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Record No. 1971/5

Notes on a Geological Reconnaissance of the Officer Basin, W.A., 1970

by

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SUMMARY

The Officer Basin underlies the Great Victoria and Gibson Deserts in the eastern part of Western Australia. The ground surface is predominantly a monotonous, arid, semi-desert plain; rock outcrops are sparse and deeply weathered. Most of the outcrops belong to an undifferentiated sequence of Permian fluvioglacial sediments. Coarse, immature, feldspathic sandstones are the dominant lithology. Sedimentary structures are common and indicate a terrestrial, fluvial environment of deposition. White silicified claystones (Bejah Beds) form steep-sided, flat-topped mesas in the Gibson Desert, north of latitude 26°S.

Gently dipping bluffs or dissected rubble-strewn areas containing rocks of pre-Permian age were found in a number of widely separated areas. Stromatolitic dolomites, cherty oolites, and sandstones of possible Upper Proterozoic age, and basalts of probable Ordovician age were examined.

Recommendations for systematic geological mapping of the area at 1:250,000 scale using helicopters are included in the report.

INTRODUCTION

General

The Bureau of Mineral Resources, in conjunction with the Geological Survey of Western Australia, is planning systematic geological mapping in the Officer Basin, Western Australia in 1971 so a reconnaissance of the area was made between 8th August and 12 September 1970. The purpose was fourfold; firstly to assess the accuracy of the existing geological information; secondly to collect fossils to assist accurate stratigraphic dating; thirdly to inspect previously unrecorded outcrops that from air-photo interpretation appeared to be unusual; and finally to assess the logistic problems likely to occur when using helicopters in the area. Systematic geological mapping was not attempted.

This report gives an account of the more important geological observations made, and comments on some of the field problems encountered. It is accompanied by a bibliography and an appendix containing hand specimen and thin section descriptions of some selected rock samples from the area. The characteristic landforms of the area are illustrated.

Location and access

The Officer Basin is the third largest sedimentary basin in Australia, with an area of about 325,000 sq km (130,000 sq mls). Two thirds of the basin lies in the eastern part of Western Australia and the remainder forms a major portion of western South Australia. It underlies much of the area known as the Gibson and Great Victoria Deserts. This report deals only with the Western Australian part of the basin; i.e. the area lying between latitudes 24°S and 29°S and longitudes 123°E and 129°E, an area of about 220,000 sq km; it is referred to as the Officer Basin (W.A.) throughout this report.

There are few permanent settlements in the area. The United Aborigine's Warburton Mission is the only settlement near the centre of the area so it was used as the base camp for the survey as food, petrol and drinking water were available. Warburton Mission is about 1,500 km (930 mls) northeast of Perth by road. Kalgoorlie, 1,000 km to the southwest, and Alice Springs, 1,000 km to the northeast, are the nearest large towns. There are two main routes into the area from the west; the Gunbarrel Highway which connects Warburton Mission with Wiluna, and the Warburton-Laverton road which runs southwesterly to Kalgoorlie (Plate 2). Both routes are unsurfaced graded tracks that are negotiable under normal conditions by conventional 2 wheel-drive vehicles, but they would be impassable after heavy rains. Unmaintained roads and tracks, built by Hunt Oil Company several years ago, allow reasonable access to some parts of the area; however, a great deal of the area is devoid of tracks and is accessible only by cross-country driving. Warburton Mission has an unsurfaced landing-strip for light aircraft.

Method of investigation

A preliminary examination of the airphotographs was made by D.C. Lowry (G.S.W.A.) prior to leaving for the field. The traverses were planned to include areas containing locally extensive or unusual outcrops while making optimum use of the existing roads and tracks. Six traverses were planned, each of about 5 to 6 days (800 km) duration. Most of the exposures visited were of the breakaway type. The rock types were similar so stratigraphic subdivision and correlation was not possible, and the time spent at each outcrop was relatively short. Geological observations at each outcrop took between 30 minutes and 3 hours, with an average of about 45 minutes. Observation points were accurately located on air photos in the field and later transferred to the relevant Australian (series R502) 1:250,000 map sheets. The order in which the traverses were done and the observation points are shown on Plate 2.

Previous investigation

The earliest recorded geological investigation of the area is that by Talbot & Clarke (1917) in 1916, who made several traverses between Laverton and the South Australian border. Utting (1955) investigated approximately the same area as that covered during this reconnaissance and produced a geological sketch map covering the area between latitudes 26°S and 28°S and longitudes 124°30'E and 128°E, for Australasian Oil Exploration Ltd. Six years later Leslie (1961) produced a geological map covering a large portion of the desert area of Western Australia for the Frome-Broken Hill Co. Pty Ltd, after field work in 1960. The area he investigated lies between latitudes 22°30'S and 29°30'S and longitudes 121°E and 128°30'E. Systematic mapping of the Gibson Desert was carried out by Wells (1963) using photogeological interpretation and helicopter traverses. He produced a regional geological map at a scale of 1:500,000 covering the 1:250,000 Sheet areas - Madley, Warri, Cobb, Herbert, Browne, Bentley (Plate 2).

Geological interest in the Officer Basin (W.A.) increased in the 1960's. Hunt Oil-Placid Oil Company carried out geological mapping, geophysical investigations and stratigraphic drilling between 1961 and 1966. A number of reports were written at various stages during the investigation, but the final results were combined and reviewed by Jackson (1966b) when field investigations ceased. Small scale geological, geophysical and structural maps of the Officer Basin (W.A.) were prepared by Jackson; they cover twenty 1:250,000 map sheets between latitudes 25°S and 30°S and longitudes 123°E and 129°E.

During 1961 and 1962 reconnaissance seismic surveys were made along the Gunbarrel Highway between Carnegie Homestead and the Giles Meterological station by the BMR (Watson, 1963; Fowler, 1963). Turpie (1967) reinterpreted the results of these surveys in the light of geological information obtained between 1962 and 1967.

Since Hunt Oil Company left in 1966 only minor interest has been shown in the area. However, regional mapping has been carried out by Lowry (1970) of the Geological Survey of Western Australia in the Eucla Basin to the south of the area (Mason, Jubilee and Plumridge sheets), and by Daniels (1969) in the PreCambrian metamorphics to the northeast of the Basin (Bentley, Talbot, Scott and Cooper sheets).

The Mines Department (S.A.) and several exploration companies have made geological and geophysical investigation in the South Australian part of the Basin, especially during the last ten years. The resulting geological information is likely to be of great significance when interpreting the geology of the W.A. portion of the Basin.

A bibliography listing all the known reports on the Officer Basin forms part of this report.

GEOLOGICAL OBSERVATIONS

Physiography

The area is an arid, monotonous desert plain with average elevations of about 300 m (1,000 ft) in the south and 450 m (1,500 ft) in the north. A number of distinctive landforms have been recognized and described by Wells (1963) and Jackson (1966b). A brief description of the major landforms is given below.

SAND PLAINS AND DUNES

Sand plains and longitudinal dunes blanket much of the area. The plains are featureless stretches of loose aeolian sand with a cover of spinifex and sparse eucalypts. The dunes vary in shape and size, but are commonly 10 to 15 m high and several kilometres long. The thickness of the sand blanket is unknown (Figs 3 and 4).

IRONSTONE PLAINS AND RISES

Extensive areas are underlain by undulating plains and low broad rises which have a surface of rubbly ferruginized ironstone (Fig 5). This landform is common in areas where breakaways of Permian? rocks are found. The relief is only slight, but it is more pronounced than in areas covered by sand plains.

The areas blanketed by sand and ferruginous ironstone make up at least 90 percent of the total area. The remaining area is occupied by hills and drainage features.

HILLS

Dissected ranges of marked relief (hundreds of metres) are confined to the edges of the basin where Precambrian volcanic and metamorphic rocks are exposed at the surface. Outcrops of Phanerozoic rocks within the basin give rise to mesas or buttes (Fig 9), or more commonly breadaway country of low relief (less than 30 m). Deep weathering and undercutting of breakaway faces, with the development of caves, is a common feature of many outcrops (Fig 6).

DRAINAGE FEATURES

Permanent surface water is non-existent in the Great Victoria and Gibson Deserts. The main drainage features are dry salt lakes and alluvial depressions that are often partly filled with calcrete deposits. Jackson (1966b) has reconstructed the former drainage pattern, and groups the drainage trends and lakes into eight drainage systems. The major drainage is south or southeast, consequent to the slope of the land.

General geology

For the purposes of this report the Officer Basin is tentatively defined as the deep, elongated structural depression situated between the Yilgarn Block on the west, the Musgrave-Mann Block on the north and northeast, and the Gawler Platform on the southeast. The basin is filled with unmetamorphosed, Proterozoic to Tertiary sedimentary rocks which stretch from the Canning Basin in the northwest to the Great Artesian Basin in the east (Plate 1). The southern flanks of the basin are hidden by the overlying Tertiary Eucla Basin. However, owing to a lack of geological information the boundaries of the basin are generally poorly defined, even where not obscured by later deposits. The sediments overlie a Precambrian basement, which in most areas consists of crystalline igneous or metamorphic rock. Geophysical investigations indicate that the basin is asymmetrical, with the deepest section lying close to its northern boundary; from here the basin gradually shallows southwards.

