COMMONWEALTH OF AUSTRALIA

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

REPORT No. 108

Completion Report BMR 8, Mount Madeline and 9, Daurie Creek, Byro Basin Western Australia

BY

C. R. MERCER

Issued under the Authority of the Hon. David Fairbairn
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MINISTER: THE HON. DAVID FAIRBAIRN, D.F.C., M.P.

SECRETARY: R. W. BOSWELL.

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SUMMARY

In 1959 the Bureau of Mineral Resources drilled two wells in the Byro Basin, Western Australia, to provide information on the petroleum source-rock possibilities of the Permian rocks in the area, and to investigate the stratigraphy and the relations between structure and sedimentation.

Both wells were drilled entirely in Permian rocks. Possible reservoir strata were noted at intervals between 1664 and 2321 feet in BMR 8, and between 1513 and 2011 feet in BMR 9. The favourable intervals consist of permeable and porous marine quartz sandstones of the Lyons Group. Electric logging indicated that they contain salt water.

BMR 8 started lower in the Permian section than BMR 9; both wells penetrated the Keogh, One Gum, Callytharra, and Carrandibby Formations, and reached total depth in argillaceous sediments of the Lyons Group. Correlations between the two wells of rocks within the stratigraphic limits of the Keogh Formation particularly were complicated by facies changes (see Fig. 4, p.10). Most of the sections drilled were known on the surface, the notable exception being 60 feet of limestone penetrated at the base of the One Gum Formation in BMR 8.

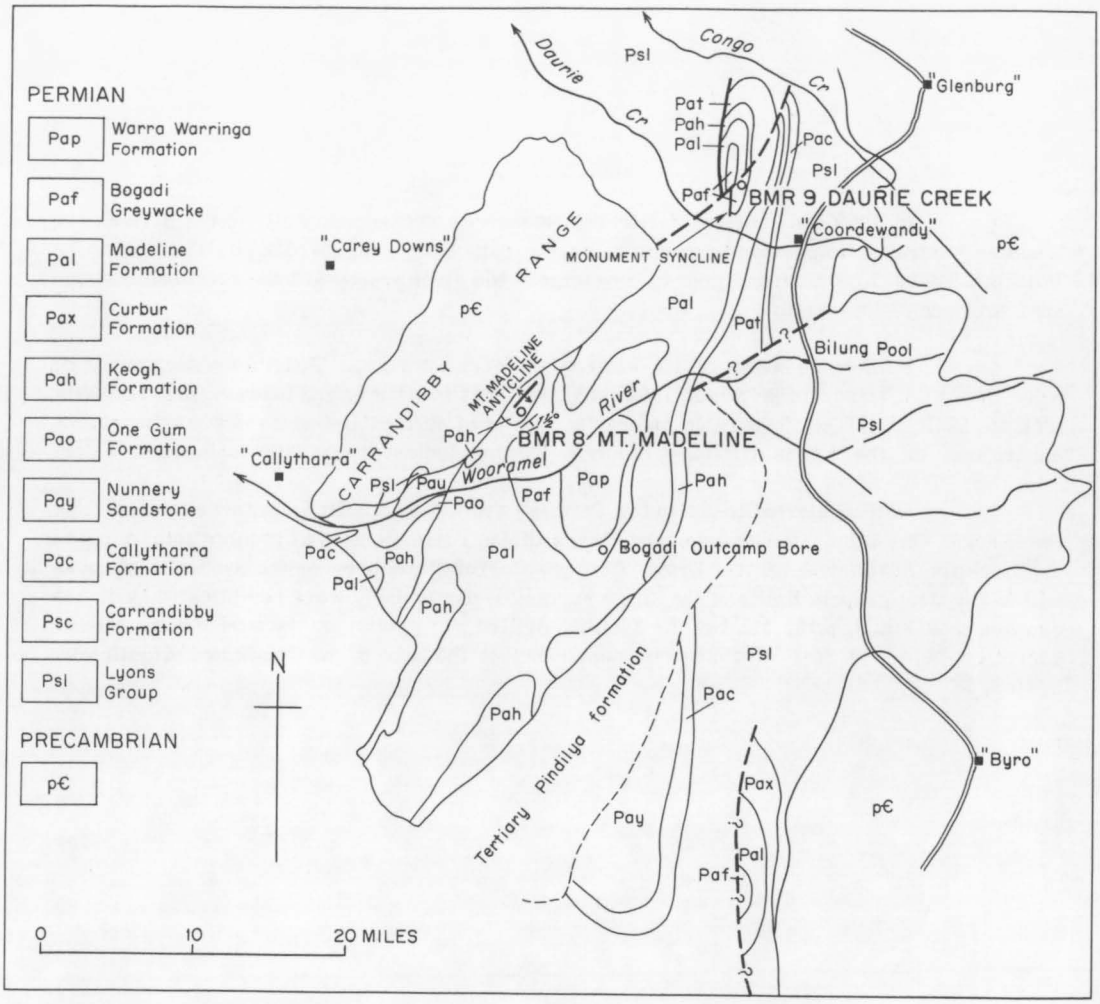

Fig. 1. Geological sketch map of the central part of the Byro Basin (after Konecki et al., 1958) showing the location of bores BMR 8 and BMR 9.

INTRODUCTION

BMR 8 and BMR 9 were drilled to supplement the geological survey of the Byro Basin by the Bureau of Mineral Resources (Konecki, Dickins, & Quinlan, 1958). BMR 8 was sited on the east flank of the Madeline Anticline and BMR 9 on the Monument Syncline, 20 miles to the north-east (Fig. 1).

BMR 8 was planned to investigate the contact between the Permian and Precambrian. BMR 9 was drilled in the syncline to investigate what effect structure (to the west) would have on the lithology in the synclinal area.

WELL HISTORY

GENERAL DATA

Well name and number:	Mount Madeline BMR 8	Daurie Creek BMR 9
Location*:	Lat. 25°45'5"S. Long. 115°38'23"E.	Lat. 25°33'17"S. Long. 115°53'17"E.
Tenement holder:	West Australian Petroleum Pty Ltd, 251 Adelaide Terrace, Perth, Western Australia	
Details of tenement:	Petroleum Permit to Explore 28H	
District:	Coastal	Coastal
Total depth:	3004 feet	2299 feet
Date spudded:	25th May 1959	16th July 1959
Date completed:	12th July 1959	12th August 1959
Approximate elevation:	G.L. 800 feet R.T. 4 feet above surface (Estimated from height of gravity station in the area).	G.L. 900 feet R.T. 4 feet above surface
Status:	Abandoned, with surface casing set at 83 feet and 10-foot cement plug	Abandoned, with surface casing set at 70 feet and 10-foot cement plug; cement plug at 2030 feet

DRILLING DATA

Drilling contractor:	Oil Drilling and Exploration Company, 237 Adelaide Terrace, Perth, W.A.

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* Well sites are plotted on the Glenburgh 1:250,000 Geological Sheet

Drilling plant:	(owned by Bureau of Mineral Resources)	
Make:	Failing 2500	
Rated capacity:	4500 feet	
Pumps:	Rank-Wheatly 75 H.P., and Gardner Denver 29 H.P. auxiliary	
Hole sizes and depths:	6 5/8" 0 to 89 feet 6" 83 to 976 feet 5 5/8" 976 to 2994 feet 4 3/4" 2994 to 3004 feet	6 5/8" 0 to 70 feet 5 5/8" 70 to 2294 feet 4 3/4" 2294 to 2299 feet
Casing:	6 5/8" set at 83 feet	6 5/8" set at 70 feet

Mud history

BMR 8: Pump pressure averaged 100 to 150 psi from surface to 200 feet; 200 to 300 psi from 200 to 500 feet; and 350 to 400 psi from 500 feet to the total depth at 3004 feet. Rotary speed was maintained between 60 and 90 rpm. Water was used for the first 89 feet of drilling, after which mud was added. Viscosity was maintained at 30 to 40 secs until 1350 feet where 40 to 50 secs was established. The weight of the mud averaged 73 to 75 lb/cub. ft.

