1:250 000 GEOLOGICAL SERIES—EXPLANATORY NOTES

# MOUNT ANDERSON

## WESTERN AUSTRALIA


SHEET SE/51-11 INTERNATIONAL INDEX

DEPARTMENT OF NATIONAL DEVELOPMENT & ENERGY
BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

DEPARTMENT OF MINES, WESTERN AUSTRALIA
GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

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# MOUNT ANDERSON
## (Second Edition)

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COMPILED BY D. L. GIBSON and R. W. A. CROWE

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# Explanatory Notes on the Mount Anderson Geological Sheet (Second Edition)

*Compiled by D. L. Gibson and R. W. A. Crowe**

The Mount Anderson 1:250 000 Sheet area lies in the northern part of the Canning Basin, and is bounded by latitudes 18° and 19°S, and longitudes 123° and 124°30′E. The Sheet area was originally mapped by the Bureau of Mineral Resources (BMR) in the period 1948–52, during a survey of the northern part of the Canning Basin, and a 4-mile geological map and explanatory notes (Casey, 1958b) were published.

The area was re-mapped by a combined BMR/Geological Survey of Western Australia (GSWA) field party in 1976 (Crowe & others, 1978) as part of a program to map the entire Canning Basin at 1:250 000 scale. These explanatory notes are based on this mapping, and supersede those of Casey (1958b).

There are no towns in the Sheet area. Looma Aboriginal settlement and the homesteads of Liveringa, Myroodah, Luluigui, Nerrima, Mount Anderson, Mowla Bluff, and Dampier Downs are the only centres of permanent habitation. Ardjorie Station had been abandoned several years before 1976, the year in which field work was undertaken for this map and Notes.

Access within the Sheet area is by formed gravel roads, which connect with the Great Northern Highway to the north, and station tracks in the northern part of the area. Many of the old petroleum exploration tracks in the southern part of the area are impassable; many station tracks are suitable only for four-wheel drive or heavy vehicles, and most are impassable during the wet season. Some of the stations have light aircraft landing strips, but there are no regular air services.

The area has a hot, dry, monsoonal climate. Most of the rain falls between December and March; the average annual rainfall is about 500 mm in the north and 350 mm in the south of the Sheet area. Average maximum and minimum temperatures in January are 38° and 24°C, and in June 27°C and 10°C. Mild frosts may occur in the winter (Commonwealth Statistician, 1973).

Dense stands of eucalypts and melaleucas border major watercourses, but elsewhere, vegetation mainly consists of open woodlands of spinifex, coarse grasses, and pindan wattle.

*History of investigations*

*Geological.* Hardman (1884, 1885) made the first recorded geological observations in the general area of the Mount Anderson Sheet area during a regional survey of the Fitzroy Valley. Jack (1906) summarised the availability of artesian water for newly developed pastoral stations in the area, and described springs and artesian bores in the northern part of the Sheet area. Woodward (1915) described coal from a drillhole located about 8 km north of the Sheet area on Mount Anderson Station.

The discovery of traces of oil at Prices Creek to the east of the Sheet area in 1918 (see Waterford, 1941) led to increased interest in the area. Blatchford and Talbot (Blatchford 1922, 1927) mapped part of the district, and an oil

* Geological Survey of Western Australia.

well was drilled near Mount Wynne in 1922. Gas and asphalt traces found in the Mount Wynne well were analysed by Simpson (1923).

Clapp (1925, 1926a) traversed south from the Edgar Ranges, and Forman (1930) and Hobson (1936) summarised previous investigations and the petroleum prospects of the area. Woolnough (1933) carried out an aerial survey of an area around the Edgar Ranges and Nerrima homestead.

Wade (1924, 1936, 1938) made a detailed study of the area to assess its petroleum potential, and select drill-sites for the Freney Kimberley Oil Company. Subsequently, Nerrima No. 1 well was drilled in 1939–41 (Waterford, 1941). Kraus (1941, 1942), Reeves (1949), and Findlay (1942) made geological surveys in and around the area for Caltex (Australia) Oil Development Pty Ltd, and Smith (1951) summarised oil possibilities for Ampol Petroleum Ltd. Geologists from West Australian Petroleum Pty Ltd (WAPET) carried out studies of the Fenton Fault (Williams & McKellar, 1958) and the Edgar Ranges (Smith & Williams, 1955).

BMR carried out a systematic survey of the area in 1948–52. Geological results were recorded by Guppy & others (1950, 1952, 1958), Brunnschweiler (1954), and Veevers & Wells (1961). The results of stratigraphic drilling (Jurgurra Creek No. 1) are given by Henderson & others (1963). Explanatory Notes and accompanying 4-mile geological sheets were produced for Derby (Casey, 1958a), Mount Anderson (Casey, 1958b), and Noonkanbah (Thomas, 1958b) Sheet areas.

Exploration for coal in the area began in 1966 when Premier Mining Pty Ltd (Premier) and Theiss Brothers Pty Ltd (Theiss) carried out drilling programs to test the coal potential of the Liveringa Group. Coal intersected in these surveys (Baarda, 1967; Pickering, 1967, 1968) was considered subeconomic. In 1974, Dampier Mining Co. Ltd drilled two holes in the Mount Anderson Sheet area and a further seven holes along the boundary with the Noonkanbah Sheet area in the McLarty Syncline area (Dampier Mining, 1975). Dampier's exploration project was continuing at the time of writing.

The Sheet areas adjoining the Mount Anderson 1:250 000 Sheet area were re-mapped by geologists of BMR and GSWA in 1974 (Noonkanbah—Crowe & Towner, 1981), 1976 (Derby—Towner, 1982a) and 1977 (La Grange—Gibson, in prep. b; McLarty Hills—Gibson, 1982) as part of a program to remap the Canning Basin at 1:250 000 scale.

Fossils in and around the Sheet area have been described by many workers: Nicholson (1890), Hinde (1890), and Foord (1890) described fossils collected by Hardman (1884, 1885); Etheridge (1918) and Glauert (1910) described fossils collected by Jack (1906) and Woodward (1915); Chapman (1924a, b) described fossils collected by Blatchford and Talbot (Blatchford 1922, 1927); Prendergast (1935, 1943) described Upper Palaeozoic fossils, including brachiopods; and Miller (1936), Teichert (1942b), and Glenister & Furnish (1961) described some ammonoids. Permian corals were described by Hill (1937, 1943), and Permian Bryozoa were described by Crockford (1944a, b, c, 1951, 1957) and Beattie (1953a, b). Marine (mainly Permian) shelly fossils have been described by Hosking (1931), Fletcher (1946), Teichert (1951), Thomas (1954, 1958a, 1971), Dickins (1958, 1963), Dickins & others (1977), and Coleman (1957). Teichert (1941b, 1942a) and Brunnschweiler (1954, 1960) described Jurassic shelly fossils.

Vertebrates have been described by McKenzie (1961) and Cosgriff (1965, 1969, 1974). Microflora has been studied by Balme (1955a, b, 1956a, b, c, d, e, 1962a, b, 1964), and plant fossils have been described by Walkom (1921), White (1957, 1958), Balme (1963), and White & Yeates (1976). Crespin made many micropaleontological studies and these are summarised in Crespin (1947a, 1956a, 1958).

In addition to the works listed above, many palaeontological reports appear as appendixes in petroleum exploration well completion reports (see Table 2 for a list of wells and references).

Syntheses of the geology of the Sheet area have appeared in McWhae & others (1958), Veevers & Wells (1961), Playford & others (1975), and Gorter & others (1979).

*Geophysical.* Many geophysical surveys have been carried out in the Mount Anderson Sheet area by petroleum exploration companies and by BMR. Most of these surveys are listed in Table 1, and the more important ones are mentioned below.

*Gravity.* The first geophysical surveys in the area were gravity and seismic surveys of the Nerrima anticlinal structure carried out by BMR in 1952 (Wiebenga & van der Linden, 1953; Vale & others, 1953). These surveys showed that a deep basin, not a dome, exists beneath the surface anticline. The gravity surveys also indicated that the Fenton Fault System was a normal fault, and that the throw of the fault decreased to the northwest.

BMR conducted several other gravity surveys in the Sheet area between 1953 and 1962, as reported by Flavelle & Goodspeed (1962) and Flavelle (1974). A regional gravity survey carried out by Ray Geophysics for WAPET in 1956 is mentioned in some later geophysical reports (e.g. French Petroleum, 1967) but no reference for the original work is available. A gravity survey on the Jurgurra Terrace (results are reported in WAPET, 1963b) followed.

In 1967, French Petroleum carried out the Jarmura gravity survey of the Broome Arch (French Petroleum, 1967), and a combined gravity and seismic survey of part of the Edgar Ranges area (French Petroleum, 1968).

The gravity surveys have delineated the major structural features of the Canning Basin, and provided estimates of the depth to basement. Some small gravity anomalies have been followed up by seismic work, with varying degrees of success.

*Magnetics.* The first aeromagnetic survey involving the Mount Anderson Sheet area was a BMR reconnaissance survey in 1954 (Quilty, 1960). WAPET carried out aeromagnetic reconnaissance over the coastal third of the Canning Basin in 1955; this work was combined with further work in 1962–63 and published under the Petroleum Search Subsidy Acts (WAPET, 1966a). These aerial surveys delineated the main structural elements of the Canning Basin, provided estimates of depth to basement, and gave limited information on the basement lithology.

*Seismic.* Early seismic work was carried out by BMR in 1952 (Vale & others, 1953) in conjunction with gravity surveys in the area. WAPET commenced a seismic study of the Jurgurra Terrace in 1953; a seismic line across the Fenton Fault System at Geegully Creek (reported by Vale & Smith, 1959) indicated that the Fenton Fault could have some local reverse-movement in that area. BMR carried out seismic surveys in the Sheet area in 1954 and 1955 (Williams, 1955; Vale & Smith, 1959). These surveys showed that the Deep Well Anticline becomes

TABLE 1. GEOPHYSICAL SURVEYS IN THE MOUNT ANDERSON 1:250 000 SHEET AREA

| *Year* | *Name of Survey* | *Survey type* | *Company* | *Principal reference* |
|---|---|---|---|---|
| 1952 | Nerrima Dome | Detailed seismic | BMR | Vale & others (1953) |
| 1952 | Nerrima Structure | Detailed gravity | BMR | Wiebenga & van der Linden (1953) |
| 1952–62 | Fitzroy and Canning Basins | Gravity | BMR | Flavelle & Goodspeed (1962), Flavelle (1974) |
| 1953 | Jurgurra | Seismic | WAPET | WAPET (1953). See also Vale & Smith (1959) |
| 1954 | Deep Well Anticline | Seismic | BMR | Williams (1955) |
| 1954 | Canning Basin | Aeromagnetic | BMR | Quilty (1960) |
| 1955 | Fenton Fault | Seismic | BMR | Vale & Smith (1959) |
| 1955 | Canning Basin | Aeromagnetic | WAPET | WAPET (1966a) |
| 1956 | Roebuck East | Seismic | WAPET | WAPET (1956a) |
| 1956 | Jurgurra Creek | Seismic refraction | WAPET | WAPET (1957a) |
| 1956 | Frome Rocks | Seismic | WAPET | WAPET (1958) |
| 1956 | Not known | Gravity | WAPET | Mentioned in French Petroleum (1967) |
| 1958 | Fenton | Reconn-seismic refraction | WAPET | WAPET (1959a) |
| 1958 | Frome Rocks | Seismic | WAPET | WAPET (1959b) |
| 1959 | Dampier Downs, Roebuck Bay East, Townshend | Reconn-seismic | WAPET | WAPET (1959c) |
| 1959 | Broome Platform, McHugh | Seismic | WAPET | WAPET (1960a) |
| 1959–60 | Dampier Fault* | Seismic | WAPET | WAPET (1962a) |
| 1959–60 | Blue Hills-Logue* | Seismic | WAPET | WAPET (1962b) |
| 1960 | Edgar | Seismic | WAPET | WAPET (1960b) |
| 1960 | Camelgooda, Jarlemai, Babrongan | Seismic | WAPET | WAPET (1961a) |
| 1961 | Jarlemai South detail Babrongan South detail | Seismic | WAPET | WAPET (1961b) |
| 1962–63 | South Canning* | Aeromagnetic | WAPET | WAPET (1966a) |
| 1963 | Goorda-Logue* | Seismic | WAPET | WAPET (1964a) |
| 1962 | Jurgurra Terrace | Gravity | WAPET | WAPET (1963b) |
| 1964-5 | St Georges Range* | Seismic | Continental | Continental (1964) |
| 1965 | Mowla* | Seismic | WAPET | WAPET (1965) |
| 1966–67 | Lower Fitzroy* | Seismic/Magnetic | Gewerkschaft Elwerath Inc. | Gewerkschaft Elwerath (1966) |
| 1967 | Jarmura* | Gravity | French Petroleum | French Petroleum (1967) |
| 1967 | McLarty* | Seismic/Gravity | French Petroleum | French Petroleum (1968) |
| 1969 | Jurgurra Terrace* | Seismic | WAPET | WAPET (1969) |
| 1969 | Matches Springs* | Seismic | Total | Total (1970b) |
| 1970 | Oscar* | Seismic | WAPET | WAPET (1971a) |
| 1971 | North Broome-Samphire* | Seismic | WAPET | WAPET (1971b) |
| 1971 | North Broome Detail* | Seismic | WAPET | WAPET (1971c) |
| 1972 | Liveringa Ridge* | Seismic | WAPET | WAPET (1972a) |
| 1972 | East Canning* | Seismic | WAPET | WAPET (1972b) |
| 1972 | Dampier Downs-Collins* | Seismic | WAPET | WAPET (1972c) |
| 1972 | North Broome D-2* | Seismic | WAPET | WAPET (1972d) |
| 1973 | Liveringa 2* | Seismic | WAPET | WAPET (1973a) |
| 1973 | Collins 2* | Seismic | WAPET | WAPET (1973b) |
| 1973 | Doran* | Seismic | WAPET | WAPET (1974) |

* Surveys subsidised under the Petroleum Search Subsidy Acts.

more pronounced at depth, and that the Fenton Fault System at Barnes Flow is normal, with a basement throw of at least 3000 m.