Previous geological and geophysical investigations suggest that the Officer Basin in Western Australia is composed of a thick (5,500 m) Proterozoic sequence capped by a thin veneer of Palaeozoic and Mesozoic rocks. Hunt Oil Company drilled five shallow holes in 1965-66 and all entered Proterozoic rocks at shallow depth (less than 450 m). The Proterozoic age was based on isotope dating of basalt encountered from 729 to 846 m (2390 to 2775 ft), and on the recognition of simple spores from dolomite and shale below the basalt. Jackson (1966, a & b), therefore, regards the Officer Basin (W.A.) as being composed mainly of Proterozoic rocks.

In contrast, Krieg (1969a) shows the Eastern Officer Basin of South Australia as being composed of a Palaeozoic sequence 4,000 m (13,000 ft) thick overlying a Proterozoic sequence only 900 m (3,000 ft) thick. A deep stratigraphic well in the Eastern Officer Basin, Munyarai No. 1 (Continental Oil Company, 1968), penetrated 2,890 m (9,510 ft) of deposits which are no older than Silurian to Devonian. Palaeozoic rocks, unconformably overlying Proterozoic sediments, are exposed along the eastern margin of the basin. There the Palaeozoic succession consists of 610 m (2,000 ft) of doubtful Cambrian sediments, 1,830 m (6,000 ft) of Ordovician and Devonian sediments and an unknown thickness of Carboniferous sandstone.

Most of the exposures visited during this reconnaissance belong to a Permian fluvioglacial sequence. Pre-Permian sediments and volcanics were found in the Robert Sheet area, but it was not possible to definitely correlate these with any of the previously described formations, in the time available. The most important observations are recorded below.

Permian outcrops

Two thirds of the outcrops visited are tentatively grouped into an undifferentiated Permian fluvioglacial sequence. The Permian age is based on spores obtained from a BMR seismic hole, 45 km west of Mount Everard, Browne Sheet, Plate 2, (Wells, 1965, p. 15), and from Hunt Oils stratigraphic well Yowalga No. 2 (Jackson, 1966a, p. 39). Lithological similarity with Permian in the Canning Basin also invites comparison. The thickest section of Permian known is 366 m (1,200 ft) in Hunt Oil's stratigraphic well Yowalga No. 1. Fluvioglacial sandstones and tillites in the Great Victoria and Gibson Deserts, have been termed Wilkinson Range Series by Talbot & Clarke (1917, p. 105), Paterson Formation by Wells (1963, p. 12), and Yowalga Sandstone by Jackson (1966, p. 39). The adoption of any stratigraphic nomenclature is avoided until the geology is better understood. The dominant lithology in the outcrops visited during this survey is a medium to very coarse grained poorly sorted, poorly bedded, angular to sub-rounded feldspathic arenite. Conglomerate, fine sandstone, claystone, and siltstone are interbedded with the arenites at almost all outcrops. Primary sedimentary structures are generally well preserved; washouts, scour and fill, pull-apart structures, cross-bedding, churned-bedding, grading, slumping, and dessication cracks were recorded. Invertebrate fossil shells were not found, but organic burrows were seen at many outcrops. The burrows were single unbranched vertical tubes a few millimetres in diameter and 2 to 10 cm long. A cliff face 10 m high at Cooper Creek (Lennis Sheet area, exposure 19) showed two horizons crowded with organic burrows; an upper horizon crowded with large burrows (5 mm x 15 cms), and a lower one containing small thin burrows.

The above observations suggest a continental environment of deposition that was dominantly fluvial, but possibly shallow water marine or aeolian at times. Rapid changes in the rock types and many irregular sedimentary breaks indicate that the depositional interface was unstable and that sub-aerial denudation was common.

Two exposures of tillite indicate that glacial conditions prevailed at some time during the deposition of these fluvial sediments. The tillites are composed of rounded pebbles and boulders (up to 60 cm diameter) of quartz, quartzite, sandstone, siltstone, shale, granite, basalt and metamorphic rocks (including silicified oolites) set in a fine sandstone to siltstone matrix. Fine sandstones and silt-stones containing isolated, rounded pebbles (1 to 3 cm diameter) of quartz and granite were found at a few localities. These rocks are also probably of glacial origin.

In many outcrops sandstone beds of irregular thickness and composition are separated by diastems, minor disconformities and erosional contacts. It was, therefore, impossible to logically subdivide or intercorrelate the Permian outcrops. Sections were measured at all the well exposed outcrops, and Plate 3 shows twenty columnar sections arranged in a sequence running southwest to northeast across the basin, approximately along the line of the Laverton-Warburton Road. Two features emerge from an examination of this diagram:

(a) finer grained rocks appear to be dominant in the sections measured in the northeast (the deeper part of the Basin?).

(b) the Permian succession commences with a thin basal conglomerate in the southwest, i.e. in the area near Lake Yeo.

It is evident that correlation of the sections illustrated would be imprudent.

At all outcrops the Permian rocks were flat-lying to sub-horizontal. However, photo-interpretation for Hunt Oil Company outlined numberous anticlinal and synclinal axes with dips on their flanks of 2^{o} to 5^{o}. Seismic investigations (Turpie, 1967) suggests that the Permian is mainly flat-lying and may be up to 610 m (2,000 ft) thick.

Mount Smith exposures

Previously unrecorded exposures of basalt and sandstone were found in low rubbly ridges between Mount Smith and the Herbert Wash, in the northeast corner of the Robert Sheet area (Plate 2, exposures 40-44). At exposure 42 the section comprises:

TOP

0-2 metres	Light-brown, coarse-grained, limonitic, feld-spathic greywacke/sandstone. The rock was found in pockets and appears to interfinger with the underlying conglomerate; it resembles the Permian arenites described in the preceding section.

FIGURE 1

DIAGRAMMATIC CROSS SECTIONS OF EXPOSURES IN THE MOUNT SMITH AREA

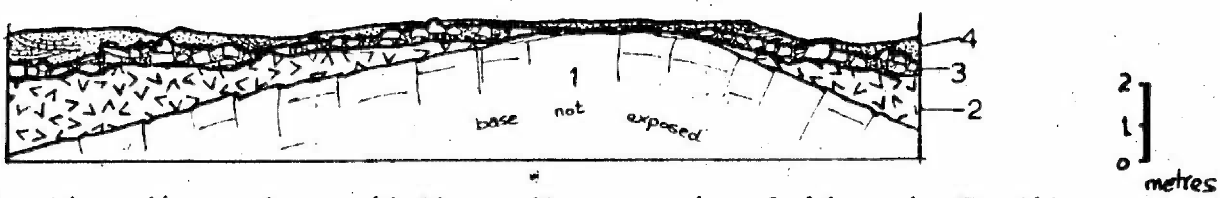
1a

4 Sandstone, red, ferruginized, very coarse-grained and conglomeratic. Cross-bedded, irregular thickness (less than 2 metres exposed). Permian ?

3 Conglomerate, angular cobbles of 1 and 2 set in very coarse, unsorted sandstone. Rounded agate and quartz present. Irregular thickness (0 to 1 metre).

2 Basalt, purple-grey, fine, very hard. Top scoriaceous and weathered, base chilled. Irregular thickness (1 to 3 metres).

1 Orthoquartzite, light brown to white, medium-grained, well sorted, gently folded, faulted. Sandstone baked by overlying basalt in places.



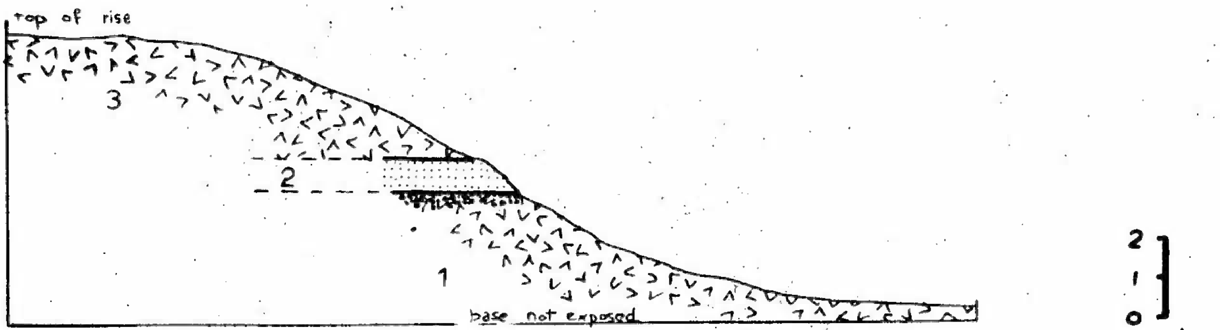
Section through anticline 4km east of Mount Smith

1b

3 Basalt, fine grained, massive, very hard, no amygdales seen. Base crumbly and weathered, probably chilled.

2 Quartzitic sandstone, purple-brown, medium-grained, well sorted, cross-bedded, faulted.

1 Basalt, purple-grey, amygdaloidal, fine-grained, very hard. Highly vesicular close to top.



Section through low rise 3km east of Mount Smith

MJJ

0-1 m	An irregular pebble and cobble conglomerate bed composed largely of sub-angular blocks of quartzite (up to 50 cm diameter) and basalt weakly cemented in a very coarse-grained pebbly sandstone. Rounded agates (1-4 cm diam.) and pebbles of milky quartz are scattered about in the matrix.
0-4 m	Purplish grey fine-grained basalt. The base of the flow is chilled and the top 1 metre is amygdaloidal, vesicular and deeply weathered.
2 m	Light brown quartzitic sandstone. The rock appears massively bedded in outcrop, but faint laminations are visible in hand specimen. The quartzite is medium-grained, well-sorted and moderate to well-rounded (Appendex 1, sp. 70880007). The unit is folded into a gentle northeasterly plunging anticline which is cut by several small faults having the same trend. The top is baked by an overlying basalt flow; the base is not exposed.
BASE	

The relationship of the various rock units is shown in Fig 1a. The geological history represented by these deposits is as follows. (a) Deposition and lithification of a mature clean sand to produce the quartzite. (b) Folding and faulting along northeast axes, followed by a period of erosion or non-deposition. (c) Igneous activity resulting in the deposition of a thin basalt flow on an irregular surface of quartzite; the top few centimetres of quartzite being baked by the heat of the extrusion. Agate and quartz crystallized in vesicles in the basalt some time during or after emplacement. (d) A period of non-deposition between basalt emplacement and the deposition of the overlying conglomerate and sandstone is suggested by the deep weathering of the top of the flow. (d) The conglomerate represents a deposit which has undergone very little transport; it is composed of blocks of the underlying basalt and quartzite which show no evidence of abrasion or rounding. (f) Finally, poorly sorted conglomeratic sandstone was laid down on an irregular surface so that the deposit became patchy and discontinuous.

