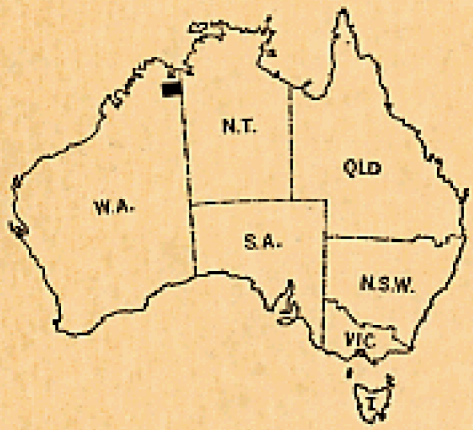
1 : 250,000 GEOLOGICAL SERIES—EXPLANATORY NOTES

LISSADELL

WESTERN AUSTRALIA



SHEET SE/52—2 INTERNATIONAL INDEX

COMMONWEALTH OF AUSTRALIA
STATE OF WESTERN AUSTRALIA

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Compiled by K. A. Plumb (Bureau of Mineral Resources)

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By K. A. Plumb

Explanatory Notes on the Lissadell Geological Sheet

The Lissadell 1 : 250,000 Sheet area is bounded by latitudes 16°S and 17°S and longitudes 127°30′E and 129°E, and covers part of the East Kimberley Division of north Western Australia.

The Great Northern Highway from Perth to Wyndham runs through the middle of the Sheet area, and the Duncan Highway from Wyndham to Nicholson station and then Darwin follows the eastern edge. The Duncan Highway is a formed gravel road, cut by flood waters during the wet season. Station tracks give fair access to the eastern half of the Sheet, but those in the west are suitable only for 4-wheel-drive vehicles. The Speewah Valley can be reached by 4-wheel-drive vehicle, and it is reported that Plants homestead has been reached from Karunjie homestead to the west of the Sheet area.

Ships and aircraft from Perth and Darwin call at Wyndham, 40 miles north of the Sheet area.

The only settlements are the pastoral properties of Argyle Downs, Bow River, Dunham River, Glenhill, El Cuestro, and Lissadell. The total population is about 200.

The climate is monsoonal, with a short wet summer season and a long dry winter. The area lies between the 20 and 30 inch isohyets; up to 90 percent of the rain falls during the months of January and February.

Maps and air-photographs available in 1963 were: air-photographs at a scale of 1 : 50,000 flown by the Royal Australian Air Force in 1948; photomosaics at a scale of 1 inch to 1 mile, compiled by the Department of Lands and Surveys, Perth; a topographic map at 1 : 250,000 scale with 250-foot contours, produced by the Royal Australian Survey Corps; and a planimetric map at 1 : 250,000 scale compiled by the Department of Lands and Surveys, Perth.

The geological map accompanying these Notes was compiled on Survey Corps photoscale compilations and subsequently reduced to 1 : 250,000 scale.

Previous Investigations

In 1879 Alexander Forrest led the first expedition to cross the Kimberley Division. He was accompanied by a geologist, Fenton, who made brief geological observations (Johnston, 1962).

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Hardman (1885) traversed the East Kimberleys in 1884 and outlined the geology of the region. His gold report inspired the eventual rush to Halls Creek, resulting in the development of the port of Wyndham. Other contributions to the regional geology were made in subsequent years by Wade (1924), who reported on the oil prospects of the region, and Blatchford (1927), who made notes on the rocks of the Sheet area between the Speewah Valley and Argyle Downs homestead. Edwards & Clarke (1940) investigated the petrology of the basic rocks of the region.

Little was added to Hardman's knowledge of the regional geology, however, and his work formed the basis for all post-war investigations, especially in the Palaeozoic basins. Matheson & Teichert (1946) were the first to subdivide the Proterozoic stratigraphy, followed by Traves (1955), who reconnoitred the regional geology of the east Kimberleys and the adjoining Victoria River Basin in the Northern Territory. Guppy, Lindner, Rattigan, & Casey (1958), working in the West Kimberleys, subdivided the Kimberley Basin sediments for the first time, and Harms (1959) extended their work by mapping the major Precambrian rock units throughout the Kimberley Region. Harms' work provided the framework for the current mapping of the Precambrian.

These notes and the accompanying geological map are based on a joint survey carried out in 1963 and 1964 by the Geological Survey of Western Australia and the Bureau of Mineral Resources, as part of a programme, begun in 1962, of mapping the whole of the Kimberley Division at 1 : 250,000 Scale.

PHYSIOGRAPHY

Drainage

The Lissadell Sheet area is drained by two major groups of streams which rise in the southwest. One group flows north or northeast and includes the Chamberlain, Salmond, and Pentecost Rivers; the second flows northeast then east as tributaries of the Ord River—the Bow, Wilson, Castlereagh, O'Donnell, and Dunham Rivers. The Ord River rises south of the Sheet area; initially it flows west, and then turns north to cross the eastern side of the Sheet area in a broad valley. All these streams, with the exception of the Chamberlain River (see below), have a superimposed consequent pattern, subsequently modified along part of their length by the structure of the rocks they traverse. Tributaries are markedly subsequent.

The superimposition suggests an ancient land surface extending across the Sheet area. Subsequent uplift has produced dissection and superposition of the present landform. This is supported by the general uniform elevation of the tops of major ranges throughout the area. The highest part of the surface was probably the southwest corner, where the major streams now rise.

Physiographic Divisions

The most striking feature of the physiography of the Sheet area is the relationship between topography and rock-types. This greatly facilitates the use of air-photographs in geological mapping.

The Sheet area contains five of the seven physiographic provinces defined by Plumb (in prep.). These are: the Kimberley Plateau, Kimberley Foreland, Lamboo Hills, Ord Plains, and Cambridge Gulf Lowlands. Within some of these broad divisions smaller areas of distinctive topography have been recognized and called subprovinces.

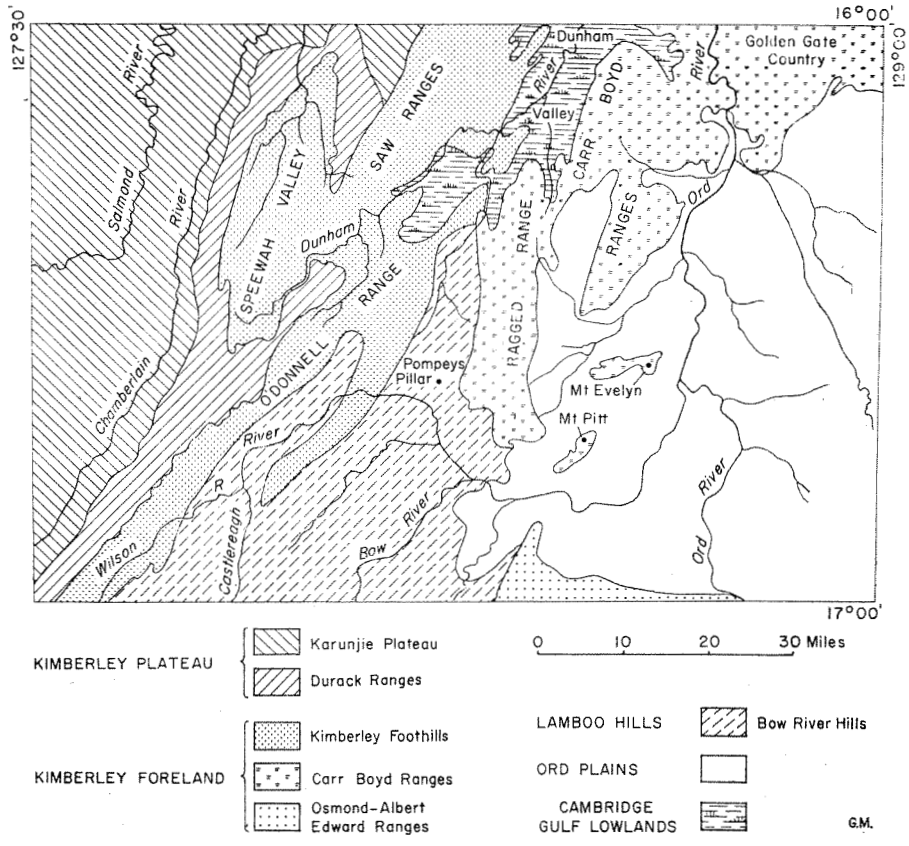

Fig. 1. Physiographic divisions.

Kimberley Plateau. The Kimberley Plateau is a broad dissected plateau which covers a large region to the west and extends into the western part of the Sheet area. It is the most extensive province in the Kimberley Region. The bedrock is mainly gently dipping sedimentary rocks of the Kimberley Group, and the eastern margin of the Plateau is a prominent scarp along the edge of the Durack Ranges, controlled by the contact of the Kimberley Group with the underlying Speewah Group.

The *Karunjie Plateau* consists of structural benches and gently dipping cuestas bounded by scarps up to 250 feet high. These benches are controlled by resistant sandstone beds from which the overlying soft beds are being stripped by scarp retreat. The bedrock of the Plateau is composed of sediments from the Kimberley Group, excluding the King Leopold Sandstone, and from the Bastion Group. The sandstone bedrock crops out boldly throughout the Plateau, and there is limited soil cover and sparse vegetation. Elevations are generally between about 1500 and 1800 feet in the south, and decrease gradually to between 1000 and 1500 feet in the north.

The *Durack Ranges* subprovince forms the eastern margin of the Kimberley Plateau and consists of a rugged bevelled cuesta formed on a bedrock of King Leopold Sandstone. Elevations range from about 2250 feet in the southwest to about 1500 feet in the north. The cuesta generally has a relief of about 500 feet above its immediately bounding valleys.

The Ranges generally stand about 200 to 300 feet above the Karunjie Plateau to the west, although mesas formed on the resistant upper Pentecost Sandstone near the western margin of the Sheet area have similar elevations. These peaks, and the Durack Ranges themselves, are apparently remnants of an uplifted ancient peneplain surface.

Kimberley Foreland. The Kimberley Foreland is an area of highly dissected topography controlled by the structure of its folded and faulted bedrock.

The *Kimberley Foothills* border the Kimberley Plateau in the east, where Carpentarian rocks are folded and faulted adjacent to the strongly deformed central zone of the Sheet area. The foothills are erosional remnants of a Kimberley Plateau surface. Differential erosion of interbedded resistant and non-resistant rocks has produced rugged topography—a complex system of high hogbacks and cuestas. Small plateaux occur locally where the bedrock is flat-lying. The ridges rise to 1750 feet, and have a maximum relief of 1000 feet.

Most of the drainage is subsequent and controlled in a rectangular pattern by either bedding, joint, or fault directions in the bedrock. Major streams, the Dunham and Wilson Rivers, are superimposed consequent streams subsequently modified by the underlying bedrock.

Perennial spring-fed steams are common in the Foothills, especially close to the margins of the Kimberley Plateau. They rise along joint and fault planes.

The Saw Ranges are a striking example of the Foothills: parallel hogbacks, with dip-slopes up to 70°, rising 1000 feet above the Cambridge Gulf Lowlands. There is less relief in the O'Donnell Range and the topography is more complex. The pattern of strike ridges is complicated by folding and faulting in the bedrock.

Large valleys occur in the Foothills on outcrops of dolerite. The largest of these, the Speewah Valley, has formed on a large dolerite sheet which occupies the core of an elongate dome 20 miles long and 8 miles wide. Erosion of the dolerite has produced a valley of subdued rounded hills completely surrounded by prominent cuestas of the overlying rocks.

The *Carr Boyd Ranges,* east of the Dunham River, include some of the most rugged country in the Sheet area. Elevations of the ridges range from 2000 to 1000 feet, generally decreasing northwards, and relief is up to 1500 feet. The bedrock is mainly interbedded sandstone and siltstone of Adelaidean age, deeply dissected by narrow valleys and gorges.

Most of the drainage in the Ranges is superimposed, but modified by the structure of bedrock to an irregular dendritic pattern. Superimposed drainage is well illustrated where the Ord River cuts through the Carlton Gorge. Springs are common within the Ranges and along the large 'bounding' faults. Many of the smaller streams terminate in hanging stream junctions.

The Ranges are commonly bounded by high steep fault scarps. The Glenhill and Carr Boyd Fault are examples. In the Revolver Creek valley and Golden Gate country erosion has removed the sandstone cover and exposed the less-resistant Lower Proterozoic rocks in large valleys.

The southern edge of the Ranges near Pompeys Pillar is a high scarp, which rises to over 2000 feet, and slopes eastwards in a series of sandstone cuestas to a base-level of about 750 feet, in the valley around Glenhill homestead.

A prominent shallowly dipping dissected cuesta, about 20 miles long and 3 miles wide, is situated between this range and the Glenhill Fault. It is called the Ragged Range, from the ragged skyline along its prominent western scarp. The elevation of the scarp is about 1500 feet, and the Range slopes gradually eastwards. It has a dendritic insequent drainage pattern deeply incised into the gently dipping soft Palaeozoic conglomerate and sandstone.

Mount Pitt and Mount Evelyn are erosional remnants of the Carr Boyd Ranges within the Ord Plains and have a relief of over 750 feet.

The northern margin of the *Osmond-Albert Edward Ranges* crosses the southern boundary of the Sheet area. Here the high cuestas and hogbacks of the Dixon Range Sheet area (Dow & Gemuts, 1967) slope northwards to the Ord Plains. The ridges dip gently north and are dissected by a feathered dendritic drainage. Relief is up to 700 feet.

