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The Geology of Auvergne 1:250,000 Sheet Area (Victoria River Basin) Northern Territory

(Excluding Bonaparte Gulf Basin)

I.R. Pontifex, C.M. Morgan, I.P. Sweet, A.G. Reid

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(VICTORIA RIVER BASIN) NORTHERN TERRITORY.

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SUMMARY

Most of the Auvergne 1:250,000 Sheet area covers part of the Victoria River Basin, a sedimentary basin which extends over about 40,000 square miles of the north-west corner of the Northern Territory.

This basin consists essentially of Proterozoic sediments. It is bounded on its north-west side by Palaeozoic sediments of the Bonaparte Gulf Basin, and surrounded, almost completely, on other sides by Antrim Plateau Volcanics, of probable Lower Cambrian age. Minor Archaean to Carpentarian basement rocks occur on the north and southwestern edges of the basin.

In 1967 a party from the Bureau of Mineral Resources mapped the geology of the Auvergne sheet, and adjacent areas. This was the beginning of a three-year project to map the entire basin.

Basement rocks of Archaean or Lower Proterozoic and Carpentarian age in the far south-west corner of the Auvergne Sheet area, are extensions of various units in the Halls Creek Mobile Zone. Sediments overlie basement rocks along the western margin of the mobile zone on the Port Keats 1:250,000 sheet area.

Two basically different successions of sedimentary rocks indicate two basically different regional environments of deposition, or geotectonic units, inherent to the Victoria River Basin. These are:

1. A stable shelf, or platform, of epicontinental type, called the Sturt Block, on which the basin sediments proper were deposited. Sediments which accumulated in this environment are found as a relatively undisturbed sequence of sandstones, siltstones, dolomites and minor glacial deposits.

2. A mobile zone, which runs along the north-west margin of the shelf area and contains a thick monotonous sequence of much faulted sandstone and siltstone.

The two units are separated by a major thrust fault.

The mobile zone contains four formations; the lower three comprise the Fitzmaurice Group, the upper is the Legune Formation.

The Fitzmaurice Group consists almost entirely of sandstone: massive, coarse, and commonly texturally immature; with subordinate conglomerate and pebble beds. Minor siltstones occur. The Legune Formation is mostly siltstone with interbedded quartz sandstone. The rocks in the mobile zone are probably greater than 12,000 feet thick. Rapid lateral facies changes and abundant faulting makes it difficult to determine the exact thickness.

A summary of the stratigraphy of the stable shelf is:

Duerdin Group	(youngest)	1000 + ft. thick
Bullo River Sandstone		1000 + ft. thick
Auvergne Group		about 3000 ft. thick
Bullita Group	(oldest)	2000 + ft. thick

The Bullita Group comprises dolomitic siltstone, dolomite, siltstone, sandstone and chert. The carbonate content increases in abundance and purity towards the top.

The Auvergne Group unconformably overlies the Bullita Group and forms almost two-thirds of the exposed Proterozoic rocks in the Sheet area. It is composed of seven conformable formations. The lower four consist mainly of quartz sandstone and siltstone, with minor dolomite and dolomitic siltstone. The upper three contain an abundance of dolomite, dolomitic siltstone and sandstone. Most of the formations are fairly consistent in their thickness and composition.

The rocks in both the above groups show abundant sedimentary features characteristic of shallow-water and sub-aerial conditions of deposition; they indicate a stable, mature environment.

The Duerdin Group unconformably overlies the Bullo River Sandstone and Auvergne Group and contains sandstone, siltstone and sediments of glacial and fluvioglacial origin.

The age of the Victoria River Basin sediments is not accurately known. Only the Duerdin Group can confidently be correlated with previously established stratigraphy - in the East Kimberley region - and this group is between 700 and 800 million years old (late Adelaidean).

The mobile zone sediments are possibly older than the sequence on the stable platform, although deposition could have taken place in both areas simultaneously.

Tentative correlations with units in the East Kimberley Region indicate that the mobile zone sediments are early or middle Adelaidean, and that the stable shelf sequence is probably middle to late Adelaidean in age.

No actual contact was found between rocks of the two tectonic units forming the basin. The contact is represented by the Victoria River Fault, the trace of which is mostly obscured on the ground.

With the exception of very small ochre production, no minerals have been mined from the Auvergne Sheet area and the mapping in 1967 found no further indications of potentially economic mineralization. Exploration for oil and coal is being carried out in the Bonaparte Gulf Basin. Oil seeps have been reported from Precambrian rocks in the area but, have not been substantiated. Most water used in the area is obtained from permanent waterholes and dams. Some groundwater is utilised, and the geological mapping can be used to find potential aquifers.

INTRODUCTION

This report describes the preliminary results of 1:250,000 scale mapping of the Precambrian geology mainly in the Auvergne Sheet area in the Victoria River Basin in the Northern Territory. (Fig. 1).

Mapping was carried out between May and October, 1967, by a party of the Bureau of Mineral Resources comprising four geologists: I.R. Pontifex (leader), C.M. Morgan, I.P. Sweet and A.G. Reid, and for a short time P.R. Dunn. They were supported by three field assistants, a mechanic, a cook and a camp manager. Planning of much of the field work was based on geological photo-interpretation by W.J. Perry.

The Precambrian geology of part of the Port Keats 1:250,000 Sheet area was also mapped, and reconnaissance traverses made in the Delamere, Fergusson River and Cape Scott Sheet areas. It is intended to complete the mapping of the Victoria River Basin in 1969.

Location and access

The Auvergne Sheet area lies between longitudes 129° and 130° 30'E, and latitudes 15°S and 16°S. It is bounded to the west by the N.T. - W.A. border, and to the north (in part) by Joseph Bonaparte Gulf (see Fig. 1).

The main Katherine-Wyndham road cuts across the area. It is a gravel road, frequently impassable when the Victoria River, and minor un-bridged streams flood during the summer "wet-season".

Access tracks within the area comprise those to Legune (from Kununurra, W.A.), and Bullo River Stations, minor tracks along the Keep River in the southwest, and through Bradshaw and the Koolendong Valley to the Fitzmaurice River in the northeast. Off the tracks it is generally only possible for vehicles to traverse valleys. Access to the north and central western portions of the Auvergne Sheet, was obtained by helicopter.

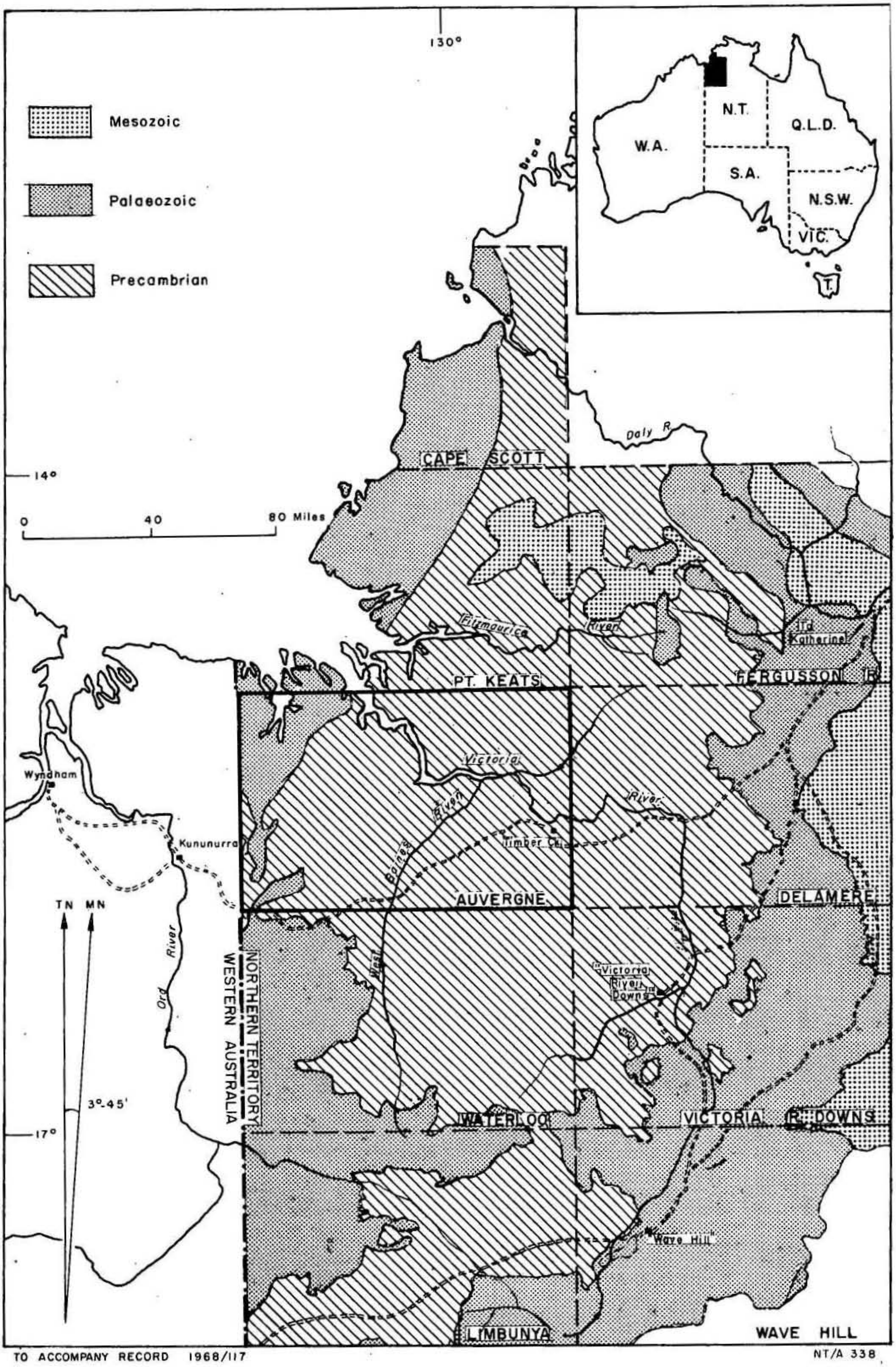


FIG. 1 VICTORIA RIVER BASIN, LOCALITY and GENERALIZED GEOLOGY

During the dry season, the Victoria River is tidal up to 100 miles from its mouth; Timber Creek, near the upper tidal limit, has a tidal range of up to 7 feet. The river is navigable, by craft with a draft of less than about 5 feet, as far upstream as Timber Creek. Strong tidal currents, (up to 7 knots), mud banks, and occasional rock bars make navigation hazardous.

Habitation and industry

There are no towns within the Auvergne Sheet area. The closest town is Kununurra (in W.A.), 24 miles by road west of the sheet area; it is linked to Perth and Darwin by regular air services. Wyndham, 70 miles west of Kununurra is linked by both air and shipping services. Katherine, on the Stuart Highway, is 180 miles by road east of the sheet area. Apart from a police station, a store, and a road maintenance camp at Timber Creek, the only habitations are those on Auvergne, Bullo River, Legune, and Bradshaw Stations. The total population is probably less than 200, the large majority of whom are aboriginals. Kununurra has a population of about 1000, and Katherine about 2,000.

The only industry is cattle raising. Holdings are large: (Auvergne 3,950 sq. miles, Coolibah 3,960 sq. miles, Legune and Bullo River each about 1200 sq. miles). The majority of cattle are moved by road train to the Wyndham or Katherine meat-works.

Climate

The climate is described by Traves (1955) as "a warm dry monsoonal climate with a short rainy season in summer and a long dry season in winter". The rainfall ranges from almost 40 inches in the north to just under 30 inches in the south, most of it falling between the months December to March, with lesser amounts in November and April. The remainder of the year is almost rainless.

The monthly mean maximum temperatures range from about 85° in June and July to about 100° for November to March. Mean minimum temperatures range from about 50° in July to the high 70°s in January and February.

Vegetation

The vegetation of the whole area is characterized by a number of eucalypt species which grow from 20 to 50 feet high. They grow both on the ranges and tablelands, and on the flatter country which also includes open grassland.

The hilly country has a thin cover of very poor soil derived mostly from weathering of sandstone and siltstone. It supports a cover of spinifex which grows in even the roughest areas, and annual sorghums (including "cane-grass") which grow on slopes with a thicker soil cover.

The plains, generally with thicker soil cover, support better pastures, including annual and perennial sorghums, kangaroo and spear grasses.

Watercourses are generally lined with paperbark trees. Other distinctive trees in the area are the boab (bottle tree) and a species of bauhinia.

Along the coast in the north, areas of mangrove and samphire swamp are associated with salt flats.

Survey methods

The mapping of the Auvergne 1:250,000 Sheet area was carried out mainly by Land-Rover and foot traverses, from a central base camp. The camp site was on a large permanent water hole in the East Baines River, ½ mile south of the Katherine-Kununurra road crossing. A launch was used to map along the Victoria and Fitzmaurice Rivers as far inland as Timber Creek on the Victoria, and to within 3 miles of the Koolendong Valley on the Fitzmaurice. Otherwise inaccessible areas were visited by helicopter - about 30 flying hours were logged. Much of the field mapping, particularly in the early part of the season, was based on geological photo-interpretation by W.J. Perry (1967a).

All plotting of field information was done on airphoto overlays. Air photographs covering the area, and available during 1967 are at a scale of 1:50,000 and were flown by the R.A.A.F. in 1948. (New photos at a scale of 1:85,000 flown in 1967, were available in 1968).

The overlays were compiled on Division of National Mapping photo-scale planimetric sheets. The resulting geological compilations were photographically reduced to 1:250,000 scale, and the final geological map compiled at this scale. The area covering the Bonaparte Gulf Basin was copied from the 1:250,000 special map accompanying Veevers & Roberts (1968).

Previous geological investigations

Geological work prior to 1955 is summarized by Traves (1955). One of the first Europeans to explore the Victoria River Basin area was J.L. Stokes who in 1837 navigated the Victoria River to about Timber Creek, and continued on foot to about the present Katherine road crossing of this river. Several very general geological observations were recorded (Stokes 1846).

H.Y.L. Brown (1895) first named sediments in the Victoria River Basin, referring to sandstone and shale which crop out in the scarps along the lower tracts of Victoria River, as the Victoria River Sandstone and Victoria River Shale.

Following Brown, several geologists reconnoitred the area and made broad, general correlations of the stratigraphy; these included Wells (1907), and Woolnough (1912). More recently Dunn, (1965), of the Bureau of Mineral Resources, made reconnaissance traverses through the area. Traves (1955) produced a map and report covering the area of present investigations at a scale of 16 miles to the inch. He named the entire sequence in the Victoria River Basin the Victoria River Group.

Laing and Allen (1956), mapping an area in the Victoria River Basin covered by the Associated Freney Oil Fields N.L. Permit No. 1, N.T., were the first to subdivide the Victoria River Group of Traves; they established five formations and a composite unit, the Pinkerton Beds.

Harms (1959) produced a generalised map of part of the Victoria River Basin but his stratigraphy complied essentially to that of Traves.

Randal (1962) mapped part of the Victoria River Basin sequence on the Fergusson River 1:250,000 Sheet area.

The present investigation by the Bureau of Mineral Resources is the first complete and systematic geological survey done over the whole Victoria River Basin.

PHYSIOGRAPHY

Drainage

The south-eastern three-quarters of the Sheet area is drained by a system of tributaries all flowing into the Victoria River. The major tributaries are the East and West Baines, Angalarri, and Bullo Rivers and Paperbark and Lalngang Creeks.

Tidal movements affect the water level in the dry season; a maximum of seven feet rise and fall may be experienced in the Victoria River at Timber Creek. The lower reaches of all tributaries are also tidal.

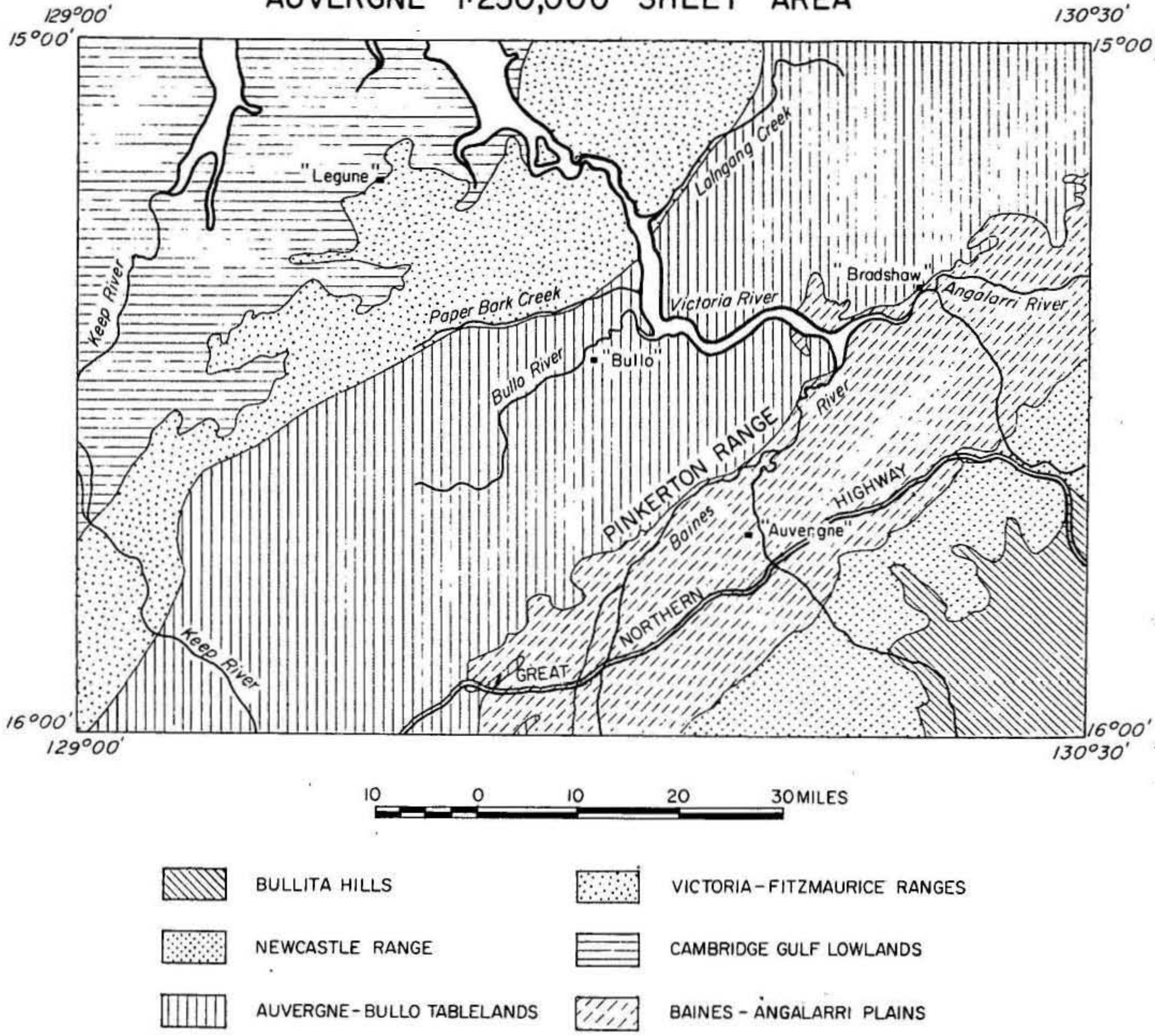
Most of the major streams have a superimposed consequent pattern; the Victoria River in particular traverses across the strike of almost all the rock units in the area. Lalngang and Paperbark Creeks are essentially subsequent streams developed along the trace of the Victoria River Fault. Minor tributaries, particularly in the Victoria - Fitzmaurice Ranges, and, to a large extent, the Angalarri River, are also subsequent.

Physiographic divisions

The main physiographic units of the Auvergne Sheet area are illustrated diagrammatically in Fig. 2. They have been largely controlled by variations in bedrock and broadly follow the structural trends; they reflect quite clearly the three basic tectonic units within the Sheet area.

FIG. 2 PHYSIOGRAPHIC SKETCH MAP

AUVERGNE 1:250,000 SHEET AREA



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The Sheet area contains two of the physiographic subdivisions of the Ord - Victoria Region used by Traves (1955), after Paterson (1954). These are the Cambridge Gulf Lowlands in the northwest, and the Victoria River Plateau over the remainder of the Sheet area. The superimposed nature of the major streams over the "Victoria River Plateau" suggests an ancient land surface previously covered this area. Subsequent uplift has resulted in dissection to produce the present land forms.

We have subdivided the "Plateau" into five physiographic units. These are the Bullita Hills, Newcastle Range, Baines - Angalarri Plains, Auvergne - Bullo Tablelands, and the Victoria - Fitzmaurice Ranges.

The Cambridge Gulf Lowlands include the erosional remnants of Palaeozoic and Precambrian rocks and extend into the adjacent Cambridge Gulf Sheet area. They include a sub unit, the Tidal Flats.

The Bullita Hills are restricted to areas of exposure of dolomite and dolomitic siltstone units in the far south-east of the Sheet area. Low rounded and minor conical shaped hills are typical, commonly with "layer cake" structure. Some are capped by sandstone or chert. The drainage is characteristically dendritic, but is controlled in places by lineaments caused by faulting and, to a lesser extent, folding.

The Newcastle Range is immediately north west of the Bullita Hills and is formed by outcrops of the resistant Jasper Gorge Sandstone. The Range is essentially a plateau; its surface is virtually a dip slope dipping about 5° to the north west; the trend of the Range follows the regional strike.

The southern margin of the Range is an irregularly dissected scarp; its northern boundary is where the Jasper Gorge Sandstone dips beneath the Baines - Angalarri Plains.

