary Block. In the east of the Olary Block, a significant density contrast exists between the Willyama Complex and Adelaidean sediments to the southwest. This may be due in part to a higher magnetite content in the OMZ4 (Section 4.4) in the eastern Olary Block. Metamorphic grade within the Olary Block appears to downgrade to the northwest, where no significant contrast exists with the Adelaidean sediments.

Large granite masses have intruded the area, giving rise to large areas of anomalous negative gravity. Several basins are outlined parallel to major structural trends, whilst several small scale and subtle features require detailed gravity work to resolve their true character.

4. MAGNETICS

4.1 Comparison of Aeromagnetic Data with Detailed Geological Mapping in the Outalpa Area

To fully use airborne data as an aid to geological mapping, it is necessary to determine the relationships between stratigraphic and magnetic units. The area of the Outalpa and Bulloo 1:50 000 standard sheets was chosen because it displays good outcrop, contains most of the major rock types in the Olary Province, and has been geologically mapped in detail. In addition, its central location makes it the best area from which to extend the relationships in all directions. The following comments are based on mapping by G. Pitt. Other authors have commented that his failure to recognise F1 isoclinal folding has led to stratigraphic repetitions being mapped as separate units, which has led to a confused and hence complex stratigraphy being proposed. As most of these units are informally named, they will be referred to by their stratigraphic symbols as defined by the Outalpa:Bulloo stratigraphic column (Figure 4).

4.1.1 Surficial Cainozoic Sediments

Though always non-magnetic, these sediments are generally too thin to have any discernable attenuative affect on the magnetic response of the underlying rocks.

4.1.2 Adelaidean

In general, these rocks are non-magnetic (e.g. the Burra Group, Pualco Tillite and Wilyerpa Formation, Figure 9), the only major exception being the Benda Siltstone and its basal member the Braemar Iron Formation. The mineralogy of this unit (Whitten, 1970) shows magnetite euhedra (3-100% martitized) and fine grained hematite.

Along the MacDonald Corridor (Figure 9), the aeromagnetic contoured data reflect differences in depositional histories. To the north, the iron appears to have concentrated at one stratigraphic level, whereas to the south it is well dispersed through the Benda Siltstone. In this area (Figure 10), the aeromagnetic contours clearly reflect the regional fold style and also parasitic folds.

4.1.3 Willyama Complex

4.1.3.1 Acid Intrusions (E_{γ})

This group of rocks are granitic to granodioritic in composition and have generally intrusive contact relationships. The Antro and Triangle Hill granite bodies are thought to be parts of a single body dissected by the MacDonald Fault, as are the Binberrie granite and Tietz Dam granite bodies (Pitt pers. comm.).

These intrusions are non-magnetic, except the Triangle Hill body which is weakly magnetic. This difference in magnetic susceptibility may be explained in terms of slightly different composition and grain size.

Magnetic features of the acid intrusions (as defined by Pitt) are summarised below.

a) All are non-magnetic except the Triangle Hill body and hence its related origin to the Antro body is queried.

b) The Triangle Hill body shows strong intrusive boundary features.

c) The Tietz Dam and Binberrie bodies have similar magnetic characters, consistent with their geologically inferred related origin.

d) With the exception of the Triangle Hill body and possibly the Nine Mile Gate body, the aeromagnetic data do not support intrusive contact relationships.

e) None of the bodies has clearly defined aureoles.

4.1.3.2 <u>Metamorphic Basic Igneous Rocks</u>

a) <u>Discordant Metadolerite Dykes</u> (β_1) - None of the metadolerite dykes examined shows a magnetic response, neither on the contour map nor on the stacked profiles. This is notable in that dolerite dykes are often magnetic (e.g. the Gairdner Dyke Swarm, Gerdes, pers. comm)

b) <u>Semiconcordant Massive Amphibolites</u> (β_2) - Occurring at Weekeroo (32°11', 140°01') (Figure 9) and 3 km north of Doughboy Well (32°04', 140°06'), these bodies are thought to have related origins. Both are strongly magnetic, giving anomalies of similar magnitude supporting the proposed relationships.

4.1.3.3 <u>Albite-rich Foliated Granitoids</u> $(P_{w\gamma})$ - Five of these large granitoid bodies occur in the Outalpa area. Mineralogically they are very similar to the previously discussed acid intrusions (P_{γ}), differing principally in their feldspar composition. The division of these rock types into two groups is artificial, as the groups represent end points in the composition of their feldspars rather than different rock types (Figure 11). Texturally the albite-rich granitoids are more foliated, and stratigraphically they are more conformable.

Granitoids are summarised below.

a) With the exception of the ill defined Meningie Well body, all other bodies appear as well defined magnetic lows.

b) The similarity between the magnetic signatures of the Walparuta and Outalpa Springs bodies supports the interpretation that they are parts of a single body disrupted by the MacDonald Fault.

c) The aeromagnetic contour map supports a similar relationship between the Peryhumuck and Mt. Mulga bodies.

4.1.3.4 Metasediments and Metamorphics

The bulk of the Willyama Complex rocks consists of a strongly metamorphosed sequence of sedimentary units. Many metasediments contain sedimentary iron which concentrates parallel to bedding. At times, these concentrations are high enough to be termed banded iron formations. These horizons form good geological markers and are discussed below.

As mentioned, iron is ubiquitous within the basement metasediments, although its distribution is highly inhomogeneous. The massive to layered, quartz-plagioclase-magnetite "quartzite" EWq, is the most strongly magnetic unit. Magnetite is dispersed throughout and is concentrated at the top to form iron formations. Wherever it occurs, this unit is magnetic, although it varies from weakly to strongly magnetic (Figure 12). Similarly, its gneissic equivalent EWf, a massive to thickly layered feldspar-rich gneiss, is variably magnetic (Figure 4).

At the other end of the scale are the pelitic quartz-muscovite schists EWs$_4$ and gneissic equivalent EWg$_4$. These rocks are demonstrably non-magnetic wherever they occur (Figure 13).

4.1.3.5 Marker beds

Three major types of geological marker units are present: gossans, calc-silicates and ironstones, of which the latter two occur widely throughout the basement.

a) Ironstones - Due to their thinness (often 1 m or less) and mineralogy, many of the ironstones are not detected aeromagnetically. Mineralogical descriptions of ironstones from several localities (see Appendix B) show that in almost all cases the primary iron mineral was magnetite which was consequently replaced to a greater or lesser extent by hematite (martite) and/or goethite.

At Peryhumuck Mine where the ironstone is best developed, it is clearly reflected by the aeromagnetic contours. Petrographic descriptions, however, show that here too the initial magnetite (25-30%) has been oxidised to hematite (Appendix B, P1087/75). It would appear that this oxidation is a surface feature and that magnetite still exists at depth. At Meningie Well, however, hematite (oxidised magnetite) concentrations reach 50-60% of the total volume of the rock (Appendix B, P1201/76) yet the iron formation is not detected aeromagnetically. This implies that no magnetite remains unoxidized. Detailed petrographic studies and susceptibility measurements of core from below the weathered zone are necessary to resolve this inconsistency.

b) Calc-silicates and Albitic rocks - As with the ironstones, this group of rocks shows great variety in its mineralogy and spatial distribution. Small, narrow bodies are not delineated by the aeromagnetic contour map. The large body 2 km northeast of Antro Well is strongly magnetic (Figure 14), whilst that at Tonga Hill shows patches of magnetic material.

c) Gossans - None of the stratabound gossans are apparent on the aeromagnetic map. The magnetic relationships of these three types of marker beds are more clearly visible in the Kalabity area and are discussed below.

4.2 Kalabity Area

The Kalabity aeromagnetic survey covers an area of basement outcrop extending across the southern portion of the Kalabity 1: 50 000 map sheet to Mt. Victoria on the Curnamona 1: 50 000 map sheet. Comparison of mapped lithologies with the aeromagnetic contour map confirms the correlations made on the Outalpa aeromagnetic survey area.

Basement outcrop in the Kalabity area forms a dome which plunges northwards beneath the Adelaidean. Large outcrops of pelitic schist occur along the northern margin of the basement and are non-magnetic (Figure 13). Stratigraphically below this lies the marker horizon composed of gossans, calc-silicates and ironstones. Their narrowness and proximity to each other make it difficult to separate their magnetic characteristics with this detailed aeromagnetic data. In general, the gossans seem to be non-magnetic, whilst the ironstones and calc-silicates give strong but variable magnetic responses. The Dome Rock Copper Mine area (31°55', 140°28') (Figure 14) illustrates well the magnetic variability of the ironstones. Along their length they often cease to be magnetic, and conversely, magnetic anomalies continue beyond the mapped termination of the ironstones. These features are probably due to changes in facies the degree of weathering, and subsurface extension.

Calc-silicates, east and southwest of Waukaloo Mine (139°53', 31°50') (Figure 14) are strongly magnetic, and commonly the anomalies have amplitudes of about 3000 nT. This amplitude is greater than most anomalies caused by Willyama Complex ironstones, which are generally about 2000 nT, reaching an occasional peak of 3000 nT.

4.3 Regional Subdivision of the OLARY and CURNAMONA Aeromagnetic Maps

After the detailed comparison between the geology and aeromagnetic data of the Outalpa area, the aeromagnetic maps of total intensity of OLARY and CURNAMONA (Figures 16 and 17) (Gerdes, 1982 b and a) were broadly subdivided into zones of characteristic response. Although these are generally consistent with major geological zones, this is not always so, especially in the case of the Braemar Iron Formation. Where practical the responses of this unit are separated from those of Willyama Complex sources.

To provide continuity of interpretation across the S.A./N.S.W. border, a nomenclature system compatible with that of Isles (1983) was chosen. Where possible, zones on either side of the border are equated. The following abbreviations are used:

OMZ Olary Magnetic Zone
MMZ Mulyungarie Magnetic Zone
BMZ Benagerie Magnetic Zone
BHZ Broken Hill Magnetic Zone
KMZ Kalkaroo Magnetic Zone
SMZ Strathearn Magnetic Zone

NCMZ North Curnamona Magnetic Zone
FDMZ Frome Downs Magnetic Zone
TMZ Toolabie Magnetic Zone

4.3.1 Olary Magnetic Zone (OMZ)

Essentially all known outcrops of Willyama Complex north of the Mutooroo area occur within this large Magnetic Zone. Other minor outcrops occur at Mooleulooloo Hill (approx. 31°37', 140°30') and just north of the Benagerie Homestead (approx. 31°25', 140°25').

The OMZ is a multiple zone containing numerous subzones and because of its size and complexity, OMZ has been subdivided into subzones, which are discussed in detail in Section 4.4. This is characterised by a continuous magnetic zone high gradient, narrow, elongate anomalies due to Willyama Complex sources. This is the same Zone as 'PHZ' as defined by Isles (1983). Major west-northwest/northwest trends indicate a pervasive fracture system which crosscuts this zone and are subparallel to the MacDonald Fault. These fractures appear to radiate from a location northwest of OMZ, approximately central to the gravity zone A1, which may be related to granite pluton emplacement. This is a seismically active area (Stewart 1973, p.42 fig. 1). Lithological trends in the north and east of the OMZ show a strong east-northeast element, whereas in the centre and west these trends, while present, are less pronounced.

The boundary between the OMZ and surrounding Magnetic Zones is highly variable depending on its cause, (e.g. faults/unconformity) and the magnetic characteristics of the Zones on either side. In general, the southern margin of the OMZ is fault-bounded and sharply defined, whereas the northern margin is less well defined and strongly embayed, possibly coinciding with an unconformable contact between the Willyama Complex and overlying Adelaidean sediments.

The southeastern boundary between OMZ and BHZ is a very sharply defined northeast-southwest lineament, which parallels the major magnetic trends in both Zones. This unknown geological boundary is possibly a major fault, as interpreted by the edge effects along its southern side. It is displaced at several places by the major west-northwest fractures. The eastern extension of this major boundary divides the 'PHZ' and 'BHZ' as defined by Isles. He states that

> "the boundary is segmented by WNW trending features which generally coincide with recognised shear zones (e.g. Thackaringa-Pinnacles and Pine Creek Shears)."

In the Dey Hill area (S.A.) it is clearly displaced by the Dey Fault and is finally terminated by the northwest MacDonald Fault.

The southern margin of OMZ is fault-bounded by the northwest MacDonald and Outalpa Faults, and a series of arcuate faults which outline the Weekeroo Inlier. Along all of these faults, 'fingers' of Adelaidean sediments invade the southern margin of the OMZ. Although the basal Burra Group is totally non-magnetic, the Braemar Iron Formation and host Benda siltstone are strongly magnetic. For this reason and the fact that they are surrounded and underlain by Willyama Complex rocks, they have been included in OMZ. This inclusion of Adelaidean ironstones within OMZ is encountered again along the northern edge of the Weekeroo Inlier, where detailed comparison of the aeromagnetic contours with geological data is necessary to isolate these sources, as their magnetic character is very similar to Willyama Complex sources.

The western edge of OMZ is sharply defined by a north-northwest trending fault expressed as a narrow linear magnetic negative, which extends for over 30 km. The southern end of this feature has been interpreted on the State 1: 1 000 000 geological map as curving to the east along the southernmost outcrops of Willyama Complex in the Ethiudna area. This, however, may be an extension of the Outalpa fault, whilst the major north-northwest fault may continue south-southeast below Adelaidean cover, along the western edge of two arcuate anomalies, caused by uplifting sections of the Braemar Iron Formation. Lack of outcrop leaves this interpretation open to speculation, but the Weekeroo Inlier terminates along this proposed south-southeast extension, and ironstones around the Anabama Granite are distributed along this trend.

The northwestern boundary between the OMZ and FDMZ (Figure 16) is a well defined east-west discordant feature lying 7 km north of the last outcrops of Willyama Complex. This feature has been displaced several times by northwest fractures and appears to dip north beneath the sediments of the Frome Embayment.

East of the FDMZ and IMZ boundary, (Figure 16), the internal boundary between the OMZ(1) and SMZ loses all ressemblance to a faulted margin. The OMZ is embayed with large 'fingers' of non-magnetic material up to 30 km in length and about 5 km in width. These features are subparallel to the trend of the surrounding magnetic anomalies, unlike the non-magnetic Adelaidean sediments of the Outalpa and MacDonald corridors which transgress the surrounding magnetic trends almost at right angles. This implies that these non-magnetic features are not related to faulting but are probably zones of non-magnetic Willyama Complex rocks.

In the northeast of OMZ, the boundary with KMZ (Figure 16) is well defined north of Mundaerno Hill. Here the boundary is subparallel with the northeast magnetic trends within the OMZ. To the south of this, adjacent Mundaerno Hill, the boundary is poorly defined because of the proximity of a weakly magnetic zone within the OMZ due to the the Mundaerno Hill granite within OMZ4a. To the north, this boundary divides MMZ from KMZ. It is, however, less sharply defined because of the depth of the sources within the MMZ.

4.3.2 Mulyungarie Magnetic Zone (MMZ)

Although an obvious subsurface continuation of the OMZ, the MMZ is characterised by numerous strong (500-1000 nT) oval-shaped anomalies due to sources at depths between 500 and 1200 m (Figure 18). Although defined by relatively few points in this area, the depth to magnetic basement map indicates MMZ is a broad basement dome centred just west of Wallace Bore (approx. 31°29', 140°52').

This Zone is separated from OMZ because of the absence of shallow sources north of a poorly defined east-west boundary at about 31°41'. This boundary is noted by Isles as the division of his 'PHZ' and 'MMZ', and he comments:

> "The boundary between the PHZ and MMZ is... fairly irregular and is difficult to precisely define because the magnetic material associated with the PHZ is evident at moderate depths (c. 500 metres) for a distance of at least 10 km north of the east-west fault (proposed by McIntyre and Wyatt, 1978) which marks the northern limit of shallow magnetic sources beneath the Mundi-Mundi plain".

4.3.3 Benagerie Magnetic Zone (BMZ)

This large triangular zone (Figure 16) is the third zone characterised by strongly magnetic rocks. Within it are several subzones which, although showing different magnetic characteristics, are grouped together, due to their spatial proximity within a surround of non-magnetic rocks. The eastern half (BMZ1), is characterised by narrow, elongate anomalies, associated with shallow sources (less than 300 m) within the Benagerie Ridge. In the west (BMZ2), the anomalies are much broader and more circular being associated with deeper sources (c. 300-700 m). These subzones are discussed in Section 4.4.2.

The southwestern boundary of the BMZ is an indistinctly defined northwest linear feature which terminates several features within BMZ. The discontinuous nature of the magnetic pattern within BMZ with large non-magnetic zones between the isolated anomalies, leads to the indistinct definition of this major transgressive linear feature.

The northern edge of BMZ is outlined by a magnetic discontinity which separates the strongly magnetic anomalies of this Zone, just below 31°12', except for a narrow northeast extension in the northeast corner of the zone, from a relatively deep non-magnetic zone of the north. This east-west feature is at a depth of 500 m, and from its linearity suggests a fault.

The eastern margin of BMZ trends N-S, but is not clearly understood geologically. In the north, dislocations of this boundary at several places are subparallel to similar dislocations in the MMZ/KMZ boundary, which suggests a set of north-northwest faults or flexures have been active in the area. This fracture pattern is also reflected in the ephemeral stream pattern and Bouguer gravity contours.

To the south, this generally north-south trending boundary is strongly displaced to the west. The boundary between the MMZ and the OMZ trends eastwest at this approximate latitude.

4.3.4 Broken Hill Magnetic Zone (BHZ)

This zone is the western extension of the Broken Hill Magnetic Zone (BHZ), described by Isles (1983) as featuring

> ..."a relatively low gradient background variation on which are superimposed discrete predominantly linear anomalies, trending NE in the southern part of the block... .The linear anomalies commonly have amplitudes between 200 and 500 nT and widths around 500 metres.
>
> The 'average' level of magnetic intensity within the BHZ is significantly lower than that of surrounding zones... which McIntyre and Wyatt (1978) attribute to 'major changes in magnetic properties through a considerable proportion of the earth's crust'".

In terms of gravitational and magnetic comparison alone, this zone is the most obvious area to search for Broken Hill-type mineralisation, as it clearly reflects the same type of rocks that occur in and around Broken Hill. However, it is necessary to consider Isles' interpretation of the geophysics of the Broken Hill area. He divided the 'BHZ' into four magnetic domains which are interpreted as depositional rather than tectonic domains. The MMZ is the continuation of Isles' 'Southern Domain' which he defines as the zone within 'BHZ' south of the Thackaringa-Pinnacles Shear. In comparing this 'Southern Domain' with the 'Central Domain' which contains the Broken Hill ore deposit he states':-

> "Of prime importance is the Central Domain which apparently constitutes an environment highly favourable for the development of chemically precipitated iron formations and the related stratiform lode rocks. The Northern and Southern Domains are by comparison much poorer in magnetite bearing rocks and lode horizon and almost certainly represent terrains where Broken Hill type mineralisation is less likely to occur."

In this respect the MMZ does not appear to be highly prospective for a significant Broken Hill-type deposit.

4.3.5 Kalkaroo Magnetic Zone (KMZ)

This large, elongate, non-magnetic north-south zone occurs between the MMZ and BMZ. A small outcrop of Willyama Complex pelitic schist occurs in the Mooleulooloo Hill area, but is not typical of the entire Zone. The general shape and non-magnetic character of KMZ suggests a sedimentary trough. However, the lack of a strong Bouguer gravity low along this feature rules out the possibility of a large pile of low density sediments. The same conclusion was drawn by McIntyre and Wyatt (1978) about the Mundi-Mundi Plain, which lies within the eastern extension of the KMZ they state

> "The absence of a strong negative Bouguer gravity anomaly over the Mundi-Mundi Plain suggests that the thickness of undeformed sediments is much less than in the Bancannia and Menindee Troughs".

These two troughs of Tertiary, Cretaceous, Permian and possible Devonian sediments have a very similar magnetic character to the Mundi-Mundi Plain but also have associated large negative Bouguer gravity anomalies of -250 and -450 micro Gallileos respectively. The CURNAMONA Bouguer gravity map reveals a weak negative anomaly coincident with KMZ, indicative of a small density contrast. Thus KMZ is underlain by non-magnetic rocks with a density similar to those within either the Willyama Complex, or Adelaidean. It is suggested that a thick pile of Adelaidean sediments occurs within the Zone.

4.3.6 Strathearn Magnetic Zone (SMZ)

This non-magnetic zone lying between the BMZ and OMZ is characterised by a series of north to northeast trending curved structures, which are embayed into the OMZ to the south, and appear to terminate along the major northwest lineament, which defines the southwestern margin of BMZ.

In the Nancatee Hill area (31°45', 140°18') and to the southeast of Strathearn (31°49', 140°22'), isolated outcrops of Adelaidean sediments indicate an unconformable contact along the northern edge of the OMZ between the Willyama Complex and overlying Adelaidean rocks. Willyama Complex metasediments appear to dip under the Adelaidean, to the north which is in keeping with the domal structure of the Kalabity region (OMZ2); the Benagerie Ridge represents the northern continuation of this basement dome. The curved nature of these features may be due to the overprinting of an Adelaidean generation folding episode of the Delamerian Orogeny; or to the intrusion of the large granite pluton which gives rise to gravity zone A1.

