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NOTES ON THE GEOLOGY OF THE SOUTHERN PART OF THE CANNING BASIN

by

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The semi-desert area within the WILSON, URAL, TABLETOP, SAHARA, PERCIVAL, RUNTON, MORRIS and RYAN 1:250 000 Sheet areas in the south Canning Basin were geologically mapped by the Bureau of Mineral Resources (BMR) and the Geological Survey of Western Australia (GSWA) in 1975. Large tracts of Cainozoic red aeolian sand, laterite, and evaporitic lacustrine sediments separate sparse outcrops of pre-Cainozoic rocks that form scattered low hills, ridges, mesas, buttes and undulating terrain. The latter consist of units of the Canning and Officer Basins, and, in the east, representatives of the basement Arunta Block and the Amadeus Basin.

In the south the Permian rocks that are exposed include glacio-lacustrine, fluvio-glacial and marine sediments (the Paterson and Grant Formations); these are overlain by mainly marine sediments in the north (Poole Sandstone, Noonkanbah Formation and Triwhite Sandstone). Thin Mesozoic sediments underlie virtually the entire area and include the fluvial Callawa Formation and Cronin Sandstone, the brackish-water Anketell Sandstone and its time-equivalent the marine Samuel Formation, and the marine Bejah Claystone. Continental deposition in the Late Cretaceous to Early Tertiary is represented by the fluvial Lampe Beds and the pedogenic Lake George Beds. Stratigraphic units recognized for the first time are described in detail, but subsurface units are only briefly described. Macrofossils collected during the surveys are described by J.M. Dickins and S.K. Skwarko.

1. INTRODUCTION

The information in this report derives from part of a program of regional reconnaissance geological mapping at a scale of 1:250 000 being carried out jointly by the Bureau of Mineral Resources and the Geological Survey of Western Australia, that is designed to map all the Phanerozoic rocks of the Canning Basin. The program began in 1972 and the following sheet areas have been mapped and reports written: Billiluna, Stansmore, Lucas, Webb, Mount Bannerman, Cornish, Helena, Crossland, Dummer (Yeates et al., 1975) and Noonkanbah (Crowe & Towner, 1976).

This report describes the Phanerozoic rocks mapped in 1975 in the Wilson, Ryan, Percival, Ural, Morris, Sahara, Tabletop, Runton and Rudall Sheet areas (designated in capital lettering throughout the text) and the Precambrian in the Wilson and Ryan Sheet areas. The adjoining rocks of the Pilbara Block were mapped by the Geological Survey of Western Australia (Williams et al., 1976). Explanatory Notes which briefly describe the geology of each 1:250 000 Sheet area are being published.

The mapping was carried out by A.N. Yeates, R.R. Towner (BMR) and R.W.A. Crowe (GSWA). M.J. Jackson (BMR) joined the party for three weeks as he had previously mapped adjacent areas to the south, and J.M. Dickins (BMR) spent two weeks collecting Permian faunas.

The exposed Phanerozoic rocks are described according to the classification of Gilbert (1958), and the outcropping Precambrian rock units are described as either sandstone or siltstone and are qualified by the usage of the terms quartzose, feldspathic and so on according to the classification of Pettijohn (1957). Grainsize is classified on the Wentworth scale, and the terms used for bedding thickness are those of Ingram (1954). The subsurface units are described according to the terms used in exploration company reports.

Location and access

The area lies in Western Australia between latitudes 21° and 24°S and longitudes 121°30' and 127°30' (Fig. 1).

Geologically the area is bounded in the west by the Precambrian sedimentary, metamorphic and igneous rocks of the Bangemall Basin and Paterson Province (Williams et al., 1976; Playford et al., 1975). To the east lie Archaean metamorphic and volcanic rocks of the Arunta Block (Blake, in press) and the Proterozoic-Phanerozoic sedimentary rocks of the Amadeus Basin (Wells et al., 1970).

Within the survey area, sedimentary rocks of both the Canning Basin (Forman et al., 1973) and Officer Basin (Lowry et al., 1972; Jackson & van de Graaff, in prep.) occur. An area of elevated basement, corresponding to the Warri Gravity Ridge, has been chosen as a convenient boundary between the two basins (Lowry et al., 1972; Playford et al., 1975). Consequently, most of RUNTON and the southwest portion of MORRIS lie within the Officer Basin, and the rest of the area in the Canning Basin.

Access to the area from the northwest is by a gravel road which branches southeast from the Great Northern Highway 230 km north of Port Hedland. This road runs southeast for 738 km across SAHARA, and TABLETOP to the site of WAPET Kidson No. 1 petroleum exploratory well (now abandoned) on URAL. Access from the south can be gained via the "Gary Highway" which branches off the "Gunbarrel Highway" about 9 km west of Mount Everard and joins the northwestern track near WAPET Kidson No. 1 well site. A poorly defined track branches off the "Gary Highway" on MORRIS and leads west to the Lake Disappointment area and onto the Great Northern Highway. Another track runs east from near WAPET Kidson No. 1 across URAL and WILSON to Papunya Native Settlement in the Northern Territory, where it joins a maintained gravel road which connects to Alice Springs. The now abandoned Canning

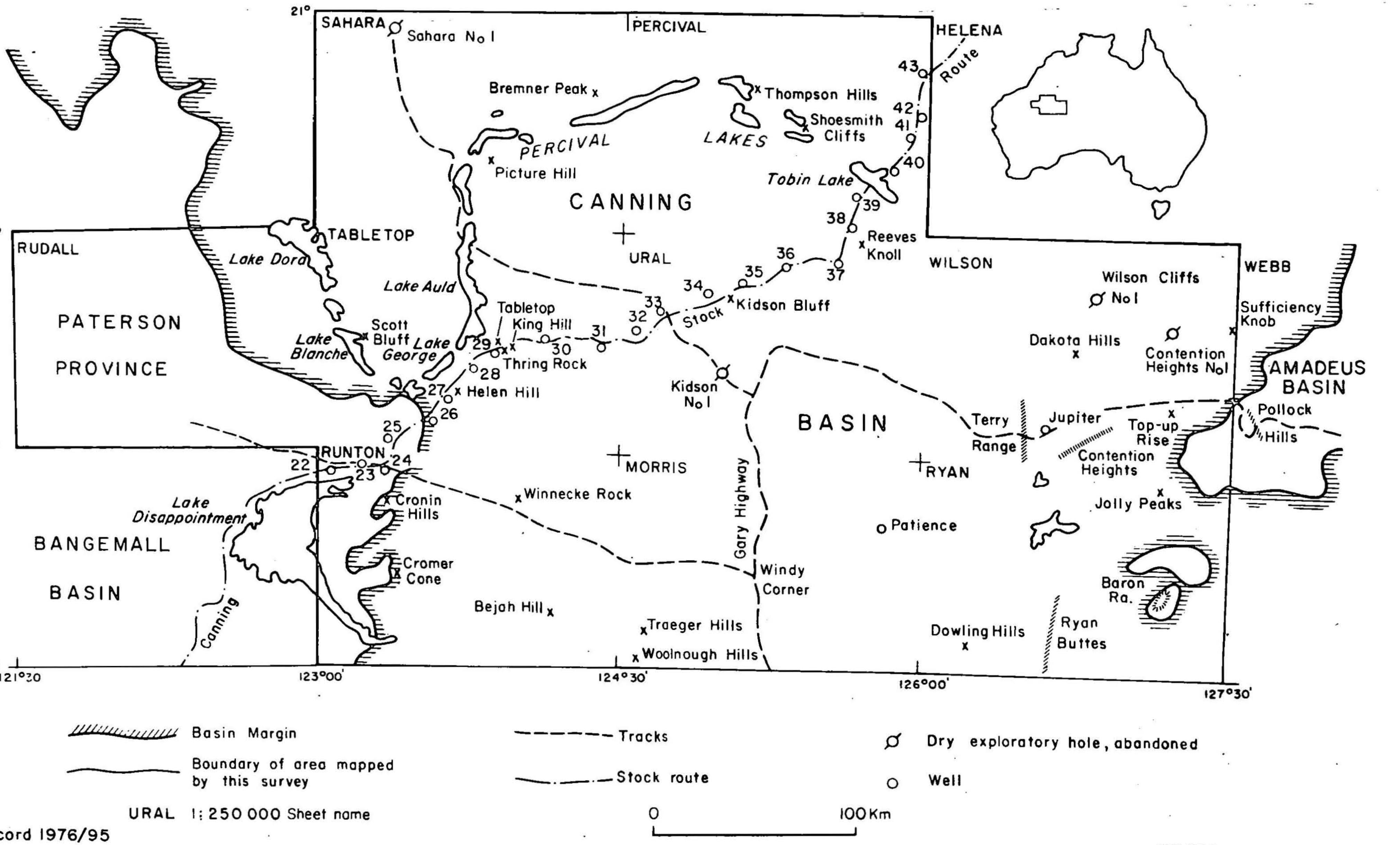

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Fig 1 LOCATION AND GEOLOGICAL SETTING

Stock Route, which joins Wiluna to Halls Creek, crosses the area from northeast to southwest. The tracks are unmaintained, and are suitable only for 4-wheel-drive vehicles.

Some access to other parts of the area away from these tracks is facilitated by graded seismic lines which have become overgrown through disuse. To supply seismic and drilling parties within the area, several airstrips were made during 1964-66. Although these are also unmaintained, the airstrip 8 km southeast of WAPET Kidson No. 1 was still in fairly good order in 1975 and was used to position fuel and supplies for the mapping party.

There are no permanent settlements in the area and the nearest supply points are Giles Meteorological Station and Warburton Mission (about 450 km to the southeast), Alice Springs (over 950 km to the east), Balgo Mission, (about 350 km to the northeast), and Port Hedland (750 km to the west).

Development

The land is undeveloped except for a few water bores which have provided water for drilling companies that have operated in the area. In 1975 most of the water bores were caved-in except for one drilled by Geophysical Services International in 1973, 16 km north of WAPET Sahara No. 1 well. The water was potable and was used by the field party throughout the season. Several water wells along the Canning Stock Route were visited, but most were either caved in or polluted by dead animals.

Climate

The area has a desert climate with an annual rainfall of 200-300 mm, most of which falls from December to March with sporadic falls during the winter months. The average annual evaporation is 2750-3000 mm. The days are hot and the nights cool. In January, the average daily minimum and maximum temperatures are about 22^{o}C and 38^{o}C respectively; and in July, 5^{o}C and 22°C respectively (Australia, Bureau of Census and Statistics, 1970). The average frost-free period for the area is 300 days.

Flora

Most of the area is covered by hummock grassland in which the grass plants are organized into dense rounded clumps of the genera Triodia and Plectrachne, with irregularly scattered eucalypt trees and Acacia shrubs. Communities of small-stemmed succulent shrubs (samphire) or leaf-succulents (salt-bushes) are associated with lake beds and depressions. Groves of desert oaks (Casuarina decaisneana) are present in the Jupiter Well area (WILSON) and on western RYAN.

The area lies within the Eremaean Province and Desert Formation as defined by Gardener (1942) and shown on his Vegetation Formation Maps of Western Australia. More recently, Beard (1969) in a synoptic treatment of the desert areas of Western Australia has suggested a revision of the botanical districts of the Eremaea. Within the Eremaean Province, he recognized four botanical districts: the Carnegie and Canning Botanical Districts which occupy most of the area, and minor portions of the Mueller Botanical District (on WILSON) and Keartland Botanical District (in the southwest) (Beard & Webb, 1974).

Survey methods

The area was mapped using a helicopter, as ground access is impractical due to numerous longitudinal sand dunes. The base camp was established near WAPET Kidson No. 1 airstrip, as fuel for the helicopter, fixed-wing aircraft and motor vehicles was delivered by air.

Field work was planned using vertical airphotos to assist in the location of, and navigation between, the sparse outcrops. All airphotos used were at a scale of 1:80 000 (taken in 1973) except those of SAHARA and PERCIVAL which were at a scale of 1:50 000 (taken in 1953).

The 1:250 000 topographical maps of the Sheet areas, which show nearly all of the sand dunes and most other topographical features, were used for general navigation.

Observation sites were recorded on the airphotos their density is shown in Figure 2. Geological data were plotted on either the photographs or transparent overlays, and were later transposed to planimetric sheets reduced from 1:50 000 scale. The compilation sheets were photographically reduced to 1:250 000 scale and redrawn by a draftsman. Preliminary editions of these geological sheets will be available from the Bureau of Mineral Resources (Canberra) and the Geological Survey of Western Australia (Perth).

Marine macrofossils collected during the survey were studied by Dickins (Appendix C) and Skwarko (Appendix D).

During the survey, new units were recognized in the area for the first time, and the distribution of most of the others was considerably modified. A solid geology map of the area (Fig. 3) shows the distribution of the various units. This map differs substantially from the map of Veevers & Wells (1961).

2. PREVIOUS INVESTIGATIONS

Geological

Although many members of exploration and prospecting expeditions have described outcrops within the area, until 1954 no systematic attempt had been made to map the units and determine their succession.

Colonel Warburton (1875) was first to cross the desert, to which he gave the name Great Sandy Desert, to the north of the area. The first crossing from south to north was by L.A. Wells (1902) who travelled from Wiluna to the Fitzroy River, passing by Separation Well (RUNTON) and Joanna Spring in 1896. In the following year Rudall journeyed near the salt lakes on TABLETOP and over a large part of SAHARA, while trying to locate the lost members of the Wells expedition (Feeken, et al., 1970).

The first crossing in the western part of the area was by Carnegie (1898) who crossed MORRIS and WILSON naming various rock holes and wells on his journey from Kalgoorlie via Godfrey Tank to Halls Creek in 1897.

In 1906-07, in order to help in the movement of cattle from the Kimberleys to Wiluna, Canning surveyed the stock route which now bears his name. Water wells along this stock route were made mainly by the deepening of native wells during Canning's well-sinking trip begun in 1908. A geologist, H.W.B. Talbot, who accompanied Canning for much of the latter journey, published an account of his geological observations and made an excellent assessment of the groundwater resources along the route (Talbot, 1910). Drovers began moving cattle along the Stock Route in 1911. Kidson (1921) recorded magnetic observations along the Stock Route in 1914.

L.J. Jones investigated the geology and water resources of the area. He made the first assessment of the petroleum potential of the area for Locke Oil Development Syndicate and Kimberley Petroleum Company. He also discovered Permian fossils northeast of Well 27 on TABLETOP (Jones, 1922).

The western margin of the Canning Basin in the area covered by this report was investigated geologically by T. Blatchford (1924).

One traverse by D.F. McKay during an aerial survey of the Canning Basin crossed over TABLETOP (McKay, 1934).

In 1940 and 1941, C. St J. Bremner flew over the southern part of the area as part of an aerial geological reconnaissance of the "Fitzroy Basin" by Caltex (Australia) Oil

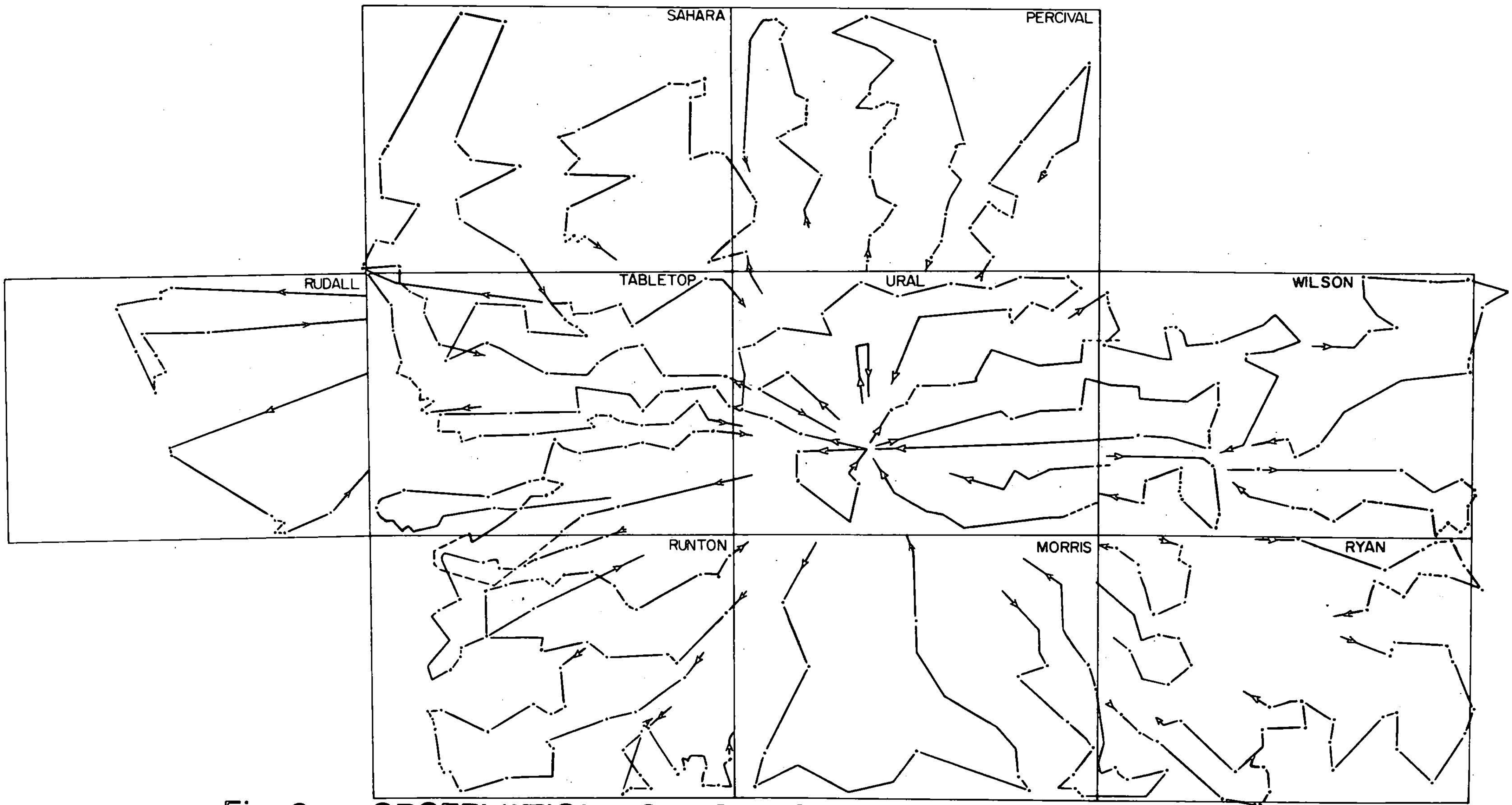


Fig 2 OBSERVATION SITES VISITED DURING SURVEY

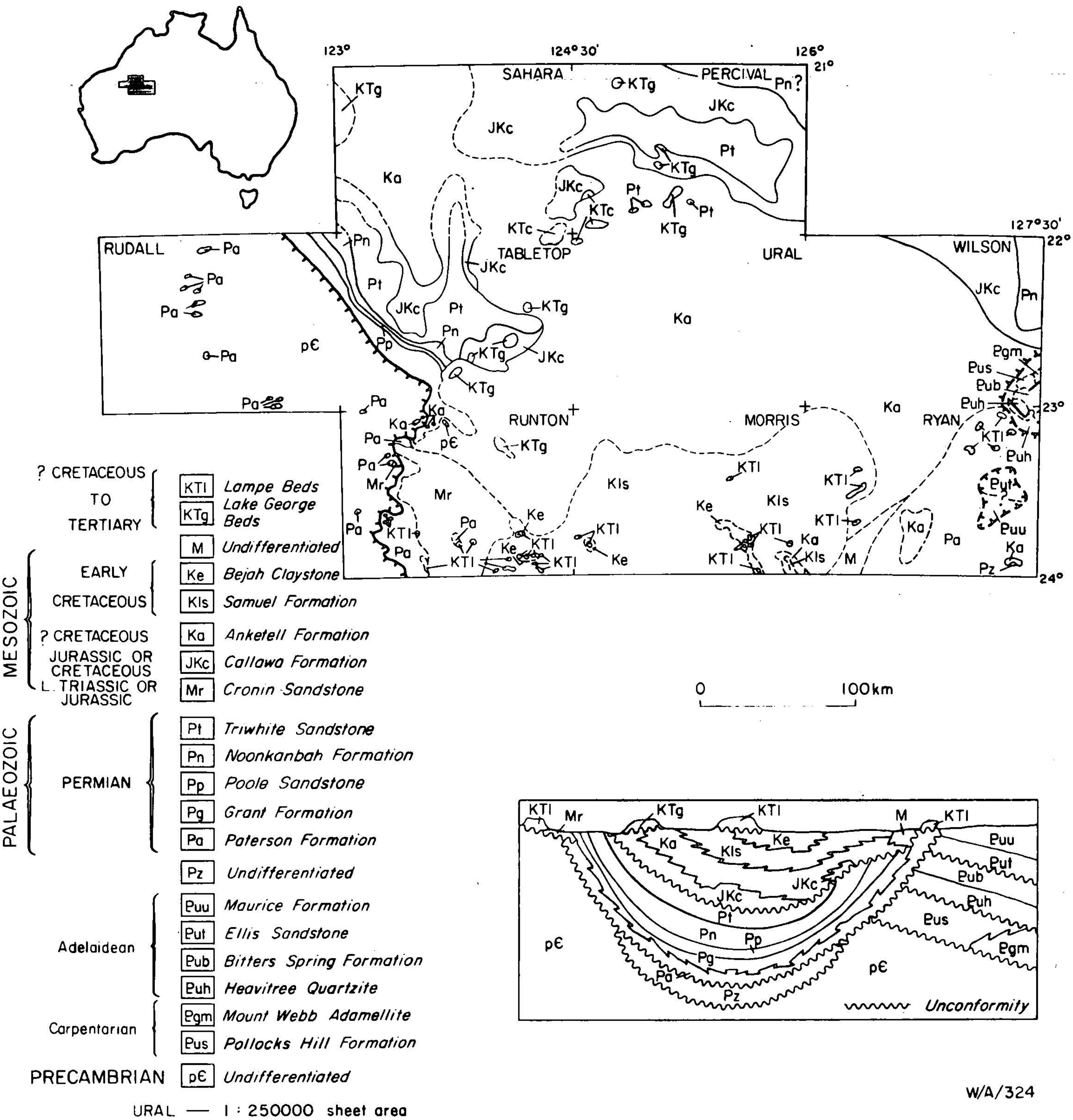


Fig 3 Interpretation of solid geology and diagrammatic relationship between the outcropping Phanerozoic rock units in the southern part of the Canning Basin, Western Australia

Development Pty Ltd; he established that the Devonian limestone in the northern part of the basin does not crop out in the south. He photographed the Percival Lakes, and noted low rises of "sandstone and shale" in PERCIVAL and SAHARA. (Bremner, 1940, 1942).

Using aerial and ground surveys and a reassessment of previous surveys, F. Reeves described the geology and petroleum potential of the Canning Basin (Reeves, 1949). He found Permian fossils at Lake Blanche and near Well 26 on TABLETOP.

Using airphotos flown in 1953, Traves, Casey & Wells (1956) mapped the outcrops and erected a stratigraphy for the area along the southwestern margin of the Canning Basin. In 1957, J.J. Veevers (BMR) during a regional helicopter survey in the central part of the Canning Basin made geological observations and took gravity readings on WILSON, RYAN, URAL and TABLETOP (Veevers, 1957).

In 1956, Stinear, Wells (geologists) and Waterlander (geophysicist) of BMR mapped the southern part of the Canning Basin adjoining the Officer Basin and collected fossils from several localities (Veevers & Wells, 1961). From the results of this and other BMR surveys such as those of Guppy et al. (1952, 1958) and Casey & Wells (1964) outside the area, Veevers & Wells (1961) published an account on the geology of the entire Canning Basin with an accompanying geological map at a scale of 1 inch to 20 miles.

Other reports which refer to the area (McWhae et al., 1958; Playford et al., 1975) are based on compilations of previous work.

Geological reconnaissances were made by companies including West Australian Petroleum Pty Ltd (WAPET), Australian Aquitaine Petroleum Pty Ltd (Aquitaine), Alliance Petroleum (Alliance), and Union Oil Development Corporation (Union Oil); most of their information is unpublished. Parts of the area

(RUNTON and RYAN) were examined during geological survey of the Gibson Desert by Leslie (1961) for Frome Broken Hill Company Pty Ltd.

A.T. Wells (1963) visited localities in southern RYAN during his mapping of the Gibson Desert.

In 1965, during reconnaissance geological survey by Union Oil to evaluate the petroleum potential of the Gibson Desert, geological observations were carried out on RUNTON and RYAN (Mack & Herrmann, 1965).

The configuration of the laterite surface in the eastern part of the area was contoured photogrammetrically at 25-foot vertical intervals by Aquitaine. The results of this method of mapping, described by Creevey (1971), show that most of the geomorphological surface "anomalies" can be correlated with seismically defined subsurface structures.

The petrology of the halite-bearing Palaeozoic Carribuddy Formation was described by Glover (1973) who indicated a diagenetic origin for its red pigment.

Evans & Brown (1974) visited localities in northern WILSON and URAL including Redknap Mound and Kidson Bluff.

During the 1970s adjacent areas have been mapped by geological parties from BMR and GSWA; to the south the Officer Basin (Lowry et al., 1972; Jackson & van de Graaff, in prep.); in the northeast Canning Basin (Yeates et al., 1975); to the east the Webb Sheet area (Blake & Towner, 1974). During the 1975 survey, a crater thought to be of meteoritic origin, was located for the first time (Yeates et al., 1976).

<u>Geophysical</u>

The earliest geophysical investigations of the area were reconnaissance aeromagnetic and gravity surveys carried out by BMR.

In 1954, BMR flew an essentially reconnaissance aeromagnetic survey with ten widely spaced flight-lines over the northern part of the Canning Basin. Only two of these flight-lines reached into the area of this report - one onto WILSON, the other onto PERCIVAL (Quilty, 1960).

Gravity investigations were commenced in the Canning Basin by BMR in 1952, and by 1960 most of the basin had been covered (Flavelle & Goodspeed, 1962). However, the density of the gravity stations varies greatly owing to the remoteness of some areas; the stations were in general located near rock outcrops. Numerous gravity features were delineated, including an extensive gravity low called the "South Canning Regional Gravity Low" (Fig. 4).

In 1962, during a reconnaissance gravity survey by BMR, a single gravity traverse - flight B - was flown in a northeasterly direction across MORRIS and RYAN and thence eastwards across south WILSON to investigate the gravity low found by Flavelle & Goodspeed (1962). The results of this traverse suggested that the gravity low is divided by an east-trending gravity ridge in northern RYAN; the gravity low to the north was named the South Canning Regional Gravity Low and that to the south the Cobb Regional Gravity Low (Lonsdale & Flavelle, 1968).

Subsurface company investigations did not commence in the area until after the introduction of the Commonwealth Petroleum Search Subsidy Act in 1959 when subsidy became available for 50% of acceptable costs of approved geophysical operations and stratigraphic drilling. Before the cessation of the Commonwealth Petroleum Search Subsidy Act 1959-1969, in June 1974, - fifteen subsidized geophysical operations were carried out and four subsidized wells were drilled.

The first subsidized survey in the area was part of the South Canning Basin Aeromagnetic Survey and was flown in 1962-63 by Aero Services Limited for West Australian Petroleum Pty Ltd

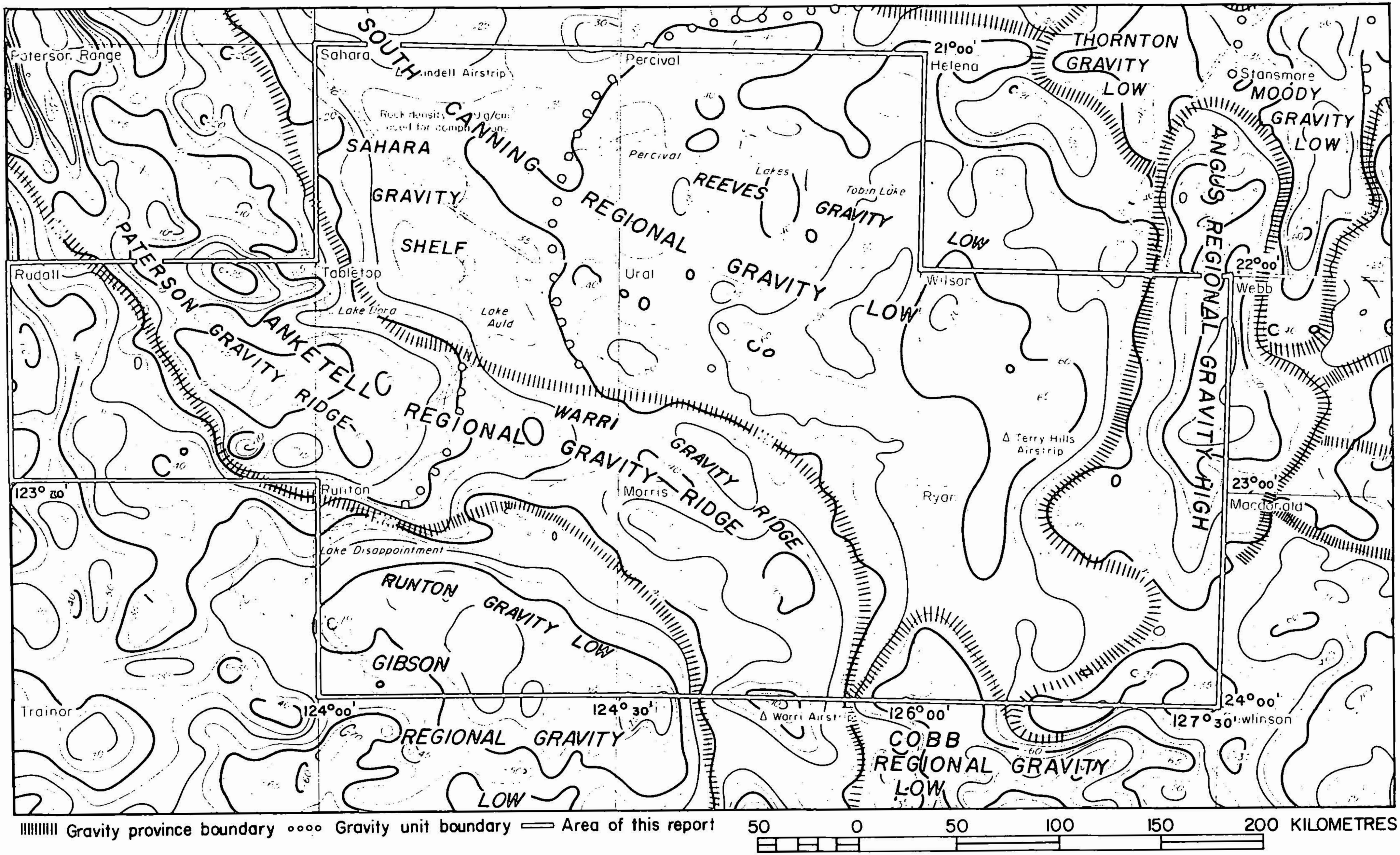
(WAPET, 1966a). The survey was a regional reconnaissance airborne magnetometer survey covering all Sheet areas except RYAN. The objective of the survey was to delineate the depth and configuration of the South Canning Basin and to reveal other major structural features. The existence of the Kidson Sub-basin, a northwest-trending basin with a maximum thickness of between 9000 m and 10 500 m of sedimentary rocks, was confirmed by the survey.

WAPET drilled three shallow stratigraphic holes in the northwest of the area to examine the near-surface stratigraphy and to establish a water supply (WAPET, 1964) and then carried out a number of gravity and seismic surveys during 1963-64:

1. WAPET Sahara Reconnaissance Gravity Survey was carried out by helicopter in 1963 with the object of providing regional structural information to help in the geological interpretation of the area and to guide the planning of more detailed geophysical work. The results of the survey showed a gravity minimum trending northwest through the middle part of SAHARA (Fig. 4). The gravity values along this minimum have been interpreted as representing basement depths of approximately 4500 m below sea level in the northwest and more than 7500 m in the southeast. Many local residual gravity maxima were mapped, some of which may represent sedimentary structures at depth (WAPET, 1963a).

2. The Sahara Seismic Reconnaissance Survey was conducted to investigate the configuration and structure of the north-western part of the Kidson Sub-basin and to locate a favourable well site. Three subsurface horizons were mapped and several broad anticlinal features were located (WAPET, 1963b). This survey led to the drilling of WAPET Sahara No. 1 (WAPET, 1966b).

3. The Joanna Springs Gravity Survey was carried out in an area interpreted from aeromagnetic data as the "Joanna Springs Sub-basin" located on SAHARA and JOANNA SPRINGS. The survey was the northern continuation of the Sahara Gravity Survey, and its objective was to extend the regional gravity coverage over the



ig 4 BOUGUER ANOMALIES AND GRAVITY FEATURES (from Darby & FRASER 1969)

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Joanna Springs Sub-basin in the hope of finding gravity anomalies attributable to sedimentary structures. The dominant features observed in the results were: a large east-west positive gravity trend across northern JOANNA SPRINGS attributed to changes within the basement rocks; a broad gentle northwest negative trend which marks the axis of the Kidson Sub-basin, diagonally across the centre of SAHARA; and an east-west gravity positive at the junction of SAHARA and JOANNA SPRINGS which correlates roughly with some magnetic features as well as having expression in the sedimentary section (WAPET, 1963c).

In 1965, Aero Services Ltd conducted an aeromagnetic survey in the western part of the area for Aquitaine, involving parts of RYAN and WILSON. The purpose was to map the magnetic basement and to indicate the volume of potentially productive sediments in the area (AAP, 1965). Interpretation of the results indicate a deep trough in central WILSON and northern RYAN (the Kidson Sub-basin).

During mid-1965, Wongela Geophysical Pty Ltd conducted an aerial reconnaissance gravity for WAPET involving URAL, MORRIS and WILSON. The survey was carried out to determine the regional structure of the area and in particular to investigate structure in relation to a large gravity high feature with flanking gravity lows suggested as a result of a few gravity readings in the area by previous surveys (Flavelle & Goodspeed, 1962; Lonsdale & Flavelle, 1968). The results delineated an elongate sedimentary trough trending northwest and deepening to the east, which contains up to 4000 m of sediments. Southwest of this feature the sedimentary section thins towards a northwest-trending basement ridge. Numerous local gravity features were recognized but due to the lack of subsurface structural information the significance of these features was difficult to assess (WAPET, 1965a).

In the same year, the Southeast Kidson Seismograph Survey was carried out by WAPET in URAL. Data was generally good to fair, serving to define the possible axes of the Kidson Sub-basin and the structural and tectonic alignment which appears to be northwest. Several small anticlinal features were also delineated (WAPET, 1965b).

In 1967, a reconnaissance reflection/refraction seismic survey was carried out by Ray Geophysics Pty Ltd for French Petroleum (Australia) Pty Ltd with the purpose of establishing drill sites to help in the initial evaluation of the prospect (French Petroleum, 1967). Only a very minor portion of the survey occurred within the area of this report in far north SAHARA; most of it occurred in JOANNA SPRINGS and MCLARTY HILLS to the north, where two favourable geological structures were located.

In 1967, Compagnie Generale de Geophysique carried out a series of geophysical surveys on behalf of Aquitaine involving both WILSON and RYAN. The first of these, the Dakota Seismic and Gravity Survey (AAP, 1968) employed both reflection and refraction methods. The broad features of the Kidson Sub-basin in the area were delineated. Depth to basement was shown to decrease gently to the east, and the eastern limit of the basin was postulated to be palaeogeographic rather than tectonic.

