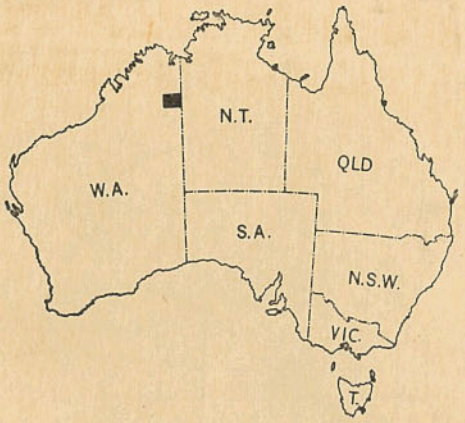
1:250,000 GEOLOGICAL SERIES—EXPLANATORY NOTES

GORDON DOWNS

WESTERN AUSTRALIA



SHEET SE/52—10 INTERNATIONAL INDEX

COMMONWEALTH OF AUSTRALIA
STATE OF WESTERN AUSTRALIA

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Compiled by I. Gemuts (Geological Survey of Western Australia) and
J. W. Smith (Bureau of Mineral Resources)

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COMMONWEALTH OF AUSTRALIA

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Explanatory Notes on the Gordon Downs Geological Sheet

The Gordon Downs 1 : 250,000 Sheet area lies between latitudes 18° S and 19° S and longitudes 127°30′ E and 129°00′ E in the north-eastern part of Western Australia. The eastern edge of the Sheet area borders the Northern Territory. Halls Creek, the only town, is situated in the north-western part of the Sheet area: it is about 380 miles and 250 miles respectively from the ports of Derby and Wyndham.

Two hundred white people live within the Sheet area; 160 at Halls Creek and the rest at Flora Valley, Gordon Downs, Nicholson, and Ruby Plains cattle stations. There are semi-permanent inhabitants at Old Halls Creek township, about 7 miles east of the present town, Koongie Park, Sophie Downs Station, Elvire Homestead, Palm Springs, Duffers Mine, and Golden Crown Mine. Halls Creek, which was originally a gold-mining centre, is now a small supply town for cattle stations in the surrounding district, and an administrative centre.

The two main roads in the area are the newly constructed Great Northern Highway joining Derby and Wyndham, which passes through Halls Creek, and a road from Halls Creek to Nicholson Station which continues to join the Stuart Highway in the Northern Territory. Another well-used road leads from the Great Northern Highway to Ruby Plains Station and stations to the south. The eastern part of the Sheet area is well served by roads between stations.

Air flights connect Halls Creek with Perth and Darwin at least once weekly. The major stations are also visited weekly by a flight from Wyndham to Alice Springs in the Northern Territory.

Air photographs and maps of the area include: air-photographs at a scale of 1 : 50,000; photomosaics at 1 inch to 1 mile and 1 inch to 4 miles, obtainable from the Department of Lands and Surveys, Perth, Western Australia; and a planimetric map at 1 inch to 4 miles prepared by the Mapping Branch, Department of Lands and Surveys, Perth, Western Australia.

Climate

The region has a monsoonal climate, with heavy rains and thunderstorms between December and March, and a long dry season from June to September. The average annual rainfall of the region is between 13 and 19 inches

per year. The long periods of little rain and high temperatures result in high evaporation rates (100-110 inches per year).

Day temperatures are high throughout the year, and in summer maximum readings of over 110° F are quite common. The average daily mean temperature at Halls Creek is 78° F. Occasional frosts have been noted in the region and the average minimum temperature recorded in Halls Creek for July is 45° F.

The prevailing winds are the south-east trades of the winter months and the north-west monsoons which bring the rain during the wet season.

Vegetation (after Teakle, 1944).

Savanna and grasslands make up the rich grazing area within the Sheet area. The most important grasses are Mitchell (*Astrebla* spp.) and Flinders (*Iseilema* spp.) grasses and *Dicanthium.*

The rivers and small streams are fringed by grassy woodland, and where the rivers have cut deep gorges, there are small areas of dense tropical forests growing in the bottoms on continuously moist soils.

Previous Investigations

The first geological work on the Gordon Downs Sheet was by Hardman (1883, 1884, 1885), then Government Geologist, who was attached to the Kimberley Survey Expedition. His map is remarkably accurate and his main rock groups are approximately the same as the broad divisions now recognised. Hardman's discovery of alluvial gold in the Halls Creek area led to a gold rush, and mining continued until nearly the end of the nineteenth century. The gold-bearing area was surveyed by Woodward (1891) and later by Smith (1898). Wade (1924) made a reconnaissance of the East Kimberley region, and reported on the prospects of finding petroleum in the area. Finucane (1938) mapped the old mines and adjacent geology in the area. Edwards & Clarke (1940) made a special study of the Antrim Plateau Volcanics. Matheson & Guppy (1949) mapped the Precambrian rocks near Halls Creek and Traves (1955), contributed greatly to the knowledge of the geology of the Ord-Victoria region during a land-use survey conducted by the Land Research and Regional Survey Section of CSIRO in 1949 and 1952. Harms (1959) made an appraisal of the whole Kimberley region. Ruker (1961) mapped an area around Saunders Creek and subdivided the Hall Creek Metamorphics, and his nomenclature, where practicable, has been used in this report. Mercer (1961) reported on diamond drilling for uranium at Saunders Creek Prospect.

PHYSIOGRAPHY

The Gordon Downs Sheet area lies across the headwaters of the large drainage systems of the Ord and Fitzroy Rivers and Sturt Creek. The Ord drains northwards and the Fitzroy westwards to the sea, and Sturt Creek drains inland southwards. Rivers of the Fitzroy System, mainly the Margaret River and its tributaries, drain the lower western part of the Halls Creek Ridges. They have shallow sandy river beds, and waterholes are rare. The Ord River

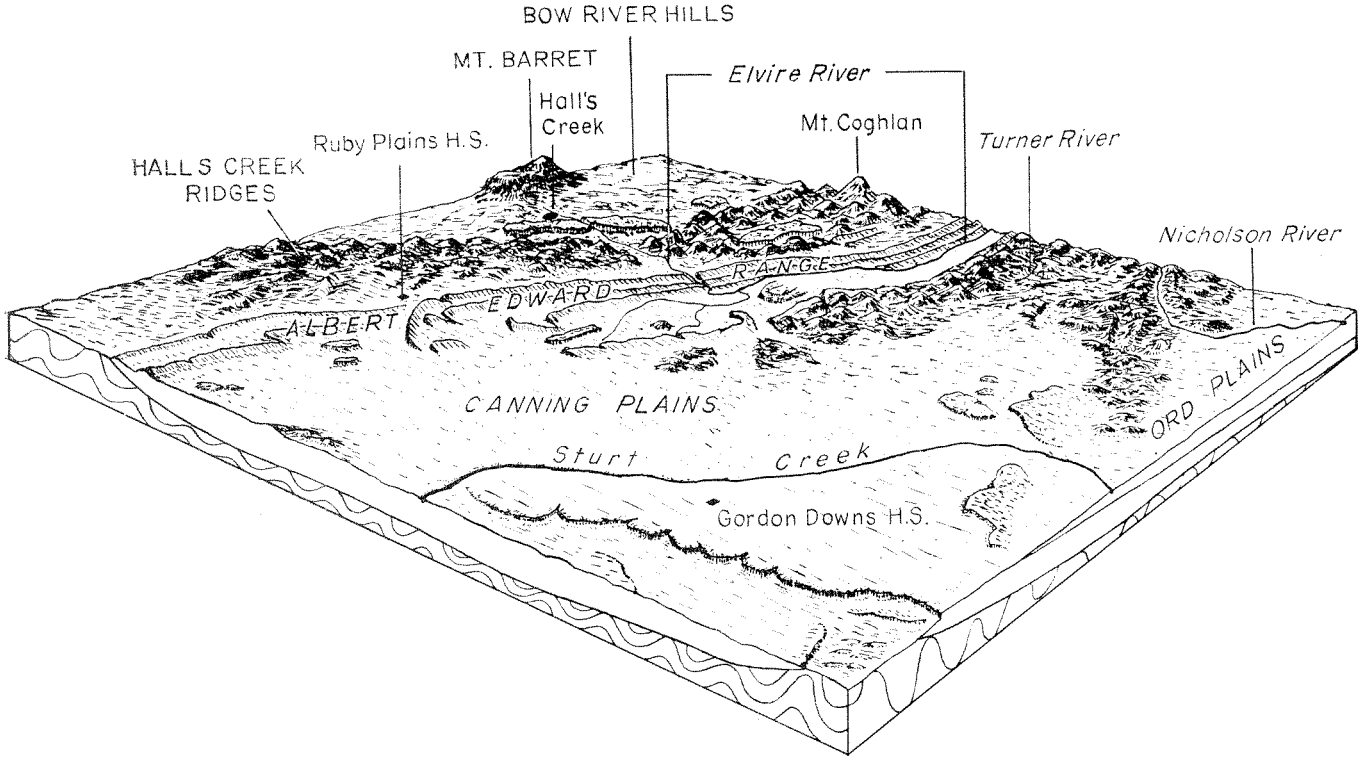

Fig. 1. Physiographic block diagram

System, whose principal tributary on the Sheet area is the Elvire River, drains the rest of the Halls Creek Ridges, with the exception of the area south of Ruby Plains. The Turner and Nicholson Rivers drain most of the north-eastern part of the Sheet area. Permanent waterholes exist along the Elvire River and its tributaries, particularly where they cut through the scarps of the Albert Edward Range. The Sturt System is characterized by flat, broad, senile drainage, particularly Sturt Creek itself, which is a mile wide in places; it contains only scattered shallow waterholes which are all usually salty and not permanent.

The area has been divided into five physiographic units, shown on Figure 1. This is an extension of Traves' (1955) original subdivisions.

