DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

REPT.BK.NO. 80/151
GEOLOGY OF THE OLARY REGION

GEOLOGICAL SURVEY

by

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and

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Regional Geology Section

DME. 590/68

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NOTE: OLARY refers to the OLARY 1:250 000 map area;

Olary refers to the Olary 1:100 000 map area unless stated otherwise.

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GEOLOGY OF THE OLARY REGION

ABSTRACT

The OLARY 1:250 000 map area include the southwestern part of the Willyama Inlier and surrounding Adelaidean (upper Precambrian) sequences 300 km northeast of Adelaide. The Willyama Complex is separated by northwesterly-trending faults into blocks of metasedimentary rock of upper amphibolite grade with amphibolite, migmatite and granitoid. Broad correlation is possible with the Broken Hill area to the east. The Adelaidean is over 16 000 m thick and includes two glacial phases within the lower glacial sequence. In the Murray Basin, to the southeast, the oldest known Tertiary is of Early Miocene age, in a total known thickness of 150 m. Minor sedimentary uranium is present. The region has been multiply deformed. Three deformation phases of the Olarian orogeny are widely recognised in Willyama Complex rocks. The Adelaidean was folded in phases four and five, during the Delamerian orogeny, when major northeasterly-trending folds were formed and the Anabama Granite was intruded. Current mining activity is restricted to barite from Mount Mulga and small parcels of gold ore. Past mining activity shows a potential for uranium, as at Radium Hill, copper, as at Mutooroo and feldspar-beryl-mica from pegmatites.

INTRODUCTION

The OLARY 1:250 000 map area covers part of the Willyama Inlier and northern Murray Basin in low semiarid ranges and plains against the eastern border of South Australia, just southwest of Broken Hill (New South Wales). National Route 32 provides access: Yunta is 310 km by road northeast of Adelaide. Within the area there is a network of unsealed tracks and main roads servicing sheep stations. The ranges, composed of Adelaidean and older rocks, form the northeastern end of the Mount Lofty-Olary arc and separate the lower lying Cainozoic terrains of the Murray Basin and Lake Frome region.

Previous geological investigation has been mostly concentrated on the crystalline rocks of the Willyama Complex because of their uranium content and close relationship to the Broken Hill silver-lead-zinc ore body. Most of the geological literature is listed in a bibliography by Pitt (1978b). After earlier petrological work by Mawson (e.g. 1916, 1944), an extensive mapping and exploration programme by the Geological Survey was carried out by Sprigg, Campana, King, Whittle, Dickinson, Summers, Wilson and Johnson (Campana and King, 1958). Between 1958 and 1970, examination of iron formations resulted in the Manunda 1:63 360 geological map, a report on Razorback Ridge and other publications (Mirams, 1962; Whitten, 1970).

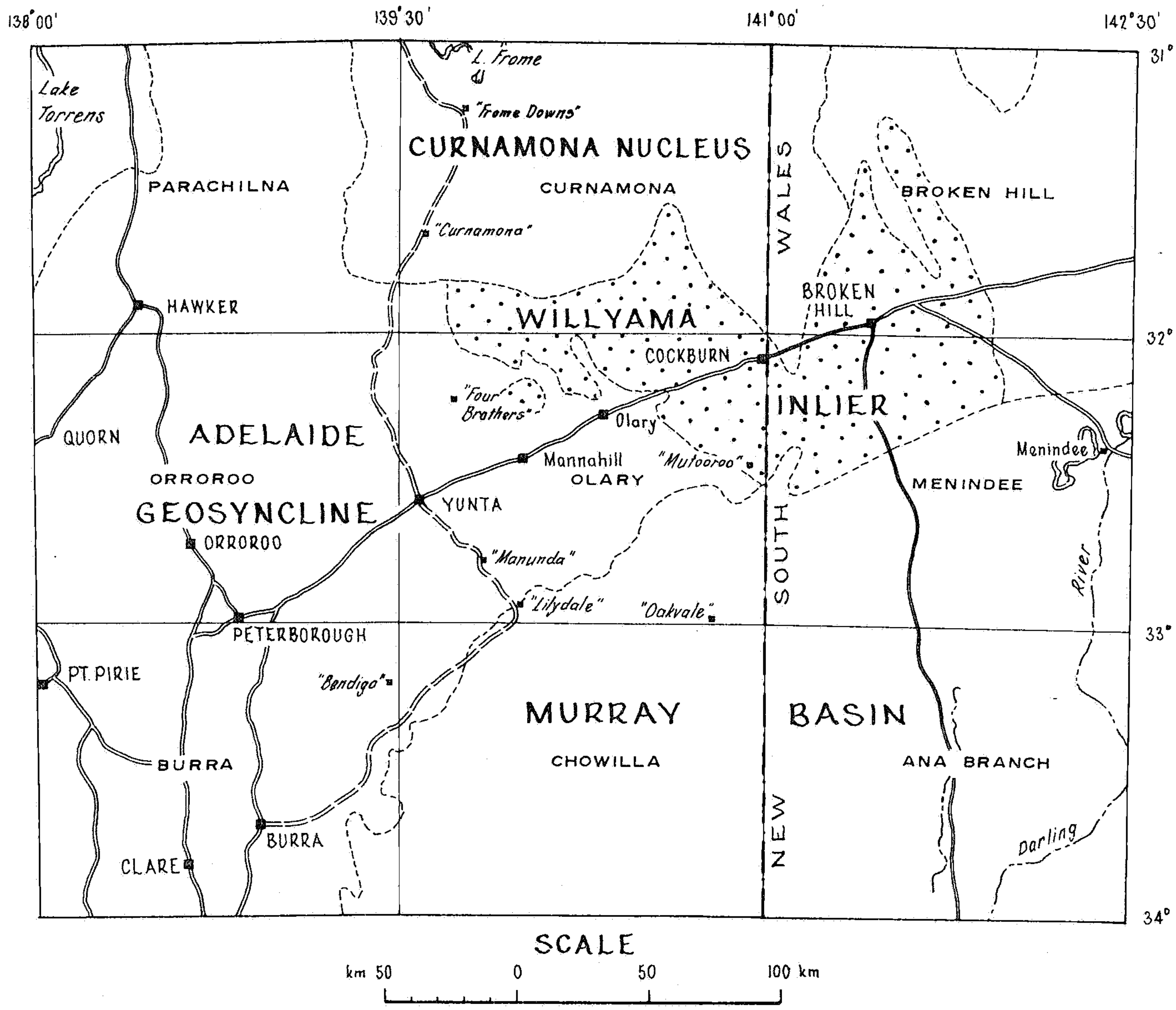
The current phase of Geological Survey mapping began in 1967 (Forbes, 1970) but was interrupted by other projects. Contributions have been made by Cramsie (1968), Callen (1969), Currie and Williams. The most recent Survey field work has been mainly on crystalline basement (G.M.P.), and on the Adelaidean (B.G.F.).

Valuable information has also been contributed by Survey and company geologists examining or exploring for mineral deposits, and by University workers. Spry (1977) provided a summary of petrology based partly on work by Henley, Whitehead and others, of AMDEL.

WILLYAMA COMPLEX

Introduction

Willyama Complex rocks are present in northern and northeastern OLARY (Fig. 1). A complex of curved, branching shears determines the distribution of the Willyama Complex: as a



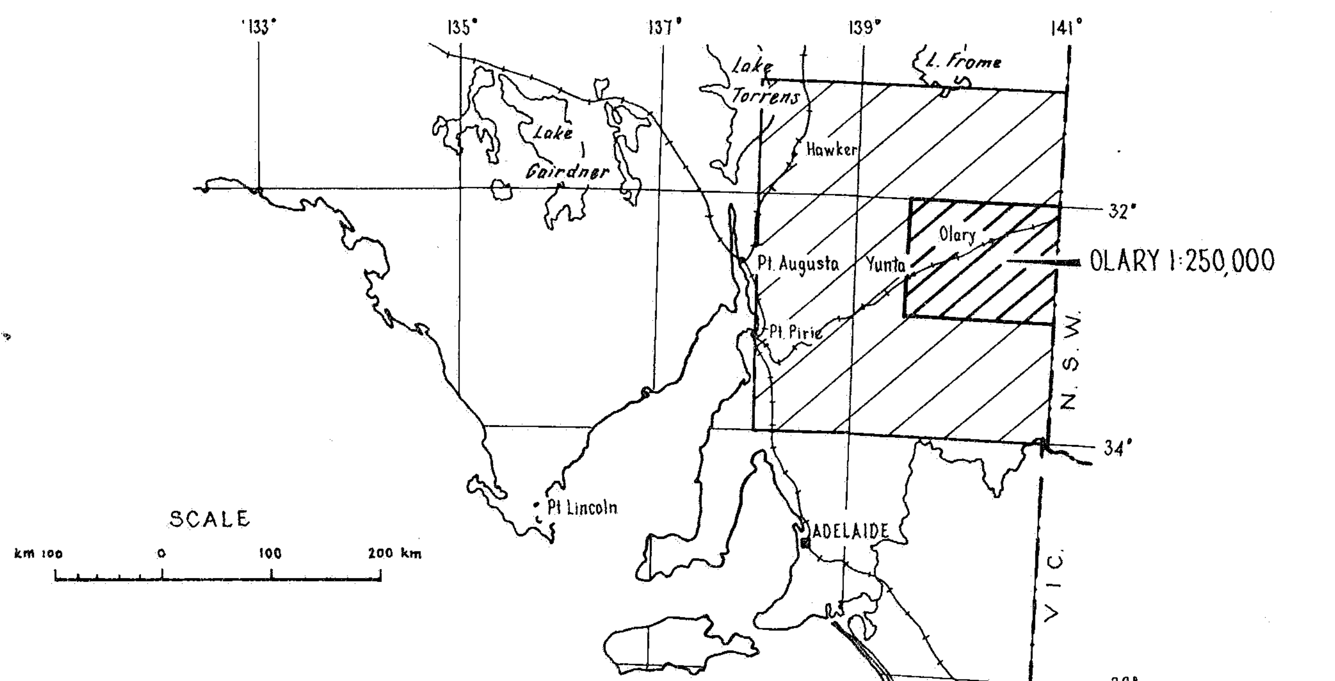


FIG. 1

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

OLARY 1:250 000 SHEET

LOCALITY PLAN

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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. Some key localities are provided in a guide by Pitt (1972). Age is Proterozoic.

Stratigraphy, mapping units

The following three distinct domains are recognised in the Willyama Complex on OLARY

(1) granitic Crocker Well-Ethiudna Hill area on Winnininnie

(2) Old Boolcoomata (-Weekeroo-Olary) area

(3) Mutooroo area.

