1:250 000 GEOLOGICAL SERIES—EXPLANATORY NOTES

MANDORA

WESTERN AUSTRALIA

SHEET SE/51-13 INTERNATIONAL INDEX

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

DEPARTMENT OF MINES, WESTERN AUSTRALIA
GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

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COMPILED BY R. R. TOWNER

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Explanatory Notes on the Mandora Geological Sheet

Compiled by R. R. Towner

The Mandora 1:250 000 Sheet area, two thirds of which is ocean, lies between latitudes 19° and 20°S and longitudes 120° and 121°30′E, in the north of Western Australia. The Sheet area covers part of the western edge of the Great Sandy Desert (Warburton, 1875). It contains scattered inliers of Mesozoic rocks in Cainozoic superficial sediments, and is part of the Phanerozoic Canning Basin.

Main access to the Sheet area is by the partly-sealed and maintained Great Northern Highway which connects Port Hedland to the south with Broome to the north. The old Great Northern Highway, which is now a station track, branches off the new road near Wallal Downs Homestead and runs northeastwards, parallel to and much closer to the coast. A gravel road runs southeast off the Great Northern Highway, near Wallal Downs Homestead, into the Great Sandy Desert to the site of West Australian Petroleum Pty Ltd (WAPET) Sahara 1 exploration well in the Sahara Sheet area to the southeast. Access within the area is mainly by the numerous station tracks, most of which are west of the Great Northern Highway. The station tracks and parts of the main roads are at times impassable during the wet season.

Permanently inhabited homesteads in the area are Anna Plains, Mandora, and Wallal Downs. A roadhouse/caravan park is located at Sandfire, on the Great Northern Highway. Landing grounds are located at all the homesteads and near the Sandfire Roadhouse.

The climate is semi-arid monsoonal, characterised by a warm, dry winter and a hot, wet summer. As there are no meteorological stations in the Sheet area, climatic data has to be inferred from nearby stations. The annual rainfall is extremely variable and probably averages less than 350 mm, the heaviest falls occurring between November and March, the cyclonic period. The annual evaporation rate is 2250-2500 mm. The average daily minimum and maximum temperatures are about 24° and 35°C in January, and 17° and 26°C in July (Commonwealth Statistician, 1978). The prevailing winds are from the east and southeast.

The Sheet area lies within two distinct regions, each having a characteristic landscape and associated vegetation. The coastal strip is part of the Northern Botanical Province and the rest lies within the Canning Botanical District (Beard, 1969). The floras of these two areas are described by Beard (1969) and Beard & Webb (1974). The sparse vegetation of the Canning Botanical District consists mainly of small eucalypts, Acacia shrubs, and spinifex grass. The flanks of dunes are normally thickly vegetated with spinifex hummocks and sparse shrubs, but the crests are commonly bare and subject to wind action.

The Northern Botanical Province is characterised by pindan and a thin strip of grass savanna. The savanna occurs on mainly silty and clayey soil on the coastal plain between the coastal dunes and the pindan-covered higher ground; the savanna grasses are perennial but strongly seasonal in their growth, flowering during the rainy season but drying out during the dry season. Pindan is essentially a grassland, wooded by a sparse upper layer of trees with a dense thicket forming a middle layer of phyllodal acacias (Beard, 1969). Small prostrate succulent plants or 'samphires' are generally present on the saline marsh areas, especially north of Mandora Homestead.

A detailed study of the vegetation of the coastal fringe, particularly in the section along Eighty Mile Beach, has been made by Burbidge (1944).

History of investigations

The earliest exploration of the Mandora Sheet area was by Alexander Forrest in 1879; he travelled along the coast on his way from the De Grey River (Port Hedland Sheet area) to Darwin (Feeken & others, 1970).

Surface geology. In 1954, Traves, Casey, & Wells of the Bureau of Mineral Resources (BMR), during their mapping of the southwestern part of the Canning Basin, travelled from Wallal Downs Homestead southwards to Callawa Homestead (on the adjacent Yarrie Sheet area).

In the same year, WAPET carried out a traverse from Anna Plains Homestead to McLarty Hills (in the McLarty Hills Sheet area to the east).

Review accounts of the geology of the entire Canning Basin which include the Mandora Sheet area have been made by Veevers & Wells (1961), McWhae & others (1958), and Playford & others (1975).

Magnetics. During 1954, BMR carried out a reconnaissance aeromagnetic survey of the Canning Basin; none of the widely-spaced flight lines crossed the Mandora Sheet area but six closely-spaced parallel lines were flown along the coastal strip. The aeromagnetic results indicated a depth-to-basement section of less than 3000 m beneath the whole area traversed (Quilty, 1960). In the same year, WAPET flew a semi-detailed aeromagnetic survey of the coastal Canning Basin. The aeromagnetic anomalies at the site of BMR Wallal 4 & 4A, and WAPET Samphire Marsh 1 were mapped by the WAPET survey (unpublished WAPET report, on microfilm at the Geological Survey of Western Australia (GSWA), Perth). Depth to basement estimates of between 300 m and 900 m near Wallal Downs Homestead were confirmed by the drilling of BMR Wallal Boreholes (Henderson & others, 1963).

The only other magnetic survey in the Sheet area, the Wallal Aeromagnetic Survey conducted by WAPET in 1968 (WAPET, 1969a) under the conditions of the Commonwealth Petroleum Search Subsidy Act, covered the western half of the Mandora Sheet area (mainly offshore) and the northwestern sector of the Yarrie Sheet area. Its aim was to delineate the offshore extension of the 'Wallal Platform' and the 'Wallal Embayment' and the faults separating these two features. The survey confirmed the offshore extension of both these features and revealed two other structural zones and faults associated with them (WAPET, 1969a).

Gravity. The gravity contours shown on the accompanying map are those of the 1960 BMR helicopter gravity survey incorporating unpublished data from 1954–55 WAPET gravity surveys along the coast, originally processed by Flavelle & Goodspeed (1962), modified partly by Darby & Fraser (1969), and then by Fraser (1974). The nomenclature of the various gravity provinces used here and on the map is the revised version of Fraser (1976). The contours outline parts of two gravity provinces: the Anketell Regional Gravity Ridge; and the Fortescue Regional Gravity Complex in the southwest.

A synthesis of all the available pre-1962 gravity information in the Canning Basin, relating it to known surface geology and the borehole stratigraphy, was published in 1974 (Flavelle, 1974).

The only other gravity survey in the Sheet area involved a series of gravity meter and barometer readings taken by BMR in 1953 at intervals of about 32 km along the old Great Northern Highway from Onslow to Derby. The brief survey conclusions were tentative in the absence of definite information on rock densities in much of the area (Dooley, 1963).

Seismic. In the period 1956–58, WAPET conducted considerable semi-detailed seismic surveys (including the Samphire Marsh Prospect seismograph survey, and the Wallal Prospect refraction profile seismograph survey—these and other unpublished data are on microfilm at GSWA). These surveys help to delineate the regional structural framework necessary to locate WAPET Samphire Marsh 1.

In 1968, WAPET conducted a short reconnaissance survey, the Wallal Marine Seismic Survey, to determine whether a structural embayment occurs at the northwestern end of the Anketell Shelf (Playford & others, 1975; Wallal Platform of Flavelle & Goodspeed, 1962). The survey results confirmed that a structural embayment does occur, and that it is bounded to the northeast by a major fault, and to the southwest by thinning of the sedimentary section adjacent to an upthrown fault-block. The thickest sedimentary section is on the downthrown (northeastern) side of the major fault. Three structural traps with fault closures were indicated (WAPET, 1967).

In 1969, the Bedout Marine Seismic Survey (WAPET, 1969d) was carried out by WAPET, covering the area adjacent to the present-day coastline. The results of the survey indicate that the offshore sediments were an extension of the onshore Jurassic-Cretaceous sediments of the Willara Sub-basin.

