1:250 000 GEOLOGICAL SERIES—EXPLANATORY NOTES

ONSLOW

WESTERN AUSTRALIA

SHEET SF 50-5 INTERNATIONAL INDEX

WESTERN AUSTRALIA
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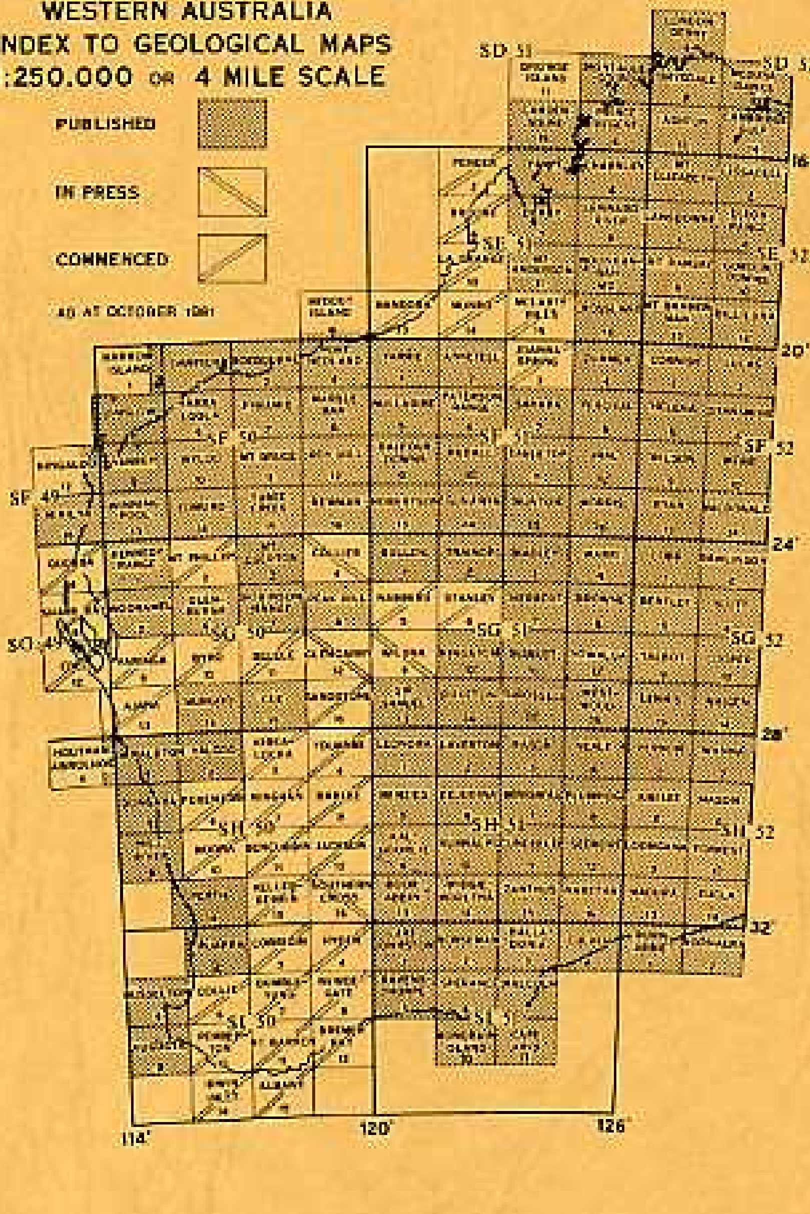

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

1:250 000 GEOLOGICAL SERIES—EXPLANATORY NOTES

ONSLOW

WESTERN AUSTRALIA

SHEET SF 50-5 INTERNATIONAL INDEX

COMPILED BY W. J. E. VAN DE GRAAFF,
P. D. DENMAN, AND R. M. HOOKING

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Explanatory Notes on the Onslow Geological Sheet

Compiled by W. J. E. van de Graaff, P. D. Denman, and R. M. Hocking.

INTRODUCTION

GENERAL

The ONSLOW* 1:250 000 Geological Sheet, SF/50-5 of the International Series, is bounded by latitudes 21°00'S and 22°00'S, and longitudes 113°54'E and 115°30'E. The sheet area covers a northern, largely offshore, part of the Carnarvon Basin.

Vertical air photographs at scales of approximately 1:85 000 and 1:40 000 were used in field mapping. Topographic maps at 1:100 000 scale, available from the Division of National Mapping, Canberra, were used as base maps.

Exmouth and Onslow are the only townships in the area. In 1976 their populations were 2 336 and 220, respectively.

The North West Cape area is served by a bitumen road past Exmouth and the Harold E. Holt Naval Communication Station to Vlaming Head. Gravel roads branch off and lead into the Cape Range National Park, which covers much of the Cape Range. In the eastern part of the Sheet area, formed roads and station tracks branch off the main gravel roads to Onslow.

The climate is semi-arid to arid, with an average annual rainfall of about 300 mm, and a potential annual evaporation of between 2 000 and 2 400 mm. Both summer and winter rains occur, and the wettest months are February and March. In January, average daily minimum and maximum temperatures are about 23°C and 37°C, and in July, 14°C and 24°C.

The area has mostly an open to dense shrub steppe vegetation, with tall trees lining the main rivers, and mangrove thickets fringing parts of the coast. Details of the flora and fauna are given by Ride and others (1974).

PREVIOUS GEOLOGICAL WORK

The first systematic geological investigation of ONSLOW took place during the survey of the Carnarvon Basin by the Bureau of Mineral Resources and the Geological Survey of Western Australia during 1948 to 1955 (Condon and others, 1953; Condon, 1968). The eastern part of ONSLOW was studied by Hoelscher and McKellar (*in* McWhae and others, 1958). Ozimic (1970) compiled a biblography of the Carnarvon Basin (to 31-12-69), and the stratigraphy and structure of this region was summarized by Thomas and Smith (1974, 1976), and Playford and others (1975). Earlier geological references to the region are by Clapp (1925, 1926), Condit (1935), Raggatt (1936), and Teichert (1947).

Since 1957, a large amount of information on the subsurface geology of this part of the Carnarvon Basin has been obtained through geophysical surveys and drilling. Much of this work was subsidized under the Petroleum Search Subsidy Acts and is available to the public.

* To avoid confusion with place names, Sheet names are written in full capitals (ONSLOW).

PHYSIOGRAPHY

ONSLOW covers the northern part of the Cape Range peninsula and part of the coastal plain which borders the eastern coast of Exmouth Gulf. The continental shelf part of the offshore area is called the Rowley Shelf, and Exmouth Gulf is the southern extremity of this unit.

Islands dot the shelf up to about 25 km from the coast, and the sea is generally less than 20 m deep in these parts.

The eastern part of ONSLOW is generally featureless and rises gently from the coast to about 60 m in the southeast, whereas Cape Range is fringed by narrow coastal plains from which it rises fairly abruptly to a height of about 200 m.

The Ashburton and Cane Rivers are the only two major rivers which cross ONSLOW, and both flow only after heavy rain.

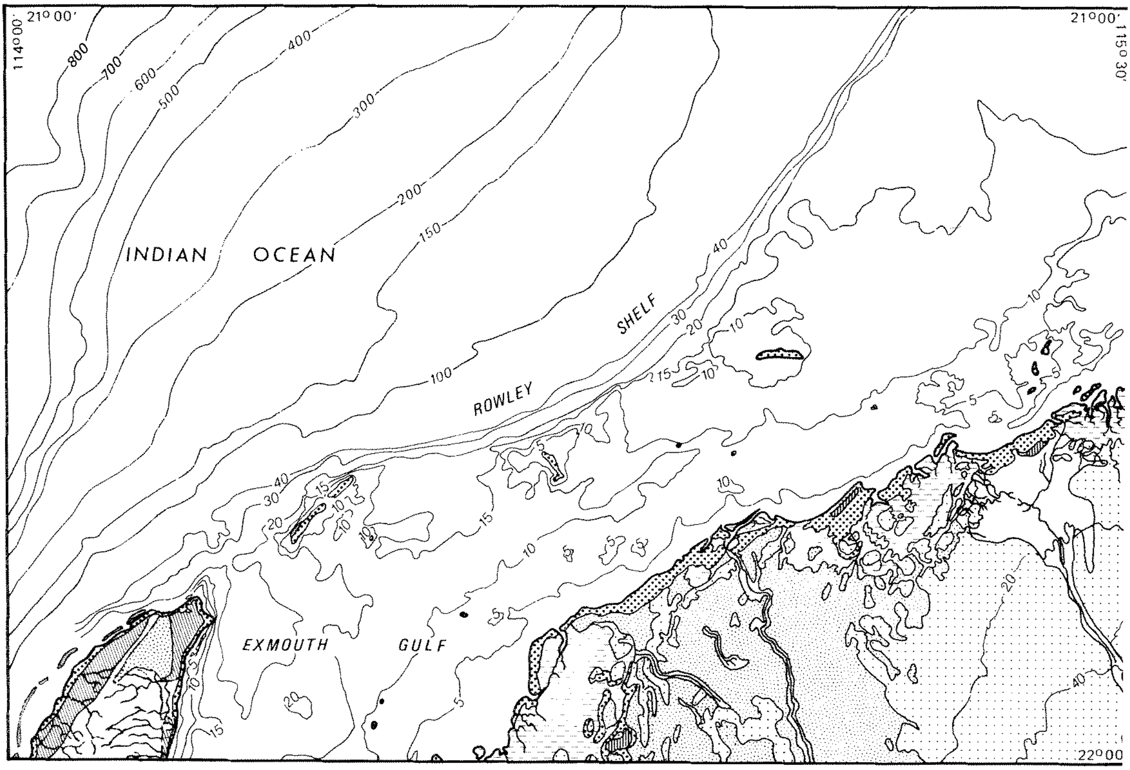

FIGURE 1

PHYSIOGRAPHIC FEATURES

ONSLOW SHEET SF 50–5

0 25 km

REFERENCE

- Coral reefs
- Coastal dunes and beach ridges
- Tidal and supratidal flats
- Sand dunes and claypans
- Claypans
- Floodplains, alluvial fans, river valley floors
- Sand dunes and plains
- Coastal terraces and shorelines scarps
- Dissected limestone ranges

The Cainozoic geology shown on the east part of ONSLOW is in large part based on physiography, and thus may be used to describe the physiography. Figure 1 shows the various subdivisions recognized.

STRATIGRAPHY

Only Cainozoic sediments are known to crop out on ONSLOW, although calcreted Precambrian granitic and gneissic rocks, and Cretaceous Windalia Radiolarite occur close to the surface southeast of Mount Minnie homestead. However, exploration for petroleum has established the presence of thick Palaeozoic and Mesozoic sequences in the subsurface. A systematic listing of the units recognized is given in Table 1.

PALAEOZOIC

Carboniferous siltstone, claystone, and shale, with minor sandstone and limestone were penetrated in Cane River 1 (Hematite Petroleum Pty Ltd, 1972) and in Minderoo 1 (Johnstone and others, 1963). Both sequences are tentatively regarded as late Early Carboniferous in age (Balme, *in* Hematite Petroleum Pty Ltd, 1972), but their age is poorly established. For this reason, correlation with established Carboniferous units has not been attempted.

In Onslow 1, Permian (Sakmarian) Lyons Formation glacial sediments are overlain in turn by Wooramel Group sandstone, shale, siltstone, and limestone; and Byro Group limestone, sandstone, siltstone, and shale; both of Artinskian age. These were deposited in tectonically quiet, stable, marine-shelf conditions. The Byro Group is disconformably overlain by marine sandstone and shale, dated palynologically as Late Permian by Balme (1969). Jones (1967) assigned this sequence to the Kennedy Group, but the Kennedy Group is of Early Permian age (although age-specific fossils are known only from the lower part of the group; Cockbain, 1980). The sequence may instead correlate with the Wagina Sandstone of the Perth Basin.

MESOZOIC

Middle to Upper Triassic sediments were penetrated by six wells and have a thickness exceeding 1 650 m on ONSLOW. They consist of a predominantly shale sequence, conformably overlain by a sand and shale sequence. Triassic sedimentation in the northern Carnarvon Basin appears to have continued from the Late Permian with no major breaks, indicating continued tectonic stability (Thomas and Smith, 1976). The Permian-Triassic sequence is preserved in Onslow 1.