Halls Creek Ridges occupy most of the western part and range in elevation from 1600 feet in the south to 2017 feet at Mount Coghlan. They are underlain by rocks of the Halls Creek Group, and the country consists of either rough irregular hills up to 300 feet high, which are mainly composed of basic igneous rocks of the Biscay Formation, or closely spaced dissected hogbacks of the Olympio Formation, which are rarely over 100 feet high. The drainage is closely spaced and structurally controlled. Steep-sided ridges follow the regional north-north-easterly strike of the underlying rocks and are cut by small dendritic streams, controlled by joints and faults. Run-off is very fast, and there is little soil cover; the hills are covered by spinifex and stunted eucalypts.

Albert Edward Range and Mount Barret. The Albert Edward Range is characterized by prominent northerly trending cuestas and hogbacks, which have smooth curved dip-slopes on the east and near vertical scarps up to 400 feet high on the west. Trellised drainage is controlled by joints and faults, and the larger streams break through the range in deep gorges. In the south, bold cuestas of Mount Forster Sandstone are up to 250 feet high; other units tend to form low discontinuous strike ridges. South-east of Flora Valley Homestead the country is low-lying with the exception of the low cuestas of Nyuless Sandstone and flat-topped mesas of the Tertiary Lawford Beds. Pastoral areas are confined to alluvial plains overlying the Timperley Shale. In the north-western corner the prominent cuesta of Mount Barret (2227 feet) rises 500 feet above the surrounding country.

The *Bow River Hills* in the north-west are low rounded boulder-strewn hills, up to 300 feet high, and subdued strike ridges, sculpted by an open-textured drainage on crystalline rocks that trend north-east. Granite whale-backs rise above low-lying plains underlain by basic igneous rocks. Areas of intense shearing have been eroded more quickly and provide easy access to the north; they are used for pasture.

The *Ord Plains* occupy the north-eastern corner of the Sheet area, within the upper part of the Ord River drainage system, and east of the Halls Creek Ridges. The Antrim Plateau Volcanics have a rectangular drainage pattern controlled by major joints and steep canyons, and boulder-strewn mesas and hills up to 300 feet high have been carved out by the tributaries of the main streams. Gently dipping Headleys Limestone is cut by many narrow, vertical-sided ravines formed by the enlargement of joints. Around Nicholson Homestead extensive black-soil plains form pastoral areas.

The *Canning Plain* is a flat and elevated plain, drained inland by the Sturt and Wolf Creek drainage system. In the north laterite overlies the Antrim Plateau Volcanics and Proterozoic rocks. Streams cutting the laterite have formed mesas and plateaux, some of which are more than 100 feet high. In the south-east the Gardiner Beds form an arcuate ridge, trending roughly west, with a scarp on the south side about 100 feet high. Low rises of Halls Creek Group and isolated low ranges of the Gardiner Beds occur south of the scarp. West of this arcuate ridge, low ridges and eroded domes of Proterozoic rocks rise 50 feet above the surrounding plains. Most of the Canning Plain is valuable pasture land, consisting of black soil plains cut by senile meandering creeks.

STRATIGRAPHY

The stratigraphy of the Sheet area is summarized in Tables 1, 2, and 3. The oldest rocks are probably Archaean, consisting of tightly folded and regionally metamorphosed geosynclinal sediments, volcanic rocks, and igneous intrusives. They are intruded by Proterozoic gabbros and granites and overlain by gently folded Proterozoic sediments and volcanics. Palaeozoic plateau volcanics and overlying limestone and sandstone are unconformable on the Precambrian succession. Thin Tertiary (?) sediments form scattered outcrops and Cainozoic soils occur throughout the area. Quaternary alluvium is confined to river channels.

Archaean or Proterozoic (Table 1)

The *Halls Creek Group* crops out in a north-north-easterly belt which strikes across the western part of the *Gordon Downs* Sheet area.

The oldest rocks within the group, the *Ding Dong Downs Volcanics,* form the core of the Saunders Creek Dome. Quartz conglomerate and standstone of the *Saunders Creek Formation* overlie the volcanics, apparently conformably. These clastic rocks were laid down in shallow water and there may have been a distinct break in sedimentation after the volcanics were extruded and folded. A thin indurated remnant of the Saunders Creek Formation also occurs around the northern margin of the Sophie Downs Dome, which has an intruded granite core. The *Biscay Formation* consists of marine sediments and basic volcanics, intruded by sills and dykes of Woodward Dolerite and sills and stocks of microgranite. The basic rocks are invariably uralitized and it is difficult to distinguish between extrusive and intrusive rocks. Dolomite, and carbonated basalt and dolerite, define the top of the Biscay Formation east of the Halls Creek Fault. On the western side of the fault this marker unit is disrupted by dolerite dykes which intrude the top of the formation.

The *Olympio Formation* is composed of rhythmically bedded greywacke and shale. Many of the greywacke bands are graded and show sedimentary structures, such as load casts, micro cross-bedding, and current ripple marks, which are common in greywacke sequences deposited by turbidity currents. Schist and quartzite crop out in the south-eastern corner of the map area; they are overlain unconformably by Proterozoic sediments, and have been mapped as 'undifferentiated Halls Creek Group'.

TABLE 1. ARCHAEAN AND LOWER PROTEROZOIC STRATIGRAPHY

Group	Formation and symbol	Thickness (feet)	Lithology	Relationships with underlying units	Remarks
	Moola Bulla Formation (Ɛx)	10,000+	Green shale and fine-grained sandstone; feldspathic arkose and quartz-pebble conglomerate—current bedded; greywacke with interbeds of phyllitic slate and siltstone and lenses of quartz-pebble conglomerate.	Unconformable on Halls Creek Group.	Mostly shallow-water sediments.
Lamboo Complex	Ɛbr		Rhyolite, dacite, and microgranite dykes and sills.	Intrude Biscay and Olympio Formations.	
	Undifferentiated (Ɛb)		Granite and uralitized gabbro, and minor metamorphic rocks.		
	Sophie Downs Granite (Ɛbs)		Coarse even-grained granite, with granophyric and rapakivi textures.	Intrudes lower part of Halls Creek Group.	Dark flow layered(?) acidic margin in north.
	Bow River Granite (Ɛbo)		Porphyritic coarse-grained granite, microcline phenocrysts; minor potassic leucogranite, fine-grained granite, granodiorite.	Intruded by quartz-feldspar porphyry dykes.	Granodiorite may be more extensive than mapped. Fine-grained chill margin to large masses.
	Tickalara Metamorphics (Ɛbt)		Calc-silicate rocks, paragneiss, and minor amphibolite.	Rafts in McIntosh Gabbro Subulayered with coarse granite.	Intruded, dispersed and metasomatized by later igneous intrusives.
	McIntosh Gabbro (Ɛbi)		Uralitized gabbro, norite, troctolite; minor dolerite, syenite, pyroxenite, amphibolite.		Large sills disrupted by granite intrusions. Central portions fresh, margins uralitized.
	Woodward Dolerite (Ɛbd)		Uralitized dolerite and ultrabasic sills and dykes.	Intrude Halls Creek Group; possibly same age as McIntosh Gabbro.	
Halls Creek Group	Undifferentiated (Ah)		Schist and quartzite.	Overlain unconformable by Gardiner Beds.	High-greenschist metamorphic facies.
	Olympio Formation (Aho)	10,000+	Subgreywacke, feldspathic subgreywacke, arkose; subordinate phyllite, shale and siltstone. Minor conglomerate. Slightly metamorphosed.	Apparently conformable on Biscay Formation.	Gold in quartz shears in basal part; minor alluvial gold in dry streams. Some subgreywacke deposited by turbidity current.
	Biscay Formation (Ahr)	500+ (probably up to 5000)	Pillow basalt, dolerite dykes, minor andesite, rhyolite, dacite; subgreywacke, tuffaceous greywacke, siltstone, slate and carbonaceous slate. Limestone, dolomite, and calc-silicates in middle and top of formation.	Conformable on Saunders Creek Formation.	Gold in uppermost basic intrusives. Limonitic gossans in dolomite and calc. Silicates contain secondary copper, lead, zinc. Malachite stains and minor native copper in basic volcanics.
	Saunders Creek Formation (Ahs)	640	Indurated blocky thinly-bedded grey fine-grained quartz sandstone, interbedded with thinly bedded dark blue fine-grained quartz greywacke. Pebbly conglomerate bands 1–5 ft thick, and minor slate, near base.	Conformable on Ding Dong Downs Volcanics.	Thorogummite in basal quartz-pebble conglomerate.
	Ding Dong Downs Volcanics (Ahd)	At least 1000	Amygdaloidal epidotized basalt, intercalated with basic crystal tuff and tuffaceous greywacke. Minor rhyolite, acid crystal tuff, quartz mica schist, and slate. Basic rocks uralitized.	Oldest unit in map area.	Small crystals and aggregates of copper in amygdales. Thin veins of quartz and native copper reported.

PROTEROZOIC

Lamboo Complex (Table 1)

The Lamboo Complex consists of metamorphic and igneous instrusive rocks; they crop out in the north-north-easterly Halls Creek Mobile Zone, which lies immediately to the west of, and parallel to, the main belt of outcrop of the Halls Creek Group.

The *Woodward Dolerite,* which consists of uralitized dolerite and pyroxenite sills and dykes, was intruded into the Halls Creek Group before or during its deformation. The Dolerite may be co-magmatic with the *McIntosh Gabbro,* which is restricted to the crystalline rocks of the Halls Creek mobile zone. The McIntosh Gabbro consists dominantly of coarse-grained gabbro; but pyroxenite, troctolite, norite, diorite, and syenite are also present. The gabbros were once part of a large sill extending to the north, which was subsequently folded, intruded, metamorphosed, and broken up by the *Bow River Granite.* The pyroxene of the basic rocks has been uralitized to form green hornblende or actinolite by the intrusive granite. In most of these rocks the plagioclase still retains its original composition.

