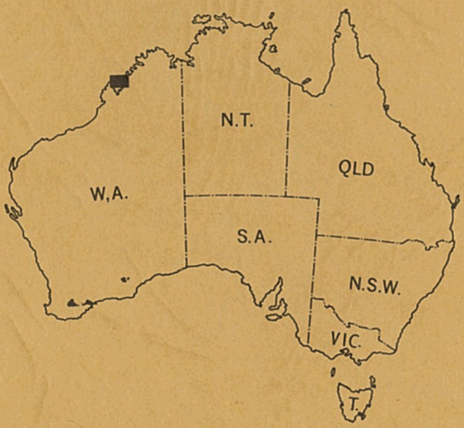
1:250 000 GEOLOGICAL SERIES—EXPLANATORY NOTES

YAMPI
WESTERN AUSTRALIA



SHEET SE/51-3 INTERNATIONAL INDEX

DEPARTMENT OF MINERALS AND ENERGY

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

DEPARTMENT OF MINES, STATE OF WESTERN AUSTRALIA

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COMPILED BY D. C. GELLATLY AND J. SOFOULIS

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Explanatory Notes on the Yampi Geological Sheet

Compiled by D. C. Gellatly and J. Sofoulis***

The Yampi 1:250 000 Sheet area lies in the western part of the Kimberley Land Division of Western Australia between latitudes 16°S and 17°S and longitudes 123°E and 124°E. It includes Yampi Peninsula, part of Dampier Peninsula, and numerous islands. About half of the Sheet area is covered by ocean.

The two principal settlements are the iron-ore producing centres of Cockatoo and Koolan Islands, both operated by Dampier Mining Co. Ltd. The only other settlements are the cattle stations of Oobagooma at the tidal mouth of the Robinson River, and Kimbolton, a newly established station 22 km west-northwest of Oobagooma. Derby, the main town, seaport, and centre of communications, supplies, and administration for the West Kimberley region, is situated south of Stokes Bay near the head of King Sound, some 30 km south of the southern boundary of the Sheet area.

Graded inland and coastal roads from Oobagooma meet north of Meda homestead (south of the Sheet area) and connect with the Derby Kimberley Downs road 48 km east of Derby. A graded track runs northwards from Kimberley Downs through Limestone Springs to Mondooma Yard on the Robinson River. Access to the Dampier Peninsula is by graded track from Broome. There are airstrips suitable for light aircraft at all centres of permanent habitation. Communications with Derby are provided by radiotelephone, the Royal Flying Doctor Service radio network, and charter air services.

Vertical air-photographs at a scale of 1:50 000 taken in 1949 by the RAAF were used during the survey. Vertical air-photographs at a scale of 1:85 000 (RC-9 Series) taken in 1967 are also available now. Photomosaics, at scales of 1:63 360 and 1:250 000, and topographic maps at scales of 1:50 000 and 1:250 000 are also available.

The climate is monsoonal, and rain mostly falls between November and April. Average annual rainfall ranges from 680 to 850 mm but is variable from year to year. Temperature data for Derby (Speck et al., 1964), which are probably an accurate guide to the coastal regions of the Sheet area, indicate average minima from 14°C (July) to 27°C (December) and average maxima from 29°C (July) to 37°C (November and December). Cyclones may occur during the summer.

The typical vegetation of low-lying ground is grassy open eucalyptus woodland. Sandstone ridges support only stunted wattle and curly spinifex. Low hills, especially near the coast, have a heavy cover of tall cane grass. Black-soil plains are treeless, with a cover of tussocky grass. Baobabs, river gums, paperbarks, and pandanus palms fringe the watercourses. Sand plains in the south support stands of tall wattle shrubs ('pindan') and sparse curly spinifex.

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*Bureau of Mineral Resources.

**Geological Survey of Western Australia.

Bare mud flats of sheltered bays and inlets are fringed to seaward by mangrove thickets, and samphire meadows encroach on the landward side of some.

The area is characterized by a high tidal range (10 m) which restricts use of port facilities, but offers potential for tidal power development.

Previous investigations

Parts of the Yampi Sheet coast were sighted by Tasman in 1644 and visited by Dampier in the ship *Cygnet* in 1688 (Sharp, 1963). P. P. King explored the coastline in 1820-21 and named numerous prominent coastal and inland features (King, 1827), and Stokes (1846) explored and surveyed the coast more fully in 1838-41. Fitzgerald (1907) and Basedow (1918) described briefly some rocks from the island and coastal mainland after visiting Sunday Island Mission and other localities.

The iron ore of Koolan and Cockatoo Islands has been described by many writers, the most informative of whom are Campbell (1909), Canavan & Edwards (1938), Finucane (1939), Canavan (1953), and Reid (1958, 1965a,b,c).

Small copper deposits at Coppermine Creek, Little Tarraji River, and Mondooma have been described briefly by Maitland (1919), Simpson (1952), Harms (1959), Low (1963), and Sofoulis (1967).

The geology of Dampier Peninsula was described by Brunnschweiler (1951, 1957) and McWhae et al. (1958). A brief description of the physiography and geology of the Yampi Sheet area and adjoining regions is given in Speck et al. (1964). The only previous systematic account of the Precambrian geology of the area is that by Harms (1959), who produced the first geological map of the whole Kimberley region, and named many of the rock units in the area. This map, together with the preliminary photo-interpretation of the Yampi Sound area (Perry & Richard, 1965), assisted considerably in the planning of the 1966-67 mapping.

The principal geophysical surveys are an aeromagnetic survey over King Sound (WAPET, 1967), and a reconnaissance gravity survey of all onshore parts of the area (Whitworth, 1970). Several seismic surveys, either partly or wholly within the Yampi Sheet area, are listed in the Bibliography.

The survey on which the map is based was carried out in 1966 and 1967 as part of a program of regional mapping of the Precambrian of the Kimberley Region by the Geological Survey of Western Australia and the Bureau of Mineral Resources.

PHYSIOGRAPHY

The Yampi Sheet area includes part of the North Kimberley and Fitzroyland physiographic divisions of Jutson (1950), subdivided by later authors (Table 1). Figure 1 shows the distribution of the physiographic units.

Kimberley Plateau Province

The *Harding Plateau,* which is one of four subdivisions of the Kimberley Plateau Province, is a rugged and deeply dissected sandstone plateau containing numerous cuestas in the extreme northeast. It is underlain mainly by gently dipping sandstone. Its elevation decreases southwards from 190 m near Raft Point to about

90 m near Secure Bay. Topography is controlled partly by a strong system of joints and faults. Joints have been preferentially eroded to give a rugged landscape in places and a rectilinear pattern of deeply incised, essentially consequent, minor streams. Principal streams tend to follow strike valleys developed in the more readily eroded siltstone, basalt, and dolerite.

TABLE 1. PHYSIOGRAPHIC SUBDIVISIONS, YAMPI 1:250 000 SHEET AREA

Division	*Province*	*Sub-Province*
North Kimberley (1)	Kimberley Plateau (2)	Harding Plateau (6), (8)
	Kimberley Foreland (2)	King Leopold Range (3) Yampi Ridges (2) Lillybooroora Plateau (9)
Fitzroyland (1)	Lamboo Hills (5)	Lennard Hills (7) Halls Creek Ridges (7) Napier Plains (7)
	Fitzroy Plains (2)	North Fitzroy Plains (7) King Sound Lowlands (9)
	Dampierland (4)	Lombadina Plateau (4) Pender Bay Lowlands (4)

(1) Jutson (1950); (2) Wright (1964); (3) Traves (1955); (4) Brunnschweiler (1957); (5) Dow & Gemuts (1969); (6) Plumb (in prep.); (7) Gellatly et al. (1968); (8) Gellatly et al. (1969); (9) Sofoulis et al. (1971).

Kimberley Foreland Province

The *King Leopold Ranges* extend into the Sheet area from the adjoining Charnley Sheet area. They are broad, essentially flat-topped ridges traversed by narrow joint-formed gullies. As the dip of the bedrock steepens westwards the Ranges become narrow and finally pass into the Yampi Ridges.

The *Yampi Ridges* consist of a series of parallel flat-topped ridges, hogbacks, and cuestas, formed by steeply-dipping beds of resistant sandstone between beds of easily eroded siltstone, basalt, and dolerite. Elevations range from 30 m to 240 m above sea-level, and relief from 60 m to 150 m. The flat ridge tops are remnants of an early erosion surface (the High Kimberley surface of Wright, 1964), which slopes gently downwards from the High Range area to the west, southwest, and south. The minimum elevation of this surface is about 150 m.

The *Lillybooroora Plateau* is surrounded by the Yampi Ridges, but the parallel ridges give way to a uniform smooth plateau surface flanked by areas of rounded hills with a dendritic drainage pattern.

Lamboo Hills Province

The *Lennard Hills* comprise landforms developed on the older Precambrian igneous rocks (Lamboo Complex) of the Sheet area: dissected plateaux (e.g. Mount Disaster), rocky tors, and broad whalebacks separated by sandy pediments. The lower-lying southwestern parts of the Lennard Hills are characterized by broad

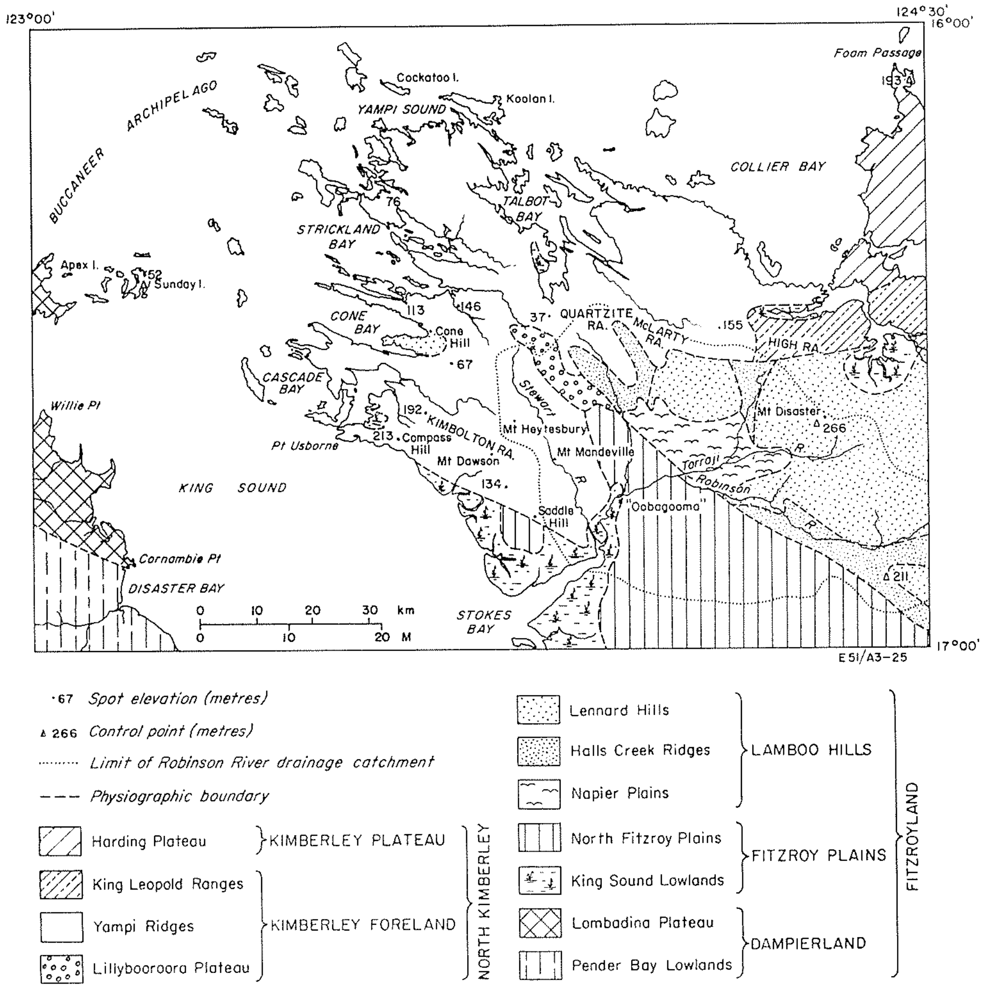

Fig. 1. Yampi physiographic sketch map.

convex pediments at the apexes of which are scattered granite tors and monadnocks. They are particularly well developed east and northeast of Boulder Hill.

