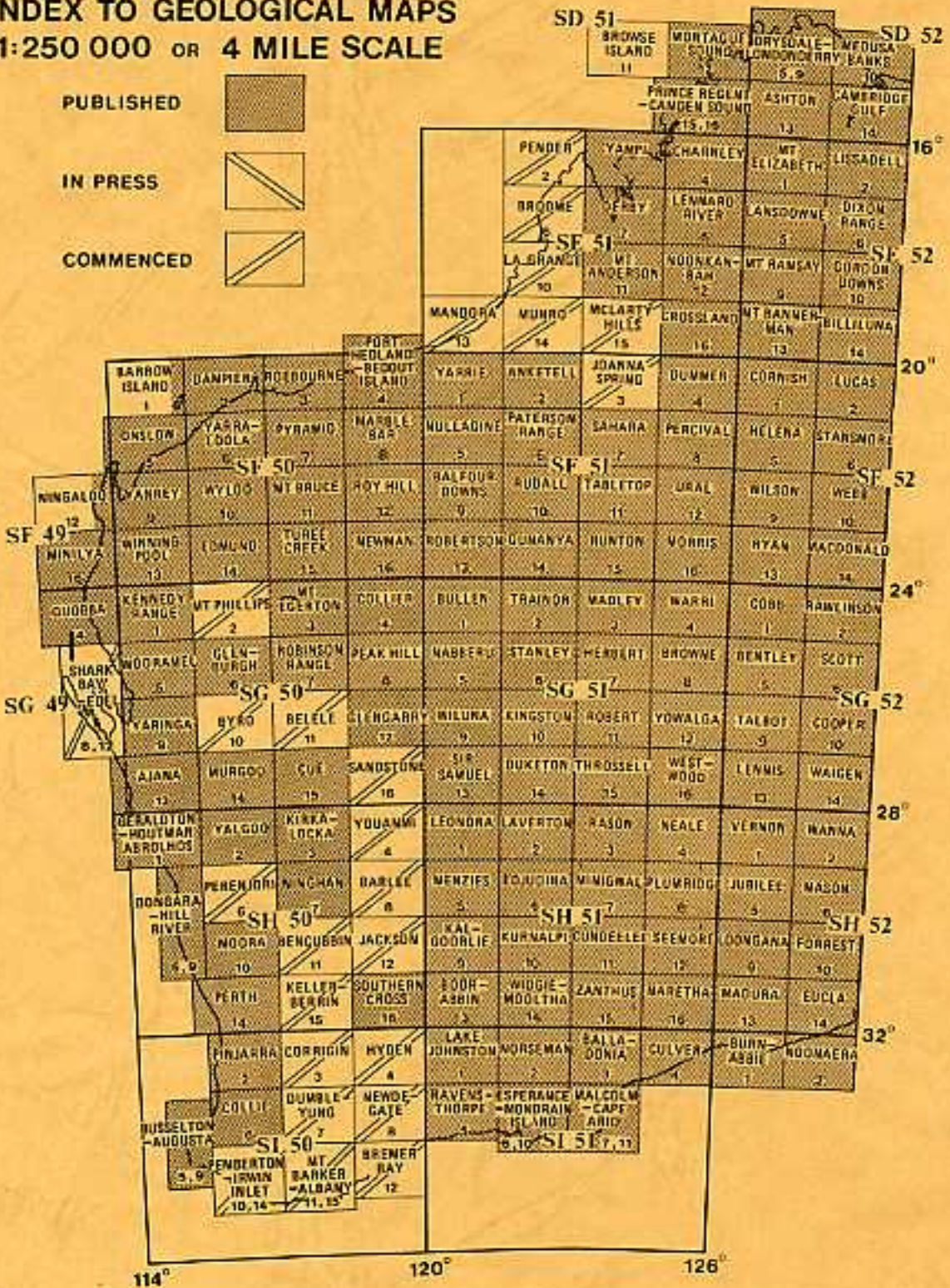
1:250 000 GEOLOGICAL SERIES—EXPLANATORY NOTES

YARINGA

WESTERN AUSTRALIA

SHEET SG50-9 INTERNATIONAL INDEX

WESTERN AUSTRALIA
INDEX TO GEOLOGICAL MAPS
1:250 000 OR 4 MILE SCALE



Explanatory Notes on the Yaringa Geological Sheet

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INTRODUCTION

The YARINGA* geological sheet, SG 50-9 of the International Series, is bounded by latitudes 26°00'S and 27°00'S, and longitudes 114°00'E and 115°30'E. The area contains parts of the south-central Carnarvon Basin and the northern Perth Basin.

Air photographs at scales 1:84 000 and 1:40 000 were used in field mapping, in conjunction with 1:100 000 topographic base maps.

Station homesteads and two roadhouses are the only settlements in the area. Access is by the North West Coastal Highway, shire roads and numerous station tracks, except in the southeastern part of the area, where no access roads exist.

The climate is arid; the average annual rainfall, about 200 mm; and the potential annual evaporation, between 2 800 and 3 200 mm. The period May to July is the wettest. In January, average daily minimum and maximum temperatures are about 21°C and 36°C, and in July, 9°C and 24°C.

The area has an open to dense shrub-steppe vegetation. Ride and others (1974) give details on flora and fauna of parts of YARINGA, and Beard (1976) discussed the land flora of the Hamelin Pool area.

The algal flora and the resulting algal deposits along the shores of Hamelin Pool are of great geological interest.

PREVIOUS GEOLOGICAL WORK

Reconnaissance mapping of the area was carried out by the Bureau of Mineral Resources from 1953 to 1955 and was reported on by Konecki and others (1958), Perry and Dickins (1960), and Condon (1968). The former also gave details of earlier work.

Subsequent interest has mainly centred on Quaternary carbonate sedimentation in Hamelin Pool (Logan and others, 1970, 1974; Playford and Cockbain, 1976).

The geology of the Perth and Carnarvon Basins was summarized by Jones (1976), Thomas and Smith (1974, 1976), Playford and others (1975), Johnstone and others (1976), and Playford and others (1976). A summary of the geology of the Shark Bay area is given by Logan and others (1976).

Exploration for oil by West Australian Petroleum Pty Ltd (WAPET) (Johnstone and Playford, 1955; Johnstone and others, 1958), Continental Oil (Arrington, 1966; Henderson and Shannon, 1966). Oceania Petroleum (Ingall, 1970; Pfitzner and others, 1972; Wilde and others, 1972) and for evaporites by Magellan Petroleum (Butler and Sanderlin, 1968; Pendery and others, 1969) has provided most of the

* To avoid confusion with place names, 1:250 000 sheet names appear in capitals (e.g. YARINGA)

subsurface information on YARINGA. Megallaa (1978) presented a comprehensive synthesis of all available geophysical data and the structural sketch map (Fig. 2) is based on his work. A useful bibliography on the Carnarvon Basin is by Ozimic (1970).

PHYSIOGRAPHY

Physiographic features of YARINGA are shown on Figure 1.