The second Aquitaine survey, the Ryan Seismic and Gravity Survey (AAP, 1969a) was aimed to establish the shape and depth of the eastern end of the Kidson Sub-basin. The reflection and refraction results showed a thick geological section thinning towards the eastern edge of the basin, and in general confirmed and better defined the results obtained in the first survey. Simultaneously with this survey, Aquitaine carried out the first subsidized magnetotelluric survey in Australia - the Terry Range Magnetotelluric Survey (AAP, 1969b). The method professes to show sedimentary layers of different conductivity or resistivity properties, and the instruments measure the relative amplitude

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of the telluric current and the magnetic fields inducing them within a broad frequency range. The results of this survey confirmed in general terms the shape of the eastern part of the Kidson Sub-basin.

The third Aquitaine survey, the Contention Heights Seismic Refraction and Gravity Survey, was carried out in 1969 with the objective of mapping the eastern edge of southeast Kidson Sub-basin and the delineation of any structures. The results were generally good with four reflection markers being recorded, one in Upper Proterozoic 'basement', one in the Ordovician, and two within the Devonian (top of the Carribuddy Formation, and top of the Mellinjerie Limestone). The 'Ordovician' marker pinches out eastwards against the basement and is overlapped by the 'Carribuddy' marker (AAP, 1969d).

To the south of this survey, the fourth Aquitaine survey was carried out - the Baron Range Seismic and Gravity Survey (AAP, 1969e). Its objectives were to map the eastern border of the southeastern Kidson Sub-basin, to correlate refractors with those in Aquitaine's Wilson Cliffs No. 1 well (WILSON), to delineate the geographic extent of Palaeozoic sediments, and to investigate the possibilities of pinch out. The seismic quality was good enough to show that basement rises to the east, that the Ordovician thins eastwards, and that the Carribuddy Formation totally covers the Ordovician and overlaps the limit of the pinch-out.

In 1968, under contract to BMR, Wongela Geophysical Pty Ltd completed a systematic helicopter gravity reconnaissance survey covering the southeastern part of the Canning Basin, thus permitting full delineation to be made of gravity features which were only partly defined from previous work. The results of this survey are given in Darby & Fraser (1969) and the gravity features delineated are shown in Figure 4.

During 1970, the Tabletop Seismic Survey involving TABLETOP, SAHARA and URAL investigated the structure of the southern flank of the Kidson Sub-basin and the adjoining 'Tabletop Shelf' (WAPET, 1970a). Four horizons were mapped, within or near the top of the following formations: the Grant Formation, Tandalgoo Red Beds, Carribuddy Formation and Thangoo Limestone. Structures were defined in the vicinity of both WAPET Sahara No. 1 and WAPET Kidson No. 1 wells.

During 1971, three seismic surveys were carried out in and near the area. The first, the Lake Auld Seismic Survey, investigated the southern flank of the Kidson Sub-basin and the adjoining 'Tabletop Shelf'. Three horizons were mapped: the Tandalgoo Red Beds, the Carribuddy Formation, and the top of the Thangoo Limestone. The survey provided definition of the southwest flank of the Kidson Sub-basin and confirmed faulting indicated by gravity and aeromagnetic data (WAPET, 1971a).

The other two surveys, the Helena Seismic Survey (WAPET, 1970b) and the Crossland Platform Seismic Survey (WAPET, 1971b), were carried out mainly in the Sheet areas north of the area but involved parts of PERCIVAL and WILSON. The former survey produced generally poor-quality data with only two horizons mapped. The results of the latter survey allowed better definitions of the Crossland Platform. Three horizons were mapped.

In 1972, the Hickey Hills Seismic Survey (AAP, 1972) was carried out in the eastern part of the area. Data quality was fair and two traverses, one trending north and one northwest, demonstrated the northerly thickening of sediments into the Kidson Sub-basin by a series of terraces which are bounded by northwest-trending faults. Three unidentified horizons were mapped. Additional seismic work and some stratigraphic drilling were recommended.

In 1974, a report on the study of all the available gravity information in the Canning Basin, relating it to known geology including published information from surface surveys and boreholes logging up to the end of 1962, was released (Flavelle, 1974).

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The results obtained from a comprehensive reconnaissance and detailed surface geological mapping program as well as reflection seismic survey utilizing the 'Vibroseis' technique carried out mainly to the northeast of the area are presented in a paper by Drew & Evans (1975).

Drilling

To help in the determination of the age and nature of the stratigraphic column and to evaluate the hydrocarbon potential of Permian and other sediments within the Kidson Sub-basin, four petroleum exploration wells were drilled, two by WAPET and two by Aquitaine.

WAPET Sahara No. 1 (Lat 21°04'40"S, Long 123°13'30"E) was designed to test the unknown stratigraphy of the western Kidson Sub-basin. The well penetrated Mesozoic, Permian and Devonian sediments before being abandoned at 2120.2 m in undated evaporites (WAPET, 1966b). The pre-Permian sequence had not been encountered elsewhere and three new formations were defined by Koop (1966a). A summary of the stratigraphy is given in Appendix B1.

WAPET Kidson No. 1 (Lat 22°37'00"S, Long 125°00'22"E) was programmed as a stratigraphic test of a structural terrace in the southern Kidson Sub-basin. The well penetrated to a total depth of 4431.5 m in a Early Ordovician sequence (WAPET, 1966c). A summary of the stratigraphy is given in Appendix B2.

Aquitaine Wilson Cliffs No. 1 was drilled in 1968 on an anticlinal feature in the eastern part of the basin (Lat 22°16'39"S, Long 126°46'55"E). Total depth was reached at 3722 m in Proterozoic sediments (AAP, 1969c). Appendix B3 gives a summary of the stratigraphy of the well.

Aquitaine Contention Heights No. 1 (Lat 22°25'36"S, Long 127°13'31"E) was drilled in 1973 near the southeastern margin of the basin to investigate the reservoir potential of the Ordovician sequence. The well penetrated a Palaeozoic sequence similar to that encountered in Wilson Cliffs No. 1, and terminated at a depth of 1709.7 metres (AAP, 1974). Appendix B4 gives a summary of the stratigraphy of the well.

No significant hydrocarbon shows were recorded in any of the wells. The significance of the well information and the possible prospects and techniques for further exploration within the Kidson Sub-basin have been summarized at various stages by Koop (1966b) and Creevey (1971).

3. STRATIGRAPHY

Introduction

Major difficulties in elucidating the geology of the southern Canning Basin are the occurrence of extensive Cainozoic superficial deposits between widely scattered outcrops, the fact that most of the rocks exposed are quartz sandstones and are difficult to tell apart, and a paucity of useful marker beds. Deep and intensive weathering involving ferruginization, lateritization and silicification has affected most rocks in the region. The region has been subjected to subaerial denudation since the beginning of the Tertiary (or earlier), and the rocks most susceptible to weathering tend to form topographic depressions and to be concealed beneath superficial deposits.

The stratigraphy of the area is summarized in Table 1. The oldest rocks in the area are the Archaean and Early Proterozoic sediments intruded by granites which form the basement Arunta Block. Adelaidean sedimentary rocks of the Amadeus Basin sequence lie unconformably on basement. These rocks form the eastern margin of the Canning Basin. Basement to the western margin of the basin is made up of gneiss, schist and igneous rocks of the Rudall Metamorphic Complex, which is overlain by a moderately to strongly folded and faulted, mixed sedimentary succession (the Yeena Group) of Early or Middle Proterozoic age, and are described in detail elsewhere (Williams et al., 1976).

The Precambrian units are overlain by marine and/or fluvial sediments of the Canning and Officer Basin sequences. Thin terrestrial and marine Mesozoic and Cainozoic sequences complete the stratigraphy.

Units older than the outcropping Permian Paterson Formation occur only in the subsurface, and the information on them is based mainly on data obtained from the wells drilled in the area: WAPET Sahara No. 1, WAPET Kidson No. 1, Aquitaine Wilson Cliffs No. 1, and Aquitaine Contention Heights No. 1. Interpretations of the environments of deposition of the subsurface units have not been attempted in this report.

PRECAMBRIAN

Pollock Hills Formation

The Pollock Hills Formation crops out as strike ridges, hills and undulating terrain in southeastern WILSON, and it extends eastwards onto WEBB. The type section is across part of the Pollock Hills from lat. 22°50'S, long. 127° 40'E to lat. 22°49'S, long. 127°38'E (WEBB).

Lithology

The unit consists mainly of quartz and feldspathic sandstone; acid lava is also exposed in low hills. The latter is porphyritic, hard, dense and jointed. A detailed description is given by Blake & Towner (1974). The sandstone is fine to medium-grained, medium to thin-bedded; lithic fragments are common.

On WEBB, the formation contains andesitic lava, tuffaceous siltstone and sandstone, conglomerate, lapilli tuff and agglomerate (Blake & Towner, 1974).

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Stratigraphic relations

The relation of the Pollock Hills Formation to any underlying and overlying unit is not known as no contacts are exposed in the area.

On WEBB the formation is intruded by the Mount Webb Adamellite, which may be comagmatic with the acid lava of the formation, and it is overlain unconformably by the Heavitree Quartzite. It is inferred to overlie Archaean metamorphic rocks (Blake & Towner, 1974).

Age

The age of the formation has been determined isotopically by the Rb-Sr method as 1526 ± 25 m.y. (Page et al., 1976).

Thickness

The maximum thickness of the formation is uncertain, as the base is not exposed: over 600 m was measured in the type section but it may be as thick as 1500 m.

Mount Webb Adamellite

During the 1975 field season, no outcrops of the Mount Webb Adamellite were visited in the field by members of the BMR/GSWA party, but photointerpretation and mapping by Blake (Blake & Towner, 1974) in 1973 has shown a small area of granitic rocks in southeast WILSON, where the adamellite apparently occurs as scattered groups of spherical boulders and tors surrounded by sand.

The Mount Webb Adamellite intrudes metamorphic rocks and the Pollock Hills Formation, and is cut by later basic dykes. It is overlain unconformably by Heavitree Quartzite (Blake & Towner, 1974).

The adamellite has been dated isotopically by the Rb-Sr method at 1526 ± 25 m.y., indicating that it may be comagmatic with the acid lava of the Pollock Hills Formation (Page et al., 1976).

Heavitree Quartzite

The Heavitree Quartzite was named and defined by Joklik (1955), Heavitree Gap at Alice Springs being the inferred type locality (Wells et al., 1970). It is the basal formation of the Amadeus Basin sequence and crops out in southeast WILSON and northeast RYAN, where it forms a series of strike ridges, low cuestas and hills.

Lithology

The main rocks are quartz sandstone, feldspathic sandstone and subordinate siltstone and conglomerate. Bedding is generally laminated to medium. Small-scale, low-angle, planar cross-bedding is present. The quartz sandstone is medium-grained and well sorted; it consists mainly of rounded grains and contains fine laminae of coarse to very coarse grains. Near Corroboree Valley (RYAN), the fine-grained, poorly-sorted quartz-feldspathic sandstone at the base of the section contains pebbles and cobbles of quartz.

Between the strike ridges of quartz sandstone are small exposures composed mainly of very thin-bedded to laminated, friable, fine-grained sandstone and siltstone.

Most of the quartz sandstone has a siliceous cement, and surface silicification is common.

At lat. 22°48'48"S, long. 127°30'06"E, a 20 m cliff exposure consists of coarse to very coarse-grained poorly-sorted sandstone, and beds of boulder and pebble conglomerate. The sequence is cross-bedded with sets of 5 m or more. This passes up into better-sorted, coarse to very coarse-grained lithic sandstone with cross-bedding sets 1 m thick, containing small-scale cross-laminations.

Stratigraphic relations

On WEBB, the Heavitree Quartzite unconformably overlies Archaean metamorphics, Pollock Hills Formation, and Mount Webb Adamellite (Blake & Towner, 1974). The basal contact of the Heavitree Quartzite is not exposed in the area, but a conformable contact with the overlying Bitter Springs Formation is assumed because of the presence of a conformable contact on WEBB. In south WILSON, the contact between the Heavitree Quartzite and Bitter Springs Formation is faulted. The formation is unconformably overlain by the Cretaceous-Tertiary Lampe Beds.

Thickness

No section of the Heavitree Quartzite was measured, but it is considered to be at least 200 m thick. In the Pollock Hills area on WEBB, over 500 m of Heavitree Quartzite is exposed.

Age

The Heavitree Quartzite is known to be younger than 1076 $\pm$ 50 m.y. (Marjoribanks & Black, 1974).

Environment of deposition

Wells et al. (1970, p.21) considered that 'The widespread distribution of the Heavitree Quartzite suggests deposition in a shallow marine epicontinental sea under relatively stable conditions', and that the coarse basal beds may indicate a littoral environment.

Bitter Springs Formation

The Bitter Springs Formation was originally named the Bitter Springs Limestone by Joklik (1955) and revised to Bitter Springs Formation by Wells et al. (1967). It crops out in far southeast WILSON and northeast RYAN as low mounds and hills.

Lithology

The rock types exposed are quartz sandstone, micaceous siltstone, dolomite and minor limestone. The quartz sandstone is fine to medium-grained, laminated to thin-bedded, moderately sorted and in places calcareous. The dolomite and limestone are generally capped with Cainozoic calcrete. The dolomite which is yellowish grey contains coarse rounded quartz grains.

On WEBB, limestone and dolomite are the predominant rock types and locally they appear to be stromatolitic; thin lenses and laminae of dark grey chert are associated with the carbonate rocks. Farther east, evaporitic minerals are present in the formation (Wells et al., 1970).

Stratigraphic relations

The contact of the Bitter Springs Formation with the overlying and underlying units is concealed by superficial deposits. The formation is conformable on the Heavitree Quartzite in the Pollock Hills area (WEBB). It is probably unconformably overlain by the possible Proterozoic-Cambrian sediments intersected in Aquitaine Wilson Cliffs No. 1 or by other Phanerozoic sediments of the Canning Basin.

Thickness

Although no sections were measured, the Bitter Springs Formation is considered to be 100 m or more thick. In the Western Australia side of the Amadeus Basin, the formation has a thickness of about 366 m (Playford et al., 1975).

Age

The Bitter Springs Formation is probably Adelaidean (Wells et al., 1970).

Environment of deposition

Wells et al. (1970) suggest that the formation was probably deposited in a relatively stable, highly saline, shallow-marine environment.

Ellis Sandstone

The name Ellis Sandstone was introduced by Wells et al. (1964) and the name has tentatively been assigned to outcrops which occur to the north of the Baron Range in central east RYAN. The outcrops form low hills and pinnacles.

Lithology

The predominant rock is a white, fine to medium-grained, quartz sandstone, laminated to thin-bedded, cross-laminated and cross-bedded. The sandstone contains mainly moderate to well-rounded grains but also some very well rounded to spherical grains of quartz and minor heavy minerals. A few beds of well-rounded coarse to very coarse-grained sandstone occur in several places.

Cross-bedding, common throughout the sequence, is mainly of the planar type with asymptotic bases and eroded tops. The sets range from small scale (3-5 cm) to large scale (3 m). Opposing dips of the foreset beds are present in adjacent sets of cross-bedding, giving rise to herringbone cross-bedding.

At one locality (lat. 23°10'00"S, long. 127°11'21"E) in a joint block 4 m high, the interbedding of planar stratified and cross-stratified sandstone is repeated 20 times.

Current wave ripple marks, and possible current lineations are present.

Stratigraphic relations

The contact between the Ellis Sandstone and other units is not exposed as it is covered by Cainozoic deposits. To the east, in the Amadeus Basin, the Ellis Sandstone probably lies unconformably above the Carnegie Formation or Board Formation, interfingers with the Sir Frederick Conglomerate, and is conformably overlain by the Maurice Formation (Wells et al., 1970). The Ellis Sandstone may be correlated with the Erica Sandstone of the Redcliff Pound Group in the Granites-Tanami area (Blake et al., 1973).

Thickness

No sections were measured, but the formation is estimated to be at least 50 m thick on RYAN.

Age

In 1964, Wells et al. assigned a Late Proterozoic or Early Palaeozoic age to the formation. However, later work showed that the Ellis Sandstone interfingers with Sir Frederick Conglomerate and is equivalent in part to the Late Proterozoic Winnall Beds (Wells et al., 1970). The Ellis Sandstone is considered to be Late Proterozoic (Adelaidean) in age.

Environment of deposition

Wells et al. (1970, p 41) consider that "... the complex interfingering of the Sir Frederick Conglomerate with the Ellis Sandstone suggests deposition close to the provenance area in alternating continental and transitional environments. The conglomerates were probably mainly fluvial and the interfingering sand mainly littoral".

Maurice Formation

Wells et al. (1964) introduced the name Maurice Formation for the sequence of sandstone and siltstone which conformably overlies the Ellis Sandstone in the western part of the Amadeus Basin. The formation crops out in the Baron Range and hills nearby in the central east part of RYAN.

Lithology

At the base of the Baron Range, fine to medium-grained, thin to medium-bedded, grey-green quartz sandstone, which occurs as strike ridges, is interbedded with laminated, fissile, micaceous, very fine-grained sandstone and siltstone. This is overlain by cream to pale grey, highly silicified fine to very fine-grained sandstone containing 5% clay pellets (weathered feldspar). This sequence is distinctly thin bedded to very thick bedded with no visible internal lamination. This highly silicified sequence is interbedded in places with pale brown, coarse-grained sandstone and siltstone. Bedding dips range from 35^{o} to vertical.

Stratigraphic relations

In the Amadeus Basin, the Maurice Formation is conformable on the Ellis Sandstone and is unconformably overlain by the Permian Buck Formation.

Thickness

No sections were measured, but the formation is estimated from dip reading and airphoto to be at least 900 m thick. It is estimated to be at least 1800 m thick in the Maurice Hills (Wells et al., 1970, p. 39).

Age

Wells et al. (1964) tentatively assigned a Late Proterozoic or Early Palaeozoic age to the Maurice Formation. However, later work has shown that this formation is equivalent in part to the Late Proterozoic Winnall Beds (Wells et al., 1970), and is therefore considered to be Late Proterozoic and the topmost Proterozoic unit of the Amadeus Basin.

Environment of deposition

Wells et al. (1970, p. 41) suggest that the Maurice Formation was probably deposited in alternating fluvial and shallow-marine environments.

LATE PROTEROZOIC? OR CAMBRIAN?

Sedimentary rocks of possible late Proterozoic or early Palaeozoic age were intersected at the base of Aquitaine Wilson Cliffs No. 1 (AAP, 1969c). The sequence intersected has been informally named by the company as the 'Carbonaceous Shale Beds' and 'Ferruginous Shale Beds'.

The "Carbonaceous Shale Beds" are almost entirely black, silty, non-calcareous, carbonaceous, micaceous, pyritic and partly silicified shale. Interbedded with the shale are grey to white siltstone, and minor carbonates occur near the base of the beds. Bedding ranges from laminated to massive. The beds are strongly jointed, the fractures being filled with pyrite, quartz and calcite. The dipmeter log indicates that these beds dip at 22° WSW.

The thickness of the beds penetrated in the well is 143.9 m. No age can be determined but the beds are possibly Late Proterozoic.

The 'Ferruginous Shale Beds' consist of interbedded, multicoloured silty shale and siltstone; they are ferruginous, micaceous, and slightly calcareous, and contain minor pyrite. The siltstone grades in part to fine-grained sandstone. The sediments are well laminated and contain small faults with microdisplacements; the faults are filled with quartz and carbonate. Dipmeter readings in the well show that the beds dip at 6° NW. The total thickness of section penetrated in the well is 75 m.

The age of these beds is unknown; the overlying formation contains marine macrofossils and microfossils of Early to Middle Ordovician age.

The dipmeter readings in the well indicate a strong angular unconformity at the boundary between the 'Carbonaceous Shale Beds' and the overlying 'Ferruginous Shale Beds'.

UNDIVIDED PALAEOZOIC

Outcrops of cross-stratified sandstone and minor siltstone occur at a prominent mesa/breakaway 30 m high in southeast RYAN at lat 23°55'18"S, long 127°20'42"E. The base of the sequence is not exposed and the top of the sequence is unconformably overlain by the Cretaceous Anketell Sandstone. Since this sequence is not as friable and soft as the Mesozoic sediments observed elsewhere in the southern Canning Basin, the exposure has been mapped as Undivided Palaeozoic.

Lithology

Near the base of the hill are outcrops of fine to coarse, friable, micaceous sandstone, moderately sorted and cross-bedded throughout. The cross-sets are less than 10 cm thick and are mostly planar, with a maximum dip of 15° on foresets. Overlying this is a sequence of interbedded cross-bedded and non-cross-bedded sandstone. The non-crossbedded sandstone ranges in thickness up to 5 cm and contains large siltstone clasts up to 20 cm long. In the cross-bedded sequence, opposing dip directions on the foresets occurs. This sequence is capped by 30 cm of deeply weathered micaceous siltstone.

The top 5 m of the section contains fine to coarse-grained, thin to medium, parallel-bedded sandstone which grades upwards into laminated siltstone and fine-grained sandstone at the top. Cross-bedding is poorly developed and some beds wedge out along strike.

Thickness

At least 30 m is exposed.

Environment of deposition

As only one outcrop of this unit was visited, it is difficult to suggest an environment of deposition. The opposing direction of the cross-bedded sand separated by planar laminated sand is consistent with a shallow-water environment in which opposing current directions are common; possibly a tidal environment.

ORDOVICIAN

Ordovician sediments have been intersected in three of the four wells drilled in the area: WAPET Kidson No. 1, Aquitaine Contention Heights No. 1 and Aquitaine Wilson Cliffs No. 1; the last well has the most complete section.

The Ordovician sequence has been divided into three units; the basal and middle units have been informally named the 'Lower Formation' and 'Middle Formation' respectively in company reports (AAP, 1969c; 1974) and the upper unit is placed in the Goldwyer Formation.

'Lower Formation'

The 'Lower Formation' is almost entirely quartz sandstone with minor shale and shaley siltstone. The sandstone is white to grey, is fine-grained, and contains angular to sub-rounded grains. The siltstone and shale are grey to black and form scattered interbeds throughout. The formation has a maximum thickness of 540.1 m in Aquitaine Wilson Cliffs No. 1 well and is at least 45.7 m thick in Aquitaine Contention Heights No. 1 well.

Marine fossils including graptolites, brachiopods, and molluscs, indicate a Middle Ordovician age (Arenigian to Llandeilian-Llanvirnian age). The 'Lower Formation' has been tentatively correlated with the 'Nambeet Formation' (Playford et al., 1975).

'Middle Formation'

The 'Middle Formation' consists of predominantly white, fine-grained, slightly calcareous sandstone with minor glauconite and pyrite, and, towards the base, grey argillaceous limestone and dolomite. Grey to black shale forms rare interbeds. In Aquitaine Contention Heights No. 1 well the formation contains mainly medium to coarse-grained, poorly sorted sandstone with interbeds of siltstone and very little carbonate cement (AAP, 1974).

Marine fossils including echinoderms, pelecypods, brachiopods, and trilobites are present, particularly in the carbonate beds. Microfossils from the cores indicate a Middle Ordovician age (Llandeilian-Llanvirnian) for the formation. The 'Middle Formation' may correlate with the Willara Formation (Playford et al., 1975).

Goldwyer Formation

The Goldwyer Formation (Elliott, 1961) is a sequence of shale, limestone, dolomite and siltstone which overlies the Willara Formation and is conformably overlain by the Nita Formation. It is named after Goldwyer No. 1 well and the type section is in Thangoo No. 1A well between 848 m and 1060 m. Both these wells are located outside the area, to the northwest. The formation has a wide distribution in the subsurface of the southern Canning Basin being intersected in WAPET Kidson No. 1 well and both of the Aquitaine wells, Wilson Cliffs No. 1 and Contention Heights No. 1.

Lithology

The formation consists of interbedded grey, calcareous siltstone and shale with thin beds and lenses of limestone. The limestone is finely crystalline and slightly dolomitic, and contains rare crystals of pyrite and gypsum. In Aquitaine Contention Heights No. 1 well, a fine to medium-grained grey sandstone occurs in the middle of the formation.

Age

Fossils include brachiopods, trilobites and graptolites which date the Goldwyer Formation as Mid-Ordovician (Llanvirnian, possibly Llandeilian).

Thickness

Sections of Goldwyer Formation penetrated in the wells include at least 133.5 m in WAPET Kidson No. 1; 314.6 m in Aquitaine Wilson Cliffs No. 1 and 237.7 m in Aquitaine Contention Heights No. 1.

?LATE ORDOVICIAN TO EARLY DEVONIAN

Carribuddy Formation

The Carribuddy Formation (Koop, 1966a) is named after Carribuddy Springs, 16 km northeast of WAPET Sahara No. 1 well, in which the type section is located between 1727 m and 2120 m (total depth of well). The formation is widespread over the south Canning Basin and has been intersected in Aquitaine Contention Heights No. 1, Aquitaine Wilson Cliffs No. 1, and WAPET Kidson No. 1.

Lithology

The formation was first informally subdivided into two units A and B in WAPET Sahara No. 1 (Koop, 1966a), and later into five units A, B, C, D, and E in WAPET Kidson No. 1 (WAPET, 1966c), Unit A being the top and Unit E the bottom of the sequence:

Unit A:	mainly dolomite with minor interbedded siltstone and shale with rare sandstone beds.
Unit B:	predominantly halite with minor siltstone.
Unit C:	mainly grey, calcareous claystone with a little siltstone. Minor interbeds of halite near the top and bottom.
Unit D:	red-brown claystone with quartz and dolomite with halite interbeds.
Unit E:	mainly interbedded and gradational red-brown claystone and argillaceous dolomite with thin beds of halite and anhydrite. In Aquitaine Contention Heights No. 1, this unit contains medium-grained sandstone at the top with interbedded sandy shale and siltstone with fine sandstone at the base.

Unit B, the evaporitic unit, is absent in both the Aquitaine wells. The sandstone unit in Contention Heights No. 1 is tentatively correlated with the evaporitic unit D in the Wilson Cliffs No. 1 well.

Thickness

The thicknesses of Carribuddy Formation encountered in the various wells include:

WAPET Sahara No. 1	:	393.5+ m
WAPET Kidson No. 1	:	1709.3 m
Aquitaine Wilson Cliffs No. 1	:	754.4 m
Aquitaine Contention Heights No. 1	:	431.6 m

The formation therefore appears to thicken towards the centre of the Kidson Sub-basin.

Stratigraphic relations

The contact of the Carribuddy Formation with the Goldwyer Formation is a disconformity. The contact with the overlying Tandalgoo Red Beds is sharply defined on electrical and gamma-ray logs. It is an abrupt, but apparently conformable, change from sandstone to dolomite.

Age

The dating of the Carribuddy Formation remains imprecise. In Aquitaine Contention Heights No. 1 well, rare spores with Devonian affinities and acritarchs are present, but the types and specimens are too unrelated to give any definite stratigraphic position (AAP, 1974). Fossils are absent in the other wells in the area. The formation disconformably overlies the Mid-Ordovician Goldwyer Formation and is overlain by the Early Devonian Tandalgoo Red Beds and is therefore inferred to be Late Ordovician to Early Devonian in age.

DEVONIAN

Tandalgoo Red Beds

The Tandalgoo Red Beds (Koop, 1966a) are a sequence of red and brown sandstone with minor siltstone and limestone overlying the Carribuddy Formation. The name of the formation is derived from Tandalgoo Rock Hole, 8 km north-northeast of WAPET Sahara No. 1 well (SAHARA) in which the type section is located between 1128 m and 1727 m. The formation has been intersected in all the wells drilled in the area.

Lithology

The Tandalgoo Red Beds are composed almost wholly of sandstone with interbeds of siltstone, shale and limestone. The red-brown sandstone ranges from very fine to coarse-grained and has clean, well-rounded, moderately to well-sorted quartz grains. Some of the quartz grains are frosted. The sandstone is massive to well bedded and cross-bedded with foresets dip of up to 15o. The siltstone and shale interbeds are red-brown, argillaceous, and slightly calcareous. Rare limestone beds occur near the base of the sequence in WAPET Sahara No. 1 well.

Thickness

Sections penetrated in the wells:

WAPET Sahara No. 1	:	599 m
WAPET Kidson No. 1	:	733 m
Aquitaine Wilson Cliffs No. 1	:	684.4 m
Aquitaine Contention Heights No. 1	:	60 m

This indicates that the formation thickens rapidly westwards from Contention Heights No. 1 well to Wilson Cliffs No. 1 well and then gradually into the centre of the Kidson Sub-basin.

Stratigraphic relations

The boundary between the overlying Mellinjerie Limestone and the Tandalgoo Red Beds is sharply defined by a change in lithology from interbedded dolomite and siltstone to red-brown sandstone. In WAPET Sahara No. 1 well, the sandstone of the Tandalgoo Red Beds is separated from the carbonates of the Mellinjerie Limestone by a transitional unit of siltstone, limestone and shale. This contact is regarded as either transitional or slightly disconformable.

The contact between the Carribuddy Formation and the Tandalgoo Red Beds is an abrupt but apparently conformable one.

Age

The Tandalgoo Red Beds do not contain any fossils in either Aquitaine Contention Heights No. 1 or WAPET Kidson No. 1 wells. However, fish scales (Turinia australiensis) collected in a core about 425 m above the base of the formation in Aquitaine Wilson Cliffs No. 1 well date the Tandalgoo Red Beds as Early Devonian (Dittonian) (Gross, 1971).

Mellinjerie Limestone

The Mellinjerie Limestone is a sequence of limestone and dolomite with minor shale interbeds which overlies the Tandalgoo Red Beds. The name is derived from the Mellinjerie Rock Hole, 7 km northwest of WAPET Sahara No. 1 well. The type section of the formation is in WAPET Sahara No. 1 well from 931 m to 1128 m. The formation is also recognized in the other petroleum exploration wells drilled in the area.

Lithology

In WAPET Kidson No. 1 and Aquitaine Wilson Cliffs No. 1 wells, the formation is largely a carbonate sequence of anhydrite-bearing dolomite, in parts silty, grading to dolomitic siltstone with minor interbeds of shale. The sequence is red and ripple marked; small scour-and-fill structures occur.

In Aquitaine Contention Heights No. 1 well, the dominant lithology is soft, red to brown, ferruginous dolomitic shale with fine quartz grains interbedded with argillaceous dolomitic siltstone. Anhydrite is absent.

In WAPET Sahara No. 1 well, the formation contains very fine-grained limestone and dolomitic limestone and minor silty dolomite. Argillaceous siltstone beds occur near the top and bottom of the formation.

Thickness

WAPET Sahara No. 1	:	197 m
WAPET Kidson No. 1	:	266 m
Aquitaine Contention Heights No. 1	:	17.7 m
Aquitaine Wilson Cliffs No. 1	:	127.4 m

The formation thickens rapidly towards the centre of the Kidson Sub-basin.

Stratigraphic relations

The Mellinjerie Limestone rests on the underlying Tandalgoo Red Beds with probable disconformity which is well marked by an abrupt lithological change from clastics to carbonates. In all the wells, the Mellinjerie Limestone is overlain unconformably by the Permian Grant Formation. The contact between the two is a good seismic reflector.

Age

No macrofossils have been collected from the Mellinjerie Limestone, but the microflora indicate a Middle Devonian age for the formation (WAPET, 1966b). To the north of the area in Total Kempfield No. 1 well, a conodont fauna indicates a Frasnian (Late Devonian) to possibly Givetian (Middle Devonian) age for the Mellinjerie Limestone (Total, 1969).

PERMIAN

Paterson Formation

The Paterson Formation is identified as a conglomerate-bearing facies, partly laterally equivalent to the Grant Formation. It consists of unsorted conglomerate, sandstone and

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graded siltstone and claystone, interpreted as glacial in origin. It occurs along the southern margin of the Canning Basin and is also widespread in the Officer Basin to the south.

Distribution and type locality

The type section of the Paterson Formation (Talbot, 1920; Traves et al., 1956) is outside the area, in the Paterson Range (21°45'00"S, 122°10'00"E, PATERSON RANGE). In the area the formation occurs as scattered outliers resting on Precambrian rocks on RUDALL and RUNTON and is identified at the base of the Permian section near No. 26 Well on TABLETOP. It also occurs as scattered outcrops around the northwestern and northeastern margins of the Officer Basin on RUNTON and RYAN respectively, and has been tentatively identified in the Ryan Buttes (RYAN).

WAPET Sahara No. 1 and Kidson No. 1 wells intersected a basal conglomerate in the Grant Formation (WAPET, 1966b,c) and this is tentatively identified as Paterson Formation (termed Braeside Tillite by WAPET). In Aquitaine Wilson Cliffs No. 1 and Aquitaine Contention Heights No. 1 wells in the eastern part of the area, the Paterson Formation cannot be confidently identified, but to the northeast, in Aquitaine Point Moody No. 1 well (STANSMORE), the basal 1091 m of Permian is identified as Paterson Formation because of the occurrence of probably tillite in the section (AAP, 1966).

Lithology

On RUDALL the sequence normally consist of a basal, unsorted conglomerate containing some faceted and striated boulders set in a sandstone matrix unconformably overlying Precambrian rocks. This passes gradationally up into massive and laminated mudstone with a few dropstones, graded bedding (Plate 1) slump structures and lenses of cross-bedded sandstone and conglomerate. In southeastern RUDALL the sequence is disconformably overlain by unbedded, poorly sorted, silicified quartz wacke which contains lenses of pebbles and boulders. The Paterson Formation on RUDALL commonly overlies a striated pavement which defines the shape of the Permian landsurface (Plate 2). The straight-sided northwest-trending valleys on RUDALL appear to be exhumed parts of this landsurface and in the Coolbro Creek area, a roche moutonnee structure was tentatively identified.

On RUNTON the Paterson Formation is subdivided into a glacial-lacustrine facies and a fluvio-glacial facies. The glacial-lacustrine facies consists of massive, very poorly sorted mudstone containing abundant dropstones ranging up to boulder size (Section A1, A2, A10, A12). The dropstones (Plate 3), some of which are faceted and striated (Plate 4), are composed of a wide variety of Precambrian rock types, granitoid rocks being most abundant. The fluvio-glacial facies is characterized by the presence of cross-bedded sandstone and mudstone which contains conglomerate clasts of a similar lithological range to the dropstones found in the glacial-lacustrine facies (Plate 5). Synsedimentary brecciation and slumping occur locally.

On RYAN the Paterson Formation overlies Precambrian rocks in the eastern part of the Sheet area and consists of both fluvio-glacial and glacial-lacustrine facies similar to the exposures on RUNTON. In the north-central part of the Officer Basin (MORRIS) the formation is not exposed, but a complete section does occur just south of the area in the Woolnough Hills Diapir on WARRI (see Jackson & van de Graaff, in prep.).