WAPET continued its survey of the Jurgurra Terrace in 1956 with the Roebuck East, Jurgurra Creek, and Frome Rocks surveys in the area west of Geegully Creek (WAPET 1956a, 1957a, 1958). The reports of these surveys are not generally available, but summaries in later reports filed with the BMR indicate that the Frome Rocks, Babrongan, and Clanmeyer structures were recognised. Further seismic work in 1958 (WAPET, 1959b) added to the knowledge of the Frome Rocks structure. WAPET then carried out the Fenton Project, a large scale reconnaissance refraction survey on Jurgurra Terrace (WAPET, 1959a) that broadly defined several structural basement anomalies. This survey was followed by the Dampier Fault (also known as Edgar) and Blue Hills-Logue detailed seismic surveys in 1959–60 (WAPET, 1962a, 1962b) and several pre-Permian anticlines, including the Jarlemai Anticline, were delineated on the Jurgurra Terrace.

The Dampier Downs, Roebuck Bay East and Townshend surveys (WAPET, 1959c) and the Broome Platform and McHugh surveys (WAPET, 1960a) also mapped out several positive structural leads. The Camelgooda, Jarlemai, and Babrongan surveys (WAPET, 1961a) and the Jarlemai South and Babrongan South surveys (WAPET, 1961b) showed that there is closure independent of faulting on the Babrongan Anticline, but not on the Jarlemai Anticline. The Goorda-Logue survey (WAPET, 1964a) provided additional information on the Logue, Frome Rocks, and Doran Structures. The Mowla survey of 1965 (WAPET, 1965) was a detailed project designed to locate new closures on the Jurgurra Terrace; however, none were found.

The McLarty survey (French Petroleum, 1968) was the first major seismic survey to be carried out by a company other than WAPET in the Sheet area. This survey indicated a possible anticlinal structure in the Edgar Range area, which was subsequently drilled by Total Exploration Australia Pty Ltd (Total Edgar Range 1).

WAPET continued its seismic work on the Jurgurra Terrace with two lines across the Doran and Logue structures (WAPET, 1969). Data quality from this survey was slightly better than from earlier surveys. The Matches Springs survey (Total, 1969) showed that the Edgar Range Anticline persists at depth. The survey also indicated another structure, which was subsequently drilled (Total Matches Springs 1). The Oscar survey of 1970 (WAPET, 1971a) was carried out mainly to the north of the Sheet area, but a tie line south to the Jurgurra Terrace revealed a promising area on the transition zone between the Fitzroy Trough and the Jurgurra Terrace, northeast of the Frome Rocks area. This survey was followed up by the Liveringa Ridge (WAPET, 1972a) and Liveringa 2 (WAPET, 1973a) surveys, which mapped several closed structures in this area.

Meanwhile, WAPET (1972c) carried out the regional Dampier Downs-Collins reflection surveys on the Jurgurra Terrace and Broome Arch. These added information on structures in the area, but the quality of the data was poor. The Doran seismic survey of 1973 (WAPET, 1974) detailed the Doran Structure, and a drillhole site was proposed, but was not followed up. The Collins 2 seismic survey of 1973 (WAPET, 1973b) showed that Matches Springs 1 was not drilled in the optimum location on the Matches Springs Structure, but that more seismic control would be needed before any re-drilling was attempted. It was also considered doubtful that a maximum effort program would lead to better data.

TABLE 2. SUMMARY OF DEEP WELLS IN MOUNT ANDERSON 1:250 000 SHEET AREA

| *Well* | *Operator* | *Location* | *Year drilled* | *Total depth (m)* | *Hydrocarbon shows* | *Principal reference* |
|---|---|---|---|---|---|---|
| Babrongan 1* | WAPET | 18°23′23″S 123°35′37″E | 1962 | 1949 | Gas—Grant Group Bitumen—Clanmeyer Siltstone | WAPET (1966b) |
| Dampier Downs 1 | WAPET | 18°18′00″S 123°06′00″E | 1956 | 923 | | WAPET (1957b) |
| Doran 1* | WAPET | 18°10′56″S 123°29′06″E | 1968 | 763 | Bitumen—Betty Formation | WAPET (1968a) |
| Edgar Range 1* | Total | 18°45′26″S 123°35′33″E | 1968 | 1968 | Free Oil—Nita Formation Gas show—Nambeet Formation | Total (1968) |
| Frome Rocks 1* | WAPET | 18°11′48″S 123°38′42″E | 1959 | 1219 | | WAPET (1962c) |
| Frome Rocks 2* | WAPET | 18°15′15″S 123°39′35″E | 1959 | 2287 | Traces of oil—Gumhole and Luluigui Formations | WAPET (1962c) |
| Grant Range 1 | WAPET | 18°01′00″S 124°00′22″E | 1954–1955 | 3936 | Bitumen, fetid gas, fluorescence—Anderson Formation | WAPET (1956b) |
| Jurgurra Creek 1 | BMR | 18°20′04″S 123°43′05″E | 1955 | 512 | | Henderson & others (1963) |
| Logue 1* | WAPET | 18°07′33″S 123°23′24″E | 1968 | 2699 | Oil stain and methane—Betty Formation | WAPET (1971d) |
| Matches Springs 1* | Total | 18°41′28″S 124°03′11″E | 1969 | 2834 | Fluorescence—Nita Formation | Total (1970b) |
| Mount Wynne 1 | Freney Oil | 18°06′00″S 124°27′00″E | 1922–1923 | 273 | Bitumen—Carolyn Formation | Blatchford (1927) |
| Mount Wynne 3 | Freney Oil | 18°06′00″S 124°27′00″E | 1923–1925 | 657 | Oil globules and bitumen—Grant Group | Blatchford (1927) |
| Mowla 1* | Total | 18°43′50″S 123°42′35″E | 1969 | 762 | | Total (1969) |
| Myroodah 1 | Associated Freney Oilfields | 18°16′30″S 124°11′27″E | 1955–1956 | 1829 | | AFO (1956) |
| Nerrima 1 | Associated Freney Oilfields | 18°26′55″S 124°22′17″E | 1955 | 2765 | Bitumen and dead oil stain—Grant Group | AFO (1955) |
| Nerrima 1 | Freney Kimberley Oil | 18°28′16″S 124°24′02″E | 1939–1941 | 1302 | Slight gas shows—Poole Sandstone | Reeves (1949) |

* Subsidised under the Petroleum Search Subsidy Acts.

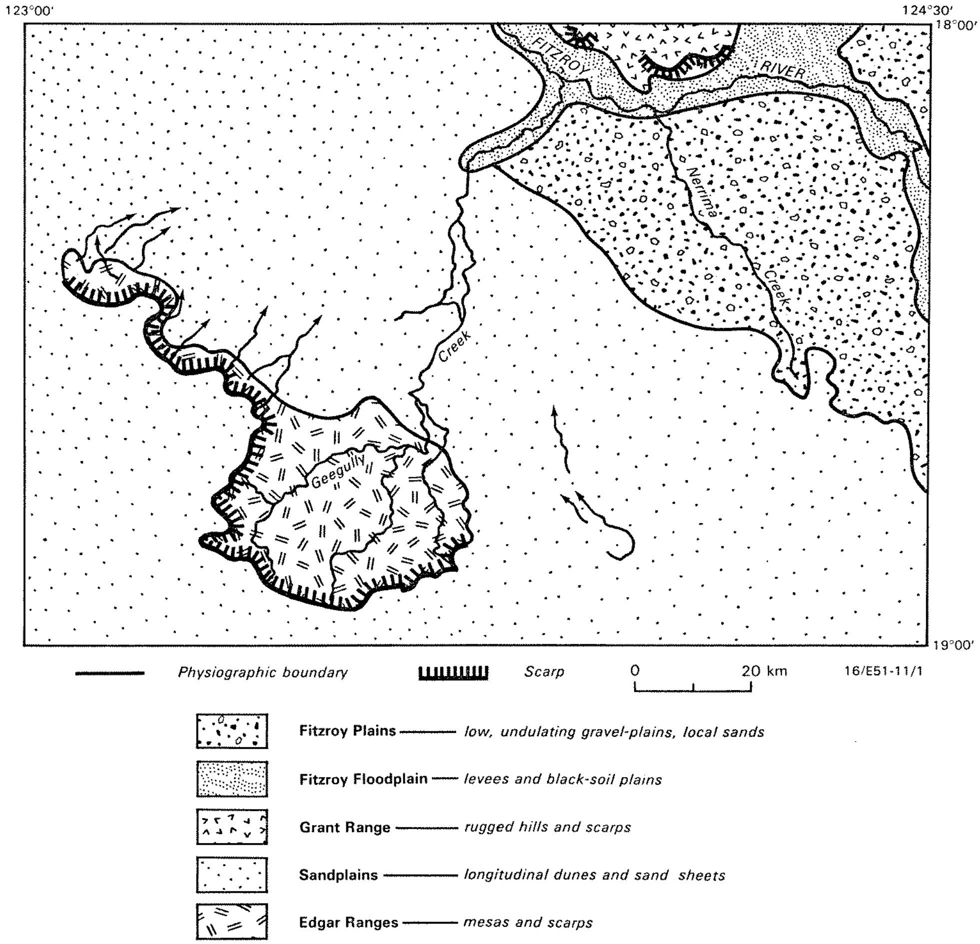


**Fig. 1. Physiography.**

*Petroleum exploration drilling.* Sixteen deep wells have been drilled in the search for hydrocarbons in the Mount Anderson Sheet area (Table 2). Well completion reports of the eight wells subsidised under the Petroleum Search Subsidy Acts are available at the Bureau of Mineral Resources and the Geological Survey of Western Australia. At best, only minor shows of hydrocarbons were found in the wells.

*Aerial photographs and maps.* The Sheet area is covered by vertical aerial photographs at a nominal scale of 1:86 000 flown in 1967. Photography flown in 1947 at a nominal scale of 1:48 000 is also available. The Royal Australian Survey Corps prepared a 1:250 000 scale topographic map in 1964 from the 1947 photography, and six contoured topographic maps covering the Sheet area at 1:100 000 scale, were constructed in 1971–72 from the 1967 photography.

## PHYSIOGRAPHY

The basic physiographic divisions of the Sheet area are shown in Figure 1. These divisions are based on the land systems of Speck & others (1964) and geomorphic regions of Wright (1964).

The *Fitzroy Plains* consist of low, undulating, gravel-covered plains vegetated with spinifex, grasses, and open woodlands. Local relief is usually less than 20 m, and rock outcrops are generally poor. Aeolian sands are locally present. The Fitzroy Plains were formed by partial dissection of the Fitzroy Surface (Speck & others, 1964).

The *Fitzroy Floodplain* formed on alluvial deposits of the Fitzroy River and its major tributaries. The floodplain is characterised by broad levees, plains of heavy cracking clays (black soil) with extensive gilgai, and active and relict watercourses, The levees are vegetated with grassy woodlands, and the floodplains support grasses, scattered trees, and shrubs.

The *Grant Range* is a rugged area of dissected Permian sandstone that rises from the Fitzroy Floodplain and the Fitzroy Plains. Local relief reaches 250 m and scarps are common. Vegetation consists of spinifex, grasses, and open woodlands. The range is a result of dissection of the Kimberley Surface (Speck & others, 1964).

The *Sandplains* consist of aeolian dune fields and sand sheets, with little organised drainage. The longitudinal (seif) dunes have been referred to by Crowe (1975) as simple dunes being formed by helicoidal wind cells. The dunes are up to 30 km long, and the average height is up to 12 m. They are separated by broad swales, which are, in places, floored by a mixture of aeolian and alluvial sediments. A few small, steep-sided rock outcrops protrude through the sand cover, but the regional relief is generally small. The sandplains are vegetated with low scrubby woodlands and spinifex grassland.

The *Edgar Ranges* is an area of dissected Mesozoic sandstone and mudstone. It is characterised by steep-sided mesas, and has a north-facing scarp at its southern margin. The tops of the mesas are generally at the same elevation or lower than the sandplains to the south. Vegetation mainly consists of spinifex grasslands; trees are usually present only along watercourses.

## STRATIGRAPHY

The stratigraphy of the area is summarised in Table 3 and described briefly below.

### PRECAMBRIAN

Basement rocks shown in the cross-sections and subsurface correlation diagram have been termed *Precambrian undivided* (pЄ). Their nature is not known, except in the Edgar Ranges area where they consist of pelitic schist intersected at the base of Total Edgar Range 1 (Total, 1968), and just west of the Sheet area, where they consist of biotite phyllite intersected in WAPET Thangoo 1A (WAPET, 1961d).

### PALAEOZOIC

#### *Early to Middle Ordovician*

The *Nambeet Formation* (Ot; Johnstone *in* WAPET 1961c; Koop, 1966a) is the oldest Phanerozoic unit known in the area. It contains an Early Ordovician or Late Cambrian fauna in the western Canning Basin (Gilbert-Tomlinson, 1961) but is of Early Ordovician age in the Sheet area. The unit is known only from Total Edgar Range 1 on the Broome Arch, but probably extends throughout the area. It may correlate with the Emanuel Formation exposed to the east in the Noonkanbah 1:250 000 Sheet area (Crowe & Towner, 1981).

The overlying *Willara Formation* (Ow; McTavish *in* Playford & others, 1975, p 323) probably extends throughout the area. The upper part of the Willara Formation may correlate with the Gap Creek Formation (McTavish *in* Playford & others, 1975, p 322) exposed in the Noonkanbah Sheet area.

The *Goldwyer Formation* (Oo; Elliot, 1961) conformably overlies the Willara Formation; it is known to be present on the Broome Arch and Jurgurra Terrace in the area, but also probably extends into the Fitzroy Trough.

