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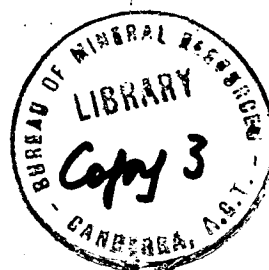
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CARPENTARIA BASIN
SUMMARY OF BACKGROUND TO EXPLORATION
FOR HYDROCARBONS

by

H.F. Douth

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SUMMARY

The hydrocarbon potential of the onshore part of the Carpentaria Basin, Queensland, is poor. Prospects are slightly better offshore. The Jurassic-earliest Cretaceous sandstone sequence should offer good reservoirs, and the overlying Lower Cretaceous mudstone sequence may have been a source rock. However, not many traps have been recognized in the sandstone, and wherever it has been drilled it has produced water.

Nearly all geological and geophysical exploration has been of a regional, reconnaissance nature.

INTRODUCTION

This report is an expanded version of an article on the Carpentaria Basin prepared for the Petroleum Volume of 'Economic Geology of Australia and Papua New Guinea', currently being compiled by the Australasian Institute of Mining and Metallurgy.

The expansion is an attempt to add recently gathered information to Meyers' (1969) Geological Survey of Queensland Report 34, and to offer more compendious references.

The Carpentaria Basin is situated in northern Queensland under, and to the south and east of, the Gulf of Carpentaria. The basin extends from about lat. 11°S to 20°S and Long. 137°E to 144°E; its northern and western margins have not yet been established even approximately. It is about 950 km from north to south, 600 km from east to west, and it covers an area of about 560 000 km², of which at least 300 000 km² underlies the Gulf (Fig. 1).

Strictly speaking it is a Jurassic-Cretaceous Basin, above which the deposits of a new sedimentary basin are accumulating as a consequence of Tertiary tectonism. Geophysical data suggest that the thickest section of Mesozoic plus Cainozoic rocks (2000 m?) is under the centre of the Gulf of Carpentaria west of Weipa (Fig 2).

Exploration History

The earliest geological reconnaissances of parts of the area were made by Maitland (1898), Cameron (1901), Jackson (1902, 1903), Dunstan (1920), and Morton (1924). Whitehouse (1940, 1941, 1944) discussed aspects of the Cainozoic history of the southern part of the area, and in 1955 gave a general description of its geology in the same publication in which Ogilvie reported on groundwater. Nothing covering groundwater of the Carpentaria Basin generally has been published since.

Between 1958 and 1969 the Bureau of Mineral Resources and petroleum exploration companies carried out geophysical surveys in parts of the area, both onshore and offshore. None of the work has been published; most of it is listed in the References.

During the same period a small amount of geological surveying was done: Evans (1959, 1965) reported on the bauxite at Weipa, Woods (1961) mapped around Wrotham Park, and Reynolds (1960, and in White, 1965) mapped the Gilberton-Croydon area. Warner (1968) in carrying out groundwater investigations around the lower Gilbert and Staaten Rivers secured the most useful data yet obtained on the Cainozoic Wyaaba Beds (q.v.). Rivereau (1966, a,b,c), Perry (1967), Simpson (1969) and Maffi (1970) produced airphoto interpretation maps at 1:250 000 scale.

Eight petroleum exploration wells were drilled between 1958 and 1966. Details are given in Table 1. The company reports remain mostly unpublished. No economic shows of hydrocarbons were reported. This work established the general lithostratigraphic succession in the Carpentaria

Basin; it has been confirmed by numerous gamma-ray logs of water bores and other holes. Since discussion by Meyers (1969), stratigraphic nomenclature has been modernized by Smart et al. (1971, 1972) and Smart (1972) - see Table 2 and Fig. 1.

Summary reviews of the geology of the area have been made by Hill (1951), Laing, Power, and others (in Hill & Denmead, eds., 1960), Reynolds et al. (1963, 1965), and Meyers (1969). Hydrocarbon resources and oil exploration history have been summarized by Mott (1952), Geological Survey of Queensland (1961) and Allen & Hogetoorn (1970).