In the Ryan Buttes area (RYAN) the exposed rocks are tentatively assigned to the Paterson Formation following the practise of Jackson & van de Graaff (in prep.). There is no positive evidence of a glacial origin or a Permian age but the sequence does contain rock types similar to those found in the Paterson Formation elsewhere. The section (Section A3) consists mainly of fine to coarse-grained conglomeratic quartz arenite and quartz wacke. The lower part contains both small and large-scale

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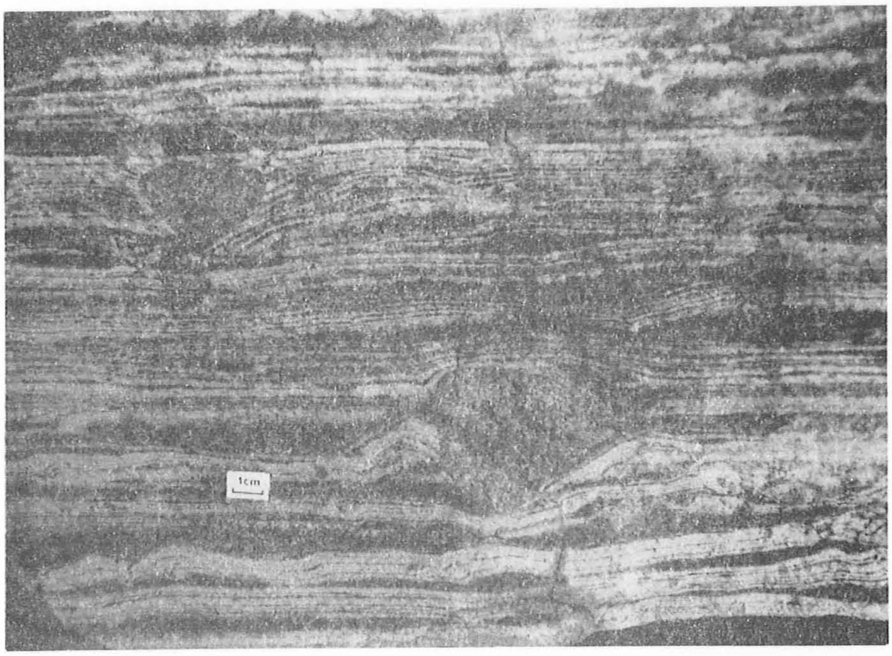


Plate 1: Graded sand and silt containing dropstones, interpreted as varves. Note depressed and penetrated laminae beneath the dropstones, Coolbro Creek, RUDALL. GSWA Negative

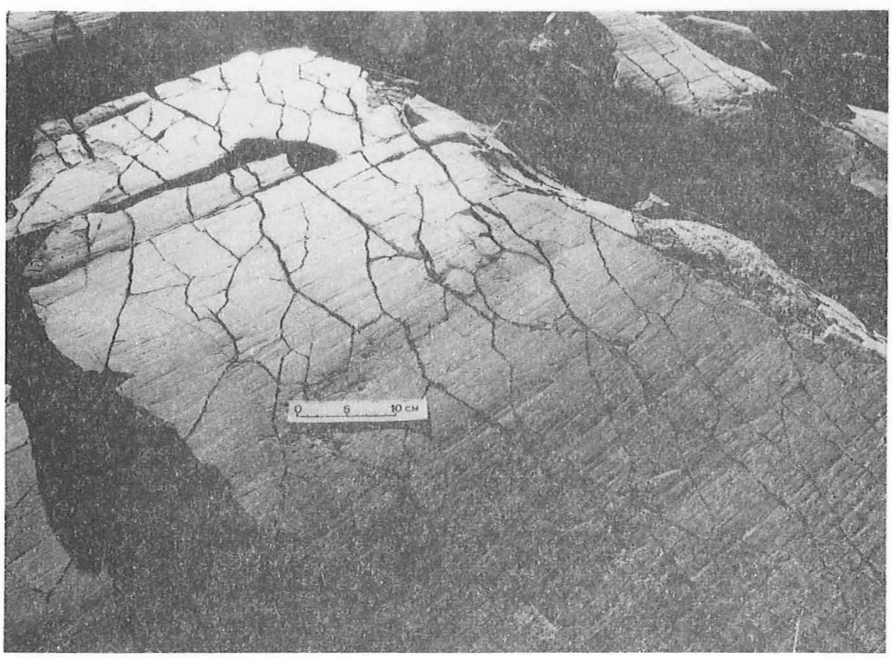


Plate 2: Striated pavement, RUDALL. GSWA Negative

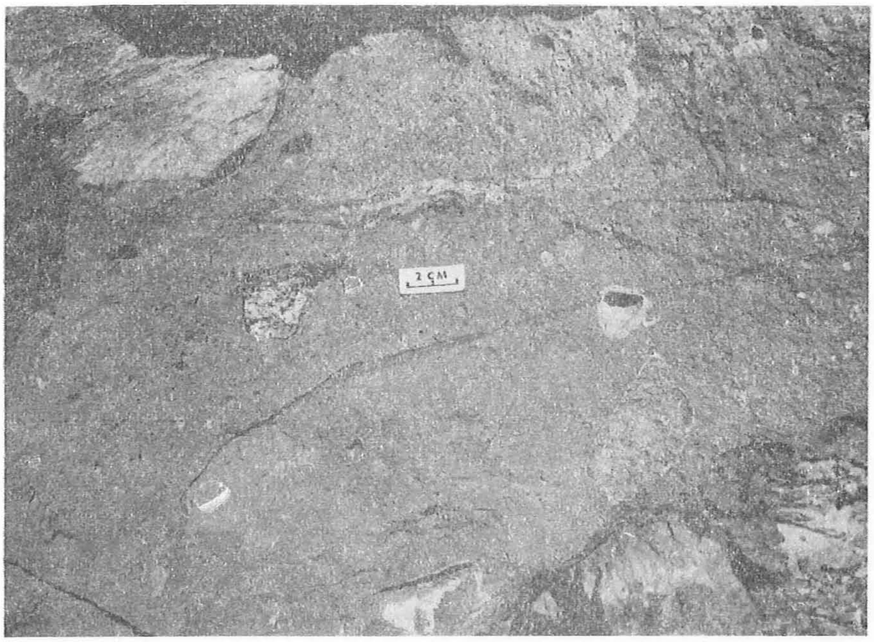


Plate 3: Weathered dropstones within poorly sorted massive mudstone, Paterson Formation, RUNTON. GSWA Negative.

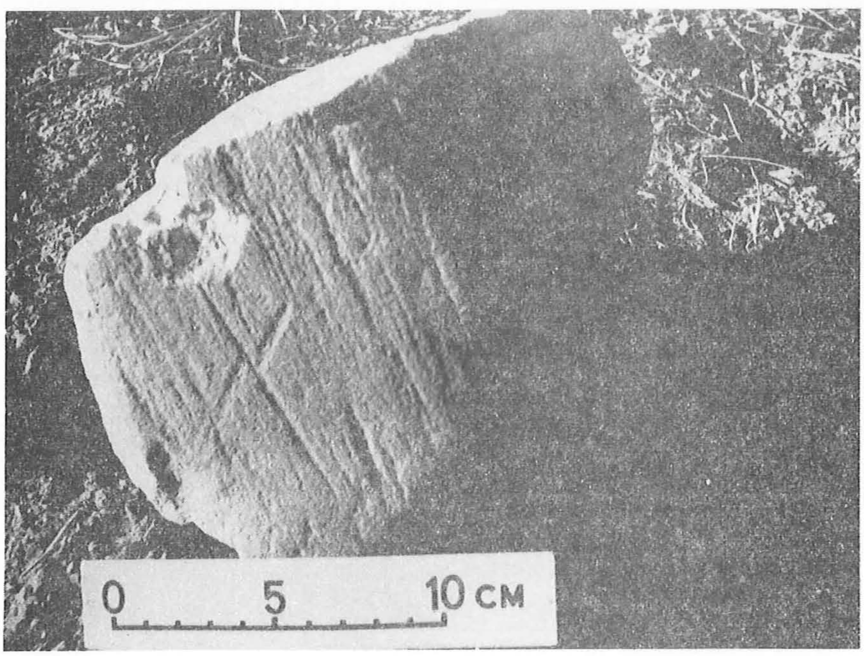


Plate 4: Striated boulder from the Paterson Formation in eastern RYAN. GSWA Negative.

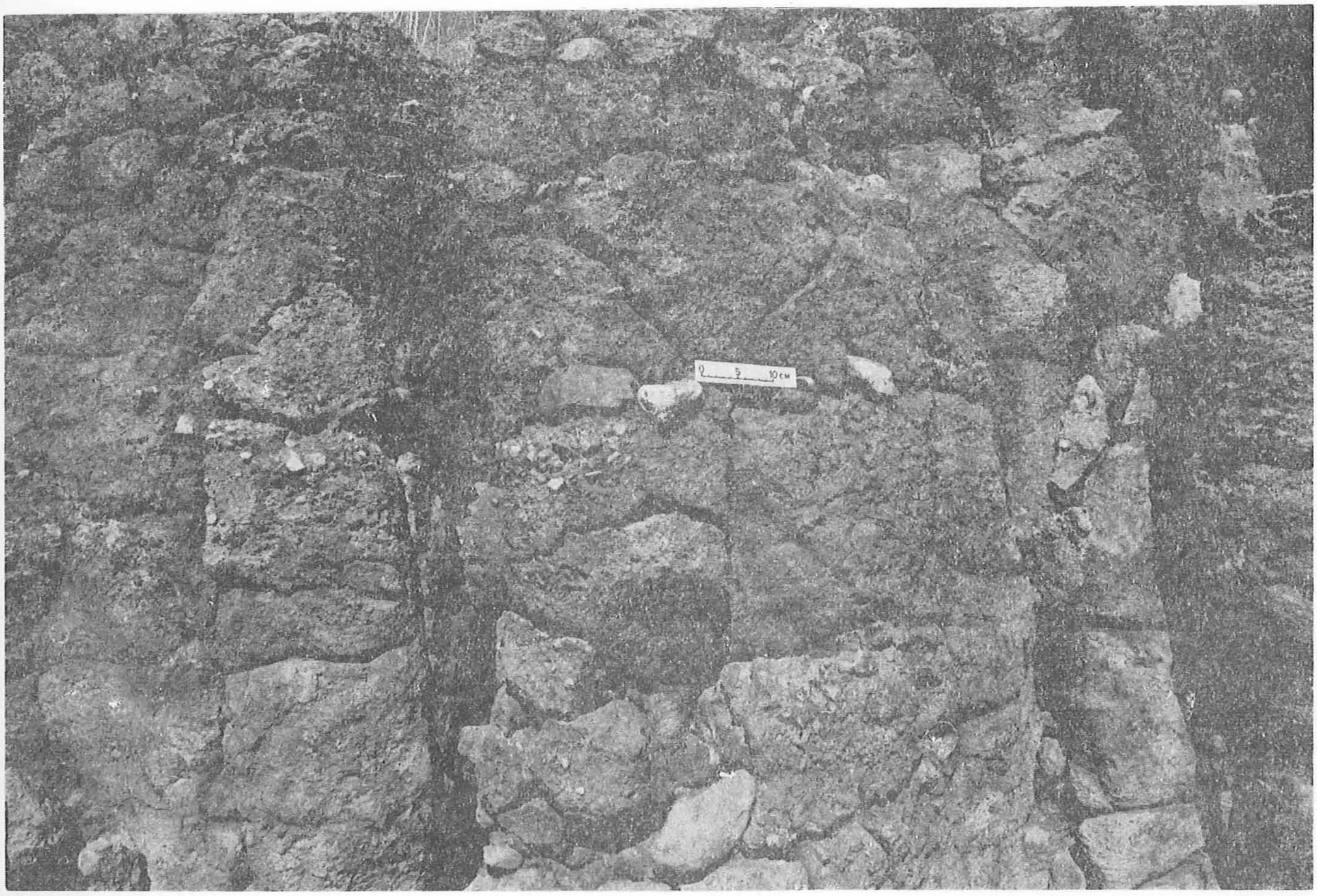


Plate 5: Very poorly bedded, fine to conglomerate sandstone from the upper part of Paterson Formation, RUDALL. GSWA Negative.

trough and planar cross-bedding with scour-and-fill structures and fining-up cycles about 5 m thick, the upper part comprises fine-grained quartz wacke with minor interbeds of granule conglomerate and abundant ripple cross-bedding and bioturbated beds. There is an overall upward decrease in grainsize and an increase in sorting.

In the Canning Basin, the tentatively identified Paterson Formation intersected in petroleum exploration wells consist of coarse to very coarse-grained sandstone and conglomerate with abundant granitic material. Smaller amounts of very fine-grained sandstone and mudstone also occur.

Thickness

The thickness of the Paterson Formation varies considerably as the unit occurs mainly as an infill of the valleys in the pre-existing landsurface. Sections on RUDALL are up to 75 m thick and in the Officer Basin the formation is 450 m thick just south of the area in Woolnough Hills Diapir. In the south Canning Basin the tentatively identified Paterson Formation in WAPET Kidson No. 1 well is 93 m thick between 1478 and 1571 m.

Stratigraphic relations

The Paterson Formation is a facies equivalent to parts of the Grant Formation (see Fig. 5). In the Canning Basin exposures it rests unconformably on Precambrian rocks and in the subsurface on Devonian and possibly other Early Palaeozoic sediments. The upper boundary with the Grant Formation is gradational and probably interfingering (see Fig. 5), and in the Officer Basin and on the southern margin of the Canning Basin the unit is unconformably overlain by Mesozoic rocks.

Fossils and age

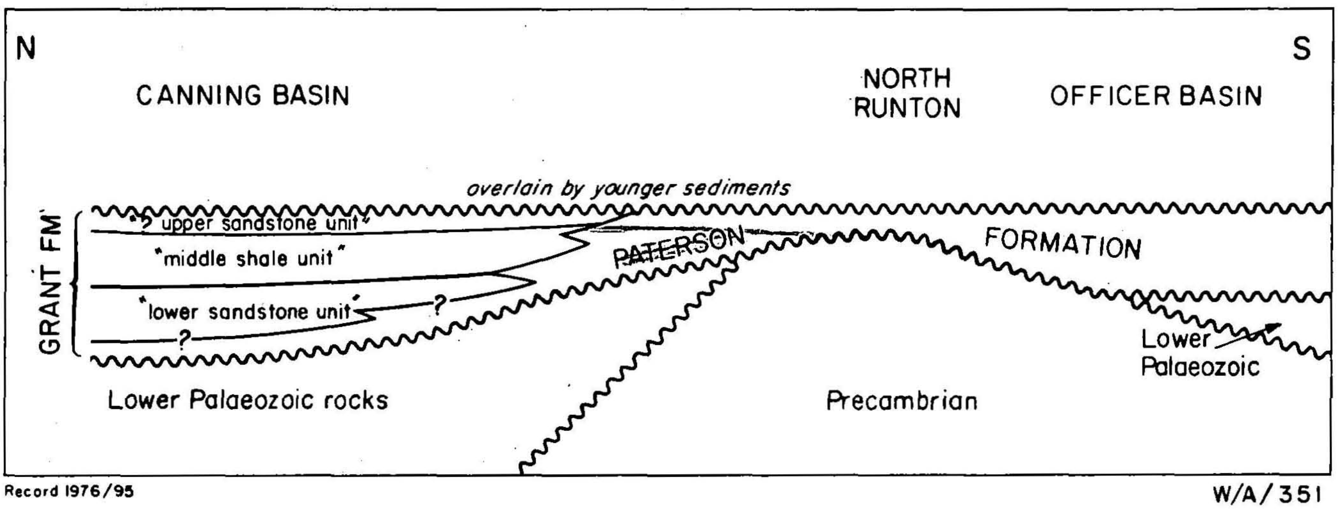
No age-diagnostic fossils are known from the Paterson Formation in the study area. To the south, in the Officer Basin, the unit is palynologically dated as Early Sakmarian (sensu stricto) by Kemp (1976). In the Canning Basin the formation has been intersected in coal-exploration bores in the Oakover River Valley (YARRIE & NULLAGINE) to the west of the area. In these bores it has been dated as Late Sakmarian (sensu lato) by J. Backhouse (writ. comm.), but the interval interpreted as Paterson Formation in WAPET Sahara No. 1 and WAPET Kidson No. 1 wells is probably of Early Sakmarian age (WAPET, 1966b, c) and this supports the diachronous relationship shown in Figure 5.

Environment of deposition

The Paterson Formation is interpreted as glacial in origin. It contains abundant dropstones, in some of which faceting and striation indicate their transport by ice. In places the sediment overlies a striated pavement which exhibits glacial geomorphic features.

In most exposures the dropstones are set in a massive mudstone matrix which indicates deposition from suspension in a standing body of water. Microfossil assemblages from the Officer Basin do not contain marine indicators so it is likely that the water-body was fresh. The interpretation of varves in the sequence (Jackson & van de Graaff, in prep.) supports this suggestion (see Kuenen, 1951), although time-equivalents of the formation in the Canning Basin are partly marine in origin.

In other outcrops, the formation is cross-bedded, and poorly sorted sandstone predominates over massive mudstone. In such exposures the depositional environment is interpreted as fluviatile.



Erosional contact —— Non-erosional contact

Fig 5 Relationships of Lower Permian Grant and Paterson Formations

See Canning Basin Report. Basin Studies Group - for an alternative interpretation

In summary, the environment of deposition of the Paterson Formation is interpreted as continental, with deposition taking place in rivers and lakes under the influence of glacial climate.

Grant Formation

The Grant Formation consists of a sequence of sandstone with a middle mudstone part. It is not present in the Officer Basin, and in the Canning Basin only one area of exposure has been identified.

Distribution and type locality

Crowe & Towner (1976) have described how the Grant Formation can be divided into an 'upper sandstone unit', a 'middle shale unit' and a 'lower sandstone unit' in the northern part of the basin. These units are identified in all of the petroleum exploration wells drilled in the area (Appendix B).

A sequence that underlies the Poole Sandstone in the Well 26-27 area (TABLETOP) is identified as Grant Formation and is correlated with the 'upper sandstone unit' and the 'middle shale unit' in WAPET Sahara No. 1 and WAPET Kidson No. 1 wells (WAPET, 1966b, c).

The type section of the Grant Formation was defined by Guppy et al. (1952) in the Grant Range (lat. $18^{o}02'$S, long. $124^{o}05'$E, MOUNT ANDERSON).

Lithology

The 'middle shale unit' of the Grant Formation as exposed in the Lake George area consists of laminated siltstone and claystone with minor very fine-grained sandstone. Many of the laminae are well graded and they are interpreted as glacially formed varves (Plate 6). This interpretation is supported by the rare presence of dropstones (boulder size) in the sequence. Near the top of this sequence sandstone becomes dominant and this upper part is tentatively correlated with the 'upper sandstone unit' of the northern part of the basin (Crowe & Towner, 1976).

The lithology and correlation of the sections between Well 26 and Well 27 is shown in Figure 6. This figure may be compared with Figure 46 of Veevers & Wells (1961) who did not differentiate the Cretaceous and Permian sediments in the Well 26-27 area.

The subsurface 'lower sandstone unit' consists mainly of fine to medium-grained sandstone with subsidiary interbeds of coarse-grained sandstone, mudstone and conglomerate. The conglomerate clasts include a wide variety of Precambrian rock types and may be glacially derived. The unit is calcareous and rarely pyritic, and in Aquitaine Wilson Cliffs No. 1 well it contains rare marine fossils (AAP, 1969c).

In the subsurface, the 'middle shale unit' consists mainly of sandy mudstone with minor argillaceous sandstone. It is commonly calcareous, micaceous and pyritic and the lower part is carbonaceous and contains coal. The unit contains rare pebbles and marine macrofossils in WAPET Sahara No. 1 well (WAPET, 1966b). In the subsurface, the 'upper sandstone unit' is dominantly fine to medium-grained sandstone with minor traces of mudstone and limestone. Pebbles are rare.

<u>Thickness</u>

The Grant Formation is 855 m thick in WAPET Kidson No. 1 well but thins towards the basin margin as it is 388 m thick in Aquitaine Wilson Cliffs No. 1 well and is probably less than 100 m thick between Wells 26 and 27.

Both 'lower sandstone unit' and the 'middle shale unit' are thickest in the Kidson Sub-basin, where they are 511 m and 264 m thick respectively in WAPET Kidson No. 1 well (WAPET,

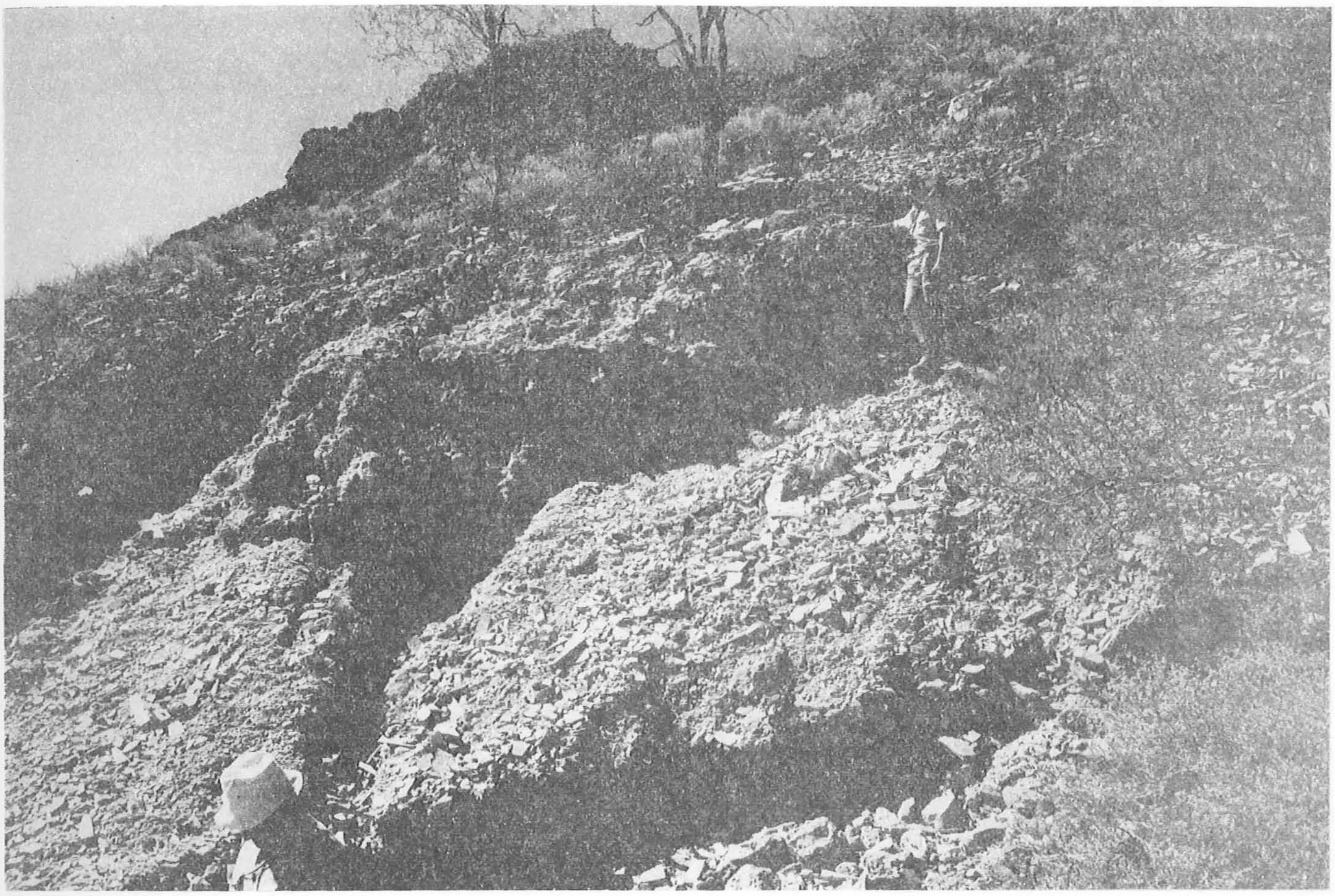


Plate 6: Exposures of fine-grained sandstone and siltstone (varves) of the Grant Formation near Well 26 on the Canning Stock Route, TABLETOP. GSWA Negative.

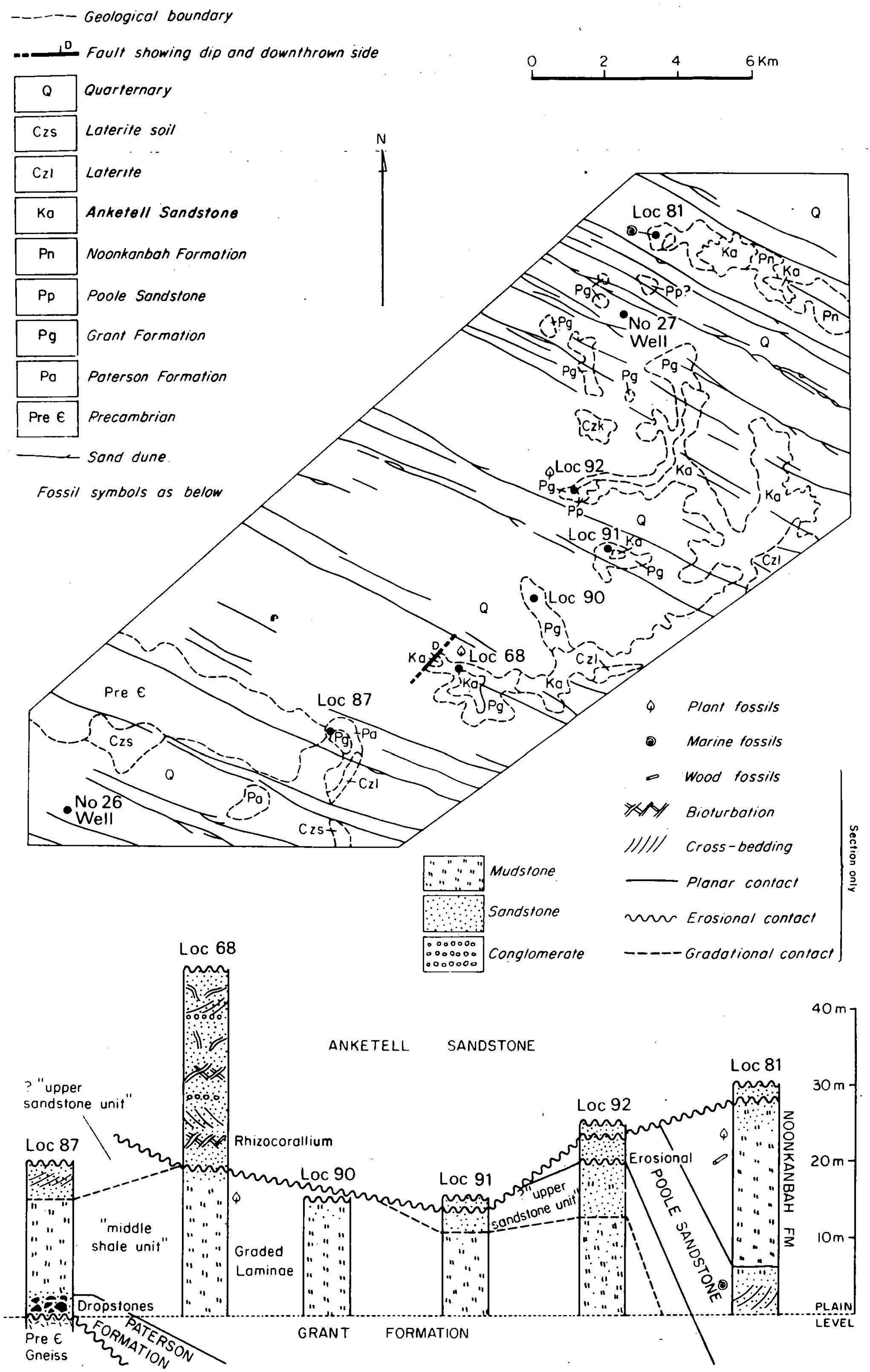


Fig 6 GEOLOGY OF WELL 26-27 AREA (TABLETOP)

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1966c). The 'upper sandstone unit' is thickest in the western part of the area, where it is 82 m thick in WAPET Sahara No. 1 well (WAPET, 1966b).

Stratigraphic relations

The Grant Formation is interpreted as conformably overlying and interfingering with the Paterson Formation, which in turn unconformably overlies older rocks. Figure 5 shows these relations. In places where the Paterson Formation is missing the Grant Formation lies unconformably on the Devonian Mellinjerie Limestone (eg. Aquitaine Wilson Cliffs No. 1; AAP, 1969c) and probably on other Early Palaeozoic rocks and on Precambrian basement.

In outcrop, the upper boundary of the Grant Formation is an erosional contact, and as no angular relationship could be seen, it is probably a disconformity. The Early Cretaceous Anketell Sandstone also overlies the Grant Formation unconformably.

WAPET (1966b, c) termed the 'lower sandstone unit' and the 'middle shale unit' the Cuncudgerie Sandstone and the Dora Shale respectively; however, as defined by Traves et al. (1956), the terms refer to younger units, which in this report are identified as the Poole Sandstone and Noonkanbah Formation respectively.

Fossils and age

No age-diagnostic fossils have been found in the Grant Formation in the area, but palynological determinations elsewhere indicate a Sakmarian age (WAPET, 1966b, c). Farther north and west of the area, the Grant Formation extends into the Late Carboniferous, but available evidence suggests it is entirely Permian in the study area. A specimen of Glossopteris found in the Well 26-27 area is consistent with this age. ?

Glossopteris extends into $\overline{R}$

Environment of deposition

Glacial varves are interpreted in the exposed Grant Formation ('middle shale unit') and they imply deposition from suspension in a quiet standing body of fresh water which was covered in part by ice. However, subsurface information indicates that parts of the sequence are of marine origin so the water-body was at times connected to the sea. Coal in the unit elsewhere suggests the presence of vegetation, which was rapidly covered by sediments. The topmost part of the exposed sequence ('upper sandstone unit') contains large-scale cross-bedding and is coarser-grained, indicating some bed-load deposition by currents.

The subsurface 'lower sandstone unit' is commonly slightly calcareous and contains marine fossils in Aquitaine Wilson Cliffs No. 1 Well (AAP, 1969c) which indicate that at least part of it was laid down in a marine environment. The interbeds of immature coarse-grained sediments suggest shallow-water deposition. The variety of Precambrian rock types in conglomerate intersected in the wells suggest a glacial origin as a similar variety is present in the underlying Paterson Formation.

In summary, the Grant Formation was probably initially laid down in a shallow-water glacial environment with some marine influence. Later, deposition took place in deeper, quiet water which was partly covered in ice and periodically connected to the sea.

Nomenclature

As mapping of the Canning Basin progresses, particularly in the northern part, it is proposed to formally define the subdivisions of the Grant Formation (Crowe & Towner, 1976). These units, the 'lower sandstone unit', the 'middle shale unit' and the 'upper sandstone unit', will be given formation status and the Grant Formation will be upgraded to group status.

Poole Sandstone

The Pwole Sandstone is confined to the Canning Basin. It overlies the Grant Formation disconformably and is overlain conformably by the Noonkanbah Formation.

Distribution and type locality

The Poole Sandstone (Wade, 1936; Guppy et al., 1952) was identified on the surface in only two parts of the area. The best exposures are at, and to the south of, Helen Hill (TABLETOP; Figure 6 and Section A4) but poor exposures also occur to the south of Scott Bluff (TABLETOP). The unit has been identified in all the petroleum exploration wells in the area but it is not present in the Officer Basin.

The type section of the Poole Sandstone is defined by Guppy et al. (1958) in the Grant Range (MOUNT ANDERSON, lat. 17°46'S, long. 125°51'E).

Lithology

In outcrop, the Poole Sandstone consists of fine to medium-grained feldspathic quartz and lithic wacke with intraformational clay-pellet conglomerate. The lower part of the unit is massive, but the upper part is thinly bedded and contains large and small-scale planar cross-bedding and scour-and-fill structures. Marine fossils occur in ferruginized siltstone concretions and in the intraformational conglomerate.

In the subsurface, the Poole Sandstone consists mainly of fine and very fine-grained sandstone which is interbedded with siltstone. It is partly calcareous and pyritic and the lower half contains lignite and coal seams in Aquitaine Wilson Cliffs No. 1 and WAPET Kidson No. 1 wells (AAP, 1969c; WAPET, 1966c). The basal part of the unit is also coarse to very coarse-grained in these wells.

Thickness

The Poole Sandstone thickens eastwards from 51 m in WAPET Sahara No. 1 to 116 m in WAPET Kidson No. 1 to 206 m in Aquitaine Wilson Cliffs No. 1. Near Helen Hill, it is estimated to be about 75 m thick.

Stratigraphic relations

The exposures of the Poole Sandstone in the area correlate with the Cuncudgerie Sandstone, which was defined by Traves et al. (1956) on PATERSON RANGE. However, the outcrops can also be correlated with the Poole Sandstone intersected in the petroleum exploration wells in the area, and since the term Poole Sandstone has precedence, the name Cuncudgerie Sandstone is dropped.

The lower boundary of the Poole Sandstone with the Grant Formation is exposed to the south of Helen Hill (see Figure 6) and is an erosional disconformity. The upper boundary with the Noonkanbah Formation is planar and conformable.

Fossils and age

Pelecypods and brachiopods present in the Poole Sandstone in the area are listed in Appendix C.

The fossils are similar to those found in the Nura Nura Member of the Poole Sandstone which occurs in the northern part of the Canning Basin. An Artinskian age is indicated by these species and this agrees with the palynological date obtained from the unit in WAPET Kidson No. 1 well (WAPET, 1966c).

Environment of deposition

The fossils found in the Poole Sandstone indicate that it is marine. The massive, well-sorted nature of the sandstone that occurs at the base of the unit is typical of sediments laid down in a near-shore environment where wave action causes a high degree of winnowing. The presence of coal in the lower part of the unit also suggests near-shore conditions.

2° deposit?

In the upper part of the unit there are intraformational conglomerate lenses at the base of sets of cross-strata. These sequences are interpreted as current deposits possibly laid down in channels. Such deposits are commonly found in deeper water of the tidal and subtidal zones.

We, therefore, tentatively interpret the Poole Sandstone as a transgrassive sequence laid down in the area as the sea covered the post-Grant Formation landsurface.

Noonkanbah Formation

The Noonkanbah Formation consists of poorly bedded mudstone and laminated to thin-bedded quartz wacke. It is marine in origin and does not extend into the Officer Basin.

Distribution and type locality

The type section of the Noonkanbah Formation (Wade, 1936; Guppy et al., 1952) is defined by Guppy et al. (1958) near Bruten Hill (lat. 18°41'S, long. 125°38'E, NOONKANBAH) in the northern part of the basin.

In the study area the Noonkanbah Formation is identified in all the petroleum exploration wells, and it crops out at Helen Hill and Scott Bluff (TABLETOP) and low ridges and mounds east of Wilson Cliffs (WILSON). It is also exposed in small cliffs on the eastern margin of Lake Dora (PATERSON RANGE), just outside the area.

Lithology

The best exposure of the Noonkanbah Formation is at Helen Hill. This section is believed to be almost complete (Section A4) and consists of poorly bedded and laminated brown mudstone (white where leached) which contains poorly preserved fragmental plant remains. At Scott Bluff, the Noonkanbah Formation is carbonaceous near the lake level and passes gradationally up into Triwhite Sandstone. In east WILSON, the formation consists of deeply weathered laminated to thin-bedded micaceous lithic and quartz wacke.

In the subsurface, the Noonkanbah Formation is mainly siltstone with minor sandstone interbeds. In the east lignite is common (AAP, 1969c) and elsewhere it is carbonaceous and partly calcareous, pyritized and glauconitic. In WAPET Kidson No. 1 well minor dolomite is also recorded (WAPET, 1966c).

Thickness

The thickest recorded section of Noonkanbah Formation in the area is in WAPET Kidson No. 1, where it is 310 m thick. The unit thins to the east and is 192 m in Aquitaine Wilson Cliffs No. 1; it also thins southward towards the basin margin as the almost-complete section at Helen Hill is only 30 m thick. In WAPET Sahara No. 1, the formation is 228 m thick, but the section is not complete.

Stratigraphic relations

Exposures of the Noonkanbah Formation in the area were previously defined as Dora Shale (Traves et al., 1956). However, the outcrops can be correlated with the Noonkanbah Formation intersected in the petroleum exploration wells and so the name Dora Shale is dropped. The sections encountered in the wells are identified on the basis of their lithology, electric-log character, stratigraphic relations, and age.

