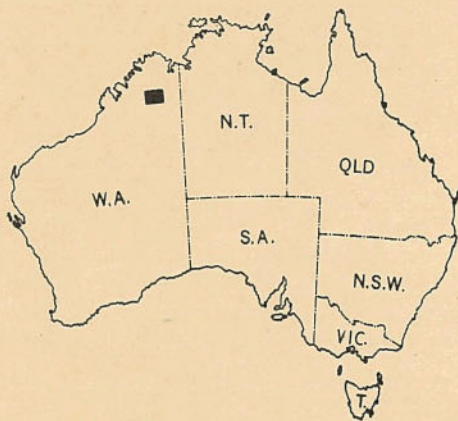


1:250,000 GEOLOGICAL SERIES—EXPLANATORY NOTES

# LANDSLOWNE

## WESTERN AUSTRALIA



SHEET SE/52—5 INTERNATIONAL INDEX

COMMONWEALTH OF AUSTRALIA  
STATE OF WESTERN AUSTRALIA

1:250,000 GEOLOGICAL SERIES—EXPLANATORY NOTES

# Lansdowne

## Western Australia

SHEET SE/52—5 INTERNATIONAL INDEX

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Mineral Resources)

*Issued under the authority of the Hon. David Fairbairn  
Minister for National Development*

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COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

MINISTER: THE HON. DAVID FAIRBAIRN, D.F.C., M.P.

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## Explanatory Notes on the Lansdowne Geological Sheet

The Lansdowne 1 : 250,000 Sheet area lies in the Kimberley Land Division in the north-eastern corner of Western Australia. It is bounded by longitudes 126° E and 127° 30' E and by latitudes 17° S and 18° S.

Lansdowne homestead, near the centre of the Sheet area, is about 300 miles by road from Derby and 340 from Wyndham. These towns are connected by way of Halls Creek by a regularly maintained gravel road. Spasmodically maintained station tracks give access to the Sheet area from Fitzroy Crossing, and from near Halls Creek. Shortest access from Derby to the north-western part of the Sheet area is by way of Mount House. Within the area graded station tracks radiate to stockyards and bores. All roads in the region are impassable at times during the wet season.

The homesteads in the area are served by fortnightly air services from Derby and Wyndham, which have frequent connexions with Perth and Darwin. Light aircraft are available for charter in Derby and Wyndham.

### *Climate and Vegetation*

The climate is semi-arid and monsoonal, with a short wet summer and a long dry winter. The average annual rainfall varies between 18 and 27 inches; 90 percent falls during January, February, and March. Mean daily temperature maxima range from about 80° F in winter to 100° F in summer, and the mean winter minimum falls as low as 45°.

The natural vegetation consists predominantly as a savannah-type association of stunted eucalypts and spinifex, with patches of grass, especially on basic rock. Large eucalypts and locally baobabs fringe the watercourses.

### *Population and Industry*

The station homesteads of Glenroy, Tableland, Mornington, Bedford Downs, and Lansdowne are the only centres of habitation. The population, which is entirely engaged in cattle-raising, numbers about 250, most of whom are aboriginals.

The proposed irrigation scheme in the Fitzroy Basin, with storage dams at Diamond Gorge, Pyra Gorge, and on the Leopold River, may bring the area into greater prominence.

### *Air-Photographs and Maps*

Air-photographs at a scale of approximately 1 : 48,000 were flown in 1949 by the Royal Australian Air Force. Mosaics based on these photographs, at



scales of 1 : 250,000 and 1 : 63,360, and a topographic map at 1 : 250,000 scale produced by the Royal Australian Survey Corps are also available.

The geological map which these notes accompany was prepared on Royal Australian Survey Corps 1 : 50,000 photo-compilations, and subsequently reduced to 1 : 250,000 scale.

### *Previous Work*

Because the Lansdowne Sheet area is relatively inaccessible and is not known to contain any worthwhile mineral deposits, little geological investigation has taken place.

Hann (1901) explored the north-west of the Sheet area, and named many topographic features, including the Traine River and Lake Gladstone, but made few observations on the geology.

Jack (1906) wrote on the prospects of obtaining artesian water in the Kimberley Division. Easton (1922), a surveyor, described in very general terms the geology of the Kimberley Plateau, where he found 'basalt' and 'sandstone'. Maitland (1928) wrote briefly on the volcanic rocks of the region. Jutson's (1950) physiographical study of the Kimberleys included geological observations on the Plateau and Fitzroy River Basin, though no specific reference was made to the Lansdowne area. Edwards (1943) enlarged on the comments of Maitland, and presented the first detailed petrological study of the basic volcanic rocks of the area. Guppy, Lindner, Rattigan, & Casey (1958), working in the West Kimberleys south and west of the Lansdowne Sheet area, subdivided the Kimberley Basin sediments for the first time.

Harms (1959) extended their work by mapping the major Precambrian rock units throughout the Kimberley region, and his work has provided the framework for all subsequent work in the Precambrian rocks of the Kimberleys.

The Devonian reef complex which crops out in the extreme south-west corner of the Lansdowne Sheet has recently been studied in detail by Playford & Lowry (1967) of the Geological Survey of Western Australia, who have kindly provided us with their maps and notes.

These Notes and the geological map are based on a joint survey carried out in 1964 by the Bureau of Mineral Resources and the Geological Survey of Western Australia, as part of a programme begun in 1962 to map all Precambrian rocks of the Kimberley Division at 1 : 250,000 scale. The Notes are summarized from a more detailed report on the geology of the Lansdowne Sheet area (Gellatly, Derrick, & Plumb, 1965).

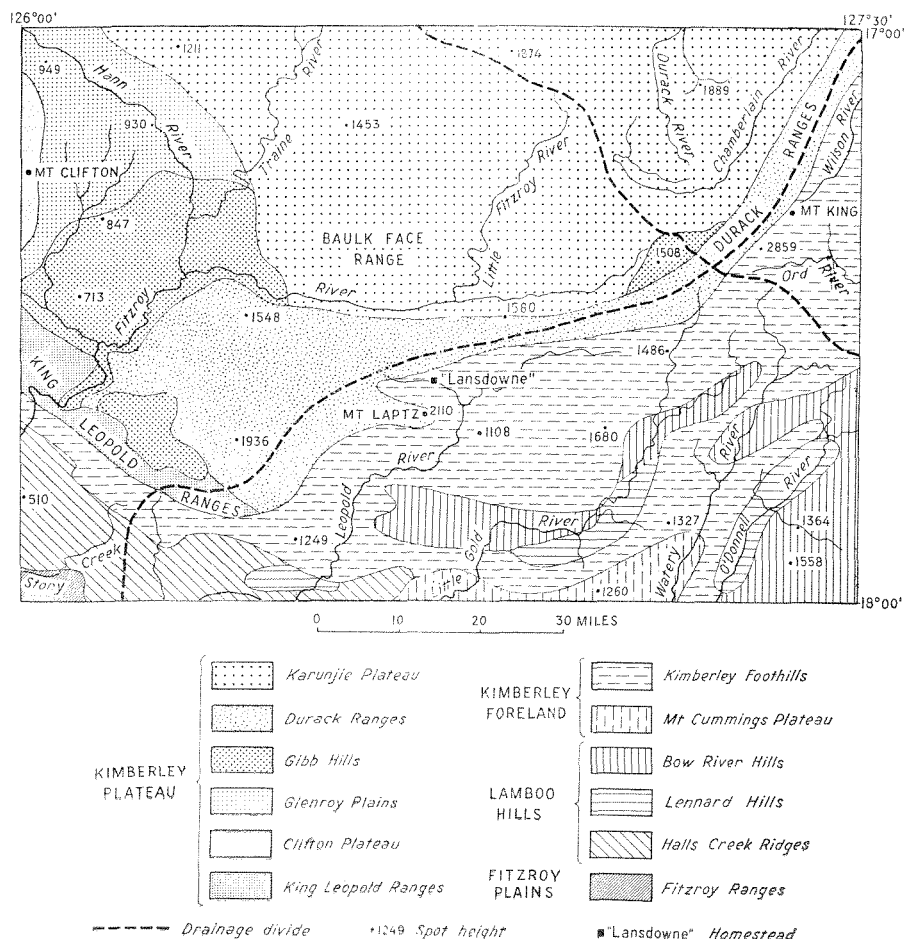
The adjoining Sheet areas to the east, Gordon Downs (Gemuts & Smith, 1968), Dixon Range (Dow & Gemuts, 1967), and Lissadell (Dunnet & Plumb, 1968), were mapped in 1962 and 1963, and the Mount Ramsay Sheet area (Roberts, Halligan, and Playford, 1968) to the south in 1964.

## **PHYSIOGRAPHY**

### *Drainage*

The Lansdowne Sheet area is drained by four major river systems: the Hann-Fitzroy and Chamberlain River Systems, both of which drain the Kimberley Plateau, the Ord River Wilson River system draining the Foreland area to

the east, and the Margaret River system draining similar areas in the south. The Margaret River itself drains the Mount Ramsay Sheet area, and the more important tributaries which drain the Lansdowne area southwards are the O'Donnell River<sup>\*1</sup>, Watery River<sup>2</sup>, Little Gold River<sup>3</sup>, Leopold River<sup>4</sup>, and Stony Creek. With the exception of the Chamberlain River, and upper reaches of the Fitzroy River, all these streams are superimposed and consequent, though the Ord and Fitzroy Rivers become obsequent where they break through the King Leopold Ranges.



**Fig. 1. Physiographic elements.**

The Chamberlain River and the upper parts of the Fitzroy River are sub-sequent, their courses being controlled by preferential erosion of soft bedrock.

### *Physiographic Divisions*

The Kimberley region was divided physiographically into the North Kimberley Division and Fitzroyland Division by Jutson (1950) and Wright (1964). These Divisions have been subdivided by Plumb (in prep.) into the Kimberley Plateau, Kimberley Foreland, Lamboo Hills, and Fitzroy Plains Provinces, which in turn are subdivided into various subprovinces.