The SMZ is generally elongate in a northwest-southeast direction parallel to, if not coincident with, the projected extension of the Fitzroy-Spencer fracture zone, as discussed by Stewart (1973). This is thought to be a major transform fault, dividing Australia into two plates, with possible subduction along the Flinders Ranges.

4.3.7 North Curnamona Magnetic Zone (NCMZ)

The northern edge of the BMZ is marked by a sharp change in magnetic character across an east-west lineation. North of this lineation, NCMZ is characterised by a regional magnetic gradient increasing to the northeast superimposed with weak anomalies, which disturb the regional field and rarely form closures. These features are indicative of volcanic sources.

The disturbed nature of the NCMZ appears to diminish to the west across a well defined north-south trending lineation (?fault), which continues south through BMZ, where it is displaced by several lateral dislocations, and terminates at the projection of the Fitzroy-Spencer fracture zone. Along this proposed fracture lies a well defined dipolar anomaly. The source of this anomaly is probably a fault-controlled intrusion and may be a feeder pipe to the volcanics.

The western margin of this zone with KMZ is undefined, as the aeromagnetic data in this area is insufficiently detailed to resolve any distinct feature.

4.3.8 Frome Downs Magnetic Zone (FDMZ)

This Zone within the northwestern corner of the study area is characterised by a fairly even spread of broad circular anomalies due to deep sources (500-2000 m). These lie beneath Tertiary, Cambrian and Adelaidean sediments, which thicken to the west and terminate against the eastern edge of the Flinders Ranges.

The strongest and shallowest anomalies occur in two subparallel belts in the southeast corner of FDMZ. Their alignment especially along the western belt indicates tectonic control. The source of the southernmost anomaly is shallow at 100 m and the sources may compare to those 10 km east within the OMZ. The source of these isolated anomalies are unknown geologically, and based on their amplitudes are not comparable to the responses over banded ironstones further east.

A comparison with the Bouguer gravity map shows that these sources occur along the zone of high gradient coincident with the eastern edge of gravity zone A1 and are interpreted to be associated with the edge of the batholith. The Billeroo Palaeochannel runs north-south through this area and may also be spatially related to the eastern edge of this granite or a major fracture.

4.3.9 Toolabie Magnetic Zone (TMZ)

The zone, which has various magnetic responses, contains large linear anomalies with amplitudes of about 4000 nT over outcrops of the Braemar Iron Formation at Toolabie Hills (31°50', 139°33'), north of Weekeroo Hill (32°10', 139°35'), south of Radium Hill (32°30', 140°10'), and around the margins of the Anabama Granite (32°52',139°57'). In fact, wherever these rocks or the surrounding glacials are mapped, strong anomalies of at least several hundred nanoTeslas occur. The wide line spacing and broad contour interval (50 nT) covering much of TMZ, limits the resolution of these features within this zone, and as they coincide with Adelaidean sources, they are not discussed.

The Plumbago-Glenorchy aeromagnetic survey has resolved several features not clearly seen in the regional data. In particular, a large fault (interpreted) trending west-northwest from the southwest corner of the Weekeroo Inlier appears to define the southwestern side of an anomalous magnetic area, the source of which is unknown. This fracture is coincident with the gradient zone of a large dipolar anomaly 10 km to the west of the Weekeroo Inlier (32°12', 139°44', Figure 17). The origin of the deep seated feature is unknown. The magnetic features in this area are generally due to the Braemar Iron Formation, but a zone of shallow magnetic sources warrants further geophysical investigations to evaluate the possible mineral potential of this fault-controlled zone close to the Teetulpa and Manna Hill Goldfields.

4.4 Subdivision of the Olary and Benagerie Magnetic Zones

Due to their complexity and large areal extent, the OMZ and BMZ were further subdivided, into the subzones based on their magnetic character.

4.4.1 OMZ Subdivision

The OMZ was subdivided into five major subzones, three of which were further subdivided. Adelaidean rocks occur within OMZ, specifically in the southwestern corner, where they are isolated from the Willyama Complex basement. These are unzoned despite their varying magnetic character. The magnetic character of Adelaidean rocks is discussed in Section 4.1.2.

OMZ1, is characterised by a series of subparallel, arcuate, elongate anomalies, ranging from 1000 to 2500 nT, but are generally less than 1500 nT. This subzone is quite distinct from the rest of OMZ, because of its relatively undisturbed nature. The curved nature of these anomalies is interpreted to reflect deformation (D4), (as outlined by Berry et al., 1978), but may also be related to movement along the Fitzroy-Spencer fracture zone. A tight fold with a northeast fold axis, in the southwest corner of OMZ1, is interpreted as a possible D3 basement fold.

Outcrop within this magnetic subzone is sparse. In the extreme southeastern corner, the Willyama Complex outcrops and is unconformably overlain by Adelaidean sediments. This unconformity trends generally easterly across the northern extremity of OMZ2. The northeasterly trend of the anomalies within the OMZ1, generally parallels the major trend in OMZ2, and is at an high angle to the Adelaidean sediments, implying Willyama Complex source rocks. The relatively undisturbed nature of the sources within this subzone is consistent with a general trend towards less complex folding and fracturing (as indicated by the aeromagnetics) along the northern edge of the Olary Block.

OMZ2, its northern margin is formed by a folded magnetic/stratigraphic 'unit', composed of calc-silicates, gossans and ironstones. Folding is tighter than in OMZ1, although it maintains a northeast fold axial trend. Anomaly amplitudes generally range from 1300 to 2000 nT, occasionally reaching 3000 nT.

Along the northern margin of this subzone, the fold closures extend north beneath the overlying Adelaidean sediments. The eastern boundary shows strong similarities to the MacDonald corridor, and represents an Adelaidean sedimentary trough deepening to the east, where it is in faulted contact with uplifted Willyama Complex. The southern margin is chosen to coincide with a major west-northwest fracture.

OMZ3a, in the northeast corner of the OMZ, is subdivided into two parts, and is relatively undisturbed by magnetic lineaments. Along the northwestern edge, the undisturbed north-northeast magnetic units show minor offsets, where disrupted by sets of pervasive northwest and east-west minor faults. This magnetic/stratigraphic "unit" appears to be deformed into a regional fold with a northeasterly axis. The southeastern limb is more deformed and perhaps more highly metamorphosed. The nose of this fold may have been removed by the Fitzroy-Spencer fracture zone.

OMZ3b, is a non-magnetic, polygonal shaped subdivision central to and along the axial zone of OMZ3a, interpreted as a granite intrusion. The polygonal shape and high magnetic gradient of its boundaries suggest its emplacement was controlled by conjugate fracture systems and is near surface.

Although this appears to be an isolated feature, the gravity data (Zone A3) suggest a larger laterally extensive body at depth, trending northeast and centred beneath the folds axial zone OMZ3a. This interpreted granite pluton may have uplifted this block of Willyama Complex (OMZ3a) forming a dome, and in part, intruded it (OMZ3b) at the intersection of major fractures. A remobilized granite within a basement dome, is similar to the Hiltaba Granite Suite within the Glenloth Dome, (R. Gerdes, pers. comm.).

OMZ4, situated in the southeastern corner of the OMZ, is characterised by a series of intense elongate anomalies, commonly in excess of five kilometres long. It differs from other subzones in that the anomalies:

a) are generally longer, straighter and more continuous;
b) compose in excess of 90% of the zone; and
c) are often negative implying (?) retrograde shear zones.

The five subdivisions of this subzone differ principally in the orientation and amplitude of their constituent anomalies.

OMZ4a, the anomalies trend east to east-northeast and have amplitudes between 1000-1500 nT. Several elongate negative anomalies subparallel the major trends, which suggests that shearing may be a significant feature. In the far west of the area, the anomalies occur over outcropping feldspar mica-gneiss, which contains disseminated magnetite, which in places is sufficiently concentrated to be termed iron formation.

OMZ4b, varies from the last mainly because the anomalies are more intense (1500-3000 nT) and trend more generally east-west. The northern, western and eastern boundaries appear to be sheared or faulted.

OMZ4c, a small subdivision, has a conspicuous circular shape as does the magnetic layering within it. Its southwestern edge has been downfaulted by the MacDonald Fault. Anomalies are generally less intense, being 750-1000 nT. The Radium Hill orebody lies within this subdivision.

OMZ4d, a magnetic subdivision is apparently a 'block' of similar material oriented in a northeasterly direction. It is pervaded with fractures and surrounded by shears suggesting more tension, perhaps related to relative movement between the Olary and Broken Hill Blocks. The anomalies have amplitudes generally around 1000 nT, but reach 2000 nT. At the southwestern end is a non-magnetic circular feature, surrounded by a strongly magnetic rim due to a small basin of Adelaidean sediments. Its location is apparently due to the intersection of several major fractures.

OMZ4e, whilst is also strongly magnetic (400-1000 nT), unlike the others it has a very low background level. The magnetic data may be explained by a region of granitic gneiss, but certainly the gravity data do not indicate an area of granitic intrusion.

Although not well understood, the area is in a structurally critical region, being at the approximate intersection of the Fitzroy-Spencer fracture zone and the Thackaringa-Pinnacles shear zone.

OMZ5a,b,c; in the extreme southwestern corner of the OMZ represent the Weekeroo Inlier. They form in microcosm a structural picture of the Olary Block.

The aeromagnetic data shows that each has a different character, although individually they are consistent with the mapped geology. This agrees with Pitt's (1980) comments on the general structure of the Olary Block (Section 2).

The most marked difference between them is the much higher magnetic background level of OMZ5c relative to the other two.

OMZ5d,e,f; are considered together because of their similar magnetic signatures. Each is elongated east-west and offset by a series of north-south faults subparallel to the western end of the Olary Block. Most anomalies peak at ~2000 nT and their size and shape are well within the range for Willyama Complex ironstones and calc-silicates. It is not clear whether the subdivisions represent a repeated sequence or not.

OMZ5 g,h; are moderately magnetic, but have a low background level. Comparison with the mapped geology shows a good correlation with large granitic areas which are surface expressions of the source of gravity anomaly A1.

The magnetic anomalies within these subzones are generally less than 1000 nT, being commonly ~500 nT. Small anomalous areas in excess of 1000 nT are probably due to migmatoid variants or small inliers of metasediments. As the gravity indicates a large continuous granitic body here, it appears that subdivisions OMZ5d,e,f represent Willyama Complex metasediments which overlie granitic material similar to that exposed in OMZ5g,h.

4.4.2 BMZ Subdivision

The BMZ is divided into two subzones (along an interpreted north-south fault), each of which is subsequently subdivided. Boundary trends have a strong north-south element which is not prevalent elsewhere.

BMZ1, occupying the western half of the BMZ, is characterised by moderately deep (300-700 m), subequidimensional anomalies.

BMZ1b, which bisects BMZ1 is non-magnetic and appears to delineate a small sedimentary basin. It does not reflect in the reconnaissance Bouguer gravity contours, but a gravity traverse across this feature (Nelson, 1973) showed a -30 μGalileo anomaly. Although explained as a thickening of Tertiary sediments, the non-magnetic nature of the underlying rocks suggests that both Cambrian and Adelaidean sediments may also be present.

BMZ1a,c; are due to similar source rocks. Drilling by Mines Administration on EL's 722 and 522 (M.I.Q. 23) bottomed in Middle Proterozoic volcanics.

Northwest trending dislocations separate the subequidimensional anomalies in the north, from narrow, elongate north-northeast anomalies. These may be remnants of a system of feeder dykes similar to the Gairdner Dyke Swarm on the Stuart Shelf.

BMZ2, occupies the eastern half of the BMZ, has shallower sources and is characterised in general by more elongate anomalies.

BMZ2a, is characterised by a series of near surface anomalies ranging in amplitude from 100-500 nT. In the southern part, anomalies are elongate (up to 20 km), contorted and trend generally north to northeast. In the north they are shallow, rounded features.

The subzone lies within a probable northeast fracture zone, a good locus for the intrusive bodies indicated by igneous activity as suggested from the aeromagnetic data. Some ironstones may be present in the southern part.

BMZ2b, lies in the northeastern extension of the same fracture zone as BMZ2a, is also characterised by small circular anomalies and is due to volcanic intrusions or extrusions.

The northern fracture zone controlling both BMZ 2a, and b is thought to be a crustal feature, as it downthrows 4 km north.

BMZ2c, a north-south subdivision contains three major elongate anomalies, overprinted by many small circular ones. The three large anomalies are interpreted as iron-rich sources, which have been folded and faulted. The southernmost anomaly is fractured by an E-W fault. Narrow, elongate negative anomalies in the region support this concept.

Data over the major anomaly were downward continued in an attempt to discriminate sources through amplitude comparison. An amplitude of 4000 nT was obtained which is in the overlapping zone between Willyama Complex and Adelaidean ironstones (Figure 16). The downward continuation did, however, resolve this anomaly into several narrow features, but further studies on adjacent lines may confirm these as valid banding.

The small circular features in the zone are mainly associated with the northern of the three major anomalies. Some may be intrusions, but their intimate association with the major anomaly suggests the same source, perhaps dislocated by local fracturing. Alternatively these responses may coincide with banded iron formation.

BMZ2d, consists of three features. The northernmost is a tightly folded ironstone with a northeast fold axis, which may reflect the fold deformation D3 within the basement, (Berry et al, 1978).

An outcrop near Benagerie H.S. is thought to be Willyama Complex, which agrees with the interpretation source, of an anomaly with an amplitude of 2900 nT. This anomaly is terminated in the south by an east-west fault. South of this, is a circular non-magnetic zone surrounded by a semicircular anomaly, interpreted as a granite intrusion with an associated aureole.

This feature is within gravity anomaly A4, (Section 3.3.2.3), and occurs in the southern part of the gravity anomaly, but is smaller than the gravity zone. This feature is interpreted as a deep seated granitic body and has intruded the Willyama Complex locally as resolved by the magnetic data.

To the southeast there is a large strongly magnetic area composed of several subcircular anomalies. Willyama Complex pelitic schists outcrop immediately northeast of this feature at Mooleulooloo. The anomaly is probably due to folded ironstones and calc-silicates as at Kalabity to the southwest, although deeper.

BMZ2e, an elongate non-magnetic subdivision lies between the BMZ2c and 2d and strongly resembles the BMZ1b. A gravity traverse is necessary to test this subdivision for the presence of Cambrian or Adelaidean sediments.

4.5 CURNAMONA Depth to Magnetic Basement Map

4.5.1 Data

Where available, data were used from low level detailed surveys flown by private companies and the South Australian Department of Mines and Energy. Where low level data were unavailable, charts of the original CURNAMONA survey flown in 1962 by the Bureau of Mineral Resources were used.

The detailed airborne surveys are tabulated below.

Low Level Surveys	Flight height (A.G.L.)	Company
Lake Charles	100 m	Geoex Pty. Ltd. for S.A.D.M.E.
Benagerie	100 m	"
Telechie	100 m	"
Mingary	110 m	"
Plumbago-Glenorchy	90 m	"
Olary 'A'	60 m	Esso Australia Ltd.
Olary 'B'	60 m	"
Kalabity	60 m	Carpentaria Exploration Co. Ltd. Pty.
Crocker's Well	90 m	Pacminex Pty. Ltd.

Of the low level surveys, only those flown for the South Australian Department of Mines and Energy were readily available. The original data of the Olary 'A' and 'B' surveys had been lost, but as they covered outcropping basement, a depth of around 50 m was assumed, being compatible with average depths (to which magnetic material is weathered), obtained in the adjacent outcropping Outalpa area. The data from the Kalabity and Crocker's Well surveys, although available, were recorded in a coded digital form on sensitised paper making them both difficult and time consuming to examine. As the Kalabity survey covers an area of predominantly outcropping basement, a depth of 50 m was again assumed. To circumvent the decoding process on the Crocker's Well survey, the original Bureau of Mineral Resources wider spaced data were used.

4.5.2 Depth Determination Methods

The straight slope method and Peter's rule were used on all anomalies, with the method of Tafeev (1950) being employed on a few selected anomalies. This map is intended only as a guide to areas of potential interest and further work will require detailed depth determinations, dip and susceptibility calculations.

The horizontal scale of the profiles used was generally 1:100 000, and in areas of shallow basement, straight slope horizontal distances were commonly of the order of 1 mm. In this case, errors due to pencil thickness were similar in order to the depth of the causative bodies, and hence exceed the error inherent in the depth estimate methods used. Thus depth estimates of less than 100 m must be treated with caution.

4.5.3 Contouring

Two major problems complicated the process of contouring; those of data density and multiple magnetic horizons.

It can be seen from the total intensity contour map that in areas of shallow basement there are many more anomalies available for interpretation than in areas of deep basement. This leads to a bias in contouring due to data density variations.

The problem of multiple magnetic horizons at different stratigraphic levels is of fundamental importance as the depth to magnetic basement map is based on the assumption that only one surface, the basement - cover interface, is being contoured. A consideration of the stratigraphic succession in the Olary area reveals two strongly magnetic horizons lying stratigraphically above the Willyama basement; Middle Proterozoic volcanics and the Benda Siltstone. As the intention was to delineate areas of subsurface Willyama Complex, anomalies known to be associated with other sources were ignored. For this reason, the area along the northern edge of CURNAMONA was not included, as it is underlain by Middle Proterozoic volcanics. At the time of compilation of this map, the western side of the Benagerie Ridge was thought to be Willyama Complex, but recent drilling by Mines Administration (M.I.Q. No. 23) has intersected volcanics.

The depth to magnetic basement map (Figure 18) shows clearly the Arrowie Basin deepening to the northwest and the Benagerie Ridge central to the area. The Ridge is divided laterally and vertically into two zones separated by a trough-like feature apparently associated with the Namba Palaeochannel. The northwest trend of the MacDonald Fault is also revealed in the contour pattern. The depth to magnetic basement map was used as a structural basis for the CURNAMONA tectonic sketch (Figure 19).

5. EXPLORATION TARGET AREAS

5.1 Uranium

Tertiary Uranium

Exploration for sedimentary uranium deposits in the Lake Frome region began in the late 1960's following earlier uranium exploration in the surrounding Proterozoic crystalline rocks of the Mt. Painter Province to the northwest, and Willyama Complex to the south. Initial exploration east of Mt. Painter led to the discovery of the Beverley Deposit in 1969. Early work in the southern Lake Frome region located the Lower Tertiary, Yarramba Palaeochannel within which the East Kalkaroo Deposit was found in 1971, and the Honeymoon Deposit in 1972. In 1979 the Curnamona and Billeroo Palaeochannels were located, within which the Gould's Dam Deposit was located.

In the Frome Embayment, which is surrounded by basement outcrops, sources of primary uranium, such as Mt. Painter, Radium Hill and Crocker's Well are readily located by airborne radiometric surveys, regional mapping, geochemical sampling or track-etch surveys. As source rocks are known to exist, the exploration problem reduces to one of paleodrainage delineation, for which various regional methods such as pattern drilling (Rudd, 1970), LANDSAT 1 imagery and barometric elevation contours (Barnes and Pitt, 1976) have been used. Geophysical methods such as gravity, electrical resistivity and magnetics (Nelson, 1971) have been used for more detailed work. Once a channel has been located its direction of flow is easily followed by shallow drilling.

If, however, the area is totally covered, a different approach to source rock location is necessary. In the Olary Block, primary uranium is found only within the crystalline formations and is believed to be related to the granitisation of large portions of the Willyama Complex metasedimentary series. Most radioactive deposits are concentrated within the migmatitic rocks at the border zones of the principal granite masses (Campana and King, 1958). Thus, if granitic masses can be located within an area, it is a potential uranium bearing area. Where cover prohibits the use of radiometric surveys and reconnaissance geological mapping, the gravity and magnetic methods are ideal.

Granitic rocks give rise to a characteristic gravity low in the Olary region (Figure 7, zones A1, A2, A3, A4), whereas they are variably magnetic (Figures 16, 17, zones OMZ5g,h, OMZ3b, BMZ2d), although their generally equidimensional shape is useful in identification. Having located a granitoid, it should be tested for radioactivity, especially the surrounding metasediments. The Yarramba Palaeochannel lies directly between the two interpreted granite centres of gravity zone A3. This may suggest that in the Tertiary, the granites formed hills with the channel flowing in the valley between, being fed by runoff from these granitic soruces and other surrounding hills. On reaching the eastern margin of the interpreted Adelaidean basin (the K.M.Z), the channel turned southwest and flowed along a probable low palaeoscarp, turning north again along the centre of the KMZ. An interpreted reconstruction of the palaeogeography is shown in Figure 15.

The Billeroo and Curnamona Palaeochannels lie along the eastern and northern margins of the large granitic mass reflected in gravity zone A1. The situation here is different from the Yarramba Palaeochannel in that the Curnamona Palaeochannel flows along a magnetic/gravity lineament which was probably well north of the basement outcrop at the time. This may account for the fact that it is unmineralised. The Billeroo Palaeochannel, however, had its headwaters draining directly from the Crocker's Well area, and skirted the eastern edge of this granitic terrain. Mineralisation at the Gould's Dam prospect is most probably from this source.