The overlying *Nita Formation* (On; McTavish *in* Playford & others, 1975, p 324) is also known from the Broome Arch and the Jurgurra Terrace in the area, and probably extends into the Fitzroy Trough. However the Nita Formation's correlative, the *Roebuck Dolomite* (Or; McWhae & others, 1958) is probably present only in the northwest of the area.

On the map sections, the five formations mentioned above are shown in areas with well control, such as on the Broome Arch and the Jurgurra Terrace; however, in some areas of the Jurgurra Terrace and in the Fitzroy Trough, they have been combined and given the one symbol (O).

*Late Ordovician? to Middle Devonian*

*The Carribuddy Formation* (Sc; Koop, 1966a, 1966b) disconformably or unconformably overlies Middle Ordovician rocks in the area; the formation is known only from petroleum exploration wells on the Jurgurra Terrace and Broome Arch in the area, though it probably occurs in the Fitzroy Trough. No age diagnostic fossils are known from the formation, so it has been dated as Late Ordovician(?) to Early Devonian on stratigraphic grounds. WAPET Frome Rocks 1 (WAPET, 1962c) intersected halite in a salt dome between 688 m and its total depth of 1220 m. It is thought that the salt may have moved up the Fenton Fault from the Carribuddy Formation in the Fitzroy Trough to a structural high at the northern margin of the Jurgurra Terrace at this point (see WAPET, 1962c; also R. V. Burne, BMR Basin Studies Group, personal communication, 1977).

The time of the intrusion of the salt is uncertain. The salt dome itself contains several beds of dolomitic breccia; fish plates and a conodont from the dolomite fragments are of Late Devonian or Early Carboniferous age (Glenister, 1962), indicating that the salt has penetrated through rocks of this age. Cap rock above the salt is unconformably(?) overlain by rock of Early(?) Jurassic age, and the intrusion has apparently displaced rocks of Early Permian age present in nearby WAPET Frome Rocks 2. Therefore, major mobilisation probably occurred between the Early Permian and Early(?) Jurassic, possibly during the Late Triassic—Early(?) Jurassic tectonic event.

The *Tandalgoo Red Beds* (Dt; Koop, 1966a, b) conformably overlie the Carribuddy Formation, and consist of calcareous very-fine and fine sandstone, with beds of red and grey-green shale. These deposits have been dated as Middle Devonian(?) in Total Matches Springs 1 (Total, 1970b); determinations from wells outside the Sheet area give ages ranging from Early to Late Devonian.

*Middle Devonian to Early Carboniferous*

The Tandalgoo Red Beds are unconformably overlain in places on the Jurgurra Terrace and in structural lows on the Broome Arch by *reef complex deposits* (D) which are possible equivalents of the Pillara Limestone, Gogo Formation, and

TABLE 3. STRATIGRAPHY OF MOUNT ANDERSON SHEET AREA

| | *Age* | *Rock unit and map symbol* | *Estimated thickness (m)* | *Lithology* |
|---|---|---|---|---|
| CAINOZOIC | QUATERNARY | Qa | 15 | Sand, silt, clay; minor gravel |
| | | Qb | 10 | Clay, silt |
| | | Qs | 10 | Sand, silt; minor gravel |
| | | Qz | 20 | Fine to medium sand; minor silt |
| | | Warrimbah Conglomerate Czh | 10 | Pebble and cobble gravel |
| | | Czk | 5? | Calcrete; minor chalcedony |
| | | Czl | 5 | Pisolitic and massive laterite |
| MESOZOIC | EARLY? JURASSIC TO EARLY CRETACEOUS | Undivided JK | 350 | Sandstone, mudstone; minor conglomerate, siltstone |
| | EARLY CRETACEOUS | Broome Sandstone Kb | 30? | Fine to medium sandstone; minor conglomerate |
| | LATE JURASSIC TO EARLY CRETACEOUS? | Barbwire Sandstone JKb | 33 | Fine to coarse, poorly sorted sandstone, conglomerate; minor mudstone; large scale planar and trough cross-bedding |
| | | Mowla Sandstone JKo | 15 | Discontinuous lower part of channel fill conglomerate; middle part of fine to coarse trough cross-bedded sandstone with pebbles; top part of rippled fine sandstone and mudstone overlying thin-bedded, partly bioturbated medium to fine sandstone with clay pellets |
| | | Jarlemai Siltstone JKr | 80–160? | Sandy mudstone, with scattered granules and pebbles; upper part in eastern Edgar Ranges mainly fine silty sandstone; bioturbated, massive; glauconitic and phosphatic in part, in subsurface |
| | LATE JURASSIC | Alexander Formation Ja | 40–72 | Fine to medium sandstone, interbedded mudstone; minor granule conglomerate; thin bedded, cross-bedded, rippled, flaser bedded, partly bioturbated |
| | EARLY? TO LATE JURASSIC | Wallal Sandstone Jl | 69–154+ | Sandstone; minor siltstone, conglomerate, lignitic beds |
| | | Jurgurra Sandstone Member Jlj | 20+ | Medium to coarse sandstone; minor mudstone, clay pellet conglomerate; abundant large scale trough cross-bedding and ripple cross lamination |

| *Stratigraphic relations* | *Fossils* | *Remarks* |
| --- | --- | --- |
| Superficial deposit | | Alluvial and lacustrine |
| Superficial deposit | | Flood plain deposits—'black soil' |
| Superficial deposit | | Alluvial and aeolian |
| Superficial deposit | | Aeolian |
| Superficial deposit | | Old alluvial deposits of the Fitzroy River |
| Superficial deposit | | Pedogenic |
| Superficial deposit | | Pedogenic |
| | | Undivided Jurassic and Cretaceous units; not used on face of map |
| Conformably(?) overlies JKr; probably equivalent to JKo; top eroded | Plant fossils, pelecypods outside area | Possibly crops out in the south-western part of the Edgar Ranges, and probably present in most of the far west of the Sheet area; a shallow water marine deposit |
| Conformably overlies, and probably partly equivalent to Ja; possibly partly equivalent to JKr; unconformably overlies Pj, Phk, Pn; top eroded | | Fluvial |
| Disconformable and in places gradational lower boundary with JKr; probably equivalent to Kb; top eroded | Plant fossils in top part | Deltaic regressive sequence |
| Conformably overlies Ja; disconformably overlain by, and in places gradational with JKo; conformably(?) overlain by Kb; possible partial equivalent of JKb | Pelecypods, ammonites, palynomorphs; gastropods outside area | Marine, laid down below wave base |
| Conformably(?) overlies Jl, Jlm in subsurface; disconformably or gradationally overlies Jlj; conformably overlain by JKr and JKb; probably partly equivalent to JKb | Pelecypods, ammonoids, stelleroids, brachiopods, palynomorphs, microplankton; contains root moulds, wood fragments in places | Shallow marine |
| Unconformably overlies PzM, Ph, Pj, Pn, Pp, Pg; conformably(?) overlain by Ja | Palynomorphs, microplankton | Does not crop out; on the subsurface correlation diagram and simplified geological map, includes rock mapped as Jlm and Jlj; probably includes continental and paralic deposits; excellent aquifer |
| Lower boundary not known; disconformably(?) overlain by or gradational boundary with Ja; partial equivalent of Jlm | Pelecypods, plant fossils, root moulds | Aeolian (Burne & Crowe, 1977); excellent aquifer |

TABLE 3. STRATIGRAPHY OF MOUNT ANDERSON SHEET AREA *(continued)*

| Era | *Age* | Group | *Rock unit and map symbol* | *Estimated thickness (m)* | *Lithology* |
|---|---|---|---|---|---|
| MESOZOIC | EARLY? TO LATE JURASSIC | | Mudjalla Sandstone Member Jlm | 80? | Lower part of medium to coarse poorly sorted sandstone, abundant trough and planar(?) cross-bedding, lenses of conglomerate and siltstone; upper part of very fine to medium sandstone, planar bedded, rippled, wavy bedded |
| MESOZOIC | EARLY TO MIDDLE TRIASSIC | | Erskine Sandstone Re | 30? | Very fine and fine sandstone, laminated to thin bedded, minor clay pellet conglomerate, mudstone; large scale trough and planar cross bedding, current ripple marks |
| MESOZOIC | EARLY TRIASSIC | | Blina Shale Rb | 200? | Mudstone, sandy mudstone; minor very fine sandstone; laminated to thin bedded; glauconitic; ripple marks and small scour and fill structures near top |
| MESOZOIC | EARLY TRIASSIC | | Millyit Sandstone Rm | 25? | Fine micaceous sandstone, minor mudstone; thin bedded, commonly bioturbated, minor low angle cross-bedding, ripple marks; basal conglomerate |
| PALAEOZOIC TO MESOZOIC | | | Salt dome cap rock PzM | 464 | Dolomite breccia; fragments of dolomite, minor quartz and anhydrite in matrix of fine dolomite with minor clay and authigenic quartz |
| PALAEOZOIC | LATE PERMIAN | LIVERINGA GROUP | Hardman Formation Ph | 650? | Sandstone, mudstone |
| PALAEOZOIC | LATE PERMIAN | LIVERINGA GROUP | Cherrabun Member Phc | 100? | Lower part of interbedded mudstone and sandstone; upper part of cross-bedded sandstone |
| PALAEOZOIC | LATE PERMIAN | LIVERINGA GROUP | Hicks Range Sandstone Member Phh | 325? | Lower part of fine sandstone, ripple-marked, thin bedded; middle part of interbedded mudstone and sandstone, cross-bedded, bioturbated; top part of medium sandstone with pebbles, cross-bedded |
| PALAEOZOIC | LATE PERMIAN | LIVERINGA GROUP | Kirkby Range Member Phk | 230 | Lower part of interbedded fine sandstone and mudstone, calcareous, ripple marked, lenses of granule conglomerate; upper part of cross-bedded sandstone |
| PALAEOZOIC | EARLY TO LATE PERMIAN | LIVERINGA GROUP | Lightjack Formation Pj | 167 | Lower part of interbedded fine sandstone and mudstone, ripple-marked; middle part of medium sandstone, cross-bedded, contains coal; top part of interbedded mudstone and fine sandstone; contains oolitic ironstone in parts (Edwards, 1953) |
| PALAEOZOIC | EARLY TO LATE PERMIAN | LIVERINGA GROUP | Pl | 825? | Sandstone, mudstone |

| *Stratigraphic relations* | *Fossils* | *Remarks* |
|---|---|---|
| Unconformably overlies Ph, Pj, Pn; conformably(?) overlain by Ja; partial equivalent of Jlj | Plant fossils, wood fragments | Fluvial (channel deposits overlain by overbank deposits) |
| Disconformably overlies Rb | Plant fossils, wood fragments outside area | Regressive deltaic |
| Unconformably and possibly disconformably overlies Phc; conformably overlies Tm; disconformably overlain by Re | Amphibians, fish and other vertebrates, conchostracans, pelecypods, brachiopods; palynomorphs, acritarchs outside area | Vertical burrows occur throughout; some phosphatic bone beds, particularly near base; restricted marine |
| Unconformably overlies Phc; conformably overlain by Rb | Plant fossils, wood fragments, palynomorphs from outside area | Depositional environment unknown; crops out only in McLarty Syncline in area |
| Overlies salt dome of Carribuddy Formation (Sc); unconformably overlain by Jl | | Intersected in WAPET Frome Rocks 1 |
| Unconformably overlain by Jlm, Jl | | Mapped where members are not recognisable |
| Disconformably overlies Phh; unconformably and possibly disconformably overlain by Rb; unconformably overlain by Rm | Brachiopods, pelecypods, gastropods, bryozoans | Poorly exposed in area; regressive shallow marine sequence |
| Conformably overlies Phk; disconformably overlain by Phc | Plant fossils, palynomorphs | Unit is best exposed part of the Hardman Formation; intersected in AFO Myroodah 1; lagoonal passing up into possible fluvial deposits |
| Disconformably overlies Pj; conformably overlain by Phh; unconformably overlain by JKb | Brachiopods, pelecypods, palynomorphs | Poorly exposed in area; occurs as scattered lines of calcareous float in soil; intersected in AFO Myroodah 1; lower part tidal, upper part offshore barrier sand bar |
| Conformably overlies Pn; disconformably overlain by Phk; unconformably overlain by Jl, Jlm, JKb | Pelecypods, gastropods, brachiopods, bryozoans, forams, ammonoids, plant fossils and palynomorphs | Top part only probably present in McLarty Syncline area; intersected in AFO Myroodah 1 and WAPET Frome Rocks 2; regressive sequence, from tidal through beach or barrier bar to lagoonal |
| | | Shown on sections and subsurface correlation diagram only |