The Lower to Middle Triassic Locker Shale (Parry, *in* Jones, 1967) has its type section in Onslow 1, between 1 587.7 m and 2 097.2 m, and consists of interbedded, dense, calcareous shale and siltstone, with minor lenses of silty sandstone. The formation overlies the Upper Permian sequence and is conformably overlain by the Mungaroo Formation.

The Middle to Upper Triassic Mungaroo Formation overlies the Locker Shale with a gradational contact and is unconformably overlain by the Cretaceous Birdrong Sandstone. The type section, in Long Island 1 between 794 m and 1 992 m, consists of poorly sorted, subangular sandstone, with interbedded shale and siltstone, overlying fine-grained, calcareous, slightly glauconitic sandstone, with minor siltstone, shale, and thin beds of limestone.

TABLE 1. Stratigraphy of ONSLOW

Age			Map symbol	Rock unit	Max thickness (m)	Lithology	Stratigraphic relationships	Remarks
CAINOZOIC	QUATERNARY	Holocene	*Qr*	Coral reef deposits	?10	Coralgal reef deposits with calcarenite to calcirudite		Widespread in Exmouth Gulf and Ningaloo Reef Tract
			Qs	Coastal-dune and beach deposits	?20	Well-sorted, calcareous quartz sand, locally rich in heavy minerals	Grades into *Qw, Qe*	
			Qw	Intertidal-flat and mangrove-swamp deposits	?10	Clay, silt, minor authigenic gypsum	Grades into *Qs, Qt*, overlies *Qe*	
			Qt	Supratidal-flat deposits	?1	Clay, silt, sand, with authigenic silt and gypsum	Grades into *Qs, Qw*, overlies *Qe*	
			Qp	Clay-pan deposits	?2	Poorly sorted clay, silt, sand, and minor gravel	Grades into *Czp, Czc, Qe*	Larger clay pans in areas of *Czp*
		Pleistocene	*Qe*	Dune and sandplain deposits	?20	Red quartz sand	Grades into *Cza, Czc, Czp, Qs*	Eolian, but includes extensive residual soil and colluvial deposits
			Qm	BUNDERA CALCARENITE: Mowbowra Conglomerate Member	?6	Limestone-pebble conglomerate, minor calcarenite and coralgal reef deposits	Lateral equivalent of parts of *Qbj* and *Qbt*	Mostly beach to storm-beach deposit
			Qbt	BUNDERA CALCARENITE: Tantabiddi Member	20	Calcarenite, calcirudite, and coralgal reef deposits	Unconformable on *Qbj*, or *Qx*, or Cape Range Group	Approximately 123 000 years old, from uranium-series dating
			Qbj	BUNDERA CALCARENITE: Jurabi Member	20	Calcarenite and coralgal reef deposits	Unconformable on *Qx* or Cape Range Group	Only distinguishable from *Qbt* where *Qbt* and *Qbj* occur on different terraces
			Qxm	EXMOUTH SANDSTONE: Milyering Member	30	Quartzose calcarenite to calcareous granule conglomerate; minor coralgal reefs	Unconformable on *Qxn* and Cape Range Group	
			Qxn	EXMOUTH SANDSTONE: Muiron Member	25	Quartzose calcarenite to calcareous granule conglomerate	Unconformable on Cape Range Group	Only distinguishable from *Qxm* where *Qxm* and *Qxn* occur on different terraces
		?Pliocene to Holocene	*Czk*	Calcrete	?10	Massive to lumpy or nodular, authigenic limestone	Formed in pre-existing deposits	
			Czp	Clay-pan and dune deposits	?30	Well-sorted eolian sand, interbedded with poorly sorted silt, clay, sand, and gravel	Grades into *Cza, Czc, Czk, Qe, Qt, Qs*	Includes areas of other surficial deposits
			Czc	Colluvium	?10	Poorly sorted silt, sand, and gravel	Grades into *Cza, Czp, Czk, Qe, Qt*	Includes minor laterite, residual soils, and small areas of other surficial deposits
			Cza	Alluvium	?40	Poorly sorted clay, silt, sand, and gravel, partly calcreted	Grades into *Czc, Czp, Czk, Qe, Qt*	Important aquifer

CAINOZOIC	TERTIARY	Miocene	*Tv*	CAPE RANGE GROUP	Vlaming Sandstone	?65	Well-sorted, medium-grained quartzose calcarenite with large-scale (12 m) steep cross-bedding; occasional calcreted? soil beds	Conformable on Pilgramunna Formation	Crops out on Cape Range, and recorded (within "Yardie Group") in Hilda 1A, distribution apparently similar to Pilgramunna Formation, linear from North West Cape to Hilda 1A; eolian
			Tp		Pilgramunna Formation	?70	Quartzose calcarenite and coralgal limestone, fine to very coarse-grained, cross-bedded; rare silicified ?soil beds	Disconformable on Tulki Limestone, interfingers with Trealla Limestone	Crops out on Cape Range, and recorded in West Muiron 1 (69 m) and Hilda 1A ("Yardie Group", 460 m); distribution apparently restricted in subsurface to a linear trend from North West Cape to Hilda 1A; shallow-marine to littoral, high-energy
			Tt		Trealla Limestone	415	Pure white calcirudite to calcisiltite, with coralgal limestone; thin to massive bedded with sharp-edged karst features common; foraminifers, corals, echinoids, and molluscs present	Disconformable on Tulki Limestone (Cape Range) or Mandu Calcarenite (elsewhere); unconformable under Quarternary units	Crops out on Cape Range, and occurs throughout ONSLOW in subsurface except SE of Minderoo 1; unit thickens to NNE through ONSLOW, maximum recorded in Hilda 1A; shallow-marine, high-energy
			Tk		Tulki	?90	Reddish to yellowish, marly, foraminiferal, calcarenitic packstone; *Lepidocyclina* abundant, also echinoids (mainly *Conoclypus*), crustaceans, gastropods, bryozoa, bivalves, nautiloids	Conformable on Mandu Calcarenite	Top 40 m of unit exposed on Cape Range, ONSLOW; at type section formation is 95 m thick, pinches out in subsurface away from Cape Range; shallow-marine, relatively high-energy
		Oligocene to Miocene	*		Mandu Calcarenite	362	White, chalky calcarenite to calcilutite; rare flint nodules; abundant foraminifers, particularly *Lepidocyclina*; also echinoids, bivalves, bryozoa, sponges, crustaceans	Unconformable on Giralia Calcarenite	Subsurface; only differentiated in Hilda 1A (362 m) and West Muiron 1 (222 m); shallow-marine, low-energy
		Eocene	*	Giralia Calcarenite		70	Calcarenite overlying calcilutite and basal sandstone; minor limestone beds at base and top	Assumed disconformity at base	Subsurface; few wells differentiate the unit but these indicate it is absent beneath the Onslow-Minderoo land area, and possibly throughout ONSLOW except beneath Cape Range and in the NE; shallow-shelf environment, relatively high energy

* not exposed on ONSLOW

TABLE 1. Stratigraphy of ONSLOW

Era	Period	Age	Map symbol	Group	Rock unit	Max thickness (m)	Lithology	Stratigraphic relationships	Remarks
CAINOZOIC	TERTIARY	Paleocene to Eocene	*		Cardabia Group	100	Calcarenite and calcilutite, with minor calcareous sandstone and claystone; in places (Locker 1) highly fossiliferous; basal greensand unit present in some areas	Assumed to be disconformable on Toolonga Calcilutite	Subsurface; distribution irregular, occurs below Cape Range and beneath the area of oil wells Hilda 1, Locker 1, and Onslow 1, and the NE; absent elsewhere; shallow-shelf environment
MESOZOIC	CRETACEOUS	Campanian	*		Toolonga Calcilutite	190	Mainly calcilutite; some claystone, calcareous siltstone, sandstone; variably glauconitic; *Inoceramus* sp. fragments common (trace to 80 per cent)	Disconformable on Gearle Siltstone	Subsurface; probably includes some Korojon Calcarenite in some wells; thickness irregular; absent to SE of Cane River 1; eroded in S and E; open shelf deposit
		Turonian to Albian	*	WINNING GROUP	GEARLE SILTSTONE Upper	599	Grey-green-black glauconitic siltstone, claystone, minor limestone; calcareous, pyritic	Conformable on Windalia Radiolarite	Subsurface; not differentiated in all wells; differentiated by colour and electric logs
			*		GEARLE SILTSTONE Lower		Grey-black siltstone, claystone, shale; slightly glauconitic, calcareous, pyritic; sometimes very similar to Windalia Radiolarite		Maximum thickness in Hilda 1; open shelf deposit
		Aptian to Albian	*		Windalia Radiolarite	80	Radiolarite, siltstone, claystone, minor very fine-grained sandstone; white specks of radiolarians and bentonite	Conformable on Muderong Shale	Crops out in SE corner of ONSLOW; subsurface in nearly all wells; 82 m thick in Anchor 1; pelagic shelf deposit
		Aptian	*		Muderong Shale	200	Siltstone, claystone, shale, silty sandstone, minor limestone, greensand	Conformable on Birdrong Sandstone	Subsurface includes "Windalia Sands" (main oil reservoir in Barrow Island Oil Field); open shelf deposit
		Neocomian to Aptian	*		Birdrong Sandstone	45	Sandstone, siltstone, conglomerate; frequently very glauconitic	Unconformable on older rocks	Subsurface sometimes called "basal Cretaceous sandstone" or classified as member of Muderong Shale; maximum thickness in Minderoo 1; sometimes oil- and gas-bearing; important aquifer

MESOZOIC	JURASSIC	Tithonian to Neocomian	*	Barrow Formation	300	Sandstone, siltstone, interbedded claystone and siltstone	Nature of contact uncertain	Subsurface, offshore eastern part of ONSLOW; includes Barrow Island oil and gas reservoirs; thickens northward to over 1 000 m below Barrow Island, 40 km N of ONSLOW; deltaic
MESOZOIC	JURASSIC	Late Jurassic	*	Dupuy Member	88	Fine-grained, massive sandstone, minor shale interbeds	Patchily developed at top of Dingo Claystone	Subsurface, Anchor 1; 2 042 m thick below Barrow Island, 100 km to NE; shallow-marine, basal deltaic
MESOZOIC	JURASSIC	Early to Late Jurassic	*	Dingo Claystone	1 409	Siltstone, claystone, minor sandstone	Unconformable on Triassic or older units; overlain by Barrow Formation or Winning Group	Subsurface; base not reached in Anchor 1 which gave 1 409 m; absent in Locker 1, Minderoo 1, Onslow 1; marine
MESOZOIC	TRIASSIC	Middle to Late Triassic	*	Mungaroo Formation	1 198.7	Siltstone, shale, sandstone, minor limestone and coal	Conformable on Locker Shale	Subsurface; type section in Long Island 1; regressive
MESOZOIC	TRIASSIC	Early to Middle Triassic	*	Locker Shale	509.4	Shale, siltstone, silty sandstone	Unconformable on Late Permian sequence	Subsurface; type section in Onslow 1; transgressive
PALAEOZOIC	PERMIAN	Late Permian	*	Unnamed sequence	162	Sandstone, shale, siltstone	Unconformable on Byro Group or Lyons Formation	Subsurface, Onslow 1, Direction 1; regressive
PALAEOZOIC	PERMIAN	Artinskian	*	Byro Group	386	Limestone, sandstone, siltstone, shale	Overlies Wooramel Group	Subsurface, Onslow 1; marine
PALAEOZOIC	PERMIAN	Artinskian	*	Wooramel Group	64	Sandstone, shale, siltstone, limestone	Overlies Lyons Formation	Subsurface, Onslow 1; marine
PALAEOZOIC	CARBONIFEROUS	Late Carboniferous to Sakmarian	*	Lyons Formation	290	Sandstone, siltstone, shale, greywacke; tillite at base of Onslow 1	Base unknown on ONSLOW	Subsurface, Direction 1, Onslow 1; glacial, glacial marine, fluvioglacial
PALAEOZOIC	CARBONIFEROUS	Late Early Carboniferous	*		223	Sandstone, shale, siltstone, argillaceous limestone	Part of large area of block-faulted Palaeozoic and Proterozoic underlying Cretaceous	Subsurface, Minderoo 1; marine. Maximum thickness possibly <400 m, from aeromagnetic data
PALAEOZOIC	CARBONIFEROUS	Late Early Carboniferous	*		280	Siltstone, claystone, shale, minor sandstone; dolomite		Subsurface, Cane River 1; marine

* not exposed on ONSLOW

The Locker Shale is mainly a transgressive sequence, representing a continuation of the transgression which began in the Late Permian and extended to the Middle Triassic. The Mungaroo Formation and the top of the Locker Shale form a regressive sequence, the marine Locker Shale being followed by the mixed continental and paralic Mungaroo Formation (Playford and others, 1975).