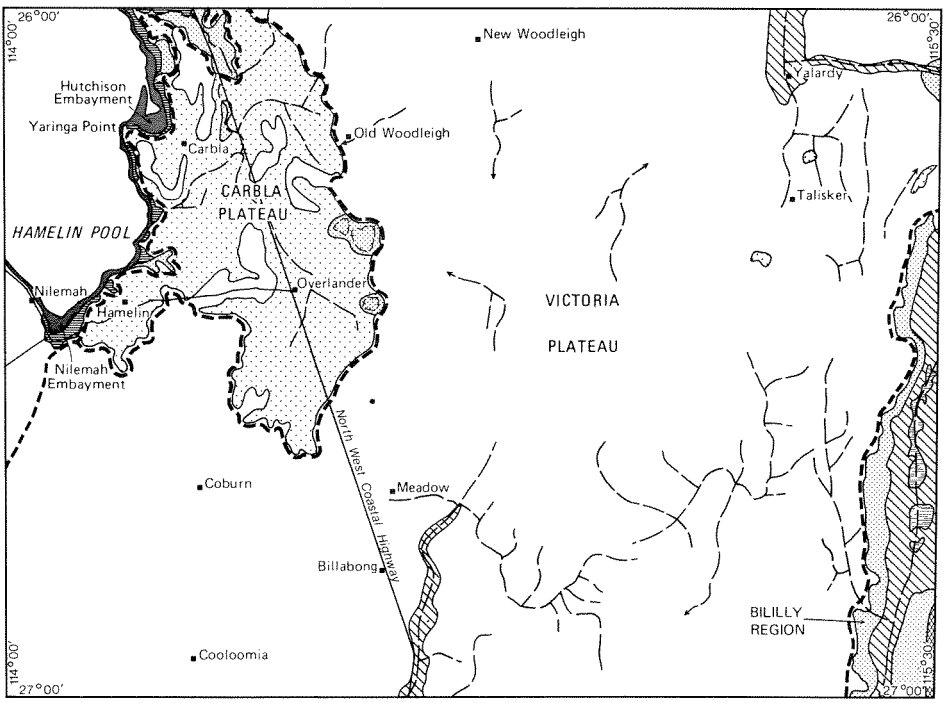

FIGURE 1

G.S.W.A. 17451

PHYSIOGRAPHIC SKETCH MAP

YARINGA SHEET SG50-9

0 10 20 30 km

REFERENCE

- Strike ridges
- Duricrusted terrain
- Dissected duricrust terrain
- Undulating sandplain with minor dunefields
- Major valley floor
- Major playas
- Pleistocene tidal and supratidal flats with associated beach ridges
- Tidal and supratidal flats with associated beach ridges
- Deflation depression
- Palaeo drainage
- Approximate boundaries of named physiographic units
- Homestead or roadhouse

More than half the area is a gently undulating, generally featureless sand plain with minor dune fields. This plain forms the northern continuation of the Victoria Plateau of the northern Perth Basin, and rises from near sea level at Hamelin Pool to about 300 m in the southeast. East of this sand plain is a major depression with numerous claypans and salt lakes which marks the course of a relict tributary of the Murchison River. This palaeodrainage parallels the trend of the Darling Fault, which has no other surface expression in this area.

In the northwest, a partly dissected calcrete duricrust plateau, here named the Carbla Plateau*, rises from sea level to an elevation of about 80 m. As Hamelin Pool may be the surface expression of a synclinal structure, the gentle seaward slope of the Carbla Plateau may reflect the east flank of this syncline. This very gentle synclinal structure is best considered as an eastern subdivision of the Bullara Sunkland of Logan, Read and Davies (1970), who considered the whole of Shark Bay to be a gentle syncline.

Along the east coast of Hamelin Pool, some shore platforms are covered by block fields of resistant Tertiary Lamont Sandstone. These block fields are resistant to erosion and form many coastal headlands (e.g. Point Sweeney Mia). *In situ* Lamont Sandstone is only found at the tops of some cliffs of Cretaceous Toolonga Calcilutite. The block fields of haphazardly oriented quartzite blocks are therefore interpreted as lag deposits which formed as the underlying, softer Toolonga Calcilutite was eroded down to sea level.

STRATIGRAPHY

Sediments ranging from Precambrian to Holocene age crop out on YARINGA. The Phanerozoic sequence is little deformed, and consists of block-faulted Palaeozoic sediments, unconformably overlain by gently dipping to flat-lying Cretaceous and Cainozoic sediments (Table 1).

PROTEROZOIC

In the southeast of YARINGA, predominantly sandy sediments of Proterozoic age crop out, and can be divided into two units, one largely unmetamorphosed, the other metamorphosed. Both are intruded by Proterozoic dolerite dykes and sills (*Pd*). The largely unmetamorphosed sediments belong to the Badgeradda group, but the metamorphosed sediments cannot be readily assigned to any named stratigraphic unit.

Badgeradda Group

Bililly Formation (PAb): This, the basal formation of the Badgeradda Group, is very poorly exposed along the western side of the Badgeradda Range, and consists of thin-bedded, fine-grained, silty sandstone and sandy siltstone.

Woodrarrung Sandstone (PAw): The Woodrarrung Sandstone overlies the Bililly Formation with apparent conformity and is a well-sorted, cross-bedded, medium- to coarse-grained, quartzose to feldspathic sandstone, in large part recrystallized to quartzite.

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* 'Toolonga Plateau' of Logan, Read and Davies (1970); here renamed as their name is not derived from a topographic feature but from a Cretaceous formation that underlies the plateau.

TABLE 1. STRATIGRAPHY OF THE YARINGA SHEET

Age			Symbol & rock unit		Thick-ness (m)	Lithology	Stratigraphic relationships	Remarks
CAINOZOIC	QUATERNARY	HOLOCENE	*Qs*	Coastal dune, beach ridge, and beach deposits	≃10	Ooid-rich calcarenite; locally shelly; mostly rich in foraminifers and small gastropods	Grades into *Qsh, Qu, Qm;* unconformably overlies older units	
			Qsh	Hamelin Coquina	≃10	Calcirudite coquina consisting predominantly of small shells of *Fragum erugatum*	Grades into *Qs, Qu, Qm;* unconformably on older units	Forms predominantly during cyclones; beach-ridge deposit
			Qu	Supratidal flat deposits	≃0.5	Shelly calcisiltite, calcarenite, calcirudite	Grades into *Qs, Qsh Qm;* unfonformably on older units	Minor authigenic evaporites at surface
			Qm	Tidal flat deposits	≃1	Shelly calcisiltite, calcarenite, calcirudite; extensively bound by algae	Grades into *Qs, Qsh, Qu,* and subaqueous sediments; unconformably on older units	Extensive algae mats, and columnar stromatolites which extend into sub-tidal zone
		PLEISTOCENE TO HOLOCENE	*Qa*	Alluvium	?20	Clay, silt, sand, and gravel, locally calcreted	Grades into *Qc, Ql, Qlg, Qle, Qk, Qe*	Deposited by intermittent creeks
			Qc	Colluvium	?5	Poorly sorted clay, silt, sand, and gravel	Grades into *Qa, Ql, Qlg, Qle, Qk, Qe*	Deposited by sheet floods and soil creep
			Ql	Claypan and salt-lake deposits	?20	Clay, silt, sand, minor gravel; authigenic gypsum and salt	Grades into *Qa, Qc, Qlg, Qle, Qk, Qe*	Substantial thicknesses only expected in major palaeodrainage valley