BMR 9: Pump pressure averaged 100 to 150 psi for the first 300 feet; 150 to 250 psi from 300 to 1000 feet; and 250 to 300 psi from 1000 to 2300 feet. Rotary speed ranged from 50 to 100 rpm. Water was used for the first 100 feet; mud was then added and a viscosity of 40 to 50 secs and a weight of 75 to 80 lb/cub. ft were maintained for the remainder of the drilling.

LOGGING AND TESTING

Ditch cuttings were taken every 5 feet in both holes. Cores were taken at depths as near as possible ($\pm$ 20 feet) to 100-foot intervals, actual depths depending on drilling expediency.

After T.D. in BMR 9 was reached a plug was set at 2030 feet and bailing began in order to observe suspected oily water. The water level rose rapidly in the hole, owing to a swabbing action by the bailer. The sand line broke and the bailer fell to the cement plug at 2030 feet. Two unsuccessful attempts to recover the bailer were made, after which the hole was abandoned.

Logging: A Widco 4000 foot electric logging unit was used in both wells to obtain a self-potential and resistivity log. (Jewell, 1959; Wiebenga & Jewell, 1959).

Deviation records were obtained by a Totco recorder. At no time was deviation over 2^{o}.

GEOLOGY

SUMMARY OF PREVIOUS WORK

W.G. Woolnough made a line reconnaissance through the area in 1928. Subsequently Waterford collected fossils from the Permian strata and prepared a map of the area, which was not published. From 1948 to 1955 investigations were carried out in the Carnarvon Basin (of which the Byro Basin is a possible subbasin to the south-east) by geologists of the Bureau of Mineral Resources (Condon, 1954; Konecki et al., 1958), and from 1952 to 1954 by geologists of West Australian Petroleum Pty Ltd (McWhae, Parry, & Stanley, 1954).

Dickins (1956) determined marine macrofossils in the Gap Pool area and tabulated sections of the Madeline Formation. Work was also done on marine faunas in the Lyons Group (Dickins & Thomas, 1959). All the Permian formations mapped in the area and all the formations intersected in BMR 8 and BMR 9 are of Lower Permian Age (Sakmarian to Artinskian).

The fullest and most detailed geological information on the area was presented in the report by Konecki et al. (1958), and it was on the basis of this work that BMR 8 and 9 were planned. The mapping had shown that the Mount Madeline Anticline abuts and is probably faulted against the Precambrian Carrandibby Range to the west. BMR 8 was sited on the east flank of the anticline in order to intersect a possible pitching axial plane at depth; there was also the possibility that it might have intersected the fault or unconformity (see Fig. 2). BMR 9, sited a little to the east of the axis of the Monument Syncline, might also have been expected to cross a fault at depth (Fig. 3).

RESULTS OF THE DRILLING

BMR 8

BMR 8 was sited on the upper part of the Keogh Formation about 100 feet west of its contact with the outcropping Madeline Formation. The bit penetrated 70 feet of weathered siltstone, fine quartz greywacke, and quartz sandstone, before entering 330 feet of dark carbonaceous siltstone, greywacke, and quartz sandstone, typical of the Keogh Formation. For an alternative interpretation of this section see Appendix 1.

Several thin coals or coaly shales occur, preceded and followed by silty quartz sandstone, quartz greywacke, and shale. Marine and continental cyclothems are characteristic of coal measure sequences and it would seem that such conditions existed here before the development of the fully marine environment of the Byro Group. The presence of sporadic marine fossils with animal trails and wood in the upper Keogh Formation at the surface also clearly indicates a transitional environment (Konecki et al., 1958, p. 37).

The type section of the Keogh Formation, 15 miles south of BMR 8, was measured in 1955 by M.A. Condon. The base is marked by a change from poorly sorted rough-bedded quartz greywacke with quartz sandstone beds to medium and fine-grained quartz greywacke 'with laminated and carbonaceous siltstone above' (Konecki et al., 1958). The first recognizable coarse quartz sandstone (rather unevenly bedded and possibly ferruginous), below the last siltstone bed, was chosen as the lower boundary of the Keogh Formation (at 400 feet). The ferruginous staining may have resulted from contamination of the samples.

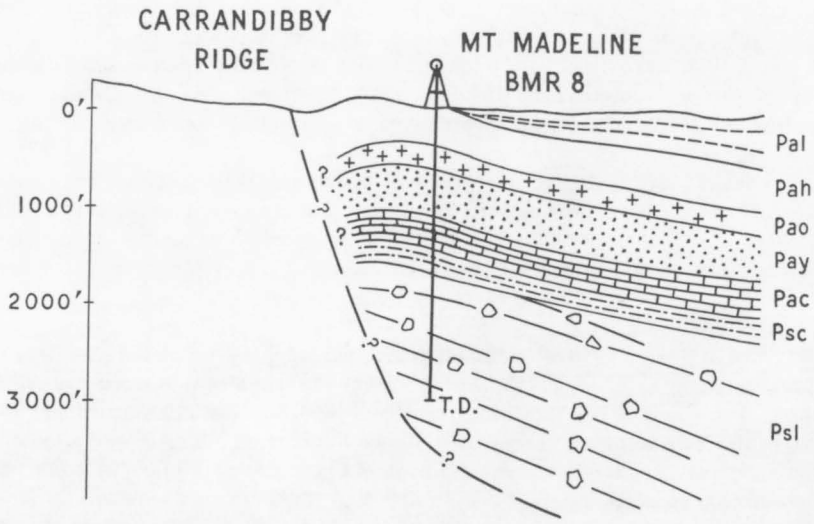

Fig. 2. Diagrammatic section east-west through the Madeline Anticline (adapted from Konecki et al., 1958). Symbols as in Figure 1.

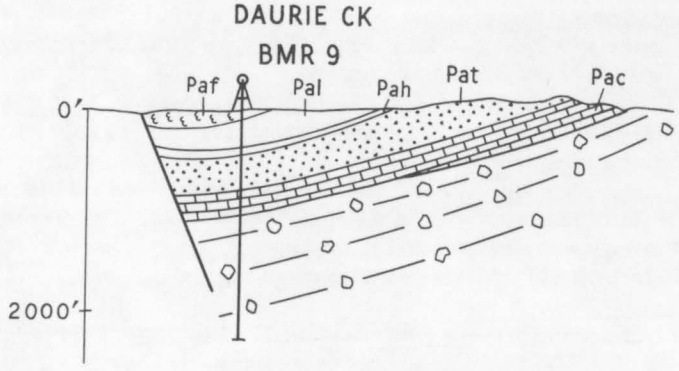

Fig. 3. Diagrammatic section east-west through the Monument Syncline (adapted from Konecki et al., 1958). Symbols as in Figure 1.

The cuttings from 400 to 530 feet depth have been identified as the One Gum Formation. The identification is made on the basis of its position in the stratigraphical column, electric log relationships above and below, and the broad lithological similarity to the type section at Gap Pool. This however, applies to only the upper 70 feet; the lower 60 feet consist of a limestone which has not been recorded at the surface. The upper member is a pyritic and very poorly sorted quartz sandstone; the lower is a massive fossiliferous and slightly argillaceous limestone. In the One Gum Formation type section (about 12 miles south-south-west of BMR 8) the lowest 18 feet consist of soft siltstone which is fossiliferous, ferruginous, and possibly calcareous in part, and which may be equivalent to part of the limestone section intersected in the well.