Deep gorges are incised in the range by the Victoria and Baines Rivers. Jointing is prominent and controls the courses of minor tributaries.

The Baines - Angalarri Plains form a northeast-trending belt, about 20 miles wide, which extends from the southern-central margin to the eastern-central margin of the Sheet area. Locally the belt is called the Whirlwind Plains. The Baines - Angalarri Plains have developed on, and are essentially restricted to, outcrop of the Angalarri Siltstone. The Koolendong Valley in the north-eastern part of the Sheet area is similarly developed on this siltstone unit.

The Victoria, Angalarri, East and West Baines Rivers, which cut through the plains, form large alluvium-covered flats, with terraces along the Victoria River. Much of the plains is covered by residual soils, predominantly clayey, developed on the underlying siltstone. The plains have a maximum elevation of 150 feet above sea level.

In several areas, between the East Baines and Victoria Rivers thin sheets of Cainozoic gravels, possibly river gravels or piedmont deposits, are relatively resistant and give the plains a local relief of up to 70 feet.

Auvergne - Bullo Tablelands. This is the most extensive physiographic unit in the Auvergne Sheet area, and includes the Pinkerton, Yambarra, and Spencer Ranges, plus a large area in the central western area occupied by the Bullo River Sandstone. It is a continuation of the "Tablelands" of the Fergusson River Sheet area (Randal, 1962). Relief is moderate. The highest spot, near Skinners Point, is 1130 feet above sea level. Local relief ranges to 900 feet (in the Pinkerton Range).

The tablelands consist mainly of dissected plateaux, mesas and cuestas; commonly they are structural benches bounded by scarps up to 250 feet high. Benches are controlled by gently dipping, resistant sandstone beds from which the overlying soft beds are being, or have been stripped. Major consequent streams are deeply incised into the sandstone; minor tributaries are largely controlled by joints and fault. The tablelands are extensively dissected, particularly in the north-east of the area.

Much of the tableland surface follows the massive Pinkerton Sandstone. The central-western area consists of extremely rugged topography formed on the Bullo River Sandstone.

The Victoria - Fitzmaurice Ranges are an extension of the Carr Boyd Ranges of the adjacent Cambridge Gulf Sheet area (Plumb and Veevers, 1965). It continues across the Port Keats Sheet area to join the "Uplands" of Randal (1962), in the Fergusson River Sheet area. This is some of the most rugged country in the Auvergne Sheet area: local relief is up to 650 feet; maximum elevation above sea level however, is only about 700 feet. The bedrock is mainly interbedded sandstone and siltstone, faulted and jointed. The physiographic unit coincides with the Fitzmaurice Mobile Zone.

With the exception of the superimposed Victoria River, drainage in this unit is largely subsequent; the bedrock structure, particularly faults, produces an irregular dendritic pattern. Springs are common in places, particularly along large fault scarps.

Massive sandstones form either widespread areas of monotonous rugged topography or individual prominent ridges. Siltstone forms relatively low rounded hills. The basement rocks in the far south-west form low, rounded hills and prominent dissected ridges.

The Cambridge Gulf Lowlands are in the north-west part of the Sheet area, overlying the Bonaparte Gulf Basin sediments. They consist of low-lying plains, gradually increasing in elevation from sea level to about 50 feet where they meet the foot hills of the Victoria - Fitzmaurice Ranges. Erosional remnants of flat-lying Palaeozoic rocks, between Cockatoo Creek and the Legune track on the western margin of the Sheet area, are continuations of the Burt Range and the Weaber Range in the adjacent Cambridge Gulf Sheet area.

The plains are generally covered by Cainozoic sand and soil; alluvial plains, apparently younger than the sand, have developed along the main streams. The Keep River has cut into its own alluvium for a depth of 30 feet or more, and between the Keep River and Legune extensive alluvial black soil has been deposited.

The Tidal Flats are low-lying areas surrounding the estuaries of the Keep and Victoria Rivers, and minor coastal streams. In the lower reaches the flats are covered by mud and salt deposits and are subject to tidal and seasonal inundation. Inland they grade into emerged salt and mud flats, subject only to seasonal flooding.

Correlation of land surfaces

Within the Auvergne Sheet area three surfaces can be recognized; they can be equated with the mature weathering surfaces defined in the Northern Territory by Hays, (1967).

North of Mount Golla Golla in the far north-east of the Sheet area, residuals of lateritized Cretaceous rocks form the general plateau surface of the Auvergne - Bullo Tablelands; these are believed to be residuals of the Tennant Creek Land Surface of Hays (1967), of which the Bradshaw Surface of Wright (1963) is a part.

The Wave Hill Surface (Hays, 1967) is one of advanced erosion, standing below and encroaching upon the Tennant Creek Surface; it contains some remnants of the Tennant Creek Surface. It survives as dissected tablelands and accordant hill summits and can be traced, sloping gently, into the Joseph Bonaparte Gulf and the Daly River Basin. It is represented by the main plateau surface of the Auvergne - Bullo Ranges, and in the general surface of accordant summits in the Bullita Hills, Newcastle Range, and Victoria - Fitzmaurice Ranges.

The Baines - Angalarri Plains, other inland plains of the Victoria River Basin, major river valleys (notably the Koolendong Valley), and the Cambridge Gulf Lowlands, are part of the Koolpinyah Surface (Hays, 1967). It is the youngest surface recognized and is encroaching into the Wave Hill Surface.

STRATIGRAPHY

Most rocks exposed in the Auvergne Sheet area are relatively undeformed sediments of Proterozoic age, deposited in the Victoria River Basin. Their age is uncertain but they are probably all Adelaidean. They lie on a basement of metamorphic and igneous rocks of the East Kimberley Region and Pine Creek Geosyncline, ranging in age from Archaean to early Carpentarian.

Two distinctly different tectonic environments are found in the Basin, separated by the Victoria River Fault. Age relationships between the strata in either side of the fault are uncertain but it is tentatively thought that they are rough time equivalents.

At least 12,000 feet, and probably much more, of sandstone and siltstone were deposited in the Fitzmaurice Mobile Zone, to the north-west of the Fault. These comprise the Fitzmaurice Group and Legune Formation.

About 8,000 feet of sandstone, siltstone, and dolomite are exposed in the Sturt Block, to the south-east of the Fault. These comprise the Bullita, Auvergne and Duerdin Groups and the Bullo River Sandstone. Unconformities are common.

The Proterozoic rocks are unconformably overlain, in the north-west, by Palaeozoic rocks of the Bonaparte Gulf Basin (Veevers and Roberts, 1968); these are not discussed in this report.

All the stratigraphic units in the Victoria River Basin are being formally named for the first time.

The Precambrian stratigraphy of the Sheet area is summarized in Table 1 and more detailed summaries of the individual Groups are given in Tables 3 to 7. Table 2 compares the new nomenclature with previous names, both published and unpublished, used in this and adjoining areas. Tentative stratigraphic correlations are given in Table 8.

ARCHAEAN OR LOWER PROTEROZOIC

The Halls Creek Group and Lamboo Complex form the basement rocks of the Victoria River Basin, and a summary of their lithology is given in table 3.

The basement rocks crop out in a 500-mile long arcuate belt which stretches from the coast near Derby in Western Australia to just inside the Northern Territory on the Auvergne 1:250,000 Sheet area. The Lamboo Complex is represented on the Auvergne Sheet area by the Bow River Granite and the Whitewater Volcanics, and their intrusive equivalents.

HALLS CREEK GROUP

Introduction

The type area for the Halls Creek Group is the Gordon Downs 1:250,000 Sheet area, where Dow & Gemuts (1969) recognise four subdivisions. In the Cambridge Gulf and Lissadell Sheet areas the group has not been subdivided. On the Cambridge Gulf Sheet area the rocks consist mainly of quartz greywacke and slate, regionally metamorphosed to the low greenschist facies with later contact metamorphism adjacent to the granite.

Distribution and topographic expression

Rocks of the Halls Creek Group crop out in the south-west corner of the Sheet area. They form a discontinuous belt running north-north east; it is twenty miles long and up to five miles wide. The rocks form dissected ridges with a maximum relief of about one hundred feet. Outcrop is poor. The photopattern is uniform and medium toned.

Contact relationships

On the Auvergne Sheet area the Halls Creek Group is overlain by the Devonian Cockatoo Sandstone. Five miles north-north east of Ernie Lagoon it is faulted against or overlain by what is thought to be the Legune Formation. All other contacts are either faulted or not exposed.

On the Cambridge Gulf Sheet area (Plumb and Veevers 1965) - "the metamorphics are intruded by the Bow River Granite and overlain with a strong angular unconformity by the Whitewater Volcanics."

Lithology

(a) In hand specimen Most of the rocks are green fine-grained phyllites with varying quantities of small (1 mm.) quartz grains. Euhedral andalusite prisms up to 5 mm. long are common on the eastern side of the belt. Quartz veins are not abundant, but in places contorted veins and segregations of quartz range in size from under 1 mm. to about 10 cm. There is no indication of bedding.

TABLE 1. SUMMARY OF THE STRATIGRAPHY: AUVERGNE 1:250,000 SHEET AREA - (EXCLUSIVE OF BONAPARTE GULF BASIN SEDIMENTS)

AGE	UNIT NAME	MAP SYMBOL	LITHOLOGY	THICKNESS
CAINOZOIC				
Quaternary		Qac	Coastal deposits, mud, silt, evaporites.	
		Qa	Alluvium	
Undifferentiated				
		Czt	Terrace deposits, mud, sand, gravel.	
		Czs	Sand soil, colluvium.	
		Czb	Black soil.	
		Czg	Sand, gravel, colluvium.	
		Czl	Laterite.	
		Unconformity		
CRETACEOUS	Mullaman Beds	Klm	Friable and ferruginous sandstone, lateritic soil.	100
		Unconformity		
CAMBRIAN (Lower)	Antrim Plateau Volcanics	Cla	Basalt	200
		Unconformity		
PROTEROZOIC	Duerdin Group			
	Ranford Formation	Bos	Massive red-brown ferruginous sandstone.	-
	Ernie Lagoon Member	Bor	Light brown quartz sandstone; minor grit interbeds	35
	Beasly Knob Member	Bob	Brown quartz sandstone, pebblebeds, conglomerate, grits.	40
	Bucket Spring Member	Bou	Siltstone and micaceous sandstone.	180
	Moonlight Valley Tillite	Bom	Unconsolidated boulder beds, tillite; overlain by dolomite.	400
	Skinner Glacials	Boi	Tillite, conglomerate, pebbly sandstone, sandstone.	630
		Unconformity		
	Bullo River Sandstone	Pb	Reddish-brown ferruginous sandstone, grit and conglomerate.	1000+
	Black Point Sandstone Member	Pk	Reddish-brown feldspathic quartz sandstone; minor conglomerate.	150
	Big Knob Beds	Br	Reddish-brown ferruginous sandstone, grit and conglomerate.	-
		Local Unconformity		
	Auvergne Group			
	Shoal Reach Formation	Bah	Sandy and silty dolomite, dolomite, minor siltstone, shale.	350
	Spencer Sandstone	Bao	Quartz sandstone, silty sandstone, minor dolomitic sandstone.	550
	Lloyd Creek Formation	Bal	Dolomite, oolitic and stromatolitic, sandy and silty dolomite.	250
	Pinkerton Sandstone	Bap	Massive quartz sandstone, siltstone, minor shale.	300+
	Saddle Creek Formation	Bad	Basal cross-bedded sandstone, upper siltstone - some dolomitic.	330
	Angalarri Siltstone	Baa	Siltstone, grey-green shale, dolomitic siltstone.	1000+
	Jasper Gorge Sandstone	Baj	Massive quartz sandstone, minor basal conglomerate and pebble beds.	200+
		Unconformity		
	Bullita Group			
	Skull Creek Formation	Bbs	Dolomite, limestone, carbonate-rich silt and sandstone.	700
	Bardia Chert Member	Bbm	Massive laminated chert, brecciated chert, sandstone.	100
	Timber Creek Formation	Bbt	Siltstone, dolomitic siltstone, dolomite.	380+
	Limbunya Formation	Bl	Interbedded quartz sandstone, siltstone, shale.	2000+
	Fitzmaurice Group			
	Lalngang Sandstone	Bfa	Quartz sandstone, grit, conglomerate.	4500+
	Goobalieri Formation	Bfb	Basal quartz sandstone, siltstone.	2000+
	Moyle River Formation	Bfm	Quartz, sandstone, minor siltstone, conglomerate.	3500+
	Lamboo Complex			
	Bow River Granite	Bbw	Coarse-grained and porphyritic biotite granite.	-
	Whitewater Volcanics	Bw	Acid lavas, tuffs, intrusive quartz-feldspar-porphyry.	-
ARCHEAN OR LOWER PROTEROZOIC OR LOWER PROTEROZOIC				
	Halls Creek Group	Ah	Slate, greenschist, mica schist, andalusite schist.	

TABLE 2. RELATIONSHIPS BETWEEN PROTEROZOIC STRATIGRAPHY ESTABLISHED BY DIFFERENT WORKERS IN THE VICTORIA RIVER BASIN (EXCLUDING BASEMENT ROCKS)

H.Y.L. Brown 1895	Traves 1955	Laing & Allen 1956	Randal 1962	Pontifex, Morgan, Sweet, Reid 1968.
				Duerdin Group
				Bullo River Sandstone Black Point Sandstone Member
		Pinkerton Beds	Yambarra Beds (undifferentiated)	Auvergne Group Shoal Reach Formation Spencer Range Sandstone Lloyd Creek Dolomite Pinkerton Sandstone Saddle Creek Formation
	Victoria River Group	Auvergne Shale	Angalarri Siltstone	Angalarri Siltstone
Victoria River Sandstone		Jasper Gorge Sandstone	Palm Creek Beds	Jasper Gorge Sandstone
Victoria River Shale		Coolibah Formation		Bullita Group Bynoe Formation
		Skull Creek Limestone (& lateral equivalent)		Skull Creek Formation
		Timber Creek Formation		Timber Creek Formation
				Legune Formation
				Fitzmaurice Group

TABLE 3. SUMMARY OF LITHOLOGY OF BASEMENT ROCKS

AGE	ROCK UNIT		MAP SYMBOL	LITHOLOGY	PHYSIOGRAPHIC EXPRESSION	RELATIONSHIPS
CARPENTARIAN	Lamboo Complex	Bow River Granite	Bbo	Coarse-grained and porphyritic biotite granite	Boulders or piles of boulders lying on soil plain	Relationships not exposed, Intrudes Whitewater Volcanics and Halls Creek Group on adjacent sheets
		Whitewater Volcanics	Bw	Acid lavas, tuffs, intrusive quartz-felspar porphyry	Low rounded hillocks with little outcrop	Overlain by probable Legune Formation. Other relationships not exposed on this sheet. Overlies Halls Creek Group unconformably on adjacent sheets.
ARCHAEAN OR LOWER PROTEROZOIC	Halls Creek Group		Ah	Slate, green schist mica-schist, andalusite schist	Dissected ridges with little outcrop	Overlain unconformably by suspected Legune Formation

(b) <u>In thin section</u> The most common rock type is chlorite - quartz - sericite phyllite of the greenschist facies. Quartz ranges from zero to sixty percent: the grains are ragged and up to 2 mm. long. The chlorite replaces biotite which is left unaltered in a few places. The sericite (and minor amounts of muscovite) are extensively altered to a fine brown product. Andalusite is pseudomorphed by sericite. Accessory amounts of tourmaline and (?) apatite also occur.

The rocks have a marked foliation produced by the alignment of elongated quartz grains and sericite flakes. The chlorite flakes lie across this foliation suggesting that biotite was formed during a later metamorphism.

CARPENTARIAN

WHITEWATER VOLCANICS

Derivation of name

The rocks were named Whitewater Volcanics by Dow et al, (1964).

Distribution and topographic expression

About one square mile of the volcanics crop out in the southwest corner of the Auvergne Sheet area.

Twelve miles north-east of this outcrop, a three-mile long belt of intrusive prophyry is probably the intrusive equivalent of the volcanics. The volcanics and intrusives form low, rounded hills with little outcrop. Fresh outcrop is restricted to creek channels. The rocks give a monotonous medium-toned photo-pattern.

Contact relationships

The volcanics are faulted against the Burt Range Formation to the north, the Halls Creek Group to the south and are overlain by the Cockatoo Sandstone to the east.

The intrusives are adjacent to probable Legune Formation but the contact has not been observed. This rock is probably an intrusive equivalent of the Whitewater Volcanics as it contains abundant micropegmatite and also is similar to intrusives in the lower part of the volcanics on the adjacent Cambridge Gulf 1:250,000 Sheet area.

No relationships between the volcanics and the intrusives are exposed.

In the adjacent Lissadell and Cambridge Gulf Sheet areas (Plumb and Veevers, 1965) the Whitewater Volcanics overlie the Halls Creek Group with a strong angular unconformity and are overlain by the Hensman Sandstone (possible equivalent of the lower part of the Fitzmaurice Group). The intrusive porphyry in the lower part of the sequence "are similar to the Castlereagh Porphyry of the Lamboo Complex which is considered to be comagmatic with the volcanics. This porphyry intrudes the Whitewater Volcanics and both are in turn intruded by the Bow River Granite"

Lithology

(a) Volcanics

In hand specimen. Phenocrysts of euhedral and subhedral white feldspar up to 5 mm long, and subhedral or anhedral light blue and brown quartz up to 2 mm. long are set in a grey-green cryptocrystalline groundmass. Fine dark-green chlorite forms aggregates up to 5 mm. long; they 'may be pseudomorphs of a mafic mineral, possibly biotite. A slight foliation is defined by partial alignment of phenocrysts and chlorite blebs.

In thin section. The proportion of andesine to microcline phenocrysts is about 10 : 1. Andesine phenocrysts are all heavily or completely altered to sericite and epidote, and some are partly replaced by aggregates of calcite. Some contain small rectangular and rounded inclusions of fine chlorite.

Some of the phenocrysts are composed of a mosaic of smaller grains.

Most of the quartz phenocrysts are heavily embayed but the pyramidal form is recognisable in some.

Microcline microperthite phenocrysts are up to one mm. long: they are euhedral or subhedral and little altered.

Subhedral grains of (?) ilmenite are extensively altered to (?) leucoxene.

The groundmass is formed of interlocking grains of feldspar with quartz, chlorite and sericite.

(b) Intrusives

In hand specimen. The rock has a cryptocrystalline red-brown groundmass. Quartz phenocrysts are white, light pink or clear; they vary from anhedral to euhedral and are up to 5 mm. long. Subhedral plagioclase phenocrysts are dark grey, and are up to 5 mm. long. Dark green chlorite occurs as vaguely defined blebs and streaks.

In thin section. Quartz phenocrysts are embayed and corroded but some retain a bipyramidal form. Plagioclase phenocrysts are completely sericitised. A very few of the phenocrysts are of alkali feldspar. These are subhedral, up to 2 mm. long and only slightly sericitised. Anhedral grains of (?) leucoxene are up to $\frac{1}{2}$ mm. long. Small flakes of chloritised biotite form irregular grains and lenticular aggregates up to 2 mm. long. Zircon is included in the biotite flakes.

The groundmass is formed of ragged grains of quartz, feldspar, and granophyric intergrowths of the two, and flakes of biotite and sericite. The grain size ranges from fine to nearly the size of the phenocrysts.

Lamboo Complex-Bow River Granite

Distribution and topographic expression

About five square miles of outcrop of Bow River Granite are exposed in the south-west corner of the Auvergne sheet area. It occurs as sporadic boulders or piles of boulders up to twenty feet high lying on the soil plain.

Derivation of name

The granite is extensive in the East Kimberley Region and has been defined by Dow and Gemuts (1969).

Contact relationships

The granite is overlain by the Cockatoo Sandstone. The area of outcrop is flanked to north and south by metamorphics of the Halls Creek Group, but its relationship to them was not established on this sheet area. On the adjacent Cambridge Gulf and Lissadell 1:250,000 Sheet areas (Plumb & Veevers, 1965) the granite intrudes the metamorphics.

Lithology

The composition of the rock ranges from biotite granite to biotite adamellite. Textures range from coarse even grained to coarse porphyritic.

In hand specimen. Rounded grains of blue opalescent quartz, subhedral green plagioclase grains and anhedral white or pink microcline grains are all up to 0.5 cm long. In the porphyritic variety ovoid tabular microcline phenocrysts are up 2 cm. in diameter. Biotite forms segregations of similar size.

In thin section. The plagioclase ranges from oligoclase to andesine, it is extensively altered to sericite and epidote. Microcline microperthite forms ragged anhedral grains with inclusions of plagioclase. The feldspars are surrounded by mosaics of quartz grains of widely varying size.

Graphic intergrowth between quartz and alkali feldspar is common. Green and brown biotite is associated with muscovite, zircon and magnetite.

PROTEROZOIC (Undifferentiated)

Fitzmaurice Group

Introduction

The stratigraphy of the Fitzmaurice Group (and Legune Formation) is summarised in Table 4.

The Fitzmaurice Group consists of the following units,

Lalngang Sandstone (youngest)
Goobaieri Formation
Moyle River Formation (oldest)

Together with the Legune Formation they constitute the only Precambrian units within the Fitzmaurice Mobile belt, apart from the small area of Halls Creek Group and Lamboo Complex in the south-west of the Sheet area. They consist of thick and very monotonous successions of sandstone with varying amounts of conglomerate, grit and siltstone. On the whole they are photo-geological units and are difficult to distinguish in the field. Their differentiation is further complicated by very severe faulting and apparent facies changes. Therefore the geological boundaries as mapped in this belt are questionable in some areas. In particular, the definition of the geology on Entrance Island and the land immediately to the south-west of it is uncertain.

