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EXPLANATORY NOTES ON THE YARRIE 4-MILE GEOLOGICAL SHEET.

by

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INTRODUCTION

The Yarrie Sheet covers the area between latitudes 20° and 21° south and longitudes 120° and 121°30' east. Yarrie Station is 130 miles by road from Port Hedland. The Sheet includes two contrasting physiographic divisions: highlands with adjacent river flats that are used for cattle and sheep raising, and the desert area. It covers part of the south-western margin of the Canning Basin. The southern part, which has been settled by white people, is easily accessible by several roads and many station tracks; access to the desert area to the north is more difficult. An old road connects Yarrie Station in the south with Wollal Station on the coast to the north, and water can be obtained at wells about 20 miles apart along this route. The desert can also be reached by an old track following the Overland Telegraph Line which connects Marble Bar through Talga-Talga and Callawa Stations to LaGrange. Both tracks are in too bad condition for any but four-wheel-drive vehicles. Water can be obtained along the Telegraph Line at a catchment tank about 40 miles north-east of Callawa Homestead; but none of the water supplies so far mentioned can be relied upon, and any future parties working in the desert must carry ample supplies of water and food for the duration of the traverse. Areas east of the Yarrie Sheet can be reached from the Overland Telegraph Line, which lies parallel to the sand dunes, thus eliminating time-consuming dune crossings.

History of Investigations

Most geological reconnaissance has been concentrated on the Upper and Lower Proterozoic rocks on the south-west part of the sheet; only the margins of the desert area had been geologically reconnoitred before the recent survey by the

Bureau of Mineral Resources.

Several important early expeditions started or finished in this area. One of these was the journey of Warburton (1875), who crossed the desert from Alice Springs to the Oakover River. The first surveyor to work on the desert margin was A.C. Gregory, who surveyed the area of the Nullagine and Oakover Rivers in 1861. Smith (1898) traversed the Oakover-Nullagine River area to see if artesian water could be obtained. Maitland (1904) was the first geologist to undertake extensive and comprehensive work in the Pilbara area, and his results were the basis for all future workers. He also reported on individual workings in the Pilbara Goldfield (Maitland, 19(, and described the Oakover Beds and the Nullagine dolomite in the Oakover River area.

Blatchford (1924) surveyed the Precambrian margin of the desert in the Isabella Range area. He described the Braeside mine 1 belt and indicated areas of lead, vanadium, and manganese mineralization.

Clapp (1925) recognised and named the Braeside Tillite in the Oakover-Nullagine River area, and assigned to it a pre-Jurassic, possibly Permo-Carboniferous, age. He correlated the rocks with the Wilkinson Range Series. He found (1926) no structures or seepages that would indicate oil, and considered that commercial deposits of oil were unlikely to occur in the "Desert" Basin.

Harris (1926) gave a brief account of the geology of the Braeside Lead field, dealing mainly with lead mining and transport. He also mentioned Jurassic? mesas and buttes west of Braeside Station.

Between 1936 and 1939 the Aerial Geological and Geophysical Survey of Northern Australia carried out geological and geophysical surveys in the Pilbara area. Finucane (1936) described the Bamboo Creek Mining Centre together with details of the individual mines. An electro-magnetic survey of this area was carried out by Blazey, Rayner & Nye (1938). A general summary of survey results is given in A.G.G.S.N.A. Report for the period ended 31st December 1937, which includes descriptions of the Pilbara area and various mine workings. Finucane (1938) discussed the geology of the Braeside Lead Field and individual areas.

Bremner (1942) made several flights over the southern margin of the basin so as to delineate the southern margin of the basin and determine if Devonian rocks were present. Reeves (1949) carried out extensive aerial and ground geological reconnaissance in the Fitzroy and Canning Basins for the Vacuum Oil Company. He described Jurassic plant fossils from Callawa Hills, and showed that the Basin is composed of essentially subhorizontal Permian and Mesozoic sediments.

In 1953 the Sheet area was photographed by the R.A.A.F. from 25,000 feet, giving vertical coverage at a scale of approximately 1:50,000. Semi-controlled 4-mile photo-mosaics made by the National Mapping Division were used for geological compilation of the present map. A one-mile photo-map series of the sheet has been planned by the Western Australian Government. Contact prints are available of a planimetric compilation produced by the Western Australian Lands and Surveys Department at a scale of 1:48,000, covering the Yarrie sheet. A planimetric 4-mile map of the Sheet produced by the Royal Australian Survey Corps is now being replaced by a similar map produced by the Lands and Surveys Department.