The third major palaeochannel in the area, the Namba Palaeochannel, shows no clear relationship to source rocks although weak mineralisation exists. The magnetic basement depth map shows the Namba Palaeochannel coincides with a narrow depression in the basement rocks, which begins near the margin of an interpreted granite (gravity zone A4). If this granite were the source of the mineralisation in the Namba Palaeochannel, the surrounding magnetic rocks should be tested for a primary source, and the basement channel should be tested for validity and southern extensions.

5.2 B.I.F. Related Mineralization

Base metals associated with iron formations are well known in the Olary Block. A good example is the Dome Rock area. Whilst much of the area has been explored in this respect, several areas of potential remain. The OMZ1,3 and 4 represent areas of strong ironstone development. Willyama Complex rocks outcrop in the south of OMZ1 and disappear beneath a slowly thickening cover sequence to the north, whilst the OMZ4 is subcropping over much of its area, and the OMZ3 has a shallow veneer of cover over Willyma Complex rocks. The aeromagnetic data are again useful in identifying crosscutting fractures which may form loci for deposition. Certainly they have controlled the emplacement of large granitic masses which are possible sources of hydrothermal activity.

5.3 Olympic Dam type Mineralization

The similar tectonic setting of the Stuart Shelf and eastern extension of the Arrowie Basin across the Curnamona Nucleus have long been known. Drilling in both areas has confirmed sequences of Cambrian and Adelaidean sediments overlying Middle Proterozoic volcanics. Until more is known about the Olympic Dam ore body and its genesis, the Curnamona Nucleus presents an alternative target area. Careful consideration should be given to the geophysical data north of the Olary Block, as this area has a very real potential for this type of mineralization.

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RAGerdes for

A. MILLS

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APPENDIX A

PETROPHYSICAL INFORMATION

APPENDIX A - PETROPHYSICAL INFORMATION

Tucker and Brown (1973) discussed the density of rocks important to the survey area under three tectonic classifications: Adelaidean sediments, metamorphic basement rocks, and intrusions into Adelaidean sediments. Densities were derived from direct S.G. measurements from drill core, and from indirect methods such as density profiles and seismic P wave velocities. No densities derived from seismic P wave data are quoted here. Data in this Appendix are quoted directly from their work.

Tables A5-A10 list specific gravity and magnetic susceptibility measurements from a variety of sources.

Rock Types

Adelaidean Sediments. For their study they considered Adelaidean sediments as four types:-

1. Carbonates (dolomite, limestones and intermediate members);
2. Siltstones and calcareous siltstones;
3. Shales (argillaceous rocks);
4. Quartzites (includes siliceous tillites).

The sediments of Cambrian age in the Adelaide Geosyncline can be similarly classified except that tillites are absent.

Metamorphic Basement Rocks. In the Olary area these rocks are from the Willyama Complex and are considered in two groups:

1. Metasediments (including schists, quartzites, sandy metasediments, dolomites, gneisses and iron formations);
2. Extrusive and intrusive acid igneous and related rocks.

Intrusions into Adelaidean Sediments. For this report, only the Anabama Granite is considered.

Density of Adelaidean Sediments

Direct. Measurements on 121 hand specimens are tabulated (Table A1) and plotted as density histograms (Fig. A1). Because Adelaidean sediments of different lithologies are essentially 'mixed' by the folding in the Adelaide Geosyncline, they are considered to correspond to a single geological unit for the interpretation of regional Bouguer gravity. An estimate of the average density of this composite unit is calculated by weighting the densities of each lithological unit according to its proportionate thickness in the section (Table A2).

Indirect. Topographic lines were drawn on 13 east-west lines crossing COPLEY, PARACHILNA, ORROROO, OLARY, CURNAMONA and FROME. Bouguer gravity profiles were calculated for each line using densities in the range 2.0 to 3.0 t/m^3 (not shown in this report). The correlation was studied and the Bouguer density appropriate to each profile determined (Table A3). Only the lines relevant to this report are considered here. An average of the density estimates is 2.68 t/m^3 compared with 2.73 t/m^3 calculated by Tucker and Brown for the entire area of their report.

The density histograms (Fig. A1) all show a wide scatter of values indicative of variations in the composition and the condition of weathering of the samples. The low density tails of siltstones and shales are attributed to higher porosity for those samples.

Density of Metamorphic Basement Complexes

Direct. Measurements on 23 specimens from 10 core holes in the Broken Hill area are the only data available for the Willyama Block and are tabulated below in Table A4.

Density of Intrusions

Direct. Measurements were made by Tucker on 194 samples of core from 3 drill holes into the Anabama Granite. Density logs are shown on Fig. A2. The linear increase of density with depth implies that the true density of unweathered granite approaches 2.70 t/m^3.

Conclusions

Because measurements on the Gawler Range Volcanics gave an average density of 2.55 t/m^3 the lower density limit of the basement complexes was set at that value. An upper limit is difficult to establish because there are so few data available. There is a general conformity of densities of various metamorphic lithologies with those established by Smithson (1971). Therefore it is considered likely that this upper limit of 2.79 t/m^3 for metamorphic terrains applies to the metamorphic complexes in the area.

Individual lithologies within the Adelaidean sediments have average densities which differ by up to 0.16 t/m^3. Therefore it is to be expected that detailed gravity surveys will allow some of the mapped formations (often essentially of a single lithology of 1000 m thickness) to be traced below the surface.

Because the average density of the Adelaidean sediments lies within the range of densities for the metamorphic basement, the Bouguer anomaly field cannot be directly interpreted to reflect depth to Willyama Complex basement.

From the data discussed in this chapter, the average true densities of the three important rock groups probably lie within the following limits:

Granitic intrusions	2.65 to 2.70 t/m^3
Adelaidean sediments	2.68 to 2.73 t/m^3
Metamorphic basement	2.55 to 2.79 t/m^3

(Table A1)

DENSITY OF ADEALIDEAN HAND SPECIMENS

Lithology	No. of samples	Dry Density Mean (t/m^3)	Standard Deviation	Range (t/m^3)	Dry Density Mode (t/m^3)	Estimated 80% Confidence Limit (t/m^3)
Carbonates	21	2.76	.07	2.65-2.88	2.78	2.68-2.85
Siltstones & Calcareous Siltstones	47	2.63	.12	2.31-2.82	2.72	2.6-2.8
Shales	38	2.58	.15	2.18-2.81	2.68	2.6-2.8
Quartzites	15	2.63	.05	2.54-2.72	2.62	2.55-2.70

(Source: Tucker and Brown, 1973)

(Table A2)

AVERAGE DENSITY OF THE ADELAIDE UNIT

Lithology	Estimated % of Section	Dry Density Mode (t/m^3)
Carbonates	7.5	2.78
Siltstones & Calcareous Siltstones	39.0	2.72
Shales	9.5	2.68
Quartzites	44.0	2.62
	Average Density	2.68 t/m^3

(Source: Tucker and Brown, 1973)

(Table A3)

DENSITY ESTIMATES FROM DENSITY PROFILES

Profile Latitude	Density
31°29'	2.7
31°45'	2.6
32°0'	2.6
32°16'	2.8
32°31'	n.e.
32°47'	n.e.
32°58'	n.e.

Mean density = 2.68 t/m^3

n.e. = no estimate made because of low topography or influence from granites.

(Source: Tucker and Brown, 1973)

(Table A4)

DENSITY ESTIMATES FOR WILLYAMA BLOCK

Rock Type	n	Broken Hill South Results (t/m^3)	SD	Range
Garnet rich biotite & sericite schists & gneisses	14	2.88	.14	2.67-3.15
Biotite & sericite schists & gneisses	9	2.71	.03	2.66-2.77

(Table A5)

S.G. data

Anabama Granite

DDH	No. of Samples	Range	S.G. mean	Standard devn.
AN1	37	2.29-2.79	2.65	0.0943
AN2	89	2.52-3.23	2.66	0.0883
AN3	43	2.41-2.85	2.61	0.0927

Data from Tucker, D., 1972. Ph.D. Thesis University of Adelaide (unpublished). Drilling by Asarco.

S.G. Logs for AN1, 2 & 3 are in the B.M.R. report by Tucker, plan SA/B2-15A.

(Table A6)

Braemar Iron Formation

Population	No. of Samples	range	S.G. mean	S.D.	95% confidence limit
Above 30 m	61	3.2-4.2	3.56	0.168	3.39-3.72
tillitic *I.F(A)	55	2.9-3.3	3.12	0.132	3.09-3.25
bedded* I.F(B)	20	3.8-5.0	4.095	0.250	3.85-4.34

Data taken at 5' intervals from Razorback Range DD hole no.'s RB1, 2 & 3, (Gerdes, 197

*Iron Formation

(Table A7)

Kanmantoo Group

No. of Samples	Range	S.G. mean	S.D.	95% confidence level
178	1.85-3.66	2.87	0.24	2.34-3.32

S.G.'s 2.5 are considered to be non-pyritic members of Nairne pyrite member.

Data from S.A.D.M.E. (1966) D.D. R.D. 11, 12, 13, & 15.

	dry bulk	app. grain
m/m's of K.G. in B.M.R. (1964) D.D. Berri South 1:	2.77	2.78
metagreywacke, W.R.C. Beach Pet. N.L. (1967) Berri North 1:	2.68	2.68

(Source: Gerdes, 1973)

(Table A8)

Magnetic Susceptibility Data

Braemar Iron Formation

Popn.	No. of samples	range ($\times 10^{-3}$ cgs units)	mean ($\times 10^{-3}$ cgs units)	S.D.	95% c.l.
A	58	0-26	8.24	4.09	4.05-12.22
B	6	34-54	43.64	3.64	39.70-46.97
also B	3	132,240,240	(79.0)	(33.86) + total.	

from RD1, 2, & 3.

31/67 were non-magnetic.

(Source: Gerdes, 1973)

(Table A9)

Kanmantoo Group - Nairne Pyrite Member

Rock type	No. of samples	($x10^{-3}$ cgs units) range	mean	S.D.	95% c.l.
overall amphibolite	24	0-2.54	0.60	0.38	0.216-0.98
granofels amphibolite	8	0.69-2.54	1.59	0.26	1.34 -1.85
amphibolite	15	0-2.96	0.109	0.05	0.06 -0.16
schist	27	0.06-1.27	0.59	0.18	0.41 -0.77
gneiss metasilts.	33	0-1.05	0.36	0.13	0.23 -0.49
gneiss with zeros	56	0-1.67	0.30	0.22	0.08 -0.53
gneiss with zeros	26	0.19-1.67	0.66	0.22	0.43 -0.88

data from DDH11, 12, 13, 15.

(Source: Gerdes, 1973)

(Table A10)

Anabama Granite

No. of samples	range	($x10^{-3}$ cgs units) mean	S.D.	95% c.l.
18	0-12.24	4.84	3.77	1.06-8.61

Data from Asarco DDH AN1, 2, 3.

Acid volcanics/rhyolite of Lower Cambrian or Ordovician.

range	mean	S.D.	
0.03-0.87	0.31	0.40	data from samples P235/70, P243/70, & P250/70 collected by B. Forbes

(Source: Gerdes, 1973)

APPENDIX B

PETROLOGICAL INFORMATION

SAMPLE IDENTIFICATION: P1252/76
PS24854
6933001RS00054

Location:
5.8 km on true bearing 079° from Old Boolcoomata Homestead. 'Iron formation' forming poor outcrop near Blue Dam.

Hand Specimen:
A porous, moderately fine-grained quartzitic rock heavily stained by dark red and brown iron oxides and containing numerous small vein-like patches of limonitic material. There is indistinct evidence of layering which appears to have been largely obscured by fracturing and deposition of limonitic material. One weathered surface is encrusted with a rather porous mass of black manganese oxide and there are some colloform masses containing ochrous goethite, brown goethite and manganese oxide. There are also traces of white clay, probably kaolin.

Polished Section:
This is through the body of the rock and shows mainly a mosaic of quartz grains with scattered voids from which another, more soluble mineral has been leached.

The rock contains scattered grains or crystals which have been replaced by varying proportions of fine-grained hematite and goethite and a few of these show external shapes suggesting a cubic mineral and some suggestion of concentric structure in the replacing hematite and goethite, similar to that commonly found in oxidized pyrite. The largest of these 'crystals' has a shape suggesting a pyritohedron and it is almost certain that some of these crystals or grains were of pyrite. There are also some grains which have been replaced entirely by a slightly porous mass of very fine-grained hematite which, between crossed nicols, shows some suggestion of an octahedral pattern similar to that found in oxidized magnetite (martite).

Films of hematite and goethite occur along main grain boundaries in the quartz mosaic and small fractures in the rock have also been filled by varying proportions of hematite and goethite.

No evidence of boxworks after other minerals was found in the polished section and, in the area sectioned there is none of the manganese oxide which occurs mainly on the weathered surface.

Inferred Origin:
Probably a sediment but this cannot be determined with certainty from the polished section.

Metamorphic History:
This cannot be determined from the polished section.

Rock Type:

Probably a quartzite containing minor amounts of oxidized magnetite and traces of oxidized pyrite.

Geochemistry:

Analytical results in ppm are as follows:

Co 150, Ni 5, Mo 50, Mn >1%, Cu 200, Pb 800, Zn 300, Ag 50, Ba 1500, P_2O_5 <0.5, Au 0.20.

This sample contains anomalous values of several heavy metals and an interesting 50 ppm of silver. However, it also contains greater than 1% of manganese oxide which is sufficient to have scavenged these heavy minerals.

This particular samples does not appear to have contained sulphide minerals other than a trace of pyrite and it is suggested that the anomalous metal values are probably in the manganese oxide. It remains a matter for speculation as to the origin of these trace amounts of heavy metals which have probably been collected and transported by the manganese oxide.

SAMPLE IDENTIFICATION: P1201/76
TS35732
PS24851
6933001RS00003

Location:
0.7 km on true bearing 075° from Meningie Well. Iron formation only 0.5 to 1 m thick. Calc-silicate layers occur 100 to 200 m along strike.

Hand Specimen:
A finely-banded iron formation containing layers and thin laminations up to 2 mm thick, alternating with very thin layers composed mainly of brown goethite and quartz. Although most of the layering is straight and parallel there is locally some evidence of wavy bedding.

Mineral Assemblages:

	%
Quartz	40-50
Hematite (oxidized magnetite)	50-60
Goethite	3-5
Garnet	Trace
Remnant silicate	Minute Trace
Altered and leached, unidentified mineral	Trace
Iron phosphate mineral	Trace
Remnant magnetite	V. minute trace
Pyrite inclusion in quartz	V. minute trace

Grain Size:
Former magnetite, 0.02 to 0.2 mm, with very few larger crystals to 0.5 mm. Quartz, 0.05 to 0.2 mm.

Special Features:
The iron oxide-rich laminae were formerly composed mainly of a mosaic of integrown magnetite crystals with minor amounts of interstitial silicate? and quartz. The magnetite has been almost completely replaced by hematite but the external shape of the former magnetite crystals has been clearly preserved and, in very few crystals there are very small remnants of unoxidized magnetite. Some of the minerals intergrown with the former magnetite have been replaced by goethite.

The paler-coloured laminae or layers contain quartz and varying concentrations of oxidized magnetite, some of which occurs as separate 'crystals' and some as elongate aggregates parallel to the banding. These layers also contain higher concentrations of goethite, some of which shows poorly-preserved, relict textures, suggesting that it may have replaced a prismatic silicate. Most of it, however, shows no definite evidence of relict textures. There are trace amounts of garnet occurring as very irregularly-shaped and porous, fine-grained aggregates or possibly partly altered and leached grains.

In a few places there are trace amounts of a secondary mineral with strong pleochroism in greenish-blue to greyish-violet, moderate birefringence and strong dispersion. This is possibly an iron phosphate mineral but probably there is insufficient to confirm its identity, however, if necessary, X-ray diffraction could be tried on material from the area where it is most abundant.

Much of the quartz in the thin section shows textures suggesting that it is secondary and that it has replaced pre-existing minerals including a prismatic silicate? much of which has also been partly replaced by goethite. This suggests that the history of this rock has probably been rather complex and other minerals, including silicate, may formerly have been more abundant.

It is cut by small veins containing slightly stained, very fine-grained quartz, grading to coarser-grained quartz in the interior of the vein. Some of this quartz also contains small shreds or remnants of a fibrous mineral which may once have been more abundant.

A minute trace of pyrite was found included in very few of the quartz grains.

Inferred Origin:
Iron-rich sediment, probably formed by chemical precipitation but its exact origin remains obscure.

Metamorphic History:
The presence of some garnet remnants and of relict textures indicating the former presence of elongate or prismatic silicate minerals suggests that, at one time, the rock was subjected to at least medium-grade metamorphism but the silicate mineral has been replaced by goethite and also partly by quartz and therefore its identity cannot be determined.

Rock Type:
Banded iron formation (not Lake Superior-type) which formerly contained abundant magnetite and probably moderately-abundant silicate as well as some quartz. The presence of a little secondary iron phosphate suggests that it may once also have contained apatite.

Note: A microchemical test for phosphate gave a positive result.

Geochemistry:
The results of analysis expressed as parts per million are as follows:-

Co 80, Ni 50, Mo 20, Mn 300, Cu 400, Pb 30, Zn 400, Ag 0.1, Ba -, P_2O_5 <0.5, Au 0.20.

Copper and zinc are slightly anomalous and may indicate traces of chalcopyrite and sphalerite in unoxidized zones of this iron formation.

SAMPLE IDENTIFICATION: P1919/75
TS34736
PS24280
6933001RS00083

Photo Reference and Location:

Outalpa Enlargement 6/007/20a. 1.6 km true bearing 220.5° from Olary Silver Mine. Reported to be layered rock "bedded beside the extension of the Olary Silver Mine Iron Formation".

Hand Specimen:

A moderately fine-grained rock in which parallel but slightly wavy layers 2 to 6 mm thick are defined by variations in grey, white and slightly pink colours. At one end of the sample there is a larger, lenticular body of quartz.

Mineral Assemblage:

	%
Quartz	50-60
Apatite	20-25
Muscovite/sericite	10-15
Biotite	trace
Opaque minerals	2-3
Goethite	3-5
Graphite	1-2
Galena (inclusions)	minute trace
Pyrite (inclusions)	minute trace

Grain Size:

Mainly 0.1 to 0.6 mm with finer grained muscovite.

Special Features:

The most unusual feature is the presence of abundant apatite concentrated along layers up to 2 mm thick. A few thin layers are composed almost entirely of apatite but slightly thicker layers contain over 60% apatite intergrown with quartz. Apatite is also dispersed in lesser concentrations through quartz-rich layers. In general the layers are moderately well defined but some tend to swell and pinch, and locally there are lenticular patches of quartz.

Fine-grained muscovite is distributed unevenly through the rock and it occurs in irregular and elongate patches many of which are oriented subparallel to the layering and to a direction of weak foliation. Much of the muscovite in these elongate aggregates however shows apparently random orientation and the general appearance suggests that this fine-grained muscovite has replaced a pre-existing mineral.

Fine-grained opaque material is distributed sporadically through the rock, occurring mainly in interstices between the transparent minerals and there is also an appreciable amount of translucent goethite, at least some of which may have replaced sulphide. Some small leached voids are also lined with goethite.

The polished section shows flakes of graphite up to 0.2 mm long concentrated along some layers. Most of these are parallel to the weak foliation.

All of the larger sulphide grains have been oxidized and show little evidence of relict textures other than one cubic pseudomorph but locally there are a few very small inclusions of galena in some non-opaque mineral grains. There are also a few inclusions of pyrite.

Inferred Origin:
A layered, siliceous sediment containing anomalous phosphate, probably some pelitic material, minor carbonaceous material and sulphide.

Metamorphic History:
Much of this remains obscure as the present mineral assemblage does not contain any significant metamorphic minerals. The general appearance of many of the aggregates of fine-grained muscovite suggests replacement of an earlier, possibly metamorphic mineral but there is no evidence from which to determine its identity. There is a weak foliation parallel to the sedimentary layering.

Rock Type:
Banded quartz-apatite-muscovite gneiss.

Note: Taken in conjunction with the reported, adjacent extension of the Olary Silver Mine Iron formation, could this be related to the magnetite-apatite Iron Formation of the Broken Hill Area?

SAMPLE IDENTIFICATION: P1019/74
TS31725
PS21814
6933001RS00174

Location:
1.2 km 035° Blue Dam

Rock Name:
Bedded quartz-hematite rock.

Hand Specimen:
This specimen is banded, the bands being between 1 mm to 1 cm thick, and composed essentially of either quartz or iron oxides/hydroxides. The grain size is 1 mm or less.

Thin Section and Polished Section:
An optical estimate of the constituents gave the following:

	%
hematite	10-20
magnetite	trace
chalcopyrite	trace
pyrite	trace
quartz	75-85
garnet	trace-1
apatite	1-2
amphibole	trace

The rock has a subidiomorphic granular texture and is composed principally of interlocked polygonal crystals of quartz and subidiomorphic grains and granular aggregates of hematite. Variations in the concentration of quartz and iron oxide define the banding. The grain size is very even with most crystals between 0.1 and 0.4 mm in diameter, and only rare bands where the grain size is coarser, with crystals up to 2 mm.

The hematite occurs as spongy; equant subidiomorphic grains and granular aggregates (probably martite). Rarely is it seen altered to goethite.

Small amounts of garnet are present and this mineral occurs typically as overgrowths on the hematite grains. It is a pale yellow-brown and not completely isotropic. Traces of a brown to yellowish amphibole also occur along the margins of some iron oxide grains.