Thickness.

The total thickness of the group is difficult to measure but more than 10,000 feet are exposed in the northern part of the Sheet area where all three units crop out

Moyle River Formation

Distribution:

The Moyle River Formation crops out extensively in the central - northern part of the Auvergne Sheet area, and it also extends, within the Fitzmaurice Mobile Belt, into the Port Keats Sheet area.

Derivation of name:

The name is taken from the Moyle River in Port Keats 1:250,000 Sheet.

Reference area:

10 miles north-east of Goobaieri Bay (Victoria River).

Stratigraphic relationships:

The formation is overlain, apparently conformably, by the Goobaieri Formation and is faulted against rocks of the Auvergne Group along the Victoria River Fault. Its base is not exposed in the Auvergne Sheet area, but it unconformably overlies sheared conglomerates of the Noltenius Formation in the Port Keats Sheet area.

Lithology and thickness:

The formation consists of sandstone which is white, mostly massive, thin to thick bedded, fine to coarse grained, and poorly to moderately sorted. Minor amounts of fissile siltstone, grit and pebble conglomerate also occur. Mud flakes, rock fragments and yellow, green and white clay occur both in fragments and interstitially, but are not abundant. The sandstone consists of sub-angular to rounded quartz grains many of which have secondary siliceous overgrowths. Sericite occurs both as a matrix (5%) and pseudomorphing rocks fragments (or possibly feldspar). Zircon and tourmaline are accessories.

TABLE 4. SUMMARY OF STRATIGRAPHY, FITZMAURICE GROUP AND LEGUNE FORMATION - (FITZMAURICE MOBILE BELT SEDIMENTS)

	ROCK UNIT	SYMBOL	LITHOLOGY	THICKNESS (in ft.)	PHYSIOGRAPHIC EXPRESSION	STRATIGRAPHIC RELATIONSHIP
	Legune Formation	B1	Monotonous sequence of siltstone with interbedded sandstone	2000+	Rugged hills with sandstone scarps varying to moderately low hills with stepped and rounded slopes	Conformably overlies Lalngang Sandstone of Fitzmaurice Group. Its contact with Palaeozoic sediments in adjacent Bonaparte Gulf Basin not exposed
Fitzmaurice Group	Lalngang Sandstone	Bfa	Quartz sandstone, grit, conglomerate,	4500+	Varies from extremely rugged topography, much jointed and with prominent sandstone scarps to undulating ranges in its western extent	Conformably underlies Legune Formations. Conformably overlies Goobaieri Formation
Fitzmaurice Group	Goobaieri Formation	Bfb	Basal quartz sandstone with overlying siltstones and interbedded sandstone	2000+	Forms large areas of no outcrop and forms low undulating hills and talus slopes below Lalngang Sandstone. Two sandstone bands form prominent ridges	Conformably underlies Lalngang Sandstone Conformably overlies Moyle River Formation
Fitzmaurice Group	Moyle River Formation	Bfm	Interbedded massive and bedded quartz sandstone with lesser siltstone and conglomerate	3500+	Alternating hard and soft bands and severe faulting produces very rugged and inaccessible topography of benches, scarps and ridges	Conformably underlies Goobaieri Formation. Unconformably overlies Noltenius Formation on Pt Keats Sheet area.

Fig. 3 Sandstone of Moyle River Formation: massive, fine to medium-grained.
North side of Victoria River, adjacent to Entrance Island.

GA/515(I.R.P.)

The thickness is difficult to determine accurately due to the extensive faulting in the area of outcrop. A minimum thickness of 3500 feet (estimated from air photos) is exposed six miles due north of Goobaieri Bay.

Distinguishing features:

Alternating hard and soft beds and the severe faulting in this unit produce a very rugged and inaccessible topography of benches, scarps and ridges. On air photos the different lithological types show up as different tones, producing a banded pattern; this unit contrasts with the Lalngang Formation which has a uniform tone.

Goobaieri Formation

Distribution:

The Goobaieri Formation crops out predominantly in the central-northern part of the sheet area and there are small areas of suspected Goobaieri Formation in the central western part of the area. It may occur immediately south of Entrance Island but some, if not all of it has been removed by faulting.

Derivation of name:

The name is taken from Goobaieri Bay on the Victoria River.

Reference area:

In the nose of a syncline, eight miles north of Goobaieri Bay (lat, 15°05' S, long. 129°48' E)

Stratigraphic relationships:

The formation is overlain by the Lalngang Sandstone and underlain by the Moyle River Formation: both contacts are apparently conformable. The rock mapped as Goobaieri Formation in the central western part of the Sheet area is so mapped because it underlies what is suspected to be Lalngang Sandstone.

Lithology and thickness:

The major part of the formation consists of grey, green and purple, fissile siltstone interbedded with fine and medium-grained grey sandstone. This part of the formation crops out very poorly. A prominent friable, white, blocky, thin-bedded, medium-grained sandstone occurs in the middle of the sequence.

The section in the reference area is:

Overlain By Lalngang Sandstone

	Thickness (ft)	
	160	Siltstone: light grey, fissile, becoming fine blocky thin bedded sandstone with ferruginous and micaceous partings, towards the top. Mudcracks are common.
	100	Siltstone: grey fissile
	15	Interbedded siltstone and fine sandstone: laminated to thin bedded with mudcracks.
	450	Siltstone: grey fissile
	40	Sandstone: white, blocky thin bedded fine to medium grained moderate sorting friable due to soft white matrix. which becomes more abundant towards top.
	1250	Mainly no outcrop, with a few thin outcrops of sandstone: grey-purple, blocky, medium grained, well rounded, well sorted.
Total	2015	

In the central - western part of the Sheet area the Goobaieri Formation consists of dark grey or green, fissile, laminated shale and siltstone with minor thin (up to 3 feet) sandstones which are grey or purple, blocky to massive, thin bedded and fine to medium grained.

Lalngang Sandstone

Distribution:

The Lalngang Sandstone crops out extensively in the central-northern part of the Sheet area both to the north and south of the Victoria River. The bulk of the rock in the ranges immediately to the north of the Victoria River Fault in the western half of the seet area has also been mapped as Lalngang Sandstone, but a definite correlation has not been possible because of severe faulting between the two areas.

Derivation of name:

The name is taken from Lalngang Creek, major tributory of the Victoria River, Auvergne 1:250,000 Sheet area.

Reference area:

The reference area is in the ridge to the north west of Lalngang Creek.

Stratigraphic relationships:

The formation overlies the Goobaieri Formation apparently conformably. Twelve miles south of Entrance Island it grades up into what is thought to be the Legune Formation. It is faulted against rocks of the Auvergne Group along some of the Victoria River Fault.

Lithology and thickness:

The formation consists of interbedded sandstone, grit, conglomerate and very minor siltstone and fine sandstone. Near Indian Hill the formation contains more siltstone than elsewhere, and little or no grit or conglomerate. The sandstone is pink, light brown or grey, massive but flaggy at the base of the formation, medium to thick bedded, medium to coarse grained and very poorly to moderately sorted. It is highly ferruginous in places. Mud flakes, and shale fragments are common. Cross bedding is very well developed.

The grit and conglomerate beds are up to one foot thick: the conglomerate contains rounded or angular pebbles up to one inch in diameter grit and conglomerate also occur as small (6 in) lenses in the fore-set beds of the sandstone. The sandstone consists of sub-anfular to well rounded quartz grains with siliceous overgrowths. Tourmaline and zircon are accessories.

All thicknesses were measured from air-photos. In the syncline in the central-northern part of the sheet about 1500 feet of the formation are exposed. Four miles north-east of Bucket Springs about 2000 feet are exposed. Seven miles west of Bucket Springs about 4500 feet are exposed. Near the Fitzmaurice River on the Port Keats 1:250,000 sheet a minimum of 4000 feet is exposed.

Distinguishing features:

In the field the abundance of pebble-conglomerate and grit beds, the scarcity of siltstone beds and the well developed cross bedding are distinctive. The formation tends to form flat-topped ranges. The fine jointing (produced by the abundant cross bedding?), the small amount of soil cover and sparseness of vegetation are very characteristic of the northern outcrops. The western outcrops have more soil cover and form more undulating ranges. North of the Victoria River the bedding planes form steps which are conspicuous on the air photographs.

Legune Formation (new name)

Distribution:

The Legune Formation is confined to the Fitzmaurice Mobile Zone. It extends along the entire length of this zone, mostly along its northern margin, adjacent to the Bonaparte Gulf Basin.

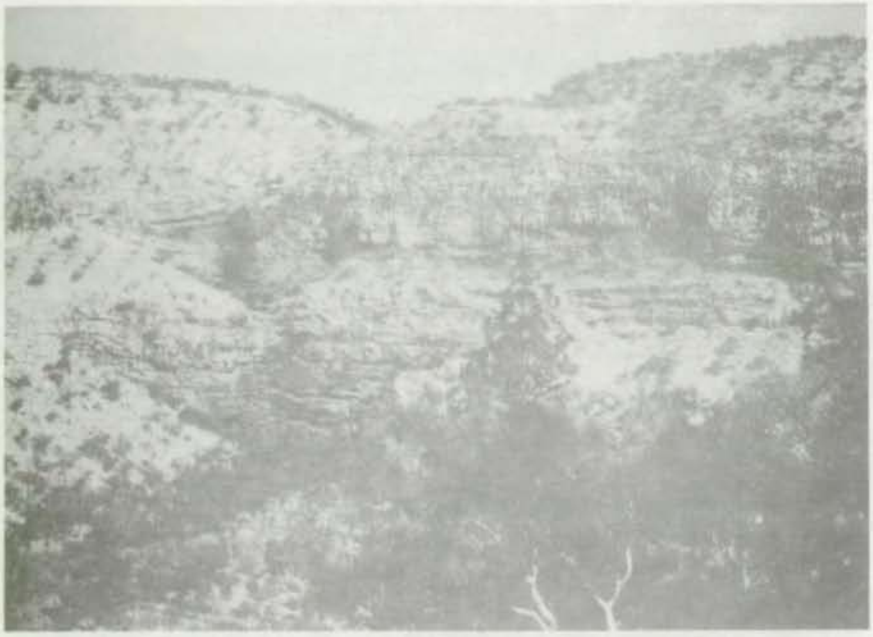


Fig. 4 Massive, thick bedded coarse-grained sandstone, Lalngang Formation. Location: Nap Springs, Auvergne 1:250,000 Sheet Area.

GA/514(I.R.P.)

Fig. 5 Sandstone of Lalngang Formation: coarse, gritty, minor pebble beds, commonly cross-bedded. Eight miles south-west of Indian Hill.

GA/511(I.R.P.)

Derivation of name:

The name is derived from the Legune Pastoral Lease, the homestead of which is situated between the Keep and Victoria Rivers, in the N.W. part of the Auvergne Sheet area.

Reference area:

The formation is best exposed, (and most readily examined) within an area of rugged hills about 10 miles south and south - east of Legune homestead. The type section, was measured 4 miles east of Alligator Springs on the Legune track.

Stratigraphic relationships

The definition of a top and bottom to the Legune Formation, and hence its stratigraphic relationships, in some areas are not clear. This applies particularly to the area in the south-west extremity of the mobile belt just north of Ernie Lagoon where the unit forms a wedge between folded Auvergne Group which is faulted against Bonaparte Gulf Basin sediments.

In other places the stratigraphic relationships are more definite. In the general area 10 miles southwest of Alligator Springs (on the Legune track), and also 10 miles southeast of Nap Springs, the Legune Formation conformably overlies the Lalngang Formation.

Because of the local similarity in many respects of the Legune Formation and Lalngang Sandstone it is difficult to recognise the exact contact between them. In some areas, notably in the southwest end of the mobile belt, and southeast of Nap Springs, this contact may in fact be gradational.

No rocks of Precambrian age were found to overlie the Legune Foramtion. For most of its extent, along the northern margin of the mobile zone, it is adjacent to the Bonaparte Gulf Basin, and has a general northerly dip below sandy and black soil plains. The plains mostly overlie Phanerozoic sediments of the Bonaparte Gulf Basin.

No contact between the Legune Formation and these sediments was found, and the nature of the contact, apart from it obviously being unconformable, is not known. Sandstone unconformably overlying rocks of the Lamboo Complex near Ernie Lagoon are tentatively mapped as Legune Formation.

Lithology and thickness:

The Legune Formation consists essentially of a monotonous sequence of interbedded sandstone and siltstone. (see fig. 6). Exposed sections of up to 2000 feet of this lithology are common in the area south and south-east of Legune homestead - e.g. at Transit Hill.

Typically the sandstone forms hard bands (commonly cliffs) between 1 foot and 25 feet thick. In the Transit Hill and Alligator Springs area individual sandstone bands can be traced for up to 12 miles. However in the central part of the area, south of Legune massive sandstone bands are few and the rocks consist mainly of siltstone and fine sandstone.

The sandstone is reddish and very dark grey on the weathered surface, light grey and white when fresh; medium grained, and variably flaggy, blocky and massive. Thin lamellae and lenses of siltstone and mudstone, mud-flakes, and minor sericite are common in the sandstone. Rarely, discontinuous grit and small pebble bands occur in the sandstones.

The interbedded finer sediments range from very fine siltstone to fine sandstone; they contain variable proportions of sand and silt. These rock types probably form up to 70% of the formation. They are generally fissile, and occur in bands up to 200 feet thick between sandstone bands. The siltstone is generally chocolate brown and in places ferruginous and sericitic; some is dark grey-green.

Fig.6 Legune Formation: showing monotonous sequence of siltstone with abundant interbeds of sandstone. 11 miles south-west of Alligator Springs.

GA/603(I.P.S.)

Ripple marks, mud cracks, current lineations and cross bedding are common in some areas but not in others. Accumulations of irregular tubular structures on some bedding planes appear to be mud cracks, or small troughs caused by desiccation, which have been filled, by subsequent desposition of sediment.

In some sections a vertical gradation from relatively poorly sorted, thick-bedded medium to coarse sandstone through to well sorted, thin-bedded fine sandstone and siltstone can be recognised over thicknesses of 15 to 30 ft.

The following section was measured 4 miles east of Alligator Springs (on the Legune track), and is typical of the Legune Formation on the Auvergne Sheet area.

Thickness (ft)	Lithology
	Top of hill
70	Sandstone: fine, blocky, thin bedded, quartzitic
160	Mainly sandstone scree covering siltstone
10	Sandstone: Fine grained, thin bedded.
48	Blocky sandstone scree covering coarse, friable thin bedded sandstone
120	Sandstone: fine grained, thin bedded, massive in bands of up to 4 ft thick. Intercalated with 4 in. to 8 in. bands and lenses of shaley siltstone.
55	Silty sandstone: poorly sorted; abundant
5	Sandstone: massive, fine grained.
80	Largely scree covered; some exposure of sandy siltstone.
10	Sandstone: fine grained, thin bedded
145	No outcrop, scree covered slope
170	Sandstone: fine, silty and thin bedded; interbedded medium-coarse thick-bedded sandstone. Fine cross-bedding, ripple marks and abundant mud clasts.
55	Reddish, shaly siltstone.
5	Sandstone: fine to medium grained, thin bedded, ripple marked

cont.

Thickness (ft)	Lithology Top of hill
95	Siltstone: grey-green; minor thin sand lenses
10	Sandstone: massive, medium grained, ripple marked.
250	Mainly scree covered slopes, poor exposure of sandy siltstone.
Total 1288 ft.	Base of hill

Twenty thin-sections of "sandstones" from different beds in the area south of Legune were examined, mainly in an attempt to detect variations which are not evident in hand specimen.

Almost without exception the sandstone is orthoquartzite (Pettijohn, 1957). Some grade to metaquartzites. It generally contains greater than 95% quartz in its detrital fraction; accessory minerals in order of abundance are tourmaline, zircon, rutile and muscovite. The proportion of cement in the rocks ranges from 20% ferruginous and/or clay, to nothing. Secondary quartz overgrowths commonly surround the quartz grains. Most of the rocks examined are medium to fine grained, and commonly grade into siltstone. Most are well sorted.

The composition and textures of these rocks indicate that they are very mature sediments, normally with a very low porosity. Most contain interlocking quartz grains, associated with recrystallisation and strain effects in the form of striations, fracturing of grains and distortion of muscovite around quartz grains.

There are no significant variations in the composition of the 'sandstones'.

North of the Legune area the Legune Formation generally contains more siltstone, and in the Madjellindi Valley area, north of the Fitzmaurice River (Port Keats Sheet area) it is almost entirely siltstone.

In the south-west of the mobile belt the Legune Formation contains a greater proportion of sandstone; also the sediments are more gritty, some are poorly sorted, and generally less mature then described above.

The following section was measured through the Legune Formation, 12 miles north north east of Ernie's Lagoon.

Thickness (ft)	Description
	Victoria River Fault
20	Siltstone: red-brown to grey, flaggy to fissile.
210	No outcrop, (probably siltstone)
443	Sandstone with interbedded granule sandstone and siltstone. Coarser sediments poorly sorted. Mud cracks common in siltstone.
55	Granule sandstone; interbeds of finer poorly sorted sandstone and siltstone.
15	Granule sandstone; grey, massive to flaggy. Iron stained matrix, siliceous, angular quartz grains up to 2 mm. ? minor feldspar grains.
229	No outcrop; minor "sub-outcrop" of interbedded well sorted sandstone and poorly sorted granule sandstone
34	Sandstone: coarse, poorly sorted (½ mm. to 2 mm.) Hematite-stained, sericitic matrix. Flaggy, thin to thick bedded.
261	Sandstone, thin bedded, coarse, well sorted. Minor interbeds of poorly sorted granule sandstone containing coarse (2 mm.) angular quartz grains.
237	Sandstone: grey, blocky, thin-bedded, coarse, well sorted, iron-stained clay matrix.
Total 1504 Ft.	
	Gradational boundary with underlying Lalngang Sandstone.

Distinguishing features

Thick monotonous sequences of interbedded siltstone and sandstone, with the siltstone generally comprising up to 70% of the section are typical of this unit. The character of the siltstone, and the gross lithology differs from any unit belonging to the stable shelf succession. It also differs from the other formations in the mobile belt which consist mainly of generally coarser grained, relatively poorly sorted sandstone, and show much more drastic lateral facies variations. Structural deformation, particularly faulting, although fairly common in the Legune Formation is generally less marked than in the other formations.

Although some sandstone bands in the unit form rugged cliffs (e.g. Transit Hill) the unit as a whole generally forms less rugged country than other formations in the mobile belt.

Palaeogeographic significance

The Legune Formation is the last observed unit to have been deposited in the mobile zone. The sediments are more mature than in the underlying formations which indicates relatively more stable conditions during the later history of deposition in the mobile zone. Most sedimentation was apparently submarine, with alternating influxes of sand and silt in various proportions. Mud cracks and other sedimentary features however indicate that the environment was probably deposited in fairly shallow water. The less mature sediments in the southwest end of the mobile zone suggests relative instability in this area during the deposition of the Legune Formation.

BULLITA GROUP (new name)

The stratigraphy of the Bullita Group is summarized in table 5. The group occupies a triangular area in the southeastern corner of the Auvergne 1:250,000 Sheet area bordered to the northwest by the Newcastel Range. It crops out extensively further to the south and east, on the Waterloo, Delamere and Victoria River Downs 1:250,000 Sheet areas.

TABLE 5 : SUMMARY OF STRATIGRAPHY - BULLITA GROUP (ON AUVERGNE 1:250,000 SHEET AREA).

Rock Unit	Symbol	Lithology	Thickness (in ft.)	Physiographic Expression	Stratigraphy Relationships	Remarks
Skull Creek Formation	Bbs	Dolomite: stromatolitic, silty and sandy; dolomitic siltstone and fine-grained sandstone; thin chert lenses	415 (minimum excluding Bardia Chert Member)	Low rounded hills where not capped by Jasper Gorge Sandstone. Dendritic drainage pattern except where structurally complex - drainage then controlled by faults and folds.	Overlies and may be partly intertongued with Timber Creek Formation. Overlain unconformably by Jasper Gorge Sandstone	
Bardia Chert Member	Bbm	Chert: laminated, massive brecciated. Grey to pink and red brown in colour	Up to 100	Forms flat cappings of Bbs on many hills, commonly edged by a small cliff. Also as steep ridges where structurally complex.	At top of Skull Creek. Overlain unconformably by Jasper Gorge Sandstone	Brecciation result of partial collaps and subsidence of this chert into probable sink hole cavities in the underlying Skull Creek Formation.
Timber Creek Formation	Bbt	Siltstone, dolomitic siltstone, fine-grained sandstone, dolomite	320 minimum	"Layer cake" low rounded and conical hills, reflects the alternation of hard and soft layers in the formation.	Conformable with, and underlies, the Skull Creek Formation	

The Bullita Group comprises three formations, the Timber Creek, Skull Creek and Bynoe Formations.

The group is overlain unconformably by basal formations of the Auvergne Group, which in this area is the Jasper Gorge Sandstone.

Total thickness is unknown, as the base of the Timber Creek Formation is not exposed, but about 800 feet of Bullita Group is exposed on the Auvergne 1:250,000 sheet area. The Bynoe Formation crops out on neighbouring sheet areas, but not on the Auvergne Sheet area.

Timber Creek Formation

Distribution

The Timber Creek Formation on the Auvergne 1:250,000 Sheet area crops out in an area of about 200 square miles to the south and south-west of Timber Creek store in the south east corner of the sheet area. It is exposed in the scarps and valleys below the Jasper Gorge Sandstone and is almost flat lying,

From the Auvergne Sheet area this unit extends to the east onto the Delamere; and to the south onto the Waterloo Sheet areas.