Jurassic sediments are known from oil wells to be widely distributed in the Exmouth, Barrow, and Dampier Sub-basins. On ONSLOW they have been penetrated by several wells between the Muiron Islands and the eastern boundary of the Sheet area.

The Dingo Claystone has been identified in wells between Cape Range and Barrow Island. On ONSLOW it is a monotonous sequence of dark shale, siltstone, and claystone, with minor sandstone and limestone. In the Cape Range area, the formation is entirely marine, but to the east and northeast it is thought to interfinger with paralic sediments (Playford and others, 1975).

The Dupuy Member of the Dingo claystone, a potential Jurassic oil reservoir, is present in some wells. It is a fine-grained, massive, light-coloured sandstone at the top of the Dingo Claystone, and is interpreted as a shallow-marine, basal-deltaic deposit, laid down prior to the thick deltaic deposits of the Barrow Formation, and conformable beneath them (Crank, 1973). It is of Tithonian age (Thomas and Smith, 1976).

Cretaceous sediments are present in all wells drilled on ONSLOW, ranging from the Lower Cretaceous/Upper Jurassic Barrow Formation to the Upper Cretaceous Toolonga Calcilutite and Korojon Calcarenite. There are no known exposures of Cretaceous rocks on ONSLOW, but Lower Cretaceous Windalia Radiolarite and Nanutarra Formation crop out immediately to the south, in the northeastern corner of YANREY-NINGALOO.

BARROW FORMATION

The Barrow Formation is known in the offshore sub-surface from wells in the eastern and northern parts of ONSLOW, where it lies between Winning Group sediments and the Dingo Claystone. Playford and others (1975) considered that the contacts are probably conformable, whereas West Australian Petroleum Pty Ltd geologists interpreted the upper contact as disconformable (Andrejewskis, 1969; Meath and Wright, 1974). The unit is of highly variable thickness and consists of sandstone and siltstone, with interbedded claystone. It has been dated by microplankton, spores and an ammonite as Tithonian to Neocomian in age (Casey, *in* McTavish, 1965). Balme (1969; *in* Playford and others, 1975) considered that the formation could be entirely Neocomian, based on palynological evidence. The Barrow Formation formed as a series of coalescing and migrating deltaic lobes.

Parts of the Barrow Formation may correlate with the Wogatti Sandstone of the Rough Range area, the Nanutarra Formation and Yarraloola Conglomerate of YANREY and YARRALOOLA, and possibly the Birdrong Sandstone.

NANUTARRA FORMATION AND YARRALOOLA CONGLOMERATE

The Nanutarra Formation and Yarraloola Conglomerate (Hoelscher and McKellar, *in* McWhae and others, 1958), consisting of sandstone, siltstone, and conglomerate, are present on ONSLOW beneath the Cainozoic cover. These units correlate with the lower formations of the Winning Group, with which they interfinger complexly on YANREY.

WINNING GROUP

The Winning Group consists of the Birdrong Sandstone, Muderong Shale, Windalia Radiolarite and Gearle Siltstone. It is present in the subsurface throughout virtually the entire Sheet area. The Mardie Greensand Member of the Muderong Shale, a sub-littoral equivalent of the Birdrong Sandstone defined by Lowry (1979), may be present in parts of ONSLOW. The Winning Group probably thins towards the eastern margin of ONSLOW, either by erosion or nondeposition of the top part of the sequence, and in the region of mount Minnie homestead there are only remnants of a veneer of Cretaceous Windalia Radiolarite and ?Nanutarra Formation, resting on Precambrian rocks, and underlying the Cainozoic laterite and sandplain. Wiseman (1979) described the Early Cretaceous sequence of events and palaeogeography which produced the Winning Group.

Birdrong Sandstone

The Birdrong Sandstone marks the base of the Cretaceous in most wells where the Barrow Formation is absent. It is conformably overlain by the Muderong Shale, and overlies either the Barrow Formation, possibly conformably, or older units, sometimes with angular unconformity. The unit is a friable quartz sandstone, variably glauconitic, with minor shale, siltstone, and conglomerate interbeds. Its thickness is highly variable, averaging 18 m to 30 m, with a maximum known thickness of over 100 m. Carbonized plant fossils are sometimes present.

In Cane River 1, Hematite Petroleum Pty Ltd (1972) identified a basal Cretaceous unit, 20 m to 40 m thick, as Yarraloola Conglomerate. This unit consists of fine- to coarse-grained quartz sand and sandstone, and pebble conglomerate with minor glauconite and lignite. We consider it to be Birdrong Sandstone, because this name is more generally used for the basal sandy, marine unit of the Winning Group.

The Birdrong Sandstone is dated as Late Neocomian to Aptian from its stratigraphic position, and from microfossils found further south in the basin (Cookson and Eisenack, 1958).

Muderong Shale

The Muderong Shale lies conformably between the Birdrong Sandstone and Windalia Radiolarite, and is mostly between about 60 m and 80 m thick. In Hilda 1A it is 200 m thick. It consists of siltstone, claystone, shale, and silty sandstone, with minor limestone in some wells (Locker 1, Long Island 1). The principal oil- and gas-bearing sands in the Barrow Island Oil Field, known as the "Windalia Sands", occur in the upper part of the Muderong Shale (Playford and others, 1975).

Microplankton (Cookson and Eisenack, 1958), foraminifers (Glaessner and Crespin, *in* McWhae and others, 1958), microflora, and microfauna indicate an Aptian age for the Muderong Shale.

Windalia Radiolarite

The Windalia Radiolarite lies conformably between the Muderong Shale and Gearle Siltstone. This unit and the Nanutarra Formation/Yarraloola Conglomerate are the only Mesozoic units occurring near the surface on ONSLOW. In wells the formation consists of greyish siltstone and claystone, occasionally sandy, with gradations to very fine-grained sandstone, and sometimes with minor glauconite. White specks of radiolarians and bentonite are common. The thickness of the Windalia Radiolarite ranges from about 20 m to 140 m.

The Windalia Radiolarite has been dated as Albian to Aptian, based on a fauna of radiolarians, foraminifers, ostracods, ammonites (Brunnschweiler, 1959), belemnites, and bivalves.

Gearle Siltstone

The Gearle Siltstone conformably overlies the Windalia Radiolarite and conformably underlies the Toolonga Calcilutite. It consists of dark siltstone and claystone, locally calcareous, and grading into rare limestone beds. Locally the formation is glauconitic and pyritic. In places the Gearle Siltstone is very similar to the underlying Windalia Radiolarite, and the boundary is picked on geophysical log characteristics. The maximum known thickness of the Gearle Siltstone on ONSLOW is 599 m in Hilda 1A, and its thickness is generally between 190 m and 250 m.

The Gearle Siltstone contains a fauna which includes ostracods (Bate, 1972), bivalves, foraminifers, and belemnoids, which indicate an Albian to Turonian age (Belford, 1958; Quilty, *in* Playford and others, 1975).

TOOLONGA CALCILUTITE

The Toolonga Calcilutite disconformably overlies the Gearle Siltstone, and consists of light-coloured calcilutite to calcareous siltstone, variably glauconitic, with some claystone, siltstone, and sandstone, and containing *Inoceramus* sp. fragments. It is absent in some wells in the eastern part of ONSLOW (for example, Minderoo 1 and Cane River 1), and its thickness is highly variable. This variability may be partly erosional and partly depositional.

The age of the Toolonga Calcilutite in Hilda 1A is Campanian, based on microfauna and microflora (Meath and Wright, 1974). Elsewhere in the Carnarvon Basin it extends from the Santonian to the Campanian (Belford, 1958) or Maastrichtian (Cockbain, 1976a; Playford and others, 1975).

Korojon Calcarenite

The Korojon Calcarenite is differentiated from the underlying Toolonga Calcilutite only in Hilda 1A, where it is 58 m thick. It may overlie the Toolonga Calcilutite in other areas, and some of the upper Toolonga Calcilutite in wells on the Northwest Shelf might better be placed in the Korojon Calcarenite. In outcrops on YANREY, it is distinguished from the Toolonga Calcilutite by a much greater abundance of *Inoceramus* sp. fragments and a generally coarser grained appearance. In Hilda 1A it is a cream and brown limestone, largely composed of fibrous calcite (?shell fragments), with claystone and shale (Meath and Wright, 1974). Its age is Late Campanian (Dolby and others, *in* Meath and Wright, 1974.).

TERTIARY

Tertiary sedimentation in the northern Carnarvon Basin occurred in four main episodes (Quilty, 1977, 1980): (1) Paleocene to early Eocene (Cardabia Group), (2) middle to late Eocene (Giralia Calcarenite), (3) late Oligocene to middle Miocene (Cape Range Group), and (4) late Miocene to Holocene. The fourth episode formed a continuous sequence only north of Barrow Island (Quilty, 1974). In the Cape Range area it is represented by the Quaternary Exmouth Sandstone and Bundera Calcarenite.

Oil wells showed that Tertiary sediments occur throughout the subsurface of ONSLOW, except in the southeast. The only exposed Tertiary is on the North West Cape peninsula, where units of the Cape Range Group crop out.

The subsurface Tertiary has not been differentiated in most wells, and the sequence is usually described as bioclastic limestone, calcarenite, calcilutite, and dolomite, with minor sandstone and siltstone. In some wells, the Tertiary is divided into the Cardabia Group, Giralia Calcarenite, and Cape Range Group. In a few wells, units of the Cape Range Group are also differentiated. The thinnest Tertiary intersected is 31 m in Cane River 1 (Hematite Petroleum, 1972), and the thickest is 1 247 m in Hilda 1A (Meath and Wright, 1974).

PALEOCENE-EOCENE

A basal Tertiary greensand, such as the 6-m thick unit in Locker 1 (Hosemann and Parry, 1967), may correlate with the Boongerooda Greensand, the basal unit of the Cardabia Group. The Cardabia Group has its type area on the Giralia Anticline on YANREY and ranges from Paleocene to Middle Eocene in age. It disconformably overlies Upper Cretaceous Miria Marl, and disconformably underlies Middle to Upper Eocene Giralia Calcarenite. The unit's thickness ranges from zero (Minderoo 1, Johnstone and others, 1963; Muiron 1, Johnson, 1968) to 75 m (Long Island 1, Brownhill, 1967). It consists of calcarenite and calcilutite, with minor calcareous sandstone and claystone. Quilty (1974) described the general distribution, isopachs, and palaeogeography of the Cardabia Group in this region, and showed that deposition occurred in the Cape Range area and north of the Long Island and Flinders Faults, with thickness increasing to the northeast to over 100 m thick north of Hilda1A. He omitted an "embayment" of deposition in the Onslow 1 area, where the unit is up to 33 m thick (Onslow 1, Jones, 1967).

MIDDLE TO LATE EOCENE

Giralia Calcarenite

The Giralia Calcarenite, which has its type section on the Giralia Anticline on YANREY, rests disconformably on the Cardabia Group, and is overlain unconformably by the Cape Range Group.

On ONSLOW, the Giralia Calcarenite is absent in some wells, and in other wells it is not differentiated from other Tertiary units, except in Long Island 1 (Brownhill, 1967). In this well it is described as white, fine to medium-grained calcarenite overlying a grey, soft, moderately glauconitic calcilutite, the base of which grades into light grey to white, medium-grained, well-sorted sandstone.