\* The locally used names, which are given in parentheses on the accompanying map, are as follows: (1) Sandy River; (2) Stony River; (3) Watery River; (4) Horse Creek.

On the Lansdowne Sheet area the following Provinces and Subprovinces are recognized:

<i>Subprovince</i>	<i>Province</i>	<i>Division</i>
Karunjie Plateau	Kimberley Plateau	North Kimberley Division
Durack Ranges		
Gibb Hills		
Glenroy Plains		
Clifton Plateau		
King Leopold Ranges		
Kimberley Foothills	Kimberley Foreland	
Mount Cummings Plateau		
Bow River Hills	Lamboos Hills	Fitzroyland Division
Lennard Hills		
Halls Creek Ridges		
Fitzroy Ranges		
	Fitzroy Plains	

#### *Kimberley Plateau Province*

The *Karunjie Plateau* is a terraced landform and consists of gently dipping cuestas, and mesas bounded by scarps up to 300 feet high. Elevations range from 1200 feet to 1900 feet, and the bedrock is predominantly resistant sandstone with minor interbeds of siltstone and friable sandstone.

The rugged *Durack Ranges* form the south-eastern margins of the *Karunjie Plateau*, and elevations range from 2000 feet to nearly 3000 feet. Consequent and subsequent drainage patterns predominate, the latter being controlled by the softer interbeds of siltstone.

The *Gibb Hills* are developed on flat-lying or gently dipping rocks of the Carson Volcanics. Mesas with terraced slopes are common, e.g. Mount Brennan, and the intervening ground is broken and undulating. Elevations in this subprovince range from 850 feet to 1500 feet.

The *Glenroy Plains*, lying mostly west of the Hann River, have formed over the soft siltstone and shale of the Mount House Group and (near Number 2 Yard) over soil-covered Carson Volcanics, illustrating the close adjustment of erosional surface to lithology. A resistant sandstone remnant capping the shade forms a prominent mesa whose broad flat surface constitutes the *Clifton Plateau*. The minor streams in the *Gibb Hills*, *Glenroy Plains*, and *Clifton Plateau* show a dendritic drainage pattern over flat-lying rocks, or a parallel and rectangular pattern controlled by jointing and bedding over dipping rocks. Away from the river courses there is thin and scattered soil cover and sparse vegetation, though some areas of the *Gibb Hills* subprovince are covered by red and black soils.

The *King Leopold Ranges* form a westerly extension of the *Durack Ranges*; both rise abruptly from the plainlands to the north. Elevations (up to 2300 feet) are generally higher than those of the *Karunjie Plateau*. Obsequent drainage predominates along the southern margins of the ranges, and consequent drainage to the north is well developed on the steep dip slopes. As a result of these drainage patterns, wind and water gaps through the ranges are relatively common.

### *Kimberley Foreland Province*

The *Kimberley Foothills* extend from the King Leopold and Durack Ranges southwards. They are confined to the areas of folded and gently dipping rocks, and range in elevation from 1000 feet to 1500 feet above sea level, with an average of about 1300 feet. The Foothills form a complex system of hogbacks and cuerdas, interspersed with extensive tracts of undulating hills and broad valleys characteristically developed on areas of dolerite. The drainage, controlled by preferential erosion of bedding and jointing, is mainly subsequent, but because of the variable nature of the bedrock no single drainage type predominates.

The *Mount Cummings Plateau*, on the southern margin of the Sheet area, is a remnant of the Karunje Plateau to the north, and shows an undulating surface at a general altitude of 1000 feet to 1500 feet with some higher peaks. The surface relief is controlled by gentle folding of the underlying sandstones.

### *Lamboo Hills Province*

*Bow River Hills* and *Lennard Hills* are areas of relatively low relief formed on crystalline basement rocks which crop out in the south-east (Bow River Hills) and south-west (Lennard Hills). Both subprovinces are characterized by low rounded boulder-strewn hills and isolated tors, between which are erosional pediments, and river flats of alluvium and sandy soil supporting a poor and sparse vegetation. The Bow River Hills have an average elevation of about 1400 feet; the Lennard Hills are lower, with an average elevation of 800 feet. Relief varies from 50 feet to 200 feet.

The *Halls Creek Ridges* are developed on steeply dipping metasediments of the Halls Creek Group. Major streams are consequent, but meander and appear superimposed. Minor tributaries tend to be subsequent, subparallel, and closely spaced, and lateral erosion at their heads has breached the ridges to form a hummocky topography.

### *Fitzroy Plains Province*

The *Fitzroy Ranges* are best developed on the Mount Ramsay Sheet area, and extend into the south-western corner of the Lansdowne Sheet area. The subprovince consists of broad sandy plains from which walls of massive Devonian reef limestone rise sharply to give relief of about 100 feet.

## **STRATIGRAPHY**

The stratigraphic nomenclature used will be fully defined in future publications by Dow & Gemuts (in prep.), Plumb (in prep.), and Gellatly, Sofoulis, & Derrick (in prep.). The current usage is based essentially on Guppy et al. (1958) and Harms (1959), but differs in that certain units have been further subdivided as a result of more detailed work.

With the exception of the Halls Creek Group, which is tentatively regarded as Archaean, all the Precambrian rock-units present are assigned to the Proterozoic. The Speewah, Kimberley, and Bastion Groups are tentatively correlated with the Carpentarian of the Northern Territory, and the Mount House Group is correlated with the Adelaidean of South Australia and the Northern Territory.

ARCHAEAN (?)

Halls Creek Group (Table 1)

Rocks of the *Olympio Formation* are the oldest found in the Lansdowne Sheet area and are the only representatives of the Halls Creek Group present. Rare thin beds of finely banded limestone occur near the top of the exposed sequence. Sedimentary structures such as graded bedding and flute casts are found, but only rarely. Slaty cleavage is locally well developed, and minor quartz veins are common throughout the area. Where the formation is intruded by granite, thermal metamorphism has produced muscovite, biotite, and pyroxene bearing hornfelses. The base of the formation is not exposed and its thickness cannot be estimated.

The Olympio Formation is intruded by granites of the Lamboo Complex and by dykes of porphyry lithologically similar to the unconformably overlying Whitewater Volcanics.

TABLE 1: HALLS CREEK GROUP AND LAMBOO COMPLEX

Era	Group	Rock Unit and Symbol	Lithology	Topography	Remarks
PROTEROZOIC	LAMBOO COMPLEX	Bickleys Porphyry (Pbb)	Grey acid porphyry and porphyritic microgranite with quartz and feldspar phenocrysts.	Low rounded hills consisting of large residual blocks.	Similar to Whitewater porphyry but intrusive into it. Postdates shear zones which affect Whitewater Volcanics.
		Mulkerins Granite (Pbu)	Coarse leucocratic white non-porphyrific biotite-bearing granite.	Very low rounded hills with sandy pediments.	Elliptical outcrop. Dykes of tourmaline-bearing aplite and pegmatite, and quartz veins.
		Lerida Granite (Pbl)	Grey to pink-grey porphyritic biotite granite with euhedral phenocrysts of pale green feldspar and quartz, and pale pink feldspar locally.	Low rugged hills, rectilinear drainage. Sandy pediments locally.	Overlain unconformably by O'Donnell Formation and intruded by Bickleys Porphyry. Possibly intrudes Whitewater Volcanics. Aplite dykes abundant.
		Chaney's Granite (Pby)	Coarse grey biotite granite; commonly foliated; essentially even-grained.	Low rounded 'whale-backs' with isolated residual tors.	Even grain and pale grey quartz characteristic. Some quartz and aplite dykes.
		Long Hole Granite (Pbg)	Coarse porphyritic grey biotite granite, pink-grey biotite gneiss, augen gneiss.	Very low easily weathered outcrops with broad sandy pediments.	Blue-grey quartz over pink feldspar (where present) characteristic.
		Violet Valley Tonalite (Pbv)	Dark grey coarse to medium tonalite.	Low residual bouldery hills.	Distinctive dark grey photopattern. Probably younger than Bow River Granite.
		Bow River Granite (Pbo)	Coarse grey biotite granite, pink porphyritic biotite granite, minor granodiorite.	Low tors with sandy pediments.	Grey granite xenolithic. Pink porphyritic type found mainly near Turnagee.
		Tickalara Metamorphics (Pbt)	Biotite paragneisses with cordierite, sillimanite, and staurolite.	Low residual bouldery hills.	Dark-grey tone on air-photographs. Only within granites.
ARCHAEAN OR PROTEROZOIC	HALLS CREEK GROUP	Olympio Formation (Aho)	Phyllitic shale and siltstone, interbedded greywacke; minor quartzite and limestone.	Distinctive rounded hills-hummocky topography. Meandering watercourses.	Isoclinally folded. Intruded by minor quartz veins. Unconformably overlain by Whitewater Volcanics.

## PROTEROZOIC

### *Lamboo Complex* (Table 1)

The Lamboo Complex consists almost entirely of intrusive granitic rocks and associated dykes and veins. Metamorphic rocks are of secondary importance, and are confined to roof pendants and narrow contact zones of hornfels derived from pre-existing sedimentary and igneous rocks.

The Complex crops out mainly in the south-eastern and south-western corners of the Sheet area, forming low rounded hills, with sandy pediments or residual tors. Small isolated outcrops also occur in the core of a dome 3 miles west-south-west of Mad Gap Yard, and in a complex fault zone 6 miles west-north-west of Pyra Gorge.

Granites of the Lamboo Complex cut rocks of the Halls Creek Group and Whitewater Volcanics. Their age probably ranges from Lower Proterozoic to Carpentarian, but younger intrusions may be represented.

The age relationships of the various granites are only partly known. In the east the Violet Valley Tonalite is thought to be younger than the Bow River Granite. In the west Lerida Granite is intruded by Bickleys Porphyry and Mulkerins Granite. The other two granites in the west, Long Hole and Chaney's Granites, probably both antedate the Lerida Granite, and the Long Hole mass is thought to be older than Chaney's Granite. With the possible exception of the Long Hole and Chaney's Granites, and parts of the Bow River mass, the granites in the Lansdowne Sheet area postdate the White-water Volcanics.