Derivation of name

The name Timber Creek Formation was originally given by Laing and Allen (1956) to what they considered to be a lateral facies variant of the Skull Creek Formation. This name is retained. The extent of the unit as defined by Laing and Allen is slightly greater than mapped in 1967, but the general reference area is the same.

The name is derived from Timber Creek, a tributary of the Victoria River, and also the name of a small settlement on the main highway on the Auvergne 1:250,000 Sheet area.

Reference area

The type section is in the scarp about one mile west-north-west of the Timber Creek store.

Stratigraphic relationships

The stratigraphic relationships with the Skull Creek Formation are discussed in the section on the latter formation. The base of the Timber Creek Formation was not observed in the Auvergne Sheet area but may be defined in subsequent mapping of areas to the south and east.

Lithology and thickness

The Timber Creek Formation is well exposed in a scarp formed by a water fall about 1 mile west-north-west of the Timber Creek store. The sediments are almost flat lying; the scarp is about 400 ft. high, and is capped by Jasper Gorge Sandstone. Timber Creek Formation is exposed in the lower 250 feet and for 20 feet just below the Jasper Gorge Sandstone.

The lower 250 feet of the sequence consists of thin-bedded intercalated bands of the following rock types, listed in approximate order of abundance.

(a) Silty dolomite and dolomitic siltstone.
(b) Fine to very fine quartz sandstone.
(c) Fissile siltstone and mudstone.
(d) Dolomite

These rock types and combinations of them are thin bedded to laminated, they form bands up to 10 inches thick which are consistent along strike for up to 200 feet. The bands are intercalated, and random alternation of them makes up the exposed 250 feet forming the scarp.

The silty dolomite may be laminated or massive, it is extremely fine-grained and greenish grey or reddish brown. Commonly it contains chocolate mud flakes up to 1 mm. across, but excepting the mud flakes the rock is fairly well sorted and homogeneous.

Fig. 7 "Layer Cake" topography in rounded hills of Timber Creek Formation. Thin hard bands are mostly dolomite. Gentle slopes, dolomitic siltstones and siltstone. Flat top of hills in far distance, Jasper Gorge Sandstone.

Photo looking NW from Bullita track, ½ mile south of Katherine road intersection.

GA/521(I.R.P.)

Fig. 8 Section through Timber Creek Formation in cliff ½ mile NW of Timber Creek Store. Shows thin-bedded sequence of siltstone, sandstone and dolomite. Scale indicated by persons arrowed.

GA/513(I.R.P.)

In thin-section the dolomitic siltstone (ore silty dolomite) consists of silt-size quartz grains vemented by a fine-grained dolomitic matrix. In some bands subhedral crystals of dolomite up to 0.2 mm. form small agregates, and in places they form trains along bedding planes. Up to 5% barite in small lenses localised along bedding planes was found in one section. Common accessory minerals are tourmaline, zircon, sericite, chlorite and feldspar. It is common to find slight variations in grain size, and in the amounts of silt and carbonate between lamellae and fine lenses in any one specimen.

The fine sandstone is thin bedded and laminated and only contains minor dolomite. It commonly shows ripple marks and fine-scale cross-bedding. Very fine sand lamellae within dolomite bands are common and these show very fine sets of migrating fore set beds, and small cut and fill structures.

The siltstone and mudstone are characteristically chocolate, grey-green and green. Thay are fissile and mud flakes are common; pseudomorphs after halite and preserved mud cracks are also present.

The dolomite consists of extremely fine-grained massive dolomite grains. It contains minor disseminated and broken trails of silt size quartz grains. Thin bands of chert up to ½" thick occur in some dolomite beds.

The 20 feet exposed below the Jasper Gorge Sandstone consist of siltstone and mudstone which are reddish brown, grey, and laminated at the top and grade down into thin-bedded reddish brown dolomite which form bands up to 2 feet thick.

Elsewhere near Timber Creek exposure of this formation below the Jasper Gorge Sandstone is generally poor. One exception is a cliff on the south side of the Victoria River, 3 miles N.N.E. of the Timber Creek store which shows a similar sequence to the lower part of the exposure described above.

A rock bench at water level, adjacent to the junction of Timber Creek and the Victoria River, consists of a buff-grey dolomite containing irregular bands up to 2 inches thick of black chert. The chert consists of cryptocrystalline chalcedonic silica, probably recrystallised. The enclosing dolomite is crystallised. Although black chert may contain recognisable organic forms the recrystallisation of this rock probably destroyed any such organisms.

About ½ mile south east of Timber Creek Police Station, on the east bank of Timber Creek about 40 feet of predominantly grey green and purple, laminated and thin-bedded siltstone is overlain by about 15 feet of dolomite. The dolomite forms bands up to about 4 feet thick, which are thin bedded, silty, pock marked and contain fairly abundant chert. The chert forms highly irregular bands and nodules. Funnel-shaped structures, of finely laminated chert which are concave upwards and cut across the bedding of the enclosing dolomite (see fig. 10) may be stromatolites which have been replaced by chert or possibly chert-filled solution cavities.

The following section was measured through the Timber Creek Formation on a hill about 4 miles south south east of the store.

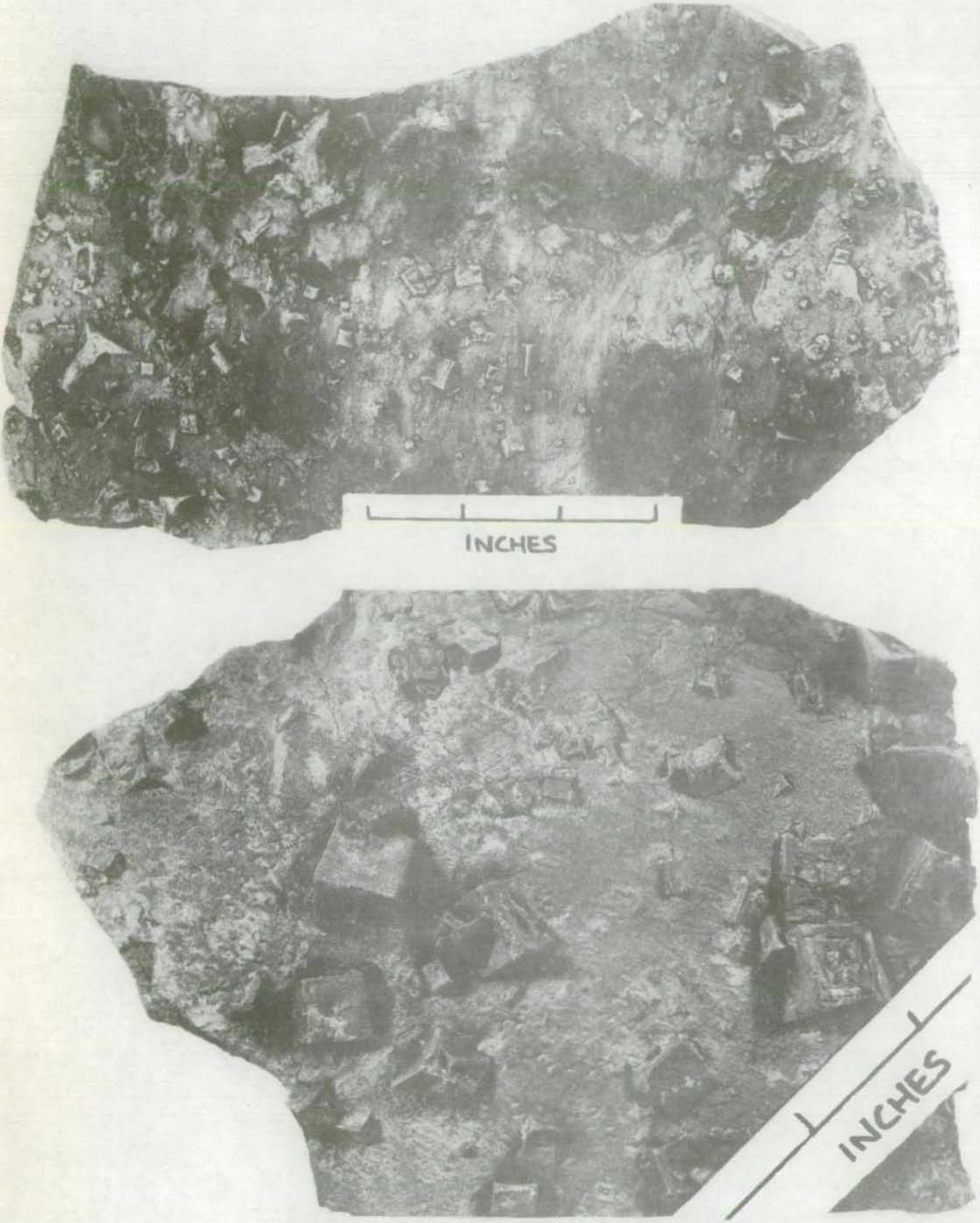


Fig.9 Halite casts and mud-flake moulds in very fine sandstone in Timber Creek Formation.

GA/845
GA/843 (I.R.P.)

Fig. 10 Chert, replacing stromatolite structures, or possibly filling solution cavities in massive dolomite band in Timber Creek Formation $\frac{1}{4}$ mile south-east of Timber Creek Police Station.

GA/499(I.R.P.)

Thickness (ft)	Top of hill Jasper Gorge Sandstone
85	Mostly no exposure; apparently soft weathering ? siltstone Several discontinuous dolomite bands up to 1ft. thick.
4	Thin dolomite band protecting dolomitic siltstone.
27	Mainly fine-grained sandstone; fissile siltstone, 5 to 10% easily eroded, minor hard thin bands of dolomite.
7	Dolomite: pinkish, silty; in 2ft band associated with easily eroded calcareous siltstone.
27	Mainly siltstone and dolimitic siltstone: thin-bedded and interbanded, bands upto 3 ft. thick. Thin bands dolomite up to 4 in. contain chert. One distinctive band of granule (feldspathic) dolomite. Well rounded and spherical grains of quartz and feldspar (total 35%) in microcrystalline matrix of dolomite. 2 generations of quartz grains, ? one aeolian. (Band of identical rock found about 50 ft below Jasper Gorge sandstone in scarp due east of Timber Creek Police Station.)
5	Dolomite: grey, thin-bedded, undulating bedding. Forms small cliffs. Contains lenses of chert up to 10 in. long. Thin interbeds fine sandstone with halite casts.
48	Intercalated bands of siltstone (bands up to 3 ft.); dolomite containing minor chert (2 in. to 4 in. bands); chocolate silty mudstone (2 in. to 3 in); fine sandstone and siliceous siltstone
10	Siltstone, interbanded (encrusted with secondary limestone) and dolomite in bands up to 3 ft.
4	Interbedded dolomite and very fine grained feldspathic sandstone: thin bands 2 in to 3 in thick.
51	Interbanded silty dolomite thin flaggy dolomite, light brown sandstone. Dolomite in bands up to 2 in thick.
Total 268 ft.	Base of hill

A section measured through 320 feet of Timber Creek Formation six miles south-south-west of Timber Creek store showed the following:

Thickness (ft)	Top of hill
50 +	Alternating flaggy dolomite and light purple, fissile siltstone and shale.
80	Dolomite: massive and blocky, contains minor silt and sand. Ripple-mark laminations and halite casts.
5	Sandstone: very fine-grained, purple-brown, indurated. Fine-scale cross bedding and contorted (slumped) laminae.
20	Dolomite: massive, silty. Minor interbedded white friable siltstone. Halite casts and minor small chert lenses.
135	Mostly dolomitic siltstone. Some dolomite: fissile to flaggy, very fine grained.
5	Quartz sandstone: flaggy, fine-grained.
15	Dolomite: massive, laminated, slightly recrystallised. Contains numerous sub-spherical and elongate chert badies up to 1 ft across. Bedding laminations continue through them and are contorted within them.
10 +	Sandstone: fine-grained, light brown, contains mud flakes and pellets.
Total 320 ft.	Base of hill

These sections are typical of the Timber Creek Formation south of Timber Creek. The beds in the area are flat lying and exposures in shallow creeks indicate that the general plain level coincides with a distinctive tough, dark brown, dolomitic and feldspathic sandstone which is medium bedded to massive. It comprises about 50% fine sand grains cemented by an extremely fine-grained aggregate of dolomite. Dolomite also forms discrete crystals and small aggregates up to 3 mm. long. The dolomite crystals weather out to give the rock a pitted surface. The rock may contain up to 10% feldspar, and accessory tourmaline, sericite and secondary iron oxides.

Dolomite layers and, less commonly, quartz sandstone beds form the hard bands imparting the layer-cake topography to the otherwise gentle slopes of the Timber Creek Formation.

Generally the lower part of the sequence is predominantly silty and the upper part, about 150 feet, is carbonate rich.

Samples of carbonate rock from the Timber Creek Formation were chemically analysed to determine their CaO/MgO ratio.

The results are:

Field No.	Location				Insol. Residue	CaO Wt.%	MgO Wt.%	CaO/MgO
P156H	lat.	15°37'	long.	130°27'	34.8	19.5	14.9	1.31
P156D	"	15°37'	"	130°27'	22.1	24.6	16.5	1.49
P382E	"	15°44'	"	130°29'	10.2	23.5	19.0	1.23
S155A	"	15°40'	"	130°27'	20.5	24.0	16.5	1.45
S155B	"	15°40'	"	130°27'	34.8	19.5	14.9	1.30

The CaO/MgO ratios indicate that these rocks are essentially dolomites. (The CaO/MgO ratio in pure dolomite is 1.40) P382E and S155A probably contain some magnesite. A comparison in hand specimen and thin section of other carbonate rocks from the formation, with the five analysed samples indicates that all the carbonate rocks are dolomitic, and contain variable amounts of clastic impurities.

Skull Creek Formation

Distribution

The Skull Creek Formation is exposed within an area of about 300 sq. miles in the extreme south-east part of the Auvergne Sheet area. This is only a small part of this unit which covers a large portion of the centre of the Victoria River Basin.

Derivation of name

The Skull Creek Formation was included in the Victoria River Group by Traves (1955) but it was not named separately by him. Laing & Allen (1956) named it the Skull Creek Limestone. However the composition of the unit on the Auvergne Sheet area, at least is not predominantly limestone; almost all of the carbonate rocks is dolomite, and in places it contains considerable amounts of siltstone.

Therefore the name Skull Creek Limestone is abandoned and the unit is formally renamed Skull Creek Formation.

Reference area

The type section of Laing and Allen (1956) is in the domes on the Timber Creek - Jasper Gorge road, 20 miles from the Timber Creek Police Station, on the Victoria River Downs 1:250,000 Sheet area. The formation takes its name, from Skull Creek which passes between two of the domes near the type section in a gap between the western two domes.

Components

Thick irregular masses of laminated and brecciated chert occur at the top of the Skull Creek Formation. They have been mapped as the Bardia Chert Member.

Stratigraphic relationships

The stratigraphic relationships of the Skull Creek Formation and Timber Creek Formation are closely related.

Laing and Allen (op cit.), considered the Timber Creek Formation was a silt-dolomite facies variant of the Skull Creek Limestone. They state that the boundary is gradational but have defined it where more than 10% siltstone enters into a predominantly limestone section.

On the Auvergne Sheet area the boundary between these two units, or the differentiation between them using Laing and Allen's definitions, could not be substantiated.

There is undoubtedly a considerable facies change within the area, from mainly carbonate in the extreme south-east of the Sheet area to predominantly silt in the areas underlying the Jasper Gorge Sandstone to the northwest. It is possible that the boundary between these rock types is gradational but its position has not been positively fixed. There is some evidence on the Delamere Sheet area however that the Skull Creek Formation, conformably overlies the Timber Creek Formation, This will be checked by later mapping.

There is no <u>distinctively</u> different photo pattern between the two formations and in most places on the Auvergne Sheet area the Skull Creek Formation contains more than 10% silt or sand fraction. However field observations do provide some basis for interpretating a boundary between a predominantly silty and a mainly carbonate sequence from air photos.

Such a boundary has been tentatively mapped on the Auvergne Geological Sheet. For the present, the name Timber Creek Formation has been retained for the unit, north and west of the boundary, and Skull Creek Formation has been retained for the unit southeast of it.

The Skull Creek Formation contains a large amount of chert. Thick irregular masses of chert are interbedded with the Skull Creek Formation mainly in the western part of the Delamere Sheet area, but smaller bodies occur in the Auvergne Sheet area. This massive chert lies near the top of the Skull Creek Formation and its distinctive lithology, mode of occurrence, and pattern on air photos enables it to be mapped as a member of this formation.

<u>Lithology and Thickness</u>

The Skull Creek Limestone as defined by Laing and Allen consists of about 1000 feet of dolomitic limestone, chert and very minor amounts of quartz sandstone and siltstone.

On the Auvergne Sheet area the Skull Creek Formation was mainly examined near the eastern margin of the Sheet where access is obtained with some difficulty from the Bullita track. Here, a maximum of 415 feet was measured but between Coolibah Station and Timber Creek, on the Delamere Sheet area, it measures up to 700 feet thick.

The exposure on the Auvergne Sheet area is generally poor: much of it is flat or moderately undulating and the surface consists of large scattered remnant flaggy blocks or broken flat-lying beds of dolomite. The maximum vertical section exposed in these areas is about 30 feet. Where the unit is preserved by overlying sandstone and chert, and in rare areas of steeply dipping beds, a vertical section of 400 feet may be seen.

The Skull Creek Formation consists essentially of grey, thin-bedded, flaggy and massive, silty and sandy dolomite, minor dolomitic fine-grained sandstone, minor flaggy and blocky relatively "pure" dolomite. The sandy dolomite on its weathered surface is dark coloured and shows fine-scale sedimentary structures, rare shrinkage cracks and pseudomorphs after halite. The more "pure" dolomite has a smooth weathered surface which in places shows insipient development of fluting.

The following section was measured through the Skull Creek Formation at lat. 15° 56'S long. 130° 26'E, (Auvergne Sheet area just south of Barrabarrac Creek, see fig. 11).

THICKNESS (ft)		TOP OF HILL
55	Sandstone: reddish, light brown, thin to medium-bedded, fine to medium-grained. Ripple marks and fine to medium-scale cross bedding in places. Rare mud-flake cavities. This forms top of hill	Jasper Gorge Sandstone 55 ft.

Fig. 11 Skull Creek Formation: interbedded dolomite bands, silty dolomite, and dolomitic siltstone. Dolomite contains bands and lenses of chert.

From section at lat 15°56' long 130°26'

GA/500(I.R.P.)

Fig. 12 Skull Creek Formation: dolomite bed from base of section measured 10 miles south of the Bullita-Katherine road intersection.

GA/970(I.R.P.)

THICKNESS (ft)		TOP OF HILL
15	Chert: poor exposure, thin, irregularly banded, grey, Brecciated, highly irregular loosely cemented lumps. Solid bands up to 3 feet thick commonly standing on end.	
10	No outcrop, rubble of chert and fine-grained quartz sandstone	Bardia Chert Member of the Skull Creek Formation.
6	Chert: poorly defined band, highly contorted and brecciated, thin-banded, with yellow ochreous earthy material along and across bands	65 feet of this irregularly banded, contorted and brecciated chert, with minor ochreous earthy material.
35	Mainly rubbly scree and boulders of irregularly thin bedded chert. Appears to be weathered chert band (bed). Abundant small cavities along banding containing yellow ochreous clay and manganese oxides.	
20	No outcrop. (possibly siltstone). Rubbly scree cover of chert and some fine grained sandstone.	
71	Silty dolomite: grey, thin-bedded and flaggy, forms hard bands up to 1 feet thick. These show shallow ripple marks. Some partly silicified and contain minor chert; some drusy cavities after calcite. Intercalated with siltstones, commonly encrusted with secondary limestone. Carbonate forms 60% of this section.	Skull Creek Formation
3	Dolomite: hard band, grey thin bedded, with interbands of chert.	153 feet of mainly dolomite with intercalated siltstone.

THICKNESS (ft)	
5	Dolomite: grey, thin-bedded with chert as below. Interbedded weathered grey ? calcareous shaley siltstone.
4	Dolomite: hard band, grey, thin-medium bedded. Contains lenses of chert up to 6" x 2" and bands of chert ½" thick. Spotted with small crystals of dolomite.
50	Dolomite: thin-bedded, grey, minor chert, exposed through basal scree slope which forms the bottom of the hill.
6	Silty dolomite: Small scarp formed by 5 bands of flaggy pinkish, brownish-grey, interbedded up to 1 ft., intercalated with thin bands of dolomitic and fine-grained sandstone.
53	Fine-grained dolomitic sandstone in bands of up to 15 ft. Interbedded with calcareous siltstone and silty dolomite.
3	Small scarp of dolomite: grey-pink, thin bedded, flaggy, minor segregations of dolomite crystals. Irregular chert bands.
150	Basal slope of scarp. No rock exposure.

Total 408 feet

The following section is a composite section comprising a lower carbonate sequence which forms a low "lay-cake" banded hill, and a sequence about 2 miles north which is almost certainly continuous with and stratigraphically higher than that in the banded hill. The outcrops are all on the Delamere Sheet area south of the Bullita - Katherine road intersection. The thicknesses are estimated only.