Below the One Gum Formation BMR 8 penetrated 580 feet of clean well-sorted massive and very poorly cemented sandstone. This appears to correspond lithologically and stratigraphically to the 545-foot sandstone sequence measured by M.A. Condon about 1.3 miles west of Gap Pool. The formation, which is non-fossiliferous, is known as the Nunnery Sandstone.

The base of this monotonous quartz sandstone is marked by a sharp change of lithology to a light tan crystalline massive limestone at 1110 feet. This in turn very rapidly becomes sandy and argillaceous and by 1200 feet is almost 90 percent shale. From here it ranges between a sandy and silty shale down to 1280 feet, after which the alternation is between argillaceous calcilutite and a sandy argillaceous limestone. At 1330 feet it is a light grey to tan limestone, still argillaceous, but cryptocrystalline. At 1375 feet it starts to become softer and more argillaceous until at 1440 feet it is a very soft and sandy limestone and the shale bands are distinct and carbonaceous.

The sequence between 1110 feet and 1425 feet is considered to be equivalent to the 330-foot type section of the Callytharra Formation (Konecki et al., 1958, p. 24). The electric log shows much interbedded limestone and argillaceous limestone from about 1330 to 1440 feet. (This is true of this section in BMR 9 also).

From 1425 feet the well passes through a sandy limestone and calcilutite to predominantly shale at 1550 feet. The electric log reveals a decrease in limestone, which rapidly changes to dense bands of carbonaceous shale (Jewell, 1959, p. 5). Under the microscope the cuttings commonly show a small coiled pelecypod (possibly Eurydesma). The crinoid fragments and productid spines common in the Callytharra Formation above are missing.

This sequence has been correlated with 'the sequence of shale, calcilutite, and sandstone which rests with apparent conformity on the Lyons Group and is conformably overlain by the Callytharra Formation' (Konecki et al., 1958, p. 22), that was named the Carrandibby Formation. Further evidence for this correlation is given by the change in faunas. The marine pelecypod is present to the exclusion of the richer fauna above. This corresponds to the description of the top of the Carrandibby Formation given by Konecki et al., (1958, p. 22): 'The top of the Carrandibby Formation is taken at the top of a bed of hard calcareous quartz greywacke containing marine fossils (including Eurydesma) which marks the change in lithology into the predominantly calcareous sequence of the Callytharra Formation with a more varied fauna which includes brachiopods, molluscs, solitary corals, crinoids, bryozoans, gastropods and foraminifera'. The 'hard bed' referred to in outcrop could be the bed in the bore from 1425 to 1445 feet just above the very soft 15-foot section from 45 to 1460 feet (well shown in the drilling rate log).

At the base of this sequence (at 1664 feet) a very sharp break occurs and a marine limestone is penetrated. It is clear both on the electric log and from the cuttings (equally so in BMR 9). This limestone at the base of the Carrandibby Formation is apparently widespread at depth, although it is not known in outcrop, and consists of 10 feet of limestone, the cuttings of which are white to light tan-coloured, sandy and commonly resembling cements, followed by 10 to 15 feet in which the silica content increases until the rock consists of up to 70 percent quartz sandstone, still very calcareous and containing much argillaceous material. The next 10 to 15 feet show an increase in limestone content again, followed by a marked increase in argillaceous material, until, 50 feet from the top, the rock becomes a very brittle and friable dense black shale.

The top of the Lyons Group was tentatively placed at the top of this bed (1664 feet), although it was perhaps derived from an environment very similar to that of the Carrandibby Formation. Consequently, an alternative boundary was chosen at the second black shale at 1805 feet, which underlies 65 feet of calcareous white to light grey siltstone and conforms more closely to the top of the Lyons Group as described by Konecki et al. (1958, p. 17): 'The top of the Lyons Group is placed at the sharp change in lithology from poorly sorted generally non-calcareous glacial sediments to sediments of generally calcareous lithology containing marine fossils of either Callytharra Formation or Carrandibby Formation'.

The first boulder tillites occur at 1805 feet, only 45 feet below the second boundary, and this certainly represents Lyons Group. This lower boundary was also identified in BMR 9. The next section of the Lyons Group consists of shale and very fine quartz sandstones and siltstones extending to 2084 feet.

Below this zone, a tillitic sequence follows, containing boulder beds, sandstones, siltstones, and shales, alternating with tillitic beds of the same character; all are poorly sorted and typical glacial sediments.

At 2640 feet a bed of remarkably pure massive limestone was penetrated. It becomes sandy at 2700 feet and reverts to finely tillitic shale at 2780 feet. This limestone bed has not been observed in outcrop and has certainly laid down in a deeper sea than the rest of the Lyons Group. Presumably it was laid down a considerable time before the glacial environment of most of the Lyons Group was established.

From 2780 to total depth at 3004 feet the bit passed through a hard dense black shale which contains rare granite gneiss pebbles, some an inch or more in diameter. By 2900 feet the pebbles are absent and the well continues to total depth in uniformly massive dense shale.

In the Lyons Group good reservoir possibilities are believed to exist, especially between 1664 and 2321 feet, where porous and permeable sands are found. Geophysical logging indicates that they contain salt water (Jewell, 1959, p. 6).

BMR 9

BMR 9 was sited 20 miles north-east of BMR 8 on the Bogadi Greywacke half a mile north of a small hill where the formation crops out. In the well the formation consists of 70 feet of weathered quartz greywacke and greywacke siltstone identical with the outcrop.

From 70 to 390 feet the well penetrated carbonaceous and finely micaceous fine-grained quartz greywacke and siltstone containing much shale which is commonly gradational with the greywacke. The lower part from 250 to 390 feet is very silty and commonly arenaceous. The sequence as a whole is lithologically comparable with the Madeline Formation at its type section at Madeline Creek. McWhae, Parry, & Stanley in their unpublished report (1954) first proposed the name Madeline Formation, which was defined by Konecki et al. (in McWhae et al., 1958) as the unit which underlies the Bogadi Greywacke and overlies the Keogh Formation. At and near Gap Pool sections 395 feet thick and 508 feet thick have been measured (Condon in Konecki et al., 1958; and Dickins, 1956); 3 miles south of Gap Pool the formation is 635 feet thick, and in the Daurie Creek area (nearest to BMR 9) it is 284 feet thick.

By comparison with the outcrop the whole of the section from 70 to 390 feet can be assigned to the Madeline Formation, but an increasing sand and silt content from 250 to 275 feet, carbonaceous shale from 275 to 390 feet, with interbedded gritty quartz greywacke, together with certain electric log characteristics, suggest that the interval from 250 to 390 feet might be a lateral variation of the Keogh Formation.

From 390 to 465 feet the sequence is of carbonaceous and poorly sorted quartz greywacke and siltstone, whose content of sand grains and pyrite increases downwards: by 430 feet it can be termed a sandstone, and at 460 feet contains 20 percent pyrite. The greywacke sandstone sequence continues to 830 feet; to 550 feet it is calcareous, but below that is clearly comparable with the type section of the Monument Formation, measured near Measurement Bore by M.A. Condon in 1955. Stratigraphically, therefore, it would be expected that the sequence from 390 to 465 feet represents the Keogh Formation; but lithologically it resembles the upper One Gum Formation in BMR 8. Moreover, if the lower One Gum limestone in BMR 8 is correlated with the calcareous sequence from 465 to 550 feet in BMR 9, the lithological and electric logs of the two wells are brought to a close match.

It therefore seems that the sequence from 390 to 550 feet is more probably One Gum Formation, and the Keogh is represented, as suggested above, by the interval 250 to 390 feet.

In BMR 9 the entire Wooramel Group appears to be finer-grained and its upper part passes transitionally into the Madeline Formation. The suggested correlation between the two bores and the outcrop sections in the Wooramel River and Daurie Creek is shown in Figure 4. An alternative interpretation of part of this section in BMR 9 is given in Appendix 1.