A metamorphic sequence (interpreted to closely reflect the original sedimentary sequence) has been defined for the Old Boolcoomata area, and may be applied to the Ethiudna area. However, such is not the case for Mutooroo, where a small group of unrelated rock types has been mapped. These will be described briefly later.

Old Boolcoomata area: The recognition of a sequence in this area depends on the validity of interpreted isoclinal D_2 folds which often lack preserved closures. Grades of deformation and metamorphism can vary from limb to limb resulting in schistose, gneissic or migmatoid variants of any particular unit or sequence of units. The consistent nature of local and regional sequences, erected on this basis, however, supports the inferred structure.

The interpreted sequence of the Old Boolcoomata area is therefore broadly as follows:

(Top) 4. Interlayered schist and quartzite.

3. Knotted aluminosilicate and/or muscovite schist, with ubiquitous tourmaline and garnet. Fibrolite often appears to be later than both kyanite and andalusite. Andalusite is often retrogressed to corundum plus pyrite or to muscovite. Chiastolite is developed locally in an upper, carbonaceous member. Calcsilicate and calc-albitic marker beds are present at the top and base - the "Ethiudna Calc-silicate Group" of Campana and King (1958).

2. Layered, often magnetitic and/or feldspathic, gneiss, containing one to three thin, lenticular but extensive, iron formations which display ± sulphide ± magnetite ± hematite ± barite ± quartz ± albite mineralogy.

(Base). 1. A thick, lower sequence of quartzo-feldspathic gneiss, which may be migmatoid or anatectic, containing lenticular semiconcordant granodiorite gneiss bodies near the top.

A more detailed explanation of the stratigraphy forms the Reference to the Outalpa and Bulloo 1:50 000 sheets, contained in this report (Enclosures 1, 2). This Reference also describes late-stage acid intrusives (granitoid, pegmatoid) and basic igneous rocks but a detailed discussion of them is not possible here.

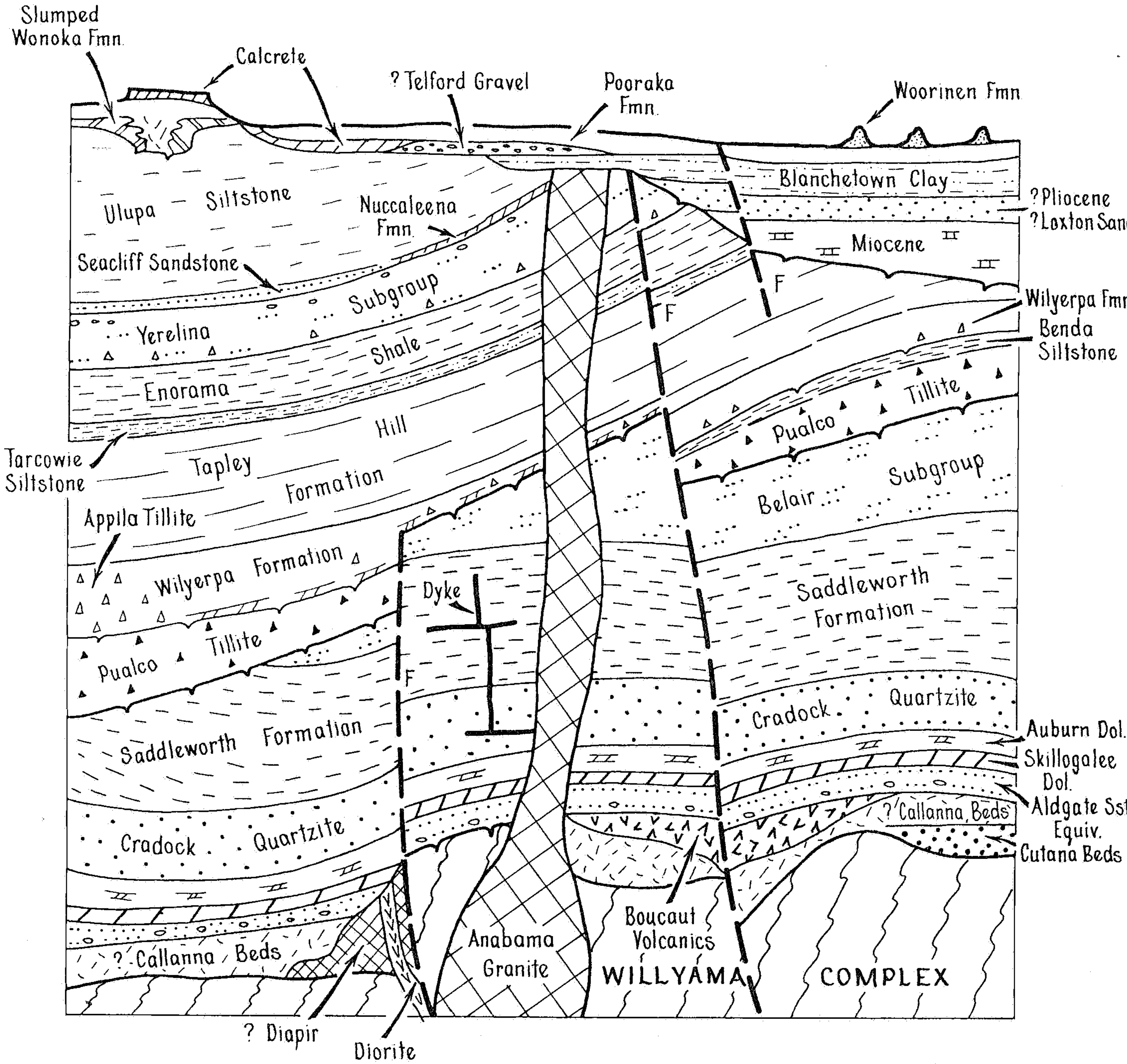

FIG. 2

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED B. G. Forbes	for C.D.O. 6/3/81 DATE
OLARY 1: 250 000 SHEET	DRAWN M. Ross	SCALE Not to scale
ROCK RELATIONSHIP DIAGRAM FOR ADELAIDEAN AND YOUNGER ROCKS	DATE July 1980	PLAN NUMBER
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There are no indications of an Archaean basement to the succession and preliminary estimates give a thickness of 4-6000 m for the Willyama in the Old Boolcoomata area. This succession correlates well with that described from Broken Hill although the latter is considerably thicker.

Ethiudna area: Calcsilicate rocks and iron formations of the Old Boolcoomata area also occur but in a gneissic host rock and intruded by large alaskitic and porphyritic, adamellitic granitoids which form part of the Mount Victoria granitoids on southern CURNAMONA.

Mutooroo area: Grade (upper amphibolite) is notably higher than the other two areas described above and the rocks consist of undifferentiated, coarser-grained sillimanite-kyanite-garnet schist and quartz-feldspar gneiss. Local occurrences of "Aplite", "augen gneiss" and "Q.M." (quartz-magnetite iron formation) lithologies, like those of broken Hill, are recorded, but poor outcrop does not permit the establishment of a stratigraphic succession. However, it seems likely that these rocks are equivalent to the lower-grade successions to the north. A notable feature, not present in the other areas, is the presence of conformable amphibolite, regarded as of igneous origin.

Metamorphism, Geochronology

The age of early, high grade metamorphism of the Willyama Complex is estimated at ca. 1700 Ma, from work by Pidgeon (1967) and others in the Broken Hill area. Geochronology of the South Australian Willyama by A.W. Webb (Amdel Project 1/1/140) has not been successful in obtaining this age, due in part to the effects of later retrogressive phases (discussed below) and the problem of selecting suitable rock-types. Dating of Olary granitoids and metamorphics by Webb (reviewed by Flint and Webb, 1979) has given values of ca. 1500 Ma, which approximates the Mundi Mundi granite date from Broken Hill. This would suggest nearly complete overprinting of the earlier ages in the Olary region. A poorly defined grouping of ca. 1050-1200 Ma ages has also been obtained, and may reflect some limited influence of the Musgravian Orogenic Phase (Thomson, 1980) in the Olary region. Its effect in metamorphic terms is unknown.

The early, prograde "Olarian" metamorphism reached mid- to upper amphibolite grade in the Mutooroo area and was responsible for the development of coarse kyanite and large porphyroblastic garnet. To the north, in the Old Boolcoomata area, migmatites were developed; large crystals of andalusite and chiastolite, as well as sillimanite, formed in schist of the appropriate composition. Isograds of this phase are not well defined. Certainly, the Zones A, B and C of Binns (1964) have not been recognised. It would appear that the grade drops from upper amphibolite in the southern areas of the South Australian Willyama Complex on CURNAMONA, previously regarded as the lowest grade parts of the Willyama. Thus on the basis of mineral species present, there is no metamorphic difference between the Kalabity (CURNAMONA) and Old Boolcoomata areas.

Wollastonite, produced during this early phase, has been recorded in the Ethiudna area and at Old Boolcoomata. Normally a contact-metamorphic mineral, it would appear to indicate relatively high temperature but low pressure in a regional metamorphic setting. This is compatible with the presence of the major, probably high-level, granitoids of Crocker Well - Mount Victoria, near Ethiudna.

Later metamorphic phases served to retrogress the amphibolite-grade mineral assemblages to mid - to upper grenschist. Three such phases are recognised, two pre-Adelaidean, the other Delamerian, and as a consequence, most aluminous minerals are retrogressed to muscovite and, more rarely, staurolite and corundum. Petrographic studies (Flint, 1980) suggest that these metamorphic phases may be directly correlated with deformational phases, discussed on page 14.

Derivation of mapping symbols

As the Willyama Complex has never previously been mapped as a system of formal units, a new system of symbols was required. The most important influence on the structure of this system is 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. Correlation was accomplished by reference to through-going marker-horizons such as calcsilicates or iron formations. The three main meta-stratigraphic sequences are therefore represented in a triple-column form on the Reference to Bulloo and Outalpa 1:50 000 sheets (Encl. 1, 2), in which correlatives are clearly indicated. The system of symbols employed is based on a sequence of schist units, designated BWs_1 to BWs_5. In gneissic form, they are known as BWg_1 to BWg_5 respectively. A less confident correlation with the units in migmatitic areas is reflected in use of broader units (BWc) with rare marker horizons indicating the local stratigraphic level. Other symbols (BWm, x, z, l, i) define gneissic or migmatoid units which have an unknown, or no stratigraphic significance. Granitoid units which have undergone metamorphism during the Olarian Orogeny are prefixed BW, while those which are essentially late to post tectonic are shown as B. The same logic is applied to basic intrusives: BB.

ADELAIDEAN AND YOUNGER ROCKS

Adelaidean

Oldest Adelaidean rocks, possibly equivalent to Callanna Beds, occur in the southwest in crush zones resembling the Paratoo Diapir (Binks, 1971). They include hornblende diorite plugs or blocks, folded and brecciated dolomite, limestone, silty carbonate, and siltstone or sandstone with halite casts, mud cracks and cross bedding.

