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THE CRETACEOUS BELOW THE MURRAY BASIN

by

P.R. Evans & P.J. Hawkins

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ABSTRACT

Palaeontological and petrological evidence of the age and lithology of the Cretaceous sediments encountered in deep wells through the Murray Basin is examined. Separate correlations between wells on microfaunal and microfloral evidence closely correspond to each other but the microfloral data indicate modification is required to previous assessments of the periods at which deposition occurred. The Cretaceous is preserved in two known areas; one near Ivanhoe, where it is marine and Aptian in age, the other centred on Renmark, where Aptian basal sandstones are overlain by marine Aptian and early Albian glauconitic shales and sandstones. The youngest Cretaceous sediments in the Renmark area are Albian in age and non-marine. The marine character of the Aptian and early Albian transgressions indicates connections with the Great Artesian Basin to the north, rather than with the Otway Basin to the south. However, the succeeding non-marine Albian has a volcanic provenance and petrologically is similar to its correlates in the Otway Basin. A tectonic event which cut off the marine environment from the region and which changed the provenance of sediment source is inferred from this evidence. Uplift of the Cobar - Broken Hill Ridge could have been part of this movement. Whether or not there was connection between the Otway and Murray Basin regions cannot be ascertained from the evidence.

INTRODUCTION

A request by Beach Petroleum N.L. for palynological determination of the age of samples from their well Berri North No. 1 in the Murray Basin led to an appraisal of all palaeontological and petrological information about the Cretaceous of the region. Some of the palaeontological data might be construed as stratigraphically contradictory and other data have been so generalized that their geological significance is obscured. The present paper briefly attempts to sort these data in order to determine when the main phases of deposition occurred in the region of the Murray Basin during Cretaceous times (P.R.E.).

Apart from the work done reports by well-site geologists on sediments encountered in deep wells, no other petrology of the Cretaceous of the region has been reported in the past.

A macroscopic petrological examination was carried out on cores 1 and 2 from Beach Berri North No. 1, cores 7-12 from A.O.C. Renmark North No. 1, cores 6 and 7 from A.O.G. Lake Victoria No. 1, and core 3 from A.O.G. Tarrarra No. 1. In addition, detailed thin section studies of selected core material from these wells were undertaken. The objectives in the petrological study were: to study the gross lithologies from the cores; to determine the mineralogy of the sediments and the framework of the sandstones; and to compare as far as possible the mineralogy of the sandstones in the Murray Basin with those observed in the Otway Basin (P.J.H.).

An understanding of the age, duration and lithological character of these sections is vital to any comparison of the depositional histories of the Great Artesian, Murray and Otway Basins.

PALAEONTOLOGICAL SCALES

Ludbrook (1966) recognized a sequence of foraminiferal zones in the South Australian portion of the Great Artesian Basin, which have not yet been applied to the Cretaceous below the Murray Basin. All determinations have been in terms of the internationally accepted Cretaceous stage names.

Dettmann (1963) recognized a suite of microfloral assemblages in the eastern Australian Cretaceous, which she applied to the Great Artesian, Murray and Otway Basin regions. Evans (1966b; in Bureau of Mineral Resources, 1966) recognized sequences of palynological units based on spore distribution and of microplankton zones based on the occurrence of dinoflagellates, which he applied to the Cretaceous throughout Australia. Each of these palaeontological scales (Table 1) is applicable to the Cretaceous below the Murray Basin and are interchanged as necessary during the ensuing discussion.

TABLE 1. CRETACEOUS PALYNOLOGICAL AND MICROPALAEONTOLOGICAL SCALES FOR EASTERN AUSTRALIA

DETTMANN (1963)	EVANS (1966b)		LUDBROOK (1966)	STAGE
Paradoxa	K2b	O. operculata	N. australiana	Albian
	K2a		V. howchini/ T. flosculus	
Speciosus	K1d	O. operculata/ M. tetracantha		
	K1b-c	D. cerviculum	H. jonesi	Aptian
			T. raggatti/ T. ancooraensis	
	K1a	D. cerviculum/ S. attadalense		
Stylosus		S. attadalense/ C. mirabilis		Neocomian

OBSERVATIONS - OUTCROP

Few outcrops of Cretaceous sediments flank the Murray Basin and none occurs within it (figure 1). None has been detected around the South Australian portion of the basin (Ludbrook, 1961) or the eastern margin in New South Wales. In Victoria outcrops occur near Casterton (Kenley, 1954; Evans, 1961; Bureau of Mineral Resources, 1966), the evidence from which indicates that they are no older than Albian, palynological unit K2b in age. Furthermore, they are best regarded as a development of the Otway Basin (Ludbrook, 1961; Bureau of Mineral Resources, 1966). A small outlier is preserved to the north of the Murray basin about 40 miles west of Cobar, from which Ludbrook identified a "Tambo" microfauna (Spence, 1958, p.54). Others flank Pondie Range, north of Wilcannia, and would appear to be remnants of a southerly extension of the lobe of the Great Artesian Basin which passes below White Cliffs. The 1:1,000,000 geological map of New South Wales (Geological Survey of New South Wales, 1962) shows Cretaceous sediments about 25 miles north of Menindee, but the more recent Wilcannia 1:250,000 Sheet geological map (Geological Survey of New South Wales, 1966) shows most of these beds as Cainozoic in age.

OBSERVATIONS - SUBSURFACE

The existence of Cretaceous sediments below the Murray Basin was first identified by Ludbrook (in Glaessner & Parkin, 1958), when she discovered foraminifera at depths below 1587 feet in A.O.G. Loxton No. 1 Well, which had been drilled to test gravity and magnetic anomalies in the Renmark area (Seedsman, 1964). The discovery of Permian sediments below the Murray Basin in A.O.G. Wentworth No. 1 and A.O.C. North Renmark No. 1 influenced subsequent exploration of the basin, and wells were sited for investigation of the Permian, rather than the Cretaceous. Information concerning the Cretaceous below the Murray Basin is therefore available from not necessarily the most favourable sections. However, for completeness of the record, every deep oil exploration well drilled into the basin since 1956 is

considered below, in alphabetical order, whether or not they encountered Cretaceous beds. Their co-ordinates are listed in Table 2* and their approximate locations plotted in figures 1 and 2.

Woodside (Lakes Entrance) Oil Co. N.L. Balranald No. 1

Penetrated 1064 feet of Cainozoic, which overlies ?Ordovician, steeply dipping grey shale (Benbow, 1962; Evans & Hodgson, 1963; Bureau of Mineral Resources, 1964). No Cretaceous was identified.

Beach Petroleum N.L. Berri North No. 1

Penetrated 1709 feet of Cainozoic, 1258 feet of Cretaceous, 100 feet of ?Permian or ?Cretaceous and entered ?Cambrian Kanmantoo Group (Laws & Heisler, 1967). Evans (in Laws & Heisler, op. cit.) recorded Cretaceous microfloras from:

Core 1, 1912 feet; including, Trilobosporites trioreticulosus, T. tribotrys and Pilosisporites grandis of the Coptospora Assemblage and unit K2.

Core 2, 2440 feet; including dinoflagellates of the Odontochitina operculata or Odontochitina operculata/Muderongia tetracantha Zones and the spores Dictyotosporites speciosus, Cyclosporites hughesi and Crybelosporites striatus of the Speciosus Assemblage, unit K1d.