A geological party from the Bureau of Mineral Resources which investigated the area in 1954 (Traves, Casey & Wells, 1956) was the first to use conventional four-wheel-drive vehicles for cross-country travelling in the desert area. State Lands and Surveys Department surveyors accompanied the party and observed astrofixes at several localities. The conditions encountered and methods of investigation are described by Traves & Casey (1954).

In 1954 the Geophysical Section of the Bureau of Mineral Resources made an airborne magnetometer reconnaissance of the southern areas of the basin, of which one traverse, between Marble Bar and Christmas Creek, crosses this sheet; and in 1955 the Section made an airborne reconnaissance scintillograph survey of part of the Pilbara area (Parkinson and Daly, 1955), which included the south-western part of the Yarrie Sheet.

In 1956 surveyors from the Department of the Interior, carried out levelling along roads in the south-western corner of the sheet and along the Yarrie-Wollal track. One ast[illegible]ix was observed by this party at No. 3 Desert Well along this track. Th[illegible] results of these astrofixes observed by both parties are as follows (astr[illegible]ixes observed by the State Lands and Surveys Party ar[illegible] prefixed by the letters BC and one by the Department of Interior Party by AT):

STATION	LATITUDE	LONGITUDE	EASTING	ne 2 NORTHING
BC 4	20° 09' 24.15"	121° 19' 04.80"	436358.4	2477460.8
BC 6	20° 15' 57.75"	120° 57' 38.55"	395510.8	2464258.5
BC 7	20° 36' 57.84"	120° 29' 55.50"	342858.9	2421794.0
BC 8	20° 36' 56.50"	120° 03' 00.45"	291713.9	2421611.0
BC 9	20° 32' 11.26"	120° 00' 34.05"	287019.3	2431177.2
BC 19	20° 51' 02.2"	120° 41' 52.95"	365630.8	2393452.7
BC 20	20° 59' 57.27"	120° 03' 29.7"	292911.4	2375174.0
AT 42	20° 17' 34.4"	120° 22' 49.8"	-	-

PHYSIOGRAPHY

The topography of the area falls into three categories: the dissected hills of the south-western area bordering the desert, the alluvial flats and wide valleys of the O[illegible]over—Nullagine—De Grey River System, and the desert area, corresponding to the southern part of the Canning Basin. The first two divisions form part of the Pilbara Block and as they are intimately related they will be discussed together.

Dissected Hills and River Valleys This area consists mainly of resistant low ridges and dissected hills of Precambrian rocks that strike north-westerly. Areas of granite in this division form extensive plains on either side of the major rivers. Drainage is well developed and dissection moderate. The altitude ranges from about 350 feet on the granite plain near Muccan Station to about 700 feet, which is the average height of the highest peaks of the isolated ranges.

The major drainage channels, the De Grey, Nullagine, and Oakover Rivers, are at grade and have wide alluvial valleys and detritus-strewn courses. The rivers are braided and many old deserted courses are visible on the aerial photographs. The upper reaches of the Oakover and Nullagine Rivers cut through Precambrian rocks and form steep gorges in which lie permanent pools. The smaller streams of the higher ranges lie in almost V-shaped valleys and generally leave little detritus on the valley floor.

Desert Division The desert covers about two-thirds of the sheet area. It is characterized by scattered small breakaways and rises, abundant red sand commonly formed into seif dunes, a scant vegetation consisting chiefly of spinifex, and the absence of any major drainage channels. There is hardly any relief and the altitude ranges from about 205 feet at No. 2 Desert Bore to 630 feet 7½ miles south-west of the catchment on the Telegraph Line.

The isolated mesas of Palaeozoic and Mesozoic rocks of the desert do not rise more than about 50 feet above the level of the surrounding sand plain. The mesas and buttes close to the basement rocks north of Yarrie and Callawa Stations, however, are up to 200 feet high and a few have a poorly developed radial drainage pattern.

Only vestigial streams drain the isolated rises of the desert; they mostly end abruptly on the sand plain. Any alluvial deposits formed by these streams have been assimilated by the wind-blown sand deposits. The greater part of the drainage is subterranean.

