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# PRELIMINARY RESULTS OF GEOLOGICAL MAPPING IN THE OFFICER BASIN, WESTERN AUSTRALIA, 1971

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## ABSTRACT

This report describes the results of the joint mapping project conducted in the Officer Basin during 1971 by the Geological Survey of Western Australia and the Bureau of Mineral Resources. The Officer Basin, which extends from South Australia into Western Australia, contains a poorly known sedimentary sequence of Proterozoic and Phanerozoic age. The following basin boundaries have been provisionally adopted for the Western Australian part of the basin:

(1) the Warri Gravity Ridge in the north;

(2) the base of the Townsend Quartzite in the northeast;

(3) the northern limit of the Tertiary deposits of the Eucla Basin in the south;

(4) the extent of the Permian glacial deposits in the west and southwest.

The following new stratigraphic names are herein defined: Lefroy Beds, Lupton Beds, Clutterbuck Beds (Proterozoic), Babbagoola Beds, Browne Beds (Proterozoic or Palaeozoic), Wanna Beds (Palaeozoic), Samuel Formation (Cretaceous), Lampe Beds (Cretaceous to Cainozoic) and Plumridge Beds (Cainozoic). The Townsend Quartzite is redefined to exclude the Lefroy Beds (old name: Brown Range Siltstone). Babbagoola Beds and Browne Beds are amended names with respect to previous unpublished usage, and Bejah Claystone is an amendment of "Bejah Beds". The name Paterson Formation is used in preference to "Wilkinson Range Beds" or "Yowalga Sandstone", which names were previously used for the Permian glacial and fluvioglacial deposits in the Officer Basin.

Permian and Cretaceous deposits have been traced from the Canning Basin southwards into the Officer Basin. Permian fluvioglacial and lacustrine deposits were mapped over most of the basin. Fossiliferous marine Cretaceous strata are confined to the northern part of the Officer Basin (north of latitude 27°45′S), while unfossiliferous siliciclastics and tholeiitic basalt of probable Lower Palaeozoic age crop out near the South Australian border.


## INTRODUCTION

The Western Australian part of the Officer Basin, which has an area of about 260,000 square kilometres (100,000 miles$^2$), underlies much of the area known as the Gibson and Great Victoria Deserts (Plate 10). The Gibson Desert was mapped by Wells (1963), but only a few geological traverses were made over the remainder prior to 1970, (Talbot and Clarke, 1917; Forman, 1933; Utting, 1955; Leslie, 1961; Sofoulis, 1962; and Daniels, 1969a, b, c).

The Hunt Oil-Placid Oil-Exoil consortium made aeromagnetic, photogeological, gravity and seismic surveys over parts of the basin, culminating in stratigraphic drilling during 1965 and 1966 (P. Jackson, 1966b). However, little attention was paid to the surface exposures and little information was collected on the relative distribution of the marine Cretaceous rocks in the north (Wells, 1963), the fluvial and glacial Permian deposits in the south (Talbot and Clarke, 1917), and the Lower Palaeozoic sequence now known near the South Australian border.

The Alliance Petroleum-Union Oil consortium, which worked on the northern part of the basin, made an aeromagnetic and a photogeological survey in addition to their surface reconnaissances. Their reconnaissance surveys gave some useful information on the regional distribution of the various formations (Wilson, 1964; Mack and Herrmann, 1965).

A geological reconnaissance by the Geological Survey of Western Australia and the Bureau of Mineral Resources in 1970 resulted in a preliminary reappraisal of the geology of the basin (M. Jackson, 1971; Lowry, 1971). This reconnaissance was followed by a systematic mapping programme in 1971. Because of difficult ground transport, mapping was mainly done by helicopter. The results of this survey, which will be followed by stratigraphic drilling and geophysical work in 1972, are to be recorded on 18 geological maps on a 1:250,000 scale and in a bulletin synthesizing the geology of the basin. The aims of this paper are to systematize the stratigraphic nomenclature and to make available rapidly the principal findings of the 1971 mapping programme. Rock unit names which do not conform to the Australian Code of Stratigraphic Nomenclature (Geol. Soc. Aust., 1964) have been used in previous literature on the basin. To avoid confusion and to systematize the stratigraphy of the basin all the names used have been examined and modified where necessary to bring them into accord with the code. In addition two units which do not form part of the Officer Basin sequence, i.e. the Clutterbuck Beds (a Precambrian inlier forming part of the Amadeus Basin Proterozoic succession) and the Plumridge Beds (Eucla Basin), are also described.

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An expanded version of this paper will be available as a Bureau of Mineral Resources 1972 Record