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* Since this manuscript was completed Texam Corporation have drilled the additional wells Berangabah No. 1, Holy Box No. 1 and Dolmoreve No. 1, but data are not available from them for this discussion.

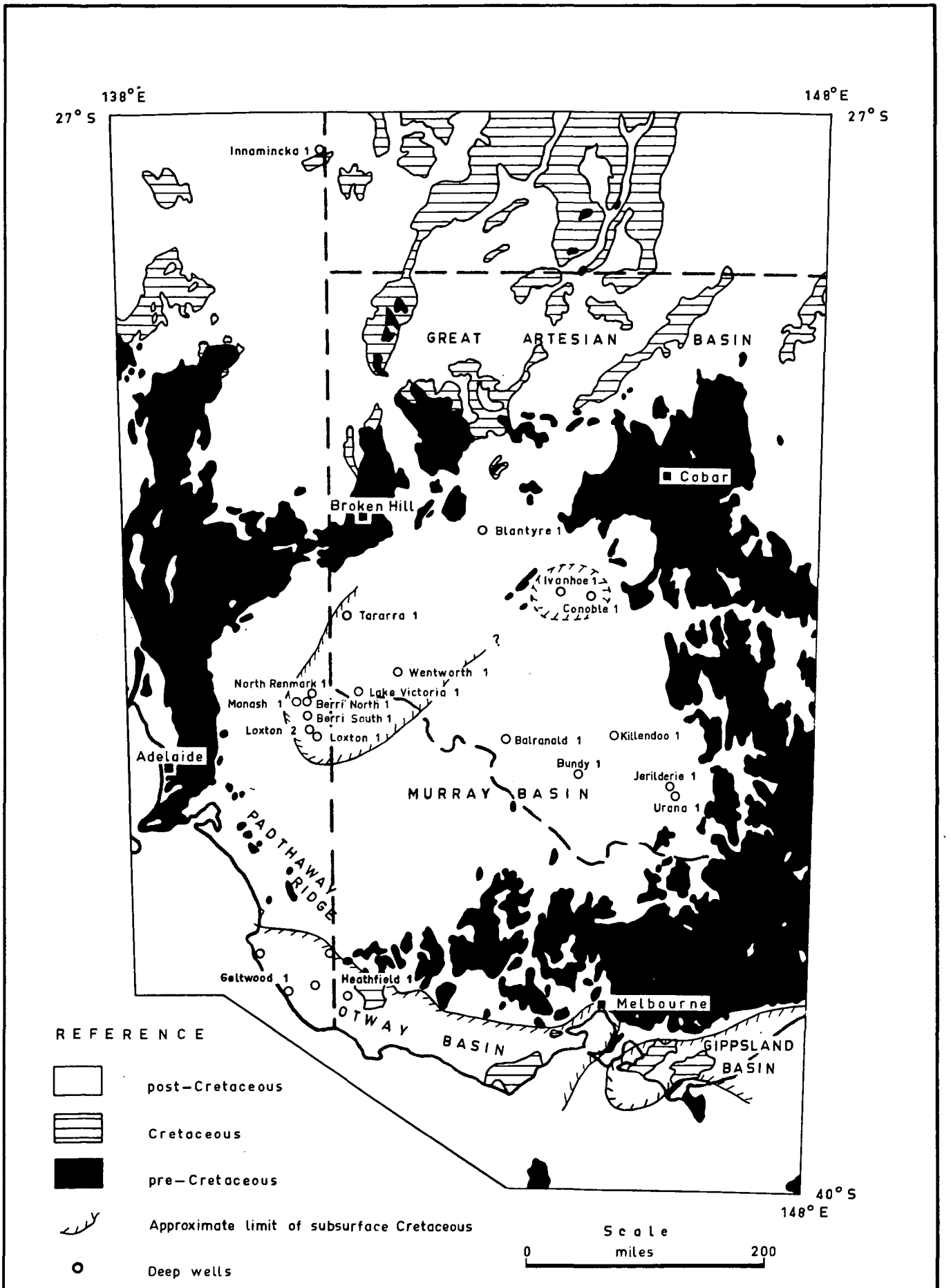

FIGURE 1. LOCATION MAP: MURRAY BASIN & RELATED AREAS

TABLE 2. OIL EXPLORATION WELLS DRILLED INTO THE MURRAY BASIN SINCE 1956

NAME	LATITUDE (S)	LONGITUDE (E)	GROUND LEVEL	DATUM +	TOTAL DEPTH
Balranald No. 1*	34°39'20"	143°29'32"	215'	227'	1322'
Berri North No. 1*	34 12 17	140 38 06	157	150	3100
Berri South No. 1*	34 22 16	140 38 05	170	180.9	2177
Blantyre No. 1*	32 09 15	143 09 40	239	252	7510
Bundy No. 1*	35 03 00	144 31 18	262	271	1376
Conoble No. 1	32 55 19	144 43 04			827
Ivanhoe No. 1*	32 54 11	144 17 51	270	277	2187
Jerilderie No. 1*	35 15	145 58	376	382	4360
Killendoo No. 1	34 41 01	145 04 09	310	324	2478
Loxton No. 1				143	1601
Loxton No. 2	34 32 43	140 37 40	40		1804
Lake Victoria No. 1*	34 03 15	141 20 53	97.5	111.5	2475
Monash No. 1	34 12 05	140 29 57	109.4	113.4	3445
North Renmark No. 1*	34 07	140 41	77.4	80.4	4018
Tararra No. 1*	33 20 12	141 15 49	210	223	6349
Urana No. 1	35 16 33	146 00 10	376	382	2216
Wentworth No. 1*	33 48	141 58	130	133	2081

* Commonwealth subsidized wells; + Kelly Bushing or Rotary Table.

The petrography of these cores follows:

Core 1, 1912-1932 feet, rec. 17 feet 6 inches.

(Macroscopic)

Sandstone: Medium greenish grey, friable, dense, angular, very fine-grained, and moderately sorted. Quartz and mica; abundant chloritic clay matrix. Thin interbeds of greenish grey claystone and mudstone.

(Thin Section); sample 1922 feet 0-4 inches.

Lithic Sandstone (Subgreywacke): Greenish grey, angular, very fine-grained and moderately sorted. Quartz-straight extinction (20%), oligoclass (10%); abundant lithics of microcrystalline siliceous fragments (16%), chloritized siliceous fragments (30%), volcanic fragments containing feldspar microlites (5%), chloritic fragments (2%); metaquartzite (1%). Muscovite flakes (1%) are chloritized and may be replaced with finely crystalline siderite. Pellicular chlorite (10%) in flaky form around detrital grains. Patches of siderite (5%). Thin carbonaceous laminations.

The framework of the sandstone in this core is similar to lithic sandstones observed in the Eumeralla Formation, Otway Basin.

Core 2, 2431-2441 feet, rec. 9 feet.

(Macroscopic)

This core consists of sandstone and siltstone (lower half).

Sandstone: Medium-dark green, dense, angular, very fine-grained, coarser grained towards the base and moderately to poorly sorted. Mica flakes. Abundant clay matrix. Root marking at 2432 feet in horizontal position.

Siltstone: Medium greenish-grey, dense, sandy, muscovite flakes. Finely dispersed carbonaceous matter. Thin very fine-grained sandstone laminations. Root markings.

The gross lithology is similar to lithologies observed in Lower Cretaceous sediments in the Otway Basin.

