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DONGARA— HILL RIVER

WESTERN AUSTRALIA



SHEET SH/50-5, 9 INTERNATIONAL INDEX

WESTERN AUSTRALIA
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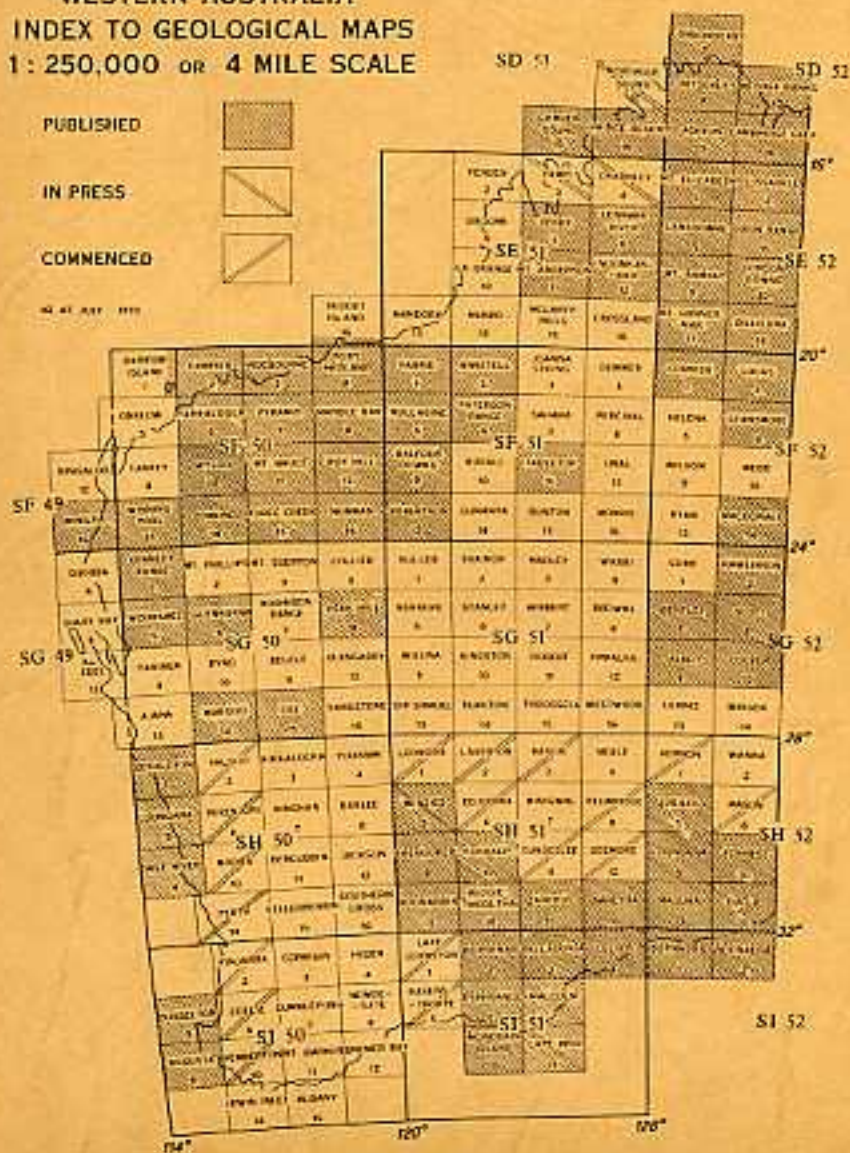
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GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

1:250,000 GEOLOGICAL SERIES—EXPLANATORY NOTES

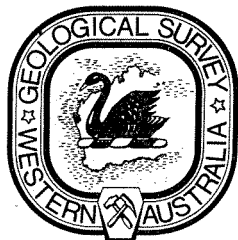
DONGARA— HILL RIVER

WESTERN AUSTRALIA

SHEET SH/50-5, 9 INTERNATIONAL INDEX

COMPILED BY D. C. LOWRY

Geological Survey of Western Australia



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Explanatory Notes on the Dongara-Hill River Geological Sheet

Compiled by D. C. Lowry

INTRODUCTION

LOCATION

The Dongara-Hill River Geological Sheet covers the area between latitudes 29°S and 31°S and longitudes 114°45'E and 115°30'E; it thus consists of the eastern parts of the Dongara (SH/50-5) and Hill River (SH/50-9) Sheets. The mapped area adjoins the coast of Western Australia and covers part of the northern Perth Basin.

SETTLEMENT AND ACCESS

The largest settlements on the Sheet area are the towns of Dongara, Jurien, and Mingenew, and there are several smaller townships and fishing villages. Primary industries include farming (mainly wheat and sheep), and fishing (especially for rock lobsters).

Most of the Sheet area is served by formed gravel roads, but some coastal parts have only rough sandy tracks that are best negotiated by four-wheel-drive vehicles. The Geraldton Highway (Highway 1) and Perth-Geraldton railway cross the northern part of the Sheet area.

PREVIOUS GEOLOGICAL WORK

Campbell (1910) made a reconnaissance survey of the northern part of the Sheet area, and published the first geological map and description of that area. Later work concentrated especially on the Irwin Sub-basin (Woolnough and Somerville, 1924; Clarke and others, 1951; Johnson and others, 1954), and a real understanding of the geology of the remainder of the Sheet did not develop until after 1948 when the search for petroleum stimulated geological mapping, geophysical surveys, and drilling. The first petroleum geologists to study the area were Conrad and Maynard (1948) for Richfield Oil Corporation. Subsequent exploration was carried out by the Bureau of Mineral Resources (for example Thyer and Everingham, 1956; Quilty, 1963;

and McTavish, 1965), West Australian Petroleum Pty. Ltd. ("Wapet") and French Petroleum Company Australia Pty. Limited (now Total Exploration (Australia) Pty. Ltd.) (see Tables 2 and 3). Hydrological and stratigraphic information has also been gained by drilling for water by the Public Works Department and by the Geological Survey of Western Australia (for example Maitland, 1902; Allen, 1965; Barnett, 1970).

PRESENT SURVEY

The Dongara-Hill River Geological Sheet was prepared as part of a mapping programme in the Perth Basin by the Geological Survey of Western Australia. The Hill River Sheet was mapped in 1968 by G. H. Low and D. C. Lowry, and most of the Dongara Sheet in 1969 by D. C. Lowry, R. Dedman, and G. H. Low. The Irwin Sub-basin and part of the adjoining area in the northeast of the Dongara Sheet were mapped by P. E. Playford, who also supervised the programme.

PHYSIOGRAPHY

CLIMATE

The area has hot dry summers and cool wet winters with a moderately reliable rainfall. The average annual precipitation is highest near the coast where it ranges from 630 mm in the south to 500 mm in the north; it decreases inland and is only 380 mm in the northeast part of the Sheet area.

DRAINAGE

The area is drained by watercourses that flow only in the winter months; the main rivers are the Irwin, Lockier, Arrowsmith, Hill, and Namban Rivers. Of these only the Irwin and Hill Rivers reach the sea; the Lockier is a tributary of the Irwin, and the others terminate in large swamps or lakes near the coast.

GEOMORPHOLOGY

The Sheet area can be divided into seven physiographic units; the Coastal Belt, Bassendean Dune System, Greenough Flats, Alluvial Fans, Dissected Region, Victoria Plateau, and Dandaragan Plateau (Fig. 1).

1. The *Coastal Belt* consists of two Quaternary dune systems. The younger one (the Quindalup Dune System of McArthur and Bettenay, 1960) is formed of fixed and mobile sand dunes while the older (the Spearwood Dune System of McArthur and Bettenay, 1960) consists of dunes lithified to limestone.

On the coast, sandy straight beaches are separated by low limestone headlands. Offshore there are two or three partly or completely submerged ridges of dune limestone whose westward edges probably mark former coastlines.