The boundary of the Noonkanbah Formation with the underlying Poole Sandstone is a sharp, planar conformable contact. It is well exposed at the base of Helen Hill (Section A4). The upper contact with the overlying Triwhite Sandstone is gradational and is placed where sandstone predominates over mudstone. This latter boundary is exposed at Scott Bluff and about half way up the section exposed on the eastern side of Lake Dora (Section A5), just outside the area (PATERSON RANGE).

Fossils and age

Crespin (in Traves et al., 1956) assigned a Permian age to the species of foraminifera collected from the Noonkanbah Formation at the northern end of Lake Dora (PATERSON RANGE).

In WAPET Kidson No. 1 well, the Noonkanbah Formation has been dated by palynology as Artinskian (WAPET, 1966c). In Aquitaine Wilson Cliffs No. 1 well, marine macrofossils are common in the unit.

Koop (1966a) recorded marine macrofossils from the Dora Shale (Noonkanbah Formation) at Scott Bluff, but the species identified indicated a correlation with the Nura Nura Member of the Poole Sandstone. At that time (1966) the Poole Sandstone was not known to occur in the Scott Bluff area and it is likely that Koop's locality was to the south of Scott Bluff in the area where the Poole Sandstone is now mapped.

Environment of deposition

The presence of marine fossils in the Noonkanbah Formation indicates that it is marine in origin. The absence of sandstone over most of the area and well-defined bedding planes in the sequence suggest continuous deposition in a quiet standing body of water. This is supported by the association of pyrite and carbonaceous matter in the sequence which indicate reducing, anaerobic conditions. Such conditions can only be maintained in 'the absence of turbulence or current activity, a low rate of deposition, and almost no reworking of sediment (Reineck & Singh, 1973). The abundance of sandstone in the formation in the far eastern part of the area may be due to near-shore conditions.

The environment of deposition is thus envisaged as an extensive shallow sea where deposition took place, below wave base, under mainly reducing conditions, and where there was little influx of terrigeneous material except in the east.

Triwhite Sandstone

The Triwhite Sandstone consists mainly of thin to medium-bedded quartz wacke interbedded with thin-bedded siltstone and shale. It is Early Permian in age and is marine in origin.

Distribution and type locality

Outcrops of the Triwhite Sandstone (Traves et al., 1956) are known only on TABLETOP, SAHARA and PERCIVAL, but it is probably present in the subsurface to the south and east of here. The type section is 1.6 km east of Dunn Soak (northwest TABLETOP). The unit appears to be restricted to the Kidson Sub-basin (see Fig. 9).

The best exposures are at Scott Bluff, Triwhite Hills and other unnamed mesas east of Lake Dora (TABLETOP). Good exposures are also present along parts of Percival Lakes (PERCIVAL) where an ancient drainage system has incised below the base of the overlying Mesozoic rocks.

Lithology

The Triwhite Sandstone is dominantly fine to medium-grained quartz wacke and quartz arenite interbedded with siltstone, shale and intraformational claystone conglomerate (Sections A6, A7, A8, A9). The sandstone is moderately to well sorted and laminated to medium-bedded. Planar cross-bedding commonly with horizontally stratified top-sets occurs, and thinner-bedded parts contain lenticular and wavy bedding. Ripple cross-lamination is present (Plate 7).

The siltstone and shale is laminated to thin-bedded with wavy laminations in places, but the shales are mainly planar laminated.

A minor, but characteristic, lithology of the Triwhite Sandstone is intraformational claystone conglomerate which occurs in beds up to 5 cm thick. These are commonly fossiliferous and contain ferruginous concretions; the claystone fragments, being platy and poorly rounded, define imbrication and indicate current deposition.

Thickness

No complete section of the Triwhite Sandstone is exposed (Sections A6, A7). In WAPET Kidson No. 1 well, it is 77.2 m thick (WAPET, 1966c) which is probably close to its maximum thickness. The unit probably thins towards the southern margin of the Canning Basin.

Stratigraphic relations

The Triwhite Sandstone is conformable on the Noonkanbah Formation and is unconformably overlain by the Lake George Beds, Callawa Formation and Anketell Sandstone. Its base is gradational in northwest TABLETOP; the actual contact is chosen where sandstone predominates over mudstone and siltstone of the Noonkanbah Formation (Section A5).

Lithologically, the Triwhite Sandstone is similar to the Lightjack Formation exposed in the Fitzroy Trough in the northern part of the basin, but since continuity between these two units has not been proved the name Triwhite Sandstone is retained.

Fossils and age

A fauna including pelecypods, brachiopods, gastropods, shark teeth and trace fossils (Plate 8, 9) was found at several localities in TABLETOP and at Shoesmith Cliffs, PERCIVAL (Appendix C). Rare wood fragments are also present. The fossils indicate an Early Permian age and suggest that the Triwhite Sandstone is a time-equivalent of the Lightjack or Noonkanbah Formations exposed in the Fitzroy Trough to the north.

Environment of deposition

The gradual upward increase in grainsize from mudstone of the Noonkanbah Formation to sandstone of the Triwhite Sandstone suggests regressive conditions. In the Triwhite Sandstone, shallow-water conditions are indicated by channel deposits (cross-bedding, intraformational conglomerate) interbedded with suspension deposits (shale and mudstone units). Wavy and lenticular bedding is also characteristic of shallow-water marine conditions.

LATE TRIASSIC? TO EARLY CRETACEOUS

Most of the study area is underlain by Late Triassic to Early Cretaceous rocks, and there has been confusion about the nomenclature of this sequence (cf. Traves et al., 1956; Veevers & Wells, 1961; Playford et al., 1975). We believe the reason for this confusion is that the described units define diachronous facies. Figure 7 shows our interpretation of the stratigraphic relations of the units involved.

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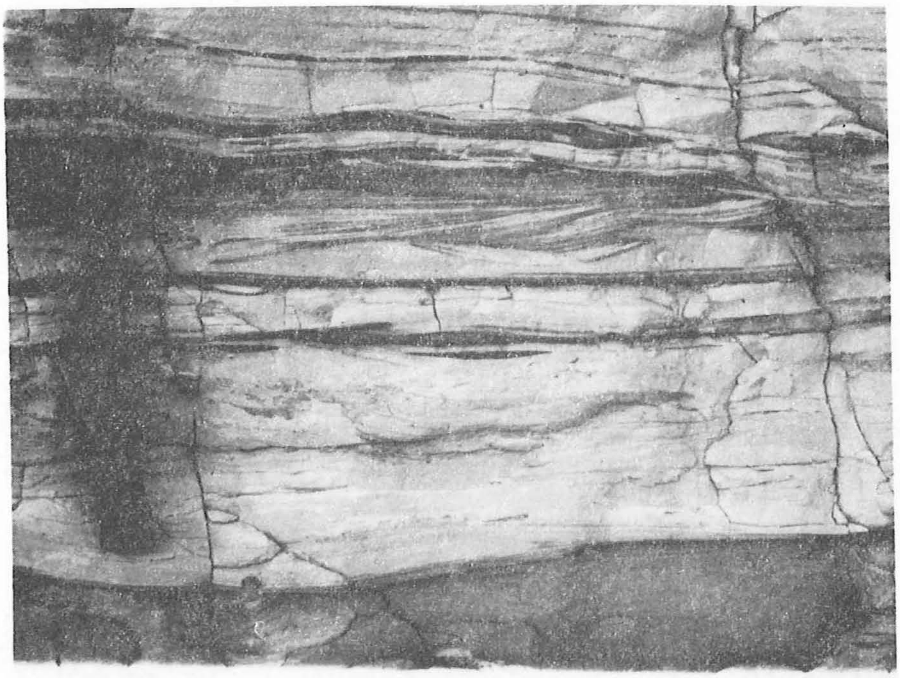

Plate 7: Ripple cross-laminated fine-grained quartz sandstone and micaceous siltstone of the Triwhite Sandstone near Scott Bluff, TABLETOP. BMR Negative GB/1080

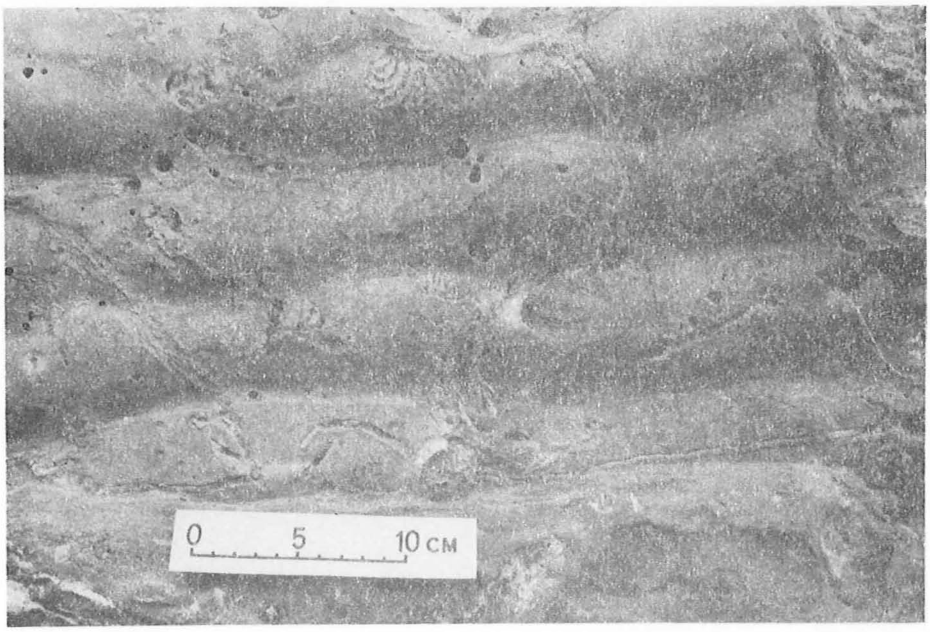

Plate 8: Trace fossils on ripple marked surfaces of the Triwhite Sandstone, Shoesmith Cliffs on edge of Percival Lakes, PERCIVAL. GSWA Negative

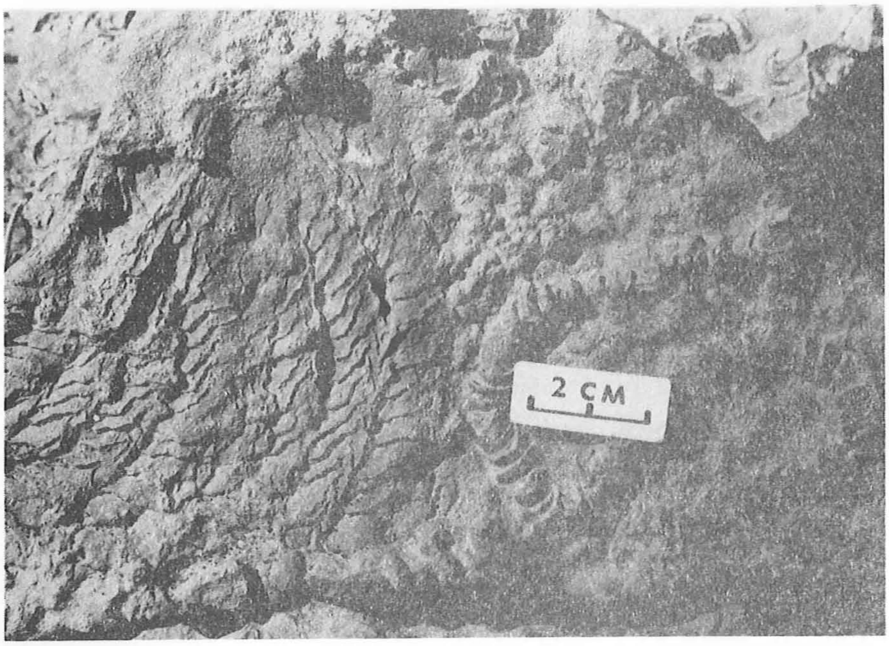

Plate 9: Trace fossils (?Zoophyeus) from the Triwhite Sandstone, TABLETOP. GSWA Negative.

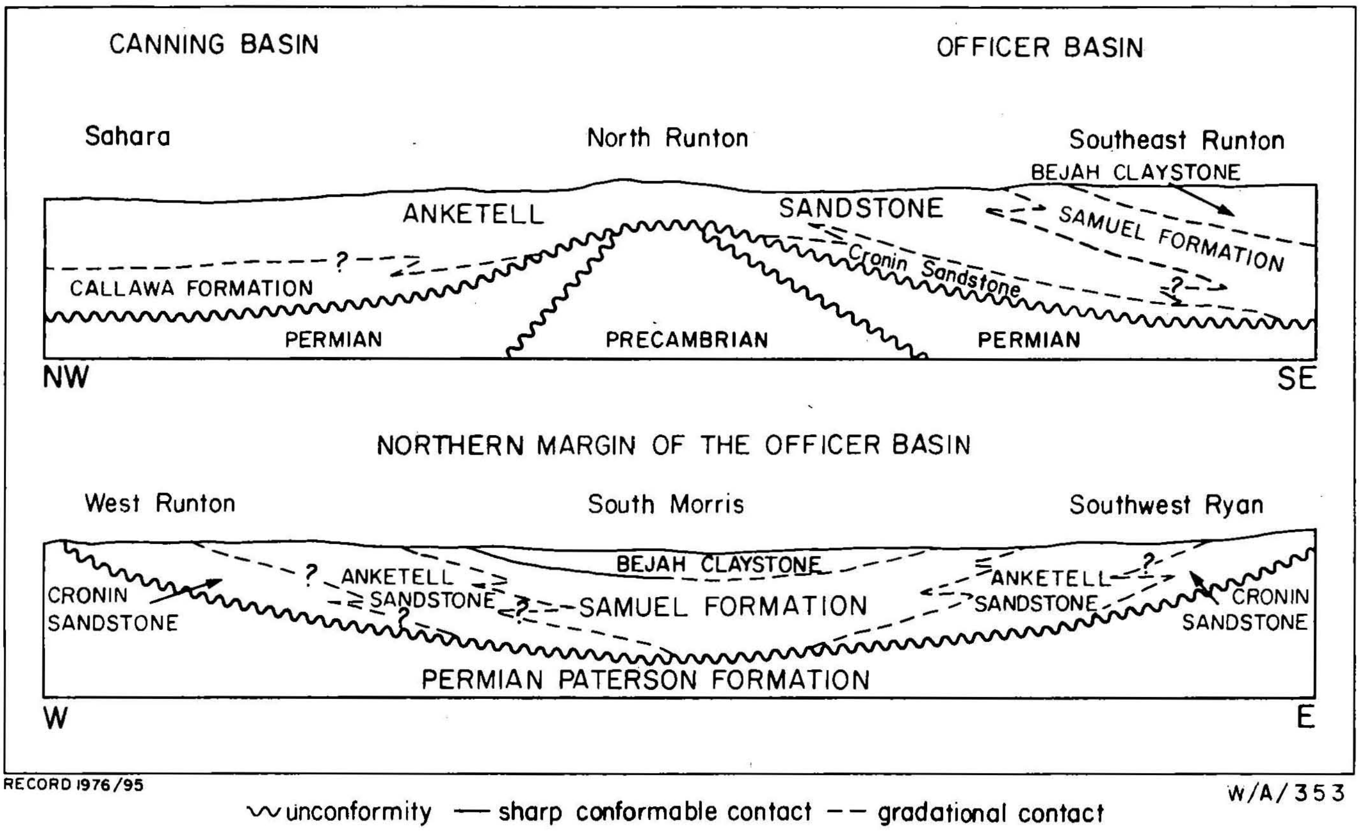

Fig 7 Schematic sections showing relationships of Mesozoic units in south Canning Basin and north Officer Basin

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Following the suggestion of Playford et al. (1975), the term Anketell Sandstone is retained as originally defined by Traves et al. (1956). The term Kidson Beds (Veevers & Wells, 1961) is not used, and all the areas shown as Kidson Beds on Veevers & Well's map are assigned to the Anketell Sandstone. On TABLETOP and PERCIVAL the exposures shown as Mesozoic undifferentiated by Veevers & Wells are now assigned to the Callawa Formation (Traves et al., 1956), and the Cronin Sandstone (Veevers & Wells, 1961) is extended throughout RUNTON in the northern Officer Basin. The marine Samuel Formation and Bejah Claystone (Lowry et al., 1972) are both recognized in the southern part of the study area.

Callawa Formation

The Callawa Formation is the lowermost Mesozoic unit in the Canning Basin part of the area. In consists of cross-bedded conglomerate, sandstone and mudstone, and is interpreted as fluviatile in origin.

Distribution and type locality

The Callawa Formation was defined by Traves et al. (1956) and the type section is in the Callawa Hills (lat. 20°23'S, long. 120°36'E), outside the area mapped. The formation is identified in the Canning Basin part of the area on TABLETOP, SAHARA, PERCIVAL, and WILSON. The unit has not been differentiated from the overlying Anketell Sandstone in the petroleum exploration wells in the area.

Lithology

The Callawa Formation is lithologically heterogeneous and consists mainly of conglomeratic, coarse to very coarse-grained quartz wacke interbedded with fine-grained feldspathic and quartz wacke and mudstone. It is extensively cross-bedded with individual large-scale trough-shaped sets mostly less than 50 cm thick. Cosets are 3 to 5 m thick and have conglom-

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eratic erosional bases and pass gradationally up into small-scale cross-bedded (Kappa type of Allen, 1963) sandstone which in turn passes gradationally into laminated mudstone. These sequences are repeated vertically.

Exposures of the formation are ferruginized and this gives them a dark tone on the airphotos. The formation is best exposed along the flanks of the north-trending depression which contains Lake Auld, particularly at its northern end. It is also well exposed at King Hill and Thring Rock.

Thickness

No complete section of the Callawa Formation is exposed and it has not been recognized in the subsurface. We estimate an approximate thickness of 100 m for the unit, based on topographic evidence. In the northern part of the area (SAHARA) it may be thicker.

Stratigraphic relations

The lower boundary of the Callawa Formation with Permian rocks is an unconformity and is exposed at lat. 22°23'S, long. 123°44'E (TABLETOP). The upper boundary of the coarser-grained Callawa Formation with the overlying finer-grained Anketell Sandstone is gradational and is exposed beside the road 19 km west of the type section of the Anketell Sandstone (TABLETOP). This upper gradational boundary between the formations is probably diachronous and the units may interfinger in places (e.g. southern PERCIVAL).

The Callawa Formation is probably, at least in part, equivalent to the Cronin Sandstone that occurs in the northern Officer Basin. However, available evidence indicates that the two units may be of slightly different ages and it cannot be shown that they were ever continuous. Consequently it is preferred, at this stage, to retain the two separate units.

Fossils and age

No age-diagnostic fossils were collected from the Callawa Formation in the study area. However, outside the area, the unit has yielded plant fossils which Brunnschweiler (in Traves et al., 1956) regarded as Early Jurassic or Late Triassic in age. White (in Veevers & Wells, 1961) re-examined the collections and believes the forms are Late Jurassic or Early Cretaceous.

Environment of deposition

The fining-up cyclic nature of the Callawa Formation and the associated cross-bedding types indicate meandering-channel deposition. The poorly sorted, heterogenous nature of the unit suggests continental deposition and the presence of well-preserved plant fossils in the unit supports this suggestion. The formation is therefore thought to be fluviatile in origin.

Cronin Sandstone

The Cronin Sandstone is similar to, and may be laterally equivalent to, parts of the Anketell Sandstone. It is the oldest Mesozoic unit in the Officer Basin part of the area and may correlate with the Callawa Formation in the Canning Basin.

Distribution and type locality

The Cronin Sandstone (Veevers & Wells, 1961) was previously only identified around the Cronin Hills (RUNTON) but is now traced over most of RUNTON. The type section is at the eastern end of the Cronin Hills (lat. 23°18'S, long. 123°21'E).

Lithology

At its type section (Section A10), the Cronin Sandstone consists of a lower part of bioturbated fine and very fine-grained quartz wacke with minor mudstone and pebble conglomerate, and an upper part of medium to coarse-grained quartz wacke which is cross-bedded and moderately sorted. The lower part contains mainly small-scale ripple cross-bedding with some large-scale planar cross-bedding, whereas the upper part contains large-scale trough cross-bedding. This sequence is similar to exposures of Anketell Sandstone on northern RUNTON, and the position of the boundary between the two units is therefore tentative (Fig. 3).

Two small hills to the west of Bejah Hill (southeast RUNTON) are also identified as Cronin Sandstone on lithological grounds. In these exposures the bedding is partly destroyed by bioturbation but is probably also cross-bedded (Section A11).

Thickness

Only 24 m of Cronin Sandstone is preserved above the Paterson Formation at Cronin Hills (Section A10). The unit may thicken southeast of there but probably does not exceed 100 m. In southeast RUNTON the formation gradually thins to the south and it is not present at Woolnough Diapir on adjoining WARRI (van de Graaff, 1975).

Stratigraphic relations

The Cronin Sandstone lies unconformably on the Paterson Formation at Cronin Hills and at other exposures to the south and southeast. The unconformity surface appears fairly flat, but absence of bedding in the Paterson Formation makes it difficult to detect any angular relationship. The upper boundary of the Cronin Sandstone is more problematical. The lithological similarity of the unit to the Anketell Sandstone suggests a gradational boundary which may or may not be diachronous. Available age data on the two formations suggests they are chronologically distinct, and it is on this basis that the Anketell Sandstone is thought to overlie the Cronin Sandstone.

In southeast RUNTON the Cronin Sandstone is overlain by the Samuel Formation (Fig. 7) but the contact, near Bejah Hill, is not exposed.

The Cronin Sandstone is probably partly equivalent to the Callawa Formation of the Canning Basin, but as explained above we prefer to retain the two as separate formations.

Fossils and age

The Cronin Sandstone contains well-preserved fossil leaves including *Taeniopteris*, *Elatocladus*, and *Ptilophyllum* which White (*in* Veevers & Wells, 1961) regards as Late Triassic or Jurassic in age. Thus, according to White, the Cronin Sandstone could be older than Callawa Formation (Late Jurassic or Early Cretaceous). Therefore, a re-examination of the collection from Cronin Hills is desirable in order to clarify the above problem.

Environment of deposition

The cross-bedded, poorly sorted nature of the sediment and the presence of well-preserved plant fossils in the Cronin Sandstone suggest that it was laid down in a continental environment, possibly fluvial.

CRETACEOUS

Anketell Sandstone

The Anketell Sandstone (Traves et al., 1956) is a sequence of alternating fine and coarse-grained quartz wacke interbedded with mudstone and conglomerate. It now includes the Kidson Beds of Veevers & Wells (1961), so this latter name is dropped, in accordance with the Australian Code of Stratigraphic Nomenclature.

Distribution and type locality

The Anketell Sandstone (Traves et al., 1956) is present throughout the area. The best exposures of it are in mesas along the edge of an eroded plateau in northwest URAL, southeast SAHARA, southwest and southeast PERCIVAL and eastern TABLETOP. The best section is at Kidson Bluff, URAL (Section A13), and we propose that this be a reference section for the Anketell Sandstone. The type section is at a hill 25.7 km east of Lake Auld at lat. 22°08', long. 124°20'E (northeast TABLETOP). The Anketell Sandstone has not been differentiated from other Mesozoic units in the subsurface.

Lithology

The Anketell Sandstone consists of siltstone and fine-grained quartz wacke interbedded with coarse-grained quartz wacke and granule and pebble conglomerate. The Anketell Sandstone is thinner-bedded, finer-grained and less cross-bedded than the Callawa Formation (Sections A13, A14, A15).

The formation is laminated to thin-bedded with interbedded lenticular units of poorly sorted, coarse-grained quartz wacke and granule and pebble conglomerate. Intraformational claystone clasts also occur. Within these beds, high-angle planar cross-bedding is present, grading upwards into ripple cross-bedding. The contacts between the coarse and fine-grained parts of the sequence are sharp.

The fine-grained units, in contrast, are mainly parallel laminated. Some have wavy lamination. Scour-and-fill contacts are present where these beds are overlain by coarse units with intraformational claystone conglomerate present at the base of the coarse units.

The Anketell Sandstone is bioturbated in places, and contains some small-scale slump structures.

Thickness

No complete sections are known. The thickest measured section is 30 m at Kidson Bluff (Section A13, URAL). The unit is probably no thicker than 100 m.

Stratigraphic relations

The Anketell Sandstone lies conformably on the Callawa Formation, and in many places the contact is gradational. The Anketell Sandstone is interpreted as being laterally equivalent to the Samuel Formation in the southern part of the area where both units are horizontally bedded and occur at the same topographic level, and where one appears to grade into the other.

The Anketell Sandstone in places overlaps the Callawa Formation and lies unconformably on Permian and Precambrian rocks. The unit is also unconformably overlain by the Lake George Beds, and is capped by Cainozoic laterite.

Fossils and age

The only known fossils in the unit are foraminifera (Traves et al., 1956), rare wood fragments, and trace fossils which include the burrow Rhizocorallium. Bioturbation is also abundant. The Anketell Sandstone was thought to be Early Cretaceous on the basis of Rhizocorallium (Traves et al., 1956; Veevers, 1962), but this fossil is no longer considered a Early Cretaceous index fossil (Hantzschel, 1962). However, foraminifera collected from the units in ANKETELL indicate an Early Cretaceous age (Crespin in Traves et al., 1956) which is consistent with the interpretation that the Anketell Sandstone is laterally equivalent to the Samuel Formation, also of Early Cretaceous (Aptian) age (Appendix D).

Environment of deposition

The Anketell Sandstone appears to be transitional between the Callawa Formation to the north and the Samuel Formation to the south. The Callawa Formation is interpreted as a fluviatile deposit and the Samuel Formation is marine. Foraminifera found in the Anketell Sandstone indicate marine or brackish-water conditions (Crespin, in Traves et al., 1956). Rhizocorallium is also commonly associated with brackish environments.

The occurrence of trough and planar cross-bedded, fining-upwards cycles in the formation indicates deposition in channels, particularly near the base of the unit (Sections A2, A13, A15). Abundant flaser-bedded sandstone units (Section A2, A13) are commonly formed in a tidal environment where alternating periods of strong current activity and slack water allow preservation of flasers. The extensive bioturbation in the formation (Sections A2, A13) probably reflects a slow rate of deposition.

In summary, the sedimentological and palaeontological evidence suggests that the Anketell Sandstone was deposited under brackish-water conditions, probably in a nearshore environment.

Samuel Formation

The fossiliferous, marine Samuel Formation consists of fine-grained sandstone and mudstone, with minor glauconite. It is of Aptian age.

Distribution and type locality

The Samuel Formation (Lowry et al., 1972) occurs in southeastern RUNTON, western RYAN and most of MORRIS. The type section is at Mount Charles (lat. 25°45'S, long. 126°11'E, BENTLEY) to the south of the area where the unit is widespread (Jackson & van de Graaff, in prep.). The best exposures of the formation in the area are in the breakaways on eastern MORRIS and on southeastern RUNTON and at Traeger Hills and other more isolated hills on MORRIS.

Lithology

Typically the Samuel Formation consists of thin-bedded, fine and very fine-grained quartz and feldspathic wacke interbedded with mudstone. Ripple cross-bedding and bio-turbation are common, and the unit characteristically weathers yellow or brown. A few lenses of coarse-grained quartz wacke occur, and the unit contains glauconite.

Thickness

The thickest measured section of the Samuel Formation is 14.5 m (Section A16) but is incomplete. The formation is thought to be 30 m thick at Bejah Hill but it may be thicker to the east.

Stratigraphic relations

At lat. 23°54'15"S, long. 125°52'35"E about 10 m of fine-grained quartz wacke and mudstone, identified as Samuel Formation, overlies very coarse-grained, moderately to poorly sorted quartz wacke with angular grains which is assigned to the Anketell Sandstone (see also Veevers & Wells, 1961). The contact between these two units is gradational. The Samuel Formation is also interpreted as being laterally facies equiv-alent to the Anketell Sandstone in northern MORRIS and these relationships are shown in Figure 7.

The upper boundary of the Samuel Formation with the Bejah Claystone is essentially conformable, but it is locally erosional (Section A16) and is probably diachronous. The Lampe Beds unconformably overlie the Samuel Formation, and the formation has a well developed laterite profile in most areas.

Fossils and age

Fossils in the Samuel Formation include pelecypods and gastropods (Appendix D). They indicate an Early Cretaceous (Aptian) age which agrees with palynological evidence to the south of the area (Kemp, 1976).

The Samuel Formation is probably a time-equivalent of the Anketell Sandstone and may be partly equivalent to the Callawa Formation and the Cronin Sandstone.

Environment of deposition

Marine fossils and glauconite indicate deposition in a marine environment. The interbedding of sandstone and mudstone and the presence of ripple marks suggest that deposition took place in a shallow sea, but the absence of large-scale cross-bedding probably indicates that deposition was subtidal. The Anketell Sandstone is interpreted as a nearshore facies of the sea that deposited the Samuel Formation (and the Bejah Claystone). The Early Cretaceous sea in which these sediments were laid down, was connected to the oceans along the south coast of the Australian continent (Jackson & van de Graaff, in prep.), and there is no evidence to suggest that it was connected to the Indian Ocean via the Canning Basin. However, the sea did extend into the southern Canning Basin, indicating that the Warri Gravity Ridge area (the boundary between the two basins) was not a raised topographic high during the Early Cretaceous.

Bejah Claystone

The marine Bejah Claystone consists almost entirely of claystone, with only minor siltstone and sandstone. It is of Aptian-Albian age.

Distribution and type locality

The Bejah Claystone (Veevers & Wells, 1961; Lowry et al., 1972) occurs in southeast RUNTON and MORRIS and at the Traeger Hills. It is widespread in the Officer Basin, south of the area (Jackson et al., 1975). The type section is at Bejah Hill (lat. 23°46'S, long. 124°08'E, RUNTON) but we believe that the lower part of the Bejah Hill section is Samuel Formation and only the upper 3-4 m can be confidently assigned to the Bejah Claystone.

Lithology

The Bejah Claystone is almost entirely composed of claystone, with only minor amounts of siltstone and rare thin laminae of very fine-grained sandstone. At Bejah Hill, there is an apparently coarse-grained bed, but examination with a hand lens shows that the 'grains' are in fact mostly weathered-out radiolaria with a siliceous cement.

The formation is normally massive to poorly bedded and no sedimentary structures were discernible; however, in places mottled weathering patterns may indicate bioturbation.

At Section A16 the base of the Bejah Claystone is marked by a porcellanized clay pellet conglomerate, but elsewhere it appears gradational (Jackson et al., 1975).

Thickness

The Bejah Claystone is not more than 4 m thick at its type section but it may be as much as 10 m thick at the Traeger Hills. MORRIS.

Stratigraphic relations

The Bejah Claystone lies essentially conformably on the Samuel Formation although the boundary is locally erosional. The formation is unconformably overlain by the Lampe Beds and it is lateritized.

Fossils and age

The radiolaria *Lithocyclia exilis* and *Cenosphaera* sp. have been found in the Bejah Claystone in the area and they indicate an Albian age (Crespin *in* Veevers & Wells, 1961). Outside the area the unit contains pelecypods which Skwarko (1967) believes indicate an Aptian age.

The lower boundary of the Bejah Claystone with the Samuel Formation is probably diachronous, so the two units are probably partly time-equivalents.

Environment of deposition

The Bejah Claystone contains a marine fauna which indicates that it is a marine deposit. The fine grain size of the sediment and the absence of sedimentary structures indicate extremely quiet deposition with little influx of terrigenous material by currents. Such deposits appear to have been laid down over large parts of Australia during the Early Cretaceous (Brunnschweiler, 1958) and they indicate that the particular conditions responsible were not restricted to the Officer and southern Canning Basins.

UNDIVIDED MESOZOIC

About 10 m of fine to medium-grained, moderately to poorly sorted sandstone with clay pellets together with granule conglomerate and laminae of mudstone, is exposed (Section A17) at Dowling Hills, a group of small, low hills in southwest RYAN

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(lat. 23°45'S, long. 126°12'E). The sequence is undated but may be equivalent to the Callawa Formation. Since the Dowling Hills area is transitional between the Canning and Officer Basins, the sandstone exposed there could also be correlated with the Cronin Sandstone. As there is no evidence to indicate which of these correlations is correct, the sequence is mapped as Mesozoic undivided. Palynological data would probably be needed to solve the problem.

CRETACEOUS TO TERTIARY

Lake George Beds (new name not yet approved)

The Lake George Beds consist of massive sandstone and granule conglomerate which are interpreted as overbank deposits and partly pedogenic. The Beds unconformably overlie the Callawa Formation and the Anketell Sandstone.

Distribution and type locality

The Lake George Beds occur in SAHARA, PERCIVAL, TABLETOP, RUNTON and URAL. The best exposure is at the type section, 8 km southeast of Helen Hill, on TABLETOP. Good exposures also occur in southern PERCIVAL, southeast SAHARA and at Winnecke Rock, RUNTON. Photo-interpretation suggests the unit is widespread in northwest SAHARA.

Lithology

The Lake George Beds are composed of poorly sorted, fine to very coarse-grained quartz wacke and granule conglomerate. The massive appearance of the Lake George Beds distinguishes them from the underlying rocks. Interstices contain limonite, chalcedonic silica and clay.

Silicified pipe-like structures, possibly caused by solution, are present within the Beds. Moulds interpreted as root casts also occur.

Thickness

At the type section the Lake George Beds are 5 m thick, but they may be thicker elsewhere.

Stratigraphic relations

The Lake George Beds unconformably overlie the Callawa Formation and the Anketell Sandstone. Locally the contacts are gradational. The Beds are capped by laterite.

Fossils and age

No age-diagnostic fossils are known from the unit. A Cretaceous to Tertiary age is assigned to the Lake George Beds because they occupy a similar stratigraphic and topographic position to the Lampe Beds.

Environment of deposition

The Lake George Beds are interpreted as overbank deposits which have been deeply weathered. The absence of bedding and sorting, the gradational lower contact of the beds with the underlying units, and the presence of moulds interpreted as root casts suggests that the unit may be pedogenic in part. It is envisaged that the Lake George Beds formed contemporaneously with the Lampe Beds, which are interpreted as fluviatile deposits.

Lampe Beds

The Lampe Beds (Lowry et al., 1972) consist of silcretized sandstone and conglomerate which overlie Cretaceous and Permian rocks in the Gibson and Great Victoria Deserts. They are interpreted as fluviatile in origin and are assigned a Cretaceous-Tertiary age.

Distribution and type locality

The Lampe Beds were recognized in the south Canning Basin for the first time during field mapping in 1975, where they occur as cappings on mesas and small rises on RYAN, MORRIS and RUNTON. The type section is located at Mount Johnson (lat. 25°24'S, long. 124°25'E) on HERBERT in the Officer Basin.

Lithology

Silicified quartz pebble and granule conglomerate together with coarse to very coarse-grained poorly-sorted quartz wacke are the dominant lithologies of the Lampe Beds. The constituent grains are subrounded to subangular. Many of the exposures lack distinct bedding, but where present the bedding is thick and is locally cross-bedded. The Beds are commonly altered to silcrete.

Stratigraphic relations

The Lampe Beds unconformably overlie Proterozoic sediments, the Paterson and Samuel Formations, and the Bejah Claystone. The upper contact of the Lampe Beds is commonly an erosional surface, but at Cromer Cone (RUNTON) laterite overlies the Lampe Beds. However, at the Traeger Hills (MORRIS) laterite is also overlain by the Lampe Beds.

Fossils and age

The age of the Lampe Beds is uncertain as no fossils have been found in them. The beds are younger than the Early Cretaceous Bejah Claystone and are considered to be older than the main laterite horizons, which may be early Tertiary in age (see under Palaeodrainages).