Boucaut Volcanics (Forbes, 1977) are of restricted occurrence and uncertain age. From infolded relationships with the Aldgate Sandstone equivalent south of "Mutooroo", they are inferred to be of Willouran age and possibly equivalent to Wooltana Volcanics.

Cutana Beds (Pitt, 1979) are a quartzitic sequence which is possibly of Willouran age and tentatively correlated with Lady Don Quartzite and Christine Judith Conglomerate near Broken Hill.

Sedimentary rocks assigned to the Burra Group are most widely exposed in the Wadnaminga Anticlinorium between "Oak Park" and "Taltabooka", but smaller areas occur adjacent to crystalline basement in northern and eastern parts of the map area and also north of Mount Victor. Subdivision of the Burra Group is based on lithologic correlation with the Burra Group on ORROROO (Bruks, 1971) and elsewhere. Sandstone with black, hematitic lamination similar to Rhynie Sandstone or lower Aldgate Sandstone occurs in sequence southwest of "Mutooroo", east of "Weekeroo" and the Outalpa Hills and as blocks in crush zones in the "Oak Park" region. Skillogalee Dolomite occurs west of "Outalpa" where a complete, but condensed Burra Group sequence is exposed.

The Umberatana Group features early glacial units which are absent over a great part of the Adelaide Geosyncline. These units are Pualco Tillite, possibly equivalent to the Bolla Bollana Formation of the Arkaroola region, and Benda Siltstone. Braemar Iron "Formation" is a ferruginous facies of these two formations. Wilyerpa Formation shows rapid regional variation in thickness, notably in the Manunda region, where the controlling factor was probably movement in crush zones. Sturtian tectonism resulted in erosion of glacial beds below Wilyerpa Formation as well as warping and erosion of the Burra Group below the Pualco Tillite.

In central and southwestern areas, it is difficult to distinguish Waukaringa Siltstone Member of Tarcowie Siltstone from Enorama Shale (Farina Subgroup). South and northeast of "Spring Dam" (central Yunta), both Enorama Shale and underlying Tarcowie Siltstone are difficult to distinguish because they are composed of pale reddish and grey coarse and fine-grained sandstone and dolomitic siltstone. This lithology is also similar to overlying Yerelina Subgroup. The local sandy facies may be related to movement of faults and crush zones in the Torrensian inlier to the south.

The thin basal units of the Wilpena Group, Nuccaleena Formation and Seacliff Sandstone Member of Brachina Formation, intertongue in various proportions and appear to be lateral equivalents. Ulupa Siltstone on OLARY is not divisible into mappable sub-units. These findings are contrary to Plummer's (1978) placing of Seacliff Sandstone in the upper glacial sequence and proposed revision of Brachina Formation.

Correlation with the Broken Hill region has been made by Cooper et al., 1978.

Cambro-Ordovician (Delamerian)

Anabama Granite (Mirams, 1961) is a light grey biotite granite, adamellite and granodorite which crops out intermittently between "Lilydale" and Maldorky Hill. The main part of this region coincides with a Bouguer gravity low. The granite contains sedimentary rock xenoliths and is locally foliated. With some of its associated dyke rocks, it has been hydrothermally altered at upper levels to a pyritic quartz-muscovite greisen containing minor amounts of chalcopyrite and molybdenite. Greisen has been investigated at Netley Hill, Anabama Hill and Giles Nob by Hosking and Satkoski (for Asarco, 1969), Blissett and Read (1973) and Morris (1977).

The commonly-occurring granite contains coarse anhedral microcline with quartz, orthoclase, oligoclase and biotite. An analysis by Amdel, 1979 is as follows:

CHEMICAL ANALYSIS

Amdel report GS 4235/79

Sample 6932 RS273, Anabama East Hut

Analysis Percent

SiO_2	77.49
TiO_2	.11
Al_2O_3	12.33
Fe_2O_3	.66
FeO	.23
MnO	.02
MgO	.19
CaO	.85
Na_2O	2.84
K_2O	4.66
P_2O_5	.05
H_2O^+	.32
H_2O^-	.02
Co_2	.03
So_3	
TOTAL	99.80

Dyke rocks post-date the granite and include pegmatite, microgranite, aplite, rhyolite, rhyodacite, dacite, lamprophyre, trachyandesite, and micromonzonite and micro-diorite porphyries. Morris (1977) suggested the following sequence of events after intrusion of the Anabama Granite: crystallization (468Ma: Steveson and Webb, 1976), jointing, brecciation and shearing, hydrothermal alteration and dykes (450 Ma), minor faulting and jointing with quartz veining and metamorphism (440 Ma), quartz porphyry with microgranite and quartz veining (430 Ma: Compston et al., 1966).

Cainozoic

Oldest known Tertiary rocks were penetrated in the subsurface of the Murray Basin in the search for sedimentary uranium by Tricentrol Aust. Ltd., Sedimentary Uranium NL and Mines Administration Pty. Ltd. (Bryan, 1971, 1972; Jarre, 1972; Middleton, 1975). These are fossiliferous marine marl and clay of Early Miocene age (Lindsay & Harris, 1973; Cooper, 1978) and are overlain by sand possibly of Pliocene age. Company geologists (e.g. Burns, 1980) infer an unconformity below the sand. In outcrops in southeastern Oakvale, the sand is partly silicified white kaolinitic fine-grained sandstone or reddish, ferruginous, micaceous, laminated medium-grained sandstone (Callen, 1969).

Blanchetown Clay (Pleistocene mottled clay) is widespread over the Murray Basin and extends along major drainage lines. Specimen 6832 RS109 from Manunda Creek contains kaolinite, illite, montmorillonite, gypsum and halite.

Wide areas of calcrete on OLARY are not far removed from the broader features of the present day topography. Chiefly near main drainage lines such as Manunda Creek and Olary Creek, calcrete cements old higher-level gravel sheets resembling Telford Gravel which are possibly equivalent to part of Millyera Formation (Callen and Tedford, 1976). Calcrete related to an old land surface in southern Olary and adjacent regions has prominent marginal scarps south of "Morialpa" (west-facing), southeast of "Oulnina" and east of "Wadnaminga" (south-facing).

Pleistocene reddish alluvial clay to gravel commonly exposed in creek banks is correlated with Pooraka Formation (Firman, 1969) and is possibly equivalent to Eurinilla and Coonarbine Formation of Callen (Callen & Tedford, 1976). In addition to the softer Loveday Soil carbonate, some alluvial clay contains lenses of subangular quartz and quartzite boulders cemented by harder calcrete. This gravel is younger than Telford Gravel.

Callabonna Clay occasionally occurs as a thin, reddish clay layer above Pooraka Formation.

In the southeast, over the Murray Basin, there are reddish east-trending sand ridges (Woorinen Formation) with a sandy unit (Qp) transitional to Pooraka Formation.

Holocene light brownish alluvial silt, sometimes laminated and rippled and up to 1 m thick, may often be seen above reddish Pleistocene clay at the top of creek banks. This silt appears to form the basis for clay flats adjacent to some main creeks. Other Holocene deposits are gravel and sand of drainage channels, younger sand drifts and veneers of silt, clay, salt and ?gypsum of clay pans and areas of poor drainage.

STRUCTURE

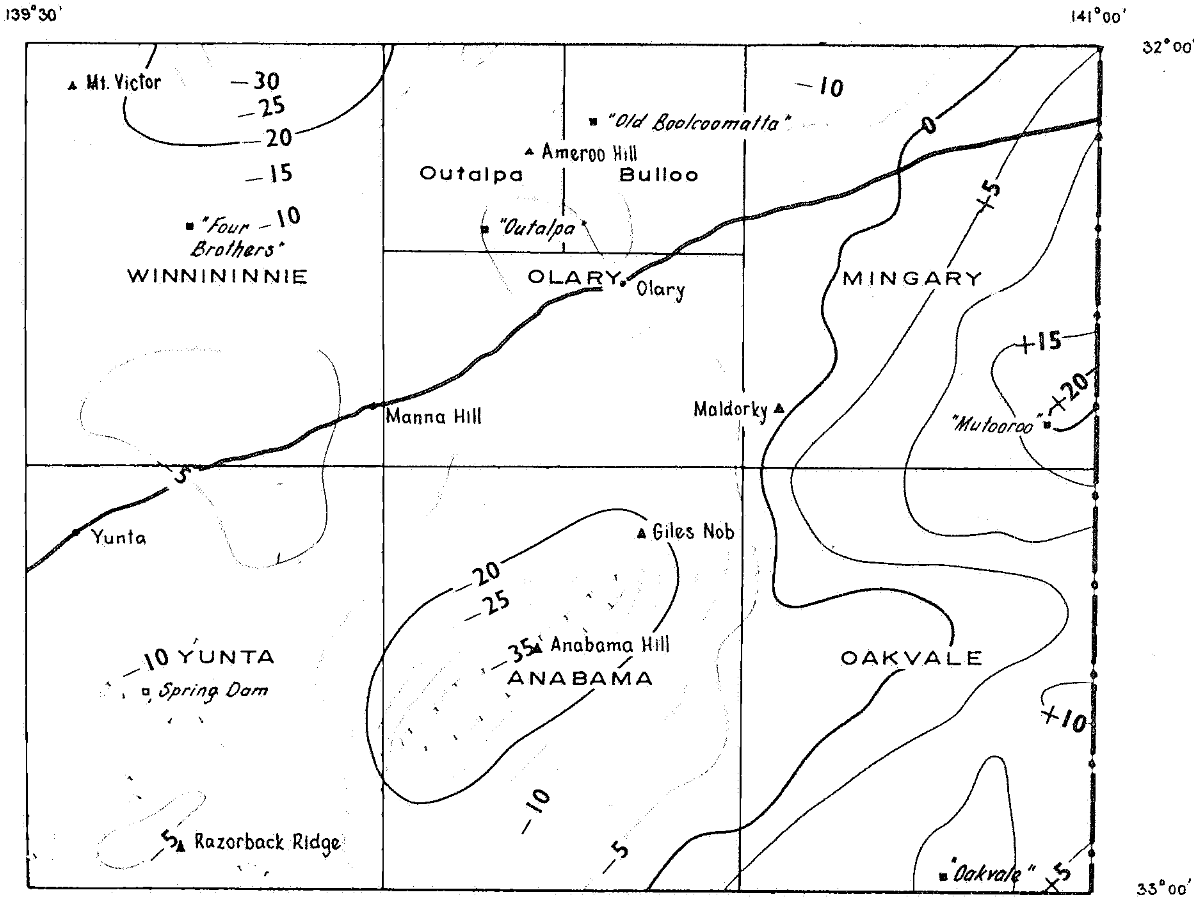
Willyama Complex

Berry et al. ¶1978) recognised five deformational phases. Three of these are pre-Adelaidean, two are Delamerian. The conclusions of Berry et al., (1978) which were based on a detailed study of the Outalpa Springs area are now considered to be applicable to most of the South Australian Willyama Complex, with the exception of the Mutooroo area where no comment can be made due to lack of data and poor outcrop.