In 1969 a combined party from the Commonwealth Bureau of Mineral Resources, Geology and Geophysics and the Geological Survey of Queensland began a systematic regional geological survey of the onshore part of the area. At the time of writing the survey has still to map the area north of Weipa. Three progress reports, four drilling reports, and two others are complete but unpublished (see References). Preliminary geological maps at 1:250 000 scale are available or in press for all sheet areas covering the Carpentaria Basin south of Lat. 12°S and a preliminary geological map at 1:1 000 000 of the area south of Lat. 15°S is in press. Most of the Explanatory Notes for 1:250 000 Sheet areas south of Lat. 15°S are in press (Grimes; Ingram, a & b; Needham and Douth, a & b; Simpson; Smart, a & b). A little geophysical work has been done by the Bureau during this period in the (Shelley et al., 1971; Watts, 1972) and Pinchin (in prep.) has analysed all geophysical work done in the area to the time of writing.

Tectonic Framework (Fig. 2)

The Carpentaria Basin is an epeirogenic intracratonic downwarp which formed during Jurassic and Cretaceous times. It is a depositional sedimentary basin, classified by Olenin (1967) as a 'homogeneous basin on platform, subgroup downwarping or syncline'. It is a contemporaneous tectonic analogue of the Eromanga Basin, to which it is joined in the south across the Euroka Arch, but in contrast to the Eromanga it may not be underlain by any extensive infrabasins like the Galilee, Cooper, and Adavale Basins.

The cratonic basement of the Carpentaria Basin appears to consist mainly of Precambrian rocks, but few bore holes have penetrated below the basin sequence. The basin is flanked on the west by the Precambrian rocks of the Arnhem and Mount Isa Blocks and the McArthur Basin. Along its eastern margins the Georgetown, Yambo, and Coen Inliers consist of Precambrian metamorphic rocks and Precambrian and Palaeozoic intrusives and extrusives; the Cape York - Oriomo Ridge is made up entirely of Carboniferous igneous rocks.

Although the Euroka Arch separates the Carpentaria and Eromanga Basins structurally, the epicontinental platform-cover Cretaceous rocks of the two basins are continuous, more or less unchanged, across the arch. Both basins appeared to have sagged away from the arch during deposition of their contents.

Table 1

Petroleum Exploration Wells drilled in the Carpentaria Basin

Date	Company	Name of Well	Location	References
1957	Frome-Broken Hill	Wyaaba No. 1	16°29'S; 141°37'E	Derrington (1957)
1957	Zinc Corporation	Weipa No. 1	12°43'S; 141°56'E	Power & Lindhø (1958)
1958	Associated Aust. Oilfields	No. 8 (Karumba)	17°25'S; 140°52'E	Laing (1960)
1961	Delhi-Santos	Mornington Is No. 1	16°33'S; 139°15'E	Harrison et al. (1961)
1961	Delhi-Santos	Mornington Is No. 2	16°29'S; 139°31'E	Harrison et al. (1961)
1963 1963/4	Mid-Wood Exploration Mid-Wood Exploration	Normanton Scout No. 1 Normanton Scout No. 2	17°39'S; 141°32'E	(see Douth et al., 1970)
1964	Mid-Eastern Exploration	Burketown No. 1	18°04'S; 139°32'E	Perryman (1964)

TABLE 2 - STRATIGRAPHY

AGE		UNIT	GENERALIZED LITHOLOGY	MAXIMUM THICKNESS ONSHORE (METRES)	OTHER AUTHORS' TERMS	
CAINOZOIC	PLIOCENE TO PLEISTOCENE	Armraynald Beds) Wondoola Beds)	Clay, silt and sand	50 65	Lynd Formation	
		Vyaaba Beds *	Sandy clay, clayey sand, quartzose granule gravel	100		
		UNCONFORMITY (with 'laterite', etc.)				
	CRETACEOUS? OR TERTIARY	Bulimba Formation) Floraville Formation)	Sandy claystone, clayey sandstone, granule conglomerate	100 40		
		MAJOR UNCONFORMITY				
	EARLY CRETACEOUS	Rolling Downs Group	Normanton Formation	Labile sandstone, mudstone	250	Normanton Formation
			Allaru Mudstone	Mudstone, minor limestone	300	
			Toolebuc Limestone	Calcareous & bituminous shale; limestone	25	
	MESOZOIC	Albian	Wallumbilla Formation	Mudstone, minor labile sandstone, limestone	200	Blackdown Formation
			Trimble Member	Labile sandstone, mudstone, minor limestone	70	Trimble Formation
Aptian		Gilbert River Formation		60	Gilbert River Formation	
		Coffin Hill Member	Medium-grained clayey quartzose sandstone	25		
		Yappar Member	Coarse to medium-grained clayey quartzose sandstone	35		
MID? TO LATE JURASSIC		Eulo Queen Group	Loth Formation	Clayey quartzose sandstone, siltstone		65
			Hampstead Sandstone	Clayey quartzose sandstone, conglomerate	50	
* not known if older or younger than unconformity		Louisa Formation (not shown on Figure 1)	Quartz cobbles, pebbles, sand	5	(not part of Lynd Formation)	