Thickness

No sections were measured but the maximum thickness observed in the field is approximately 2 m.

Environment of deposition

The coarse nature and poor sorting of the Lampe Beds indicate that they are fluviatile (Jackson & van de Graaff, in prep.; van de Graaff, et al., in prep.).

CAINOZOIC

Calcrete, chalcedony (Czk)

Calcrete and chalcedony occur mainly in palaeo-drainage depressions and were probably mostly deposited as the drainages were drying up in the early Tertiary. However, some calcrete bodies may be younger than early Tertiary so the unit is mapped as a Cainozoic deposit.

The calcrete consists of impure argillaceous and arenaceous limestone with secondary chalcedony locally abundant. In many places most of the carbonate is weathered out, and all that is present on the surface are slightly calcareous deposits. In the Well 30 area, the calcrete is cavernous; the collapse of some caves has caused a 'hummocky' (karst) topography (TABLETOP).

Calcrete bodies are important aquifers in the region and most wells on the Canning Stock Route are sited in them.

Laterite (Czl)

Laterite is ubiquitous in the area and where it is not mapped on the surface it is probably present under the blanket of aeolian sand. On finer-grained rocks (Samuel Formation and Bejah Claystone) in the southern part of the

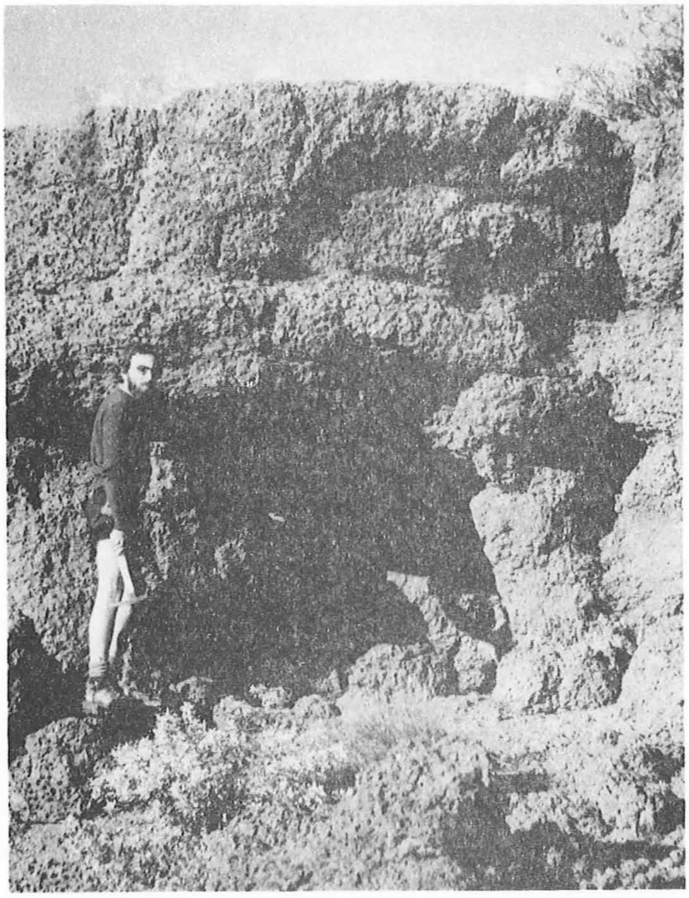

Plate 10: Outcrop of massive, pisolitic laterite forming thick capping in western WILSON. BMR Negative GB/1078

area the massive or pisolitic laterite capping (Plate 10) may be up to 10 m thick. On the coarser-grained sediments of the northern part of the area it is not as thick and is associated with other weathering products such as ferricrete and silcrete.

In the Gibson Desert, the laterite preserves the palaeodrainages, and the present lateritic surfaces represent a more subdued replica of the landscape under which it was formed. The laterite was probably formed as the palaeodrainages began to dry up in the Early Tertiary (van de Graaff et al., in prep.) but as younger laterites are known in Western Australia we prefer to map the unit as Cainozoic in age.

All the pre-Early Cretaceous Phanerozoic rock units are lateritized to a greater or lesser extent, and the Cretaceous to Tertiary Lampe Beds are both overlain and underlain by the laterite. The Lake George Beds - the probably equivalent of the Lampe Beds - are also lateritized.

<u>Lake deposits</u> (Ql)

Lake deposits occur in the palaeodrainage depressions in which they were deposited. Most of the playas are still active sites of sedimentation as clay, silt and minor sand are washed into them during heavy rain. Consequently the surface deposits are marked as Quaternary in age; however, many of the larger lakes contain thick sequences (probably up to 100 m), of sediments and such deposits probably date back to the Tertiary.

The playas containing these deposits probably formed as the palaeodrainages became dammed with sediments due to insufficient run-off. This is thought to have occurred in the Early Tertiary (van de Graaff et al., in prep.).

Authigenic gypsum is common in the lake deposits and also near Scott Bluff (TABLETOP), where layers of authigenic gypsum crystals (up to 10 cm thick) occur in deeply weathered exposures of Paterson Formation around the shores of Lake Blanche.

Alluvium (Qa)

Surface deposits of alluvium are rare in the area as there are few modern drainages. Some deposits occur beside the Rudall River (RUDALL) and other creeks that drain the Precambrian highland areas. A few smaller deposits also occur as washout fans, where small creeks drain breakaways. Most alluvium in the area is mixed with aeolian sand and is mapped as 'mixed aeolian and alluvial deposits'. This unit occurs mainly in the palaeodrainage depressions where surface run-off (mainly sheet wash) has deposited finer-grained sediment (silt, clay and minor sand) in the depressions and this has later become mixed with aeolian sands during dry periods.

Aeolian Sand (Qz)

Aeolian sand is abundant and occurs in the northern, eastern and western parts of the area. It mainly occurs as longitudinal (seif) dunes but some small sand plains without dunes also occur (eg. east RUNTON). The sand dunes are mainly fixed by vegetation, and significant sand movement occurs only after the vegetation has been burned off. In such places the dunes appear to have been eroded rather than maintained or rebuilt (Plate 11).

Crowe (1975) has described the formation, evolution and distribution of the sand dunes in this part of the desert and he has shown that denser dune patterns correspond with depressions. All of Crowe's (1975) three types of sand dunes occur: simple longitudinal, chain longitudinal (Plate 12), and net-like dunes. The sand dunes in the area were formed by easterly winds, which still prevail.

The sand that comprises the sand dunes was probably derived from:

(a) erosion of Precambrian rocks to the east of the area
(b) erosion and retreat of breakaways in the area
(c) redistribution of soil that must have existed over the laterite when it formed.

The third source is probably the most important as evidenced by the abundance of sand dunes over the more weathered sandy bedrock and their absence over the more resistant clayey bedrock.

4. PALAEODRAINAGES

Palaeodrainages are conspicuous and important features of the landscape over much of the area. Many of the ancient valleys show up clearly on the airphotos and many are reflected in the mapped distribution of Cainozoic units (e.g. MORRIS). Bunting et al. (1974) have shown that, to the south of the study area, contour maps can be used to elucidate the ancient drainage patterns, even in areas that are obscured by the thin cover (less than 5 m) of aeolian sand. The map (Figure 8) and the following summary is based mainly on a paper by van de Graaff et al. (in prep.).

Palaeodrainage patterns and age

Fine-textured palaeodrainage patterns, such as occur on MORRIS, are characteristic of fine-grained impermeable clayey bedrock, whereas coarser-textured patterns, such as occur on URAL, are typical of areas with sandy bedrock (Bunting et al., 1974) (Plate 13). Another example of bedrock control on the ancient drainage pattern is seen where the chain of playas that includes Lakes Dora and Blanche has a northwesterly trend parallel to the regional strike of the bedrock.

Most palaeodrainages in the area drained towards Lake Dora (see Fig. 8) and from there into the Indian Ocean via the present-day location of the De Grey River; however, in the eastern part of the area there is an enclosed depression centred about playas on RYAN. Van de Graaff et al. (in prep.) believe that the drainages in this depression originally flowed south to the Great Australian Bight via Lake Newell (COBB) but that epeirogeny along the site of the Warri Gravity High (probably during the Early Tertiary) resulted in diversion of the drainages and the formation of an area of internal drainage. They also believe that the 'S' bend in which Lake Auld is situated was caused by diversion of the Percival Lakes drainage system southwards into the system that contains Lakes Blanche and Dora (Plate 14).

The maximum possible age of the palaeodrainages in most of the area is early Late Cretaceous, as the ancient valleys are incised into the marine Bejah Claystone of Aptian-Albian age. Van de Graaff et al. (in prep.) believe that the Lampe Beds represent early deposits of the ancient drainages. However, at present, the Lampe Beds have not been dated accurately. On the edges of the Precambrian shield (on RUDALL) some palaeodrainages follow exhumed Early Permian valleys; however, none of these palaeodrainages are demonstratably as old as that, and they are more likely to be superimposed features. Evidence for the minimum age of the palaeodrainage is not present in the area, but Bunting et al. (1974) have shown that, about 600 km to the south of the area, on the edge of the Nullarbor Plain, significant water-flow had ceased in the ancient valleys before the Middle Miocene, as marine sediments of that age, in the Eucla Basin, abut the old valleys.

Implications of the palaeodrainages

The presence of such a well-developed Late Cretaceous to Early Tertiary drainage system in the area indicates that the climate of that period was more humid than at present. This is supported by the presence of laterite, which requires a higher

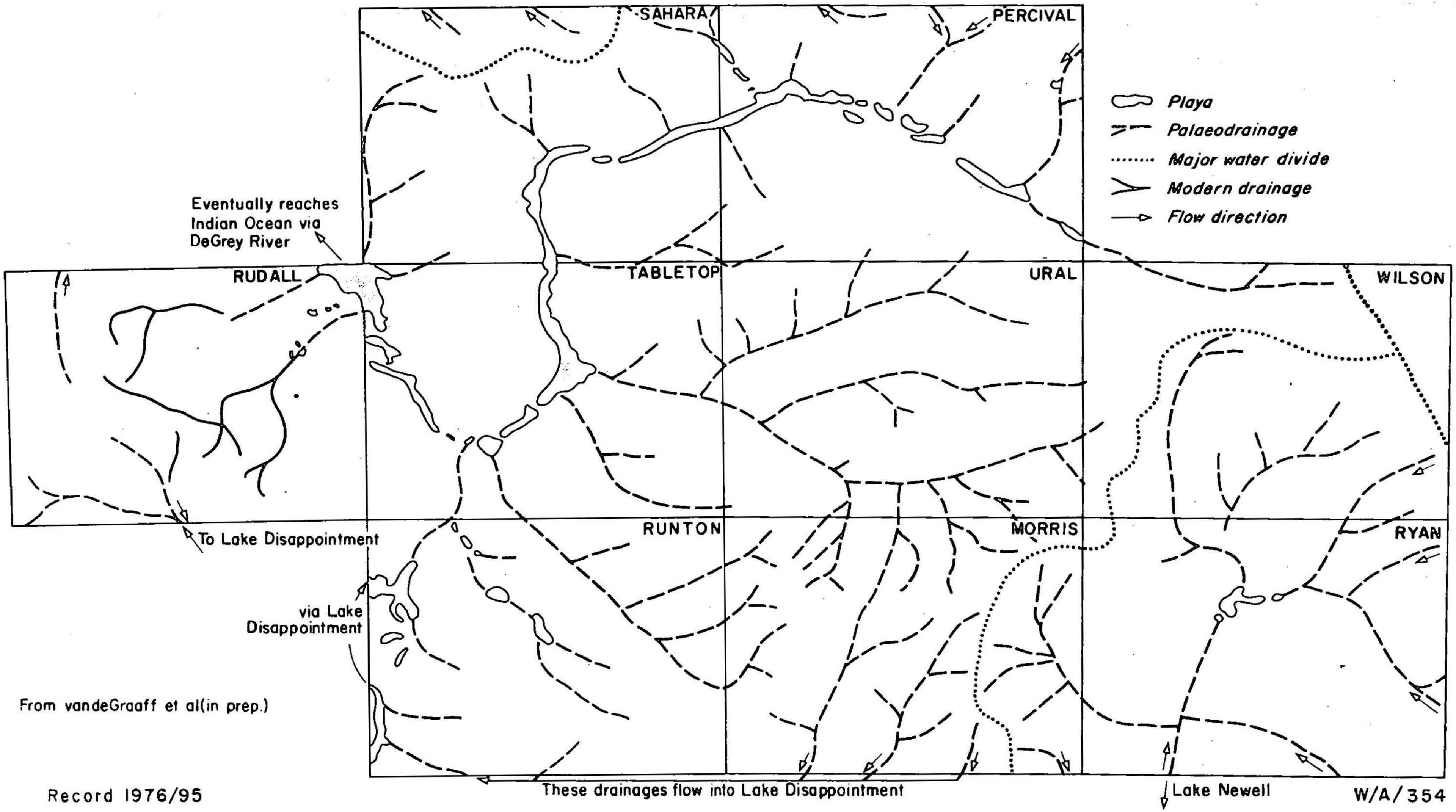

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Fig 8 PALAEODRAINAGES OF THE SOUTH CANNING BASIN

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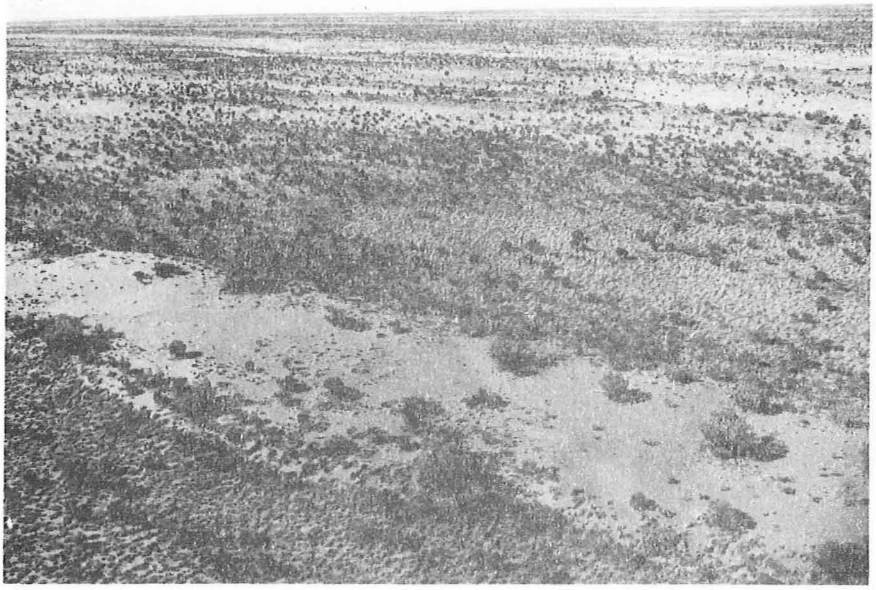

Plate 11: Eroded sand dunes with the crest almost completely flattened indicating active erosion of sand dunes in the area, WILSON. GSWA Negative.

Plate 12: Simple, longitudinal dune merging into chain longitudinal dunes in the background, Western WILSON. GSWA Negative.

Plate 13: Lines of dense vegetation mark the trunk valleys of the fossil drainage channels, with laterite flanking these valleys in the middle background, URAL. GSWA Negative.

Plate 14: View looking southwest of western end of the Percival Lakes, PERCIVAL. These lakes mark one of the prominent palaeodrainages in the area. Note the dense dunes adjacent to the lakes. GSWA Negative.

rainfall than occurs in the area today. The laterite has preserved the ancient drainage system from erosion, but the main reason that the valleys are still so well preserved is that the area has experienced remarkable tectonic stability and an arid climate, resulting in little erosion and only minor burial.

5. STRUCTURAL GEOLOGY

Parts of the four tectonic units that occur within the area are described below. They are the Phanerozoic Canning Basin, the Proterozoic-Phanerozoic Officer and Amadeus Basins, and the Precambrian Arunta Block. These are depicted in Figure 9.

Rocks of the Arunta Block crop out in a small area in southeast WILSON, where they consist of folded sedimentary rocks intruded by adamellite. Immediately to the east, on WEBB, the Arunta Block is composed of tightly folded Archaean metamorphic rocks which trend parallel to the foliation trends of the Mount Webb Adamellite and to the closely-spaced jointing within the acid lavas of the Pollock Hills Formation (Blake & Towner, 1974).

The western fringe of the Amadeus Basin occurs in the east of WILSON and RYAN. The Amadeus Basin is a complex intracratonic depression elongated east-west in central Australia and containing Late Adelaidean and Early Palaeozoic sediments which have been folded and faulted several times. Evidence for two of these events is present on RYAN. The Areyonga Movement produced the unconformity between the Bitter Springs Formation and the Ellis Sandstone, and the Petermann Range Orogeny (Late Proterozoic or Early Cambrian) was responsible for tight folding of the Ellis Sandstone and Maurice Formation (Wells et al., 1964; 1970).

A small part of the Officer Basin occurs within the area in southern RUNTON and southwest MORRIS. The Officer Basin contains a Proterozoic and Phanerozoic sequence which may be up to 12 000 m thick in places (Jackson, 1966; Lowry et al., 1972; M.J. Jackson, pers. comm.). The boundary between the Officer and Canning Basins remains uncertain. However, a gravity high, the Warri Gravity Ridge, part of the Anketell Regional Gravity Ridge, is interpreted as representing an area of very shallow basement, and other geophysical evidence indicates that the thickness of sedimentary rocks on either side becomes greater away from the feature (Darby & Fraser, 1969). Thus, the boundary between the two basins is tentatively placed along the axial region of Bouguer anomaly contours (Fig. 4). Surface information does not allow any more precise definition of this boundary although there are stratigraphic differences between the two basins.

Further seismic information across the Warri Gravity Ridge is needed to delineate the nature of the boundary more accurately.

Most of the area described in this report belongs to the Canning Basin, of which the Kidson Sub-basin (WAPET, 1966a) forms a major subdivision. A small portion of the Crossland Platform is present along with the 'Tabletop Shelf' (Koop, 1966a) and the 'Ryan Shelf' (Fig. 9; Basin Studies Group, pers. comm.).

The Crossland Platform is present in the northeast on PERCIVAL and WILSON. Though it is a platform with respect to the tectonic elements in the northern part of the Canning Basin, it slopes gradually southward into the Kidson Sub-basin, and the boundary as shown in Figure 9 is arbitrarily taken at the 3000 m depth-to-basement isopach (Basin Studies Group, pers. comm.). The BMR Basin Studies Group is currently reviewing the structural nomenclature of the Canning Basin, and the results will be published shortly.

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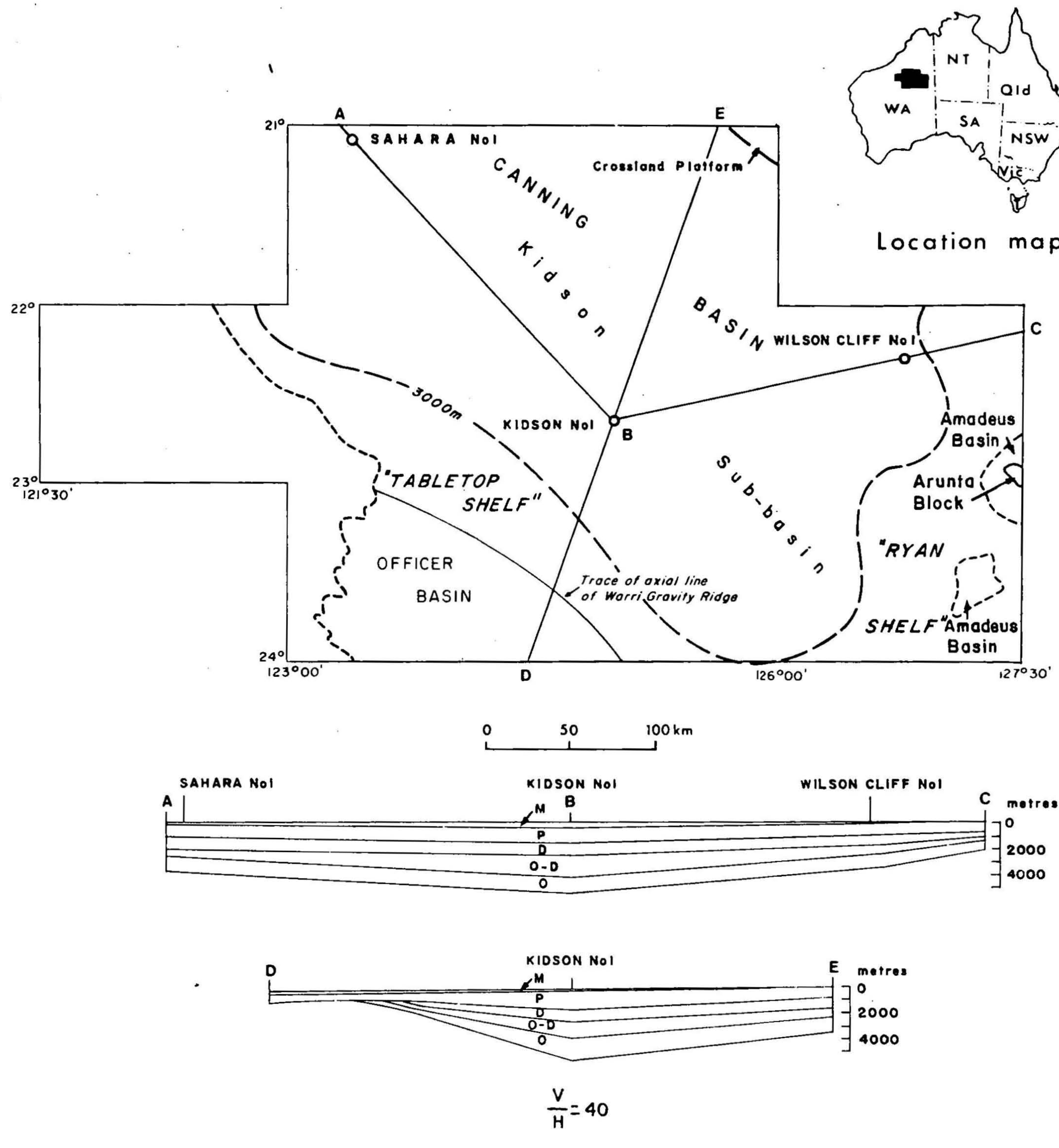

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Fig 9 Provisional tectonic map and cross-section of the southern part of Canning Basin

The <u>Kidson Sub-basin</u> succession has a gentle regional dip towards its axial region, which trends northwest across the area. The regional dip is up to 2^{o} below the base of Grant Formation and up to 1^{o} above it. A few low-amplitude flexures are suggested by gravity results in northwest SAHARA (WAPET, 1963b). A seismic survey conducted over these areas confirmed the presence of broad anticlines with gentle relief.

There are apparently no major faults cutting the Kidson Sub-basin sequence. Along the southwest margin in TABLETOP, seismic surveys have revealed subsurface faults with up to 200 m of near-vertical displacements cutting the pre-Middle Devonian section. A few similar subsurface faults are present near the edge of the Kidson Sub-basin in RYAN and WILSON. A northwest-trending zone of <u>en echelon</u> north-trending faults is present centred on Scott Bluff, TABLETOP. However, it is unlikely that these faults have vertical displacements of more than 20 m.

At latitude $22^{o}58'18''$, longitude $123^{o}35'48''$ is a small reverse fault zone which is younger than the Anketell Sandstone in age. The movement along the fault has caused the coarse-grained, bioturbated quartz wacke of the Anketell Sandstone to crop out beside the graded siltstone and fine quartz wacke of the Grant Formation. Aerial reconnaissance in northern WILSON in 1973 and 1975 by the authors over a zone of major earthquake epicentres (Denham et al., 1974) did not reveal any surface evidence of fractures.

The Veevers Crater found during the survey is thought to be of meteoritic origin (Yeates et al., 1976) but it is structurally insignificant within the Kidson Sub-basin sequence.

6. GEOLOGICAL HISTORY

In at least the eastern part of the area, Archaean sand, silt and mud were metamorphosed during Proterozoic times to form the Arunta Complex. In the mid-Carpentarian, following a period of uplift and erosion, acid volcanics and sedimentary rocks (Pollock Hills Formation) accumulated during a marine transgression, and simultaneously or shortly afterwards, acid magma (Mount Webb Adamellite) intruded the sequence. A long period of erosion ensued until in the Adelaidean, when sand, silt and gravel (Heavitree Quartzite) were deposited in a widespread shallow sea which flooded the bevelled crystalline basement. Sand, mud and lime, and possibly evaporites, then accumulated in barred lagoons (Bitter Springs Formation). The final phase of Amadeus Basin sedimentation was the deposition of sand and silt (Ellis Sandstone and Maurice Formation) probably in alternating fluvial and near-shore marine environments.

Near the end of the Adelaidean or early in the Cambrian, possibly during the Petermann Ranges Orogeny (Wells et al., 1970), the Adelaidean sediments were strongly folded and faulted, and the area was uplifted to form a landmass, part of which may subsequently have been the provenance for early Palaeozoic sedimentation in the Canning Basin.

In the very late Adelaidean, or in the earliest Cambrian, mud accumulated along the extreme western edge of the Amadeus Basin and in the Canning Basin.

Following a period of erosion during which the landscape became relatively flat, silt, sand and lime were deposited when the sea flooded a large area in northwestern Australia. These sediments represent earliest deposition in an area that was to become the Canning Basin during Early to Middle Ordovician time (Goldwyer Formation). No sedimentation occurred in the southern part of RUNTON and MORRIS. In the Late Ordovician, the sea became shallower, and it partly retreated from the area, allowing evaporitic conditions to prevail. Salt deposition was more extensive in the centre of the Kidson Sub-basin, as peripheral areas became slightly emergent during Late Ordovician to Early Devonian times. Silt and clay of probable continental origin were laid down during salt deposition (Carribuddy Formation).

In the Early Devonian, red sand and silt was deposited by winds and rivers in a dominantly continental environment (Tandalgoo Red Beds).

Postdating the deposition of the Tandalgoo Red Beds, mobilization of the salt units within the Carribuddy Formation may have occurred producing structural features referred to as 'salt wells' recognized in the northern Canning Basin (Willmott, 1962).

The sea returned during the Middle Devonian and covered a large part of the area. Lime and sand accumulated (Mellinjerie Limestone), the thickest deposit occurring in the centre of the Kidson Sub-basin.

Throughout Ordovician to Middle Devonian time, the area was slowly sinking by tilting and subsidence, the subsidence occurring at a slightly faster rate in what is now the axial region of the Kidson Sub-basin. The area south of latitude 23°S and west of longitude 126°E (that is, RUNTON and southwest MORRIS) was probably emergent and formed a landmass.

From late Middle Devonian to early Late Carboniferous time, sand, mud and lime may have accumulated periodically within the area as it did in the Fitzroy Trough and Gregory Sub-basin to the north. However, post-Middle Devonian to pre-Permian uplift and subsequent erosion has stripped most of the inferred Devonian-Carboniferous sediments from the area.

In the earliest Permian, adjacent areas were undergoing glaciation as indicated by striated pavements. Within the exhumed valleys in the Precambrian landmass and probably on various parts of the pre-Permian floor of the Canning and Officer Basins, deposition of silt and sand with striated pebbles was taking place in rivers and lakes under the influence of a glacial climate (Paterson Formation). Following this the whole of the area was blanketed by silt, sand and minor gravel laid down in shallow water with some marine influence (Grant Formation).

As the climate became warmer, by late Sakmarian to early Artinskian times, sand, silt and minor gravel (Poole Sandstone) were laid down in a sea to the north of the site of the Warri Gravity Ridge. Rivers in the east probably contributed some detrital material.

In late Artinskian times, this shallow sea deposited mud, lime and some sand (Noonkanbah Formation), mainly under reducing conditions. Terrigenous material was deposited mainly in the eastern part of the area. Then the sea probably regressed from the area, the water shallowed, and the influx of terrigenous material increased as sand and silt (Triwhite Sandstone) were laid down.

A period of non-deposition and some erosion followed until the Late Jurassic to Early Cretaceous, when meandering rivers deposited sand and gravel in the Kidson Sub-basin (Callawa Formation) and in the Officer Basin (Cronin Sandstone). In the Early Cretaceous (Aptian), shallow seas extended from the Officer Basin area northwards as far as southern RUNTON, western RYAN and most of MORRIS, depositing sand and mud in a possible subtidal environment in which invertebrates flourished (Samuel Formation). Simultaneously, near-shore conditions prevailed to the north of this sea and the Anketell Sandstone was deposited in brackish water.

? not from the NW.

In Albian times, clays were deposited under extremely quiet conditions in a marine environment with little influx of material from outside the area (Bejah Claystone).

Following the final retreat of the sea in the Late Cretaceous, deep chemical weathering affected the basin area which was mainly of low relief with the exception of Baron Range (RYAN). Soils formed on the alluvial plains of the Anketell and Callawa Formations (Lake George Beds), and a large drainage system formed over most of the area; sand and gravel of the Lampe Beds represent early deposits of these rivers. As the climate became hotter and humid, extensive laterite profiles developed. Lateritic processes may also have continued at intervals throughout the Cainozoic until the climate eventually became arid.

With the onset of arid conditions, dessication of the laterite surface and the formation of mesas and buttes occurred. Drainages became dammed with alluvium and lakes developed. Calcrete and minor evaporites formed in these lakes and in the drainage channels, and may still be forming at present. Subaerial erosion of the laterite surfaces produced sand dunes.

7. ECONOMIC GEOLOGY

Petroleum

Estimates of source-rock and reservoir-rock potential for the Kidson Sub-basin sequence is summarized in Table 2.

The Ordovician sequence, known from Aquitaine Wilson Cliffs No. 1 (AAP, 1969c) and Contention Heights No. 1 (AAP, 1974) has source-rock potential, and as it contains sandy facies it may also have reservoir potential. However, in both these deep drill holes, the sandstone was found to have low porosity.

The Carribuddy Formation and the overlying Tandalgoo Red Beds, being deposited mainly under oxidizing conditions, have low source potential. However, evaporites within the Carribuddy Formation may be potential cap rocks because of the impermeability associated with evaporites. Diapiric folding, a feature of evaporitic sequences, occurs within the formation in the north of the Canning Basin. If present in the south Canning Basin, it could provide suitable structural traps for petroleum.

The Mellinjerie Limestone may also be prospective. It has some potential as a source rock and it contains sandy facies which have a moderate porosity.

Drew & Evans (1975) have interpreted possible reef structures in the Ordovician-Devonian sequence on the Crossland Platform to the north of the area on HELENA. Since the Phanerozoic sequence dips generally towards the axial region of the Kidson Sub-basin, any petroleum generated within the sediments would most likely migrate up-dip towards the margins of the sub-basin and towards the Crossland Platform.

The Permian sequence, apart from the Noonkanbah Formation, appears to lack generative source rocks and, in all parts of the area, it is too close to the surface to have undergone sufficient thermal diagenesis to generate petroleum. The sequence does, however, contain potential reservoirs such as the Grant Formation and Poole Sandstone. The Noonkanbah Formation is a prospective cap rock.

The Mesozoic rocks have no petroleum potential.

Groundwater

The area is prospective for groundwater. The present distribution of wells in the area has not completely tested the resources. All water wells drilled and utilized by petroleum exploration companies in the area were found to be dry or collapsed when examined during 1975. The condition of water wells on the Canning Stock Route in the area is summarized in Table 3. Their positions are accurately located on the respective 1:250 000 preliminary geological maps.

The water-table is generally within 10 m of the surface in the larger ancient drainages, and deeper elsewhere.

The few petroleum exploration and stratigraphic wells have indicated mainly saline water for most pre-Permian units encountered. However, the Early Devonian Tandalgoo Red Beds contained fresh water in Aquitaine Wilson Cliffs No. 1 (AAP,

Table 2. Summary of petroleum potential for pre-Permian units

Age	Stratigraphic Unit	Porosity	Permeability	Remarks
Middle Devonian	Mellinjerie Limestone	generally low	low	Porosity in sandstone units
Early Devonian	Tandalgoo Red Beds	variable; low to good	variable low to high	Potential reservoirs; flushed with fresh water deposited mainly in oxidizing conditions
Late Ordovician to Early Devonian	Carribuddy Formation	low to moderate	low	Evaporitic; low source potential; some reservoir potential; if diapiric folding exists it could provide suitable structure.
Ordovician	Undivided - includes Goldwyer Formation and informally named units in Aquitaine Wilson Cliffs No. 1 and Contention Heights No. 1	low	low	Reasonable source potential; known sandstones lack good porosity and are water saturated; traces of methane recorded (AAP, 1969c; 1974).

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1969c) and in WAPET Kidson No. 1 (WAPET, 1966c). Good porosity and fair permeability have been indicated in some intervals of the unit (WAPET, 1966c). The Tandalgoo Red Beds are therefore a prospective aquifer, but they occur at a much greater depth than more prospective units above them.

Parts of the Grant Formation and overlying Poole Sandstone are excellent aquifers in other parts of the Canning Basin (Veevers & Wells, 1961; Yeates et al., 1975) and they may yield good water in this area. Much of this sequence is composed of porous, clean quartzose sandstone units with porosities of up to 20% in WAPET Kidson No. 1 (WAPET, 1966c). The overlying shales and siltstones of the Noonkanbah Formation provide confining beds for these aquifers. The Triwhite Sandstone would most probably yield small supplies of saline water.

The Callawa Formation and sandy facies within the Anketell Sandstone have yielded water in bores sunk and utilized during petroleum exploration surveys. The quartzose sandstone and conglomerate, being porous and widespread, make the units prospective for groundwater where they can be intersected beneath the water-table. However, much of their known distribution (especially around the edges of the basin) would be above the water-table.

Deposits of the ancient drainage system are excellent aquifiers. Many of the wells along the Canning Stock Route are located in such settings, principally within calcrete. The ancient drainage system, in many places, has dissected the base of the Mesozoic rocks, so that the Cainozoic deposits lie on the relatively impervious rocks of the Triwhite Sandstone and the Noonkanbah Formation. The water salinity within these aquifers is variable; it becomes more saline towards the large salt lakes of the area, where the salt water is less than 1 m below the lake surface.

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Table 3. Condition of water wells along Canning Stock Route, July 1975

Well	Condition
26	Unknown; not visited
27	Unknown; not visited
28	Unknown; not visited
29	Timber of well in reasonable condition, but loose at surface; water is weed-filled, uncovered
30	Dry; caved-in and silted-up to within 2 m of surface
31	Dry; caved-in and silted-up; very insecure timbering; uncovered
32	Timber secure; uncovered; water polluted with dead birds
33	Timber secure; partly covered; water polluted with dead birds and dingo
34	Timber secure; uncovered; water green with algae
35	Dry; caved-in
36	Timber insecure; uncovered; water polluted with dead animals
37	Timber insecure; uncovered; water filled with algae and weeds
38	Dry rockhole; numerous small rockholes nearby contained a total of about 70 litres of water collectively, July 1975
39	Timber secure; uncovered; water putrid with dead animals and algae
40	Timber secure; uncovered; water contained dead birds and green algae
41	Timber insecure; uncovered; water contained dead birds
42	Secure open cut well; water full of green algae
43	Timber secure; half-covered; water putrid from dead dingo.

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Coal

Thin coal seams have been intersected in the Grant Formation, Poole Sandstone and Noonkanbah Formation. However, as the coal occurs in predominantly marine units, the prospects of finding large deposits are slight.

Evaporites

Thick sequences of evaporites (chiefly halite and gypsum) are present at depth in the Carribuddy Formation (Glover, 1973). Evaporites (chiefly gypsum) up to 1 cm thick cover the surface of the large salt lakes, and further thin layers are present within the lake sediments.