The following comments are derived in part from the work of Berry et al. (1978). The earliest deformation (D_1) produced a layer-parallel schistosity and gneissosity; however, the isoclinal folding normally presumed to be responsible for such foliation has not been observed. This deformation was associated with the early, amphibolite-grade metamorphism discussed above. A second deformation, D_2, produced a new foliation and was responsible for both open and large, isoclinal folds. This phase is particularly important to stratigraphic interpretations on Outalpa and Bulloo 1:50 000 sheets. D_2 isoclinal folds occur, for instance between "Bimbowrie" H.S. and Ameroo Hill. Closures to these folds have generally been removed by faulting or post-Willyama erosion, and only parallel limbs are preserved. The recognition that these are, nevertheless, folds which repeat the sequence, is vital to interpreting a correct stratigraphy.

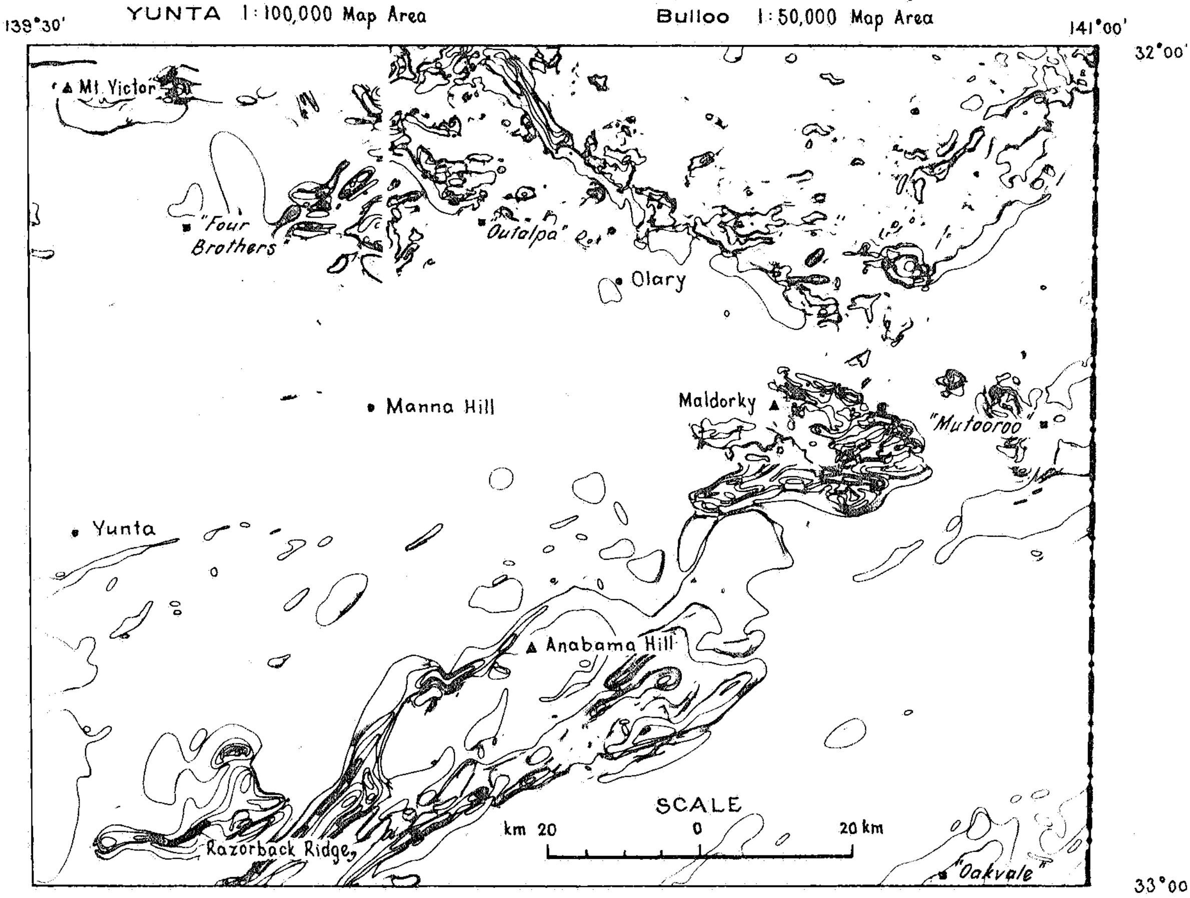
Structural and petrographic studies (e.g. Flint, 1980) would indicate that D_2 was associated with a metamorphic phase which, though relatively high, was somewhat lower than the first and as a consequence, probably initiated retrogression of the D_1 mineralogy.

Deformation D_3 is responsible for the general distribution of Willyama Complex units as presently mapped. D_3 produced east-northeast trending, macroscopic, tight to moderately open folds, of which the major east-plunging synforms of Ameroo Hill and Mount Mulga and the large antiform north of Walparuta are examples (see Encls. 1-3).



BOUGUER GRAVITY CONTOURS (Milligals) after Coppin et al 1971

YUNTA 1:100,000 Map Area Bulloo 1:50,000 Map Area



TOTAL MAGNETIC INTENSITY CONTOURS from FRITH 1980

FIG. 4

DEPARTMENT OF MINES AND ENERGY
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OLARY 1:250 000 SHEET

BOUGUER GRAVITY AND TOTAL MAGNETIC INTENSITY CONTOURS

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Deformation D_4 (north-south trending) and D_5 (east-west) both affect Adelaidean and Willyama Complex rocks, and are attributed to the Delamerian orogenic phase. Together they are responsible for the overall shape and distribution of, for example, the three Weekeroo Inliers (Encl. 3; refer particularly to the tectonic sketch) and Adelaidean rocks surrounding them. Mesocopic D_4 or D_5 features in the Willyama Complex are rare. The similarity of trends for D_3 and D_5 folds led Wiltshire (1975a, b) to erroneously conclude that the Mount Mulga D_3 synform (Encl. 2), actually an overturned anticline, was produced by D_5 folding during the Delamerian orogenic phase. In fact, the Mount Mulga synform and the Walparuta antiform are examples of coaxial D_3 and D_5 structures with Adelaidean and Willyama rocks separated by a D_5 folded fault and unconformity, respectively.
Adelaidean and younger rocks.

Structure and metamorphism of Adelaidean rocks is largely an expression of the Delamerian Orogeny of Ordovician age. Except near Anabama Granite, Adelaidean rocks are of biotite zone, greenschist facies of metamorphism.

The largest structural units within Adelaidean rocks are broad folds, such as the Ulupa Syncline, which have steep axes, generally trending east-northeasterly. The Anabama Fault is also parallel to these fold axes. The Adelaidean has been strongly affected by northwesterly-directed faults, such as the McDonald Shear Zone, which limit the southwestern edges of crystalline basement inliers.

With reference to Figure 3, region A is characterised by tightly folded and sheared metasediments and volcanics associated with lineaments parallel to, and just north of the Anabama Fault. South of "Mutooroo", Arnold (1971) recognised two phases of folding. Region B is covered by Anabama Granite. Gravity studies by Tucker (quoted by Gerdes, 1973, p. 16) suggest that the granite has a vertical southern contact, a 70 degrees north-dipping northern contact and an origin at about 20 km depth. Region C, the Wadnaminga Anticlinorium and Bulyninnie Anticline, contains tightly folded and partly fractured and brecciated sedimentary rocks largely of the Burra Group. Some anticlines show a similar style of folding, with attenuated limbs. Regions labelled D, typified by the Ulupa Syncline, are the least metamorphosed and structurally simplest. As on ORROROO (Binks, 1971) folds appear to be of parallel or cylindrical type. Region E is characterised by schist and hornfels which have suffered folding and recrystallisation in proximity to crystalline basement inliers. Foliation and folding appear to be directionally controlled by the edge of the crystalline basement. Tight, northerly-trending synclines are related to the D_4 deformation of Berry and others (1978) while stretched, easterly-oriented pebbles against the eastern sides of inliers are a result of D_5.

ECONOMIC GEOLOGY

The region contains varied mineralization, mainly related to the Willyama Complex, and has been investigated by a large number of exploration companies. Reviews have been provided by Campana and King, 1958, Blissett, 1975 and Pitt, 1978a. A total of 13 253 tonnes of oil drilling grade barite has been mined from Mount Mulga since 1962. Present rate is 1 500 tonnes per year. 18 507 tonnes of felspar were mined from pegmatites from 1932 to 1979 and 136 tonnes of associated beryl from 1941 to 1963.

Willyama Complex

Davidite, a complex iron-uranium titanate, was mined at Radium Hill from 1954 to 1961, when 954 000 tonnes of ore averaging 1.2 kg U_3O_8 per tonne were produced. Davidite was associated with steep shears in gneiss and amphibolite of the Willyama Complex. Davidite also occurs in the Mount Victoria, Spring Hill (CURNAMONA) and Mindamereeka prospects. Low grade uranium occurs at Crocker Well as absite (uranium-thorium titanate) with adamellite and pegmatite.

Approximately 6 000 tonnes of high-grade, secondary copper ore, including chalcocite, cuprite and carbonates, were obtained from the Mutooroo mine between 1887 and 1908. This was the major deposit for the region, associated with shear zones in an amphibolite body.

Stratiform cobaltiferous copper deposits and barite occur in association with bedded iron formation and calcsilicate rocks of the Willyama Complex. At the Ethiudna mines, scheelite and galena occur with chalcopyrite and oither minerals. Copper and barite occur at Walparuta (west-northwest of "Outalpa"), near Ameroo Hill and at Mount Mulga (southeast of "Old Boolcoomata"). This stratigraphic level, below the schist of Ameroo Hill, may approximate the mine sequence of the Broken Hill region. Some iron formations have been prospected as possible sources of iron ore. Small quantities of sillimanite, andalusite and kyanite have been mined in the past.

Pegmatites within the Willyama Complex are potential sources of potash and soda feldspar, with beryl and mica as minor accessories. Small deposits of fluorite were worked near "Plumbago" and "Mutooroo" and apatite near "Old Boolcoomata".

Adelaidean

Sedimentary martite and magnetite within the Yudnamutana Subgroup (Braemar ironstone facies) were investigated at Razorback Ridge (Whitten, 1970). Reserves of over 120 million tonnes averaging 26 per cent iron were proved but were considered uneconomic.