Small apatite grains up to 0.05 mm in size are included in some of the quartz.

There are trace amounts of pyrite and chalcopyrite.

SAMPLE IDENTIFICATION: P1869/75
TS34629
6933001RS00109

Applicant's mark and location:
0.5 km north of Mt. Bull.

Hand Specimen:
A fine to medium-grained, grey rock composed predominantly of quartz and dark iron oxide with fine banding or laminations defined by varying concentrations of iron oxide. The rock tends to split along very few of the bedding planes and on the surface of one of these there is a small amount of a fine grained, micaceous mineral.

Mineral Assemblage:

	%
Quartz	60-65
Magnetite/martite	30-35
Apatite	5-10
Chlorite	Trace

Grain Size:
Quartz mainly 0.1-1 mm with a few to 2 mm. Iron oxide mainly 0.1 to 0.5 mm with a few to 1 mm. apatite 0.05-0.5 mm with a few larger.

Special Features:
Compositional layering is defined by variations in the concentration of iron oxide and to a lesser extent of apatite. The iron oxide occurs as isolated octahedral crystals and as irregular and slightly elongate aggregates of similar crystals and although some of these elongate aggregates are parallel to the bedding, others are at a high angle to this direction.

Apatite occurs mainly in the layers containing more abundant iron oxide and many of the larger apatite grains contain very small iron oxide grains and in a few apatite crystals these included iron oxide grains occur along poorly defined lines at a high angle to the direction of sedimentary layering.

Most of the quartz shows strain or undulose extinction between crossed nicols and the larger grains contain small inclusions of iron oxide crystals.

Traces of chlorite occur along grain boundaries in a few places and the section contains one patch of chlorite associated with a trace of muscovite and locally there is also a trace of partly altered biotite.

Some of the apatite grains are stained and partly altered and a few have been partly replaced by minor amounts of a yellow mineral with high birefringence which may be jarosite?

Inferred Origin:

This was probably derived from a chemically precipitated sediment but its exact nature is a matter for speculation.

Metamorphic History:

There ae no diagnostic minerals to accurately determine the grade of metamorphism but the presence of relatively coarse grained quartz and former magnetite suggest at least medium grade metamorphism.

The S_o surface is defined by the compositional layering and the presence of a few elongate aggregates of magnetite or martite at a high angle to this S_o surface may define an S_2 foliation, but there is insufficient evidence for this to be certain.

Rock Type:

Oxidized magnetite (martite)/apatite iron formation. The possibility that this may be related to, or correlated with the magnetite/apatite iron formation in the Broken Hill area should be considered.

SAMPLE IDENTIFICATION: P1087/75
TS33566
6933004RS00273

Outalpa 3/76/2. 2 km 45° Ameroo Hill.

Folded iron formation from the Peryhumuck Mine area.

Hand Specimen:

A medium to moderately coarse-grained rock composed of dark grey iron oxide intergrown with paler coloured minerals including some aggregates of prismatic amphibole crystals which have been extensively altered. There are also traces of yellow sulphide and of a pale blue to bluish-green secondary mineral which may be related to chrysocolla. the iron oxide has a dark red streak and is probably now mainly hematite although the crystal form suggests former magnetite.

Mineral Assemblage:

	%
Quartz	60-70
Oxidized magnetite	30-40
altered amphibole	3-5
Pyrite	trace
Jarosite?	trace

Apatite was detected in the hand specimen as a minor constituent and phosphate was confirmed microchemical tests. It was not found in the thin section.

Grain Size:

0.1-0.5 mm with a few up to 0.8 mm.

Special Features:

The rock is now composed predominantly of uneven mosaic of quartz grains which in places appear to have crystallized across earlier textures and include a few very small prismatic crystals of pale green amphibole. Some quartz also contains numerous small inclusions of iron oxide.

In coarser grained zones the quartz is intergrown with crystals and aggregates of opaque iron oxide and with varying amounts of prismatic amphibole crystals which have been replaced by turbid alteration products. The external shape and evidence of cleavage in these altered crystals have been well preserved but in general the mineral has been replaced by turbid almost isotropic material with a very low refractive index and some of it may be clay and/or chrysocolla associated with opaline silica.

The iron oxide varies in grain size and also in concentration but although the hand specimen shows moderately fine banding which has been folded this is not readily apparent in the thin section. There is however some evidence to suggest that larger grains or aggregates of iron oxide have been fractured and the portions displaced by movement after the iron oxide crystallized.

There is no definite evidence of apatite in the thin section although its presence was confirmed in separate material removed from the hand specimen and examined in refractive index liquids. the apatite is friable and partly leached and is associated with minor amounts of small globular or granular grains of another alteration product with a higher refractive index which could be a secondary phosphate mineral of undetermined identify.

Barite was not found in the thin section or hand specimen.

Inferred Origin:

Iron formation of sedimentary origin, possibly a chemically precipitated sediment.

Metamorphic History:

Except for the remnant traces of pale green amphibole there are no diagnostic minerals. The amphibole suggests metamorphism to the equivalent of upper greenschist facies but the presence of fractured and displaced grains or aggregates of iron oxide suggest a more complex history and there may have been more than one phase of metamorphism.

Rock Name:

Oxidized magnetite-quartz iron formation.

SAMPLE IDENTIFICATION: P1918/75
TS34735
6933004RS00082

Photo Reference and Location:
Outalpa Enlargement 3/177/16. 9.1 km on true bearing 142° from Bimbowrie H.S.

Hand Specimen:
A reddish-grey medium-grained gneissic rock containing scattered crystals and aggregates of dark iron oxide up to 3 mm in size and many of these larger crystals exposed on the surface are octahedral.

Mineral Assemblages:

	%
Quartz	50-55
Oxidized magnetite	25-30
Biotite	5-10
Chlorite	5-10
Muscovite	trace
Tourmaline	trace
Oxidized pyrite	1-2

Grain Size:
Very variable but mainly between 0.2 and 1 mm with some crystals up to 3 mm.

Special Features:
A weak foliation is defined by subparallel orientation of much of the biotite and chlorite which occurs as elongate streaks and aggregates and also as separate flakes intergrown with quartz. Some quartz also occurs as elongate and lenticular aggregates a few millimetres long parallel to the foliation.

The iron oxide is scattered unevenly through the rock but there is very little evidence of concentration along particular bands or layers. Some is closely intergrown with, or partly surrounded by biotite and chlorite and the general appearance suggests that some crystals and/or aggregates have been fractured and drawn out in the direction of foliation. Some elongate groups of small iron oxide crystals are now enclosed by quartz.

One bluish-green tourmaline grain was found in the section and its presence is significant in that it probably indicates that there was some clastic material in the original sediment.

Limonitic boxworks and pseudomorphs after former pyrite crystals are associated with, and partly surround some oxidized magnetite grains.

Inferred Origin:

A sediment probably containing some pelitic material and also an anomalous amount of iron. It does not resemble typical banded iron formation in either texture or composition.

Metamorphic History:

The presence of mineral assemblage indicates that the latest phase of metamorphism was probably equivalent to greenschist facies. It is possible that some of the aggregates of biotite and iron oxide may have replaced earlier metamorphic minerals but no definite textural evidence was found to confirm this and the full history must remain undetermined.

Rock Type:

Oxidized, quartz-magnetite-biotite gneiss with minor oxidized pyrite.

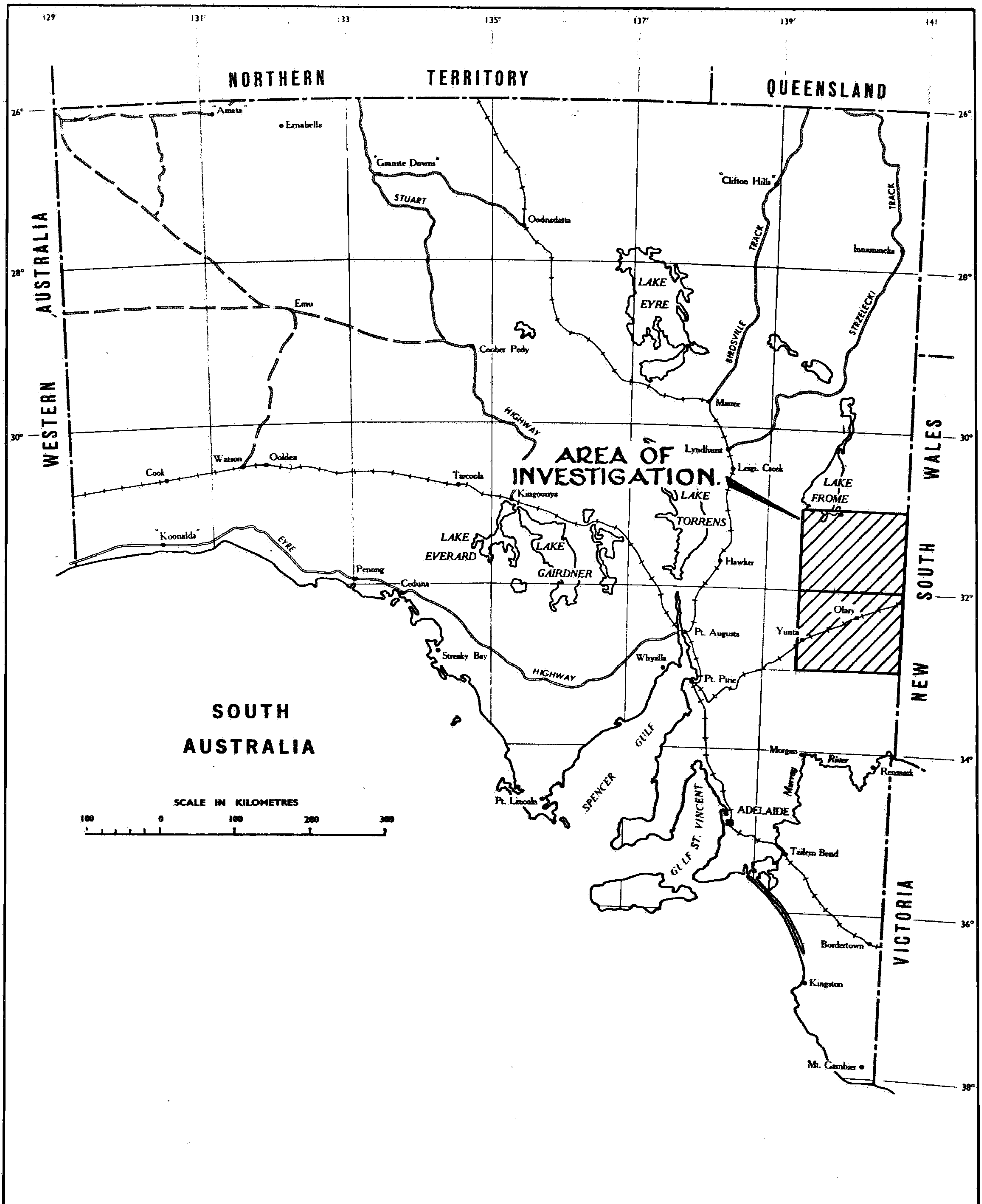


Fig. 1

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

Compiled. A. Mills	INTERPRETATION OF REGIONAL GEOPHYSICAL DATA	Date: Oct. 1980
Drn. M.R. Ckd.	OLARY REGION	Drg. No.
	LOCALITY PLAN	S 15147

2185

P.F. No 55850 994 2

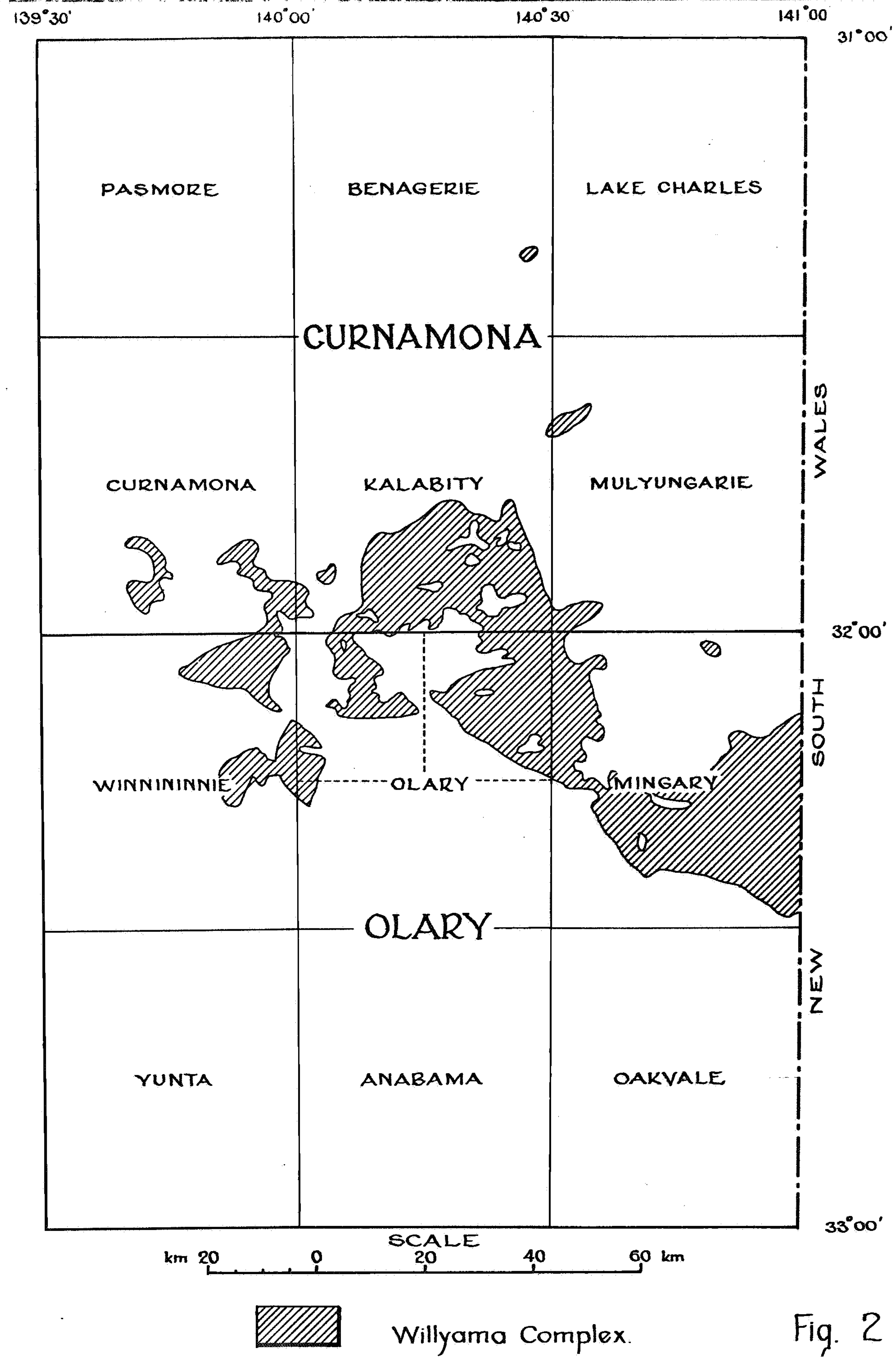


Fig. 2

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

INTERPRETATION OF REGIONAL GEOPHYSICAL DATA
OLARY REGION
EXTENT OF OUTCROPPING
WILLYAMA COMPLEX

COMPILED A. Mills	C.D.O 12 · 4 · 83 DATE
DRAWN M.R.	SCALE 1 : 1,000,000
DATE Oct. 1982	PLAN NUMBER
CHECKED	S 15148

2185

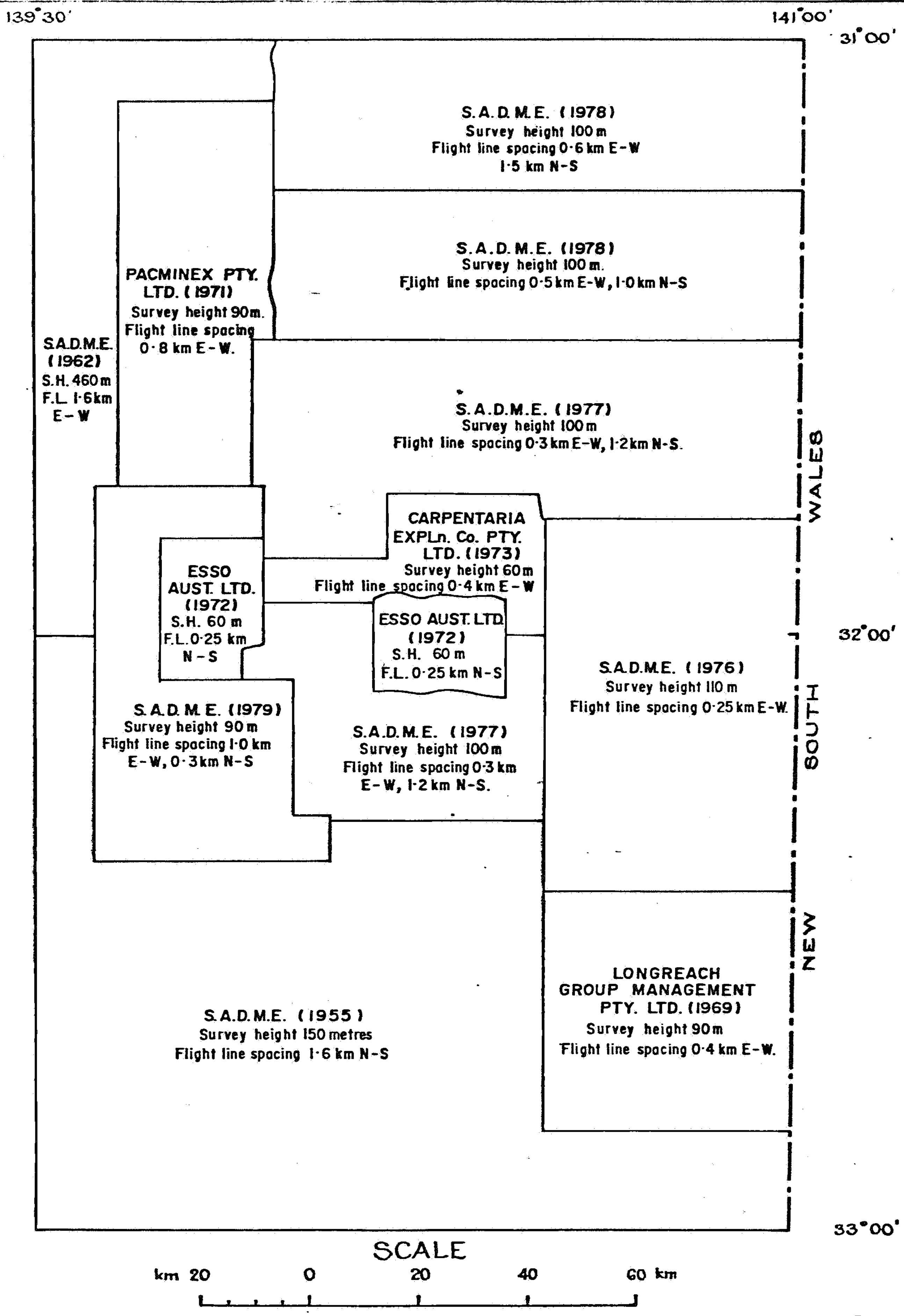


Fig. 3

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED A. Mills	C.D.O. 12-4-83 DATE
INTERPRETATION OF REGIONAL GEOPHYSICAL DATA	DRAWN M.R.	SCALE 1:1,000,000
OLARY REGION INDEX TO LOW LEVEL AEROMAGNETIC SURVEYS	DATE Oct. 1980 / CHECKED	PLAN NUMBER S 15149

2185

OUTALPA, BULLOO 1:50000

REFERENCE

QUATERNARY

SURFICIAL CAINOZOIC SEDIMENTS

Qhf — Flood plains fringing drainage lines, consisting of thin spreads of sand and clay overlying compacted gravelly and sandy clays of Qh unit.

Qh — Undifferentiated low-angle slope deposits and valley-fill plains of surficial clays sands and gravels overlying compacted red-brown sandy and gravelly clays representing a condensed sequence of POORAKA FORMATION, its equivalents and younger units.

Qha — Alluvial sands, clays and gravels of modern drainage channels

unconformity

PROTEROZOIC — LATE PROTEROZOIC (ADELAIDEAN)

ADELAIDEAN SYSTEM

ᵽuw — WILYERPA FORMATION: thick basal quartzite overlain by siltstone.

unconformity

STURTIAN — UMBERATANA GROUP

ᵽye — BENDA SILTSTONE: indurated metasiltstone with thin diamictic layers and interbedded quartzites; lenses of granite conglomerate. Thin, multiple horizons of BRAEMAR IRON FORMATION at the base: hematitic siltstone, often pebbly and associated with a characteristic grey, pebbly, micaceous dolomite.

ᵽyp3, ᵽyr — PUALCO TILLITE, Member 3: Diamictite with predominantly crystalline basement clasts in a greywache matrix. Thin interlayers BRAEMAR IRON FORMATION facies (Pyr) near top. Lenses of massive (granitic) boulder diamictite interfinger with Benda Siltstone in the MacDonald Corridor.