Thickness (ft)	Lithology
	<u>Top of ridge</u> consists of highly brecciated, banded <u>chert</u>. Where bands preserved, orientation mostly at random. Generally rectangular banded chert fragments of various sizes and colours in reddish cryptocrystalline siliceous matrix. Poorly defined bands at base roughly conformable to underlying dolomite. -<u>Bardia Chert Member</u>.
100	<u>Dolomite</u>: 3 to 4 ft bands, massive to flaggy; discontinuous chert bands ½" thick. Intercalated with purplish grey <u>silty dolomites</u> and dark weathering <u>calcareous siltstone</u>.
20	<u>Dolomite</u> containing abundant <u>chert</u>, chert dominant toward top. Some bands consist of angular chert fragments in a light brown cryptocrystalline siliceous matrix.
60 to 100	<u>Dolomite</u>: purplish grey, cherty, overlain by about 20 ft. band of <u>chert</u>: massive, irregularly nodular and bedded.
50	<u>Microcrystalline dolomite</u>: light brownish-grey, massive contains very thin plates and scales of <u>chert</u> along bedding. Rare <u>silt</u> rich bands up ½ inch.
60	<u>Silicified dolomite</u>: several bands up to 3 ft thick distinctive, spotted, pinkish - grey, massive. Spots consist of enhedral crystals of dolomite (up to 2 mm. across) in a microcrystalline dolomitic matrix. Bands of <u>chert</u> up up to ½ in, in dolomite. These bands intercalated with silty dolomite and siltstone, which make up about 75% of this unit.
15	<u>Dolomite sandstone</u>: pinkish-brown, thin-bedded, fine-grained, cross-bedded, several bands up to 2 ft. thick.
20	<u>Dolomite</u>: massive, thin-bedded, banded. Minor <u>chert</u>.
6+	"<u>Pure dolomite</u>". grey, massive. Weathered surface light grey and shows thin bedding with fine-scale crossbedding, ripple troughs and minor convolute bedding structures. This forms the base of hill.

On the Waterloo Sheet area, the Bullita track crosses a steeply dipping sequence of mainly carbonate rocks about ¼ mile wide.

The lowermost bed is a light brown friable thin-bedded sandstone about 6 feet thick. It is overlain by about 200 feet of thin-bedded dolomite, silty dolomite and dolomitic siltstone. These rocks show small-scale sedimentary structures and chert is associated with the carbonates. Overlying them is a fairly distinctive 20-foot band of purplish grey cherty dolomite which is overlain by about 20 feet of massive, irregularly nodular and bedded chert.

These steeply dipping beds form the elbow of a monocline which runs in a long sinuous line up to 25 miles long and $\frac{1}{4}$ mile wide; such structures are common in the Skull Creek Formation. The flatlying beds adjacent to this monocline consist of grey to buff thin-bedded cryptocrystalline dolomite in bands up to 4 feet thick, intercalated with thinner dolomite and silty dolomite bands. The dolomite contains irregular bodies and bands of chert. The sequence imperceptibly grades in places into predominantly thin-bedded dolomitic siltstone, associated with minor siltstone.

The total carbonate content in the formation in this area is apparently greater than in the same formation to the north on the Auvergne sheet area.

The following section was measured in the Skull Creek Formation at lat. 15° 58' long. 130° 18', (Auvergne Sheet area, six miles upstream from East Baines Gorge).

LITHOLOGY

Thickness (ft)	Top of Hill	
30	Sandstone: scattered o/c, flaggy and blocky, white - reddish, medium to coarse-grained, friable in places. Forms prominent band.	Jasper Gorge Sandstone
20	Lower distinct band of some sandstone	50 ft.

Thickness (ft)	Top Of Hill	
5	Chert: whitish-grey, medium bedded, breciated.	
10	Silty sandstone: thin-bedded. Contains pseudomorphs after halite. Also spiral fossil & possible jelly fish imprints. (Forms considerable bench at top of hill, below upper sandstone bands)	Bardia Chert Member of Skull Creek Formation 27 ft.
12	Chert: thin-bedded, black and grey, banded. Commonly brecciated and contorted.	
31	Intercalated dolomite: grey, thin-bedded, flaggy, contains irregular bands and pockets of chert, and dolomitic siltstone	
60	Soft weathering band. (? calcareous siltstone) Several minor thin bands dolomite, and intercalated remnants of thin-bedded, tough, fine-grained cross-bedded dolomitic sandstone	Skull Creek Formation 408 ft.
15	Dolomite: grey, flaggy to massive. Some bands very fine-grained, some medium to coarse-grained. Contorted folding and crenulated slump-like structures in some interbeds; (p) interformational folding. Top 4 ft contains highly irregular pock-marked chert bands.	
10	Dolomite and silty dolomite: medium-bedded, pink-grey, flaggy, irregular bands of chert up to 2" thick, often lens-like.	
14	Intercalated grey silty dolomite and dolomitic limestone in bands up to 2 ft. thick. Also bands of dolomitic sandstone: pinkish grey (weathers blackish), fine grained, cross bedded, in bands up to 10" thick.	
12	Small scarp of dolomite: pinkish-grey, flaggy to massive. Interbeds of variants rare, hence continuous scarp. Top of scarp caused by introduction of sand and silt into sequence.	

Thickness (ft)	
25	Mainly <u>dolomite</u>: pinkish-grey, flaggy to massive. Contains beds up to 3 ft. thick of chocolate-grey calcareous mudstone which contains rectangular fragments of silty dolomite which are broken, slightly displaced, bands
8	<u>Dolomitic siltstone and silty dolomite</u>: brownish-grey, bands up to 10" thick. Interbedded with thin bands (4" - 6") whitish-grey laminated <u>limestone</u>.
21	<u>Dolomitic sandstone</u>: light brownish-grey, fine grained, thin bedded, flaggy, forms bands up to 15 ft. Interbedded with light grey <u>calcareous silt stone</u> and laminated <u>limestone</u>.

Samples of the carbonate rock from the Skull Creek Formation were analysed to ascertain their CaO/MgO ratio. These ratios indicate that they are essentially dolomites.

Field No.	Location	Insol. Residue wt%	CaO wt%	MgO wt%	CaO/MgO
P355A	Lat. 15° 47', long. 130° 31'	23.1	23.9	16.5	1.45
P355C	" " " "	57.0	12.3	9.80	1.26
P356	" " " "	3.5	31.3	19.45	1.61
P390D	Lat. 15° 55', long. 130° 10'	21.1	24.0	16.5	1.45

Specimen P356 was described in hand specimen as "pure" dolomite i.e. it contained no apparent sand or silt. The insoluble residue in P355A is mainly chert. P355c is a dolomitic fine-grained sandstone. P390A is dolomite and interbedded silty dolomite.

Bardia Chert Member

Distribution

On the Auvergne Sheet area the Bardia Chert Member forms several rather elongate, isolated hills within the Skull Creek Formation. It has a fairly distinctive photo pattern and its presence has been photointerpreted in the inaccessible southern margin of the Sheet area where it forms the cappings of some hills. (Jasper Gorge Sandstone caps other hills in the same area).

Mount Dempsey consists of up to 100 feet of Bardia Chert and associated sandstones. Massive chert is also localised along a fault in the Timber Creek Formation, 15 miles south east of Auvergne homestead.

Massive chert is far more extensive in the western part of the Delamere Sheet area, and also in the northern part of the Victoria River Downs Sheet area (e.g. it is readily seen where the Katherine road crosses Skull Creek). The mapping of the massive chert in these areas will provide a more complete definition of the member and may also establish a more appropriate reference area for the unit than is known on the Auvergne Sheet area.

Derivation of name

The Bardia Chert Member is named after Bardia Yard in the S.W. corner of the Delamere Sheet area.

Reference area

The reference area is a prominent ridge on the western boundary of the Delamere Sheet area, 4 miles south of the Katherine and Bullita roads.

Lithology and relationships

In the areas of the previously described sections of Skull Creek Formation, the Bardia Chert Member consists of white, grey and red-brown, extremely fine-grained chert; it is generally banded. The banding is distorted in places by contorted folding; more commonly the chert is brecciated, and angular, rectangular fragments of banded chert have been displaced and cemented by chalcedonic silica; all processes apparently have taken place in situ. Voids and drusy cavities lined with chalcedony and very fine quartz crystals are common. In the section at lat. 15° 56', long 130° 26' cavities and interbeds consisting of ochreous-looking clay are common. Also in this area, a remnant hill in an equivalent stratigraphic position to the near-by chert member consists almost entirely of brown and yellowish banded "mudstone", containing minor siliceous areas. The mudstone may have been the original rock-type which the chert has replaced in other areas. Alternatively the "mudstone" is an alteration product of the chert.

Mount Dempsey is formed by highly brecciated chert and light brown silty, sericitic chert which is interbedded with silicified sandstone. The sequence is in a faulted anticline adjacent to four intersecting photo-linear features and it is surrounded by lower lying, essentially flat, dolomite of the Skull Creek Formation. The chert is non-banded and massive and it consists of a microcrystalline aggregate of silica which contains about 15% of detrital silt-size quartz, sericite grains, and diffuse lenses of clay. It is likely that the rock is a silt or mudstone which has been replaced by chert. Well preserved pseudomorphs after halite up to $\frac{1}{2}$ inch across are common on weathered surfaces. The sandstone is a silicified, heterogeneous labile sandstone which contains minor amounts of altered feldspar. Bands in the sandstone contain abundant elongate to globular mud pellets and pseudomorphs after halite.

It is difficult to estimate the thickness of the member at Mount Dempsey, because of its structural situation. Also the boundaries between the chert and silicified sandstone are vague.

Although the dolomite of the Skull Creek Formation which underlies the chert member contains bands and lenses of chert, there is no apparent increase in the abundance of chert towards the base of the chert member.

In two of the sections measured, Jasper Gorge Sandstone directly, and apparently conformably, overlies the chert member. In the section at Lat. 15° 58' long 130° 18' a 10 foot band of reddish, thin bedded silty sandstone lies within the chert member. This sandstone contains fine-scale cross bedding, ripple marks, pseudomorphs after halite and moulds of possible fossil jellyfish and of a peculiar spiral soft bodies animal form (see fig. 15). The spiral mould is almost certainly the same type as previously described by Opik (1957).

Several elongate hills in the general area six miles south-west of Twelve Mile Water Hole (western margin of Delamere 1:250,000 Sheet area) consist of up to 100 feet of chert. The chert forms the upper three quarters of each hill, resting on Skull Creek Formation which makes up the lower quarter and the surrounding plains. The chert is massive but forms crude bands several feet thick, which tend to strike parallel to the axis of the hill they form, and also dip fairly steeply towards the centre of the hill. The chert at the ends of each ridge also dip toward the centre of the hill, forming an elongate basin structure. Along the spine of some ridges the chert bands (which may be laminated) are nearly vertical. These attitudes are not reflected in the underlying Skull Creek Formation sediments which are flatlying or dip very gently.

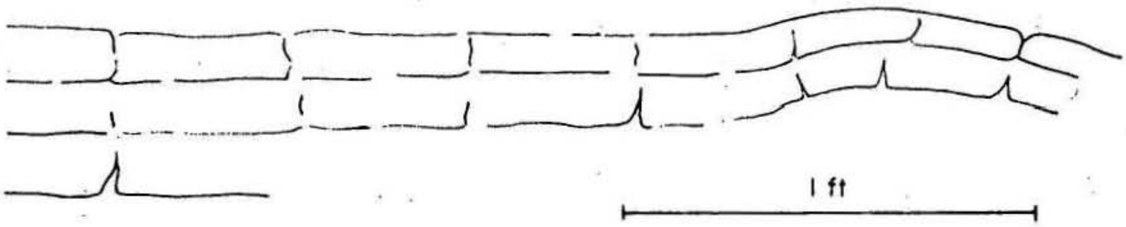
It is suggested that the chert originally overlay the Skull Creek Formation conformably. Leaching, and possibly incipient sink-hole development, of the dolomite immediately below the chert, caused collapse and subsidence of the chert into cavities, which produced the steep dips and breccia textures in the chert.

Fifteen miles south-east of Auvergne homestead banded and brecciated chert form a ridge about 5 miles long adjacent to a prominent strike fault. The chert occurs at the top of the Skull Creek Formation, and is overlain by a distinctive conglomerate at the base of the Jasper Gorge Sandstone. The sequence forming the ridge dips steeply to the north, but within one hundred yards either side of the ridge the rocks have a maximum dip of 10°.

A generalised section of the sequence forming the ridge on the south side of the strike fault is: (- See Table on Page 52.)

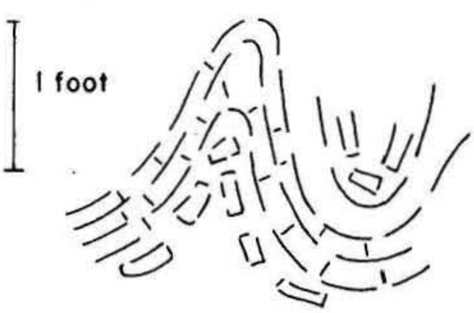
The chert forming the Bardia Chert Member in this sequence occurs in a variety of structures as shown in the following diagrams.

1. Regularly bedded chert.



This chert tends to be flaggy and weathers into blocks from $1\frac{1}{2}$ to 2 inches thick. Banding is defined by variation in colour from white, light grey, cream and pale brown. (see fig. 13).

2. Folded bedded chert



In places the chert is folded; the sequence of folding ranges from gentle undulations to almost isoclinal folds. (see fig. 14).

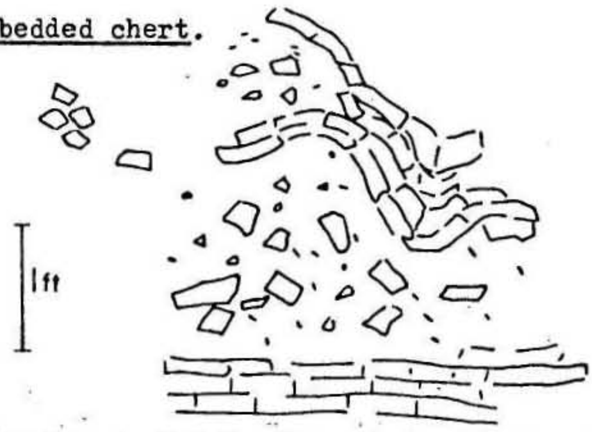
Fig. 13 Banded chert, Bardia Chert Member, 15 miles south-east of Auvergne homestead.

GA/554(C.M.M.)

Fig. 14 Folded and brecciated chert, Bardia Chert Member, 15 miles south-east of Auvergne homestead.

GA/545(C.M.M.)

3. Folded and disrupted bedded chert.



On some horizons the bedding is completely disrupted. Blocks of chert are randomly oriented or maintain some degree of position and orientation giving an indication of the original banding (or bedding).

The matrix between the chert fragments is white or purple-stained chert. In some bands the matrix is a very fine-grained silicified sandstone.

In places chert beds form massive boulders up to 15 feet in diameter, although generally the outcrop is flaggy.

Thickness (ft)	Top of Ridge	
360 maximum measured	Sandstone: white, blocky, thin-bedded, medium to coarse-grained. Interbeds of coarse sandstone. Tends to form thick bands on a lower sandstone shelf.	Jasper Gorge Sandstone 410 ft. (estimated thickness)
50 maximum	Sandstone: white, blocky to flaggy, medium to thin-bedded, fine to medium-grained, rather friable. (Tends to form lower bench)	
variable from 2 to 10	Interbedded sandstone and conglomerate. The conglomerate beds up to 2 inches thick, has a sandy matrix and clasts of quartzite, chert, and clay.	Basal Conglomerate Jasper Gorge Sandstone 20 ft. maximum
maximum 10 (Very limited extent)	Mixed conglomerate (as above) and chert breccia.	

25	Banded chert, commonly disrupted and folded.	
4	No out crop	
3	Bedded chert	
2	Feldspathic sandstone: light purple, thick bedded, poorly sorted, coarse grained. Containing angular chert fragments at the base, less common and smaller near the top.	Bardia Chert Member
2	Sandstone as above: medium to coarse-grained. No chert but feldspar grains up to 4 mm.	59 ft.
1	Bedded Chert.	
6	No out crop	
16	Bedded Chert. Folded but not disrupted. Intermittent disrupted bands.	

Minimum 25	Interbedded fissile to flaggy dolomitic siltstone and flaggy thin-bedded sandy dolomite.	Skull Creek Formation.

Base of Section

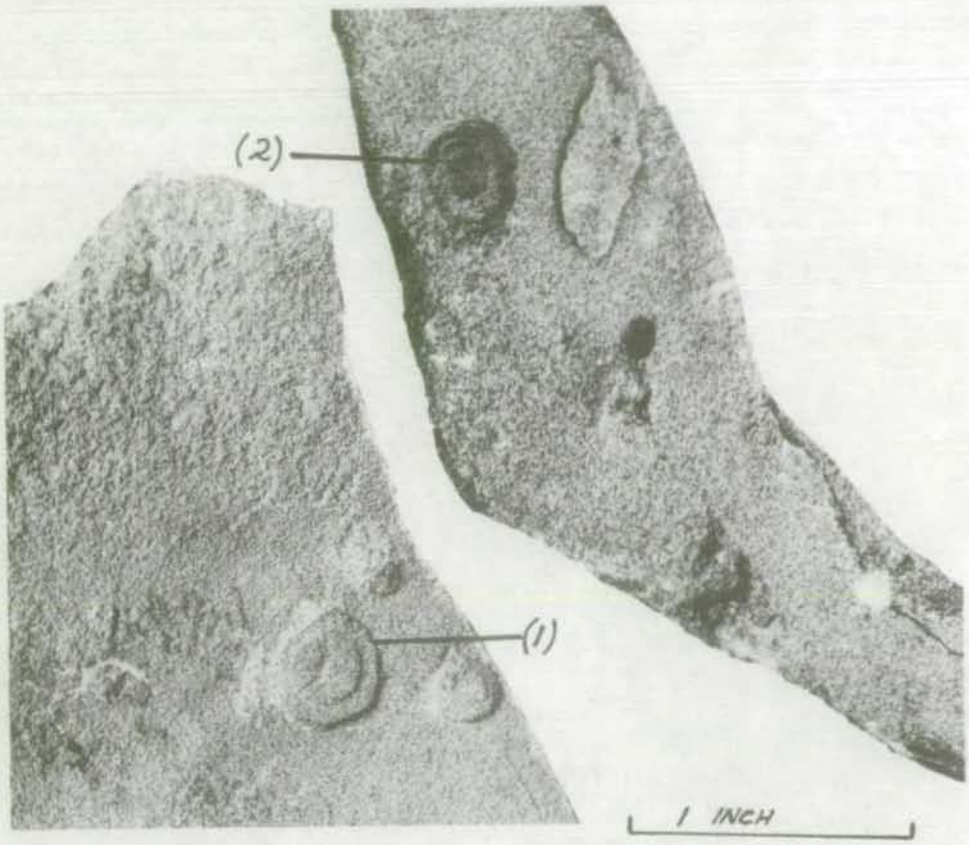


Fig. 15 Moulds of ? fossil jelly fish (1) and peculiar spiral shaped fossil (2) in a thin sandstone bed associated with chert in the Bardia Chert Member at lat. 15°58', Long. 130°18'.

GA/842(I.R.P.)

<u>Palaeogeographic significance of Timber Creek and Skull Creek Formations</u>

The Skull Creek and Timber Creek Formations only cover a small part of the Auvergne Sheet area, relative to their whole extent. It is apparent that both formations were deposited in a quiet, marine, shallow water environment which extended over a slowly subsiding stable shelf. The carbonate rocks are essentially chemical deposits. The contribution of carbonate in the form of algal growth is minor.

The predominance of silt and very fine sand intimately associated with dolomite in the Timber Creek Formation and the sedimentary structures found in these rocks, suggests deposition under lagoonal conditions, possibly alternating with an intertidal mud-flat type environment. The surrounding areas were probably almost at base level, providing fine detritus.

Some areas, perhaps disconnected basins, were free of mud-silt contamination long enough to allow relatively pure dolomite and chert to form, some with stromatolites.

The rocks forming the Skull Creek Formation contain generally less clay and silt indicating that conditions favourable for a predominantly chemical deposition and the formation of more "pure" dolomite and more abundant chert existed.

Mud and silt were minimal in the Skull Creek Formation sediments but the presence of stromatolites and the sedimentary structures indicate deposition in intertidal waters.

The Bardia Chert Member is probably a horizon of silicification at the top of the Skull Creek Formation, and not a primary chemical deposit.

AUVERGNE GROUP (new name)

Introduction

The summary of the stratigraphy of the Auvergne Group is given in table 6. This group forms most of the Pinkerton and Yambarra Ranges and extends north and east onto the Port Keats, Delamere and Fergusson River sheet areas, and south onto the Waterloo and Victoria River Downs Sheet areas.

Auvergne Group is a new name, derived from the Auvergne pastoral lease which occupies most of the Whirlwind Plains.

The Auvergne Group forms the upper part of the sedimentary rock succession within the Victoria River Basin.

The group comprises seven conformable formations which consist of shale, siltstone, sandstone and dolomite. Its total thickness is about 3,000 feet.

The group unconformably overlies the Bullita Group and is unconformably overlain in part by the Bullo River Sandstone, and in some areas by the Duerdin Group and Antrim Plateau Volcanics. In places the Auvergne Group is thrust-faulted up against Halls Creek Group and the Fitzmaurice Group.

Jasper Gorge Sandstone

Distribution

The Jasper Gorge Sandstone forms the Newcastle Range, a belt up to 20 miles wide across the south-eastern corner of the Sheet area. It has a very gentle regional dip to the north west, dipping below the Whirlwind Plain.

The sandstone extends onto the central parts of the Waterloo and Delamere Sheet areas and the north eastern part of the Victoria River Downs Sheet area.