The innumerable parallel seif dunes in the central and south eastern areas trend west-north-west, average 40 feet in height, and on this sheet are up to 25 miles long without a break. Braiding of the dunes produces several parallel crests and a complex system of anastomosing branches. The dunes end abruptly against the eastern margin of any obstruction such as small hills or mountain ranges, but generally continue unobstructed over low rises.

The history of the Nullagine-Oakover River System can be traced back to Permian times, when it formed in valleys filled with the Braeside Tillite. In the Tertiary Period the river valley was occupied by a lake or series of lakes in which was deposited the Oakover Beds. After capture of the Oakover-Nullagine system by the westerly flowing De Grey River, the rivers cut back from their heads and dissected the Oakover Beds, producing mesas and buttes 100 feet high. Well graded slopes on the hills of the highland areas are rare: rock outcrops and rugged hill profiles still persist and no piedmont plains have been formed.

The northern desert area has developed quite differently. A period of lateritization affected some of the probably peneplaned sediments. A later cycle of desert weathering resulted in a plain of arid erosion at a lower level, which left the isolated breakaway scarps common in the area. Seif dunes are now partly fixed; so during their initiation, growth, and migration to their present position, the climate must have be very much more arid than at present. The iron-coated sand forming the dunes has originated from the easily eroded arenaceous rocks or the laterite, or both; the disintegration of the country rock has been accelerated by an arid climate; and bi-directional winds have formed the sand into seif dunes.

STRATIGRAPHY*

The Yarrie sheet includes outcrops of almost horizontal sedimentary rocks of Permian and Mesozoic age resting unconformably on Precambrian metamorphic, sedimentary, and igneous rocks. The topography of the floor of the Canning Basin is almost unknown, but aeromagnetic traverses along the coastal areas north-west of the sheet indicate that parallel downwarps may be present.

The Precambrian of the Pilbara Block, part of which is included on the Yarrie sheet, was divided into Nullagine Beds, Mosquito Creek Beds, and Warrawoona Beds by Maitland (1904). He suggested that the Warrawoona Beds may be intimately related to the Mosquito Creek Beds; both are generally referred to as Archaeozoic in Western Australia. The Nullagine Beds rest on both these units with a marked unconformity (Maitland, 1919). Forman (1937) and Finucane (1939) both described an unconformity between the Warrawoona Beds and the Mosquito Creek Beds.

Geologists of the Bureau of Mineral Resources have placed the sediments of the Kimberley Plateau in the Upper Proterozoic (Traves, 1956; Guppy, Lindner, Rattigan, and Casey, 1958) and the metamorphosed rocks below, such as the Hall's Creek Metamorphics (Traves, 1956), are placed in the Lower Proterozoic. Because of confusion in nomenclature and the lack of detailed mapping by the Bureau of Mineral Resources in the Precambrian of the Yarrie Sheet up to the time the map went to press, the rocks have not been formally named, but broadly described under the headings of Lower and Upper Proterozoic.

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* Specimen localities are marked on the Sheet by numbers, e.g. Y23, and specimens are housed in the Bureau of Mineral Resources Museum, Canberra.