Several caves are known in the Coastal Belt and some of these have clearly

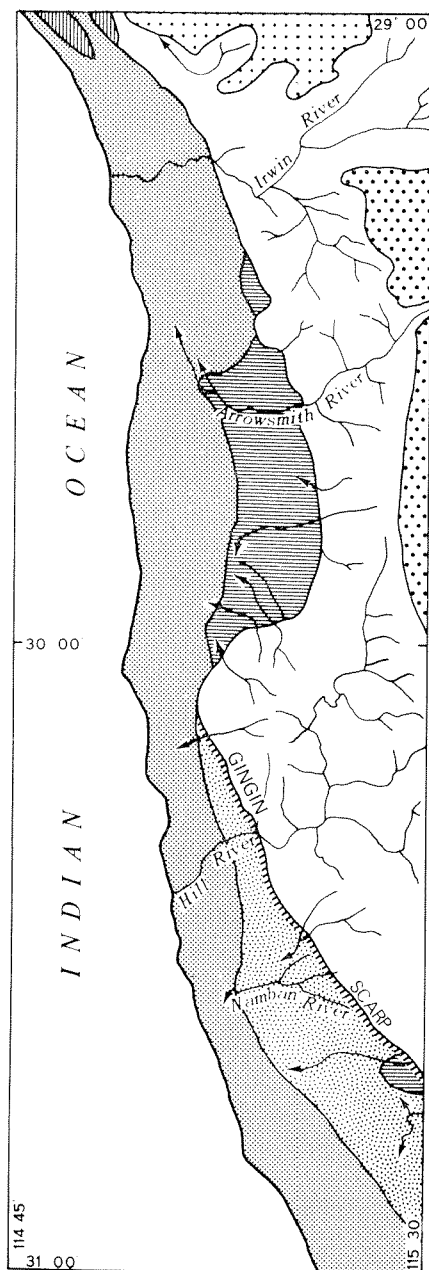
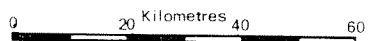


FIGURE 1
PHYSIOGRAPHIC DIAGRAM
DONGARA-HILL RIVER SHEET

SCALE



REFERENCE

	Coastal Belt
	Bassendean Dune System
	Greenough Flats
	Alluvial Fans
	Dissected Region
	Victoria Plateau
	Dandaragan Plateau

12901

been formed by water from ponded rivers percolating seawards through the dune limestone; for example at the end of Stockyard Gully, Arrowsmith River, and Namban River. Several other caves in the area may also be related to watercourses, for example the caves at Jurien Bay which may have been formed by Hill River, and Weelawadji Cave which may have been formed by Eneabba Creek. The Arrowsmith River and Stockyard Gully Caves have several hundred metres of passages which are occupied by streams for a few weeks of the year, but most other caves are small and are formed by roof collapse above subterranean stream passages. With the exception of Weelawadji and Drover Caves, they have few secondary calcite deposits.

The Pinnacles and Tombstone Rocks are curious erosional limestone features of popular interest. A Pleistocene carbonate-rich dune system was lithified to form limestone, leaving an overlying soil of leached quartz sand. With continued leaching the concealed soil-limestone contact became highly irregular, the underlying limestone being dissolved to form pinnacles beneath the sand. In Recent times, a younger mobile dune system moved northwards across the old dune system and when it had passed, the leached quartz sand, no longer stabilized by vegetation, was blown northwards exposing the underlying pinnacles of limestone.

2. The *Bassendean Dune System* (McArthur and Bettenay, 1960) can be recognized in the southern part of the Sheet area landward of the Coastal Belt. The area consists of leached Pleistocene dunes with a subdued topography and numerous inter-dunal swamps.

3. The *Greenough Flats* are alluvial plains built by the Greenough River. The unit is developed mainly on the Geraldton Sheet (see Playford and others, 1970) and extends into the northernmost part of the Dongara-Hill River Sheet.

4. The *Alluvial Fans* have been built where westward-flowing rivers decrease in gradient as they approach the Coastal Belt. In the Eneabba area small dunes appear to have been locally blown out from the sandy stream channels.

An ancient (Tertiary or Pleistocene) coastline trends obliquely to the modern coast some 16 to 32 km inland, and separates the physiographic units described above from those described below. South of Jurien Bay this old coast is marked by a subdued scarp known as the *Gingin Scarp*.

5. The *Dissected Region* is occupied by hills of lateritized Mesozoic strata reaching elevations of 250 to 300 m. The valleys are mature in most areas but there are youthful valleys in the headwaters of Cockleshell Gully. The topography is influenced by the presence of hard laterite which overlies soft weathered sedimentary rocks. Many hills have a capping of exposed laterite, and where it is dissected the hills are fringed by breakaways 3 to 15 m high.

The laterite is believed to have formed as a soil horizon on a landscape which itself already showed a range of dissection comparable to that of the modern surface. Thus in the north and east it formed on the plateau surfaces and is scarcely dissected, whereas in the Cockleshell Gully area it formed on an eroded land surface and is itself now strongly dissected. The laterite on the Victoria and Dandaragan plateaux is still largely covered by the eluvial quartz sand (the *A* horizon of the laterite profile), whereas in the Cockleshell Gully area this sand has been stripped off and the laterite remains as inclined caps on hillsides and hilltops (for example Mount Lesueur).

6. The *Victoria Plateau* (Johnson and others, 1954) is a laterite-capped plateau standing about 250 m above set level. The plateau represents an old erosion surface developed on Mesozoic rocks and subsequently lateritized. Erosion around the margin of the plateau has produced characteristic break-aways.

7. The *Dandaragan Plateau* (McArthur and Bettenay, 1960) is similar to the Victoria Plateau and is separated from it by the Irwin and Lockier River Valleys.

VEGETATION

Most of the area has a poor sandy soil covered by a sclerophytic heath in which the blackboy (*Xanthorrhoea preissii*) is a prominent component. Scattered trees include banksias and the Christmas tree (*Nuytsia floribunda*). Large eucalypts grow along watercourses and on the clay soils of the Gairdner Range-Eragilga Hills area.

STRATIGRAPHY

The stratigraphy of the Sheet area is given in Table 1.

PRECAMBRIAN BASEMENT

Precambrian basement rocks do not crop out on the Dongara-Hill River Sheet, but they have been intersected in several deep exploratory wells (see Table 2). The basement rocks are granite and gneiss comparable to the Proterozoic rocks found in the Northampton Block to the north (Peers and Trendall, 1968).

LOWER PALAEOZOIC

Tumblagooda Sandstone

The *Tumblagooda Sandstone*, a thick sequence of sandstone and conglomerate probably of Early Silurian age, is developed in the northern part of the Perth Basin (Playford and others, 1971). The unit is absent from the Beagle Ridge on the west side of the Dongara-Hill River Sheet and from the Irwin Sub-basin on the east (Fig. 3, p. 26), but it could possibly be present at

TABLE 1. STRATIGRAPHIC UNITS

<i>Age</i>	<i>Unit Name</i>	<i>Map Symbol</i>	<i>Lithology</i>	<i>Maximum thickness (metres)</i>	<i>Relationship to underlying unit</i>	<i>Remarks</i>
RECENT	Swamp deposits	Qrw	Sand, clay, diatomite	3 (e)	Variable and complex	
	Alluvium	Qra	Sand, silt	9 (e)	Variable and complex	
	Safety Bay Sand	Qrs, Qrsm	Unconsolidated to weakly lithified calcareous sand	?60 (e)	Variable and complex	Qrs—fixed dunes; Qrsm—mobile dunes
	Lagoonal deposits	Qrg	Clay, silt, marl; in places gypsiferous	?3 (e)	Variable and complex	
PLEISTOCENE TO RECENT	Colluvium	Qpo	Quartz sand	?3 (e)	Variable and complex	
	Dune sand	Qpe	Quartz sand	?9 (e)	Variable and complex	Derived from ephemeral swamps
PLEISTOCENE	Coastal Limestone	Qpcs, Qpck	Calcarenite, kankar, and quartz sand	150 (e)	Variable and complex	Qpck—mainly limestone and kankar
	Bassendean Sand	Qpb	Quartz sand	?60 (e)	Variable and complex	Qpcs—mainly sand Leached coastal dunes
CAINOZOIC	Laterite	Czl	Ferruginous laterite	3 (e)		
	Residual sand	Czls	Quartz sand	3 (e)		
MIDDLE JURASSIC TO EARLY CRETACEOUS	Yarragadee Formation	Jky	Sandstone, siltstone, shale	2,681 (d)	Conformable on Cadda Formation	
	Otorowiri Siltstone Member		Siltstone	30 (d)	Member within Yarragadee Formation	Not mapped; Early Creta- ceous in age

TABLE 1. STRATIGRAPHIC UNITS.—(cont.)

<i>Age</i>	<i>Unit Name</i>	<i>Map Symbol</i>	<i>Lithology</i>	<i>Maximum thickness (metres)</i>	<i>Relationship to underlying unit</i>	<i>Remarks</i>
MIDDLE JURASSIC	Cadda Formation	Jmd	Sandstone, siltstone, lime- stone	110 (e)	Conformable on Cockle- shell Gully Formation	Northernmost part of sheet only
	Champion Bay Group	Jm	Sandstone, limestone	43 (e)	Disconformable on Chap- man Group	
EARLY JURASSIC	Chapman Group	Jl	Sandstone	150 (e)	Unconformable on Kocka- tea Shale	Northernmost part of sheet only
	Cockleshell Gully Formation	Jlo	Sandstone, siltstone, shale, coal	1,523 (d)	Conformable on Lesueur Sandstone	
LATE TRIASSIC	Lesueur Sandstone	Tru	Sandstone	1,035 (d)	?Disconformable on Woo- dada Formation	
EARLY TO MIDDLE TRIASSIC	Woodada Formation		Fine-grained sandstone, silt- stone	276 (d)	Gradational with Kocka- tea Shale	Subsurface only
EARLY TRIASSIC	Kockatea Shale		Shale, siltstone, minor sandstone	1,061 (d)	Unconformable on Permian units	Subsurface only
	Bookara Sandstone Member		Sandstone	23 (d)	Member within Kockatea Shale	Subsurface only
	Dangara Sandstone Member		Sandstone	27 (d)	Member at base of Kocka- tea Shale	Subsurface only
LATE PERMIAN	Wagina Sandstone		Sandstone	225 (d)	Unconformable on Lower Permian units	Subsurface only
	Yardarino Sandstone Member		Sandstone	41 (d)	Member at top of Wagina Sandstone	Subsurface only

TABLE 1. STRATIGRAPHIC UNITS.—(cont.)