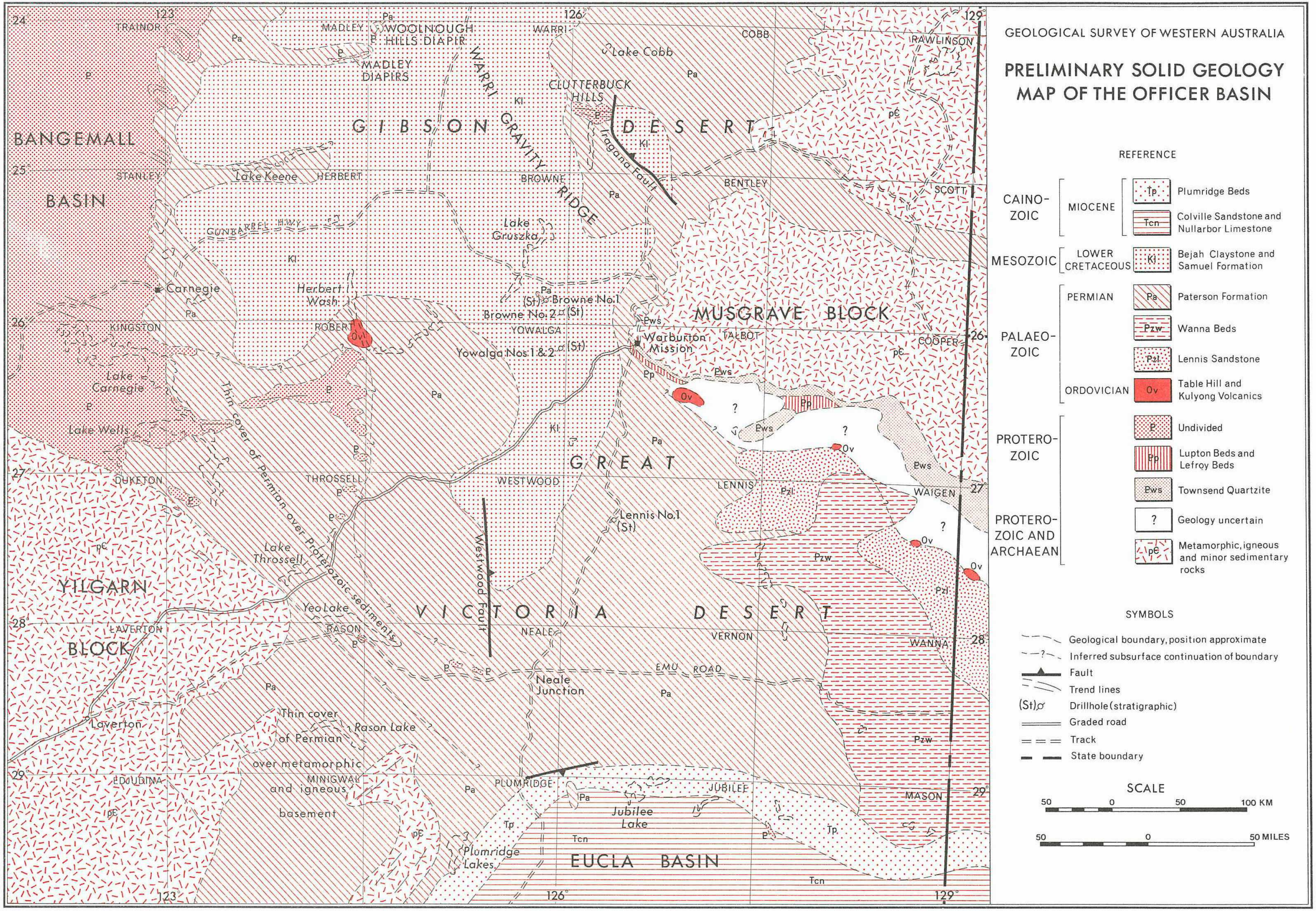


PLATE 10

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## BASIN DEFINITION

The name Officer Basin has been used in Western Australia for the area between the Bangemall Basin, the Yilgarn Block, the Eucla Basin, the Musgrave Block and the Canning Basin. This basin contains a Proterozoic and Phanerozoic sequence and is the extension of the Officer Basin in South Australia, where the name Officer Basin originated (Australia B.M.R., 1960, p. 39). Geophysical evidence indicates that a sedimentary sequence up to 5,500 metres (18,000 ft) thick is present in parts of the area (P. Jackson, 1966b; Turpie, 1967). Owing to the flat-lying attitude of the surface strata, exposures give little information on the nature of this thick sedimentary sequence.

Ideally, a sedimentary basin, i.e. an area characterized by long-continued subsidence and more or less concomittant sedimentation, should be defined in genetically meaningful terms. That is, the boundaries chosen should preferably be of structural and/or palaeogeographic significance. In the present state of knowledge it is unfortunately impossible to give more than a provisional definition of the Officer Basin.

The limits of the Officer Basin (W.A.) used here are the Warri Gravity Ridge in the north, the extent of the continuously preserved Permian in the west and southwest, the Tertiary cover of the Eucla Basin in the south, and the base of the Townsend Quartzite in the northeast. The first three of these limits were used by Playford and Cope (1970, Fig. 3) and the fourth limit is in accordance with South Australian usage (Johnson, 1963; Parkin, 1969). Two of these boundaries, the extent of the Permian deposits and the extent of the Tertiary cover of the Eucla Basin, are merely convenient limits. The Warri Gravity Ridge probably corresponds with a basement high, and is a convenient boundary with the Canning Basin. The base of the Townsend Quartzite is chosen as a boundary as it is the first major, well exposed, angular unconformity of regional significance beneath the Phanerozoic strata that crop out over much of the basin. Although in the overlying sequence some low-angle unconformities do occur, none of these seem to be of the same magnitude and extent as the one at the base of the Townsend Quartzite, which marks the beginning of a widespread depositional phase.

Two of these other unconformities are fairly important. These are the unconformity beneath the Kulyong, Table Hill, and Officer Volcanics, and that beneath the Paterson Formation. Neither of these unconformities is adopted as the boundary of the Officer Basin in the eastern part of the surveyed area, because it would not conform to South Australian usage, where the Officer Basin was first named and described.

The subsurface extent of the Townsend Quartzite and the overlying Proterozoic units is unknown. Also unknown is the relationship of the Proterozoic sequence in the Musgrave Block to the gently folded, southeasterly striking, evaporite-bearing siliciclastic and carbonate sequences on the western edge of the basin (Trainor (SG/51-2), Stanley (SG/51-6), Kingston (SG/51-10), 1:250,000 Sheets). Mack and Herrmann (1965) estimated the sequence on the western side of the basin, which belongs to the Bangemall Group, to be 9,000 metres (30,000 ft) thick. These Bangemall Group sediments of probable Middle Proterozoic age, possibly form the bulk of the succession indicated by aeromagnetic data in the deeper parts of the Officer Basin.

## STRATIGRAPHY

### *TOWNSEND QUARTZITE*

The name Townsend Quartzite was used by Sofoulis (1962) for a unit of sandstone and quartzite exposed in the Brown and Townsend Ranges (Talbot (SG/52-9) 1:250,000 Sheet). Daniels (1969b) evidently considers a section near Lilian Gorge as the type section. Farbridge (*in* Daniels, 1969b) describes this section as consisting of a lower unit, 85 metres (280 ft) thick, of thin to thick-bedded, flaggy, feldspathic, micaceous sandstone with sparse pebble and shale-flake beds, which is overlain by a unit of coarse to very coarse-grained, thick to very thick-bedded sandstone, 170 metres (560 ft) thick, with large-scale cross-bedding and containing some cobble and pebble beds.