In marked contrast to the above succession and situated 1 km to the south, are two basalt flows separated by a bed of quartzite in a small rubble-strewn rise (Fig. 1b). The lower flow has a marked vesicular upper surface indicating terrestrial extrusion. Above this is 1 m of flat lying, brown, medium-grained, well sorted quartzite, almost identical in texture and appearance to that seen at the base of exposure 42. The upper basalt flow has a crumbly weathered zone immediately above the sandstone which may represent a chilled base.

The presence of crystalline agate and quartz in the basalt at exposure 42 suggests that tentative correlation with basalts in the Officer Basin in South Australia may be attempted. Major & Teluk (1967) have described agate and quartz-bearing tholeiitic basalts on the Birksgate 1:250,000 Sheet in the Officer Basin in South Australia. They have named these the Kulyong Volcanics and have established their minimum apparent age* as 480 m.y. i.e. Lower Ordovician. These basalts cap a sequence of fine micaceous sandstones, silicified greywackes, and a 5 cm bed of limestone.. Because of the lack of faulting and folding, Major & Teluk suggest that there has been little or no tectonic activity in this area since the formation of the Kulyong Volcanics.

A sample of basalt taken from exposure 40, 11 km east of Mount Smith, is petrographically similar to samples described by Major & Teluk (1967) and Peers (1969). (Appendix 1. spec. 70880006).

Empress Spring Exposures

Dolomite and sandstone are exposed 17 km west of Empress Spring (exposure 48, Robert Sheet, Plate 2). The exposures consist of dissected rubble-strewn ground broken by 2 to 4 m steps of resistant bedrock. On air photos these ridges dip in a northeasterly direction at about 5°. The thickness of the section was not measured, but is estimated from air photos as between 50 and 100 metres; it consists of the following succession:

TOP

1. Sandstone : red and green, fine to medium grained, well rounded, friable sandstone.
2. Dolomite : with sparse stromatolites.
3. Sandstone : red and green, fine to medium grained, well rounded, thinly bedded sandstone.
4. Dolomite : with some stromatolites.
5. Siltstone : green, fissile, micaceous, sandy siltstone. Thinly bedded to laminated, about 2 m thick.
6. Dolomite : grey to red, silicified dolomite and calcareous sandstone and siltstone. The rocks are generally fresh and hard and commonly exhibit sharp jagged surfaces. Several types of stromatolitic/ algal concretions are preserved along the wavy, crenulated bedding planes. The bedding dips at about 3° to 5° to the north.

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* K-A dating of two samples by Isotopes, Inc. (U.S.A.): 485 ± 20; 475± 20 m.y.

7. Silicified Oolites: white, grey, green, blue, pink and red oolites and oolitic sandstone. The individual oolite grains range in size from 1 to 10 mm; they are mostly spherical although some irregular-shaped concretionary fragments were seen. The rocks are very hard, very strong and highly silicified; deformation and elongation of many of the oolites indicates metamorphism and pressure solution. Bedded outcrops were not seen, but the ground was strewn with debris indicating solid rock at shallow depth. Base not seen.

BASE

Lithologically this sequence is similar to part of the succession in Exoil's Emu No. 1 well in the Officer Basin in South Australia, where limestone, dolomitic limestone, siltstone and cherty oolite were intersected between 240 m and 370 m. The South Australian sequence is unfossiliferous, but has been considered Upper Proterozoic (Lidbrook, 1966) or Lower Palaeozoic (Wopfner 1967) on lithological grounds. Krieg (1969) suggests a Middle Cambrian age based on similarities with the Middle Cambrian Lake Frome Group of the Adelaide Geosyncline.

Leslie (1961) reported a grey-green intraformational and oolitic limestone interbedded with purple-red silty limestone from Nullagine sediments near the Wongawol Homestead, at the western end of Lake Carnegie, 200 km northeast of exposure 48.

Red, well rounded and sorted ferruginous sandstone was found at exposure 49, 12 km southwest of exposure 48. The sandstone is strongly jointed and dips at up to 45° towards the southeast. Well developed cross bedding was observed in one breakaway, and pebbles and irregular fragments of white silicified chert are common on the ground in areas where this sandstone crop out. As exposure 48 is basinward of exposure 49, the sandstone and chert are tentatively regarded as underlying the dolomite and oolites.

North Lennis outcrops

Interbedded sandstone and siltstone were examined in a 50 m high mesa at exposure 54, which is in the northeast corner of the Lennis Sheet (Pl. 2, Fig. 2). Thinly bedded or cross-bedded feldspathic, micaceous, ferruginous, or limonitic sandstone makes up about three-quarters of the succession. Finer grained siltstone and silty shale were recognized at three horizons. A detailed description of the rock types is given on Figure 2, which is a stratigraphic section measured at the eastern end of the mesa. Cross-bedding indicating currents from the southeast is present at many horizons, but it is exceptionally well developed in the top 5 m of section, which was also jointed and faulted. Intraformational breccias and beds containing clay clast impressions indicate sub-aerial conditions in part. Aeolian deposition is thought to have led to the formation of the three thin bands of highly ferruginized sandstone that were mapped close to the top of the exposure. Petrographic examination of a thin section of a specimen from one of these bands shows that the high iron content is probably a depositional feature rather than post-depositional staining (Appendix 1, sp. 7088009).

Bejah Beds

Lower Cretaceous Bejah Beds were examined at several exposures along the Gunbarrel Highway on the Herbert and Browne Sheet areas. The exposures are steep-sided, flat-topped mesas of hard, white to pink siliceous claystone and fine sandstone. Veevers & Wells (1961), Wells (1963), and Leslie (1961) give detailed descriptions of the Bejah Beds of the Gibson Desert. The distinctive white porcellanite was not seen south of latitude 26°S, although some of the outcrops in the Great Victoria Desert contained light coloured siltstones and claystones.

CONDITIONS AND LOGISTICS

The geological party was made up of a BMR geologist, a GSWA geologist, a mechanic and a cook, using two LWB Landrover utilities for transport. Two 2-wheel trailers, containing enough field equipment and tinned food supplies to complete the survey, were towed from Perth to the base camp at Warburton Mission. As all traverses included crossing areas of soft sand the trailers were not used on traverse. Carrying capacity for water and petrol for traverses of 5 to 6 days (800 km) duration was ample. The State Survey Landrover, UQA 292, had been used for similar geological reconnaissances in the Eucla Basin and consequently was well equipped to cope with the conditions encountered during this survey. The extra equipment fitted to UQA 292 included:

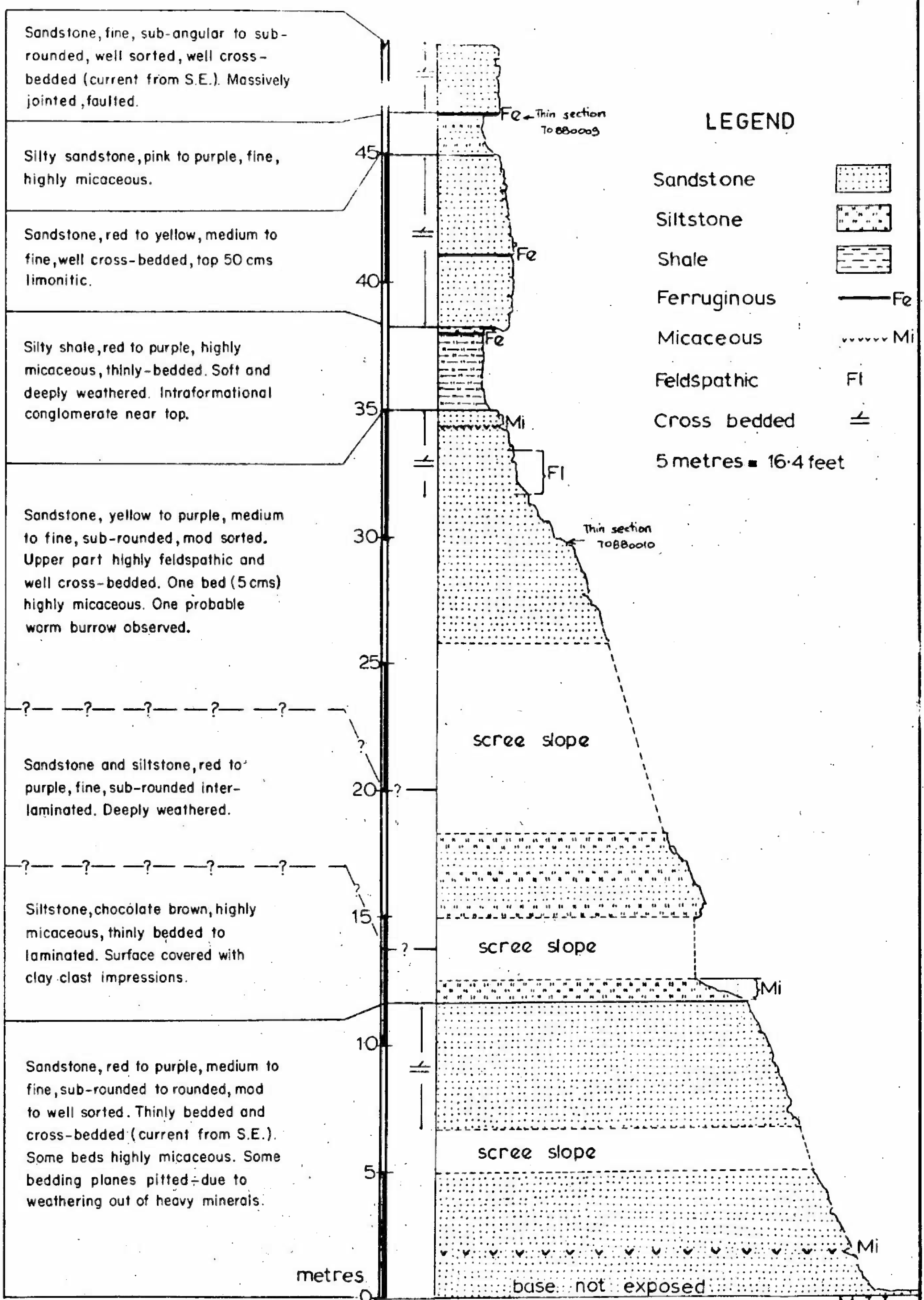
1. Auxiliary galvanized 50 gallon petrol tank behind the cab.

2. Water tanks below and slightly behind the cab seats with taps opening down below the vehicle. Rupture of taps due to the water freezing at night was avoided with the taps in this position, but damage from objects thrown up by the front tyres was possible. An auxillary 17 gallon water tank was installed in the Commonwealth vehicle (ZSM 769) at the near, rearside of the tray with a tap on the back of the tray. In this position the tank took up valuable storage space and the tap was ruptured when it froze one night.

3. Tyres with 8-ply rating instead of the standard 6-ply tyres as were fitted to ZSM 769. The fact that ZSM 769 had 8 punctures and UQA 292 had only one during 6 weeks of field work speaks for itself.

FIGURE 2

CLIFF SECTION AT EXPOSURE 54



4. A spare main leaf spring, which was used during the survey, and a cooking grill bolted to the front of the vehicle.

5. Trays fitted to the doors and roof of the cabin. This facilitated safe storage and retrieval of field equipment and maps, photos, pencils etc.

6. A car compass. This proved extremely useful when driving 'blind' through tall scrub, and when crossing featureless sand plains.

Additional modifications suggested to improve the strength durability, safety or comfort of the vehicle include:

1. Aluminium canopy with rear doors. This would be stronger, easier to load and unload, and more dust proof than a canvas cover.

2. Steel plating be installed under the vehicle to protect oil sump, gearbox, brake lines etc.

3. Accurate milometer. The two vehicles used had errors of +6% and -4%. Accurate determination of distances travelled is important when crossing featureless sand plains.

4. Transceivers should be securely fitted to the insides of the cab, preferably from the roof. Radio serviceability is paramount in an isolated area such as this. The Traeger carried in ZSM 769 was unserviceable even before the base camp was reached, although it had been packed in a sponge-lined carbdoard box. Traverses were delayed unnecessarily by the need to unpack and pack the radio equipment in UQA 292 everytime it was required.

In general, the Landrovers performed admirably. They were serviced every 500 miles and repairs were done as required. The necessity to be completely self-sufficient in such an isolated area required that a competent mechanic and a comprehensive tools and spare parts supply be available at all times.

The average performance obtained from ZSM 769 (-4 cylinder, 2,500 ccs, long-wheel-base utility) was:

Route	Petrol Consumption (mpg)	Speed (mph)
Surfaced highway (with loaded trailer)	12-13	25-30
Graded track	13-14	20-30
Seismic line (5 years old bulldozer track)	-	12-15
Cross-country	10	6-8

CONCLUSIONS

The Great Victoria and Gibson Deserts are blanketed by an extensive cover of sand and ferruginous ironstone; rock outcrops are found in only about 5 percent of the surface area. Most of the outcrops belong to a monotonous and fairly uniform suite of fluvioglacial tillites and sandstones of probable Permian age, but fossiliferous marine Cretaceous rocks have been mapped in the Gibson Desert. Small isolated patches of Lower Palaeozoic or Proterozoic rocks were found close to the edges of the basin.

Reconnaissance mapping of the Permian and Cretaceous outcrops should be possible by making short (half hour) geological inspections at about 10 to 20 carefully selected localities per 1:250,000 sheet, and using photointerpretation for drawing most of the geological boundaries. Detailed mapping of the remaining outcrops will be required. These rocks are so poorly exposed and they represent such a vast period of geological time that the fullest possible use of every good exposure is essential.

As confirmed by this reconnaissance land surveys are possible, but they are extremely slow, tedious and highly inefficient; at least 80 percent of the working time was spent travelling between outcrops. Geological inspections on eighteen 1:250,000 sheets will be required if the Officer Basin (W.A.) is to be mapped in 1971; an ambitious approach to the project is, therefore, required.

RECOMMENDATIONS

Most of the systematic mapping should be done from a helicopter. The associated logistical problems will be kept to a minimum if a small number of bases, say about 3, are used. These could be set up close to graded tracks so that ground transport and supply would not be too difficult. Experience gained during the 1970 reconnaissance indicates that a helicopter with a range of about 500 miles and a speed of about 100 knots would be ideal. Complete daily circuits could be made and most outcrops could be visited in about 150 rotor hours. Areas containing Proterozoic or Lower Palaeozoic rocks would need more detailed examination, and could be mapped using landrover traverses in a similar manner of mobile camping to that used during the 1970 survey.

Isotopic age dating and palaeomagnetic investigations of all basalt outcrops could yield worthwhile results: The basalt is a distinctive, presumably isochronic, rock type, and also an important seismic reflector. Absolute age dating and intercorrelation of widely separated outcrops of basalt will enable some of the more important stratigraphic problems to be elucidated.

The recovery of fossils from the area is also important; only Cretaceous shells and Permian spores have been recorded to date. Tentative lithological correlations with other sedimentary basins may be confirmed if fossils are available for comparison.

Finally, it should be emphasized that extensive geophysical and drilling operations will be necessary before the geology of the Officer Basin can be satisfactorily documented.

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*P.S.S.A. - Petroleum Search Subsidy Act - i.e. Commonwealth subsidized operation

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APPENDIX 1 - PETROGRAPHIC DESCRIPTIONS

The localities of the rocks described below are shown on Plate 2. The specimen number refers to the BMR specimen register system.

SPECIMEN 70880001: Cross-laminated arkose.

Field number: 5

Field book: OB 70/1 (page 8)

Locality: Muggun rock hole, 160 km southwest of Warburton Mission on the Laverton-Warburton road.

Sheet: Westwood G51/16. Co-ords: 328648.

Hand specimen: A red and purple, thinly cross-bedded to cross-laminated, medium to fine-grained, highly feldspathic sandstone. Weathering has bleached the exposed surfaces to produce a white friable zone up to 5 mm thick. The fresh rock is hard and strongly cemented, but it absorbs water rapidly indicating marked porosity. Small white flecks of feldspar and plates of muscovite are visible on the surface of the specimen. A thin (5 mm) lenticular bed of purple, very fine-grained siltstone forms the base of a series of cross-laminations.

Thin section: Variations in the composition of individual laminations are present, but an average composition would be: quartz 20-30%, feldspar 40-60%, limonitic clay matrix 10-20%, mica 3%, accessories 2%. The rock is composed of fine to very fine, angular to sub-angular grains of fresh quartz and medium to fine, irregular patches of cloudy feldspar set in a pale reddish brown, limonitic, clay matrix. Half of the grains are separated by the matrix, the remainder are cemented together by a thin intergranular siliceous cement. The matrix contains large numbers of small elongated laths of muscovite, and is crowded with minute spots of limonite after hematite. Pitting of quartz grains and replacement of feldspar by limonite is common. Sorting is poor, but the grains are often orientated along the bedding planes. The sample is a relatively fine-grained immature arkosic sediment with a high feldspar and clay content. The cross-bedding and presence of the siltstone band in a predominantly sandstone deposit indicate marked changes in sedimentary deposition.

SPECIMEN 70880002: Limonitic feldspathic sandstone.

Field number: 12

Field book: OB 70/1 (page 12)

Locality: 8 km north of Manton Knob. About 60 km south of Warburton Mission on the Warburton-Rawlinna road.

Sheet: Talbot G52/9. Co-ords: 445695.

Hand specimen: An orange, massively bedded, poorly sorted, limonitic coarse to very coarse-grained, feldspathic sandstone. The rock is hard, silicified and strongly cemented; it contains isolated small pebbles of quartz and ?granitic rock fragments.