Beach Petroleum N.L. Berri South No. 1

Penetrated 1634 feet of Cainozoic, 494 or 360 feet of Cretaceous (top uncertain), and entered ?Cambrian Kanmantoo Group. No microfauna or microflora have been reported (Gausden & Watts, 1966).

Mid-Eastern Blantyre No. 1

Penetrated 760 feet of Cainozoic, which overlies Permian sediments (Campe & Cundill, 1965).

Woodside (Lakes Entrance) Oil Co. N.L. Bundy No. 1

Penetrated 1339 feet of Cainozoic, which overlies ?Ordovician granite (Shiels, 1962; Evans & Hodgson, 1963; Bureau of Mineral Resources, 1964).

North Star Oil Corporation Conoble No. 1

An unsubsidized hole for which no completion report is generally available. A section accompanying the Ivanhoe 1:250,000 Sheet area geological map (Geological Survey of New South Wales, 1966) shows that the well penetrated about 350 feet of Cainozoic, about 370 feet of Cretaceous and then entered the Devonian. Hodgson, in an unpublished report to the Chief Geologist, Bureau of Mineral Resources, reported a Cretaceous microflora in cuttings from the well. Based on Hodgson's report and re-examination of his slides, cuttings at 500-510 feet contained the spores Cicatricosisporites australiensis and Murospora florida of the Speciosus Assemblage and unit K1a. They also included the dinoflagellates Muderongia

tetracantha, M. mcwhaei and acritarch Micrhystridium spp. of the Dingodinium cerviculum or the Dingodinium cerviculum/Scriniodinium attadalense Zones.

North Star Oil Corporation Ivanhoe No. 1

Penetrated 531 feet of Cainozoic, 130 feet of Cretaceous, and entered the Permian (Brundall, 1964). Terpstra, Hodgson & Evans (in Brundall, op. cit.) reported the presence of an unlisted Cretaceous microfauna below 550 feet and microfloras as follows:

Cuttings, 560 feet; included Dictyotosporites speciosus of the Speciosus Assemblage and Muderongia tetracantha, M. mcwhaei, Odontochitina operculata and D. cerviculum of the base of the O. operculata/ M. tetracantha Zone.

Cuttings, 650 feet; included M. mcwhaei and D. cerviculum of the D. cerviculum Zone.

Terpstra has reexamined the microfauna from the well and furnished a description of it which is appended to this report.

The lithology of the Cretaceous section consists of porous, loosely cemented, subangular, fine-grained quartz sandstone and fine to medium grained, rounded to subangular, porous sandstone with brown light grey and dark grey clay stringers. There are some traces of pyrite and plant remains (Brundall, 1964).

Australian Oil & Gas Corporation Jerilderie No. 1

Penetrated 1182 feet of Cainozoic and entered the Permian (Wright & Stuntz, 1963; Evans & Hodgson, 1963; Bureau of Mineral Resources, 1964).

Amalgamated Petroleum Exploration Killendoo No. 1

Penetrated 1156 feet of Tertiary and entered the Permian or Devonian (Haites & Stewart, 1964).

Australian Oil & Gas Corporation Ltd Loxton No. 1

Penetrated 1315 feet (from Kelly Bushing of Tertiary and 281 feet of Cretaceous (Ludbrook, in Glaessner & Parkin , 1958; Ludbrook, 1961; Yakunin & Sprigg, 1963; Bureau of Mineral Resources, 1964). Although the well did not pass through the Cretaceous, refraction surveys in the region suggest that pre-Cretaceous beds were near the base of the hole at about 1800 feet below surface (Seedsman, 1964, p.99).

Ludbrook identified the megaspore Arcellites (al. Azolla) at unspecified levels between 1350 and 1587 feet. Below 1587 feet she found the arenaceous foraminifera Ammobaculoides romaensis and Trochammina minuta with a few individuals of Gaudryina, Dorothia, Textularia, Haplophragmoides and Ammobaculoides, which "on somewhat negative evidence" she determined as Albian.

Cookson & Dettmann (1958, p. 119) and Dettmann (1963, p. 119) recorded spores from 1410-1415 feet and 1465-1470 feet, which included Balmeisporites holodictyus, Crybelosporites striatus, Pilosisporites parvispinosus and Dictyotosporites speciosus of the Paradoxa Assemblage and unit K2a.

Beach Petroleum N.L. Loxton No. 2

No stratigraphic or palaeontological logs are available, but Gausden & Watts (1966) recorded that it, "encountered metamorphic basement at a relatively shallow depth . . . ".

Australian Oil & Gas Corporation Ltd Lake Victoria No. 1

Penetrated 1766 feet of Cainozoic, 925 feet of Cretaceous and entered ?Cambrian Kanmantoo Group (Grasso, 1964). Ludbrook (in Grasso, op. cit.) recognized Arcellites between depths of 1780 and 2165 feet and referred the section to the Albian. In the lower 155 feet she found Bigerina loeblichae and referred the containing beds to the Aptian. Harris (in Grasso, op. cit.) found elements of the Paradoxa Assemblage in core 6, 1807 feet and an indeterminate Cretaceous assemblage in core 7, 2105 feet.

Petrographic study shows these cores to be:

Core 6, 1807-1817 feet; rec. 10 feet.

(Macroscopic)

Sandstone: Medium green, friable, dense, angular, fine-grained and well sorted. Quartz, some lithic fragments, muscovite flakes. Chloritic clay matrix. Carbonaceous fragments and specks. Near horizontal bedding.

(Thin Section), sample 1810 feet.

Lithic Sandstone (Subgreywacke): Medium green, angular to subangular, fine-grained and moderately sorted. Quartz-straight extinction - (30%), oligoclase and albite (10%); abundant lithics of microcrystalline siliceous fragments (11%), chloritized siliceous fragments (30%), volcanic fragments containing feldspar laths (2%), chloritized volcanic fragments (2%), chloritic fragments (5%), and brown ironstained fragments (2%). Muscovite (2%) - sometimes chloritized and contorted; rare biotite; rare glauconite, garnet and zircon. Chloritic coatings (5%) around grains, and patches of calcite (1%). Much wlding of lithic grains. Carbonaceous fragments and specks.

The composition of this sandstone is similar to that observed in sandstones of the upper part of the Eumeralla Formation in the western part of the Otway Basin.

(Thin Section), sample 1812 feet.

Lithic Sandstone (Subgreywacke): Medium green, angular to subangular, fine-grained, and moderately to well sorted. Quartz-straight extinction - (30%), oligoclase (5%); abundant lithics of microcrystalline siliceous fragments (24%), chloritized siliceous fragments (20%), volcanic fragments with feldspar microlites (1%), chloritic fragments (5%), siliceous fragments with sericite flakes (5%); metaquartzite (2%). Muscovite (3%) - bleached and chloritized. Pellicular chlorite (5%) in flaky form around detrital grains. Interlocking and welding of lithic grains. Carbonaceous fragments.

The mineralogy of this sandstone is similar to that of sandstones encountered in Eumeralla Formation in the Otway Basin.

Core 7, 2105-2115 feet; rec. 8 feet.

(Macroscopic)

Sandstone: Dark green, friable, angular, fine-grained and well sorted. Quartz and lithic fragments, muscovite flakes. Chloritic clay matrix. Thinly bedded at 2110'. Dark thin claystone laminations and micro-crossbedding at 2112'. Near horizontal bedding.