The *Tickalara Metamorphics* are present in the Lansdowne Sheet area only as two small outcrops in the south-east, where they form roof pendants in the porphyritic Bow River Granite. The most common rock types are foliated and compositionally banded cordierite-sillimanite and sillimanite-staurolite-bearing biotite paragneisses. Contacts between xenoliths and granitic host rock are sharp, with no obvious contact effects. Metamorphic minerals such as sillimanite, cordierite, and garnet antedate a prominent secondary foliation; the metamorphism was thus probably earlier than, and not a result of, the granite emplacement.

The *Bow River Granite* is the most widespread mass in the south-eastern corner of the Sheet area. It is a complex mass which includes coarse-grained grey biotite granite, minor granodiorite, and pink porphyritic biotite granite, and is intruded by quartz reefs and aplite and dolerite dykes.

The Bow River granite is massive and shows irregular discordant contacts. Lenticular xenoliths of fine-grained biotite granite up to 9 inches across are common. Xenoliths of sedimentary rock predominate near the contact with the Halls Creek Group. Towards the contact the granite, normally massive, becomes foliated and finer-grained. Large flakes of muscovite appear and tourmaline grains are widespread.

In thin section the Bow River Granite consists essentially of zoned sericitized and epidotized plagioclase (An 30-10) with myrmekitic rims, perthitic potash feldspar, and chloritized biotite, and minor accessory zircon and apatite.

The *Violet Valley Tonalite* is a small coarse-to-medium-grained tonalite body found only in the south-eastern corner and has a distinctive dark grey air-photograph pattern. It intrudes the Halls Creek Group and is apparently later than the Bow River Granite.

The *Long Hole Granite* crops out over 6 square miles in the south-west. It is a coarse-grained porphyritic grey biotite granite, with zones of biotite and augen gneiss commonly developed. Milky blue-grey quartz and pink potash feldspar distinguish it from Chaney's Granite in hand specimen, but they are similar in thin section. Plagioclase crystals are zoned, with cores of An 35-38 and outer margins of An 8-12. The calcic cores are generally altered to sericite and epidote, and myrmekite is well developed between the altered core and albitic rims. Biotite is commonly deformed and chloritized, and contains abundant needles of rutile and rare inclusions of apatite and zircon, the latter producing marked pleochroic haloes.

*Chaney's Granite* is a coarse and even-grained grey biotite granite, which crops out over 40 square miles in the south-west. It is commonly foliated and locally sheared, resulting in the development of small patches of biotite gneiss. Dolerite dykes and sporadic quartz reefs occur within it.

The *Lerida Granite* also crops out in the south-west, and near Mad Gap Yard, immediately under sedimentary rocks of the Speewah Group at the former locality, and in contact with Whitewater Volcanics at the latter. It is a porphyritic grey-green biotite granite, distinguished in hand specimen by pale creamy green phenocrysts of zoned feldspar. It shows a hypautomorphic-granular texture in thin section, and is characterized by sporadic development of micropegmatite. Plagioclase is highly altered, more so than in the other granite masses, and biotite flakes are almost completely altered to chlorite. Pale green actinolite is present in foliated specimens, and tourmaline, zircon, and epidote are common minor accessories. A dyke of rhyodacite intrudes the Lerida Granite 4 miles east of Saddlers Yard. Relationships between the Lerida, Long Hole, and Chaney's Granites are uncertain.

*Mulkerins Granite* is a coarse and even-grained leucocratic granite which intrudes the Lerida Granite and sheared rocks of the Whitewater Volcanics. It is strongly weathered and characteristically forms broad sandy pediments in which massive quartz reefs crop out prominently. The granite contains numerous endogenetic barren quartz reefs and composite dykes of tourmaline-bearing aplite and granite pegmatite.

In thin section the granite shows a typical hypidiomorphic granular texture. Plagioclase is zoned and strongly altered to sericite and epidote, albitic rims and myrmekite are common, and intergranular albite occurs between grains of perthitic potash feldspar. The small amounts of biotite present are fresh and undeformed.

*Bickleys Porphyry*, which consists of acid porphyry and porphyritic micro-granite, crops out as small bodies within the Lerida Granite near Torrens Yard and near Bickleys Yard. No definite contacts with the enclosing granite have been found, though xenoliths of Lerida Granite in the porphyry suggest an intrusive relationship. It postdates the Whitewater Volcanics. Quartz and feldspar phenocrysts are common and are set in a fine-grained granular



matrix of quartz, potash feldspar, and small amounts of plagioclase. Plagioclase phenocrysts of An 34 composition are epidotized and sericitized like those of all the granite masses in the south-west. Phenocrysts of perthitic potash feldspar with zones of quartz inclusions in their outer margins, and the presence of sporadic orthopyroxene phenocrysts partly altered to chlorite and a pale green amphibole, are characteristic.

#### CARPENTARIAN

The *Whitewater Volcanics* (Table 2) are a thick series of acid porphyries which form low rocky hill country in the south and south-east and crop out as elongated inliers. They lie unconformably on the Halls Creek Group, are intruded by Bickleys Porphyry and Lerida Granite of the Lamboo Complex, and are overlain unconformably by the O'Donnell Formation, and in one locality by the King Leopold Sandstone.

The rocks are predominantly red-brown to grey-green quartz-feldspar and feldspar 'porphyries'. Lapilli tuff and volcanic pebble conglomerate and interbedded siltstone are found locally. Poorly preserved bedding is present in places but is not common. The porphyries consist essentially of xenocrysts of quartz, plagioclase, and potash feldspar, and rare altered pyroxene and biotite, in a cryptocrystalline matrix of devitrified glass. Glass shards have been found in a few specimens. Most of the rocks are probably ashflow tuffs. Concordant acid intrusives are present locally in the Whitewater Volcanics, e.g. 4 miles east-north-east of Pyra Gorge, but apparently are rare.

The actual thickness is uncertain, but is estimated to be at least 6000 to 9000 feet.

The *Little Gold River Porphyry* is a dark grey to black dacitic rock characterized by an abundance of small cognate xenoliths. It crops out in the southern part of the Sheet area as low rounded hills, and forms a flat-lying laccolith about 8 miles across. It contains phenocrysts of orthopyroxene, plagioclase, and quartz, in a fine-grained feldspathic matrix. The Porphyry is lithologically similar to thin dark horizons within the Whitewater Volcanics, except that the latter are slightly less mafic, and contain completely chloritized pyroxene, whereas the pyroxene in the Little Gold River Porphyry is fresh.

#### *Speewah Group*

The Speewah Group is a succession of quartzose and feldspathic arenites interbedded with chloritic lutites and minor acid volcanics. The Group crops out in a broad arc, concave to the north, across the north-eastern, south-eastern, and southern parts of the Sheet, and is about 3200 feet thick. The rocks are openly folded and extensively intruded by dolerite. The Speewah Group lies unconformably on rocks of the Lamboo Complex, Halls Creek Group, and Whitewater Volcanics, and conformably overlain by rocks of the Kimberley Group, except in one locality in the south-east where rocks low in the succession are unconformably overlain by the Kimberley Group.

The *O'Donnell Formation* at the base of the group lies unconformably on rocks of the Lamboo Complex, Halls Creek Group, and Whitewater Volcanics. It is overlain conformably by the Tunganary Formation and, in one place in the south-east, unconformably by the King Leopold Sandstone.

TABLE 2: CARPENTARIAN STRATIGRAPHY

Group	Rock Unit and Symbol	Thickness (feet)	Lithology	Topography	Remarks
BASTON GROUP	Hart Dolerite (Pdh)	Up to 10,000	Dark grey to black tholeiitic dolerite and gabbro: pink to pale red-brown pyroxene-bearing granophyre.	Low rounded boulder-strewn hills, small black soil plains. Granophyre slightly more resistant.	Intrudes formations up to Pentecost Sandstone, but principally Speewah Group. Granophyre locally caps dolerite.
	Mendena Formation (Ptm)	?100	Purple siltstone, quartz sandstone, micaceous feldspathic sandstone.	Gently undulating plains; partly soil-covered.	Only lowest beds present.
KIMBERLEY GROUP	Pentecost Sandstone Upper (Pkpu)	ca 1000	Coarse to medium quartz sandstone.	Undulating and hilly plateau country with rounded mesas and cuestas. Basal beds form low cliffs.	Too inaccessible for complete measurement. Glauconitic sandstone a marker. Base of upper member near top of prominent escarpment.
	Middle (Pkpm)	ca 2000	Light fine to medium feldspathic sandstone and quartz sandstone; grey siltstone and glauconitic sandstone at base.		
	Lower (Pkpl)	500	White to pale brown medium quartz sandstone.		
	Elgee Siltstone (Pke)	700* (including Teronis Member)	Red-brown friable siltstone with grey-green reduced zones; brown to white quartz sandstone.	Steep easily eroded escarpments preserved by hard capping of Pentecost Sandstone.	Siltstone grades upwards into sandstone.
	Teronis Member (Pkt)	70*-300	Grey micaceous siltstone with thin feldspathic sandstone interbeds; limestone and dolomite, with algal structures.	Poorly exposed gently dipping pediments with low limestone outcrops.	Basal beds of Elgee, much intruded by Hart Dolerite in North.
	Warton Sandstone (Pkw)	900-1200	Cross-bedded white to pale purple and pale brown quartz sandstones; feldspathic sandstone form upper part.	Gentle cuestas. Basal beds scarp-forming.	Thickness as calculated from air-photos. Cross-bedding indicates transportation from north-west.
	Carson Volcanics (Pkc)	1300* to 2300*	Tholeiitic basalt and minor spilite, amygdaloidal in part, agglomerate, and lapilli tuff; thin interbeds of clean-washed and silty feldspathic sandstone; chert and siltstone.	Very low cuestas, largely soil-covered, major valleys.	Amygdaloidal flow near base of sequence contains sporadic small vesicle infillings of chalcopyrite. Top 200 feet very poorly exposed.
	King Leopold Sandstone (Pkl)	3500 to 4000	Massive cross-bedded pale purple, white, and pale brown poorly sorted quartz sandstone; local pebble and cobble conglomerate granule sandstone and siltstone.	Rugged mountainous terrain; cliff forming where dips are gentle.	Poor sorting of lower part characteristic. Cross-bedding indicates transportation from north-east and north-west.
	Luman Siltstone (Ppl)	240*	Purple-grey and green-grey micaceous shale and siltstone with thin sandstone interbeds especially near top of sequence.	Steep scarp-slopes below King Leopold Sandstone cliffs.	In Carola Syncline and at Pyra Gorge, upper part consists of feldspathic sandstone.