The crests lie at 240 to 270 m and conform with the general level of the High Kimberley surface (Wright, 1964) in this area. Relief over most of the Lennard Hills is generally less than 90 m and commonly ranges between 30 and 60 m. The pattern of small streams is mostly dendritic.

The *Halls Creek Ridges,* which occupy only a small part of the Yampi Sheet area, are developed on schist and phyllite as low ridges and irregular round-topped hills with closely spaced minor drainage. Together these features produce a hummocky topography.

The *Napier Plains* consist of areas of hummocky black soil separated from river courses by sandy levees, residual sandy soil and scattered inselbergs surrounded by eluviated plains.

Fitzroy Plains Province

The *North Fitzroy Plains* are extensive sandplains southeast of Oobagooma. They consist of deep red and yellow sands overlying ferricrete, and form a gently undulating pindan-covered plain developed largely upon Palaeozoic and possibly Mesozoic rocks. Drainage is poorly defined and dendritic.

The *King Sound Lowlands* comprise extensive coastal mud flats southeast of Point Usborne. Mangrove communities flourish on the seaward fringe of the mud-flats and line tidal creeks, some of which have prominent meanders.

Dampierland Province

The *Lombadina Plateau* occupies the northern part of the Dampier Peninsula west of King Sound. The Plateau, which is covered by a veneer of sandy soil, has an average elevation of only 30 m. It is bounded to the south by a low escarpment of sandstone cliffs, which form much of the coastline and extend northwest from Cornambie Point. Pleistocene sand dunes are found locally on the plateau surface.

The *Pender Bay Lowlands,* a low-lying sand-plain depression south of the Lombadina Plateau, were probably the source of a large Tertiary river system flowing westwards to Pender Bay (Brunnschweiler, 1957).

Drainage

Major drainage falls into two broad systems: those around the periphery of the Yampi Peninsula, draining directly seaward, and those that comprise the Robinson River system and drain into King Sound. The McLarty Range, a strike ridge of sandstone, forms the divide between them in the north; in the west the divide is irregular and independent of lithology.

Principal river courses of the peripheral drainage system are dominantly subsequent and follow strike valleys. Most small tributaries are consequent or obsequent, except for the insequent dendritic drainage surrounding the southern part of Secure Bay. The rivers are mainly stony-bottomed and have immature longitudinal profiles.

The larger streams throughout the Yampi Peninsula are controlled by northwest-trending strike valleys in siltstone and volcanic rock in the Kimberley Group sequence. Smaller streams commonly breach the resistant strike ridges.

The Robinson River and its main tributaries are largely dendritic, but the headwaters of western tributaries are commonly subsequent. Minor tributaries in the east tend to follow joints and are reticulate; in the west they are more mature in their lower courses.

Coastal features

A drowned coastline with ria features is well developed north of Point Usborne, where dissected Kimberley Group rocks strike at right angles to the coast. It is characterized by sandstone promontories, narrow tidal channels, and numerous islands along the strike of the mainland structures. Reid (1955) estimates that the depth of submergence in the Buccaneer Archipelago was approximately 60 m.

Limestone reefs fringe parts of the north mainland coast and are extensive about the islands. Beaches are scarce and confined mainly to restricted bays of the outer coast and islands. Mud-flats (partly covered by mangrove) occupy sheltered bays, inlets, and estuaries. Other small bays, partly cut off from the sea by sandbars, have formed intratidal lagoons.

Edwards (1958) described some wave-cut platforms in the Yampi Sound.

The coastline flanking Collier Bay is controlled by the regional structural trend of sandstones of the Kimberley Group. Drowned river gorges and strike valleys in the interbedded basic rocks are now narrow tidal channels. Examples are Yule Entrance and The Funnel, which give access to broad mangrove-fringed reaches of Walcott Inlet and Secure Bay.

STRATIGRAPHY

The stratigraphy of the Yampi Sheet area is summarized in Tables, 2, 3, 4, and 5. Most of the exposed rocks are Precambrian. The subdivision of the Precambrian into Archaean (?) (older than 2300 m.y.), Lower Proterozoic (2300 m.y. to 1800 m.y.), and Carpentarian (1800 m.y. to 1400 m.y.) is based on isotopic age determinations (Bofinger, 1967; Bennett & Gellatly, 1970). Stratigraphic nomenclature is defined fully in Dow & Gemuts (1969), Gellatly, Sofoulis, & Derrick (in prep.) and Plumb (in prep.). The Precambrian sequence is overlain by sediments of Devonian, Permian, and Cretaceous age.

ARCHAEAN(?) (Table 2)

Halls Creek Group

The Halls Creek Group is a uniform sequence of strongly folded eugeosynclinal sediments metamorphosed to phyllite and mica schist. Rocks exposed in the Sheet area are tentatively correlated with the Olympio Formation, the topmost formation of the Halls Creek Group of the East Kimberley (Gellatly, Sofoulis, & Derrick, in prep.). Grade of metamorphism is low except in the southeast, where andalusite and garnet-bearing schists are found. The thickness of the group is unknown. The Halls Creek Group is intruded by the Woodward Dolerite and by granites of the Lamboo Complex.

LOWER PROTEROZOIC

Lamboo Complex

The Lamboo Complex (as redefined by Gellatly et al., 1968) consists of Whitewater Volcanics and all intrusive rocks younger than the Halls Creek Group and older than the Kimberley Basin sediments. The Lamboo Complex is subdivided into three informal groups: the pre-Whitewater intrusives (Woodward Dolerite and Nellie Tonalite); the Whitewater Volcanics and associated high-level intrusives (Mount Disaster Porphyry and Mondooma Granite); and the post-Whitewater intrusives (Lennard Granite, Secure Bay Adamellite, Tarraji Microgranite, Cone Hill Granite, and part of the Kongorow Granite).

Isotopic ages of the Whitewater Volcanics and associated granites fall mostly in the range 1900 to 1950 m.y. (Bennett & Gellatly, 1970): individual age differences within this span are not significant and the order of intrusion suggested here (Table 2) is thus based on field evidence.

The *Woodward Dolerite* occurs as discontinuous, steeply dipping sills that intrude the Halls Creek Group but not the younger formations. It has been strongly folded and metamorphosed to amphibolite. It is locally porphyritic with large plagioclase phenocrysts in the southeast, but in the northwest, near Mount Nellie, it can be distinguished from metamorphosed Hart Dolerite only by its darker hornblende.

The *Nellie Tonalite,* a hornblende-bearing mesocratic tonalite, is bordered by lit-par-lit migmatite where it is in contact with the Halls Creek Group. Strongly sheared equivalents are quartz-chlorite schist, rich in sphene.

The *Whitewater Volcanics* consist essentially of welded ash-flow tuff and have been informally subdivided into three lithological groups: crystal-poor rhyodacitic ash-flow tuff (Pwo), crystal-rich rhyodacitic ash-flow tuff (Pwa), and bedded tuffaceous sediments (Pws). These subdivisions are not entirely stratigraphic, but the two former units may be approximate correlatives of similar units in the Lennard River Sheet area. The *crystal-poor tuff* (with less than 50% of crystals and crystal fragments) occurs mainly near the base of the Whitewater Volcanics. The *crystal-rich tuff* (with more than 50% of crystals and crystal fragments) is interlayered with it and probably constitutes the upper part of the sequence, but its stratigraphic position cannot be defined accurately. It is lithologically similar to the Mondooma Granite in hand specimen, but can generally be distinguished in thin section by the presence of a very fine-grained matrix. The *bedded tuffaceous sediments* overlie the crystal-rich tuff. They have well developed graded bedding locally, but also contain potash feldspar fragments with marginal quartz inclusions suggesting high-temperature crystallization. They could represent welded ash-fall tuffs.

The *Mount Disaster Porphyry* is characterized by its fine-grained matrix and by large phenocrysts of potash feldspar (2 to 3 cm) and of quartz and plagioclase (both 0.5 to 1 cm). It is interlayered in places with crystal-rich tuff of the Whitewater Volcanics, but contact relationships are uncertain. In the Lennard River Sheet area Mount Disaster Porphyry intrudes the Whitewater Volcanics: similar relationships are inferred in the Yampi area.

The *Mondooma Granite* consists of microporphyritic granite and porphyritic microgranite and microgranodiorite. It is characterized by the presence of abundant well formed 2-3 mm bipyramidal phenocrysts of quartz, of orthopyroxene, and of quartz inclusions in K feldspar.

The *Lennard Granite* is the most extensive of the post-Whitewater granites and was probably the parent from which some of the others were derived. It is characterized by equant and slightly elongated 2-3 cm potash feldspar phenocrysts in an even-grained granitic matrix. Close to contacts with the Halls Creek Group it contains muscovite, and along the contact with the Mondooma Granite it is xenolithic.

The Secure Bay Adamellite is similar to the Lennard Granite except that it is non-porphyritic or sparsely porphyritic. It is thought to have been derived from the Lennard Granite magma through removal of the phenocrysts.

TABLE 2. ARCHAEAN AND LOWER PROTEROZOIC STRATIGRAPHY

Era	*Group*	*Rock Unit and Symbol*	*Thickness (m)*	*Lithology*	*Topography*	*Stratigraphic Relationships*	*Remarks*
LOWER PROTEROZOIC	LAMBOO COMPLEX	Cone Hill Granite Pbkc		Biotite granite, coarse, mainly porphyritic. Minor xenoliths	Low rocky promontory, dissected along joint lines	Overlain unconformably by King Leopold Sst	Roof pendants of tourmaline-rich Halls Creek Gp. Includes varieties similar to both Lennard and Kongorow Granites
		Kongorow Granite Pbkk		Granite and adamellite, foliated, porphyritic, biotite-rich. Mafic xenoliths locally	Same as enclosing Lennard Granite	Intrudes Lennard Granite	Mainly dykes and veins. Few outcrops big enough to show on map
		Tarraji Microgranite Pbkt		Microgranite, pale grey, porphyritic in potash feldspar, plagioclase, and biotite	Small prominent peaked hills	Intrudes Lennard Granite	More resistant to weathering than surrounding Secure Bay Adamellite and Lennard Granite. May be related to Lennard Granite
		Secure Bay Adamellite Pkbs		Adamellite, coarse, even pale grey. Sparsely porphyritic locally	Prominent rocky hills and low tors	Intrudes Mount Disaster Porphyry and Lennard Granite	Contains xenoliths of Lennard Granite, but elsewhere possibly contact-altered by Lennard Granite
		Lennard Granite Pbkl		Biotite granite and granodiorite, coarse, grey, leucocratic, porphyritic, and muscovite-rich marginally. Tourmaline pegmatites, aplites, quartz veins	Rounded whalebacks and rocky tors: low rock pavements. Tors commonly surrounded by thinly veneered pediments	Intrudes Halls Creek Gp, Whitewater Volc, Mount Disaster Porphyry and Mondooma Gran. Overlain unconformably by Speewah and Kimberly Gps	Low biotite content and coarse porphyritic nature distinctive. Contains meta-sedimentary xenoliths near contacts with Mondooma Granite
		Mondooma Granite Pbko		Granite, microgranite, and microgranodiorite, porphyritic with 2-3 mm phenocrysts or quartz and feldspar. Xenoliths of Pbkd	High, rounded but rugged boulder-strewn hills	Intrusive into Whitewater Volc and Halls Creek Gp in Charnley Sheet area. Intrudes Mount Disaster Porphyry. Intruded by Lennard Granite	Probably equivalent to Bickley's Porphyry on Lennard R Sheet area
		Mount Disaster Porphyry Pbkd		Microgranite, minor microgranodiorite, feldspar phenocrysts up to 3 cm	Prominent steep-sided boulder-strewn hills	Probably intrudes Whitewater Volc. Intruded by Lennard Granite, Secure Bay Granite, and Mount Disaster Porphyry	Mainly associated with Whitewater Volc
				INTRUSIVE CONTACTS			