The metamorphic rocks of the Lamboo Complex are grouped together as the *Tickalara Metamorphics*; they are thought to be essentially Proterozoic in age, and may be highly metamorphosed equivalents of the Halls Creek Group. In the vicinity of Palm Creek they consist of calc-silicate skarn rocks, paragneiss, and minor amphibolite which form large rafts and lit-par-lit interbeds in later intrusive granite. The contact metamorphic assemblages are indicative of the pyroxene-hornfels facies.

The Bow River Granite is a coarse granite that ranges from even-grained to porphyritic. Fine-grained chilled margins occur at contacts with the Halls Creek Group and the McIntosh Gabbro. The composition ranges from granite through adamellite to granodiorite. All these rock types and textures grade into each other.

The *Sophie Downs Granite* intruded the Sophie Downs Dome during or after the folding of the Halls Creek Group. The main mass is a fine to coarse-grained granophyric granite containing rapakivi feldspars; but the northern margin is a microgranite with quartz and feldspar phenocrysts.

Dykes ranging in composition from dolerite to pegmatite are the youngest intrusives of the Lamboo Complex. Sills, dykes, and stocks of dacite, microgranite, and rhyolite intrude the Biscay Formation; some of the bodies mapped as sills may be extrusive and conformable with the sedimentary and volcanic units in the Formation.

Areas of igneous rocks containing almost equal amounts of gabbro and granite have been mapped as 'undifferentiated Lamboo Complex'.

Carpentarian (Table 2)

The Carpentarian rocks rest unconformably on the Halls Creek Group and the Lamboo Complex.

The oldest rocks of this succession are predominantly arenaceous sediments of the *Moola Bulla Formation.* The basal formation of the *Kimberley Group,*

TABLE 2. UPPER PROTEROZOIC STRATIGRAPHY

Period	Group	Formation and symbol	Thickness (feet)	Lithology	Relationships with underlying units	Remarks
ADELAIDEAN		Gardiner Beds (Pyd)	1000–5000	Blocky to coarse-grained quartz sandstone, rare fine to pebble conglomerate, ferruginous sandstone siltstone, shale and algal dolomite, minor chert.	Unconformable(?) under Albert Edward Group.	Probably equivalent to Kimberley Group. Named by Wells (1959). Dolomite has abundant stromatolites—*Conophyton* cf. *inclinatum*.
		Flat Rock Formation (Paf)	About 1000	Fissile purple shale, ferruginous dolomitic sandstone, quartz sandstone.	Conformable on Nyuless Sandstone.	Thickness incomplete
	ALBERT EDWARD GROUP	Nyuless Sandstone (Pay)	125	Flaggy to coarsely flaggy fine to medium-grained quartz sandstone, green fine-grained feldspathic Sandstone and minor black and white pebble conglomerate at base.	Conformable on Timperley shale.	
		Timperley Shale (Paj)	4150	Massive grey and green shale, minor siltstone; fine-grained sandstone and dolomite near top and bottom.	Conformable on the Boonall Dolomite.	
		Boonall Dolomite (Pab)	100	Coarsely flaggy yellow and light grey dolomite, minor dolomite-breccia, maroon shale, siltstone.	Conformable on Elvire Formation.	Some stromatolites.
		Elvire Formation (Pae)	200	Maroon shale with green siltstone, minor sandstone.	Conformable on Forster Sandstone.	Rhythmic alternations of shale and siltstone.
		Mount Forster Sandstone (Pao)	320	Fine to coarse-grained quartz sandstone, fine conglomerate with black and brown quartz fragments, minor shale and siltstone. Cross-bedding common.	Angular unconformity on Duerdin Group.	
	DUERDIN GROUP	Ranford Formation (Pos)	500+	Khaki-green, brown, and grey thin bedded fine-grained sandstone and siltstone, minor shale. Prominent dolomitic sandstone at base.	Conformable on Moonlight Valley Tillite.	More sandstone occurs in south of Sheet area.
			0–600	Blocky thick laminated dolomitic feldspathic sandstone. Small chert and feldspar fragments scattered throughout.	Conformable on Moonlight Valley Tillite.	Top part of the sandstone may be silicified marker dolomite overlying tillite in same stratigraphic position as Jarrad Sandstone Member in Dixon Range Sheet area.
		Moonlight Valley Tillite (Pom)	0–450	Tillite, overlain by marker beds of laminated and thin-bedded pink and cream dolomite. In south of map area intercalated sandstone lens (*see* member above).		Dolomite marker disappears to south.
		Wade Creek Sandstone (Psn)	500+	White medium-grained pure quartz sandstone, massive or flaggy; vague cross-bedding.	Angular unconformity with Bungle Bungle Dolomite.	

Period	*Group*	*Formation and symbol*	*Thickness (feet)*	*Lithology*	*Relationships with underlying units*	*Remarks*
ADELAIDEAN OR CARPENTARIAN		Bungle Bungle Dolomite (Psb)	900+	Massive to thin-bedded and laminated dolomite and dolomitic-shale. Minor limestone, shale, chert.	Apparently conformable on Mount Parker Sandstone.	Many stromatolites.
		Mount Parker Sandstone (Psp)	550	Moderately indurated blocky to flaggy pure quartz sandstone; lenses of quartz pebble conglomerate near base. Foreset bedding common, many ripple marks.	Very strong unconformity on Kimberley.	
CARPENTARIAN	KIMBERLEY GROUP	Carson Volcanics (Pkc)	Unknown	Bedded coarse volcanic agglomerate: scoriaceous basalt and sandstone in green basaltic matrix. Epidotized vesicular basalt; minor bedded basic crystal tuff. Thin-bedded laminated siltstone intercalated at base.	Conformable on King Leopold Sandstone.	Coarse volcanic agglomerate occurs near Moola Bulla Homestead.
		King Leopold Sandstone (Pkl)	Unknown	Blocky thick-laminated quartz sandstone, minor feldspathic sandstone and ferruginous sandstone; grit with red jasper fragments at top.	Unconformable on Moola Bulla Formation.	

the *King Leopold Sandstone,* rests unconformably on the Moola Bulla Formation. This crops out in two tightly folded synclines; one west of Mount Barret, the other east of Halls Creek. In each case the Carson Volcanics form the core of the structure.

Adelaidean or Carpentarian

Adelaidean or Carpentarian sandstone, shale, and dolomite crop out along the western margin of the Albert Edward Range as far south as Beaudesert Bore and in an outlier north of Mount Kinahan.

The *Mount Parker Sandstone* rests on the Halls Creek Group with a strong angular unconformity. It is conformably overlain by the *Bungle Bungle Dolomite,* partly an algal dolomite, which is eroded and overlain by both the Wade Creek Sandstone and by the glacial sediments of the Adelaidean. Consequently the Mount Parker Sandstone forms small lenticular remnants along the Albert Edward Range.

Adelaidean (Table 2)

Adelaidean sediments crop out along the eastern margin of the Albert Edward Range as far south as Beaudesert Bore, and in an outlier north of Mount Kinahan.

The Basal Formation is the *Wade Creek Sandstone,* which rests unconformably on the Mount Parker Sandstone and the Bungle Bungle Dolomite. The Wade Creek Sandstone is truncated by Adelaidean glacial sediments, and only remnants of the formation occur in the Duerdin Anticline.

The rest of the Adelaidean succession has been subdivided into two groups: the *Duerdin Group* (fine-grained marine sediments with tillite at the base), and the *Albert Edward Group* (marine sandstone, shale, and dolomite), which unconformably overlies the Duerdin Group.

The *Moonlight Valley Tillite* is preserved as small remnants along the Albert Edward Range. A thin dolomite caps it to the north, but to the south this marker grades into dolomitic sandstone, which overlies the tillite in the Duerdin Anticline and is probably partly glacial, because pebble erratics are distributed throughout the unit. The marine *Ranford Formation* overlies the glacials conformably and is characterized by khaki-green fine-grained sandstone and siltstone.

In the Albert Edward Group, the *Mount Forster Sandstone,* the *Elvire Formation,* and the *Boonall Dolomite* have the widest distribution and show little variation in either thickness or lithology. The upper part of the Mount Forster Sandstone is variable in the south, where it contains some siltstone, shale, and fine conglomerate; in the north it is almost entirely a medium-grained quartz sandstone. The boundary between the Elvire Formation and the Boonall Dolomite is more gradational in the north. The *Timperley Shale* constitutes over half the total observed thickness of the Albert Edward Group. It occurs only in the north and centre of the belt, and is generally poorly exposed. The *Nyuless Sandstone* and the *Flat Rock Formation,* generally obscured by the unconformably overlying Lower Cambrian Antrim Plateau Volcanics, are only found west and south of Flora Valley Homestead.

Gardiner Beds

Following Wells' (1955) nomenclature on the Billiluna 1:250,000 Sheet area, sandstone, pebble conglomerate, siltstone, shale, and algal dolomite cropping out in the south and east of the Sheet area have been named the Gardiner Beds. Because of the poor outcrop, detailed rock relationships are not known, and the rocks are probably equivalent to several of the rock units mapped to the west. Thus, the basal sandstone and conglomerate may be correlated with the Kimberley Group, and the algal dolomite, at the base of which is an unconformity, may be equivalent to the Bungle Bungle Dolomite or the dolomite marker bed in the Duerdin Group.

Palaeozoic (Table 3)

Volcanics and sedimentary rocks of Palaeozoic age crop out in the north and east. They form the southern margin of the Hardman Basin.

Cambrian: Very extensive tholeiitic basalts, the *Antrim Plateau Volcanics,* unconformably overlie the Albert Edward Group, and are overlain, possibly unconformably, by the *Headleys Limestone.* The basalts are considered to be Lower Cambrian. Several flows can be recognized in the basalts, exposed over large distances; some are up to 200 feet thick and in some the amygdaloidal top constitutes up to half the thicknesss of the flow. In the eastern part of the area algal chert is interbedded with the basalt: it contains *Conophyton* sp., *?Collenia* sp. aff. *symmetrica* Fenton & Fenton, and *Newlandia* sp.