TABLE 6: SUMMARY OF STRATIGRAPHY - AUVERGNE GROUP (ON AUVERGNE 1:250,000 SHEET AREA)

		LITHOLOGY (in order of abundance)	THICKNESS (maximum in feet)	PHYSIOGRAPHIC EXPRESSION	STRATIGRAPHIC RELATIONSHIPS	REMARKS.
Shoal Reach Formation	Ꞓah	Dolomite, sandy and silty dolomite, minor siltstone and shale.	350	Soft weathering unit, poorly exposed except where protected in scarp slopes by overlying Bullo River Sandstone.	Conformably overlies Spencer Sandstone; probably unconformably overlain by Black Point Member of Bullo River Sandstone.	Becomes thinner towards the N.E. of Auvergne Sheet area where it is rarely preserved.
Spencer Sandstone	Ꞓae	Quartz sandstone, silty sandstone, minor dolomitic sandstone. Mud clasts and minor glauconite common	550	Fairly prominent basal sandstone band, poorly exposed "sub outcrop" and minor step forming for remainder.	Conformably overlies Lloyd Creek Dolomite; conformably underlies Shoal Reach Formation.	
Lloyd Creek Dolomite	Ꞓal	Dolomite, oolitic and stromatolitic, sandy and silty dolomite. Glauconitic.	250	Soft weathering, most common in scarp slopes below Spencer Sandstone, dolomite bands form "layer-cake" structure	Conformably overlies Pinkerton Sandstone; conformably underlies Spencer Sandstone.	Stromalolite content diagnostic of this dolomite formation.
Pinkerton Sandstone	Ꞓap	Massive quartz sandstone, siltstone, minor shale.	300	Scarp and plateau-forming in Pinkerton and Yambarra Ranges. Commonly deeply incised.	Conformably overlies Saddle Creek formation; conformably underlies Lloyd Creek Dolomite.	Generally forms barrier tableland country, very poor vegetation cover, but good surface water.
Saddle Creek Formation	Ꞓad	Basal cross-bedded sandstone, upper siltstone, minor shale and oolitic dolomite.	330	Mainly in scarp slope below Pinkerton Sandstone, basal band usually prominant, upper siltstone very poorly exposed.	Conformably overlies Angalarri Siltstone; conformably underlies Pinkerton Sandstone.	Thin dolomite bands in upper silt. in S.W. areas. Basal band has abundant sedimentary structures. Upper siltstone thins towards N.E.
Angalarri Siltstone	Ꞓaa	Siltstone, grey-green shale; minor dolomitic siltstone, limestone. Glauconitic in places.	1000 (?+)	Soft weathering. Mainly as lower part of scarp slopes, and plains country, cut and exposed by some major creeks.	Conformably overlies Jasper Gorge Sandstone; conformably underlies Saddle Creek Formation	Forms good grazing country of Whirlwind Plains. Green colour distinctive. Thin flaggy limestone beds rare.
Jasper Gorge Sandstone	Ꞓaj	Massive quartz sandstone, minor basal conglomerate, siltstone.	200+	Resistant, plateau and scarp-forming, Deep Gorges.	Unconformably overlies Timber Creek and Skull Creek Formations. (Bullita Group).	Aquifer under Ꞓaa in some areas. Jointing prominant.
			Total 2980+			

In the Newcastle Range it forms flat hill-tops and prominent scarps. Typically steep-sided gorges cut into the sandstone.

Derivation of name

From Jasper Gorge in the Victoria River Downs Sheet area on the road between Timber Creek and Victoria River Downs. The Jasper Gorge Sandstone was first used by Laing and Allen (1956). It is equivalent to the Victoria River Sandstone of Brown (1895), who gave this name to the sandstone in scarps round the lower reaches of the Victoria River. Traves (1955) also called it the Victoria River Sandstone, and included it in his Victoria River Group. The name Jasper Gorge Sandstone is retained rather than Victoria River Sandstone because of the previous multiple usuage of the latter name.

Reference area

The type section chosen by Laing and Allen for the Jasper Gorge Sandstone is the eastern end of Jasper Gorge where about 600 feet of red and white quartz sandstone is exposed.

Components

A distinctive basal sandstone unit is present in the Jasper Gorge Sandstone in many areas. However a distinctive chert-rich conglomerate forms the base of the unit near the strike fault 15 miles south east of Auvergne Homestead. The cherty basal unit is easily recognised on air photos but at this stage it is not proposed to differentiate or name it separately.

Stratigraphic relationships

On the Auvergne Sheet area the Jasper Gorge Sandstone mostly overlies the Timber Creek Formation and partly the Skull Creek Formation. Locally the contact between these units appears to be conformable or slightly disconformable, but on a regional scale there is a low angular unconformity between them.

The Jasper Gorge Sandstone has a fairly consistent shallow dip to the north west where it dips below the Angalarri Siltstone which forms the Whirlwind Plain. The actual contact between the Angalarri Siltstone and Jasper Gorge Sandstone was not seen but the attitude of both units indicates that they have conformable relationships.

Lithology and Thickness

On the Auvergne Sheet area the Jasper Gorge Sandstone has a maximum thickness of about 200 feet, on the sandstone plateau east of the West Baines River.

In the scarps near Timber Creek, the Jasper Gorge Sandstone is consistent in thickness and composition. The following section was measured ½ mile W.N.W. of Timber Creek store. The upper part of the unit is missing from this section.

Thickness (ft)	Top of hill
45	Interbanded silty sandstone: reddish to light brown (on weathered surface), fine-grained; and micaceous siltstone: fissile, poorly bedded. Forms uppermost scarp. Both rock types contain abundant mud-flakes and laminated ripple marks. Intercalated 6 in to 8 in bands of massive hard sandstone.
25	Sericitic siltstone: predominantly reddish, fissile, fine-grained, weathers to platy fragments. Poorly exposed, tends to form a bench on underlying beds.

Thickness (ft)	Top of Hill
33	Sandstone: basal, strongly outcropping, rather massive band. Reddish (weathered surface) massive to medium-bedded, coarse-grained to granule sandstone. In places poorly sorted, some lenses of granule sandstone and fine conglomerate contain accessory feldspar and mud-flakes. The sandstone forms bands 4 to 6 ft thick. Minor intercalated fissile siltstone bands up to 2". Upper beds ripple-marked, some friable. Cross bedding very common, with foreset beds up to 24" thick.
Total 103 ft	

Underlain by Timber Creek Formation

A section was also measured through the Jasper Gorge Sandstone in the head waters of Little Horse Creek.

Thickness (ft)	Top of hill
10+	Sandstone: poorly outcropping, blocky and flaggy, slightly ferruginous.
25	Quartz sandstone: white, blocky, fine-grained.
105	Fine-grained silty and micaceous sandstone. Large-scale cross bedding, abundant primary current lineations.
40	Sandstone: strongly outcropping band, medium to coarse-grained, well rounded grains, slightly argillaceous. Ripple-marked and cross-bedded.
Total 180+	

Underlain by Timber Creek Formation

The sequence along the strike fault 15 miles south east of Auvergne homestead contains a massive conglomerate bed at the base of the Jasper Gorge Sandstone, immediately overlying the Bardia Chert Member. Its thickness varies considerably up to a maximum of 20 feet. It forms a prominent bench which shows clearly on air photographs. Current bedding occurs in coarse sandstone within the conglomerate.

Clasts make up to 50% by volume of the conglomerate: they are heterogeneous in shape, size, composition and distribution. They are angular to sub rounded; many of the larger fragments tend to be tabular; they range in size from coarse sand size to pebbles 2 inches across. The tabular clasts are roughly parallel, and conformable to the bedding. In hand specimen the clasts consist of (roughly in order of abundance):

(a) white and grey chert and fine-grained siliceous meta-quartzite;
(b) soft white claystone (? mudstone or lumps of completely decomposed feldspar);
(c) glossy and bluish opalescent quartz;
(d) sandstone of similar composition to matrix;
(e) accessory small subrounded granules of pink feldspar.

The rock commonly contains voids which are lined by crystals of drusy quartz.

The matrix consists of darkish brown, well rounded, clear quartz grains, average diameter 0.8 mm. They are poorly sorted and all have secondary overgrowths of quartz which almost fill spaces between grains. Between the overgrowths cryptocrystaline silica cements the matrix.

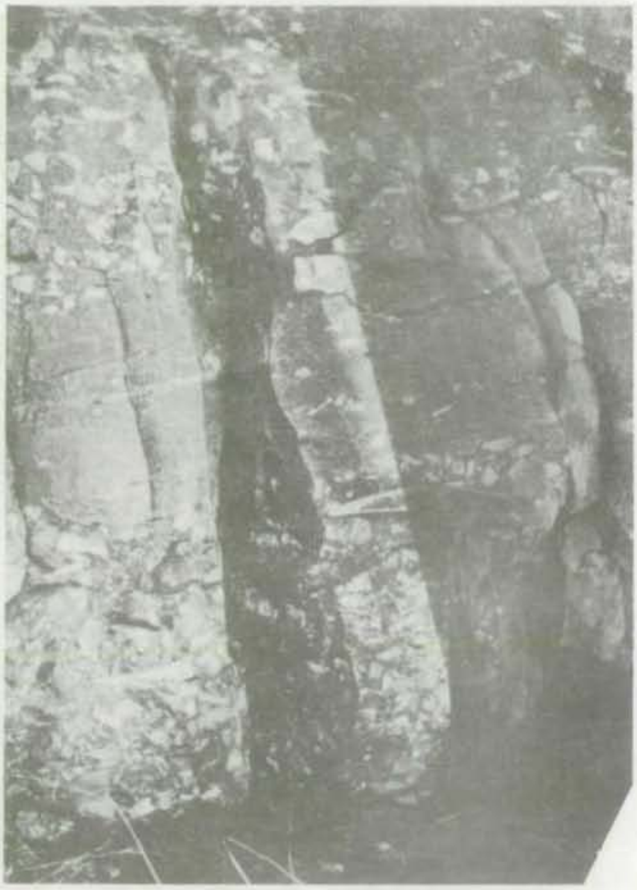


Fig. 16 Bands of predominantly angular chert fragments intercalated with bands of fine-grained sandstone. Matrix between chert fragments is also sandstone. Basal conglomerate of Jasper Gorge Sandstone, 15 miles southeast of Auvergne Homestead.

GA/546 (C.M.M.)

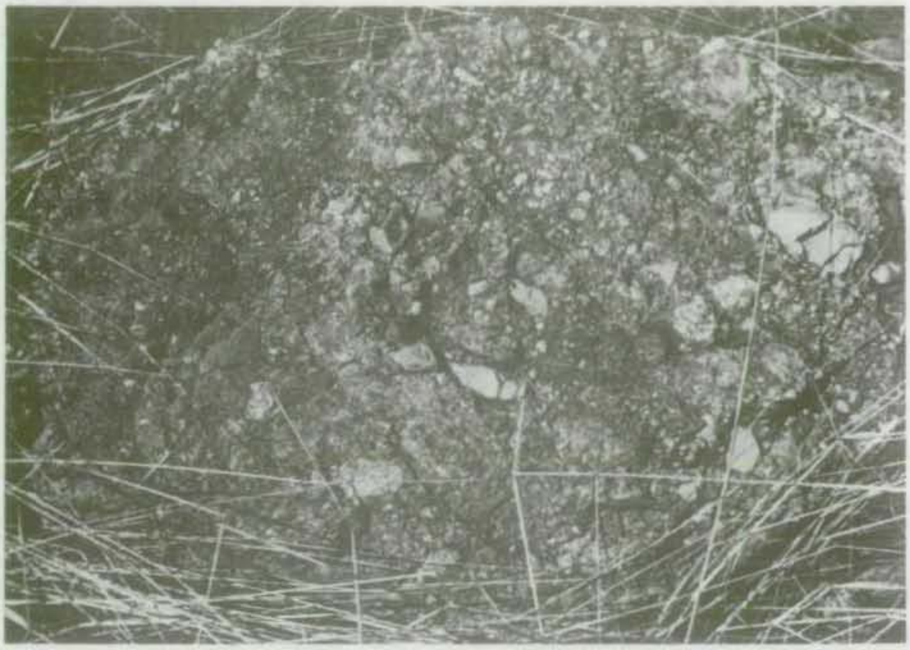


Fig. 17 Basal conglomerate of Jasper Gorge Sandstone. Much poorer sorting than rocks in fig. 16. Fragments are angular to subangular. Matrix is poorly sorted sandstone. About 11 miles south of Timber Creek Police Station.

M/796(I.P.S.)

In some places the conglomerate passes down into mixed conglomerate/chert - breccia which has a maximum thickness of 10 feet; the matrix is coarser and the fragments are more angular and cherty than in the overlying conglomerate.

Near the Timber Creek Police Station several thin pebble bands near the very base of the Jasper Gorge Sandstone suggests the insipient stages of development of the conglomerate described above.

A basal red sandstone band is continuous along most of the scarps in the Timber Creek area. In other areas it is not continuous and as one sandstone bed lenses out another appears just under or over it.

Most sandstone samples from the Timber Creek area are orthoquartzite (Pettijohn, 1957). The basal band contains about 90% well rounded medium to coarse clear quartz grains, with secondary quartz overgrowths. It contains about 10% clouded, and composite grains which were probably derived from volcanic rock or metaquartzites, accessory limonite and matrix.

In more poorly sorted gritty and pebbly sandstones the coarser fragments are poorly rounded and sorted and commonly consist of chert, bluish opalescent quartz, and various rock fragments. Comparatively, the finer sandstone matrix is fairly mature. These coarse rocks have some affinities to a sedimentary breccia (or conglomerate) containing chert clasts.

Distinguishing features

Jasper Gorge Sandstone forms a distinctive topography and hence is readily distinguished on air photographs.

It forms mesa and plateau-type topography and dip slopes with large areas of bare rock commonly strewn with blocky boulders up to 6 feet across. It typically forms the top of scarps, and is dissected by steep gorges. Joint lineaments are abundant and form a clearly defined pattern; some joints are up to 5 miles long.

Palaeogeographic significance

The distribution and lithology of the Jasper Gorge Sandstone indicates that it is a mature to very mature sandstone which is the product of deposition on a stable, broad continental shelf. The structures indicate that it was laid down in shallow water, possibly in a neritic environment.

In most places the lower part of the formation above the basal conglomerate probably represents a very slowly advancing marine transgression across an erosion surface. Adequate time was available for reworking and sorting of the sand.

The sporadic distribution of local areas of silt through the sequence indicates fluctuation in depth of deposition. There is, however, an apparent general increase of the proportion of silt toward the top of the unit which indicates that the deposition of the Jasper Gorge Sandstone probably accompanied a general deepening of the Victoria River Basin.

Angalarri Siltstone

Distribution

The Angalarri Siltstone underlies the Whirlwind Plain which forms a north-east-trending belt, averaging 16 miles wide, extending across the south-eastern half of the sheet area. It also occurs in the scarp slopes of the Yambarra and Pinkerton Ranges and in the scarp slopes bordering the Koolendong Valley. It occurs adjacent to the Victoria River Fault near Holdfast Reach, where its characteristic lithology aided the identification of massive overlying sandstone units. Isolated outcrops occur in the Spencer Range, near the Keep River, and in the far north east of the Sheet area.

It continues north and east onto the Fergusson River, Delamere and Port Keats Sheet areas, and south onto the Waterloo Sheet area.

Derivation of name

The unit was named by Randal (1962) after the Angalarri River in the south-west corner of the Fergusson River Sheet area.

Laing and Allen (1956) informally named this unit the Auvergne Shale from exposure in the East Baines River. Previously it had been included in Traves' undifferentiated Victoria River Group.

Reference area

No complete section of the Angalarri Siltstone is exposed on the Auvergne Sheet area. It is generally only exposed where overlying sandstone formations protect it from weathering, and where rivers cut into it in the Whirlwind Plain.

The lower part crops out along the East Baines River at, and south of, the main road crossing. The upper part forms the slopes of scarps in the Pinkerton and Yambarra Ranges where it is well exposed at Mount Razorback and at Curiosity Peak.

Stratigraphic relationships

The Angalarri Siltstone lies apparently conformably on the Jasper Gorge Sandstone. The exact contact was not found and the relationship is inferred largely from photo interpretation. This indicates that the Jasper Gorge Sandstone dips gently below the siltstone which has the same gentle regional dip to the north west. This lower contact may be gradational in places as the lower part of the Angalarri Siltstone contains a number of sandstone interbeds.

The upper contact is generally well defined by the marked change in lithology from green fissile siltstone to flaggy sandstone at the base of the overlying Saddle Creek Formation. This boundary is conformable. In the south-west part of the area there is evidence that it may also be gradational in some places.

Lithology and thickness

Although no single complete stratigraphic section has been observed, for most of the Sheet area it is possible to divide the Angalarri Siltstone into a lower, flaggy, coarse-grained siltstone, and an upper fissile, finer grained siltstone. Dolomitic siltstone and flaggy dolomite have been observed east of Bradshaw near the Angalarri River, and 7 miles east of Skinners Point in the southwest. The rocks in the latter locality are probably in the lower or middle part of the formation.

The lower siltstone is best exposed along the East Baines River south of Auvergne homestead. It is light to medium grey and grey-green, coarse-grained quartz siltstone. Finer grained quartz and clays probably form less than 20% of the total rock. Accessory pyrite and barite occur in some areas. Beds vary from vaguely laminated to thin bedded, and the partings from fissile to flaggy. Partings are commonly due to concentrations of micaceous minerals on some bedding planes. Well defined flaggy to blocky interbeds of coarse silt to fine sand-size grains occur just above the Jasper Gorge Sandstone, suggesting a gradational contact. The contact is defined, however, by a marked change in resistance to weathering which corresponds to the change from sandstone (Jasper Gorge Sandstone) to interbedded siltstone and sandstone (Angalarri Siltstone). Intraformational breccia of sandstone blocks within the normal bedded siltstone matrix, was observed at one locality in the East Baines River valley.

Large areas on the Whirlwind Plain display a prominent joint pattern on aerial photographs. Although extremely weathered, the rocks underlying these areas are very similar to the coarse siltstone and fine sandstones mentioned above. The joint pattern may be a reflection of major joints in the underlying Jasper Gorge Sandstone, indicating that the cover of Angalarri Siltstone is relatively thin in these areas.

Interference and oscillation ripple marks, and to a lesser extent, current ripple marks, are very common (see figs. 18, 19, and 20). The first two structures reach amplitudes of 6 inches with wavelengths up to 6 feet, although they are generally of the order of $\frac{1}{2}$ inch to 1 inch and 2 inches to 6 inches respectively. There is no obvious preferred orientation of structures and ripple axes on consecutive beds several inches thick show vastly different orientations (see fig. 18).

The upper beds of the Angalarri Siltstone crop out along the entire length of the southern scarp of the Pinkerton and Yambarra Ranges. They consist of very finely interlaminated coarse siltstone and shale, (see figs. 21 and 22). Individual laminae are commonly only about 0.2 mm thick, the fine ones consisting of extremely fine-grained clay minerals, and the coarser ones of angular quartz silt, with minor muscovite, clay, and feldspar. The clay minerals impart a green colouration to the rock. Some thin laminae contain light green silt-size pellets of glauconite.

Within the siltstone in the upper 50 feet of the formation there are a number of discontinuous sandstone lenses from 6 inches to 3 feet, and rarely up to 10 feet, thick. Current bedding, ripple marks and sole markings are developed in these beds. This is particularly well shown in the north in the Koolendong Valley where the Angalarri Siltstone is at least 600 feet thick. It consists of the following generalised section:-

Thickness (ft)	Lithology
50	Basal sandstone of Saddle Creek Formation forming top of dissected tableland.
150	Siltstone: grey-green, reddish brown intercalated with quartzitic sandstone bands up to 18 in. thick. These bands are glauconitic and may have a silty matrix.
100	Siltstone: grey-green, laminated, platey. Slightly coarser than the underlying 350 ft.
350	Siltstone: grey-green, highly fissile and shaley, laminated. Fairly homogeneous sequence.
	Bottom of slope, (base not exposed).

The thickness of the formation can only be estimated. The unit has a generalised regional dip between 0 and 5° to the north west, although there are minor reversals of dip. Assuming only a 1° dip to the northwest the thickness of the unit is computed to be about 1500 feet. The Argument Camp and Amanda bores penetrate about 500 feet of shale and siltstone, but since they are sited several hundred feet below the top of the formation, about 1,000 feet is a conservative estimate of its thickness.

Distinguishing features

The uniform lithology over a large area, is the most important distinguishing feature of the Angalarri Siltstone. Also, the almost ubiquitous occurrence of grey-green fissile siltstone which weathers to scree of fine flakes and scales below the fairly distinctive basal sandstone of the Saddle Creek Formation, is diagnostic, Because of its soft nature it has been easily eroded to form the extensive plains surrounding the East and West Baines and Angalarri Rivers.

Fig. 18 Two sets of oscillation ripplemarks in lower part of Angalarri Siltstone. The minor second set has formed only in the troughs of the major set.

GA/598(I.P.S.)

Fig. 19 Angalarri Siltstone. Bottom of a bed showing casts of oscillation ripplemarks with minor interference ripple marks.

GA/576(I.P.S.)

Fig.20 Angalarri Siltstone. Three sets of oscillation ripple marks on different bedding planes. Note the different orientation of the ripple axes in each set.

GA/592(I.P.S.)

Fig.21 Upper beds of Angalarri Siltstone. Fissile sandstone and shale on side of gully, capped by the basal sandstone of the Saddle Creek Formation.

GA/621(A.G.R.)