Thin section: A visual estimate of the composition of the rock is: quartz 60-70%, feldspar 10-15%, limonitic matrix 20-25%, accessories 2%. The rock is composed of sub-angular to well-rounded grains of quartz and weathered feldspar set in a pale brown limonitic matrix. The quartz is fresh; the grains vary from minute to 4 mm, but most fall within the range 0.3 to 0.6 mm (medium to coarse sand). Irregular strain extinction and a poorly developed sub-rectangular cleavage is common. The feldspar grains are normally about 0.3 mm in diameter, but grains up to 2 mm were seen. Incipient alteration of the feldspar is common, especially along cleavage traces. The matrix is composed of minute, angular quartz and feldspar grains and rock flour. Iron staining of the matrix is blotchy, oxidization of the iron must be irregular. Most of the constituent grains are separated from each other by the matrix, suggesting that the matrix is primary. Carozzi (1960) comments on the difficulty of visualizing conditions under which sand deposition in a ferruginous precipitate could occur unless extensive wind action is considered. The presence of isolated small pebbles of quartz and weathered ?granite is difficult to explain.

SPECIMEN 70880003: Feldspathic sandstone.

Field number: 23A

Field book: OB 70/1 (page 23)

Locality: Waulfe Creek exposures, 60 km north of Neale Junction.

Sheet: Westwood G51/16. Co-ords: 386552.

Hand specimen: A yellow, pale brown and red, thinly bedded, slightly micaceous sandstone. Feldspathic layers approximately 1 mm thick indicate sub-parallel bedding which is disturbed by burrows. Beds range from fine to very coarse grained; the rock is poorly sorted.

Thin section: The rock is composed of the following minerals: quartz 70-80%, feldspar 15-20%, clay matrix 10%, limonite 2-4%, accessories 2%, and mica 1%. The quartz and feldspar are either closely packed together and cemented by a thin limonitic cement, or they are separated by patches of a grey clayey matrix. The quartz grains range in size from minute to 0.6 mm, with a mean of about 0.2 mm (fine sand); they are predominantly angular to sub-angular. Inclusions of minute minerals with high relief, and a poorly developed rectangular cleavage are common. The feldspar is cloudy throughout the slide and it is normally crowded with large numbers of minute ?zircon crystals. The mean grain size of the feldspar is about 0.3 mm. The intergranular matrix is sub-microscopic so determination of composition is impossible, however, anhedral grains of limonite and small fibrous aggregates of sericite were recognized. Bedding is indicated by feldspar rich layers.

SPECIMEN 70880004: Colour-banded siltstone/claystone.

Field number: 30

Field book: OB 70/1 (page 28)

Locality: Mesa near eastern end of Lake Yeo, 110 km west of Neale Junction.

Sheet: Neale H51/4. Co-ords: 258498.

Hand specimen: A very fine grained, colour-banded, micaceous siltstone. The colour is predominantly salmon pink, but it grades through orange and light purple to deep red in a band 5 mm thick. The rock is moderately hard and strong; it breaks with a conchoidal fracture.

Thin section: The rock is composed of small (0.05 mm) grains of fresh angular quartz (20%) in a grey-brown, sub-microscopic clay matrix (80%). Quartz rich layers indicate bedding. The deep red band seen in hand specimen is composed of about 30% angular quartz grains in a hematitic/limonitic cement. The colour banding is due to variation in state of oxidation and amount of iron oxide in the various parts of the slide; it is partly original, partly secondary.

The angularity of the quartz grains indicates a lack of transport. The fine microscopic bedding would suggest deposition in quiet water conditions.

SPECIMEN 70880005: Silicified feldspathic conglomerate.

Field number: 33

Field book: OB 70/1 (page 40)

Locality: Yeo Hills, south of Lake Yeo.

Sheet: Rason H51/3. Co-ords: 238516.

Hand specimen: A very hard, silicified, ill sorted, unbedded, conglomeratic sandstone. An irregular, sub-conchoidal fracture gives the surface a flint like appearance. Grains of white feldspar, up to 5 mm diameter, and quartz, up to 3 mm diameter, are visible on the surface, they are set in a pale-grey to pink, fine-grained matrix.

Thin section: Petrographic examination shows that the rock is composed almost exclusively of quartz. Quartz grains ranging in size from minute to 3 mm form about 90% of the rock. The smaller fraction (i.e. that below about 0.3 mm in diameter) forms an interlocking mosaic of strongly cemented, angular to sub-angular grains that form the body of the rock. Solution and secondary enlargement of individual grains is common. Feldspar grains ranging in size from 1 to 5 mm have been completely replaced by an interlocking mosaic of small quartz grains. The original identity of the feldspar grains is visible under plane polarized light only, where they show up as rounded areas with iron-oxide staining. The original feldspar grains were probably weathered and attacked by iron staining before silicification took place. A few highly altered grains of feldspar remain; they are crowded with large numbers of minute high relief minerals. The coarser grained quartz fraction (0.3 mm to 3 mm) is composed of irregularily shaped grains that show evidence of secondary solution and crystal growth; lobate and lenticular boundaries are seen in almost all grains. A few small intergranular patches of a dark grey, sub-microscopic clay matrix are present; they probably form about 5% of the rock. Bedding was not seen in the specimen or in the field.

The original sediment would have been an immature, highly feldspathic conglomerate. Total lack of sorting and bedding suggests a terrestrial origin, most likely within a granitic terrain. Silicification took place some time after the sediment became a consolidated deposit.

SPECIMEN 70880006: Tholeiite basalt.

Field number: 40

Field book: OB 70/1 (page 40)

Locality: 4 km north of the western edge of Lake Gillen.

Sheet: Robert G51/11. Co-ords: 245749.

Hand specimen: The hand specimen is a heavy, massive, fine-grained, purplish-brown basalt. The surface is crowded with small, subhedral crystals of a dark green mineral, probably pyroxene. Several rounded amygdales filled with lime green chlorite and ranging in size from 2 mm to 10 mm are present on the surface. Small (½ mm) flakes of mica and minute flecks of ?hematite were also seen. The exposed surface of the basalt weathers to a soft, orange, powdery clay.

Thin section: The basalt is composed of the following minerals: plagioclase feldspar 40-50%, pyroxene 30%, magnetite 15-20%. The ground mass is formed of an interlocking framework of small, elongated, euhedral plagioclase laths, with the interstitial areas filled with an opaque mineral (probably magnetite) that is commonly altered to hematite or limonite. Pyroxene phenocrysts up to 5 mm long occur in this groundmass. The plagioclase laths of the groundmass vary in length between 0.05 and 0.2 mm. They are well twinned on the Carlsbad

Law and some alteration to sericite and chlorite has taken place. Large phenocrysts of plagioclase are not developed. The large anhedral pyroxene phenocrysts ophitically and sub-ophitically enclose many small laths of plagioclase. Augite and orthopyroxene were recognized, but distinction of the pyroxene proved difficult. The augite has moderate birefringence and is in places twinned on (100). The orthopyroxenes are notably free from alteration and iron staining, they have low birefringence and parallel extinction. The composition of the basalt is over saturated or tholeiitic. It is petrographically similar to those described by Peers (1969) from other localities in the Officer Basin.

SPECIMEN 70880007: Orthoquartzite.

Field number: 42/1

Field book: OB 70/1 (page 41)

Locality: Exposures near Mount Smith, 7 km southwest of Herbert Wash.

Sheet: Robert G51/11. Co-ords: 232749.

Hand specimen: A light brown, sub-rounded, well sorted, quartz sandstone. It is massively bedded in outcrop, but faint laminations at 1 to 4 mm spacing in the hand specimen are produced by concentrations of iron oxide. A reverse fault with 4 mm displacement runs through the specimen at 70° to the bedding. The weathered surface is oxidized to a rusty, reddish-brown.

Thin section: The rock is composed almost exclusively (95%) of closely packed, sub-rounded to rounded, fine grains of quartz. A thin coating of limonite surrounds many of the grains, but few anhedral grains of limonite are present. The grains of quartz are generally strongly cemented by a fine mosaic of quartz granules and some secondary fibrous films. No clay matrix was seen. Most quartz grains exhibit irregular strain extinction and a poorly developed rectangular cleavage. A few small elongated laths of mica and a few crystals of apatite are present. The rock is a mature, rounded, well-sorted, clean orthoquartzite.

SPECIMEN 70880009: Limonitic sandstone and ferruginous sandstone.

Field number: 54/1

Field book: OB 70/2 (page 5)

Locality: unnamed exposures 17 km southeast of Sydney Yeo Chasm.

Sheet: Lennis G52/13. Co-ords: 552623.

Hand specimen: Two rock units are present in this hand specimen. A light brown, medium-grained, poorly sorted sandstone is capped by a 2 cms thick dark brown band of highly ferruginized sandstone. The ferruginized bed is crowded with large numbers of minute white spots (probably feldspar), and contains two brown clay clasts (5 mm diameter). The contact between the two sandstones is sharp, but irregular; the ferruginized bed was probably deposited on a rippled surface of sandstone. However, thin irregular, ferruginous streaks are developed along some bedding planes in the brown sandstone, below the ferruginous band. Conditions of deposition for the two types of sandstone would appear, therefore, to be fairly similar. The reason for the marked concentration of hematite in a distinctive band 2 cms thick is unknown.