Delamerian

Gold associated with quartz veins drew many miners to the region between 1885 and 1900. The main fields were Mannahill (1885) where veins occur in Enorama Shale, Teetulpa (1886), mainly alluvial and with veins in Tapley Hill Formation, Olary (Kings Bluff) (1887), veins in Wilyerpa Formation, and Wadnaminga (1888), veins in Belair Subgroup. Total production estimates exceed 900 000 gm of gold. The gold and copper deposits of the Luxemburg and Queen Bee mines are associated with east-trending quartz veins and amphibolite bodies. A total of 5 300 gm of gold are recorded for the period from about 1887 to 1915.

Cainozoic

Sedimentary uranium has been found in uneconomic quantities in the Murray Basin by Tricentrol Aust. Ltd., Sedimentary Uranium NL and Mines Administration (e.g. Burns, 1980). Gamma-ray anomalies of low amplitude occur in lignite and carbonaceous clay in the middle and upper parts of Lower Miocene marine beds. An unfavourable feature of the area is the strong oxidation of beds above about 90 m depth.

Near Cutana (Whitten, 1964), there are small low grade deposits of concretionary pisolitic or fragmental ironstone of possible Tertiary age.

Groundwater supplies are generally poor and unreliable, with salinities from 370 to over 20 000 mg/l. Salinities in the

Murray Basin are over 9 000 mg/l and there are no artesian supplies (Safta and MacKenzie, 1978).

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TABLE 1 ADELAIDEAN STRATIGRAPHY

Age	Stratigraphic unit and symbol	Lithology	Thickness (m)	Remarks
Marinoan	Wilpena Group		(total 2 600+)	Equivalent to lower Farnell Group (Broken Hill) ?shallow marine.
	Wonoka Formation Pww	Flaggy limestone, siltstone, shale and brecciola (slump breccia)	60+	Top not exposed. Slump breccias incise Ulupa Siltstone.
	Ulupa Siltstone Bwu	Flaggy greenish siltstone and fine sandstone	2 500	Pyritic. Ripple marks, small scale cross bedding, load casts, slump structures.
	Seacliff Sandstone Bws Member of Brachina Formation	Brownish and grey quartzite, siltstone minor dolomite	40	Lateral equivalent of, and intertongues with, Nuccaleena Formation. Clay pellet cavities.
	Nuccaleena Formation Bwn	Flaggy to medium-bedded greyish orange dolomite rock.	10	Some finely sandy laminae.
	Umberatana Group		(total 7 200)	Equivalent to Torrowangee Group (Broken Hill)
	Yerelina Subgroup Be	Unnamed grey and greenish siltstone, sandstone, carbonate with dropstones.	400	Upper glacial sequence. Upper massive siltstone outcrops sometimes carry aboriginal carvings. Ripple marks. ?Shallow marine, glacial.
	Grampus Quartzite Beg	Medium to coarse-grained feldspathic	40	Lenticular. Cross-bedding, ripple marks, wavy bedding,

		quartzite.		slump structures, ?shallow marine.
	Pepuarta Tillite Bep	Calcitic and dolomitic grey siltstone, brown sandstone matrix with sparsely scattered metasedimentary and igneous clasts.	200	?Shallow marine to fluviatile.
	Gumbowie Arkose Member Beu (of the ?Pepuarta Tillite)	Medium-bedded quartzite, sandy siltstone, siltstone	50	Partly pebbly; fining-upwards of grain size. ?Fluviatile. Lenticular
	Farina Subgroup			?Marine.
	Enorama Shale Bfe	Greenish and grey laminated siltstone calcitic siltstone, fine-grained sand stone, minor lime-stone.	1 200	Upper transitional sandstones in southwestern Winnininnie. Sandy facies in central Yunta.
	Waukaringa Siltstone Bfk Member of the Tarcowie Siltstone	Grey laminated silt-stone, shale, limestone, dolomite, calcitic sandstone.	400	Difficult to differentiate from Enorama shale in some some areas.
	Tarcowie Siltstone Bfr	Grey laminated sandy siltstone, calcareous siltstone, quartzite, carbonates.	500	Wavy and lenticular bedding. ?Tidal.
Sturtian	Tapley Hill Formation Bft	Finely laminated grey siltstone, grey-green dolomite, fine sandstone.	1 800	Wide areas in central Winnininnie. Pyritic.
	Tindelpina Shale Bfd Member of the Tapley Hill	Dark finely laminated dolomite and siltstone.		

Fmn			
Wilyerpa Formation Buw	Green siltstone, quartzite, dolomite scattered erratics, lenticular pebble or boulder beds, limestone.	600	Glacial, correlated with Appila and Sturt Tillites. Erratics up to 1 m in diameter.
Appila Tillite Bua	Diamictite with reddish quartzite boulders.	500	Westernmost Winnininnie
	(UNCONFORMITY)		
Yudnamutana Subgroup Benda Siltstone Bye	Grey calcareous laminated siltstone, limestone, quartzite, rare dropstones, martite-rich silt-stone.	500	Contains upper part of Braemar ironstone facies. Small-scale cross-beds, ripple marks, graded bedding ?shallow marine or lacustrine. Possibly equivalent to Lyndhurst Formation.
Pualco Tillite Byp	Tillite, quartzite, siltstone, partly calcitic, dolomite; martitic siltstone and tillite.	1 000	Glaciomarine to ?lacustrine. Erratics up to 40 cm in diameter. Correlated with the Bolla Bollana Formation.

(UNCONFORMITY)

	Burra Group Belair Subgroup Bl	Grey flaggy silt-stone, sandy silt-stone, dolomite, quartzite, schist, pebbly sandstone.	(total 7 400) 1 600	?Tidal. Cross-bedding, ripple marks, slump structures.
Torrensian	Saddleworth Formation Bbs	Dark grey siltstone, dolomitic siltstone, dolomite, rare sand-stone.	2 600	?Marine. Best developed northeast from "Manunda".
	Cradock Quartzite Bbd	Fine-grained quart-zite, greenish silt-stone, slate, phyllite.	1 000+	Southeast of "Oulnina"
	Auburn Dolomite Bba	Grey siltstone, schist, pale dolomite, quartzite.	500	?Shallow marine. West of of "Outalpa".
	Skillogalee Dolomite Bbk	Grey dolomite, silt-stone, magnesite conglomerate, chert.	200	?Marine to lacustrine. With talc and tremolite in places.
	Aldgate Sandstone Equivalent Bbl	Conglomerate, hematitic arkose, pebbly sandstone, siltstone, schist.	400	?Fluviatile. Cross-bedding.
?Willouran	Boucaut Volcanics Bo	Pale reddish, grey rhyolite, dacite, trachyte; greenish andesite, basalt, schist.	700	Amygdaloidal extrusives and ?welded tuff. Age uncertain. Possibly equivalent to Wooltana Volcanics.
	Cutana Beds Bc	Quartzite, schist, sandstone, amphibole schist, ferruginous	400+	Cross-bedding, shale flakes.

			sandstone.		
Holocene		Qh1	Clay, evaporites		Lake deposits.
		Qh	Clay, sand, gravel	2	Alluvium of present creek channels and flood plains.
Pleistocene	Woorinen Formation	Qpo	Red-brown aeolian quartz sand with carbonate of Loveday Soil	3-6	East-west sand ridges; over Murray Basin.
		Qp	Red-brown silt and sand	1-5	Transitional between Qpo and and Qpp
	Pooraka Formation	Qpp	Red-brown clayey sand with gravel lenses and Loveday Soil carbonate	10	Alluvial. Large polygonal cracks north of "Oakvale". Overlain by reddish Callabonna Clay
		Qca	Calcrete of the Bakara Soil; calcreted older gravel	3	Older gravels may be Telford Gravel
	Blanchetown Clay	Qph	Partly red-mottled grey, green-grey and yellow clay, sandy clay.	80	Sometimes gypseous. Rare nodular limestone ?Bungunnia Limestone.
Tertiary		Cz fe	Ironstone	4	Near Cutana.
		Cz si	Silcrete, partly yellowish	2	Scattered minor occurrences, mainly in the east and southeast
		Tp	Yellowish medium-grained quartz sand, sandstone	60	Murray Basin subsurface and minor outcrop in the south-east ?Equivalent of Loxton Sand.

Tm	Partly fossiliferous carbonaceous clay.	90	Murray Basin subsurface. Early Miocene, marine.

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

LATE PROTEROZOIC (ADELAIDEAN)

ADELAIDEAN SYSTEM

Ɛuw — WILYERPA FORMATION thick basal quartzite overlain by siltstone

unconformity

STURTIAN — UMBERATANA GROUP

Ɛye — 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

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

Ɛyp₂ — Member 2 Massive, crossbedded quartzite

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

Ɛyo — OLD BOOLCOOMATA GRANITE CONGLOMERATE granite clast conglomerate, interpreted as a local talus derived from the Binberrie Granite, which it overlies unconformably or in faulted contact with all other Adelaidean units; stratigraphic position inferred by correlation to granite conglomerates in Ɛyp₃ and lower Ɛye units

unconformity

TORRENSIAN — BURRA GROUP

Ɛb₃ — (?) BELAIR SUBGROUP equivalent interlayered quartzite and siltstone

Ɛb₂ — (?) SADDLEWORTH FORMATION equivalent predominantly greenish-grey siltstone
(?) AUBURN DOLOMITE equivalent interbedded dolomite and siltstone, a prominent quartzite bed ("Wiagay Quartzite") marking the top

Ɛb₁ — 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

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

Ɛγ₁ — ANTRO GRANITE, TRIANGLE HILL GRANITE (Ɛγ₁) 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

Ɛγ₂₋₄ — Adamellitic to slightly granodioritic intrusive granitoids at Mooleugore Hill, Binberrie Hill (BINBERRIE GRANITE) and Tietz Dam (Ɛγ₂) poorly foliated and generally non-porphyritic, all regarded as parts of the same intrusive body
Adamellitic to slightly granodioritic granitoids at Nine Mile Gate (Ɛγ₃) and Blue Dam (Ɛγ₄) poorly foliated, generally non-porphyritic

Ɛp — 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. uraninite). 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 Boolcoomata" 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

ƐWγ₁ — Granodiorite gneiss, west of Meningie Well, also minor small gneissic granodiorite bodies

ƐWγ₂ — Lenticular, semiconcordant, magnetite-bearing adamellite and granodiorite at Percyhammuck Mine and Mt Muigo-Drew Hill respectively, interpreted as the same body despite the apparent compositional difference

ƐWγ₃ — Concordant to partly intrusive tonalite gneiss at Waiparata and Outalpa Springs, interpreted as the same body, disrupted by the Outalpa fault