TABLE 2. ARCHAEAN AND LOWER PROTEROZOIC STRATIGRAPHY.—*cont.*

Era	*Group*	*Rock Unit and Symbol*	*Thickness (m)*	*Lithology*	*Topography*	*Stratigraphic Relationships*	*Remarks*
					INTRUSIVE CONTACTS		
LOWER PROTEROZOIC	LAMBOO COMPLEX	Whitewater Volcanics Bw		Undifferentiated, mainly crystal-poor rhyodacitic ash-flow tuff; minor rhyolitic lava		Unconformable on Halls Creek Gp (Lansdowne Sheet area). Overlain by King Leopold Sst. Intruded by Mount Disaster Porphyry	
		Bws		Greywacke; fine-bedded tuffaceous greywacke, bedded tuff			Graded bedding. K-feldspars have marginal quartz inclusions
		Bwa		Tuff, crystal-rich, rhyodacitic, densely welded ash-flow tuff	Prominent rounded boulder-strewn hills	Mondooma Granite and Lennard Granite	Lithologically similar to Mondooma Granite
		Bwp		Tuff; crystal-poor, rhyodacitic, densely welded ash-flow tuff			Interlayered with crystal-rich tuff, probably low in sequence
		Nellie Tonalite Pbkn		Tonalite and granodiorite, mesocratic with hornblende and biotite	Low rounded hills and discontinuous ridges	Contacts with Halls Creek Gp concordant, locally migmatitic. Unconformably overlain by King Leopold Sst	Resembles more mafic varieties of McSherrys Granodiorite (Lennard R Sheet). Strongly sheared locally
		Woodward Dolerite Pbd	Sills up to 150	Metadolerite and metagabbro, dark green, fine to coarse amphibolite, locally porphyritic	Discontinuous boulder-strewn ridges or isolated 30 m hills. Low rock pavements	Intrudes Halls Creek Gp. Intruded by Lennard Granite	Sills mostly discontinuous and lenticular. Well foliated
					INTRUSIVE CONTACTS		
ARCHAEAN?	HALLS CREEK GROUP	Halls Creek Group Ah		Muscovite, sericite, and chlorite schist; phyllitic shale, siltstone, greywacke; minor chloritized, andalusite, and garnet schist; minor gneiss	Low hummocky hills and ridges	Intruded by Woodward Dolerite and granites of Lamboo Complex. Unconformably overlain by King Leopold Sst	

The *Tarraji Microgranite* is characterized by sparse phenocrysts of potash feldspar, plagioclase, and biotite (each up to 1 cm) in a fine-grained matrix. It is closely associated with the Lennard Granite and is probably related to it.

The *Kongorow Granite* is a porphyritic biotite granite which characteristically contains more biotite and fewer phenocrysts than the Lennard Granite. In the Yampi Sheet area, it invariably intrudes Lennard Granite, whereas in the Lennard River Sheet area it is thought to be mostly older. The Kongorow Granite magma was probably derived by anatexis of high-grade metamorphics of the Halls Creek Group.

The *Cone Hill Granite* has been named separately only because it is remote from other granite outcrops. It contains variants that resemble both Lennard and Kongorow Granites, and also a type with tabular potash feldspar phenocrysts (up to 10 cm) rather than equant ones as in the Lennard Granite.

CARPENTARIAN

Sediments of the *Speewah Group* and *Kimberley Group,* both of Carpentarian age, which together form the Kimberley Basin succession, lie unconformably on the older Precambrian rocks. The *Hart Dolerite* (ca 1800 m.y.) intrudes both groups. The *Wotjulum Porphyry,* also of Carpentarian age, intrudes the Kimberley Group.

The Kimberley Basin is a large structural basin which occupies most of the Kimberley region. The western extremity of the basin lies within the Yampi Sheet area, where Carpentarian rocks within the basin were strongly folded and locally metamorphosed before Palaeozoic sediments were deposited.

Speewah Group

The Speewah Group in the Yampi Sheet area is lithologically similar to the overlying King Leopold Sandstone. The group is thicker in the west around Cone Hill (360 m) than farther east near Mount Nellie (135 m). It has not been recognized between these localities and the King Leopold Sandstone may overlap it locally.

Kimberley Group

The *King Leopold Sandstone* consists of medium-grained quartz sandstone in the High and McLarty Ranges, but is coarse-grained in the northwest. On and around Sunday Island it consists of coarse-grained tourmaline-rich muscovite-bearing quartzite. Over much of the area cross-bedding is prevalent and indicates sediment transport mainly from the north and northeast. The King Leopold Sandstone is mostly 1050 m to 1200 m thick, but apparently could be more than 1200 m thick on Sunday Island.

The *Carson Volcanics* are conformable between the King Leopold and Warton Sandstones. The tuff and siltstone are commonly phyllitic and in the west (e.g. near the mouth of Lydarrba River) the basalts are amphibolitic. The thickness increases northeastwards from 360 m in the Kimbolton Range to 1140 m north of Mount Nellie, partly because of a thick accumulation of pyroclastics probably from eruptive centres in the near north.

The *Warton Sandstone* north and northeast of Mount Nellie has been partly, and in one place completely, eroded, and the Elgee Siltstone there rests directly on the Carson Volcanics. The thickness of complete sections is 340 m in the northwest and about 520 m in the northeast and south. Current directions are mainly from northwest and northeast. In the northwest the siltstone has been metamorphosed locally to andalusite-chloritoid granofels. On Koolan Island, three members of the Warton Sandstone have been recognized, the Blinker Hill Sandstone Member, Jap Bay Member, and Arbitration Cove Sandstone Member.

The *Elgee Siltstone* forms easily eroded escarpments and valleys. The conglomerate at the base is found mainly between Dugong Bay and Secure Bay and between Oobagooma and Kimbolton. Andalusite hornfels, phyllite, and muscovite schist are present in the western part of the Yampi Peninsula. Current directions are predominantly from the northwest, except immediately above the conglomerate, where they are from the south. The Elgee Siltstone is eroded away between Secure Bay and Walcott Inlet, and may have been partly removed on the south side of Koolan Island.

Current directions in the *Pentecost Sandstone* are largely from the northwest, except in the Yampi Member, where they are mostly from the south. The Yampi Member includes the iron ore beds of Cockatoo and Koolan Islands. In the east it conformably overlies the lower part of the Pentecost Sandstone to the northeast of the Yampi Sheet area, but in the northwest (e.g. Koolan and Cockatoo Islands) it overlaps on to the Elgee Siltstone and probably lies on it unconformably.

The thickest and most persistent sills (up to 1300 m) of the *Hart Dolerite* are found close to the boundary between the Speewah and Kimberley Groups. The Dolerite is difficult to distinguish from the Carson Volcanics where the two are in contact. The sills are mostly concordant, but many are locally transgressive, especially those within the King Leopold Sandstone. Hart Dolerite from the Lansdowne Sheet area has been dated at about 1800 m.y.—about the same age as the strata it intrudes.

The *Wotjulum Porphyry* intrudes the topmost beds of the Warton Sandstone, various horizons within the Elgee Siltstone, and the basal beds of the Pentecost Sandstone, in areas where the Hart Dolerite has not reached these levels. It is around 900 m about 3 km southeast of Nares Point, and could be even thicker around Coppermine Creek and Boonook Bay. It is about 1750 m.y. old; the same age (within the limits of significance) as the Hart Dolerite (Bennett & Gellatly, 1970).

PALAEOZOIC

Devonian

Upper Devonian rocks form the northwestern end of the Napier Range reef complex, and crop out as a rough, narrow range of limestone in the extreme southeast. They are probably no more than 250 m thick, though the Napier No. 4 well farther west penetrated about 800 m of Devonian strata (Lennard Oil N.L., 1970).

Details of the Devonian geology of the northern Canning Basin are given by Guppy et al. (1958), Veevers & Wells (1961), and Playford & Lowry (1966).

TABLE 3. CARPENTARIAN STRATIGRAPHY

Group	Rock Unit and Symbol	Thickness (m)	Lithology	Topography	Stratigraphic Relationships	Remarks
			UNCONFORMITY			
	Wotjulum Porphyry Pqw	Up to 900	Quartz porphyry feldspar, grey; abundant quartz phenocrysts, minor pink feldspar	Dissected low rocky hills and pavements	Intrudes Warton Sst, Elgee Sltst and Pentecost Sst	Wotjulum Porphyry and Hart Dolerite appear to be mutually exclusive. Minor copper mineralization in quartz veins at Coppermine Cr
	Hart Dolerite Pdh	Up to 1200	Dolerite, dark grey, medium grained; some grey granophyre	Rounded boulder-strewn hills or low undulating hills in valleys	Intrudes Halls Creek Gp. Whitewater Volc, Lennard Gran, and Kimberley Gp.	
KIMBERLEY GROUP	Pentecost Sandstone Pkp	1350 to 360	Quartz sandstone, white, well sorted, and minor feldspathic sandstone; grey siltstone, minor glauconitic sandstone	Resistant mesas in NE: flat-topped strike ridges in W	Conformable on Elgee Sltst	Top not preserved: all sections incomplete
KIMBERLEY GROUP	Yampi Member Pkpy	Up to 780	Arkose and feldspathic sandstone; hematitic quartz sandstone; siltstone Minor iron ore, glauconitic sandstone	Rounded hills and gently dipping cuestas in E. Rocky steep-sided plateaux in W	Conformable on lower Pentecost Sst, in E: Elgee Sltst in NW	Hematite ores at Koolan and Cockatoo Islands
KIMBERLEY GROUP	Elgee Siltstone Pke	35 to 480	Siltstone, fine-grained sandstone interbeds; conglomerate; minor andalusite granofels	Scarp slopes and valleys; recessive	Mostly conformable between Warton Sst and Pentecost Sst. Locally overlaps unconformably on to Carson Volc	Intruded Wotjulum Porphyry
			LOCAL DISCONFORMITY			

TABLE 3. CARPENTARIAN STRATIGRAPHY.—*(cont.)*

Group	*Rock Unit and Symbol*	*Thickness (m)*	*Lithology*	*Topography*	*Stratigraphic Relationships*	*Remarks*
KIMBERLEY GROUP	Warton Sandstone Pkw	340 to 520	Sandstone, white to cream, coarse to medium-grained, partly feldspathic; siltstone; andalusite granofels	Prominent scarps, ridges, small plateaux	Conformable on Carson Volc	Strongly cross-bedded; megaripples locally. Partly removed by erosion. Thicknesses refer to complete sections
	Carson Volcanics Pkc	360 to 1140	Tholeiitic basalt and spilite, dark grey, green, commonly amygdaloidal; tuffaceous siltstone, agglomerate, feldspathic sandstone	Rounded hills in valleys; poor outcrop locally	Conformable on King Leopold Sst	Thickens
	King Leopold Sandstone Pkl	1050 to 1200	Sandstone, coarse, white to pale buff	Broad flat-topped ridges, ranges, dissected plateaux	Partly unconformable on Speewah Gp; probably locally unconformable on older Precambrian	Cross-bedding common. Some beds poorly sorted
PROBABLE PARTIAL UNCONFORMITY						
SPEEWAH GROUP	Pp	Up to 360	Quartz sandstone, pale purple-grey to buff, locally micaceous, and chloritoid; minor pebble conglomerate and phyllite	Narrow steeply-dipping ridges		Constituent formations not recognizable. Difficult to distinguish from King Leopold Sst