TABLE 3. STRATIGRAPHY OF MOUNT ANDERSON SHEET AREA *(continued)*

| | *Age* | | | *Rock unit and map symbol* | *Estimated thickness (m)* | *Lithology* |
|---|---|---|---|---|---|---|
| PALAEOZOIC | EARLY PERMIAN | | | Noonkanbah Formation Pn | 300–400 | Mudstone, calcareous, pyritic; interbeds of limestone, sandstone, granule conglomerate |
| PALAEOZOIC | EARLY PERMIAN | | | Poole Sandstone Pp | 60–433 | Sandstone, mudstone |
| PALAEOZOIC | EARLY PERMIAN | | | Tuckfield Member Ppt | 53–323 | Fine sandstone, thin-bedded flaser bedded, interbedded mudstone, cross-bedded lenses of clay pellet conglomerate |
| PALAEOZOIC | EARLY PERMIAN | | | Nura Nura Member Ppn | 8–110 | Lower part of fine sandstone, well-sorted, cross-bedded; middle part of fine sandstone and mudstone, thin-bedded, rippled; upper part of fine to medium sandstone, cross-bedded, poorly laminated; minor limestone in some areas |
| PALAEOZOIC | EARLY PERMIAN | GRANT GROUP | Carolyn Formation (Pc) | Millajiddee Member Pcm | 75 | Medium sandstone, minor fine sandstone and mudstone, ripple marks, cross-bedded |
| PALAEOZOIC | EARLY PERMIAN | GRANT GROUP | Carolyn Formation (Pc) | Wye Worry Member Pcw | 110 | Fine to medium sandstone and mudstone, calcareous; contains rare facetted and striated dropstones |
| PALAEOZOIC | EARLY PERMIAN | GRANT GROUP | Carolyn Formation (Pc) | Undivided Pc | 112–415 (total) | Fine to coarse sandstone, poorly bedded, cross-bedded, scour and fill structures |
| PALAEOZOIC | EARLY PERMIAN | GRANT GROUP | | Winifred Formation Pw | 55–134 | Shale, carbonaceous, pyritic; minor siltstone and fine sandstone |
| PALAEOZOIC | LATE CARBONIFEROUS TO EARLY PERMIAN | GRANT GROUP | | Betty Formation Pb | 192–1714 | Very fine to coarse sandstone, minor conglomerate; Precambrian rock clasts may be glacial dropstones |
| PALAEOZOIC | LATE CARBONIFEROUS TO EARLY PERMIAN | GRANT GROUP | | Pg | 318–2060 | Sandstone, mudstone, minor conglomerate |

| *Stratigraphic relations* | *Fossils* | *Remarks* |
|---|---|---|
| Disconformably or conformably overlies Ppt; conformably overlain by Pj; unconformably overlain by JKb, Jl, Jlm | Brachiopods, bryozoans, corals, crinoids, forams, pelecypods, gastropods, ostracods and palynomorphs | Very poorly exposed; intersected in AFO Myroodah 1, Nerrima 1, BMR Jurgurra Creek 1, WAPET Frome Rocks 2, Logue 1, Dampier Downs 1, Babrongan 1; unrestricted marine |
| Unconformably overlain by Jl | | Mapped where members not recognisable |
| Conformably overlies Ppn; disconformably or conformably overlain by Pn | Plant fossils, abundant wood fragments | A good aquifer; intersected in AFO Myroodah 1, Nerrima 1, WAPET Frome Rocks 2, Babrongan 1, Logue 1, Dampier Downs 1, BMR Jurgurra Creek 1; lagoonal |
| Unconformably overlies Pc, Pcm; conformably overlain by Ppt | Brachiopods, bryozoans, forams, ammonoids, molluscs, conodonts, crinoids, ostracods | Lower part only identified in Grant Range area; intersected in AFO Myroodah 1, Nerrima 1, WAPET Frome Rocks 2, Babrongan 1, Logue 1, Dampier Downs 1, BMR Jurgurra Creek 1; upper and lower parts offshore sandbar, middle part shallow marine |
| Conformably overlies and interfingers with Pcw; unconformably overlain by Ppn | Wood fragments | Exposed in rounded steep cliffs; commonly covered by a siliceous weathering skin; an excellent aquifer; not identified in subsurface; nearshore marine |
| Overlies undivided Pc (boundary not identified); conformably overlain by and interfingers with Pcm | Pelecypods, gastropods, brachiopods, bryozoans, crinoids from outside area | Sequence of Pcw going up into Pcm is repeated several times in the Grant Range; not identified in the subsurface; glacial marine laid down below wave base |
| Conformably overlies Pw; overlain by Pcw, unconformably overlain by Ppn where members not recognised | Palynomorphs | Includes rocks that may be part of Pcw, Pcm; excellent aquifer; identified in WAPET Grant Range 1, Doran 1, Logue 1, Dampier Downs 1, Frome Rocks 2, Babrongan 1, AFO Nerrima 1, Myroodah 1, Freney-Kimberley Mount Wynne 3, Total Edgar Range 1, BMR Jurgurra Ck 1; possibly shallow water marine |
| Conformably overlies Pb; conformably overlain by Pc | Palynomorphs; crinoids, bryozoans, echinoids from outside area | Not easily recognised in some bores (e.g. WAPET Babrongan 1, AFO Myroodah 1); identified in WAPET Grant Range 1, Logue 1, Doran 1, Frome Rocks 2, Dampier Downs 1, Total Edgar Range 1, AFO Nerrima 1, Freney-Kimberley Mount Wynne 3 |
| Unconformably overlies Ca, Dug, Dl, Dc, Db, D, Dt, Sc, Or; conformably overlain by Pw | Palynomorphs; unspecified marine fossils from outside area | Identified in WAPET Grant Range 1, Frome Rocks 2, Doran 1, Logue 1, Dampier Downs 1, Babrongan 1, Total Edgar Range 1, Mowla 1, Matches Springs 1, AFO Nerrima 1, Myroodah 1, Freney-Kimberley Mount Wynne 3 |
| Unconformably overlain by Jl | | Used only on sections |

## TABLE 3. STRATIGRAPHY OF MOUNT ANDERSON SHEET AREA *(continued)*

| | *Age* | *Rock unit and map symbol* | *Estimated thickness (m)* | *Lithology* |
|---|---|---|---|---|
| PALAEOZOIC | CARBONIFEROUS | Anderson Formation<br>Ca | 0–>2500? | Sandstone, siltstone, shale, minor limestone, dolomite, anhydrite |
| | MIDDLE? DEVONIAN TO CARBONIFEROUS? | Undivided<br>DC | | |
| | | Gumhole Formation (Fairfield Group)<br>Dug | 260 | Interbedded limestone, siltstone, shale, sandstone |
| | | Luluigui Formation<br>Dl | 571 | Interbedded siltstone, shale, limestone, fine sandstone |
| | LATE DEVONIAN | Clanmeyer Siltstone<br>Dc | 1067 | Siltstone, shale; minor limestone |
| | | Babrongan Beds<br>Db | 213+ | Shale, siltstone; partly calcareous; minor limestone and dolomite |
| | MIDDLE? TO LATE DEVONIAN | Reef Complex deposits<br>D | 0–1159 | Dolomite, dolomitic limestone, shale, fine sandstone |
| | MIDDLE DEVONIAN? | Tandalgoo Red Beds<br>Dt | 72 | Very fine to fine sandstone, red and grey-green shale; calcareous |
| | LATE ORDOVICIAN? TO EARLY DEVONIAN | Carribuddy Formation<br>Sc | 241 | Siltstone, claystone, sandstone, dolomite, halite, anhydrite; minor limestone; halite, minor dolomite, anhydrite, dolomite breccia in salt dome |
| | EARLY TO MIDDLE ORDOVICIAN | Undivided<br>O | | Limestone, dolomite, shale, siltstone, sandstone |
| | | Roebuck Dolomite<br>Or | 123+ | Dolomite, minor calcilutite |
| | MIDDLE ORDOVICIAN | Nita Formation<br>On | 240 | Limestone; minor dolomite and shale |

| *Stratigraphic relations* | *Fossils* | *Remarks* |
|---|---|---|
| Conformably overlies Dl, DC; unconformably overlain by Pb | Palynomorphs; pelecypods from outside area | Intersected in WAPET Grant Range 1 and AFO Nerrima 1; probably deposited only in the Fitzroy Trough |
| Unconformably overlies Dt; conformably underlies Ca | Unknown | Postulated equivalent of D, Dug, Dl, Dc and Db in the Fitzroy Trough; not intersected in any well |
| Conformably overlies and partial equivalent of Dl; unconformably overlain by Pb | Conodonts, fish, ostracods, conchostracans, palynomorphs, microplankton, scolecodonts | Recognised only in WAPET Frome Rocks 2 (Druce & Radke, 1979); probably deposited only on the Jurgurra Terrace in the area |
| Conformably overlies Dc; conformably overlain by, and partially equivalent to Dug; conformably overlain by Ca; unconformably overlain by Pb; partial lateral equivalent of D | Ostracods, palynomorphs, conodonts, pelecypods | Intersected in WAPET Babrongan 1, Doran 1, Frome Rocks 2, and possibly Logue 1 |
| Conformably overlies Db; conformably overlain by Dl; unconformably overlain by Pb; partial lateral equivalent of D | Ammonoids, palynomorphs | Intersected in WAPET Babrongan 1, Logue 1, and Frome Rocks 2 |
| Base not penetrated; unconformably overlies Dt, Sc; conformably overlain by Dc; unconformably overlain by Pb; partial lateral equivalent of D | Palynomorphs | Intersected in WAPET Babrongan 1 and Logue 1 |
| Unconformably overlies Dt, Sc, On; unconformably overlain by Pb; partial lateral equivalent of Dl, Dc, Db | Palynomorphs, chitinozoans, pelecypods, algae, conodonts, scolecodonts, fish | Reef complex deposits; includes possible equivalents of Nullara Limestone, Gogo Formation and Pillara Limestone to northeast of area (see Playford and others, 1975); intersected in Total Matches Springs 1, Mowla 1 |
| Conformably overlies Sc; unconformably overlain by D, DC, Db, Pb | Palynomorphs | Intersected in Total Matches Springs 1; probably deposited over most of area |
| Disconformably or unconformably overlies On, Or; conformably overlain by Dt, and unconformably by Pb, Db; salt dome of Sc overlain by PzM | Palynomorphs; conodonts, fish plates in dolomite clasts in breccias in salt dome | Intersected in Total Edgar Range 1 and Matches Springs 1; probably deposited over most of area; includes salt dome intersected in WAPET Frome Rocks 1 |
| | | Used in the Fitzroy Trough and some parts of the Jurgurra Terrace where there is no well control |
| Equivalent to On; conformably overlies Oo; unconformably overlain by Pb, disconformably or unconformably overlain by Sc | Conodonts | Intersected in WAPET Dampier Downs 1; probably deposited only in northwest of area |
| Conformably overlies Oo; disconformably or unconformably overlain by Sc; equivalent to Or | Palynomorphs, conodonts, molluscs, brachiopods, acritarchs, chitinozoans, crinoids, conulariids(?) | Intersected in Total Edgar Range 1 and Matches Springs 1; probably deposited over most of area |

TABLE 3. STRATIGRAPHY OF MOUNT ANDERSON SHEET AREA *(continued)*

| *Age* | *Rock unit and map symbol* | *Estimated thickness (m)* | *Lithology* |
|---|---|---|---|
| MIDDLE ORDOVICIAN | Goldwyer Formation Oo | 431–566+ | Shale, limestone, dolomite and siltstone |
| EARLY TO MIDDLE ORDOVICIAN | Willara Formation Ow | 401 | Limestone; minor dolomite, shale, sandstone |
| EARLY ORDOVICIAN | Nambeet Formation Ot | 162 | Shale; minor limestone and sandstone |
| | UNCONFORMITY | | |
| PRECAMBRIAN | Undivided p€ | | Igneous, metamorphic, and sedimentary rocks; quartz-muscovite-biotite schist in Edgar Ranges area |

Nullara Limestone of the Lennard Shelf area to the northeast (Playford & Cockbain, 1976). Elsewhere on the Broome Arch, the reef complex deposits are absent (e.g. not intersected in Total Edgar Range 1), probably due to non-deposition or having been eroded during the Carboniferous.

Elsewhere on the Jurgurra Terrace, the Late Devonian *Babrongan Beds* (Db; Playford & others, 1975) defined from WAPET Babrongan 1, form the base of the Devonian sequence intersected in petroleum exploration wells. The base of this unit has not been penetrated, but it probably unconformably overlies the Tandalgoo Red Beds. The Babrongan Beds resemble the Virgin Hills Formation of the Lennard Shelf area (WAPET, 1966b).

The *Clanmeyer Siltstone* (Dc; Willmott, 1966) overlies the Babrongan Beds, and was also defined from WAPET Babrongan 1. This unit may be an inter-reef deposit equivalent to part of the Piker Hills Formation of the Lennard Shelf area (Playford & others, 1975). The overlying *Luluigui Formation* (Dl; Willmott, 1966) was defined from WAPET Frome Rocks 2. Jones (*in* WAPET 1968a) states from palaeontological evidence that the Luluigui Formation is probably a partial equivalent of the Fairfield Formation (now Fairfield Group), defined from the Lennard Shelf to the northwest of the area.

Druce & Radke (1979) have identified the *Gumhole Formation* (Dug), a member of the Fairfield Group, overlying the Luluigui Formation in WAPET Frome Rocks 2. The interval assigned to the Gumhole Formation was originally defined by Willmott (1966) as being part of the Luluigui Formation.

It is not known whether the last four formations extend into the Fitzroy Trough in the Sheet area; however, the Clanmeyer Siltstone and Luluigui Formation have been identified at the northern edge of the Fitzroy Trough east of the Sheet area in WAPET Mimosa 1 (WAPET, 1973d) and WAPET Mt Hardman 1 (WAPET, 1973e). Rocks of Late Devonian to Early Carboniferous age that are probably present in the Fitzroy Trough are labelled *undivided Devonian and Carboniferous* (DC) on the sections and subsurface correlation diagram.

| *Stratigraphic relations* | *Fossils* | *Remarks* |
|---|---|---|
| Conformably overlies Ow; conformably overlain by On, Or | Palynomorphs, conodonts, molluscs, trilobites, sponge spicules, graptolites, brachiopods, ostracods, chitinozoans, echinoderms | Intersected in Total Edgar Range 1 and Matches Springs 1; probably deposited over most of area |
| Conformably overlies Ot; conformably overlain by Oo | Brachiopods, trilobites, echinoderms, graptolites, molluscs, conodonts, ostracods, chitinozoans, acritarchs, algae, conulariids(?), sponge spicules | Intersected in Total Edgar Range 1; probably deposited over most of area |
| Unconformably overlies p Є; conformably overlain by Ow | Graptolites, trilobites, brachiopods, mulluscs, conulariids(?), chitinozoans, algae | Intersected in Total Edgar Range 1; probably deposited over most of area |
| | UNCONFORMITY | |
| Unconformably underlies Canning Basin rocks | | Forms basement in the area; intersected in Total Edgar Range 1 |

*Early Carboniferous to Early Permian*

The Carboniferous *Anderson Formation* (Ca) (McWhae & others, 1958) appears to be confined to the Fitzroy Trough, and was defined from WAPET Grant Range 1. The Anderson Formation is unconformably overlain by the *Grant Group* (Pg; Guppy & others, 1958; Crowe & Towner, 1976d), which contains three formations. The lowest, the *Betty Formation* (Pb), is a sub-surface unit which occurs throughout the area. It contains a Late Carboniferous section in the Fitzroy Trough and possibly on the Jurgurra Terrace, but is mainly of Early Permian age. The *Winifred Formation* (Pw) is also a subsurface unit. It is present throughout the area, except where eroded out by the Late Triassic–Early(?) Jurassic unconformity. It is recognised in most bores in the area, and is a mudstone sequence lying between two sandstone formations.