Uranium

No uranium has been found in the area, but there is a possibility of secondary concentrations occurring within deposits of the ancient drainage systems.

Constructional materials

Goethite pisolites within laterite and reworked laterite are present within the area in large quantities and are suitable for constructing roads.

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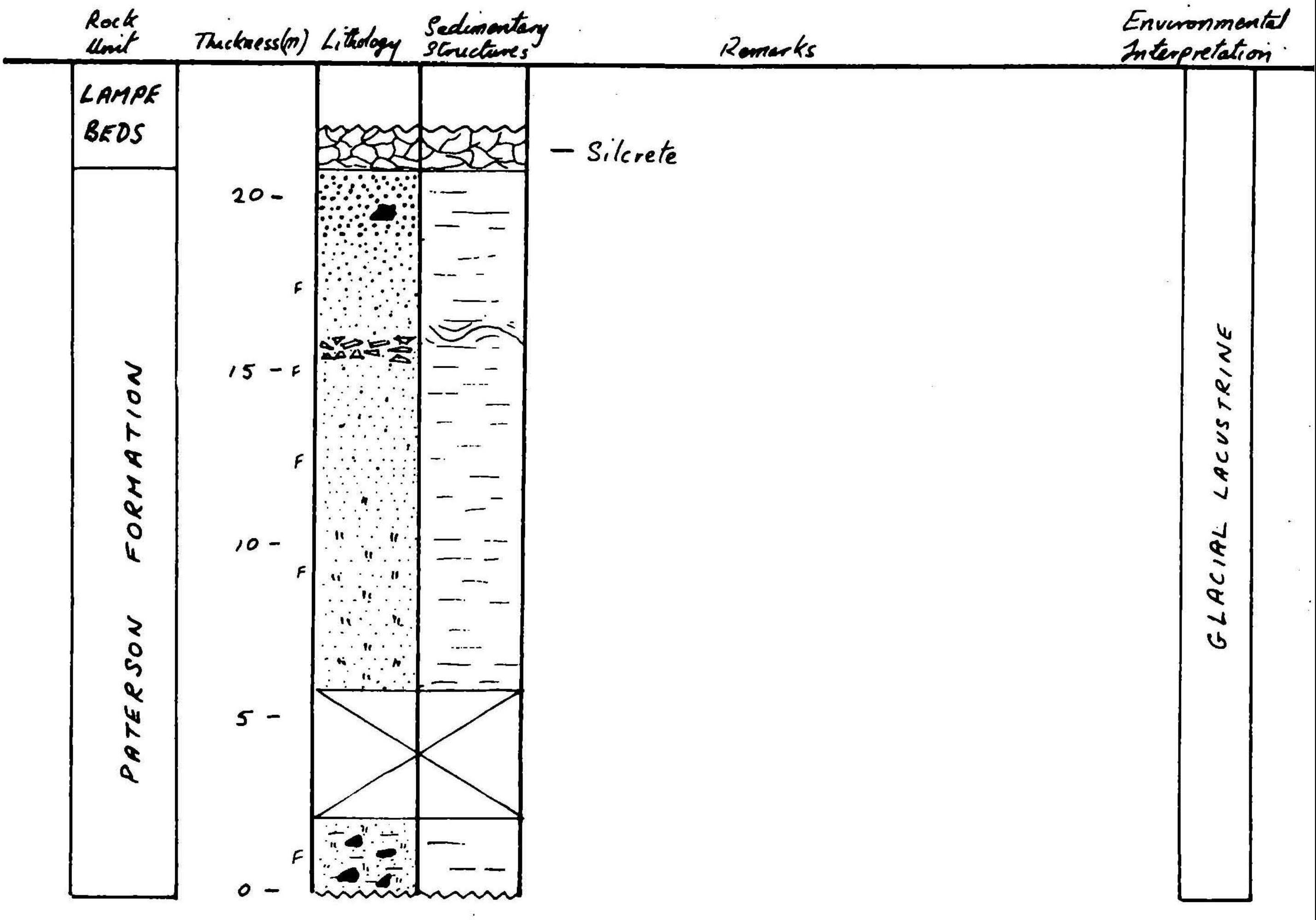
APPENDIX A

MEASURED SECTIONS

SOUTH WEST RUNTON SECTION NO. A1

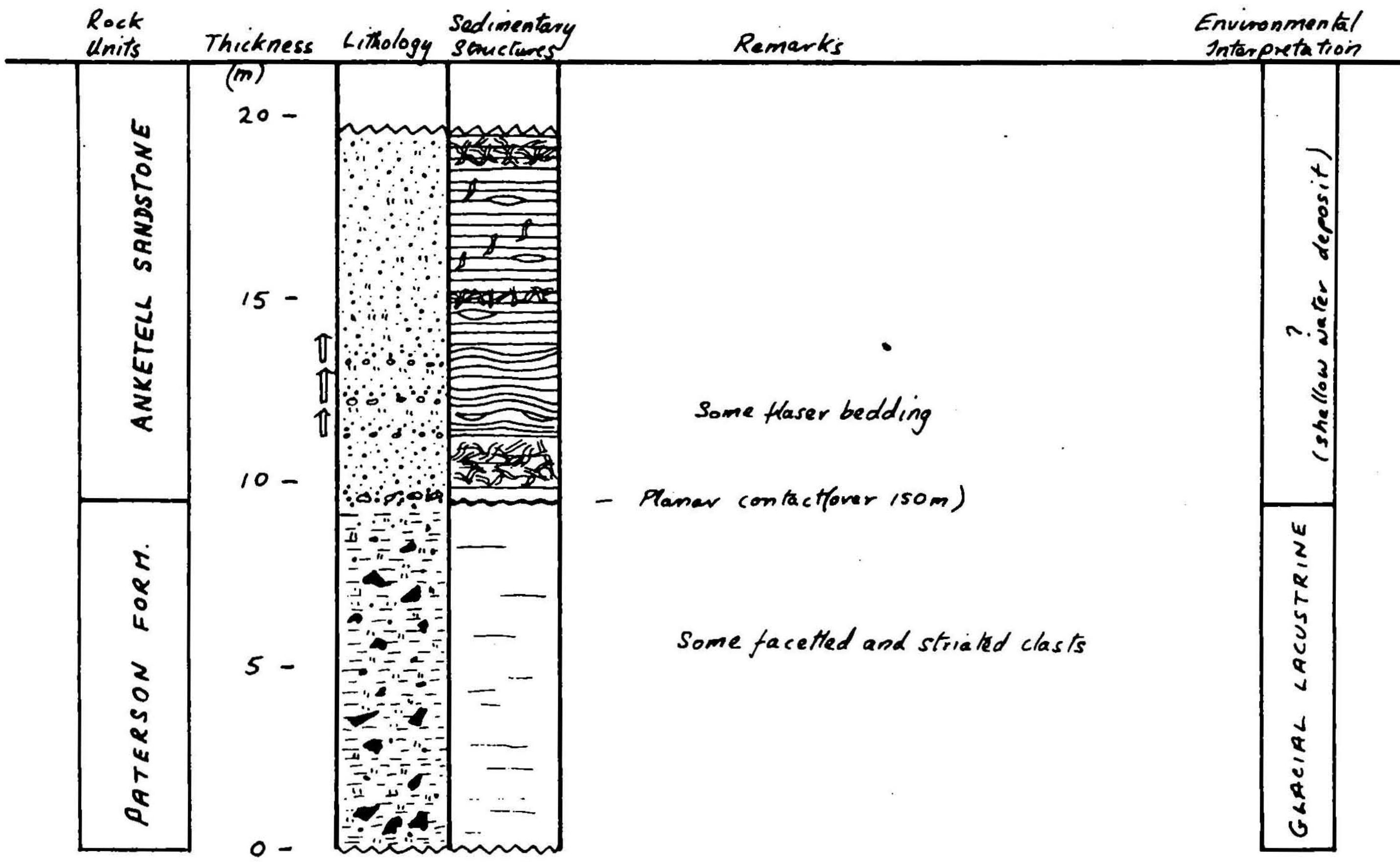
23° 55' 00" S. 24° 25' 40" E



NORTH RUNTON

SECTION No. A2

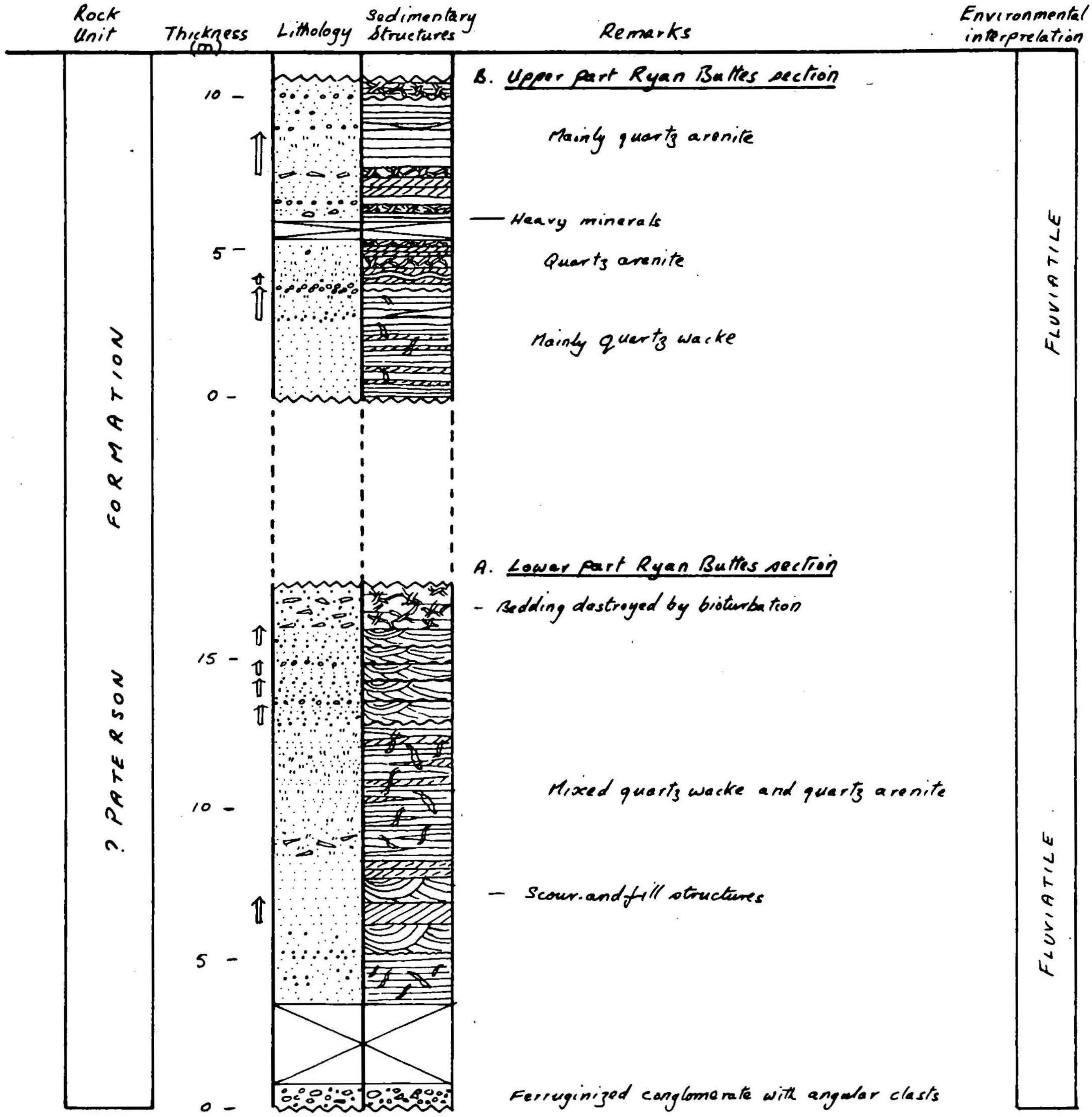
23° 07' 00"S. 123°35'45"E.



RYAN BUTTES

A. 23° 59' 18", 126° 30' 24"
B. 23° 53' 48", 126° 40' 51"

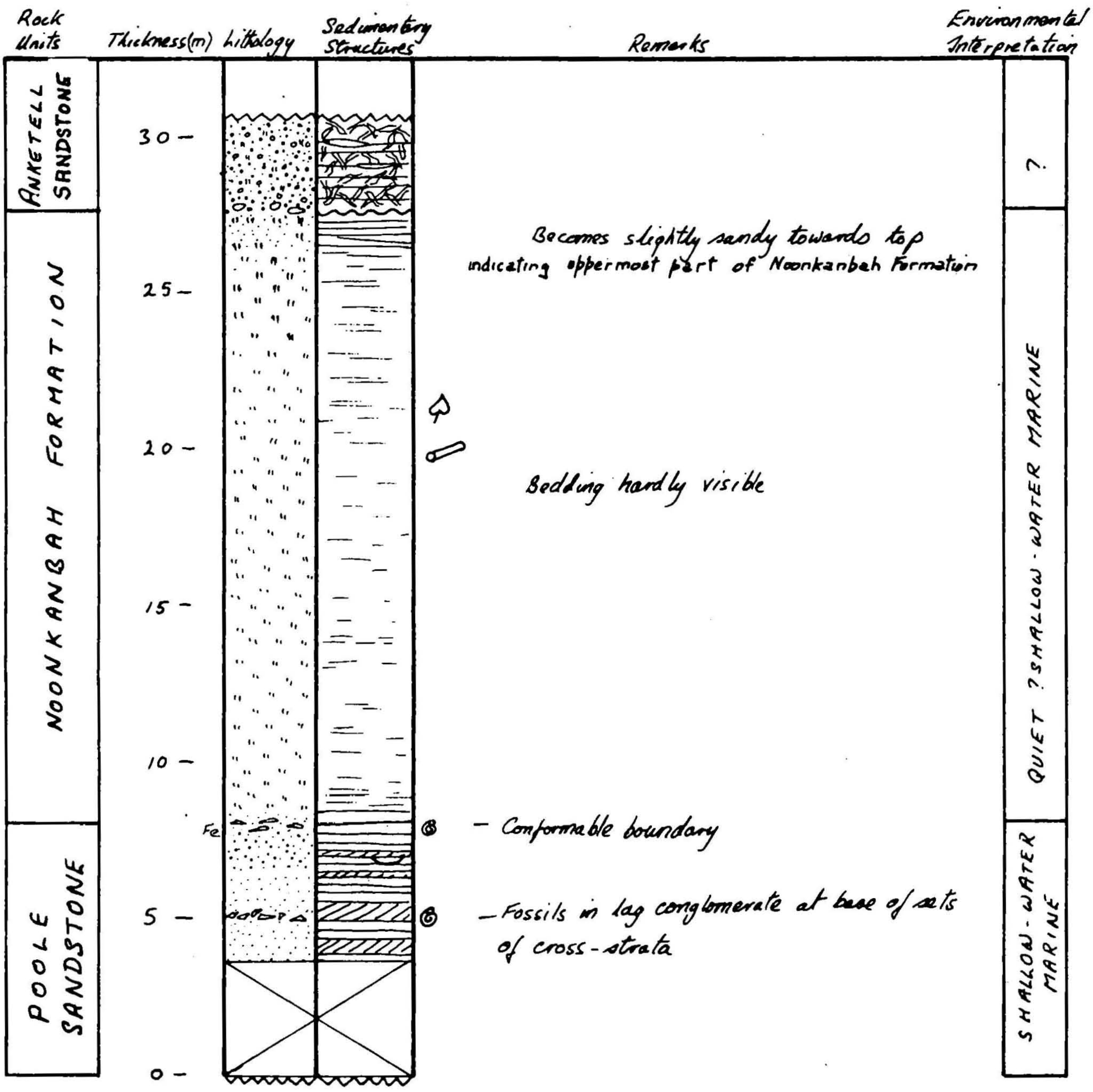
SECTION No. A3



HELEN HILL

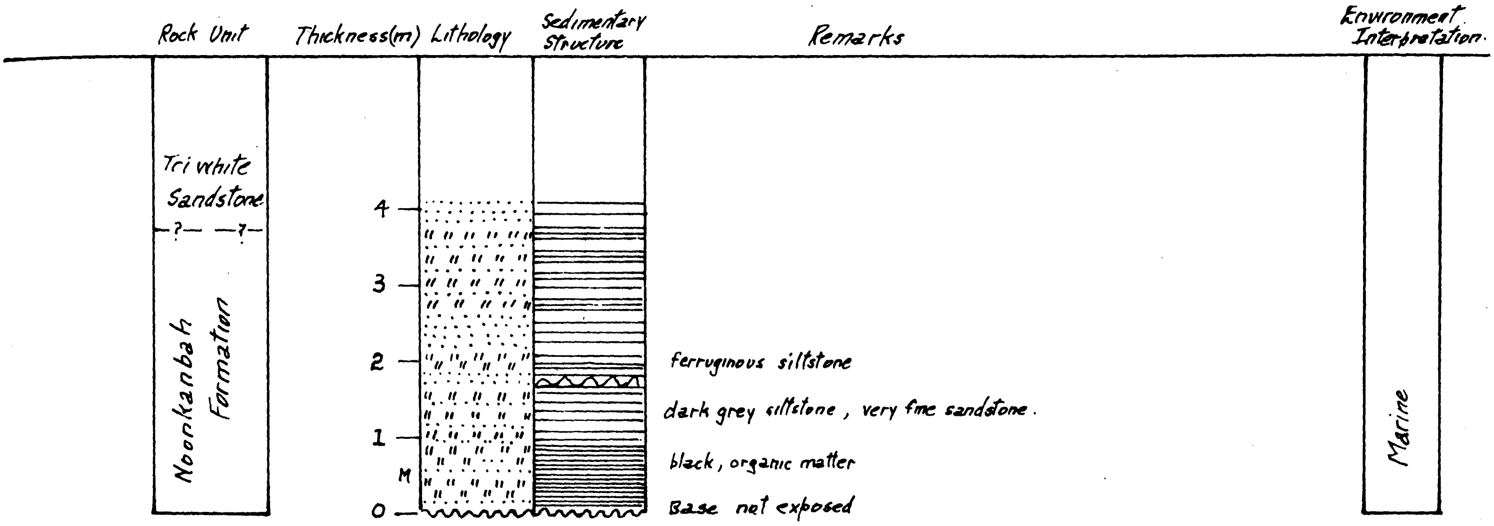
SECTION No. A4

22° 47' 15" S. 123° 39' 10" E



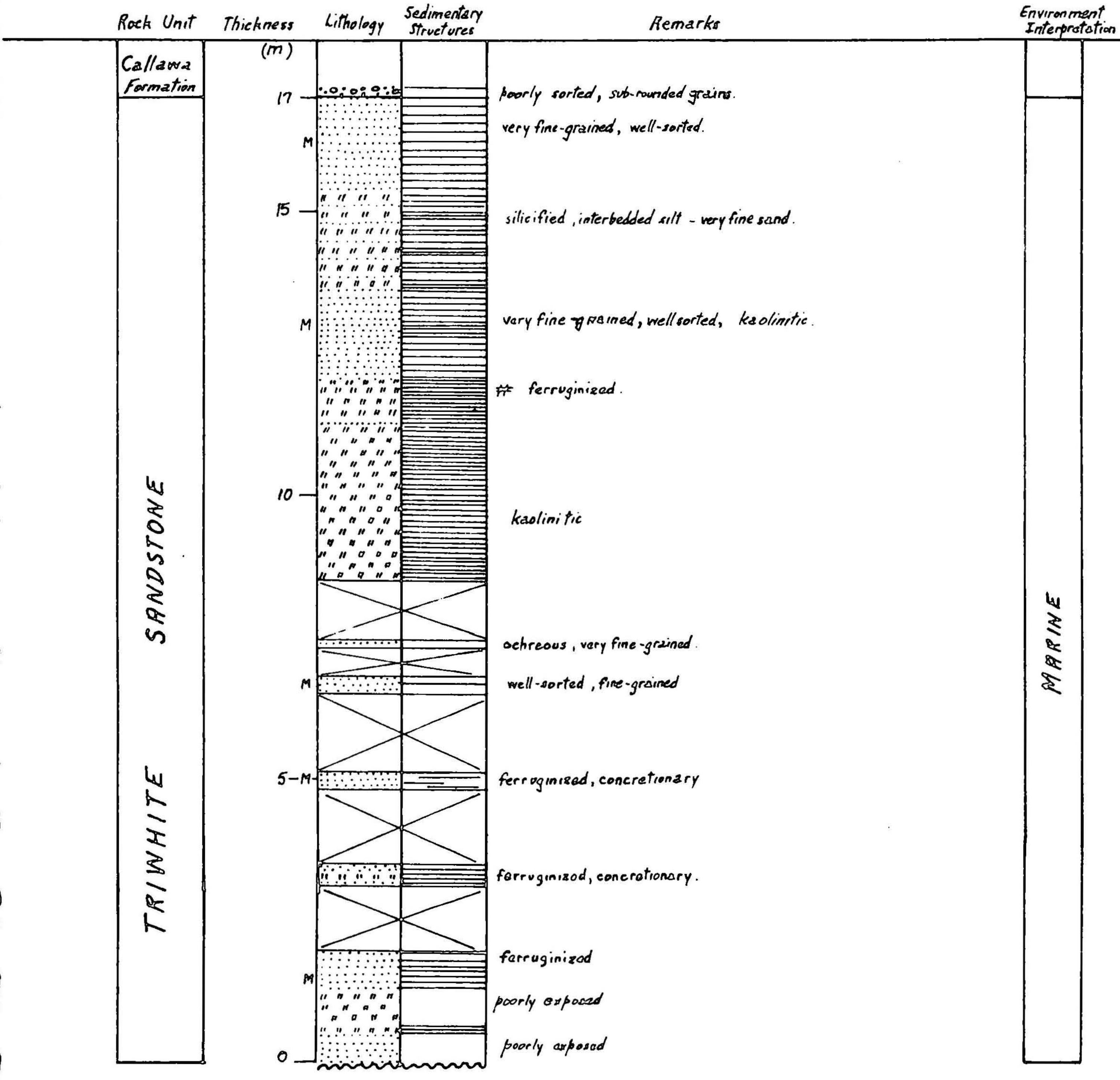
SOUTH EAST PATERSON RANGE (on edge Lake Dora) SECTION A5