CAINOZOIC	QUATERNARY	PLEISTOCENE TO HOLOCENE	*Qlg*	Lake-derived dune deposits		≃8	Silt, sand, locally gypsiferous	Grades into *Qa, Qc, Qi, Qle, Qk, Qe*	Presence on all sides of playas indicates variable wind directions
			Qle	Claypan and dune terrain		?10	Clay, silt, sand, minor gravel and authigenic gypsum and/or calcrete	Grades into *Qa, Qc, Ql, Qlg, Qk, Qe*	
			Qk	Valley calcrete		?20	Friable and earthy limestone, contains lenses and tongues of host sediment	Grades into *Qa, Qc, Ql, Qlg, Qle, Qe*	Authigenic limestone formed within valley fill deposits
			Qe	Sandplain and dune deposits		≃15	Reddish to yellowish quartz sand	Grades into *Qa, Qc, Ql, Qlg, Qle, Qk*	Mostly derived from weathering profile on underlying sandy bedrock; locally dunes may reflect grain-size differences; Nilemah Sands
		PLEISTOCENE	*Qb*	Bibra Limestone		≃10	Shelly calcarenite to calcirudite	Unconformable on Dampier Limestone, Peron Sandstone, Lamont Sandstone, or Toolonga Calcilutite	Shallow-marine to beach-ridge deposit
			Qd	Dampier Limestone		≃10	Shelly calcarenite to calcirudite	Unconformable on Peron Sandstone, or Toolonga Calcilutite	Shallow-marine to beach-ridge deposit
				Qdc	Carbla Oolite Member	≃10	Ooid calcarenite with minor basal conglomerate	Unconformable on Peron Sandstone, Lamont Sandstone, or Toolonga Calcilutite	Facies variant of Dampier Limestone along eastern shore of Hamelin Pool. Shallow-marine to coastal-dune deposit

TABLE 1—continued

Age			Symbol & rock unit		Thick-ness (m)	Lithology	Stratigraphic Relationships	Remarks
CAINOZOIC	QUATERNARY	PLEIS-TOCENE	*Qp*	Peron Sandstone	?20	Red quartz sand with numerous soil structures	Uncomfortable on Lamont Sandstone or Toolonga Calcilutite	Eolian deposit; probably equivalent of *Qpe*
			Qpe	Older eolianite	?10	Yellow-brown quartz sand, ubiquitous soil structures	Unconformable on Pindilya Formation	Probably major source for *Qe* *derived from weathering profile on underlying sandy bedrock*
	TERTIARY	MIOCENE TO PLEISTOCENE	*Czk*	Calcrete	≃8	Brecciated, locally pisolitic, well-indurated calcilutite	Duricrust on Toolonga Calcilutite	Formed under semi-arid to arid climate
			Czl	Laterite	≃2	Lumpy, pisolitic, vuggy to massive ironstone	Duricrust on Lamont Sandstone, Pindilya Formation, Permian or Proterozoic	Formed under seasonal humid climate
			Czb	Silcrete	≃2	Structureless, very poorly sorted, intensely silicified sandstone	Duricrust on Lamont Sandstone, Pindilya Formation, Permian or Proterozoic	Formed under seasonal humid climate simultaneously with *Czl*
		MIDDLE MIOCENE		Trealla Limestone		Well indurate, quartzose calcarenite	Grades into lamont Sandstone	Probably present on YARINGA
			Tl	Lamont Sandstone	≃3	Well to moderately sorted, fine to coarse-grained quartz sandstone	Unconformable on Giralia Calcarenite or Toolonga Calcilutite	Contains silicified wood; shallow marine deposit; probable equivalent of Pindilya Formation.
		?MIDDLE MIOCENE	*Tp*	Pindilya Formation	≃5	Moderately to poorly sorted sandstone, mostly intensely silcreted	Unconformable on Permian or Proterozoic	Mapped as silcrete where stratigraphic position not clear

CAINOZOIC	TERTIARY	Eocene	*Tg*	Giralia Calcarenite		≃5	Sparsely glauconitic, greenish, fossiliferous calcarenite	Unconformable on Toolonga Calcilutite	
MESOZOIC	CRETACEOUS	Santonian/ Campanian	*Kt*	Toolonga Calcilutite		125	Sparsely fossiliferous greenish-grey calcilutite to marl	Unconformable on Winning Group	Pelagic open marine shelf deposit
		Albian/ Turonian		WINNING GROUP	Gearle Siltstone	?50	Dark grey siltstone and claystone	Lateral equivalent of Alinga Formation	Open marine shelf deposit
					Alinga Formation	50	Glauconitic siltstone and sandstone grading to greensand	Overlies Windalia Radiolarite	Possibly condensed, open-marine shelf-deposit
		Aptian to Albian			Windalia Radiolarite	20	Dark radiolarian chert and interbedded claystone; chert very low specific gravity	Conformable on Muderong Shale or Birdrong Sandstone	Pelagic, open-marine shelf-deposit
					Muderong Shale	46	Claystone, siltstone, minor greensand	Conformable on Birdrong Sandstone	Forms upper part of marine, transgressive fining-upwards sequence
		Neocomian/ Albian			Birdrong Sandstone	67	Glauconitic, poorly consolidated fine to very coarse-grained sandstone	Unconformable on Jurassic or Palaeozoic	Basal sandstone of transgressive sequence; excellent artesian aquifer

TABLE 1—continued

Age			Symbol & rock unit		Thick-ness (m)	Lithology	Stratigraphic relationships	Remarks
MESOZOIC	JURASSIC			Woodleigh Beds	91	Grey shale	Unconformable on Palaeozoic	Lacustrine; Playford and others (1975) incorrectly gave the type section as Woodleigh 1 instead of 7
	PERMIAN	ARTINSKIAN		Byro Group	?100	Intensely bioturbated, poorly sorted calcareous siltstone and sandstone	?Conformable on Keogh Formation	Marine, slow sedimentation; only expected on north-eastern YARINGA
			Pk	Keogh Formation	≃60	Siltstone, sandstone, minor claystone and carbonaceous shale	Gradational contact with High Cliff/Moogooloo Sandstone	Subtidal to ?coastal environment; Carnarvon Basin unit
			Pg	High Cliff Sandstone	≃250	Quartzose to feldspathic sandstone, minor siltstone, claystone, carbonaceous shale	Unconformable on Holmwood Shale/Callytharra Formation	Deltaic to subtidal environment; Keogh Formation & Moogooloo Sandstone 310 m thick in Deep Bore, BYRO; Moogooloo Sandstone is Carnarvon Basin equivalent
		SAKMARIAN	*Ph*	Holmwood Shale	?220	White weathering, calcareous claystone to siltstone; minor limestone; micaceous	Conformable on Nangetty/Lyons Formation	Open marine shelf; probable thickness in Deep Bore, BYRO. Callytharra and Carrandibby Formations are Carnarvon Basin equivalents
				Nangetty Formation	?1200	Immature sandstone, siltstone, shale, and tillite; numerous erratics	Unconformable on Precambrian	Glacial, glaciolacustrine, and fluvioglacial; Lyons Formation is Carnarvon Basin equivalent