One line from the Broome-Samphire Seismic Survey (WAPET, 1971a), part of a regional re-appraisal of this part of western Canning Basin, cuts across the southeastern corner of the Mandora Sheet area. The survey showed that the stratigraphic section thinned markedly onto the Anketell Regional Gravity Ridge (equated with the Anketell Shelf), where data quality deteriorated.

From 1972 to 1977, the BMR Basin Study Group re-interpreted much of the seismic data in the Canning Basin (Gorter & others, 1979).

Drilling. Five petroleum exploration/stratigraphic wells have been drilled in the Mandora Sheet area; WAPET Wallal Core Hole 1 (WAPET, 1957); WAPET Samphire Marsh 1 (WAPET, 1961); WAPET Chirup 1 (WAPET, 1968b); and BMR Wallal 4 & 4A (Henderson & others, 1963).

Aerial photographs and Maps. Aerial photographs, one set at 1:48 000 scale flown in 1949 and the other set at 1:80 000 flown in 1967, cover the Sheet area and are obtainable from the Division of National Mapping, Canberra, and the Department of Lands and Surveys, Perth.

A topographic base map at a scale of 1:250 000 (Mandora SE/51-13, Edition 1, Series R502), compiled in 1958 by the Department of Lands and Surveys, Western Australia from 1949 aerial photography and with field revision in 1965, is also available from the same sources.

Latest investigations. In 1977, geologists from BMR and GSWA mapped the Mandora Sheet area and the surrounding Sheet areas as part of a survey in the

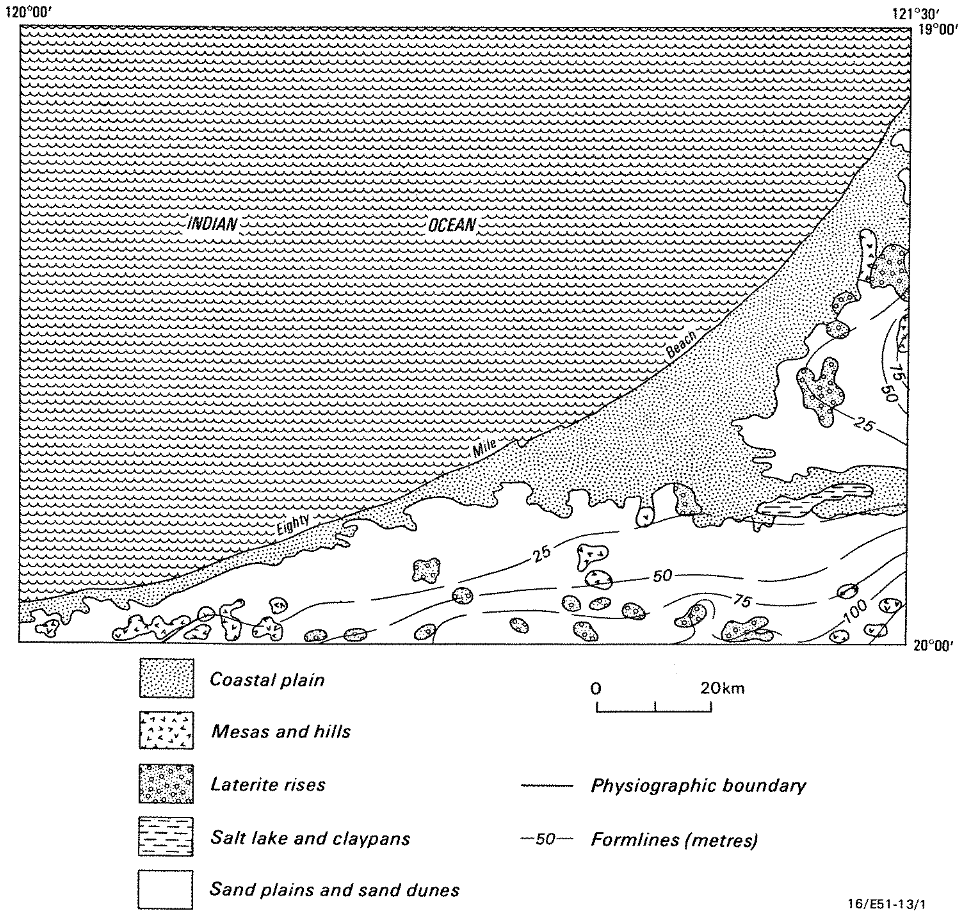

Fig. 1. Physiography.

western Canning Basin which was carried out mainly by helicopter and vehicular traverses (Towner & Gibson, 1980).

PHYSIOGRAPHY

The Mandora Sheet area is characterised by two dominant physiographic units; sand dunes and plains, and the coastal plain (Fig. 1). Other minor physiographic units include scattered hills and mesas, laterite rises, and a salt lake. The form lines shown on the physiographic map (Fig. 1) have been compiled using widely-spaced elevation information from BMR gravity station heights. The maximum altitude in the Sheet area is 126 m.

Coastal plain

The coastal plain forms a continuous fringe from 4 to 40 km wide. Small salt pans, clay flats (Qci), or thickly grassed supratidal flats (Qcs) form swales between and behind the subparallel systems of beach and sand ridges (Qpd, Qcd). The beach ridges rise up to 5 m above the beach; inland, they are covered with low thick scrub, but those towards the coast support poorer vegetation, perhaps because they are younger. The present beach is sandy, but mud flats are exposed at low tide; tidal mega-ripples parallel the shore. The supratidal flats commonly support halophytic plants and rare patches of mangroves.

Sand plains and sand dunes

Sand plains occur across the southern part of the Sheet area together with a small area north of latitude 19°40′S; associated with the sand plains are elongate sub-parallel longitudinal sand dunes with a predominant west-northwesterly trend, particularly in the south; the dunes in the north are predominantly east-west. The dunes vary in length, separation, and complexity. They were formed by the prevailing winds which blew from the east and east-southeast.

Laterite rises

A small remnant of a laterite plain occurs in the south and east of the Sheet area, and is characterised by smooth, pisolite-strewn rises. The surface is underlain by pisolitic laterite and in places by a thin blanket of red sand, or longitudinal sand dunes.

Mesas and hills

Isolated mesas and hills up to 10 m high are present mainly along the southern boundary of the Sheet area. Breakaways up to 5 m high, flanked by sand plains or coastal sediments, occur in the north. These have formed where erosion has cut through the laterite crust into the underlying, deeply weathered rock.

Salt lake and claypans

A salt lake and claypans are located within and adjacent to the coastal plain sediments. The claypans are underlain by hard, sandy clay, and the salt lake contains gypsum. Saltbush, grasses, teatrees, and eucalypts are present along the margin of the claypans.

There are no permanent watercourses in the Mandora Sheet area, although the claypans retain water after heavy rain. Salt Creek drains into the salt lake in the east of the Sheet area but is known to dry up during the exceptionally hot, dry summers. Small ephemeral streams meander across the coastal plains with low bed gradients on the flatter slopes at the front of the beach ridges.

STRATIGRAPHY

The stratigraphy of the Sheet area is summarised in Table 1. Cainozoic terrestrial superficial units up to 30 m thick blanket 95 percent of the land area. Flat-lying Cretaceous sedimentary rocks crop out in the east and south. Units older than the Late Jurassic-Early Cretaceous Callawa Formation occur only at subsurface, and information on them is based on data obtained from WAPET Samphire Marsh 1 (WAPET, 1961), WAPET Wallal Core Hole 1, WAPET Chirup 1 (WAPET, 1968b), and BMR Wallal 4 & 4A (Henderson & others, 1963). Extrapolation of geophysical data from the Munro Sheet area was used to aid the interpretation of the stratigraphy in eastern Mandora Sheet area. Information from the offshore Hematite Keraudren 1 (Hematite, 1974), located north-west of the Sheet area, has been used to discuss the stratigraphy under the Indian Ocean.