21° 59' 00" S, 121° 59' 00" E



TRIWHITE HILLS. SECTION A6

22° 05' 30" S, 123° 13' 40" E

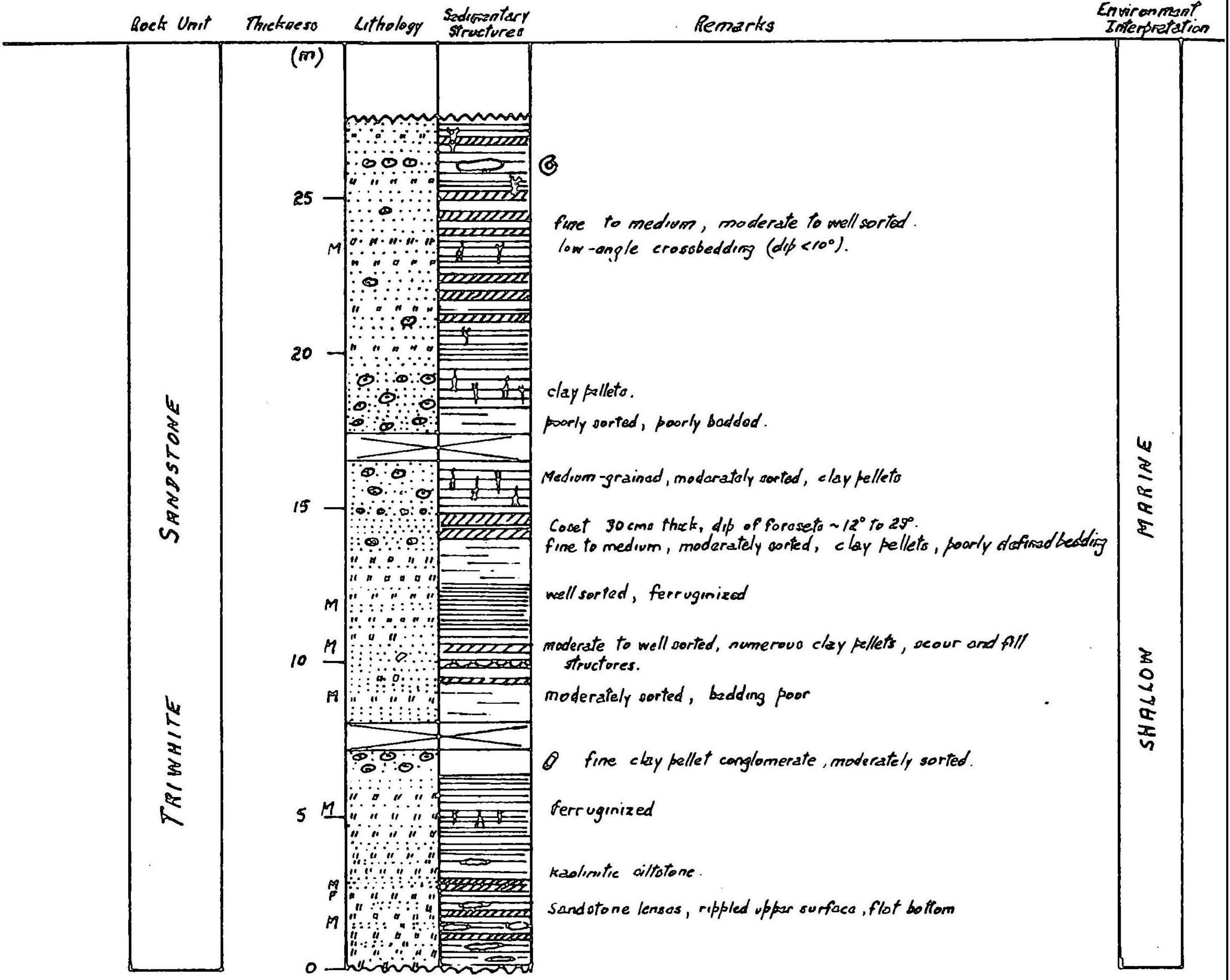


Record 1976/95 W/A/338

WEST-CENTRAL TABLETOP

SECTION A7

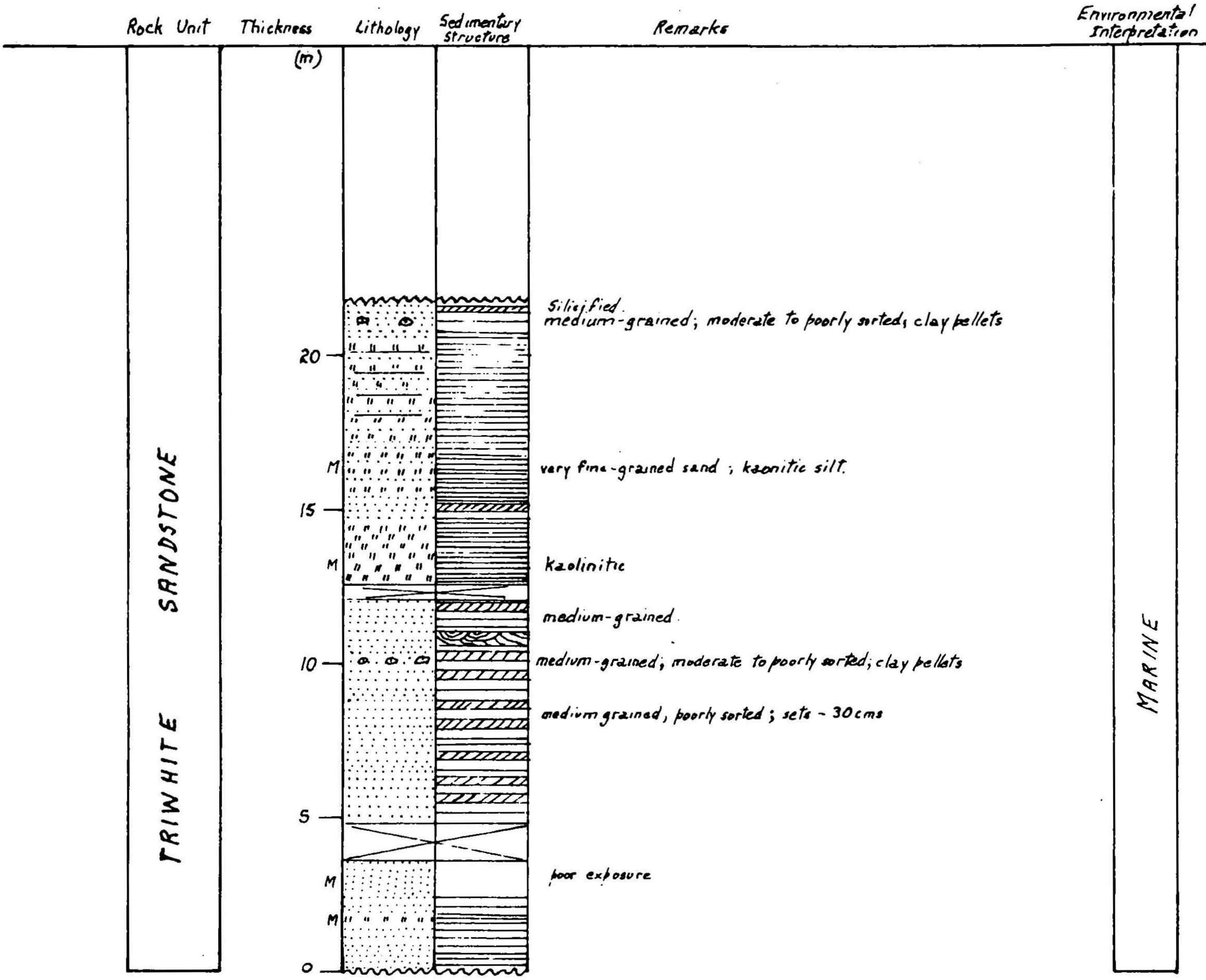
22° 29' 06'S, 123° 16' 21"E



WEST CENTRAL TABLETOP

SECTION A8

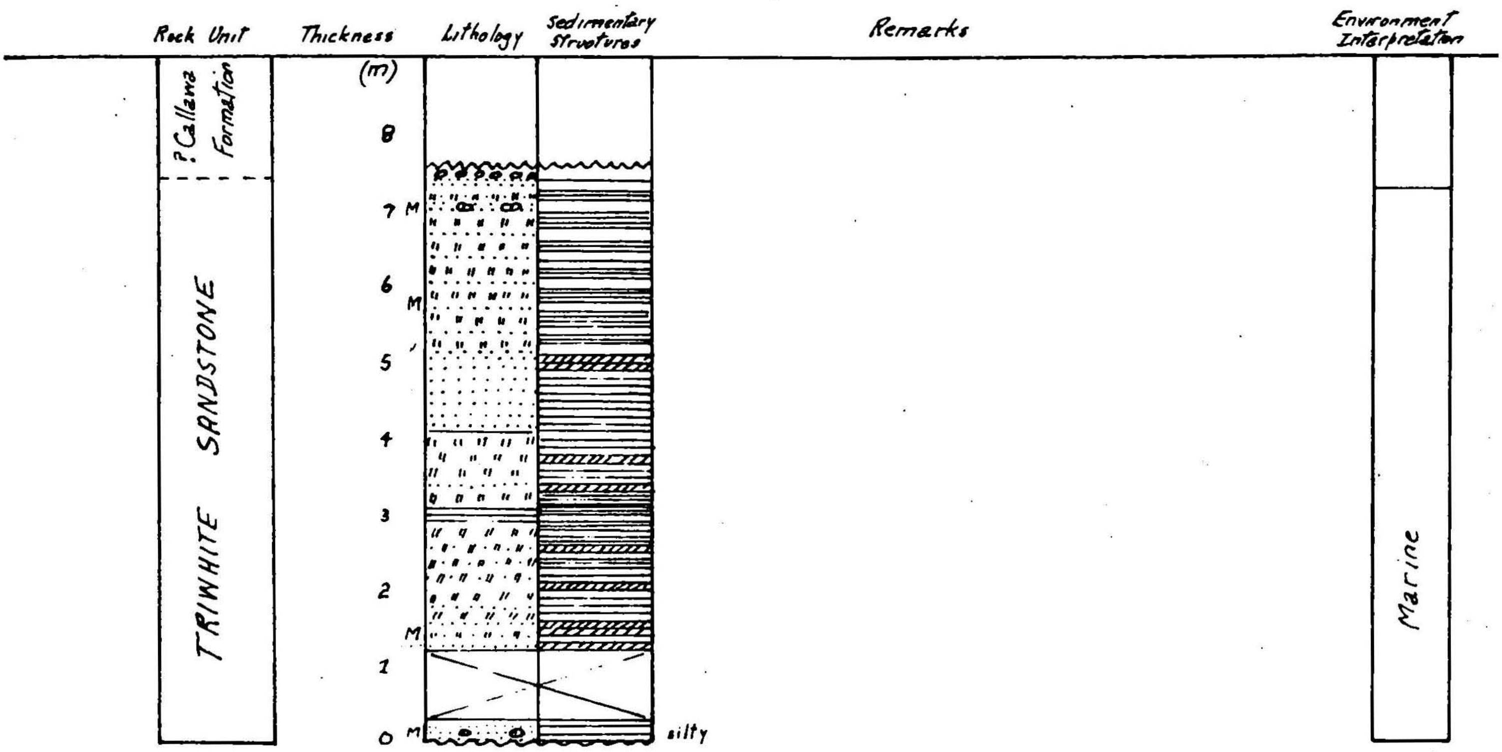
22° 32' 00" S, 123° 17' 15" E



EAST - CENTRAL TABLETOP

SECTION A9

22° 34' 03"S 124° 14' 12" E

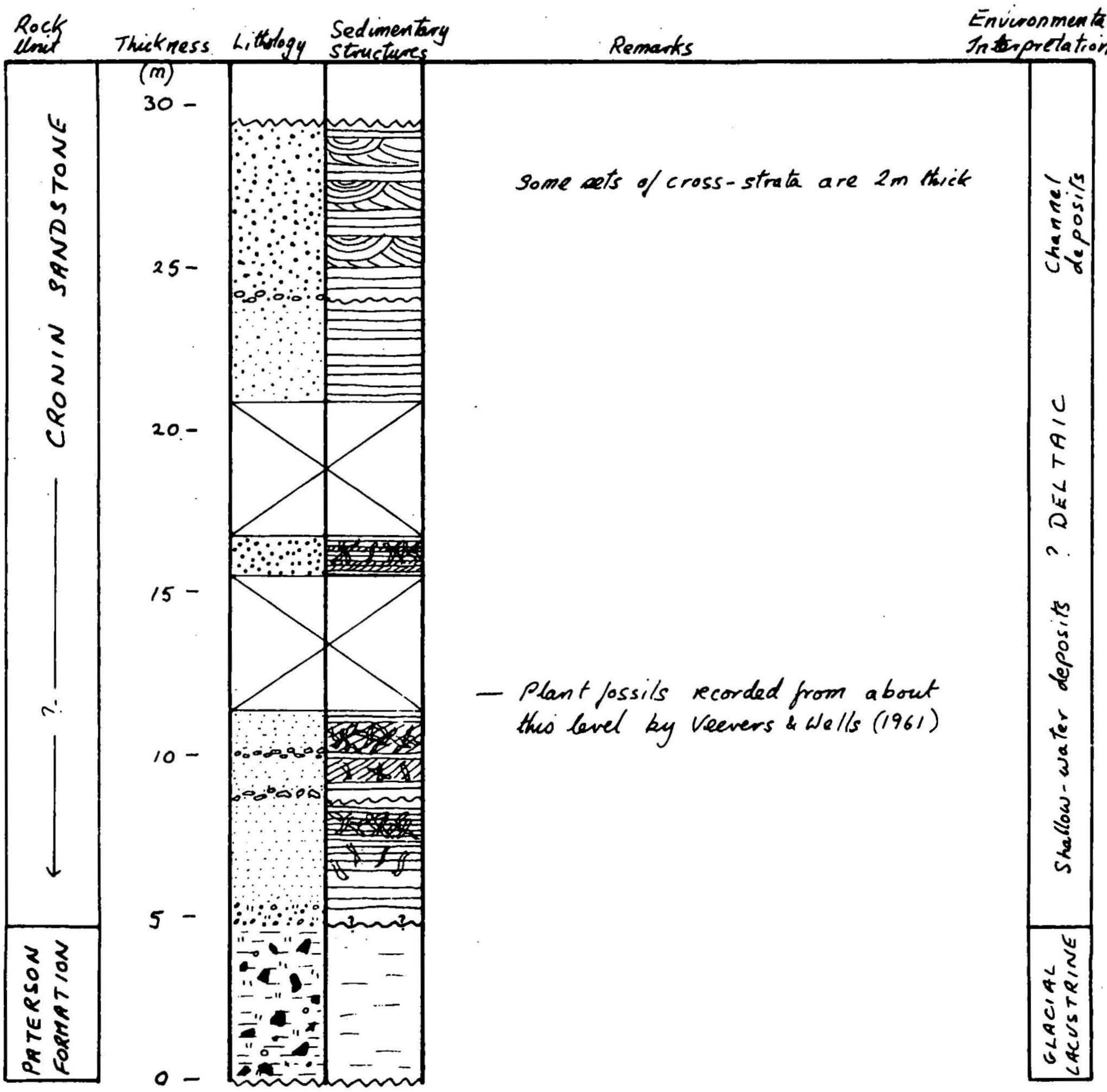


CRONIN HILLS

SECTION NO: A10

23° 14' 40"S. 123°22'20"E

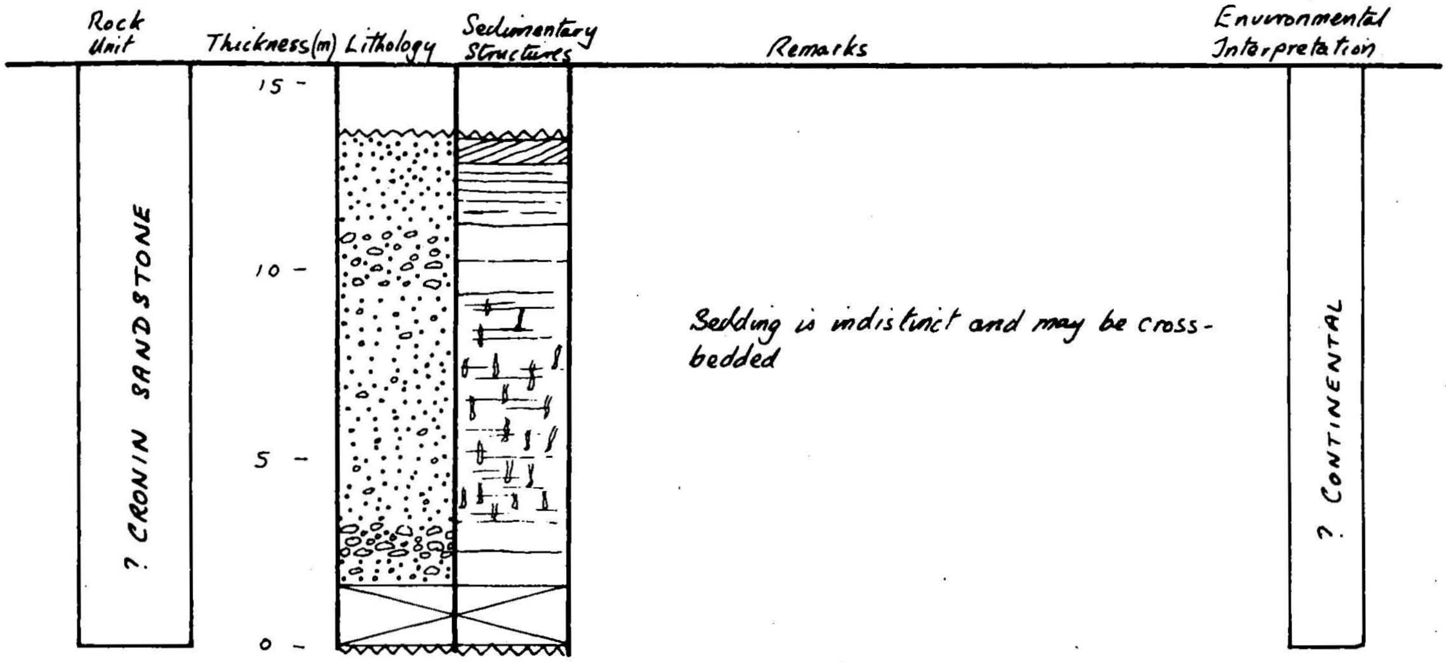
Type section of Cronin Sandstone



SOUTH EAST RUNTON

SECTION No. A11

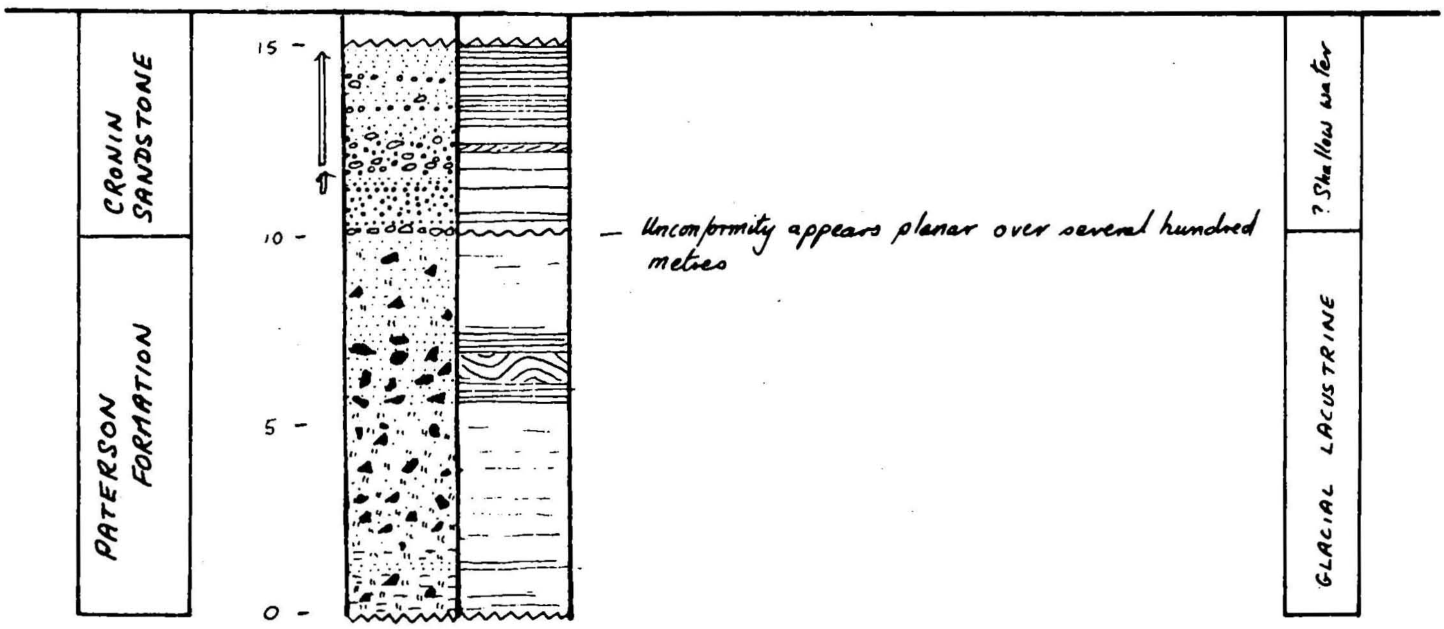
23° 45'55"S. 124° 05'50"E.



WEST CENTRAL RUNTON

SECTION No. A12

23°23'30"S. 123°28'25"E.



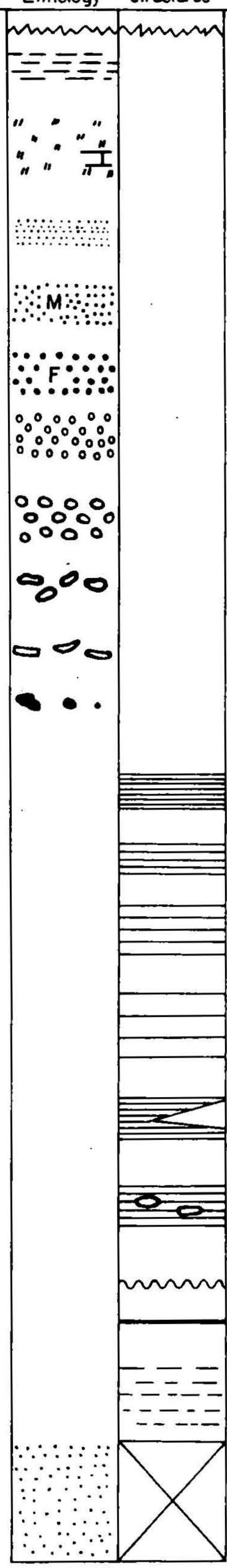
SECTION No.

REFERENCE

Latitude and Longitude

Status

Lithology	Sedimentary structures	Remarks	Environmental Interpretation



Limit of exposure

Shale

Siltstone — Calcareous

Fine and very fine-grained sandstone

Medium-grained sandstone — Micaceous (>10%)

Coarse and very coarse-grained sandstone — Feldspathic (>10%)

Granule conglomerate

Pebble conglomerate

Boulder conglomerate

Clay-pellet conglomerate

Dropstones (sizes as above)

Laminated

Thin and very thin bedded

Medium bedded

Thick bedded

Wedge shaped bed

Lensoid beds

Erosional boundary

Sharp boundary

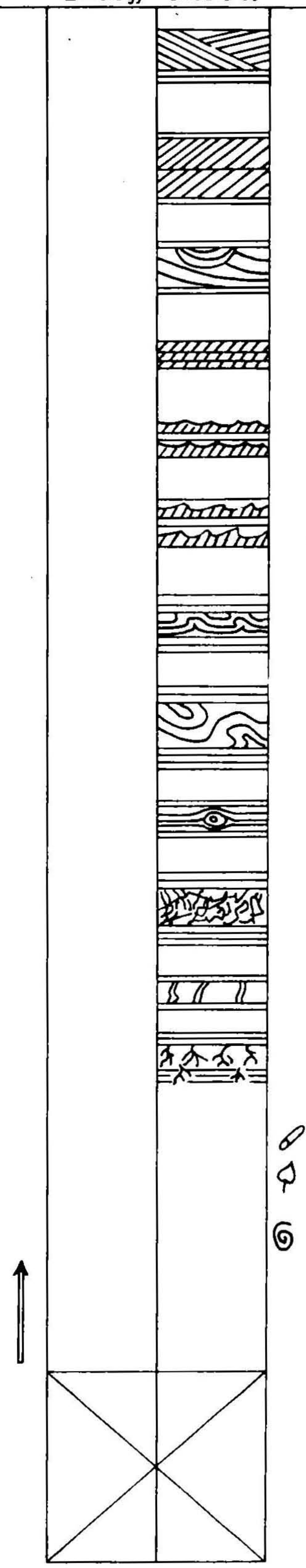
Bedding indistinct (sizes as above)

Bedding not seen but lithology interpreted from scree material

CONTINUED

E51/A12/21

Lithology	Sedimentary structures	Remarks	Environmental interpretation



Simple cross-bedding
Planar cross-bedding } *Large scale (greater than 5cm thick)*
Trough cross-bedding

Small scale cross-bedding (less than 5cm thick)

Small scale cross-bedding with symmetrical ripple marks on bedding plane

Small scale cross-bedding with asymmetrical ripple marks on bedding plane

Slump and flowage

Slump (minor sliding)

Concretion

Bioturbated

Burrows

Roots

Wood fragment fossils

Plant fossils

Marine macrofossils

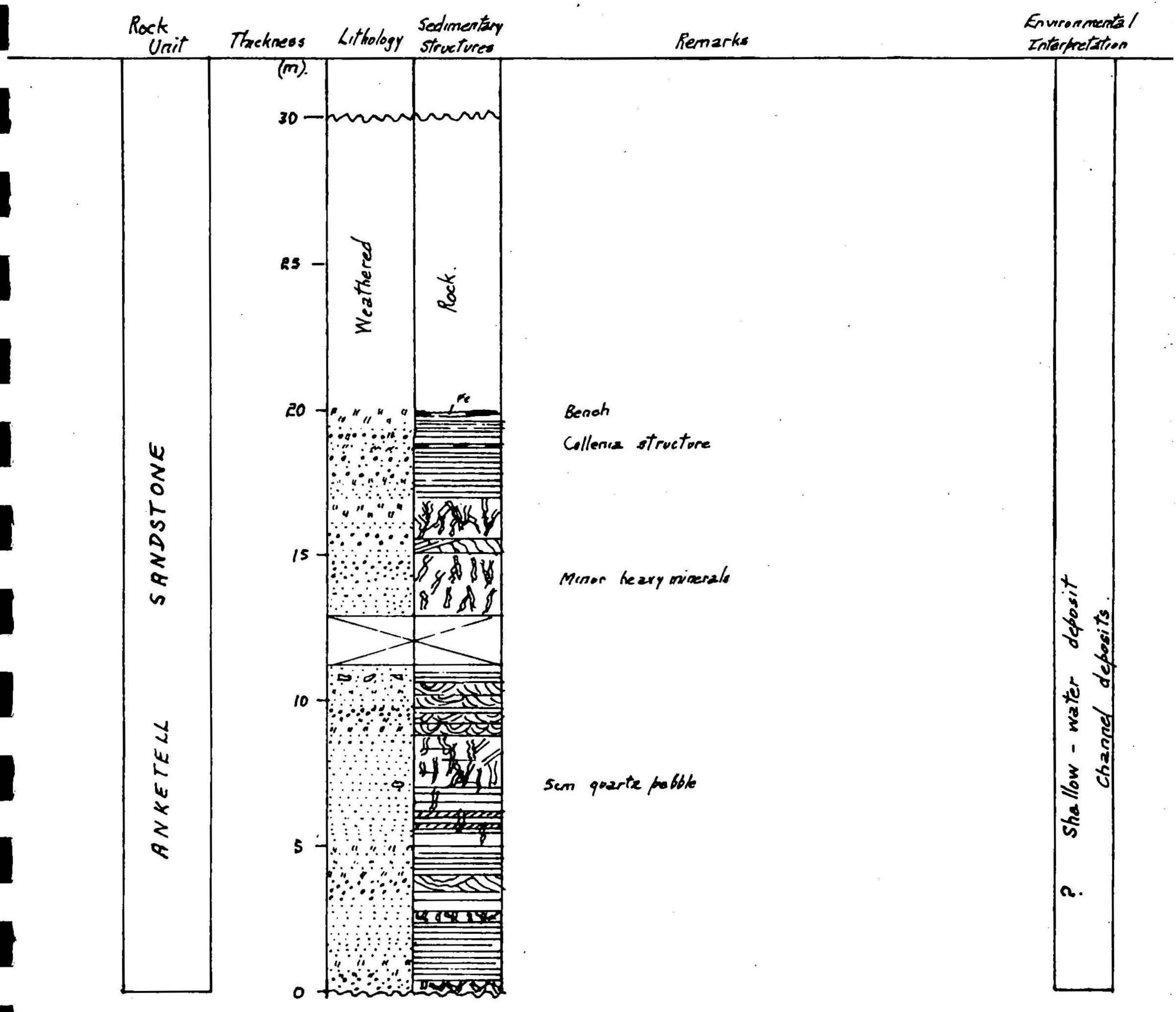
Arrow indicates lining-up sequence. Length of arrow indicates thickness of sequence

Section not exposed

KIDSON BLUFF

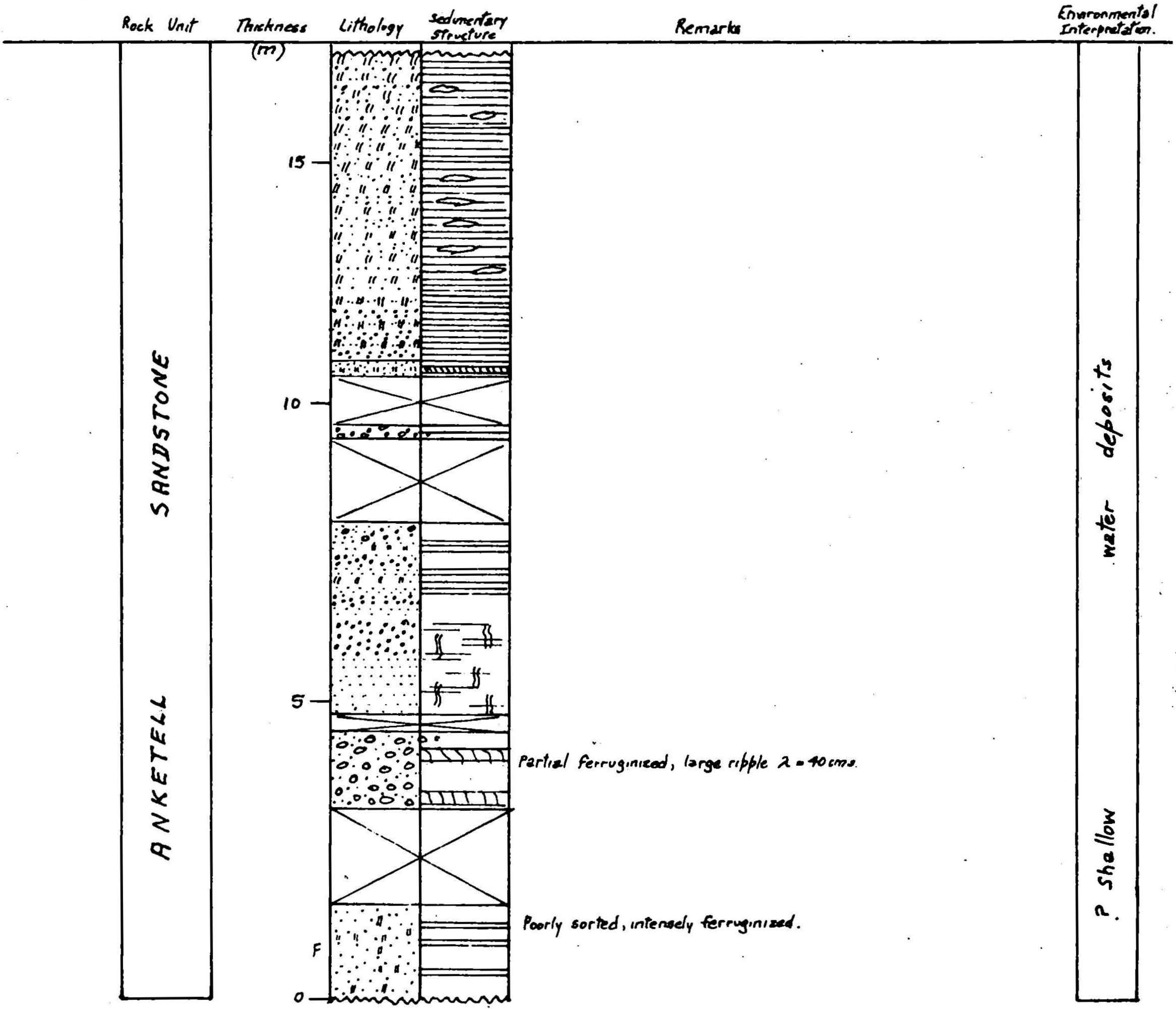
22° 15' 36" S, 125° 03' 56" E

SECTION No. A 13



SOUTH-WEST URAL SECTION No. A14

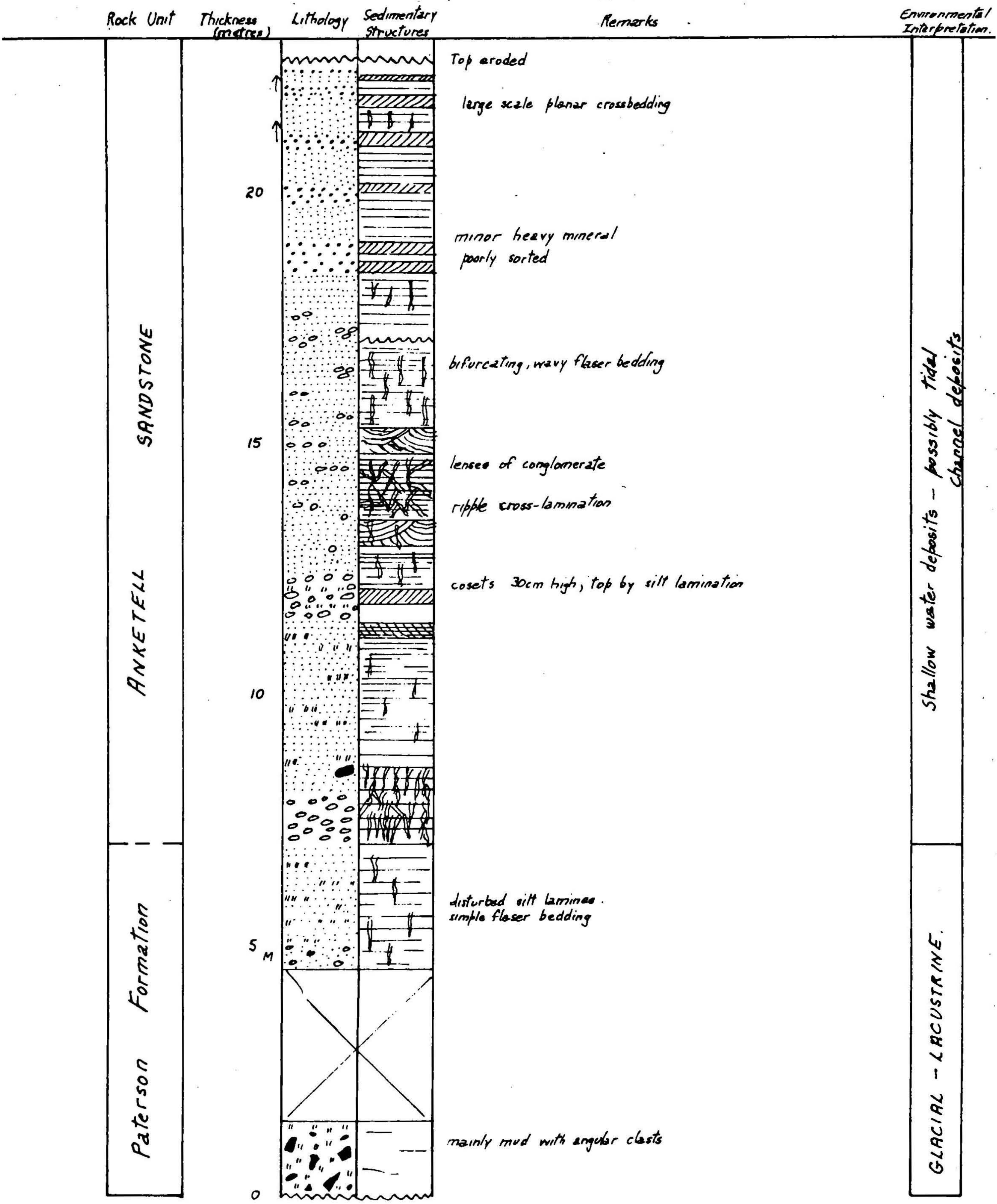
22° 41' 03" S, 124° 45' 36" E



NORTH RUNTON

SECTION No A15

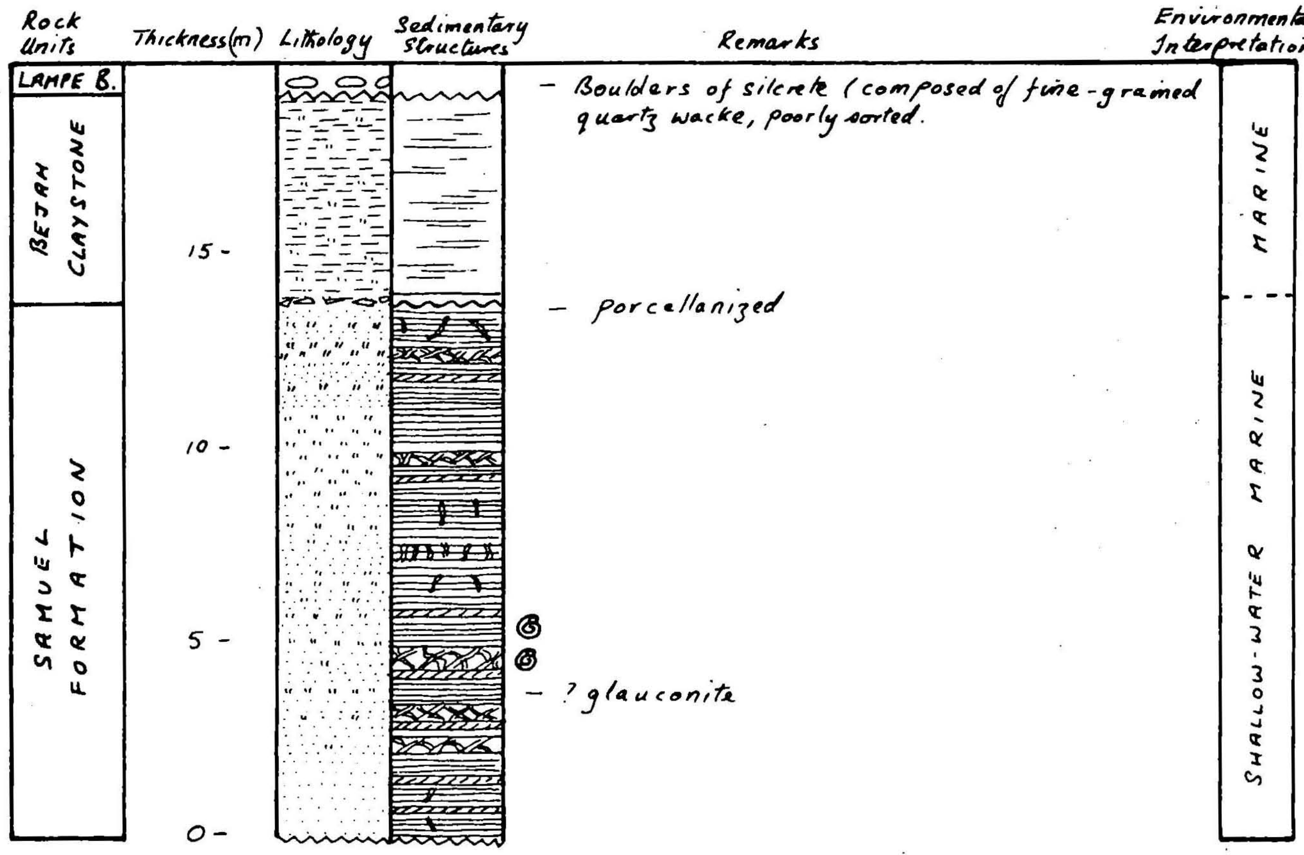
23° 11' 09"S , 123° 31' 03"E.



SOUTH EAST MORRIS

SECTION No. A16

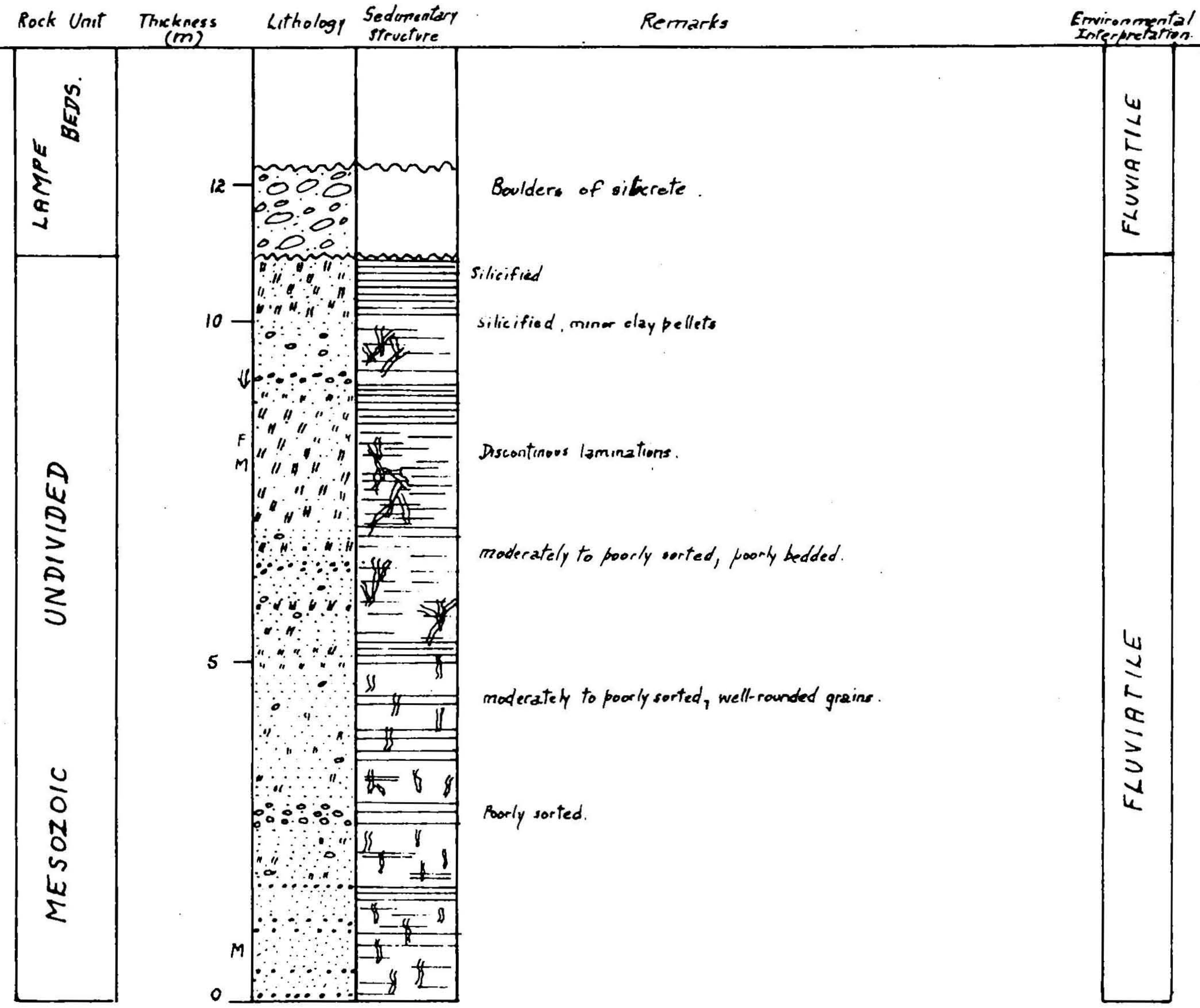
23°55'40"S. 125°43'25"E

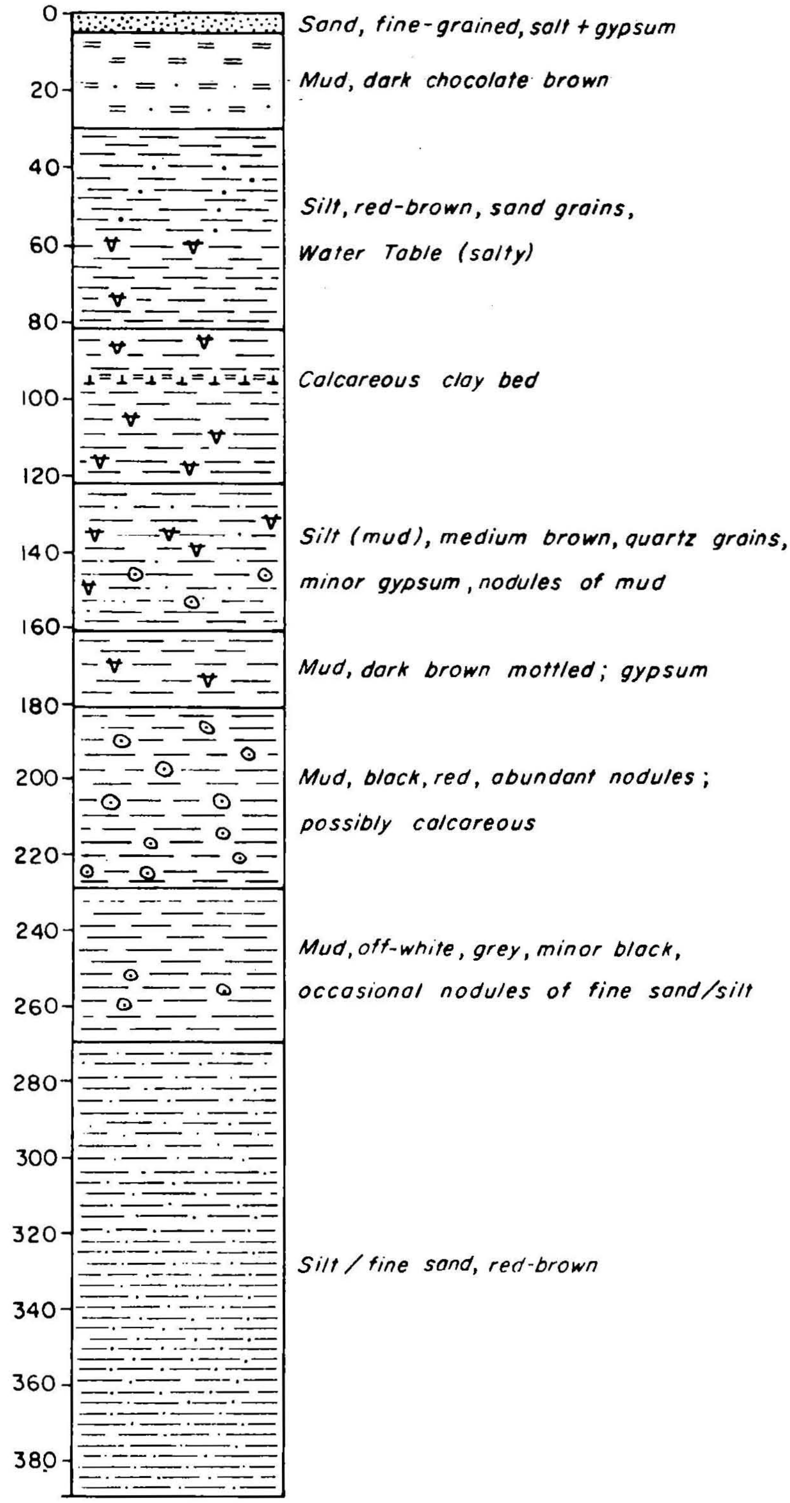


DOWLING HILLS

SECTION A17

23° 53' 48"S, 126° 17' 42" E.