TABLE I - STRATIGRAPHY OF THE YARRIE SHEET

AGE	MAP SYMBOL	FORMATION	APPROXIMATE THICKNESS (feet)	LITHOLOGY	FOSSILS	TOPOGRAPHY	ECONOMIC GEOLOGY	TIME EQUIVALENT
RECENT	Qa		50	Alluvial clays, gravels & boulder beds.	-	Confined to valley floors & river systems	Water	Similar deposits occur in neighbouring parts of the basin.
	Qy		10	Soil, grey gypsum bearing	-	Confined to coastal area. Small deposits	-	
	Qs		130	Aeolian sand. Stained red by hematite.	-	Sand plains & seif dunes covering Palaeozoic & Mesozoic sediments.	Water	
	Ql		10	Travertine	-	Small deposits, particularly in desert area.	"	
TERTIARY	To	OAKOVER BEDS	100	Lacustrine marl & limestone with chalcedonic capping.	Traces of ostracods	Mesas & buttes	-	
	Not mapped	Laterite	20 +	Lateritic & pisolitic ironstone	-	Cappings on mesas & rounded rises	Road surfacing	Sporadic cappings in other parts of the Canning Basin.
CRETACEOUS	Ka	ANKETELL SANDSTONE	100	Marine sandstone, shale & claystone.	Rhizocorallium & foraminifera on the Anketell Sheet.	Low small flat topped outcrops.	-	May be equivalent to Frezier Sandstone (Lindner & Drew, in McWhae et al. 1958), to beds at Rumbalara, N.T., & to Dampier Group (Brunnschweiler, 1957).
JURASSIC-TRIASSIC	Ms	Undifferentiated Mesozoic including CALLAWA FORMATION.	250	Current-bedded coarse sandstone alternating with coarse conglomerate, probably passing into marine fine grained clastics basinwards.	Abundant plants	Mesas & buttes especially near basin margin, low rises in desert.	Water	Possibly part equivalent to Erskine Sandstone of Fitzroy Basin & possibly Parda Form. (Lindner & Drew, in McWhae et al, 1958).
			DISCONFORMITY					
PERMIAN	Pc	CUNCUDGERIE SANDSTONE (basal Artinskian)	130	Ferruginous coarse to fine sandstone. Some conglomerate & greywacke	Marine fossils abundant in restricted horizons.	Coarse sandstone, resistant; generally low rises.	Water	Nura-Nura member of Poole Sandstone, Fitzroy Basin.
	Pb	BRAESIDE TILLITE (?Sakmarian)	400	Fluvioglacial deposits with slumping, contortion & striated boulders. Some varves.	-	Low relief, capped by Oakover Beds in most cases.	-	Paterson Formation on Paterson Range sheet. Grant Formation of Fitzroy Basin & Lyons Group of Carnarvon Basin.
			ANGULAR UNCONFORMITY					

UPPER PROTEROZOIC	Pub	20	Coarse breccia with angular chert fragments.	-	Follows topography of dolomite.	Small deposits of manganese, replace breccia	Upper Proterozoic succession of the Kimberley Plateau and Nullagine "Series" of Pilbara area.
	Puv	500	Basaltic lavas, probably of different ages & separate flows	-	Valley flows producing undulating country.	-	
	Pup	100-3800	Quartz-feldspar porphyry intruded as sill into base of U. Proterozoic succession; hornblende porphyry sills invade sandstones.	-	Undulating hills & small plateau	Disseminated radioactivity	
	Pul	1000	Dolomitic limestone with sporadic chert & slump structures. Very sandy in some sections.	-	Linear low ridges, rugged topography due to differential hardness.	Lime in selected areas.	
	Pus	1200	Arkosic sandstone with red micaceous shale at base. Sandstone well jointed, medium to coarse grained.	-	Sharp ridges. Shale in gullies.	-	
			ANGULAR UNCONFORMITY				
LOWER PROTEROZOIC	Plg	-	Subsequent batholiths of granite intruded by quartz reefs & dolerite dykes. Some gneissic granite.	-	Large open plains country. Dykes resistant & form linear ridges.	Alluvial & residual tin at Talga-Talga.	Probably part equivalent of Lamboo Complex and Halls Creek Metamorphics of Fitzroy Basin, and Warrawoona "Series" of Pilbara area.
	Plm	Thousands of feet	Basic volcanics, quartz & mica schist, talc-chlorite-carbonate schist, dolomitic marble, banded hematite-jasper, slate & possibly pillow lavas.	-	Dissected mountain ranges & hills with moderate relief.	Gold at Bamboo Creek. Small deposits of copper, vanadium, & lead in Isabella Range.	

The post-Precambrain sediments are represented by a small thickness of predominantly clastic rocks containing few fossils. Selected rock specimens from the Yarrie sheet have been described by Lovering (1956).

<u>Lower Proterozoic Rocks</u>

<u>Metamorphics</u>: The predominant rock types in the Bamboo Creek area are " greenstone", calcareous schist, and marble. These rocks are assigned by the Geological Survey of Western Australia to the "Warrawoona Series". The " greenstones" are derived from tuffaceous and other sedimentary rocks as well as basic volcanics.

"Greenstone", and calcareous schist with pseudomorphs of limonite after pyrite, crop out at Y58. Slate and calcareous and hornblende schists are unconformably overlain by banded hematite-jasper in the hills north of Yarrie homestead. A similar hematite-jasper is faulted against slate at Mt. Cecilia.