Headleys Limestone crops out in the central northern portion of the Sheet area as small outliers in Antrim Plateau Volcanics. No fossils have been recorded in this limestone, but it is conformably overlain by Middle Cambrian sediments to the north, and is probably basal Middle Cambrian. *Devonian* (?): A small outcrop of quartz sandstone, tentatively assigned to the *Elder Sandstone,* unconformably overlies Headleys Limestone at the headwaters of Addie Creek east-north-east of Flora Valley Homestead.

Cainozoic (Table 3)

Tertiary: Probable Tertiary rocks in the area have been subdivided into three units: the Lawford Beds; scattered deposits of gravel, sandstone and siltstone; and laterite.

Unfossiliferous chalcedonic limestone on the Billiluna Sheet area was called *Lawford Beds* by Wells (1959). We have extended the name to include similar limestone on the Gordon Downs Sheet area, since it is probable that the unit represents a formerly continuous deposit of freshwater limestone.

Gravel, Sandstone, siltstone, and shale form poor outcrops in the Wolf Creek area, south west of Halls Creek, and siltstone and shale also occur under the lateritic cap at the headwaters of the Fox River and Duerdin Creek. These rocks may be of different ages, since those in the Wolf Creek area are consolidated and may post-date lateritization.

Laterite forms low mesas and plateaux, which are remnants of a lateritized surface of probable Tertiary age.

TABLE 3. PHANEROZOIC STRATIGRAPHY

Period	*Formation and Symbol*	*Thickness (Feet)*	*Lithology*	*Relationships with underlying units*	*Remarks*
QUATERNARY	Qa		Alluvium.		Areas adjacent to major rivers.
TERTIARY	Czt		Travertine.		Drainage channels over basalt.
	Czs		Sand, soil.		
	Czb		Black clay soil (with gilgais).		
	Czl		Ferruginous pisolitic soil.		
	Lawford Beds (Tl)	50?	Chalcedonic limestone, chert, siltstone.	Unconformable on Antrim Plateau Volcanics and Albert Edward Group.	Unfossiliferous, but probably correlative of White Mountain Formation (Traves, 1955).
	Tp		Laterite.		
	Tf	50	Gravel, sandstone, siltstone.		
DEVONIAN	Elder Sandstone (Db)	50	Friable medium-grained white quartz sandstone. Lenses of quartz cobble conglomerate at base. Cross-bedded.	Erosional unconformity at base.	One small outcrop, 23 mi. east of Flora Valley homestead.
MIDDLE CAMBRIAN	Headleys Limestone (Cmy)	60	Massive grey limestone, with chert nodules, overlain by laminated and thin-bedded grey limestone.	Slight angular unconformity on Antrim Plateau Volcanics.	Unfossiliferous, contains nodules and disseminations of chalcocite at top.
LOWER CAMBRIAN	Antrim Plateau Volcanics (Cla)	1550	Commonly amygdaloidal tholeitic basalt lava. Rare andesite lava and basalt agglomerate, minor tuff and chert, Basal cobble and boulder conglomerate.	Marked angular unconformity on Adelaidean.	Amygdales and geodes of amethyst-quartz and chalcedony, small; lenses of native copper and malachite. Stromatolites in chert bands.

Units assignable only to the Cainozoic Era include (a) sand and soil covering the Canning Plains and Ord Plains; (b) black clay soil, with gilgais, overlying volcanics throughout the Sheet area; and (c) lateritic soils derived from laterite mesas and plateaux.

Quaternary: Alluvium is confined to stream channels and areas adjacent to Major rivers.

STRUCTURE

The major structural feature of the East Kimberleys is the *Halls Creek Mobile Zone,* a belt of intensely deformed metamorphic and igneous rocks which occupies the western half of the Gordon Downs Sheet area. To the east of the Mobile Zone is a tectonically stable region called the *Sturt Block,* in which the Proterozoic rocks are not greatly deformed and have reacted to stress by faulting and broad folding. A structural sketch map of the area is shown in Figure 2.

Folding: East of the Halls Creek Fault, the Halls Creek Group has been tightly folded into the Biscay Anticlinorium, which trends north-north-east. Two domes, the *Saunders Creek Dome* and the *Sophie Downs Dome,* form the nuclei of this structure. Measurements on minor folds and bedding-cleavage intersections indicate that the anticlinorium pitches 30° to 50° south-south-west to south-west throughout most of the Sheet area; but in the north, around *Saunders Creek,* there is a major change in pitch to 60° to the north-north-east. To the west the anticlinorium is cut off by the Halls Creek Fault. In the south of the sheet, east of the Halls Creek Fault, another large dome is outlined by a folded dolerite sill; this may be the western part of the Biscay Anticlinorium. Two narrow anticlines exposing the Biscay Formation occur to the north of this structure.

Tightly folded Biscay Formation also crops out marginally to the Lamboo Complex in the Halls Creek Mobile Zone. The structure defined by the rocks is an anticline with numerous small drag folds; a north-trending major fault parallel to the Great Northern Highway has downthrown the eastern block of the anticline against the Halls Creek Fault.

The Olympio Formation generally occupies broad synclines; although the overall structures are synclinal, numerous drag folds and minor anticlines are present and beds are locally overturned. Shales within the formation are folded very tightly, whereas the more competent greywackes form broad folds.

Folding in the more competent Carpentarian rocks is less complex than in the Halls Creek Group. The Moola Bulla Formation forms a syncline plunging steeply north, and the Kimberley Group has been folded into a gentle syncline near Mount Barret and a tight syncline bounded by faultless east of Halls Creek.

Folding in the Adelaidean sediments along the Albert Edward Range is gentle and bedding dips generally become shallower (40° to 10°) away from the unconformity on the Archean or early Proterozoic basement. However, in a series of north-north-easterly domes and anticlines north of 'Flora Valley'

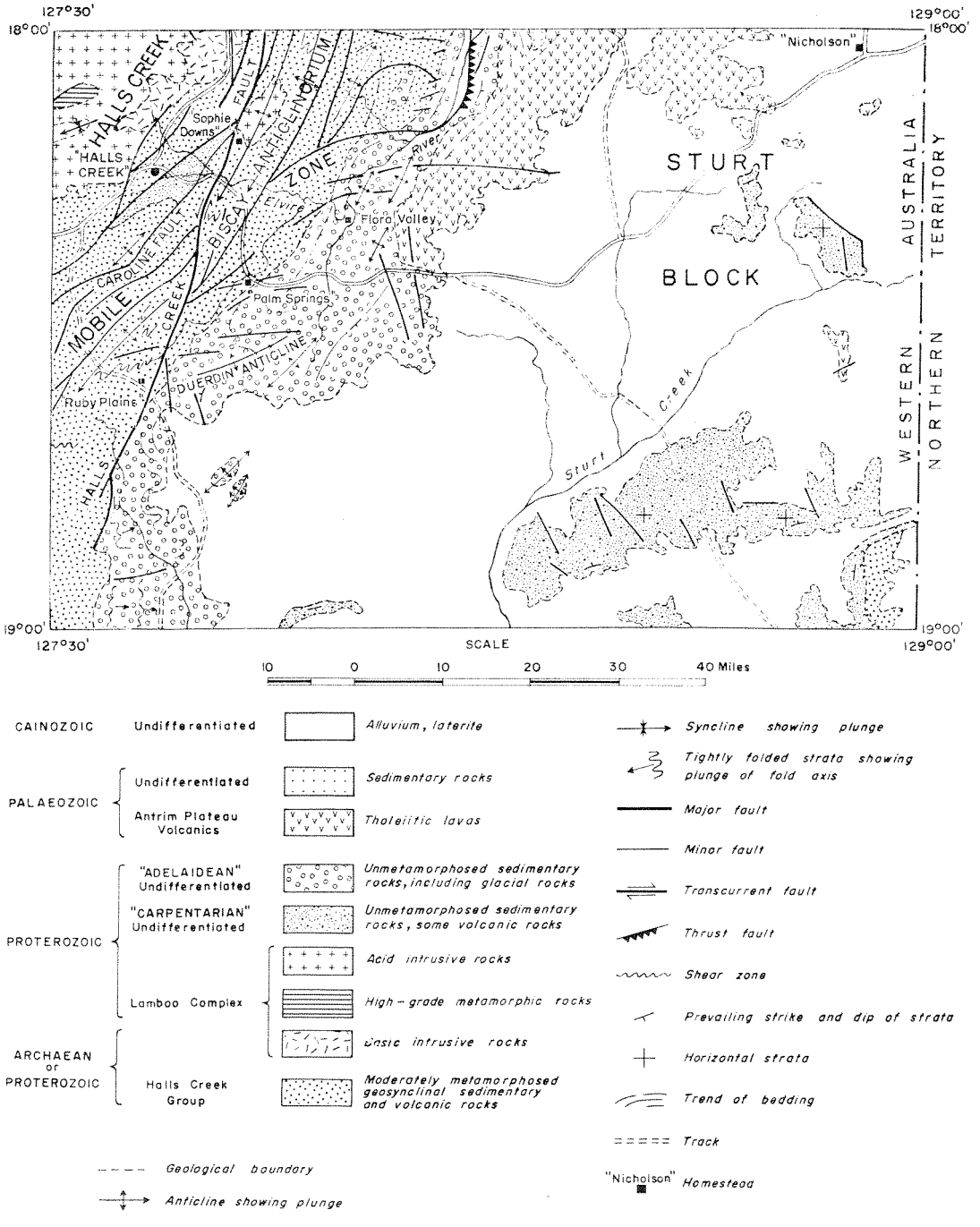

Fig. 2. Structural sketch map

along the Duerdin Creek, and east of the Douri Dam, the bedding is steep. These structures are all flanked by shallow synclines, and the domes may represent small drag folds caused by splay faults.

Strong concertina folding is present east and south-east of Beaudesert Bore; the axes of these folds are approximately at right angles to the regional strike. There is an indication that the fold processes that began early in the Proterozoic extended into the Adelaidean. In the *Duerdin Anticline* the following events can be deduced:

(i) The core of the structure contains rocks of the Halls Creek Group; these were deposited and folded into an anticline and then eroded.