Fig. 22 Thin bedded to laminated, fissile, green, quartz siltstone. Light green glauconite and dark green chlorite are present. Characteristic of much of the Angalarri Siltstone.

GA/509 (I.R.P.)

Palaeogeographical significance

The prevalence of oscillation ripples and the lack of current bedding suggests that the formation was deposited off-shore away from littoral currents, but still above wave base. The size of some ripples may indicate an environment exposed to long wave-length ocean waves.

The occurrence of glauconite in the upper part of the formation is of some interest as an enviornment indicator. This mineral has been found only in marine environments (Cloud, 1955). Cloud states that "the formation of glauconite requires marine water near normal salinity, reducing conditions, and appropriate source materials. It is favoured by high organic content of the bottom sediments in which it forms, and by slow or negative sedimentation. It may form under a fairly wide but not unlimited range of temperature and depths". Chilingar (1955) considers that weakly oxidising conditions are required.

The glauconite may be detrital, since it occurs in thin laminae as pellets of similar size to the surrounding silt. However, as it is also abundant throughout the Auvergne Group, it is likely that it reflects a long period of marine deposition.

The occurrence of pyrite and glauconite in the Angalarri Siltstone, indicates that reducing conditions probably prevailed.

Saddle Creek Formation (new name)

Distribution

On the Auvergne Sheet area the Saddle Creek Formation crops out along the length of the Pinkerton and Yambarra Ranges, a distance of about 120 miles. It also occurs in scarps in the Spencer Range, in the folded zone between No. 7 bore and Ernie Lagoon, and along the eastern margin of the Koolendong Valley.

It extends north-east and east-north-east of the Auvergne Sheet area onto the Port Keats, Fergusson River, and Delamere Sheet areas.

This unit is essentially soft and crops out poorly unless capped by the resistant Pinkerton Sandstone. Where it is protected, a basal sandstone of the unit is exposed as a distinctive "hard band" in the scarp; the upper part of the unit forms a slope immediately below the base of the Pinkerton Sandstone.

Derivation of name

This formation is named after Saddle Creek, at the south-western end of the Pinkerton Range on the Auvergne Sheet area.

Reference area

The type section of this unit is at 2419E, 30029W; about 1 mile west of where the road to Bullo River homestead traverses the Pinkerton Range.

Stratigraphic relationships

The Saddle Creek Formation forms part of the Auvergne Group; it conformably overlies the Angalarri Siltstone and is conformably overlain by the Pinkerton Sandstone. (see fig. 26).

In the south west the lower contact is not everywhere clearly defined due to the presence of minor sandstone bands at the top of the Angalarri Siltstone. However, the lower contact in other places and the upper contact in all places is sharp and distinct.

This unit is overlain unconformably in several areas by rocks of the Ranford Formation.

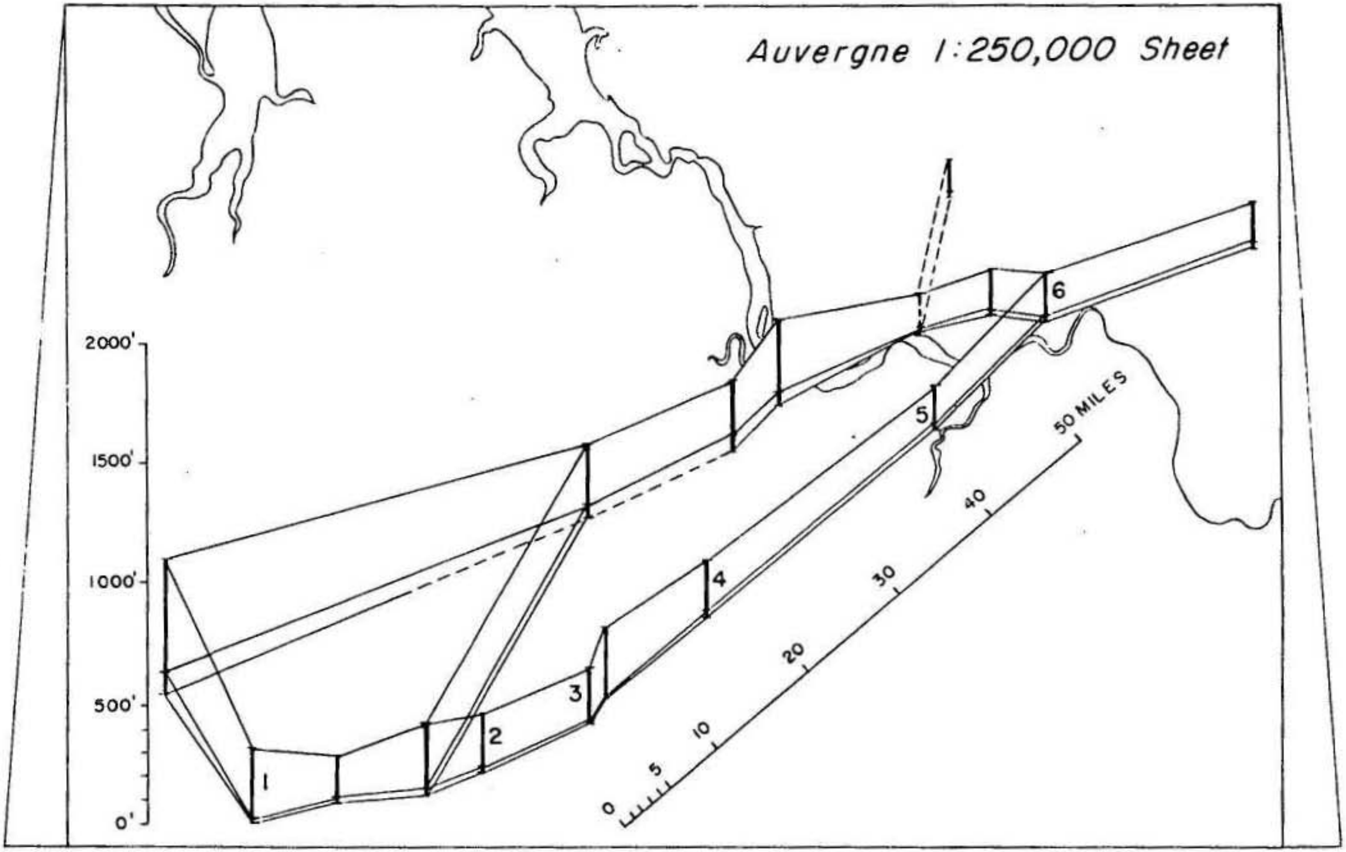


Fig. 23: Stratigraphic Sections through the Saddle Creek Formation.

To accompany Record 1968/117.

D52/A15/16

Lithology and thickness

The Saddle Creek Formation along most of the Pinkerton - Yambarra Range scarp consists of a basal sandstone band about 25 feet thick which is overlain by up to 300 feet of dolomitic siltstone. In the south-west part of the Pinkerton Range this upper siltstone contains several bands of sandy, oolitic dolomite. Near the Victoria River the upper siltstone contains bands of massive, friable, fine-grained sandstone, which are glauconitic.

In the Nutwood Creek area and adjacent to the Halls Creek Metamorphics the basal sandstone dominates the formation and may measure up to 100 feet thick. The thickness of the upper siltstone part varies; in the south-west part of the Pinkerton Range it measures up to 350 feet thick, at Karracumby Peak it measures 165 feet. To the north and north-east it tends to be thinner, but along the eastern margin of the Koolendong Valley on the Port Keats Sheet area it is about 220 feet thick. In the Koolendong Valley it locally comprises flaggy and cross-bedded sandstone, with little siltstone (see section 7).

A number of sections through the formation have been measured, and these are summarized in the form of a fence diagram (Fig. 23). The first six sections described below are numbered on the figure. Section No. 7 is not shown, as it is not on this Sieet area. The basal sandstone member is shown on Fig. 25.

The sections measured through the Saddle Creek Formation are:

1. In Pinkerton Range scarp, 5 miles due south No. 7 Bore.

Thickness (ft)	Pinkerton Sandstone
135	Poor exposure. Miner scree of flaggy, fairly pure dolomite, patches of "sub-outcrop" of light grey weathering dolomitic siltstone.

Thickness (ft)	Pinkerton Sandstone
20	Sandstone: very friable, blocky to flaggy, contains abundant mud flakes.
145	Mainly a soft, very silty and ferruginised sandstone. Varies from red to yellow and brown. Interbedded with siltstone.
15	Quartz sandstone: blocky and flaggy, cross-bedded, contains minor feldspar and glauconite.

Total 315 ft.

Angalarri Siltstone

2. Pinkerton Range scarp, 1 mile east of Saddle Creek

Thickness (ft)	Pinkerton Sandstone
55	Siltstone: grey, calcareous, flaggy to fissile. Contains bands of sandy, oolitic dolomite up to 3 ft. thick.
190	Siltstone: grey-khaki, calcareous. Bands of very fine-grained dolomite up to 2" thick.
5	Dolomite: light brown, grey, sandy, glauconitic.
50	Siltstone and mudstone: light green, grey, chocolate dolomitic.
25	Sandstone: light green, grey, very friable, massive. Thin to medium-bedded, large-scale cross bedding. Poorly sorted, individual relatively coarse-grained beds and discontinuous lenses. Glauconitic.

Total 325 ft.

Angalarri Siltstone

3. Pinkerton Range scarp, ½ mile west of Bullo River track jump up.

Thickness (ft)	Pinkerton Sandstone
70	Siltstone: (dolomitic) light-brown-grey, flaggy to fissile. Minor fine-grained sandstone.
5	Dolomitic siltstone, varying to silty dolomite, flaggy, forms bands up to 6".
65	Siltstone as above in uppermost 70 ft.
10	Dolomitic siltstone and silty dolomite intercalated with lesser grey fissile siltstone (carbonate rich).
25	Siltstone as above in uppermost 70 ft.
5	Dolomitic siltstone and silty dolomite band.
30	Siltstone as above in uppermost 70 ft.
5	Dolomite, grey, oolitic, nodular, minor chert.
80	Siltstone as above in uppermost 70 ft.
35	Siltstone - fine-grained sandstone: light brown grey and greenish grey, interbedded, fissile to flaggy, abundant primary sedimentary structures.
Total 330 ft	

Angalarri Siltstone

4. Pinkerton Range scarp, due north of Hayes Billabong.

Thickness (ft)	Pinkerton Sandstone
65	Siltstone: light grey-brown, calcareous, very fissile.
10	Dolomitic siltstone, grey. Also bands flaggy fine-grained dolomite up to 6" thick.
50	Siltstone: green-grey, very fissile.

Thickness (ft)	Pinkerton Sandstone
30	Quartz sandstone: light grey-brown very fine-grained, silty, massive, friable.
95	Siltstone: green-brown, very fissile, contains abundant glauconite.
30	Sandstone - silty sandstone: light brown-grey, flaggy fine siltstone interbeds. Abundance of different primary sedimentary structures.
Total 270	

Angalarri Siltstone

5. Karracumby Peak

Thickness (ft)	Pinkerton Sandstone
80	Poor exposure apparently calcareous (? dolomite) siltstone. Minor concretionary iron nodules up to 2" in lower 10 ft.
5	Quartz sandstone: white well sorted, friable, low clay content.
70	Siltstone: dark brown, varies to fine-grained sandstone. Isolated nodules of concretionary secondary iron-oxides.
25	Silty sandstone: light brown, silt interbeds common at base, poorly sorted. Various sedimentary structures common.
Total 190	

Angalarri Siltstone

6. Yambarra Range scarp, 5 miles NE of the mouth of Lobby Creek

Thickness (ft)	Pinkerton Sandstone
35	Shaly siltstone: fissile very poor exposure.
8	Fine-grained sandstone - silty sandstone: massive, grey-green to light brown. Commonly contains irregular sedimentary flame structures.
17	No outcrop: scree covered slope.
3	Shaly siltstone: grey-green
17	Siltstone - fine-grained silty sandstone. Massive, essentially non-bedded, although lower 3 ft. show flame structures and other preconsolidation sedimentary structures.
6	Interbedded fine-grained sandstone and siltstone. Grey-green, weathering to light brown. Irregularly alternating fairly 'clean' quartz sandstone (commonly with small glauconite pellets, up to 5%) and sericitic 'dirty' siltstone. Thin bedded, fine structures, fissile to flaggy. Mud cracks and ripple marks.
91	Siltstone: shaly, fissile, laminated, grey-green. Chloritic and sericitic, some light brown limonite rich bands - (possibly weathered glauconite).
30	Basal sandstone band.
	Sandstone: light grey, weathers to brown and dark grey. Thin-bedded, fine, medium and coarse grained, and poorly sorted. Commonly pale green due to glauconite and flakes of green clay. In lower 10 ft. abundant sedimentary structures, shows transgression and regression of beds, cross-bedding, scour and fill, flame structures, minor ripple marks, mud cracks.
Total 207	

Angalarri Siltstone

7. <u>Eastern margin of Koolendong Valley, 12 miles south of the Fitzmaurice River (on Port Keats Sheet area)</u>.

Thickness (ft)	Pinkerton Sandstone
94	Sandstone: flaggy to blocky, medium-bedded, white to purplish.
17	White medium-grained sandstone. Extremely large scale foreset beds which are thinly bedded, and show up through differential weathering.
110	Blocky to massive sandstone: some medium scale cross beds. Interbedded with red-weathering, flaggy sandstone with minor purple and green siltstone.

Angalarri Siltstone

The Saddle Creek Formation was also examined between 2 and 4 miles north of Bullo Gorge on both sides of the Bullo River. Only the upper part is exposed and consists of grey-green siltstone, fissile dolomitic siltstone and one thin bed of a ferruginous carbonate rock. Three miles NNE of Bullo Gorge 250 feet of the upper Saddle Creek Formation are exposed. Here and in the Nutwood Creek area the basal sandstone attains its greatest known thickness of 50+ feet and 70+ feet respectively.

An examination of the lithology of the Saddle Creek Formation is described below.

<u>The basal sandstone</u> is generally white to light grey-brown, commonly greenish and weathers to red-brown, and dark-grey. It is poorly sorted, fine to medium grained with coarse-grained thin beds (commonly foreset beds). Rarely the sandstone contains minor pebbles and pebble beds. The high clay content makes the rock friable. The development of under-caving at the base of this unit is caused by its friable nature and its flaggy, ragged partings. The parting (or bedding) planes show abundant ripple marks and mud cracks.

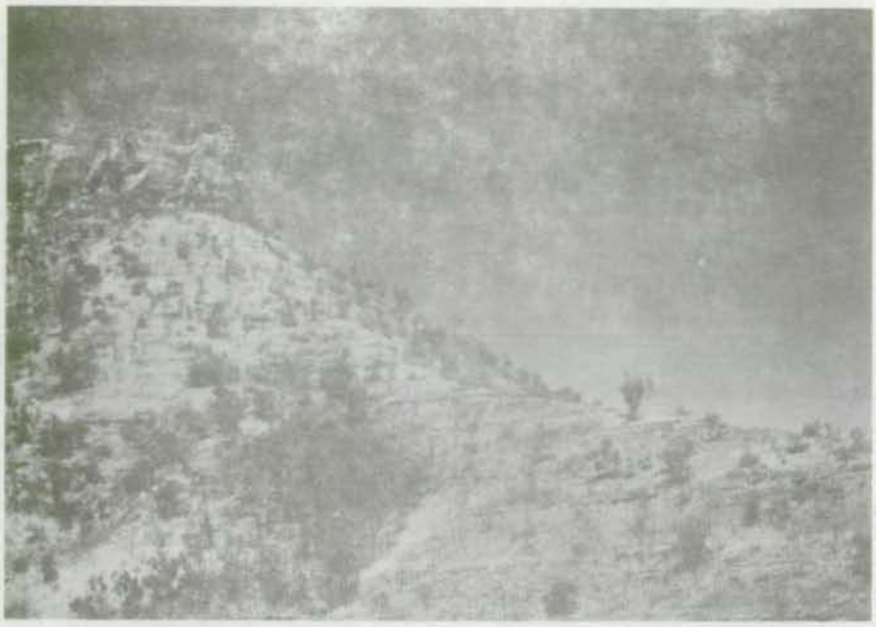


Fig.24 Saddle Creek Formation (soft slope), capped by Pinkerton Sandstone. The slope consists of the upper siltstone of the Saddle Creek Formation containing minor thin dolomite bands in the lower part.
Auvergne 1:250,000 Sheet area, 8 miles south of No.7 bore.

GA/524(I.R.P.)

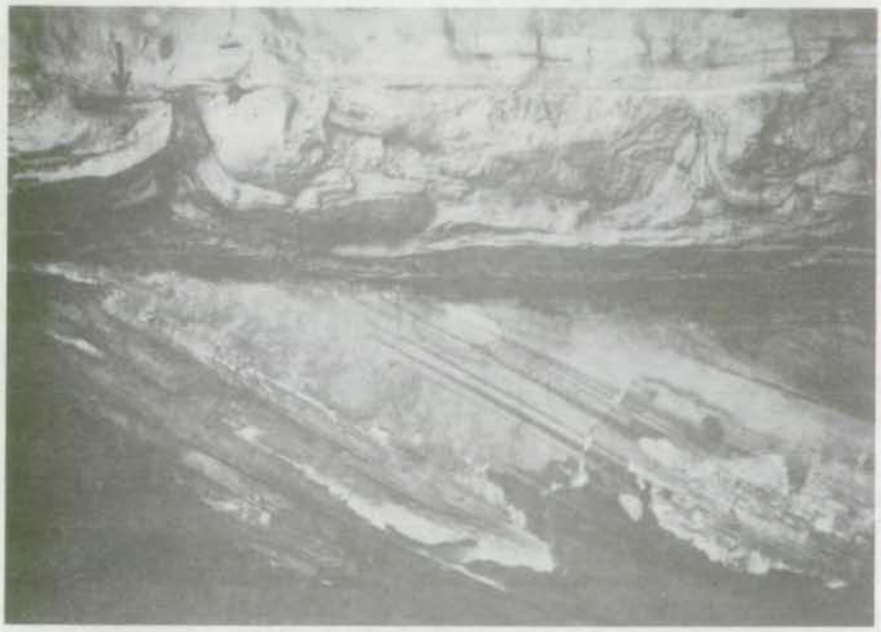


Fig.25 Basal sandstone of Saddle Creek Formation, showing typical sedimentary structures - cross bedding, convolute bedding and associated flame structures. (Hammer arrowed)

Fergusson River 1:250,000 Sheet area 15 miles east of Coolamon Homestead ruins.

GA/518(I.R.P.)

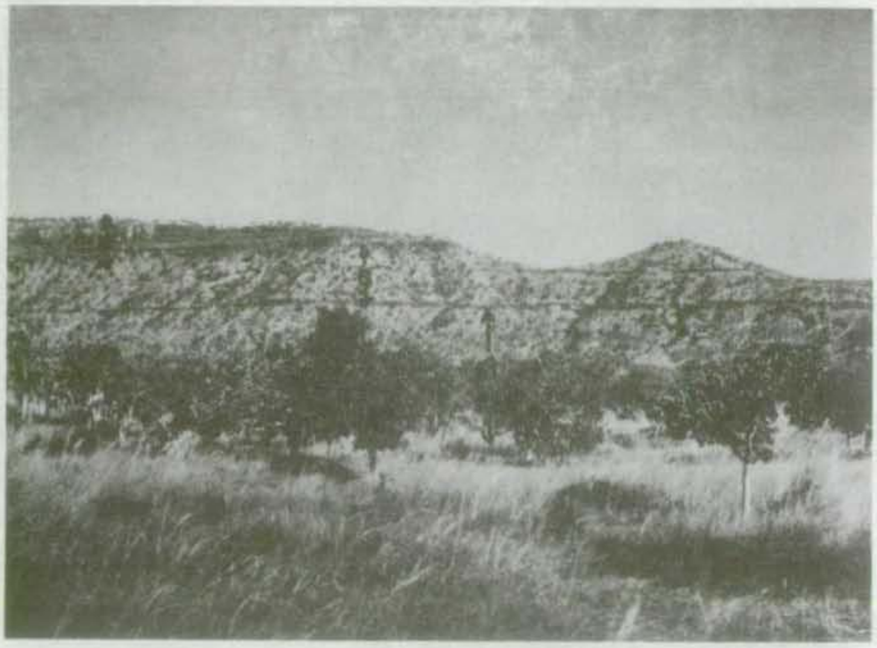


Fig.26 A = Angalarri Siltstone
B = Saddle Creek Formation, showing basal sandstone and thin dolomite bands in upper part of this unit.
c = Pinkerton Sandstone.

Scarp of Pinkerton Range near Bullo River track jump up: Auvergne 1:250,000 sheet area.

GA/1194(I.R.P.)

The grains are subrounded and sub-spherical. Siltstone bands, commonly thin and discontinuous are interbedded with the sand; typically they contain glauconite. With decreasing grain size the roundness and sphericity of the grains becomes less well developed until the fine grains (0.05 mm) are commonly sliver-like.

Quartz is the main constituent, as many grains of which contain fine inclusions. Grains of chert and quartz of metamorphic origin form up to 10% of the grains. Feldspar, both plagioclase and microcline form up to 7% in some sections. Accessory minerals include zircon, tourmaline, magnetite and glauconite. Glauconite occurs in subordinate amounts in places Magnetite grains associated with glauconite-rich beds are probably authigenic.

Primary sedimentary structures are highly characteristic, of this basal sandstone band. Cross bedding is the most common sets of fore-set beds are up to 8 ft. thick. Convolute bedding and flame structures are also typical and, commonly about 2 feet thick. Such a band may cut off a series of fore-set beds, or simply be part of a normal thin bedded horizontal sequence. (fig. 25).