TABLE 1. STRATIGRAPHY OF MANDORA SHEET AREA

	Age	*Rock unit and symbol*	*Estimated thickness (m)*	*Lithology*	*Stratigraphic relationship*	*Remarks*
CAINOZOIC	Quaternary	Qa	3+	Sand, silt, clay; minor gravel		Unconsolidated alluvial deposits
		Ql	5	Clay, silt, sand; minor gypsum		Salt-lakes, claypans
		Qs	5	Sand, silt; minor gravel		Mixed alluvial and aeolian; in depressions
		Qz	5±	Red quartz sand, fine to medium-grained; minor silt		Aeolian sand in dunes and sand plains; occurs throughout the area
		Qcd	5±	Calcareous sand, partly oolitic	Superficial deposit	Coastal aeolian dunes; includes reworked Qpb
		Qci	10±	Silty clay, black organic clay; minor salt	Superficial deposit	Intertidal and mangrove swamp deposits
		Bossut Formation Qpb	10±	Quartzose calcarenite, fine to coarse calcilutite; partly oolitic, cross-bedded	Interfingers with Qcs; unconformable on JKc, Kb, Kp	Shoreline beach-ridge deposits; fossiliferous
		Qcs	10±	Clay, silt, sand; minor salt	Superficial deposit	Supratidal mud flat deposits
		Czk	3	Calcrete; minor chalcedony		Evaporitic and pedogenic
		Czs	2	Sand, silt, ferruginous pisoliths; minor gravel and clay		Residual lateritic soil capping laterite plateaux
		Czl	3	Laterite, pisolitic or massive		Upper part of lateritic weathering profile; pedogenic; well developed on Kp
MESOZOIC	Early Cretaceous	Frezier Sandstone Kf	0–5+	Sandstone, fine to coarse, feldspathic, poorly sorted; poorly bedded, remnant cross-bedding; minor conglomerate	Conformable on Kp; top eroded	Forms small dark hills on air-photographs in the south-eastern corner; fluvial to deltaic, partly pedogenic
		Parda Formation Kp	0–10+	Mudstone, minor fine sandstone lesnses; thin-bedded or massive	Disconformable on Kb and JKc; conformable beneath Kf	Outcrops in eastern Mandora Sheet area; lagoonal(?)
		Broome Sandstone Kb	0–50±	Sandstone, fine to medium, well-sorted; mudstone in part; minor conglomerate; ripple-marked, cross-bedded; minor bioturbation	Conformable on JKr; disconformable beneath Kp; possibly laterally equivalent to JKc	Subsurface only; intersected in WAPET Samphire Marsh 1; shallow marine

TABLE 1. STRATIGRAPHY OF MANDORA SHEET AREA *(continued)*

	Age	*Rock unit and symbol*	*Estimated thickness (m)*	*Lithology*	*Stratigraphic relationship*	*Remarks*
MESOZOIC	Late Jurassic to Early Cretaceous	Callawa Formation JKc	3–50±	Sandstone, very fine to coarse; pebble conglomerate; cross-bedded; minor siltstone; bioturbated	Disconformable or conformable(?) on JKr; disconformably overlain by Kp; possibly lateral equivalent to Kb	Plant-bearing in Callawa Hills in Yarrie Sheet area; fluvial
		Jarlemai Siltstone JKr	0–100	Mudstone, sandy glauconitic	Conformable between Ja and Kb; disconformable or conformable(?) beneath JKc	Subsurface only; intersected in wells drilled in Mandora Sheet area; fossiliferous; marine
	Late Jurassic	Alexander Formation Ja	0–30+	Sandstone, fine to medium, interbedded mudstone, bioturbated	Conformable between Jl and JKr	Subsurface only; intersected in wells drilled in Mandora Sheet area; marine
	Early(?) to Late Jurassic	Wallal Sandstone Jl	0–500±	Sandstone; minor siltstone, conglomerate, coal	Unconformable on Rb, Pi, Pg; conformable beneath Ja	Subsurface only; intersected in wells drilled in Mandora Sheet area; palynomorphs; continental to shallow marine
				UNCONFORMITY		
	Triassic	Blina Shale Rb	0–25	Siltstone, shale, grey, micaceous, carbonaceous, with thin sandstone lenses	Conformable on Pi; unconformable beneath Jl	Subsurface only; intersected in BMR Wallal 4A; possibly confined to small area in the centre of the Sheet area along the coast; shallow marine
PALAEOZOIC	Late Permian	Chirup Formation Pi	0–40	Shale, grey to black, sandy, carbonaceous; interbedded sandstone, fine to conglomeratic	Possibly unconformable on Pg; conformable(?) beneath Rb; unconformable beneath Jl	Subsurface only; intersected in BMR Wallal 4A and WAPET Chirup 1; palynomorphs; paralic
	Early Permian	Grant Group Pg	0–800	Sandstone, fine to coarse; mudstone; minor conglomerate	Unconformable on pЄ, Sc, Ot, Ow, Oo; possibly unconformable beneath Pi; unconformable beneath Jl	Subsurface only; intersected in WAPET Samphire Marsh 1, WAPET Chirup 1, and BMR Wallal 4 and 4A; glacial marine
				UNCONFORMITY		

TABLE 1. STRATIGRAPHY OF MANDORA SHEET AREA *(continued)*

	Age	*Rock unit and symbol*	*Estimated thickness (m)*	*Lithology*	*Stratigraphic relationship*	*Remarks*
PALAEOZOIC	Late Ordovician(?) to Early Devonian	Carribuddy Formation Sc	0–100+	Dolomite, dolomitic siltstone, shale, halite, anhydrite; minor sandstone	Unconformable beneath Pg; disconformable on Oo	Subsurface only; inferred to be present from drilling NE and east of Sheet area; mainly non-marine
	Middle Ordovician	Goldwyer Formation Oo	0–100+	Shale, black fossiliferous, calcareous, pyritic; interbedded limestone, dolomite; minor siltstone	Conformable on Ow; disconformable beneath Sc; unconformable beneath Pg	Subsurface only; interpreted to be confined to NE Mandora Sheet area; marine
	Early Ordovician	Willara Formation Ow	0–300+	Limestone, dolomitic, fossiliferous; interbedded shale and siltstone	Conformable between Oo and Ot; unconformable beneath Pg	Subsurface only; interpreted to be confined to NE Mandora Sheet area; marine
		Nambeet Formation Ot	0–775+	Shale, grey to green; interbedded limestone and fine to coarse sandstone	Unconformable on pЄ; conformable beneath Ow; unconformable beneath Pg	Subsurface only; intersected in WAPET Samphire Marsh 1; possibly confined to northern and eastern Mandora Sheet area; marine
UNCONFORMITY						
PRECAMBRIAN		pЄ	Unknown	Igneous, metamorphic, and sedimentary	Basement rocks	Section only

The geological cross-sections have been compiled largely from information from the above-mentioned stratigraphic wells, together with some aeromagnetic data (WAPET, 1967).

PRECAMBRIAN

Precambrian rocks (p€) form the basement to the Canning Basin succession. Granite and gneisses have been penetrated in WAPET Samphire Marsh 1 (WAPET, 1961) and BMR Wallal 4 & 4A (Henderson & others, 1963). Basement in the adjacent Yarrie Sheet area to the south comprises Archaean volcanic, sedimentary, and associated stratiform rocks overlain by Lower Proterozoic basaltic to rhyolitic volcanics, sandstone, shale, and carbonate rocks which have been deformed into northwesterly-trending, tight to open folds (Hickman & others, in press). Rocks of the same age may also be present in the subsurface of the Mandora Sheet area.

PALAEOZOIC

Ordovician

Ordovician rocks do not crop out in the Sheet area but evidence from WAPET Samphire Marsh 1 and from well sections in the adjacent Munro Sheet area to the east indicate that Ordovician rocks are present, unconformably overlying Precambrian rocks. Ordovician rocks in Samphire Marsh 1 consist of grey-green shale with interbeds of limestone and sandstone, termed the *Nambeet Formation* (Ot; Johnstone *in* WAPET, 1961). Fine to coarse-grained, poorly sorted sandstone is the dominant lithology at the base of the formation. Other Ordovician units that are present in WAPET Willara 1 (WAPET, 1965b) in the adjacent Munro Sheet area and are likely to occur in the northeast of the Sheet area are the *Willara Formation* (Ow; Playford & others, 1975), and the *Goldwyer Formation* (Oo; Elliott, 1961).