Lamboo Hills. The *Bow River Hills* are an area of relatively low relief between the Kimberley Foothills and Carr Boyd Ranges, formed on the north-northeasterly belt of crystalline rocks of the Lamboo Complex. The Bow River Hills have an open-textured dendritic drainage pattern between rounded, low, rocky hills, subdued strike ridges, and dissected mesas.

The porphyritic crystalline rocks produce high terraced plateaux and mesas, dissected by a joint-controlled rectangular drainage. Sheared and basic rocks are exposed as low fertile pockets within the poorly vegetated granitic rocks.

Relief is commonly about 500 feet, but is up to 1000 feet in the Bow River area. The elevation ranges from less than 500 feet to 1952 feet on Castlereagh Hill.

Ord Plains. The Ord River has formed widespread low-lying plains east of the Carr Boyd Ranges. The bedrock is poorly outcropping Cambrian basalt and carbonate rocks, and large areas are covered by residual and alluvial soils. Extensive black soils form excellent cattle-grazing country.

The Plains are about 250 feet above sea level in the north, and rise gradually south and east to about 1000 feet to merge with the Victoria River and Sturt Plateau (Traves, 1955). Away from the river, low structural benches and rounded hills of basalt have a relief of up to 300 feet.

Cambridge Gulf Lowlands. The Lowlands are represented in the Lissadell Sheet area only by the black-soil flats at the mouth of the Dunham Valley, which lies on Palaeozoic rocks between the Kimberley Foothills and the Carr Boyd Ranges.

STRATIGRAPHY

The nomenclature of the Precambrian is by no means uniform. In these notes and the accompanying map the nomenclature adopted by the Bureau of Mineral Resources is used: Figure 2 compares it with the system in use by the Geological Survey of Western Australia.

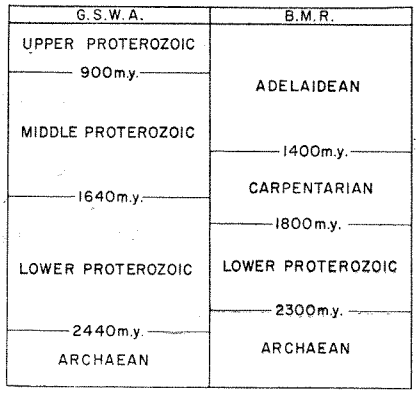

Fig. 2. Precambrian terminology of the Geological Survey of Western Australia and the Bureau of Mineral Resources.

The Precambrian rock units have not yet been formally defined: definitions will appear in more comprehensive studies by Dow & Gemuts (in press) and Plumb (in prep.). A collection of rocks is being isotopically dated at present.

The stratigraphy is summarized in Tables 1 to 4 and Figure 3.

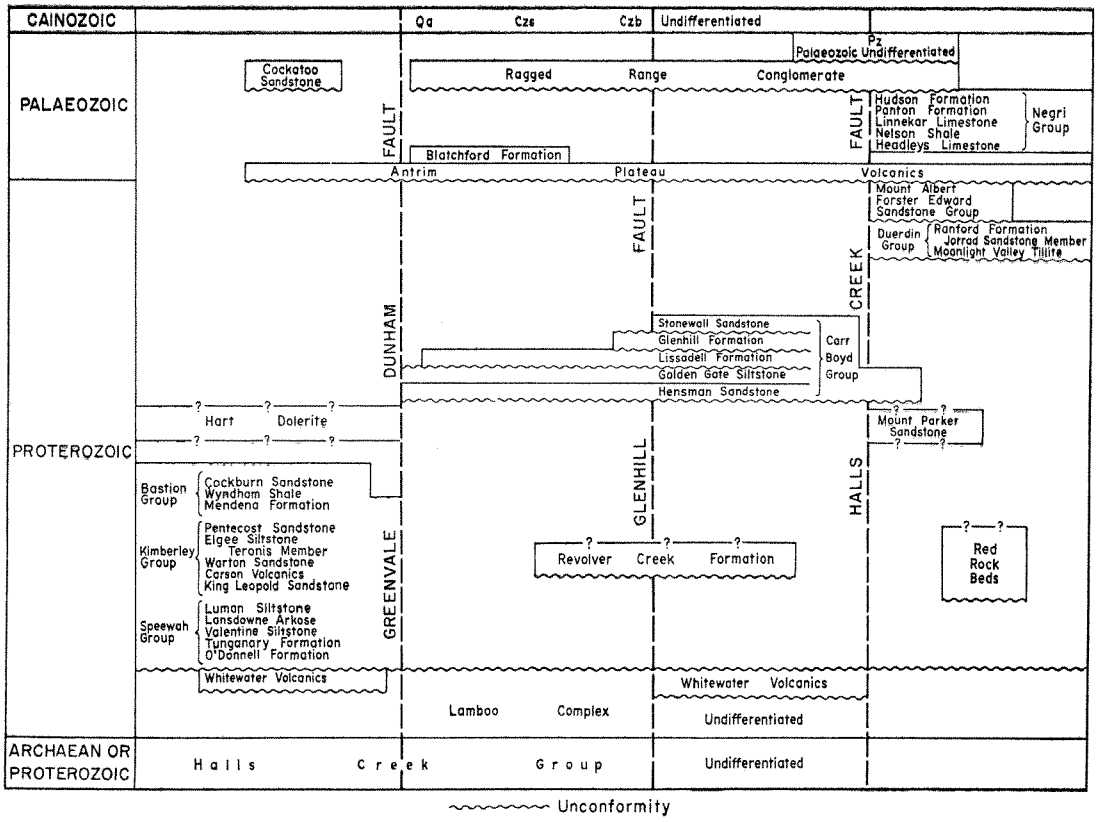

Fig. 3. Stratigraphic succession in the Lissadell Sheet area.

TABLE 1. STRATIGRAPHY—LISSADELL SHEET AREA—HALLS CREEK GROUP AND LAMBOO COMPLEX

	Rock unit and symbol	*Lithology*	*Topography*	*Distribution*	*Remarks*
Lamboo Complex	(Pbe)	Muscovite granite and pegmatite, epidotized granite.	Rounded rocky hills, tors, and plateaux. Poor outcrop in part.	Southern central part of Sheet area; Revolver Creek; Golden Gate Country.	Late-stage dykes and small stocks. Intrudes base of Revolver Creek Formation.
	Undifferentiated (Pb)	Intimate mixture of granite, granodiorite, diorite, gabbro and metamorphic rocks.			Cannot be separated at scale of map.
	Violet Valley Tonalite (Pbv)	Tonalite.			Intrudes rocks as young as Bow River Granite.
	Castlereagh Hill Porphyry (Pbc)	Quartz-feldspar porphyry, adamellite.			Comagmatic with Whitewater Volcanics. Intruded by Bow River Granite in Carr Boyd Ranges. Intrudes Bow River Granite in Greenvale area to south. Unconformably overlain by Carr Boyd Group.
	Bow River Granite (Pbo)	Porphyritic to even-grained coarse-grained granite and granodiorite. Microcline phenocrysts.			Biotite tends to form knots. Quartz-rich groundmass. Intrudes Whitewater Volcanics. Variable relationship to Castlereagh Hill Porphyry. Unconformably overlain by Speewah and Carr Boyd Groups. Post-tectonic granite intrudes Halls Creek Group, Tickalara Metamorphics and McIntosh Gabbro.
Lamboo Complex	Mabel Downs Granodiorite (Pbm)	Foliated hornblende granodiorite and tonalite. Some biotite granite and orthopyroxene granodiorite.	Low rocky hills.	South-central part of Sheet area.	Syntectonic orthogneiss. Contains xenoliths of McIntosh Gabbro. Related to Tickalara Metamorphics.
	Tickalara Metamorphics (Pbt)	Schist, amphibolite, paragneiss, migmatite, granulite, calc-silicates.			Equivalent, at least in part, to Halls Creek Group.
	McIntosh Gabbro (Pbi)	Gabbro, troctolite, dolerite, uralitized dolerite and gabbro, amphibolite, basic granulite.			Affected by granulite facies regional metamorphism.
Halls Creek Group	Undifferentiated (Ah)	Subgreywacke, slate, mica schist. Minor greenschist, tuff, conglomerate.	Low rubbly hills with rectilinear drainage.	Carr Boyd Ranges and Golden Gate Country.	Isoclinally folded. Low-grade regional metamorphism.

PROTEROZOIC OR ARCHAEAN

Halls Creek Group

Rocks of the Halls Creek Group are exposed mainly in the Gordon Downs (Gemuts & Smith, 1967) and Dixon Range (Dow and Gemuts, 1967) Sheet areas. The subdivisions used there cannot be recognized in the Lissadell Sheet area.

The precise age of the Halls Creek Group is unknown. Preliminary isotopic dating (V. M. Bofinger, pers. comm.) of the metamorphism of the Tickalara Metamorphics shows that the Group is older than about 2000 m.y.—perhaps Archaean, but more probably early Proterozoic.

PROTEROZOIC

Lamboo Complex

The Lamboo Complex forms a belt nearly 200 miles long and 30 miles wide between Halls Creek (to the south of the Sheet area) and Dunham Hill. Isolated outcrops occur throughout the Carr Boyd Ranges. Major faults delineate the eastern and western margins of the belt.

The Complex can be divided broadly into two units: older, regionally metamorphosed rocks, and younger, generally acid, post-tectonic intrusive rocks.

The older rocks are Lower Proterozoic: preliminary isotopic dating of the Tickalara Metamorphics and Mabel Downs Granodiorite indicates an age of about 1950 m.y. for the metamorphism (V. M. Bofinger, pers. comm.). The McIntosh Gabbro was intruded before the metamorphism.

The ages of the younger intrusive rocks overlap the lower boundary of the Carpentarian. The Castlereagh Hill Porphyry and younger muscovite granite are lower Carpentarian. Most of the Bow River granite is pre-Carpentarian, although some appears to be younger.

The Lamboo Complex is unconformably overlain by the Speewah and Carr Boyd Groups.

Older Rocks

The *McIntosh Gabbro* crops out in irregular bodies, rarely more than 4 miles long, as remnants within the Mabel Downs Granodiorite and younger intrusive granites. Most of the larger bodies have a foliated marginal zone, which in some places is metamorphosed to granulite facies; the central parts of the body are only uralitized. The gabbro therefore antedates the high-grade metamorphism that affected the Tickalara Metamorphics and Mabel Downs Granodiorite.

The *Tickalara Metamorphics* are mostly migmatite gneisses and fall within the granulite facies of regional metamorphism. They are considered to have been formed from the same sediments as the Halls Creek Group and both were metamorphosed at the same time. Brown weathered micaceous metasediments and banded amphibolite, which crop out west of Bow River and just north of Mount Nyulasy close to large shear zones or later granite intrusions, are possibly migmatite gneiss which has undergone retrograde metamorphism. The migmatite contains dark lenses and bands of basic granulite which represent outcrops of McIntosh Gabbro too small to be shown at the scale of this map.

The *Mabel Downs Granodiorite* is thought to have originated by anatexis of the Tickalara Metamorphics. The most common rock-type in the Sheet area is an orthopyroxene-rich granite. It is brown to dark blue, rarely foliated, and has a distinctive vitreous lustre. It grades into gneiss in a transition zone up to half a mile wide. A large body of gneissic granite near the Halls Creek Fault on the southern margin of the Sheet area is concordant with and grades into the surrounding metasediments.

Younger Intrusive Rocks

The *Bow River Granite* is the most common rock-type in the Lamboo Complex in the Sheet area. The rocks in outcrop grade texturally from even-grained to porphyritic. In the southwest the Granite is intruded by Castlereagh Hill Porphyry, but in the Carr Boyd Ranges rocks identical with the Bow River Granite intrude the Porphyry and the Whitewater Volcanics. Available isotopic ages from the Granite are significantly older than the Porphyry (Bofinger, pers. comm.).

The *Castlereagh Hill Porphyry* is intrusive and almost identical with intrusive phases of the Whitewater Volcanics. Both give similar isotopic ages (Bofinger, pers. comm.) and are regarded as being comagmatic.

The *Violet Valley Tonalite* intrudes Tickalara Metamorphics and McIntosh Gabbro. In areas to the south (Dow and Gemuts, in press) it is thought to intrude the Bow River Granite but could in fact be simply a phase of the Granite.

The *'Undifferentiated Lamboo Complex'* (Pb) is an intimate mixture of rocks occurring as scattered outcrops along the Halls Creek Fault. It was impossible to map the individual rock types.

The white muscovite granite (Pbe) generally crops out as dykes, only some of which are extensive enough to be shown on the map.

CARPENTARIAN

By analogy with the standard rock-time succession in the Carpentaria area, Northern Territory, the base of the Carpentarian succession in the Kimberleys is taken at the base of the Whitewater Volcanics. This is supported by preliminary isotopic work.

The Carpentarian succession consists of a thick sequence of arenites, lutite, and volcanics which are only mildly deformed except near faults. The succession is markedly unconformable on the Halls Creek Group and older rocks of the Lamboo Complex; the youngest rocks of the Lamboo Complex intrude the lowermost Carpentarian rocks.

The oldest Carpentarian rocks, the Whitewater Volcanics, are unconformably overlain by three apparently laterally equivalent sequences, the Kimberley Basin succession, the Revolver Creek Formation, and the Red Rock Beds, which also unconformably overlie the youngest rocks of the Lamboo Complex.