The unit is 122 m thick and includes minor fine-grained limestone beds at the top and base. The formation has been recognized in the Cape Range and Rough Range wells (YANREY-NINGALOO) where it is dated as Middle to Late Eocene. Quilty (1974) described the general distribution, isopachs and palaeogeography of the Middle to Late Eocene in this area. The unit is absent in the Exmouth Gulf area, and between West Muiron 1 and Onslow 1, and apparently thickens rapidly north of Locker 1 (where it is absent) to 122 m in Long Island 1 (Brownhill, 1967). It also thickens westward of Exmouth Gulf, to over 200 m beneath Cape Range. It is absent in Hilda 1A, and its present distribution may be controlled by post-Eocene erosion.

The formation is richly fossiliferous, particularly in the basal portion, and marks the first appearance of large *Discocyclina*—type foraminifers.

OLIGOCENE—MIOCENE

Following the regional emergence and lateritization during the Early Oligocene period, sedimentation recommenced in the Late Oligocene (Quilty, 1974) in the Cape Range area with deposition of the Cape Range Group; this, as originally defined, included, in ascending order, the Mandu Calcarenite, Tulki Limestone, and Trealla Limestone. Condon (1968) amended the group to include only the lower two formations. However, we consider that the Mandu Calcarenite, Tulki Limestone, Trealla Limestone, Pilgramunna Formation, and Vlaming Sandstone form part of a depositionally related sequence, and include these units in the Cape Range Group. All the above units have their type sections on YANREY-NINGALOO.

Mandu Calcarenite (Tm).

The Mandu Calcarenite is a unit of friable, white, chalky to marly calcarenite to calcilutite which unconformably overlies the Giralia Calcarenite, and conformably underlies the Tulki Limestone in the Cape Range area. The unit, which is not exposed on ONSLOW, has its type section in Badjirrajirra Creek (lat. 22°06′ 00″S, long. 114° 01′ 30″E; YANREY-NINGALOO). The maximum thickness of the formation, indicated by drilling on Cape Range, is about 240 m (Playford and others, 1975).

The Mandu Calcarenite is differentiated in only two wells on ONSLOW: West Muiron 1 and Hilda 1A, in which it is 222 m and 362 m thick, respectively. It is almost certainly present in Muiron 1 which penetrated a Tertiary sequence 565 m thick. It is probably present in other wells which recorded a thick Tertiary sequence, such as Peak 1 and Observation 1. East of these wells it thins, and is absent in Onslow 1.

Crespin (1953, 1955) dated the lowest exposed Mandu Calcarenite as earliest Miocene, and Quilty (1974) and Chaproniere (1975) considered the lower, subsurface part of the formation to be Oligocene.

Tulki Limestone (Tk)

The Tulki Limestone consists predominantly of cream to reddish-coloured foraminiferal calcarenite (packstone). It conformably overlies the Mandu Calcarenite, and is disconformably overlain by the Trealla Limestone in the Cape Range area (Quilty, 1974; Chaproniere, 1975).

The type section (lat. 22° 06′ 00″, long. 114°02′00″E; YANREY-NINGALOO) is 95 m thick.

The top of the Tulki Limestone has been recorded by Condon and others (1953, p. 25) as "a thin band of pisolitic ferruginous limestone wich appears to have resulted from the weathering of the limestone". This is a calcrete vein, and similar calcrete veins occur commonly in the Trealla Limestone. They do not mark a depositional and erosional break between the two formations but are a much younger phenomenon. However, the uppermost Tulki Limestone is commonly highly recrystallized (Chaproniere, 1975) whereas the Trealla Limestone is not, and this recrystallization appears to have taken place prior to Trealla Limestone deposition. The disconformity is confirmed by a small gap in the planktonic zones between the two units in the Cape Range area (Quilty, 1974; Chaproniere, 1975).

The Tulki Limestone consists of coarse-grained muddy foraminiferal packstone, and grainstone, with low-angle cross-bedding in places, suggesting clastic deposition on shoals or banks.

The reddish to yellowish colour of much of the Tulki Limestone is produced, according to Chapronière (1975), by "red soil particles and fossils derived by sub-aerial erosion from an adjacent coastline", probably to the southeast where the younger Trealla Limestone progressively oversteps older deposits.

The Tulki Limestone fauna is dominated by foraminifers described by Crespin (1953, 1955), and by Chapronière (1975) who assigned the unit to an Early Miocene age (N6-N8). Echinoids are common, and Crustaceans, gastropods, bryozoans, bivalves, and nautiloids also occur.

The Tulki Limestone has not been differentiated in the oil wells on ONSLOW, and the unit may not be present in any of them, except possibly in the Muiron 1 and the West Muiron wells.

Trealla Limestone (Tt)

The Trealla Limestone is a unit of thin to massive-bedded, hard limestone characteristically showing small-scale, sharp-edged karst features; it disconformably overlies the Tulki Limestone, Giralia Calcarenite, or older rocks, and is overlain with angular unconformity by the Exmouth Sandstone or younger Quaternary deposits. The type section is at lat. 22°13′10″S, long. 114°00′30″E (YANREY-NINGALOO), and is 48 m thick, but in most parts of the Cape Range less than 20 m of the unit remains.

The uppermost Tulki Limestone and lower Trealla Limestone are difficult to differentiate in the field, and the boundary is taken at the base of the thinly bedded limestone which directly overlies the massive recrystallized Tulki Limestone.

Chapronière (1975) has divided the Trealla Limestone of the Cape Range area into a lower and an upper unit. The lower is dominantly packstone, very similar to the uppermost Tulki Limestone. It was deposited in shallow-water conditions, possibly protected by a barrier (the Pilgramunna Formation) forming to the west.

Chapronière's (1975) upper unit is more widely distributed, and mainly consists of coarse-grained calcarenite (grainstone) containing *in situ* compound corals and pockets of shell fragments—probably a reefal facies in parts.

Crespin (1948, 1953) dated the formation as 'f' stage Middle Miocene. Quilty (1974) gave an early Middle Miocene date (N9 to N12) to the Trealla Limestone. In addition to foraminifers the formation contains corals, echinoids, and molluscs.

The Trealla Limestone is widespread in the subsurface of ONSLOW, and, though not differentiated in many oil wells, is probably absent only to the southeast of Minderoo 1 and Cunaloo 1 (15 km west of Minderoo homestead, and 1 km south of ONSLOW). In the former the unit is 8 m thick, and in the latter it is 6 m thick. The formation thickens northeast of the Cape Range area, and is 415 m thick in Hilda 1A.

Pilgramunna Formation (Tp)

The Pilgramunna Formation is a unit of well-sorted, fine to very coarse-grained grainstone to calcereous quartz arenite, with interbedded quartzose lenses of muddy coralgal calcarenite (packstone to coralgal boundstone). It rests disconformably on the Tulki Limestone, and interfingers laterally with the Trealla Limestone. The Vlaming Sandstone conformably overlies the Pilgramunna Formation. The type section, at Yardie Creek (lat. 22°20′00″S, long. 113°49′45″E) on YANREY-NINGALOO, is 30 m thick, and the formation is exposed only along the west flank, and at the northern end of the Cape Range Anticline. The unit apparently extends in the subsurface to the northern part of ONSLOW, as it has been identified in West Muiron 1 and Hilda 1A.

The Pilgramunna Formation is similar in lithology to the Trealla Limestone with an admixture of silt to granule-sized quartz, and the unit formed under sub-littoral to littoral conditions.

Quilty (1974) and Chaproniere (1975) dated the formation as Middle Miocene. In addition the nautiloid *Aturia* cf. *australis* has been identified from the formation (Cockbain, 1976b).

Vlaming Sandstone (Tv)

The name Vlaming Sandstone was introduced by Condon and others (1955) for the unit overlying the Pilgramunna Formation. Later, Condon (1968) withdrew the name as he then considered the unit to be part of the Exmouth Sandstone, but we consider the Vlaming Sandstone to be a valid unit. The type section is 1.6 km south-southeast of Tulki well, at lat. 22°06'20"S, long. 113°56'15"E on YANREY-NINGALOO, where the unit is about 38 m thick, the basal 3 to 4 m being transitional with the underlying Pilgramunna Formation. The thickest exposed section measured was 65 m.

The unit consists of well-sorted medium-grained quartzose calcarenite with large-scale, steep cross-sets up to 12 m high. They are separated in places by calcrete soils. The Vlaming Sandstone rests conformably on the Pilgramunna Formation, and is overlain with angular unconformity by the Exmouth Sandstone.

The Vlaming Sandstone is an eolian deposit, associated with the beach and littoral facies of the Pilgramunna Formation.

The Vlaming Sandstone has no age-diagnostic fossils, but on its stratigraphic position it is considered to be Middle Miocene in age.

QUATERNARY

EXMOUTH SANDSTONE *(Qx)*

The Exmouth Sandstone consists of quartzose calcarenite, showing large-scale cross-bedding, with occasional interbedded calcrete soils. The type locality is at lat. 22°21'00"S, long. 114°00'00"E; (YANREY-NINGALOO).

The unit occurs on the west side of the Cape Range peninusla, where it unconformably overlies the Miocene Cape Range Group, and is in turn unconformably overlain by the Bundera Calcarenite.

The Exmouth Sandstone in this area is divided into the older Muiron Member *(Qxn)* and the younger Milyering Member *(Qxm)* (van de Graaff and others, 1976). The two members are lithologically similar; both consist of coarse-grained to pebbly quartzose calcarenite, with steep, large-scale cross-bedding. These members are differentiated because they occur on two different, emerged shoreline terraces.

Crespin (1953) considered the Exmouth Sandstone to be of Pleistocene age on the basis of foraminiferal assemblages, and physiographic evidence supports this.

BUNDERA CALCARENITE *(Qb)*

The Bundera Calcarenite consists of calcarenite to calcirudite, with extensive coralgal reef deposits. The type locality is at lat. 22°24'48"S, long. 113°45'50"E (YANREY-NINGALOO). On the Cape Range peninsula, the formation unconformably overlies the Exmouth Sandstone or the Miocene Cape Range Group.

Two members are recognized in the Bundera Calcarenite on the west side of Cape Range: the older Jurabi Member (*Qbj*) and the younger Tantabiddi Member (*Qbt*). These are lithologically similar, but physiographically distinct, because they occur on separate, emerged shoreline terraces. The Jurabi Member differs from the Tantabiddi Member in containing more coralgal reef deposits and less calcarenite. The type sections of the Jurabi and Tantabiddi Members are at lat. 22°06′20″S, long. 113°53′40″E (YANREY-NINGALOO), and lat. 21°50′10″S, long. 114°04′18″E respectively, and the thickness of both units is not thought to exceed about 20 m onshore. Corals from the Tantabiddi Member have recently been dated at 123 000 years (Veeh and others, 1979).

On ONSLOW the Bundera Calcarenite is composed of oolitic calcarenite and minor calcirudite. Exposed Bundera Calcarenite in this area formed as oolitic dune deposits, overlying coarser grained littoral deposits.

The Mowbowra Conglomerate Member *(Qm)* consists of limestone-pebble conglomerate, well-sorted calcarenite, and minor coralgal reef deposits and is considered to be a member of the Bundera Calcarenite. The type section of the unit is at the mouth of Mowbowra Creek at lat. 22°01′S, long. 114°07′E (YANREY-NINGALOO), where it is about 6 m thick.

In the type area the Mowbowra Conglomerate Member is a beach conglomerate interfingering with a coralgal reef.

The Bundera Calcarenite contains a fauna of modern aspect, but its physiographic expression suggests that the unit is of Pleistocene age.

POST-MIOCENE SUPERFICIAL DEPOSITS

Post-Miocene superficial deposits cover the whole of onshore ONSLOW with the exception of Cape Range. Most of these superficial deposits are not mapped on the basis of lithology alone, but also on differences in morphology, and often-subtle changes in photographic tone and vegetation. That is, most Quaternary map units are morphostratigraphic, not lithostratigraphic units, in the sense of Frye and Willman (1962).

ALLUVIUM *(Cza)*

Extensive alluvial deposits, mostly poorly sorted silt, sand, and gravel, have been formed by the Ashburton and Cane Rivers. The thickness of these sediments probably does not exceed a few tens of metres, and their age is in the range Pliocene to Holocene. On Cape Range peninsula, alluvial limestone-gravel deposits occur as small fans at the foot of the range. Alluvial sediments grade laterally into colluvium, eolian, and claypan deposits.