(Thin Section)

Lithic Sandstone (Subgreywacke): Medium green, angular to subangular, fine-grained and moderately to well sorted. Quartz-straight extinction - (30%), oligoclase and rare microcline (10%); abundant lithics of microcrystalline siliceous fragments (15%), chloritized siliceous fragments (33%), volcanic fragments with feldspar microlites (1%), chloritic fragments (2%); chalcedonic fragments (1%), and metaquartzite (1%). Contorted muscovite flakes (1%). Pellicular chlorite (5%) in flaky form around detrital grains. Spots of calcite (1%). Interlocking and welding of lithic grains. Carbonaceous specks.

The mineralogy of this sandstone is similar to that of sandstones observed in the Eumeralla Formation in the Otway Basin.

Beach Petroleum N.L. Monash No. 1

Penetrated 1756 feet of Cainozoic, 1560 feet of Cretaceous, and entered the Permian (Walter, 1965). Harris (in Walter, op. cit.) identified Trilobosporites tribotrys and Crybelosporites striatus of the Paradoxa Assemblage at 1865 feet; Balmeisporites holodictyus, Dictyotosporites speciosus and dinoflagellates of the basal Paradoxa Assemblage, unit K2a at 2380 feet, and an assemblage with Coronatispora perforata and Ischyosporites punctatus, which he referred to the Speciosus Assemblage, at 2880 feet. Ludbrook (in Walter, op. cit.) thought that the top 540 feet of the Cretaceous might be Albian and the remainder Aptian.

Australian Oil Corporation North Renmark No. 1

Penetrated 1797 feet of Cainozoic, 1445 feet of Cretaceous and entered the Permian (Grasso, 1963; Yakunin & Sprigg, 1963; Bureau of Mineral Resources, 1964). Ludbrook (in Grasso, op. cit.), divided the Cretaceous between an upper 605 feet of ?Cenomanian - Albian sandstone and siltstone with Arcellites (al. Pyrobolospora) reticulatus; 435 feet of Aptian shale with foraminifera, which increase in abundance towards the base of the section; 175 feet of Aptian shale and sandstone with abundant arenaceous foraminifera and a basal 230 feet of ?Neocomian sandstone with no foraminifera other than forms presumed to be cavings. Harris (in Grasso, op. cit.) examined only two cores from the Cretaceous section of the well with little positive result. Hodgson examined core 10, 2723 feet during the course of a study of the Permian section of the well (unpublished information).

In view of the thick section of Cretaceous penetrated by the well, advantage was taken of the number of cores cut from the section and further samples were processed from cores 7 - 12 for the purposes of this report. In summary, the results of this work are as follows:

Core 7, 1823 feet; an abundant, diverse microflora and much other plant debris ; no microplankton to be found. The spores included Triloboporites trioreticulosus, T. tribotrys, Balmeisporites holodictyus, Arcellites hexapartitus, Laevigatosporites ovatus and Coptospora paradoxa of the Paradoxa Assemblage, unit K2b.

Macroscopic petrography;

Sandstone: Light greenish-grey, friable, thinly bedded, angular, very fine-grained, and well sorted. Quartz, muscovite flakes. Chloritic clay. Thin carbonaceous laminations and wisps. Micro-crossbedding.

Thin section petrography, sample 1824 feet 0-4 inches.

Sandy Siltstone: Greenish-grey, angular with very fine-grained, and fine-grained quartz. Sandy fraction more common in laminations. Quartz-straight extinction, rare composite - (35%), plag. feldspar (2%); abundant lithics of microcrystalline siliceous fragments (26%), chloritized siliceous fragments (26%), and chloritic fragments (2%). Muscovite flakes and sericite (5%); muscovite may be bleached and contorted. Rare garnet, rare chlorite grains. Chloritic clay matrix (5%). Much welding of lithic grains. Carbonaceous specks and patches.

The mineralogy of this siltstone is similar to siltstones in the Eumeralla Formation, Otway Basin.

Core 8, 2114 feet; an abundant microflora with no micro plankton, dominated by saccate pollen and in which the thick walled spores so common in core 7 were mainly absent. Coptospora paradoxa and Crybelosporites striatus were recognized. Coptospora Assemblage, unit K2.

Macroscopic petrography.

Sandstone: Medium greenish-grey, friable, angular, very fine-grained and moderately sorted. Quartz. Thin dark carbonaceous laminations. Sandstone is hard at bottom of core.

Thin section petrography, samples 2416 feet 0-4½ inches;

Lithic Sandstone (?Subgreywacke): Greenish-grey, angular, very fine-grained and moderately sorted. Quartz-straight extinction - (20%), oligoclase (15%), lithics of clean micro-crystalline siliceous fragments (12%), rare volcanic fragments with feldspar microlites (1%), and chloritic fragments (2%). Muscovite flakes (1%). Finely crystalline calcite (49%) which appears to be stained with dispersed iron-oxide, or contains siderite. Much replacement of grains has taken place and corrosion of existing grains by calcite. Laminations rich in carbonaceous matter and carbonate. Micro-crossbedding.

This rock is almost a replacement limestone due to the precipitation of a large amount of diagenetic calcite.

This type of sandstone has been observed in the upper part of the Eumeralla Formation, particularly in the western part of the Otway Basin.

Core 9, 2421 feet; both spores and microplankton were present. The spores included Lycopodiumsporites circolumenus, Crybelosporites striatus and Pilosisporites parvispinosus: the microplankton included Muderongia tetracantha, Gonyaulacidae and Micrhystridium spp., indicative of the Speciosus Assemblage, unit K1d, O. operculata/M. tetracantha Zone.

Macroscopic petrography;

Claystone: Greenish-grey, hard, dense, fractured. Some slickensiding. Root markings in near horizontal position.

Thin section petrography, sample 2420 feet 0-5½ inches;

Claystone: Greenish-grey, rare angular detrital quartz (1%). Sericite flakes. Chloritic and illitic clay (99%) - 2:1. Scattered carbonaceous specks.

This claystone may be similar to claystones in Eumeralla Formation, Otway Basin.

Core 10, 2723-2726 feet; a fairly abundant microflora of D. speciosus, Klukisporites lunaris, L. circolumenus, Pilosisporites notensis, Pterospermopsis sp., Micrhystridium spp. (common) and O. operculata; by stratigraphic position of the O. operculata/M. tetracantha Zone.

Macroscopic petrography;

Medium greenish-grey, hard, chloritic. ?Root markings.

It is similar to mudstones of Lower Cretaceous age encountered in the Otway Basin.

Core 11, 2960 feet; abundant microflora, including the spores D. speciosus, Cicatrocosisporites australiensis, C. ludbrooki, Densoisporites velatus, L. circolumenus, Cyclosporites hughesi Ceratosporites equalis, Neoraistrickia truncta, Coronatispora perforata.

It compares closely with the floras of unit Klb-c of the Speciosus Assemblage and the D. cerviculum Zone. D. cerviculum could not be found by a prolonged search, but neither could C. striatus and O. operculata of unit Kld and its correlates be found.

Macroscopic petrography;

The topmost part of this core consists of claystone and the remainder is sandstone.

Claystone: Medium greenish grey, hard.

Sandstone: Light greenish grey, friable, angular, fine-grained and moderately sorted. Quartzose. Clay matrix.