Thin section: The light brown sandstone is composed of approximately 60-70% quartz and 30-40% feldspar, i.e. it is an arkose. The individual grains range in size from 0.05 to 0.3 mm with a mean of about 0.2 mm (medium sandstone). The grains are generally angular to sub-angular, the quartz being less rounded than the feldspar which tends to occur in irregular, sub-rounded aggregates. The grains are well packed, but erosion has removed many and given the rock a high porosity. The grains are cemented by an intergranular matrix of quartz granules set in a pale brown limonitic cement. Staining of the feldspars by limonite is common.

The ferruginous band is composed almost exclusively of quartz and weathered feldspar grains (60%) set in an opaque hematitic clay matrix (40%). The grains are angular to sub-angular and range from 0.05 to 0.5 mm (mean about 0.2 mm). The sandstone is poorly sorted and loosely packed; most grains are separated from each other by the ferruginous cement. Some of the grains are very irregular in shape and often have jagged outlines; this is probably due to etching by hematite.

The fact that the grains are not in contact with each other suggests a primary cement/matrix. Carozzi (1960) comments on the difficulty of visualizing conditions under which sand grains could be distributed during the deposition of an original ferruginous precipitate, unless extensive wind action is considered. For the origin of these types of sandstones Carozzi envisages an original calcareous cement that is replaced by iron oxides during a later diagenetic phase. However, field and petrological examinations indicate that this ferruginous band (and others in the same exposure) is an original sedimentary feature.

SPECIMEN 70880010: Feldspathic greywacke.

Field number: 54/3

Field book: OB 70/2 (page 5)

Locality: as specimen 70880010.

Sheet: Lennis G52/13. Co-ords: 552623.

Hand specimen: A flesh to pinkish-brown, medium to fine, moderately well sorted sandstone. The rock is thickly to massively bedded, but leaching has left it porous and friable.

Thin section: The rock is composed of the following minerals: quartz 60-70%, feldspar 10%, sub-microscopic matrix 20-25%. The quartz and feldspar grains are angular to sub-angular, poorly sorted and range in size from 0.2 - 0.3 mm (mean about 0.2 mm). Most of the quartz grains show strain extinction, some contain trains of minute high relief minerals. About half of the grains are in contact, the rest are separated by a light greyish-brown, very fine grained to sub-microscopic, intergranular matrix. Minute granules of quartz, feldspar and sericite form part of the matrix; the remainder is probably rock flour or clay. About 5% of the thin section is occupied by voids. A few euhedral grains of hematite are present. Pressure solution between some of the quartz grains was the only important textural feature seen.

SPECIMEN 70880011: Grey siltstone (Bejah Beds?).

Field number: 58

Field book: OB 70/2 (page 10)

Locality: Road cutting 3 km southeast of Hunt Oils' Browne No. 1 Well.

Sheet: Browne G51/8. Co-ords: 391784.

Hand specimen: A pale-purple to grey, very fine grained, cross-laminated siltstone. The rock is very hard and breaks with a conchoidal fracture. The bedding is cross-laminated in part, but irregular erosional contacts are also visible.

Thin section: The rock is composed of 20% quartz grains set in a grey, very fine grained matrix. The quartz grains range in size between 0.01-0.05 mm, they are angular to subangular, but often have very irregular jagged boundaries probably formed by secondary quartz overgrowths. The matrix is predominantly sub-microscopic, but minute quartz granules and sericite laths were recognized. The sericite laths range from 0.02-0.2 mm in length; they are often orientated parallel to the bedding. The matrix also contains scattered isolated euhedral grains of hematite up to 0.02 mm in diameter and large numbers of minute disseminated opaque spots (also hematite?). A few slightly curved elongated siliceous shards (up to 0.4 mm in length) were also seen. These are visible under X-nicols only and they possibly represent calcareous shell fragments that have been replaced by silica.

SPECIMEN 70880013: Red siltstone/claystone (Bejah Beds?).

Field number: 64/3

Field book: OB 70/2 (page 13)

Locality: Mount Beadell, on the Gunbarrel Highway.

Sheet: Browne G51/8. Co-ords: 320826.

Hand specimen: The hand specimen is a patchily coloured, salmon pink and red, very fine grained siltstone. The rock is hard and breaks with a conchoidal fracture. The bedding is irregular; it is possibly slumped or churned up by organisms.

Thin section: A visual estimate of the composition is difficult, as the rock ranges from a very fine grained siltstone to a very fine grained sandstone with a matrix:grains ratio of 50:50. The grains are of quartz 10-15%, feldspar 20-25% and mica 5-10% in the sandstone fraction. The quartz and feldspar grains range in size from 0.05-0.1 mm; the quartz grains are generally smaller than the feldspars; both have irregular jagged outlines. This is probably a result of secondary silification. The mica laths are generally less than 0.05 mm in size; they are usually stained by limonite. Sparse anhedral grains of an opaque mineral, and red and brown diffuse areas of disseminated hematite and limonite produce the patchy colouring. The siltstone fraction is sub-microscopic; it forms between 50-100% of the rock.

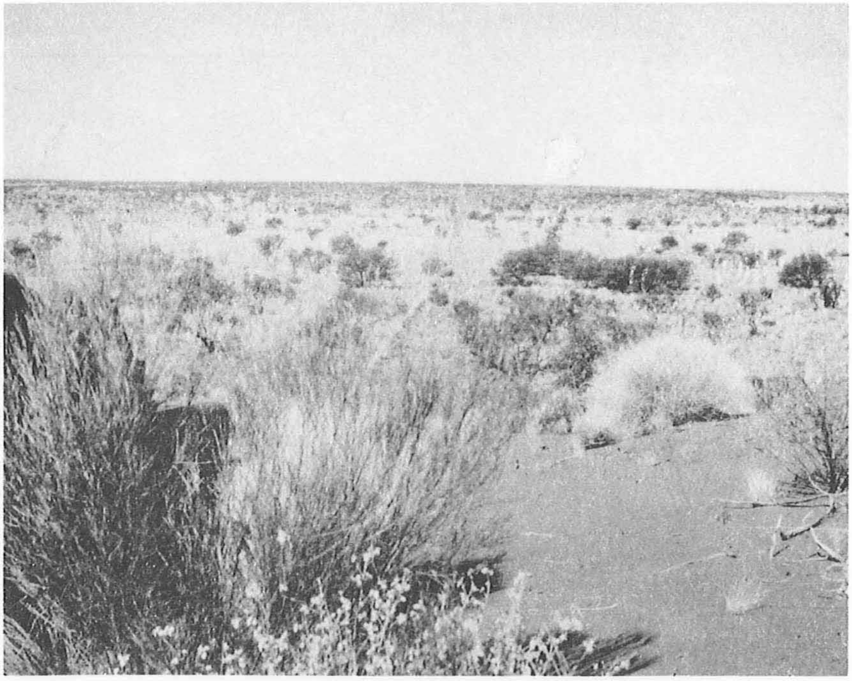

FIG. 3 - Typical sand plain and dune topography, Lennis Sheet area. Neg. no. GA/4238

FIG. 4 - Sand plain with low dunes and salt pans. Lennis Sheet area. Neg. no. GA/4241

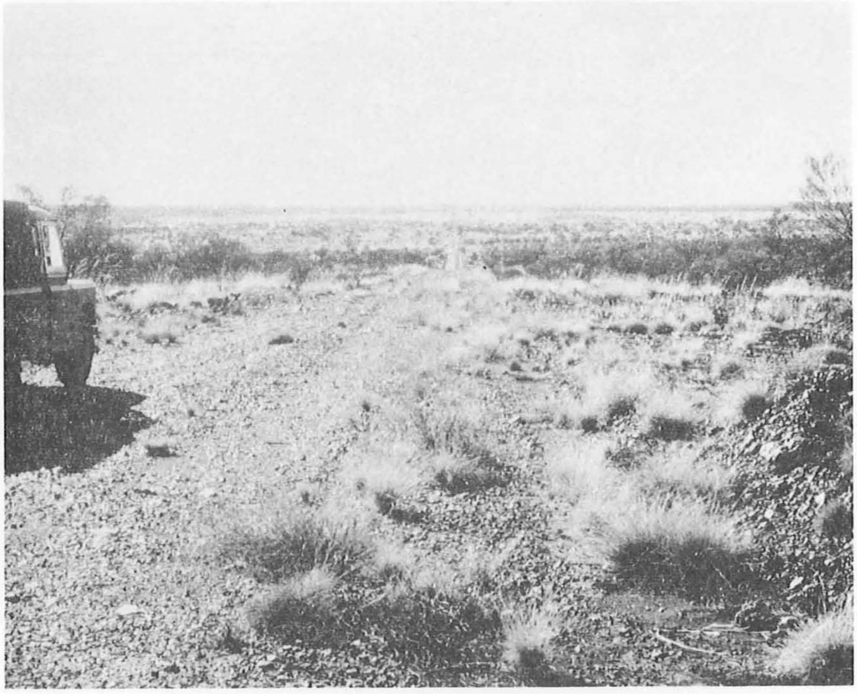

FIG. 5 - Typical ironstone rise and plain, 27th paralled road, Yowalga Sheet area. Neg. no. GA/4242