SILURIAN			Dirk Hartog Formation	1380	Limestone, shale, siltstone, anhydrite, salt	Conformable on Tumblagooda Sandstone	Includes Yaringa Evaporite Member; evaporitic-marine to coastal environment
			Tumblagooda Sandstone	?3000	Red, yellow, white quartz and feldspathic sandstone	?Unconformable on Precambrian	Fluviatile to marine
PROTEROZOIC		*Pd*	dolerite		dolerite	Intrusive into older rocks	
	MIDDLE LATE	*PAw*	Woodrarrung Sandstone	≃600	Cross-bedded, coarse-grained, quartz and feldspathic sandstone, quartzitic	Conformable on Bililly Formation	?Shallow marine or fluviatile
		PAb	Bililly Formation	≃360	Thin-bedded siltstone and sandstone	Unconformable on Nilling Beds	?Marine
	? MIDDLE	*P (s)*		?1000	Phyllitic pelite and sandstone	?Unconformable on granitic basement	Intensely deformed shale, siltstone, minor sandstone sequence; stratigraphic relationships uncertain
		P (q)			Metamorphosed sandstone (quartzite)	?Unconformable on granitic basement	Dynamically metamorphosed sandstone; stratigraphic relationships uncertain

Metamorphosed sediments

On MURGOO, the Badgeradda Group is underlain by the lithologically similar Nilling Formation ("Nilling Beds" of Perry and Dickins, 1960, amended Hocking and others, 1980), which differs from the former in that constituent rocks are cleaved and show quartz veining. Perry and Dickins suggested that these differences indicated a period of dynamic metamorphism prior to deposition of the Badgeradda Group.

The Proterozoic sediments west of the Woodrarrung Range were not assigned to either unit by Perry and Dickins. They show a well-developed cleavage, minor quartz-veining, and consist of phyllitic siltstone, sandstone, quartzite and (to the south on AJANA) basaltic volcanics. Some outcrops are very similar to the Woodrarrung Sandstone and Coomberarie Formation of the Badgeradda Group. The well-developed cleavage suggests a correlation with the Nilling Formation, but this may equally have been developed in a Late Proterozoic to Early Palaeozoic dynamic metamorphic event related to significant movement on the Darling-Woodrarrung Fault system, which would allow the sequence to be correlated with the Badgeradda Group. Because of the uncertainty of these correlations, these rocks are here shown as unassigned to any group.

PALAEOZOIC

Tumblagooda Sandstone: The Tumblagooda Sandstone, of probable Silurian age, is only known from the subsurface. It consists of red and white sandstone, with some interbeds of siltstone and conglomerate, and is interpreted as a fluviatile and shallow-marine deposit. The formation was penetrated by Yaringa 1, Hamelin Pool 1, and several water bores on Meadow Station, and probably underlies the western half of YARINGA.

Dirk Hartog Formation: The overlying Dirk Hartog Formation is only known from Yaringa 1 and Hamelin Pool 1 and 2 wells. The unit consists of interbedded shale, siltstone, limestone, dolomite, halite, and anhydrite. The main halite-bearing part of the formation has been called the Yaringa Evaporite Member. Although the formation has been dated as Late Silurian (Philip, 1969), the uppermost parts could possibly extend into the Devonian (Henderson and Shannon, 1966).

Devonian and Carboniferous rocks are not known from YARINGA, and Permian sediments are probably restricted to the Coolcalalaya Sub-basin to the east of the Ajana-Wandagee Ridge. Perth Basin stratigraphic nomenclature is used for the Permian sequence as the Coolcalalaya Sub-basin forms part of the Perth Basin.

Nangetty Formation: The Sakmarian Nangetty Formation comes close to the surface in the major palaeodrainage valley in the east of the area. In adjoining areas the formation consists of tillite boulder beds, fluvioglacial sandstone, and glaciolacustrine claystone and siltstone.

Holmwood Shale (Ph): The glacial sequence is conformably overlain by the Sakmarian Holmwood Shale, which is a white-weathering, indistinctly bedded, locally calcareous and fossiliferous silty claystone of marine origin.

High Cliff Sandstone (Pg): The Artinskian High Cliff Sandstone consists of medium- to coarse-grained, irregularly bedded and cross-bedded sandstone. On AJANA, the formation conformably overlies the Holmwood Shale, but at Pats Dam the relationship is disconformable as is the case further north-east in the Carnarvon

Basin. This disconformity is marked by scattered cobbles and boulders of chert, quartz, and quartzite, and the scree from this bed is similar to that of tillitic boulder beds. However, its stratigraphic position above the Holmwood Shale and the absence of labile rock types such as granite serve to distinguish this unit from the Nangetty Formation.

Keogh Formation: On BYRO and GLENBURGH the equivalent of the High Cliff Sandstone, the Moogooloo Sandstone, is conformably overlain by the Keogh Formation. The Keogh Formation consists of fine- to medium-grained sandstone with interbedded siltstone and claystone, and it formed in agitated, shallow-marine conditions. Small outcrops of Keogh Formation on northeastern YARINGA are grouped with the High Cliff Sandstone on the map face.

Byro Group: The Artinskian Byro Group, although not exposed, probably extends on to northeastern YARINGA. On BYRO it consists of poorly sorted sandstone and siltstone, mostly bioturbated, which formed in open-marine conditions.

MESOZOIC

Triassic rocks are not known from the area, and the only Jurassic sediments are the relatively thin, lacustrine Woodleigh Beds, which were penetrated by water bores on Woodleigh Station. The formation is restricted to a small, possibly fault-controlled basin.

Cretaceous sediments on YARINGA were deposited after the breakup of Gondwanaland, and sedimentation began during the major Neocomian transgression. The post-Neocomian sequence overlies a fairly featureless unconformity which cuts across the Jurassic and the block-faulted Lower Palaeozoic rocks. This transgressive sequence consists of a basal sandstone overlain by fine-grained siliciclastics and siliceous pelagic sediments, followed by an upper unit of calcareous pelagic sediments. The pelagic sediments reflect the very high Cretaceous sea levels which resulted in considerably reduced land areas on the Australian continent and thereby largely eliminated the supply of terrigenous detritus.

Winning Group (Kw): On southern YARINGA the Winning Group consists, in ascending order, of the Birdrong Sandstone, Windalia Radiolarite, and Alinga Formation, whereas in the north it comprises the Birdrong Sandstone, Muderong Shale, Windalia Radiolarite and Gearle Siltstone. None of these units crop out on YARINGA.

The Birdrong Sandstone is a locally glauconitic, weakly lithifield sandstone and quartz sand, which forms an excellent artesian aquifer in most of the basin. Cookson and Eisenack (1958) dated the formation as Late Neocomian to Early Aptian.

The Aptian Muderong Shale is a fine-grained, locally glauconitic unit, which conformably overlies the Birdrong Sandstone. It formed in deeper, quieter waters than the Birdrong Sandstone during a later stage of the transgression. South of the Yaringa-Woodleigh area the Muderong Shale becomes thin and difficult to recognize in waterbore logs.