(ii) Carpentarian sediments were deposited on this eroded surface and subsequently folded along the same axis and then eroded.

(iii) Adelaidean glacial sediments of the Duerdin Group were deposited on this surface and again folded along the same axis.

The Palaeozoic rocks of the Sheet area lie in the *Hardman Basin.* They have a gentle regional dip to the north-west and are gently folded or subhorizontal. To the west of Flora Valley Homestead, dips in the Antrim Plateau Volcanics lessen from 15° on the margins of the Hardman Basin, to subhorizontal towards the centre.

The Tertiary laterite surface appears to be folded into very broad synclines and anticlines.

Faulting: The major fault is the Halls Creek Fault, which strikes north-north-east through Old Halls Creek and extends at least as far as Wyndham, a distance of 250 miles.

The fault has a shear-zone up to one-quarter of a mile wide, which dips steeply either to the east or west. The fault has a large vertical component, with downthrow to the east and a large horizontal component; it appears to have displaced the Biscay Formation horizontally at least 16 miles, west block south. The fault affects both the Halls Creek Group and the Carpentarian and Adelaidean rocks; it is not cut by other faults. Minor faults in the basement reflect the movement pattern of the Halls Creek Fault. On its western side, faults with large vertical components strike north-east. The *Caroline Fault* has thrown Proterozoic sediments against the basement. On the eastern side of the Halls Creek Fault, a long fault defines the eastern margin of the Biscay anticlinorium. Between the Sophie Downs and Saunders Creek Domes a number of small normal faults trend east-west.

The faulting pattern of Carpentarian and Adelaidean sediments is generally unrelated to that in the basement. Long splay faults run east-west and have large vertical and probably small horizontal displacements. North-south strike faults, which are generally hinge-faults and minor low-angle thrusts, are common in the northern part of the Albert Edward Range. Most strike faults pass into splay faults along strike. Many Carpentarian faults ceased movement in the Adelaidean and are covered by Adelaidean sediments.

In the Beaudesert Bore area, small tension faults parallel the axes of concertina folds.

The Palaeozoic sediments show little evidence of faulting, but one of the large splay faults which affect the Adelaidean continues into the Antrim Plateau Volcanics. A graben is developed along this fault, where a block of Headleys Limestone and Elder Sandstone is downthrown against the volcanics.

No faults affect the post-Palaeozoic rocks in the Sheet area.

ECONOMIC GEOLOGY

Many small deposits of various minerals are known; they are well documented by Harms (1959). Some exploration and development has been done by companies and private individuals, but it has been spasmodic and on a small scale.

Most of the region, particularly those areas covered by rocks of the Halls Creek Group, forms a promising metalliferous province, and undoubtedly warrants large-scale exploration.

Copper

Small showings of copper minerals have been found throughout the area in rocks of many ages, but the only known prospects of economic interest occur in the Biscay Formation.

Amygdales of quartz and calcite containing native copper occur two miles south-south-west of Bulman Waterhole in a highly epidotized basalt of the Ding Dong Downs Volcanics. The mineralization is near the contact with the Saunders Creek Formation, and also contains scattered crystals of pyrite and altered magnetite crystals which are surrounded by a halo of malachite staining. The known mineralized area is small, about 200 feet by 10 feet, and the deposit has no commercial significance. However, thin persistent veins of quartz containing native copper, up to 1 inch wide, are known in the basalt in the same locality, and the Ding Dong Downs Volcanics warrants further prospecting.

Limonitic gossans containing secondary copper, lead, and zinc minerals were discovered in the Biscay Formation north of the Sophie Downs Granite during the regional mapping in 1962, and were further investigated in 1963. Two of the gossans are of sufficient size to warrant testing by diamond drilling. The mineralization was reported by Gemuts (1963). The two deposits are on the north-western limb of the Sophie Downs Dome, the core of which is occupied by the intrusive Sophie Downs Granite. They occur near the top of the Biscay Formation in dolomite and dolomitic shale which has been isoclinically folded along axes plunging about 25° to the north. Both limbs of the folds dip steeply to the west. The area is faulted, and the prospects appear to be localized along shear-zones trending at a slight angle to the regional strike of the beds.

Malachite stains have been observed in basic rocks of the Biscay Formation near Bulman Waterhole and north of the Faugh and Ballagh Gold Mine, but neither occurrence has been investigated.

Minor occurrences of malachite occur on joints and in vesicles in basalt lava flows of the Antrim Plateau Volcanics. Irregular blobs of covellite surrounded by malachite occur sparsely in the Headleys Limestone, but the mineralization appears to be of too low a grade to be of economic significance.

Gold

Gold was discovered in the Kimberley Region in 1884 by Hardman (1885), during a reconnaissance geological survey of the area. He reported promising alluvial prospects over a large area of metamorphic rocks in the Gordon Downs Sheet area and, in the ensuing rush, large quantities of gold were quickly won. However, the auriferous gravels, though mostly rich, were thin and of small extent, and the field was rapidly worked out. By 1890, when Woodward (1891) visited the field, very few alluvial miners were still working. At the time of writing (1966) the only alluvial mining is done by aboriginals who pan gravels during the wet season for small returns. Most of the alluvial gold had been traced to its source and, by the time of Woodward's visit, all the reefs known today had been discovered, partly developed, and abandoned. Almost all the lode mines are located either in the Halls Creek/Ruby Creek area or in the Mary River Goldfield; these were mapped by Finucane, and his reports of 1938 provide a valuable reference. The small size of the reefs, remoteness of the area, lack of water and fuel, and in some cases the mineralogy of the ores, all contributed to the failure of the mines. Since Woodward's time, spasmodic attempts have been made to re-open the larger mines, but most appear to have been unprofitable and in 1966 there was no lode mining in the area.

The gold in the Halls Creek/Ruby Creek area is found in small, generally concordant quartz reefs, either in basic rocks of the Biscay Formation, or in basal greywacke and slate of the Olympio Formation. Most of the reefs have been worked only in the oxidized zone, and the gold occurs free, generally in a very finely divided state, though specimen stone containing coarse gold was not rare. In the unoxidized zone, the quartz reefs contain small amounts of pyrite, chalcopyrite, and galena. The reefs are rarely more than 700 feet in length or wider than 5 feet, and as their average grade is low (between 1 and 3 dwt gold per ton), work has been confined to selective mining of rich shoots.

The most important mines of the area were: Ruby Queen (recorded production 7947 ounces fine gold), Saint Lawrence (1533 ounces), Mount Bradley and Brockman (1563 ounces), and Golden Crown (1281 ounces). The only other lode mines worthy of note are the Duffers Mine, which is in a small quartz reef in the Biscay Formation north of the Sophie Downs Granite, worked recently, and the Reform Mine in the head of the Mary River, which in 1894 produced 210 ounces of fine gold from a small quartz reef in the Biscay Formation.

Uranium: Uranium was discovered at Bulman Waterhole in the Saunders Creek area in 1955. Two exploratory drill holes were sited by the Bureau of Mineral Resources and one was drilled about 1¼ miles south-south-west of Bulman Waterhole (Mercer, 1961). The radioactive mineral is thorogummite

associated with heavy minerals in conglomerate bands. No subsequent work has been carried out and the occurrence is not considered economic.

Water

Although the Gordon Downs Sheet area has an annual rainfall of 13 to 19 inches, most of this rain falls during the wet season from November to March. The rest of the year is hot and dry, resulting in an evaporation rate of 100 to 110 inches a year, and surface waters, unless fed by groundwater, are not permanent. Because most of the springs occur in the more rugged parts of the area where cattle grazing is impracticable, the local cattle industry relies heavily on subsurface water supplies. The hydrogeology of the region has been described by Morgan (1963).

Surface water: The Halls Creek Group has a close-textured dendritic drainage and there are few permanent water holes, even in the larger streams. The streams draining the igneous intrusive rocks are wider-spaced and larger, and contain sand and gravel in their beds in which underflow water can commonly be found at a depth of a few feet. Permanent waterholes are not present.

Permanent spring-fed rockholes are common in gorges in Proterozoic rocks of the Albert Edward Range, but permanent surface water is rare in any of the streams crossing the alluvial plains that overlie Adelaidean shales. Spring-fed streams cutting the Antrim Plateau Volcanics flow for most of the year and in some years may flow all the year along part of their courses.

The Canning Plain is drained by slow-moving mature rivers, which have large pools of water during the wet season, a few of which last even through severe dry seasons.

Underground Water: Positions of bores and wells on the Gordon Downs Sheet area are shown on Figure 3 and the groundwater bore records are shown in the Appendix.

Rocks of the Halls Creek Group are well consolidated and have low permeability. Secondary permeability may have been induced by fracturing and faulting, but the rocks have not been adequately tested. Shallow wells near the gold mines in these rocks have yielded water, but supplies are generally small.

The rocks of the Lamboo Complex are generally impervious, but contain adequate supplies of underground water where they are highly jointed or deeply weathered. Salinity of the water from both the Halls Creek Group and the Lamboo Complex is generally less than 700 parts per million.

Carpentarian and Adelaidean sandstones are potential aquifers, but most have not been tested, mainly because they form rugged topography unsuited for cattle grazing, and also because they have permanent waterholes. Several bores have been sunk in the Gardiner Beds, and have yielded good supplies of water. The dolomites are crystalline and are normally not permeable, but in some localities springs issue from highly fractured dolomite and it is evident that such highly fractured portions of the dolomite beds can act as reservoirs. The Adelaidean shales provide the best pastures, but 18 unsuccessful test holes have been sunk in them and they appear to have little or no potential as a source of groundwater.

Springs are common along watercourses in the Antrim Plateau Volcanics and, as they have well-developed open joints, these rocks have considerable potential as aquifers.

Younger rocks such as the deep soils, laterite, and alluvium yield good supplies of shallow water in many areas, but supplies are seldom predictable on geological grounds.