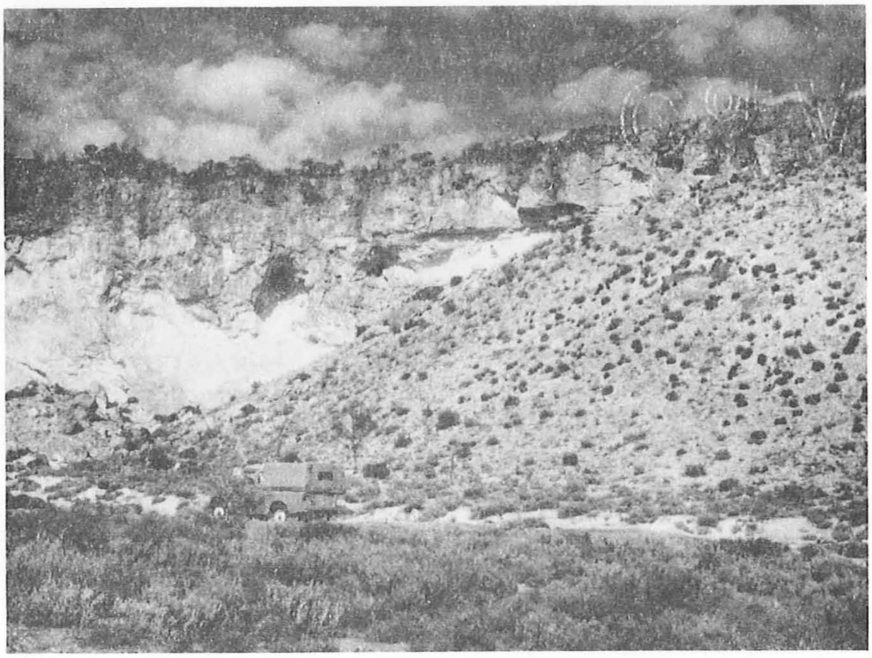

FIG. 6 - Breakaway of Permian sandstones, Morton Craig Ranges, Rason Sheet area. Neg. no. GA/4245

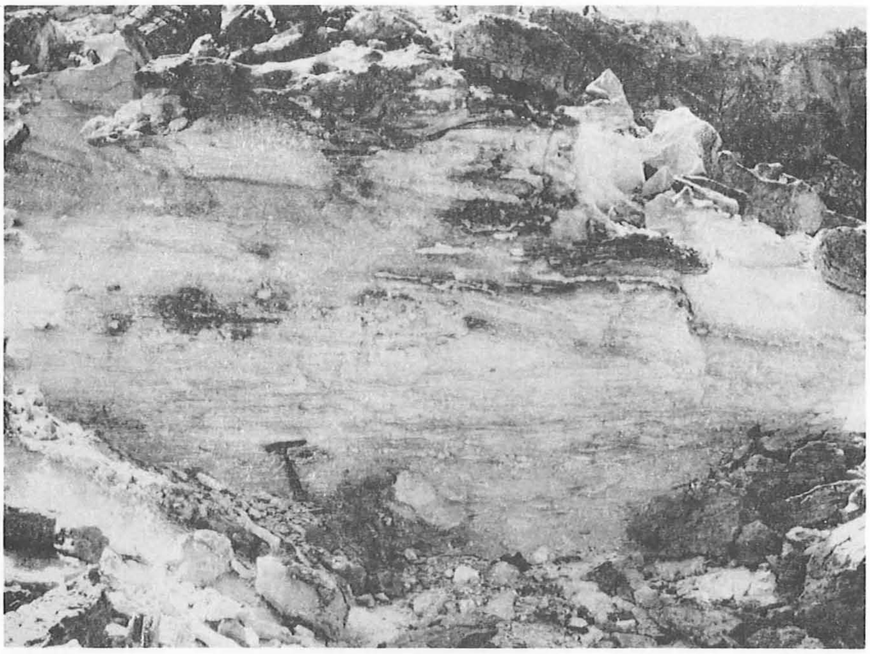

FIG. 7 - Cross-bedding, washouts, pull-apart structures and differential weathering, Saunders Point, Westwood Sheet area. Neg. no. GA/4243

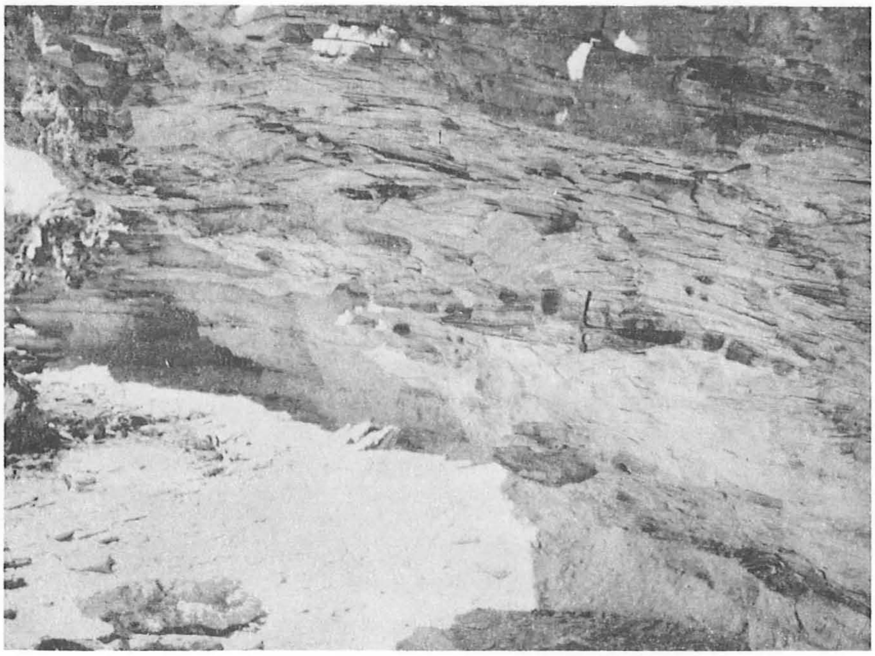

FIG. 8 - Thinly cross-bedded, medium-grained sandstones, Exposure No. 35, Rason Sheet area. Neg. no. GA/4244

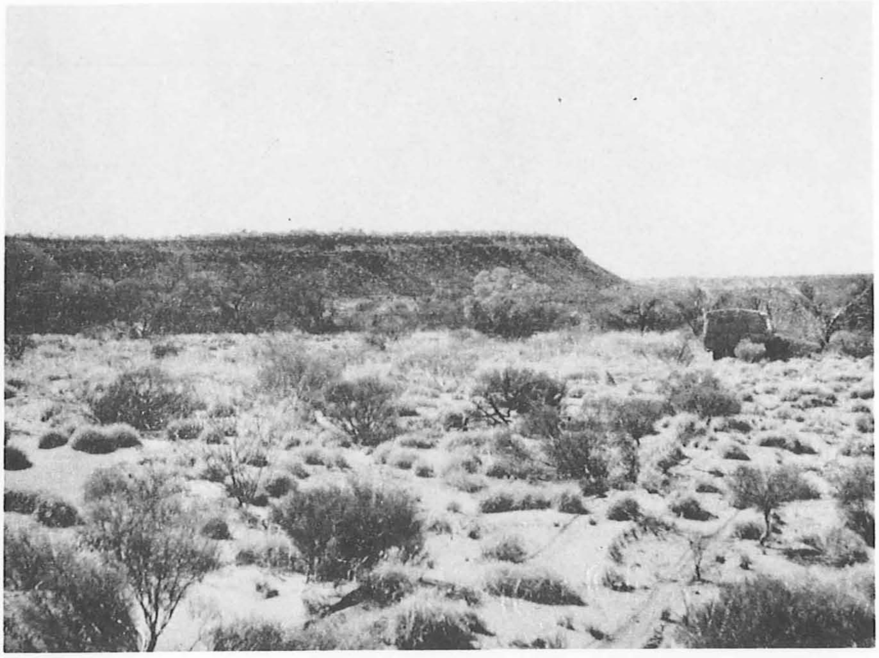

FIG. 9 - Mesa of gently dipping Palaeozoic? sandstones, northeast Lennis Sheet area. Exposure No. 54. Neg. no. GA/4240

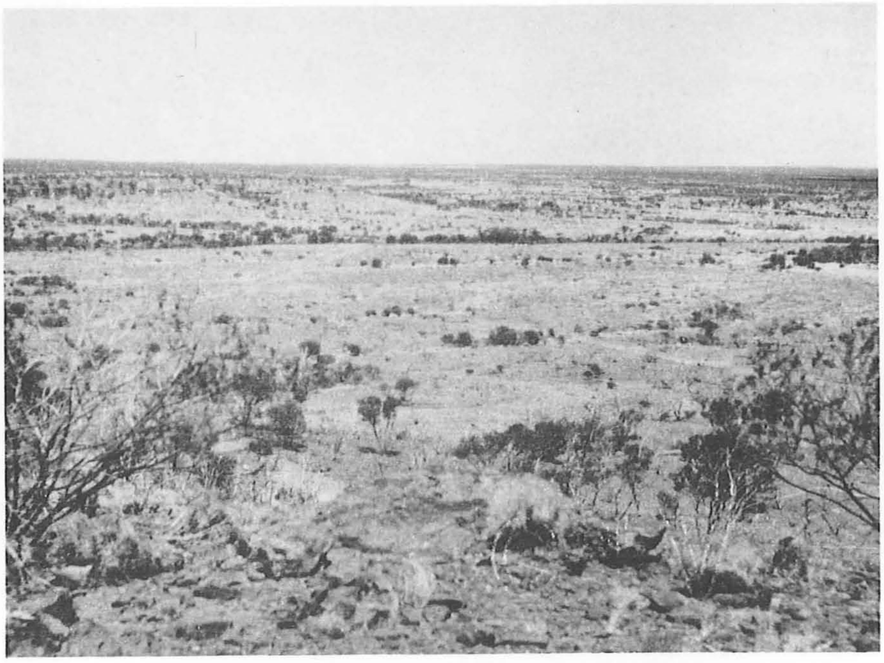

FIG. 10 - Sand plain, Gibson Desert from Mount Samuel, Browne Sheet area. Neg. no. GA/4239