Daniels' mapping shows the Townsend Quartzite to be comformable on the Mission Group near Warburton, but further east it overlies progressively older units of the Musgrave Block, with an angular unconformity. On the Birksgate (SG/52-15) 1:250,000 Sheet (S.A.) the lateral equivalent of the Townsend Quartzite, the Pindyin Sandstone, unconformably overlies granites and gneisses of the core of the Musgrave Block (Major, 1968). The base of the Townsend Quartzite is therefore an angular unconformity of regional significance. The Lefroy Beds conformably overlie the Townsend Quartzite.

A littoral to sub-littoral environment of deposition is interpreted for the well sorted, evenly bedded sandstones, whereas the coarse-grained pebbly parts are probably fluviatile.

The Townsend Quartzite is considered to be of Middle to Upper Proterozoic age as it unconformably overlies the Tollu Group, which was dated as 1,060 ± 140 million years old (Daniels 1969b), and as its lateral equivalent, the Pindyin Sandstone, underlies a sequence that contains rare Ediacara-type (latest Proterozoic) fossils (Major, 1968).

### *LEFROY BEDS*

Lefroy Beds is the name proposed herein for a sequence of well bedded siltstone to very fine-grained sandstone, which has been referred to informally as "Brown Range Siltstone" (P. Jackson, 1966; Daniels, 1969b). Daniels (1969b) included this unit, which is about 200 metres (700 ft) thick at Ainslie Gorge, in the Townsend Quartzite. The type section of the Lefroy Beds is located near Ainslie Gorge (26°14'S, 126°38'E, grid reference 469742, Talbot (SG/52-9) 1:250,000 Sheet), and its name is taken from Point Lefroy, 11 kilometres (7 miles) east-southeast of the type section.

Though Daniels (1969b) considered the upper boundary to be a disconformity we interpret both the upper and lower contacts as conformable, as they are located in gradational sequences. A very quiet, shallow-marine environment of deposition is interpreted for the Lefroy Beds, and their age is Middle to Upper Proterozoic.

### *LUPTON BEDS*

The name Lupton Beds is proposed herein for a sequence of conglomerate and sandstone which Daniels (1969b) informally called the "Upper Proterozoic Glacial Deposits". The type section is located at Lupton Hills, 26°31'S, 128°01'E, on the Cooper (SG/52-10) 1:250,000 Sheet. The name Lupton Hills has been submitted to the Geographic Nomenclature Committee, and has been formally approved. At the type locality a lower unit, approximately 175 metres (580 ft) thick, of unbedded, very poorly sorted, pebble to boulder conglomerate, and an upper unit, about 65 metres (210 ft) thick, of medium to fine-grained, well sorted, medium to thick-bedded quartz arenite with interbeds of siltstone and conglomerate, can be distinguished. Near the type section of the Lefroy Beds dropstones are common in the Lupton Beds.

Pebbles and boulders (maximum size 80 centimetres or 2 ft 8 in) in the conglomerates can be matched with various lithologies of the Blackstone Range area, indicating important erosion. Nevertheless the only exposed contact with the underlying Lefroy Beds is considered to be conformable, as it is located in a gradational sequence. The Lupton Beds are unconformably to disconformably overlain by the Kulyong, Table Hill, or Officer Volcanics, or by younger units.

The poorly sorted conglomerates are interpreted as tillites, and the sandier part of the sequence, with dropstones, as fluvioglacial deposits. Being a glacial deposit of pre-Permian age, the Lupton Beds are considered to be of Upper Proterozoic age.

### *CLUTTERBUCK BEDS*

Clutterbuck Beds is the name proposed herein for a 4,260-metre (14,000 ft) thick sandstone sequence exposed in the Clutterbuck Hills (24°35'S, 126°15'E, Cobb (SG/52-1) 1:250,000 Sheet). Leslie (1961), Wells (1963), Wilson (1964), and Brown and others (1968) referred to this range as the "Iragana Hills", but the name Clutterbuck Hills has priority.

The Clutterbuck Beds in the type section (from grid reference 428944 to 427938 and 422938 to 422934) consist of red-brown, purple-brown, fine to coarse-grained, well sorted, medium to thick-bedded, feldspathic arenites, with thin interbeds of laminated siltstone or very fine-grained sandstone. Low-angle cross-stratification in sets less than 1 metre (3 ft) thick, and beds with clay-clast impressions are common in the lower part of the sequence. Scattered, well rounded quartz and quartzite pebbles, pebble beds, and festoon cross-stratification in sets several metres thick are common in the upper 1,000 metres (3,300 ft).

The Clutterbuck Beds are exposed in a steeply dipping, partly fault-bounded inlier, which is completely surrounded by Permian and younger deposits. Little is known about their stratigraphic relationships because of the isolated position of the inlier, the absence of fossils, the lack of distinction of the lithologies and the concealment of the upper and lower boundaries of the unit. Wells (1963) noted lithological similarities between this unit and the Upper Proterozoic Carnegie Formation, Maurice Formation, and Ellis Sandstone of the Amadeus Basin. On the basis of these similarities an Upper Proterozoic age is inferred for the Clutterbuck Beds. A shallow marine to intertidal environment of deposition is inferred for these sediments.

As the Clutterbuck Hills outcrops occur to the northeast of the Warri Gravity Ridge, the Clutterbuck Beds probably do not occur in the Officer Basin.

### *BABBAGOOLA BEDS*

The name Babbagoola Beds is herein proposed for a unit first described in an unpublished report by P. Jackson (1966a) as "Babbagoola Formation" which name was published by Peers and Trendall (1968). Jackson used the name "Babbagoola Formation" for an evaporite-bearing sequence, which was intersected in Hunt Oil-Placid Oil Yowalga No. 2 well (26°10'S, 125°58'E, Yowalga (SG/51-12) 1 : 250,000 Sheet). As this unit is only known from this one drillhole, the name Babbagoola Beds is preferred. The name is derived from the Babbagoola Rock Hole (26°26'S, 126°11'E, Talbot (SG/52-9) 1 : 250,000 Sheet). The interval from 846 to 989 metres (2,775 to 3,246 ft) in Yowalga No. 2 is the type section. P. Jackson (1966b) described three separate units within the Babbagoola Beds. Unit "A", from 846 to 887 metres (2,775 to 2,910 ft) consists of interbedded sandstone and shale with anhydrite and gypsum as fracture and vein fillings. Unit "B", from 887 to 893 metres (2,910 to 2,930 ft) consists of fine-grained dolomite, with anhydrite and gypsum as fracture and vein fillings. Unit "C", from 893 to 989 metres (2,930 to 3,246 ft) consists of interbedded shale and siltstone.