REFERENCES

EDWARDS, A. B., and CLARKE, E. DE C., 1940—Some Cambrian basalts from the East Kimberley, Western Australia. *J. Roy. Soc. W. Aust.*, 26, 77.

FINUCANE, K. J., 1938 a—The Halls Creek-Ruby Creek area, East Kimberley District. *Aer. Surv. N. Aust., W. Aust. Rep.* 27.

FINUCANE, K. J., 1938 b—The Mary River gold mining centre, East Kimberley District. *Ibid.*, 41.

FINUCANE, K. J., 1938 c—The Twelve-Mile alluvial workings and Elvire River dredging reserves (893H and 948H) Halls Creek, East Kimberley District. *Ibid.*, 42.

GEMUTS, I., 1963—Preliminary report on copper mineralisation in the Duffers Limestone, near Halls Creek, Kimberley Goldfield. *Geol. Surv. W. Aust. Rec.* 1963/28 (unpubl.).

HARDMAN, E. T. 1883—Preliminary report on the geology of part of the Kimberley District. *W. Aust. parl. Pap.* 23.

HARDMAN, E. T. 1884—Report on the geology of the Kimberley District, W.A. *Ibid.*, 31.

HARDMAN, E. T., 1885—Report on the geology of the Kimberley District, W.A. *Ibid.*, 34.

HARMS, J. E. 1959—The geology of the Kimberley Division, Western Australia, and of an adjacent area of the Northern Territory. *M.Sc. Thesis, Adelaide University* (unpubl.).

MERCER, C. R., 1961—Results of drilling at Saunders Creek, near Halls Creek, Western Australia. *Bur. Miner. Resour. Aust. Rec.* (1961/39 (unpubl.).

MORGAN, K. H., 1963—Hydrogeology of the Gordon Downs 1 : 250,000 Sheet, Kimberley Division, Western Australia. *Geol. Surv. W. Aust. Rec.* 1963/12 (unpubl.).

RUKER, R. A. 1961—The Saunders Creek radioactive prospect, Halls Creek District. *Bur. Miner. Resour. Aust. Rec.* 1961/103 (unpubl.).

SMITH, R. N., 1898—The State of mining in the Kimberley District. *Geol. Surv. W. Aust. Bull.* 1, 7.

TEAKLE, L. J. H., 1944—The Kimberley project. *J. Agric. W. Aust.*, 27. 28.

TRAVES, D. M. 1955—The geology of the Ord-Victoria region, Northern Australia. *Bur. Miner. Resour. Aust. Bull.* 27.

WADE, A., 1924—Petroleum prospects, Kimberley District of Western Australia and Northern Territory. *Cwlth Aust. parl. Pap.* 142.

WELLS, A. T. 1959—Billiluna, W.A., 4-mile Geological Series, Sheet E/52-14. *Bur. Miner. Resour. Aust. Explan. Notes* 24.

WOODWARD, H. P., 1891—Report on goldfields of the Kimberley District. *W. Aust. parl. Pap.* 18.

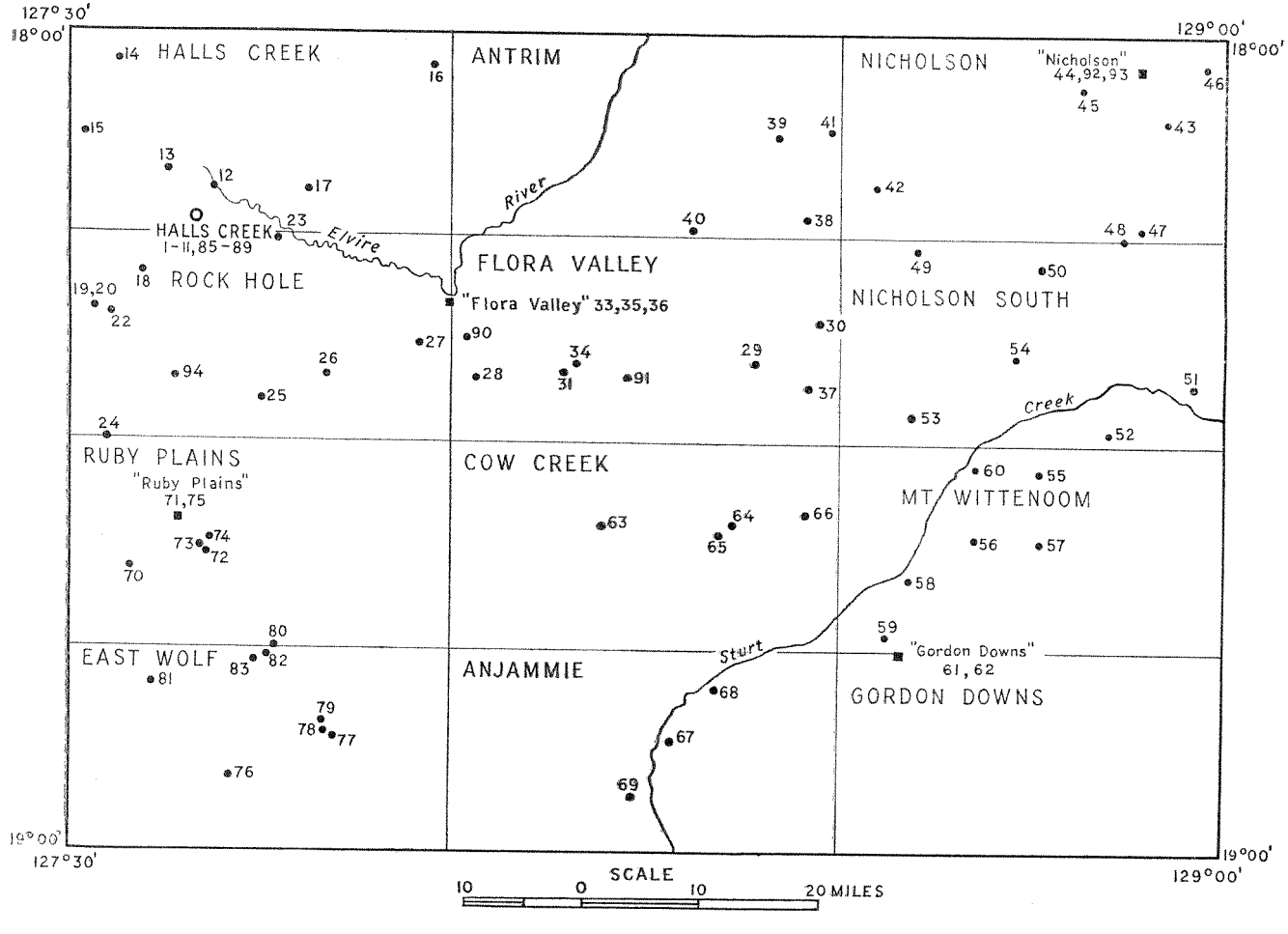

Fig. 3. Positions of bores and wells, Gordon Downs

APPENDIX

GROUNDWATER—BORE RECORDS

Serial number	*Name*	*Type**	*Depth (feet)*	*Supply (gph)*	*Aquifer*	*Salinity p.p.m.*	*Locality*
HALLS CREEK 1-MILE SHEET							
1	—	b, abd	96	450	Alluvium	?	Township, Valda Avenue
2	—	b, abd	80	nil	Laterite profile	—	DCA
3	Post Office	b, np	130	?	,, ,,	?	Post Office
4	Council reserve	b, np	135	150	,, ,,	600	Townsite
5	—	b, abd	?	nil	Weathered Halls Creek Group	—	Pensioners reserve
6	Pensioners	b, np	60	700	Alluvium	good	Pensioners reserve
7	Garden	b, np	100	1,300	,,	good	Township
8	Race-course	b, np	148	1,000	,,	good	Township
9	—	—	?	400	,,	good	Township No. 3
10	—	w	451	500	,,	480	Township No. 1
11	—	w	?	?	,,	good	Mission bore
12	Banjo's	b	?	good	,,	350	Moola Bulla Station
13	Shephards	w, np	?	poor	,,	210	,, ,, ,,
14	Douglas	w, np	?	poor	Weathered Lamboo Complex	280	,, ,, ,,
15	5 mile	w, np	?	?	Alluvium	280	,, ,, ,,
16	Ding Dong Downs	w	—	—	—	—	Ding Dong Downs Station
17	—	—	—	—	—	—	Sophie Downs Station
85	—	b, abd	140	—	—	—	Township
86	Drovers Camp	b	186	300	Halls Creek Group	600	Township
87	No. 2	b	145	950	Halls Creek Group	—	—
88	—	—, abd	?	—	—	—	Hotel
89	—	b	?	—	—	—	Township
ROCK HOLE 1-MILE SHEET							
18	Fly Well	w, np	30 approx	—	Laterite over Lamboo Complex	—	Koongie Park Station
19	—	b	—	—	Lamboo Complex	—	,, ,, ,,
20	—	b, abd	120	—	,, ,,	—	,, ,, ,,
21	—	b	?	poor	Weathered Lamboo Complex	good	,, ,, ,,
22	—	w	30 approx	?	,, ,,	350	,, ,, ,, (Old Rockhole homestead)
23	—	w	40 approx	?	Halls Creek Group	?	Old Halls Creek Town well
24	—	w	40 approx	?	,, ,, ,, ,,	?	Mullens homestead
25	—	w	?	?	,, ,, ,,	?	Ruby Queen Mine Shaft
26	—	w	10	good	Bungle Bungle Dolomite	good	Palm Springs
27	—	b	50	poor	Timperley Shale	good	Elvire Station homestead
94	—	w	20	?	Halls Creek Group	good	North-east Mullens homestead
FLORA VALLEY 1-MILE SHEET							
28	Black Bank	b	156	580	Alluvium over Timperley Shale	good	Flora Valley Station
29	Woongoverri	b	395	600	Alluvium?	good	,, ,, ,,
30	Eurootoo (No. 3)	b	157	2,800	Alluvium	490	,, ,, ,,
31	FV4	b, abd	635	small	Flat Rock Formation	?	,, ,, ,,
32	—	w, np	?	?	Antrim Plateau Volcanics	good	,, ,, ,,
33	—	b, abd	80	—	Timperley Shale	—	,, ,, ,, (horse yard)
34	Government well	w, abd	15	reported fair	Antrim Plateau Volcanics	good	,, ,,
35	—	w, np	50	200	Timperley Shale	good	,, ,, (homestead)
36	FB.	b	71	400	,, ,,	good	—
37	—	w	?	?	Alluvium	—	Gordon Downs Station
90	FV24	b	?	?	Timperley Shale	—	Horn Valley Station
91	Mungo Tank Bore	b	?	?	Flat Rock Formation	—	,, ,, ,,

* b=bore; w=well; np=non pressure water; p=pressure water; abd=abandoned.