COLLUVIUM *(Czc)*

Colluvial silt, sand, and gravel form an extensive veneer, probably no more than a few metres thick, in the southeastern part of the area; smaller scattered deposits are common elsewhere. The unit formed primarily by sheet flood processes, but a residual component is also present.

Colluvium as mapped includes, and is gradational to, alluvial, clay-pan, and eolian deposits, and in the Mount Minnie area it also includes minor lateritic ironstone and calcrete. The age of colluvium is in the range of Pliocene to Holocene.

CLAY-PAN AND DUNE DEPOSITS *(Czp)*

These deposits have been mapped as one unit because it is impractical, on a regional scale, to separately map the innumerable small areas of clay pans and dunes west of the Ashburton River. The dune sands are well-sorted, reddish, fine- to medium-grained quartz sand, whereas the clay-pan deposits consist of poorly sorted, silty clay to gravel. The unit grades laterally into colluvium and alluvium, and its age is in the range Pliocene to Holocene. The unit originated in large part by the eolian reworking of ancient fluviatile deposits of the Yannarie and Ashburton Rivers. In the present day, dominance by either eolian or alluvial/diluvial processes varies from area to area. The unit probably does not exceed a few tens of metres in thickness.

CALCRETE *(Czk)*

Massive to lumpy and/or nodular calcrete has formed authigenically in pre-existing sediments. It is rarely seen at the surface in the eastern part of the area where clastic sedimentation is still taking place, but poorly developed calcrete is commonly present as shallow as 0.5 m. The $CaCO_3$ content generally increases downward, and the thickness of the calcrete may be similar to that of the host sediment. Calcretization continues at present.

DUNE AND SAND-PLAIN DEPOSITS *(Qe)*

Extensive dune and sand-plain deposits consisting of reddish-brown quartz sand occur in the eastern part of the area. The dune deposits have formed from residual sand, alluvial, colluvial, and clay-pan deposits that were deflated and redeposited as dunes. The interdunal and sand-plain deposits have since probably been largely reworked by colluvial processes. The thickness of these eolian deposits is unlikely to exceed a few tens of metres. Dunes are primarily longitudinal, but grade locally into network and stellate dunes up to about 25 m high.

Vegetation has stabilized the dunes, which are believed to be of Pleistocene age, although the occurrence of dust storms and evidence of important deflation indicates that some minor reworking and deposition is still taking place. The last major shaping of the dunefields took place during an arid phase 16 000—25 000 years B.P. (Bowler, 1976).

Isolated areas of such dunes form "islands" on the supratidal flats.

CLAY-PAN DEPOSITS *(Qp)*

The larger clay pans in the area of clay-pan and dune deposits are shown individually on the map. Their deposits consist of poorly sorted clay, silt, and sand with rare pebbles.

SUPRATIDAL-FLAT DEPOSITS *(Qt)*

Supratidal-flat deposits consist predominantly of calcareous clay, silt, and sand, in a thin veneer, less than a metre thick, over intertidal-flat and mangrove-swamp deposits. Due to intense evaporation, salt crusts form at the surface of the supratidal-flat sediments, whereas authigenic gypsum crystals form in the sediment. Although some of the sediment is undoubtedly supplied by creeks discharging onto the flat, most of the calcareous silt and sand is thought to have been swept onto the flats from the bottom of Exmouth Gulf during summer cyclones.

Deposition of this unit appears to have been controlled by the Holocene transgression which drowned the pre-existing topography, as evidenced by the "islands" of reddish-brown dunes in the supratidal flats. It is therefore considered to be Holocene in age.

INTERTIDAL-FLAT AND MANGROVE-SWAMP DEPOSITS *(Qw)*

Intertidal-flat and mangrove-swamp deposits consist of poorly bedded to homogeneously mottled, poorly calcareous clay and silt, with a minimum thickness of several metres. The intense bioturbation of these muds is primarily due to the extensive root systems of the mangroves, but also to burrowing crustaceans and other swamp dwellers. Where supratidal-flat sediments have covered these clays and silts, authigenic gypsum is common in the sediment. Considering the small number of ephemeral creeks that reach the coast it is probable that the clay and silt forming the tidal flats is supplied by the sea, or recycled from previous deposits.

COASTAL-DUNE AND BEACH DEPOSITS *(Qs)*

Light-coloured quartzose calcarenite to calcareous quartz sand, locally rich in heavy minerals, forms coastal dunes and beaches on moderate to high energy parts of the shoreline. Where unvegetated, the dunes are commonly still migrating.

Similar deposits occur locally on the landward side of the supratidal flats. These form during summer cyclones when sediment is swept across the flats and deposited along the temporary coast.

Near the mouth of the Ashburton River such sandy deposits have been built out into the sea, forming a wave-dominated delta, indicating sediment supply by the river; elsewhere along the coast these sediments must have been supplied by longshore drift. The thickness of these deposits is probably no more than a few tens of metres, and a Holocene age is inferred.

CORAL-REEF DEPOSITS *(Qr)*

Living coral reefs consisting of coralgal boundstone occur along the western and northern shores of Cape Range peninsula and around islands in Exmouth Gulf. They can be examined on foot during low tide on Bundegi Reef (lat. 21°51'S, long. 114°10'30"E). Along the western coast of the peninsula extensive lagoonal deposits occur behind the reefs, which here are the northern part of the Ningaloo Reef Tract.

STRUCTURE

The structural elements of ONSLOW are shown inset on the geological map.

Sediment thickness increases from 2 to 3 m on Precambrian in the southeast, to probably over 15 000 m in the Barrow Sub-Basin in the northwest (Thomas and Smith, 1974). The structure of the concealed Precambrian is unknown, but is believed to be similar to that exposed in the northern part of YANREY to the south.

The dominant structural feature at the surface is the Cape Range Anticline. It is a very large anticline that formed through post-Middle Miocene reverse movement on a much older normal fault. The warping of coastal terraces indicates that this folding continues at present. Exmouth Gulf, with 200 to 300 m of Pleistocene to Holocene sediments overlying older consolidated sediments, is a synclinal feature of similar magnitude to the Cape Range Anticline. The major structural feature of the area is the extensive and major normal faulting in the subsurface. The major faulting took place at the end of the Middle Jurassic and represents the onset of complete continental breakup (Powell, 1976).

The thickness and distribution of sediments, particularly the Mesozoic units, has been controlled to a large extent by this block faulting.

Further details on the structure of this region are given by Powell (1976), Thomas and Smith (1974, 1976), and Meath and Wright (1974). Some structural features of the Exmouth Plateau, northwest of ONSLOW, are described by Wright and Wheatley (1979); and part of the discussion by Crostella and Baxter (1980) is relevant to ONSLOW.

GEOLOGICAL HISTORY

Since Carboniferous time, sedimentation has been intermittent, but has been predominantly in shallow water and shelf environments. Before the Late Cretaceous much of the sedimentation was in semi-enclosed, restricted basins well removed from the open sea. Although sedimentation has been structurally controlled for much of Phanerozoic time, little tectonic deformation of sediments has taken place, except for a period of major block faulting and deformation in the Jurassic and Early Cretaceous. The most recent regional review of the geological history is by Thomas and Smith (1976).

ECONOMIC GEOLOGY

PETROLEUM

Exploration for petroleum on ONSLOW commenced in 1963 and continues to date, but the period of most activity was 1966 to 1972, with notable geophysical survey activity during 1974-75. A considerable amount of money has been expended on geophysical surveys and drilling, but to date no commercial oil or gas field has been located in the area.

Table 2 shows the oil wells drilled, and Table 3 the geophysical surveys conducted in the area. Of the 25 wells drilled, only two had oil and gas shows, and four had gas shows only. Hilda 1A (Low, 1974) had a minor show of oil and gas in what we interpret as (Cretaceous) Birdrong Sandstone. Thevenard 1 (Playford and Low, 1967) had a minor oil and gas show, and Airlie 1 (Crank, 1976), Glenroy 1 (Crank, 1976), Onslow 1 (Playford and Low, 1967), and West Muiron 2 (Crank, 1976) had gas shows. These hydrocarbon shows were located at several levels in the succession.

Source rocks in the area are considered to be Triassic to Cretaceous fine-grained clastic units of marine facies. The Jurassic Dingo Claystone is the most important of these; other possible sources are the Triassic Locker Shale, and the Cretaceous Muderong Shale, Windalia Radiolarite, and Gearle Siltstone. Reservoir rocks occur in the Triassic Mungeroo Formation, Jurassic Dupuy Member of the Dingo

TABLE 2. Wells drilled for petroleum on ONSLOW

Name	Type	Location		Elevation (m)	Total depth (m)	Bottomed in	Drilled or	Year Completed	Status
		Lat. (S)	Long (E)						
Airlie 1	STR	21 19 35	115 10 02	GL 4.9	2218.6	U. Jurassic	WAPET	1967	Minor gas shows, p & a
Anchor 1	NFW (O)	21 32 56	114 42 45	GL −18	3048.6	L. Jurassic	WAPET	1969	Dry, p & a
Cane River 1	STR	21 40 51	115 05 54	GL 7.6	695.9	L. Carb.	HPPL	1971	Dry, p & a
Cane River 2	STR	21 38 13	115 15 51	GL 4.6	412.9	?L. Carb.	HPPL	1971	Dry, p & a
Cane River 3	STR	21 42 28	115 19 28	GL 14.9	255	Proterozoic	HPPL	1972	Dry, p & a
Cane River 5	STR	21 47 22	115 28 48	GL 34.1	201	Proterozoic	HPPL	1972	Dry, p & a
Direction Island	STR	21 32 08	115 07 50	GL 4.6	672.7	L. Permian	WAPET	1968	Dry, p & a
Glenroy 1	NFW	21 49 10	114 52 35	GL 3.0	648.3	?Triassic	WAPET	1966	Gas show, p & a
Hilda 1	NFW (O)	21 11 59	114 38 13	WD − 145	1546	Tertiary	WAPET	1974	Dry, p & a
Hilda 1A	NFW (O)	21 11 59	114 38 13	WD − 145.0	3466	U. Triassic	WAPET	1974	Oil and gas show, p & a
Locker 1	STR	21 43 21	114 45 42	GL 2.7	765.7	M. Triassic	WAPET	1967	Dry, p & a
Long Is. 1	STR	21 37 15	114 41 17	GL 4.9	2158.3	M. Triassic	WAPET	1966	Dry, p & a
Minderoo 1	STR	21 50 45	115 04 47	GL 10.7	609.6	U. Carb	WAPET	1963	Dry, p & a
Muiron 1	STR	21 39 09	114 21 25	GL 419	1785.2	Jurassic	WAPET	1967	Dry, p & a
Observation 1	STR	21 44 33	114 32 19	GL 4.9	2289.0	M. Triassic	WAPET	1968	Dry, p & a
Onslow 1	NFW	21 46 01	114 52 24	GL 0	2997.7	L. Permian	WAPET	1966	Gas show, p & a
Peak Island 1	STR	21 36 22	114 30 29	GL 4.9	2141.5	Jurassic	WAPET	1967	Dry, p & a
Pepper 1	NFW	21 03 34	115 18 12	WD −76	2743.2	U. Jurassic	WAPET	1970	Dry, p & a
Ripple Shoals 1	NFW (O)	21 07 16	115 24 14	WD −7.9	2278.7	U. Jurassic	WAPET	1970	Dry, p & a
Thevenard 1	NFW	21 27 50	115 01 12	GL 4.9	2075.7	U. M. Jurassic	WAPET	1968	Minor oil and gas shows, p & a
Tortoise Island 1	STR	21 35 13	114 51 18	GL 4.9	2133.6	U. Jurassic	WAPET	1966	Dry, p & a
Urala 1	STR	21 49 11	114 43 29	GL 2.1	762.0	U. Jurassic	WAPET	1968	Dry, p & a
West Miuron 1	NFW (O)	21 33 56	114 14 41	WD − 142.0	781	U. Cretaceous	WAPET	1972	Dry, p & a
West Muiron 1A	NFW (O)	21 34 14	114 14 45	WD − 62.5	345	Tertiary	WAPET	1972	Dry, p & a
West Miuron 2	NFW (O)	21 35 39	114 13 31	WD − 62	3320	U. Triassic	WAPET	1975	Gas shows, p & a