Lansdowne Arkose (Ppo)	1300*– 1600	Buff to pale pink cross-bedded feldspathic sandstone and arkose; deep pink arkose; purple-grey and green-grey micaceous siltstone and shale.	Parallel ridges with dip and scarp; low cliffs locally. Topmost member has smooth rounded topography.	Two siltstones and 4 arenite members. Cross-bedding indicates transportation from north-east.
Valentine Siltstone (Ppv)	140*	Chloritic siltstone, dark grey and grey-green blocky mudstone, feldspathic sandstone, minor rhyolitic tuff.	Low gentle scarp slope preserved by cap of basal Lansdowne Arkose.	Tuff characteristic. Siltstone generally non-micaceous. Much intruded by Hart Dolerite.
Tunganary Formation (Ppt)	740*–940*	Buff to pale grey feldspathic sandstone; quartz sandstone; pale pink arkose; minor brown granule sandstone, grey-green and grey shale, and flaggy purple micaceous sandstone and siltstone; minor chert.	Gently dipping rounded cuestas and strike ridges.	Rock types similar to Lansdowne Formation. Upper beds locally ripple-marked e.g. near Bluff Yard.
O'Donnell Formation (Ppn)	480*–760*	<i>Upper O' Donnell:</i> Grey-green to khaki shale and siltstone, minor interbeds of sandstone and greywacke (320).  <i>Lower O' Donnell:</i> White to pale purple and brown coarse silica-cemented quartz sandstone; minor green-grey silt and glauconitic sandstone. Local feldspar porphyry, granule sandstone, conglomerate in east (38–430)	Lower part a resistant ridge; upper part mainly a narrow valley.	Thickness of lower part varies greatly; upper relatively constant but becomes more arenaceous in extreme west.
UNCONFORMITY				
Little Gold River Porphyry (Pwl)		Dark grey orthopyroxene-feldspar porphyry with sporadic phenocrysts of quartz. Locally xenolithic.	Low rounded hills – dissected peneplain. Watercourses controlled by faults and joints.	Intrudes Whitewater Volcanics. Colour and paucity of quartz phenocrysts are diagnostic.
Whitewater Volcanics (Pw)	?6000 9000	Quartz-feldspar porphyry, feldspar-pyroxene porphyry; minor lapilli tuff, volcanic conglomerate, and siltstone interbeds.	Low rugged hill country, and sandy pediments with isolated low residual hills.	Probably mainly ashflow tuffs. Quartz veins common along major joints.
UNCONFORMITY				

\*Thickness derived from section measured with Abney Level and tape. Other thicknesses estimated from air-photographs.

The *Tunganary Formation* overlies the O'Donnell Formation conformably, and is approximately 750 feet thick. It is extensively intruded and disrupted by dolerite, particularly in the area immediately to the east of Lansdowne homestead.

The formation crops out mainly as a series of low dissected strike ridges. A prominent member of resistant quartz sandstone locally associated with granule sandstone occurs about the middle of the sequence and is a valuable marker horizon in certain parts of the Sheet area. The arenites are generally medium-grained with abundant siliceous overgrowths and contain up to 10% of clay and chloritic material. The siltstones are highly chloritic and sericitic.

The *Valentine Siltstone*, which lies conformably on the Tunganary Formation, is a sequence of mudstone and siltstone with thin local feldspathic sandstone interbeds, and, in the middle of the sequence, a characteristic band up to 25 feet thick of rhyolitic tuff and tuffaceous siltstone. The formation throughout the area is consistently about 140 feet thick, except in the south-east, where it is thinner. It is commonly intruded by the Hart Dolerite.

The *Lansdowne Arkose*, which forms a series of low strike ridges, crops out mainly as a north-east to west-trending arcuate belt concave to the north. Within the formation six mappable members can be recognized:

- |                                     |            |
|-------------------------------------|------------|
| 6. Arkose and quartz sandstone      | (350 feet) |
| 5. Feldspathic sandstone            | (480 feet) |
| 4. Siltstone                        | (25 feet)  |
| 3. Feldspathic sandstone and arkose | (360 feet) |
| 2. Siltstone                        | (170 feet) |
| 1. Arkose and feldspathic sandstone | (240 feet) |

These thicknesses, totalling over 1600 feet, refer to localities a few miles east of Lansdowne homestead. The formation thins to about 1300 feet in the west, mainly by thinning of the arenite members, especially the top and bottom members. An additional siltstone is present within member 6 in the north-east, but disappears towards the south-west.

Cross-bedding is common throughout the formation, and slump structures, ripple marks, and clay pellets are also found. In the basal beds of member 5, which form low cliffs, cross-bedding is extremely well developed, with foreset units 3-4 feet thick, whereas in other members foreset units rarely exceed 1 to 2 feet in thickness. This member forms a useful marker within the Speewah Group succession.

The *Luman Siltstone*, the topmost formation of the Speewah Group, occurs throughout the area at the base of the King Leopold Sandstone cliffs and is mostly poorly exposed. It is essentially an argillaceous sequence. Grey shale predominates in the lower part of the sequence and siltstone in the upper part, though in the south buff to pale grey feldspathic sandstone forms the topmost beds. The thickness, measured  $1\frac{1}{2}$  miles east of Mount Laptz, is 235 feet, but the formation thins towards the west. In most places there is a gradation from siltstone into purple flaggy sandstones at the base of the King Leopold Sandstone. The Luman Siltstone is extensively intruded by the Hart Dolerite.

### *Kimberley Group*

The Kimberley Group lies conformably on the Speewah Group, but in the south-east it is locally transgressive and lies unconformably on the Speewah Group, the Halls Creek Group, and Whitewater Volcanics. It is conformably overlain by the Bastion Group in the north-east and unconformably by the Mount House Group in the north-west.

The Kimberley Group consists essentially of sandstone with subordinate basalt, siltstone, and carbonate rocks, and is intruded locally by dolerite.

The maximum thickness of the group in the Lansdowne Sheet area is about 11,000 feet, of which arenites make up more than 8000 feet.

The *King Leopold Sandstone*, at the base of the Kimberley Group, is a massive cliff-forming resistant unit which forms the King Leopold and Durack Ranges. A characteristic conglomerate overlain by granule sandstone about the middle of the succession can be traced for more than 80 miles from north-east to south-west. Purple micaceous sandstones are characteristic of the basal beds. Cross-bedding indicating a north-westerly to north-easterly source is ubiquitous, and ripple-marking and slumping are present locally. In thin section the rocks are coarse-grained and poorly sorted and consist of rounded to subangular quartz grains with minor amounts of feldspar, and rare muscovite, iron oxides, zircon, and green tourmaline. The cementing material is generally silica, except in the basal beds, which are cemented by clay. The thickness ranges from over 4000 feet in the Durack Ranges between Elgie Cliffs outcamp and Lansdowne to 3000 feet north of Lansdowne and 2300 feet at Diamond Gorge. Nine hundred feet of the succession are present south-west of Goanna Spring, where only the topmost part is represented, but at Pyra Gorge farther to the west-south-west on the same structure a full succession, 3300 feet thick, is found.

The *Carson Volcanics* lie conformably on the King Leopold Sandstone and are similarly distributed. The formation is overlain conformably by the Warton Sandstone and, in the north-west unconformably by the Walsh Tillite. It is mainly valley-forming, with low rounded hills up to 100 feet.

The formation is 2300 feet thick north-west of Lansdowne homestead, but thins to about 1200 feet in the north-east, near Elgie Cliffs outcamp and to around 800 feet in the Lissadell Sheet area. About 1700 feet are present in the south of the Lansdowne Sheet area near Pyra Gorge.

The *Warton Sandstone* overlies the Carson Volcanics conformably, and is overlain conformably in the east by the Elgee Siltstone, and unconformably in the west by the Walsh Tillite. The basal beds form a prominent scarp and the upper beds form rounded, gently dipping cuestas. Cross-bedding with 1 to 2-foot foreset units is ubiquitous, and indicates a north-westerly source. Slumping is also found, but is comparatively rare. The thickness, measured from air-photographs, ranges from 900 to 1200 feet.

The *Elgee Siltstone*, which overlies the Warton Sandstone and underlies the Pentecost Sandstone, forms scarp slopes and is poorly exposed. It consists of red-brown siltstone which contains numerous pale grey-green spots up

to 3 inches in diameter. The siltstone grades upwards into brown silty quartz sandstone, with thin interbeds of flaggy fine-grained sandstone. The *Teronis Member*, which consists of grey micaceous siltstone with interbeds of feldspathic sandstone, and of massive algal limestone, lies at the base of the Elgee Siltstone. Dolomitic limestone is the most common carbonate rock, though almost pure limestone and dolomite are also present.

The thickness of the formation ranges from approximately 600 feet in the north-east to 700 feet in the central plateau area, where the Teronis Member makes up 75 feet near the Baulk Face Range. The Teronis Member is up to 300 feet thick in the south.

The *Pentecost Sandstone* is a relatively resistant unit which occurs as upstanding dissected plateaux bounded by strongly developed escarpments of the cliff-forming basal quartz sandstone of the Pentecost Sandstone overlying the more easily eroded Elgee Siltstone.

Within these plateau areas mesas and cuestas are well displayed. The total thickness of the formation, estimated from air-photographs, is about 3500 feet.

The Pentecost Sandstone consists of three mappable members. Cross bedding is well developed in the lowest member and indicates derivation from the north-west.