Late Ordovician(?) to Early Devonian

The *Carribuddy Formation* (Sc; Koop, 1966a) is inferred to be present only in the northeast as it was not intersected in any of the wells drilled in the Mandora Sheet area, but was encountered in WAPET Parda 1 (WAPET, 1965a) on La Grange Sheet area to the northeast, and in WAPET Willara 1 (WAPET, 1965b) on the Munro Sheet area to the east. The age of the Carribuddy Formation is poorly known; information from outside the Sheet area suggest mainly an Early Devonian age for the unit but it may range down into the Late Ordovician (Total, 1968). Within the Sheet area, it is considered to be unconformably overlain by the Grant Group.

Early Permian

The subsurface *Grant Group* (Pg; Guppy & others, 1952, 1958; Crowe & Towner, 1976) was intersected between 688 m and 1240 m in WAPET Samphire Marsh 1 (WAPET, 1961) and penetrated in WAPET Chirup 1 (WAPET, 1968b). In the southwestern corner of the Sheet area, it lies unconformably on Precambrian rocks (Henderson & others, 1963). In WAPET Samphire Marsh 1, the group comprises a lower sandstone unit overlain by mudstone. An upper sandstone unit, which is present in the WAPET Willara 1, is absent from WAPET Samphire Marsh 1.

Palynomorphs recorded from cores and cuttings in the wells indicate an Early Permian (Sakmarian) age for the Grant Group (WAPET, 1961, 1968b). The overlying Poole Sandstone and Noonkanbah Formation present in WAPET Munro 1, in the adjacent Munro Sheet area, were not encountered in the wells drilled on highs on this map sheet, but they may be present on the synclinal areas.

Late Permian

The *Chirup Formation* (Pi) possibly unconformably overlies the Grant Group (Gorter & others, 1979). This formation occurs entirely subsurface, and appears to be restricted to the Samphire and Wallal Embayments, having been intersected only in BMR Wallal 4A and WAPET Chirup 1. The unit is predominantly a shale sequence with interbeds of fine-grained to conglomeratic sandstone, and probably represents a coastal-swamp or marsh deposit (Gorter, 1978). It is possibly unconformable on the Grant Group and is unconformably overlain by the Wallal Sandstone and conformably by the Blina Shale. Spores and pollen from the formation indicate that it is Late Permian in age, and that it may be equated with the upper part of the Hardman Formation in the Fitzroy Trough (Balme *in* WAPET, 1968b).

MESOZOIC

Triassic

The *Blina Shale* (Rb) is confined to the subsurface in the Samphire Embayment adjacent to the Willara Sub-basin. It has been intersected in BMR Wallal 4A where 25 m of carbonaceous, shaley, micaceous siltstone with thin sandstone interbeds was encountered. The unit conformably overlies the Chirup Formation, and is unconformably overlain by the Wallal Sandstone. Microfossils in BMR Wallal 4A indicate an Early Triassic age (Balme *in* Henderson & others, 1963).

Over 1300 m of Middle to Late Triassic, fine to medium-grained sandstone, multicoloured claystone, and dark carbonaceous siltstone are present in the offshore Hematite Keraudren 1 (Hematite, 1974), and equivalents of this section may extend into the northwestern sector of Mandora Sheet area.

Early(?) to Late Jurassic

The *Wallal Sandstone* (Jl; McWhae *in* WAPET, 1961) is only present in the subsurface in the Sheet area; it is basal Jurassic unit in the western Canning Basin. It is 334 m thick in WAPET Samphire Marsh 1 in the northeast and 238.7 m thick in WAPET Chirup 1 in the southwest. It thins to the east where it is 227 m thick in WAPET Willara 1. The unit consists dominantly of quartz sandstone with lenses of siltstone, conglomerate, and coal; it has been dated as Early(?) to Late Jurassic (Toarcian to Oxfordian) from the abundant microflora and microfauna. It unconformably overlies the Triassic Blina Shale and the Permian Chirup Formation and Grant Group in the north. The top of the sandstone is conformable with the overlying Alexander Formation.

Late Jurassic

The *Alexander Formation* (Ja; Brunnschweiler, 1954) does not crop out but has been penetrated in all the wells in the Sheet area and in the adjacent Munro Sheet area. The formation conformably overlies the Wallal Sandstone and is conformably overlain by the Jarlemai Siltstone. The predominantly fine to medium-grained sandstone with mudstone interbeds has been dated as Late Jurassic (late

Oxfordian) by a rich macroflora in exposures in the north in the Mount Anderson Sheet area, and by microflora in well cores and cuttings.

Offshore, the possible time (and lithological) equivalents of the Wallal Sandstone and Alexander Formation consist of quartzose sandstone with interbedded claystone, siltstone, and thin coal beds (Hematite Keraudren 1; Hematite, 1974). These sediments rest unconformably on the unnamed Triassic sequence and are of Early to Late Jurassic age.

Jurassic to Early Cretaceous

The *Jarlemai Siltstone* (JKr; Brunnschweiler, 1954) does not crop out but has been intersected in all the exploration wells within the Sheet area. The results of the drilling indicate that it thickens northwards from 29.0 m in WAPET Chirup 1 to 108.2 m in WAPET Samphire Marsh 1. The formation consists of sandy mudstone, and fossils indicate a Late Jurassic (late Oxfordian to Tithonian) age, but it may range into the Early Cretaceous (Towner & Gibson, 1980). It lies conformably between the Alexander Formation and the Broome Sandstone.

The *Callawa Formation* (JKc), which is exposed in small hills in the southern part and southwestern corner of the Sheet area, is the oldest unit to crop out. It consists of cross-bedded, poorly-sorted, very fine to coarse-grained, fluvial sandstone, conglomerate, and minor siltstone. It disconformably or possibly conformably overlies the Jarlemai Siltstone. It overlaps this formation and unconformably overlies Permian rocks and Precambrian rocks on the adjacent Yarrie Sheet area to the south (Hickman & others, in prep.). Plant fossils present in the formation at the Callawa Hills (Yarrie Sheet area) have been assigned Late Triassic or Early Jurassic (Brunnschweiler *in* Traves & others, 1956) and Late Jurassic or Early Cretaceous (White *in* Veevers & Wells, 1961) ages; the Late Jurassic or Early Cretaceous age is the more likely as the underlying Jarlemai Siltstone is of Late Jurassic age. An incomplete section of 52 m of Callawa Formation was measured in the Callawa Hills on the Yarrie Sheet area to the south; it is probable that the maximum thickness in the Mandora Sheet area is no more than this.

In Hematite Keraudren 1, a 323-m thick sequence of claystone and interbedded sandstone and siltstone rests disconformably on the unnamed Late Jurassic clastic sediments, and is of Late Jurassic (Tithonian) to earliest Cretaceous age based on palynology. This sequence may be equivalent to parts of the Jarlemai Siltstone and the Callawa Formation, and may be present in the northwestern part of the Sheet area.

Early Cretaceous

The *Broome Sandstone* (Kb; Reeves, 1951; amended by Brunnschweiler, 1957) is a sequence of sandstone, mudstone, and minor conglomerate which does not crop out in the Sheet area. In wells in the Munro Sheet area to the east, Broome Sandstone overlies the Jarlemai Siltstone and is overlain disconformably by the Parda Formation. The sandstone is confined to the northeastern sector of the Mandora Sheet area. Plant fossils, dinosaur footprints (Colbert & Merrilees, 1967), and palynomorphs from the unit elsewhere in the Canning Basin indicate an Early Cretaceous (possibly Neocomian) age.

The *Parda Formation* (Kp; McWhae & others, 1958) crops out beneath laterite in hills in the northeastern part of the Sheet area. It consists of thinly bedded or massive mudstone with some interbedded fine-grained sandstone. It is probably of Aptian age because, outside the Sheet area, it occurs within rocks of probable Aptian age (Towner & Gibson, 1980). The formation lies disconformably on the Callawa Formation and the Broome Sandstone. The thickness of the Parda Formation in the Sheet area is unknown but up to 5 m is exposed.