TABLE 3 - OIL AND GAS SHOWS

Well/Bore	Location	Formation	Type of show
D.S. Mornington Island 2	16°29'S. 139°31'E.	Gilbert River Toolebuc	Dead oil staining Bituminous shales
A.A.O. 8 (Karumba)	17°25'S. 140°52'E.	Gilbert River Toolebuc	Brown stain and yellow fluorescence Petroliferous odour and fluorescence
Mid-Eastern Burketown 1	18°04'S. 139°32'E.	Toolebuc	Petroliferous odour
Inverleigh West	18°10'S 139°55'E.	?	Oil and gas reported
Normanton	17°40'S. 141°05'E.	?	Methane
Wrotham Park Spring	16°26'S. 143°54'E.	Surface	Inert gas, methane, carbon dioxide
Vanrook	16°56'S. 141°56'E.	?	Oil and gas

after Meyers (1969)

A similar Mesozoic succession found in New Guinea, in the Morehead Basin and elsewhere, appears to reflect northern analogues of the Carpentaria Basin. The Carpentaria Basin and Morehead Basin beds join across a broad, shallow, stable basement which has an irregular surface. The same beds also probably extend westward across similarly irregular basement into another less stable analogue, a basin in the vicinity of Honey Shoal, which lies mostly below the Arafura Sea. The irregular basement may include a small basin between the Carpentaria Basin and Merauke in New Guinea.

The older sandstones of the Carpentaria Basin continue over the Kimba Arch between the Coen and Yambo Inliers into the Laura Basin, where they thicken markedly as a result of movement during deposition by the faults which controlled development of the Laura Basin's western margin. At the northern end of Cape York Peninsula the same older sandstones apparently continue northeastward through the geophysical features of the Olive River Basin and Peninsula Trough, between the Coen Inlier and the Cape York-Oriomo Ridge, towards the tectonically unstable Gulf of Papua. The sandstone sequence probably develops into the thicker and more heterogeneous sequence at the bottom of Anchor Cay No. 1 (Oppel, 1969).

In late Tertiary times irregular uplift along the eastern margin of the basin resulted in tilting and minor block faulting (Douch et al., 1970). At the same time the Gilbert-Mitchell Trough, a modification of the Mesozoic Staaten River Embayment, was formed by downwarping and faulting (Douch et al., 1972). This large but shallow trough can be regarded as the structural beginnings of a new sedimentary basin; it formed penecontemporaneously with the Pliocene Strickland Basin (APC, 1961) and the 'peri-orogenic trough' (Visser & Hermes, 1962), which together make up a foredeep in southern New Guinea, and with adjacent uplifts.

Stratigraphy (Table 2 and Fig. 1)

The Mesozoic stratigraphy of the Carpentaria Basin begins with mid(?) and late Jurassic continental quartzose sandstone with subordinate siltstone and conglomerate, the Eulo Queen Group and unnamed equivalents. These rocks are restricted to the Millungera, Canobie, Burketown and Weipa Depressions (Figs 1 & 2), structurally controlled erosion hollows. The rocks in the depressions and of the areas between them are blanketed by relatively thin Neocomian? or earliest Aptian continental and marine quartzose sandstone, the Gilbert River Formation, from which gold has been mined at Wenlock (Connah, 1951).

Overlying this uppermost quartzose sandstone is a relatively thick marine mudstone sequence of Aptian and Albian age, divided into the Wallumbilla Formation (including its Trimble Member), the Toolebuc Limestone, and the Allaru Mudstone. The middle part of the sequence, the Toolebuc Limestone, is thin, conspicuously calcareous, and in places phosphatic (Williamson, 1967) and bituminous (see below); it is restricted to the southern part of the basin.

The top of the Mesozoic succession, which is nearly everywhere a conformable one, is paralic labile sandstone of Albian, and possibly Cenomanian, age, the Normanton Formation.