PROTEROZOIC — EARLY PROTEROZOIC

METASEDIMENTS AND METAMORPHICS

"OLARY SEQUENCE"

schistose equivalents — gneissic equivalents — gneissic to migmatoid equivalents

ƐWs — Undifferentiated quartz-mica-plagioclase schist, minor quartzite

ƐWs₁ — Pelitic quartz-muscovite schist, with very coarse andalusite generally retrogressed to massive pinite which encloses crystals of blue corundum
ƐWg₁ — Not recorded

ƐWs₂ — Massive quartz-muscovite schist
ƐWg₂ — Not recorded

ƐWs₃ — Interlayered quartz-muscovite schist and quartz-muscovite-plagioclase quartzite in which sedimentary structures are often well preserved
ƐWg₃ — Layered quartz-plagioclase-biotite gneiss, migmatoid in places

ƐWs₄, **ƐWs₄g** — Pelitic quartz-muscovite schist with tourmaline, staurolite, chloritoid and retrogressed andalusite and chiastolite porphyroblasts. Knotted alumosilicate 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 (ƐWs₄g) and stratiform gossan horizon (g) near top or in base of ƐWs₃ unit, in some areas
ƐWg₄ — Pelitic gneiss, containing andalusite, sillimanite and, rarely, kyanite

ƐWs₅ — Interlayered schist and (often highly albitic) quartzite
ƐWg₅ — Layered psammitic-pelitic gneiss with iron formation and related horizons (f₁₋₃, a, q see below, "MARKER BEDS")

ƐWg — Massive homogeneous tonalite gneiss, conformable with adjacent schist sequence, probable non-mobilised equivalent of ƐWγ₃ (see Rock Relation Diagram), underlain by ƐWc and ƐWf units (see gneissic to migmatoid equivalents)
ƐWq (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

ƐWb — Coarse-grained semipelitic biotite gneiss, minor interlayered quartz-plagioclase gneiss

ƐWc,f

Gneissic to migmatoid equivalents:

ƐWc — Undifferentiated complex gneiss terrain incorporating and/or equivalent to other gneiss units

ƐWb — Semipelitic migmatite gneiss with characteristic steel grey biotitic melanosome schlieren in a quartzo-feldspathic leucosomal matrix

ƐWf (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 (ƐWb lithology) present but not mapped individually, rare concordant gneissic amphibolites in some areas

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

ƐWm — Layered migmatitic biotite gneiss, forming a contact zone around ƐWγ₃ and developed in ƐWg₅ and ƐWs₄

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

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

GNEISS UNITS OF UNCERTAIN STRATIGRAPHIC RELATIONSHIP

ƐWl — Layered quartzite and quartz-plagioclase leucogneiss

ƐWi — Layered, often migmatoid, quartz-plagioclase-biotite gneiss. ƐWi and ƐWl units appear to correlate with ƐWs₃ on the basis of regional relationships

FIG. 3

DEPARTMENT OF MINES AND ENERGY – SOUTH AUSTRALIA

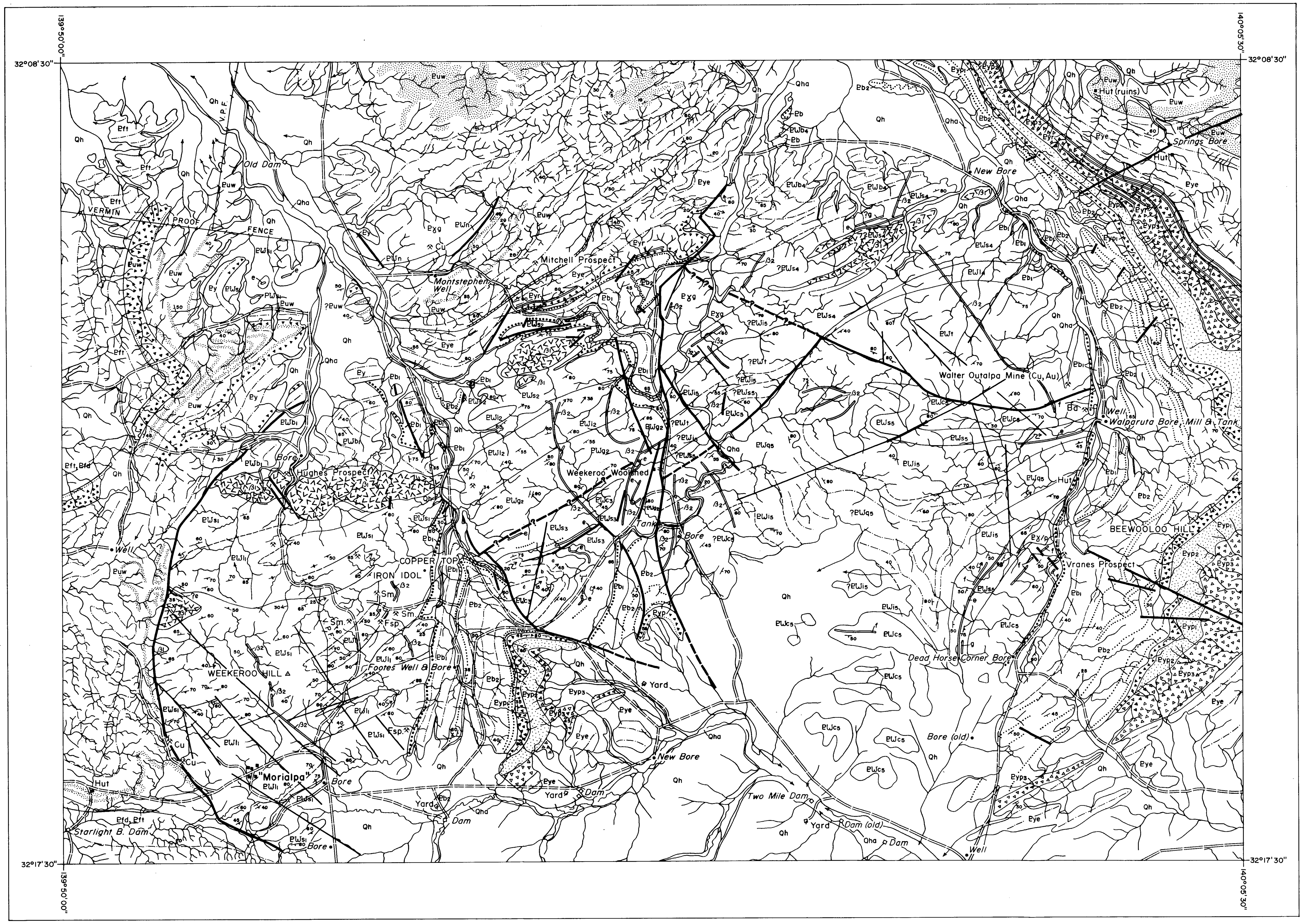
OLARY 1:250 000 SHEET

STRUCTURAL FEATURES

DIRECTOR GENERAL	COMPILED: B.G Forbes	DRN: M.R.	SCALE: As shown
		CKD:	DATE: July 1980

PLAN NUMBER 80-482

2078



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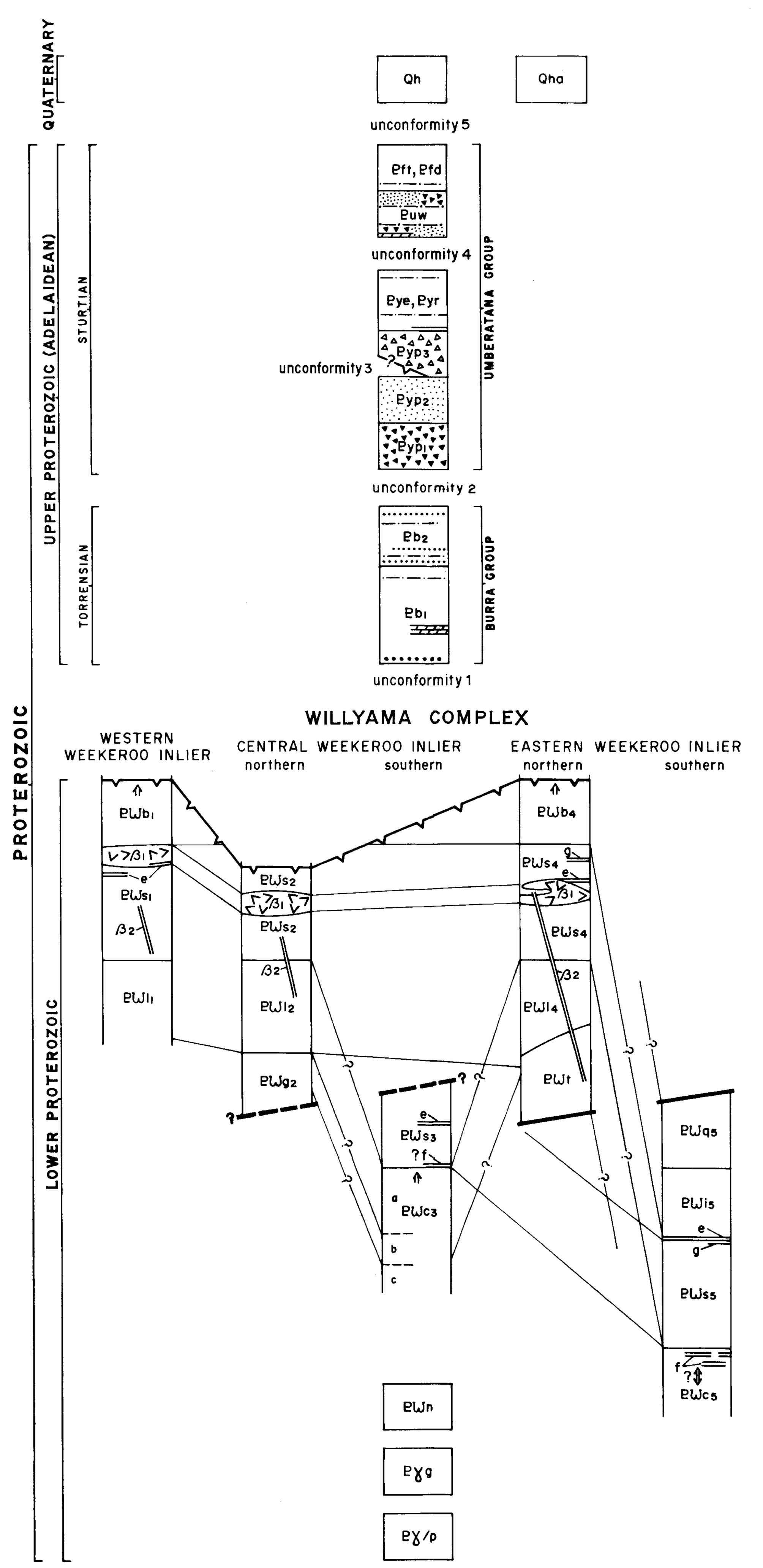


Note: Willyama Complex legend takes the form of a diagram showing interpreted correlations between columns representing stratigraphies of each block or sub-block.