A large area of rocks in the Lochinvar-Isabella Range area has been mapped as Lower Proterozoic Metamorphics. The present opinion of the Geological Survey of Western Australia, based on mapping of the adjacent Nullagine Sheet since the Yarrie Sheet was mapped, is that they are Upper Proterozoic (Nullagine "Series") and are to be correlated with other Upper Proterozoic rocks cropping out farther west and south-west.

<u>Igneous Rocks</u>: Granite forms synchronous batholiths and is possibly a late tectonic intrusion. Many of its margins are gneissic and the associated dykes are not folded; but in neighbouring areas granite has been somewhat faulted and deformed. Quartz and quartz dolerite dykes are abundant, particularly near the contact of the granite with the metamorphics, and the quartz dolerite has been mapped as intrusive into the Lower Proterozoic metamorphics by the Geological Survey of Western Australia.

<u>Upper Proterozoic</u>

The oldest sediments of the Upper Proterozoic (Nullagine "Series") in the Bamboo Creek area are predominantly arkosic sandstone, and some red shales and conglomerates overlain probably conformably by dolomite and limestone, although exposures are partly obscured by overlying volcanics. The more resistant beds of sandy limestone protrude through the volcanics as linear ridges. About 10 miles north-east of Bamboo Creek Mine the limestone shows wavy bulbous laminated structures from 1/4" to 2 feet across which are probably slump structures.

At the northern end of the Isabella Range near Barramine beds of dolomite are overlain by a siliceous breccia. This breccia is regarded by the author as a residual deposit mainly derived from the chert and insoluble residues from the dolomite. The breccia conforms to the contours of the eroded dolomite surface and fills the interstices and any irregularities of the surface.

Small fragments of dolomite occurring at Y87 and limestone with shale and sandstone at Moxams Mill are probably both Upper Proterozoic. At Cundaline Gap dolomitic shale is overlain by calcareous siltstone, followed by a porcellanite, the whole sequence overlying a Lower Proterozoic banded hematite-jasper. Intrusions and extrusions of a dioritic magma have baked the shales.

A sill of quartz-feldspar porphyry intrudes the Upper Proterozoic rocks at the unconformity with the Lower Proterozoic Metamorphics. At Y44 and Y45 the porphyry has an apparent dip of 18^{o} to the S.W. and intrudes and bakes the Upper Proterozoic shale above it. Small hornblende porphyry sills that intrude the overlying arkosic sandstone may be genetically related to the larger porphyry sill.

The basic volcanics were poured out on a surface that had as much as 300 feet relief. In neighbouring areas there is evidence of volcanic activity during the deposition of the dolomite and two periods of volcanic activity may be present.

Permian

The Permian rocks on the south-eastern quarter of the sheet consist mostly of the basal Permian glacials of the Braeside Tillite (Clapp, 1925). Between the Oakover and Nullagine Rivers the Tillite is exposed at the base of mesas and buttes of the Tertiary Oakover Beds. At Y35 at the head of Eel Creek there is evidence of a moraine with numerous subrounded striated pebbles and boulders. 50 feet of varved shale overlies the moraine and at Y22 is in turn disconformably overlain by a Mesozoic sandstone. The Braeside Tillite was at least in part a terrestrial deposit formed by glaciers flowing down the Nullagine-Oakover Valley, whereas the Paterson Formation on the neighbouring Paterson Range Sheet was possibly deposited in a marine environment.

One or two outcrops of the overlying Cuncudgerie Sandstone (Traves et al., 1956) in the south-eastern part of the Sheet were mapped by photo-interpretation only.

Mesozoic

Permian and Mesozoic sediments are in many places difficult to distinguish because they are both predominantly ferruginized sandstone. Two lithological units in the Mesozoic are given the rank of formation: the Callawa Formation and the overlying Anketell Sandstone (Traves et al., 1956).

The Callawa Formation overlies the Braeside Tillite with an erosional break; the Callawa Formation fills the irregularities caused by scouring of the underlying surface. The conglomerate in the formation grades basinwards into finer sediments probably deposited in a marine environment.