An angular unconformity separates the Babbagoola Beds from the overlying Officer Volcanics in the structure in which Yowalga No. 2 was drilled. The base of the unit is unknown.

Glover (*in* P. Jackson, 1966a) suggests an oxidizing, evaporitic environment of deposition for the Babbagoola Beds. Balme (*in* P. Jackson, 1966a) infers an Upper Proterozoic to Lower Cambrian age, as primitive microfossils (leiospheres), known from the Sinian of the U.S.S.R., occur in this unit. Balme based his opinion also on the absence of typically Lower Palaeozoic cuticular microfossils. He then adds: "The data are consistent with a Proterozoic age, insofar as one can place reliance on the biostratigraphic value of such poorly diversified assemblages of indistinctive microfossils". The Babbagoola Beds are lithologically similar to the Proterozoic evaporite-bearing deposits described by Mack and Herrmann (1965) from the western edge of the basin, and to the ?Ordovician carbonate-shale sequences of the Southern Canning Basin. However, without reliable datings no correlations can be established.

### *BROWNE BEDS*

The name Browne Beds is herein proposed for a unit first described in an unpublished report by P. Jackson (1966b) as the "Browne Evaporites". This name was published by Peers and Trendall (1968). The unit consists of interbedded dolomitic limestone, calcareous shale, anhydrite, gypsum and salt, and as it is only poorly known from Hunt Oil-Placid Oil wells Browne Nos. 1 and 2, the name Browne Beds is preferred. The interval from 133 to 387 metres (435 to 1,269 ft) in Browne No. 1 (25°51'S, 125°48'E, Browne (SG/51-8) 1:250,000 Sheet) is considered to be the type section and the name is derived from that of the map sheet.

Both Browne Nos. 1 and 2 were drilled in a structure of diapiric origin and therefore little can be said about the stratigraphic position of the Browne Beds, except that they are unconformably overlain by the Paterson Formation.

An evaporitic environment of deposition is inferred for this unit and its age is probably Proterozoic (cf. Babbagoola Beds).

Considering their relative position and the lithological similarities it is possible that the Babbagoola Beds and the Browne Beds will be shown to form a single stratigraphic unit.

### *KULYONG, TABLE HILL AND OFFICER VOLCANICS*

Major and Teluk (1967) described exposures of tholeiitic basalt on the Kulyong (SG/52-16-620) 1 : 63,360 Sheet, S.A., and named these Kulyong Volcanics. These outcrops in South Australia form the eastern extremity of a discontinuous band of basalt outcrops extending into Western Australia. At 26°49'S, 128°05'E, grid reference 628670, Cooper (SG/52-10) 1:250,000 Sheet, this basalt is overlain with a sharp contact by the Lennis Sandstone.

Basalts that are petrographically very similar are exposed at Table Hill. These were first described by Talbot and Clarke (1917) who referred to these outcrops as "volcanic rocks of Table Hill", and regarded them as part of their Townsend Range Series. Daniels (1969b) and Peers (1969) use the name Table Hill Volcanics. We examined a section at Table Hill (26°28'S, 126°53'E, grid reference 497713, Talbot (SG/52-9) 1 : 250,000 Sheet) and measured approximately 26 metres (85 ft) of finely crystalline, greyish-green to dark grey basalt, with approximately 2 metres (6 to 7 ft) of poorly exposed very fine-grained to medium-grained micaceous sandstone in the middle of the sequence. The basalt is unconformably overlain by 4 to 5 metres (13 to 16 ft) of highly ferruginous conglomeratic sandstone of the Paterson Formation.

P. Jackson, in an unpublished report (1966a) first used the name Officer Volcanics for a basalt sequence encountered in the Hunt Oil-Placid Oil Yowalga No. 2 and Hunt Petroleum-Exoil Lennis No. 1 wells. Peers and Trendall (1968) first published the name. The choice of the name "Officer" was unfortunate as the nearest geographic feature of that name is the Officer River (Woodroffe (SG/52-12) 1 : 250,000 Sheet, S.A.), about 600 kilometres (370 miles) east of the drillholes. The Officer Volcanics most probably correlate with a seismic high-velocity layer which has been recognized over a large part of the Officer Basin, and P. Jackson (1966b) concluded that the volcanics are present throughout most of the deeper portion of the basin.

Yowalga No. 2 intersected 118 metres (385 ft) of Officer Volcanics between 728 and 846 metres (2,390 to 2,775 ft) which interval is considered to be the type section.

The Officer Volcanics overlie the Babbagoola Beds with an angular unconformity in Yowalga No. 2, and in both Lennis No. 1 and Yowalga No. 2 the volcanics are overlain with an erosional contact by the Lennis Sandstone.

Peers (1969) described the petrology of these three units of volcanic rocks and concluded that all three occurrences are petrologically very similar, describing them as massive to vesicular tholeiitic basalts. The great lateral continuity of the Officer Volcanics, the fact that both the Kulyong and the Officer Volcanics are overlain by Lennis Sandstone, and their petrological similarity, strongly suggest that they are in fact a single unit. The Table Hill Volcanics most likely also form part of this extensive basalt layer, but due to poor exposure their stratigraphical relationships have not been determined.