Qh: undifferentiated surficial units

Qha: creek-bed alluvium.

UMBERATANA GROUP

FARINA SUBGROUP

Eft: Tapley Hill Formation, Efd: Tindelpina Shale Member.

Euw: Wilyerpa Formation: quartzite, siltstone, tillite, dolomite.

YUDNAMUTANA SUBGROUP

Eye: Benda Siltstone: metasiltstone, minor diamictic layers. Thin, multiple layers of Braemar Iron Formation (Eyr) at base: hematitic siltstone minor grey, pebbly dolomite

Eyp: Pualco Tillite; Eyp3: Member 3: diamictite, with crystalline basement clasts, greywacke matrix.

Eyp2: Member 2: massive crossbedded quartzite.

Eyp1: Member 1: diamictite with Burra Group and crystalline basement clasts in a quartzite matrix.

BURRA GROUP

Eb2: Unit 2 (?) BELAIR SUBGROUP equivalent: quartzite, siltstone.
(?).Saddleworth Formation eqivalent green-grey siltstone, prominent quartzite at base

Eb1: Unit 1 (?) Auburn Dolomite equivalent: dolomite, siltstone. Skillogalee Dolomite: dolomitic marble, sedimentary magnesite and intraformational breccias Host to galena veins at Vranes Prospect.
Aldgate Sandstone equivalent: basal conglomerate with overlying silty sandstone and greywacke.

WILLYAMA COMPLEX

β_2: amphibolite (metadolerite) dykes

EWb1,4: bedded quartzite, quartz-muscovite schist

EWq5: massive to well-layered quartzite and feldspathic quartzite.

EWi5: interlayered, well layered, quartz-feldspar gneiss and biotite gneiss, migmatitic in part.

β_1: "Weekeroo amphibolites", interpreted as metamorphosed basaltic volcanic plug(s) possibly subaqueous extrusive in part.

EWs1: aluminous muscovite schist in the north, grading south to higher grade, knotted aluminous schist of the EWs5 and EWs3 type.

EWs2: muscovite schist with retrograde andalusite

EWs3: knotted, aluminous, pegmatoid schist, minor calc-silicate horizon (e).

EWs4: muscovite schist, graphitic schist (g) and garnet marble (e) near top.

EWs5: knotted aluminous schist, with graphitic schist (g) and marble-calcsilicate horizon (e) near and at top.

EWl1,2,4: well-layered quartz-feldspar gneiss and biotitic schist interlayers, minor quartz-feldspar gneiss with magnetitic laminae at top.

EWc3a: feldspar-quartz gneiss, with fine, crossbedded magnetitic laminae.

EWc3b: layered migmatitic gneiss

EWc3c: poorly layered aplitic to granitic gneiss (? ≡ to EWg2).

EWc5: massive albitic and quartz-albite gneiss with fine, crossbedded magnetitic laminae, coarse disseminated magnetite, barite-iron formations (f), minor layered migmatite gneiss.

EWg2: quartz-plagioclase granitic gneiss.

EWt: quartz-plagioclase tonalite gneiss.

EWn: undifferentiated gneiss and schist.

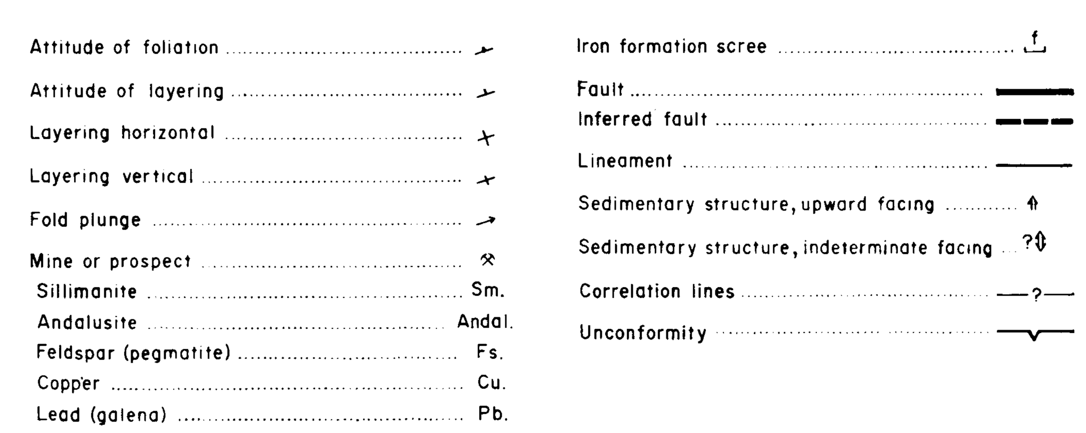
Eγg: gneissic granitoids

Eγ/p: granitoid-pegmatoid intrusives.

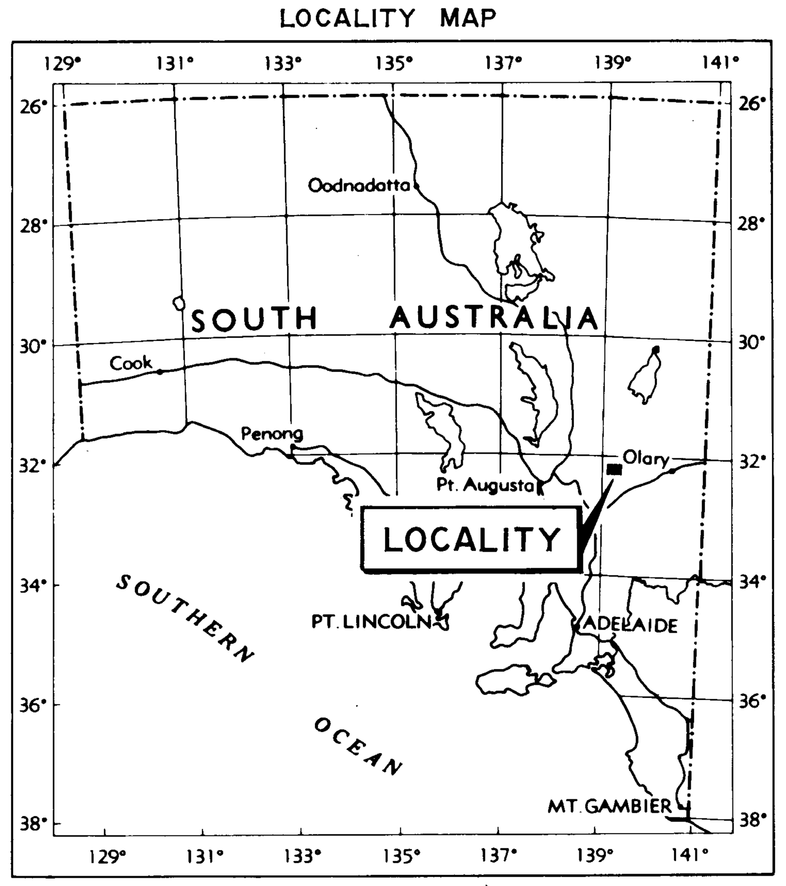
f: iron formation.

e: calcsilicate rocks.

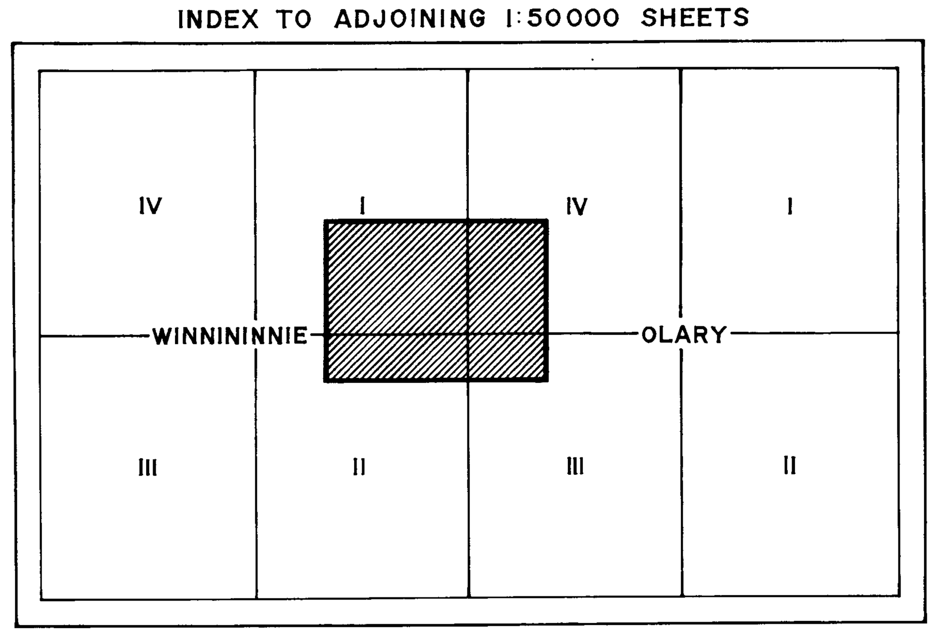
g: graphitic schist.