Palaeontological determinations and dating have been made by Burger (in press), Cookson & Eisenack (1958, 1960), Crespin (1956, 1958, 1960), Crespin & Dickins (1955), Day (*in Douth et al., in prep.*), Eisenack & Cookson (1960), Evans (1966), Fleming (1965), Haig (*in Douth et al., in prep.*), Skwarko (1963, 1966, 1973, and *in Douth et al., 1970*), Walkom (1928), White (1957, 1972), and Woods (1961).

Cainozoic deposition was in two episodes. The first followed erosion of Mesozoic rocks and preceded both extensive development of deep weathering zones and subsequent tectonism, and the clayey sands and sandstones and sandy clays deposited constitute the contemporaneous Floraville and Bulimba Formations. The second episode was partly consequent on the tectonism, partly on a change in climate. Erosion followed the tectonism in many places before deposition of more clayey sand and sandy clay, the pene-contemporaneous Wyaaba, Wondoola and Armraynald Beds.

Onshore Cainozoic deposits are mainly continental, although marine fossils were found in one bore (Day & Palmieri, *in Douth et al., in prep.*). The bauxite around Weipa and Aurukun (Evans, 1959, 1965) developed on the Bulimba Formation.

It must be presumed that both Cainozoic and Mesozoic rocks continue offshore, below the Gulf of Carpentaria. They probably all thicken and do not become finer grained, if the tectonic settings and sequences in bores in the Eromanga and Morehead Basins can be used as a guide.

Structure (Fig. 2)

The structure of the southern part of the area at first sight is dominated by the northwest trends of basin margins. Although the axis of the Staaten River Embayment/Gilbert-Mitchell Trough does indeed plunge to the northwest, south of the Gulf of Carpentaria the basin plunge is to the north as a result of control by the Boomarra and Kamileroi Horsts.

The structure of the onshore portion of the northern part of the area is still being worked out. Northwest, northeast, and eastnortheast trends predominate, but other directions, particularly north, may be equally important. Geophysical work in the offshore portion suggests both north and northwest-trending faults.

In general, the pattern of structural discontinuities in the Mesozoic and Cainozoic rocks coincides with changes in patterns of Bouguer Anomalies, suggesting that basement structures had a strong effect on basin evolution.

There are few structures other than faults and warps (Fig. 2). The faults are all normal and most have very little displacement, the greatest being of the order of 300 m. The Alice-Palmer and Robertson Structures seem to be part faults, part warps. The very few folds that occur are shallow and open and appear to be the result of the regional faulting and warping.

The faults bounding the Boomarra Horst were possibly active during Jurassic (?) and Cretaceous deposition. All other structures appear to be younger than the Lower Cretaceous Normanton Formation, and may be of Pliocene age (Doutch et al., 1970, 1972 & in prep.).

Hydrocarbon Potential

Table 3 lists typical oil and gas hydrocarbon shows recorded from the area; the Toolebuc Limestone shows oil traces in many water bores (and see Senior & Smart, 1973). No shows are definitely known from Cainozoic rocks.

Some sandstones of the Eulo Queen Group and Gilbert River Formation are suitable reservoir beds. They are sealed by the overlying mudstones, which may also be source rocks. However, in bores the sandstones have invariably yielded fresh water from aquifers which are recharged where they crop out along the eastern margin of the area. The few onshore stratigraphic and structural traps have probably all been flushed.

Although the Cainozoic succession is relatively thin, artesian water has been tapped from it near the coast south of the Mitchell River, showing that traps in the succession could exist elsewhere.

In both the thicker Mesozoic and Cainozoic successions offshore there is a possibility that unflushed structures occur. It should be possible to drill them as the Gulf of Carpentaria is nowhere greater than 65 m deep.

The Toolebuc Limestone is bituminous in many places. The 'oil shale' can be up to 25 m thick. Only one petrochemical analysis is available (Powell, in Senior and Smart, 1973); the sample came from 104 m in BMR Croydon 1 (Needham et al., 1971). Weight of extract was 1.15 percent of the sample; of this, in weight %, asphalts were 32.4, paraffinic hydrocarbons (C₁₇-C₂₄) 4.4, aromatics 2.2, polar compounds 41.1, and oxygen, nitrogen and sulphur compounds absorbed on alumina 20.0. No areal variations in thickness and grade have been reported, but proposals have been made to work the oil shale commercially at Julia Creek in the Eromanga Basin (see also Table 2, Vine 1964).

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