Below the Monument Formation BMR 9 penetrated the Callytharra Formation, which consists of about 80 percent limestone and is easily recognizable on the electric log owing to the rapid alternation of limestone and argillaceous limestone. It contains productid spines and crinoid fragments. The well entered a black to dark grey limy shale at 1090 feet, which clearly represents the Callytharra/Carrandibby contact. The Callytharra and Carrandibby Formations in BMR 9 correlate well with the same formations in BMR 8. The Carrandibby Formation is not definitely known to crop out in the Daurie Creek area (i.e. in the vicinity of BMR 9); in fact the Callytharra Formation section in Daurie Creek has definite Callytharra fossils down to the contact with Lyons Group, but M.A. Condon (pers. comm.) has observed a thick shale sequence between Callytharra Formation and Lyons Group outcrop at several other places in the vicinity, and, in BMR 9, the cuttings contain a Eurydesma-like fossil in place of the richer Callytharra fauna. The evidence generally leaves little doubt that the Carrandibby Formation is present.

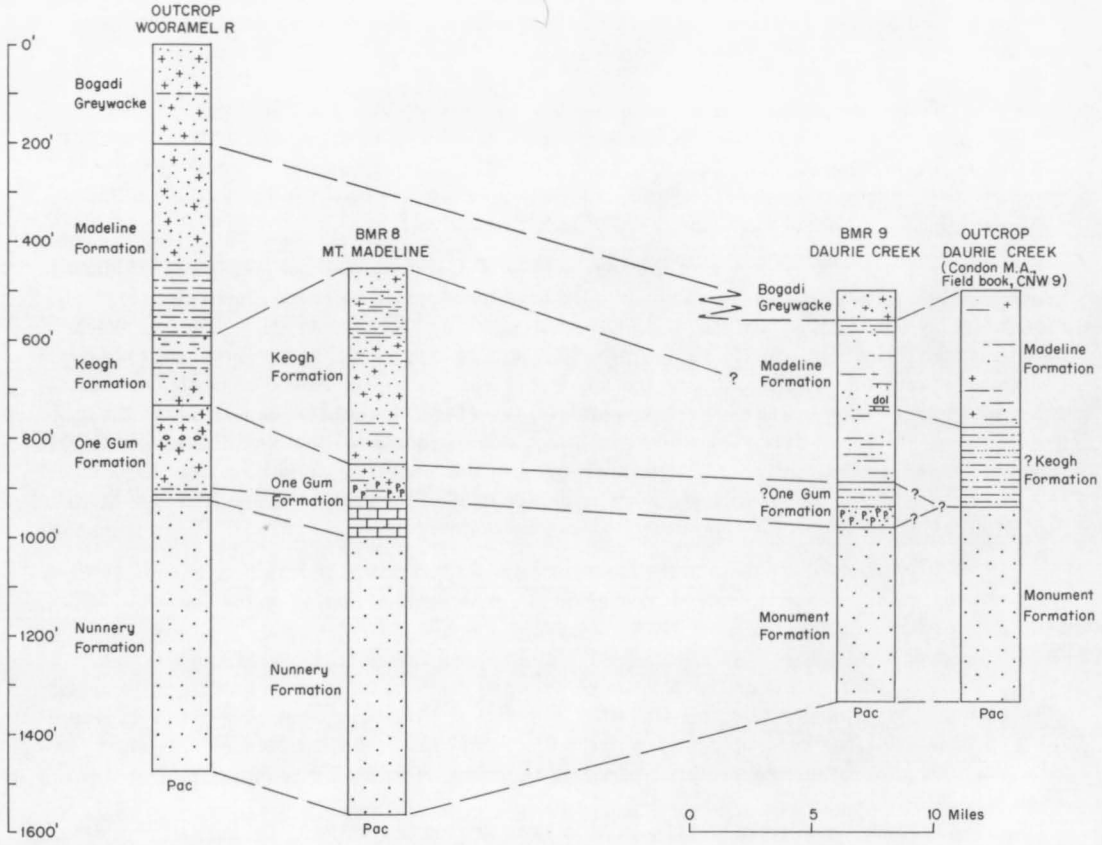

Fig. 4. Comparative stratigraphic sections of the Wooramel and Byro Groups in the Byro Basin.

A boundary with the Lyons Group was tentatively chosen at 1320 feet, where a well-defined bed of limestone occurs. As in BMR 8 this is easily distinguishable, but seems derived from an environment so similar to that of the typical Carrandibby that a second possible position for the top of the Lyons Group has been chosen at 1405 feet, at the top of a dense black shale. There is no boulder bed directly below this lower marker bed in BMR 9, and generally the Lyons Group is cleaner, finer-grained, and better sorted than in BMR 8.

From 1513 to 1641 feet the well penetrated a permeable sandstone bed which showed good reservoir characteristics. It is apparently filled with salt water (Wiebenga & Jewell, 1959, p. 4). After an intervening silty section another permeable sandstone bed with thin bands of limestone followed from 749 to 2011 feet. A white shale bed occurs between 2011 and 2050 feet. From 2050 to 2100 feet boulders occur in a tillitic quartz sandstone matrix. BMR 9 intersected 25 feet of varved clays at 2200 feet and finished in dense black shale at 2299 feet.

CONCLUSIONS

Neither bore provided much information on structure. No regional dips were apparent in the cores and only current-bedding was noted; nor did any new facts come to light on the large faults which affect the Byro Basin.

BMR 8 penetrated rocks less well-sorted, more coarse-grained, partly thicker, and less uniform than those intersected in BMR 9. Bogadi Bore, 10 miles south-east of BMR 8, appears to have penetrated a sequence similar to that of BMR 9; no coarse sediments or greywacke were reported, puggy dark shales were recorded for the Madeline Formation, and fine-grained sandstones for the Wooramel Group (Konecki et al., 1958, p. 115). The relative lack of lithic material and the better sorting in BMR 9 and the Bogadi Bore, compared with BMR 8, suggest that both were farther from the source of sediments than was BMR 8, and consequently closer to the centre of the basin.

The 18 feet of weathered fossiliferous siltstone at the base of the type section of the One Gum Formation, which originally may have been calcareous, is represented in BMR 8 by 60 feet of limestone somewhat similar in lithology to the Callytharra Formation; in BMR 9 it seems to be represented by calcareous sandstone.

The intersection of the permeable and porous strata which might constitute reservoir rocks in the Lyons Group in both wells was an important result of the drilling programme. Unfortunately the bailing operation to observe suspected oily water with a plug at 2030 feet in BMR 9 was not completed, as the bailer broke and necessitated the abandonment of the well.

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APPENDIX 1

ALTERNATIVE INTERPRETATIONS OF THE UPPER PARTS OF BORES BMR 8 AND BMR 9

by

J.M. Dickins and M.C. Konecki

BMR 8

Cuttings show that the lithology of the upper part of the interval from 0 to 470 feet corresponds to that of the Keogh Formation and that of the lower part to that of the One Gum Formation. The differences between the two formations, however, are less than in the type area and it might be best to regard the whole interval as One Gum plus Keogh Formation. If it is felt desirable to determine a boundary, then the main lithological change, from fine to coarse-grained sandstone, appears to us (from the electric log) to take place at 225 feet.

BMR 9

In the interval above the Callytharra Formation (0 to 830 feet) we would place the upper boundary of the Monument Formation slightly higher, at 440 feet (from electric log), where the first coarse-grained sandstone appears, as we consider that this corresponds more closely to the upper boundary of the formation in the type section in Daurie Creek about 2 miles east of BMR 9 (see Konecki et al., 1958). This boundary corresponds closely to the suggested boundary between the One Gum and Keogh Formations at 225 feet in BMR 8. We regard the interval 225 to 440 feet as Keogh Formation as it retains the lithological characteristics of this formation in its type area, i.e. laminated to thin-bedded, interbedded siltstone and fine-grained quartz greywacke. Between 225 and 440 feet in BMR 9 the quartz greywacke is finer and the proportion of siltstone is higher than in the type area, but lithologically the unit is distinguishable from the black shale and siltstone characteristic of the Madeline Formation.