STR Stratigraphic test
GL Ground level

WAPET West Australian Petroleum Pty Ltd
p & a Plugged and abandoned
NFW New field wildcat

WD Water depth
HPPL Hematite Petroleum Pty Ltd
(O) Offshore

TABLE 3: Geophysical surveys carried out on and neighbouring ONSLOW

Title	Company	Year	GSWA reference S File No.
Barrow MSS	Wapet	1965	247
Onslow Seismic Programme (168)	Wapet	1966	283
Glenroy Seismic Programme	Wapet	1966	318
Mary Anne MSS	Wapet	1968	339
Cape Range Gravity (193) Survey	Wapet	1967	350
Onslow Offshore Aeromagnetic (197)	Wapet	1967	351
Cane River—Onslow SS (205)	Wapet	1967	358
Barrow (Table) MSS (221)	Wapet	1970	411
Helby MSS	Wapet	1969	444
Jurabi MSS	Wapet	1968/69	453
Fraser MSS	Wapet	1969	461
Rosily MSS	Wapet	1973	475
Offshore NW Cape—Dampier Archipelago Aeromagnetic Survey	Wapet	1967	507
Flinders Shoals MSS (187)	Wapet	1967	512
Exmouth Marine (74) and Cuvier Marine (75) Reconn. SS	Wapet	1961	513
Gravity Survey of the Cape Range (27)	Wapet	1958	515
Barrow Shoals (174) MS	Wapet	1965	516
South Rough Range (223) SS	Wapet	1968	519
Muiron MSS, Barrow (200) and Pasco (204) MSS	Wapet	1967	521
Barrow Waters (253) MSS	Wapet	1970	539
Barrow MSS	Wapet	1971	612
Scientific Investigation No. 2 SL	Gulf	1972	669
Yardie 2 (322), Sunday Is. (323) and Barrow 3 (324) MSG and Mag.S	Wapet	1971/72	695
Alpha (343) MSG and Mag. S	Wapet	1972	754
Flat 2 (308) and East Flank (309) MSS	Wapet	1971	789
Murat (310), Yardie 2 (344), Barrow Is. (345), Onslow (335) MSS	Wapet	1972	790
Barrow 4 MSG and Mag. S (352)	Wapet	1974	804
West Muiron No. 2 Wellsite Survey	Wapet	1973	871
Hilda (366) and Sultan (367) MSS and Mag. S	Wapet	1974	897
Barrow 5 Shallow Water MSS	Wapet	1975	959
Murat 2 MS and GS (382)	Wapet	1974	961
Wave (381) MS and Mag. S	Wapet	1974	962
Blackledge (377) MSG and Mag. S	Wapet	1974	964
Bluebell (378) MSG and Mag. S	Wapet	1974	965
Airlie MSG and Mag. S (376)	Wapet	1974	1042
Ashburton Shallow Water (397) MSS	Wapet	1975	1062
Rest Shallow Water MSS	Wapet	1975	1063
Murat 2 SS (396)	Wapet	1974	1077
Observation Shallow Water MSS	Wapet	1975	1106
Airlie 2 (405) MS and Mag. S	Wapet	1975	1118
Alpha 2 (406) MS and Mag. S	Wapet	1975	1119
Nares (416) MSS	Wapet	1975	1166
Bundegi (411) SS	Wapet	1975	1167
Airlie 3 (415) SS	Wapet	1975	1168
Hermite 2 (414) Deep Water HSS	Wapet	1975	1176

KEY

SS	Seismic Survey
MSS	Marine Seismic Survey
MSG and Mag. S	Marine Seismic Gravity and Magnetic Survey
(168)	Project Number
WAPET	West Australian Petroleum Pty Ltd
GULF	Gulf Research and Development Company

Claystone, Jurassic-Cretaceous Barrow Formation, and Cretaceous Birdrong Sandstone. In Barrow Island (10 km north of ONSLOW), siltstone beds in Windalia Radiolarite (Cretaceous) contain small amounts of oil, but the main oil producer of the Barrow Island Oil Field is the "Windalia Sand Member" (Crank, 1973) which is part of the Muderong Shale. This unit is found only on Barrow Island. Other producers there are Barrow Formation sands and the Dupuy Member of the Dingo Claystone. The genesis of Barrow Island oil was discussed by Alexander, Kagi and Woodhouse (1980).

Future prospects for ONSLOW appear to be offshore, possibly related to the "Hilda Structure", or possibly on the "Yardie-Muiron Trend" (name from Meath and Wright, 1974). Good prospects may exist in the northwest part of ONSLOW where there is a southern extension of the Rankin Platform, as shown by Powell (1976). The northern extension of the Yanrey High also offers some potential, where the Birdrong Sandstone may be present at relatively shallow depth, pinching out against the Yanrey High where the unit was not deposited (Yanrey 1, YANREY-NINGALOO).

There has been recent intense exploration on the Exmouth Plateau, northwest of ONSLOW, but most results remain confidential. Wright and Wheatley (1979) discussed the potential of some parts of the area.

WATER SUPPLY

Surface supplies in the area are limited to permanent pools in the Ashburton River, earth dams on the western part of the Ashburton River coastal plain where groundwater is too saline for stock, and a few small seepages in Cape Range.

Domestic needs at homesteads are partly met by rainwater tanks, but requirements for the townsites of Exmouth and Onslow, and the Harold E. Holt Naval Communication Station, are obtained from groundwater. Stock quality supplies of groundwater have been obtained in most of the area.

In the eastern part of ONSLOW the main sources of water are alluvial aquifers. Minor supplies are drawn from dune and beach sands on Urala Station, and from weathered basement rocks on Mount Minnie Station. Petroleum exploration has established the presence of very large quantities of sub-artesian water in the basal Cretaceous sands.

Onslow obtains its water from a bore field on the banks of the Cane River, where partly calcreted alluvial sediments are prolific aquifers. The bores have been slotted at depths ranging from 5.4 m to 33.5 m, and produce water with salinities in the range of 270 to 560 mg/L. Individual bores have been tested in excess of 250 m^3/day, and capacity of the bore field is of the order of 1 000 m^3/day.

Along the Ashburton River on Minderoo Station, salinities in calcreted alluvium aquifers increase markedly with increasing distance from the river.

Urala Station obtains domestic-quality water for stock watering from Holocene dune and beach sands. Similar supplies can be expected elsewhere along the coast where dunes and sandy beaches have developed. As the fresh-water lenses are thin, great care should be taken in sinking bores or wells so as not to penetrate the underlying salt water, and they need to be produced at low rates.

On the east side of Cape Range peninsula fresh water is obtained in large quantities from karstic aquifers in the Miocene Tulki and Trella Limestones, which overlie the relatively impermeable, marly Mandu Calcarenite. Forth (1973) discussed the Exmouth water supply and concluded that a safe yield of 0.81 x 10^6 m^3/year with an average salinity of 1 200 mg/L is available from the existing bore field. Pumping rates for individual bores, however, are highly variable, and depend on the particular aquifer characteristics at the site, and on closeness of the fresh/saline groundwater interface. Because of the karstic nature of the aquifer, prediction is difficult. The supply may not be present on the western side of the range.

The water supply for the Harold E. Holt Naval Communication Station is drawn from identical karstic aquifers in Miocene limestones in a separate bore field, a few kilometres north of Exmouth.

In the Quaternary Bundera Calcarenite, which underlies the coastal plain, a number of large sinkholes have developed. Some of these have been pumped at rates in excess of 200 m^3/day, but water in these sinkholes is of variable quality, and can be very saline.

LIMESTONE

Two localities on ONSLOW have been of interest for the production of limestone or lime sand: a zone off the Onslow coast, and a part of the east flank of Cape Range.

During 1967, Ocean Mining A.G. tested the offshore coral sand deposits between Exmouth Gulf and Cape Preston (DAMPIER). Although large deposits of promising grade were discovered off the Onslow coast, the cost of mining them could not compete with other sources and the project was abandoned. A typical analysis of the sand was 47.5 per cent CaO and 87.8 per cent (Ca, Fe, Mg) CO_3. The best quality recorded was 50.5 per cent CaO, 93.6 per cent (Ca, Fe, Mg) CO_3 and 89.9 per cent Ca CO_3.

The limestones of the Cape Range area were investigated by The Broken Hill Proprietary Co. Ltd (BHP) in 1961, 1962, and 1964 (McEwen, 1964). Lewis, Tomich, Hammond Syndicate, who hold mineral claims near Exmouth, carried out limited testing in 1973-74. The BHP work, some of which was on YANREY-NINGALOO, indicated that much of the Trealla and Tulki Limestones tested is of good quality, and is potentially suitable for the manufacture of steel. From BHP analyses, a typical better quality limestone from the Cape Range area contains 0.83 per cent SiO^2, 54.66 per cent CaO, and 0.23 per cent MgO, whereas a typical sample of poorer quality dolomitic limestone from this area contains 0.75 per cent SiO_2, 34.4 per cent CaO, and 17.2 per cent MgO. Phosphorus content is commonly below 0.02 per cent and no sample tested was above 0.074 per cent. Inferred reserves, in a 1.6km square block with a mean depth of 30 m above base creek level, were estimated to be 80 to 90 million tonnes of limestone. Much of the area is presently covered by a Ministerial Reserve.

HEAVY MINERAL SANDS

The Onslow Prospect (Baxter, 1977) is an iron sand occurring between 10 and 30 km southwest of Onslow town, on both sides of the Ashburton River (lat. 21°43'S, long. 114°54'E). Access is from the road to Urala homestead.

Two lines of mineralized sand dunes occur parallel to the shore. The average grade of all dunes is between 8 and 11 per cent heavy minerals, of which 60 to 70 per cent is iron ore (Baxter, 1977). The deposit is not economic at the present time. A noncommercial occurrence of heavy mineral sands in the coastal area northeast of Onslow was investigated by Vam Limited in 1969.

SALT

The intertidal and supratidal flats along the east coast of Exmouth Gulf were investigated in 1968 for the production of solar salt by Exmouth Salt Pty Ltd.

The major part of the planned work lies south of ONSLOW. Due to the world market situation for salt, the project is in abeyance at the present time.

CLAY

The tidal and supratidal flats of ONSLOW are underlain by plastic clays. Composition may be in the range of 15-50 per cent clays, 10-40 per cent quartz, 0-20 per cent calcite, 5-10 per cent halite, 5-10 per cent gypsum, 5-10 per cent microcline, and 5 per cent hematite/goethite. The clay minerals are mainly micas, montmorillonoids, and kaolin.

AGGREGATE

Fine aggregate in the form of silica sand and gravel is available from some river beds such as the Cane River. The material in the Ashburton River on ONSLOW may be unsuitable as aggregate because it appears to contain a high proportion of clay. In the Exmouth area, calcrete and calcreted Bundera Calcarenite have been used extensively in road making, and the Harold E. Holt Naval Communication Station has used local Pilgramunna Formation for aggregate.

REFERENCES

ALEXANDER, R., KAGI, R., and WOODHOUSE, G. W., 1980, Origin of the Windalia oil, Barrow Island, Western Australia: Australian Petrol, Expl. Assoc, Jour., v. 20, p. 250-256.

ANDREJEWSKIS, A. J., 1969, Anchor No. 1 well completion report: West Australian Petroleum Pty Ltd, Petroleum Search Subsidy Acts Rept (unpublished).

BALME, B. E., 1969, The Triassic System in Western Australia: Australian Petrol. Expl. Assoc. Jour., v. 9, pt 2, p. 67-78.

BATE, R. H., 1972, Upper Cretaceous Ostracoda from the Carnarvon Basin, Western Australia: Palaeont. Assoc. Spec. Papers in Palaeontology, No. 10, p. 1-85.

BAXTER, J. L., 1977, Heavy mineral sand deposits of Western Australia: West. Australia Geol. Survey Mineral Resources Bull. 10.