TABLE 4. PALAEOZOIC AND MESOZOIC STRATIGRAPHY

Period	*Stage*	*Rock Unit and Symbol*	*Thickness (m)*	*Lithology*	*Topography*	*Stratigraphic Relationships*	*Remarks*
CRETACEOUS	APTIAN	Melligo Sandstone Klm		Quartz sandstone, medium to coarse, silicified locally	Low rises, mesas, or buttes; low cliffs	Mostly overlies Jowlaenga Fm. Overlies Precambrian on Apex I.	
	VALANGINIAN	Jowlaenga Formation Klj	75 to 120	Sandstone, fine to medium, often ferruginous, well bedded	Low mesas and buttes; low coastal headlands	? equivalent to Jarlemai Sltst (Brunnschweiler, 1954)	
UNCONFORMITY							
PERMIAN	SAKMARIAN	Grant Formation Pg	Unknown: 132 in type area	Sandstone, conglomerate, tillite, siltstone, shale. Glacial and aqueoglacial	Low outcrops, partly soil-covered	Overlies Fairfield Fm in SE and ?Laurel Fm in Napier No 4	Excellent aquifer
PERMIAN(?)		Lillybooroora Conglomerate Plc	Up to 60	Boulder and cobble conglomerate, megaclasts are quartzite, well lithified	Rounded boulder-strewn hills; flat topped mesas and valley side benches flanking Proterozoic sandstone ridges	Overlies Precambrian unconformably	Well defined dendritic drainage pattern
UNCONFORMITY							

TABLE 4. PALAEOZOIC AND MESOZOIC STRATIGRAPHY.—*(cont.)*

Period	*Stage*	*Rock Unit and Symbol*	*Thickness (m)*	*Lithology*	*Topography*	*Stratigraphic Relationships*	*Remarks*
CARBONIFEROUS	TOURNAISIAN		100	Sandstone, coarse clayey; interbedded claystone	Not exposed (Napier No 4)	Overlain unconformably by Grant Fm: overlies Fairfield Fm in Napier No 4	Lithologically distinct from defined Laurel Fm (mainly calcarenite), but of equivalent age
		Fairfield Formation Dcf	130 (subsurface)	Silty limestone and calcarenite, calcareous shale and siltstone, micaceous sandstone, claystone, and marl subsurface	Low outcrops on plains of limestone range. Also Napier No 4	Conformably overlies reef complex	
DEVONIAN		Windjana Limestone Dw		Massive algal-stromatoporoid reef limestone partly dolomitized		Interfingers with back-reef and fore-reef	Reef-facies; discontinuous
	FRASNIAN	Pillara Limestone Dp	Reef Complex 240	Limestone, partly dolomitized, calcarenite, and calcilutite	Prominent outcrops in narrow, hilly limestone range	Interfingers with reef and fore-reef	Back-reef facies, well bedded and flat-lying. Subsurface 'Pillara Fm' is 280 m thick
	TO	Napier Formation Dn		Calcarenite and calcirudite, megabreccia, minor dolomite		Interfingers with reef and back-reef	Fore-reef and inter-reef facies. Distinguished from back-reef by steep depositional dips
	FAMENNIAN	Unit 'C'	360	Sandstone, minor shale, limestone, dolomite, calcilutite and conglomerate	Not exposed (Napier No 4)	Overlies probable King Leopold Sst. Overlain by Pillara Fm	Known as Unit 'C' in Napier No 4

In the reef complex the *Windjana Limestone* is the (rather discontinuous) reef facies, the *Pillara Limestone* the back-reef, and the *Napier Formation* the fore-reef. All three interfinger with each other.

The *Fairfield Formation* is poorly exposed in front of the Napier Range. The exposed limestone is thought to be interbedded with unexposed calcareous shale and siltstone. The formation is a shallow marine deposit thought to have been laid down after extinction of the reef complexes.

Exposures of the Fairfield Formation in this area are probably entirely Upper Devonian (Famennian) in age, but elsewhere in the Canning Basin the unit extends into the Lower Carboniferous (Tournaisian) (Playford & Lowry, 1966). Thomas (1959) regarded the Tournaisian section as a separate unit, the Laurel Formation; opinion is still divided as to whether it is a valid unit, but the latest work (see Roberts et al., 1972) inclines to a separation, because there is a break both in time and space between the two.

Permian

The *Lillybooroora Conglomerate* forms a discontinuous belt from near Dugong Bay to the Robinson River; scattered outcrops extend southwest to Saddle Hill. Boulders have surface chatter marks but mostly lack striations which might indicate a glacial origin.

The *Grant Formation* is exposed in the extreme southwest near Limestone Spring. Low-lying outcrops of probable Grant Formation are present about 30 km southeast of Ooobagooma, where they display large-scale trough cross-bedding discernible on air-photographs.

SUBSURFACE PALAEOZOIC

In Napier No. 4 well Lennard Oil N.L. (1970) identified Grant Formation, possible equivalents of the Laurel Formation and Fairfield Formation, the Pillara Limestone, and an unnamed Frasnian or Famennian unit ('Unit C') which lies unconformably on possible King Leopold Sandstone.

'Unit C' lies conformably below the Pillara Limestone and consists of three members. Of these, the middle member contains only rare interbeds of shale, limestone, and dolomite, whereas these rocks are more common in the overlying and underlying members. Unit C is younger than the Van Emmerick Conglomerate.

The section tentatively assigned to the *Pillara Limestone* consists of massive limestone and dolomite with minor claystone and shaly dolomite. The unit has a northerly dip, which contrasts with the southerly dip recorded in the overlying section.

Units believed by Lennard Oil N.L. (1970) to be age equivalents of the Fairfield and Laurel Formations are lithologically distinct from them. The *Fairfield Formation equivalent* consists of friable slightly micaceous sandstones with some grey-green claystone and marl, while the *Laurel Formation equivalent* is a clayey sandstone. The overlying Grant Formation is a coarse-grained and pebbly sandstone with minor shale and siltstone.

In addition, the Permian *Poole Sandstone, Noonkanbah Formation,* and the *Liveringa Formation,* which are known from surface outcrop to the southeast of the Yampi Sheet area (Guppy et al., 1958) apparently extend into the area and are probably present under King Sound.

Upper Palaeozoic formations encountered in Fraser River No. 1 to the south of the Sheet area may be present subsurface in the southwest, underlying the Cretaceous rocks of the Dampier Peninsula. These are the Poole Sandstone and Grant Formation (both Permian) and the *Anderson Formation* (Carboniferous). Except for the Grant Formation, these Upper Palaeozoic units are designated Pzv on the rock relationship diagram.

Mesozoic

Rocks of Devonian to Jurassic age are present in parts of the Fitzroy Crossing Basin south and southeast of the Yampi Sheet area, but in the west Cretaceous rocks lie unconformably on Precambrian. This apparently indicates that the Cretaceous rocks overlap Jurassic and Palaeozoic subsurface in the southwest. The only Mesozoic rocks exposed are of Cretaceous age.

The *Jowlaenga Formation* contains a Valanginian fauna, mainly belemnites and ammonites. It thins northwards and is absent from the islands of Buccaneer Archipelago.

The *Melligo Sandstone* forms the resistant Lombadina Plateau. Large scale trough cross-bedding is discernible in places on air-photographs.

The *Blina Shale* and *Erskine Sandstone* (both Triassic) are probably present subsurface under King Sound. Also, formations encountered in Fraser River No. 1 to the south of the Sheet area may be present subsurface in the extreme southwest: these are the *Jarlemai Siltstone, Alexander Formation,* and *Wallal Sandstone* (Jurassic). These Mesozoic units are designated M on the rock relationship diagram.

Cainozoic

Tertiary

The *Pender Bay Conglomerate* is a ferruginous boulder conglomerate of fluviatile origin probably deposited by a large Tertiary river system that debouched into an ancient Pender Bay.

The *Borda Sandstone* is found on Apex Island and at Cunningham Point. It overlies the Pender Bay Conglomerate disconformably and contains material reworked from it. Outcrops are too small to be shown on the map.

A small outcrop of pisolitic aluminous *laterite* is exposed about 8 km west-northwest of Mount Nellie, and, with the limonitic, partly detrital, iron ore ('canga') overlying hematite ore and hematite quartzite on Cockatoo and Koolan Island, probably is the remnant of a once more extensive high-level laterite surface.

Cainozoic (undifferentiated)

Low level *ferricrete* and unconsolidated *lateritic soil* (Czl) and pisolitic detritus derived from ferricrete overlie Palaeozoic sandstone and conglomerate in the southeast, and Cretaceous rocks on Dampier Peninsula. They are mostly

TABLE 5. CAINOZOIC STRATIGRAPHY

Era	*Period*	*Rock Unit and Symbol*	*Thickness (m)*	*Lithology*	*Topography*	*Stratigraphic Relationships*	*Remarks*
CAINOZOIC	QUATERNARY	Qa		*Alluvium*, river sand and gravel	River flats and terraces	Superficial; overlie other rock units unconformably	Mainly coarse sand or silty sand
		Qc		Coastal mud, silt and sand	Coastal mud flats; tidal marsh, intertidal lagoons; tidal channels		Bare mud-flats, locally with salt encrustations; intertidal parts support mangrove thickets. Coarse sands in tidal channels
		Qz		Beach sand; white, with shell debris	Beaches, sand bars, beach dunes		
		Ql		Fragmental limestone, active coral reefs	Low benches near shoreline. Submerged reefs		Limestone outcrops too small to show on map
	UNDIFFERENTIATED CAINOZOIC	Czs		Residual soil, sand, eluvium, colluvium	Undulating scrub covered sand plains		Low longitudinal sand dunes locally
		Czb		Black soil: black to dark grey heavy-textured cracking clay soils	Plains with some shallow depressions. Gilgai patterns with hummocky surfaces. Local relief 25-50 cm		Generally grass covered; boggy in wet season
		Czl		Ferricrete; ferruginous pisolitic sandy soil, ferricrete conglomerate	Surface veneers associated with eluvial soils, sand plains, and pediments		Mainly associated with Phanerozoic sediments
		Tp	up to 6	Laterite, pisolitic, aluminous, detrital limonitic iron ore ('canga')	Flat-lying residual cappings on plateau surface		Possibly remnants of formerly extensive laterite surface. Canga deposits mostly mined out
		UNCONFORMITY					

TABLE 5. CAINOZOIC STRATIGRAPHY.—*(cont.)*

Era	*Period*	*Rock Unit and Symbol*	*Thickness (m)*	*Lithology*	*Topography*	*Stratigraphic Relationships*	*Remarks*
CAINOZOIC	TERTIARY	Borda Sandstone	4	Ferruginous, uncemented angular sandstone rubble; pisolitic limonite	Low outcrops	Postdates Pender Bay Conglomerate	Outcrops too small to show on map. Reworked from Pender Bay Conglomerate
		DISCONFORMITY					
		Pender Bay Conglomerate Tc		Conglomerate, dark grey boulder to pebble sized clasts	Low outcrops	Overlies Jowlaenga Fm	Fluviatile; probably contemporaneous with Emerlau Sst to W
		UNCONFORMITY					

poorly exposed, but well preserved outcrops of hard ferricrete 1½ m thick are present on the Townsend River about 14 km north of Oobagooma.

Black soil (Czb) and dark grey-brown soil and cracking clays which form extensive hummocky treeless plains flanking the lower reaches of the Robinson River and its major tributaries are partly residual and partly eluvial, and mostly overlie granite and schist, in contrast to the more typical black soils elsewhere in the region, which mostly overlie basic rocks or limestone.

Residual soil, sand, eluvium, and colluvium (Czs) are most extensive in the southeast and southwest, where sand and sandy soils form scrub-covered plains overlying Palaeozoic and Mesozoic sandstone formations.

Included in this unit are low east-west longitudinal sand dunes formed during the Riss arid cycle: these fossil dunes extend into the Yampi Sheet area from the west.

Extensive sandy clay soils derived from the Precambrian rocks are found around the Tarraji and Robinson Rivers, where they form a thin veneer on broad, locally convex, pediments.