Radiometric dating of the Officer Volcanics gave ages of 1,000 and 1,143 million years and of 331, 357, 445, 446, and 447 million years (P. Jackson, 1966a). Samples of the Kulyong Volcanics have been dated as 475 and 485 million years old (Major and Teluk, 1967). The Table Hill Volcanics have not been dated. Jackson (1966b) interpreted the Officer Volcanic datings as indicating a Proterozoic age, and considered the younger ages as being due to metamorphism. Peers (1969), however, argued that the Proterozoic dates are based on the assumption of an unlikely initial $Sr^{87}/Sr^{86}$ value, and concluded that the 445 million years date is the more reliable. This age fits quite well with the datings of the Kulyong Volcanics and Peers (1969) therefore considers the Kulyong, Table Hill and Officer Volcanics to be of Ordovician age. This is corroborated by the fact that at least at Table Hill and on the Kulyong Sheet these volcanic rocks overlie the Proterozoic Townsend Quartzite, Lefroy Beds and Lupton Beds (Daniels, 1969b). Considering the fact that these units unconformably overlie the Tollu Group, which has been dated at 1,060 $\pm$ 140 million years (Daniels, 1969b), it is very unlikely that the 1,000 and 1,143-million-year datings of the Officer Volcanics are correct.

Though there is thus strong evidence that the Kulyong, Table Hill and Officer Volcanics are in fact one stratigraphic unit, we prefer to await the results of additional radiometric dating on samples from several localities before proposing to discard two of the three names.

A poorly exposed outcrop of undated, but petrologically similar basalt, at the Herbert Wash (26°10′ S, 124°28′ E, Robert (SG/51-11) 1:250,000 Sheet) is also regarded as part of this volcanic sequence.

As very few other possibilities for dating the fill of the Officer Basin are available, a reliable dating of the volcanic rocks is of the greatest importance for an understanding of the whole basin.

*LENNIS SANDSTONE*

The name Lennis Sandstone was first used in an unpublished report by P. Jackson (1966a) and published by Peers and Trendall (1968) without description. The name was apparently derived from Lennis Hills, 27°13′ S, 126°50′ E, Lennis (SG/52-13) 1:250,000 Sheet, which lie 47 kilometres (29 miles) east-northeast of Hunt Petroleum-Exoil Lennis No. 1 well, where the unit was first recognized.

The Lennis Sandstone consists of red to reddish-brown, fine to medium-grained, subangular to subrounded, moderate to well sorted, feldspathic micaceous sandstone. Red, micaceous siltstone beds up to 3 metres (10 ft) thick, are interbedded with the sandstone at several localities. Bedding ranges from laminated to very thick parallel-bedded, but medium to thick bedding is dominant. The medium to thick beds are often internally laminated or cross-laminated. Cross-stratification is mostly of the trough type, and occurs in sets 20 centimetres to 1 metre (8 in to 3 ft 4 in) thick. Tabular, red siltstone clasts up to a few centimetres in diameter are common.

Hunt Oil-Placid Oil well Yowalga No. 2 which intersected 321 metres (1,055 ft) of Lennis Sandstone between 407 and 728 metres (1,335 and 2,390 ft) is designated as the type section, and exposures at grid reference 552623 on the Lennis Sheet as the reference section.

The Lennis Sandstone unconformably overlies the Officer Volcanics in Lennis No. 1 and Yowalga No. 2. On the Cooper (SG/52-10) 1:250,000 Sheet it overlies the Kulyong Volcanics with a sharp, possibly disconformable contact. In both Yowalga No. 2 and Lennis No. 1 the Lennis Sandstone is unconformably overlain by the Paterson Formation. On the Wanna (SH/52-2), Waigen (SG/52-14), Cooper (SG/52-10) and Lennis (SG/52-13) 1:250,000 Sheets the Lennis Sandstone is conformably to disconformably overlain by the Wanna Beds.

Major (1968) described similar sandstones occurring on the Birksgate (SG/52-15) 1:250,000 Sheet, S.A., and Continental Oil Company Birksgate No. 1 well (27°56′20″ S, 129°48′10″ E, Henderson and Tauer, 1967) also intersected probable Lennis Sandstone between 159 and 501 metres (522 and 1,650 ft).

The main characteristic of the formation, its red colour, seems to be primary, as it is present both in the subsurface and in outcrop. Though red colours are most common in terrestrial deposits, the Lennis Sandstone is interpreted as a shallow marine deposit.

As it lies between the Ordovician volcanics and the Permian Paterson Formation, the age of the Lennis Sandstone is within the range of Ordovician to Upper Carboniferous, but an Ordovician, Silurian or Devonian age seems most likely. Possible lateral equivalents of the Lennis Sandstone and the overlying Wanna Beds are the ?Silurian Tandalgoo Red Beds of the Canning Basin, and the ?Silurian-Devonian Mereenie Sandstone of the Amadeus Basin.

*WANNA BEDS*

Wanna Beds is the name proposed herein for a unit of white to pale green, fine to very fine-grained, well sorted, slightly micaceous sandstone. Bedding ranges from thinly laminated to very thickly bedded. Cross-stratification in sets of up to 6 metres (20 ft) in thickness is ubiquitous. White claystone clasts commonly occur along the scoured bases of the cross-sets and along the fore-sets.

The type section is located at 28°49′S, 128°16′E, grid reference 642427, Wanna (SH/52-2) 1:250,000 Sheet, and the name is taken from the nearby Wanna Lakes. The thickness of the Wanna Beds is estimated to be in the order of tens of metres.

On the basis of their regional distribution the Wanna Beds are inferred to disconformably overlie the Lennis Sandstone on the Cooper (SG/52-10) and northern part of the Waigen (SG/52-14) 1:250,000 Sheets (Plate 10). At grid reference 649596 on the Waigen Sheet a gradational contact between the two units is exposed, which suggests a conformable relationship in the southeastern part of the surveyed area.

Outcrops of Wanna Beds along the Serpentine Lakes (Noorina (SH/52-3) 1:250,000 Sheet) in South Australia, have been described by Forbes (1969) and Krieg (1971). They regarded these deposits as probable Observatory Hill Beds of ?Cambrian age. As these sandstones do not have a very striking resemblance to the type section of the Observatory Hill Beds as described by Wopfner (1969), and as they definitely overlie the Kulyong Volcanics and the Lennis Sandstone (thus ruling out a Cambrian age) the introduction of the new name seems appropriate.