The overlying Windalia Radiolarite is of Aptian to Albian age and consists of interbedded radiolarian-rich black chert and minor shale. Its high content of pelagic microfossils indicates very quiet conditions in an area receiving little terrigenous sediment. The Windalia Radiolarite is unusual in that its stratigraphic setting indicates that it formed on a marine shelf rather than in a deep-sea environment like present-day radiolarites.

The Alinga Formation is a glauconite-rich, clayey siltstone and sandstone of Albian to Turonian age, which in its outcrop area on AJANA is locally a greensand. The high glauconite content indicates slow sedimentation rates in an open-shelf environment. Palaeotemperature measurements on belemnites from the outcrop area indicate surface water temperatures of about 18°-20°C (Bowen, 1961).

On northern YARINGA the Alinga Formation changes laterally into the Gearle Siltstone consisting of dark-grey siltstone and claystone, which is locally bentonitic further north in the basin.

Toolonga Calcilutite (Kt): The Toolonga Calcilutite of Santonian to Campanian age (Belford, 1958), disconformably overlies the Winning Group. It is the only Cretaceous unit known to outcrop on YARINGA, and consists of greenish-grey to white-weathering, slightly clayey calcilutite commonly containing greenish flint nodules. The Toolonga Calcilutite is an open-shelf deposit rich in pelagic coccoliths.

Well-developed calcrete duricrust obscures the Toolonga Calcilutite over most of its outcrop area, and the best exposure is at Flint Cliff, where the formation contains numerous irregular chert nodules. Small exposures of Toolonga Calcilutite are common along the east coast of Hamelin Pool, e.g. 2.8 km southwest of Flagpole Landing and at Goat Point.

CAINOZOIC

Cainozoic marine sedimentation in the northern Carnarvon Basin occurred in four main cycles (Quilty, 1977):

(1)	Paleocene to Early Eocene
(2)	Middle to Late Eocene
(3)	Late Oligocene to Middle Miocene
(4)	Late Miocene to Holocene.

Paleocene sediments (cycle 1) are known from adjoining SHARK BAY (e.g. Peron 2 bore (Belford, 1956), Tamala 1 (Kempin and Fujioka, 1973)); and an incomplete sedimentary record of the last three cycles is known from YARINGA.

Giralia Calcarenite (Tg): The Eocene Giralia Calcarenite (cycle 2) on adjoining WOORAMEL is a greenish-grey, well-lithified calcarenite containing bryozoans, foraminifers, and minor glauconite. On YARINGA, the Giralia Calcarenite has been recognized in cuttings from Woodleigh 4 and is thought to occur northeast of Hamelin Pool 1 although the silicified, fossiliferous limestone at this locality could also be interpreted as Trealla Limestone.

Lamont Sandstone (Tl): Quilty's cycle 3 (Late Oligocene to Middle Miocene) is represented on YARINGA by the Middle Miocene Lamont Sandstone. On YARINGA, the Lamont Sandstone has only been recognized in the vicinity of Hamelin Pool, and is thought to be of marine origin, although the only fossils found in the unit in this area consist of fossil wood.

Pindilya Formation (Tp): In the eastern part of YARINGA sandstones of probable fluvial/colluvial origin, which occur in a similar morphostratigraphic position to the Lamont Sandstone, are mapped as Pindilya Formation.

Trealla Limestone: Small areas of Trealla Limestone may also be present in the Hamelin Pool area, as this unit is known to occur at Yaringa homestead, a few kilometres to the north of YARINGA. Because of the ubiquitous calcrete duricrust

on the Cretaceous Toolonga Calcilutite, recognition of the supericially similar Trealla Limestone is difficult during regional mapping.

Dampier Limestone (Qd): The fourth cycle of marine Cainozoic deposition is represented in the onshore area by the Pleistocene Dampier and Bibra Limestones ("Dampier Formation" and "Bibra Formation" of Logan, Read, and Davies (1970) amended herein as they consist predominantly of limestone), and by various Holocene coastal deposits all of which are described in more detail by Logan, Read and Davies (1970).

The Dampier Limestone is a shelly calcirudite (conquinite) which is a nearshore and/or beach-ridge deposit. The Carbla Oolite Member (*Qdc*) ("Carbla Oolite" of Logan, Read, and Davies (1970), amended herein) which has its type section at Goat Point, is a member of the Dampier Limestone recognized along the eastern shore of Hamelin Pool. It is predominantly an ooid grainstone with a fossiliferous basal conglomerate in the type area. *In situ* oysters in this conglomerate indicate deposition at, or below, sea level. The overlying sequence of unfossiliferous very well-sorted ooid grainstone which occurs in distinct ridge-like bodies, is interpreted as a beach-ridge or coastal-dune deposit similar to the oolitic dunes presently forming north of Carbla Point. This interpretation of ridges of the Carbla Oolite Member as dunes or beach ridges, implies a significantly lower sea-level stand during the Dampier marine phase than suggested by Logan, Read and Davies (1970, p.62) who interpreted these ridges as having formed as submarine ooid shoals.

The Dampier Limestone is older than the Bibra Limestone, correlatives of which, in the Lake MacLeod area, have been dated as 120 000-130 000 years old. As the Dampier Limestone formed during a previous interglacial high sea-level stand, its likely minimum age is about 240 000 years or Middle Pleistocene (see Kukla, 1977 for ages of Pleistocene events).

The upper part of the Dampier Limestone is commonly intensely calcreted and marked by solution pipes. The presence of this weathering horizon permits the distinction of the Dampier Limestone from the overlying Bibra Limestone, when both are present.

Bibra Limestone (Qb): The Bibra Limestone is a predominantly shelly calcirudite (coquinite) that formed during last Pleistocene interglacial high sea-level stand (120 000-130 000 years ago). The morphology as well as the contained fossil assemblages of various parts of the formation permit the recognition of beach-ridge deposits (e.g. 1 km east of Hamelin Post Office; 5 km west of Sweeney Mia bore), tidal-flat deposits (south of Nilemah embayment), and subtidal deposits (coral reefs in Gladstone Embayment, WOORAMEL).

Calcrete is commonly developed on the Bibra Limestone but calcretization is generally less advanced than it is over the Dampier Limestone.

The fossil faunas in both formations indicate that near-oceanic salinities prevailed during the Pleistocene unlike the present-day hypersaline situation in Hamelin Pool.

Landward from the tidal flats and coastal cliffs neither the Dampier Limestone nor the Bibra Limestone is well-exposed because of calcretization and soil cover, and even in good exposures, recognition of the calcreted disconformity separating the two units is difficult.

Holocene sedimentation in Hamelin Pool has been strongly influenced by the formation of the Faure Sill (SHARK BAY and WOORAMEL) which restricted circulation in Hamelin Pool, thus causing hypersaline conditions. Because of the

high salinity, the fauna of Hamelin Pool is impoverished. The very reduced number of algae-consuming organisms is believed to be the main reason for the widespread development of algae stromatolites in Hamelin Pool. The stromatolites are unrivalled in diversity in modern seas and have been the subject of various studies, the most recent being by Logan, Hoffman and Gebelein (1974)—summarized by Hoffman (1976)—and Playford and Cockbain (1976). Playford and Cockbain have shown that stromatolite occurrences are widespread on the sublittoral platform as well as in the intertidal zone.