Thin section petrography, sample 2960 feet 6-8½ inches;

Lithic Quartz Sandstone: Light greenish grey, subangular, fine-grained ranging to medium-grained and moderately to poorly sorted. Quartz-straight extinction, some undulose - (67%), albite (1%), lithics of microcrystalline siliceous fragments (10%), chloritic siliceous fragments (14%), and chloritic fragments (1%), Muscovite flakes (2%); these flakes appear to be transformed to illite in places. Rare zircon. Flaky chlorite and sericite (5%)

around detrital grains. The lithic grains appear to be very altered. Scattered carbonaceous specks.

This sandstone possesses a framework and mineralogy which is not typical of the sandstones in the Eumeralla Formation, Otway Basin.

Core 12, 3205 feet; only unornamented spherical membranes could be extracted; they compare with Schizosporis spriggi and Spheripollenites psilatus, but could also be versions of some of the leiospheres which are so abundant in the underlying Permian. Harris recorded an extremely low content of spores, among which he found Foveosporites canalis and Microcachryidites antarcticus, which are of late Mesozoic age.

Macroscopic petrography;

Mudstone: Light greenish grey, hard, dense, massive. Rare muscovite flakes scattered carbonaceous specks.

Thin section petrography, sample 3207 feet 0-6 inches;

Silty Claystone: Light greenish grey. Angular detrital quartz (15%), sericite flakes. Illitic clay + quartz (85%). Thin laminations of illitic clay and dispersed carbonaceous matter.

This claystone is not very typical of the type recorded in the Eumeralla Formation, Otway Basin.

Australian Oil & Gas Corporation Ltd Tararra No. 1

Penetrated 1602 feet of Cainozoic, 300 feet of Cretaceous and entered the Permian (Boyd & Heisler, 1967). Microfloras in selected samples from the well were examined by Evans and Burger (in Boyd & Heisler, op. cit.). No core samples from in situ Cretaceous were examined, but a caving, which was caught at the top of core 3, 2676 - 2686 feet, from the Permian, contained D. speciosus, C. striatus, C. hughesi and Muderongia cf. M. tetracantha, which relate the well to the Speciosus Assemblage, unit Kld, and the O. operculata/M. tetracantha Zone. Petrographic examination of the sample showed:

(Macroscopic) sample 2676 feet, 0-2 inches.

Claystone: Medium greenish grey, dense, with ironstained patches. Very broken (Lower Cretaceous fragment).

The remainder of the core consists of grey, friable, subangular to subrounded, medium to coarse-grained, moderately sorted quartz sandstone. This sandstone is Permian in age.

(Thin Section) sample 2676 feet 0-2 inches.

Claystone: Medium greenish grey, with angular silt-size quartz grains (1%), sericite flakes and patches of finely crystalline pyrite. The bulk of the rock comprises illitic and chloritic clay. Scattered carbonaceous specks.

This claystone does not appear to be typical of the claystones observed in the Eumeralla Formation in the Otway Basin.

Australian Oil & Gas Corporation Wentworth No. 1

Penetrated 1270 feet of Cainozoic, 331 feet of Cretaceous and entered the Permian (Rose, 1962; Evans, 1962; Evans & Hodgson, 1963; Bureau of Mineral Resources, 1964). No cores were cut from the Cretaceous section, which was dated on the basis of foraminifera (Ludbrook, in Rose, op. cit.) and spores and microplankton (Evans, op. cit.) in cuttings. Gonyaulax edwardsii and Odontochitina operculata were present at 1604 feet and 1553 feet respectively and the section is placed in either the O. operculata or the O. operculata/M. tetracantha Zones.

SUMMARY OF OBSERVATIONS

Few of the wells which penetrated the Cretaceous have not been examined for their microfaunal and microfloral content, but none has been examined in great detail from either palynological or petrological points of view. Whatever may be deduced from these wells is therefore limited, but certain points of interest emerge from the survey.

Those wells which encountered Cretaceous sediments may be geographically and stratigraphically divided into two groups: the northern group, consisting of Ivanhoe No. 1 and Conoble No. 1*, and the remainder, which are centred around the Loxton - Renmark - Wentworth area.

Ivanhoe Area *

Conoble No. 1 appears to have penetrated the oldest palynologically dated sediments in the basin, which contained the combination of Cicatricosisporites australiensis and Murospora florida of unit Kla, basal Speciosus Assemblage or Stylosus Assemblage. The presence of dinoflagellates in this section is unusual in that Cretaceous sediments to the north of the Murray Basin of Kla age have rarely exhibited marine characteristics. Dinoflagellates associated with Kla have only been found in Alliance Chandos No. 1 (Evans, 1966). The Conoble dinoflagellate specimens might have caved from marine section higher in the well.

The Cretaceous at Ivanhoe was only 130 feet thick, compared to the 370 feet (about) at Conoble. The dinoflagellates at Ivanhoe indicate that the basal O. operculata/M. tetracantha Zone and the D. cerviculum Zone are represented, and that younger sediments than those sampled from low in the Conoble section are present. Thinning of the Cretaceous from

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* Since this manuscript was completed the additonal wells Texam Berangabah No. 1, Holy Box No. 1 and Dolmoreve No. 1 have been completed in the Ivanhoe region, but data from them are not available for discussion.

Conoble towards Ivanhoe by onlap appears to have taken place. The Ivanhoe section consists mainly of loosely cemented, porous quartz sandstone with minor clay stringers.

Units Kla and Klb-c and the Dingodinium cerviculum Zone are confined to the Doncaster Member of the Wallumbilla Formation and older sediments in the Great Artesian Basin and are therefore regarded as Aptian or older in age. The O. operculata/M. tetracantha Zone commences at about the base of the succeeding Coreena Member of the Wallumbilla Formation and is therefore regarded as early Albian in age (Evans, 1966; Vine, Day, Milligan, Casey, Galloway & Exon, 1967; Evans & Burger in Exon, Milligan, Casey & Galloway, 1967; Evans, in Cundill, Myers & Associates, 1967).

The Ivanhoe and Conoble section therefore seems to range within the short vertical distance of 370 feet from Aptian unit Kla into the oldest Albian at the base of Kld.

The extent of this pocket of Cretaceous cannot be accurately judged. It is depicted in a cross section accompanying the Ivanhoe 1:250,000 Sheet geological map (Geological Survey of New South Wales, 1966) as extending from about 20 miles east of Conoble No. 1 to possibly beyond the western boundary of the sheet at longitude 144°. Spence (1958) drew attention to Mullholland's report (1940) of "blue clays and white sands" in boreholes south-west of Cobar, which Spence thought might be Cretaceous in age. He mapped as ?Cretaceous sediments which are labelled Tertiary on the New South Wales 1:1,000,000 geological map and the Ivanhoe 1:250,000 map (Geolgogical Survey of New South Wales, 1962; 1966).

Renmark Area

Cretaceous beds preserved in the Renmark area appear to belong to an extensive tract of sediments which overlie the Upper Palaeozoic Renmark Trough with a configuration approximating to that of the older rocks. The cross section in figure 2 illustrates the lithological and thickness variations and the palynological age of examined horizons in wells between Loxton No. 1 and North Renmark No. 1.

To date, the thickest Cretaceous sequence has been encountered in North Renmark No. 1. The oldest palynological determination from the well is of unit Klb-c, ?Dingodinium cerviculum Zone at a point 285 feet above the base of the Mesozoic. Core from only 40 feet above the base yielded no fossils diagnostic of any particular zone and hence the section could commence in sediments of Klb-c or older age.

A marine facies of unit Kld and the O. operculata/M. tetracantha Zone is recognized in North Renmark No. 1, Monash No. 1, Berri North No. 1, and possibly Wentworth No. 1. It appears to be the most widespread zone in the area.