The presence of the large-scale cross-bedding, among other characteristics, indicates a shallow marine environment with strong tidal currents for the Wanna Beds (van de Graaff, 1972). Because of the evidence for the existence of strong tidal currents the absence of coarse-grained siliciclastics (except claystone intraclasts) indicates a lack of supply of such material. Because of this it is unlikely that the Wanna Beds are laterally equivalent to the Paterson Formation, as this formation contains a high proportion of coarse-grained siliciclastics, and the smallest distance between outcrops of the two units is only 21 kilometres (13 miles). The Wanna Beds are most likely disconformably to unconformably overlain by the Paterson Formation. Their age is probably in the range of Ordovician to Upper Carboniferous. Possible lateral equivalents of the Wanna Beds are the ?Silurian-Devonian Mereenie Sandstone of the Amadeus Basin, and the ?Silurian-Devonian Mintabie Sandstone of the eastern Officer Basin as described by Krieg (1969).

*PATERSON FORMATION*

Paterson Formation is the name used for a unit of highly variable lithology, which consists mainly of very poorly sorted conglomerate, pebbly sandstone, sandstone, and claystone with or without dropstones. Previously the names "Wilkinson Range Series", or "Wilkinson Range Beds" (Talbot and Clarke, 1916, 1917) and "Yowalga Sandstone" (P. Jackson, 1966b) were also used for this unit in the Officer Basin. However, the unit is continuous with, and is lithologically identical to, the Paterson Formation in the Canning Basin as described by Talbot (1920) and Traves and others (1956). As the Paterson Formation is better described, and as it has already been mapped by Wells (1963) in the northern part of the basin, the name Paterson Formation is preferred to "Wilkinson Range Beds", although strictly speaking the latter name has priority. The name "Yowalga Sandstone" has never been formalized through publication and does not, therefore, have priority.

Thickness of the formation is very variable as it overlies an irregular surface on the western side of the basin. At Woolnough Hills (24°05'S, 124°34'E, Warri (SG/51-4) 1:250,000 Sheet) a thickness of over 335 metres (1,100 ft) is exposed, and the Hunt Oil-Placid Oil Yowalga Nos. 1 and 2 wells intersected 367 metres (1,199 ft) and 312 metres (1,025 ft) respectively of the unit. Detailed descriptions of the Paterson Formation in the Officer Basin are given by Wells (1963), P. Jackson (1966b), M. Jackson (1971), and Lowry (1971).

The Paterson Formation unconformably to disconformably overlies all older units, and is in turn disconformably overlain by the Samuel Formation or the Bejah Claystone. In the southern part of the surveyed area the Tertiary sequence of the Eucla Basin unconformably overlies the Paterson Formation.

The quantitatively most important lithologies are interpreted as glacial tillites, and fluvioglacial outwash, quiet lacustrine, lacustrine delta, and lacustrine beach deposits. Marine deposits have not been recognized but could be present. A lower Permian (Sakmarian) age for the Paterson Formation has been established by palynological dating (Wells, 1963; Balme *in* P. Jackson, 1966a).

In the northern part of the basin, Wells (1963) recognized undifferentiated Mesozoic sediments and Wilson (1964) distinguished Jurassic deposits. At Woolnough Hills, Wilson (1964) mapped extensive Jurassic deposits. These deposits, however, contain poorly sorted conglomerates which are interpreted as tillites. A Permian age is therefore interpreted for these coarse-grained deposits which are considered to form part of the Paterson Formation. Fine-grained "Jurassic" deposits in this area are also tentatively considered as Paterson Formation. A complete lack of datings of these sediments, however, precludes any definite correlations.

*SAMUEL FORMATION*

Samuel Formation is the name proposed herein for a unit of laminated to thin-bedded, fine to medium-grained sandstone, siltstone, and claystone. The sandstones are moderately to well sorted, and indistinctly cross-bedded in part, whereas the grains are moderately to well rounded. Bioturbation is common in these sediments, which weather purple, red, green and brown.

The Samuel Formation partly corresponds to the "undifferentiated Cretaceous" of Wells (1963, p. 24), the "undifferentiated Lower Cretaceous" of P. Jackson (1966b, p. 44), and the Jurassic and Cretaceous of Wilson (1964).

Outcrops at Mount Charles, Gunbarrel Highway (25°45'S, 126°11'E, Bentley (SG/52-5) 1:250,000 Sheet) are designated as the type section, and the name is taken from Mount Samuel, 25 kilometres (16 miles) to the west (25°46'S, 125°56'E). A thickness of 15 metres (48 ft) is exposed at the type section.

The base of the formation is exposed at Browne diapir (25°51'S, 125°48'E) where it disconformably overlies the Paterson Formation. Its contact with the overlying Bejah Claystone is gradational. Seismic and drillhole information suggest a combined thickness for the Samuel Formation and Bejah Claystone of up to 300 metres (920 ft) along much of Gunbarrel Highway.

Sedimentary structures and fossils indicate a quiet, shallow marine environment of deposition. The molluscan fauna permits dating as Aptian (Skwarko, 1967).

*BEJAH CLAYSTONE*

The name Bejah Claystone is here proposed as an amendment to the name "Bejah Beds" (Veevers and Wells, 1961, p. 166), as the distribution, age and stratigraphic relationships of this unit are now better known. The Bejah Claystone consists of indistinctly bedded, often bioturbated, white claystone with minor intercalations of very fine-grained sandstone. The claystone has a conchoidal fracture, especially if silicified (porcelanite). Radiolaria are fairly common in these white claystones.

Veevers and Wells (1961) evidently considered Bejah Hill (Runton (SF/51-15) 1:250,000 Sheet) in the Canning Basin as the type locality, and an unnamed locality at 25°28'S, 125°06'E, grid reference 302833 (Browne (SG/51-8) 1:250,000 Sheet) is here designated as the main reference section for the Officer Basin.

In the surveyed area the greatest measured thickness of the Bejah Claystone is about 30 metres (100 ft). The Bejah Claystone conformably overlies the Samuel Formation, but on the western side of the basin the formation rests disconformably on the Paterson Formation. Its upper limit is always erosional and a disconformable to unconformable contact separates the unit from the Lampe Beds.