Quaternary

Coral reefs and coastal limestone (Ql). Coral reefs are common around the coast of Yampi Peninsula and adjacent islands. Calcareous beach rocks ('coastal limestone') are present on some of the islands (e.g. on Apex Island—Brunnschweiler, 1957). Outcrops are too small to be shown on the map. They consist of well cemented fragmental limestone containing coral and shell fragments and some detrital material derived locally from the Precambrian.

Beach and dune sands (Qs) are sparse. Beach deposits are confined mainly to small sheltered bays, and consist essentially of quartz sand and subordinate shell and coral fragments. Beaches on Dampier Peninsula are backed locally by dunes of similar composition.

Coastal muds and sands (Qc). Tidal mudflats border most of the bays and estuaries, particularly on the southern side of Yampi Peninsula. They consist of blue-grey clay overlain by brown mud, with a thin salt crust in areas only inundated occasionally. By contrast the tidal channels contain coarse-grained sands which commonly form cross-bedded tidal megaripples (Gellatly, 1970). Intermediate grades of sediment apparently are only deposited farther from land.

Alluvium (Qa) forms broad flood plains flanking the Robinson River and its major tributaries. These flood plains are cut by braided stream channels, commonly with levées, and are incised up to 10 m in sandy alluvium.

STRUCTURE

Three basic structural divisions are distinguished: the King Leopold Mobile Zone, the Kimberley Block, and the Fitzroy-Canning Basin (Fig. 2). The King Leopold Mobile Zone, which makes up the greater part of the Sheet area, is subdivided into two parts: older Precambrian granites and phyllites in the centre and southeast, and strongly folded younger Precambrian sediments flanking it to the north and southwest. The Kimberley Block is represented only by a small area to the north of Walcott Inlet in the northeast. The Fitzroy-Canning Basin occupies the southeast and is mostly covered by the waters of King Sound. The subdivisions can be distinguished by age and consequent subunits of deformation.

King Leopold Mobile Zone

Folds

The Older Precambrian. The wavelength of folds in the Halls Creek Group rocks is usually 30 to 60 m. The folds are mostly more or less isoclinal, with axial planes and strong axial plane cleavage dipping steeply to the southwest. Bedding is poorly displayed, but can be recognized locally by thin psammitic beds interbedded with the pelitic shists and phyllites. Dips are mainly to the southwest and parallel to cleavage. Bedding has been deflected by the intrusion of granites and is commonly parallel to granite contacts irrespective of trend. Fold axes and associated microcrenulations and lineations plunge to the southeast at about 50° to 60°; others plunge gently to the west or west-northwest.

Minor folds within the Halls Creek Group vary considerably in style. They include tight chevron folds, open low-amplitude similar folds, gentle drag-folds, and kink-folds. Both the kink-folds and the drag-folds are apparently related to post-Kimberley Group movements.

Younger Precambrian rocks within the Mobile Zone are intensely folded along west-northwest axes into close to tight folds with steeply dipping limbs. Many folds are asymmetrical or overturned, with axial planes dipping south-southwest. Overturning of fold limbs is particularly prominent between Cone Bay and Strikland Bay 2-3 km north of the Lydarrba River, on the northwestern shores of Dugong Bay, and in the vicinity of Yampi Sound. Dips of overturned limbs are 50° to 90° and of normal limbs commonly about 30°. The wavelength of major folds is usually 6 to 9 km and the amplitude about 3 to 12 km, but all variations exist from these dimensions down to minor folds which can be observed in individual outcrops. Minor north-northwest fold trends have produced elongate basin-and-dome structures in the McLarty Range.

Most major fold axes are horizontal or near-horizontal, but angles of plunge can reach 30° or more. The plunge direction is variously south-southeast and west-northwest. Minor folds are rare in the Kimberley Group rocks and vary in style from kink-folds, close to the Graveyard-Townshend River reverse fault, to relatively plastic sigmoidal folds in the Yampi Member on Irvine Island.

Faults

Faults in the King Leopold Mobile Zone are more conspicuous in the Kimberley Group than in the older rocks; most of the major faults appear to postdate the Kimberley Group. The faults parallel the fold trends; for example, high-angle reverse faults trend parallel to axial planes of the west-northwest folds, which are overturned towards the north-northeast.

North-south shear zones in the granite are older than the Kimberley Group, but some may have been reactivated later. Two dominant trends are west-northwest and north-south. Some north-northeast folds near Secure Bay and Collier Bay may form part of a fault arc system described below. Some faults are interpreted as

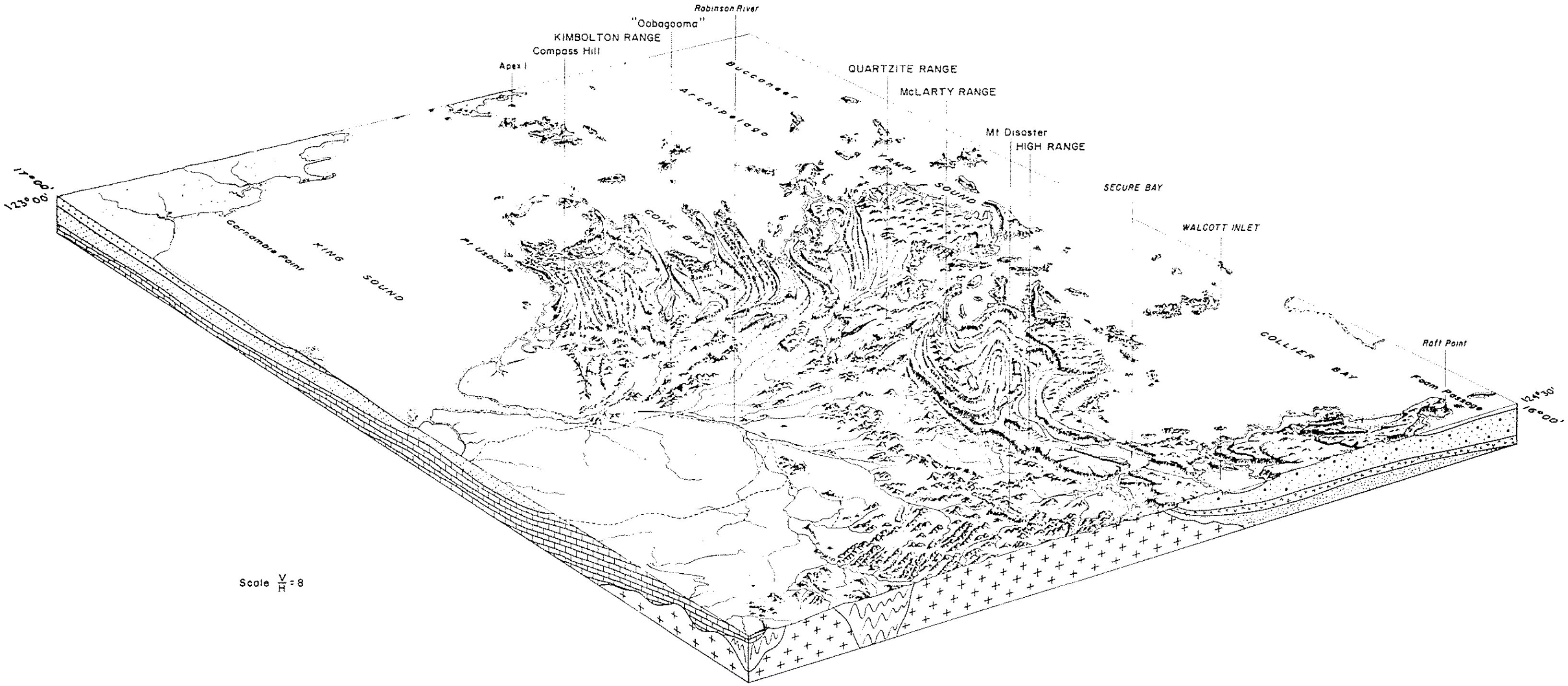

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Fig. 2. Yampi 1:250 000 relief diagram

thrusts, or possibly high-angle reverse faults (e.g. on the southwestern side of the Quartzite Range).

Mount Page Fault Arc System. An arcuate system of faults, shear-zones, joints, and dykes has been noted in the east. The fault features are discontinuous and cut the Kimberley block as well as the Precambrian rocks of the Mobile Zone. This arcuate system of fault features has a radius of curvature of about 40 to 48 km centred on Mount Page in the Charnley 1:250 000 Sheet area to the east.

Shear-Zones

Shear-zones within the granites trend north or north-northwest, and have caused intense deformation of the granite to porphyroblastic muscovite schist. The schist is more resistant to weathering than the adjacent granite and stands up as prominent ridges (e.g. 10 km north of Mount Disaster). These shear-zones are truncated at the unconformity with the overlying King Leopold Sandstone and thus antedate the Kimberley Group.

Structural Development

The structure of the Kimberley Group rocks of the Mobile Zone probably results from deformation in response to north-south compression. Folds are overturned from the south accompanied by localized reverse faulting. Some shear-folding is produced in response to movement of the granitic basement along pre-existing west-northwest faults and joints. It is suggested that the Kimberley Group rocks have undergone crustal shortening, and that the most highly deformed part of the Kimberley Group cover of the Mobile Zone is that overlying the Halls Creek Group, where compressional folding was probably operative. The granites probably yielded by shearing and fracturing to form faults and joints; the Kimberley Basin rocks overlying such fractures were probably shear-folded.

Folds of east-northeast trend possibly belong to a conjugate fold system related to renewed movement of east-northeast fractures.

Kimberley Block

In contrast to the King Leopold Mobile Zone, beds of the Kimberley Block dip only gently, rarely more than 15°, and are commonly faulted rather than folded. The beds essentially form a normal west-dipping sequence with north-northeast trend and make up the eastern limb of a large syncline whose western limb has been modified by west-northwest folds within the Mobile Zone.

Faults in the Kimberley Block trend northeast and have downthrows mainly to the southeast which cause repetition of the sequence. Most faults have a displacement of 30 to 90 m.

Fitzroy-Canning Basin

The Fitzroy-Canning Basin in this Sheet area is a very gentle north-northwest-trending anticline on the Dampier Peninsula, and a corresponding gentle downwarp of northwest trend that forms King Sound (Brunnschweiler, 1957). Except in the Napier Formation, dips nowhere exceed 3° and are mainly depositional rather than structural. The principal faults in this division trend west-northwest, south of the

Robinson River, and are probably reactivated lateral extensions of the west-north-west faults immediately south and east of the Quartzite Range.

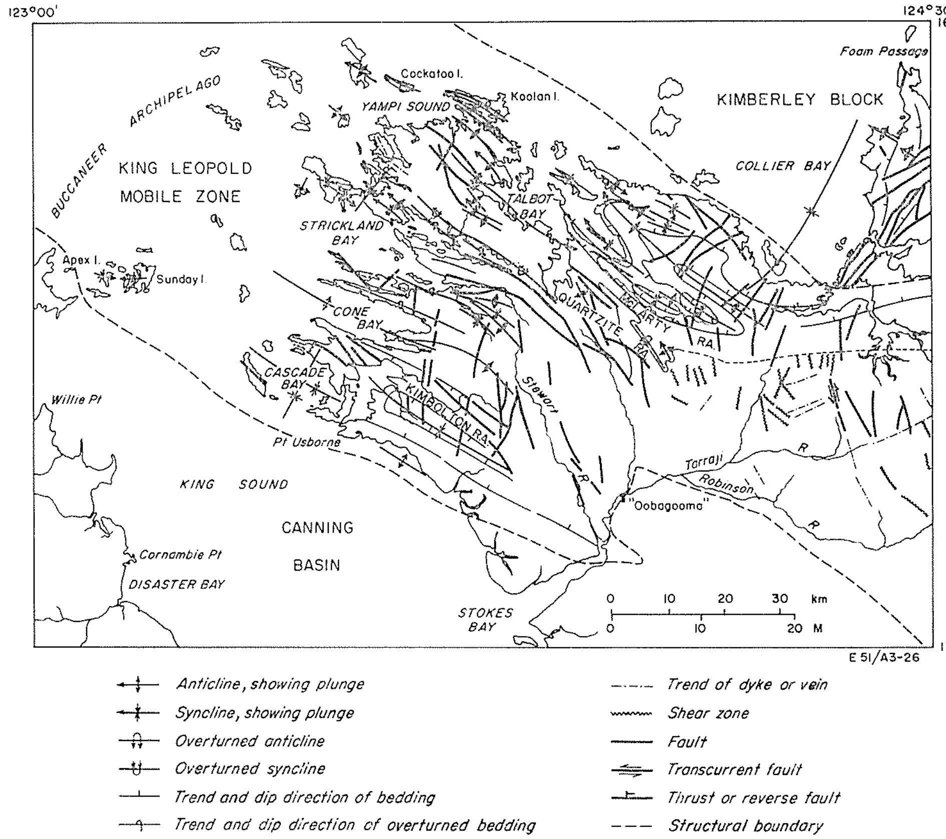

Fig. 3. Yampi structural map.