The Kimberley Basin succession contains the Speewah, Kimberley, and Bastion Groups, which include all the Carpentarian rocks above the Whitewater Volcanics exposed west of the Dunham Fault. It is about 16,000 feet thick. Between the Dunham Fault and Halls Creek Fault a much thinner sequence (4000 feet), the Revolver Creek Formation, is correlated with the

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TABLE 2. STRATIGRAPHY—LISSADELL SHEET AREA—CARPENTARIAN

	Rock unit and symbol	*Thickness (in feet)*	*Lithology*	*Topography*	*Distribution*	*Remarks*
BASTIAN GROUP	Cockburn Sandstone (Ptc)	Less than 200 preserved	Fine to medium massive quartz sandstone; interbeds micaceous fine sandstone and thin-bedded micaceous siltstone; silty and clayey sandstone.	Plateau cappings.		Top of Proterozoic succession in west. Ripple marks and cross-bedding common.
	Wyndham Shale(Ptw)	2300* (Measured in Cambridge Gulf Sheet area)	Fissile siltstone and shale with interbeds laminated green and grey fine sandstone. Minor sandstone with calcite nodules.	Crops out poorly beneath scarp of Cockburn Sandstone.	Around the Salmond River in the west, the King River and western flanks of the Dunham valley in the north.	Mud cracks, load casts, and wavy bedding. Oval black calcite nodules up to 2 feet across.
	Mendena Formation (Ptm)	360* (Measured in Cambridge Gulf Sheet area)	Blocky white medium quartz sandstone and flaggy siltstone; laminated fine micaceous and dolomitic sandstone, flaggy fine to medium sandstone and dolomite.			Ripple marks, clay pellets and cross-bedding. Copper traces near Plants homestead. Transitional between Wyndham Sh. and Pentecost Ss.
KIMBERLEY GROUP	Pentecost Sandstone Undifferentiated (Pkp)	3650*	Medium blocky to massive quartz sandstone and flaggy fine quartz sandstone. Minor fine sandstone, siltstone, shale. Glauconitic sandstone.	Resistant unit. Cuestas and plateaux with structural benches due to soft beds.	Around King River.	Ripple marks, cross-bedding, clay pellets, and minor feldspar common throughout.
	Upper (Pkpu)	1150	Blocky to flaggy medium quartz sandstone, coarse sandstone at base. Grains of black iron ore throughout. Minor ferruginous-feldspathic sandstone and clayey sandstone.	Broad plateau cappings controlled by scarp-forming bed at top of middle member in west. Poor outcrop in Dunham River Valley.		Base: friable coarse sandstone above scarp of resistant sandstone. Top: thin silicified quartz sandstone over soft ferruginous sandstone. Well jointed. Cross-bedding, clay pellets common.
	Middle (Pkpm)	1800	Blocky to massive thin-bedded fine to medium quartz sandstone, interbeds feldspathic sandstone. Ferruginous-glauconitic sandstone and shale at base. Siltstone and ferruginous sandstone interbed near top.	Cuestas and plateaux with structural benches due to soft beds.	West of Chamberlain River; west of King River in north; and Dunham River Valley.	Base: soft glauconitic sandstone. Top: cross-bedding, clay pellets, and yellow limonite spots common. Some slumped cross-beds.
	Lower (Pkpl)	700*	Blocky to flaggy fine to medium quartz sandstone and feldspathic sandstone.	Prominent cuestas above Elgee Siltstone.		White photo-pattern. No jointing. Cross-bedding and clay pellets.
	Elgee Siltstone (Pke)	610*	Massive reddish siltstone, scattered interbeds flaggy laminated fine sandstone. Minor shale.	Very poorly exposed in scarp beneath Pentecost Sandstone.	Along Elgee Cliffs and in Saw Ranges. Upper King River area.	Good stratigraphic marker. Outcrops scattered; generally covered by Pentecost Ss. talus.
	Teronis Member (Pkt)	0–50	Shale and micaceous shale, interbeds of dolomite.	Poor outcrop at base of scarp.	Southern part of Elgee Cliffs.	Lenses out northwards. Slumped dolomites and ripple-marks.
	Warton Sandstone (Pkw)	700*	Blocky to massive medium to coarse quartz sandstone and feldspathic sandstone. Minor granule sandstone and purple shale.	Resistant; prominent hogbacks and cuestas.		Ripple marks, slumping, cross-bedding and clay pellets. Thins to 430 feet east of Saw Ranges.

Speewah Group	Carson Volcanics (Pkc)	750*	Altered basalt, blocky cross-bedded feldspathic quartz sandstone. Minor flaggy micaceous sandstone, chert, chloritic siltstone.	Crops out in scarp beneath Warton Sandstone. Scattered outcrop.	Throughout Durack and Saw Ranges area, in west.	Excellent stratigraphic marker. Rapid lateral changes in proportions of basalt and sandstone.
	King Leopold Sandstone (Pkl)	3000+	Blocky to massive quartz sandstone and feldspathic sandstone. Pebble and cobble conglomerate, granule sandstone.	Resistant unit. Rugged dissected plateaux, cuestas.		Conformably on Luman Silts. Locally unconformable elsewhere.
	Luman Siltstone (Ppl)	285*	Flaggy micaceous siltstone and shale. Minor fine sandstone.	Poor outcrop in scarp beneath King Leopold Sandstone.	Along base of Durack Ranges and Saw Ranges in west.	Usually obscured by talus. Extensively intruded by Hart Dol.
	Lansdowne Arkose (Ppo)	1355*	Blocky to massive medium feldspathic sandstone, arkose, clayey sandstone. Minor medium quartz sandstone and glauconitic arkose. Prominent interbeds of flaggy micaceous siltstone, shale, and fine sandstone.	Resistant. Well defined cuestas. Characteristic thin banded pattern on air-photographs.	Bedford Stock Route and Speewah areas in west.	Cross-bedding, ripple-marks, clay and shale pellets. Extensively intruded by Hart Dol. Two prominent siltstone marker beds, and one other less prominent.
	Valentine Siltstone (Ppv)	260* Thins to 160 in south.	Thin-bedded chloritic siltstone, siliceous siltstone, tuffaceous siltstone, minor silty sandstone. Rhyolitic ashstone and tuff.	Crops out poorly in scarps below Lansdowne Arkose.		Characterized by thin beds of rhyolitic ashstone. Extensively intruded by Hart Dol.
	Tunganary Formation (Ppt)	950*	Flaggy to massive medium to coarse quartz sandstone, feldspathic sandstone, and arkose, alternates with regularly thin-bedded siltstone and fine sandstone.	Sandstones form hogsbacks and cuestas, siltstones form valleys between.	O'Donnell Range and along eastern side of Bedford Stock Route adjacent to Greenvale Fault.	Cross-beds, ripple marks, scour-and-fill structures. Prominent siltstone band in middle. Top gradational into Valentine. Siltstones weather to blade-shaped fragments.
	O'Donnell Formation (Ppn)	865*	Thin to thick-bedded coarse to fine subgreywacke, silty sandstone, quartz sandstone; granule sandstone; laminated shale and fine sandstone.	Basal arenite forms hogbacks; overlying siltstone forms valleys.		Unconformable on Whitewater Volc.
				UNCONFORMITY		
	Revolver Creek Formation (Pv)	Up to 4000	Massive amygdaloidal basalt, interbeds of arkose; blocky quartz sandstone and flaggy fine quartz sandstone, micaceous siltstone and massive siltstone, slate.	Scarp beneath Hensman Sandstone. Resistant sandstone near top forms benches.	Revolver Creek and southwestern Carr Boyd Range.	Stratigraphically equivalent to Kimberley Group. Only exposed below Hensman Ss. Shale pellets and bedding partings common.
				UNCONFORMITY		
	Red Rock Beds (Pe)	Up to 6000	Quartz conglomerate, silicified quartz sandstone, red siltstone.	Fault-bounded massive flat-topped range.	Remnants along Halls Creek Fault in south.	Stratigraphic equivalent of Kimberley Basin succession. Unconformable on Halls Creek Gp.
				UNCONFORMITY		
	Whitewater Volcanics (Pw)	Up to 6000	Porphyritic rhyolite volcanic conglomerate; agglomerate. Quartz-feldspar porphyry. Interbedded greywacke; feldspathic sandstone and siltstone; shale; chert; chert-fragment sandstone.	Rugged dissected plateaux. Rounded poorly defined strike ridges. Rectilinear drainage pattern.	From O'Donnell Range southwards along eastern side of Greenvale Fault. Revolver Creek area, Golden Gate Country.	Angular unconformity on Halls Ck. Gp. Unconformable on Halls Ck. Gp. and below O'Donnell Form., Hensman Ss., and Revolver Ck. Form.
				UNCONFORMITY		

* Thickness derived from section measured with Abney level and tape. Other thicknesses estimated from air-photographs or maps.

Kimberley Group on the basis of the basalts present in both. No equivalent of the basal Speewah Group is present. East of the Halls Creek Fault the Red Rock Beds are the only Carpentarian rocks exposed. In the Dixon Range Sheet area (Dow & Gemuts, 1967) they are associated with basic rocks.

The stratigraphic relations of the units are illustrated in Figure 2.

The *Whitewater Volcanics* crop out for over 200 miles in a belt whose discontinuity may be due to erosion (they are unconformably overlain by younger rocks) or initial scattered extrusions.

In the O'Donnell Range area the lower part of the sequence contains a considerable amount of intrusive porphyry. The fabric of the extrusive and high-level intrusive rocks is similar even in thin section, and where other criteria cannot be established, the mode of occurrence is difficult to determine. The intrusive rocks are similar to the Castlereagh Hill Porphyry of the Lamboo Complex, which is considered to be comagmatic with the Volcanics. In the Golden Gate country the Porphyry intrudes the Volcanics.

A more complete section of *Red Rock Beds* is exposed in the Dixon Range Sheet area (Dow & Gemuts, 1967). The Beds represent the only extrusive sequence east of the Halls Creek Fault which is a probable correlative of the Kimberley Basin succession.

The *Revolver Creek Formation* contains three distinct 'members': a thin basal quartz sandstone, an amygdaloidal basalt of very variable thickness with arkose interbeds, and at the top alternating blocky quartz sandstone and siltstone. In the Revolver Creek area the basal sandstone is absent and the volcanics are much thinner. The silt and shale beds have a prominent slaty cleavage.

The Formation represents a marked thinning of the Kimberley Basin succession in the Halls Creek Mobile Zone.

Kimberley Basin Succession

Over 16,000 feet of arenites, lutites, and minor volcanics are exposed in the Kimberley Basin in the west of the Sheet area: the Basin extends westwards to cover the greater part of the Kimberley Division.

The rocks in the Kimberley Basin succession were first subdivided by Guppy et al. (1958) in the West Kimberleys; Harms (1959) extended this subdivision, with minor modification, throughout the Kimberley Division. The succession has been redefined as a result of the present survey, as shown below:

Guppy et al. (1958)	*Harms (1959)*	*Present Survey*	
	Mount House Beds	Bastion Group	Cockburn Sandstone Wyndham Shale Mendena Formation
Warton Beds	Pentecost Sandstone Elgee Shale Warton Sandstone	Kimberley Group	Pentecost Sandstone Elgee Siltstone Warton Sandstone
Mornington Volcanics	Mornington Volcanics		Carson Volcanics King Leopold Sandstone
King Leopold Beds	King Leopold Sandstone	Speewah Group	Luman Siltstone Lansdowne Arkose Valentine Siltstone Tunganary Formation O'Donnell Formation

Harms correlated the rocks in the East Kimberleys mapped by us as Bastion Group with the Mount House Beds (Guppy et al., 1958). Our mapping in the Lansdowne and Mount Ramsay Sheet areas has shown that the Mount House Beds, renamed Mount House Group, unconformably overlie the Bastion Group.

Outcrops of the Kimberley Basin rocks are bounded in the east by the Greenvale-Dunham Fault system. The rocks are only gently folded and faulted, except adjacent to the Greenvale and Dunham Faults, where the lower Speewah Group is sheared and tightly folded.

In the Lissadell Sheet area the Kimberley Basin succession is conformable, but elsewhere the King Leopold Sandstone is locally unconformable on the Speewah Group.

The Speewah Group unconformably overlies the Whitewater Volcanics. In the Mount Ramsay Sheet area (Roberts et al., 1967) a stratigraphic equivalent of the Bastion Group is unconformably overlain by a possible equivalent of the Mount Parker Sandstone and then by various Adelaidean units.

The Speewah Group is extensively intruded by sills of Hart Dolerite; minor sills extend as high as the Carson Volcanics. Elsewhere in the Kimberley Basin, dolerite intrudes rocks as young as Pentecost Sandstone.

Speewah Group

The Speewah Group, about 3700 feet thick, is characterized by feldspathic arenites, chloritic lutites, and minor acid volcanics.

Sills of Hart Dolerite, which are widespread through the whole group, are particularly persistent about the level of the contact between the Tunganary Formation and Valentine Siltstone, and in the Luman Siltstone.

The *O'Donnell Formation* locally shows low-grade metamorphism, strong cleavage folds, and transposed bedding close to the Greenvale Fault. A hematite-rich sandstone, 20 feet thick, occurs locally in the Wilson River area. The overlying *Tunganary Formation* consists essentially of upper and lower arenite members separated by an easily eroded lutite member. In the southwest, near the Wilson River, the silt content increases to about 50 percent of the Tunganary Formation. The *Lansdowne Arkose* is characterized by the abundance of pink and white feldspar in the arenites. Thick bedding, large cross-beds, and ripple-marks are also distinctive.

Kimberley Group

The Kimberley Group consists mainly of quartz sandstone with minor siltstone and basic volcanics and is about 9000 feet thick. West of the Sheet area it forms the bedrock of the Kimberley Plateau. The individual formations are all distinctive and can be readily mapped both on the ground and on air-photographs.