The marker bed used in surface mapping to separate the Keogh from the Madeline Formation shows clearly in abundant coarse and very coarse quartz grains in the cuttings between 235 and 255 feet and in both the self potential and resistivity logs between 225 and 260 feet.

The interval above 70 feet contains both siltstone and quartz greywacke and therefore it is considered that this represents the upper part of the Madeline Formation in the type area. The Bogadi Greywacke contains only quartz greywacke.

If our alternative interpretation is correct, the Wooramel Group changes considerably and becomes finer-grained between the type area, near Gap Pool, and Daurie Creek, whereas the Madeline Formation remains much the same.

APPENDIX 2

PERMIAN MACROFOSSILS FROM BORES BMR 8 AND BMR 9

by

J.M. Dickins

BMR 8 MOUNT MADELINE

Identifications

Core 6 (527' - 537')

Brachiopods

- 'Chonetes' sp.
- Aulosteges cf. baracoodensis Etheridge Jnr, 1903
- Strophalosia sp. ind.
- Orthotetacea gen. et sp. ind.
- Streptorhynchus sp. ind.
- Streptorhynchus cf. plicatilis Hosking, 1932
- Neospirifer spp.
- Spiriferidae gen. et sp.
- Pseudosyrinx sp. ind.
- Cleiothyridina sp.
- Composita? sp.
- Productid spines

Pelecypods

- Parallelodon cf. bimodoliratus Dickins, 1963
- Volsellina? sp. ind.
- Pseudomyalina sp. ind.
- Deltopecten sp. ind.
- Aviculopecten? sp. ind.
- Aviculopecten cf. tenuicollis (Dana, 1847)
- Astartella cf. obliqua Dickins, 1963

Bryozoans

- Streblotrypa sp.
- Stenoporids
- Fenestellids including Lyropora

Crinoid stems

Core 11 (1010' - 1020')

Brachiopods

- Cancrinella cf. cancriniformis (Tschernyshew, 1889), (Coleman, 1957)

Core 12 (1095' - 1101')

Brachiopods

Cancrinella lyoni (Prendergast, 1942)
Productid indet.

Pelecypods

Parallelodon sp. ind.
Astartila? sp. ind.
Euchondria? sp. ind.

Core 13 (1199' - 1207')

Brachiopods

'Chonetes' sp.
Cancrinella sp. ind.

Pelecypods

Atomodesma cf. mytiloides Beyrich, 1864
Palaeocosmomya? sp.

Core 14 (1380' - 1290')

Brachiopods

'Chonetes' sp.
Cancrinella cancriniformis (Tschernyschew, 1889), (Coleman, 1957)
Linoproductus foordi (Etheridge Jnr, 1910)
Dictyoclostus sp.

Pelecypods
Astartila? sp. ind.

Plant leaf

Bryozoans

Crinoid stems

Core 15 (1382' - 1392')

Brachiopods
Cancrinella cf. cancriniformis (Tschernyschew, 1889), (Coleman, 1957)
Linoproductus foordi (Etheridge Jnr, 1910)
Neospirifer sp. (simple type)

Ostracodes

Bryozoans

Crinoid ossicles

This core has possible stylolites

Core 16 (1485' - 1497')

Numerous worm burrowings

? Leaves or seaweed

Core 18 (1665' - 1671')

Brachiopods
'Chonetes'? sp.
Taeniothaerus? sp. ind.
Indet. productids
Spiriferid indet.
Pseudosyrinx sp. ind.
Orthotetid indet.

Pelecypods
Deltopecten sp. ind.
Aviculopecten cf. tenuicollis (Dana, 1847)

Bryozoans

Ostracodes?

Crinoid ossicles

Core 30 (2782' - 2796')

Brachiopod shells including Neospirifer sp. ind.

Crinoid fragments

Core 32 (2994' - 3004')

Brachiopods
Pseudosyrinx? sp.

Rhychonellacean brachiopod (radiating ribs similar to species in Lyons Group at ML6 near Moogooree homestead - Dickins & Thomas (1959, p. 74))

Pelecypods

Astartila? sp.

Remarks

Core 6 is from the limestone at the base of the One Gum Formation, which is in a similar stratigraphical position to the predominantly siltstone member with marine fossils, recorded by Konecki, Dickins, & Quinlan (1958, p. 33) from the base of the One Gum Formation in outcrop to the south-west. In the bore, however, this unit is thicker and more calcareous and in lithology is similar to the Callytharra Formation. As in outcrop, the fauna in the bore is similar to that from the Callytharra Formation. Differences may be obscured by the fragmentary nature of the material. The pelecypods from the bore have been discussed by Dickins (1963) and the significance of Deltopecten at this level for Australia-wide correlation is assessed by Dickins (in press). A unit within the Wooramel Group, with a similar fauna and lithology, the Jimba Jimba Calcarenite, has been recognized by Condon (1965) in outcrop on Winnemia Ridge, 10 miles west of Jimba Jimba homestead near the Gascoyne River.

This part of the sequence in the bore is thicker and more calcareous, suggesting deposition in a deeper part of the basin than the outcrop to the south-west. Possibly it indicates also that the Madeline Faultline was present as a scarp during Wooramel Group time. The thickening occurs in the Mount Madeline area where maximum movement has been postulated along the faultline (Konecki et al., 1958, p. 78). In contrast the Callytharra Formation shows no indication of a shoreline to the west (Konecki et al., 1958, p. 25).

If Core 11 is from the basal part of the Nunnery Sandstone, as appears likely, this adds evidence that this part at least of the Nunnery is marine - see Konecki et al. (1958, p. 31).

Cores 12-13 are from the Callytharra Formation and contain a fauna characteristic of this formation.

Possibly Core 18 and Cores 31 and 32 are from the Lyons Group. The fauna from Cores 18 and 31 is too fragmentary to be of much value, but Core 32 contains a rhynchonellacean of a type which has been found only once before - in the basal part of the Lyons Group to the north.

BMR 9 DAURIE CREEK

Identifications

Core 1 (91' - 101')

Many burrowings and plant fragments

Core 2 (192' - 202')

Shell and fenestellid fragments

Core 3 (295' - 305')

Two ?brachiopod or gastropod shell fragments

Core 8 (807' - 817')

Many burrowings

Core 9 (892' - 902')

Brachiopods

- Strophalosia sp. nov. (as in Callytharra Formation)
- Spiriferid indet.
- Cleiothyridina or Phricidothyris sp. ind.
- Permorthotetes sp. ind.
- Streptorhynchus cf. plicatilis Hosking, 1932

Fenestellid Bryozoans

Core 10 (992' - 1002')

Brachiopods

- 'Chonetes' sp.
- Aulosteges or Taeniothaerus sp.
- Neospirifer sp. (non-alate type common in Callytharra)
- Spiriferid indet.

Fenestellid Bryozoans

Core 11 (1083' - 1093')

Brachiopods

- Cancrinella cf. lyoni (Prendergast, 1942)
- Strophalosia cf. etheridgei Prendergast, 1942
- Neospirifer sp. (alate type)
- Composita? sp. ind.
- Cleiothyridina sp.
- Phricidothyris? sp.

Pelecypods

Phestia cf. darwini (de Koninck, 1877)
Parallelodon bimodoliratus Dickins, 1963
Edmondia? sp. ind.
Aviculopecten tenuicollis (Dana, 1847)
Plagiostoma? sp. nov.