<i>Age</i>	<i>Unit Name</i>	<i>Map Symbol</i>	<i>Lithology</i>	<i>Maximum thickness (metres)</i>	<i>Relationship to underlying unit</i>	<i>Remarks</i>
EARLY PERMIAN	Mingnew Formation	Pm	Sandstone, siltstone	90+ (e)		Probably equivalent to part of Carynginia Formation
	Carynginia Formation		Siltstone, sandstone	349 (d)	Conformable on Irwin River Coal Measures	Subsurface only
	Irwin River Coal Measures		Sandstone, shale, coal		Conformable on High Cliff Sandstone	Subsurface only
	High Cliff Sandstone		Sandstone	300 (e)	Conformable on Holmwood Shale	Subsurface only
	Holmwood Shale	Ph	Shale, siltstone, limestone	450 (e)	Conformable on Nangetty Formation or unconformable on Precambrian	
	Fossil Cliff Member		Limestone, siltstone, shale,	30 (e)	Member at top of Holmwood Shale	Markedly lenticular
	Beckett Member	Phb	Limestone, shale	11 (e)	Member within Holmwood Shale	
	Nangetty Formation	Pn	Tillite, shale, sandstone	1,200 (e)	Unconformable on Precambrian	

ABBREVIATIONS: (e) estimated

(d) drilled

TABLE 2. SUBSIDIZED GEOPHYSICAL SURVEYS IN THE DONGARA-HILL RIVER SHEET AREA

<i>Title</i>	<i>Date Rept</i>	<i>B.M.R. P.S.S.A. Rept. No.</i>	<i>Author</i>	<i>Company</i>	<i>Type</i>	<i>Horizons mapped</i>	<i>G.S.W.A. Library No.</i>
1962 Perth Basin seismic surveys (includes the following 5 reports)	1962		Sheriff, R. E., Warwick, J. W., Hunnicott, P., Denton, E., and others	Wapet	Refl. and Refr.	Jurassic or Triassic	S 74
Eridon seismic reconnaissance survey	1962	62/1590	McBeath, R. G.	Wapet	Refl.	Jurassic, Permian	S 58
Greenhead refraction project	1962	?	Reynolds, C. B., Hunnicott, P., and Martin, R. H.	Wapet	Refr.	Basement	S 57
Hill River seismic survey	1962	62/1602	Warwick, J. W.	Wapet	Refr.	Triassic, Permian	S 60
Warradong seismic reconnaissance survey	1962	62/1590	Willmott, S. P., and Denton, E. R.	Wapet	Refl.	Lower Jurassic	S 61
Woolmulla south seismic survey	1962	62/1627	McBeath, R. G.	Wapet	Refl.	Triassic, Permian	S 48
Dongara-Mullewa gravity survey	1962	62/1925	Reynolds, C. B., and Kraemer, O. S.	Wapet	Grav.		S 59
Wicherina-Mungara-Dongara-Depot Hill seismic survey	1963	62/1651	Warwick, J. W.	Wapet	Refl. and Refr.	1 reflector 1 refractor	S 52
Dongara seismic project	1963	63/1507	Kendall, T. L.	Wapet	Refl.	Mesozoic	S 53
Irwin seismic survey	1964	64/4511	Denton, E. R., and McBeath, R. G.	Wapet	Refl.	Mesozoic(?)	S 155
Woodada seismic survey	1964	64/4547	Aasted, R. E., and McBeath, R. G.	F.P.C.	Refr.	Intermediate (near) basement	S 171
Poodooloo seismic survey	1965	65/11010	Sisk, G. W.	F.P.C.	Refl.	Lower Jurassic, Permian	S 222
Woodada digital reflection seismic survey	1965	66/11065	Johnston, E., McBeath, R. G., and Aasted, R. E.	F.P.C.	Refl.	Lower Jurassic ?Triassic	S 171
Athamo seismic and gravity survey	1966	65/11060	Gray, J. C., and Kilpatrick, J.	F.P.C.	Refl. Grav.	Lower Jurassic	S 270
Wedge reconnaissance seismic survey	1966	66/11082	Powell, K. E.	Wapet	Refl.	Jurassic	S 290
Lancelin seismic survey	1967	67/11182	McKinley, W. D.	Wapet	Refl.	?Jurassic	S 376
Walyering seismic survey	1967	67/11143	Whitefield, D. O., and Gray, H. D.	Wapet	Refl.	?Lower Cretaceous ?Lower Jurassic	S 340

TABLE 2. SUBSIDIZED GEOPHYSICAL SURVEYS IN THE DONGARA-HILL RIVER SHEET AREA.—(cont.)

<i>Title</i>	<i>Date Rept</i>	<i>B.M.R. P.S.S.A. Rept. No.</i>	<i>Author</i>	<i>Company</i>	<i>Type</i>	<i>Horizons mapped</i>	<i>G.S.W.A. Library No.</i>
Namban seismic survey	1969	69/3025	Sealy, B. E., and Rae, J. R.	Wapet	Refl.	Basal Cretaceous Lower Jurassic (B) Lower Jurassic (C)	S 478
Walpyring detail seismic survey	1970	70/717	Harris, E. H.	Wapet	Refl.	Upper Jurassic Lower Jurassic	S 595
Barragoon seismic survey	1971	70/999	Aasted, R., Eder, J., Nickerson, R. V., and Harris, E. H.	Wapet	Refl.	Lower Cretaceous Upper Jurassic Lower Jurassic (C) Lower Jurassic (D) Upper Triassic	S 622
Moore River seismic survey	1971	70/10001	Eder, J., and Aasted, R.	Wapet	Refl.	Basal Cretaceous Lower Jurassic	S 624
West Walpyring seismic survey	1971	71/565	Eder, J., and Buckley, T. M.	Wapet	Refl.	Upper Jurassic Lower Jurassic (B) Lower Jurassic (C)	S 661
Coomallo seismic survey	1972	71/928	Tipps, R. D., Allen, K. A., and Aasted, R. E.	Wapet	Refl.	Upper Jurassic Lower Jurassic	S 690
Coomallo II seismic survey	1973	73/206	Wilde, R. H., Eder, J., and Buckley, T. M.	Wapet	Refl.	Upper Jurassic Lower Jurassic (B) Lower Jurassic (C)	S 835

ABBREVIATIONS:	B.M.R. P.S.S.A. Rept No.:	Bureau of Mineral Resources Petroleum Search Subsidy Act Report Number
	F.P.C.:	French Petroleum Company (Australia) Pty. Ltd. (now Total Exploration Australia Pty. Ltd.)
	Grav.:	gravity
	G.S.W.A.:	Geological Survey of Western Australia
	Refl.:	reflection
	Refr.:	refraction
	Wapet:	West Australian Petroleum Pty. Limited