ᵽyp2 — Member 2: Massive, crossbedded quartzite

ᵽyp1 — Member 1. Pebble diamictite with a largely quartzitic matrix and clasts of Willyama Complex rocks and Burra Group quartzite, dolomite and (?) shale.

ᵽyo — OLD BOOLCOOMATA GRANITE CONGLOMERATE: granite-clast conglomerate, interpreted as a local talus derived from the Binberrie Granite, which it overlies unconformably, in faulted contact with all other Adelaidean units, stratigraphic position inferred by correlation to granite conglomerates in ᵽyp3 and lower ᵽye units

unconformity

TORRENSIAN — BURRA GROUP

ᵽb3 — (?) BELAIR SUBGROUP equivalent: interlayered quartzite and siltstone

ᵽb2 — (?) SADDLEWORTH FORMATION equivalent: predominantly greenish-grey siltstone.

ᵽb1 — (?) AUBURN DOLOMITE equivalent: interbedded dolomite and siltstone, a prominent quartzite bed ("Wiggly Quartzite") marking the top. SKILLOGALEE DOLOMITE: dolomitic marble, sedimentary magnesite and intraformational breccias, minor sandstone and siltstones. Host to galena veins at Vranes Prospect. ALDGATE SANDSTONE equivalent: basal conglomerate, overlying silty sandstones, greywackes.

MIDDLE PROTEROZOIC

WILLYAMA COMPLEX

ACID INTRUSIVES

ᵽγ — Undifferentiated granitoid bodies: granitic to granodioritic composition, and generally intrusive contact relationships

ᵽγ1 — ANTRO GRANITE, TRIANGLE HILL GRANITE (ᵽγ1): massive porphyritic adamellite to granite, commonly with aligned idiomorphic albite-mantled microcline phenocrysts up to 3cm long. Regarded as a single body disrupted by the MacDonald Fault

ᵽγ2-4 — Adamellitic to slightly granodioritic intrusive granitoids at Mooleugore Hill, Binberrie Hill (BINBERRIE GRANITE) and Tietz Dam (ᵽγ2): poorly foliated and generally non-porphyritic; all regarded as parts of the same intrusive body. Adamellitic to slightly granodioritic granitoids at Nine Mile Gate (ᵽγ3) and Blue Dam (ᵽγ4): poorly foliated, generally non-porphyritic

ᵽp — Pegmatoids: thin layer-parallel to discordant and/or podiform bodies. Primarily potassic or potassic-albitic varieties, with rare albitic types. Common accessories are tourmaline, and radio active minerals (e.g. orthite). A number of generations are present, but not distinguished

METAMORPHOSED BASIC IGNEOUS ROCKS

β — Undifferentiated hornblende-albite amphibolite: conformable bodies of igneous origin. Bodies south of "Old Boolcoomatta" and west of Ameroo Hill are possibly equivalent to β2

β1 — Discordant hornblende-albite metadolerite (amphibolite) dykes, original doleritic textures often preserved

β2 — WEEKEROO AMPHIBOLITE, DOUGHBOY AMPHIBOLITE: massive to breccious, predominantly hornblende-albite, semi-concordant to concordant amphibolites. Weekeroo body contains rare pillow structures and is interpreted as a probable subaqueous volcanic plug-extrusive complex of tholeiitic composition. Doughboy body occurs at approximately the same stratigraphic level and probably has a related origin

ALBITE-RICH, FOLIATED GRANITOIDS

ᵽWγ1 — Granodiorite gneiss, west of Meningie Well, also minor small gneissic granodiorite bodies

ᵽWγ2 — Lenticular, semiconcordant, magnetite-bearing adamellite and granodiorite at Perryhummuck Mine and Mt Mulga Drew Hill respectively, interpreted as the same body despite the apparent compositional difference.

ᵽWγ3 — Concordant to partly intrusive tonalite gneiss at Walparuta and Outalpa Springs, interpreted as the same body, disrupted by the Outalpa fault

EARLY PROTEROZOIC

METASEDIMENTS AND METAMORPHICS

"OLARY SEQUENCE"

Description	schistose equivalents	gneissic equivalents	Description	gneissic to migmatoid equivalents	Description
Undifferentiated quartz-mica-plagioclase schist, minor quartzite.	ᵽWs				
Pelitic quartz-muscovite schist, with very coarse andalusite generally retrogressed to massive pinite which encloses crystals of blue corundum	ᵽWs1	ᵽWg1	Not recorded		
Massive quartz-muscovite schist.	ᵽWs2	ᵽWg2	Not recorded	ᵽWc	Undifferentiated complex gneiss terrain incorporating and/or equivalent to other gneiss units
Interlayered quartz-muscovite schist and quartz-muscovite-plagioclase quartzite in which sedimentary structures are often well preserved	ᵽWs3 (e1-7, g)	ᵽWg3	Layered quartz-plagioclase-biotite gneiss, migmatoid in places	ᵽWg3	
Pelitic quartz-muscovite schist with tourmaline, staurolite, chloritoid and retrogressed andalusite and chiastolite porphyroblasts. Knotted aluminosilicate schist with tourmaline and garnet ("Ameroo Hill Schist"). Horizons of calc-silicate (e1-7, see below) near top and base, rarely within the unit; graphitic schist with chiastolite (ᵽWs4g) and stratiform gossan horizon (g) near top or in base of ᵽWs3 unit, in some areas.	ᵽWs4, ᵽWs4g (e1-7, g)	ᵽWg4	Pelitic gneiss, containing andalusite, sillimanite and, rarely, kyanite	ᵽWg4, ᵽWo, ᵽWc	Semipelitic migmatite gneiss with characteristic steel grey biotitic melanosome schlieren in a quartzo-feldspathic leucosomal matrix
Interlayered schist and (often highly albitic) quartzite	ᵽWs5 (e1-7)	ᵽWg5 (f, a, q)	Layered psammitic-pelitic gneiss with iron formation and related horizons (f1-3, a, q: see below, "MARKER BEDS").		
Massive homogeneous tonalite gneiss, conformable with adjacent schist sequence; probable non-mobilised equivalent of ᵽWγ3 (see Rock Relation Diagram), underlain by ᵽWc and ᵽWf units (see gneissic to migmatoid equivalents).	ᵽWg	ᵽWq (f, a, q)	Massive to layered, often reddish quartz-plagioclase-magnetite "quartzite", grading to leucocratic, granitic gneiss. Iron formation and, particularly, feldspathic variants thereof near top	ᵽWf (f, a, q)	Massive to thickly layered feldspar-rich and feldspar mica gneiss with a variable content of disseminated magnetite. Iron formations occur where magnetite content of gneiss is high. Lesser semipelitic to pelitic mica gneiss (ᵽWb lithology) present but not mapped individually, rare concordant gneissic amphibolites in some areas
	ᵽWc,f	ᵽWb	Coarse-grained semipelitic biotite gneiss, minor interlayered quartz-plagioclase gneiss.		

MARKER BEDS

g — Stratiform gossan horizon

e1-7 — Calc-silicate, calc-albitic albitic rocks
- e1: dark grey, fine grained laminated albite rock (hornstone of Campana and King, 1958), minor epidote, magnetite.
- e2: coarse-grained marble, often garnetiferous and/or containing disseminated or interlayered calc-silicate minerals.
- e3: stratiform breccias with albitic to albite-hornblende clasts in a predominantly hornblende matrix (e.g. Cathedral Rock).
- e4: stratiform breccias with both clasts (rounded) and matrix of quartz and albite with minor amphibole and iron oxides.
- e5: thin, evenly layered to laminated quartz-albite-epidote-hornblende rock.
- e6: "epidote quartzite" — medium grained, granoblastic-textured albite rock with lesser hornblende, epidote and quartz, and characteristic ptygmatic veins of hornblende.
- e7: coarse grained mono- or bi-mineralic rocks, e.g. quartz-actinolite, garnet-epidote or wollastonite-diopside.

f1-3, a, q — Iron formation, facies variants and related or equivalent horizons
- f: iron formation, undifferentiated.
- f1: magnetite-sulphide-quartz-albite (non-baritic) iron formation.
- f2: barite-quartz-magnetite iron formation.
- f3: tremolitic iron formation.
- a: grey, medium to fine grained albite rock ("orthoquartzite") with minor disseminated magnetite and sulphide
- q: quartz rock with minor disseminated sulphide and (?) magnetite.

NON-SEQUENCE GNEISS UNITS

ᵽWm — Layered migmatitic biotite gneiss, forming a contact zone around ᵽWγ3 and developed in ᵽWg5 and ᵽWs4

ᵽWx — Massive unlayered aplitic quartz-feldspar-biotite gneiss, probably near-anatectic.

ᵽWz — Granitic migmatite consisting of predominant quartzofeldspathic leucosome and lesser disseminated biotitic melanosome

GNEISS UNITS OF UNCERTAIN STRATIGRAPHIC RELATIONSHIP

ᵽWl — Layered quartzite and quartz-plagioclase leucogneiss

ᵽWi — Layered, often migmatoid, quartz-plagioclase-biotite gneiss. ᵽWi and ᵽWl units appear to correlate with ᵽWs3 on the basis of regional relationships.

Figure 4

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED A. Mills	(signature) 13.4.83 C.D.O. DATE
INTERPRETATION OF REGIONAL GEOPHYSICAL DATA	DRAWN M.R.	SCALE ———
OLARY REGION	DATE July 1982	PLAN NUMBER
REFERENCE FOR OUTALPA AND BULLOO 1:50,000 GEOLOGICAL SHEETS	CHECKED	82-394

2780

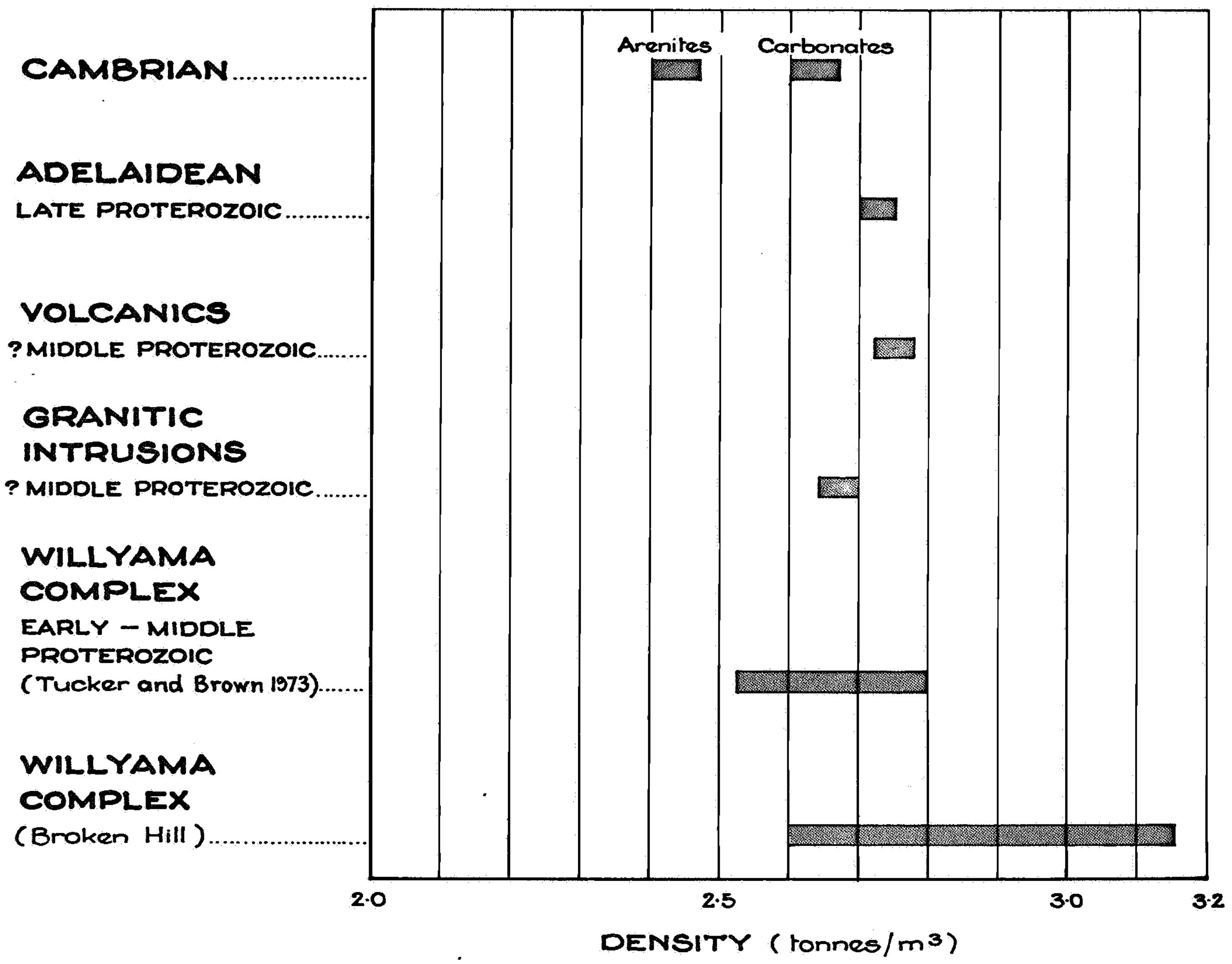


Figure 5

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED A. Mills	CDO 13·4·83 DATE
INTERPRETATION OF REGIONAL GEOPHYSICAL DATA OLARY REGION	DRAWN M.R.	SCALE
DENSITY RANGES IN OLARY AREA	DATE July 1982 CHECKED	PLAN NUMBER S 16339

2780

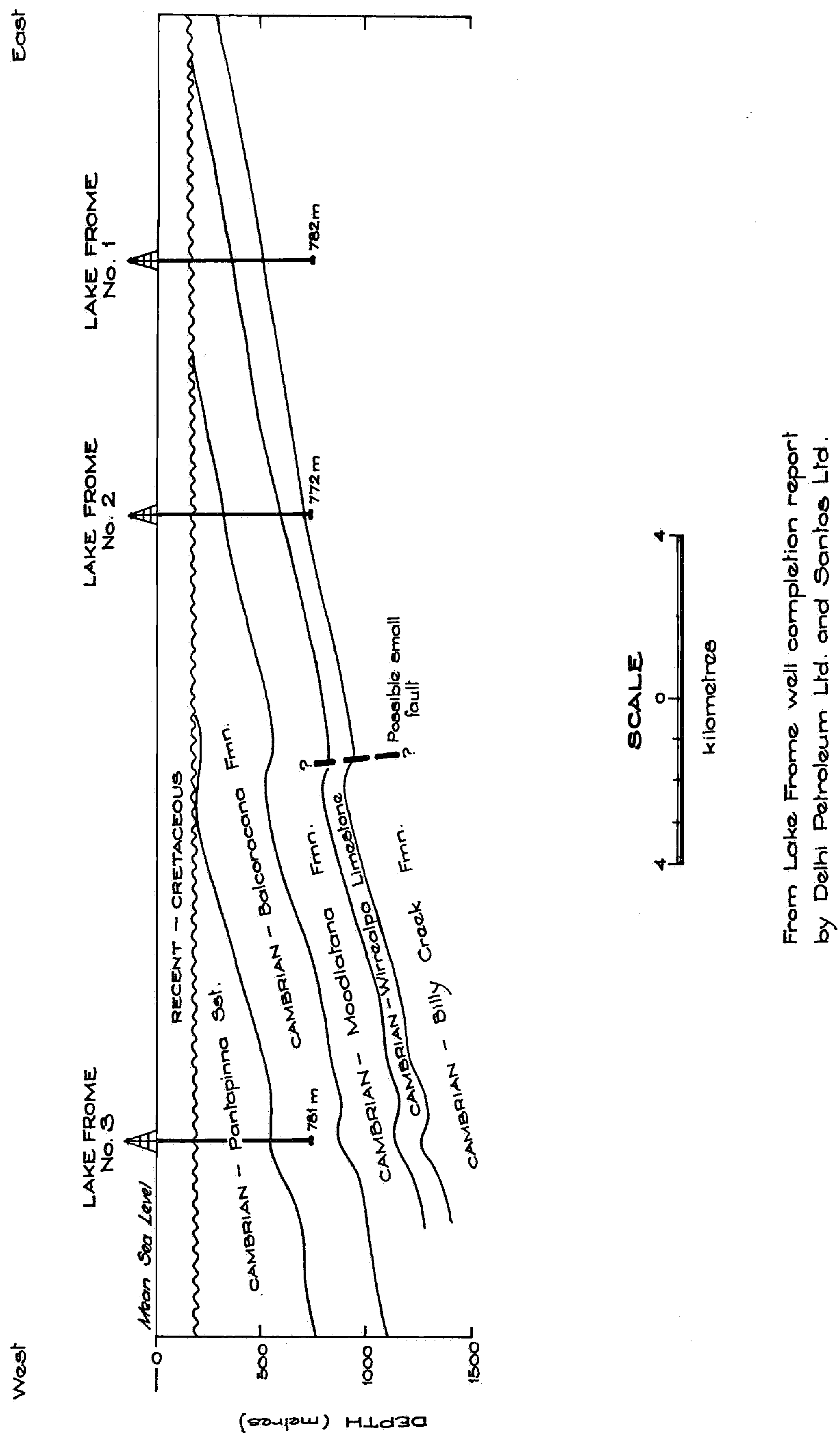
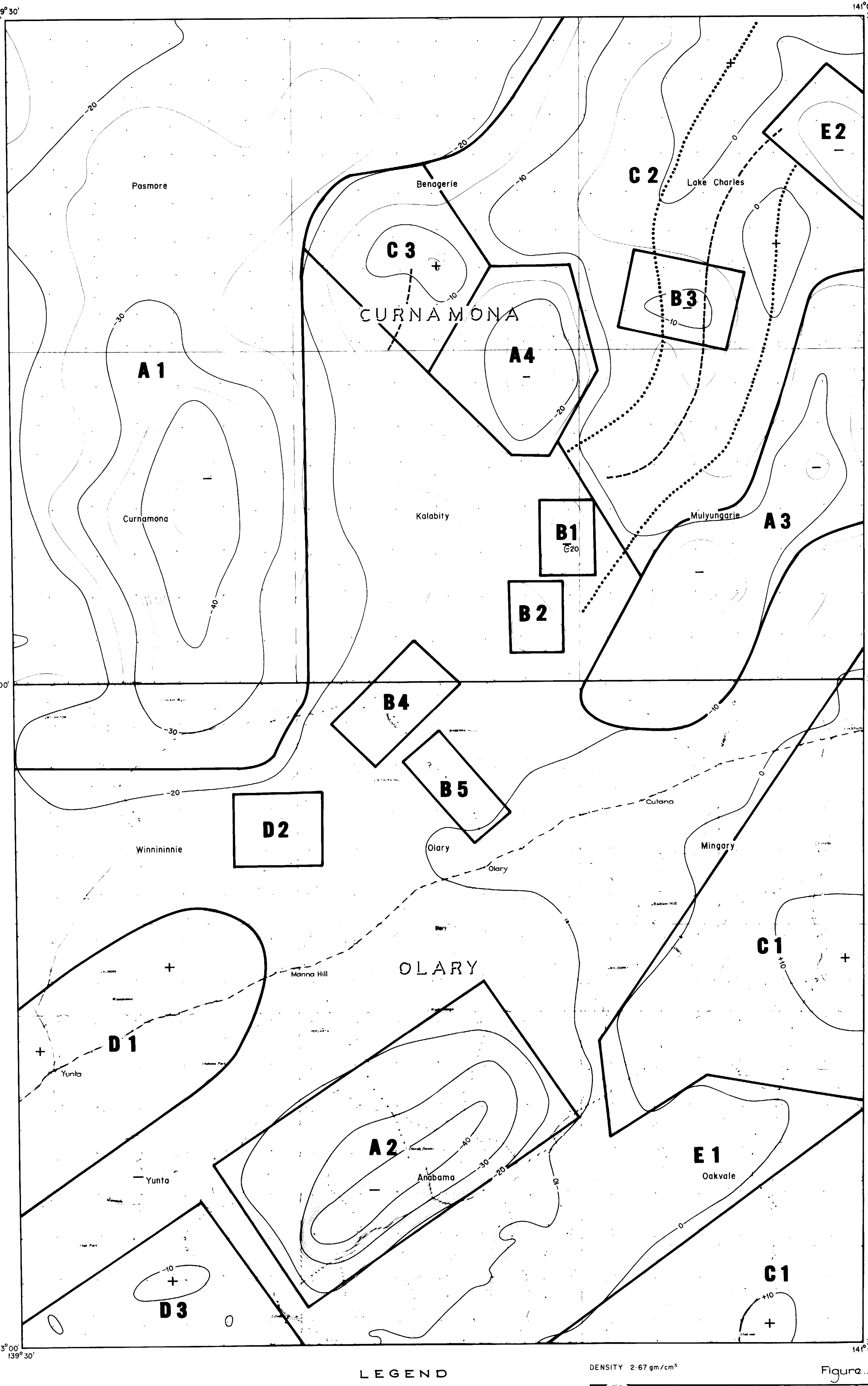