Fenestellid and ramose Bryozoans

Core 12 (1190' - 1208')

Brachiopods

'Chonetes' sp.
Neospirifer sp. (simple type)

Pelecypods

Aviculopecten tenuicollis (Dana, 1847)

Crinoid stem ossicles

Core 16 (1609' - 1690')

Many burrowings and carbonaceous plant fragments

Core 17 (1680' - 1690')

Many burrowings

Remarks

Shell fragments in Core 3 from the Keogh Formation are a possible indication of marine conditions in this unit.

Cores 9, 10 and 11 are from definite Callytharra Formation and contain a fauna characteristic of this formation.

References

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BORE BMR8 MT. MADELINE

PLATE 1

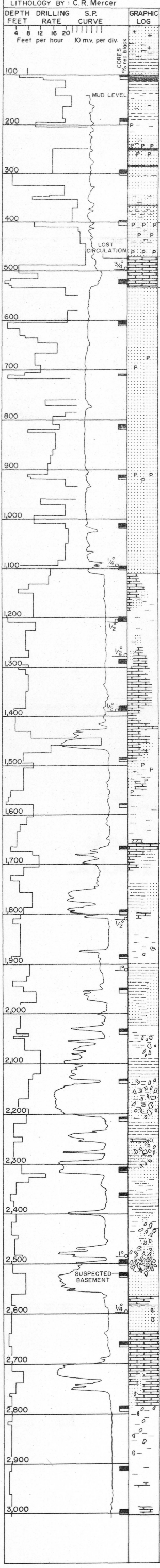
BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

STATE: WESTERN AUSTRALIA BASIN: CARNARVON AREA: BYRO BASIN

LOCATION: LATITUDE 25° 46'S LONGITUDE 115° 39' E
ELEVATION: GROUND APPROX. 800' ROTARY TABLE APPROX. 804'
DATE SPUDDED: 25th MAY, 1959 COMPLETED: 12th JULY, 1959
TOTAL DEPTH (FROM R.T.): 3,004' STATUS: ABANDONED
HOLE PROFILE: 6 5/8" 0-83', 6" 83'-976'
5 5/8" 976"-2,994', 4 3/4" 2,994'-3,004'
CASING: 6 5/8" 0-83'
PLUGS: CASING-HEAD
LITHOLOGY BY: C.R. Mercer

ELECTRIC LOG DATA: F. Jewell
DATE: 12th JULY, 1959
INTERVAL LOGGED: 142'-3,002'
MUD- NATURE: BENTONITE
DENSITY: 73-75
VISCOSITY: 30-50 sec.
RESISTIVITY: 4·1 ohm/mtr

LITHOLOGY SYMBOLS
- Quartz sandstone
- Quartz greywacke
- Siltstone
- Limestone
- Shale
- Pyrite
- Coal and coaly shale