The *Elgee Siltstone* contains lenses of quartz sandstone 200 feet long and 30 feet thick in places. The contact with the overlying Pentecost Sandstone is gradational. In the southwest Durack Ranges flaggy grey dolomite and algal dolomite, interbedded with shale, at the base of the Elgee Siltstone, has been mapped as *Teronis Member*. The Member dies out northwards and thickens

TABLE 3. STRATIGRAPHY—LISSADELL SHEET AREA—ADELAIDEAN AND ADELAIDEAN OR CARPENTARIAN

	Rock unit and symbol	*Estimated thickness (in feet)*	*Lithology*	*Topography*	*Distribution*	*Remarks*
ALBERT EDWARD GROUP	Mount Forster Sandstone (PaO)	Less than 300	Fine purple and white quartz sandstone.		Southern margin, adjacent to Halls Creek Fault.	Extensive outcrop in Dixon Range Sheet. Unconformable on Duerdin Group.
	UNCONFORMITY					
DUERDIN GROUP	Ranford Formation (Pos)	730	Laminated ferruginous and micaceous quartz sandstone and siltstone; red-brown fine subgreywacke; white to mauve claystone, siltstone, shale and fine sandstone. 'Zebra-stone'.	Poor outcrop as strike ridges; plateau capping near Mount Brooking.		Jellyfish.
	Jarrad Sandstone Member (Poj)	350	Massive red-brown ferruginous quartz greywacke and clayey quartz sandstone. Mud pellets common.	Prominent strike ridges with distinctive dark photo-pattern.	Along line of Halls Creek Fault, north of Argyle Downs and around Mount Brooking.	Base of Ranford Formation north of Argyle Downs.
	Moonlight Valley Tillite (Pom)	160	Tillite overlain by marker bed of laminated and thinly bedded pink and cream dolomite.	Poor outcrop in scarp below Jarrad Sandstone and as low rounded hills.		Tillite generally preserved as residual boulders. Dolomite good marker bed. Strong unconformity at base.
	UNCONFORMITY					
CARR BOYD GROUP	Stonewall Sandstone (Pcs)	Less than 1000 feet	Blocky to massive red to white friable medium to coarse quartz sandstone; subordinate red shale; purple ferruginous friable sandstone; feldspathic quartz sandstone. Minor subgreywacke and pebble conglomerate.	Dissected plateau.	Carr Boyd Ranges at northern boundary.	Highest unit of Carr Boyd Group exposed in Sheet area. Unconformably overlies Glenhill Formation.
	UNCONFORMITY					
	Glenhill Formation (Pcg)	2000 west to 5000 east	Flaggy red, grey, and black micaceous siltstone and shale; interbedded laminated green and white glauconitic fine sandstone and green to purple siltstone. Massive to blocky white quartz sandstone. Minor interlaminated red siltstone and white fine sandstone; laminated mudstone.	Massive sandstones form cuestas and mesas. Fine sediments in valleys.	Carr Boyd Ranges, Glenhill station, Carlton Gorge.	Unconformable on Lissadell Formation in places. 200 to 700-foot sandstone member at base. Dominantly silty in south; sudden change to dominantly sandy near Carlton Gorge.
	UNCONFORMITY					
	Lissadell Formation (Pcl)	Up to 5000	Blocky to massive white well sorted and clean fine to medium quartz sandstone and minor granule sandstone. Alternates with flaggy to fissile purple, green, and grey siliceous siltstone, micaceous quartz siltstone, and shale. Minor tuff and pyritic siltstone.	Sandstones in lower part form rugged sandstone ranges. Soft units produce dissected hill country, often with narrow gorges.	Carr Boyd Ranges.	Mainly sandstone in lower half, mainly siltstone in upper half. Disconformable or unconformable on Golden Gate Siltstone.
	UNCONFORMITY					

Carr Boyd Group	Golden Gate Siltstone (Pcd)	800 west to 7000 east	*East:* Black, grey, and purple shale and pyritic shale. Minor blocky blue-grey subgreywacke interbeds. Red-brown and grey mudstone and chert, minor sandstone at base. *West-Central:* Interbedded black to purple micaceous chloritic siltstone and siliceous siltstone and laminated black, grey, and white ferruginous quartz siltstone and fine sandstone. Minor quartz sandstone interbeds. Some massive quartz-sericite siltstone (tuffaceous). Chert-quartz sandstone and ferruginous shales at base. *Southwest:* Interbedded massive purple fine lithic subgreywacke and green micaceous shale. Interbeds of quartz sandstone and granule subgreywacke. Massive sandy hematite, ferruginous sandstone, and ferruginous shale at base. Green tuff.	Low rounded hills to deeply dissected narrow gorges with dendritic drainage.	Throughout Carr Boyd Ranges.	Mud-cracks and ripple marks in southwest. Micro-cross-bedding in west-centre. No sedimentary structures in east. Thickens from west to east; accompanied by facies change from shallow to deep water sediments. Includes Pompeys Pillar iron ore deposit.
	Hensman Sandstone (Pch)	500 west to 800 east	Massive silicified white fine to medium quartz sandstone.	Prominent cliff line above older rocks.		Good marker bed. Unconformable on older rocks.
				UNCONFORMITY		
	Mount Parker Sandstone (Psp)	Up to 400	Pink to purple micaceous coarse quartz sandstone. Minor quartz pebble conglomerate. Thin red and khaki-green shale interbeds.	Prominent strike ridges.	Between Lincoln Yard and Bow River, east of Halls Creek Fault.	Unconformable between Red Rock Beds and Ord Group.
				UNCONFORMITY		
	Hart Dolerite (Pdh)		Dolerite, quartz dolerite, gabbro, diorite, and granophyre.	Prominent rounded rocky ridges and hills.	Western part of Sheet area.	Sills common in Speewah Group. Intrudes rocks as young as Carson Volcanics in this Sheet area; Pentecost Sandstone in other Sheet areas. Unconformably overlain by Walsh Tillite in Lansdowne Sheet area. Consistent granophyre at top of thick sill below Valentine Siltstone.

southwards in the Lansdowne and Mount Ramsay Sheet areas. The *Pentecost Sandstone* has been subdivided into three unnamed 'members' mainly on the basis of distinctive marker beds defining the contacts. The base of the middle 'member' is potentially copper-bearing (see *Economic Geology*).

Bastion Group

The section of the Bastion Group exposed in the Sheet area is incomplete. The Group conformably overlies the Kimberley Group and consists mainly of green shales and siltstones alternating with quartz sandstones and minor carbonate.

The *Mendena Formation* represents a gradation between the underlying Pentecost Sandstone, which contains little siltstone, and the overlying Wyndham Shale, which lacks sandstone interbeds. Flakes of secondary copper minerals occur on bedding and joint planes near Plants homestead. The *Wyndham Shale* is the characteristic unit of the Bastion Group. Only the lowest few hundred feet of the *Cockburn Sandstone* are preserved. A more complete section occurs in the Cambridge Gulf Sheet area.

ADELAIDEAN OR CARPENTARIAN

Hart Dolerite: The Hart Dolerite is most extensive within the Speewah Group, and a sill up to 6000 feet thick has been noted in the Speewah Valley. Large blocks of sedimentary rocks over a mile square and at least several hundred feet thick have been 'rafted' along fault and joint planes and are completely enclosed in dolerite. Minor feeder dykes intrude Kimberley Group rocks. The rocks belong to a typical tholeiitic suite; Edwards (1942) shows that they are saturated with respect to quartz.

An extensive dolerite sill intrudes at or near the contact between the Valentine Siltstone and Tunganary Formation. In the Speewah area it appears to be a composite sheet. A granophyre up to 800 feet thick forms the upper contact of this sheet throughout the Sheet area. It contains numerous sedimentary inclusions and in the field it is difficult to recognize the contact between it and altered sediment. The contact effects of the smaller sills are not pronounced.

Mount Parker Sandstone: Stratigraphic relationships in the reference section of the Mount Parker Sandstone in Dixon Range, and regional correlations, suggest a Carpentarian rather than an Adelaidean age. Small remnants of similar sandstone beneath the unconformably overlying Duerdin Group, along the Halls Creek Fault, have been correlated with the Mount Parker Sandstone. They are faulted against the Red Rock Beds at Mount Pitt and overlie the early Adelaidean Golden Gate Siltstone in the Excelsior Range. The correlation in the Excelsior Range is doubtful. It could be Stonewall Sandstone.

ADELAIDEAN

The thick Carr Boyd Group sequence of early Adelaidean age crops out only between the Dunham and Halls Creek Faults, where it unconformably overlies various older units. The Duerdin and Albert Edward Groups are of late Adelaidean age and are patchily exposed along the eastern side of the Halls Creek Fault. They unconformably overlie older Proterozoic rocks and are themselves unconformably overlain by Palaeozoic rocks.

A more complete section of the Duerdin and Albert Groups is exposed in the Dixon Range Sheet area. Other units, younger than the Carr Boyd and older than the Duerdin Group, are also exposed.

Car Boyd Group

Up to 30,000 feet of arenites and lutites were deposited in the Carr Boyd Range area after erosion of the Revolver Creek Formation. These rocks have been divided into seven formations, five of which crop out in the Lissadell Sheet area. All formations in the succession, except the Golden Gate Siltstone, are unconformable on the formation below.

The age of the Carr Boyd Group cannot be demonstrated in the field since its outcrops are bounded by faults. Previously (Dow et al., 1964) the group had been equated, on the basis of tenuous lithological correlations, with the Kimberley Basin succession; but preliminary isotopic dating of shales from the group (Bofinger, pers. comm.) has indicated an early Adelaidean age.

The *Hensman Sandstone* is uniform in lithology. It sits unconformably on the Revolver Creek Formation, Whitewater Volcanics, Bow River Granite, Castlereagh Hill Porphyry, and Halls Creek Group, and grades upwards into the *Golden Gate Siltstone*. This latter unit thickens gradually from 800 feet in the west to about 7000 feet in the east, adjacent to the Halls Creek Fault; the increase in thickness is marked by a change in sediment from shallow to deeper water types. In the southwest, lithic subgreywacke and green shales, of shallow-water origin, are associated with massive sandy hematite at Pompeys Pillar Iron Deposit, suggesting an oxidizing environment of sedimentation. These rocks grade eastwards through interbedded black siltstone and laminated fine-grained sandstone to a uniform succession of black shale and pyritic shale in the eastern Golden Gate Country, laid down in a reducing environment and more unstable deeper water. Shale and siltstone in the area between the Halls Creek and Revolver Creek Faults have a prominent subvertical cleavage.

The *Lissadell Formation* in the southwest Carr Boyd Ranges sits directly on Hensman Sandstone. It does not crop out east of the Carr Boyd Fault. The *Glenhill Formation* rests on the Lissadell Formation with angular unconformity; up to 1000 feet of the Lissadell Formation has been eroded below the contact. The formation does not crop out east of the Carr Boyd Fault.

Only the lower part of the *Stonewall Sandstone* crops out, along the northern margin of the Sheet area; the Sandstone is more extensive in the Cambridge Gulf Sheet area to the north.

Duerdin Group

An incomplete section of the Duerdin Group unconformably overlies the Mount Parker Sandstone, Carr Boyd Group, or Halls Creek Group. In most outcrops the Duerdin Group is unconformably overlain by the Antrim Plateau Volcanics.

The *Moonlight Valley Tillite* contains unsorted boulders of older rocks in a fine-grained green silty matrix. The boulders range from less than an inch to tens of feet in diameter, and include quartzite, granite, metamorphic rocks, dolomite, jasper, and chert. Many boulders are highly polished and striated. The tillite is of undoubted glacial origin (Dow, 1965).

TABLE 4. STRATIGRAPHY—LISSADELL SHEET AREA—PHANEROZOIC AND INTRUSIONS OF UNKNOWN AGE

Era	*Age*		*Rock unit and symbol*	*Estimated thickness (feet)*	*Lithology*	*Topography*	*Distribution*	*Remarks*
CAINOZOIC	QUATERNARY		Alluvium (Qa)		Alluvium.	River flats.	Throughout.	Includes alluvial black soil.
	UNDIFFERENTIATED		Sand (Czs)		Sand, soil, alluvium, travertine.	Plateaux surfaces and valleys.	Throughout.	
			Black soil (Czb)		Black soil.	River valleys and plains.	Mainly Ord Valley.	Mostly residual on Cambrian rocks.
PALAEOZOIC	UNDIFFERENTIATED		(Pz)	Up to 500	Pebble and boulder conglomerate, coarse friable quartz sandstone.	Boulder-strewn hills.	West of Mount Hensman.	Age unknown: unconformable on Cockatoo Sandstone (?) Cambridge Gulf Sheet area.
			UNCONFORMITY					
	UPPER DEVONIAN		Cockatoo Formation (Duc)	200	Medium to coarse friable brown, pink, and white clayey quartz sandstone.	Low isolated hills adjacent to fault.	West of King River.	Southern extremity of extensive outcrops.
			Ragged Range Conglomerate Member (Dur)	900+	Friable red conglomerate, quartz sandstone, silty quartz sandstone.	Highly dissected cuesta with steep rounded hills.	Ragged Range; Dunham Valley; and valley south of Carr Boyd Ranges.	Pelecypods and gastropods. Equivalent to Cockatoo Formation, and probably Elder Sandstone.
			UNCONFORMITY					
	MIDDLE CAMBRIAN	NEGRI GROUP	Hudson Formation (Cme)	200	Interbedded flaggy chocolate-brown micaceous quartz sandstone and micaceous siltstone.	Plain.	Argyle Basin.	No fossils recorded.
			Panton Formation (Cmp)	500	Predominantly grey shale, siltstone, and marl. Thin limestone beds.	Mainly black soil; outcrop of limestone beds.	Argyle and Rosewood Basins.	Lower limestone contains abundant *Girvanella* and *Biconulites hardmani*.
			Linnekar Limestone (Cml)	30	Medium-bedded grey limestone under thin-bedded grey limestone and marl.	Very low strike ridges.		Characterized elsewhere by *Redlichia forresti* and *Xystridura* sp. Also contains *Biconulites hardmani* and *Girvanella*.
			Nelson Shale (Cmo)	500–600	Grey, brown, and blue shale, gypsiferous and pyritic in part. Thin sandstone and limestone beds.	Plain or valley.		Many outcrops not shown. Lithology from Dixon Range Sheet area. Sits on Antrim Plateau Volcanics in eastern Argyle Basin.
			Headleys Limestone (Cmy)	150	Massive grey limestone with abundant chert nodules, overlain by laminated and thin-bedded grey limestone.	Very low strike ridges, plains.		No fossils found. Probable hiatus at base. Rests on weathered ferruginous basalt with structural conformity. Lenses out in eastern side of Argyle Basin.