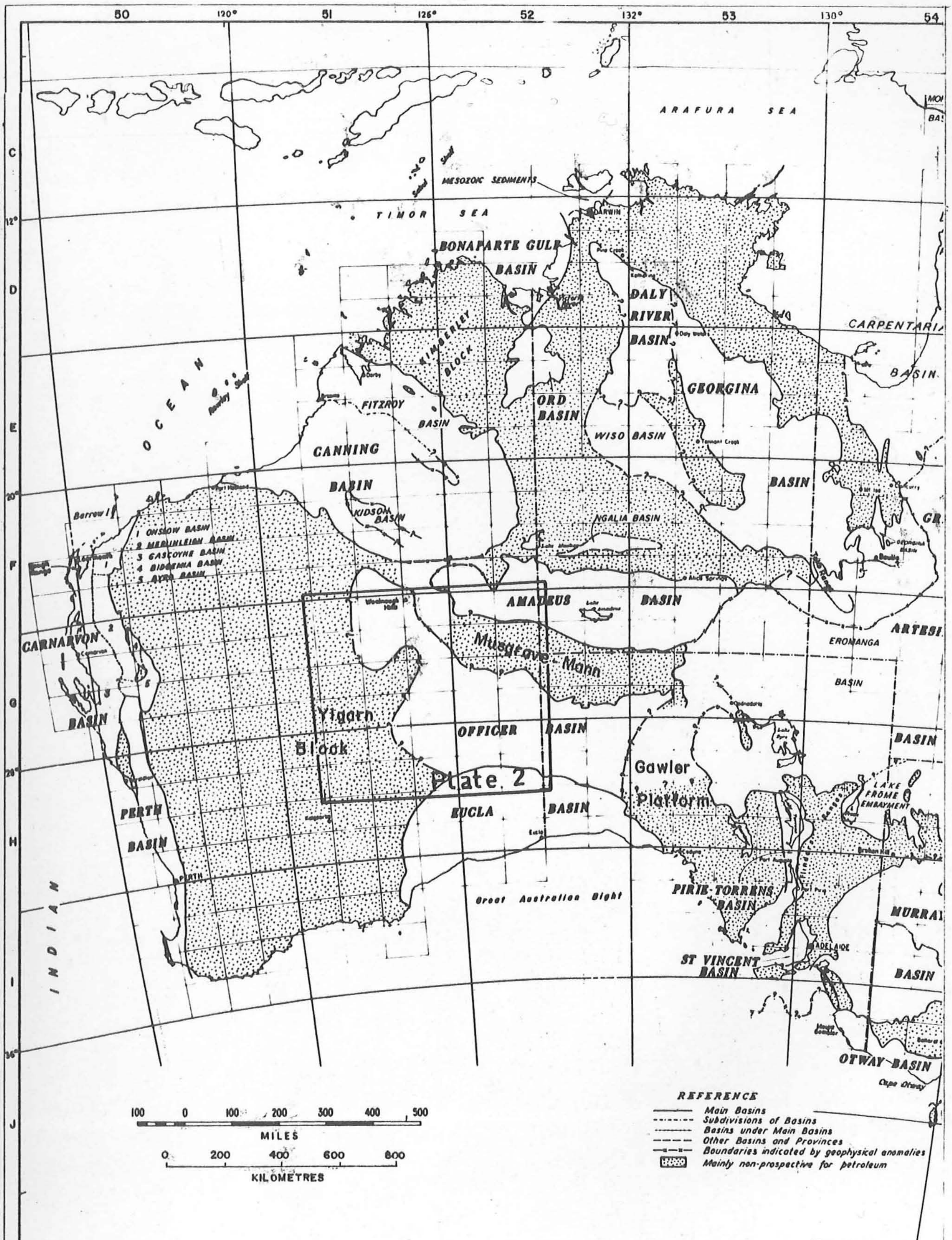

PLATE 1 LOCALITY MAP

To accompany record 1971/5

Aus/1/284

PLATE 2

GEOLOGICAL TRAVERSES OFFICER BASIN 1970

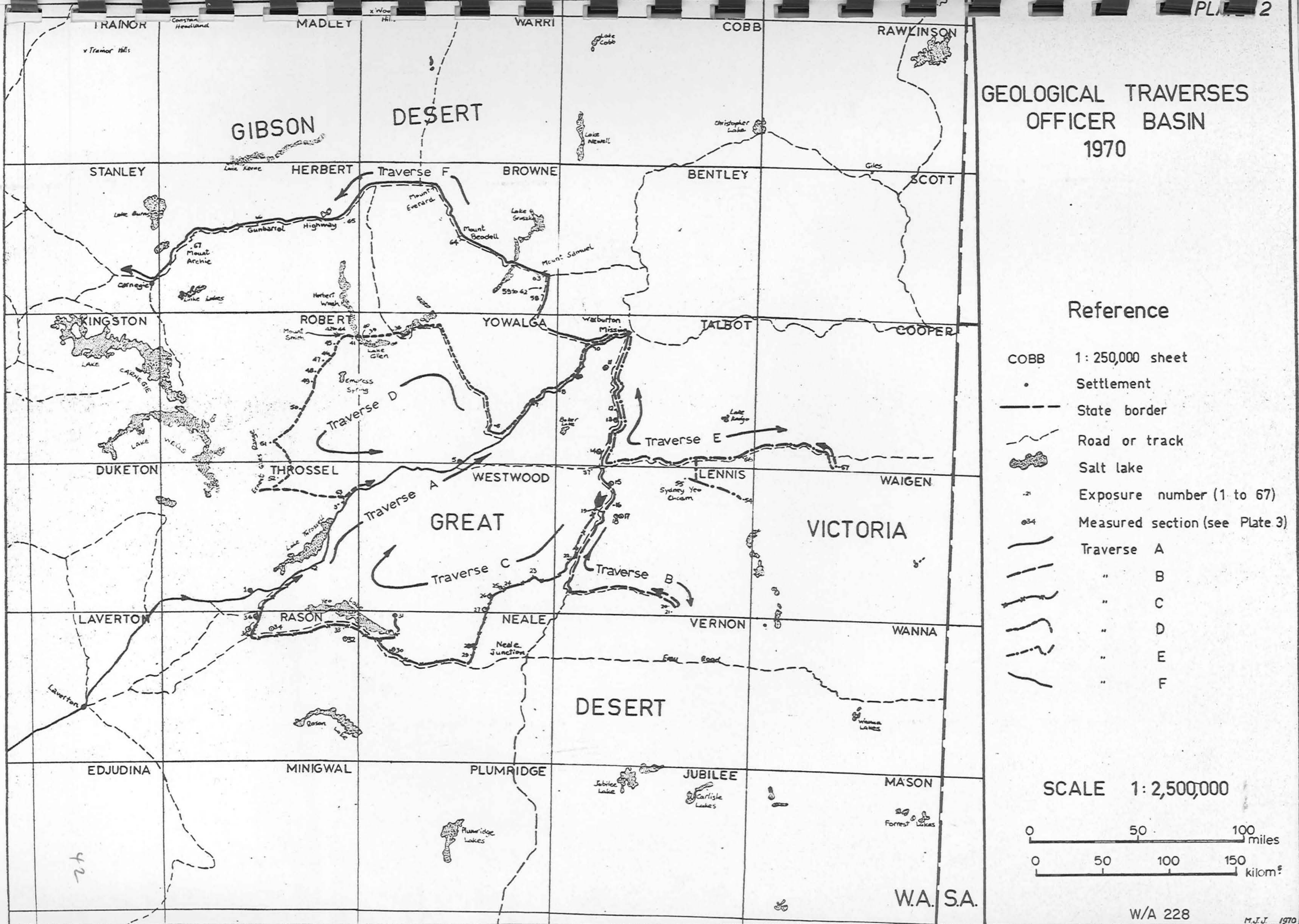

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PLATE 3

PERMIAN COLUMNAR SECTIONS
OFFICER BASIN W.A.
VERTICAL SCALE
2·5cm : 4m
REFERENCE
Claystone or siltstone
interbedded
Fine sandstone
interbedded
Medium sandstone
interbedded
Coarse sandstone & conglomerate
Cobble conglomerate
Folded metasediments (basement)
Granite or gneiss (")
Si Silicified
Mi Micaceous
Fl Feldspathic
Cross stratification
Worm burrows
Dessication cracks
Shale clasts
(see Plate 2 for section localities)
SW
NE
Metres
LOCALITY
EXPOSURE NUMBER
Point Virginia #1
N. Salvation Well #35
S. of Yamarna #36
Dorothy Hills #34
Morton craig #32
Mesa #30
Lily Rock Hole #31
Unnamed exposure #28
Mount Browne #27
Middle Hill #26
Saunders Range #25
Cooper Creek #17
Huggun R.H. #5
Henning Tank #15
Skipper Knob #14
Windulddurra R.H. #8
Marion Creek #13
Babbagoole R.H. #9
Karnaligurra R.H. #1
Unnamed exposure #57
To accompany record 1971/5
M(S) 134
MJJ 1970