Sediments of Klb-d age comprise lithic quartz sandstones (sub-greywackes) with thinly bedded siltstones and claystones.

The sandstones are angular to subangular, fine to coarse-grained and moderately to poorly sorted. The composition of the sandstone in core 11 of Renmark North No. 1 is quartz with straight and undulose extinction (67%), albite (1%), lithic fragments (25%) of microcrystalline siliceous fragments, chloritic siliceous fragments and chloritic fragments. Pellicular chlorite (5%) occurs as fine flakes around the detrital grains. Sericite flakes are present; muscovite flakes (2%) are common and sometimes show transformation to illite. Carbonaceous specks are scattered throughout.

The siltstones are dense, with dispersed carbonaceous matter; root markings occur in core 2 of Berri North No. 1.

The claystones may contain up to 15% of angular detrital quartz grains. Illitic and chloritic clay make up the bulk of the rock as observed in core 12 of Renmark North No. 1 and in core 3 of Tararra No. 1. Dispersed carbonaceous matter may be present as scattered specks or in thin laminations of illitic clay. Root markings wwre observed in cores 9 and 10 of Renmark North No. 1.

To summarize, the sandstones in this sequence are quartz-rich and were probably derived from a quartz-rich metamorphic area; some volcanic influence is evident judging by the type of microcrystalline

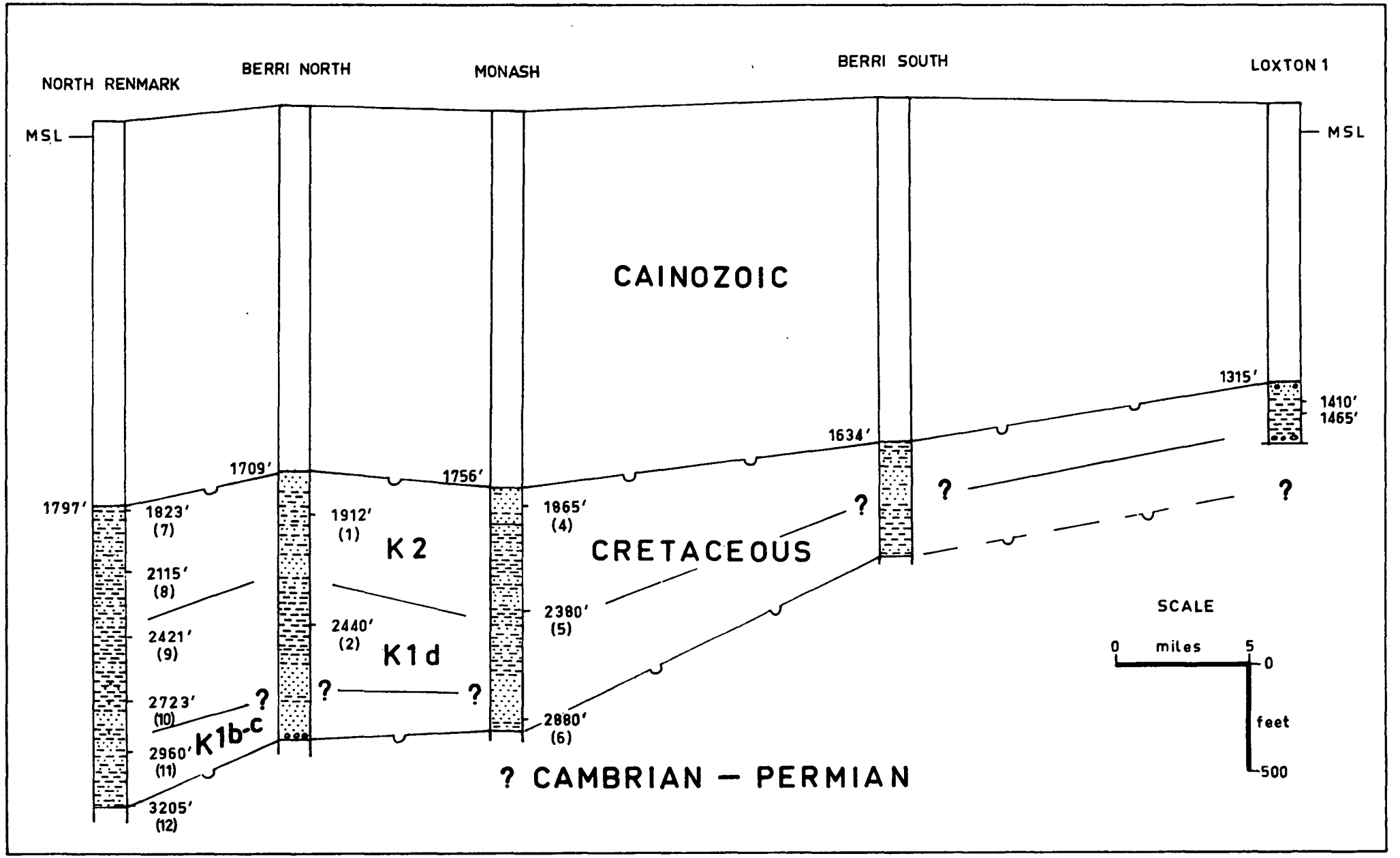

FIGURE 2. SECTION: NORTH RENMARK—LOXTON 1

siliceous fragments present. The most important clay type in the claystone is illite.

The mineralogical characteristics of these sediments show some similarity to the quartzose lithofacies (Pretty Hill sandstone) of the Geltwood Beach Formation in the Otway Basin.

The youngest palynological zones to be recognized are of the Paradoxa Assemblage, units K2a and K2b, in the Monash, North Renmark, Berri North and Loxton Wells and probably in Lake Victoria No. 1, where Ludbrook recorded Arcellites and no foraminifera.

This sequence consists of thinly bedded chloritic sandy siltstones alternating with green, lithic sandstones (subgreywackes).

The lithic sandstones are angular to subangular, very fine and fine-grained, and moderately sorted. The average composition is: quartz with straight extinction (20-30%), oligoclase, albite and rare microcline (10%); abundant lithics (52-57%) of microcrystalline siliceous fragments, chloritized siliceous fragments, rare volcanic fragments containing feldspar microlites, siliceous fragments with sericite flakes; rare metaquartzite. Pellicular chlorite (5-10%) occurs in flaky form around detrital grains. Rare spots of calcite may be present. In core 8 of Renmark North No. 1 there was an abundance (49%) of brown finely crystalline calcite. It is evident that the calcite is diagenetic as it replaces many of the lithic fragments. Other minerals present in the sandstones are: muscovite (1-5%) - often chloritized and bleached; rare biotite, rare glauconite, garnet and zircon. Carbonaceous fragments, including woody fragments, are to be found.

The siltstones are dense and sandy. Often the sandy fraction occurs in thin laminations. In core 7 of Renmark North No. 1 the composition is: quartz with straight extinction (35%), plagioclase feldspar (2%), bleached and contorted muscovite (5%) occurs. Thin carbonaceous laminations and specks have been observed.

The lithic sandstones have been derived from a predominantly volcanic source, on account of the feldspar type and the presence of volcanic flour rock fragments and chloritized microcrystalline siliceous fragments. The chloritized siliceous fragments are thought to represent the altered groundmass of a possibly acid intermediate type of volcanic rock. The most important clay type in the claystones and siltstones is chlorite.