Serial number	*Name*	*Type**	*Depth (feet)*	*Supply (gph)*	*Aquifer*	*Salinity p.p.m.*	*Locality*
ANTRIM 1-MILE SHEET							
38	Poonka (No. 4) (No. 4)	b	500	500	Alluvium	brackish	Flora Valley Station
39	—	b	73	?	Antrim Plateau Volcanics	—	,, ,, ,,
40	—	b	?	?	,, ,, ,,	?	,, ,, ,,
41	—	b	102	?	,, ,, ,,	?	Turner River Station
NICHOLSON 1-MILE SHEET							
42	10 and 10a	b	162	1,280	Alluvium	good	Turner River Station
43	N5	b	194	poor	Upper Proterozoic Shale (or basalt?)	?	Nicholson Station
44	—	w	27	?	Alluvium	?	,, ,, (old homestead well)
45	23	b	145	1,600	,,	?	,, ,, ,,
46	Koolerong	b	90	1,500	Antrim Plateau Volcanics	—	,, ,, ,,
47	24	b	?	?	Gardiner Beds	10,360	,, ,, ,,
48	GD.5	b	644	small	Flat Rock Formation?	good	,, ,, ,,
92	—	w	42	?	—	?	
93	—	w	27	?	—	?	—
NICHOLSON SOUTH 1-MILE SHEET							
49	7	b	495	1,100	Antrim Plateau Volcanics	good	Nicholson Station
50	GC	b	82	1,600	Antrim Plateau Volcanics	good	Gordon Downs Station
51	Alice (No. 15)	b	84	2,000	—	?	,, ,, ,,
52	GA	b	86	1,300	Lateritic rocks	good	,, ,, ,,
53	6GD	b	490	?	—		,, ,, ,,
54	GD4	b	251	?	Antrim Plateau Volcanics	?	,, ,, ,,
MOUNT WITTENOOM 1-MILE SHEET							
55	Myardia 13	b	564	1,000	Antrim Plateau Volcanics?	?	Gordon Downs Station
56	14	b, p	350	1,200	,, ,, ,,	good	,, ,, ,,
57	GB	b	151	1,100	Weathered Antrim Plateau Volcanics	good	,, ,, ,,
58	Apsley 12	b	395	850	Alluvium	?	,, ,, ,,
59	—	w	?	?	,,	?	,, ,, ,,
60	—	b	?	?	Weathered basalt?	?	,, ,, ,,
GORDON DOWNS 1-MILE SHEET							
61	—	b	45	1,000	Gardiner Beds	good	Gordon Downs Station
62	—	w	18	good	,, ,,	good	,, ,, ,,
COW CREEK 1-MILE SHEET							
63	SC.1	d, abd	420	?	Flat Rock Formation	?	Sturt Creek
64	27	b, abd	855	?	,, ,, ,,	?	,, ,,
65	25	b, abd	500	?	,, ,, ,,	?	,, ,,
66	—	b, abd	?	?		?	,, ,,
ANJAMMIE 1-MILE SHEET							
67	26	b	213	1,400	Alluvium	?	Sturt Creek
68	SC.4	b, abd	60	—	Alluvium	?	,, ,,
69	5	b, abd	612	nil	Flat Rock Formation	?	,, ,,
RUBY PLAINS 1-MILE SHEET							
70	Illjarrah	w	95	750	Alluvium	good	Ruby Plains Station
71	—	b	100	?	Halls Creek Group	good	,, ,, ,,
72	7	b, abd	?	—	,, ,, ,,	good	,, ,, ,,
73	4A	b, abd	117	—	Duerdin Group	—	,, ,, ,,
74	4	b, abd	99	—	,, ,,	—	,, ,, ,,
75	—	b	117	400	Soils and weathered Halls Creek Group	good	,, ,, ,,

* b=bore; w=well; np=non pressure water; p=pressure water; abd=abandoned.

Serial number	*Name*	*Type**	*Depth (feet)*	*Supply (gph)*	*Aquifer*	*Salinity p.p.m.*	*Locality*
EAST WOLF CREEK 1-MILE SHEET							
76	Beaudesert	b and w	115	900	Alluvium	420	Ruby Plains Station
77	6	b, abd	140	—	Timperley Shale?	—	,, ,, ,,
78	8	b, abd	75	—	,, ,,	—	,, ,, ,,
79	9	b, abd	138	—	,, ,,	—	,, ,, ,,
80	—	b, abd	?	small	,, ,,	good	,, ,, ,,
81	2	b, abd	175	?	,, ,,	1,540	,, ,, ,,
82	Digimont	b, abd	95	?	,, ,,	saline	,, ,, ,,
83	5	b, abd	157	small	,, ,,	5,320	,, ,, ,,

* b=bore; w=well; np=non pressure water; p=pressure water; abd=abandoned.

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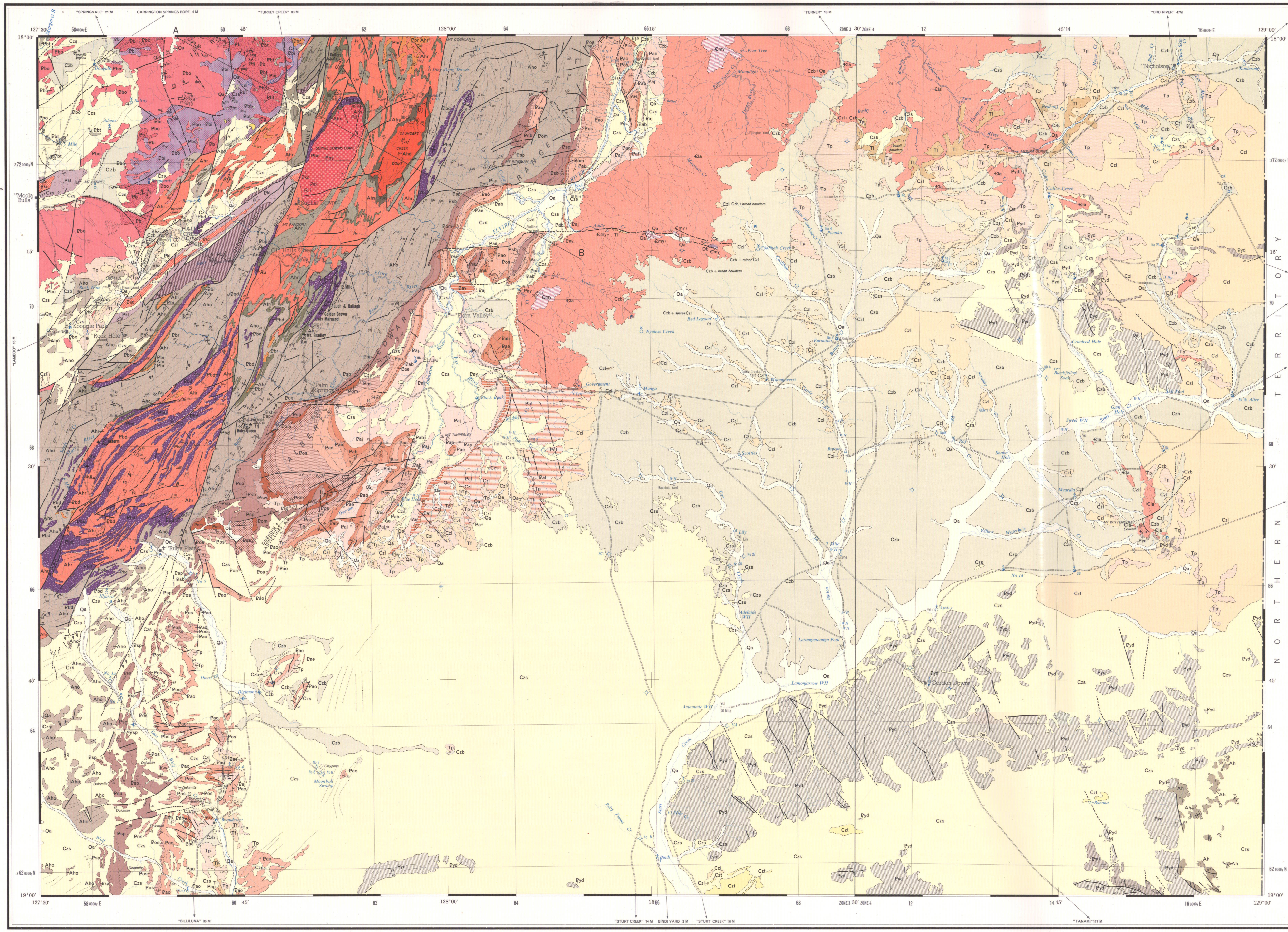
Reference