METAMORPHISM

Two major periods of metamorphism have affected the rocks of the Yampi Sheet area—one before and one after Carpentarian deposition.

The earlier period of metamorphism has affected both the Halls Creek Group and Woodward Dolerite but is probably earlier than the granites. In the Halls Creek Group it is denoted by the development of chloritoid, locally converted to biotite, and, in the extreme southeast, garnet and andalusite; and in the Woodward Dolerite by amphibolite.

The later period has affected both the Carpentarian sediments and the Hart Dolerite. It is essentially an episode of regional thermal metamorphism which may date from around 1550 m.y. or may have been closely associated with, and have immediately preceded, a period of strong deformation around 600 m.y. It was strongest in the west, and has produced amphibolite from Carson Volcanics and Hart Dolerite and andalusite-bearing hornfels and chloritoid-bearing quartzite from impure sediments.

TECTONIC HISTORY

The tectonic history of the area is summarized in Table 6. Evidence for the age relationships of the various events has where necessary been taken from other Sheet areas, e.g. Charnley and Lennard River.

Notable features of the tectonic history of the Yampi Sheet area include evidence of minor uplifts during deposition of the Kimberley Basin succession, as a result of which unconformities are present at the base of the Elgee Siltstone and the Yampi Member of the Pentecost Sandstone and possibly at the base of the King Leopold Sandstone.

Yampi is the only area in the Kimberley region in which the Kimberley Group is affected by metamorphism. Such metamorphism of 'Platform Cover' rocks is unusual. Its age is uncertain: affected rocks have given rubidium-strontium ages of 1530 m.y. and 600 m.y. (Bennett & Gellatly, 1970), but these need to be further substantiated.

The strong overfolding and reverse faulting apparently belongs to a late (600 m.y.) period of deformation (Bennett & Gellatly, 1970), and can be correlated with a period of deformation of similar age and style in the Oscar Range Inlier in the Lennard River Sheet area.

The coastal 'submergence' may be partly tectonic but is probably at least partly a result of glacio-eustasy. J. N. Jennings (pers. comm.), by studying the burial of longitudinal sand-ridges by tidal mud flats in the Derby area, has demonstrated that some of this submergence is as recent as 4000 years B.P.

ECONOMIC GEOLOGY

The only economic mineral produced in the Yampi Sheet area is iron ore mined at Yampi Sound. Small amounts of copper and muscovite and beryl have been mined in the past. At the time of the survey the Precambrian basement rocks were being explored by Pickands Mather International, and more recently other companies have commenced mineral exploration. The oil potential of the Canning Basin is being investigated by West Australian Petroleum Pty Ltd and Lennard Oil N.L. Other aspects of economic geology in the region include tidal power resources, ground water, and road construction materials.

Minerals

Iron ore

The iron ore deposits of Cockatoo Island have been mined since 1957 and those of Koolan Island since 1964. Ore is currently being produced at the rate of 2½ million tons per year. Small iron ore deposits are known on other adjacent islands, but none have been developed. All the orebodies are stratiform hematite beds, deposited as detrital ironsands (Gellatly, 1972b) and confined to the basal part of the Pentecost Sandstone. Thin hematite bands also occur higher in the succession, but are not of economic value.

A total of 22 299 752 long tons of iron ore (average grade 64.1% Fe) valued at $A47 338 313 was produced to December 1969. Details of annual production from each island are given in Sofoulis et al. (1971).

TABLE 6. SUMMARY OF TECTONIC HISTORY

Era	*Deposition*	*Igneous Events*	*Tectonic Events*	*Metamorphism*	*Remarks*
	Coastal muds and sands: alluvium	—	Drowning of Yampi coastline	—	Could be due to glacio-eustasy. Continued until 4000 years B.P.
CAINOZOIC		—	MAJOR PERIOD OF EROSION	—	Development of laterite and subsequent erosion
	Minor detrital deposits mainly on Dampier Peninsula				
MESOZOIC	Deposition of Mesozoic sediments	—	Gentle warping and submergence	—	In SW only; overlap onto Precambrian
PALAEOZOIC	Deposition of Devonian to Permian sediments	—	—	—	Mainly in extreme S. Conglomerates probably partly aqueo-glacial
			MAJOR PERIOD OF EROSION		
	—	—	Overfolding and reverse faulting: folds trend NW	—	About 600 m.y. Correlates with date of tectonism in Oscar Range
			MAJOR PERIOD OF EROSION	—	No geological record of period from about 1700 m.y. to 600 m.y.
	—	—	Folding along dominant NW and subordinate NE axes; faulting mainly N and NW	Second metamorphism	Amphibolite and andalusite granofels in NW; age uncertain
CARPENTARIAN	—	Intrusion of Hart Dolerite and Wotjulum Porphyry	—	—	—
	—	—	Minor N and NE faulting	—	Cause local fault control of Hart Dolerite
	Deposition of Speewah and Kimberley Groups	Extrusion of Carson Volcanics	—	—	Minor unconformities at base of Yampi Mbr, Elgee Sltst, and possibly King Leopold Sst

TABLE 6. SUMMARY OF TECTONIC HISTORY.—*(cont.)*

Era	*Deposition*	*Igneous Events*	*Tectonic Events*	*Metamorphism*	*Remarks*
			MAJOR PERIOD OF EROSION		
	—	—	Folding and faulting: faulting at least partly transcurrent	—	Foliation and lineation locally in granite
	—	Intrusion of basic dykes	—	—	—
	—	Intrusion of plutonic granites: Lennard, Kongorow and Cone Hill Granites, Secure Bay Adamellite etc.	—	—	—
	—	Intrusion of sub-volcanic porphyries: Mount Disaster Porphyry and Mondooma Granite	—	—	—
LOWER PROTEROZOIC	—	Extrusion of Whitewater Volcanics	—	—	—
			PERIOD OF EROSION		Cobbles of Woodward Dolerite near base of Whitewater Volc in Lennard R Sheet area
	—	Intrusion of Nellie Tonalite and early phase of Kongorow Granite	—	—	Uncertain age
	—	—	Folding along steep SE and SW axes	First metamorphism: garnet and andalusite in SW: chloritoid widespread, subsequently converted to biotite	Two-phase metamorphism in Charnley and Lennard R Sheet areas
	—	Intrusion of Woodward Dolerite	—	—	—
?ARCHAEAN	Deposition of Halls Creek Group	—	—		Probable eugeosynclinal sediments

Details of the iron ore deposits are given in reports by Campbell (1909), Canavan & Edwards (1938), Connolly (1959), Edwards (1953), Finucane (1939), Harms (1959), Montgomery (1920), and Reid (1958).

Copper

Minor copper mineralization is widespread in Precambrian rocks. The larger deposits are associated with veins and reefs of quartz and with silicified, sericitic shear and fault zones. These occurrences are restricted mainly to a belt of Halls Creek Group rocks that extends south and southeast from the Little Tarraji River area. Small showings of copper along the southeastern extension of this belt have been prospected at Mondooma and Limestone Springs. Similar metamorphic rocks of the Townshend River/Mount Nellie area, north of Oobagooma, contain copper minerals, but not in economic amounts. At Coppermine Creek near Yampi Sound quartz veins impregnating sericitized and carbonated Wotjulum Porphyry are mineralized.

The principal prospects are Grants Find, where Reid (1959) estimated 11 000 tons of 1.5% copper ore per vertical foot to a depth of 400 feet (120 m), Wilsons Reward, and a newly found deposit about 5 km south of Mount Nellie. Small copper occurrences have been found in the Carson Volcanics, Warton Sandstone, and Hart Dolerite, but none has so far been investigated. Copper mineralization in the Warton Sandstone has been noted at the same stratigraphic level from two localities about 15 km apart and constitutes one of the more promising untested copper prospects in the area.

Geological information on the various copper deposits in the Sheet area has been given by Maitland (1919), Simpson (1952), Harms (1959), Low (1963), and Sofoulis (1967a). An extensive study of the copper mineralization was made by Western Mining Corporation during their tenure of Temporary Reserve 1593H (Woodall, 1957a, b; Triglavcanin, 1958; Harper, 1959; and Reid, 1958, 1959).

Small amounts of copper ore were mined until 1920 from Coppermine Creek and from the Little Tarraji River area. Details of production are given in Sofoulis et al. (1971).

Muscovite and Beryl

A composite quartz and pegmatite dyke 7 km south of Mondooma Yard, known as Stuarts Mica Mine, has produced 31.5 lb of muscovite valued at $9 and 3.5 tons of beryl valued at $593.

The pegmatite intrudes amphibolitized Woodward Dolerite and mica schists of the Halls Creek Group; it contains scattered books of muscovite up to 58 cm by 33 cm and crystals of beryl up to 15 cm across. Most of the beryl is reported (Harms, 1959) to have been recovered from adjacent eluvial soils. Some was said to be semi-transparent and capable of producing gem quality stones.

Heavy Mineral Sands

Thin veneers of black sand have been noted at low tide in sands of the Robinson River estuary and small tidal inlets to the south of it, but their composition and economic potential are at present unknown. Similar occurrences in the estuary of the Ord River in the East Kimberley have been investigated and found to be uneconomic.

Petroleum

One test well for petroleum (Lennard Oil Napier No. 4) has been drilled in the Sheet area. It was dry. Other test wells have been drilled south (WAPET Fraser River No. 1) and southeast (Lennard Oil Napier Nos. 1, 2, 5) of the Yampi Sheet area. No significant indications of hydrocarbons have been found in any of these wells.

The apparent overlap of Cretaceous rocks on the Precambrian has complications in the search for petroleum, especially in the Dampier Peninsula and offshore areas to the west. The absence of Upper Palaeozoic and Lower Mesozoic beds means that some of the possible hydrocarbon source beds are absent, but the overlap increases the possibility of stratigraphic traps.

An aeromagnetic survey over King Sound (WAPET, 1967) indicated a probable northwesterly extension of the Oscar Range structure ('The Oscar Ridge') and also a series of closely spaced northwest-trending anomalies which probably reflect the structure of the underlying Precambrian. The Oscar Ridge is a potential target for the petroleum exploration. Reports on other petroleum exploration geophysical surveys carried out in the Yampi Sheet area are included in the Bibliography.

Construction Materials

Sand and Gravel

The beds of most major rivers draining the western part of the Yampi Peninsula contain supplies of medium-grained clean quartz sand suitable for use in cement mortar and concrete. Those draining the older Precambrian rocks in the east contain feldspar and are less suitable. Sands derived from the Palaeozoic and Mesozoic rocks in the south are mostly of feldspar but grains commonly have a ferruginous coating.

Small deposits of quartzite cobble and boulder gravels are present close to outcrops of the Lillybooroora Conglomerate. Gravel deposits are sparse elsewhere in the Sheet area.