DEPTH	LITHOLOGY	FORMATION	AGE
0	Siltstone, largely quartz greywacke, light tan to grey; sandstone, angular to subangular quartz grains; kaolin cement and ferruginous cement in the top 5' weathered	KEOGH	PERMIAN
60	Siltstone, brown, ferruginous stain and cement, fair to poor porosity; some sandstone, tan, gritty, slightly micaceous	KEOGH	PERMIAN
90	Quartz sandstone, light grey, medium to fine-grained, subangular, coarse angular quartz (80% of 95' sample), slightly calcareous	KEOGH	PERMIAN
100	Shale, black, finely gritty, sub-bituminous, very friable; some bedded siltstone and bands of sand	KEOGH	PERMIAN
108	Quartz greywacke, grey, fine-grained, micaceous, gritty, green, black, and amber	KEOGH	PERMIAN
125	Shale with siltstone, dark grey, silty, carbonaceous, micaceous; some slightly calcareous sandy and silty material	KEOGH	PERMIAN
150	Quartz sandstone, argillaceous, dark grey, brown, fine to medium-grained; partly micaceous quartz greywacke	KEOGH	PERMIAN
170	Shale, black, micaceous, carbonaceous, silty	KEOGH	PERMIAN
175	Quartz sandstone, same as 150'	KEOGH	PERMIAN
190	Shale, black, silty, carbonaceous; thin interbeds of micaceous grit	KEOGH	PERMIAN
205	Quartz sandstone, grey, fine-grained, subangular, micaceous, some silt and shaly material	ONE GUM	PERMIAN
230	Shale, black, micaceous	ONE GUM	PERMIAN
235	Quartz sandstone, white, very coarse-grained (>1·0mm), clean, well rounded	ONE GUM	PERMIAN
240	Shale, black, coaly, pyritic	ONE GUM	PERMIAN
245	Quartz sandstone, white, coarse-grained, subangular, poorly cemented, quartz grains > 1·5mm; interbedded carbonaceous and sandy material in part, largely sugary	NUNNERY	PERMIAN
280	Shale, black, very carbonaceous	NUNNERY	PERMIAN
282	Quartz sandstone, white to light grey, medium to very coarse-grained (>2·5mm), angular, subrounded, poorly cemented; some interbedded siltstone at 300'	NUNNERY	PERMIAN
320	Shale, black, carbonaceous, some sand grains	NUNNERY	PERMIAN
335	Quartz sandstone, white, coarse-grained (1-2mm), clean, poorly cemented; some quartz greywacke, light grey, fine-grained, gritty	NUNNERY	PERMIAN
355	Shale, black, very carbonaceous	NUNNERY	PERMIAN
365	Quartz sandstone, siltstone, grey, gritty, grades into greywacke in upper part, cleaner and coarser-grained in lower part, thin band of shale below	NUNNERY	PERMIAN
395	Shale bed, very coaly	NUNNERY	PERMIAN
400	Quartz sandstone, ferruginous, reddish brown, fine to coarse-grained; trace of siltstone, ferruginous cement, becoming coarser-grained (1·5mm), cleaner, rounded, considerable pyrite (1130'-440')	NUNNERY	PERMIAN
440	Quartz sandstone, white, coarse-grained (>2·5mm), angular, clean, slightly frosted, pyrite (25%)	NUNNERY	PERMIAN
465	Quartz sandstone as above; with shale, black, soft, carbonaceous	NUNNERY	PERMIAN
474	Limestone, white, massive, fragmental in lower part, crinoids, fenestellids	NUNNERY	PERMIAN
500	Limestone, white, massive, fragmental, crystalline, many productid spines, trace of silt, generally more argillaceous from 510'-520'	NUNNERY	PERMIAN
530	Quartz sandstone, white, 0·2-0·8mm, subrounded, well sorted, clean, a little kaolin cementing, frosted grains	NUNNERY	PERMIAN
680	Quartz sandstone as above, trace carbonaceous mudstone, some pyritic material	NUNNERY	PERMIAN
775	Quartz sandstone as above, 40% grains 0·1mm, size decreasing	NUNNERY	PERMIAN
920	Quartz sandstone as above; some mudstone, black, in thin interbeds and laminae	NUNNERY	PERMIAN
945	Quartz sandstone, massive, same as 530'-920'	NUNNERY	PERMIAN
1110	Limestone, light tan, slightly crystalline to massive, fossiliferous; shale interbeds, black, slightly silty, carbonaceous, calcareous	CALLYTHARRA	PERMIAN
1145	Quartz sandstone, grain size 0·3-0·6mm, subrounded, well sorted, clean; shale 20%, black, carbonaceous	CALLYTHARRA	PERMIAN
1155	Limestone, dark grey to tan, arenaceous; shale 30 to 60%, black, fossiliferous, calcareous	CALLYTHARRA	PERMIAN
1190	Shale, black, calcareous, slightly carbonaceous, silty, increasingly calcareous at base; sandstone (12%) at 1240'	CALLYTHARRA	PERMIAN
1275	Calcilutite with shale, grey-black, some fossils; limestone, tan, cryptocrystalline, semi-massive in transition zone to limestone below; sandstone and siltstone (10%)	CALLYTHARRA	PERMIAN
1305	Limestone, tan, cryptocrystalline in part; calcilutite, grey to tan, slightly silty and argillaceous, fossiliferous	CALLYTHARRA	PERMIAN
1440	Limestone, more fragmental than above; decreasing shale and sandstone, frosted grains (20%)	CARRANDIBBY	PERMIAN
1485	Shale, black; siltstone and limestone, light grey, sandy, pyritic, ? caving	CARRANDIBBY	PERMIAN
1555	Shale, black, slightly carbonaceous and calcareous, massive	CARRANDIBBY	PERMIAN
1664	Limestone, light tan to grey, cleavage surfaces 1·0mm across, fossiliferous, scattered sand grains (15%), pyritic	?	?
1670	Limestone as above; siltstone, grey, sand grains (0·01mm), occasional fragments of angular quartz	?	?
1710	Shale, black, carbonaceous; siltstone (10%), light grey, sandy, some scattered angular quartz grains	?	?
1740	Siltstone, white to light grey, calcareous; interbedded quartz sandstone, grain size 0·005-0·5mm; shale (about 20%), considerable calcareous material at 1740' and 1805', sample non-uniform, much interbedding and cross-bedding	?	?
1805	Shale, black, carbonaceous, brittle; increasing siltstone near 1850'; thin limestone bed with quartz grains	LYONS	SAKMARIAN
1850	Shale as above, but slightly siltier with 10-30% granite boulder chips	LYONS	SAKMARIAN
1880	Siltstone, grey, argillaceous, very finely sandy, black carbonaceous flecks, brittle	LYONS	SAKMARIAN
1950	Quartz sandstone and siltstone, coarser than above, generally poorly sorted, well cemented	LYONS	SAKMARIAN
1975	Shale, black, carbonaceous, brittle, quartz sandstone and siltstone (20%) as above	LYONS	SAKMARIAN
1995	Siltstone with fine sand; shale (10%), black, slight increase in grain size downwards	LYONS	SAKMARIAN
2015	Shale, black, carbonaceous, brittle, trace quartz grains	LYONS	SAKMARIAN
2030	Quartz sandstone, white to light grey, grain size 0·1-0·5mm, subrounded, poorly cemented	LYONS	SAKMARIAN
2050	Quartz sandstone (10%), grey, grain size 0·3mm, kaolin cement; siltstone (40%), light grey; shale (10%), black, carbonaceous, silty; granite boulders (20%), generally massive, trace of bedding	LYONS	SAKMARIAN
2080	Siltstone, light grey, grain size 0·01mm, fairly clean	LYONS	SAKMARIAN
2110	Quartz sandstone, light grey, grain size 0·3mm, well cemented, well sorted, subrounded	LYONS	SAKMARIAN
2135	Shale, black, carbonaceous, brittle, with sandstone (20%), grain size 0·1mm, rounded, sandstone (30%), angular quartz grains, becoming tillitic at base	LYONS	SAKMARIAN
2150	Quartz sandstone, white to black, tending to sub-greywacke, tillitic, subangular to subrounded, with smokey quartz ? (40%), black grains, some granite boulder fragments (30%), biotite flakes (5%)	LYONS	SAKMARIAN
2200	Siltstone, tillitic, dark grey to grey, many rounded sand grains, dark mineral fragments (10%), siltstone, sugary white in places, carbonaceous in others, often gritty, very calcareous in part	LYONS	SAKMARIAN
2250	Quartz sandstone and siltstone with some boulders, tillitic, much granitic gneiss and quartz splinters, occasional marble boulders; some sandstone grit with calcareous cement, silty in part; limestone flakes (10%), sugary siltstone, broken in places and re-cemented	LYONS	SAKMARIAN
2300	Quartz sandstone, light grey, grain size 0·01-0·6mm, poorly cemented, fair to well sorted	LYONS	SAKMARIAN
2335	Shale, black, fine-grained, hard black specks, trace boulder fragments	LYONS	SAKMARIAN
2360	Siltstone, black, carbonaceous, hard, massive	LYONS	SAKMARIAN
2390	Quartz sandstone and siltstone with boulders (5%), sometimes grey, 0·3mm grains in calcareous cement, moderately to poorly sorted; quartz sandstone (20%), grain size 0·2mm, fairly well sorted; siltstone (70%), dark grey, gritty, hard, poorly sorted; shale (10%); fractured quartz fragments	LYONS	SAKMARIAN
2490	Shale, black; quartz greywacke, tillitic, with increasing boulder fragments of gneiss and schist (95% of sample to 2520')	LYONS	SAKMARIAN
2525	Quartz sandstone, grey, grainsize 0·3mm, fairly to poorly sorted and cemented, feldspar and kaolin cement	LYONS	SAKMARIAN
2555	Limestone, light tan; some calcilutite, grey, grainsize 0·02mm in parts, slightly dolomitic, fossiliferous, very argillaceous	LYONS	SAKMARIAN
2570	Siltstone and greywacke, grey, gritty, sandy, calcareous	LYONS	SAKMARIAN
2580	Quartz sandstone, light grey, grainsize 0·2mm, subangular, poorly cemented; shale, black, silty; siltstone (10%), grey, quartzitic	LYONS	SAKMARIAN
2640	Limestone, dark grey, very silty and sandy, argillaceous in parts, crinoid stems in parts	LYONS	SAKMARIAN
2710	Limestone (calcarenite), argillaceous in part, with quartz grains (30%) in shale (5%)	LYONS	SAKMARIAN
2780	Shale, black, silty, tillitic, massive, clear and dark mottled, scattered throughout with numerous small pebbles, scattered quartz fragments (15%)	LYONS	SAKMARIAN
2900	Shale, black, massive, traces of silt in parts, slightly calcareous in parts	LYONS	SAKMARIAN

BORE BMR9 DAURIE CREEK

PLATE 2.

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

STATE : WESTERN AUSTRALIA BASIN : CARNARVON AREA : BYRO BASIN

LOCATION : LATITUDE 25° 32' 30"S LONGITUDE 115° 52' 50"E

ELEVATION: GROUND APPROX. 900' ROTARY TABLE APPROX. 904'

DATE SPUDDED : 16th JULY, 1959 COMPLETED : 12th AUG. 1959

TOTAL DEPTH (FROM R.T.) 2,299' STATUS : ABANDONED

HOLE PROFILE : 6 5/8" 0-70' 5 5/8" 70'-2,294'
4 3/4" 2,294'-2,299'

CASING : 6 5/8" 0-70'

PLUGS : CASING-HEAD

LITHOLOGY BY : C.R. Mercer

ELECTRIC LOG DATA : F. Jewell

DATE : 12th AUG., 1959

INTERVAL LOGGED : 115'-2,295'

MUD-NATURE : BENTONITE

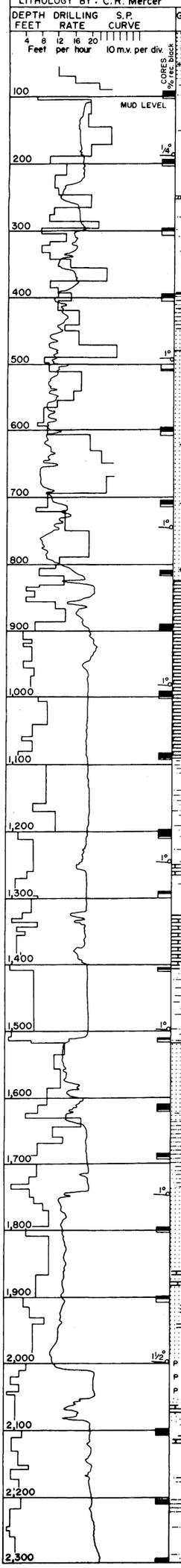
DENSITY : 78/cu. ft.

VISCOSITY : 40-50 sec.