The boulder conglomerate of the Callawa Formation is confined to the northward continuation of the Oakover and Nullagine River systems, and may be a deltaic conglomerate deposited near a river mouth at the margin of a large fresh-water Jurassic lake; the river system probably flowed northwards during the Mesozoic Era. The age of the Callawa Formation is either Upper Triassic or Lower Jurassic (for plant fossil determinations, see Brunnschweiler in Traves et al., 1956).

The Anketell Sandstone (Traves et al., 1956) caps the Callawa Formation in many places. Foraminifera and Rhizocorallium found in specimens from the adjacent Anketell Sheet indicate that the formation is of Cretaceous age and was laid down in marine or brackish cold water.

Tertiary

At least parts of the area were lateritized. Between Yarrie and Wollal some of the isolated sandstone hillocks show evidence of lateritization. The laterite is older than the Tertiary Oakover Beds, as it has been eroded and incorporated in the beds.

The Oakover Beds form mesas and buttes in the Oakover River Valley and on the northern end of the Isabella Range. They are nowhere overlain by any other unit. The Oakover Beds are a chemical lacustrine deposit in the old Oakover River Valley. The only fossils so far found in the formation have been a few ostracod tests which contained grains of glauconite, probably washed into the lake from a nearby sea. The lake was probably formed in the Tertiary Period by a blockage of the Oakover Valley by the Jurassic and Cretaceous sediments.

Quaternary

A great variety of superficial deposits, probably of Quaternary age, overlies and conceals bedrock throughout the region; the most widespread of these deposits is wind-blown sand. In the coastal belt near Wollal Station, the sand is white and has been blown and washed into low irregular coastal dunes. In the seif dunes of the interior, the sand is ironstained quartz, red and brown. The interdune valleys have a floor of sand; the depth to bedrock is unknown, but travertine protrudes through the sand in places.

Only the larger river systems on the Yarrie Sheet have valleys filled with alluvium.

STRUCTURE

The Precambrian rocks can be divided into an older tectonic unit of metamorphics and granitic rocks and a younger unit of sediments and volcanics, generally only moderately deformed, and resting unconformably on the older rocks.

The Lower Proterozoic Metamorphics are complexly folded and probably form roof pendants on the Lower Proterozoic granite. The undeformed sediments of the Upper Proterozoic generally show dips of the order of 15°; faults are common. Only remnants of the sediments, lying in synclinal folds, have escaped erosion, and the Lower and Upper Proterozoic rocks are probably similarly distributed beneath the Canning Basin Sediments. The earliest known sedimentation in the basin is Permian, although older Palaeozoic formations may have been concealed by overlap. The Mesozoic sediments lie unconformably on the eroded surface of Permian rocks. The total measured thickness of sediments is about 1000 feet; but recent airborne magnetometer traverses have indicated large parallel north-west-trending depressions in the basement which may contain a large thickness of sediments. A sharp increase of 3000 gammas occurs about 15 miles east of Warrawagine (see Fig. 1) and corresponds to the north-west-trending rocks at Mt. Cecilia. A similar ridge has been indicated by magnetometer survey near Wollal near the north-west corner of the sheet and probably represents the subsurface continuation of rocks similar to those cropping out at Mt. Cecilia. This belt of resistant rocks may have been an old topographic high and a barrier to the north-flowing Oakover-Nullagine River System in pre-Permian times and to the deposition of the Braeside Tillite.

ECONOMIC GEOLOGY

Petroleum Prospects Petroleum is unlikely to occur within the small thickness of generally arenaceous sediments cropping out in this part of the Canning Basin; but a much greater thickness of sediments, including pre-Permian rocks, may occur in basement depressions concealed by the Permian and Mesozoic rocks. The Permian and Mesozoic sequences include possible petroleum source-beds, and could also act as structural traps up dip from older concealed Palaeozoic sediments, although no closed structures are apparent in the area. The succession of Permian Braeside Tillite, resting on Precambrain rocks and overlain by the Oakover Beds, indicates that no source beds for petroleum exist in the Oakover Valley.

Water Supply Large bodies of semi-permanent water occur as pools in the larger rivers and water can usually be obtained during dry seasons by digging in the gravels of the stream courses. Rainwater catchment tanks are placed along the telegraph line to La Grange; these tanks have a 30-foot-square galvanised-iron catchment-roof. In the desert area small supplies of water may be obtained from sporadic rock holes, which occur mostly on the tops of desert breakaways.