Palaeozoic	Lower Cambrian	Blatchford Formation (Clb)	390	Brown friable medium quartz sandstone; interbedded flaggy calcarenite, calcareous sandstone, and siltstone. Green-brown crystalline limestone and pelletal limestone.	Base of scarp under Ragged Range Conglomerate Member.	Western flank of Ragged Range.	Fossils tentatively indicate Ordian (lowest Middle Cambrian) age.
		Antrim Plateau Volcanics (Cla)	Up to 2800	Tholeiitic basalt lavas. Rare andesite lavas and agglomerate. Chert capping.	Dissected plateaux and low cuestas; often covered by soil.	Extensive in east and around Dunham River.	Amygdales of quartz, amethyst, and chalcedony. Marked unconformity at base. Copper present in places.
				UNCONFORMITY			
				Fine-grained quartz-feldspar porphyry		Small intrusives along Ivanhoe Fault.	Age unknown. Not sheared by fault.

The *Ranford Formation* is about 800 feet thick, compared to 1900 feet in the Dixon Range Sheet area (Dow & Gemuts, 1967). The *Jarrad Sandstone Member* cannot be traced south of Argyle Downs homestead but occurs again in the Dixon Range Sheet area. The upper part of the formation, at Mount Brooking, contains the well known 'zebra-stone' or 'ribbon-stone' (Larcombe, 1926; Blatchford, 1927; Hobson, 1930) of Argyle Downs. Well preserved fossil 'jellyfish' are found in the fine-grained rocks at the top of the section (Dunnet, in prep.). Some of the forms are similar to the Ediacara fauna of South Australia (Sprigg, 1949), but some new forms are also present (A. A. Öpik, pers. comm.). Preliminary isotopic dating (Bofinger, pers. comm.) indicates a late Adelaidean age for the Formation.

Albert Edward Group

Only the basal 30 feet of the Group is preserved, that of the basal formation, the *Mount Forester Sandstone,* and it is the youngest Proterozoic unit exposed in the Lissadell Sheet area.

Undifferentiated

Small bodies of massive fine-grained quartz-feldspar porphyry were found within the Glenhill Fault. Their age is unknown. They show no evidence of shearing by the fault, which has affected Devonian rocks nearby.

Cambrian

Cambrian rocks crop out over most of the Sheet area east of the Halls Creek Fault and extend westwards into the Ragged Range and Dunham Valley. Matheson & Teichert (1945) and Traves (1955) subdivided them, and little was added to their mapping during the present survey.

Lower Cambrian

Antrim Plateau Volcanics. Edwards & Clarke (1940) described the Volcanics as a homogeneous petrographic province of tholeiitic basalts. They consist of a series of basalt lava flows each less than 100 feet thick, many of which can be traced for several miles. Agglomerate and about 30 feet of a red-brown cherty quartz sandstone occur at the base. The thickness ranges from 2800 feet near Mount Pitt to only about 100 feet in the Speewah area. A volcanic rock occurs in an older fault on the Dunham River 13 miles west of Dunham River homestead.

Middle Cambrian

Blatchford Formation. Öpik (1967) has determined a metadoxidid trilobite and *Biconulites* from these beds and regards their age as Ordian (lowest Middle Cambrian).

Negri Group. The Cambrian sediments which overlie the Antrim Plateau Volcanics on the Ord Plains belong to the Negri Group of Ordian age. They are folded into asymmetrical structural basins termed the Rosewood and Argyle Basins by Matheson & Teichert (1946). A third, small, unnamed basin occurs east of Mount Pitt. Most of these rocks erode easily and form open rolling plains of fertile black-soils from which resistant limestones crop out as subdued cuestas and hogsbacks.

The *Headleys Limestone* lenses out on the eastern side of the Argyle Basin, where the *Nelson Shale* sits directly on Antrim Plateau Volcanics. The Shale

is rarely exposed in the Lissadell Sheet area, like the *Linnekar Limestone,* of which only the resistant medium-bedded limestone at the base generally crops out.

Outcrops of *Panton Formation* are generally confined to the two lower massive limestone marker beds each about 10 feet thick. Only a few small outcrops of shale are known. The lower marker bed contains abundant *Girvanella* and *Biconulites hardmani.*

Very poorly outcropping chocolate-brown micaceous quartz sandstone and micaceous siltstone in the vicinity of the Argyle Downs homestead and air-strip are referred to the *Hudson Formation.* The outcrops consist mainly of rubble and only the lower 200 feet of the unit is preserved.

DEVONIAN

Rocks of Upper Devonian age crop out in the Ragged Range, southern Carr Boyd Range, Dunham Valley, and King River Valley.

Undated Palaeozoic

Conglomerate and sandstone outliers crop out south of Mount Hensman and appear to overlie the Cockatoo Formation to the north in the Cambridge Gulf Sheet area (Plumb & Veevers, in prep.). No fossils have been found, but Matheson & Teichert (1946) considered these rocks to be of possible Permian age—though they equated them on lithological grounds with the Precambrian Duerdin Group. They consist, in part, of reworked Moonlight Valley Tillite, but most pebbles are silicified sandstone derived from the Carr Boyd Group. The thickness is less than 500 feet.

CAINOZOIC

Extensive residual black soils have formed on Cambrian rocks on the Ord Plains. Residual black soils also occur on the Hart Dolerite.

Superficial sand, residual soils, eluvium, and travertine occur throughout the Sheet area. Sand occurs on the tops of sandstone plateaux and as valley deposits adjacent to sandstone ranges, associated with scree and gravels. Many scarps shown on the map as outcrop, such as the Elgee Siltstone, are, in fact, covered by thin scree. Residual arkosic soils are common on the Lamboo Complex.

Quaternary and Recent alluvium has been deposited along all major streams of the Sheet area. The Dunham and Ord Rivers have very extensive flood plains alluviated in places to more than 50 feet; these deposits show marked vertical variation in sediment type.

STRUCTURE

The Sheet area includes three major tectonic divisions. The Halls Creek Mobile Zone is a fault-bounded belt of older Proterozoic metamorphic and igneous rocks overlain in the north by faulted lower Adelaidean rocks. It is bounded on the west by the Kimberley Block, a relatively stable area of gently warped and flat-lying Carpentarian rocks. The Sturt Block in the east contains mainly Adelaidean and Cambrian rocks, which also are only gently folded. The distribution is shown in Figure 4.

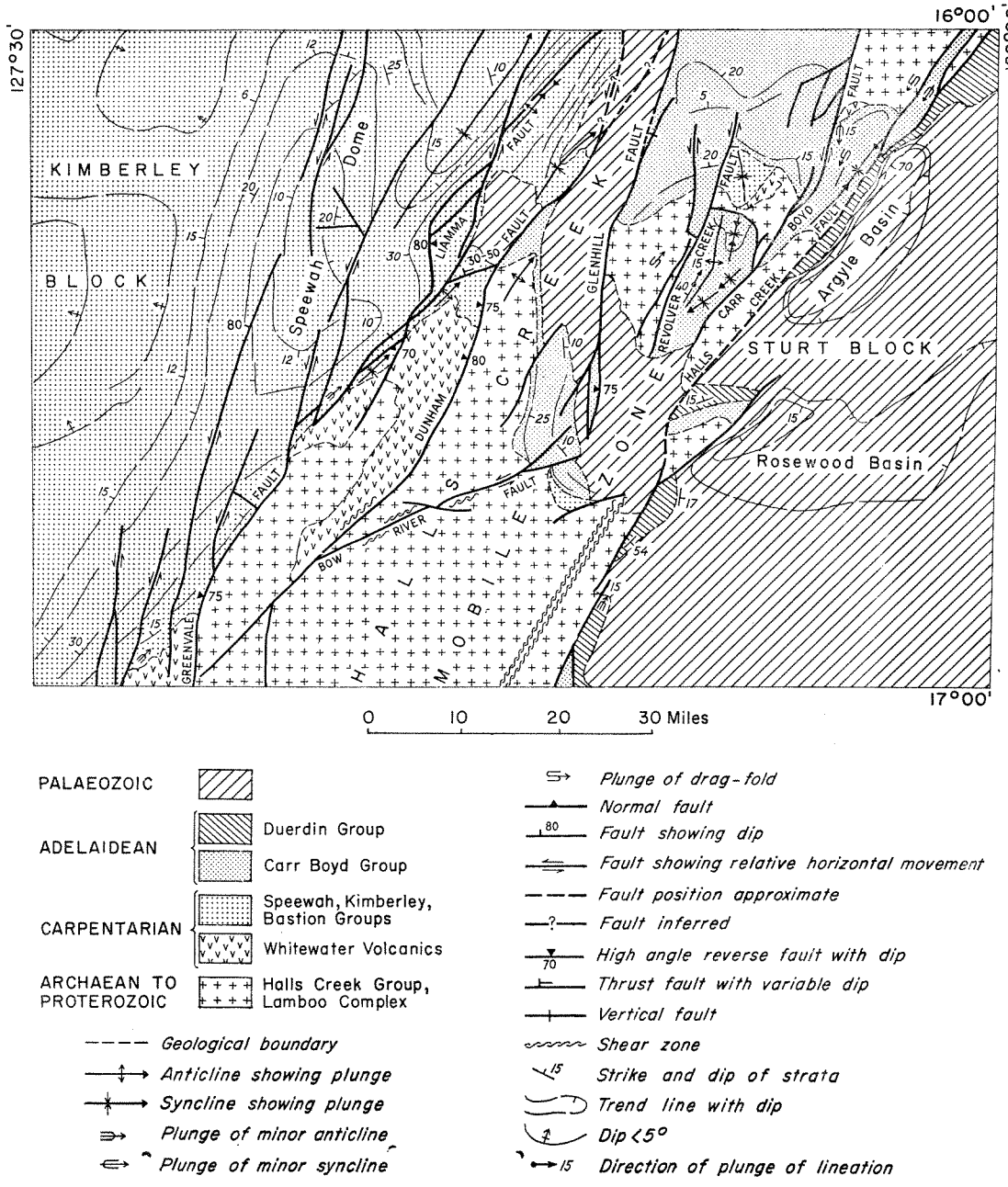

Fig. 4. Structure of the Lissadell Sheet.

Halls Creek Mobile Zone

The Halls Creek Mobile Zone is bounded by two major faults, the Halls Creek Fault in the east and the Greenvale-Liamma Fault in the west. Both trend about 200°. The Zone is cut by other major faults of similar magnitude to the bounding faults.

Folding. The Tickalara Metamorphics and Halls Creek Group have been folded and deformed by regional stresses. In the Tickalara Metomorphics the axes of isoclinal flow-folds trend north-northeast; their plunge ranges from shallow north to vertical. Adjacent to the Mabel Downs Granodiorite the

structure is very complex, with plastic flow and transposition of folded layers, coupled with anatexis to produce an irregular structural pattern of minor folds. The axial planes of these folds dip steeply; amphibolites produce 'stengel gneiss'. The 'stengels' plunge steeply north or south. Marble bands exhibit extreme flowage.

The Halls Creek Group rocks dip steeply and have a subvertical axial-plane slaty cleavage which trends between 180° and 220°. Folding is related to the competency of rocks; small-scale folds are common in slates and phyllites. The folds plunge from 35° north to vertical. Quite large vertical folds are present, and may be indicative of a second phase of folding. Around the headwaters of Revolver Creek the axial-plane slaty cleavage has been folded into broad folds plunging steeply to the northeast. This second folding may be related to movements on the Revolver Creek or Glenhill Faults.

The only tight folding developed in the Adelaidean rocks of the area is directly related to the major faults. Very broad folds can be seen, however, which have clearly been cut and displaced by major faults.

Two main directions of folding are apparent. The most dominant trend, such as near the O'Donnell Range and Saw Ranges, is about 040°. The other prominent trend, best developed in the Carr Boyd Ranges, is about 290°. These two trends correspond to the overall fold pattern throughout the Kimberley Basin. It is thought that the northwesterly trend is the later.

Faulting. The structure of the Halls Creek Mobile Zone is dominated by faulting. The faults have long complex histories of periodic movement, and intensity of movement and associated shearing tend to decrease with the age of the rocks affected.

The *Halls Creek Fault* separates areas with distinctly different geological histories and outside the Sheet area can be traced for several hundred miles. In adjoining areas movements on the fault range in age from pre-Carpentarian to post-Permian.

It has a shear zone up to ¼ mile wide and dips steeply to the east and the west. In the Argyle Downs area the movement is distributed over several faults in a zone up to 4 miles wide. Strongly cleaved phyllites, phyllonites, and mylonites are developed. Observed vertical displacements are invariably east block down, but reversals have occurred during the Fault's history. Pre-cambrian displacements are large but difficult to estimate. Post-Cambrian throw of at least 9000 feet is indicated. Horizontal displacements are probably large but again difficult to estimate. Evidence can be found in the Dixon Range Sheet area to indicate displacement of at least 50 miles, west block south (Dow & Gemuts, in press).