The molluscan fauna indicates an Aptian (Lower Cretaceous) age (Skwarko, 1967). A very quiet, shallow-marine environment of deposition with slow sedimentation is inferred from the fine grain size, the common bioturbation, and the fossils.

*LAMPE BEDS*

The name Lampe Beds is proposed herein for a thin (maximum observed thickness of 3 metres (10 ft)) sequence of poorly sorted, medium to very coarse-grained sandstone, which locally grades into quartz-pebble conglomerate. Bedding is indistinct and ranges from medium to thick. These deposits are everywhere intensely silicified and are commonly referred to as silcretes. Such deposits have been observed over nearly all older formations. If occurring on the Paterson Formation or one of the Proterozoic units which contain coarse-grained siliciclastics, such silicified deposits can have originated by *in situ* soil formation without any mechanical transport of the constituent materials. If, however, such a coarse-grained deposit overlies the Bejah Claystone, Samuel Formation, Wanna Beds, Lennis Sandstone or a Proterozoic unit which does not contain any coarse-grained siliciclastics, erosion in neighbouring areas, transport and deposition of the sediment must have occurred before silicification during pedogenesis. Therefore we only use the name Lampe Beds if such a deposit overlies one of the above mentioned fine-grained units, as we are defining rock-stratigraphic rather than soil-stratigraphic units.

The Lampe Beds are named after Mount Lampe, which is located about 16 kilometres (10 miles) north-northwest of the type section at Mount Johnson (25°24'S, 124°25'E, Herbert (SG/51-7) 1:250,000 Sheet). It is a widespread unit in the same area where the Samuel Formation and Bejah Claystone occur, i.e. the northern part of the basin.

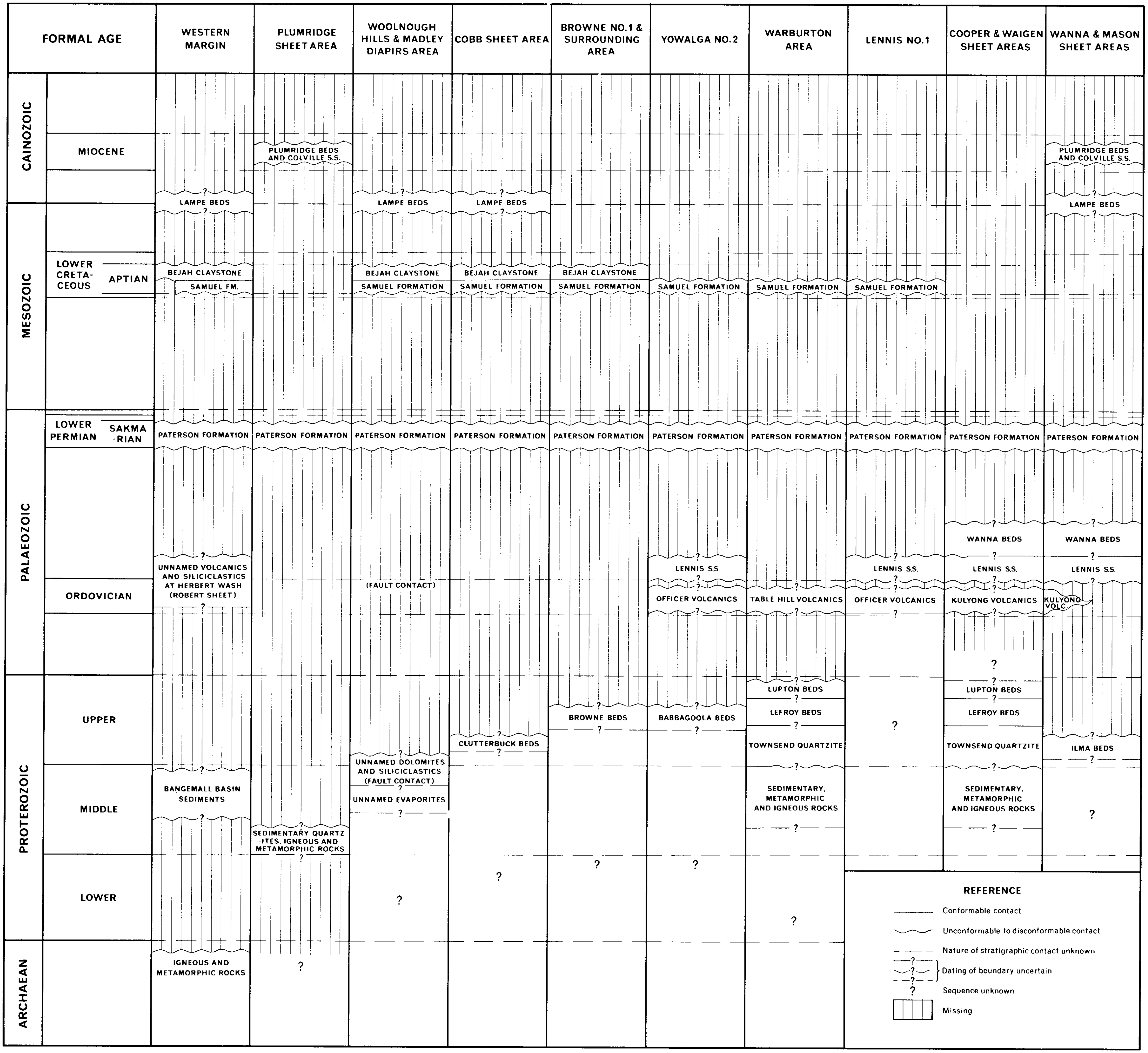


Figure 20. Correlation diagram of stratigraphic units in the Officer Basin Area.

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The Lampe Beds unconformably to disconformably overlie any older units, and as they occur as thin cappings on mesas and rises, their upper limit is always erosional.

Although intense silicification has obscured the original textures and structures, the poor sorting, moderate rounding of the quartz pebbles, indistinct bedding, and the sometimes scoured lower contact all suggest a fluviatile environment of deposition.