The *Frezier Sandstone* (Kf; Lindner & Drew *in* McWhae & others, 1958) is a unit of sandstone and minor conglomerate which rests unconformably on the Parda Formation. The unit crops out as low hills of black, strongly ferruginised rocks in the southeastern corner of the Sheet area. The age of the Frezier Sandstone is considered to be Early Cretaceous (possibly Aptian), based on rare fossils collected outside the Sheet area (Dickins *in* Veevers & Wells, 1961), and on its stratigraphic position. It is probably a fluvial to deltaic deposit which in places has been subjected to pedogenic processes. The thickness is not known but up to 5 m is exposed in some localities.

An unnamed sequence of Early Cretaceous sediments (562 m thick) penetrated in Hematite Keraudren 1, and consisting predominantly of claystone with a thick sandstone interval towards the base, is considered to be equivalent to the onshore Broome Sandstone based on microflora. This unnamed sequence is confined to the Bedout Sub-basin.

Overlying the Early Cretaceous sediments offshore is a sequence of sandstone, claystone, siltstone, calcilutite, and marl which do not have any time or lithological equivalents onshore. Fossils recovered from these sediments include foraminifera, spores, and pollens which give ages ranging from Late Cretaceous to Early Tertiary. The average thickness of the sequence is about 400 m over the continental shelf (Gorter & others, 1979).

CAINOZOIC

A thin unit of carbonate rocks with minor claystone and sandstone of Tertiary age overlies the Late Cretaceous to Early Tertiary sequence offshore, and thickens northwest into the Bedout Sub-basin.

Surficial rock and soil units, the products of weathering in arid and humid climates, cover most of the eastern and southern portions of the Sheet area. The coastal fringe of the area was intermittently submerged and a variety of coastal sediments have accumulated. Many of the Cainozoic units depicted on the map commonly grade into one another. The boundaries shown are approximate as their recognition on the aerial photographs is based on subtle differences in photo-tone arising from topographic position and expression, and vegetation cover.

Ferruginous and siliceous duricrusts overlying deeply-kaolinised zones are widespread; the duricrusts were probably formed pedogenically during the Early Cainozoic under a more humid climate than that of the present. Hard crusts of ferruginous, pisolitic, or massive *laterite* (Czl), from 1 m to 3 m thick, are well developed. Erosion of this laterite crust has formed a smooth plain capped by *residual lateritic soil* (Czs) which is composed of sand, ferruginous pisoliths, and minor clay.

Calcrete (Czk) occurs as low rises and rubble of pale grey limestone with minor, hard, vuggy chalcedony in the southwestern part of the Sheet area. It may be either a pedogenic or fluvio-lacustrine form of calcrete.

The *supratidal flats* (Qcs) occupy an extensive area in the coastal part of the Mandora Sheet area. The flats are covered by grasses, samphires, and clumps of small trees. They merge landward with grasslands and sediments of Qs, or are fringed by low 'cliffs' of aeolian sands. They are bounded seawards by the coastal dunes of the Bossut Formation (see below). Heavy rains during the wet season fill numerous small claypans on these supratidal flats. The sediments of the flats are characteristically grey clay, silt, and sand, but the incorporation of wood, roots of dead grass, and other plant litter, particularly at the landward edge of this zone, causes the colour to be darker. Minor amounts of coarse particles may be present, including quartz sand grains, pebbles, and laterite nodules. Since the zone is exposed for much of the time, strong wind action may cause spreads of blown sand or small sand drifts to accumulate.

The *Bossut Formation* (Qpb; Lindner *in* WAPET, 1961) includes the lithified dunes, offshore bar deposits, and the beach ridges which parallel the coast. It was penetrated by WAPET Samphire Marsh 1, BMR Wallal 4 & 4A, and WAPET Chirup 1. It consists of quartzose calcarenite and calcilutite, which are partly oolitic and crossbedded, and contains corals, foraminifera, and shell fragments. The beach ridges range in height from 2 to 5 m, and are well defined near the coast and more subdued inland. The Bossut Formation also underlies and inter-fingers with the Holocene silt and sand of the tidal flats; it unconformably overlies the Callawa Formation, Broome Sandstone, and Parda Formation.

Only a few small areas of *intertidal sediments* (Qci) are present within the Sheet area. They are composed of grey to dark-grey, silty clay.

Areas of calcareous, partly oolitic, sand (Qcd) occur as dunes adjacent to the seaward side of the beach ridges and also in the supratidal flat region. These form the beach of Eighty Mile Beach and include the reworked material from beach ridges.

Aeolian sand (Qz), the most widespread of the Quaternary sediments in the Canning Basin, forms extensive sand plains in the eastern and southern Mandora Sheet area. A few longitudial dunes occur, mainly in the south. The aeolian sand is composed of windblown, red, well sorted, fine to medium-grained quartzose sand. The height of the sand dunes varies from 2 m to 5 m, and the sand beneath the adjacent plain may obtain a thickness of 5 m. Veevers & Wells (1961) and Crowe (1975) have described the sand dunes of the Great Sandy Desert.

Colluvial and alluvial sand, silt, and minor gravel mixed with aeolian deposits (Qs) occur in depressions that merge with the areas of supratidal flats and alluvium. Some of these depressions may be remnants of a relict drainage system which formed before the sand dunes.

Lake Deposits (Ql) comprising clay, silt and sand occur in a large claypan northeast of Radi Hills; they are also common within the supratidal flats, but are not shown on the map. Minor gypsum occurs on the surface (as a thin crust) and may be present (as an intergranular cement) in the sediments.

Areas of alluvial deposits composed of *sand, silt, and clay* (Qa) occur near Salt Creek and adjacent to the large claypan near this creek; small occurrences in the interdune areas are not plotted on the map. Other small areas of alluvial deposits occur south of Shoonta Hill and within the supratidal flat regions.

STRUCTURE

The Phanerozoic rocks of the Mandora Sheet area comprise a small part of the large, intracratonic Canning Basin which trends northwesterly between the basement highs of the Precambrian Halls Creek Province to the northeast, and the

Pilbara Block to the southwest. No basement rocks are exposed in the Sheet area; the thickness of basin sediments decreases from about 3000 m in the southeast to possibly 500 m in the west.

Prior to the Devonian, the Canning Basin was essentially a shallow, regional downwarp with little local basement relief (see Webby, 1978). However, in the Devonian, major faulting and downwarping initiated areas with different basement morphologies and depths. These basement features are preserved today and form the basis of the structural and tectonic elements of the Canning Basin.

Four major tectonic elements on the onshore Canning Basin are present in the Mandora Sheet area: the Willara Sub-basin, the Anketell Shelf, the Samphire Embayment, and the Wallal Embayment (see map); the offshore Bedout Sub-basin is also present. The boundaries between these units are gradational and are based on depth-to-basement data, mainly geophysical.

A small portion of the *Willara Sub-basin* is present in the northern Mandora Sheet area. Its recognition is based on an interpretation of Bouguer gravity data, aeromagnetic basement depth estimates, and scattered seismic control. These geophysical data indicate a thickening of the sedimentary section to the north and east into the adjacent Munro Sheet area. The Willara Sub-basin is only partly separated from the adjacent Samphire Embayment by a slight rise in the basement topography.

The *Samphire Embayment* (formerly Samphire Depression, Veevers & Wells, 1961) is a basement depression that lies between BMR Wallal 4A and WAPET Samphire Marsh 1. Both these wells are located near aeromagnetic anomalies that indicated relatively shallow basement and, consequently, the intervening Samphire Embayment may encompass deeper basement. The embayment is bounded on its southwestern margin by a northwesterly-trending fault that affected the pre-Permian rocks. The embayment underlies, and contains nearly 2000 m of, Mesozoic, Permian, and Ordovician rocks.