Figure........ 6

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED A. Mills	C.D.O 13 · 4 · 83 DATE
INTERPRETATION OF REGIONAL GEOPHYSICAL DATA	DRAWN M.R.	SCALE 1: 150,000
OLARY REGION	DATE Oct. 1982	PLAN NUMBER
LAKE FROME STRATIGRAPHIC DRILLING	CHECKED	S 16413

2780



LEGEND

E2	Gravity Zone
- - -	Axis of negative anomaly
·····	Axis of positive anomaly

KILOMETRES
0 5 10 15 20 25
SCALE

DENSITY 2·67 gm/cm³

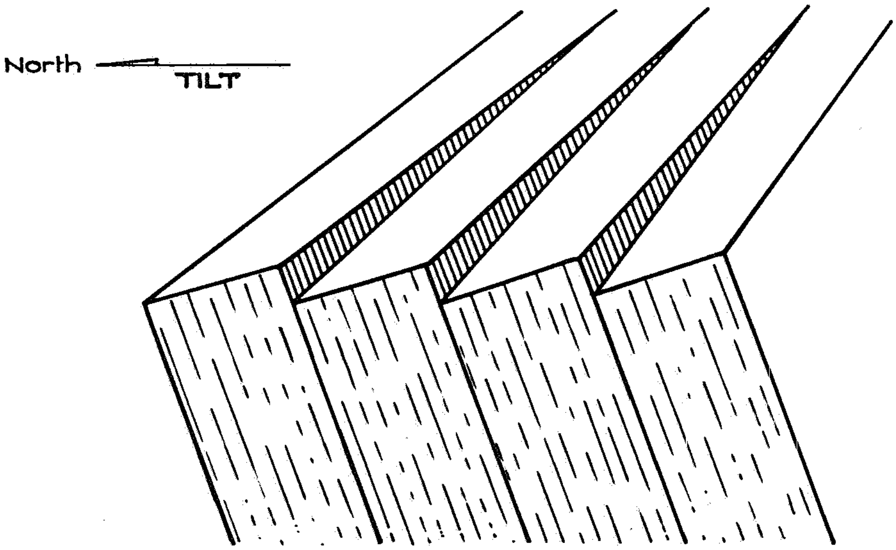
Figure 7

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA

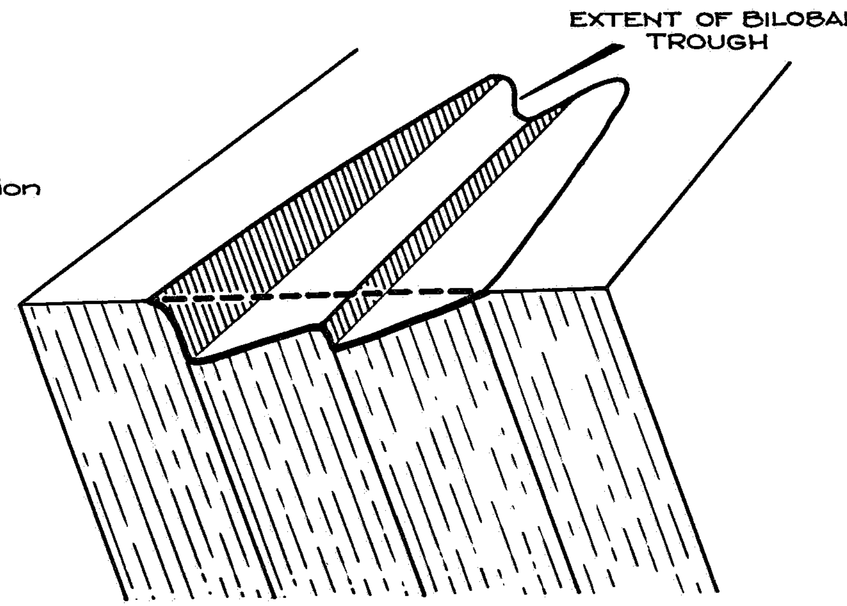
INTERPRETATION OF REGIONAL GEOPHYSICAL DATA
OLARY REGION
OLARY AND CURNAMONA 1:250,000
BOUGUER GRAVITY & ZONE BOUNDARIES

COMPILED	A. Mills
DRAWN	A.F.
DATE	July 1980
CHECKED	
	13-4-83
SCALE	1:500000
PLAN NUMBER	82-395

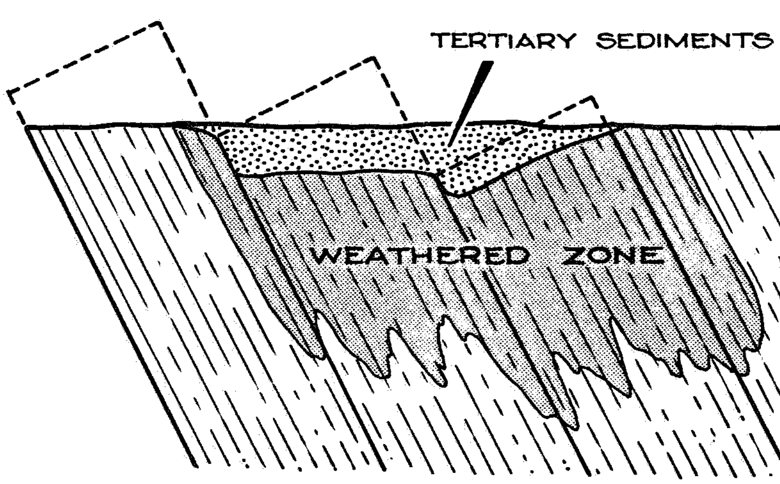
2780



a) Adelaidean basement block faulted along the Anabama – Redan lineament, tilted to the north and plunged to the southwest.



b) Post Adelaidean erosion formed a bilobal trough.



c) Tertiary sediments filled trough while deep weathering formed a low density zone within the basement.

Figure........ 8

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

INTERPRETATION OF REGIONAL GEOPHYSICAL DATA
OLARY REGION
IMPLIED STRUCTURAL HISTORY OF THE E1 GRAVITY ZONE

COMPILED	A. Mills	C.D.O. 13·4·83	DATE
DRAWN	M.R.	SCALE	Sketch
DATE	Oct. 1982	PLAN NUMBER	S 16414
CHECKED			

2780

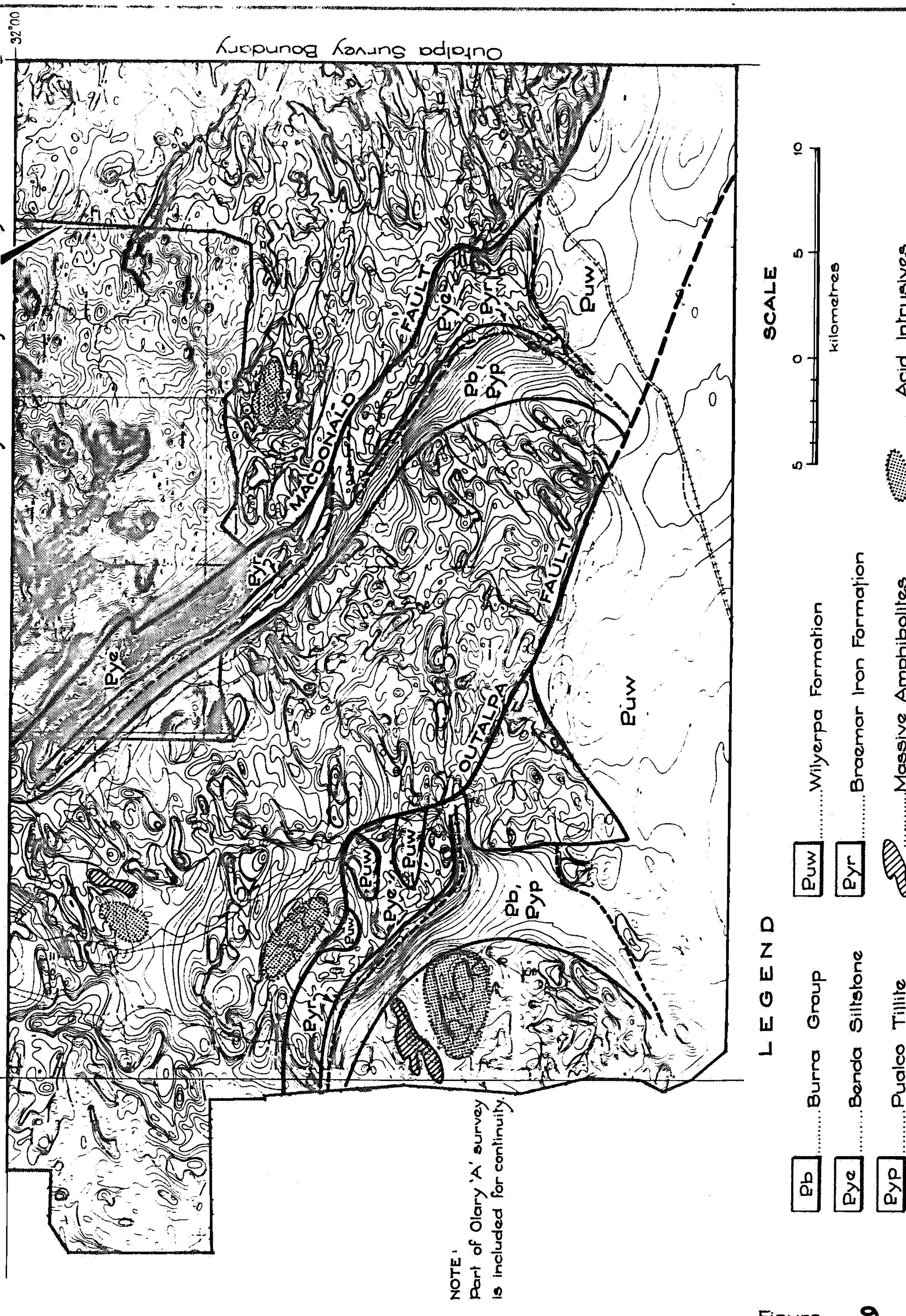
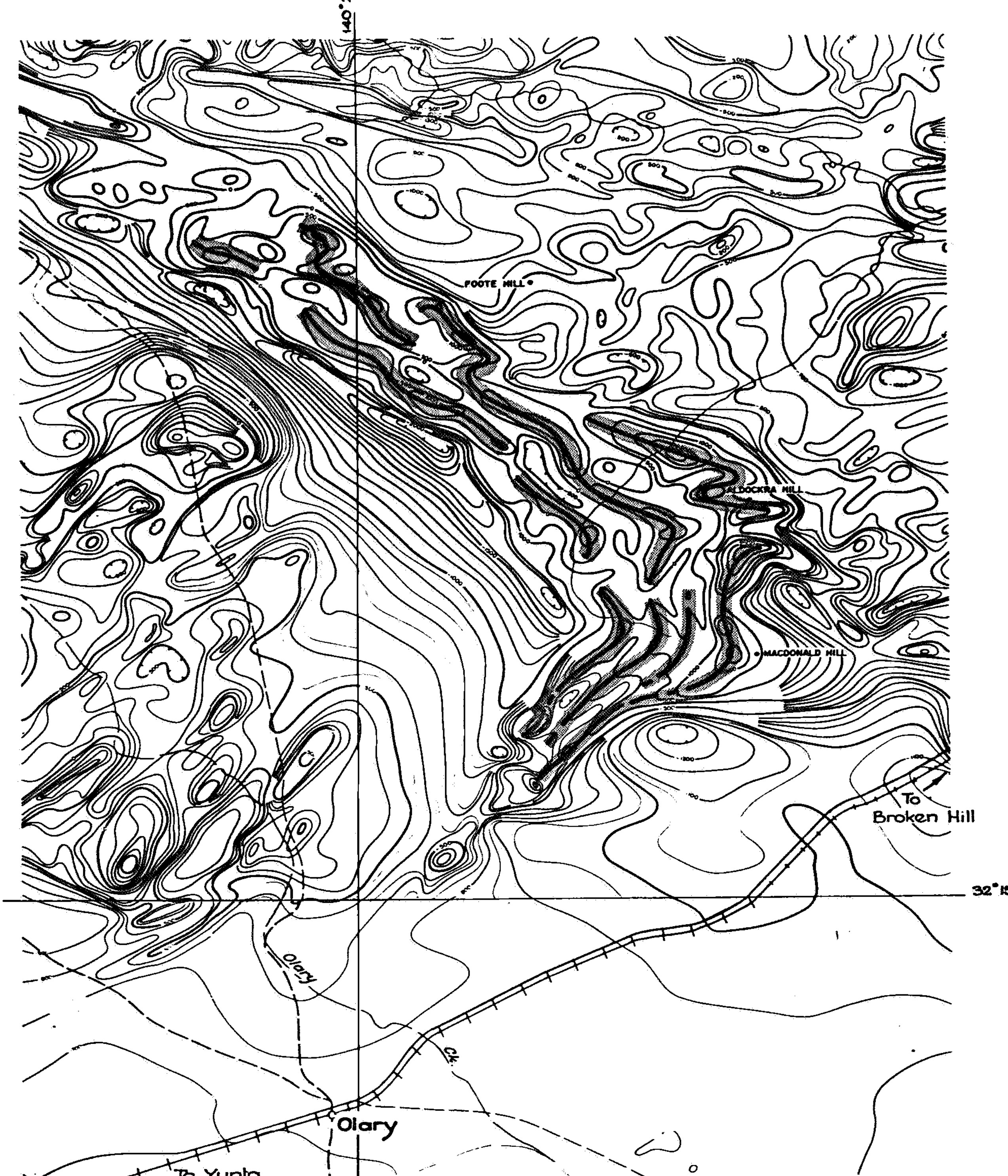


Figure 9

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED A. Mills	UR 13 · 4 · 83 C.D.O DATE
INTERPRETATION OF REGIONAL GEOPHYSICAL DATA	DRAWN M.R.	SCALE 1 : 250,000
OLARY REGION CONTOURS OF TOTAL MAGNETIC INTENSITY OF THE OUTALPA SURVEY AREA	DATE July 1982	PLAN NUMBER
	CHECKED	S 16340

2760



SCALE

2 0 2 4 6

kilometres

The east-west fold axis and the open nature of the fold are characteristic of an F-5 generation fold as described by Berry et. al., 1978

Axis of positive magnetic anomaly

Figure...... 10

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED A. Mills	C.D.O. 13.4.83 DATE
INTERPRETATION OF REGIONAL GEOPHYSICAL DATA	DRAWN M.R.	SCALE 1:100,000
OLARY REGION	DATE July 1982	PLAN NUMBER
BEDDING AND FOLDING OF ADELAIDEAN SEDIMENTS NORTH OF MACDONALD HILL AS INDICATED BY AEROMAGNETIC CONTOURS	CHECKED	S 16341

2780

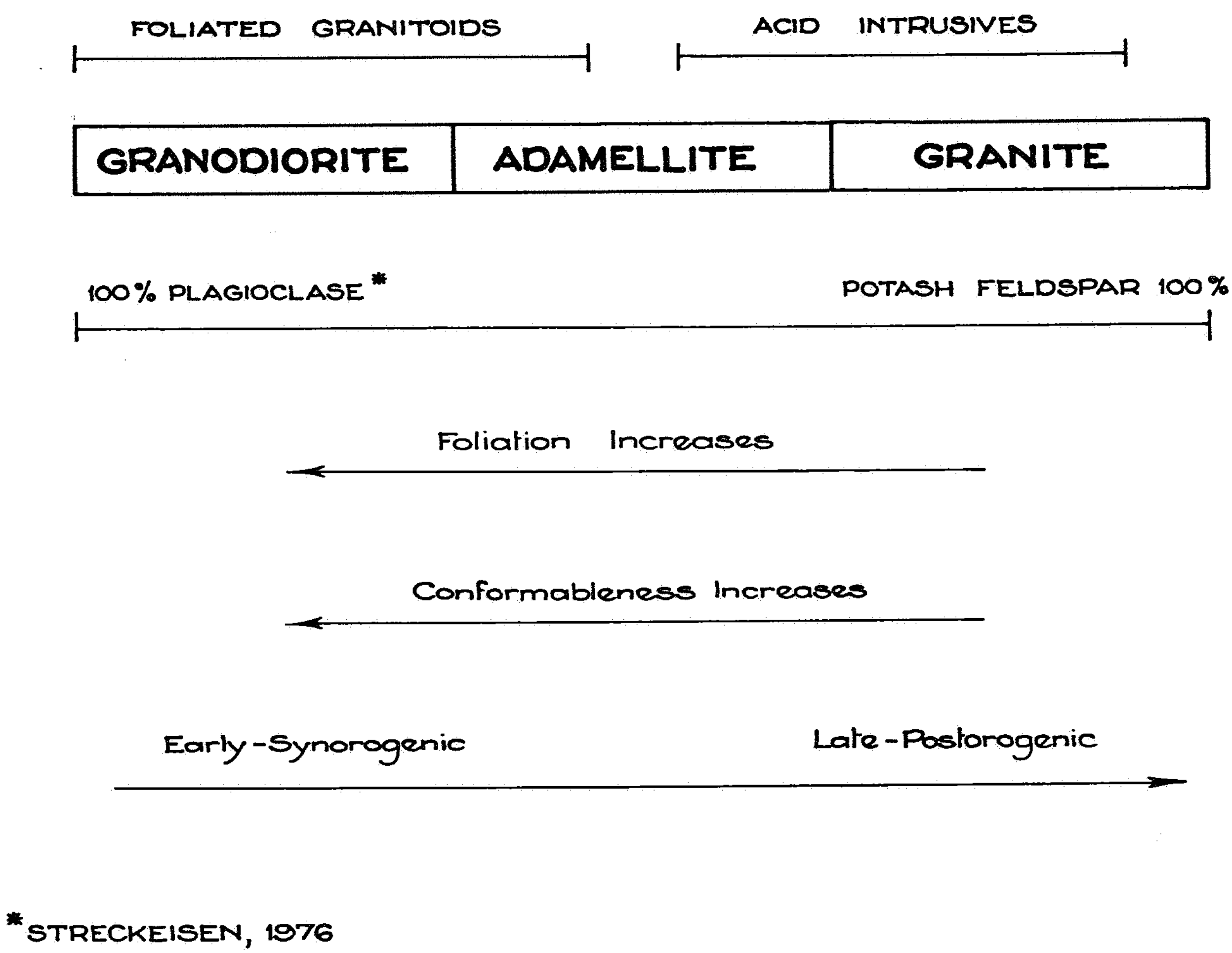


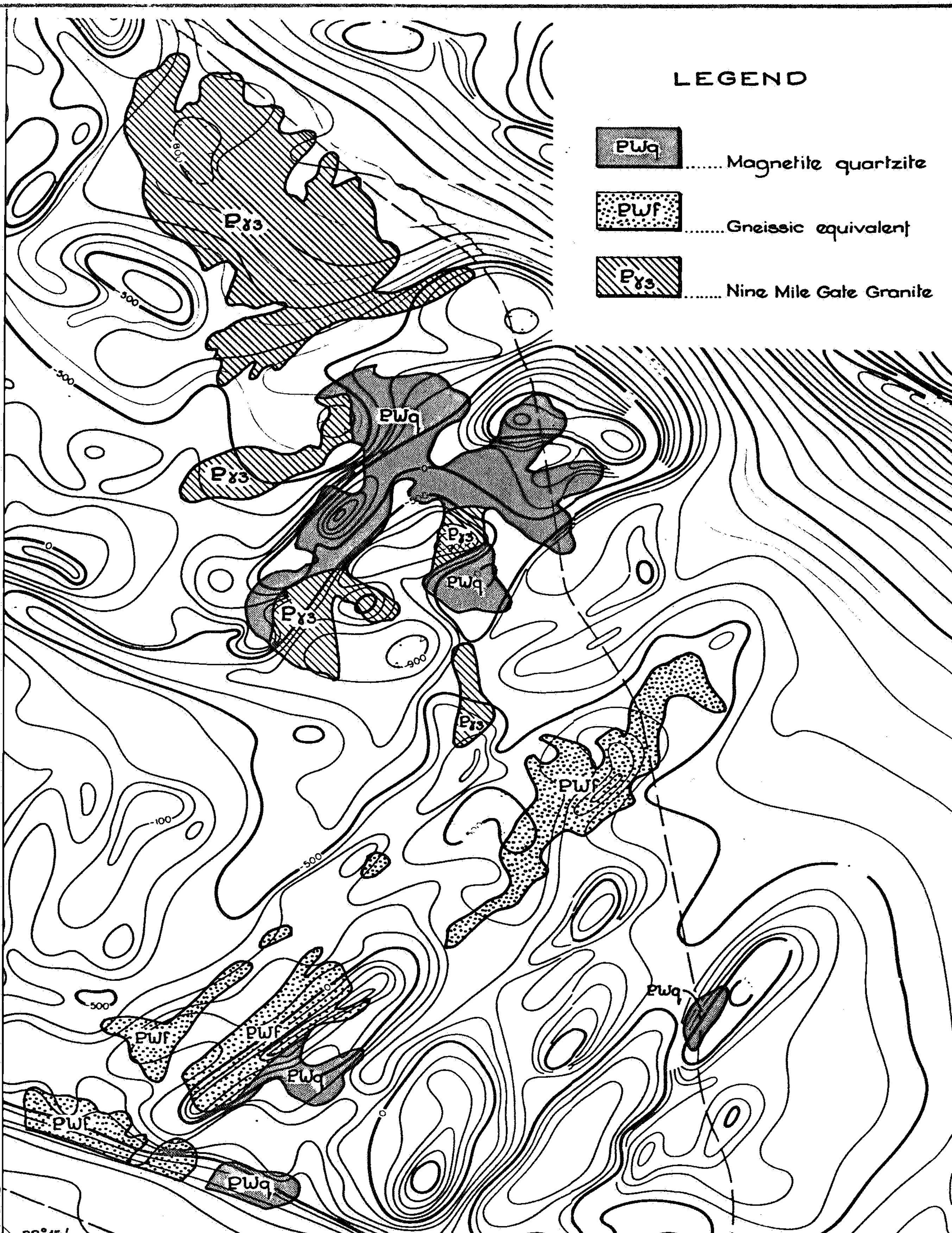
Figure 11

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

INTERPRETATION OF REGIONAL GEOPHYSICAL DATA
OLARY REGION
CLASSIFICATION OF FOLIATED GRANITOIDS AND ACID INTRUSIVES (after PITT)