As parts of the Lampe Beds are intensely ferruginized to lateritized at most localities, the Lampe Beds are distinctly older than the laterite. The laterite in the Officer Basin is considered to have formed before or during the Miocene. This contention is based on the following observations:

(1) The Lower Miocene Colville Sandstone in the Eucla Basin is not lateritized.

(2) A more or less well developed laterite is present in the Officer Basin, on the Permian and Cretaceous sediments.

(3) The lateritized surface, where not obscured by sand dunes or destroyed by erosion, displays an integrated drainage system which is now inactive.

(4) This drainage system seems to have discharged to the south, that is, into the Eucla Basin. This is supported by the fact that the Plumridge Beds, which form part of the Eucla Basin, contain silcrete and ferruginized silcrete pebbles that can only have come from the north.

(5) The lateritized surface with its old drainage system is recognizable up to the limits of the Eucla Basin, but neither on the Plumridge Beds nor on the Colville Sandstone outcrop band is there any indication that an integrated drainage system ever existed.

These observations indicate that after deposition and emergence of the Plumridge Beds and the Colville Sandstone (which is reliably dated as Lower Miocene), little surface discharge occurred, or at least insufficient surface discharge to form an integrated drainage system. This implies that the more humid conditions necessary for the formation of laterite in the Officer Basin only existed before or during the Miocene.

Therefore an Upper Cretaceous to Lower Tertiary age is inferred for the unfossiliferous Lampe Beds, as they overlie the Aptian Bejah Claystone and are older than the laterite.

### *PLUMRIDGE BEDS*

Plumridge Beds is the name proposed herein for a sequence of poorly exposed, fine-grained sandstone, siltstone and claystone, with some intercalations of poorly sorted conglomeratic sandstone, which occurs in the northern part of the Eucla Basin. The conglomeratic sandstones are characterized by the presence of pebbles of ferruginized silcrete, and fragments of fresh feldspar.

Outcrops at 29°43'S, 125°04'E, on the Plumridge (SH/51-8) 1:250,000 Sheet, are designated as the type section, and the name is taken from Plumridge Lakes, which lie approximately 25 kilometres (16 miles) northeast of the type section. The maximum exposed thickness is about 10 metres (33 ft), and the unit is estimated to be a few tens of metres thick. The distribution of the Plumridge Beds suggests that they disconformably to unconformably overlie the Wanna Beds or the Paterson Formation. A kankar soil overlies the Plumridge Beds.

A fluviatile to paralic environment of deposition is interpreted for the Plumridge Beds, and their occurrence as a band along the northern boundary of the Eucla Basin suggests that they are lateral equivalents to the Colville Sandstone. This would imply a Lower Miocene age for the Plumridge Beds.

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# THE WANNA BEDS—AN ANALOGUE OF RECENT NORTH SEA SEDIMENTS

by W. J. E. van de Graaff

## ABSTRACT

The Wanna Beds occur in the eastern part of the Western Australian section of the Officer Basin. Their lithological characteristics are uniform over a large area, and, together with the textural and compositional maturity of the sediments and the types of cross-bedding, this indicates a shallow-subtidal marine environment of deposition. They are considered to be an analogue of Recent sand deposits of the North Sea.

## INTRODUCTION

The name Wanna Beds has been formally proposed by Lowry and others (1972), for a sandstone unit exposed over a wide area in the Officer Basin. It underlies parts of the Lennis, Waigen, Wanna and Mason 1:250,000 Sheet areas and is known to extend into South Australia. Its known extent is shown in Lowry and others (1972, Plate 10). The formation is of uniform lithology over a large area (approximately 32,000 square kilometres, 12,375 miles$^2$) and the absence of any datings or of any marker beds precludes correlations within the formation. Nevertheless, the presence of well preserved sedimentary structures and of only slightly modified textures permits a reconstruction of the depositional environment.

## FIELD CHARACTERISTICS

The Wanna Beds consist predominantly of white-weathering (pallid zone of laterite profile), well to very well sorted, fine to very fine-grained, quartz arenite. Stratification ranges from thinly laminated to very thick bedded. The laminated to thin, or occasionally medium-bedded parts are characterized by very regular, continuous, and mostly very distinct bedding planes. The medium to very thick beds are mostly cross-bedded. These large-scale cross-beds are predominantly of the scoop type (Allen, 1963). Preserved set thickness generally ranges from 0.05 metres to about 1.50 metres (2 in to 5 ft). The width of the scoops is up to at least 10 metres (33 ft). In the down-current direction individual cross-sets have been traced for over 60 metres (200 ft). The cross-sets are laminated to very thin bedded. The laminae of the cross-sets are normally concave upwards, and have an asymptotic relationship to the basal contact, and horizontally bedded strata can often be traced into low-angle cross-stratification. Although scoop cross-stratification of Allen's (1963) pi type is most common, cross-bedding of types nu and xi also occur quite frequently. Cross-stratification similar to the planar types of cross-bedding described by McKee (1966) was observed at one locality.

In one outcrop, on the southern side of a small salt lake (lat. 28° 21′, long. 127° 45′) on the Wanna Sheet area, a large-scale beta cross-set is exposed. The preserved height of this set is 5.3 metres (17 ft). This cross-set can be traced in the original down-current direction for over 50 metres (165 ft), but its preserved extent could be much greater. On the northern side of the salt lake, cross-stratification of similar dimensions and orientation is exposed, which indicates that both exposures are in a single cross-set which has a lateral extent of at least 150 metres (490 ft). Superimposed on, and alternating with the steeply dipping (up to 25°) fore-sets are some large-scale cross-sets of beta-type cross-stratification, which indicate a direction of transport diametrically opposite to that of the bigger set (Fig. 21). The smaller cross-sets are up to 81 centimetres (2 ft 8 in) thick. They are present only in the upper two-thirds of the preserved larger cross-set over a distance of 12 metres (40 ft). On the northern side of the salt lake small-scale cross-beds, opposing the largest set, occur at the toes of these larger fore-sets. The opposing cross-sets are locally erosive on the larger one, and are in turn covered with an erosive contact, by the larger cross-set. Interfingering of the laminae of the two opposing cross-sets has not been observed. Several discontinuity planes were observed in the larger cross-set. Such discontinuity planes were also seen in other outcrops.