#### *Bastion Group*

The *Mendena Formation* lies conformably on the Pentecost Sandstone. Only the lower part, amounting to about 100 feet, is preserved. The Formation crops out in the north-east, where it has a distinctive light tone on air-photographs. Exposures are poor. Outside the Sheet area it consists predominantly of purple-grey shale and siltstone with 10 to 20-foot interbeds of fine to medium-grained white quartz sandstone and grey-green and purple-grey micaceous feldspathic sandstone.

#### *Hart Dolerite*

Extensive sills of dolerite and associated granophyre intrude formations ranging in age from the Olympio Formation to the Pentecost Sandstone, and occur principally within the Speewah Group. The dolerite forms relatively low rounded boulder-covered hills with intervening areas of black soil; the granophyre forms mesas and narrow strike ridges. The Hart Dolerite is only locally discordant. It follows individual beds, mainly siltstones, for distances up to 15 miles, and is continuous, though partly transgressive, for distances of more than 100 miles. The thickness of the dolerite sills is mainly between 50 and 3000 feet, but one example, that north of Mud Spring, may be about 10,000 feet thick. The granophyre is associated only with some of the relatively thick dolerite sills; where present it consistently overlies dolerite.

The dolerite is a medium to coarse-grained dark grey even-textured rock. A distinctive coarse-grained dolerite or gabbro with elongate dark green pyroxenes is also found, mostly associated with the granophyre and generally

overlying it. Petrographically the dolerite consists essentially of pigeonite, calcic augite, and strongly zoned plagioclase ( $An_{60-35}$ ) with minor accessory olivine pseudomorphs, micropegmatite, magnetite and apatite.

The granophyre, which is characteristically pink to red-brown in hand specimen, is mineralogically similar to the dolerite except that micropegmatite makes up most of the rock, plagioclase is more sodic, and ferromagnesian minerals are less abundant. All gradations exist between dolerite and granophyre, but intermediate types are not abundant. Its age relationships are variable: gradations from dolerite to granophyre have been noted, and also examples of dolerite chilled against granophyre and granophyre intruding dolerite. Contact metamorphism of sediments by dolerite is slight, but metasomatism is appreciable at the contact of granophyre with overlying arkose. The granophyre is thought to be partly a differentiate of a tholeiitic magma and partly a result of metasomatism of arkose.

#### ADELAIDEAN

##### *Mount House Group* (Table 3)

The Mount House Group contains the youngest Precambrian rocks of the Lansdowne Sheet area and is correlated with the Duerdin Group of the Dixon Range Sheet area (Dow & Gemuts, 1967) and the Kuniandi Group of the Mount Ramsay Sheet area (Roberts et al., 1968).

It overlies the Warton Sandstone with slight angular unconformity and transgresses on to the Carson Volcanics.

The strata are flat-lying and essentially undeformed.

The *Walsh Tillite*, the lowermost unit, consists mainly of a basal tillite overlain by a distinctive flaggy thin-bedded pink to yellow fine-grained dolomite which locally carries pyrite pseudomorphs, and by a massive algal dolomite. Isolated lenses of quartz sandstone occur within the tillite. The tillite is poorly exposed and the dolomite is thus a valuable marker bed. Most of the glacial erratics are probably derived from the Speewah and Kimberley Groups. The thickness of the tillite varies markedly. Over most of the area it is 20 to 40 feet thick, but about 200 feet are present in the Warton Range. It is absent at Glenroy homestead, and at the northern boundary of the Sheet area. The dolomite sequence is generally about 15 feet thick, but it lenses out to the north-east.

The overlying *Traine Formation* occurs only in the Traine River area, where it forms a prominent scarp. The thickness cannot be estimated accurately, but may be as great as 200 feet.

The *Throssell Shale* consists dominantly of distinctive uniform flaggy grey-green to blue-grey chloritic-micaceous shale. In the west the base is gradational from the underlying Walsh Tillite and contains dolomite and dolomite breccia with chlorite and dolomitic sandstone interbeds. The Throssell Shale is about 600 feet thick.



TABLE 3: ADELAIDEAN AND PHANEROZOIC STRATIGRAPHY

Era	Age	Rock Unit and Symbol	Thickness (feet)	Lithology	Topography	Remarks
CAINOZOIC	Quaternary	Qa		Alluvium; boulder gravel and fluviatile sand.	Narrow riverside flats.	
	Tertiary to Quaternary	Czs		Residual soil. Red and grey soils, sands, ferricrete.	Pediments and featureless plains.	
		Czb		Residual black soil.	Pitted stony plains.	Mainly over dolerite and basalt. Also locally on limestone.
		UNCONFORMITY				
PALAEOZOIC	Devonian & Permian ?	(Undifferentiated conglomerates) (D–Pc)		Conglomerate: rounded pebbles, cobbles, and boulders of quartzite, set in arkosic matrix.	Prominent rounded hills with dendritic drainage.	In part Upper Devonian; in part Permian ? and unconformably on Devonian rocks.
	Devonian ?	Stony Creek Conglomerate (Ds)	500	Conglomerate: boulders, cobbles, and pebbles of granite, and minor quartz, quartzite, and sheared acid volcanics.	Prominent rounded hills with dendritic drainage.	Interfingers with reef complex. Overlain by ?Permian conglomerates.
	Devonian	Windjana Limestone (Dw)	500	Limestone: Reef facies; colonial organisms with interstitial calcareous sediment; partly dolomitized.	Prominent massive outcrops; sparse vegetation cover.	Discontinuous band between Pillara Limestone and Napier Formation.
		Pillara Limestone (Dp)	500	Limestone: Back-reef facies; well bedded stromatoporoid limestone; partly dolomitized.	Prominent massive outcrops; sparse vegetation cover.	Interfingers with Windjana Limestone, Stony Creek Conglomerate and locally with Napier Formation.
		Napier Formation (Dn)	500	Limestone: Fore-reef to inter-reef facies; silty limestone, calcarenite and calcirudite; partly dolomitized.	Prominent massive outcrops; sparse vegetation cover.	Essentially a talus deposit; interfingers with Stony Creek Conglomerate and Windjana Limestone.
		UNCONFORMITY				
	ADELAIDEAN	MOUNT HOUSE GROUP	Estaughs Formation (Phe)	255	Hematitic quartz sandstone, siltstone, subgreywacke; interbeds of micaceous siltstone.	Caps Mount Clifton plateau and forms marginal scarp.
Throssell Shale (Pht)			500	Flaggy grey-green chloritic-micaceous shale; fine micaceous sandstone; minor dolomite.	Scattered outcrops within soil covered plain and screen slope beneath Estaughs Formation scarp.	Green shales distinctive, upper and lower contacts gradational.
Traine Formation (Pha)			About 200	Massive purple-brown ferruginous sandstone.	Scarp in Traine River area.	Disappears westwards.
Walshe Tillite (Phw)			15 to 200	Tillite; flaggy pink-yellow fine-grained dolomite; quartz sandstone lenses.	In creeks or soil-covered plains and in scarp beneath Traine Formation.	Marked lateral variations in thickness. Pink dolomite excellent marker bed.
UNCONFORMITY						

The *Estaugh's Formation* forms a cap to the Mount Clifton Plateau. The contact with the underlying Throssell Shale is gradational and the basal sub-greywacke bed is characterized by complex intraformational folding and lensing due to slumping or compaction deformation. About 250 feet of section are preserved.

#### PALAEOZOIC

The Palaeozoic units represented in the Lansdowne Sheet area are the Windjana Limestone, Pillara Limestone, and Napier Formation, which together constitute a Devonian reef complex; the Stony Creek Conglomerate of Devonian age; and conglomerates of Devonian and ?Permian age. The reef complex in this area has not been dated accurately, but is regarded as being of Frasnian or Famennian age. Some Givetian (Middle Devonian) may be present. The total thickness of the various facies of the reef complex in this area is not known precisely, but it is unlikely to exceed 500 feet.

The *Windjana Limestone* is the reef facies. It consists of massive limestone, which is commonly dolomitized. The limestone is built up of a framework of colonial organisms, especially algae and stromatoporoids, the interstices between which are filled with calcarenite or calcilutite. The Windjana Limestone occurs as a discontinuous band between the Pillara Limestone and the Napier Formation and interfingers with each. It also interfingers with the Stony Creek Conglomerate, north-west of Long Hole Bore.

The *Pillara Limestone* is the back-reef facies of the reef complexes. It consists predominantly of well-bedded biostromes of stromatoporoid limestone with some beds made up largely of algal nodules (oncolites). Dolomitization is common. The unit interfingers with the Windjana Limestone and with the Stony Creek Conglomerate. In areas where the reef (Windjana Limestone) is absent it interfingers directly with the Napier Formation.

The *Napier Formation* is the fore-reef and inter-reef facies of the reef complex. The poorly exposed area of outcrop south of Long Hole Bore is referred to the inter-reef facies; the rest is fore-reef facies. The fore-reef facies is essentially a talus deposit built up of calcarenite and calcirudite derived by erosion of the growing reef, together with contributions from organisms which grew on the fore-reef slope. The limestone is dolomitized in some localities.

The fore-reef facies is crudely to well bedded and shows depositional dips of 30° or more away from the reef. The inter-reef facies contains relatively little material derived from the reef and is made up of silty limestone and calcareous siltstone, shale, and sandstone. The inter-reef deposits are largely red, in contrast to the light grey and yellow limestone and dolomite of the other parts of the reef complex. The Napier Formation interfingers with the Stony Creek Conglomerate and the Windjana Limestone. Where the reef (Windjana Limestone) is absent it interfingers directly with the Pillara Limestone.

The phenoclasts of the *Stony Creek Conglomerate* are angular to subangular, and are set in a matrix of very coarse arkose; they are believed to have been transported only a short distance from the adjacent Precambrian rocks. The thickness of the formation is not known precisely, but it is estimated to be

about 500 feet. The conglomerate interfingers with the reef complex and is overlain south-east of Long Hole Bore by conglomerate of possibly Permian age.