The *Carr Boyd Fault* is separated by a shear zone up to 4 miles wide from the Halls Creek Fault. In the south the Fault is lost beneath a cover of unfaulted Devonian rocks. It has affected deposition of the Carr Boyd Group. A horizontal displacement of about 18 miles, west block south, is postulated, while the rocks in the Golden Gate country have been uplifted by rotation of the wedge between the Carr Boyd and Halls Creek Faults about a horizontal east-west axis. In the southern apex of this wedge the Golden Gate Siltstone has been strongly folded, and an axial plane cleavage developed subparallel to the Halls Creek Fault.

In the southern part of the Sheet area a wide shear zone within the Lamboo Complex trends towards the Carr Boyd Fault but is lost beneath the Devonian cover. It ultimately links with the Springvale Fault in the Dixon Range Sheet area (Dow & Gemuts, 1967).

Swarbrick (1965) has postulated gravitational gliding tectonics associated with splays of the Carr Boyd Fault. We believe these features are only of minor importance.

The *Revolver Creek Fault* illustrates the pulsatory nature of faulting in the area. Folded cleavage in the adjoining Halls Creek Group suggests considerable movement. North of Revolver Creek the Revolver Creek Formation is strongly faulted, while the unconformably overlying Hensman Sandstone is displaced comparatively little: either 5000 feet horizontally, west-block south, or 600 feet vertically, west-block down, on each of two adjoining splays. The Fault dies out within the Lissadell Formation to the north.

The southern end of the wedge between the Revolver Creek and Carr Boyd Faults has been subjected to rotational strain which was released on a curved cross-fault to the north. The whole block has subsided about 6000 feet. Compression on this block has produced broad anticlines and synclines, whose axial planes lie at about 15° to the bounding faults. These major anticlines culminate, plunging 20° south and 25° north. An axial plane cleavage is developed in the less competent rocks of the Golden Gate Siltstone.

The *Greenvale Fault* is a complex zone composed of a composite system of intersecting faults striking about 210° and 180°. These combine to produce a 'dog-leg' trend to the Fault. The 210° faults are the older and are represented by shear zones up to 2 miles wide, with axial-plane cleavage developed subparallel to the fault, and bedding transposed. Near the Wilson River the Fault dips about 75° east and shows reverse vertical displacement of about 6000 feet. Farther north near Moonlight Valley Yard the Fault branches into several faults forming a zone with a complex movement pattern. The main fault here appears to be the easterly arm, which trends about 075° and merges with the Dunham Fault about 4 miles south of Dunham River homestead. This arm is a thrust fault dipping between 30° and 50° to the north.

The 180° striking legs diverge westwards as splays which can be followed for many miles within the Kimberley Block as narrow zones of brecciation. They show little vertical displacement, but horizontal movements up to 20,000 feet, west-block-south, are indicated. They displace the 210° legs by a similar amount.

The *Liamma Fault* diverges northwards from the Greenvale Fault near Moonlight Valley Yard and varies in trend between 180° and 210°; 210° is the more common. Vertical displacement is invariably west-block-up and in the Dunham River the Fault dips 80° west. The Fault is displaced by a north-trending wrench fault similar to the Greenvale Fault.

The *Dunham Fault* is a prominent easterly splay of the Greenvale Fault; it is also connected to the main Springvale Fault of the Dixon Range Sheet area. The northern extension of the Dunham Fault is obscured by soil cover

in the Dunham River Valley. It probably trends into the Ivanhoe Fault of the Cambridge Gulf Sheet area. Within the Lamboo Complex the Fault has a shear zone up to a mile wide and contains reef quartz. Along the O'Donnell Range it dips steeply to the east, and drag-folds in the Carpentarian rocks suggest reverse vertical movement.

A soil-covered northerly-trending splay of the Dunham Fault is postulated as passing along the western edge of the Dunham Valley to meet the Liamma Fault at Optic Hill in the Cambridge Gulf Sheet area. Horizontal displacement of 25,000 to 40,000 feet west-block-south is postulated for this fault.

The *Bow River Fault* is a short splay of the Dunham Fault which crops out as a shear zone up to 4000 feet wide where it crosses rocks of the Lamboo Complex. It strikes about 070° and dips steeply to the north and south. Its easterly extension is obscured by a cover of Devonian rocks.

Rocks of the Carr Boyd Group show an apparent horizontal displacement of 10,000 feet, north-block-west. This movement occurred as several movements during deposition of the group and died out within the Glenhill Formation. The magnitude of the shear zone suggests considerable movement prior to the Carr Boyd Group.

The *Glenhill Fault* trends about 195° and dips steeply to the east and west. For much of its length it is a zone of two or three closely spaced parallel faults. Its movement pattern is complex and the Precambrian history is obscured by Palaeozoic events. No horizontal movements can be detected owing to lack of datum points, but they may have been considerable. Phanerozoic movements appear to be dominantly vertical. Near Glenhill homestead the Carr Boyd Group rocks show an apparent vertical displacement of about 7000 feet, west-block-down. Farther north the displacement cannot be calculated. Near the southwest corner of the Carr Boyd Ranges the fault does not disturb Devonian rocks; 4 miles to the north, near Glenhill homestead, they are overturned against it: it is here a reverse fault dipping 75° east. Close to the Ragged Range post-Devonian vertical displacement is at least 1500 feet west-block-down, and the Devonian rocks are intensely sheared within the fault zone.

The horizontal movement sense in almost all faults is west-block-south. This is suggestive of a regional compressive stress from the north to northwest and strain expressed by anastomosing wrench faults.

Kimberley Block

The Kimberley Block, west of the Mobile Belt, consists of only slightly deformed or flat-lying Carpentarian rocks. Dips increase towards the Mobile Zone and are steeply upturned along the Greenvale Fault. The structure of the margin of the Block is dominated by splay faults of the Greenvale Fault which trend between 180° and 195°, and dip steeply east or west. Vertical displacements appear to be small, but horizontal displacements are as much as 20,000 feet, west-block-south. Fault wedges of steeply dipping rocks are found adjacent to the margins of the Block. The rocks have yielded by fracture along narrow zones, and shearing is subordinate.

Folding consists only of broad domes and basins, of which the main example is the Speewah Dome, which has a long axis trending about 010°. Near the western margin of the Sheet area very shallow basins are common. Elsewhere in the Kimberley Basin two well defined fold trends are present, striking roughly north-northeast and northwest. The structures in the Lissadell Sheet area are apparently caused by these two intersecting trends.

Sturt Block

The Sturt Block is a stable area adjacent to the eastern side of the Halls Creek Mobile Zone. In the part lying on the Lissadell Sheet fault wedges of Adelaidean rocks occur between the eastern edge of the Halls Creek Fault and its northeasterly splays. The two fault trends (020° and 045°) are the main structural features of the Block. The Cambrian sediments are little faulted.

The Rosewood and Argyle Basins are markedly asymmetrical structural basins affecting the Cambrian rocks. Their long axes trend northeast, parallel to the splay faults. The western edges of the Basins are sharply terminated against the Halls Creek Fault, producing steep dips.

The present distribution of rock units is markedly controlled by faulting. It is not known to what degree this is related to primary sedimentation. Faults are known to have influenced sedimentation during the Carpentarian, particularly in the Carr Boyd Group. The effect on Palaeozoic sedimentation is less clear. Some units may have deposited only in the fault blocks in which they now crop out, but the present distribution of most is probably the result of post-depositional faulting and erosion.

ECONOMIC GEOLOGY

No economic ore deposits are known, but the geological setting and the abundance of minor mineralization makes the Lissadell Sheet area a promising target for prospecting, particularly for base metals. The most favourable geological conditions for mineralization are probably found in the older Lamboo Complex and Halls Creek Group rocks, but the younger sedimentary and volcanic rocks cannot be ignored. Of particular interest is the deep-water facies of the Golden Gate Siltstone; a thick sequence of black shale containing pyrite must be considered as a suitable host rock for syngenetic sulphide mineralization.

Copper

Copper has been found throughout the Sheet area in rocks of many ages. No economic deposits are known yet, but recent (1966) discoveries seem encouraging. Copper-bearing minerals are present throughout the Lamboo Complex to the south. Pickands Mather Co. Ltd has recently announced the discovery of a copper prospect near the junction of the Bow River and Turkey Creek as a result of their geochemical prospecting programme.

Copper mineralization was noted in two localities in the Whitewater Volcanics: malachite staining on the surface of a waterfall in a creek 5 miles south of Dunham Jump Up; and a thin isolated quartz vein containing arsenopyrite and minor chalcopyrite crops out 6 miles northeast of Moonlight Valley Yard. The vein could only be traced for a few inches in acid

volcanics adjacent to a basic dyke. Reconnaissance stream sediment sampling in the Dixon Range Sheet area revealed anomalous copper values (D. B. Dow, pers. comm.). The Volcanics certainly warrant further prospecting.

Numerous minor occurrences of copper are known from the Carson Volcanics in the Lansdowne Sheet area. None has been recorded in the Lissadell Sheet area.

Small flakes of azurite coat bedding planes of the Elgee Siltstone west of the Chamberlain River, in the southwestern part of the Sheet area.

Harms (1959) reported copper staining on joints in Pentecost Sandstone near Grimwood Gap. During the current survey copper was found in two new localities associated with the glauconitic sediments at the base of the middle Pentecost Sandstone, one in the Cambridge Gulf Sheet area, and the other in the Ashton Sheet area. The outcrops are about 26 miles apart and are associated with the dome which extends into the northwest corner of the Lissadell Sheet area. The occurrences are small but show a remarkable stratigraphic control. The bed is worthy of further study (Roberts, Derrick, & Ivanac, 1966).

Harms (1959) reports copper minerals in Mendena Formation at Plants homestead as 'minor veinlets of copper carbonate, oxides and chalcocite in a siltstone a few chains south of the homestead. Individual veins do not exceed 4 feet in length and 3 inches in width: their origin is not apparent'. Only flakes of carbonate on joint surfaces were found during our survey.

Traces of copper carbonate are recorded from two localities within the Hart Dolerite. At Martins Silver-Lead Prospect patches of azurite and malachite are scattered within quartz (Harms, 1959). Azurite was noted in a shear zone associated with epidote and quartz about 5 miles north of Speewah homestead. Malachite and azurite also coat joints in uralitized dolerite in the Moonlight Valley Yard. Traces of copper are common in the Hart Dolerite throughout the Kimberley region, but nothing of economic potential has been found.

Copper minerals have been reported from widespread localities in the Antrim Plateau Volcanics. Most consist of carbonate, chalcocite, and cuprite: native copper is also found, either as vesicle fillings or as sparse disseminations. The basalt immediately under the Headleys Limestone in the Rosewood Wall area contains no visible copper minerals, but 6-foot channel samples across it assayed about 0.6 percent copper (Harms, 1959). Other samples from the same horizon farther afield showed no significant copper content.

Copper stains occur in the Headleys Limestone in many places. The largest is found in the Rosewood Wall. The showings are small and of no economic interest. The mineralization consists of disseminated and nodular chalcocite, and associated secondary carbonates, which are generally concentrated near the base of the Limestone. It occurs as discontinuous patches over a distance of 3 miles. Matheson & Teichert (1946) suggest that the copper has been leached from the volcanics by surface waters and fixed by the limestone.

Minor copper carbonates occur in joints in limestone of the Blatchford Formation in the western scarp of the Ragged Range.

Lead

Small deposits of lead are known in Halls Creek Metamorphics, in granite of the Lamboo Complex, and in the younger Proterozoic rocks of the Kimberley Basin, but none appears to offer economic prospects.

Two deposits occur in the Hart Dolerite of the Speewah area. Martins Silver-Lead Prospect (Blatchford, 1927) is on the northeastern side of a domed sheet forming the valley floor at its contact with the Speewah Group. The mineralization occurs in a flat narrow vein on top of the granophyre of the Hart Dolerite. The second occurrence is galena (and fluorite) in a shear zone about 5 miles north of the old Speewah homestead. The shear zone can be traced for almost 10 miles, but the mineralization occurs in lenticular veins of quartz over a strike length of about 400 feet.

Traces of galena were noted in the Valentine Siltstone above a dolerite sill, near a small fault, 2 miles north of the Dunham River. Galena has also been reported from near Mount Lookout: a hand specimen showed a little galena associated with quartz.

Reconnaissance stream sediment sampling in the Dixon Range Sheet area shows anomalous lead values within the Whitewater Volcanics.

Uranium

Uranium was discovered south of Dunham River homestead by United Uranium N.L. in 1954. The locality is close to the Dunham Fault near the Dunham Jump Up (de la Hunty, 1955). The northern mineral leases M.C. 39 and 42 covered a basic dyke intruding sheared granite. Autunite which lines joints in the dyke has been prospected by shallow costeans and a shaft: the shaft is now inaccessible. The radioactivity of the dyke, which was tested for 4000 feet, is confined to the shaft area. A second prospect straddles the Great Northern Highway (M.C. 40 and 41). North of the Highway several costeans cut the contact between sheared granite and quartz sandstone of the Hensman Sandstone. Torbernite occurs as a narrow vein up to 4 inches wide in sheared granite close to the sandstone. During 1963 the Department of Main Roads constructed a new road which passed immediately south of the prospect, but no further mineralization is visible in the road cutting.

Other claims along the Dunham Fault to the south, held by United Uranium N.L., were reported by de la Hunty. These were not located during the 1963 survey, but are apparently of even less significance than the northern ones.