The structural feature adjacent to the Samphire Embayment and the Willara Sub-basin is referred to as the *Anketell Shelf*. It is separated from the embayment by a northeasterly trending fault, and is bounded on the south by the Precambrian provinces (Yarrie Sheet area). The shelf is a broad, poorly-known area of flat-lying to gently-dipping basement.

The *Wallal Embayment* (WAPET, 1967) is a small structural embayment situated to the southwest of the Samphire Embayment. It is controlled on its northeastern flank by a small fault and on its southwestern flank by thinning of the sedimentary section towards the southwest. The embayment contains at least 760 m of Mesozoic and upper Palaeozoic sediments which were intersected in WAPET Chirup 1 (WAPET, 1968b).

The offshore *Bedout Sub-basin* contains over 6000 m of Mesozoic sediments which thin out towards the southeast where they overlap, and by many authors are considered part of, the Samphire Embayment and Willara Sub-basin.

GEOLOGICAL HISTORY

Sediments deposited during the Precambrian were intruded by igneous rocks; all were subsequently deformed, metamorphosed, and partly eroded and now constitute the basement of the Canning Basin.

Following a long period of erosion of the Precambrian rocks, mud, sand, and carbonate were deposited in a shallow sea which transgressed the present day onshore area, with the possible exception of the Anketell Shelf during the Early and Middle Ordovician (Nambeet, Willara, and Goldwyer Formations). The sea retreated in Late(?) Ordovician time, and erosion followed. After this pause in deposition, a shallow, restricted sea probably covered the northeastern part of the area (Willara Sub-basin), possibly as early as Late Ordovician, and it is likely that carbonate mud, and halite (Carribuddy Formation) were deposited some time during the period Late Ordovician(?) to Early Devonian.

The sea then withdrew from the Sheet area in the Early Devonian, and desert conditions prevailed in the Sheet areas to the east and southeast where fine sands were distributed by winds and rivers over an extensive plain. The pre-Grant Group erosion, which is conspicuous elsewhere in the Canning Basin, probably removed these sediments, if any, from the Mandora Sheet area, together with part of the Ordovician sequences. There is no evidence for sediments being laid down in Late Devonian to Late Carboniferous times.

In the earliest Permian, the sea returned, probably covering the entire Sheet area, and the climate may have been cold; the adjacent highland area to the south (Yarrie Sheet area) was undergoing glaciation. Sand with pebbles were deposited first, followed by mud and very fine sand (possibly due to a relative rise in sea level), and then sand again (Grant Group).

Outside the Sheet area, deposition of sand, followed by mud and carbonate, occurred following a short erosional break. However, within the Mandora Sheet area, because the next known depositional phase took place in the Late Permian, it is possible that these sediments may have been deposited and then eroded, though it seems more likely that there was no Early Permian deposition within the Sheet area after Grant Group time.

Sedimentation recommenced in the Sheet area in the Late Permian, and was confined to the Samphire and Wallal Embayments and northern edge of the Anketell Shelf. Fine-grained carbonaceous sediments (Chirup Formation) were probably deposited in a coastal swamp or marsh environment. A short break in time probably interceded before tidal flat muds (Blina Shale) accumulated during an Early Triassic marine transgression of the Wallal Embayment. Erosion then ensued until the Jurassic, when continental and marginal marine sediments (Wallal Sandstone) were laid down over a relative flat terrain. The sea then transgressed southeasterly across these sediments, laying down sand and mud in very shallow water (Alexander Formation), then marine muds (Jarlemai Siltstone) in deeper water. The sea commenced retreating from the area in Late Jurassic times, and alluvial sand and gravel (Callawa Formation) were deposited by meandering rivers flowing over the southern part of the area from the adjacent Precambrian highlands to the south. As this regression continued into earliest Cretaceous times, continental deposition continued in the south, while shallow-marine sand (Broome Sandstone) was laid down, mainly in the northeastern part of the Sheet area.

The sea transgressed the whole Sheet area in Early Cretaceous (Aptian) time depositing mud and fine sands (Parda Formation). As it regressed, fine clastic material (Frezier Sandstone) was laid down by rivers over the fluvial deposits of the Callawa Formation and the marine deposits of the Parda Formation.

From Late Cretaceous time onwards, erosion affected the entire Sheet area, removing much of the Early Cretaceous sediments, and deep chemical weathering occurred. Laterite profiles also developed during the more hot and humid periods until the climate became dominantly arid. Erosion of the laterite profile produced mesas and hills; drainage channels became choked with detritus eroded from higher areas, and lakes formed. Sand plains and dunefields resulted from aeolian erosion of the exposed sediments; the strike directions of the dunes, and the common orientation of their tuning-fork junctions, indicate that easterly to east-southeasterly winds prevailed. The dunes are now stabilised by their cover of vegetation and are mainly inactive.

In the Quaternary, the sea transgressed the lateritised and alluviated coastal plains, inundating a narrow strip along Eighty Mile Beach, the area of maximum transgression occurring near Mandora Homestead. Deposits representing this transgression are the Bossut Formation, and also shallow marine muds that spread across the plains. As the sea retreated, laterally-equivalent sedimentary environments migrated seawards; intertidal flat, mangrove, and supratitdal flat environment succeeded each other. Grass covered the supratidal flats as they became inactive. A series of up to four parallel beach ridges developed along Eighty Mile Beach.

ECONOMIC RESOURCES

Petroleum

The petroleum prospectivity of the area appears to be relatively poor. Although Ordovician source rocks are present at depths likely to generate hydrocarbons (1500-3000 m), pre-Permian and Early Mesozoic erosion, and the lack of suitable reservoirs and structural traps, significantly down-grades the petroleum prospectivity of the area. The Permian sediments are immature as source rocks, and the sandstone unit in the Grant Group with reservoir potential has probably been flushed with fresh water. The thin Mesozoic rocks in the Sheet area have no petroleum potential. On the Anketell Shelf, the sedimentary sequence is too thin and appears not to have been buried deep enough to generate hydrocarbons.

Water

Surface water is scarce owing to the low rainfall and high evaporation rate. Salt Creek and a neighbouring large claypan retain some water after heavy rainfall, but this evaporates during the intervening, prolonged dry periods.

The area has good prospects for groundwater as stratigraphic bores and petroleum exploration wells have produced potable water (WAPET, 1961; Henderson & others, 1963). The only area where the groundwater has been adequately and systematically tested is in the far southwestern corner of the Sheet area. Here, and in the adjacent Yarrie and Port Hedland Sheet areas, GSWA has carried out an investigation designed to overcome the increased need of water for the future development of the natural resources of the Pilbara Region. Drilling and pump tests indicate the presence of two aquifer systems, one within the Callawa Formation and Quaternary-Tertiary sequence, and the other within the Wallal Sandstone (Leech, 1974; 1979).

Small supplies of good quality water are present in the coastal dunes, but are only sufficient for pastoral needs.

Construction materials

Pisolites within laterite, and reworked laterite, are present within the Sheet area and are suitable for, and have been used for, constructing roads.