TABLE 3. WELLS DRILLED FOR PETROLEUM IN DONGARA-HILL RIVER SHEET AREA

Name	Type	Location		Elevation (metres)	Total Depth (metres)	Bottomed in	Drilled for	Year com- pleted	Status. p & a = plugged and abandoned (abd)
		Lat. (S)	Long. (E)						
Allanooka No. 1	NFW	29°08'31"	115°00'40"	R.T. 51	1,187	L. Permian	Wapet	1965	Dry, p & a
Allanooka No. 2	NFW	29°06'00"	114°59'36"	R.T. 70	1,006	Precambrian	Wapet	1965	Dry, p & a
Arrowsmith No. 1	NFW	29°36'35"	115°06'55"	R.T. 56	3,446	Precambrian	F.P.C.	1965	Gas flows, abd
Beharra No. 1	NFW	29°29'10"	115°00'45"	R.T. 27	2,056	Precambrian	F.P.C.	1966	Dry, p & a
Beharra No. 2	NFW	29°30'55"	115°01'15"	R.T. 33	1,926	L. Permian	Wapet	1967	Dry, p & a
Bookara No. 2	STR	29°09'59"	114°54'30"	R.T. 11	762	Precambrian	Wapet	1967	Dry, p & a
Bookara No. 3	STR	29°06'27"	114°53'14"	R.T. 33	538	Precambrian	Wapet	1967	Dry, p & a
BMR No. 10 (Beagle Ridge)	STR	29°49'38"	114°58'30"	R.T. 6	1,192	L. Permian	B.M.R.	1959	Minor oil shows, p & a
BMR No. 10A (Beagle Ridge)	STR	29°49'36"	114°58'30"	R.T. 8	1,482	Precambrian	B.M.R.	1960	Minor oil shows, p & a
*Cadda No. 1	NFW	30°20'15"	115°12'48"	K.B. 82	2,795	Precambrian	F.P.C.	1965	Dry, p & a
Dongara No. 1	NFW	29°15'00"	114°49'07"	D.F. 49	2,158	L. Permian	Wapet	1966	Gas well
Dongara No. 2	EXT	29°14'46"	114°58'26"	R.T. 27	1,745	L. Permian	Wapet	1966	Gas well
Dongara No. 3	EXT	29°15'18"	115°00'04"	R.T. 32	1,775	L. Permian	Wapet	1966	Gas well
Dongara No. 4	EXT	29°13'46"	114°58'49"	R.T. 66	1,818	L. Permian	Wapet	1967	Gas well
Dongara No. 5	EXT	29°11'14"	114°58'54"	R.T. 32	1,808	L. Permian	Wapet	1967	Dry, p & a
Dongara No. 6	EXT	29°11'41"	114°56'16"	R.T. 29	1,559	Precambrian	Wapet	1967	Dry, p & a
Dongara No. 7	EXT	29°18'36"	115°01'38"	R.T. 47	2,164	L. Permian	Wapet	1968	Dry, p & a
Dongara No. 8	EXT	29°15'08"	115°01'13"	R.T. 54	1,899	L. Permian	Wapet	1969	Oil well
Dongara No. 9	EXT	29°13'24"	115°00'00"	R.T. 87	1,910	L. Permian	Wapet	1969	Gas well
Dongara No. 10	EXT	29°14'17"	115°00'07"	R.T. 72	2,042	L. Permian	Wapet	1969	Gas well
Dongara No. 11	EXT	29°15'59"	115°00'25"	R.T. 67	1,835	L. Permian	Wapet	1969	Gas well
Dongara No. 12	EXT	29°14'18"	115°01'10"	R.T. 29	2,013	L. Permian	Wapet	1969	Gas well
Dongara No. 13	EXT	29°12'46"	114°59'40"	R.T. 88	2,033	L. Permian	Wapet	1969	Dry, p & a
Dongara No. 14	EXT	29°13'26"	115°00'56"	R.T. 77	1,918	L. Permian	Wapet	1969	Oil well
Dongara No. 15	EXT	29°16'29"	115°00'55"	R.T. 66	1,939	L. Permian	Wapet	1969	Gas well
Dongara No. 16	EXT	29°16'13"	114°59'28"	R.T. 29	1,924	L. Permian	Wapet	1969	Gas well
Dongara No. 17	EXT	29°17'06"	115°01'29"	R.T. 82	1,949	L. Permian	Wapet	1969	Oil well
Dongara No. 18	EXT	29°16'29"	115°01'54"	R.T. 105	1,920	L. Permian	Wapet	1970	Gas well
Dongara No. 19	EXT	29°16'14"	115°02'36"	R.T. 114	2,179	L. Permian	Wapet	1970	Oil well
*Donkey Creek No. 1	NFW	29°37'35"	115°17'25"	K.B. 111	3,853	L. Triassic	F.P.C.	1966	Dry, p & a

TABLE 3. WELLS DRILLED FOR PETROLEUM IN DONGARA-HILL RIVER SHEET AREA.—(cont.)

Name	Type	Location		Elevation (metres)	Total Depth (metres)	Bottomed in	Drilled for	Year com- pleted	Status. p & a = plugged and abandoned (abd)
		Lat. (S)	Long. (E)						
*Eganu No. 1	STR	29°59'05"	115°49'35"	D.F. 237	600	U. Jurassic	Wapet	1963	Dry, p & a
*Encabba No. 1	NFW	29°34'14"	115°19'56"	D.F. 127	4,179	L. Triassic	Wapet	1961	Minor oil & gas shows, p & a
Erregulla No. 1	NFW	29°22'28"	115°23'45"	D.F. 237	4,244	L. Permian	Wapet	1966	Minor oil show, p & a
Eurangoa No. 1	NFW	29°07'34"	115°08'10"	R.T. 254	2,277	L. Permian	Wapet	1965	Minor gas shows, p & a
*Heaton No. 1	NFW	29°07'18"	115°12'45"	D.F. 191	2,438	L. Permian	Abrolhos	1972	Dry, p & a
*Hill River No. 1	STR	30°16'00"	115°18'00"	K.B. 112	579	L. Jurassic	Wapet	1962	Dry, completed as water well
* Hill Rixer No. 2	STR	30°11'00"	115°14'00"	K.B. 191	494	L. Jurassic	Wapet	1962	Dry, p & a
*Hill River No. 3	STR	30°00'30"	115°11'15"	K.B. 126	264	U. Triassic	Wapet	1962	Dry, p & a
*Hill River No. 4	STR	30°23'24"	115°13'49"	D.F. 94	308	U. Triassic	Wapet	1962	Dry, p & a
*Hill River No. 4/1	STR	30°21'39"	115°12'03"	K.B. 68	152	L. Jurassic	Wapet	1962	abd
*Hill River No. 4/2	STR	30°21'35"	115°12'34"	K.B. 72	155	U. Triassic	Wapet	1962	abd
*Hill River No. 4/3	STR	30°22'37"	115°13'03"	K.B. 74	155	U. Triassic	Wapet	1962	abd
*Hill River No. 4/4	STR	30°22'32"	115°13'34"	K.B. 87	155	U. Triassic	Wapet	1962	abd
*Jurien No. 1	NFW	30°08'40"	115°02'54"	D.F. 12	1,026	Precambrian	Wapet	1962	Minor gas shows, p & a
Mondarra No. 1	NFW	29°18'51"	115°06'55"	D.F. 83	3,063	L. Permian	Wapet	1968	Gas well
Mondarra No. 2	EXT	29°21'07"	115°06'05"	R.T. 31	2,854	Permian	Wapet	1969	Gas well
Mondarra No. 3	EXT	29°17'32"	115°06'44"	R.T. 103	2,987	Permian	Wapet	1969	Minor oil show, p & a
Mondarra No. 4	EXT	29°19'09"	115°05'58"	R.T. 49	2,895	Permian	Wapet	1969	Minor oil & gas shows, p & a
Mt. Adams No. 1	NFW	29°24'25"	115°10'00"	R.T. 91	3,791	L. Permian	Wapet	1966	Minor gas shows, p & a
Mt. Hill No. 1	STR	29°04'05"	115°58'55"	K.B. 117	565	L. Triassic	Wapet	1964	Dry, p & a
Mt. Horner No. 1	NFW	29°07'42"	115°05'00"	R.T. 200	2,253	L. Permian	Wapet	1965	Oil well
Mt. Horner No. 2	EXT	29°08'41"	115°04'34"	R.T. 155	2,056	L. Permian	Wapet	1965	Dry, p & a
*Narlingue No. 1	NFW	29°04'14"	115°06'10"	D.F. 197	2,130	L. Permian	Abrolhos	1972	Dry, p & a
North Erregulla No. 1	NFW	29°14'44"	115°19'34"	R.T. 167	3,444	L. Permian	Wapet	1967	Minor oil, p & a

TABLE 3. WELLS DRILLED FOR PETROLEUM IN DONGARA-HILL RIVER SHEET AREA. —(cont.)

Name	Type	Location		Elevation (metres)	Total Depth (metres)	Bottomed in	Drilled for	Year com- pleted	Status. p & a = plugged and abandoned (abd)
		Lat. (S)	Long. (E)						
Strawberry Hill No. 1	NFW	29°15'17"	115°07'13"	R.T. 61	2,870	Permian	Wapet	1969	Minor oil shows, p & a
*Walyering No. 1	NFW	30°42'57"	115°27'55"	R.T. 99	3,643	L. Jurassic	Wapet	1971	Gas well
Walyering No. 2	EXT	30°42'08"	115°28'20"	R.T. 104	4,115	L. Jurassic	Wapet	1971	Gas show, p & a
Walyering No. 3	EXT	30°44'01"	115°29'33"	D.F. 96	4,187	L. Jurassic	Wapet	1972	Gas show, p & a
Wedge Island No. 1A	STR	30°49'10"	115°11'25"	R.T. 6	486	U. Triassic	Wapet	1970	Dry, p & a
West White Point No. 1	NFW	29°20'42"	115°02'23"	D.F. 80	2,248	U. Permian	Wapet	1971	Dry, p & a
West White Point No. 2	NFW	29°22'44"	115°02'24"	D.F. 36	2,350	U. Permian	Wapet	1971	Dry, p & a
*Woolmulla No. 1	NFW	30°01'24"	115°11'38"	D.F. 120	2,812	Precambrian	Wapet	1963	Gas shows, p & a
*Yardarino No. 1	NFW	29°13'13"	115°03'10"	D.F. 47	2,377	L. Permian	Wapet	1964	Oil & gas well
Yardarino No. 2	EXT	29°12'22"	115°03'38"	D.F. 92	3,075	L. Permian	Wapet	1964	Dry, p & a
Yardarino No. 3	EXT	29°13'27"	115°03'10"	D.F. 45	2,700	L. Permian	Wapet	1964	Oil & gas well
Yardarino No. 4	EXT	29°13'03"	115°02'39"	R.T. 44	2,490	L. Permian	Wapet	1964	Dry, p & a

ABBREVIATIONS (see also abbreviations used in Table 2):

*	subsidized	STR	stratigraphic test wells	R.T.	Rotary table
abd	abandoned	EXT	extension test wells	D.F.	Derrick floor
p & a	plugged and abandoned	L.	lower	K.B.	Kelly bushing
NFW	new field wildcat	U.	upper		

depth in the Dandaragan Trough below the deepest wells that have been drilled there. However, as the presence of the unit is very conjectural it has not been shown on the cross section or in the stratigraphic table.