LOCALITY MAP



INDEX TO ADJOINING 1:50000 SHEETS



SCALE
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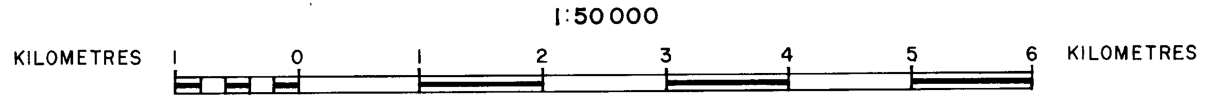
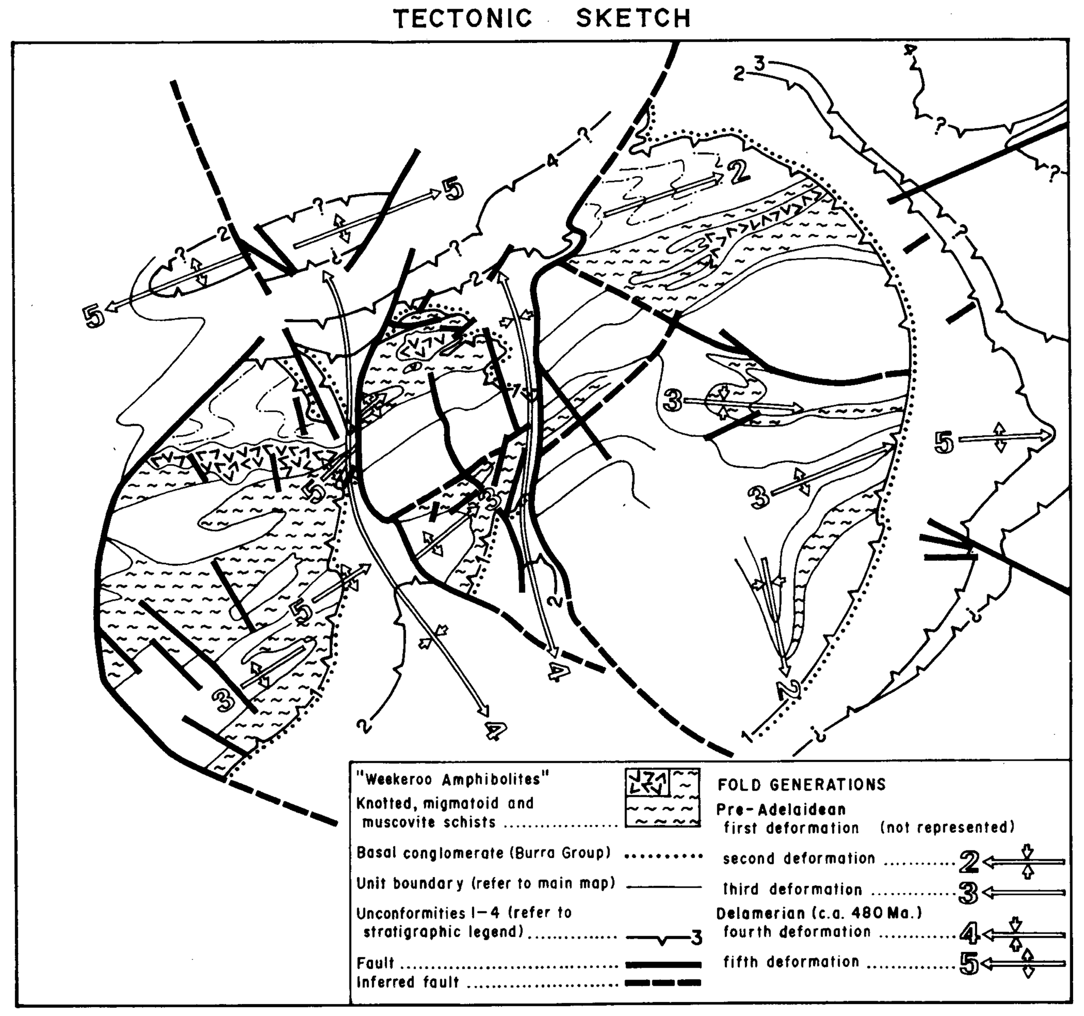


TECTONIC SKETCH

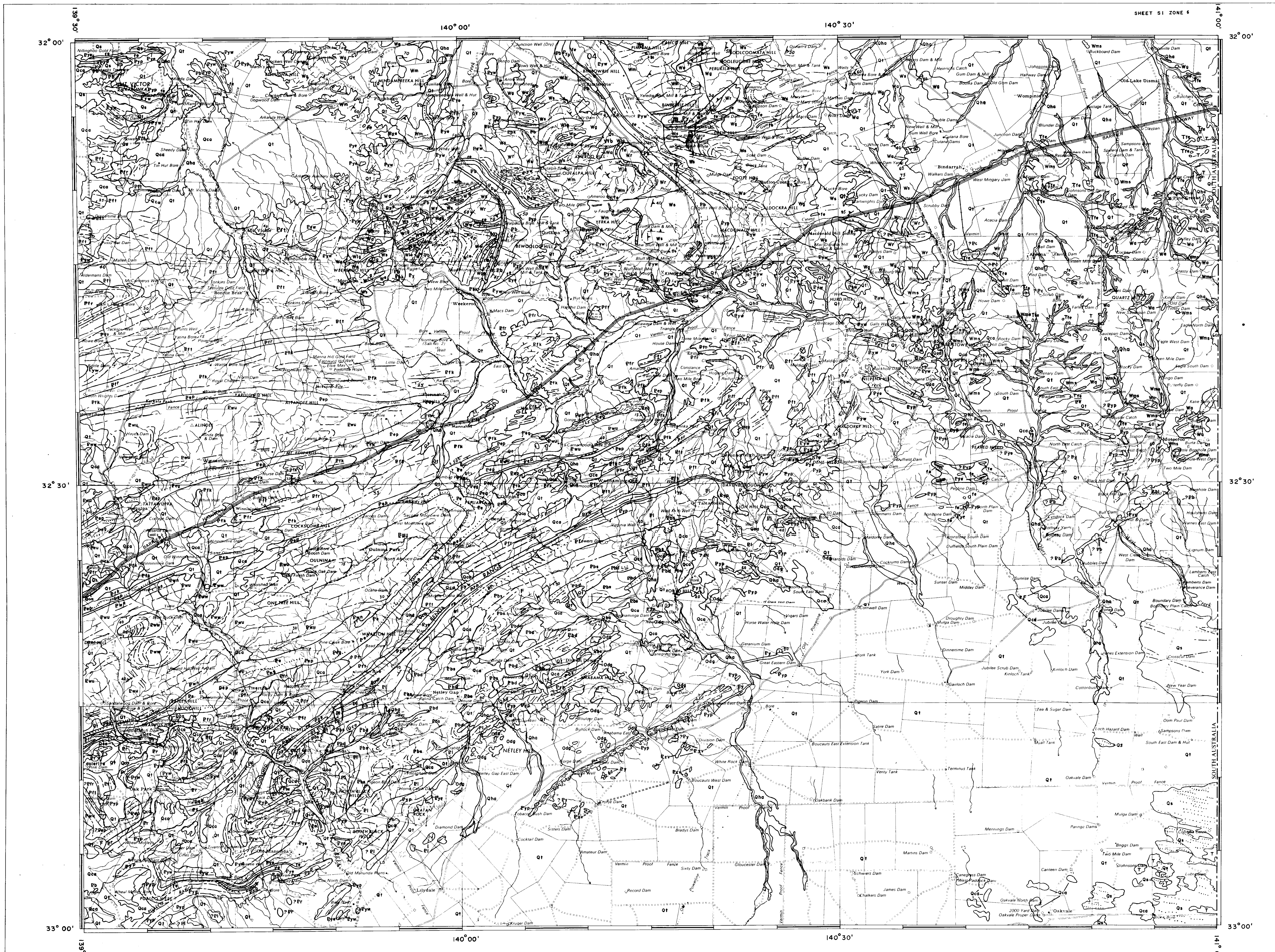


DEPARTMENT OF MINES AND ENERGY- SOUTH AUSTRALIA			
GEOLOGICAL MAP OF THE WEEKEROO INLIERS			
COMPILED G.M. PITT	DRN J.R.	SCALE 1:50000	PLAN NUMBER
DIRECTOR GENERAL	CKD	DATE 9-5-79	79-357

OLARY

GEOLOGICAL SURVEY OF SOUTH AUSTRALIA
DEPARTMENT OF MINES ADELAIDE

AUSTRALIA 1:250,000



REFERENCE

CAINOZOIC	QUATERNARY (PLEISTOCENE / HOLOCENE)	Qha	Holocene stream channel deposits
		Qt	Quaternary gravel and soil overlay frequently underlain by POORAKA FORMATION
		Qs	Reddish quartz sand of dunes and sand spread
		Qca	Pleistocene calcrete and calcreted gravels (? TELFORD GRAVEL)
	TERTIARY	T	Tertiary silcrete and associated sandstone, mainly in the south – east
		Tfe	Ironstone
PALAEOZOIC		Odg	ANABAMA GRANITE and associated quartz – muscovite rock (greisen) and other intrusives (DELAMERIAN)
		Pzv	? Palaeozoic rhyolite and melaphyre, partly schistose, south of "Mutooroo" and north – east of "Lilydale"
PRE – CAMBRIAN (ADELAIDEAN)	MARINOAN (WILPENA GROUP)	Pww	WONOKA FORMATION: Limestone, siltstone
		Pwu	ULUPA SILTSTONE
		Pwn	NUCCALEENA FORMATION: (Dolomite) intertonguing with sandstone (? SEACLIFF SANDSTONE)
	MARINOAN	Pe	Sandstone, siltstone with dropstones
		Peg	GRAMPUS QUARTZITE
		Pep	PEPUARTA TILLITE
		Peu	GUMBOWIE ARKOSE
	STURTIAN (UMBERATANA GROUP; Pf FARINA SUB-GROUP)	Pfk	WAUKARINGA SILTSTONE
		Pfr	TARCOWIE SILTSTONE
		Pft	TAPLEY HILL FORMATION
		Pyw	WILYERPA FORMATION
			Unconformity
	Py	Pye (fe)	BENDA SILTSTONE; Ironstone
		Pyp	PUALCO TILLITE
			Unconformity
	TORRENSIAN (BURRA GROUP)	Pl	Sandstone, siltstone
	Pb	Pbs	? SADDLEWORTH FORMATION: Siltstone, Dolomite
		Pbd	? CRADOCK QUARTZITE
		Pbk	? SKILLOGALEE DOLOMITE
		Pr	Quartzite, siltstone
		Pbl	? ALDGATE SANDSTONE
		?Pc	"Cutana Beds", sandstone, siltstone, age uncertain

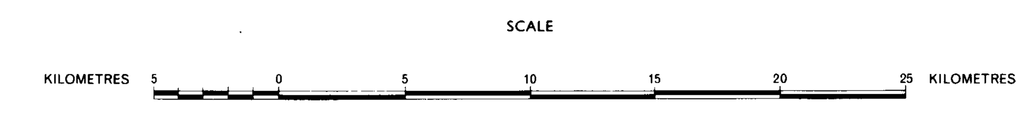
CRYSTALLINE BASEMENT
WILLYAMA COMPLEX

Wa	Amphibolite
Wm	Migmatite
Wg	Anatectic granite, "Luxemburg Granite"
Wr	Foliated granodiorite
Wb	Bedded schist
Ws	Schist, gneiss
Wlg	Layered gneiss
Wgg	Granitoid gneiss
Ww	"Walparuta Schist"
Wlo	Leucogneiss and lower beds
Wms	Gneiss, schist of Mutooroo region
(bar)	Calcsilicate rock
(bar) fe	Ironstone
(hatched)	Crushed, disturbed rocks, possibly in part WILLOURAN

INDEX TO ADJOINING SHEETS

PARACHILNA	CURNAMONA	N.S.W.
ORRORQO	OLARY	
BURRA	CHOWILLA	

SCALE



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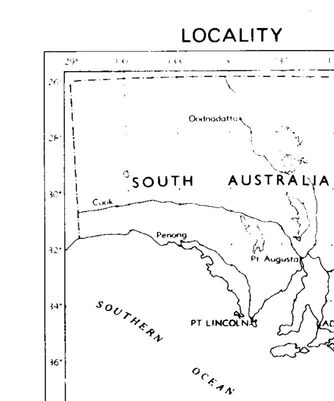

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