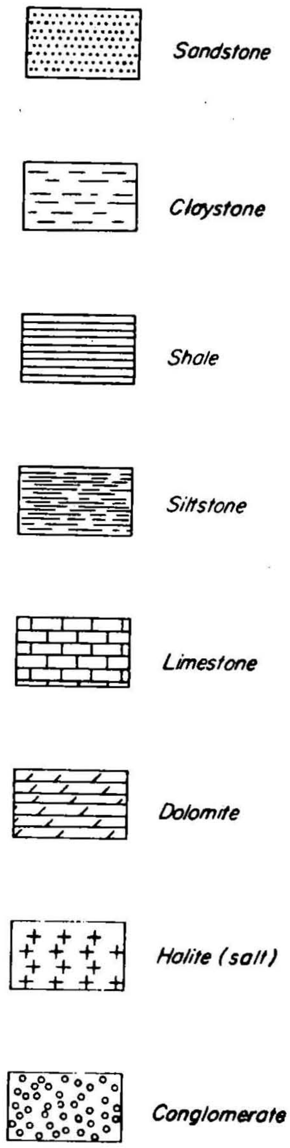
Record 1976/95 W/A/326

Section A18 Auger hole section in Lake Auld, Tabletop 1:250 000 Sheet area.

APPENDIX B

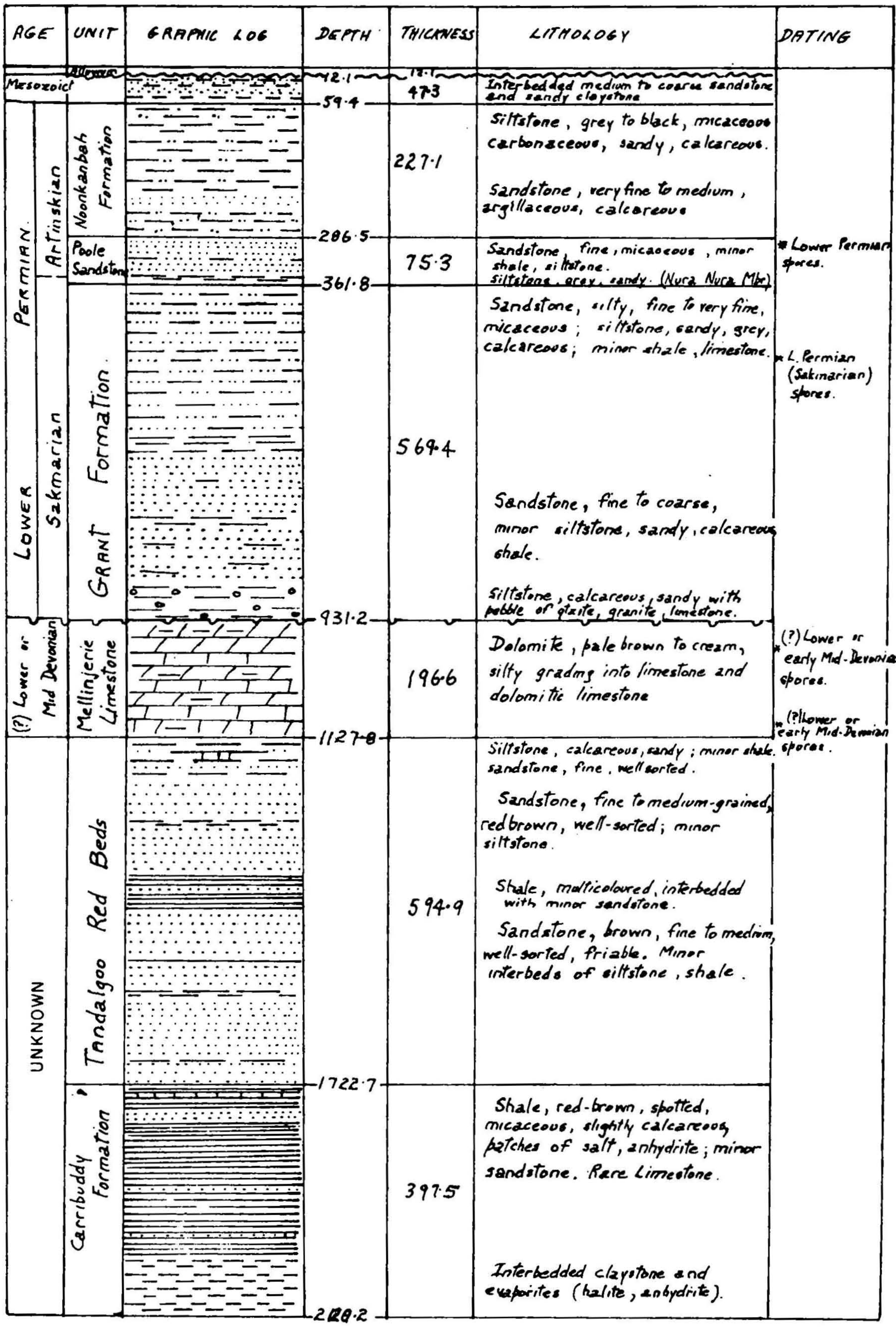
PETROLEUM EXPLORATION WELLS

Key to Lithology of Wells



BI: WAPET SAHARA No 1

Scale:- 1cm = 100m



Record 1976/95

W/A/327

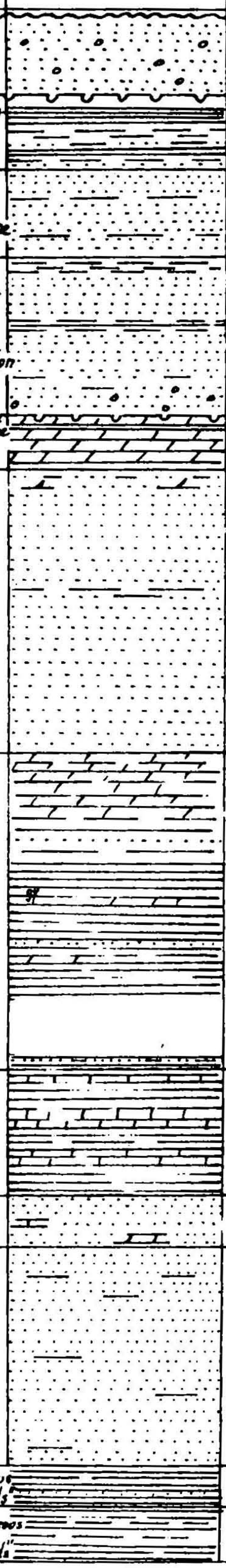
B2: WAPET KIDSON No 1

Scale: 1cm = 200m.

AGE	UNIT	GRAPHIC LOG	DEPTH	THICKNESS	LITHOLOGY	DATING.
	[illegible]		18.3			
Mesozoic				194.1	Sandstone, fine to coarse, conglomeratic clay matrix, large mica flakes. Siltstone, micaceous, silty sandstone	
Lower Permian	Lightjack Fm.		212.4	77.2	Interbedded carbonaceous siltstone, fine sst.	
	Noonkanbah Formation		289.6	310.9	Siltstone, grey, micaceous, pyritic, slightly calcareous, sandy, grades into Sandstone, fine, calcareous, micaceous. Fossil fragments.	Lower Permian (Artinskian) spores.
	Poole Sandstone		600.5	135.0	Interbedded fine sandstone + siltstone, micaceous, calcareous. Minor lignite.	L. Permian spores.
	Grant Formation		735.5	835.1	Sandstone, fine to coarse, calcareous, pebbles, minor siltstone. Siltstone, fine sandstone interbedded. Siltstone, grey, argillaceous, calcareous, minor interbeds of fine sandstone. Sandstone, medium to v. coarse, poor to well sorted, pyrite fragments, igneous pebbles; minor siltstone, shale. Sandstone, coarse to v. coarse, conglomeratic, minor siltstone.	Lower Permian Sakmarian (spores); L. Permian.— Upper Carboniferous spores.
Middle Devonian	Mellinjerie Limestone		1570.6	266.4	Interbedded, anhydrite bearing, silty dolomite, and dolomitic siltstone.	
Pre Middle Devonian	Tandalgoo Red Beds		1837	733.1	Sandstone, fine to coarse, well sorted, rounded grains, some frosted, crossbedded; minor shale, siltstone, calcareous.	
	Carribuddy Formation		2570.1	1710.0	Unit A: Dolomite, aphanatic, contains fine quartz grains, minor interbedded dolomitic shale and siltstone. Unit B: Halite, coarsely crystalline, numerous inclusions of siltstone; minor dolomitic siltstone and dolomite. Unit C: Claystone, dolomitic, calcareous; limestone, dolomite; occasional siltstone, rare sandstone, halite. Unit D: Claystone, red-brown, calcareous, dolomitic; Dolomite; halite interbeds. Unit E: Interbedded claystone, dolomite, with thin beds and veins of halite and anhydrite.	
Lower Ordovician	Goldwyer Fm.		4280.1	132.8	Interbedded siltstone and shale with thin beds of limestone. Fossils	
[illegible]			4412.9	[illegible]	Sandstone, minor siltstone.	
			4431.5			

B3: AQUITAINE WILSON CLIFFS No 1

Scale: 1cm = 175m



AGE	UNIT	GRAPHIC LOG	DEPTH	THICKNESS	LITHOLOGY	DATING
	[illegible]		12.2	12.2		
Mesozoic			181.4	169.2	Sandstone, fine to coarse, poorly sorted; minor muscovite. Ferruginous siltstone	
Lower Permian	Noonkanbah Fm.		373.4	192.0	Shale, black, silty, micaceous, grades into siltstone, fine sandstone, argillaceous calcareous, carbonaceous: marine fossils	* Lower Permian spores.
Lower Permian	Poole Sandstone		579.1	205.7	Sandstone, grey, very coarse, micaceous minor interbeds of shale, siltstone, scattered coal lenses.	* Lower Permian spores
Lower Permian	Grant Formation		966.8	387.7	Siltstone, with qtz fragments; sandstone. Sandstone, fine to medium, pyritic, minor siltstone, shale, black, carbonaceous, microconglomeratic.	* Lower Permian Spores.
Devonian	Mellinjerie Lst		1094.2	127.4	Dolomitic shale, dolomite, fine sandstone Dolomite, rare anhydrite, shale.	* Spores, Permian and Devonian mixed.
	Tandalgoo Red Beds		1778.5	684.3	Sandstone, red-brown, fine-grained with rounded and polished to subangular grains; minor dolomitic shales, silty dolomite near the top and siltstone near the middle.	
	Carribuddy Formation		2532.9	754.4	Dolomite Shale, silty, sandy, massive minor dolomitic siltstone, sandstone rare dolomicrite. "Unit A" Shale, grey, calcareous, with minor anhydrite, gypsum, mica. Minor interbeds of siltstone, sandstone, dolomitic shale. "Unit C" Halite, with minor shale and sandstone. "Unit D" Shale, minor sandstone "Unit E"	
Ordovician	Goldwyer Formation		2847.4	314.5	Shale, grey, calcareous, grade to limestone, silty with traces of anhydrite; minor siltstone, sandstone: marine fossils.	* Llandeillian * Chitinozoa * Conodonts
Ordovician	"Middle Fm."		2963.3	115.9	Sandstone, minor limestone, dolomite.	
Ordovician	"Lower Formation"		3503.6	540.3	Sandstone, quartzitic, fine to medium-grained, with minor interbeds of shale and shaley siltstone: marine fossils.	* Arenigian to Llandeillian Chitinozoa. Conodonts.
Upper Proterozoic - Cambrian	"Ferruginous Shale Beds"		3580.2	76.6	Multicoloured silty shales, siltstone, minor sandstone.	
Upper Proterozoic - Cambrian	"Carbonaceous Shale Beds"		3722.2	142.0	Black shale, minor siltstone.	

B4: AQUITAINE CONTENTION HEIGHTS No 1.

Scale: 1cm = 100m

AGE	UNIT	GRAPHIC LOG	DEPTH	THICKNESS (m)	LITHOLOGY	DATING
	[illegible]		13·7	[illegible]		
Mesozoic				74·1	Sandstone, medium to coarse, poorly sorted, argillaceous; minor siltstone, shale	
	Noonkanbah Fm.		87·8	86·9	Shales, clay, grey, silty, pyritic, carbonaceous, minor interbeds of fine sandstone.	
Lower Permian	Poole Sandstone		174·7	222·5	Sandstone, medium to coarse, poorly sorted, scattered, igneous and metamorphic rock fragments; minor interbeds of grey shale, carbonaceous siltstone.	* Lower Permian spores
Lower Permian	Grant Formation		397·2	435·5	Sandstone, medium to very coarse, poorly sorted, minor siltstone, shale. Sandstone, medium to coarse, minor rock fragments; Siltstone, grey, slightly calcareous; Shale, grey, microconglomeratic,	Lower * Permian spores.
	Mellinjerie Lst		832·7	17·7	Dolomitic shale, dolomitic siltstone.	
Devonian	Tandalgoo Red Beds		850·4	60·7	Sandstone, fine to very fine, some medium, well-sorted,	
Devonian	Carribuddy Formation		911·1	431·6	Shale, dolomitic interbedded with sandstone fine-grained, calcareous, traces of anhydrite, dolomite "Unit A" Shale, sandy interbedded with fine to medium, calcareous sandstone. Shale, grey, calcareous, and brown clay. Sandstone, medium-grained. Interbedded shale and siltstone.	
Ordovician	Goldwyer Formation		1342·7	237·7	Dolomitic shale, siltstone, dolomite Sandstone, very fine to fine, calcareous Clay, silty shale, thin limestone beds, minor sandstone.	* U. Ordovician Scolecodont. Conodonts. * Llanvirnian to Llandeilian chitinozoans.
Ordovician	Middle Fm.		1580·4	93·0	Sandstone, mainly fine with minor coarse, interbeds of shale, limestone.	
Ordovician	Lower Fm.		1673·4	36·3	Sandstone, fine to medium, grey, minor siltstone, shale.	* "Arenig"
			1709·7			

APPENDIX C

PERMIAN FOSSILS FROM THE TABLETOP 1:250 000 SHEET AREA, WESTERN AUSTRALIA

by J.M. Dickins

ABSTRACT

Identifications of Permian marine invertebrate fossils are listed from the Cuncudgerie Sandstone now replaced by Poole Sandstone, the Triwhite Sandstone and possibly the Dora Shale now replaced by the Noonkanbah Formation from the Tabletop 1:250 000 Sheet area in the southwestern part of the Canning Basin, Western Australia. The fauna from the Cuncudgerie Sandstone is regarded as the time equivalent of the Nura Nura Member of the Poole Sandstone in the Fitzroy Trough and the Triwhite Sandstone as the equivalent of the upper part of the Noonkanbah Formation or the Lightjack Formation. The age of the intervening Dore Shale is unclear. The fauna of the Cuncudgerie Sandstone lived in part in a sublittoral environment and in part probably in slightly deeper water, and the fauna of the Triwhite Sandstone was probably sublittoral with, in places, a hard substrate.

INTRODUCTION

Permian fossils from this area are first referred to in an unpublished report by W.S. Dun (Jones, 1922). Dun's identifications were published by Glauert (1925) in a paper listing Western Australia fossils. Reeves (1949) also referred to fossils in an unpublished report.

Published identifications are given by Crespin and Dickins & Thomas *in* Traves, Casey & Wells (1956) and by Dickins *in* Veevers & Wells (1961). Further unpublished identifications have been given by Dickins and Thomas. All these identifications, except the early ones of Dun and Reeves, are consolidated in the present report together with those from the present (1975) survey.

IDENTIFICATIONS

CUNCUDGERIE SANDSTONE

T 16, Lat. 22°45' Long. 123°25'[1] - Helen Hill, Canning Stock Route, 2½ miles (4 km) north-northwest of Well 27 (Veevers & Wells, 1961, pp. 287, 288).

Pelecypods

Myonia? sp. nov.[2]

Brachiopods (identified by G.A. Thomas)

Linoproductus sp. nov.

Pseudosyrinx sp. nov.

TK5A, Scott Bluff, east side of Lake Blanche, collected W.J. Koop of West Australian Petroleum Pty Ltd, 1963.

Pelecypods

Myonia subarbitrata Dickins 1963[3]

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1. The latitude and longitude is that taken from Veevers & Wells. The correct position of Helen Hill is that shown for T81.
2. This identification can now be revised to *Myonia* cf. *subarbitrata* Dickins (1963).
3. Waterhouse (1969, p.321 has proposed a new name *Myofossa* with *M. subarbitrata* as type species.

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Brachiopods

"Chonetes" sp.

Aulosteges or Taeniothaerus sp. indet.

Strophalosia cf. irwinensis Coleman 1957

Permorthetetes lindneri Thomas 1958

Pseudosyrinx sp. aff. nagmargensis (Bion) Identified by

Phricodothyris sp. nov. G.A. Thomas

T81, Helen Hill; 22°46'21"S; 123°39'18"E

Pelecypods

Oriocrassatella sp. (as in Callytharra Formation and Nura Nura Member of Poole Sandstone)

Stutchburia cf. variabilis Dickins 1957

Megadesmus sp. (as in Lyons Group)

Conulariid (unidentified)

T127, Scott Bluff, Lake Blanche; 22°31'06"S; 123°14'06"E

Pelecypods

Stutchburia cf. variabilis Dickins 1957

Etheripecten cf. tenuicollis (Dana) 1847

Gastropods

Mourlonia (_Pseudobaylea_) cf. _freneyensis_ Dickins 1963

Brachiopods

Cancrinella sp.

Aulosteges and _Taeniothaerus_

Neospiriferid

Orthotetid

Fenestellids

DORA SHALE

Northern end of Lake Dora - 2 inches (5 cm) below the base of the salt crust (Registered No. MF 948). Crespin _in_ Traves, Casey & Wells, 1956, pp. 54, 55.

Foraminifers

Ammodiscus nitidus Parr

Ammobaculites cf. _woolnoughi_ Crespin & Parr

Hyperamminoides acicula Parr

Hyperamminoides cf. _expansus_ Plummer

TRIWHITE SANDSTONE

T1, 4 miles (6.4 km) east of the central portion of Lake Dora, 1 mile (1.6 km) east-southeast of Dunn Soak (Traves, Casey & Wells, 1956, p. 51).

Pelecypods

Astartila blatchfordi (Hosking) 1931

Gastropods

Warthia cf. micromphala (Morris) 1845

Ptychomphalina maitlandi Etheridge Jnr 1903

T1141, 7 km southeast of Scott Bluff; 22°29'12"S; 123°16'19"E.

Pelecypods

Atomodesma mytiloides Beyrich 1865

Modiolus sp.

Etheripecten sp. (as in Balgo Hills)

Brachiopods

Indet. productid

Notospirifer? sp. nov. (surface pits and adminicula not characteristic of Notospirifer)

Wood and Bony plate.

T1148, 7.5 km NNW of Scott Bluff; 22°23'48"S; 123°11'06"E.

Pelecypods

Merismopteria sp.

Schizodus kennedyensis? Dickins 1956

Gastropods

Stachella sp.

Mourlonia (*Mourlonia*) sp.

T1153, 2.5 km southeast of Dunn Soak; 22°04'05"S; 123°10'12"E.

Pelecypods

Astartila cf. *blatchfordi* (Hosking) 1931

T1155, 20 km SSE of Triwhite Hills; 22°16'00"S; 123°17'42"E

Pelecypods

Astartila cf. *blatchfordi* (Hosking) 1931

Atomodesma mytiloides Beyrich 1865

CORRELATION OF FAUNAS

Cuncudgerie Sandstone

Evidence for correlation of the fauna of the Cuncudgerie Sandstone with that of the Nura Nura Member of the Poole Sandstone of the Canning Basin, the Callytharra Formation of the Carnarvon Basin and the Fossil Cliff Formation of the Perth Basin is substantial. *Myonia subarbitrata*, *Permorthotetes lindneri*, *Oriocrassatella* sp. and *Mourlonia* (*Pseudobaylea*) *freneyensis* occur also in the Nura Nura Member. *M.* (*Pseudobaylea*) *freneyensis*, *Strophalosia irwinensis* and *Myonia subarbitrata* occur in the Fossil Cliff Formation and *Oriocrassatella* sp. in the Callytharra Formation. *Pseudosyrinx* sp. aff. *nagmargensis* occurs also in the Lyons Group and Callytharra Formation of the Carnarvon Basin. The remaining elements of the fauna are consistent with this correlation, and the part of the Cuncudgerie Sandstone bearing the marine fauna can be regarded as the time equivalent of the Nura Nura Member.

Dora Shale

Although the foraminifera recorded by Crespin were regarded as coming from the Dora Shale their source is not clear. The foraminifera might have been derived from the Triwhite Sandstone or even from the Cuncudgerie Sandstone, so the identifications give no certain indication of the correlation of the Dora Shale.

Triwhite Sandstone

Time equivalence with the upper part of the Noonkanbah Formation or the Lightjack Formation of the Liveringa Group is indicated by *Astartila blatchfordi*, *Ptychomphalina maitlandi* and *Etheripecten* sp. *A. blatchfordi* and *P. maitlandi* are characteristic of the Upper Noonkanbah rather than the Lightjack which perhaps indicates that the Triwhite Sandstone is equivalent to the Upper Noonkanbah rather that the younger Lightjack Formation.

PALAEOECOLOGY

Cuncudgerie Sandstone

Two somewhat different environments appear to be represented at Helen Hill (T16; T81) and Scott Bluff (TK5A, T127). At Helen Hill pelecypods predominate greatly in numbers - hundreds of individuals compared with a few specimens of each brachiopod species. The pelecypods *Oriocrassatella*, *Stutchburia* and *Megadesmus* are commonly associated with sand and are adapted to living in littoral or sublittoral turbulent conditions (see Dickins, 1963, p. 25).

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At Scott Bluff, on the other hand, brachiopods predominate, and apparently this fauna lived in a less turbulent environment, possibly in slightly deeper water.

Triwhite Sandstone

The assemblages of the Triwhite localities are fairly similar to each other, suggesting a similar life environment/ Pelecypods of the sublittoral suite (Astartila, Schizodus) occur together with byssally attached forms such as Atomodesma, Modiolus and Merismopteria and the gastropods Stachella, Mourlonia and Ptychomphalina. A sandy, relatively shallow bottom with some hard substrate is suggested.

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APPENDIX D

EARLY CRETACEOUS BIVALVES FROM MORRIS AND RUNTON 1:250 000 SHEETS, SOUTHERN CANNING BASIN, WESTERN AUSTRALIA

by S.K. SKWARKO

Four collections of impressions after bivalves from the southern Canning Basin, Western Australia, are of Aptian (Early Cretaceous) age. The assemblage is limited in genera and species and its preservation is indifferent, so definite identifications could not be made in every case. A fifth collection (M1072: 23°54'00"S; 125°52'24"E) has a problematicum, possibly a worm burrow, which cannot be dated but which somewhat resembles another problematicum from the Gibson Desert to the south, which may be of Permian age.

The lithology at all the sampled outcrops consists of silty quartz sandstone, massive or finely laminated, strongly leached, ironstained, and in places impregnated with silica.

Locality M21: 65 km north of Traegar Hills; 23°15'26"S, 124°43'18"E; Morris 1:250 000 Sheet. Collected by M.J. Jackson and R.W.A. Crowe. Formation: Samuel Formation.

This locality yielded the richest assemblage, consisting of ?*Palaeomoera*? *mariaeburiensis* (Etheridge Snr, 1872), *Tancretella plana* (Moore, 1870), *Tatella maranoana* (Etheridge Jnr, 1892) and also some bivalves which could not be identified. ?. *mariaeburiensis* is known from the Aptian strata at Maryborough, eastern Queensland. Because of unsatisfactory preservation it is not possible to positively compare our specimens with those at Maryborough, but they are certainly identical to those from the Aptian strata of the Gibson Desert to the south. *T. plana* has a wide distribution in Australia as it is known from Aptian strata in central Queensland, the Lake Eyre area of South Australia, and northwestern New South Wales, as well as in the Bentley and Runton 1:250 000 Sheet areas in the Gibson Desert. *T. maranoana* is known from Aptian beds at Maryborough, central Queensland, Lake Eyre area, and at Rumbalara in the Northern Territory.

Locality M22: 48 km north-northeast of Traegar Hills; 23°27'42"S, 124°49'26"E; Morris 1:250 000 Sheet area. Collected by M.J. Jackson and R.W.A. Crowe.

Formation: Samuel Formation.

This locality yielded only some small specimens of ?*P. mariaeburiensis*.

Locality RN2006: 25 km east-southeast of Bejah Hills; 23°52'12"S, 124°22'12"E; Runton 1:250 000 Sheet area. Collected by A.N. Yeates and M.J. Jackson.

Formation: Samuel Formation

Locality RN2008: 40 km south-southeast of Bejah Hills; 23°57'00"S, 124°29'42"E; Runton 1:250 000 Sheet area. Collected by A.N. Yeates and M.J. Jackson.

Formation: Samuel Formation

These two localities yielded only shells which probably belong to *Pseudavicula anomala* (Moore, 1870) - one of the key Aptian fossils in Australia - previously identified from assemblages in Maryborough, central Queensland, Lake Eyre area, Rumbalara, northwest New South Wales and the Gibson Desert.

All the above bivalves further attest to the particularly uniform sedimentary and climatic conditions in the shallow seas covering much of the Australian continent in Early Cretaceous times, which allowed the individual species wide geographical distribution.

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TABLE 1. STRATIGRAPHY OF AREA

Age	Rock Unit and Map Symbol	Approximate Maximum Thickness (m)	Lithology	Stratigraphic Relations	Remarks
	Qz	5	Red quartz sand, fine to medium-grained	Superficial deposit	Aeolian; thickness does not include height of dunes
	Qs	10?	Quartz sand, silt, minor gypsum	Superficial deposit	Alluvial and aeolian; in depressions
	Qa	10?	Silt, clay, sand, minor gravel	Superficial deposit	Alluvial outwash adjacent to some mesas
	Ql	100?	Clay, silt and brine-saturated red sand, gypsum	Superficial deposit	Evaporitic and fluvio-lacustrine
Quaternary	Czk	50?	Calcrete, chalcedony	Superficial deposit	Alluvial and evaporitic in lines of ancient drainage; pedogenic in places; aquifer
	Czs	1-2	Sand, silt, ferruginous pisoliths, minor gravel, clay	Superficial deposit	Lateritic soil capping or flanking laterite plateaux

TABLE 1 (Contd)

Age	Rock Unit and Map Symbol	Approximate Maximum Thickness (m)	Lithology	Stratigraphic Relations	Remarks
	Czl	5	Laterite, pisolitic or massive	Superficial deposit	Pedogenic; upper part of lateritic weathering profile; plateau-forming
	Czf	1	Ferricrete	Superficial deposit	Weathering product
	Czt	3	Silcrete	Superficial veneer	Weathered profile developed on highly quartzose rocks
Cretaceous to Tertiary	Lampe Beds KTl	2	Sandstone, fine to coarse; poorly sorted; pebble conglomerate; intensely silicified	Unconformable on Paterson and Samuel Formations, Heavitree Quartzite; top eroded	Fluviatile
	Lake George Beds KTg	5+	Sandstone, fine to very coarse; poorly sorted; granule conglomerate; massive; locally silicified, ferruginous	Unconformable but locally gradational on Anketell Sandstone and Callawa Formation; capped by laterite	Contains possible root moulds; interpreted as fluviatile and partly pedogenic
	Undivided M	10+	Sandstone, siltstone, conglomerate	Uncertain	Possibly equivalent to Callawa Formation. Crops out at Dowling Hills (RYAN)

TABLE 1 (Contd)

Age	Rock Unit and Map Symbol	Approximate Maximum Thickness (m)	Lithology	Stratigraphic Relations	Remarks
Early Cretaceous	Bejah Claystone Ke	10	Claystone, minor siltstone, thin laminae of very fine sandstone; massive to poorly bedded; porcellanite	Conformable on Samuel Formation; unconformable beneath Lampe Beds	Fossiliferous; shallow marine
	Samuel Formation Kls	30	Sandstone, very fine to fine laminated to thin-bedded; siltstone; coarse sandstone lenses bioturbated	Grades laterally into and lies on Anketell Sandstone; disconformable on Cronin Sandstone; Conformable beneath Bejah Claystone, unconformable beneath Lampe Beds	Fossiliferous; shallow marine. Kaolinized at surface
	Anketell Sandstone Ka	100	Sandstone, fine and siltstone interbedded with lenticular coarse sandstone, granule and pebble conglomerate; laminated to thin-bedded; cross-bedded; minor intraformational claystone conglomerate; some bioturbation	Conformable on Callawa Formation and Cronin Sandstone; unconformable on Permian and Precambrian rocks; laterally equivalent to Samuel Formation	Rhizocorallium burrows, wood fragments; paralic

TABLE 1 (Contd)

Age	Rock Unit and Map Symbol	Approximate Maximum Thickness (m)	Lithology	Stratigraphic Relations	Remarks
Late Triassic(?) to Early Cretaceous	Cronin Sandstone Mr	100	Sandstone, fine to coarse, minor mudstone, pebble conglomerate; crossbedded; poorly sorted; bioturbated	Unconformable on Paterson Formation; conformable beneath Anketell Sandstone; disconformable beneath Samuel Formation	Plant fossils at Cronin Hills (RUNTON); fluvial: confined to Officer Basin only
	Callawa Formation JKc	100	Sandstone, coarse to very-coarse; conglomerate; crossbedded; minor siltstone, fine sandstone; intensely ferruginized	Unconformable on Noonkanbah Formation and Triwhite Sandstone conformable beneath Anketell Sandstone	Distinctive dark photo-pattern; fluvial
			MAJOR UNCONFORMITY		
	Undivided Pz	30+	Silty sandstone, fine to coarse, thin-bedded; crossbedded; micaceous siltstone, laminated	Unconformably overlain by Anketell Sandstone	Confined to southeast Ryan Sheet area

TABLE 1 (Contd)

Age	Rock Unit and Map Symbol	Approximate Maximum Thickness (m)	Lithology	Stratigraphic Relations	Remarks
Early Permian	Triwhite Sandstone Pt	77+	Sandstone, fine to medium, silty, micaceous, interbedded with siltstone, shale; laminated to medium-bedded; cross-bedded minor intraformational claystone conglomerate	Conformable on Noonkanbah Formation; unconformable beneath Callawa Formation, Anketell Sandstone and Lake George Beds	Fossiliferous; trace fossils: shallow marine
	Noonkanbah Formation Pn	310+	Mudstone, poorly bedded and laminated; siltstone; shale, carbonaceous; sandstone, fine, silty, micaceous, feldspathic; laminated to thin-bedded	Conformable between Poole Sandstone and Triwhite Sandstone; unconformable beneath Callawa Formation and Anketell Sandstone	Fragmental plant remains, foraminifera, marine macrofossils; shallow marine
	Poole Sandstone	206	Sandstone, fine to medium, well sorted, thin-bedded, interbedded siltstone; minor intra-formational conglomerate, coarse sandstone; cross-bedded	Disconformable on Grant Formation; conformable beneath Noonkanbah Formation; unconformable beneath Anketell Sandstone	Fossiliferous; shallow marine
	Grant Formation	855	Sandstone, fine to medium, pebbly; laminated silt-stone and claystone, slightly calcareous, micaceous, carbonaceous, rare dropstones	Disconformable beneath Poole Sandstone; uncon-formable on Mellinjerie Limestone	Shallow-water glacial environment, some marine influence. Intersected in Aquitaine Wilson Cliffs No. 1, in WAPET Kidson No1 and Sahara No. 1

TABLE 1 (Contd)

Age	Rock Unit and Map Symbol	Approximate Maximum Thickness (m)	Lithology	Stratigraphic Relations	Remarks
	Paterson Formation Pa	100+	Sandstone, fine to very coarse; conglomerate, poorly sorted; graded siltstone and claystone, laminated, with pebble and boulders; cross-bedded	Unconformable on Precambrian, undivided Palaeozoic, and Mellinjerie Limestone; Unconformable beneath Cronin Sandstone, Callawa Formation, Anketell Sandstone and Lampe Beds; laterally equivalent to parts of Grant Formation.	Rare plants; glacial continental, including fluvial and lacustrine deposits
			UNCONFORMITY		
Middle Devonian	Mellinjerie Limestone Dm	266	Dolomitic shale, dolomite, limestone. Minor fine to medium sandstone; minor anhydrite	Unconformable beneath Grant Formation; unconformable on Tandalgoo Red Beds	Subsurface only; intersected in Aquitaine Wilson Cliffs No. 1, Contention Heights No. 1, and WAPET Kidson No. 1, Sahara No. 1
Early Devonian	Tandalgoo Red Beds Dt	1400	Red-brown fine sandstone, with minor interbeds of siltstone, shale, limestone	Conformable between Mellinjerie Limestone and Carribuddy Formation	Subsurface only; intersected in Aquitaine Wilson Cliffs No. 1, Contention Heights No. 1 and WAPET Kidson No. 1

TABLE 1 (Contd)

Age	Rock Unit and Map Symbol	Approximate Maximum Thickness (m)	Lithology	Stratigraphic Relations	Remarks
Late Ordovician to Early Devonian	Carribuddy Formation Sc	2000	Dolomite, dolomitic siltstone, shale, halite, anhydrite; minor sandstone	Conformable beneath Tandalgoo Red Beds and disconformable on Goldwyer Formation	Subsurface only; intersected in Aquitaine Wilson Cliffs No. 1, Contention Heights No. 1, WAPET Kidson No. 1 and Sahara No. 1
Ordovician	O	1500	Sandstone, fine-grained; siltstone, shale, dolomite, limestone, minor evaporite	Conformable beneath Goldwyer Formation and unconformable on Precambrian sediments	Subsurface only; intersected in Aquitaine Wilson Cliffs No. 1, Contention Heights No. 1 and WAPET Kidson No. 1
			MAJOR UNCONFORMITY		
(?) Late Proterozoic or (?)Cambrian	Undivided Ƀ-Є	220+	Ferruginous shale, micaceous siltstone; black, carbonaceous shale; minor sandstone, limestone	Unconformable on Archaean and Proterozoic rocks; overlain unconformably by Ordovician; relation with other Proterozoic units unknown	Subsurface only; intersected in Aquitaine Wilson Cliffs No. 1. May be equivalent to Amadeus Basin units to the east
	Maurice Formation Ƀuu	900	Very fine to medium quartzose sandstone, cross-bedded; minor siltstone, micaceous, laminated	Conformable on Ellis Sandstone to east of Sheet area; top eroded, probably overlain by Paterson Formation unconformably	Topmost Proterozoic unit of the Amadeus Basin sequence. Occurs tightly folded in Baron Range (RYAN)

TABLE 1 (Contd)

Age	Rock Unit and Map Symbol	Approximate Maximum Thickness (m)	Lithology	Stratigraphic Relations	Remarks
Adelaidean	Ellis Sandstone Ᵽut	500+	Fine to medium, feldspathic, quartzose sandstone, thin to medium-bedded, cross-bedded; minor siltstone	Conformable beneath Maurice Formation. Unconformable on Bitter Springs Formation to the east	Probably correlated with Erica Sandstone in the Granites-Tanami area
	Bitter Springs Formation Ᵽub	100+	Fine sandstone, micaceous siltstone, dolomite, thin-bedded; minor limestone	Conformable on Heavitree Quartzite; top eroded	
	Heavitree Quartzite Ᵽuh	200+	Fine to medium quartz and feldspathic sandstone, thin-bedded, cross-bedded; minor siltstone, pebble conglomerate	Conformable beneath Bitter Springs Formation; base not exposed	Basal formation of Amadeus Basin sequence. Forms bold strike ridges
Carpentarian	Mount Webb Adamellite Ᵽgm	-	Hornblende-biotite adamellite	Intrudes Pollock Hills Formation	Photo-interpreted only
	Pollock Hills Formation Ᵽps; $Ᵽps_a$	25+	Feldspathic sandstone, fine to medium; siltstone, minor conglomerate. Porphyritic acid lava	Probably unconformable on Archaean and Proterozoic rocks; unconformably overlain by Heavitree Quartzite	Part of the Arunta Block sequence