BELFORD, D. J., 1958, Stratigraphy and micropalaeontology of the Upper Cretaceous of Western Australia: Geol. Rundschau, v. 47, p. 629-647.

BOWLER, J. M., 1976, Aridity in Australia: Age, origins and expression in aeolian landforms and sediments: Earth Science Reviews, v. 12, p. 279-310.

BROWNHILL, M. H., 1967, Long Island No. 1 well completion report: West Australian Petroleum Pty Ltd, Petroleum Search Subsidy Acts Rept (unpublished).

BRUNNSCHWEILER, R. O. 1959, New Aconeceratinae (Ammonoidea) from the Albian and Aptian of Australia: Australia Bur. Mineral Resources Bull. 57.

CHAPRONIERE, G. C. H., 1975, Palaeoecology of Oligo-Miocene larger Foraminiferida, Australia: Alcheringa 1, p. 37-58.

CLAPP, F. G., 1925, A Few observations on the geology and geography of North-West and Desert Basins, Western Australia: Linnean Soc. New South Wales Proc., v. 50, p. 47-66.

——1926, Oil prospects of the Northwest Basin of Western Australia: Am. Assoc. Petroleum Geologists Bull., v. 10, p. 1136-1149.

COCKBAIN, A. E., 1976a, On some Cretaceous and Tertiary foraminifer samples from the Carnarvon Basin: West. Australia Geol. Survey Palaeont. Rept No. 7/76 (unpublished).

——1976b, Macrofossils from the Cretaceous and Tertiary of the Carnarvon Basin: West. Australia Geol. Survey Palaeont. Rept No. 10/76 (unpublished).

——1980, Permian ammonoids from the Carnarvon Basin—a review: West. Australia Geol. Survey Ann. Rept 1979, p. 100-105.

CONDIT, D. D., 1935, Oil possibilities in the North-West district, Western Australia: Econ, Geol., v. 30, no. 8, p. 860-878.

CONDON, M. A., 1968, The geology of the Carnarvon Basin, Western Australia, Part III: Post-Permian stratigraphy; structure; economic geology: Australia Bur. Mineral Resources Bull. 77.

CONDON, M. A., JOHNSTONE, D., and PERRY, W. J., 1953, Stratigraphy and structure, *in* The Cape Range Structure, Western Australia; Australia Bur. Mineral Resources Bull. 21, pt 1, ed. 1, p. 7-42.

——1955, Stratigraphy and structure, *in* The Cape Range Structure, Western Australia: Australia Bur. Mineral Resources Bull. 21, pt 1, ed. 2, p. 7-48.

CONDON, M. A., JOHNSTONE, D., PRITCHARD, C. E., and JOHNSTONE, M. H., 1956, The Giralia and Marilla Anticlines, North-West Division, Western Australia: Australia Bur. Mineral Resources Bull. 25.

COOKSON, I. C., and EISENACK, A., 1958, Microplankton from Australia and New Guinea Upper Mesozoic sediments: Royal Soc. Victoria Proc., v. 70, p. 19-79.

CRANK, K., 1973, Geology of Barrow Island Oil Field: Australian Petrol. Expl. Assoc. Jour., v. 10, p. 49-57.

——1976, Wells drilled for petroleum exploration in Western Australia to the end of 1975: West. Australia Geol. Survey Rec. 1976/1 (unpublished).

CRESPIN, I., 1948, Indo-Pacific influences in Australian Tertiary foraminiferal assemblages: Royal Soc. South Australia Trans., v. 72, no. 1, p. 133-142.

——1953, Micropalaeontology, *in* The Cape Range Structure, Western Australia: Australia Bur. Mineral Resources Bull. 21, pt 2, ed. 1, p. 43-75.

——1955, Micropalaeontology, *in* The Cape Range Structure, Western Australia: Australia Bur. Mineral Resources Bull. 21, pt 2, ed. 2, p. 49-82.

CROSTELLA, A., and BARTER, T., 1980, Triassic-Jurassic depositional history of the Dampier and Beagle Sub-basins, Northwest shelf of Australia: Australian Petrol. Expl. Assoc. Jour., v. 20, p. 25-33.

FORTH, J. R., 1973, Exmouth water supply: West. Australia Geol. Survey Ann. Rept 1972, p. 11-15.

FRYE, J. C., and WILLMAN, H. B., 1962, Morphostratigraphic units in Pleistocene stratigraphy—Note 27, Stratigraphic Commission: Am. Assoc. Petroleum Geologists Bull., v. 46, p. 112-113.

HEMATITE PETROLEUM PTY LTD, 1972, Cane River No. 1 well completion report: Hematite Petroleum Pty Ltd, Petroleum Search Subsidy Acts Rept (unpublished).

HOSEMANN, P., AND PARRY, J., 1967, Locker No. 1 well completion report: West Australian Petroleum Pty Ltd, Petroleum Search Subsidy Acts Rept (unpublished).

JOHNSON, N.E.A., 1968, Muiron No. 1 well completion report: West Australian Petroleum Pty Ltd, Petroleum Search Subsidy Acts Rept (unpublished).

JOHNSTONE, M. H., BURDETT, J. W., SMITH, D. N., AND PEARSON, G. R., 1963, Marilla No. 1 and Minderoo No. 1 stratigraphic bores, well completion report: West Australian Petroleum Pty Ltd, Petroleum Search Subsidy Acts Rept (unpublished).

JONES, D. K., 1967, Onslow No. 1 well, Western Australia, well completion report: West Australian Petroleum Pty Ltd, Petroleum Search Subsidy Acts Rept (unpublished).

LOW, G. H., 1974, Petroleum exploration in Western Australia in 1973: West. Australia Geol. Survey Ann. Rept 1973, p. 29-36.

LOWRY, D. C., 1979, Mardie Greensand Member of the Muderong Shale, *in* Wiseman, J. F., 1979, Neocomian eustatic changes—biostratigraphic evidence from the Carnarvon Basin: Australian Petrol. Expl. Assoc. Jour., v. 19, p. 66-73.

McEWEN, R. C., 1964, Results of the 1964 Testing Programme at Cape Range, Western Australia: The Broken Hill Proprietary Co. Ltd (confidential).

McTAVISH, R. A., 1965, Barrow No. 1 well completion report: West Australian Petroleum Pty Ltd, Petroleum Search Subsidy Acts Rept (unpublished).

McWHAE, J. R. H., PLAYFORD, P. E., LINDNER, A. W., GLENISTER, B. F., AND BALME, B. E., 1958, The stratigraphy of Western Australia: Geol. Soc. Australia Jour., v. 4, pt 2.

MEATH, J. R., AND WRIGHT, J. C., 1974, Hilda No. 1 and Hilda No. 1A well completion report: West Australian Petroleum Pty Ltd, Petroleum Search Subsidy Acts Rept (unpublished).

OZIMIC, S., 1970, Bibliography of the Carnarvon Basin, Western Australia (to 31/12/69): Australia Bur. Mineral Resources Rec. 1970/71 (unpublished).

PLAYFORD, P. E., COPE, R. N., COCKBAIN, A. E., LOW, G. H., AND LOWRY, D. C., 1975, Carnarvon Basin, *in* Geology of Western Australia: West. Australia Geol. Survey Mem. 2, p. 269-318.

PLAYFORD, P. E., AND LOW, G. H., 1967, The search for oil in Western Australia in 1966: West. Australia Geol. Survey Ann. Rept 1966, p. 45-50.

POWELL, D. E., 1976, The geological evolution of the continental margin off North-West Australia: Australian Petrol. Expl. Assoc. Jour., v. 16, p. 13-23.

QUILTY, P. G. 1974, Tertiary stratigraphy of Western Australia: Geol. Soc. Australia Jour., v. 21, pt 3, p. 301-318.

——1977, Cenozoic sedimentation cycles in Western Australia: Geology, v. 5, p. 336-340.

——1980, Sedimentation cycles in the Cretaceous and Cenozoic of Western Australia, *in* Banks, M. R., and Green, D. H. (eds), Orthodoxy and creativity at the frontiers of Earth Sciences: Tectonophysics, v. 63, p. 349-366.

RAGGATT, H. G., 1936, Geology of the North-West Basin, Western Australia: Royal Soc. New South Wales Jour. and Proc., v. 70, p. 100-174.

RIDE, W. D. L., APPLEYARD, R. T., BALME, B. E., AND MORGAN, J. F., 1974, Conservation reserves in Western Australia: Report of the conservation through reserves committee *to* the W.A. Environmental Protection Authority, 1974.

TEICHERT, C., 1947, Stratigraphy of Western Australia: Royal Soc. New South Wales Jour. and Proc., v. 80, p. 81-142.

THOMAS, B. M., AND SMITH, D. N., 1974, A summary of the petroleum geology of the Carnarvon Basin: Australian Petrol. Expl. Assoc. Jour., v. 14, pt 1, 66-76.

THOMAS, B. M., AND SMITH, D. N., 1976, Carnarvon Basin, *in* Leslie, R. B., Evans, H. J., and Knight, C. L. (eds), 1976, Economic Geology of Australia and Papua New Guinea, Petroleum: Australasian Institute of Mining and Metallurgy, Mon. 7.

VAN DE GRAAFF, W. J. E., DENMAN, P. D., AND HOCKING, R. M., 1976, Emerged Pleistocene marine terraces on Cape Range, Western Australia: West. Australia Geol. Survey Ann. Rept 1975, p. 62-70.

VEEH, H. H., SCHWEBEL, D., VAN DE GRAAFF, W. J. E., AND DENMAN, P. D., 1979, Uranium-series ages of coralline terrace deposits in Western Australia: Geol. Soc. Australia Jour., v. 26, p. 285-294.

WISEMAN, J. F., 1979, Neocomian eustatic changes—biostratigraphic evidence from the Carnarvon Basin: Australian Petrol. Expl. Assoc. Jour., v. 19, p. 66-73.

WRIGHT, A. J., AND WHEATLEY, T. J., 1979, Trapping mechanisms and the hydrocarbon potential of the Exmouth Plateau, Western Australia: Australian Petrol. Expl. Assoc. Jour., v. 19, p. 19-29.

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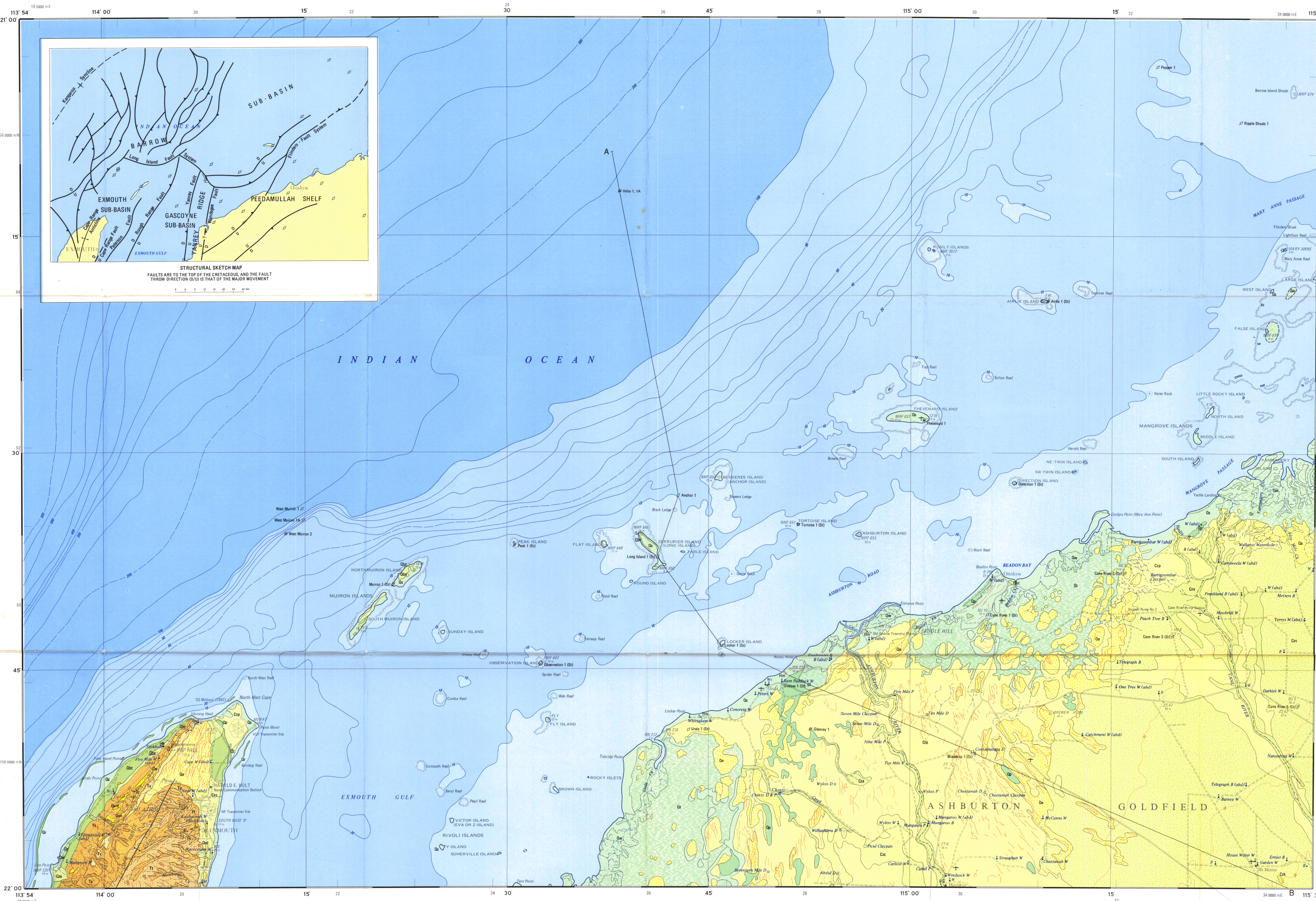
ONSLOW