Subsurface water is used by the sheep stations, and bores in granitic rocks usually strike water at less than 150 feet. Bores or wells sunk along the larger watercourses yield large supplies of good water from Recent river gravel and silts. Very salty water occurs in bores along Callawa Creek, about 4 miles south of the Rabbit-Proof Fence, and between the Oakover and Nullagine Rivers north of Braeside Homestead. Between the Oakover and Nullagine Rivers the salt water occurs in the Braeside Tillite and a deep bore through the glacials into the underlying dolomite and breccias may strike fresh water. The possibility of obtaining fresh water from the Permian and Mesozoic sediments in the desert area is extremely good. A supply of 175,000 gals. per day of artesian water occurs at 610 feet in Mesozoic rocks in B.M.R. Wollal Stratigraphic Bore No. 1A. This bore is 19 miles north of the northern edge of the Sheet at Lat. $19^{\circ}51'$S, Long. $120^{\circ}38'$E.

Metallic Deposits The main metallogenetic epoch was earlier than the deposition of the Upper Proterozoic rocks. Gold is produced at Bamboo Creek, and the mining centre has been described by Maitland (1904), Finucane (1936), and Blazey, Rayner, & Nye (1938). The lode has been emplaced along lines of shears in the Lower Proterozoic greenstones. A specimen of gold from a quartz reef was analysed by Simpson (1902) and gave 94.00% gold and 6.00% silver. The total production in the Bamboo Creek area up to the end of 1955 was 63,917.95 fine oz of gold and 133.65 fine oz of silver from 64,029.45 tons of ore. During 1955 the production was 101.82 oz. of gold from 531.50 tons of ore. Up to the end of 1936 the average grade of ore was 34 dwt of gold per ton. The deepest mine on the field is 250 feet deep.

Some small deposits of manganese occur in the Sheet area, but the largest deposits occur to the south-east at Woody-Woody. The pyrolusite has generally replaced the breccia overlying the dolomite; the manganese-rich solutions were probably derived from the dolomite itself, which contains up to 0.6% manganese.

Small lead deposits occur in the Isabella Range near Barramine Station and farther south-east, and have been described by Blatchford (1924) and Finucane (1938). Small vanadium and copper prospects also occur in this area. Small deposits of alluvial and residual tin occur in the granitic areas near Talga-Talga Station.

Radioactive Materials The southern portion of the Yarrie Sheet was covered by a scintillograph survey in 1955 (Parkinson and Daly, 1955). Flights were made at 200 and 500 feet over the area with flight lines ½ mile apart. The central portion of the one-mile area of Bamboo, just north-east of the Bamboo Creek mining centre, was found to have several particularly large anomalies, but a subsequent ground reconnaissance disclosed only slight disseminated radioactivity in the Upper Proterozoic quartz porphyry. The intensity of radioactivity is uniform over all rocks of this type in the Bamboo Creek area.

BIBLIOGRAPHY

A.G.G.S.N.A. 1938 - Report for the period ended 31st December, 1937, Aerial Geological and Geophysical Survey of Northern Australia.

BLATCHFORD, T., 1924 - Braeside lead deposits. Ann. Rep. Dep. Min. W. Aust. 1924, Append. 22., 79.

BLATCHFORD, T., 1929 - Pre-Cambrian of Western Australia. Ann. Rep. Dep. Min. W. Aust. 1929.

BLAZEY, E.L., RAYNER, J.M., and NYE, P.B., 1938 - Geophysical report on the Bamboo Creek Area, Pilbara Gold-field. Aer. Surv. N.Aust. W.Aust. Rep. 39

BREMNER, C. St. J., 1942 - Aerial reconnaissance of the south margin of the Fitzroy Basin, W.A. Unpub. Rep. for Caltex (Aust.) Pty. Ltd.

BRUNNSCHWEILER, R.O., 1956 - Plant fossils from the Callawa Formation. In: Bur. Min. Resour. Aust. Rep. 29, 50

BRUNNSCHWEILER, R.O., 1957 - The geology of Dampier Peninsula, Western Australia. Bur. Min. Resour. Aust. Rep. 13.