PERMIAN

Nangetty Formation

The *Nangetty Formation* (Clarke and others, 1951; amended Playford and Willmott in McWhae and others, 1958) consists of tillite, shale, tillitic sandstone, and conglomerate. It crops out in the Irwin Sub-basin and has its type area in the Nangetty Hills (29°00'00"S, 115°26'30"E). The formation is absent from the Beagle Ridge, but is believed to exceed 1,200 m in thickness in the Dandaragan Trough (Johnstone and Willmott, 1966).

Soil above the formation commonly contains glacial erratics, a particularly striking example being the "White Horse", a quartzite boulder (of Coomberdale Chert) 5.5 m long, 4 m wide and 2 m high.

The base of the formation is not exposed on the Dongara-Hill River Sheet, but in the Irwin Sub-basin it unconformably overlies Precambrian gneiss or Proterozoic Yandanooka Group, while in the Dandaragan Trough it probably overlies either Tumblagooda Sandstone or Precambrian crystalline rocks.

Spores and pollen grains indicate a Sakmarian age (B. E. Balme, quoted in McWhae and others, 1958).

Holmwood Shale

The *Holmwood Shale* (Clarke and others, 1951) consists of grey-green shale and siltstone with thin beds of limestone and rare glacial erratics. It crops out only in the Irwin Sub-basin but is believed to underlie most of the Sheet area. It is thinnest on the Beagle Ridge, and although there is some doubt about the correlations, it appears to be less than 60 m thick in BMR 10A (McTavish, 1965), Cadda No. 1 (Elie and others, 1965) and Jurien No. 1 (Pudovskis, 1963). It thickens eastwards to the type section where it is 555 m thick immediately east of the Sheet area (Playford and Willmott in McWhae and others, 1958). The formation overlies the Nangetty Formation conformably in the east, and Precambrian rocks unconformably in the west. Goniatites indicate a Sakmarian age and, together with the presence of rare erratics, suggest marine deposition with waning glacial influence.

The *Beckett Member* of the Holmwood Shale (Playford and Willmott in McWhae and others, 1958) is a group of limestone beds with interbedded shale, about 11 m thick in its type section, that forms a useful mapping unit in the Irwin River area.

The *Fossil Cliff Member* of the Holmwood Shale (Woolnough and Somerville, 1924, amended Clarke and others, 1951, and Playford and others, in prep.) is a unit of siltstone and richly fossiliferous limestone at the top of the Holmwood Shale cropping out in the Irwin Sub-basin immediately to the east of the Sheet area. The member is lenticular in outcrop, and although it has been correlated with intervals in some wells drilled in the Sheet area, these intervals probably represent a series of discontinuous calcareous lenses at the top of the Holmwood Shale and should not strictly be referred to the Fossil Cliff Member.

The Fossil Cliff Member contains a rich marine invertebrate fauna which is of Sakmarian age (Playford and others, in press).

High Cliff Sandstone

The *High Cliff Sandstone* (Clarke and others, 1951), consists of fine to coarse-grained sandstone and conformably overlies the Holmwood Shale. It crops out in the Irwin Sub-basin immediately to the east of the Dongara-Hill River Sheet. It may be present in the subsurface of the Sheet area, but Johnstone and Willmott (1966) believe that the unit cannot be distinguished from the overlying Irwin River Coal Measures in well sections.

Irwin River Coal Measures

The *Irwin River Coal Measures* (Clarke and others, 1951) are a sequence of lenticular fine to coarse-grained sandstone, conglomeratic sandstone, siltstone, carbonaceous claystone, and sub-bituminous coal. The type section in the Irwin Sub-basin to the east of the Sheet area is 66 m thick (Playford and Willmott in McWhae and others, 1958). Johnstone and Willmott (1966) note that the combined thickness of the High Cliff Sandstone and the Irwin River Coal Measures is constant at about 300 m throughout the Dandaragan Trough and Beagle Ridge areas. The formation is absent from the north-western part of the Dongara-Hill River Sheet area because of pre-Triassic erosion (Johnstone and Willmott, 1966). It conformably overlies the High Cliff Sandstone and contains Artinskian palynomorphs (B. E. Balme, quoted in McWhae and others, 1958).

Carynginia Formation

The *Carynginia Formation* (Clarke and others, 1951; amended Playford and Willmott in McWhae and others, 1958) consists of dark micaceous siltstone with minor beds of fine-grained sandstone. The thickest known section is 349 m in Cadda No. 1 Well (see Johnstone and Willmott, 1966). The formation crops out to the east of the area in the Irwin Sub-basin; it is present in the subsurface throughout much of the Sheet area west of the Urella Fault, except in the northwest where it has been removed by pre-Triassic erosion. The Carynginia Formation conformably overlies the Irwin River Coal Measures and contains spores, pollen and microplankton that indicate a

probable Artinskian age (B. E. Balme, quoted *in* Playford and others, in press). Rare erratic clasts in the formation may have been deposited by floating ice (Clarke and others, 1951).

Mingenew Formation

The *Mingenew Formation* (Maitland, 1919; amended Playford and Willmott *in* McWhae and others, 1958) consists of ferruginous sandstone and siltstone cropping out over a small area east of Mingeneu. The type section is at Simpson Knolls (29°11'50"S, 115°28'02"E), and the main reference section, 90 m thick, is nearby at Enanty Hill. The beds are strongly faulted and form an isolated fault block associated with the Urella Fault. Johnstone and Willmott (1966) regard fossiliferous beds within the Carynginia Formation in BMR 10A and Jurien No. 1 Wells as being equivalent to the Mingeneu Formation, but the sequence appears to be absent in other well sections. The exposures near Mingeneu contain a rich Artinskian marine fauna (Etheridge, 1907; Dickens, 1956, 1963).

Wagina Sandstone

The *Wagina Sandstone* (Clarke and others, 1951) is a medium to coarse-grained sandstone with minor siltstone, conglomerate and coal. It is widely developed in the subsurface of the northern part of the Dongara-Hill River Sheet, and crops out in the Irwin Sub-basin a short distance east of the Sheet. It is at least 242 m thick at Woolaga Creek (G. Playford, 1959) and the thickest subsurface section is some 225 m in Strawberry Hill No. 1 Well. The Wagina Sandstone rests with angular unconformity on older Permian units ranging from the Carynginia Formation to the Holmwood Shale. It contains Late Permian spores, pollen and acritarchs (Balme, 1964a, Segroves, 1971) and is probably a continental fluvial deposit grading into shallow-marine beach sands.

The *Yardarino Sandstone Member* ("Yardarino Sandstone" of Playford and Low, 1972, amended R. G. McKellar *in* Playford and others, in prep.) is a unit of quartz sandstone developed at the top of the Wagina Sandstone in the Yardarino-Dongara area. The unit had been included in the "Basal Triassic Sandstone" by Hosemann (1971) but palynological work by Wapet has now shown that much of the "Basal Triassic Sandstone" is of Late Permian age, and McKellar proposed that this part should be regarded as a member of the Wagina Sandstone. The type section of the Yardarino Sandstone Member is in Yardarino No. 1 Well from 2,284 m to 2,307 m.

TRIASSIC

Kockatea Shale

The *Kockatea Shale* (Playford and Willmott *in* McWhae and others, 1958) is a marine unit consisting of dark shale and micaceous siltstone, together

with minor sandstone and limestone. The formation is widespread in the subsurface of the Dongara-Hill River Sheet and reaches a thickness of 1,061 m in Woolmulla No. 1 Well (Bureau of Mineral Resources, 1964a). The shallowest occurrences are in a fault sliver within the Urella Fault zone at Enanty Hill (Coleman and Skwarko, 1967), and on the Beagle Ridge on the west (Bureau of Mineral Resources, 1964b). The formation rests unconformably on Permian units. The Kockatea Shale yields a rich palynomorph assemblage (Balme, 1963, 1969b), and a variety of megafossils have been described from BMR No. 10 Well (Dickins and McTavish, 1963; Cosgriff, 1965). The fauna includes ammonites that indicate an earliest Triassic age. The formation represents a period of quiet marine deposition, and is in striking contrast to the subsequent Mesozoic deposits, which are largely continental.