It is clear that sea-bottom topography has an important control on stromatolite development. Drowned beach ridges and offshore bars have been the sites of preferential stromatolite growth, and erosion remnants of calcrete-coated solution pipes form the cores of very large individual stromatolites.

Hamelin Coquina (Qsh): Another outstanding feature of modern carbonate sedimentation in Hamelin Pool is the development of the Hamelin Coquina. This is a beach-ridge complex consisting predominantly of small shells of *Fragum erugatum* which during storms are swept from the sublittoral platform, across the stromatolite belt, on to the shore.

Syndepositional dolomitization of tidal flat carbonates is common in arid regions. Yet Logan (1974, p. 225; 246) stated that only insignificant present-day dolomitization has taken place in tidal and supratidal flat sediments along the shores of Hamelin Pool. However, he also described detrital sand-size dolomite rhombs which could be 'traced to sources in Cretaceous country rocks'. As dolomitized Toolonga Calcilutite is only known to occur in tidal-flat exposures (e.g. Goat Point), it is probable that the fairly extensive dolomitization of the Cretaceous calcilutite is a Holocene phenomenon.

For further details on various aspects of carbonate sediments in Hamelin Pool, which have been mapped as beach, beach ridge, and coastal dune deposits (*Qs*), supratidal flat deposits (*Qu*), and tidal flat/algal mat deposits (*Qm*) see Logan and others (1970, 1974), or the summary by Logan, Brown and Quilty (1976).

Superficial deposits

Post-Miocene nonmarine superficial deposits cover most of YARINGA. Most of these are not mapped on the basis of lithology alone, but on differences in morphology and subtle changes in photo-pattern and vegetation. These units are therefore morphostratigraphic units in the sense of Frye and Willman (1962), not lithostratigraphic units.

Laterite (Czl) and silcrete (Czb): Laterite and its siliceous equivalent silcrete are both soil deposits indicative of a more humid climate than the present one. They are largely restricted to occurrences of Lamont Sandstone and its probable correlative, the Pindilya Formation. The occurrence of laterite on Lamont Sandstone indicates post-Middle Miocene lateritization, which contrasts with the Oligocene age of laterite further north in the basin (van de Graaff and others, 1977).

Calcrete (Czk) and valley calcrete (Qk): Mature calcrete duricrust, which post-dates both laterite and silcrete, is ubiquitously developed where Toolonga Calcilutite comes to the surface. The limestone quarried at 26°00′10″S, 114°18′30″E is probably a calcreted lacustrine limestone, coeval with calcrete duricrust, or, alternatively, a very thick, pure calcrete deposit. Valley calcrete is present in the major palaeodrainage valley on eastern YARINGA, and minor calcretization has occurred in most superficial deposits.

Peron Sandstone (Qp): The Peron Sandstone has only been recognized north of Hamelin Pool 1. It is a red-coloured eolian deposit of probable Pleistocene age, which is several tens of metres thick on Peron Peninsula (SHARK BAY-EDEL). It is characterized by numerous soil concretions ('peds') and root structures, and is unconformably overlain by the Carbla Oolite Member. It may correlate with the older eolianite (*Qpe*) of eastern YARINGA, which also contains abundant 'peds' and root concretions.

Alluvium (Qa) and colluvium (Qc): Alluvium consisting mostly of poorly sorted silt, sand and gravel is associated with major creeks on eastern YARINGA. In that area it grades laterally into colluvium, eolianite, playa deposits and calcrete. As for the following units, the age of alluvium is in the range Pleistocene to Holocene. Colluvium (*Qc*) as mapped includes many small areas of other superficial deposits.

In the Hamelin Pool area Logan, Brown and Quilty (1976) distinguish the 'Depuch Formation' which is a partly calcreted colluvium/soil deposit not mappable at 1:250 000 scale.

Claypan and salt-lake deposits (Ql): Large claypan and salt-lake deposits (*Ql*) are mapped individually. Surrounding the major playas are gypsiferous dune deposits (*Qlg*) which are derived from the lake sediments. It is impractical at the map scale to distinguish individually the innumerable claypan and dune deposits (*Qle*) that mark part of the major palaeodrainage valleys.

Dune and sandplain deposits (Qe): The claypan and dune deposits grade laterally into dune and sandplain deposits. The great extent of this unit is thought to indicate underlying sandy bedrock, which has been partly reworked in a weathering profile and by wind action. Logan, Read and Davies (1970) use the name 'Nilemah Sands' for this unit in the Hamelin Pool area.

STRUCTURE

Depth-to-magnetic-basement contours and gravity data (Fraser, 1973) indicate a major north-south basement ridge on central YARINGA (Fig.2). This is part of the Ajana-Wandagee Ridge which separates the Gascoyne Sub-basin in the west from the Coolcalalaya and Byro Sub-basins in the east. The Gascoyne Sub-basin deepens westwards, and sparse seismic data indicate that the Palaeozoic basin-fill is block faulted and gently folded. The faulted Lower Palaeozoic sequence is unconformably overlain by a very gently westward-dipping sedimentary wedge of Cretaceous and Tertiary sediments. Water-bore data indicate that this sequence is very gently folded in the Hamelin Pool area, and these fold structures apparently control the shape of the coastline. Hamelin Pool and Hutchison Embayment are thought to mark synclinal downwarps, while the Yaringa Point headland probably marks an anticline in the Cretaceous rocks (Playford and Cockbain, 1976). By analogy with similar anticlinal structures further north in the basin, post-Miocene reversal of movement on large normal faults is thought to have caused this very gentle deformation.

To the east of the Ajana-Wandagee Ridge, the subsurface continuation of the Carrandibby Inlier (WOORAMEL/GLENBURGH) stands out clearly on both the Bouguer anomaly (Fraser, 1973) and on depth-to-magnetic-basement maps (Fig.2).

The thick sedimentary fill of the Coolcalalaya Sub-basin indicated by Bouguer gravity anomalies (Fraser, 1973) is not shown in the depth-to-magnetic-basement contours because of the spurious effects on the magnetics caused by the proximity of the Darling, Woodrarrung and Madeline Fault systems.

Seismic evidence from the northern part of the area indicates that the Palaeozoic and ?Proterozoic fill of the Coolcalalaya Sub-basin is block faulted. However, although a number of low, linear scarps have been mapped on the sandplain, none of these is demonstrably of fault origin. Similarly the southern extension of the Bogadi Syncline has no surface expression. Even the very large, geophysically well-defined Darling Fault has as its only surface expression the major palaeodrainage valley on eastern YARINGA.

Only the Proterozoic rocks are moderately to intensely folded. The Woodrarrung and Badgeradda Ranges form the western limb of an asymmetric, shallow, north-northeast plunging syncline. The Woodrarrung Sandstone dips consistently east at moderate to steep angles, in contrast both with the shallow eastward dips of the upper Badgeradda Group on BYRO and the moderate to steep westward dips of the dynamically metamorphosed Proterozoic sequence to the west.