CASEY, J.N., and WELLS, A.T., 1956 - Manganese deposits at Gregory Range, Western Australia. Bur. Min. Resour. Aust. Rec. 1956/8 (unpub.)

CLAPP, F.G., 1925 - Geology and Geography of North-West and Desert Basins, Western Australia. Proc. Linn. Soc. N.S.W., 50, 47.

FINUCANE, K.J., 1936 - Bamboo Creek Mining Centre, Pilbara Goldfield. Aer. Surv. N. Aust., W. Aust. Rep. 9.

FINUCANE, K.J., 1938 - The Braeside Lead Field, Pilbara District. Aer. Surv. N. Aust., W. Aust. Rep. 24.

FINUCANE, K.J., 1939 - Mining centres east of Nullagine, Pilbara Goldfield. Aer. Surv. N. Aust., W. Aust. Rep. 19.

FORMAN, F.G., 1929 - Notes on the geology and petroleum prospects of the Desert Basin, Western Australia. Ann. Rep. Dep. Min. W. Aust. 1929, 97.

FORMAN, 1937 - A contribution to our knowledge of the PreCambrian succession in some parts of Western Australia. J. Roy. Soc. W. Aust., 23.

GUPPY, D.J., LINDNER, A.W., RATTIGAN, J.H., and CASEY, J.N., 1958 - Geology of the Fitzroy Basin, Western Australia. Bur. Min. Resour. Aust. Bull. 36.

HARRIS, C.M., 1926 - The Braeside Mineral Field; lead mining and transport. Chem. Engng Min. Rev., 18., 355.

de la HUNTY, L.E., 1953 - Report on some manganese deposits in the North-West Division, Western Australia. Unpub. Rep. geol. Surv. W. Aust.

LOVERING, K., 1956 - Description of rock specimens. In: Bur. Min. Resour. Aust. Rep. 29, 69-74.

MAITLAND, A.G., 1904 - Preliminary report on the geological features and mineral resources of the Pilbara Goldfield. Bull. geol. Surv. W. Aust. 15.

MAITLAND, A.G., 1908 - The geological features and mineral resources of the Pilbara Goldfield. Bull. geol. Surv. W. Aust. 40.

MAITLAND, A.G., 1919 - Summary of the geology of Western Australia. Extract from Mining Handbook, Geol. Surv. W. Aust. Mem. 1.

McWHAE, J.R.H., PLAYFORD, P.E., LINDNER, A.W., GLENISTER, B.F., and BALME, B.E., 1958 - The stratigraphy of Western Australia. J. geol. Soc. Aust., 4 (2).

OWEN, H.B., 1953 - Manganese deposits near Ragged Hills, Gregory Range, North-West Division, Western Australia. Bur. Min. Resour. Aust. Rec. 1953/62 (Unpub.)

PARKINSON, W.D., and DALY, J., 1955 - Preliminary report on airborne scintillograph survey in Western Australia. (1955). Bur. Min. Resour. Rec. 1955/102 (Unpub.).

REEVES, F., 1949 - Geology and oil prospects of the Desert Basin, Western Australia. Unpub. report for Vacuum Oil Co.

SIMPSON, E.S., 1902 - Notes from the departmental laboratory. Bull. geol. Surv. W. Aust. 6.

SMITH, R.N., 1898 - The prospect of obtaining water between the Pilbara Goldfield and the Great Australian Desert. Bull. geol. Surv. W. Aust. 24.

TRAVES, D.M., 1956 - Geology of the Ord-Victoria Region. Bur. Min. Resour. Aust. Bull. 27.

TRAVES, D.M., and CASEY, J.N., 1954 - Conditions in the Canning Basin Desert. Bur. Min. Resour. Aust. Rec. 1954/56. (Unpub.).

TRAVES, D.M., and CASEY, J.N., 1955 - New interest in Australia's unexplored wastes. National Development, 11 Mar. 1955, 16-23.

TRAVES, D.M., and CASEY, J.N., 1956 - Exploring for oil in the Canning Basin Desert. Walkabout, 22 (1), 10-14.

TRAVES, D.M., CASEY, J.N., and WELLS, A.T., 1956 - The geology of the south-western Canning Basin, Western Australia. Bur. Min. Resour. Aust. Rep. 29.

WARBURTON, P.E., 1875 - A journey across the western interior of Australia. S. Aust. Parl. Pap. 28.