Two sandstone members, the *Dongara Sandstone Member* and the *Bookara Sandstone Member*, are recognized in the Kockatea Shale. Both members were previously included in the "Basal Triassic Sandstone" of Hosemann (1971) and the "Yardarino Sandstone" of Playford and Low (1972), much of which are now known to be Late Permian (see above). The Dongara Sandstone Member (McKellar *in* Playford and others, *in* prep.) is a unit of quartz sandstone developed in the Dongara area. The type section is in Dongara No. 11 Well between 1,682 m and 1,701 m where the member is unconformably underlain by Wagina Sandstone; elsewhere it rests on the Carynginia Formation or the Irwin River Coal Measures. The unit is unfossiliferous. The Bookara Sandstone Member (Playford and others, *in* prep.) was first named by P. R. Lehmann of Wapet. The unit consists of feldspathic sandstone, and is best developed in the Bookara-Allanooka area, north of the area underlain by the Dongara Sandstone Member. The type section is in Dongara No. 5 Well from 1,497 m to 1,508 m. The member occurs within the lower part of the Kockatea Shale and is underlain by typical shale of that formation, dated as Early Triassic.

Woodada Formation

The *Woodada Formation* (Willmott and McTavish *in* Willmott, 1964) consists of fine-grained sandstone and siltstone. The type section is in BMR No. 10 Well (29°49'38"S, 114°58'30"E) between 334 and 610 m, and a reference section is in Woolmulla No. 1 between 1,012 and 1,231 m. The formation is known from bores on and near the Beagle Ridge. It reaches a thickness of 276 m in BMR No. 10 Well and thins towards the north and east. The formation grades downwards into the Kockatea Shale and contains diverse Early to Middle Triassic spores and pollen grains, and minor microplankton (Balme, 1969a). The formation represents a regressive phase following deposition of the Kockatea Shale (Willmott and McTavish *in* Willmott, 1964) and may be a deltaic deposit (Balme, 1969a).

Lesueur Sandstone

The *Lesueur Sandstone* (Willmott, Johnstone and Burdett *in* Willmott, 1964) is composed characteristically of coarse to very coarse-grained feldspathic sandstone with prominent large-scale current bedding. The type section is the sequence in Woolmulla No. 1 (30°01'24"S, 115°11'28"E) between 319 and 1,012 m. The formation is exposed in the Cockleshell Gully area and is the oldest unit to crop out in the Dandaragan Trough on the Dongara-Hill River Sheet. The maximum known thickness is 1,035 m in Cadda No. 1 (Elie and others, 1965). The contact with the underlying Woodada Formation is probably disconformable. Balme (1969a) recorded a sparse palynomorph assemblage and regarded the formation as ranging in age from Middle Triassic to Late Triassic or possibly Early Jurassic. A dipmeter study of Dongara No. 17 showed that there the sediments were probably derived from the Beagle Ridge to the southwest (Bird and others, 1971).

JURASSIC

Cockleshell Gully Formation

The *Cockleshell Gully Formation* (Playford, Willmott and McKellar *in* McWhae and others, 1958; amended Willmott, 1964) consists of sandstone, siltstone, shale, claystone and coal. The unit is exposed in the Hill River-Cockleshell Gully area, and the type locality is in the headwaters of Cockleshell Gully between the Peron and Lesueur Faults at 30°07'45"S, 115°11'23"E. The formation is developed throughout most of the Dandaragan Trough on the Dongara-Hill River Sheet and is the best exposed of the Mesozoic formations. Playford and others (*in* McWhae and others, 1958) record the thickness of the type section as 712 m but this cannot be a true thickness as the section is poorly exposed and is faulted. The best-known sequence is in Eneabba No. 1, which penetrated 1,187 m of the formation between depths of 1,790 and 2,977 m (Pudovskis, 1962). The thickest known section is 1,523 m in Donkey Creek No. 1 (Cooper and others, 1967). The base of the formation is nowhere well exposed, but there appears to be a transitional contact with the underlying Lesueur Sandstone in well sections.

Playford and Low (1972) divided the formation into two members: an upper *Cattamarra Coal Measures Member* (amended from "Cattamarra Coal Member" of Willmott, 1964) and a lower *Eneabba Member*. The type section of the Cattamarra Coal Measures Member is the sequence in Eneabba No. 1 between 1,790 and 2,302 m, and the member is characterized by interbedded shale, sandstone and coal seams. The Eneabba Member has as its type section the sequence in Eneabba No. 1 between 2,302 and 2,977 m. This member is characterized by multi-coloured claystone (red, brown, yellow, green, purple, white and grey) and it has been informally referred to as the "Multicoloured Member" in some earlier reports. The two members have not been distinguished in outcrop.

Silicified wood occurs on the surface near the type section, and carbonized plant remains were found in cores from Eneabba No. 1 (White, 1962). Fossil insects were recorded by Riek (1968). Palynomorphs indicate an Early Jurassic age (Balme, 1964b). The formation is believed to be a continental fluvial deposit.

Cadda Formation

The *Cadda Formation* (Playford and others in McWhae and others, 1958) has its type section at 30°24'20"S, 115°16'00"E, near Cadda Spring. The formation contains sandstone and siltstone, grading in places to sandy shelly limestone. In outcrop the strata are generally ferruginized and leached of carbonate, but moulds of small bivalves persist, and the formation is a useful marker bed in mapping an otherwise monotonous Lower Jurassic to Lower Cretaceous sequence. The formation crops out between Cadda Spring and Hill River, and is widespread in the subsurface of the Dandaragan Trough. The type section is about 37 m thick (Playford and others in McWhae and others, 1958) and the thickest known exposed section is about 110 m near Catamouri Hill (Brien and McLellan, 1962). The formation overlies the Cockleshell Gully Formation with apparent conformity and grades northwards into the Champion Bay Group. The limestone beds contain abundant small bivalves (especially oysters) and rare ammonites which indicate a Middle Jurassic (Middle Bajocian) age (Arkell and Playford, 1954). Deposition in a shallow marine environment is indicated.

An isolated outcrop at Enanty Hill correlated with the Champion Bay Group by Coleman and Skwarko (1967) is here ascribed to the Cadda Formation. A shallow bore showed that the sequence is about 24 m thick and consists of coarse-grained sandstone together with minor conglomerate and beds of micaceous claystone and siltstone. The beds occur as an isolated sliver within the Urella Fault zone. Marine megafossils (including one species of ammonite) indicate a Middle Jurassic age.

Chapman Group

The *Chapman Group* (Arkell and Playford, 1954) is developed mainly on the Geraldton Sheet (P. E. Playford, 1959; Playford and others, in press), but it crops out in the extreme north of the Dongara-Hill River Sheet around Mount Hill. Both the *Greenough Sandstone* and the overlying *Moonyoonooka Sandstone* are probably represented there, and they consist of fine to medium-grained sandstone with beds of siltstone, coarse-grained sandstone and conglomerate. Evidence from the Geraldton Sheet indicates that the Chapman Group is a fluvial unit of Early Jurassic age which unconformably overlies the Kockatea Shale. It is believed to be equivalent to the Cockleshell Gully Formation.

Champion Bay Group

The *Champion Bay Group* (Arkell and Playford, 1954) is also developed mainly on the Geraldton Sheet to the north (P. E. Playford, 1959; Playford and others, 1971), where it consists of shallow-water marine sandstone, shale, and limestone of Bajocian (Middle Jurassic) age. It rests disconformably on the Chapman Group and is believed to grade laterally into the Cadda Formation.

The *Champion Bay Group* is represented on the Dongara-Hill River Sheet by one small outcrop area at Mount Hill, where three formations of the group, the *Kojarena Sandstone*, *Newmarracarra Limestone*, and *Colalura Sandstone* (in descending order) are exposed. The *Newmarracarra Limestone* is richly fossiliferous at this locality, containing numerous bivalves, especially *Trigonia moorei*, and some Middle Bajocian ammonites (Arkell and Playford, 1954).

JURASSIC-CRETACEOUS

Yarragadee Formation

The *Yarragadee Formation* (Fairbridge, 1953; amended Playford and others *in* McWhae and others, 1958) consists of interfingering fine to coarse-grained sandstone, siltstone, shale, and conglomeratic beds. The type section lies close to the Urella Fault (29°06'00"S, 115°25'00"E) and is about 30 to 120 m thick (Fairbridge, 1953; Johnson and others, 1954). Playford and others (*in* McWhae and others, 1958) nominated a reference section 150 m thick, 1.6 km north of Cantabilling Springs Homestead at 30°15'00"S, 115°16'40"E. The formation is developed throughout most of the Dandaragan Trough and crops out in small weathered exposures beneath laterite breakaways. Dip and strike measurements made on poorly exposed outcrops of the *Yarragadee Formation* are commonly variable and not very reliable because the beds are lenticular and current bedded, and are probably deformed by compaction and slumping. The thickest drilled section on the Dongara-Hill River Sheet is 2,681 m in Walyering No. 1 (Bird and Moyes, 1971). The formation overlies, with apparent conformity, the Cadda Formation in the Hill River area and the *Champion Bay Group* in the northern part of the Sheet. The "Monksleigh Sandstone" of Johnson and others (1954) is now included in the *Yarragadee Formation*. Fossil leaves (Campbell, 1910; A. B. Walkom, quoted *in* McWhae and others, 1958) and spores and pollen grains (Balme and Ingram quoted *in* Playford and others, *in press*) indicate that the formation ranges from Middle Jurassic to Early Cretaceous in age on the Dongara-Hill River Sheet. The formation is largely a fluvatile deposit.