Rock-fill

Beneath the zone of surface leaching most of the sandstone in the area (as seen in rocky gorges) is compact and silicified, and would probably make suitable rock-fill material (dimension-stone), as would most of the igneous rocks of the area, with the exception of the Lennard Granite, which in many places is partly altered.

Road Metal

Blue metal could be obtained from the Hart Dolerite, Woodward Dolerite, Carson Volcanics, Whitewater Volcanics, or Mondooma Granite. Material for forming and surfacing earth roads is more in demand at present than is blue metal; supplies available include residual soils derived from the basic igneous rocks, from the

Lennard Granite and Halls Creek Group, pisolitic soils and ferricrete overlying Palaeozoic and Mesozoic rocks, and weathered phyllite from both the Archaean and Kimberley Group formations.

Water Supply

Mean annual rainfall in the Yampi Peninsula increases from 750 mm in the south to 1000-1130 mm in the north. Consequently, surface water is adequate for the present limited pastoral development. There are few bores and little is known directly of groundwater potential. Both Oobagooma and Kimbolton homesteads obtain their water from surface pools.

Surface Water

Surface water is common in areas underlain by Kimberley Group rocks. Streams commonly form waterfalls and rock pools where they cut through sandstone ridges. Some spring-fed streams have a permanent flow in their upper reaches, e.g. the Kyulgam and Kammargoorh Rivers. Springs emanate from fractured sandstone, the junction of sandstones with dolerite or basalt, and the reverse faulted junction of King Leopold Sandstone and Halls Creek Group metasediments. Steep-sided sandstone plateaux and islands with limited catchments have streams which dry rapidly after the wet season, and it is difficult to obtain fresh water in places, especially on the islands of the Buccaneer Archipelago.

The metamorphic and igneous rocks have little surface water, although main watercourses contain semi-permanent pools. The metasediments and granite outcrops are locally mantled with eluvial debris. The junctions of sheet joints in granite with this eluvial material are commonly the sites of low salinity soakages.

The southeastern part of the Sheet area and the Dampier Peninsula in the southwest are undulating sandy plain with little permanent surface water. Springs in the area possibly draw water from Palaeozoic and Mesozoic sediments. The lower reaches of some of the major watercourses contain large pools which are rock-bound or are maintained by underflow from river channel alluvium. Salinity of all waters is between 100 and 300 ppm.

Underground Water

Two bores are recorded: Hamilton bore cuts subartesian Permian? aquifers and a bore about 6 km farther west has artesian flow. Shallow wells in Cretaceous sandstones supply the mission stations on the Dampier Peninsula.

Subsurface Permian sandstones to the south of the Robinson River may yield usable water, but as yet are untested.

Groundwater potential in the Proterozoic rocks is untested. It is expected that fractured Proterozoic sandstones could yield large supplies. Siltstone beds in Carson Volcanics and dolerite-sandstone junctions are considered worthy of testing.

Successful bore siting in the metamorphic and igneous rocks is difficult. Bores should be sited to cut thick alluvial section, eluvial materials mantling low-level sheet joints in granite, or weathered metamorphic sandstone.

Engineering Geology

Tidal Power

Maitland (1921) commented upon the possibility of harnessing the energy of some rivers and of utilizing tidal flow as a means of providing cheap electric power. The technical aspects of a tidal power scheme were examined more recently by the Public Works Department (Lewis, 1962). Of the various sites examined, the most promising in terms of power output per kilometre of dam was Walcott Inlet, which has an area of 250 km^2 and a mean effective tide of 11 m. The adjacent site at Secure Bay with an area of 63 km^2 and of similar mean effective tide was considered as a further possibility.

Geological aspects of these two sites are discussed in a preliminary report by Gordon (1964), who concludes that most of the problems associated with the development of such a tidal power scheme appear to be engineering questions involving the constraint of tidal forces, rather than geological difficulties. The scheme has been left in abeyance at present.

Harbour Facilities

The harbour potential of the coastline has been commented upon by Easton (1921). The ria coastline has produced many natural harbours, such as the deep-water ports for the shipping of iron ore at Cockatoo and Koolan Islands. Recently, the possibility of establishing a deepwater port to serve the West Kimberley region was examined for the State Government by G. Maunsell & Partners (1960). Collier Bay, in the northeastern part of the Sheet area, was tentatively regarded as a possibility, particularly Secure Bay, which had the advantage of deep water and weather protection, but the disadvantage of large (10 m) tidal variation.

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APPENDIX 1. MEASURED AND ESTIMATED THICKNESSES OF STRATIGRAPHIC UNITS

Stratigraphic Unit		*Thickness (feet)*	*Taped T Placed P Estimated E*	*Locality*
Speewah Group	S1	449	P	5 km E of Mt Nellie (S1a—1763E, 29162N) (S1b—1758E, 29194N)
Speewah Group	S2	1200	E	Cone Hill (1300E, 2922N)
King Leopold Sandstone	L1	3479	P	5 km NNW of Mt Nellie
King Leopold Sandstone	L2	3444	E	4 km NNE of Cone Hill (1280E, 29190N)
Carson Volcanics	C1	3796	T	13 km NNE of Mt. Nellie (1798E, 29259N)
Carson Volcanics	C2	3612	E	8 km NNE of Mt Nellie (1752E, 29218N)
Warton Sandstone	W1	1685	P	3 km SW of Mt Dawson (1375E. 28982N)
Warton Sandstone	W2	1630	E	8 km ENE of Compass Hill (1308E, 29026N)
Warton Sandstone	W3	1129	T	6 km SSE of head of Coppermine Ck. (1214E, 29457N)
Warton Sandstone	W4	700	E	Koolan Is. (1345E, 29630N)
Warton Sandstone	W5	533	P	10 km N of Mt Nellie (1700E, 29246N)
Warton Sandstone	W7	794	T	6 km ESE of Slug Is. (1670E, 29360N)
Warton Sandstone	W8	1723	T	5 km SW of Shoal Is. (1895E, 29270N)
Elgee Siltstone	E1	1610	P	6 km W of Oobagooma (1577E, 28885N)
Elgee Siltstone	E2	850	P	3 km NW of Mt Dawson (1368E, 28976N)
Elgee Siltstone	E3	635	P	3 km WNW of Mt Olivia (1185E, 29048N to 1203E, 29047N)
Elgee Silstone	E4	481	P	Mouth of Kyulgam R. (1318E, 29250N)
Elgee Siltstone	E5	425	P	Mouth of Lydarrba R. (1365E, 29340N)
Elgee Siltstone	E6	384	T	10 km SE of Wotjulum Mission (1338E, 29415N)
Elgee Siltstone	E7	428	T	5 km SSW of head of Coppermine Ck. (1214E, 29459N)
Elgee Siltstone	E8	469	P	2½ km SE of Nores Pt.
Elgee Siltstone	E9	113	T	Koolan Is. (1365E, 29618N)
Elgee Siltstone	E10	500	E	Koolan Is. (1382E, 29627N)
Elgee Siltstone	E11	279	P	9 km E of Wotjulum Mission (1340E, 29470N)
Elgee Siltstone	E12	315	P	13 km SE of Koolan Is. (1458E, 29487N)
Elgee Siltstone	E13	601	T	8 km E of Slug Is. (1670E, 29368N)
Elgee Siltstone	E14	518	P	11 km N of Mt Nellie (1705E, 19254N)
Elgee Siltstone	E15	572	T	4 km SW of Shoal Bay (1898E, 29273N)
Pentecost Sandstone	P1	2657	P	3 km W of Mt Dawson (1352E, 28957N)

APPENDIX I—cont.

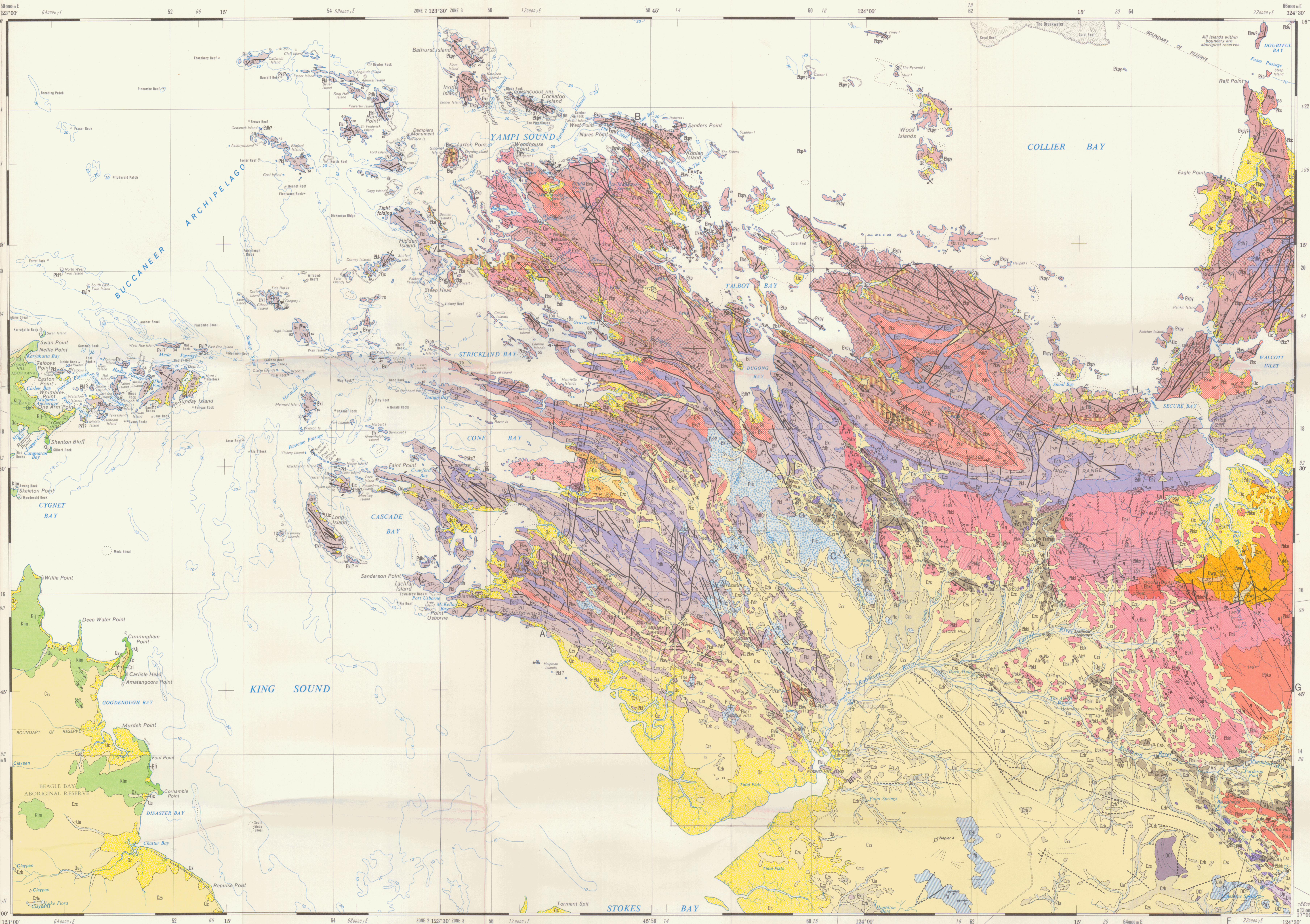
Stratigraphic Unit		*Thickness (feet)*	*Taped T Placed P Estimated E*	*Locality*
Pentecost Sandstone	P2	4264	P	8 km ENE of Compass Hill (1312E, 29005N)
Pentecost Sandstone	P3	4516	P	10 km SE of Wotjulum Mission (1335E, 29493N)
Pentecost Sandstone	P4	1200	E	4 km S of Koolan Is. wharf (1353E, 29600N)
Pentecost Sandstone	P5	1466	P	Irvine Is. (1119E, 29693N)
Pentecost Sandstone	P6	1375	T	Cockatoo Is. (Composite Section—Reid, 1958)
Pentecost Sandstone	P7	2923	P	Koolan Is, north side (1385E, 29635N)
Pentecost Sandstone	P8	3853	P	S of Shoal Bay (a—1897E, 29284N) (b—1958E, 29287N)
Pentecost Sandstone	P9	3210	E	SE of Eagle Pt (a—2181E, 29543N) (b—2168E, 29565N)
Lillybooroora Conglomerate	PZ1	24	T	5 km S of Townshend Yard (1662E, 29003N)
Cainozoic (Black Soil)	CZ1	5	T	3 km SW of Mt Nellie
Alluvium	Q1	20	T	½ km upstream from confluence of Townshend and Robinson R. (1658E, 28893N)
Alluvium	Q2	18	T	1 km upstream from confluence of Townshend and Robinson R.