- Geological boundary
- Syncline
- Anticline, showing plunge
- Overturned anticline
- Plunge of dragfold
- Fault (q-indicates quartz filled)
- Low-angle thrust fault
- Shear-zone
- Where location of boundaries, faults and folds 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
- Vertical strata
- Horizontal strata
- Overturned strata
- Prevailing strike and dip of strata
- Dip <15°
- Trend of bedding or foliation, showing direction of dip (air-photo interpretation)
- Trend of concealed bedding (air-photo interpretation)
- Joint pattern (air-photo interpretation)
- Top of bed
- Strike and dip of foliation
- Vertical dip of foliation
- Strike and dip of joints
- Apparent dip of cleavage on bedding plane
- Direction of sedimentation
- Macrofossil locality
- Sample locality for age determination with reference number
- Dyke or vein; q-quartz, peg-pegmatite, rh-rhyolite, do-dolerite
- Mine, not being worked
- Unexploited uranium deposit
- Minor mineral deposit
- Au Gold
- Cu Copper
- Battery, not operating
- DD Diamond drill hole
- GD4 Water bore with reference number
- Abandoned bore
- Bore, salinity < 5000 p.p.m.
- Bore, salinity 5000-10000 p.p.m.
- Bore, salinity > 10000 p.p.m.
- Well
- Well, salinity < 5000 p.p.m.
- Well, salinity 5000-10000 p.p.m.
- Windpump
- Water tank
- Earth tank or dam
- Dam on stream
- Waterhole on stream
- Spring
- Swamp
- Highway
- Main road and road
- Vehicle track
- Airport
- Landing ground
- "Elvire" Homestead
- Hut
- Yard
- Fence
- Telephone line
- State boundary
- Trigonometrical station



Reference

Era	Period	Unit	Symbol	Description
CAINOZOIC	QUATERNARY		Qa	Alluvium
	UNDIFFERENTIATED		Czt	Travertine
			Czs	Sand, soil
			Czb	Black clay soil
			Czl	Ferruginous pisolitic soil
	TERTIARY	Lawford Beds	Tl	Chalcedonic limestone, chert, siltstone
			Tp	Laterite
			Tf	Gravel, sandstone and siltstone
PALAEOZOIC	DEVONIAN (?)	Elder Sandstone	Db	Friable, cross-bedded quartz sandstone; cobble conglomerate at base
	MIDDLE CAMBRIAN	Headleys Limestone	Ɛmy	Massive to laminated grey limestone with chert nodules
	LOWER CAMBRIAN	Antrim Plateau Volcanics	Ɛla	Amygdaloidal tholeiitic basalt and rare andesite; basalt agglomerate, tuff and chert
PROTEROZOIC — UNDIFF	UNDIFFERENTIATED	Gardiner Beds	Pyd	Blocky quartz sandstone and rare pebble conglomerate; ferruginous sandstone
				Siltstone, shale and algal dolomite
UPPER PROTEROZOIC	ADELAIDEAN	Albert Edward Group: Flat Rock Formation	Paf	Fissile purple shale, ferruginous dolomitic sandstone, quartz sandstone
		Nyuless Sandstone	Pay	Flaggy quartz sandstone, green feldspathic sandstone, minor pebble conglomerate
		Timperley Shale	Paj	Massive grey and green shale, minor siltstone and dolomite
		Boonall Dolomite	Pab	Flaggy yellow and light grey dolomite; minor dolomite breccia and shale
		Elvire Formation	Pae	Maroon shale with green siltstone, minor sandstone
		Mount Forster Sandstone	Pao	Quartz sandstone, fine quartz conglomerate, minor shale and siltstone
		Duerdin Group: Ranford Formation	Pos	Khaki-green, brown and grey thin-bedded fine sandstone and siltstone, minor shale
				Dolomitic feldspathic sandstone
		Moonlight Valley Tillite	Pom	Tillite, overlain by laminated pink dolomite
MIDDLE PROTEROZOIC		Wade Creek Sandstone	Psw	Quartz sandstone
	ADELAIDEAN OR CARPENTARIAN	Bungle Bungle Dolomite	Psb	Dolomite and dolomitic shale, minor quartz sandstone
		Mount Parker Sandstone	Psp	Blocky to flaggy pure quartz sandstone, quartz pebble conglomerate at base
	CARPENTARIAN	Kimberley Group: Carson Volcanics	Pkc	Volcanic agglomerate, epidotised vesicular basalt, basic crystal tuff
		King Leopold Sandstone	Pkl	Blocky quartz sandstone
		Moola Bulla Formation	Px	Shale, sandstone, feldspathic arkose, greywacke, conglomerate
LOWER PROTEROZOIC			Pbr	Rhyolite, dacite, microgranite
		Lamboo Complex: Undifferentiated	Pb	Intimate mixture of granite, gabbro and metamorphic rocks
		Sophie Downs Granite	Pbs	Coarse even-grained granite
		Bow River Granite	Pbo	Porphyritic to even-grained coarse-grained granite and granodiorite
		Tickalara Metamorphics	Pbt	Calc-silicates, paragneiss, amphibolite
		McIntosh Gabbro	Pbi	Uralitised gabbro, norite, troctolite, minor dolerite, syenite, pyroxenite
		Woodward Dolerite	Pbd	Dolerite and ultrabasic sills and dykes intruding Halls Creek Group
ARCHAEAN OR PROTEROZOIC — *ARCHAEAN OR LOWER PROTEROZOIC		Halls Creek Group: Undifferentiated	Ah	Schist, quartzite
		Olympio Formation	Aho	Sub-greywacke, feldspathic sub-greywacke, arkose, subordinate shale and siltstone
		Biscay Formation	Ahr	Pillow basalt, basalt, dolerite dykes, minor andesite, sub-greywacke and slate
				Limestone, dolomite, calc-silicates, carbonate-rich basic rocks
				Greywacke, slate, carbonaceous slate, minor chert
		Saunders Creek Formation	Ahs	Quartz sandstone, greywacke, fine conglomerate, slate
		Ding Dong Downs Volcanics	Ahd	Amygdaloidal epidotised basalt, crystal tuff, rhyolite, greywacke

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

Compiled and published by the Bureau of Mineral Resources, Geology and Geophysics, Department of National Development, in conjunction with the Geological Survey of Western Australia. Issued under the authority of the Hon. David Fairbairn, Minister for National Development. Base map compiled by the Mapping Branch, Department of Lands and Surveys, Perth, Western Australia. Aerial photography by the Royal Australian Air Force; complete vertical coverage at 1:50,000 scale.
Transverse Mercator Projection.

INDEX TO ADJOINING SHEETS
Showing Magnetic Declination

CHARNLEY SE 51-4	MOUNT ELIZABETH SE 52-1	LISSADELL SE 52-2	WATERLOO SE 52-3	VICTORIA RIVER DOWNS SE 52-4
LENNARD RIVER SE 51-8	LANSDOWNE SE 52-5	DIXON RANGE SE 52-6	LIMBUNYA SE 52-7	WAVE HILL SE 52-8
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ANNUAL CHANGE 30″E

Scale 1:250,000

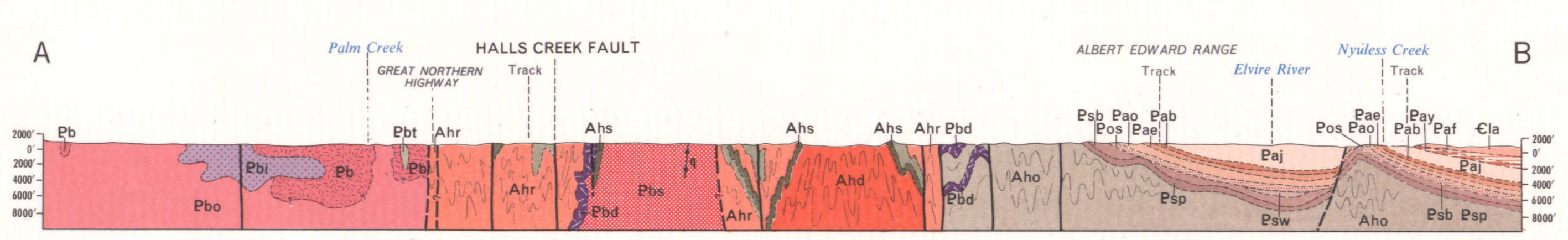
5 0 5 10 15 MILES

5 0 5 10 15 20 25 KILOMETRES

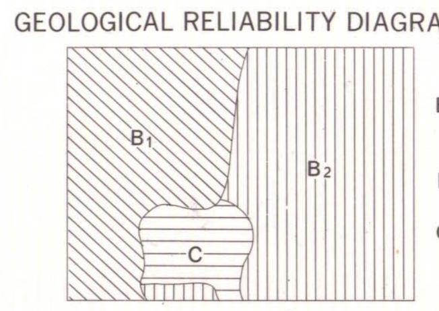
GREY NUMBERED LINES INDICATE THE 20,000 YARD TRANSVERSE MERCATOR GRID, ZONES 3 AND 4 (AUSTRALIA SERIES)

Section

Cainozoic sediments omitted from section
Attitude of faults not known
Folding schematic
Scale: $\frac{V}{H} = 1$



GEOLOGICAL RELIABILITY DIAGRAM



B1 Numerous traverses with photo-interpretation

B2 Some traverses with photo-interpretation

C Photo-interpretation only

Geology, 1962-64, by: J. W. Smith, H. L. Davies, D. B. Dow (B.M.R.)
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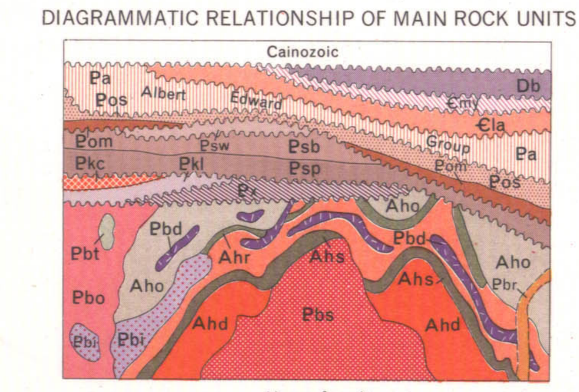
DIAGRAMMATIC RELATIONSHIP OF MAIN ROCK UNITS



GORDON DOWNS
SHEET SE 52-10

Copies of this map may be obtained from the Bureau of Mineral Resources, Geology and Geophysics, Canberra, A.C.T., or the Geological Survey of Western Australia, Perth