The *Otorowiri Siltstone Member* of the *Yarragadee Formation* (Ingram, 1967) is a grey marine siltstone about 30 m thick that can be recognized in several of the Arrowsmith River bores (Barnett, 1970) and may extend as far north as Mingenew (Edgell, 1964). It is one of the few instances

where it has been possible to establish lithological correlations between bores drilled in the Yarragadee Formation. The member contains a distinctive palynomorph assemblage of Early Cretaceous micro-plankton together with remanié forms of Jurassic, Triassic, Permian and Devonian ages.

CAINOZOIC

Laterite and Associated Sand

Laterite and associated sand are widely developed over the Mesozoic and Palaeozoic rocks of the Dongara-Hill River Sheet. The typical laterite profile consists of 1 to 3 m of quartz sand overlying 2 to 3 m of pisolitic to massive ferruginous laterite which in turn overlies a zone of kaolinized parent rock which extends to a depth of 30 m or more. The laterite is soft where it is covered by the residual quartz sand and hardens after exposure. The sand-covered laterite surface is preserved in the northern part of the Sheet area, but elsewhere it has been dissected by erosion and the sand has been redistributed down-slope as colluvium and along river valleys as alluvium. The laterite is believed to have formed close to a shallow water table. Near the

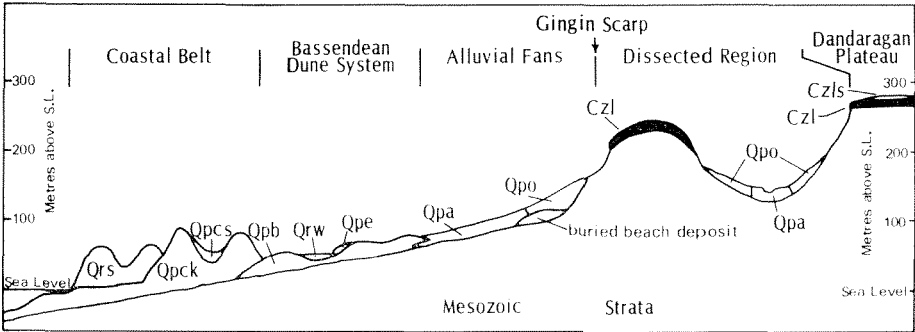


FIGURE 2
DIAGRAMMATIC CROSS SECTION
SHOWING
RELATIONSHIPS OF GEOMORPHIC AND CAINOZOIC UNITS

SEE TABLE 1 FOR KEY TO LETTER SYMBOLS

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coast the laterite crust has slopes reaching 10° and ranges through a vertical interval of a few hundred metres, so the original land surface presumably had an even more rugged topography (Playford, 1954). The age of the laterite is uncertain, but it is believed to be Pleistocene and/or Tertiary. A lower age limit is set by the fact that Upper Cretaceous rocks are lateritized a short distance east of the Sheet area. In the southern part of the Perth

Basin laterization is still proceeding in some areas, and laterite is quite widespread on Pleistocene deposits. However, no modern laterites are known to occur in the northern part of the basin, where the rainfall is less.

The relationships of the geomorphic and Cainozoic units are shown in Figure 2.

Coastal Dune and Beach Sands

Coastal dune and beach sands of several ages are developed on the coastal plain. The youngest deposits are Recent dunes, which are in places mobile and in places fixed by vegetation. They are mapped as the *Safety Bay Sand* (Playford and Low, 1972). The sand is composed chiefly of rounded quartz grains and calcium carbonate grains derived from calcareous algae, foraminifers and molluscs. At Dongara the dunes contain about 80 to 85 per cent calcium carbonate (Woodward, 1916). Some of the older parts of these dunes are weakly lithified, and in some areas (for example west of The Pinnacles), there are rubbly heaps of friable limestone that have been left behind after the bulk of the dune has blown away.

An older set of dunes formed when the sea was 2 to 3 m higher than at present, and these have now lithified to form eolianite. A coral-algal reef that formed at this time is now exposed at Leander Point (Campbell, 1910, p. 84) while a beach deposit with quartz-granule conglomerate and thick-shelled molluscs is exposed in the bed of Cockleshell Gully 5.3 km west of Padbury Homestead. The associated eolian deposits extend several kilometres inland. The molluscs are all living species (G. W. Kendrick, pers. comm.) and the deposit is probably late Pleistocene. Other dune systems that are now lithified formed when the sea was lower than at present and these crop out on the coast and form offshore reefs. The age relationships of these various dune systems are uncertain and all the limestone is traditionally grouped as "*Coastal Limestone*". With prolonged weathering the dunes develop a profile of leached quartz sand overlying a hard cap rock consisting of kankar (sandy accretionary limestone formed in the soil) and indurated and recrystallized eolianite. The cap rock is 1 to 3 m thick and grades down into softer bedded eolianite. Subsequent eastward transport of the superficial sand by wind has resulted in exposure of much of the kankar and limestone on the tops and flanks of dunes on the western side of the ancient dune belt and thickening of sand in hollows on the eastern side.

Inland from the eolianite belt is another belt of subdued dunes composed of leached quartz sand. These appear to be leached remnants of an even earlier dune system and are tentatively correlated with the *Bassendean Sand* (Playford and Low, 1972).

The oldest known beach sand is a rutile-bearing beach sand developed near Eneabba at the base of the scarp that marks the western edge of the dissected region. It is now covered by younger alluvium, colluvium, and eolian sand. The deposit probably formed during erosion of the scarp when the sea was about 100 m above its present level. It may be of early Pleistocene or Tertiary age.

Colluvium

Colluvium mantles the hillsides beneath laterite breakaways and consists mainly of quartz sand washed from above the laterite. It probably does not exceed 10 m in thickness and has been accumulating since dissection of the laterite surface began.

Alluvium

Alluvium occurs over mappable areas in the valleys of some of the larger rivers. It consists of sand and silt and probably does not exceed 10 m in thickness. Alluvium of the modern flood plains is regarded as Recent, and dissected alluvium above that level as Pleistocene. The older alluvium is commonly weakly cemented by clay.

Dune Sand derived from Swamps

Dune sand derived from swamps forms lunette dunes around the margins of ephemeral swamps. The dunes are composed of quartz sand and are about 3 to 10 m high. They are developed mainly on the eastern sides of swamps, indicating a dominantly westerly wind, although swamps near Minyulo Brook are surrounded by dune sand indicating approximately equal rates of deposition by winds from all directions.

Swamp Deposits

Swamp deposits of peaty sand occur in interdunal swamps on the coastal plain. They are forming at the present time, and probably do not exceed 3 m in thickness. In some valleys, colluvium was washed from the sides faster than the central stream could remove it, and the valleys became blocked, giving rise to swamps. Some of these swamps contain diatomite as well as sand. Large lakes and swamps also occur where rivers are blocked by coastal dunes, and clay is the dominant sediment.

Lagoonal Deposits

Lagoonal deposits are found near the coast between and within dune systems. They are filled with gypsiferous, calcareous, saline clay a few metres thick.

STRUCTURE

The Dongara-Hill River Sheet covers part of the Perth Basin and includes parts of the following basin subdivisions—Beagle Ridge, Dandaragan Trough,

and Irwin Sub-basin (Fig. 3). The basin extends westwards beneath the continental shelf and in recent years offshore geophysical surveys have been carried out there. However, the subsurface structure of the shelf is beyond the scope of these notes and only the onshore structure will be discussed.

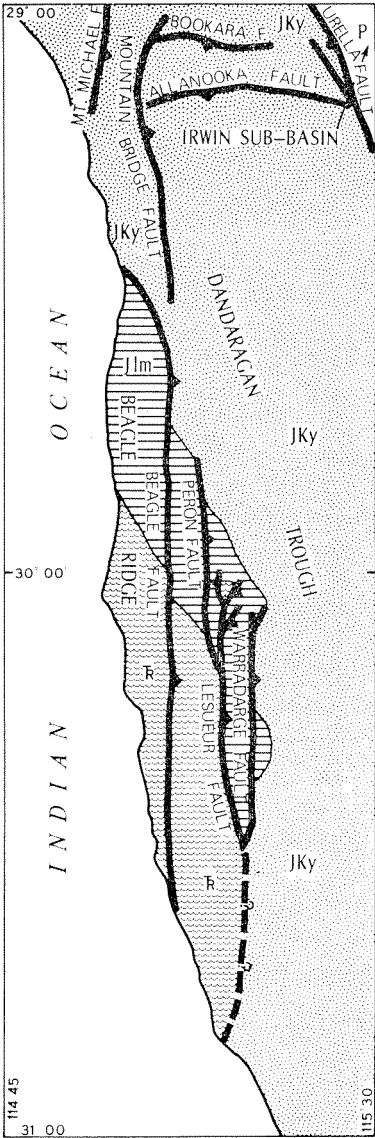
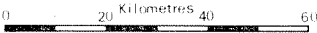






FIGURE 3
SKETCH MAP OF SOLID GEOLOGY
DONGARA-HILL RIVER GEOLOGICAL SHEET
SCALE



REFERENCE

-  YARRAGADEE FORMATION :
Middle Jurassic to Lower Cretaceous
-  CADDA FORMATION: Middle Jurassic, and
COCKLESHELL GULLY FORMATION :
Lower Jurassic
-  VARIOUS FORMATIONS :
Triassic
-  VARIOUS FORMATIONS :
Lower Permian

Fault 

The *Dandaragan Trough* (Thyer and Everingham, 1956) forms the deepest part of the basin on the Dongara-Hill River Sheet and is known to contain a thick sequence of beds ranging in age from Permian (or possibly Silurian) to Early Cretaceous. An aeromagnetic survey was interpreted by Quilty (1963) as showing a maximum depth to magnetic basement of 6,000 m but the basin is probably much deeper. Eneabba No. 1 Well penetrated 4,179 m of section without reaching the Permian, and Johnstone and Willmott (1966) show a cross section through Jurien Bay with basement reaching a depth of 15,000 m.