Iron

Beds of low-grade siliceous hematite crop out over a total strike length of about 10 miles, near the base of the Golden Gate Siltstone, in the south-western Carr Boyd Ranges near Pompeys Pillar. They have been studied and assayed by Harms (1959) and Macleod (1963), and only two deposits approach ore grade: the Western Deposit (originally the Pompeys Pillar Deposit), about 7 miles north of Mount Nyulasy, and the Eastern Deposit (originally the Matsu Deposit), about 6 miles northeast of Mount Nyulasy. The two deposits are separated by the Bow River Fault, which displaces the Eastern Deposit 10,000 feet east. The Western Deposit was drilled in 1962 and more exhaustively in 1963-64. Results are not available for publication.

The deposits crop out on the dip slope of a large cuesta of the Carr Boyd Range, and are bedded sedimentary deposits associated with shallow-water quartz sandstone and ferruginous shale. The massive hematite and sandy hematite is up to 35 feet thick in both deposits. Six million tons of 60 per-cent Fe_2O_3 grade ore is estimated to be available by selected mining in the Western Deposit, and up to 20 million tons of much lower grade ore in the Eastern Deposit (Macleod, 1963). The overall low grade and limited extent make it unlikely that either deposit could be mined economically under present market conditions to provide a direct shipping ore; but much of the hematite-rich zone is coarsely granular, and the deposits could conceivably provide a substantial tonnage of beneficiable ore.

Scattered beds of hematitic sandstone and metasomatized ferruginous sandstone occur in the Wilson River and O'Donnell Range areas; none are of economic significance.

Water

The only surface water is in springs and waterholes in the more rugged parts of the Sheet area, most of which are inaccessible to stock. All, or nearly all, the annual rainfall of 20-30 inches falls during the summer monsoon. The runoff is rapid, and streams as a result are not permanent. The surface water must be supplemented by groundwater for stock purposes.

Groundwater supplies of up to 30,000 gallons per hour are obtained in some places from crystalline rocks, soft sandstone, basalt, and alluvium. Water is very scarce in some areas: the low-grade metamorphics, some of the crystalline rocks, and shales yield very little groundwater. Most of the groundwater is suitable for domestic use, and only in rare cases is it too saline for cattle.

The hydrology of the area has been described by Passmore (1964).

Building Materials

Abundant, readily accessible deposits of sand and gravel are available from the bed of the Ord and Bow Rivers, and smaller amounts in the other major streams.

The Hart Dolerite is ideally suited for road metal, and many outcrops are readily accessible by road. Considerable overburden may have to be removed in some areas to obtain fresh material. Other suitable rocks are the Antrim Plateau Volcanics, Whitewater Volcanics, and Castlereagh Hill Porphyry.

Material suitable for road foundations, etc., is always readily available. The most common sources are clayey soils and eluvial gravels at the base of sandstone ranges. Suitable aggregate for major works such as the Ord Dam could be found in the Whitewater Volcanics and Castlereagh Hill Porphyry.

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LISSADELL
WESTERN AUSTRALIA

AUSTRALIA 1:250,000 GEOLOGICAL SERIES

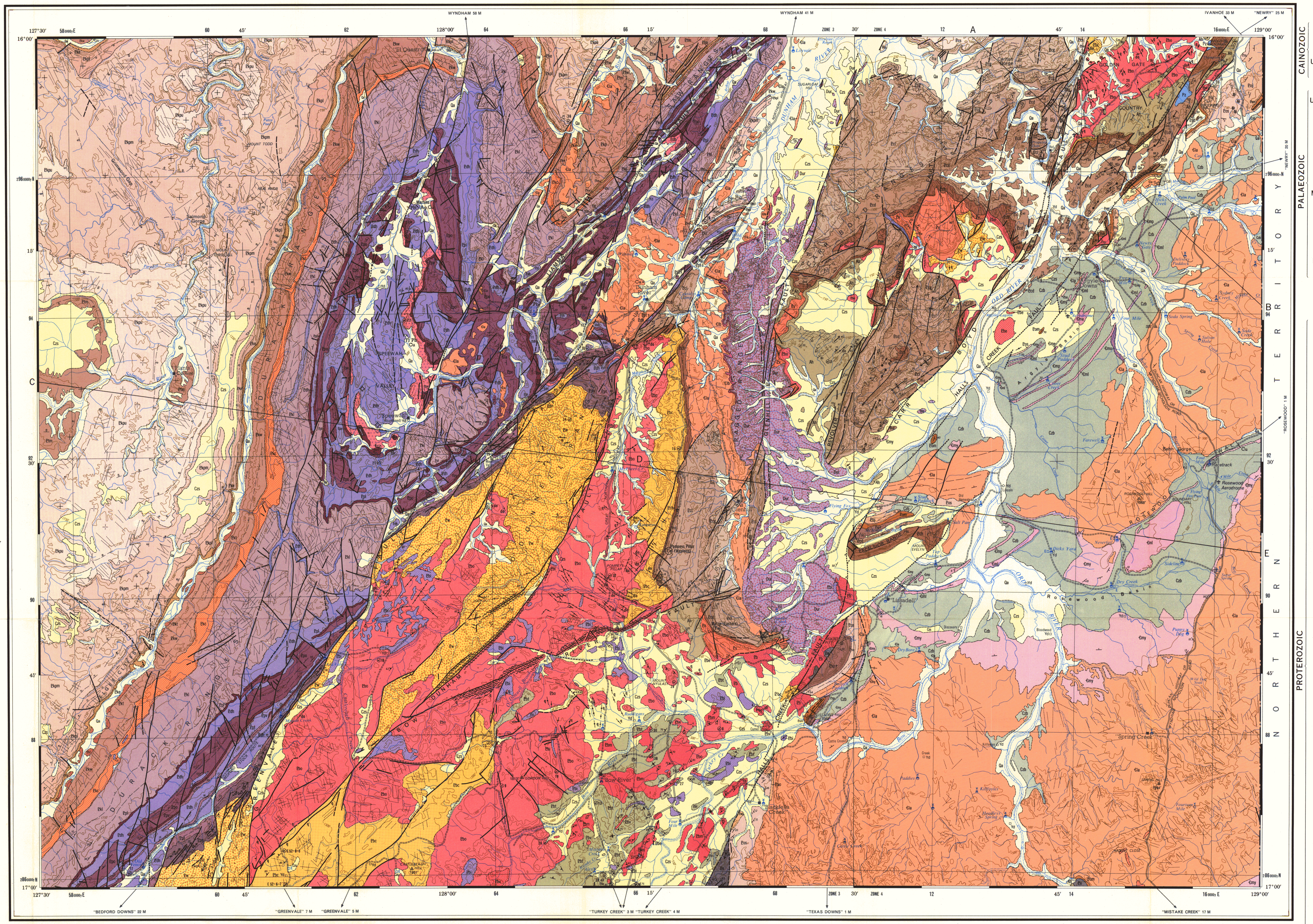
SHEET SE 52-2

Reference

- Geological boundary
- Anticline
- Syncline
- Plunge of minor anticline
- Plunge of minor syncline
- Plunge of drag fold
- Fold axis, showing plunge
- Fault (q — indicates quartz filled)
- Inclined fault
- 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
- Vertical strata
- Horizontal strata
- Overturned strata
- Dip <5° (air-photo interpretation)
- Dip 5°–15° (air-photo interpretation)
- Dip 15°–45° (air-photo interpretation)
- Horizontal dip (air-photo interpretation)
- Trend lines (air-photo interpretation)
- Plunge of anticlinal axes (air-photo interpretation)
- Plunge of synclinal axes (air-photo interpretation)
- Plunge of drag fold (air-photo interpretation)
- Joint pattern (air-photo interpretation)
- Strike and dip of foliation
- Prevailing strike and dip of foliation
- Vertical foliation
- Strike and dip of cleavage
- Prevailing strike and dip of cleavage
- Vertical cleavage
- Apparent dip of cleavage on bedding plane
- Direction and plunge of lineation
- Pitch of lineation on bedding
- Inclined platy flow
- Horizontal platy flow
- Extinct basic volcanic vent
- Macrofossil locality
- Type section locality
- Measured section
- 36 — Sample locality for radio-active age determination, with reference number
- Dyke; q — quartz, do — dolerite
- Prospect
- •Pb — Minor mineral occurrence
- (Fe) — Unexploited mineral deposit
- Ag — Silver
- Cu — Copper
- Fe — Iron
- Fl — Fluorite
- Pb — Lead
- U — Uranium
- Water bore, salinity <2500 p.p.m.
- Well, salinity <2500 p.p.m.
- Windpump
- T — Tank
- E — Earth tank
- Proposed Ord Dam Site
- Waterhole
- Spring
- Highway
- Vehicle track
- Landing ground
- "Plants" — Homestead
- Yd — Yard
- Telephone line
- State boundary
- 1813' — Trigonometrical station, showing height in feet
- Escarpment
- 1750' — Contours; interval, 250'



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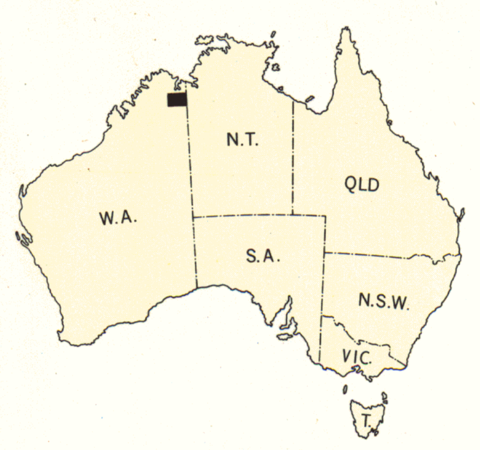
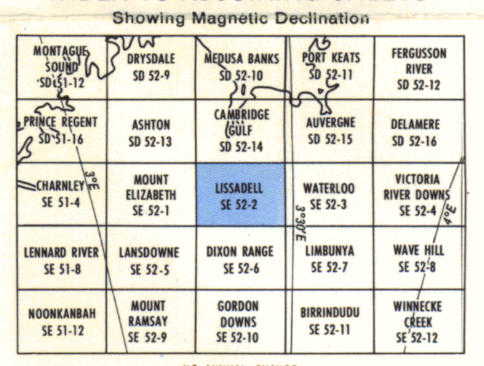
Transverse Mercator Projection.



INDEX TO ADJOINING SHEETS
Showing Magnetic Declination



Scale 1:250,000

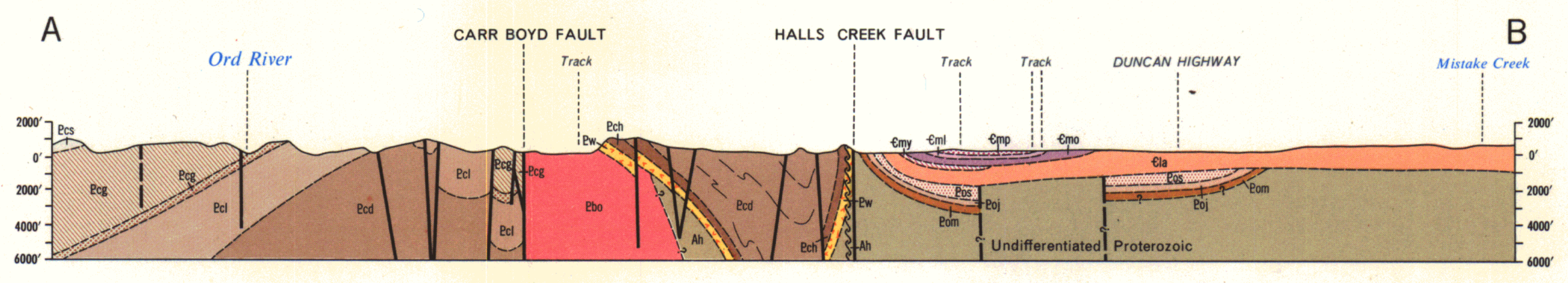
5 0 5 10 15 MILES

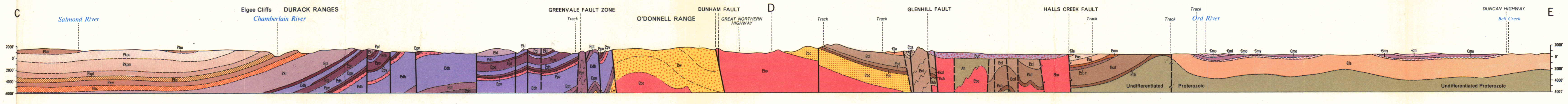
5 0 5 10 15 20 25 KILOMETRES

GREY NUMBERED LINES INDICATE THE 20,000 YARD TRANSVERSE MERCATOR GRID, ZONES 3 AND 4 (AUSTRALIA SERIES)

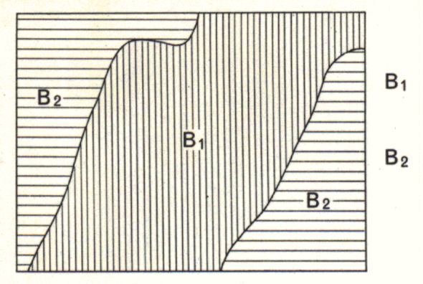
Sections

Cainozoic sediments omitted from section
Attitude of faults not known; folding schematic
Scale: $\frac{V}{H} = 2$





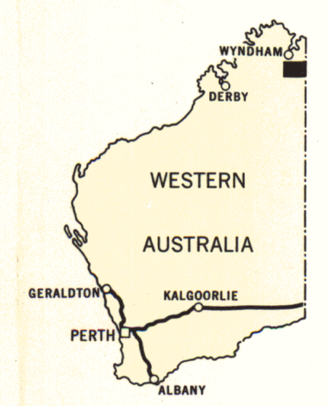
GEOLOGICAL RELIABILITY DIAGRAM



B_1 Detailed reconnaissance — numerous ground traverses and air-photo interpretation