*Undifferentiated Conglomerates.* Evidence in adjacent areas has shown that conglomerates previously mapped by Guppy et al. (1958) as the Sparke, Mount Elma, and Burrumundi Conglomerates include some conglomerate of Upper Devonian age and other conglomerate which rests with angular unconformity on the Devonian rocks and which could be Permian, perhaps equivalent to part of the Grant Formation. As the boundaries between these two conglomerates have not been mapped, they are combined as 'undifferentiated conglomerate'. In this area they consist predominantly of rounded quartzite pebbles and cobbles, with some boulders, set in an arkosic matrix.

#### CAINOZOIC

Alluvium, eluvium, and residual soils, which are developed sparsely throughout the Sheet area, are probably of Tertiary to Quaternary age.

*Residual black soil* is found mainly on outcrops of dolerite, basalt, and less commonly on limestone. Where it occurs on dolerite it is strewn with residual dolerite boulders and contains abundant small sinkholes. It supports a good cover of fodder grasses, stripped in places by heavy grazing.

Other *residual soils* include several types which are closely controlled by the source rocks. Red-brown soil predominates on granophyre, and locally on basalt and dolerite, particularly where extra source material from more acid rocks effectively inhibits the formation of black soil. Sandy grey soils are characteristic of the granite terrain and of outcrops of the Whitewater Volcanics and Halls Creek Group rocks. They support sparse vegetation and, where best developed, are notable for the abundance of small ant hills. Sandy soils and residual sands are formed on sandstone outcrops, particularly on the Kimberley Plateau. In places these are underlain by yellow-brown nodular ferricrete.

*Alluvium* is restricted principally to sand and gravel deposits, in or immediately adjacent to watercourses, but fossil river terraces are found along the course of the Hann River near Glenroy. Gravels, partly derived from the Walsh Tillite, are found in the courses of the Hann and Traine Rivers, but elsewhere in the area sands predominate in river beds.

Thin coverings of *eluvium* consisting mainly of large fallen blocks of sandstone are found on most scarp slopes in the area, and commonly obscure outcrops of the Luman and Elgee Siltstones, and the siltstones at the top of the Carson Volcanics.

#### STRUCTURE

The Lansdowne Sheet area may be divided into two main structural units, the stable Kimberley Block to the north and the bordering strongly folded King Leopold/Halls Creek Mobile Zone, which forms a broad arcuate belt concave to the north in the south and east. Both units have been affected by the same tectonic events, but to differing degrees. The division between the two is not definite, and is based primarily on the decreasing intensity of deformation northwards.

In general the outcrop area of the Kimberley Group and later rocks forms the Kimberley Block, and the older rocks form the Mobile Zone, which in the Lansdowne Sheet area includes parts of both the Halls Creek Mobile Zone and the King Leopold Mobile Zone (Traves, 1955).

Folds of several different ages with fold trends mainly parallel to the trend of the Mobile Zone are recognized in the area. Faulting along three principal directions is found in both the Mobile Zone and the Kimberley Block. The most important trend is north-east, which farther to the north-east forms the western boundary fault system of the Halls Creek Mobile Zone.

### Folding

The Halls Creek Group rocks, which are the most intensely folded in the area, are tightly and isoclinally folded along four distinct trends. The dominant folds in the eastern part of the area plunge to the north-east; those in the west plunge to the north-west. Two groups of north-west-plunging folds are recognized, the more steeply plunging and later of the two being younger than Whitewater Volcanics and apparently older than O'Donnell Formation.

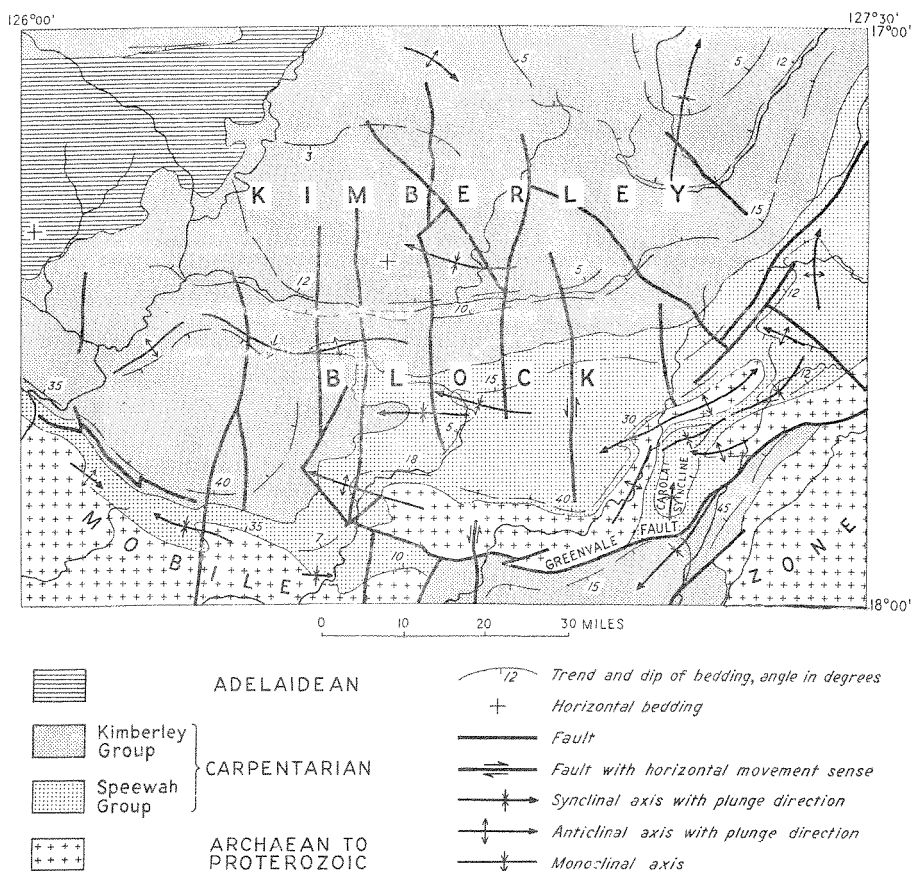


Fig. 2. Structural elements.

Folds younger than the Kimberley Group consist mainly of broad synclines and anticlines, some of which exhibit structural closure due to refolding. Two basic trends are recognized, an earlier one plunging to the north-east and a later one plunging to the north-west. The north-east trend is best developed

TABLE 4: TECTONIC HISTORY—LANSDOWNE SHEET AREA

CAINOZOIC			EROSION—Development of Soils and Alluvium			
PALAEOZOIC			EPEIROGENIC UPLIFT			
			LIMESTONE REEF COMPLEX AND CONGLOMERATE DEPOSITION IN SOUTH-WESTERN PART OF AREA ONLY	EROSION OF OTHER PARTS OF AREA		
			SUBSIDENCE AND MARINE TRANSGRESSION OF SOUTH-WESTERN PART OF AREA			
			EROSION			
PROTEROZOIC	ADELAIDEAN	MOUNT HOUSE GROUP	FOLDING AND EPEIROGENIC UPLIFT			
			SHALE, SANDSTONE, AND DOLOMITE DEPOSITION		Upper part of Walsh Tillite; Estaughs, Throssel, and Traine Formation	
			SUBSIDENCE			
			TILLITE DEPOSITION		Walsh Tillite	
			EROSION			
	CARPENTARIAN	BASTION GROUP	STRONG FOLDING AND FAULTING			
			INTRUSION OF DOLERITE AND DEVELOPMENT OF GRANOPHYRE			
			LUTITE DEPOSITION ARENITE, LUTITE, and CARBONATE DEPOSITION VULCANISM: BASIC LAVAS; partly submarine ARENITE DEPOSITION		Mendena Formation Weston, Elgee, and Pentecost Formations Carson Volcanics King Leopold Sandstone	
		KIMBERLEY GROUP	Minor UPLIFT AND EROSION: Probably in south-eastern part of area only			
			ARENITE DEPOSITION LUTITE DEPOSITION ARENITE DEPOSITION		King Leopold Sandstone Luman Siltstone Upper Lansdowne Arkose	
			Minor UPLIFT AND EROSION: Probably in south-eastern part of area only			
			ARENITE AND LUTITE DEPOSITION Minor VULCANISM AND LUTITE DEPOSITION ARENITE AND LUTITE DEPOSITION		Lower and middle Lansdowne Arkose Valentine Siltstone Tunganary and O'Donnell Formations	
		SUBSIDENCE AND MARINE TRANSGRESSION				
				EROSION		
				GRANITE EMPLACEMENT		Granites in south-western part of area
	FOLDING AND SHEAR BELT DEVELOPMENT					
	GRANITE EMPLACEMENT and localized METAMORPHISM			Bow River Granite		
	Major VULCANISM—ACID PORPHYRIES			Granites in south-western part of area Whitewater Volcanics		
	EROSION					
	ARCHAEOAN			FOLDING and REGIONAL METAMORPHISM: ? GRANITE EMPLACEMENT		Folding and metamorphism of Halls Creek Group; Tickalara Metamorphics
			DEPOSITION OF GEOSYNCLINAL SEDIMENTS		Olympio Formation    ?Part of Bow River Granite	

in the eastern part of the area, but is probably also represented in the west, where it plunges south-east owing to deflection by the later folds. In the western part of the area late south-east-plunging folds are also recognized (Gellatly et al., 1965). The north-westerly trend is represented over most of the southern part of the area but is more dominant in the west. Both fold trends include examples of monoclinial folds. The main monoclines are found east of Pyra Gorge, associated with the east-north-easterly Greenvale Fault, and west of Lansdowne homestead, where the axial trend is west-north-west.

### *Faulting*

Faulting follows three main trends: north-east, west-north-west, and north-south. Faults are common throughout the area except in the north-west. The principal fault of the north-east system is the Greenvale Fault, which cuts across the south-eastern part of the area and has a general east-north-east trend.

It is a complex fault system which locally consists of two or more sub-parallel faults. It is possibly partly transcurrent, but has a dominantly vertical movement with a downthrow in the south-east of up to 8000 feet. For much of its length, however, the throw is much smaller. Where vertical displacement predominates reverse movement is more common than normal movement, but the dip of the fault plane rarely deviates by more than about 20° from the vertical. However, dips as low as 45° to the north are found locally. Other faults of this trend, especially those near Bedford Downs homestead, have relatively small sinistral transcurrent movements with a component of vertical downthrow to the south-east.