AUSTRALIA 1 : 250 000 GEOLOGICAL SERIES

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

SHEET SF 50 - 5 AND PART OF SHEET SF 49 - 8



STRUCTURAL SKETCH MAP

FAULTS ARE TO THE TOP OF THE CRETACEOUS, AND THE FAULT THROW DIRECTION (D/U) IS THAT OF THE MAJOR MOVEMENT

REFERENCE

CAINOZOIC — QUATERNARY

Qr Ningaloo Reef – living coralgal reef
Qs Beaches and coastal dunes – light grey, unconsolidated and poorly consolidated quartzose calcarenite
Qw Intertidal flats and mangrove swamps – calcareous clay, silt and sand
Qt Supratidal flats – calcareous clay, silt and sand with authigenic gypsum and superficial algal mats and salt crusts
Qp Claypans – poorly sorted clay, silt, sand and minor pebbles

PLEISTOCENE TO HOLOCENE

Qe Longitudinal and network dunes and residual sand plains – reddish-brown to yellowish quartz sand

BUNDERA CALCARENITE

Qbe Fine to medium-grained calcarenite with intercalated ?calcrete soils, eolian; dune shapes mostly preserved

Qbt **Tantabiddi Member:** calcarenites and calcirudites, coralgal reef deposits; shallow marine and minor eolian

Qm **Mowbowra Conglomerate Member:** limestone pebble conglomerate and minor coralgal reef deposits; shallow marine to stormbeach

Qbj **Jurabi Member:** coralgal reef deposits, minor calcarenite and calcirudite; shallow marine and minor eolian

PLEISTOCENE

EXMOUTH SANDSTONE

Qx Undifferentiated: quartzose calcarenites with intercalated ?calcrete soils; eolian and minor shallow marine; dune shapes poorly preserved

Qxm **Milyering Member:** well-sorted, medium-grained, cross-bedded quartzose calcarenite, coarse-grained quartzose calcarenite, minor pebble conglomerate; eolian and shallow marine

Qxn **Muiron Member:** well-sorted, medium-grained, cross-bedded quartzose calcarenite, coarse-grained quartzose calcarenite; eolian and shallow marine

QUAT. TO ? PLIOCENE

Czk Calcrete – lumpy to nodular or massive, authigenic limestone, locally silicified
Cza Alluvium – clay, silt, sand and gravel, partly calcreted
Czc Colluvium – poorly sorted clay, silt, sand and gravel; formed on plains and slopes by sheet flood and deflation; includes minor laterite exposed in south-east of sheet area
Czp Claypan-dominant terrain – claypans with longitudinal and net dunes, and/or flat deflation-lag surfaces; clay, silt, sand and gravel

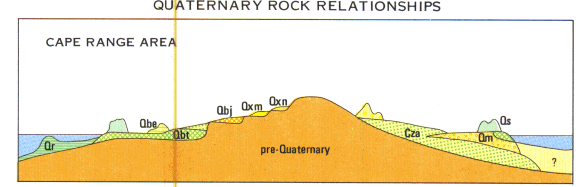
TERTIARY — LOWER TO MIDDLE MIOCENE — Cape Range Group

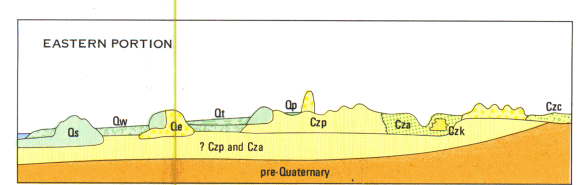
Tv **VLAMING SANDSTONE:** well-sorted, medium-grained, cross-bedded quartzose calcarenite with calcrete soils; eolian
Tp **PILGRAMUNNA FORMATION:** quartzose cross-bedded calcarenite and coralgal limestone; shallow marine
Tt **TREALLA LIMESTONE:** calcirudite to calcisiltite with coralgal limestone; shallow marine

Tk **TULKI LIMESTONE:** reddish to yellowish, partly clayey foraminiferal calcarenitic packstone; shallow marine

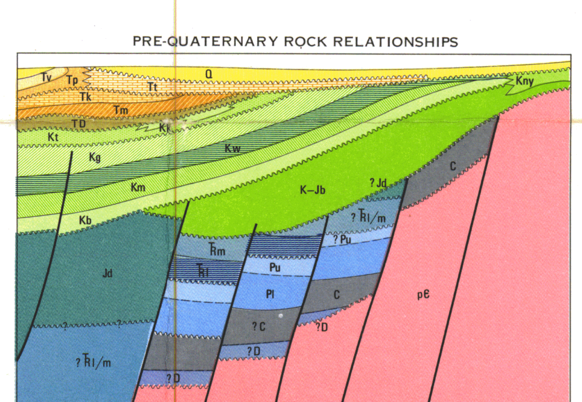
SYMBOLS

QUATERNARY ROCK RELATIONSHIPS





PRE-QUATERNARY ROCK RELATIONSHIPS



Q	Quaternary
Tm	Mandu Calcarenite
TD	Cardabia Group and Giralia Calcarenite
Kk / Kt	Korojon Calcarenite / Toolonga Calcilutite
Kg	Gearle Siltstone
Kw	Windalia Radiolarite
Km	Muderong Shale
Kb	Birdrong Sandstone
Kny	Nanutarra Formation and Yarraloola Conglomerate
K–Jb	Barrow Formation
Jd	Dingo Claystone
₸Rm	Mungaroo Formation
₸Rl	Locker Shale
Pu	Upper Permian: Kennedy Group
Pl	Lower Permian: Lyons Group, Wooramel Group and Byro Group
C	Carboniferous, unnamed
D	Devonian, unnamed
pЄ	Precambrian, probably Proterozoic

—— Fault

∿∿∿ Unconformity

Compiled and published by the Geological Survey of Western Australia. Cartography by the Geological Mapping Section, Department of Mines. Topographic base from compilations by the National Mapping, Canberra. A.C.T.

Copies of this map may be obtained from the Geological Survey of Western Australia, 66 Adelaide Tce., Perth.

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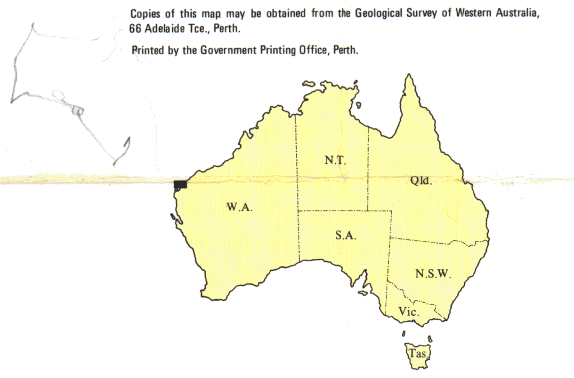
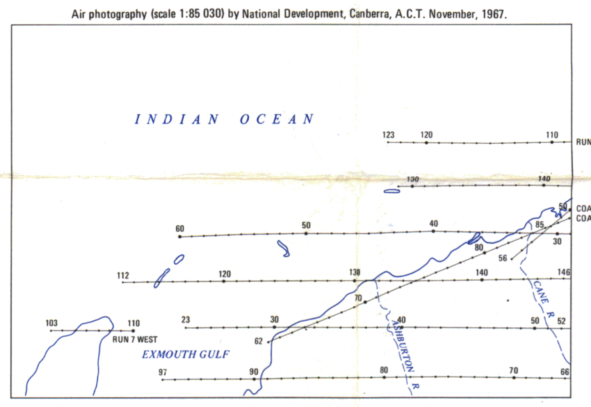


FLIGHT DIAGRAM

Air photography (scale 1:85 030) by National Development, Canberra, A.C.T. November, 1967.



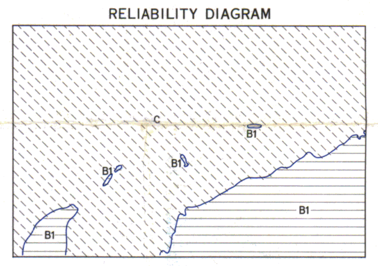
HON. P.V. JONES, M.L.A.
MINISTER FOR MINES
A.F. TRENDALL, DIRECTOR, GEOLOGICAL SURVEY

SCALE 1 : 250 000

0 5 10 15 20 25 30 Kilometres

TRANSVERSE MERCATOR PROJECTION
AUSTRALIAN NATIONAL SPHEROID ZONE 50
Ticks inside the sheet edge represent 10000 metre intervals of the Australian Map Grid

RELIABILITY DIAGRAM



B1 Numerous traverses with air photo interpretation
C Air photo interpretation

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SF 49 - 8	ONSLOW SF 50 - 5	YARRALOOLA SF 50 - 6
NINGALOO SF 49 - 12	YANREY SF 50 - 9	WYLOO SF 50 - 10

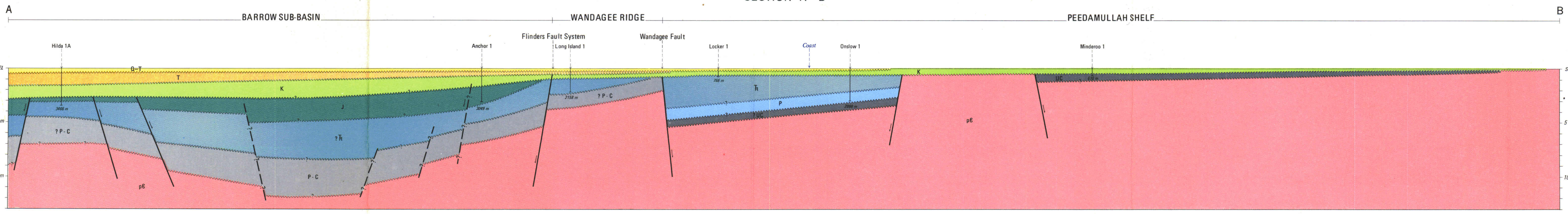
DECLINATION DIAGRAM

Geology by W.J.E. van de Graaff, P.D. Denman, R.M. Hocking 1975

DIAGRAMMATIC SECTION

NATURAL SCALE

SECTION A - B



Q–T Quaternary – Tertiary; T Tertiary; K Cretaceous; J Jurassic; ₸R Triassic; P Permian; P–C Permian – Carboniferous; UC Upper Carboniferous; pЄ Precambrian

ONSLOW

SHEET SF 50 - 5 AND PART OF SHEET SF 49 - 8

FIRST EDITION 1981