The *Beagle Ridge* (McTavish, 1965) is an elongated area of shallow basement on the western side of the basin. Jurien No. 1, drilled on the crest, encountered basement at a depth of 976 m after penetrating thin Permian and Triassic sequences.

The *Irwin Sub-basin* (Playford, 1971), formerly called the "Irwin Basin" (Clarke and others, 1951) lies between the Urella and Darling Faults and part of it occurs in the northeast corner of the Dongara-Hill River Sheet. The sub-basin contains a thick Lower to Upper Permian sequence, but only the lower part is present in the Sheet area.

FAULTING

The *Urella Fault* (Woolnough and Somerville, 1924) separates the Irwin Sub-basin and Dandaragan Trough. At the surface on the Dongara-Hill River Sheet, the fault juxtaposes Yarragadee Formation against Nangetty Formation — a downthrow to the west of at least about 6,000 m. At Enanty Hill the movement is distributed over several closely spaced faults, and Middle Jurassic beds crop out in the fault zone (Coleman and Skwarko, 1967).

The *Beagle Fault* (Bureau of Mineral Resources, 1964c) separates the Beagle Ridge from the Dandaragan Trough. The fault is concealed by Quaternary deposits and has been mapped by geophysical methods. It has a downthrow to the east of about 2,000 m.

The *Lesueur, Warradarge and Peron Faults* (Bureau of Mineral Resources, 1964c; Johnstone, 1964) are a northward-branching series of normal faults downthrowing to the east. The faults can be traced in places on the surface by resistant outcrops of strongly ferruginized sandstone. The jointing of the outcrops suggest that the faults dip eastwards at 60 to 80°. The Mount Michael, Mountain Bridge, Bookara, and Allanooka Faults (Fig. 3) have been mapped by seismic surveys.

Some of the major faults are probably growth faults active during the subsidence of the basin. Faulting probably reached its climax in the Early Cretaceous (Neocomian) and there has been very little faulting since that time.

FOLDING

Surface mapping in the Hill River area shows that the general structure is one of tilted fault blocks with associated marginal folds. Seismic surveys have identified similar folds in other parts of the Sheet area.

ECONOMIC GEOLOGY

PETROLEUM

Drilling in the Dandaragan Trough has revealed traces of hydrocarbons in all formations from the Irwin River Coal Measures to the Cockleshell Gully Formation. Oil and gas were found by Wapet at Yardarino in 1964, oil and gas at Dongara in 1966 to 1970, gas in the Mondarra wells in 1968 to 1969, and gas at Walyering in 1971. A 36 cm gas pipeline, 410 km long, has been constructed between Dongara and Pinjarra to exploit these fields. The reservoirs in the Dongara area are the Yardarino Sandstone Member of the Wagina Sandstone, Dongara Sandstone Member of the Kockatea Shale, and sandstones in the Irwin River Coal Measures, while at Walyering the gas is in sandstones of the Cattamarra Coal Measures Member of the Cockleshell Gully Formation. Probable sources of petroleum are the dark marine shales of the Kockatea Shale and the coals and carbonaceous beds of the Irwin River Coal Measures and Cockleshell Gully Formation. The Yardarino Sandstone Member is commonly a good reservoir but it has a limited and irregular distribution and in places is strongly silicified. Other formations commonly have poor reservoir characteristics because the sandstones are poorly sorted and some have had their porosities reduced by the formation of secondary clay minerals (Brien and McLellan, 1962) and silica (Caldwell *in* Bird and Moyes, 1971).

Seismic methods have been used in exploration for suitable structures, but such methods have proved difficult to apply because of the deep weathering in some areas and superficial cavernous limestone in others (Taylor, 1969). Table 3 lists the wells that have been drilled in the search for petroleum, and Table 2 lists geophysical surveys which have been subsidized by the Commonwealth for which there are reports available for public inspection.

UNDERGROUND WATER

The underground water potential of the Perth Basin has long been recognized (Maitland, 1903) and groundwater is exploited in most parts of the Dongara-Hill River area for use by towns and farms. In the Irwin Sub-basin, however, the Permian strata contain water too saline even for stock, and earth dams are constructed to hold surface water. In the Dandaragan Trough sandstones in the Yarragadee and Cockleshell Gully Formations yield water that is often suitable for domestic use (less than 1,000 ppm total dissolved solids) and are almost always suitable for stock (less than 10,000 ppm TDS). Most farms in the area have bores about 30 m deep for stock supplies. Permeable sand-

stone beds in the Yarragadee and Cockleshell Gully Formations are lenticular and bores in these units are drilled until a suitable permeable bed is encountered. Hydrogeological studies have been made in the area for supplying water to four towns: Morawa and Perenjori (Barnett, 1970); Geraldton (Allen, 1965); and Jurien (Berliat, 1963; Berliat and Morgan, 1962; Milbourne, 1966). Numerous exploratory bores were drilled around the Arrowsmith River on the eastern edge of the Sheet area, and Morawa and Perenjori are now supplied with about 1,400 m³/d from two aquifers in the Yarragadee Formation. Most of Geraldton's supply now comes from near Allanooka Swamp where a group of bores extract about 10,500 m³/d from the Yarragadee Formation at a depth of 12 to 30 m. An exploratory water bore, Jurien Bay No. 1, encountered water with a salinity of 49,300 ppm in Triassic strata, indicating that domestic supplies cannot be obtained from these aquifers on the Beagle Ridge. Jurien and other settlements along the coast obtain water from Quaternary sand and limestone, but in some areas the supplies are limited and the salinity is too high for domestic use.

COAL

Coal seams occur in the subsurface in the Irwin River Coal Measures in the northern part of the Sheet area (Johnstone and Willmott, 1966). In the Dandaragan Trough the beds are far too deep to be commercially exploited and even in the shallowest part of the Beagle Ridge, in Jurien No. 1, the seams occur at a depth of 680 to 889 m (Pudovskis, 1963). In that bore the coal had coking properties and occurred as nine seams, none more than 1.5 m thick.

The Cattamarra Coal Measures Member of the Cockleshell Gully Formation in Eneabba No. 1 contains 22 seams of weak coking grade coal with a total thickness of 12 m. Exploration by Wapet located the member at shallow depths in the Hill River area, but the seams were too thin and too low grade to be of value (Johnstone, 1964). However, recent exploration has indicated that there are some thicker seams at shallow depths farther north, near Eneabba.

Coal also occurs in the Yarragadee Formation (see for example Yardarino No. 1) but the seams are too thin and of too poor quality to be of commercial interest.

HEAVY MINERAL SANDS

Sand rich in rutile, ilmenite and other heavy minerals has been discovered near Eneabba along an ancient shoreline that forms the western boundary of the dissected region. The sand is probably a beach deposit of late Tertiary or early Pleistocene age that accumulated in an embayment of the old coast (see Fig. 1) in a similar manner to the ilmenite deposits of Geographe Bay.

The minerals were probably derived from Mesozoic strata by rivers, or by waves during erosion of the scarp. The geology of these deposits has recently been described by Baxter (1972), and Lissiman and Oxenford (1973).

GUANO

A few tonnes of phosphatic material (guano) have been mined for fertilizer from some of the limestone caves (for example Moorba Cave). The material was formed by the action of bat excreta on calcareous cave debris.

GYPSUM

Minor deposits of gypsum occur in interdunal depressions at Dooka and Cliff Head, 11 km and 32 km respectively south of Dongara (de la Hunty and Low, 1958).

LIME SAND AND LIMESTONE

Extensive Recent sand dunes along the coast contain a high percentage of calcium carbonate which reaches 80 to 85 per cent at Dongara (Woodward, 1916). The grade is controlled by the relative proportion of the two main components, quartz sand (from rivers) and bioclastic calcium carbonate (from the sea bed), and since the relative rate of supply will have varied in time and place, the grade of the lime sand can also be expected to be variable.

Extensive deposits of eolian limestone along the coast are presumably about as rich in calcium carbonate as the Recent dune sand, but no analyses are available.

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