The west-north-west faults are moderately common throughout most of the area. Some are more than 20 miles long, but displacements are mostly small, except in the south-west, where downthrows to the south-west of the order of 1000 to 2000 feet are postulated. Downthrow is almost invariably to the south-west.

North-south faults are common in the central and western parts of the area. They extend for up to 30 miles but have only small displacements. Some are known to be sinistral transcurrent faults; others appear to be normal faults with a downthrow to the west. Both senses of movement are probably combined in many faults.

The north-east faults antedate those trending to the north-west, which in turn antedate the north-south faults. Movements connected with the Greenvale Fault apparently began in early Carpentarian time. Most of the major movements postdate the intrusion of the Hart Dolerite, and are probably of Carpentarian or Adelaidean age. The latest recognizable movements are younger than Devonian.

## **TECTONIC HISTORY**

A summary of the tectonic history of the area is given in Table 4.

The oldest rocks, the Halls Creek Group, originated in an Archaean geosyncline and, in Archaean or early Proterozoic times, were intensely folded, slightly metamorphosed, and eroded, before the ashflow tuffs of the White-water Volcanics were laid down in early Carpentarian time.

After a period of gentle folding, strong shearing, and erosion, deposition of the Kimberley Basin sediments began. Except for minor earth movements in the south-east, probably associated with movements on the Greenvale Fault, sedimentation was apparently continuous during deposition of the Speewah, Kimberley, and Bastion Groups. Sediments are mainly shallow-water arenites and lutites. There appears to have been little if any interruption of sedimentation during extrusion of the Carson Volcanics, since no unconformity is recognized and some of the lavas were possibly submarine.

Strong folding, faulting, dolerite intrusion, uplift, and erosion followed the Carpentarian sedimentation and preceded deposition of the Walsh Tillite and subsequent shallow-water carbonate rocks, arenites, and lutites of the Mount House Group in Adelaidean times.

Uplift followed the 'Adelaidean' sedimentation, and erosion has apparently persisted since then over the whole of the area except the south-western corner, where a short period of limestone reef formation and conglomerate deposition occurred in Middle Palaeozoic time.

## ECONOMIC GEOLOGY

No economic mineral deposits have so far been found in the Lansdowne area, but several small showings of metalliferous minerals have been noted, mainly associated with igneous rocks. A portion of the southern part of the Sheet area is at present covered by a Temporary Reserve for base metals held by Pickands Mather International, and geochemical prospecting is in progress.

In view of the proposal for a future irrigation scheme in the Fitzroy Basin with storage dams at Diamond Gorge on the Fitzroy River, at Pyra Gorge on the Little Gold River, and on the Leopold River, supplies of sand, gravel, road-metal, etc., are potentially important.

Groundwater is one of the principal geological resources of the area and is being exploited for stock watering by means of bores and wells.

### *Minerals*

*Copper.* Small amounts of copper minerals, mainly chalcopyrite, bornite, and malachite, have been noted in quartz veins cutting the Hart Dolerite, the Whitewater Volcanics, and the Lamboo Complex granites of the south-western corner of the Sheet area. Patches of limonitic boxwork in quartz veins in the Whitewater Volcanics south-east of Coolan Creek Yard may also indicate minor copper mineralization. Small disseminated grains and vesicle fillings of chalcopyrite occur in many places in the basal flows of the Carson Volcanics, but no appreciable concentrations have been noted.

*Lead.* Small amounts of galena, mostly associated with chalcopyrite, have been recorded in quartz and calcite veins associated with the Whitewater Volcanics, and the Hart Dolerite, especially near Coolan Creek Yard, and in the Carson Volcanics near Fig Tree Yard in the north-east.



*Fluorite.* Two minor occurrences of fluorite veins are known, one from weathered Whitewater Volcanics near the Greenvale Fault 2 miles east-north-east of Goanna Spring, and the other from a quartz-feldspar-muscovite dykerock cutting Lamboo Complex granite about 2 miles north-north-west of Long Hole Bore. The veins are all less than 4 inches thick, and they are thus unlikely to be of economic importance.

*Constructional Materials, etc.*

*Building Stone.* Rocks suitable for use as building stone are abundant throughout the area. The most suitable are the relatively thin-bedded feldspathic sandstones of the Tunganary Formation and Lansdowne Arkose and of the upper part of the Warton Sandstone.

*Road Metal.* The most commonly used road metal for bitumen-sealed roads in the Kimberley region is a poorly consolidated pisolithic sandy ferricrete. Similar ferricrete has been noted in the area underlying sandy soil along the southern margin of the Baulk Face Range but is unlikely to be of use because of inaccessibility.

Where material is required for dirt roads, shale and siltstone from the Halls Creek, Speewah, Kimberley, and Mount House Group could be utilized. The Hart Dolerite, which crops out extensively in the Lansdowne Sheet area, is probably suitable for use as road metal, as is also porphyry of the Whitewater Volcanics. Some of the Lamboo granites and Carson basalts might also be utilized. Only the north-western corner of the area is more than 18 miles from an outcrop of dolerite, and thus from a potential source of road metal.

*Sand and Gravel.* Coarse-grained relatively clean-washed sands are present in watercourses draining the areas of granite outcrop in the south-eastern and south-western corners of the Sheet area, particularly in the O'Donnell River and around Saddlers Yard. They usually contain small amounts of fresh alkali feldspar and altered plagioclase. Fine to medium-grained sands mainly derived from pre-existing sandstones are present in the Little Gold River, especially south of Mud Spring Well, and in many small rivers on the Plateau.

Cobble and boulder gravels are found mainly in the Hann and Traine Rivers in the north-west and on the Fitzroy River immediately upstream from Diamond Gorge. The Devonian conglomerates of the Burramundi Range might also be worked as a source of gravel, but their consolidated nature and relatively large cobble size are disadvantageous features.

*Limestone.* Lime for agricultural purposes may be required in future. Adequate supplies are present in the Devonian rocks in the south-west and in the contiguous Lennard River Sheet area.

The limestones of the Elgee Siltstone are partly dolomitic and are less accessible than the Devonian ones, and are therefore unlikely to be utilized.

*Water Supply*

The following notes on water supply have been summarized from Allen (1965).

The Lansdowne Sheet area has an average annual rainfall of 20 to 27 inches, which falls mainly from November to April, and an annual potential evaporation of 100 to 110 inches.

Surface water is moderately abundant, mostly in rockholes, but permanent surface streams are unknown. Waterholes are found mainly in the Fitzroy, Traine, and Chamberlain Rivers in the north and the Little Gold River and Leopold River in the south.

There are 28 operating bores and wells in the area; their distribution is related to the three distinct groundwater provinces of the area—the Kimberley Province, the Halls Creek Province, and the Canning Basin Province. These correspond to the areas of (a) Speewah and post-Speewah Group rocks, and (b) Archaean to Carpentarian rocks of Figure 2, and (c) Palaeozoic rocks. The Kimberley Province includes 27 bores and wells. They are mostly less than 60 feet deep and have yields of up to 2000 gallons per hour and salinities averaging 450 ppm of total dissolved solids.

In the Lansdowne Sheet area there is only one well in the Halls Creek Province, which is underlain mainly by granitic rocks. There are numerous producing wells and shallow bores in Halls Creek Province rocks of the Mount Ramsay Sheet area to the south, and rocks of this Province in the Lansdowne Sheet area probably have a similar hydrogeological potential, but supplies are difficult to locate.

The Canning Basin Province in the Lansdowne Sheet area is of limited extent and has only one bore.