The sandstones of K2 age in the Murray Basin exhibit a framework and mineralogy similar to the lithic sandstones of comparable age encountered in the Eumeralla Formation in the western part of the Otway Basin.

There is insufficient evidence to define precisely the distribution of the Cretaceous around the Renmark area. Although the presence of Cretaceous sediments was first detected by investigating a gravity "low", geophysics is unable to firmly indicate levels which prove to be Cretaceous in age. Spence suggested that the southerly margin of the Cretaceous was bounded by the line of the Murrayville Monocline and is supported by limited bore evidence (Spence, 1958; O'Driscoll, 1960). Actual thinning in a southerly direction is observed between North Renmark No. 1 and Monash No. 1 (figure 2). A north western margin probably lies between Tararra No. 1 and the Canopus bore (Spence, 1958; Deflandre & Cookson, 1955; O'Driscoll, 1960; Ludbrook, 1961). The slight upwards slope of the base of the Cretaceous between Berri South and Loxton might indicate a fairly extensive but thin Cretaceous cover in a south-easterly direction, but drilling and geophysical evidence, although sparse, suggests that the Cretaceous does not extend much further east than Wentworth No. 1 (Crosby, 1963; Namco Geophysical Company, 1965, 1966a-c; authors of completion reports on deep test wells).

CORRELATION

At first glance, the comparisons and ages appear to contradict Ludbrook's correlations between the Great Artesian and Murray Basins and her assessments of the ages of events during Cretaceous deposition in these areas. Ludbrook consistently recognized as Aptian marine sediments

which bear the unit K1d and O. operculata/M. tetracantha Zone microfloras and which are here regarded as Albian. The available evidence in fact confirms Ludbrook's correlations, although requires that her age determinations should be modified.

Ludbrook's evidence for the Aptian determinations in the Renmark area presumably stem from her work in the South Australian portion of the Great Artesian Basin (Ludbrook, 1966).

As studies of the Cretaceous foraminifera in the Renmark area are largely unpublished and were completed prior to Ludbrook's final analysis of the microfaunas of the Great Artesian Basin, it would be unfair to closely compare the assemblages on the basis of ascribed names only. However, there is sufficient similarity between the microfaunas listed from North Renmark No. 1 (Ludbrook, in Grasso, 1963) and Ludbrook's lists from sections through the Great Artesian Basin to maintain the "Aptian" age for the North Renmark No. 1 section between depths of 2404 and 3015 feet. From North Renmark Ludbrook recorded: Marginulopsis australis, Bigerina loeblichae, Trochammina minuta, Anomoloides (Anomolina) mawsoni, Ammobaculites australis, Trochammina raggatti and Textularia ancooraensis. All except T. raggatti and T. ancooraensis are recorded from levels of "Aptian" in the Great Artesian Basin within but mainly above the Hergottella jonesi Zone. In North Renmark No. 1 they are associated with unit K1d and the O. operculata/M. tetracantha Zone. T. raggatti and T. ancooraensis have been recorded only from below the H. jonesi Zone in the Great Artesian Basin *. In Renmark No. 1, T. ancooraensis was only found below 3130 feet, i.e. below the lowest recorded occurrence of unit K1b-c and the D. cerviculum Zone. T. raggatti was found below 2875 feet, within the observed range of unit K1b-c and D. cerviculum Zone.

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* The stratigraphic value of these species may be judged from their widespread occurrence in basal sections of the marine Cretaceous, within or below the D. cerviculum Zone: for example, in the Longsight Sandstone (Crespin, 1963), in the Minmi Member of the Blythesdale Formation (Terpstra, 1967), and in the lower Wallumbilla Formation in Buckabie No. 1 (Crespin, in Kitsman, Lewis & Rowe, 1962). Compare also records by Crespin (1953, 1956) from other sections of the Great Artesian Basin.

Terpstra (Appendix A) also found T. raggatti in Ivanhoe No. 1 in an horizon ascribable to the D. cerviculum Zone.

The extension of the palynological units and zones in formations of Lower Cretaceous age along the north-eastern margin of the Great Artesian Basin has been studied for a number of years. Most noticable among the dinoflagellate zones is that of Dingodinium cerviculum, which commences within the Minmi Member of the Blythesdale Formation and extends through the Doncaster Member of the Wallumbilla Formation (Evans, 1966b; Vine et al., 1967). The end of the range of Dingodinium cerviculum just overlaps commencement of the O. operculata/M. tetracantha Zone toward the base of the Coreena Member of the Wallumbilla Formation (Evans & Burger, in Exon et al., 1967; Evans, in Cundill et al., 1967).

The extension of the D. cerviculum Zone was traced into the South Australian portion of the Great Artesian Basin by Evans (in McPhee, 1963), where he found it at the base of the marine Cretaceous section in Innamincka No. 1, no higher than core 7, 3526 feet. Further examination of the same preparation has showed that D. cerviculum may be present in the core, although it is associated with O. operculata and the sample should be assigned at the oldest to the O. operculata/M. tetracantha Zone. The next core up the section, core 6, 3020 feet, contains Trilobosporites trioreticulosus, Crybelosporites striatus, Odontochitina operculata, Oodnadattia tuberculata and Diconodinium spp. of unit K2 and the O. operculata Zone. The D. cerviculum Zone is therefore confined to depths below 3526 feet and the O. operculata/M. tetracantha Zone to all or a lower portion of the interval 3526 to 3020 feet.

According to Ludbrook, the Zone of Hergottella jonesi corresponds to the middle calcareous member of the lower Marree Formation. Ludbrook identified the H. jonesi Zone in Innamincka No. 1 between 3610 and 3710 feet, i.e. within the Zone of D. cerviculum. She tentatively placed the top of the "Aptian" at 2770 feet within the Zone of Verneuilina howchini - Trochammina flosculus, at the same level originally chosen by Ryan (1961), and well within the range of palynological unit K2 and the O. operculata Zone. The range of unit K1d and the O. operculata/M. tetracantha Zone must therefore lie well within the "Aptian" (Ludbrook) of the Innamincka section and above the H. jonesi Zone. In this respect the microfaunal and microfloral

correlations between the marine Cretaceous beds of the Great Artesian and Murray Basin regions are in full accord.

AGE OF MARINE SECTION

The ages of the sequence of foraminiferal zones in South Australia is derived from the macrofaunas in Oodnadatta No. 1 and from a few outcrops. According to Ludbrook (1966), beds in South Australia and dated as Aptian on the basis of ammonites are known only at Stuart Range, where Tropaeum imperator has been found (Howchin & Whitehouse, 1928). A species from Primrose Springs, placed by Whitehouse (1927) in Sanmartinoceras, was referred by Casey (1961) to the subgenus Sinzovia of Aptian or possibly Albian age.

The next higher horizon of determinable age lies in the Oodnadatta No. 1 Well, where Falciferella occurs at 235 feet, and in outcrop at Fossil Creek in the Yardinna 1 - mile area and is taken to signify an Upper Albian age (Brunnschweiler, 1959; Reyment, 1964).