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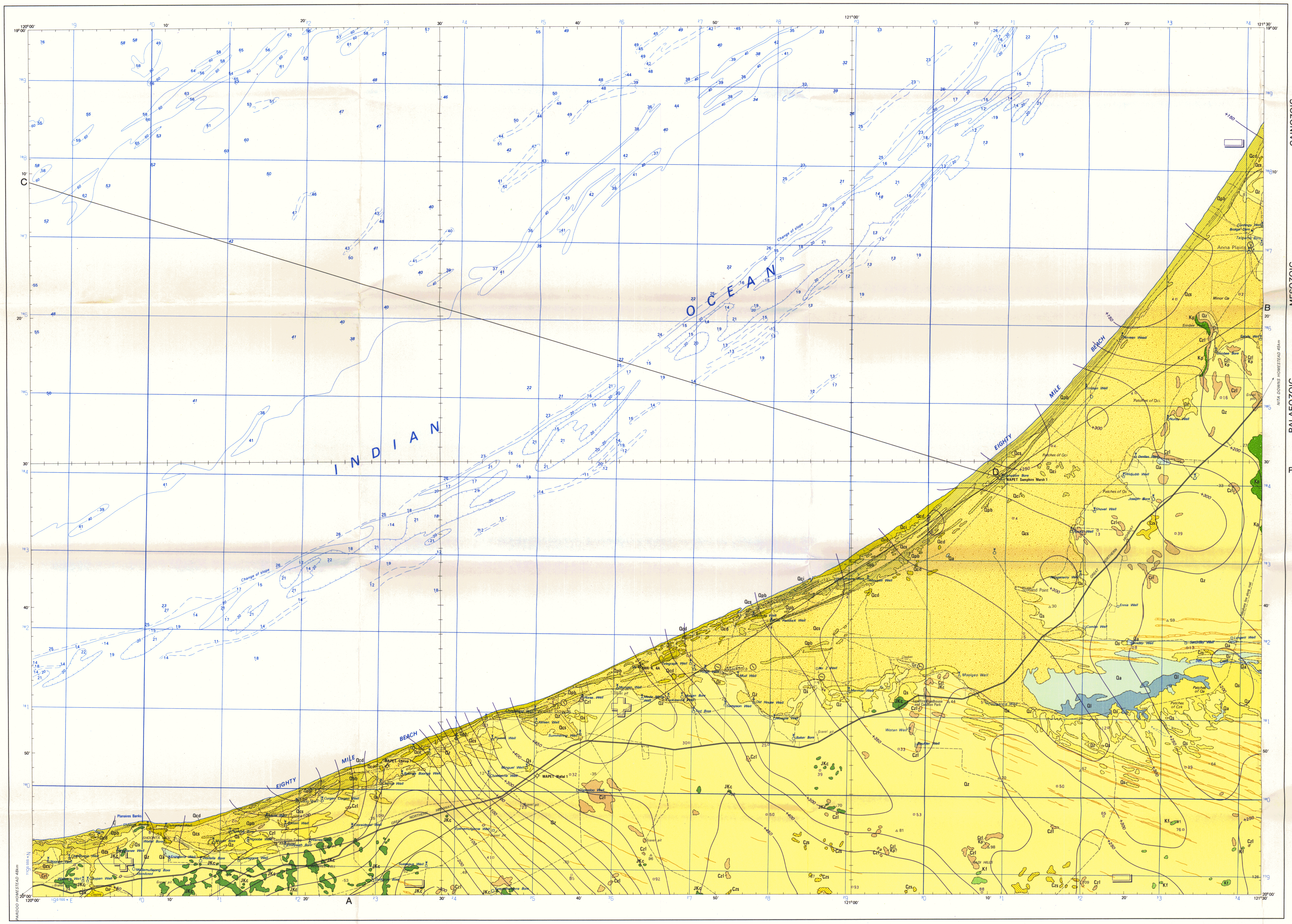
MANDORA

WESTERN AUSTRALIA

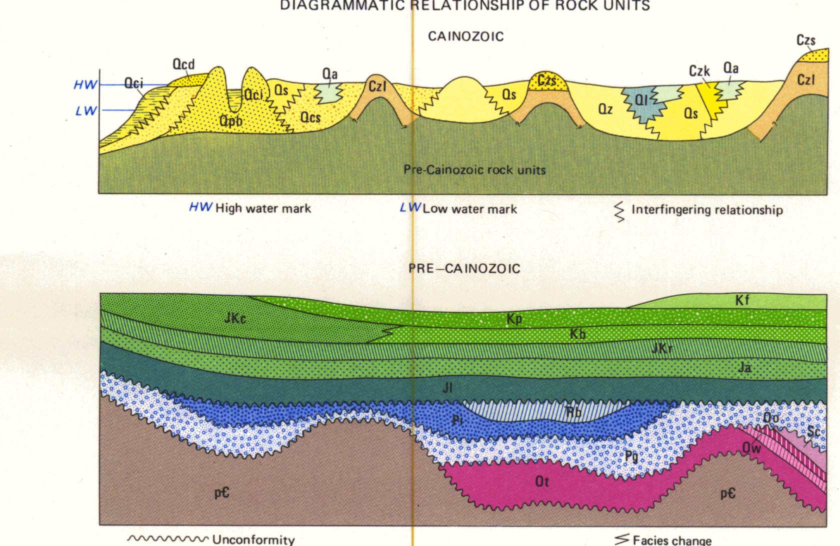


CAINOZOIC	QUATERNARY		Qa	Sand, silt, clay; minor gravel: alluvial
			Ql	Clay, silt, sand; minor gypsum: lacustrine
			Qs	Sand, silt; minor gravel: mixed alluvial and aeolian
			Qz	Red quartz sand, fine to medium; minor silt: aeolian
			Qcd	Calcareous sand, partly oolitic: coastal aeolian. Includes reworked Qpb
			Qci	Silty clay, black organic clay; minor salt: Intertidal and mangrove swamp
		Bossut Formation	Qpb	Quartzose calcarenite, fine to coarse calcilutite; partly oolitic, cross-bedded; fossiliferous: shoreline beach-ridges
			Qcs	Clay, silt, sand; minor salt: supratidal mud flat deposits
			Czk	Calcrete; minor chalcedony: evaporitic, pedogenic
			Czs	Sand, silt, ferruginous pisoliths; minor gravel and clay: pedogenic; residual plains overlying Czl
			Czl	Laterite, pisolitic or massive: pedogenic
MESOZOIC	EARLY CRETACEOUS	Frezier Sandstone	Kf	Sandstone, fine to coarse, poorly sorted, feldspathic, poorly bedded, some relict cross-bedding; minor conglomerate: fluvial to deltaic, partly pedogenic
		Parda Formation	Kp	Mudstone; minor fine sandstone lenses, thin-bedded or massive: lagoonal?
		Broome Sandstone	Kb	Sandstone, fine to medium, well-sorted; mudstone in part; minor conglomerate; ripple-marked, cross-bedded; minor bioturbation; plant fossils: shallow water marine. Section and rock relationship diagram only
	LATE JURASSIC TO EARLY CRETACEOUS	Callawa Formation	JKc	Sandstone, very fine to coarse; pebble conglomerate; cross-bedded; minor siltstone; bioturbated plant fossils: fluvial
		Jarlemai Siltstone	JKr	Mudstone, sandy, glauconitic, fossiliferous: marine
	LATE JURASSIC	Alexander Formation	Ja	Sandstone, fine to medium, interbedded mudstone, bioturbated: marine
	EARLY? TO LATE JURASSIC	Wallal Sandstone	Jl	Sandstone; minor siltstone, conglomerate, coal; palynomorphs: continental to shallow marine
	TRIASSIC	Blina Shale	Rb	Siltstone, shale, grey, micaceous, carbonaceous, with thin sandstone lenses: shallow water marine
PALAEOZOIC	LATE PERMIAN	Chirup Formation	Pi	Shale, grey to black, sandy, carbonaceous; interbedded sandstone, fine to conglomeratic; palynomorphs: paralic
	EARLY PERMIAN	Grant Group	Pg	Sandstone, fine to coarse; mudstone; minor conglomerate: glacial marine
	LATE ORDOVICIAN? TO EARLY DEVONIAN	Carribuddy Formation	Sc	Dolomite, dolomitic siltstone, shale, halite, anhydrite; minor sandstone: mainly non-marine
	MIDDLE ORDOVICIAN	Goldwyer Formation	Oo	Shale, black, fossiliferous, calcareous, pyritic; interbedded limestone, dolomite; minor siltstone: marine
	EARLY ORDOVICIAN	Willara Formation	Ow	Limestone, dolomitic, fossiliferous; interbedded shale and siltstone: marine
		Nambeet Formation	Ot	Shale, grey to green; interbedded limestone and fine to coarse sandstone: marine
PRECAMBRIAN			p€	Igneous, metamorphic, and sedimentary rocks

Section and rock relationship diagram only (Kb to p€)