COMPILED: A. Mills	13·4·83 C D O DATE
DRAWN: M.R.	SCALE: ———
DATE: July 1982	PLAN NUMBER
CHECKED	S 16342

2780



SCALE

1 0 1 2

kilometres

Figure 12

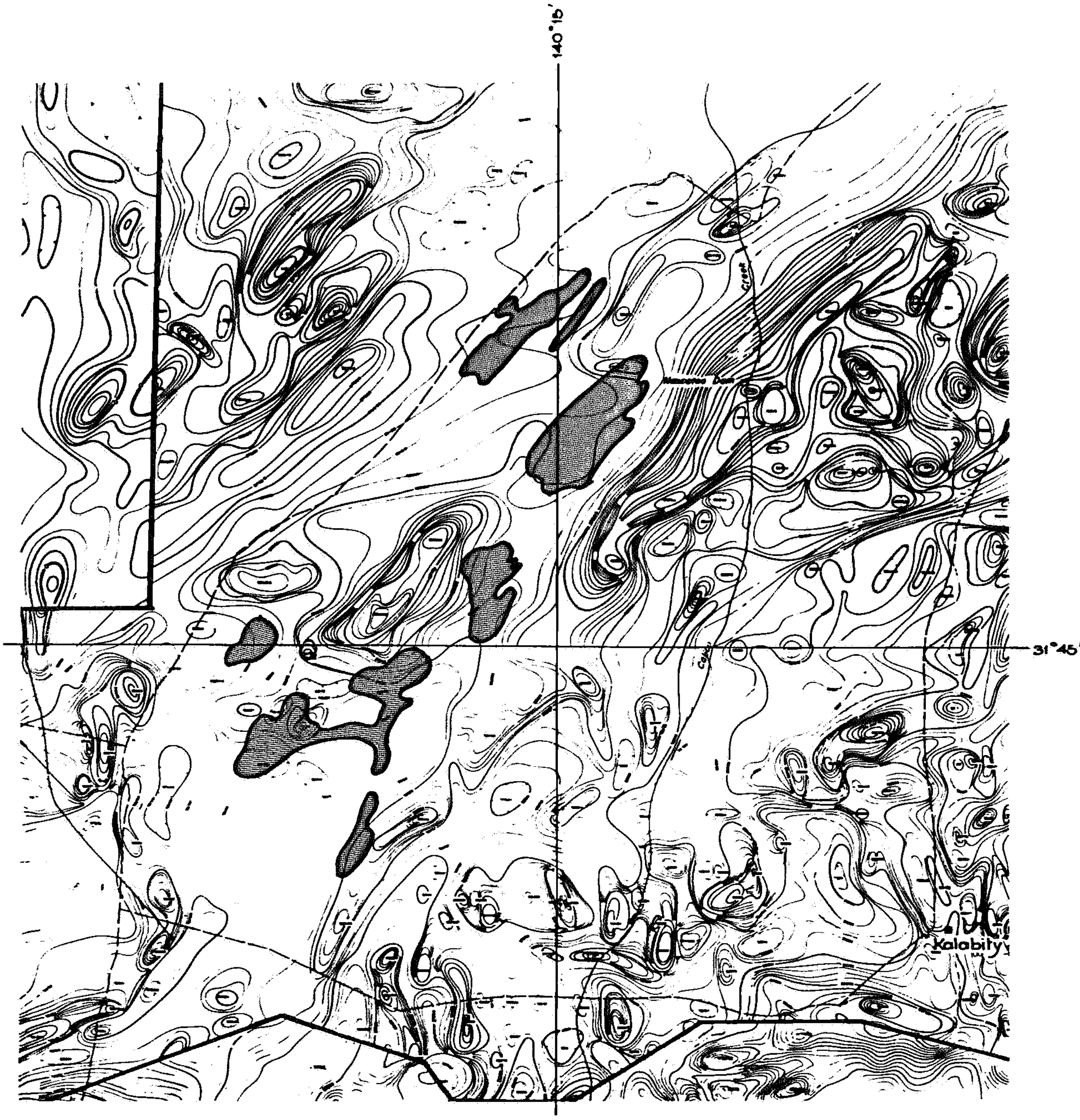
NOTE:
Major sources of magnetic anomalies in the Olary Block are magnetite quartzites (PWq) and their gneissic equivalents (PWf). Granitic masses such as the Nine Mile Gate Granite (Pγ3) are generally non-magnetic.

2780

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

INTERPRETATION OF REGIONAL GEOPHYSICAL DATA
OLARY REGION
SOURCES OF MAGNETIC ANOMALIES IN THE OLARY BLOCK

COMPILED	A. Mills
DRAWN	M.R.
DATE	July 1982
CHECKED	
CDO 13-4-83 DATE	
SCALE	1:50,000
PLAN NUMBER	S 16343



SCALE

2 0 2 4 6

kilometres

LEGEND

Pelitic Schist

A unit of pelitic schists is the most homogeneously non-magnetic unit in the Olary Block.

Figure 13

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

INTERPRETATION OF REGIONAL GEOPHYSICAL DATA
OLARY REGION
NON-MAGNETIC UNITS IN THE OLARY BLOCK

COMPILED A. Mills	C.D.O 13-4-83 DATE
DRAWN M.R.	SCALE 1 : 100,000
DATE July 1982	PLAN NUMBER S 16344
CHECKED	

2780

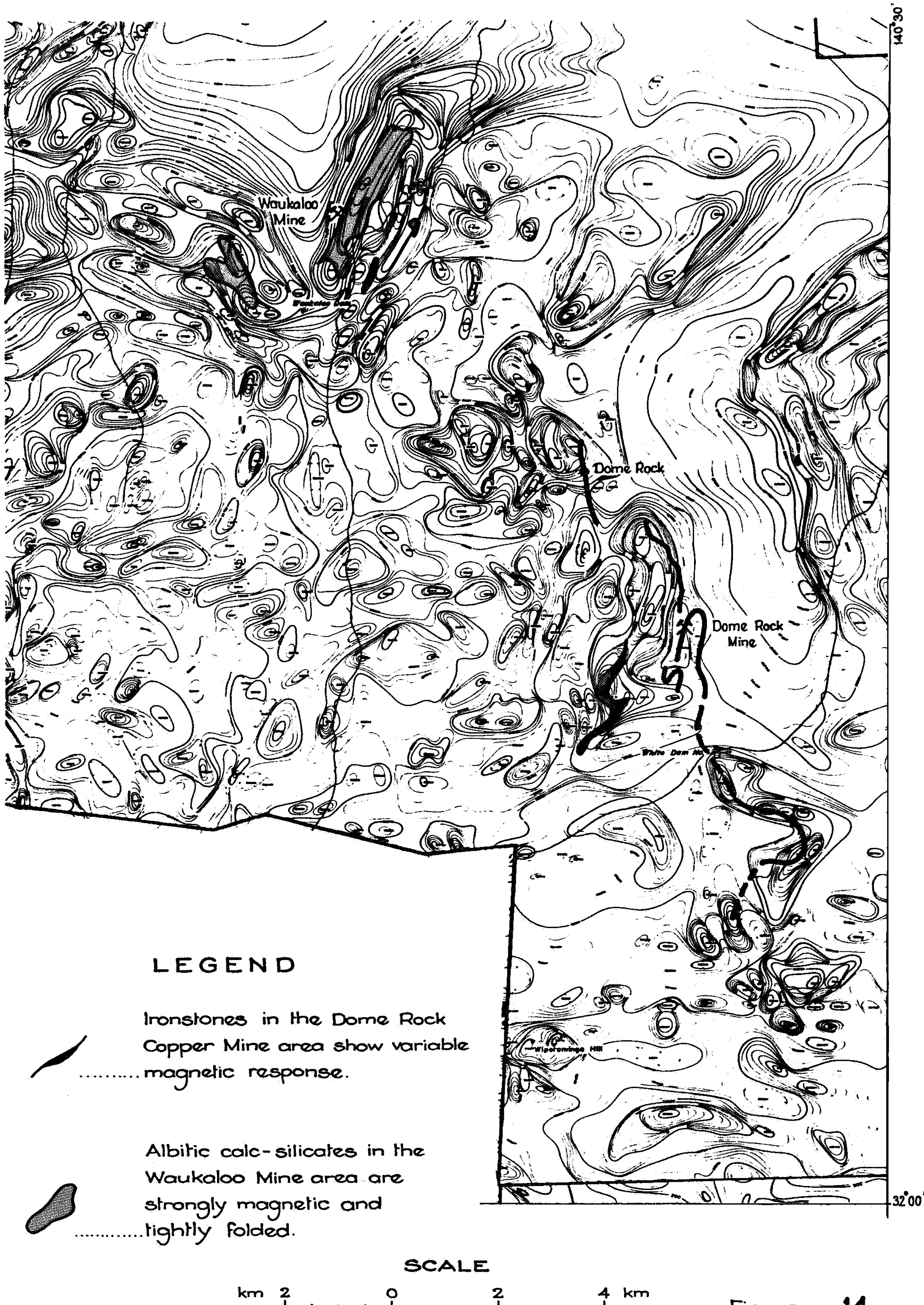
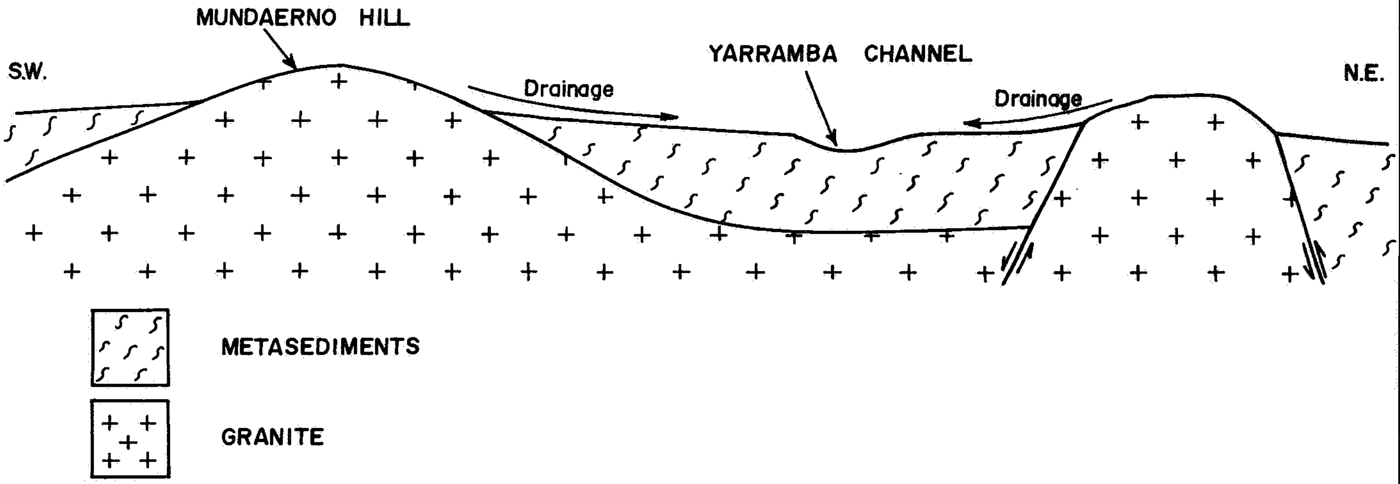


Figure...... 14

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED A. Mills	C.D.O. 13 · 4 · 83 DATE	
INTERPRETATION OF REGIONAL GEOPHYSICAL DATA	DRAWN M.R.	SCALE 1 : 100,000	
OLARY REGION	DATE July 1982	PLAN NUMBER	
MAGNETIC RESPONSE OF IRONSTONES AND ALBITIC CALC-SILICATES	CHECKED	S 16345	

2780



INTERPRETED GEOLOGICAL CROSS SECTION N.E. FROM MUNDAERNO HILL IN THE LOWER TERTIARY

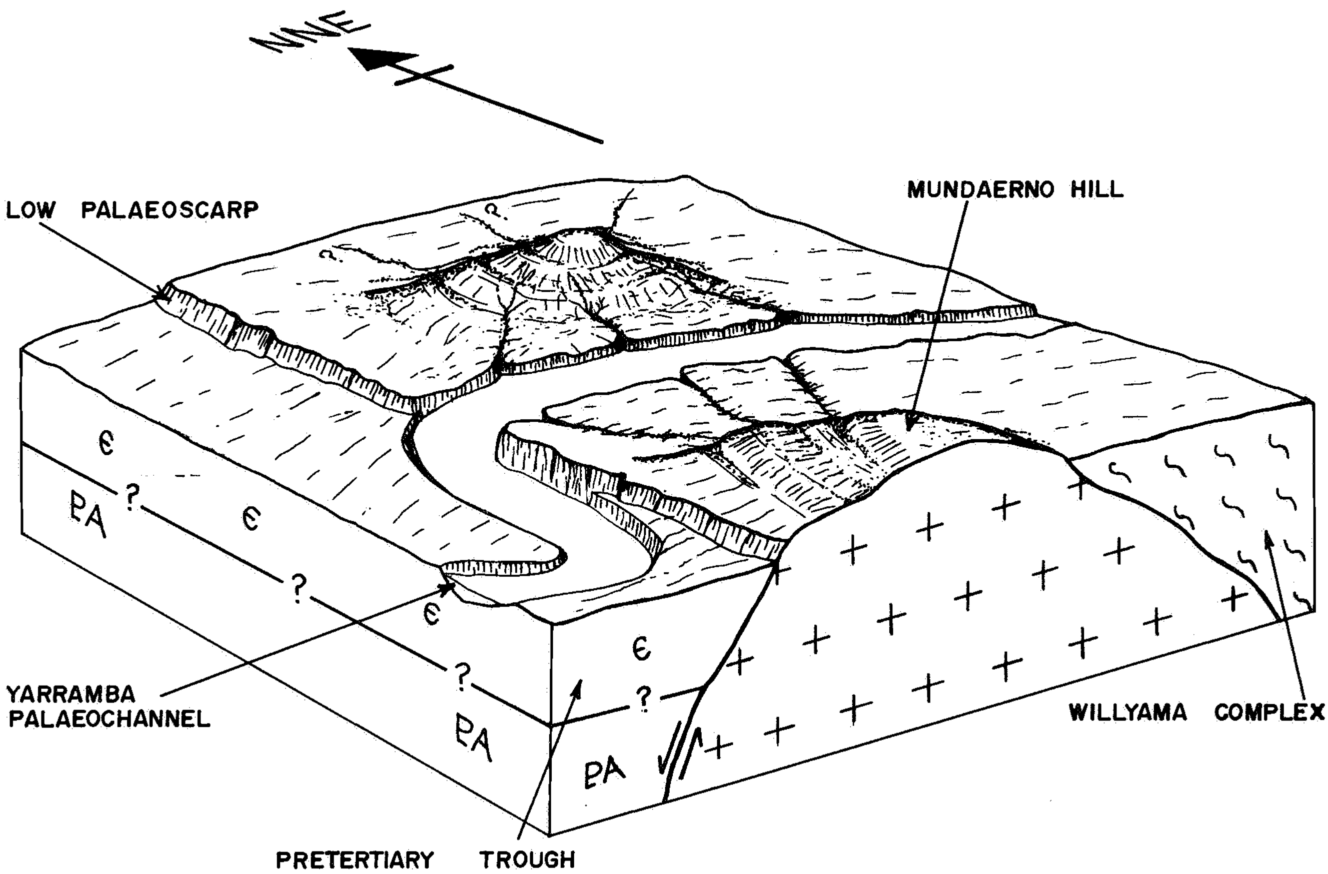
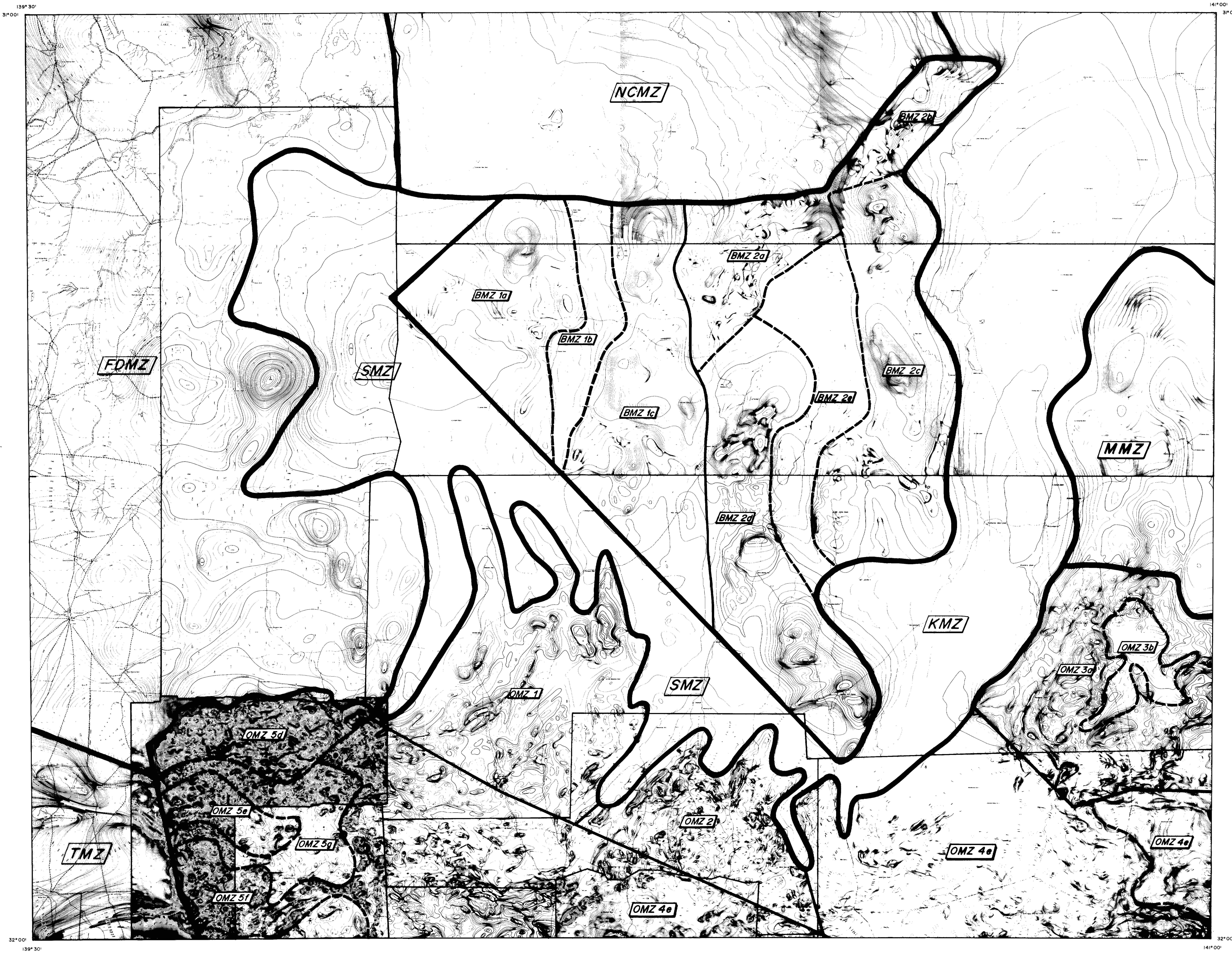


FIG. 15

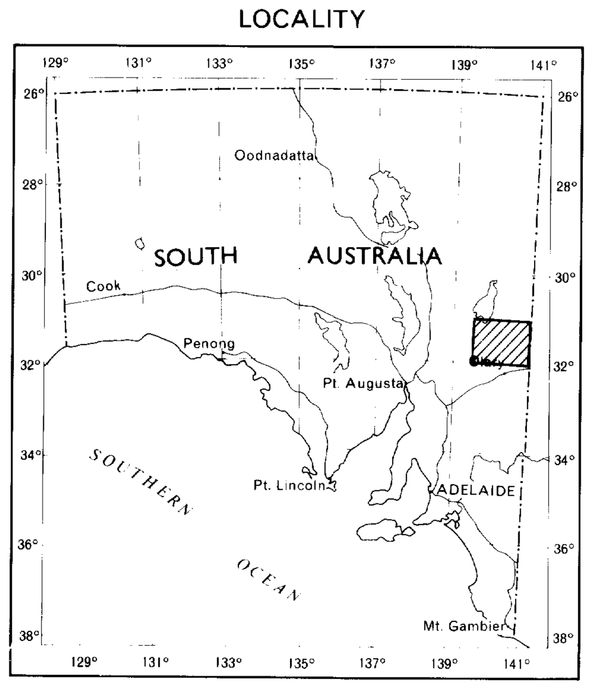
INTERPRETED LOWER TERTIARY PALAEOGEOGRAPHY EAST OF YARRAMBA H.S.