The *Carolyn Formation* (Pc) has a similar distribution to the underlying Winifred Formation, and is completely exposed in the Grant Range, Mt Wynne, and Mt Arthur areas. The best exposures are in the Grant Range, where two members are mapped in the upper part of the sequence: the *Wye Worry Member* (Pcw), and the overlying *Millajiddee Member* (Pcm) (both defined by Crowe & Towner, 1976a). Crowe & others (1978) have described how these two members appear to interfinger in the Grant Range and believe this was caused by cyclic deposition in that area.

*Permian*

The *Poole Sandstone* (Pp; Guppy & others, 1952) contains two members in the area: the Nura Nura Member, and the overlying Tuckfield Member. Crowe & others (1978) showed that there is an angular unconformity between the Poole Sandstone and the Grant Group in the Grant Range. The *Nura Nura Member* (Ppn; Guppy & others, 1958) occurs throughout most of the area, although it was not mapped in the vicinity of Mt Arthur due to incomplete exposure. The sequence in the Grant Range area (see Crowe & others, 1978) correlates well with sections exposed in the George Ranges to the east of the area (see Crowe & Towner, 1976a, b). The overlying *Tuckfield Member* (Crowe & Towner, 1976d) is best exposed in the flanks of the Grant Range.

The Tuckfield Member is overlain by the *Noonkanbah Formation* (Pn; Wade, 1938; Guppy & others, 1952), which is poorly exposed. The formation commonly consists of mudstone, but it contains coarse-grained sandstone and conglomerate with a high proportion of terriginous material in exposures south of the Fenton Fault.

The *Liveringa Group* (Pl; Guppy & others, 1952, 1958; Yeates & others, 1975a) conformably overlies the Nookanbah Formation, and contains three formations: the lower Lightjack Formation, the middle Condren Sandstone, and the upper Hardman Formation which contains three members. The upper and lower formations only are present in the Mount Anderson Sheet area as the Condren Sandstone pinches out east of the area (see Crowe & Towner, 1976c).

The *Lightjack Formation* (Pj) contains three informal subdivisions (see Table 3), although only the lower two occur at Liveringa Ridge where the unit is best exposed. The middle part, which consists mainly of sandstone, contains the most widespread coal seams in the Canning Basin (see section on 'Economic Geology').

The *Hardman Formation* (Ph) is believed to disconformably overlie the Lightjack Formation, and its three members are, in ascending order: the *Kirkby Range Member* (Phk), the *Hicks Range Sandstone Member* (Phh), and the *Cherrabun Member* (Phc) (all defined by Yeates & others, 1975a). None of the members are well exposed in the area, although they occur beneath a thin soil cover over large parts of the plains to the south of the Fitzroy River. The Hicks Range Sandstone Member is the best exposed member, especially at Liveringa Ridge.

### Palaeozoic to Mesozoic

The *cap rock* (PzM) to the salt dome penetrated by WAPET Frome Rocks 1 (WAPET, 1962c) is of uncertain age. It consists of a dolomitic breccia that was probably derived from insoluble beds within the Late Ordovician(?) to Early Devonian Carribuddy Formation from which the salt dome originated, and Late Devonian Carbonates. The cap rock is unconformably overlain by Early(?) to Late Jurassic rocks.

The salt dome may have been intruded during the Late Triassic–Early(?) Jurassic tectonic event, but earlier movement is possible. Hence, parts of the breccia might be as old as Carboniferous, and it may have continued to form till Early(?) Jurassic times.

### Mesozoic

#### *Triassic*

The *Millyit Sandstone* (Rm; Elliott, *in* McWhae & others, 1958; Yeates & others, 1975a) is of earliest Triassic age. It crops out poorly, and has been identified only in the McLarty Syncline in the area, where it unconformably overlies the Hardman Formation. The *Blina Shale* (Rb; Reeves, 1951; Brunnschweiler, 1954) overlaps the Millyit Sandstone and rests directly on Permian rocks in the Dry Corner and Myroodah Synclines. It was probably deposited in a shallow, low energy, nearshore environment with intermittent subaerial exposure, probably a mudflat not directly connected to the ocean. The overlying *Erskine Sandstone*

(Re; Brunnschweiler, 1954) is probably deltaic; it is present only in the Myroodah Syncline in the area. The three Triassic formations were probably originally deposited only in the Fitzroy Trough area and represent a single transgressive/regressive cycle.

*Jurassic to Early Cretaceous*

The Jurassic to Early Cretaceous rocks are shown as one unit (JK) on the sections, as they are too thin to show individually.

The *Wallal Sandstone* (Jl; McWhae, *in* WAPET, 1961c) is made of sandy rocks of mainly continental origin which have been penetrated at the base of the Jurassic sequence in petroleum exploration wells over most of the Canning Basin. Outcrops of this unit have been assigned to two members: the *Mudjalla Sandstone Member* (Guppy & others, 1958; Appendix I of these notes), and the *Jurgurra Sandstone Member* (Brunnschweiler, 1954; Appendix I of these notes). Broadly speaking, these are both sandstone units, but are distinguishable in that they contain different sedimentary structures, reflecting different modes of origin. The Wallal Sandstone is not known to crop out elsewhere in the Canning Basin.

The overlying *Alexander Formation* (Ja; Brunnschweiler, 1954) has its type section at Mount Alexander in the Edgar Ranges, and is interpreted as a tidal deposit. It crops out well in the Edgar Ranges, but poorly elsewhere. Near the Fenton Fault in the east of the area, it is overlain by and probably partly equivalent to the fluviatile *Barbwire Sandstone* (JKb; Guppy & others, 1958). Farther south and west, the Alexander Formation is overlain by the marine *Jarlemai Siltstone* (JKr; Brunnschweiler, 1954) which may also be partly equivalent to the Barbwire Sandstone. The base of the Jarlemai Siltstone is Oxfordian or Kimmeridgian, but it may extend up into the Cretaceous. This unit commonly forms cliffs with steep scree slopes in the Edgar Ranges and Matches Springs area, but is poorly exposed elsewhere in the basin.

The overlying *Mowla Sandstone* (JKo; Brunnschweiler, 1954; Guppy & others, 1958) is interpreted as a deltaic deposit, marking the last phase of regression of a Jurassic sea from the area. The deposit occurs in small isolated areas in the Edgar Ranges and Matches Springs areas.

*Broome Sandstone* (Kb) is interpreted to be present under sand cover in the far west of the Sheet area, as about 60 m of it is present in Thangoo 1, 1A, (WAPET, 1961d), and Thangoo 2 (WAPET 1973c); these wells are respectively about 12 km and 8 km west of the Sheet area. The Broome Sandstone is made up of fine to medium sandstone with minor conglomerate in these wells and overlies the Jarlemai Siltstone. It is a shallow-water marine deposit. An outcrop of cross-bedded, medium and coarse-grained, well-sorted, subrounded, pebbly clean sandstone at the southwestern extremity of the Edgar Ranges may be Broome Sandstone or Mowla Sandstone; it has been labelled Kb? on the map. The Broome Sandstone and Mowla Sandstone are probably lateral equivalents in this area.

CAINOZOIC

*Laterite* (Czl) is not common in the Fitzroy Trough in the area, and occurs only as small deposits over clayey formations such as the Blina Shale. South of the Fenton Fault, laterite is probably widespread under the sand plain although there are few exposures. It occurs at the top of the Edgar Ranges, and probably once covered the whole of the Edgar Range area.

*Calcrete* (Czk) is rare in the area, and appears to be restricted to areas adjacent to the Fenton Fault. Some of the calcrete may have been formed by springs which occur along this fault.

The *Warrimbah Conglomerate* (Czh; Guppy & others, 1958) is restricted to the banks of the Fitzroy River in the eastern part of the area, and is an extension of more widespread deposits to the east (Crowe & Towner, 1981).

The most widespread Pleistocene to Holocene unit is *aeolian sand* (Qz) which occurs in the southern and central parts of the area. It consists of fine-grained red quartz sand which mainly occurs as longitudinal (seif) dunes (predominantly of the simple type—term of Crowe, 1975), and sand sheets. Rare dunes also overlie the gravel plains north of the Fenton Fault.

*Mixed aeolian and alluvial deposits* (Qs) occur widely in the area, particularly in areas adjacent to the Fitzroy River, and where shaley units subcrop. *Black Soil* (Qb) occurs on flood plains of the Fitzroy River. In the northeastern part of the area, the black soil plains have been irrigated as part of the Camballin Irrigation Project.

Deposits of *alluvium* (Qa) occur in major drainages, and as alluvial fans in the Edgar Ranges.

## STRUCTURE

### *Tectonic subdivisions*

There are three major tectonic subdivisions in the area; the *Fitzroy Trough*, the *Jurgurra Terrace*, and the *Broome Arch* (see map).

The *Fitzroy Trough* (Reeves, 1951; Playford & others, 1975) is a northwest-trending graben bounded on the southwest by the Fenton Fault System, and on the northeast (outside the area) by the Pinnacle Fault System. The trough probably contains up to 10 000 m of Palaeozoic and minor Mesozoic rocks, and is thought to have originated as a separate feature during the Devonian.

The *Jurgurra Terrace* lies to the southwest of the trough in the central and northwestern part of the Sheet area. The terrace is bounded by the Dampier Fault to the southwest and the Camelgooda Fault to the southeast. Basement depths on the terrace range from about 2500 m to 4500 m.

Southwest of the terrace and trough is the *Broome Arch* (Broome Swell of Veevers & Wells, 1961; Broome Platform of Koop, 1966a), an area of relatively shallow basement (intersected in Total Edgar Range 1). The section on the Arch is 1500 m to 3000 m thick, but may be thicker in the structurally complex area to the southeast of the terrace where the arch adjoins the trough.

### *Faults, folds and joints*

The most prominent fault system in the area is the *Fenton Fault System* which dips steeply to the northeast and has a maximum normal throw of 6000 m in pre-Permian rocks (Playford & others, 1975). First movement was probably in the Devonian, but the major displacement occurred during the Carboniferous. The next recorded phase of movement was between deposition of Permian and Triassic rocks in the area (Crowe & others, 1978) and was probably also normal. However, during the Late Triassic or Early(?) Jurassic, movement on the fault system was reversed (see Williams & McKellar, 1958); this is believed to have been caused by regional right lateral compression of the Fitzroy Trough between the Kimberley

Block (to the north) and the Broome Arch (Rattigan, 1967; Smith, 1968). This tectonism generated folding in the trough with associated north-trending, tensional reverse faulting. The last phase of movement along the Fenton Fault occurred after the deposition of Jurassic to Lower Cretaceous rocks in the area, and it caused only minor displacement. Post-Permian movement was greatest in the eastern part of the Sheet area. In the west, seismic data show little or no displacement of Permian rocks by the Fenton Fault.

Most of the minor faults in the Fitzroy Trough can be attributed to the Late Triassic–Early(?) Jurassic tectonism, but Crowe & others (1978) have also described some reverse faults in the Grant Range that were formed during the Early Permian.

The other major fault in the area is the *Dampier Fault,* which is interpreted to be present on geophysical evidence as it lacks surface expression. It probably has a normal displacement of up to 3000 m. It is believed that the movement occurred mainly during pre-Permian times. Many other faults in the area have no surface expression, and have been interpreted on geophysical evidence. Some small faults occur in the Edgar Ranges (e.g. near Ardjorie Homestead) in the Jurassic to Cretaceous sequence. These faults have little displacement and are probably a result of rejuvenation of major faults in underlying rocks.

The main folds in the area were formed in Late Triassic or Early(?) Jurassic times in the Fitzroy Trough. Three major synclines are present: the *McLarty Syncline,* the *Dry Corner Syncline,* and the *Myroodah Syncline.* The associated anticlines are the *Nerrima Structure,* the *Deep Well Anticline,* the *Grant Range Structure,* and the *Mt Wynne Structure.* Smaller unnamed structures also occur adjacent to the Fenton Fault.

Dips in the major folds range up to 25°, though most are less than 5°. The axial planes seem to be near vertical. Crowe & Towner (1981) suggest that the major structures to the east of the area have acted as positive and negative features during the Permian and the same pattern may exist in the area.

Minor folds also occur to the south of the Fenton Fault, in the Jurassic to Cretaceous sequence, mainly in the Edgar Ranges and Matches Springs area. Most of these folds were mapped in detail by Smith & Williams (1955), who found that the apparently random nature of the fold axes could not be related to underlying structures defined by seismic work. They postulated that the fold axes were drape features over an underlying Jurassic landscape, and were able to plot them in a dendritic pattern, suggesting an underlying valley system. Crowe & others (1978) produced supporting sedimentological evidence, but point out that a re-interpretation of Total Mowla 1 based on recent micropalaeontological evidence indicates that a syncline is present in the area, but does not support the drape theory.

There is no surface evidence of folding on the Jurgurra Terrace. However, drilling (WAPET Frome Rocks 2) has shown that a diapiric structure occurs in the subsurface on a structural high at the northern margin of the terrace. It is thought that this structure formed by diapiric intrusion of evaporities belonging to the Carribuddy Formation up the Fenton Fault System. Many other pre-Mesozoic folds have defined by seismic surveys on the terrace and Broome Arch.

Joints are common in the more competent units in the area, particularly the Carolyn Formation. In some places they show up clearly on aerial photographs, and appear to be related to faults.