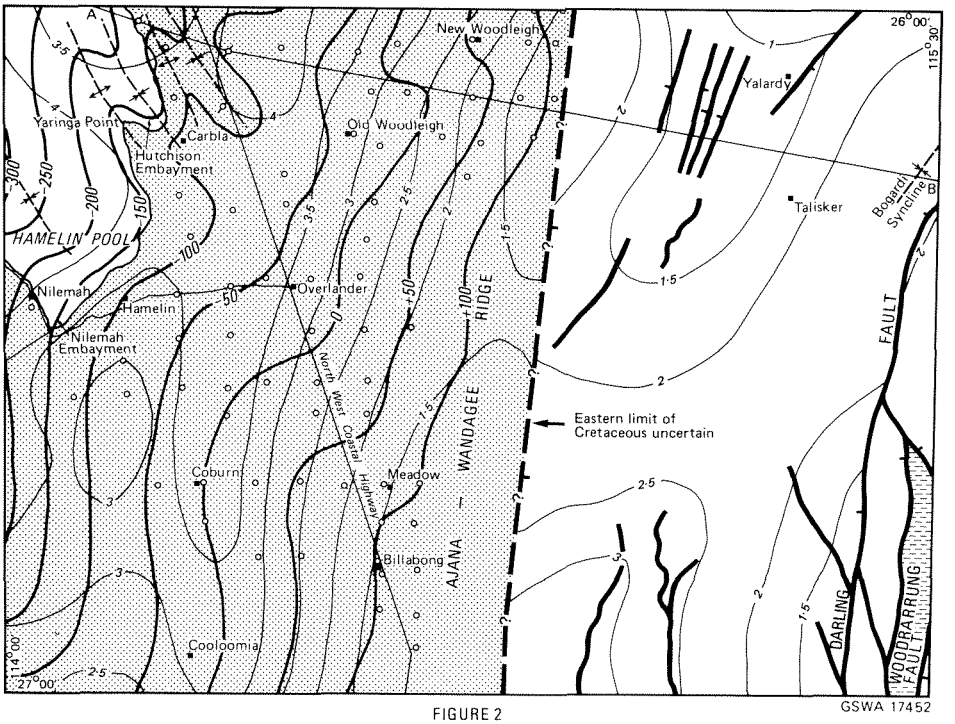

FIGURE 2

GSWA 17452

STRUCTURAL SKETCH MAP

YARINGA SHEET SG50-9

0 10 20 30 km

REFERENCE

Cretaceous

Permian

Proterozoic

Fault, major (pre-Cretaceous) movement shown

Fold axis

Depth to magnetic basement; 0.5 km contour interval

Structure contour top of Birdrong Sandstone; contours in metres relative to sea level

Petroleum/evaporite exploration well

Homestead or roadhouse

Waterbore penetrating Cretaceous

(contours from Megallaa, 1978)

The zone west of the ranges shows quite intense, high-angle, strike-slip faulting, of which the Woodrarrung Fault is a part. The cleavage developed within the metamorphosed sequence is subparallel to the strike-slip faulting, at moderate to steep angles, and commonly transposes primary bedding.

GEOLOGICAL HISTORY

Deposition of clastic sediments during the ?Middle Proterozoic, possibly in two phases, and subsequent intrusion by dolerites are the first recorded events on YARINGA. During the Late Proterozoic, and probably the early Palaeozoic, intense deformation of this sequence took place adjacent to the Darling and Woodrarrung Faults.

During the Silurian the fluviatile and marine Tumblegooda Sandstone and the overlying evaporitic Dirk Hartog Formation, together about 4 000 m thick, were deposited on western YARINGA. This phase of sedimentation ceased in the Late Silurian or Early Devonian, and whether the sequence is preserved east of the Ajana-Wandagee Ridge is not known.

Thick Permian glacial and marine sediments are preserved in the Coolcalalaya Sub-basin, but west of the Ajana-Wandagee Ridge the Permian has been completely stripped from the uplifted Gascoyne Sub-basin during pre-Cretaceous erosion.

In Jurassic and possibly Triassic times, a phase of major block faulting, associated with the rifting and eventual breakup of Gondwanaland, affected the area. This phase of normal faulting resulted in the clear differentiation of the Ajana-Wandagee Ridge and the Gascoyne and Coolcalalaya Sub-basins (Thomas and Smith, 1976).

Only minor continental deposition took place during the Jurassic, and after planation of the faulted Palaeozoic sequence, the Neocomian transgression affected at least western YARINGA and a shallow-marine and open-shelf sequence was laid down.

The eastern limit of the Cretaceous sequence is uncertain. It may be fault-controlled, by late-stage reverse movement on the Ajana-Wandagee Fault system, or a simple depositional control close to this fault system.

During the Eocene and Miocene the sea again reached northwestern YARINGA, but in the remainder of the area, superficial continental deposits formed during the Tertiary. In the ?Late Miocene the area was subjected to lateritic weathering, but a change to a drier climate is reflected by the development of calcrete and the drying-out of palaeo-drainages. During the Pleistocene, if not earlier, this trend towards a more arid climate gave rise to widespread eolian reworking of superficial sands and to local deflation.

In the Hamelin Pool area, minor folding took place during the Cainozoic. This folding is thought to be due to minor reverse movements on older, normal faults, as is the case further north in the basin.

ECONOMIC GEOLOGY

Petroleum

Yaringa 1 (Henderson and Shannon, 1966) tested the thick Silurian sequence, and confirmed that the Dirk Hartog Formation can be an adequate caprock, and that the Tumblagooda Sandstone is an excellent reservoir. Nevertheless the lack of source

rocks and the generally oxidized nature of the sequence makes the Silurian a poor prospect. Well data from further north in the basin also indicate that the Permian sequence is poorly prospective. Wells drilled for petroleum or evaporites are listed in Table 2. Table 3 lists the geophysical surveys on YARINGA.

The Cretaceous on YARINGA is still too shallow to have generated oil, and potentiometric contours in the prime reservoir rock, the Birdrong Sandstone, indicate that it is still being flushed by meteroic waters.

TABLE 2. WELLS DRILLED FOR PETROLEUM OR EVAPORITES ON YARINGA

Name	*Year completed*	*Type*	*Location*		*Elevation (m)*	*Total depth (m)*	*Bottomed in*	*Drilled for*	*Status*
			Lat (S)	*Long (E)*					
Hamelin Pool 1	1968	St(E)	26°01'31"	114°12'17"	4.9	1 595	Silurian	MPA	Completed as water well
Hamelin Pool 2	1968	St(E)	26°08'55"	114°21'24"	25	1 219	Silurian	MPA	p & a
Yaringa 1	1966	NFW	26°03'58"	114°21'35"	21	2 288	Silurian	COG	Dry, p & a

TABLE 3. GEOPHYSICAL SURVEYS ON YARINGA

Title	*Company*	*Year*	*GSWA 'S' file no.*
Hamelin Seismic Survey	OCP	1972	730
Murchison-Gascoyne Detailed Gravity Survey	OCP	1971-72	662
Murchison-Gascoyne Helicopter Gravity Survey	WAPET	1970	578
Wooramel Reconnaissance Seismic Survey	COC	1963	168
Yalbalgo-Yaringa semi-detail seismic project	COC	1966	227

KEY (Tables 2 & 3):

St(E)	Stratigraphic test, drilled for evaporites	COC	Continental Oil Company of Australia Pty Ltd
NFW	New-field well	OCP	Oceania Petroleum Pty Ltd
MPA	Magellan Petroleum of Australia Pty Ltd	WAPET	West Australian Petroleum Pty Ltd
		p & a	Plugged and abandoned

Evaporite minerals

Yaringa 1 discovered a significant salt-bearing sequence, the Yaringa Evaporite Member of the Dirk Hartog Formation. Hamelin Pool 1 and 2 were drilled to evaluate the potash potential of this unit (Butler and Sanderlin, 1968; Pendery and others, 1969; Pendery, 1970; see Wells, 1973 for review), but no economic deposits were found.