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED A.M.	C.D.O. 12·4·83 DATE
INTERPRETATION OF REGIONAL GEOPHYSICAL DATA OLARY REGION INTERPRETED RECONSTRUCTION OF THE YARRAMBA PALAEOCHANNEL	DRAWN S.R.	SCALE 1:250 000
	DATE 1/5/81	PLAN NUMBER S15508
	CHECKED	

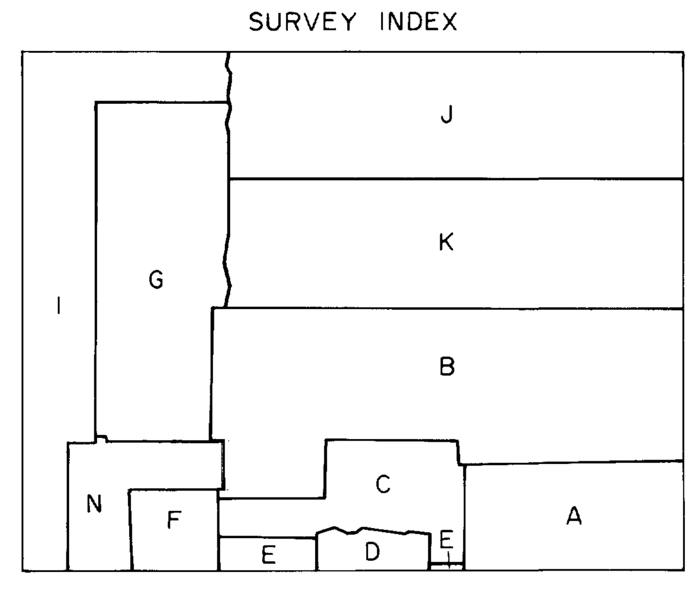
2421



LOCALITY



SURVEY INDEX



A SADM
B SADM
C Carpentaria Exploration Co Pty Ltd
D Esso Australia Ltd
E SADM
F Esso Australia Ltd
G Pacminex Pty Ltd
N SADME
I SADM
J SADME
K SADME

AEROMAGNETIC MAP OF TOTAL INTENSITY

SCALE 1: 250 000

METRES 5000 0 5 10 15 20 25 KILOMETRES

LEGEND

Zone boundary
Subzone boundary
Subdivision boundary
Magnetic contours (values in nano-teslas) 500
Magnetic Low

SURVEY SPECIFICATIONS

SURVEY ALTITUDE : A 110m, B 100m, C 60m, D 60m, E 100m, F 60m, G 90m, N 90m, I 460m, J 100m, K 100m

FLIGHT LINE SPACING : A 0·25km E-W, B 0·30km E-W and 1·20km N-S, C 0·40km E-W, D 0·25 km N-S, E 0·30km E-W and 1·20km N-S, F 0·25km N-S, G 0·80km E-W, N 0·30km N-S, I 1·60km E-W, J 0·60km E-W and 1·5km N-S, K 0·50km E-W and 1·00km N-S

The surveys were flown by :-

- A Geoex Pty Ltd for SADM in 1976
- B Geoex Pty Ltd for SADM in 1977
- C Austral Exploration Services Pty Ltd for Carpentaria Exploration Co Pty Ltd in 1973
- D Aero Service (Aust) Pty Ltd for Esso Australia Ltd in 1972
- E Geoex Pty Ltd for SADM in 1977
- F Aero Service (Aust) Pty Ltd for Esso Australia Ltd in 1972
- G Austral Exploration Services Pty Ltd for Pacminex Pty Ltd in 1971
- N Geoex Pty Ltd for SADME in 1980
- I Bureau of Mineral Resources for SADM in 1962
- J Geoex Pty Ltd for SADME in 1978
- K Geoex Pty Ltd for SADME in 1978

The surveys were flown using mosaics compiled from uncontrolled aerial photographs. The scale must be assumed to be approximate only.

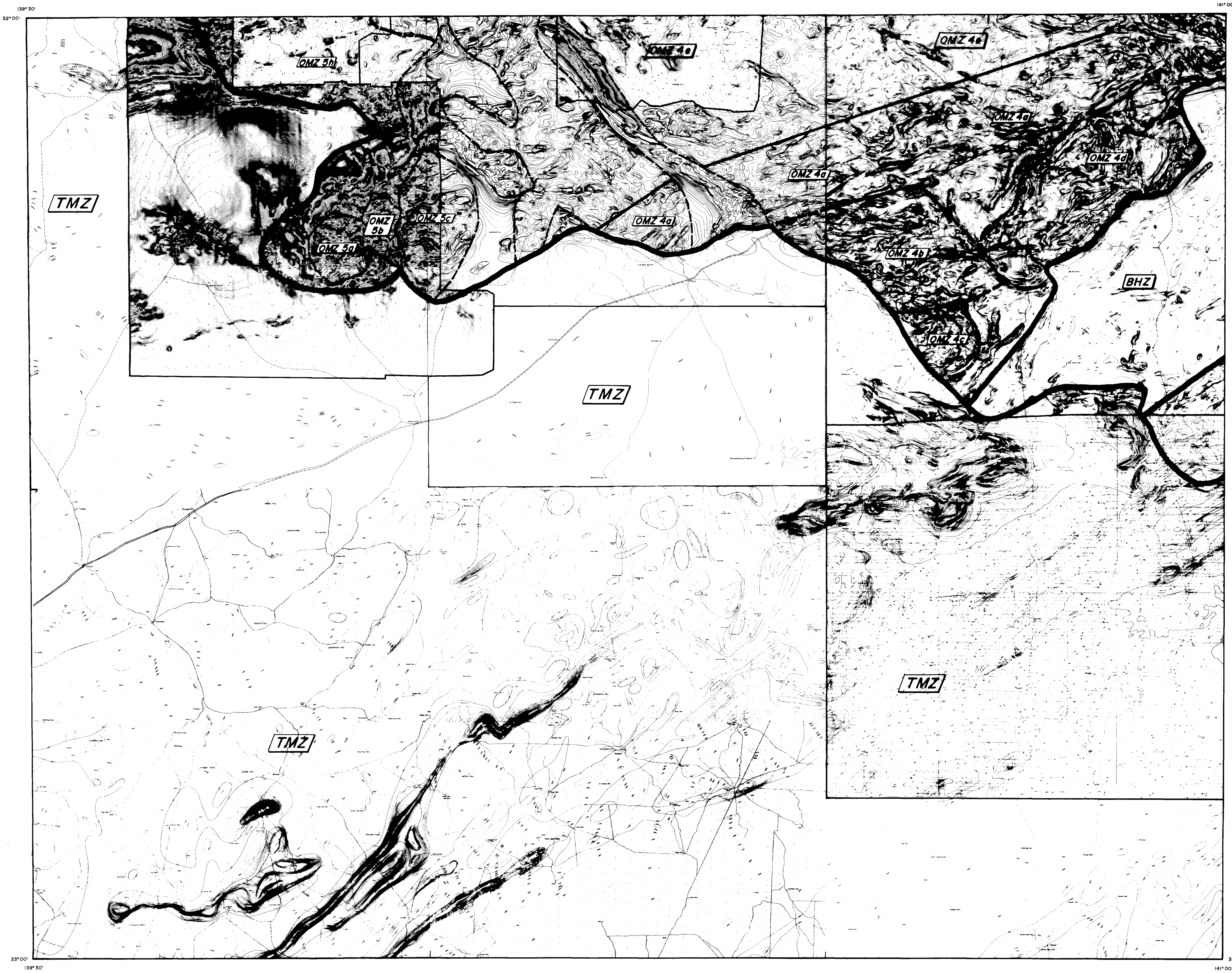
Compiled under the direction of the Director – General, S A Department of Mines and Energy.

Issued under the authority of the Honourable Minister of Mines and Energy.

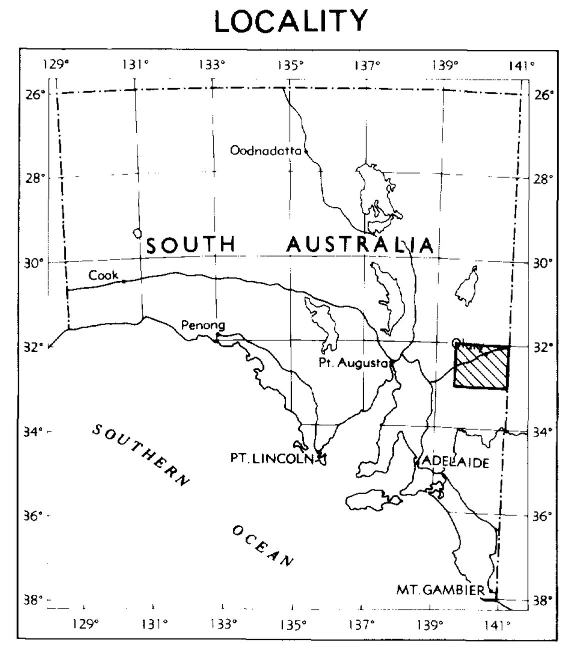
FIG. 16

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED A. Mills	C.D.O. DATE 13·4·83
INTERPRETATION OF REGIONAL GEOPHYSICAL DATA OLARY REGION CURNAMONA 1:250,000 AEROMAGNETIC MAP	DRAWN E. Calabio	SCALE 1:250,000
	DATE 22/3/82	PLAN NUMBER 82-138
	CHECKED	

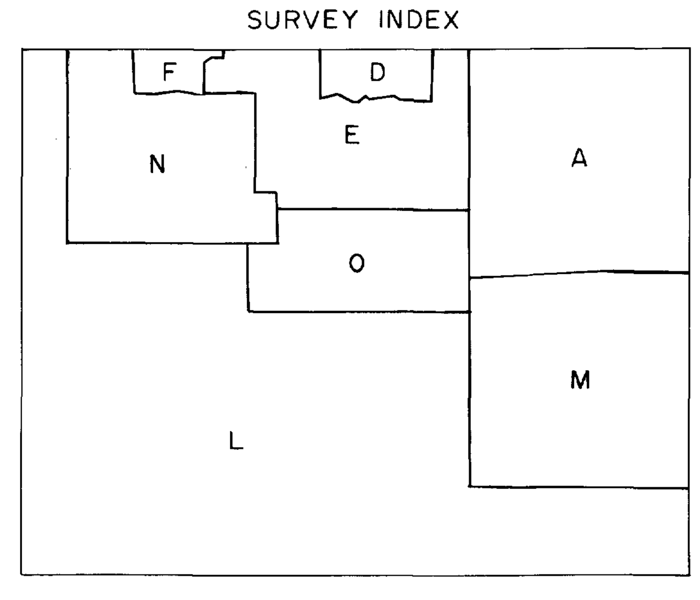
2780



LOCALITY



SURVEY INDEX



A SADM
D Esso Australia Ltd
E SADM
F Esso Australia Ltd
O SADM
L SADM
M Longreach Group Management Pty Ltd
N SADME

AEROMAGNETIC MAP OF TOTAL INTENSITY

SCALE 1:250 000

METRES 5000 0 5 10 15 20 25 KILOMETRES

LEGEND

Zone boundary . . . .

Subzone boundary . . . .

Subdivision boundary . . . .

W.C./EA boundary . . . .

Magnetic contours (values in nano-teslas). 500

Magnetic Low. . . . .

SURVEY SPECIFICATIONS

SURVEY ALTITUDE : A 110m, D 60m, E 100m, F 60m, N 90m , L 150m, M 90m, O 150m

FLIGHT LINE SPACING : A 0·25 km E–W, D 0·25 km N–S, E 0·30 km E–W and 1·20 km N–S, F 0·25km N–S, N 0·30km N–S, L 1·60km N–S, M 0·40km E–W, O 0·80km N-S

The surveys were flown by :–

- A *Geoex Pty Ltd for SADM in 1976*
- D Aero Service (Aust) Pty Ltd for Esso Australia Ltd in 1972
- E Geoex Pty Ltd for SADM in 1977
- F Aero Service (Aust) Pty Ltd for Esso Australia Ltd in 1972
- N Geoex Pty Ltd for SADME in 1980
- L Adastra Hunting Geophysics Pty Ltd for SADM in 1955
- M Geophysical Resources Development Co for Longreach Group Management Pty Ltd in 1969
- O Bureau of Mineral Resources for SADM in 1952

The surveys were flown using mosaics compiled from uncontrolled aerial photographs. The scale must be assumed to be approximate only.

Compiled under the direction of the Director-General, S. A. Department of Mines and Energy.

Issued under the authority of the Honourable Minister of Mines and Energy.

FIG. 17

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED A. Mills	13·4·83 C.D.O. DATE
INTERPRETATION OF REGIONAL GEOPHYSICAL DATA OLARY REGION OLARY 1:250,000 AEROMAGNETIC MAP	DRAWN E. Calabio	SCALE 1:250,000
	DATE 19/3/82	PLAN NUMBER
	CHECKED	82-139

2780

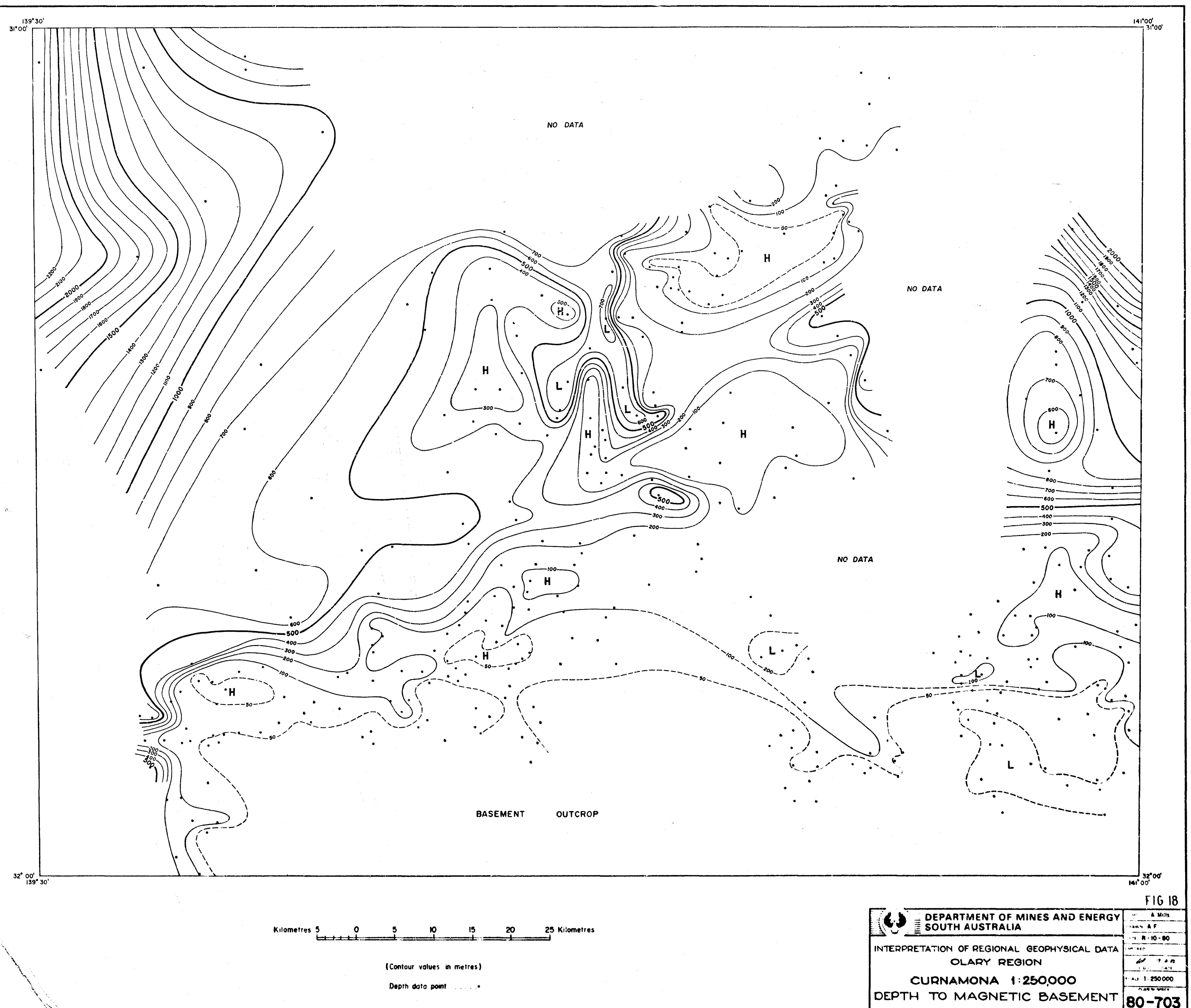


FIG 18

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

INTERPRETATION OF REGIONAL GEOPHYSICAL DATA
OLARY REGION

CURNAMONA 1:250,000
DEPTH TO MAGNETIC BASEMENT

1:250 000

80-703

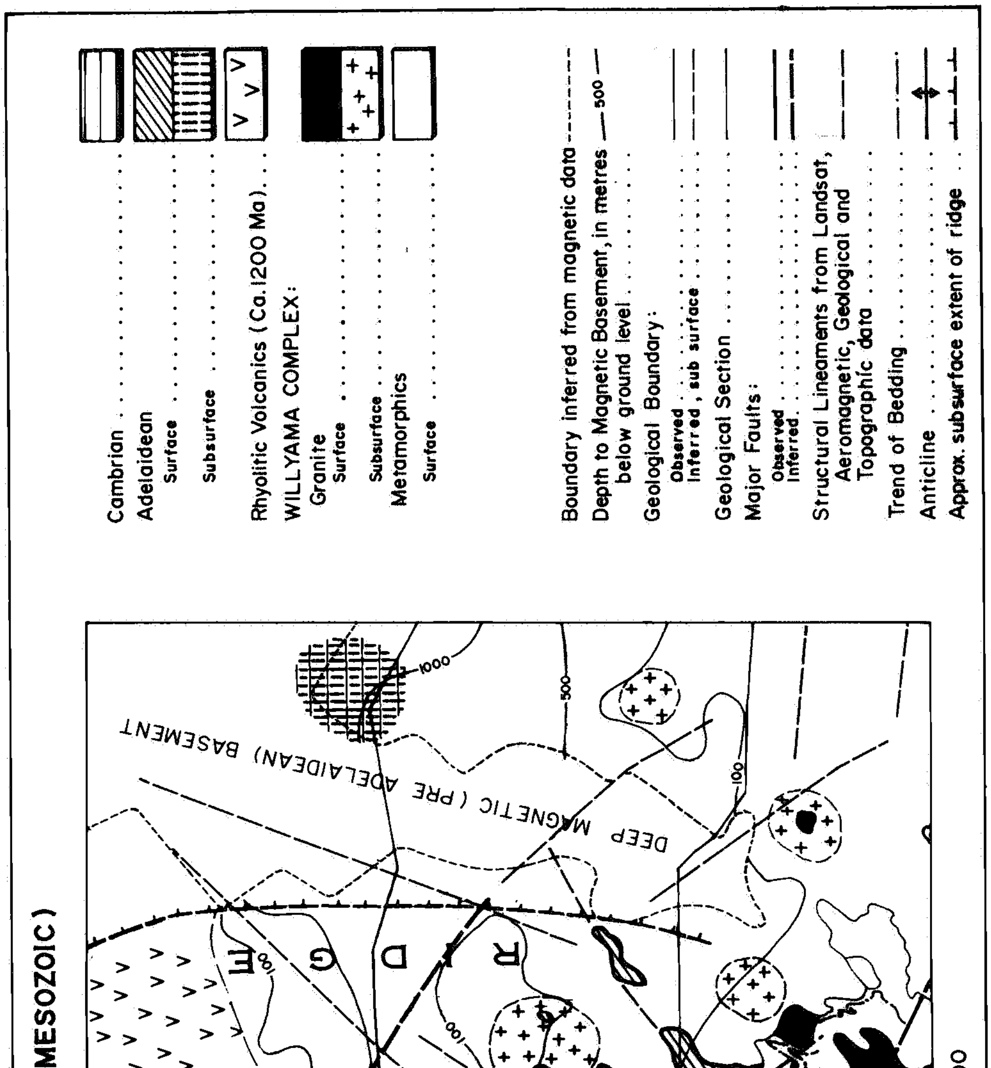


FIG. 19

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

INTERPRETATION OF GEOPHYSICAL DATA
OLARY REGION
TECTONIC SKETCH
CURNAMONA 1:250,000

COMPILED A. MILLS	C.D.O. 2·11·85 DATE
DRAWN P.D.	SCALE 1:1000000
DATE 5/4/82	PLAN NUMBER
CHECKED	S 16333

2768