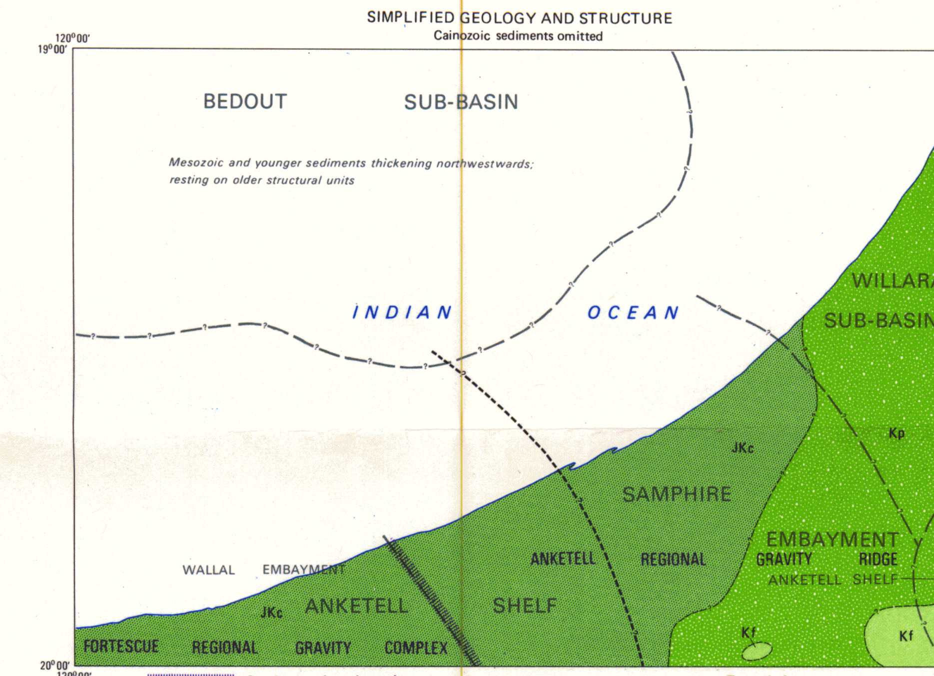
- Geological boundary
- Fault
- Where location of boundaries, folds and faults is approximate line is broken; where inferred, queried; where concealed, boundaries and folds are dotted, faults are shown by short dashes
- Stratigraphic hole completed as artesian water bore
- Petroleum exploration well, dry, abandoned
- Windpump
- Bore, Well
- Bathymetric contour in metres; closed depression
- Minor elevation in metres
- Spot depth showing general level in metres
- Spot depth on isolated feature in metres
- Sand dunes, beach ridges
- Highway
- Minor road
- Vehicle track
- Fence
- Landing ground
- Mandora — Homestead
- Building
- Yard
- Trigonometrical station
- Elevation in metres
- Selected gravity station with elevation in metres
- Bouguer gravity anomaly (micrometres sec^{-2}), computer-plotter produced
- Gravity anomaly — relative high
- Gravity anomaly — relative low

DIAGRAMMATIC RELATIONSHIP OF ROCK UNITS



SIMPLIFIED GEOLOGY AND STRUCTURE

Cainozoic sediments omitted



Published by the Bureau of Mineral Resources, Geology and Geophysics, Department of National Development and Energy, in conjunction with the Geological Survey of Western Australia. Issued under the joint authority of the Minister for National Development and Energy, and the Minister for Mines, Western Australia. Base map compiled by the Division of National Mapping from aerial photography at 1:80 000 scale.

UNIVERSAL GRID REFERENCE

GRID ZONE DESIGNATION: 51K

100,000 METRE SQUARE IDENTIFICATION

SU	TU	UU
ST	TT	UT

IGNORE the SMALLER figures of any grid number; these are for finding the full co ordinates. Use ONLY the LARGER figures of the grid number; example: 190000m E

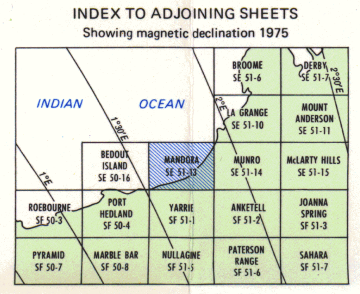
TO GIVE A STANDARD REFERENCE ON THIS SHEET TO NEAREST 1000 METRES

SAMPLE POINT: Wallal Downs

1 Read letters identifying 100 000 metre square in which the point lies:	TU		
2 Locate first VERTICAL grid line to LEFT of point and read LARGE figure labelling the line either in the top or bottom margin, or on the line itself:		5	
3 Estimate tenths from grid line to point:		2	
4 Locate first HORIZONTAL grid line BELOW point and read LARGE figure labelling the line in either the left or right margin, or on the line itself:			1
5 Estimate tenths from grid line to point:			1
SAMPLE REFERENCE:	TU5211		
If reporting beyond 18° in any direction, prefix Grid Zone Designation, as:	51KTU5211		

INDEX TO ADJOINING SHEETS

Showing magnetic declination 1975



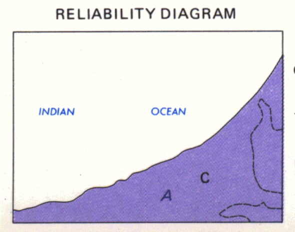
SCALE 1:250 000

5 0 5 10 15 20 25 Kilometres

BLUE NUMBERED LINES ARE 10000 METRE INTERVALS OF THE AUSTRALIAN MAP GRID, ZONE 51

TRANSVERSE MERCATOR PROJECTION

RELIABILITY DIAGRAM

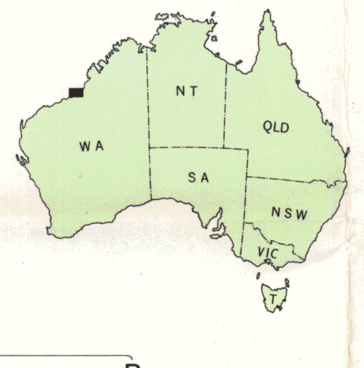


Geology C General reconnaissance: few traverses, mainly airphoto interpretation

----- Helicopter traverse

Gravity A Detailed survey

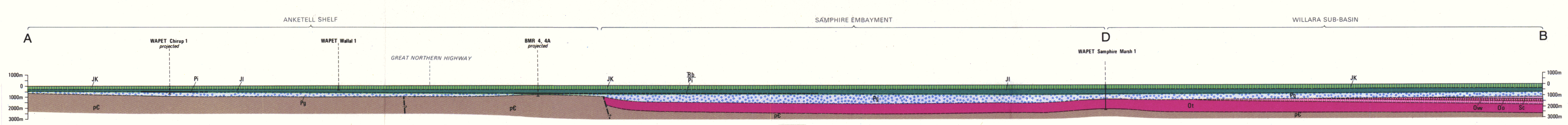
Geology 1977 by R.R. Towner, D.L. Gibson, BMR; R.W.A. Crowe, GSWA
Compiled 1978 by R.R. Towner, Lana Murray
Gravimetry 1950-69 by BMR and private companies
Design by Cartography Section, BMR
Drawn by Mercury-Walch, Hobart, Australia
Printed by Valentine Graphics, Melbourne, Australia



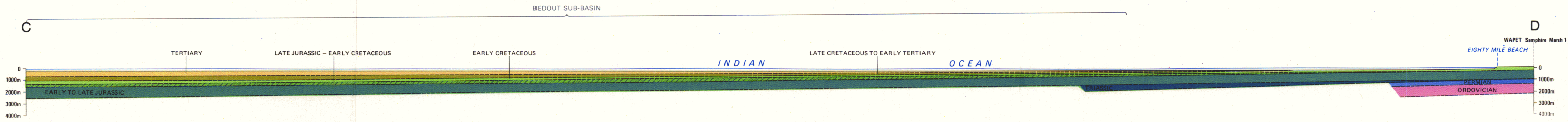
SECTIONS

Cainozoic sediments omitted

Scale V/H = 1



JK Undivided Ja, JKr, Kb, JKc, Kp



MANDORA

SHEET SE 51-13

FIRST EDITION 1981