The Upper Aptian fauna is associated with the calcareous member of the middle part of the lower Marree Formation or Bulldog Shale (Freytag, 1966) and with the Zone of Hergottella jonesi. Although the foraminiferal zone was not recognized in the well, the calcareous member is present in Oodnadatta No. 1 between 600 and 820 feet. Ludbrook placed the boundary between the Aptian and Albian in Oodnadatta No. 1 at the based of the Coorikiana Member of the Oodnadatta Formation (Freytag, 1966) at 450 feet and its equivalents in outcrop. However, as Ludbrook states (1966, p. 22), "Between the Upper Albian and the Upper Aptian no ammonites have been found to give any zonal information". There are several hundred feet of section between the Upper Aptian calcareous member H. jonesi Zone and the Ludbrook's choice of the top of the "Aptian" in both the Oodnadatta and Innamincka wells which could therefore be Aptian or Albian in age. Because of micro-floral correlation from the northern outcrops of the Great Artesian Basin to the Innamincka No. 1 Well, which brings the early Albian unit K1d and the O. operculata/M. tetracantha Zone almost immediately above the Upper Aptian foraminiferal H. jonesi Zone, the top of the H. jonesi Zone and its equivalent,

the calcareous member of the lower Marree Formation is a better choice for the base of the Albian in South Australia.

Most of the Cretaceous preserved in the Renmark area is therefore of Albian age. The sections encountered in the Ivanhoe area and in North Renmark No. 1 below 2960 feet are palynologically determined as Aptian in age. However, because of the apparently excellent correspondence between the microfaunal and microfloral scales in the Great Artesian Basin and Renmark area it is reasonable to suppose that the presence of Trochammina raggatta as high as 2875 feet is evidence of the extension to at least that horizon of the D. cerviculum Zone of Aptian age.

COMPARISON BETWEEN THE OTWAY, GREAT ARTESIAN AND MURRAY BASIN REGIONS

From the forgoing discussion it is concluded that the Cretaceous preserved below the Murray Basin is in at least two areas, one near Ivanhoe of mainly Aptian age, the other around and to the north of Renmark of Aptian and early to ?mid-Albian age. The question remains, whether these are isolated deposits of originally restricted distribution, or whether they were once connected to the more active areas of Cretaceous deposition either in the Otway Basin to the south or in the Great Artesian Basin to the north or to both?

The fact that both the Ivanhoe and Renmark deposits have marine characteristics requires connection to a major area of marine sedimentation. This rules out any main connection with the Otway Basin in which no open marine conditions of Aptian and early Albian times have yet been detected (Evans, 1966; Bureau of Mineral Resources, 1966). The Cretaceous below the Murray Basin must be thought of as deposited within a southerly extension of the Cretaceous sea which inundated the Great Artesian Basin. Whitehouse (1955) depicted the southern margin of the Great Artesian Basin upon the platform of the Eulo Shelf. The Broken Hill - Cobar ridge, which now separates the Great Artesian and Murray Basins formed the southern flank of the Eulo Shelf. However, the evidence of ?Cretaceous strata at

Pondie Range and the small patch of marine Cretaceous west of Cobar, in the middle of the Broken Hill - Cobar ridge (Spence, 1958), added to the available evidence from the Murray Basin region show that at least some connections must have passed across the Broken Hill - Cobar line. The width and position of these channels cannot be determined.

Deposition commenced as early in Cretaceous times as the upper parts of the Blythesdale Formation in the Roma area. Such early deposition appears to be localized. Even so, the sediments are very thin compared with their counterparts along the north-east side of the Great Artesian Basin.

Sedimentation in a restricted portion of the Renmark area commenced in Aptian times with deposition of the basal 230 feet of sandstone and shale penetrated by North Renmark No. 1.

These sediments bear little comparison with the typical Aptian glauconitic shales and sandstones of the Great Artesian Basin. Presumably their source could vary from the quartzose Devonian sandstones for the Ivanhoe area to the granitic and metamorphic province east of the Murray Basin and the Padthaway Ridge to the south for the Renmark area.

The petrology showed that differences in grain size, and mineral character exist between the sediments of Aptian - L. Albian K1b-K1d age and those of Albian K2 age. It appears that a tectonic event changed the type of source area from a quartz-rich metamorphic provenance during the deposition of K1b-K1d sediments to a predominantly volcanic provenance during K2 times.

The coincidence of this event with the retreat from the region of marine depositional conditions indicates that it may in part have taken the form of uplift of the Cobar - Broken Hill ridge where by the Murray Basin region was disconnected from the Great Artesian Basin.

Whether or not complete disconnection took place is uncertain. The presence of a considerable amount of diagenetic calcite in a sandstone of K2 age in Renmark North No. 1 suggests a marine influence still

persisted during that phase of deposition. Similar calcite-rich sandstones of comparable age (K2b) were observed in Heathfield No. 1 in the Otway Basin. Nevertheless, in neither area have fossil indicators of open marine conditions (foraminifera and dinoflagellates) yet been discovered.

It seems that conditions of sedimentation during Lower Cretaceous times in this part of the Murray Basin were similar to those which operated in the western part of the Otway Basin. Whether or not the sediments of these two basins were derived from a common source area, and to what extent the Padthaway Ridge acted as a barrier to sedimentation during Lower Cretaceous times, cannot be ascertained from this brief study.

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APPENDIX A: NOTE ON THE MICROPALAEONTOLOGICAL EXAMINATION OF CUTTINGS SAMPLES FROM IVANHOE NO. 1 N.S.W.

by

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SUMMARY

Cutting samples from 10-1220 feet from the Ivanhoe No. 1 (North Star Oil), N.S.W., have been examined for microfossils. A marine fauna of Lower Cretaceous age, probably Aptian, was encountered from 550 feet downwards.

OBSERVATIONS

Cutting samples from this well from 10 - 1220 feet have been examined. The interval from 0-550 feet is barren. From 550 feet downwards an arenaceous fauna of foraminifera occurs, indicating a Lower Cretaceous age (probably Aptian) for the beds penetrated at that depth. This fauna was encountered in all the cuttings between 550 and 1220 feet. However, not all sediments of this interval may be of Cretaceous age. It is likely that a great deal of caving occurred during drilling and although the top of the marine Lower Cretaceous was established at about 550 feet, the base of the Mesozoic beds cannot be ascertained on microfaunal evidence.

Although the fauna is rich in individual specimens, most specimens are crushed, and not well preserved.

The following species have been identified with the types among the B.M.R. collections:

Ammobaculites irregulariformis Bartenstein and Brand 1951. The stratigraphic range of this species is given as Roma Formation and upper Longsight Sandstone (Crespin 1963).

A. irregulariformis Crespin (non Bartenstein and Brand), recently renamed, Ammobaculites irrapatanensis Ludbrook. Its stratigraphic range is given as Aptian (rare and doubtful) and Albian, (Ludbrook, 1966). Ammobaculites succinctus Crespin 1963. Stratigraphic range Lower Cretaceous (Crespin, 1963).

Haplophragmoides chapmani Crespin, 1944. Stratigraphic occurrence, Lower Wilgunya and Roma Formations (Crespin, 1963) and Albian and Middle and Upper Aptian (Ludbrook, 1966).

Spiroplectammina aequabilis Crespin 1963. Stratigraphic range, Lower Wilgynya (Crespin, 1963).

Textularia wilgunyaensis Crespin 1963. Stratigraphic range, Lower Wilgunya Formation (Crespin, 1963) and Aptian and Lowermost Albian (Ludbrook, 1966).

Trochammina raggatti Crespin, 1944. Stratigraphic range, upper Longsight Sandstone Crespin 1963, and Lower Aptian (Ludbrook, 1966).

From the preceding evidence it appears that the Mesozoic strata penetrated in the well below 550 feet are presumably of Aptian age, anyhow should be placed fairly low in the Lower Cretaceous sequence.

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