## GEOLOGICAL HISTORY

The beginning of the Canning Basin was marked by transgression of the sea into a probably gently downwarped area of Precambrian rocks in Early Ordovician times. Carbonates and muds (Nambeet, Willara, Goldwyer, and Nita Formations, and the Roebuck Dolomite) were deposited in this shallow sea. The sea regressed from the area in Middle Ordovician times, and slight erosion followed.

Mud, dolomite, and evaporites (Carribuddy Formation) were then deposited in and by a shallow, restricted, evaporating sea which spread across the area probably in Silurian or earliest Devonian times. Emergence of the land under desert conditions probably during the Middle Devonian resulted in deposition of fine clastic red beds (Tandalgoo Red Beds). Minor erosion followed.

Major subsidence of the Fitzroy Trough started in Middle or Late Devonian times, and deep-water clastics probably accumulated here (undifferentiated Devonian and Carboniferous rocks). Reef complexes developed in shallower water on the Jurgurra Terrace and on parts of the Broome Arch, and clastics and minor carbonates were deposited between the reefs (Babrongan Beds, Clanmeyer Siltstone, Luluigui and Gumhole Formations). Growth faults were probably active at the edge of the trough.

The sea withdrew from the Jurgurra Terrace and Broome Arch areas in Devonian times, but deposition of a thick sequence of fine terriginous sediments in the Fitzroy Trough (Anderson Formation), and normal movement along the Fenton Fault System continued while the Broome Arch and Jurgurra Terrace were being eroded. The sea then withdrew totally from the area, and erosion of the whole area took place in the Late Carboniferous.

The sea transgressed across the Fitzroy Trough in the Late Carboniferous, and the whole Sheet area had been submerged by earliest Permian times. The climate was cold, and sands containing probably glacial dropstones (Betty Formation) were deposited. A relative rise in sea level or change in climate is indicated by the finer grained sediments of the overlying Winifred Formation. Sandstone of the Carolyn Formation was then deposited, probably under glacial conditions. The Wye Worry Member may have been deposited landward of sand bars possibly present in the Grant Range area, and regression left the sandy deposits of the Millajiddee Member.

The area was then mildly folded and faulted. Compressive tectonism is inferred as some of the faults are reverse. The area was eroded, probably to a fairly flat plain. A warmer sea then transgressed across the area, depositing the Nura Nura Member with its diverse fauna. The sea probably became progressively shallower, culminating in lagoonal conditions under which the Tuckfield Member was deposited.

Open marine conditions then returned, and muds and minor carbonates of the Noonkanbah Formation were deposited in the Fitzroy Trough; part of the Broome Arch may have been exposed at this time, shedding some coarse terriginous material onto the Jurgurra Terrace where the Noonkanbah Formation contains coarse sandstones. The sea then regressed from the area, leaving the sandy deposits of the Lightjack Formation. Terrestrial deposits may have then been deposited, but would have been removed before the next marine incursion took place. This incursion and subsequent regression are represented by the Kirkby Range Sandstone Member. The Hicks Range Sandstone and Cherrabun Members represent a final transgression and regression in Late Permian times. The Broome Arch and Jurgurra Terrace were probably exposed during deposition of the Liveringa Group.

This period of deposition was followed by minor movement along the Fenton Fault System, accompanied by folding. A salt dome, probably originating from the Carribuddy Formation penetrated the Permian rocks in the Frome Rocks area sometime before Early to Middle Jurassic times.

In earliest Triassic times, the Millyit Sandstone was possibly deposited by a sea transgressing across the Fitzroy Trough area. The muds of the Blina Shale were then deposited in a shallow restricted arm of the sea or on a mudflat. The retreat of the Triassic sea in Early to Middle Triassic times was marked by the deltaic deposits of the Erskine Sandstone.

This was followed by reverse movements on the Fenton Fault System and folding of the sediments in the Fitzroy Trough. The tensional stresses caused by the folding formed large numbers of north-trending faults, especially in axial areas of the folds.

The Fitzroy Trough in the eastern part of the area was probably uplifted, with a south-facing scarp or slope at the Fenton Fault System which acted as a barrier to the Jurassic sea.

Jurassic deposition started with continental and possibly marginal-marine sediments being laid down over irregular topography in Early(?) to Late Jurassic times (Wallal Sandstone, Jurgurra Sandstone Member, Mudjalla Sandstone Member). The sea then transgressed across these sediments, depositing tidal sands and muds (Alexander Formation), then deeper-water muds and sands (Jarlemai Siltstone). At the same time, fluvial and deltaic sediments were being deposited in the area of the Fenton Fault System in the eastern part of the area (Barbwire Sandstone). As the sea regressed in Late Jurassic or Early Cretaceous times, deltaic deposits (Mowla Sandstone) built out over the marine sediments and shallow water sands were probably deposited in the far west of the area (Broome Sandstone).

Since Early Cretaceous times, the area has been exposed, and the present major drainage lines may have started developing at this time (see van de Graaff & others, 1977). Minor tectonism caused minor folding in the Edgar Ranges area, and headward erosion by Geegully Creek produced scarps in the Ranges. Minor movement also occurred along the Fenton, Dampier, and other Faults.

During the Tertiary, gravel banks of the ancient Fitzroy River were laid down (Warrimbah Conglomerate) and deep weathering caused widespread lateritisation. This was followed by deposition of aeolian sand (as a result of the climate becoming drier), alluvial, and mixed alluvial and aeolian deposits.

## ECONOMIC RESOURCES

### *Coal*

Coal is recorded from various parts of the Permian and Jurassic sequences in the area, but the most prospective unit is the Liveringa Group. Coal occurs in the Lightjack Formation (Fig. 2), but appears to be discontinuous along strike and down dip (Baarda, 1967). The coal is sub-bituminous, and would need to be found in large quantities to be considered economic. However, there are several areas of Lightjack Formation exposure that have not yet been tested.

Coal intersected near Myroodah Crossing by Thiess (Pickering, 1967, 1968) probably also occurs in the Lightjack Formation. However, the possibility that these intersections occur in the Hardman Formation cannot be ruled out (see Fig. 2).

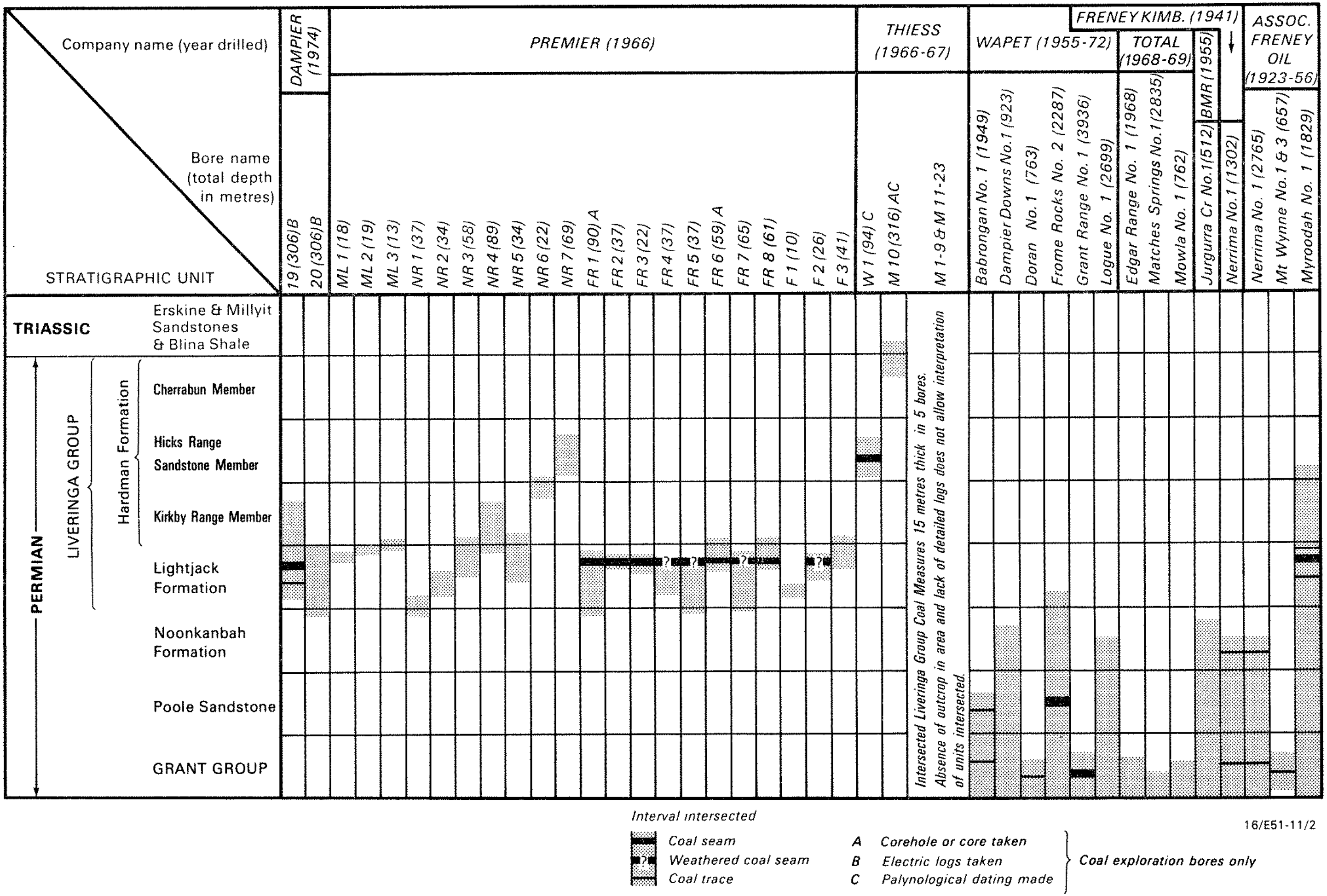


**Fig. 2. Coal intersections in petroleum and coal-exploration bores—Mount Anderson Sheet area.**

Intersections of coal in the Poole Sandstone, Grant Group, and Wallal Sandstone in petroleum exploration wells and station bores are considered too small or too deeply buried to be prospective.

Interpretations of the Permian units intersected in Figure 2 are not necessarily those of the companies involved.

*Petroleum*

Sixteen deep petroleum exploration wells have been drilled in the area with no success (Table 2). The first well, Mt Wynne 1, drilled in 1922–3 by the Freney Oil Company, encountered asphalt and bitumen in the Carolyn Formation. Mount Wynne 3, drilled only a few metres away from the first bore in 1923–25, encountered oil globules and bitumen

Free oil was found in Total Edgar Range 1 (Total, 1968), where vugs in dolomite of the Nita Formation bled oil, and a small gas show was recorded in the Nambeet Formation. Some other wells encountered minor bitumen and oil staining in Devonian, Carboniferous, and Permian rocks, and gas shows in Permian rocks (see Table 2).

Studies of the petroleum potential in the Canning Basin (Burne & Kantsler, 1977; Gorter & others, 1979; Horstman & others, 1976) have indicated that the Ordovician rocks on the Jurgurra Terrace and Broome Arch in the area have suitable thermal histories for the generation of hydrocarbons, but lack suitable reservoir rocks. Middle Devonian to Late Carboniferous and Permian rocks in the Fitzroy Graben have also reached a level of organic metamorphism suitable for the generation of oil.

The limited number of hydrocarbon shows is probably due to breaching of structure (in many cases by erosion represented by unconformities in the rock column), lack of porosity, flushing of reservoirs, or lack of suitable source rocks. Burne & Kantsler (1977) state that 'The great age, slow subsidence, and low geothermal gradients of the Canning Basin meet none of Klemme's (1975) criteria for the discovery of giant oil fields'.

*Phosphate*

A thin phosphatic bone bed lies near the base of the Blina Shale in the Dry Corner Syncline (Brunnschweiler, 1954; Freas & Zimmerman, 1965; Howard, 1972). The bed is up to 30 cm thick, lies on a thin phosphatic limestone, and is discontinuous. It consists of abundant sand to gravel-sized phosphate intraclasts and phosphatised bones and shell fragments, in a matrix of fine phosphate, silica(?), iron oxide, and clay.

The phosphatic intraclasts contain up to 24.9% $P_2O_5$, while grab samples contain up to 19.5% $P_2O_5$ (Freas & Zimmerman, 1965). The low grade and thinness of the bed make it uneconomic. Freas & Zimmerman show that the Blina Shale contains phosphate over a fairly wide stratigraphic interval, so it is possible that the shale unit contains other beds rich in phosphate.

Phosphatic limonitic beds up to 15 cm thick are present in the Lightjack Formation, Noonkanbah Formation, and Poole Sandstone (Guppy & others, 1958; Freas & Zimmerman, 1965). Samples contain up to 20% $P_2O_5$, and up to 41.7% $Fe_2O_3$. However, there seems to be little chance of finding economic phosphate in these formations.