AUSTRALIA 1:250,000 GEOLOGICAL SERIES

YAMPI

WESTERN AUSTRALIA

SHEET SE 51-3



Reference

- Geological boundary
- Anticline, showing plunge
- Syncline, showing plunge
- Overturned anticline, showing plunge
- Overturned syncline
- Monocline
- Plunge of minor anticline
- Plunge of minor syncline
- Plunge of drag fold
- Plunge of fold axis
- Fault
- Normal fault, teeth on downthrown side
- High-angle reverse fault, teeth on downthrown side
- Low-angle thrust fault, ⊢ indicates upper plate
- Inclined fault
- Transcurrent fault showing relative horizontal movement
- Shear zone

Where location of boundaries, folds and faults is approximate, line is broken; where inferred, queried; where concealed, boundaries and folds are dotted, faults are shown by short dashes

- Strike and dip of strata
- Prevailing strike and dip of strata
- Horizontal strata
- Vertical strata
- Overturned strata
- Prevailing strike and dip of overturned strata
- Strike and dip of strata with plunge of lineation
- Dip <5° (air-photo interpretation)
- Dip 5°–15° (air-photo interpretation)
- Dip 15°–45° (air-photo interpretation)
- Dip >45° (air-photo interpretation)
- Horizontal strata (air-photo interpretation)
- Trend line (air-photo interpretation)
- Joint pattern (air-photo interpretation)
- Top of bedding indicated by graded bedding
- Top of bedding indicated by cross-bedding
- Strike and dip of foliation
- Prevailing strike and dip of foliation
- Vertical foliation
- Strike and dip of foliation with plunge of lineation
- Vertical foliation with plunge of lineation
- Strike and dip of flow-foliation
- Vertical flow-foliation
- Strike and dip of cleavage
- Prevailing strike and dip of cleavage
- Strike of bedding and cleavage coincident
- Strike and dip of cleavage with plunge of lineation
- Strike and dip of cleavage and overturned strata
- Vertical cleavage
- Direction and plunge of lineation
- Strike and dip of joints
- Vertical joint
- Direction of sedimentation from cross stratification: average of 25 or more measurements
- Direction of sedimentation from cross stratification (air-photo interpretation)
- Measured section, horizontal: .Q2 measured section, vertical
- Sample locality for age determination
- Dyke; amph–amphibolite, ap–aplite, do–dolerite, peg–pegmatite, q–quartz
- Prospect
- Mine not worked
- Open cut or quarry
- • Cu Minor mineral occurrence
- Ag Silver; Fe Iron
- Be Beryl; Mi Mica
- Cu Copper; Pb Lead
- Petroleum exploration well – dry abandoned
- Artesian bore
- Sub-artesian bore
- pe Equipped with pump engine
- WH Waterhole
- Waterhole on stream
- Spring
- Swamp
- Mangroves
- Fathom line
- Coral reef
- Rock or reef location
- Tidal bank flats, shoal
- Navigation light
- Vehicle track
- Landing ground
- "Kimbolton" Homestead
- Building
- Yd Yard
- Trigonometrical station
- Astronomical station
- •49 Elevation in metres – approximate
- abd Abandoned

Reference

CAINOZOIC	QUATERNARY		Qa	Alluvium
			Qc	Coastal mud, silt and sand; thin salt crust in places
			Qs	Beach and dune sand
			Czs	Residual soil, sand, eluvium, colluvium
			Czb	Black soil
			Czl	Ferricrete; ferruginous pisolitic sandy soil
	TERTIARY		Tp	Pisolitic laterite
		Pender Bay Conglomerate	Tc	Dark grey boulder to pebble conglomerate
MESOZOIC	CRETACEOUS APTIAN	Melligo Sandstone	Klm	White to pale grey, medium to coarse silicified quartz sandstone: large scale cross-bedding locally
	CRETACEOUS OR JURASSIC	Jowlaenga Formation	Klj	Fine to medium silty sandstone, poorly sorted, commonly ferruginous
PALAEOZOIC	PERMIAN SAKMARIAN	Grant Formation	Pg	Massive aqueo-glacial unsorted silty sandstone, conglomeratic sandstone, tillite, siltstone, shale
	PERMIAN ?	Lillybooroora Conglomerate	Plc	Boulder and cobble conglomerate, interbedded coarse sandstone
	DEVONIAN TO CARBONIFEROUS FAMENNIAN TO TOURNAISIAN	Fairfield Formation	DCf	Silty limestone and calcarenite; calcareous shale and siltstone
	DEVONIAN FRASNIAN TO FAMENNIAN	Windjana Limestone	Dw	Massive algal and stromatoporoid limestone, dolomitised in part
		Pillara Limestone	Dp	Bedded birdseye limestone; calcarenite and calcilutite: back-reef facies
		Napier Formation	Dn	Calcarenite, calcirudite and megabreccia, minor dolomite: fore-reef and inter-reef facies
PROTEROZOIC	CARPENTARIAN (LOWER AND MIDDLE PROTEROZOIC*)	Wotjulum Porphyry	Ꝑqw	Massive quartz feldspar porphyry: sheared and sericitic locally
		Hart Dolerite	Ꝑdh	Medium dark grey and green-grey tholeiitic dolerite, some grey granophyre
		Kimberley Group: Pentecost Sandstone	Ꝑkp	White well-sorted quartz sandstone, grey siltstone
		Yampi Member	Ꝑkpy	Pink-brown arkose and feldspathic sandstone; minor siltstone, hematitic quartz sandstone, glauconitic sandstone; Iron ore
		Elgee Siltstone	Ꝑke	Red-brown and grey siltstone and minor phyllite; thin sandstone interbeds; Basal boulder to pebble conglomerate
		Warton Sandstone	Ꝑkw	White well-sorted quartz sandstone and feldspathic sandstone; siltstone interbeds; andalusite granofels in places
		Carson Volcanics	Ꝑkc	Tholeiitic basalt and spilite, tuff, agglomerate; Feldspathic sandstone
		King Leopold Sandstone	Ꝑkl	White to pale brown coarse well-sorted quartz sandstone
		Speewah Group	Ꝑp	Pale purple-grey to buff quartz sandstone, micaceous in places, minor phyllite and pebble conglomerate
	(LOWER PROTEROZOIC*)	Lamboo Complex: Cone Hill Granite	Ꝑbkc	Coarse porphyritic biotite granite
		Kongorow Granite	Ꝑbkk	Foliated coarse porphyritic biotite granite and adamellite
		Tarraji Microgranite	Ꝑbkt	Porphyritic biotite microgranite
		Secure Bay Adamellite	Ꝑbks	Coarse leucocratic biotite adamellite; sparsely porphyritic in places
		Lennard Granite	Ꝑbkl	Coarse leucocratic porphyritic biotite granite; Xenolith-rich granite; Muscovite granite; Biotite granodiorite
		Mondooma Granite	Ꝑbko	Porphyritic microgranite and microgranodiorite; Non-porphyritic microgranodiorite and microtonalite
		Mount Disaster Porphyry	Ꝑbkd	Coarse porphyritic biotite microgranite and microgranodiorite
		Whitewater Volcanics	Ꝑw	Rhyodacite welded ash-flow tuff; mainly crystal poor
			Ꝑws	Fine bedded tuffaceous greywacke and bedded tuff
			Ꝑwa	Crystal-rich rhyodacitic welded ash-flow tuff
			Ꝑwp	Crystal-poor rhyodacitic ash-flow tuff
		Nellie Tonalite	Ꝑbkn	Hornblende-biotite tonalite and granodiorite
		Woodward Dolerite	Ꝑbd	Dark green coarse metadolerite; porphyritic locally
ARCHAEAN?	(ARCHAEAN OR LOWER PROTEROZOIC*)	Halls Creek Group	Ah	Muscovite, sericite and chlorite schist; phyllitic shale, siltstone and greywacke; minor chloritoid, andalusite and garnet schist

* Subdivision of Precambrian time-scale used by the Geological Survey of Western Australia, shown in grey

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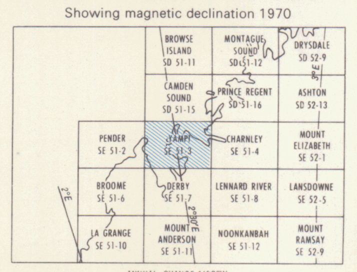
INDEX TO ADJOINING SHEETS

Showing magnetic declination 1970



Scale 1:250,000

5 0 5 10 15 20 25 KILOMETRES

5 0 5 10 MILES

GREY NUMBERED LINES ARE 20,000 METRE INTERVALS OF THE AUSTRALIAN MAP GRID, ZONE 51
GREY TICKS WITH ITALIC NUMBERS INDICATE THE 20,000 YARD GRID, ZONES 2 AND 3 (AUSTRALIA SERIES)
TRANSVERSE MERCATOR PROJECTION

Sections

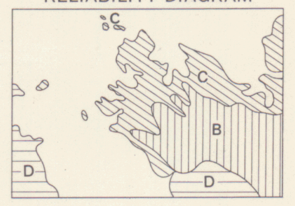
Cainozoic sediments omitted

Faults shown as vertical where attitude is unknown

Scale: V/H = 1

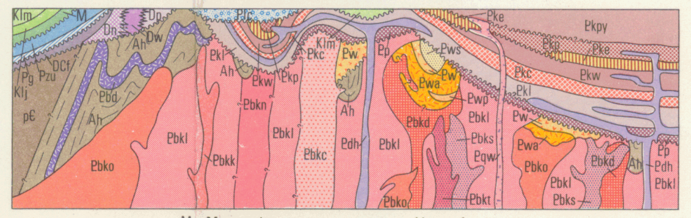
Geology 1948–51 by R. O. Brunnschweiler, D. Guppy and A. Lindner (B M R)
1963 by P. E. Playford and D. C. Lowry (GSWA)
1966–67 by D. C. Gellatly, G. M. Derrick, C. M. Morgan (B M R), J. Sofoulis and R. A. Farbridge (G S W A)
Compiled 1966–69 by D. C. Gellatly, J. Sofoulis, G. M. Derrick, J. L. McGovern, A. Tatarow
Cartography by Geological Branch, B M R
Drawn by Cartographic Drafting Services, Bendigo, Victoria
Printed by Leigh-Mardon Pty. Limited, Melbourne

RELIABILITY DIAGRAM

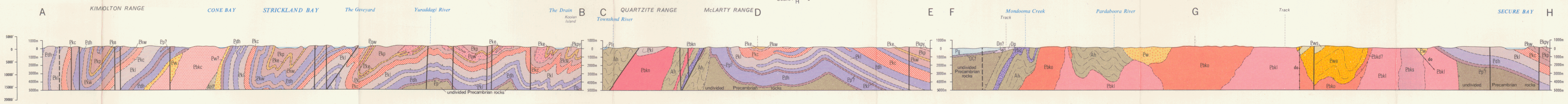


Geology B Detailed reconnaissance: numerous traverses
C General reconnaissance: some traverses and air-photo interpretation
D Air-photo interpretation

DIAGRAMMATIC RELATIONSHIP OF ROCK UNITS



M—Mesozoic
Pzu—Upper Palaeozoic
p€—Precambrian
Unconformity
Facies change



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SHEET SE 51-3

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