B_2 Reconnaissance — some ground and helicopter traverses, and air-photo interpretation

Geology, 1963-64, by: K. A. Plumb, D. Dunnet, D. B. Dow, V. M. Bofinger, J. H. Latter (B.M.R.), J. R. Passmore, I. Gemuts (G.S.W.A.)
Compiled, 1964-65, by: K. A. Plumb, D. Dunnet, A. S. Mikolajczak J. L. McGovern,
Cartography by: Geological Branch, B.M.R.
Drawn, 1967, by: R. Ritschel, B.M.R.
Printed by: P. C. Grosser & Co., Melbourne

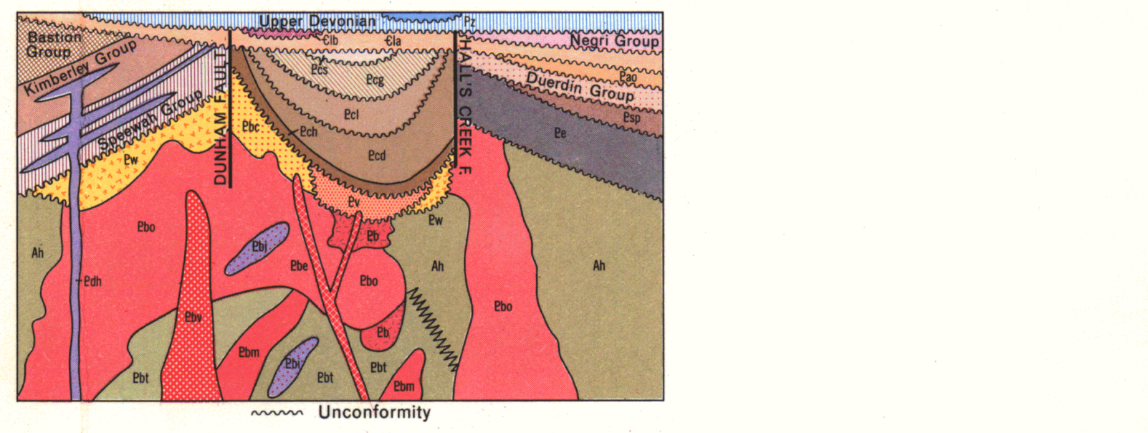


Reference

Era	Period	Unit	Symbol	Description
CAINOZOIC	QUATERNARY		Qa	Alluvium
CAINOZOIC	UNDIFFERENTIATED		Czs	Sand, soil cover, alluvium, travertine
CAINOZOIC	UNDIFFERENTIATED		Czb	Black soil
PALAEOZOIC	UNDIFFERENTIATED		Pz	Conglomerate, sandstone
PALAEOZOIC	UPPER DEVONIAN	Cockatoo Formation	Duc	Friable brown clayey quartz sandstone
PALAEOZOIC	UPPER DEVONIAN	Ragged Range Conglomerate Member	Dur	Friable red conglomerate, quartz sandstone, fossiliferous silty quartz sandstone
PALAEOZOIC	MIDDLE CAMBRIAN	Negri Group: Hudson Formation	Єme	Flaggy chocolate-brown micaceous quartz sandstone and siltstone
PALAEOZOIC	MIDDLE CAMBRIAN	Negri Group: Panton Formation	Єmp	Grey shale, siltstone, marl, limestone; Fossiliferous limestone marker bed
PALAEOZOIC	MIDDLE CAMBRIAN	Negri Group: Linnekar Limestone	Єml	Fossiliferous limestone; marl
PALAEOZOIC	MIDDLE CAMBRIAN	Negri Group: Nelson Shale	Єmo	Grey, brown and blue shale, gypsiferous and pyritic in part; minor limestone and sandstone
PALAEOZOIC	MIDDLE CAMBRIAN	Negri Group: Headleys Limestone	Єmy	Limestone
PALAEOZOIC	LOWER CAMBRIAN	Blatchford Formation	Єlb	Brown friable sandstone; flaggy calcareous sandstone and siltstone, green-brown crystalline limestone, pelletal limestone
PALAEOZOIC	LOWER CAMBRIAN	Antrim Plateau Volcanics	Єla	Chert; Basalt, vesicular basalt, agglomerate, red-brown sandstone
			P	Fine-grained quartz-feldspar porphyry
PROTEROZOIC	ADELAIDEAN (UPPER PROT.*)	Albert Edward Group: Mount Forster Sandstone	Pao	Fine-grained purple and white quartz sandstone; fossiliferous
PROTEROZOIC	ADELAIDEAN (UPPER PROT.*)	Duerdin Group: Ranford Formation	Pos	Laminated ferruginous and micaceous quartz sandstone and siltstone; subgreywacke; claystone, shale; "zebra-stone" (mottled claystone)
PROTEROZOIC	ADELAIDEAN (UPPER PROT.*)	Duerdin Group: Jarrad Sandstone Member	Poj	Massive red-brown ferruginous quartz greywacke; quartz sandstone
PROTEROZOIC	ADELAIDEAN (UPPER PROT.*)	Duerdin Group: Moonlight Valley Tillite	Pom	Tillite, pink laminated dolomite
PROTEROZOIC	ADELAIDEAN (MIDDLE PROTEROZOIC)	Carr Boyd Group: Stonewall Sandstone	Pcs	Friable quartz sandstone; minor shale, subgreywacke, conglomerate
PROTEROZOIC	ADELAIDEAN (MIDDLE PROTEROZOIC)	Carr Boyd Group: Glenhill Formation	Pcg	Black and red-brown micaceous shale, laminated fine-grained glauconitic sandstone, green siltstone, massive quartz sandstone; Massive white quartz sandstone
PROTEROZOIC	ADELAIDEAN (MIDDLE PROTEROZOIC)	Carr Boyd Group: Lissadell Formation	Pcl	Massive quartz sandstone; purple, green and grey siltstone, micaceous siltstone, shale; minor tuff, pyritic sandstone
PROTEROZOIC	ADELAIDEAN (MIDDLE PROTEROZOIC)	Carr Boyd Group: Golden Gate Siltstone	Pcd	Black pyritic shale, micaceous siltstone, fine-grained sandstone, subgreywacke, red mudstone, green shale, tuff, sandy hematite
PROTEROZOIC	ADELAIDEAN (MIDDLE PROTEROZOIC)	Carr Boyd Group: Hensman Sandstone	Pch	Massive silicified white quartz sandstone
PROTEROZOIC	ADELAIDEAN OR CARPENTARIAN (UNDIFF.)	Mount Parker Sandstone	Psp	Quartz sandstone, quartz conglomerate
PROTEROZOIC	ADELAIDEAN OR CARPENTARIAN (UNDIFF.)	Hart Dolerite	Pdh	Granophyre; Massive gabbro, dolerite, diorite, granophyre
PROTEROZOIC	CARPENTARIAN (LOWER & MIDDLE PROTEROZOIC)	Bastion Group: Cockburn Sandstone	Ptc	Massive quartz sandstone; minor grey micaceous fine-grained sandstone and siltstone
PROTEROZOIC	CARPENTARIAN (LOWER & MIDDLE PROTEROZOIC)	Bastion Group: Wyndham Shale	Ptw	Fissile green and grey shale; laminated fine-grained sandstone interbeds, siderite nodules
PROTEROZOIC	CARPENTARIAN (LOWER & MIDDLE PROTEROZOIC)	Bastion Group: Mendena Formation	Ptm	Quartz sandstone alternating with green and purple siltstone, fine-grained sandstone, dolomite
PROTEROZOIC	CARPENTARIAN (LOWER & MIDDLE PROTEROZOIC)	Kimberley Group: Pentecost Sandstone	Pkp	Undifferentiated: Blocky medium-grained quartz sandstone; minor purple siltstone and fine-grained sandstone, glauconitic sandstone
PROTEROZOIC	CARPENTARIAN (LOWER & MIDDLE PROTEROZOIC)	Kimberley Group: Pentecost Sandstone	Pkpu	Upper: Blocky medium-grained quartz sandstone with coarse-grained sandstone interbeds at base; ferruginous sandstone
PROTEROZOIC	CARPENTARIAN (LOWER & MIDDLE PROTEROZOIC)	Kimberley Group: Pentecost Sandstone	Pkpm	Middle: Blocky fine to medium-grained quartz sandstone; minor feldspathic sandstone, purple siltstone; glauconitic sandstone at base
PROTEROZOIC	CARPENTARIAN (LOWER & MIDDLE PROTEROZOIC)	Kimberley Group: Pentecost Sandstone	Pkpl	Lower: Blocky fine to medium-grained quartz sandstone and feldspathic sandstone
PROTEROZOIC	CARPENTARIAN (LOWER PROTEROZOIC)	Kimberley Group: Elgee Siltstone	Pke	Massive red siltstone; minor laminated fine-grained sandstone, green shale
PROTEROZOIC	CARPENTARIAN (LOWER PROTEROZOIC)	Kimberley Group: Teronis Member	Pkt	Green shale and micaceous shale, flaggy dolomite, algal dolomite
PROTEROZOIC	CARPENTARIAN (LOWER PROTEROZOIC)	Kimberley Group: Warton Sandstone	Pkw	Blocky quartz sandstone and feldspathic sandstone; minor granule sandstone, purple shale
PROTEROZOIC	CARPENTARIAN (LOWER PROTEROZOIC)	Kimberley Group: Carson Volcanics	Pkc	Massive altered basalt, blocky feldspathic sandstone; minor micaceous sandstone, green chert, chloritic siltstone
PROTEROZOIC	CARPENTARIAN (LOWER PROTEROZOIC)	Kimberley Group: King Leopold Sandstone	Pkl	Massive quartz sandstone, feldspathic sandstone, granule sandstone, conglomerate
PROTEROZOIC	CARPENTARIAN (LOWER PROTEROZOIC)	Speewah Group: Luman Siltstone	Ppl	Brown siltstone and shale, fine-grained sandstone
PROTEROZOIC	CARPENTARIAN (LOWER PROTEROZOIC)	Speewah Group: Lansdowne Arkose	Ppo	Massive pink feldspathic sandstone, arkose, quartz sandstone; purple micaceous siltstone, shale, fine-grained sandstone; glauconitic arkose
PROTEROZOIC	CARPENTARIAN (LOWER PROTEROZOIC)	Speewah Group: Valentine Siltstone	Ppv	Thin-bedded green chloritic siltstone and siliceous siltstone; rhyolitic ashstone and tuff
PROTEROZOIC	CARPENTARIAN (LOWER PROTEROZOIC)	Speewah Group: Tunganary Formation	Ppt	Massive quartz sandstone, feldspathic sandstone, arkose; thin-bedded green siltstone
PROTEROZOIC	CARPENTARIAN (LOWER PROTEROZOIC)	Speewah Group: O'Donnell Formation	Ppn	Brown and black subgreywacke, silty sandstone, quartz sandstone, granule sandstone; laminated green shale, fine-grained sandstone
PROTEROZOIC	CARPENTARIAN (LOWER PROTEROZOIC)	Revolver Creek Formation	Pv	Amygdaloidal basalt, arkose, quartz sandstone, flaggy purple micaceous siltstone, massive chocolate-brown siltstone, slate
PROTEROZOIC	CARPENTARIAN (LOWER PROTEROZOIC)	Red Rock Beds	Pe	Quartz conglomerate, silicified quartz sandstone, red siltstone
PROTEROZOIC	CARPENTARIAN (LOWER PROTEROZOIC)	Whitewater Volcanics	Pw	Porphyritic rhyolitic volcanics and pyroclastics, agglomerate, intrusive quartz-feldspar porphyry; greywacke, siltstone, shale, chert
PROTEROZOIC	CARPENTARIAN	Lamboo Complex	Pbe	Muscovite granite and pegmatite, epidotized granite
PROTEROZOIC	CARPENTARIAN	Lamboo Complex: Undifferentiated	Pb	Intimate mixture of granite, granodiorite, diorite, gabbro, metamorphic rocks
PROTEROZOIC	CARPENTARIAN	Lamboo Complex: Violet Valley Tonalite	Pbv	Tonalite
PROTEROZOIC	CARPENTARIAN	Lamboo Complex: Castlereagh Hill Porphyry	Pbc	Quartz-feldspar porphyry, adamellite
PROTEROZOIC	CARPENTARIAN	Lamboo Complex: Bow River Granite	Pbo	Coarse-grained granite and granodiorite; porphyritic to even-grained
PROTEROZOIC	CARPENTARIAN	Lamboo Complex: Mabel Downs Granodiorite	Pbm	Foliated hornblende granodiorite and tonalite: Some biotite granite and orthopyroxene granodiorite
PROTEROZOIC	CARPENTARIAN (ARCHAEAN OR LOW. PROT.)	Lamboo Complex: Tickalara Metamorphics	Pbt	Schist, amphibolite, paragneiss, migmatite, granulite; Calc-silicate metamorphic rocks
PROTEROZOIC	CARPENTARIAN (ARCHAEAN OR LOW. PROT.)	Lamboo Complex: McIntosh Gabbro	Pbi	Gabbro, troctolite, dolerite, uralitised dolerite and gabbro, amphibolite, basic granulite
ARCHAEAN OR PROTEROZOIC		Halls Creek Group Undifferentiated	Ah	Subgreywacke, slate, mica schist; minor greenschist, tuff and conglomerate

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

DIAGRAMMATIC RELATIONSHIP OF ROCK UNITS



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