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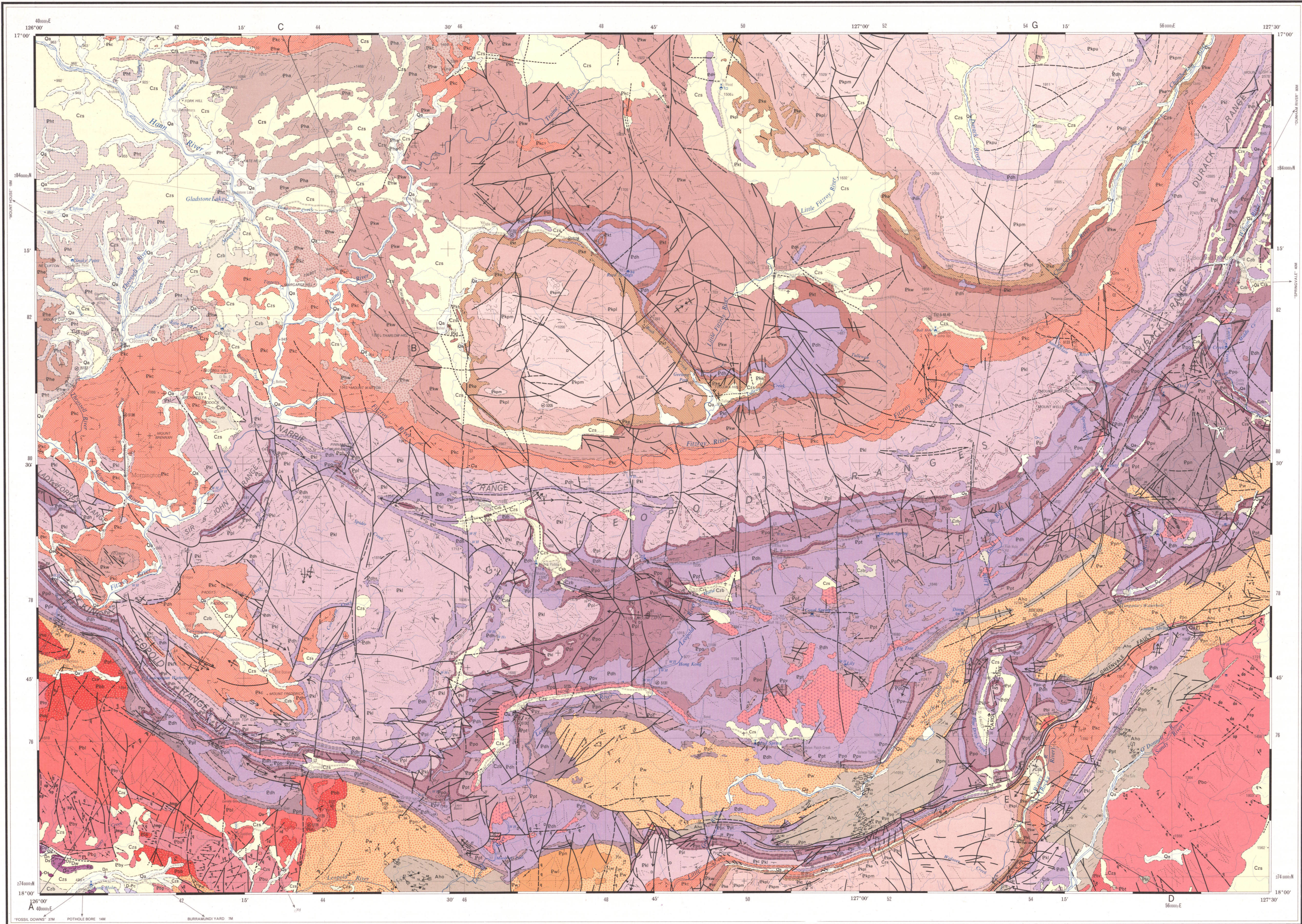
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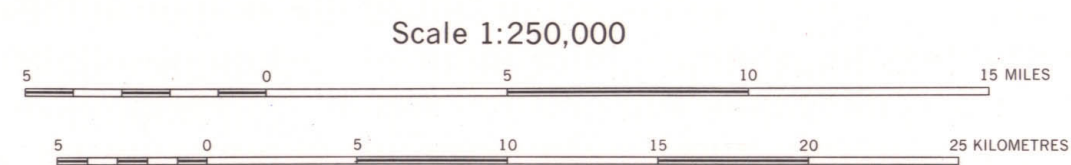
- Geological boundary
- Anticline, showing plunge
- Syncline, showing plunge
- Monocline, showing plunge
- Plunge of minor anticline
- Plunge of minor syncline
- Plunge of drag fold
- Plunge of fold axes
- Fault, showing relative horizontal movement (q indicates quartz filled); D indicates downthrown side
- Inclined fault
- High-angle reverse fault
- Shear zone
- Where location of boundaries, folds, and faults is approximate, line is broken; where inferred, queried; where correlated, boundaries and folds are dotted; faults are shown by short dashes
- Strike and dip of strata
- Presiding strike and dip of strata
- Vertical strata
- Horizontal strata
- Overturned strata
- Horizontal strata
- Trend lines
- Joint pattern
- Vertical cleavage
- Strike and dip of foliation
- Presiding strike and dip of foliation
- Vertical foliation
- Inclined platy flow
- Strike and dip of joints
- Strike and dip of cleavage
- Plunge of lineation
- Lineation on bedding
- Macrobasal locality
- Type section locality
- Measured section with reference number
- Sample locality for age determination with reference number
- Dike: q-quartz, d-dolomite, r-rhyolite, m-muscovite-granite, ap-apophyllite, th-thyolite
- Minor mineral occurrence
- Copper
- Fluorite
- Lead
- Bore, salinity <2500 ppm
- Well, salinity <2500 ppm
- Tank
- Earth Tank
- Windpump
- Equipped with pump engine
- Spring
- Waterhole
- Road
- Vehicle track
- Fence
- Homestead
- Landing ground
- Yard
- Astronomical station
- Trigonometrical station
- Height in feet; datum: mean sea level



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INDEX TO ADJOINING SHEETS

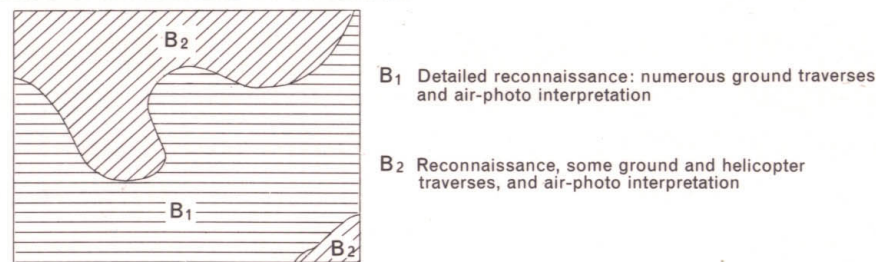
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GREY NUMBERED LINES INDICATE THE 25,000 YARD TRANSVERSE MERCATOR GRID, ZONE 5 (AUSTRALIA SERIES)

Sections  
Attitude of faults not known. Folding schematic  
Scale 1/1

GEOLOGICAL RELIABILITY DIAGRAM



Reference

- QUATERNARY
  - Qa Alluvium: boulder gravels, fluvial sand
  - Cs Residual red and grey silts, sand, and ferricrete
  - Cb Residual black soil
- UNDIFFERENTIATED
- DEVONIAN & PERMIAN (?)
  - D-P Conglomerate: mainly pebbles, cobbles, and boulders of quartzite set in arkosic matrix
- DEVONIAN
  - Stony Creek Conglomerate
    - Ds Conglomerate: pebbles, cobbles, and boulders of granite, quartz, quartzite, and sheared acid volcanics
  - Windiana Limestone
    - Dw Reef facies: limestone with colonial organisms and interstitial calcareous sediment; partly dolomitised
  - Pillara Limestone
    - Dp Black-reef facies: well-bedded stromatolopoid limestone, partly dolomitised
  - FAMENNIAN
    - Napier Formation
      - Dn Fore-reef to inter-reef facies: silty limestone, calcarenite and calcirudite; partly dolomitised
- ADELAIDEAN
  - Estuash Formation
    - Dhe Hematitic quartz sandstone and siltstone, purple green micaceous siltstone and fine-grained subgrwacke
  - Throssell Shale
    - Dht Chertic micaceous shale, grey-green micaceous sandstone, siltstone, dolomite, breccia, flaggy dolomite
  - Traine Formation
    - Dtr Purple-brown ferruginous sandstone
  - Walsh Tillite
    - Dwt Tillite, pink dolomite and quartz sandstone
- ADELAIDEAN OR CARPENTARIAN
  - Hart Dolerite
    - Dhd Pyroxene-bearing granophyre
    - Dhd Tolerite dolerite and gabbro
- PROTEROZOIC
  - UPPER PROTEROZOIC
    - Mendena Formation
      - Dm Purple siltstone, quartz sandstone, micaceous feldspathic sandstone
    - Pentecost Sandstone
      - Dps Upper: coarse-to medium-grained white quartz sandstone
      - Dps Middle: buff to white fine-to medium-grained feldspathic sandstone and quartz sandstone, grey siltstone and phreatic sandstone at base
      - Dps Lower: white to pale brown medium-grained quartz sandstone
    - Elgee Siltstone
      - Dse Red-brown friable siltstone, raggy brown to white quartz sandstone
    - Teronis Member
      - Dtm Grey micaceous siltstone, limestone, and dolomite with algal structures
    - Warton Sandstone
      - Dws Pale purple to brown feldspathic sandstone, white cross-bedded quartz sandstone
    - Carson Volcanics
      - Dcv Tolerite basalt and minor siltstone, amygdaloidal in part; rhyolitic tuff and agglomerate, feldspathic sandstone, siltstone, limestone, chert
    - King Leopold Sandstone
      - Dkl Massive white to pale purple cross-bedded poorly sorted quartz sandstone; minor siltstone
      - Dkl Localised pebble to boulder conglomerate, granite sandstone
    - Lunan Siltstone
      - Dls Purple-grey and green-grey micaceous shale and siltstone
    - Lansdowne Arkose
      - Dla Buff to pale pink cross-bedded feldspathic sandstone, arkose, purple-grey quartz sandstone, purple, green, and grey micaceous siltstone and shale
    - Valentine Siltstone
      - Dvt Chertic siltstone, grey-green mudstone, feldspathic sandstone, rhyolitic tuff
    - Tungunyan Formation
      - Dtg Buff to pale grey feldspathic sandstone, quartz sandstone, pink arkose, granite sandstone, grey-green shale, micaceous siltstone and chert
    - O'Donnell Formation
      - Dof Khaki shale, siltstone, and greywacke; white, purple, and brown quartz sandstone, phreatic sandstone, granite sandstone, conglomerate, localised feldspar porphyry
    - Little Gold River Porphyry
      - Dpdl Dark grey orthoquartzite-feldspar porphyry with sporadic quartz phenocrysts; strongly anisotropic in places
    - Whitewater Volcanics
      - Dwv Quartz-feldspar porphyry, feldspar-pyroxene porphyry, lapilli tuff, volcanic conglomerate; siltstone interbeds
  - LOWER PROTEROZOIC
    - Bickley Porphyry
      - Dbp Grey quartz-feldspar porphyry and porphyritic microgranite
      - Dbp Phase with pink feldspar phenocrysts
    - Mulkerins Granite
      - Dmg White coarse and even-grained leucocratic granite, tourmaline-muscovite apophyllite, quartz-feldspar pegmatite
    - Lerida Granite
      - Dld Grey porphyritic biotite granite with pale green feldspar phenocrysts
    - Chaney's Granite
      - Dcy Coarse and even-grained biotite granite, foliated and locally sheared
    - Long Hole Granite
      - Dlh Grey coarse-grained porphyritic biotite granite, biotite gneiss, spongy gneiss
    - Violet Valley Tonalite
      - Dvt Medium to coarse-grained tonalite
    - Bow River Granite
      - Dbr Grey coarse-grained biotite granite, pink coarse-grained porphyritic biotite granite, minor granodiorite
    - Tickalara Metamorphics
      - Dtm Biotite paragneiss with cordierite, sillimanite and staurolite
  - ARCHAEO OR PROTEROZOIC
    - Olympio Formation
      - Dol Phyllic shale and siltstone with interbedded greywacke, minor quartzite and limestone

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

DIAGRAMMATIC RELATIONSHIP OF ROCK UNITS