Freas & Zimmerman (1965) also report phosphatic sideritic ironstone in the Jarlemai Siltstone, Alexander Formation, and Wallal Sandstone in petroleum

TABLE 4. SUMMARY OF OPERATING WATER BORES VISITED IN 1976, MOUNT ANDERSON 1:250 000 SHEET AREA

| *Bore* | *Station* | *Grid reference* | | *Salinity (ppm)* | *Sample*[1] *type* | *Tank*[2] *type* | *Pump*[3] *type* | *Aquifer* |
|---|---|---|---|---|---|---|---|---|
| Bamboo | Myroodah | 655 000 mE | 7973 000 mN | 2800 | F | T | W | Kirkby Range Member |
| Big Flow | Nerrima | 646 | 7944 | 1000 | F | — | W | ? |
| Bloodwood | Mt Anderson | 605 | 8001 | 2000 | F | T + E | W | Hardman Formation |
| Bolgers | Mowla | 576 | 7934 | 1525 | F | E | W | Wallal Sandstone |
| Chappels No. 2 | Myroodah | 643 | 7971 | 3500 | F | T | W | Hardman Formation |
| Clarkson | Luluigui | 591 | 7988 | 6000 | T | T | W | Hardman Formation |
| Corner | Myroodah | 650 | 7976 | 2400 | F | T + E | W | Hicks Range Sandstone Mbr |
| Dampier Downs Homestead | Dampier Downs | 548 | 7952 | 410 | T | T | E | Wallal Sandstone |
| Deep Well | Myroodah | 627 | 7981 | 1320 | F | T | W + E | Hicks Range Sandstone Mbr? |
| Dry Corner | Luluigui | 617 | 7968 | 3700 | F | E | W | Cherrabun Member |
| Eldorado | Luluigui | 603 | 7977 | 2000 | F | E | W | Hicks Range Sandstone Mbr |
| Farrels | Nerrima | 622 | 7958 | 2200 | F | 2 × T | W | Poole Sandstone |
| Freney | Nerrima | 643 | 7964 | 1800 | T | T | W | Lightjack Formation |
| Garden Well | Myroodah | 638 | 7992 | 100 | T | T | W | Erskine Sandstone |
| Green Spring | Nerrima | 634 | 7951 | 450 | F | — | A | Alexander Formation? |
| Howards | Myroodah | 634 | 7980 | 1750 | F | 2 × T | W | Hicks Range Sandstone Mbr? |
| Horsepaddock | Mt Anderson | 595 | 8006 | 900 | F | T + E | W | Poole Sandstone |
| Kings | Myroodah | 621 | 7992 | 3200 | F | — | W | Hardman Formation |
| Langs | Mt Anderson | 605 | 8006 | 450 | F | T + E | W | Poole Sandstone |
| Little Flow | Nerrima | 630 | 7958 | 2200 | T | T | W | ? |
| Looma | Looma | 621 | 8005 | 100 | T | T | E | Carolyn Formation |
| Luluigui Homestead | Luluigui | 609 | 7993 | 2000 | T | T | W + E | Cherrabun Member |

TABLE 4. SUMMARY OF OPERATING WATER BORES VISITED IN 1976, MOUNT ANDERSON 1:250 000 SHEET AREA *(continued)*

| *Bore* | *Station* | *Grid reference* | | *Salinity (ppm)* | *Sample[1] type* | *Tank[2] type* | *Pump[3] type* | *Aquifer* |
|---|---|---|---|---|---|---|---|---|
| Macalears | Luluigui | 606 000 mE | 7966 000 mN | 2000 | F | T | W | Kirkby Range Member |
| McLarty | Nerrima | 653 | 7948 | 4500 | T | T | W | Kirkby Range Member |
| Mills | Myroodah | 633 | 7976 | 4100 | F | E | W | Hicks Range Sandstone Mbr |
| Moores | Luluigui | 611 | 7986 | 2700 | F | E | W | Hicks Range Sandstone Mbr |
| Mount James | Nerrima | 655 | 7935 | 1400 | T | E | W | Kirkby Range Member |
| Mount Anderson Homestead No. 1 | Mt Anderson | 599 | 8006 | 200 | F | } | W | Carolyn Formation |
| Mount Anderson Homestead No. 2 | Mt Anderson | 599 | 8006 | 200 | F | T | E | Carolyn Formation |
| Mount Anderson Homestead No. 3 | Mt Anderson | 599 | 8006 | 300 | F | } | W | Carolyn Formation |
| Mowla Bluff Homestead | Mowla Bluff | 571 | 7943 | 250 | T | T | E | Wallal Sandstone |
| No. 1 | Myroodah | 645 | 7984 | 570 | T | E | W | Hardman Formation |
| No. 12 | Mt Anderson | 593 | 8008 | 1500 | F | T | W | Poole Sandstone |
| Old Mowla Bluff | Mowla Bluff | 573 | 7931 | 5000 | F | T | W | Alexander Formation |
| Rig | Nerrima | 648 | 7957 | 2000 | F | T | E | Poole Sandstone? |
| Tutu | Nerrima | 629 | 7966 | 4500 | F | 2 × T | W | Hicks Range Sandstone Mbr |
| Victory | Luluigui | 589 | 7980 | 3150 | F | T | W | Liveringa Group |
| Waterford | Luluigui | 608 | 7973 | 315 | F | T | W | Hardman Formation |
| Whips | Mowla Bluff | 572 | 7943 | 200 | T | E | W | Wallal Sandstone |
| Windbag | Luluigui | 602 | 7985 | 1375 | F | T | W | Hicks Range Sandstone Mbr? |

1. F—Flowing; T—Tank. 2. T—Steel or concrete tank; E—Earth tank. 3. W—Windmill; E—Engine; A—Artesian flow.

exploration wells in and around the area. One nine-metre interval of Jarlemai Siltstone in WAPET Barlee 1 (WAPET, 1961e) to the northwest of the area assayed at 5.7% $P_2O_5$. A 15-m interval of the Jarlemai Siltstone in WAPET Thangoo 1 (WAPET, 1961d) about 12 km west of the area averaged 4.3% $P_2O_5$ and 45.8% $Fe_2O_3$.

Russell (1966a, b) reported a phosphatic zone at the base of the Jarlemai Siltstone in drill-holes near Langey Crossing about 35 km north of the area. This zone is up to 1.2 m thick, with a phosphate content of up to 13.1 percent. $Fe_2O_3$ plus $Al_2O_3$ is generally between 10 and 20 percent. It is possible that a similar zone may in places occur at the base of the Jarlemai Siltstone in the area.

*Iron*

The Lightjack Formation contains lenses of limonitic oolite near its base. A sample analysed by Edwards (1953) from north of Mount Wynne contained 51% $Fe_2O_3$, 19% $SiO_2$, and 13% $Al_2O_3$. Although the oolite-bearing interval is extensive, it is not considered to be an economic deposit of iron ore.

Iron is also associated with phosphatic intervals in Permian and Jurassic Rocks in the area (see section on Phosphate).

*Road Metal*

Pisolitic laterite and ferruginised sandstone are used as road metal. These occur in small quantities over most of the area.

*Water*

Permanent surface water is present in the Fitzroy River, in small waterholes in Geegully Creek, and in springs along the Fenton Fault and in the Edgar Ranges. Part of the water of the Fitzroy River is diverted from Fitzroy Weir into Lake Josceline to provide irrigation water for the Camballin Project.

However, most grazing depends on groundwater which is pumped to the surface, mainly by windmills. Good aquifers are present in the Alexander Formation, Wallal Sandstone, Erskine Sandstone, Hardman and Lightjack Formations, Poole Sandstone, and Carolyn Formation. Other formations are too deep to be of interest as water sources for grazing.

A list of operating water bores visited by BMR and GSWA personnel in 1976 is shown in Table 4 together with details of their pump mechanism, water storage, salinity (measured in the field by techtometer), and the rock unit from which the bore is drawing. Many bores were not working or had been abandoned at that time because of high salinity or downturns in the cattle industry.

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## APPENDIX 1: Revision of Stratigraphic Names

The Mudjalla Sandstone (Guppy & others, 1958) and Jurgurra Sandstone (Brunnschweiler, 1954) are here redefined as the Mudjalla Sandstone Member and Jurgurra Sandstone Member of the Wallal Sandstone (McWhae *in* WAPET, 1961).

The term Wallal Sandstone was introduced by McWhae (*in* WAPET, 1961) for the basal Jurassic sandstone unit that had been intersected in petroleum exploration wells in the western part of the Canning Basin. It underlies the Alexander Formation, and unconformably overlies Triassic or older rocks. It has been recognised in all the petroleum exploration wells south of the Fenton Fault in the Mount Anderson Sheet area (Crowe & others, 1978). McWhae (*in* WAPET, 1961) and Playford & others (1975) state that the Wallal Sandstone is a wholly subsurface unit, and tentatively correlate it with the outcropping Mudjalla and Jurgurra Sandstones. The BMR/GSWA fieldwork in 1976 and study of petroleum and phosphate exploration well logs in the Mount Anderson and Derby Sheet areas has confirmed these correlations (Crowe & others, 1978). In addition, the Mudjalla Sandstone and Jurgurra Sandstone can be identified as parts of the Wallal Sandstone.

However, since the Mudjalla Sandstone and Jurgurra Sandstone are units with distinct suites of sedimentary structures, and since they probably represent only local facies of the Wallal Sandstone, it is considered that they should have individual status. Hence it is proposed that these two units be called the Mudjalla Sandstone Member and Jurgurra Sandstone Member of the Wallal Sandstone.

It should be noted that rocks of these two members are, on current information, indistinguishable from the rest of the Wallal Sandstone in the subsurface; therefore their subsurface extent is not known. The Jurgurra Sandstone Member probably does not extend to the base of the Wallal Sandstone, whereas the Mudjalla Sandstone Member probably makes up all the Wallal Sandstone in the area where it crops out.

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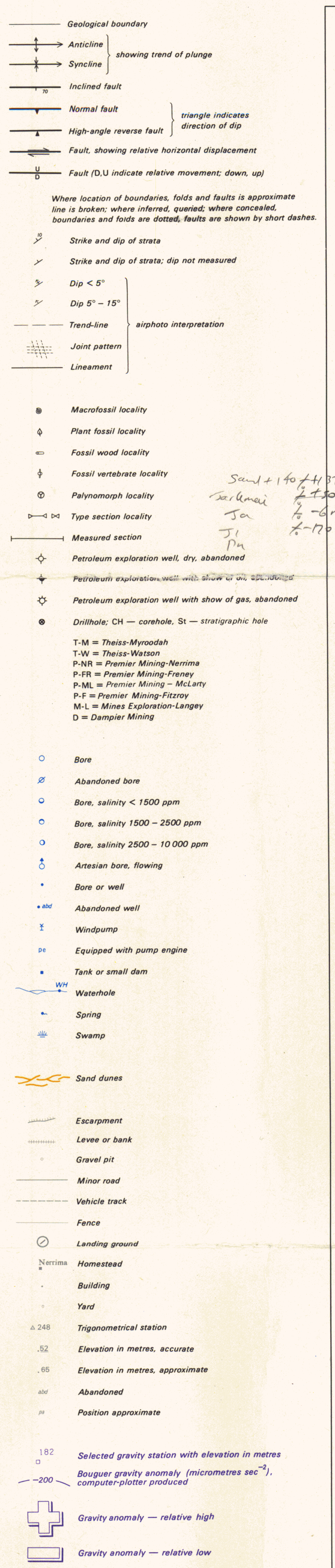