Coal

The poorly exposed Keogh Formation on northeastern YARINGA may be prospective for steaming coal.

Water supply

Surface water supplies are limited to scattered claypans and earth dams. Some of these are used for stock-watering, and at Billabong roadhouse, purified dam water is used domestically. Other domestic needs are met from roof catchments or by carting from outside the area (e.g. Billabong and Overlander roadhouses).

Stock quality pressure water (artesian or subartesian) is available on western YARINGA from the Birdrong Sandstone, Windalia Radiolarite, and Tumblagooda Sandstone. Intake areas are on eastern Meadow and Woodleigh Stations.

The flowing artesian bores such as Hamelin 1 have a production of up to 4 500 m^3/day, and production temperatures of 34°C to 35°C when the aquifer is at a depth of 110 to 120 m. Figure 2, showing the depth to the top of the Birdrong Sandstone, gives an approximate indication of the depths of the artesian aquifers.

Salinity in the artesian aquifers drops from east to west from 10 000-12 500 mg/L on Meadow/Woodleigh, to 3 500-5 000 mg/L on Carbla (Fig. 3). Such a decrease in salinity away from the intake area is most unusual in aquifer systems. It is thought to reflect a change from a humid to an arid climate with an attendant deterioration in the quality of the water entering the aquifer.

Considering the magnitude of the required climatic change and the likely range of bulk flow rates (1-10 m/year) within the aquifer, it seems probable that the slightly brackish waters on western YARINGA were infiltrated during the latest interglacial, that is 120 000-130 000 years ago.

On eastern YARINGA adequate supplies of stock-quality water have been found in Permian sandstones on all pastoral stations but aquifer development is patchy.

Phosphate

The Upper Cretaceous sequence has been explored for phosphate (Anon, 1966; Freas, 1965) but results were discouraging.

Construction materials

Red sand and unconsolidated Bibra Limestone (Nilemah Embayment) have been used for road construction, and unconsolidated Hamelin Coquina has been used for that purpose on SHARK BAY. Calcrete has been quarried for use as road metal.

Consolidated Hamelin Coquina has been quarried at Flagpole Landing and Carbla Point for building stone.

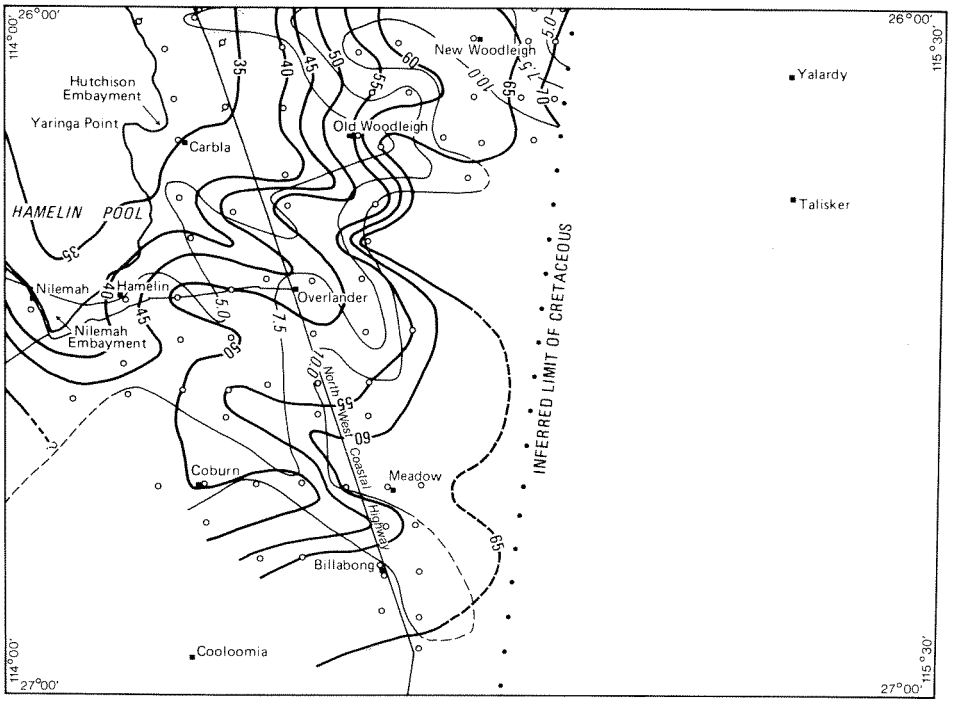

FIGURE 3

GSWA 17453

POTENTIOMETRIC SURFACE AND ISOHALINES FOR (SUB)ARTESIAN BORES

YARINGA SHEET SG50-9

0 10 20 30 km

REFERENCE

—55— Potentiometric contour in metres above sea level

—7.5— Isohaline, mg/l x 100

Petroleum/evaporite exploration well

Homestead or roadhouse

Waterbore

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AUSTRALIA 1 : 250 000 GEOLOGICAL SERIES

YARINGA

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

SHEET SG 50 - 9

SYMBOLS

- Geological boundary
- Fault
  - Accurate, downthrown side indicated
  - Concealed
  - Inferred and concealed
- Bedding
  - Inclined
  - Horizontal
  - Overturned
  - Trend
- Cleavage
  - Inclined
  - Vertical
- Lineament, probably of structural origin
- Palaeocurrent direction
- Type section
- Fossil locality
- Fossil wood locality
- Petroleum exploration well, dry, abandoned
- Mineral exploration borehole, for evaporites

- Highway with national route marker
- Formed road
- Track
- Telegraph line
- Homestead — ■ Meadow
- Locality — Bootapondie
- Hut or outcamp
- Landing ground
- Horizontal control, minor
- Bench mark, height accurate — • 24.79 (R.L.)
- Dune or beach ridge crest
- Sand, low and/or ill-defined
- Position approximate — (PA)
- Quarry

- River or creek, intermittent
- Bore drain, permanent — Bore
- Palaeodrainage, transitional to intermittent
- Bathymetric contour line, depth in metres — 5
- Well — • W
- Bore — • B
- Windpump — T
- Tank — □ T
- Dam — (T.D)
- Soak — • Sk
- Artesian bore; flowing, not flowing — ‡ ‡
  - Sub-artesian bore — ‡
- Abandoned — (abd)

FLIGHT DIAGRAM

Air photography (1: 53 600) by National Mapping, Canberra, January-April 1968