RESISTIVITY : 41 ohm/mtr.

LITHOLOGY SYMBOLS

- Quartz sandstone
- Quartz greywacke
- Siltstone
- Limestone
- Shale
- Pyrite



LITHOLOGY	FORMATION	AGE
10-Sandstone, with greywacke and siltstone, light tan, grey, red, grainsize 0·3mm, angular, poorly sorted, weathered porosity, calcareous, some mica flakes, gypsum flakes, (5%) from 40'-70'	BOGADI	PERMIAN
70-Quartz greywacke, fine-grained, argillaceous, micaceous, harder than above; siltstone and quartz greywacke (20%), non-argillaceous, micaceous; some sand grains with siltstone and greywacke (20%), non-argillaceous	MADELINE	PERMIAN
110-Shale and greywacke, black, slightly silty, slightly calcareous, soft, carbonaceous, micaceous, fine, silty (10%)	MADELINE	PERMIAN
250-Quartz greywacke, light grey to brown, very calcareous, kaolinitic, grainsize 0·3mm; with shale and greywacke (5%)	MADELINE	PERMIAN
275-Shale, black, micaceous; quartz greywacke (15%) interbedded	MADELINE	PERMIAN
400-Quartz greywacke, grey, sandy, kaolinitic, grainsize 0·2mm, fair porosity; some shale, black	MADELINE	PERMIAN
430-Quartz sandstone, grey-brown, angular quartz grains, subrounded, frosted; pyrite (10%)	MADELINE	PERMIAN
465-Quartz greywacke, grey, grainsize 1·0-2·0mm, angular, poor kaolin cement; shale (10%), black, carbonaceous, well sorted, massive, slightly calcareous to very calcareous in parts	MADELINE	PERMIAN
550-Quartz greywacke as above, non-calcareous	?ONE GUM	PERMIAN
685-Quartz sandstone as above, with slight increase carbonaceous material, shale beds, muddy	?ONE GUM	PERMIAN
825-Calcilutite, grey-brown, argillaceous, silty, sandy, micro-fossiliferous in parts, some sandstone, angular; shale (40%), black, pyritic, phosphatic (20%), brachiopod shells	MONUMENT	PERMIAN
890-Calcilutite limestone, dark grey-green, grainsize 0·3mm, very fossiliferous, argillaceous, becoming light grey-cream with green tinge	MONUMENT	PERMIAN
920-Calcilutite (20%); limestone (80%), white and light grey, subcrystalline, submassive, slightly fossiliferous in parts, fairly to very argillaceous	MONUMENT	PERMIAN
1000-Quartz sandstone and siltstone, limestone matrix, very argillaceous	MONUMENT	PERMIAN
1090-Shale, black, dark grey, very calcareous, silt (10%); quartz greywacke in shale matrix, becoming black, very calcareous	MONUMENT	PERMIAN
1105-Shale as above, with siltstone, very fine-grained; quartz greywacke, calcareous (20%)	MONUMENT	PERMIAN
1130-Shale, black, calcareous; siltstone (50%) tending to subgreywacke, very fine-grained, thin laminae, calcareous	MONUMENT	PERMIAN
1210-Shale, black and dark grey, silty in part, very calcareous, micaceous flecks	CALLYTHARRA	PERMIAN
1255-Limestone, grey-brown, translucent, micro-fossiliferous in parts, trace green-brown in parts, sand grains (20%), grainsize 0·8mm	CALLYTHARRA	PERMIAN
1275-Shale, dark grey and black, very fine silt; sub-greywacke (40%), fine-grained, micaceous; shale, black, tillitic, non-calcareous	CALLYTHARRA	PERMIAN
1320-Calcarenite with limestone, white, very sandy; some limestone, clear	CALLYTHARRA	PERMIAN
1340-Quartz sandstone, white, grainsize 0·2mm, limestone cement; greywacke in part; shale, black, slightly silty, tillitic	CALLYTHARRA	PERMIAN
1355-Limestone, white, silty and sandy, grainsize 0·08mm, cleaner than above; trace of limestone, black, fossiliferous	CALLYTHARRA	PERMIAN
1365-Limestone as above, considerable bedded shale, black	CALLYTHARRA	PERMIAN
1385-Limestone; white sand cement (5%), grainsize 0·8mm, fairly clean	CALLYTHARRA	PERMIAN
1405-Shale, black, massive, hard, tillitic	CALLYTHARRA	PERMIAN
1520-Quartz sandstone, white, grainsize 0·1-1·0mm, 80% of grains 0·4mm, angular, poorly sorted, poor kaolin cement, very porous, at 1535' grainsize 2·0-3·0mm, 70%, light tan, frosted; trace of boulder material between 1530'-1545', brown staining	CALLYTHARRA	PERMIAN
1590-Quartz sandstone and siltstone, grey, argillaceous, grainsize 0·1mm, fairly sorted and cemented; shale, (30%), black, tillitic	CALLYTHARRA	PERMIAN
1615-Siltstone, grey, argillaceous, grainsize 0·1mm, fairly well sorted, subangular, tight laminae, often very fine-grained; becoming very sandy at 1670' with suspected glauconite	CALLYTHARRA	PERMIAN
1725-Shale, black and dark grey, very silty, fine laminae, calcareous, slightly carbonaceous	LYONS	PERMIAN
1740-Quartz sandstone, grey, grainsize 0·4mm, occasional 0·1mm red grains, fairly porous, calcareous, with thin argillaceous laminae, generally poorly cemented throughout with scattered 1·0-2·0mm frosted quartz grains, brown staining 1740'-1760'	LYONS	PERMIAN
1860-Quartz sandstone, white and light grey, grainsize 0·2mm; limestone cement, quartzitic groundmass (30% volume) in limestone matrix	LYONS	PERMIAN
1900-Quartz sandstone, white, grainsize 0·3mm, fairly well sorted and cemented, calcareous, subrounded, fairly clean, very pyritic (2015'-2030'), generally massive	LYONS	PERMIAN
2030-Shale, black and dark grey, tillitic, slightly calcareous, pyritic, slightly silty, with granite pebbles (5%)	LYONS	PERMIAN
2035-Shale as above with interbedded bentonite (40%), white, fairly hard	LYONS	PERMIAN
2045-Quartz sandstone, light grey, grainsize 0·2-1·0mm, poorly sorted, fairly cemented, subangular, calcareous cement, traces of boulder fragments to 2060' where boulders (30%) start; continues to 2080' in limestone	LYONS	PERMIAN
2085-Shale, black and dark grey, tillitic, massive, sandy and silty parts; small granite pebbles (30%), 1" diameter, with flecks of shale, black	LYONS	PERMIAN
2115-Limestone, tan, silty, grainsize 0·1mm, slightly argillaceous; with siltstone, white, fairly clean, well sorted; limestone	LYONS	PERMIAN
2120-Shale, light grey, smooth, fine-grained, silty; siltstone, white, grainsize 0·1mm, calcareous; limestone (10%), silty	LYONS	PERMIAN
2155-Siltstone, white, sand grains (0·1mm), rounded; gradational sorting to shale below	LYONS	PERMIAN
2170-Shale, black, light grey and dark grey, silty in parts, massive	LYONS	PERMIAN
2200-Shale, black and light grey, varved (0·5-1·0mm) bands, massive	LYONS	PERMIAN
2225-Shale, grey and light grey, silty in parts, calcareous, massive	LYONS	PERMIAN
2230-Shale, grey; with sandstone (40%), shale, quartz greywacke, brown, tillitic; sandstone (10%), white, grainsize 0·8mm, tending to greywacke in places	LYONS	PERMIAN
2240-Limestone, brown, very silty, very argillaceous	LYONS	PERMIAN
2250-Shale, black and dark grey in silty areas, calcareous, hard	LYONS	PERMIAN