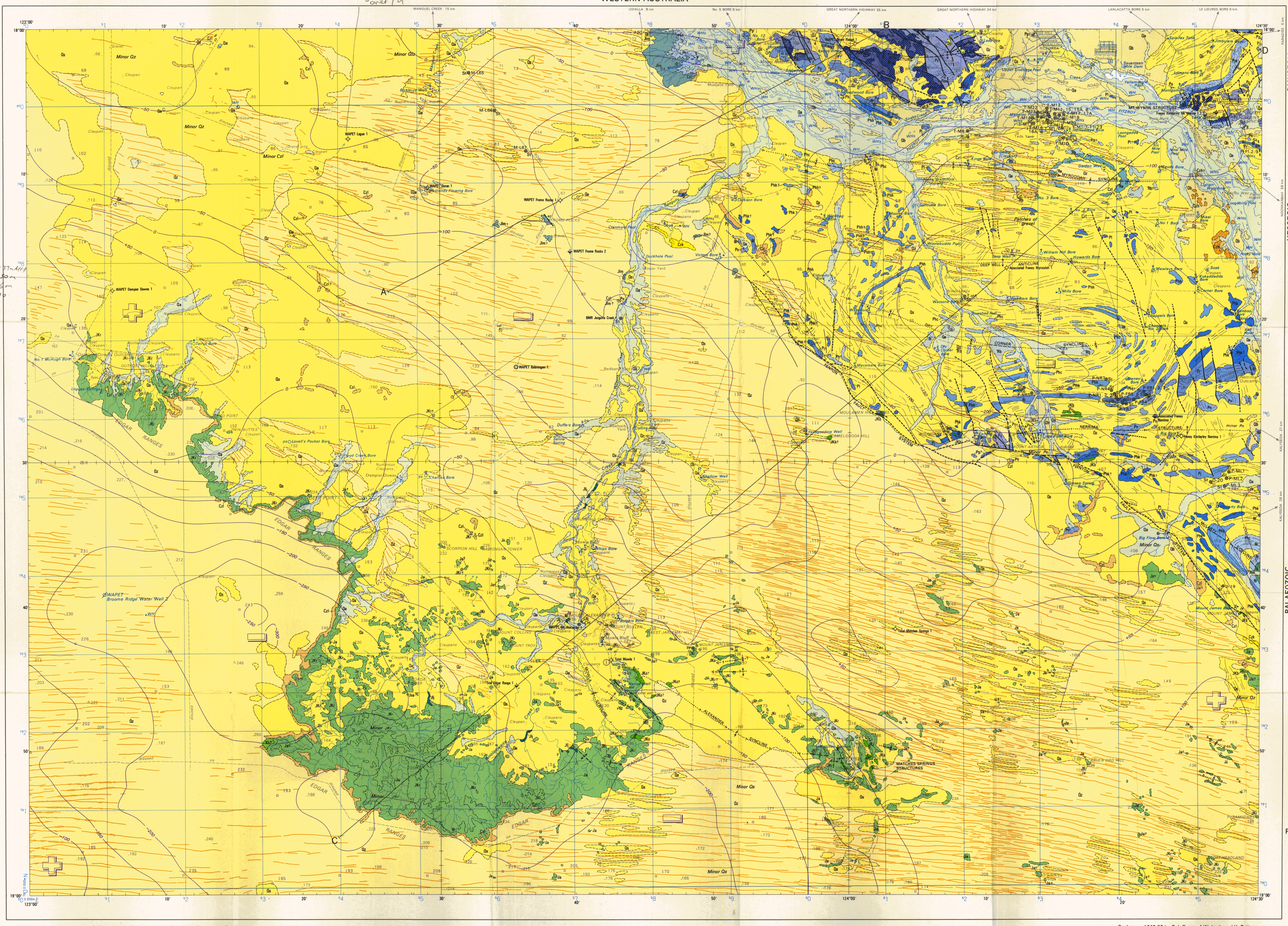

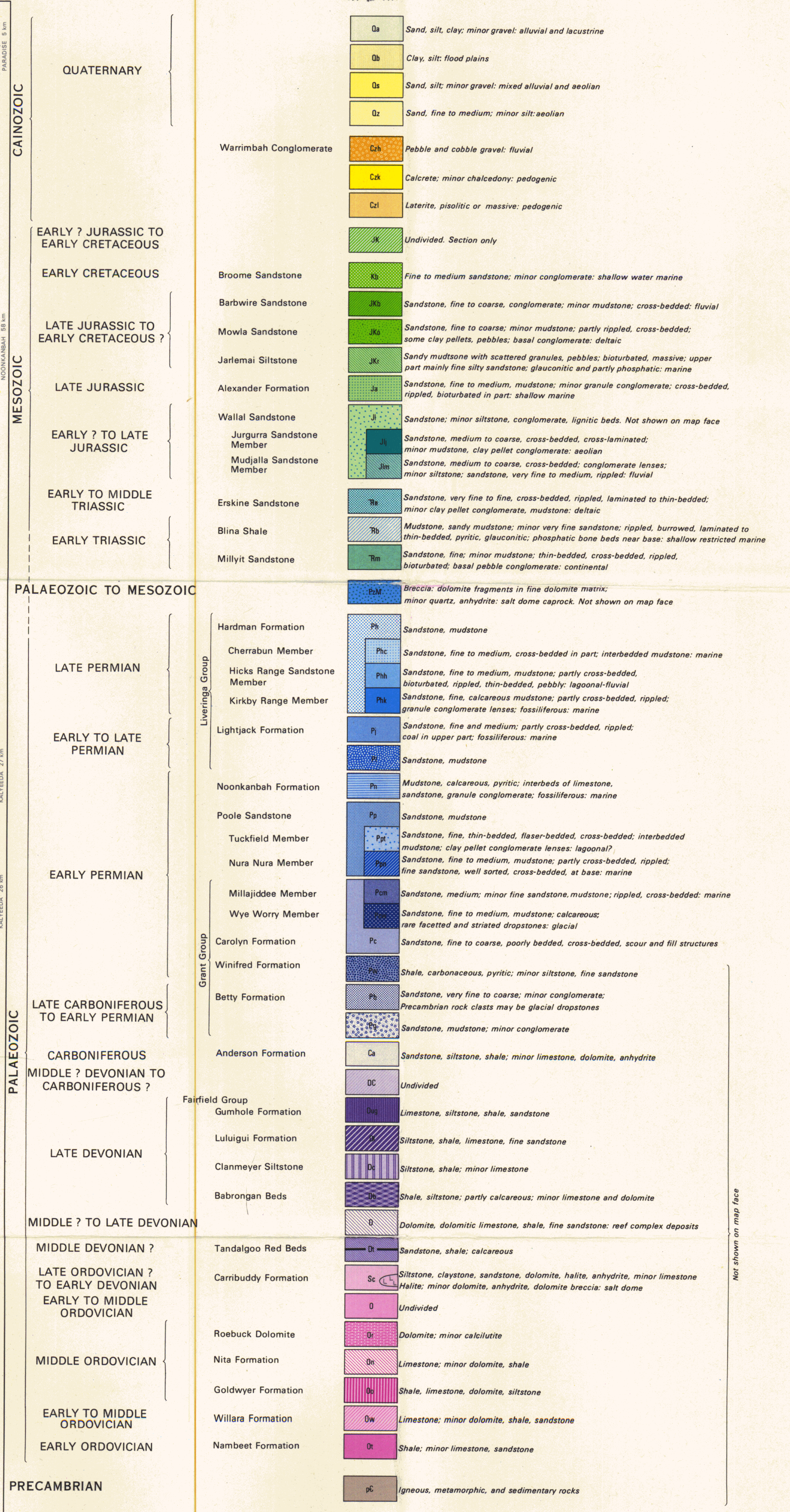


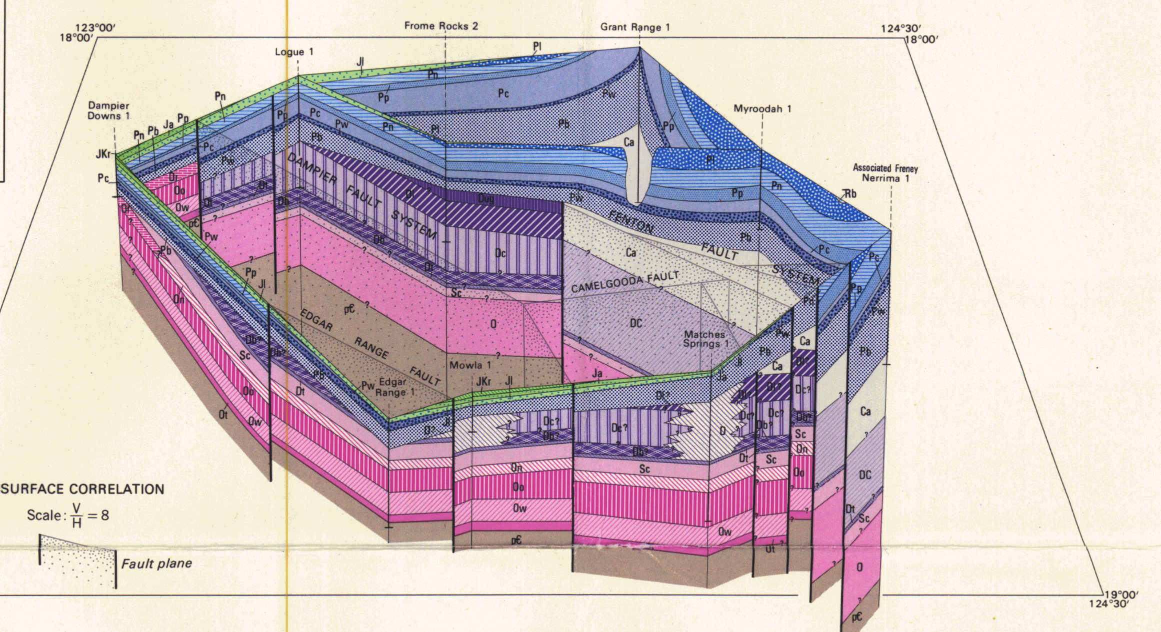


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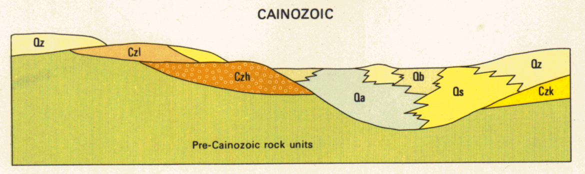


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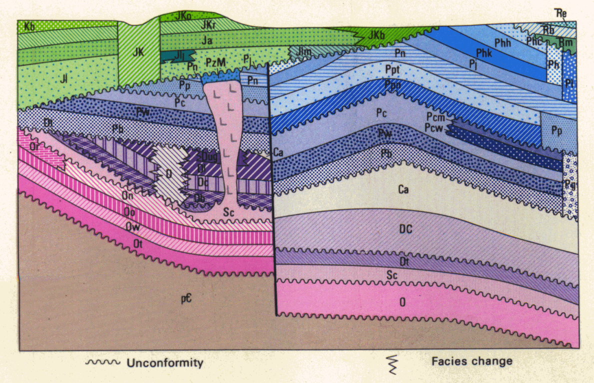



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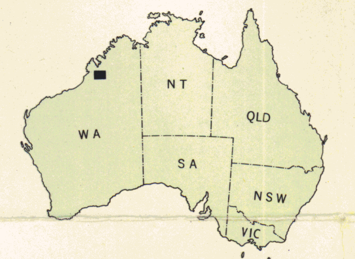


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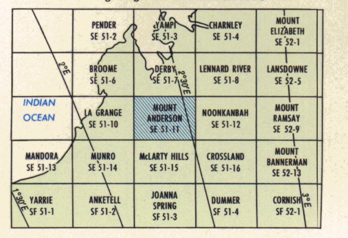


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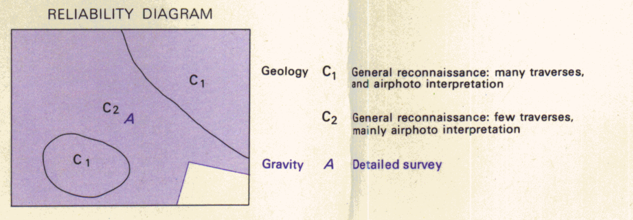


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1976 by R.W.A. Crowe GSWA, D.L. Gibson, R.R. Towner BMR
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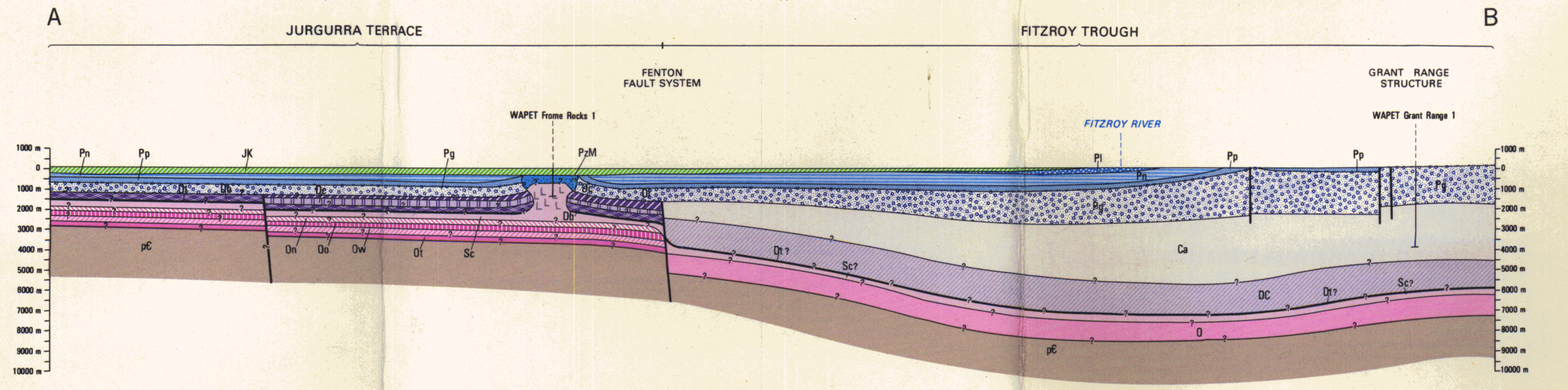


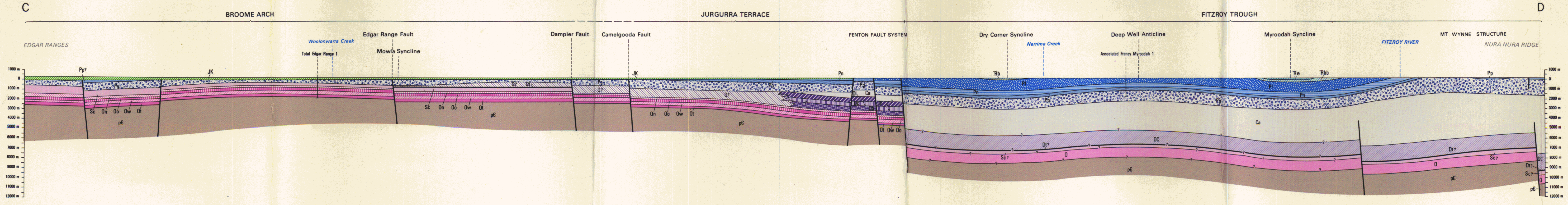


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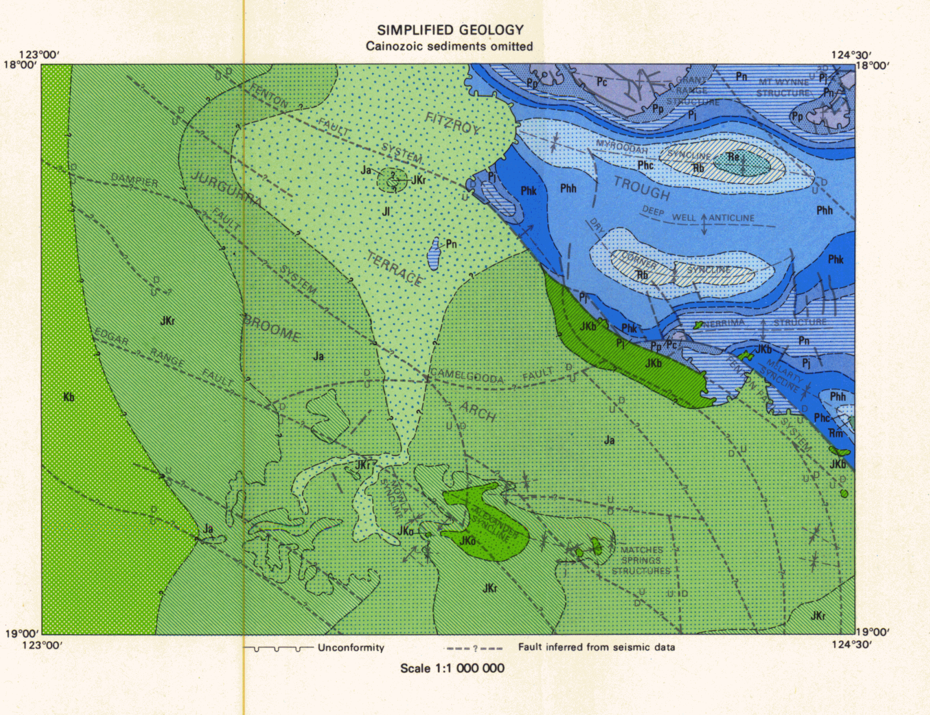


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