Other common structures are several varieties of ripple marks, mud cracks, halite pseudomorphs, sole markings, and current lineations.

<u>The upper siltstone</u> is generally grey-green, commonly fissile but varies to massive - friable. Typically it varies to fine-grained sandstone. The coarse component is mainly angular and well sorted quartz grains. Subordinate chert, plagioclase and microcline are common. Interstitial clay, chlorite, sericite and glauconite have been identified.

The glauconite content may be as high as 15% and is generally most abundant towards the base and the top of the siltstone.

Much of the siltstone is carbonate rich. The carbonate is erratic in its distribution but generally it occurs as an interstitial component; it appears to be dolomite. (Minor carbonate cement also occurs in the basal sandstone).

In the south-west half of the Pinkerton Range, bands of dolomite up to 3 feet thick are interbedded with the siltstone. The dolomite bands add strength to the siltstone and form low cliffs up to 10 feet. As many as four of these cliffs occur in the vertical section of the Saddle Creek Formation west of the Bullo River track; two are more common and in places no dolomite bands is exposed.

Several of the dolomite bands are oolitic, iron rich and commonly glauconitic. The oolites have an average diameter of 0.4 mm. and have a quartz (and rarely microcline) nucleus. The dolomite in the oolites has commonly been replaced by cryptocrystalline silica. The silicified parts form discontinuous lenses up to 10" long and 2" wide. There is very little detrital interstitial material in the oolitic dolomite and secondary, very finely crystalline quartz, cement the oolites in places.

The fine-grained, non-oolitic dolomite is invariably silty, with up to 25% of coarse silt-size quartz grains disseminated through the dolomite.

Distinguishing Features

The Saddle Creek Formation is recognised, (particularly in the scarp slope of the Pinkerton and Yambarra Range), by its stratigraphic position below the widespread, prominent Pinkerton Sandstone. The most characteristic single feature is the presence of the basal silty sandstone band, generally about 30 feet thick, and invariably displaying abundant primary sedimentary structures.

Palaeogeographic significance

The sedimentary structures in the basal sandstone indicate a predominantly shallow-water environment of deposition. The cross-bedding, asymetrical ripple marks, current lineations, and isolated pebbles up to 20 mm. in diameter, indicate intermittent high-current velocities.

The foreset beds and ripple marks lack a strong preferred orientation, suggesting that current directions were variable, a feature typical of a very shallow-water environment.

The convolute bedding and flame structures are believed to have formed by hydraulic rupturing of overlying beds by fluid trapped in lower, more permeable, beds. Some of these structures are "quick-sand structures", resulting from the disturbance of water-saturated sedimentary layers. The palaeogeographic significance of these structures is not clear, but suggests a rapid rate of deposition in a very active environment.

The deposition of the siltstones was also apparently in shallow water and in a stable-shelf environment. Glauconite and oolites indicate conditions of agitation in a shallow-water environment. Dolomite occurs only in the southwestern end of this formation, and the siltstone thins towards the northeast.

Pinkerton Sandstone (New Name)

Distribution

The Pinkerton Sandstone forms the resistant cappings of the main escarpments and dissected plateaux of the Pinkerton and Yambarra Ranges, which are about 120 miles long on the Auvergne Sheet area. It also crops out in the Spencer Ranges, and as a prominent hogback ridge along the south eastern side of the

Victoria River Fault. It extends east and north onto the Delamere, Fergusson River, and Port Keats 1:250,000 Sheet areas and south-west onto Waterloo Sheet area.

Derivation of name

From the Pinkerton Range, a prominent escarpment up to 900 feet high, which runs without break from the Keep River to the Victoria River, a distance of 65 miles.

Reference area

The type section through the formation is in the Spencer Range, 6 miles east of Bullo Gorge. Other good sections of the lower part of the formation are exposed in the Pinkerton and Yambarra Ranges.

Stratigraphic relationships

The formation conformably overlies the Saddle Creek Formation and is overlain, also conformably by the Lloyd Creek Formations. The base is defined in most places by a white massive, cross-bedded, quartz sandstone; its upper limit is marked by the first appearance of dolomite beds, some with stromatolites and in some places by intraformational breccia.

Lithology and thickness

The Pinkerton Sandstone characteristically forms stepped slopes which result from differential erosion of hard and soft bands. (Fig. 28). The base of the formation is marked by a massive to blocky, cross-bedded and thin to medium-bedded, quartz sandstone. Beds 2 to 3 feet thick are commonly interbedded with a few inches of silty, fine sandstone. The basal bed is extremely prominent, and forms the hard capping on most of the Pinkerton and Yambarra Ranges. It is only about 5 feet thick west of the Keep River but is between 50 and 70 feet in most of the Pinkerton Range, and where it caps the Yambarra Range north of Bradshaw it forms cliffs 100 or more feet high (see fig. 30).

This basal band commonly consists of a moderately well sorted quartz sandstone. Generally quartz constitutes more than 95% of the rock, while subordinate components are rock fragments (mostly siliceous), microcline, limonite, and accessory heavy minerals, mainly tourmaline and zircon. The grains are generally of fine to medium-sand-size (about 0.05 to 1 mm) and subrounded to well rounded. Syntaxial growths have in most cases partially or wholly obliterated original grain boundaries. This sandstone, contains spots comprising aggregates of grains up to 5 mm across, and loosely cemented by limonite. Silica cement is absent within the spots.

A poorly outcropping softer rock overlies the basal sandstone (see fig. 28). In rare fresh outcrops it comprises thinly interbedded green mudstone, quartz siltstone, and fine sandstone. The green colour is commonly merged into purple zones, due to a change in the oxidation rate of the iron minerals.

The soft layer is generally obscured by scree from a second cliff-forming fine-grained sandstone, which is between 50 and 100 feet thick. It has a blocky to extremely massive parting, but is thin bedded or laminated. Small-scale cross bedding and ripple marks are common; mud cracks are rare. Abundant mudflakes occur on most bedding planes, in some beds they comprise half of the rock. They are generally discoidal, a feature which is best seen where the flake has weathered out leaving a mould.

Although the rock is best described as a fine-grained sandstone a significant proportion of the grains are in the coarse silt range. Size sorting varies from moderate to good, and the grains are subrounded to rounded. Most specimens contain 90% or more quartz, and rock fragments, generally less than 5%, are mainly composite quartz grains with many inclusions, and chert. Many specimens contain a few percent of larger, well rounded grains. Secondary overgrowths obliterate some of the original sedimentary textures. Minor minerals include haematite, limonite, feldspar (mostly microline), and well rounded tourmaline and zircon.

Overlying the second hard sandstone member is a third scarp-forming member, but because it is not massive it rarely forms cliffs. It is generally a flaggy, fine to medium-grained quartz sandstone. In some areas it has an irregular parting, and does not break into rectangular or tabular blocks as do the lower and middle members.

In the steeply dipping and overturned sequence of rocks along the southern margin of the Victoria River Fault, the Pinkerton Sandstone forms a strike ridge of resistant sandstone in which individual units cannot be recognized. The sandstone is well indurated, light coloured, fine to medium grained and siliceous.

The thickness could not be determined accurately where the beds are vertical as the geological boundaries are covered by scree, but it is probably not less than 300 feet, and may be considerably more. East of Holdfast Reach, the Pinkerton Sandstone forms massive cliffs and may be 400 feet thick. The Saddle Creek Formation is very thin here, and it appears probable that there is a lateral facies change, with Saddle Creek Formation grading into Pinkerton Sandstone.

The Pinkerton Sandstone forms the resistant capping on the hills bordering the Koolendong Valley. The formation comprises a basal prominent white massive quartz sandstone overlain by a blocky, thin-bedded ripple-marked and mudflaked brown to pink fine sandstone, similar to that in the Auvergne area.

A number of sections have been measured through the Pinkerton Sandstone, and these are summarised on the fence diagram (Fig. 27). The sections show a gradually increasing thickness of the basal member of the formation from southwest to northeast.

Details of three of the sections are listed below:

(a) Section No. 1 on fence diagram (Fig. 27):- 56 miles west southwest of Auvergne homestead.

Thickness (ft)	Lloyd Creek Formation
150	Sandstone and silty sandstone: yellow and purple-brown, thin-bedded, flaggy, fine-grained. Occasional medium to coarse well rounded quartz grains. Mudflakes, some mudcracks, small ripple marks and crossbeds.
50	Flaggy sandstone - similar to that above; green shaly partings common.
60	Interbedded purple and light grey-green siltstone and fine to medium-grained sandstone.
15	Sandstone: medium-grained, massive to blocky, white, Crossbeds, ripple marks, and dark-coloured ferruginous spots up to 5 mm across.
Total 275	

Saddle Creek Formation

(b) Section No. 4 on the fence diagram (Fig. 27). $2\frac{1}{2}$ miles northeast of Bullo Gorge.

Thickness (ft)	Top of Hill
100+	Sandstone: thin-bedded, containing mudflakes. Parting surfaces are irregular.
40	Thin-bedded sandstone with blocky to massive partings. Many mudflakes, ripple marks and small-scale cross bedding.
35	Interbedded fine-grained sandstone, siltstone and green and purple mudstone; all thin-bedded.
70	Slightly feldspathic sandstone: buff to yellow, medium-grained. Yellow to brown limonite spots up to 5 mm across.
Total 245+	

Saddle Creek Formation

(c) Section No. 7 on fence diagram (Fig. 27). Lobby Creek Area.

Thickness (ft)	Top of Hill
20+	Sandstone: thin-bedded, flaggy, fine to medium-grained. Some ripple marks.
80	Fine-grained sandstone: Dark brown weathering surface; not well sorted, some beds have silt content, mudflakes are common; some thinly interbedded chocolate siltstone and sandstone with abundant mudflakes.
80	Quartz sandstone: white, friable, fine-grained, reddish brown weathering surface, prominent vertical jointing.
Total 180+	

Saddle Creek Formation

Palaeogeographic significance

The high quartz content and general lack of unstable rock fragments and minerals such as feldspar and mica show that the rocks of this formation are generally extremely mature. This maturity, and the presence of chert fragments, suggests derivation from a pre-existing sedimentary rock.

The extent and thickness of the sandstone, are consistent with deposition during a single transgression perhaps with minor depth fluctuations, giving rise to thicker sequences in the northeast.

The widespread occurrence of mudflakes suggests deposition in a very shallow marine or paralic environment with periodic subaerial exposure.

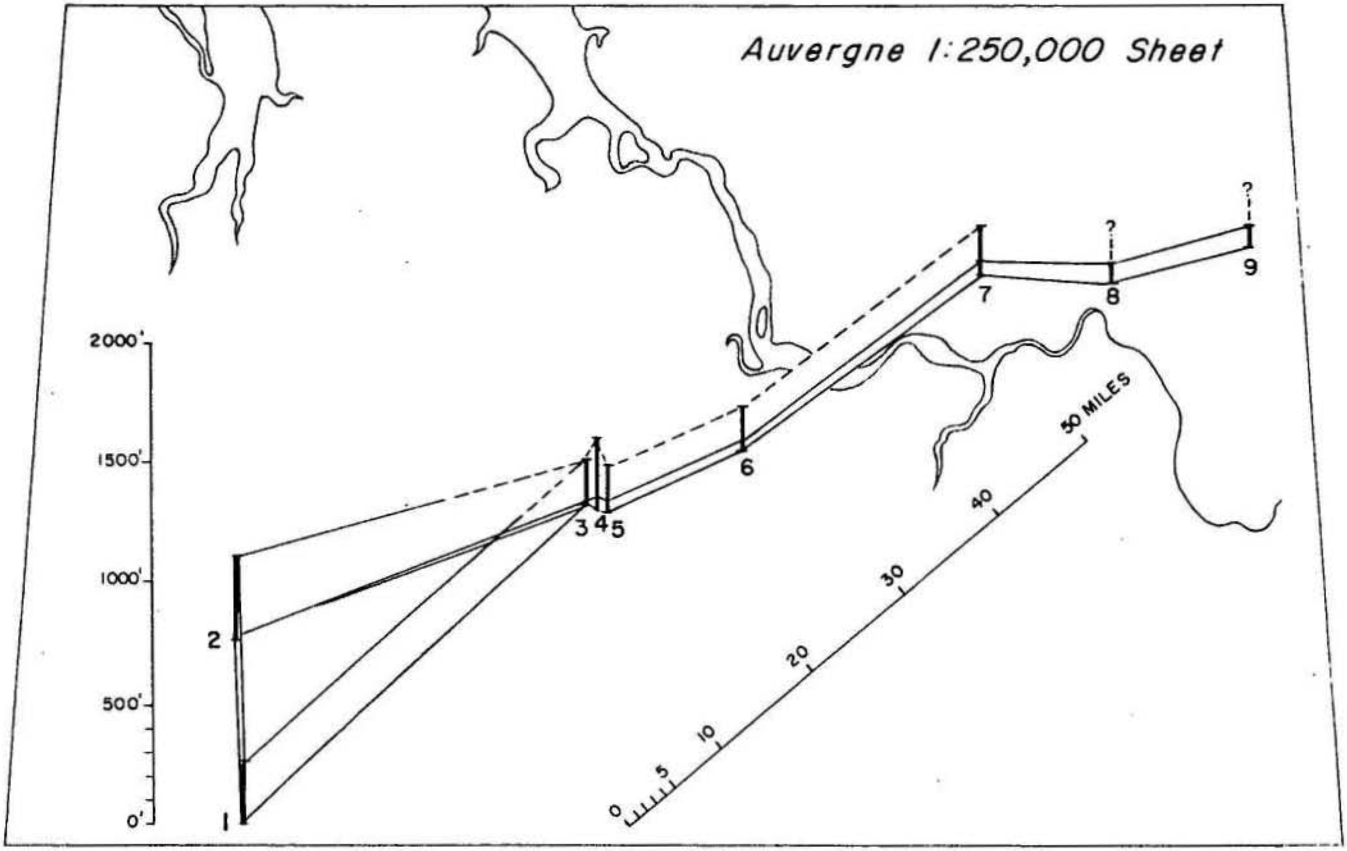


Fig. 27: Stratigraphic Sections through the Pinkerton Sandstone.

Dashed lines show data are incomplete.

To accompany Record 1968/117.

D52/A15/17

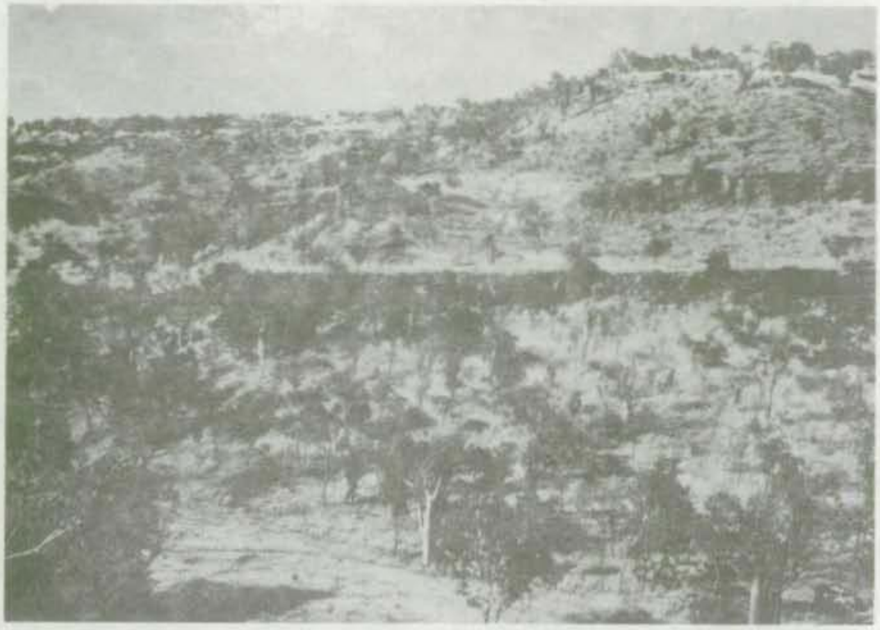


Fig. 28 Alternating hard and soft bands in the Pinkerton Sandstone. Base of lowest cliff is the base of the formation. Lower and Middle sandstone members are prominent. Third hard band forms top of hill.

GA/580(I.P.S.)

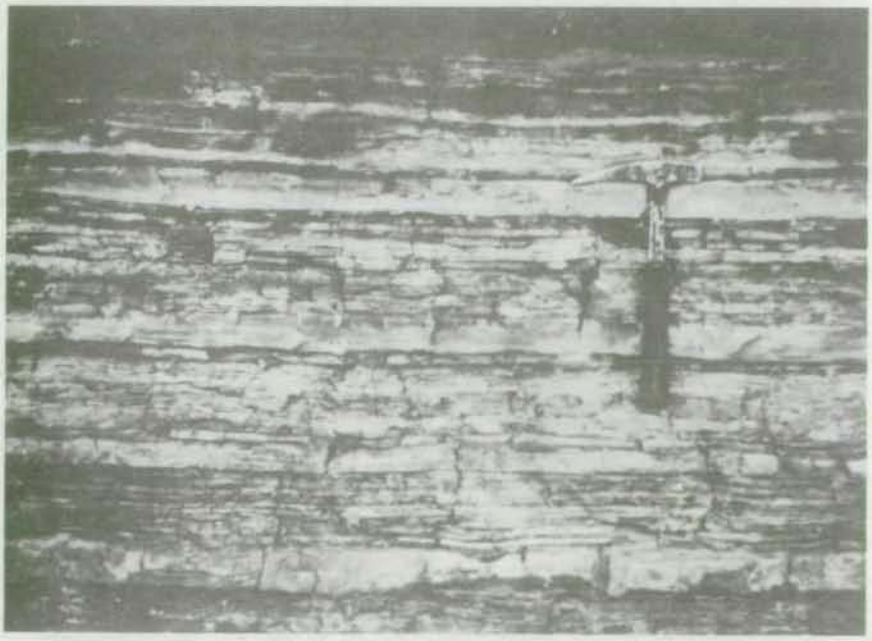


Fig. 29 Pinkerton Sandstone, soft beds between lower and middle hard members. Consists of thin bedded to laminated purple and green mudstone, siltstone and fine grained sandstone.

GA/596(I.P.S.)

Fig. 30 View from top of Yambarra Range, near Bradshaw. Pinkerton Sandstone forms prominent cliffs up to 120 feet high. Below the cliffs, a thin layer of Saddle Creek Formation is present. Its base is defined by the thin sandstone horizon visible.

GA/1002(I.P.S.)

Lloyd Creek Formation

Distribution

The Lloyd Creek Formation crops out generally in scarp faces, in numerous areas in the Pinkerton, Spencer, and Yambarra Ranges, from the southwest corner of the Sheet area, through to the northeast. It extends to the north and east, onto the Port Keats and Fergusson River Sheet areas.

Derivation of name

After Lloyd Creek, a minor tributary of the Bullo River, in the central part of the Auvergne Sheet area.

Reference area

The most complete sections were seen near the Bullo River Station track about 3 miles north of the main jumpup onto the Pinkerton Range.

Stratigraphic relationships

The Lloyd Creek Formation is apparently conformable with both the underlying Pinkerton Sandstone, and the overlying Spencer Sandstone, although the contacts are poorly exposed.

Lithology and thickness

The formation is characterized by oolitic and stromatolitic dolomites. They are interbedded with sandy dolomite, fine-grained laminated dolomite, dolomitic siltstone, and minor sandstone. Because of the hard capping of basal Spencer Sandstone, and the easily weathered rock types mentioned, the formation crops out poorly, and is generally covered by scree.

Samples of the carbonate rocks have been analysed as follows:

Registered No.	Insoluble Residue (wt%)	CaO (wt%)	MgO (wt%)	CaO/MgO	CaO/MgO (molar ratio)
67770322	15.9	23.5	18.3	1.39	0.83
67770087A	3.7	32.1	19.0	1.69	1.03
67770087B	14.3	33.7	11.8	2.87	1.73
67770117C	19.3	25.55	16.5	1.55	0.93
67770327	16.7	26.45	16.5	1.60	0.96

Sample 67770087B is more calcitic than the others and is one of the more oolitic rocks sampled; this may mean that the oolites are richer in calcite than in dolomite.

Sandy and oolitic dolomites are commonest in outcrop; they are in beds up to 2 feet thick, which contain 10% to 20% of quartz sand, and various proportions of oolites. The rocks weather to a grey-brown colour, and both oolites and quartz grains are conspicuous on these surfaces, whereas they are difficult to see on freshly broken, light grey surfaces. Some sand grains are concentrated in thin laminae, outlining small cross-beds and ripple-marks, but the majority occur as nuclei of oolites.

The quartz grains are subangular to subrounded, and 0.05 to 0.2 mm in diameter. Most oolites are within the range 0.3 to 0.5 mm., and are almost spherical. On some rock surfaces they weather away leaving a pock-marked surface, but in others the outer shell has been silicified, and the oolites stand out as cream-coloured spheres. A minor percentage of oolites are non-spherical, but these still have extremely smooth surfaces. The carbonate has been recrystallized, and only remnants of concentric structure remain.

Stromatolites were observed in most localities. In vertical section they appear as alternating light and dark weathering laminations of various shapes. Following the work of Donaldson (1963) they may be classified according to the shape of the laminations into one or more of six groups. On this basis most of the forms are "columnar" stromatolites, with some "hemispherical stromatolites." In the Bullo Gorge region a bed of partly silicified dolomite contains small "digtate" stromatolites and possibly some other types. The top of the bed is extremely uneven, because of the numerous small hemispherical projections at the t op of each column. (see fig. 33).

In several localities the stomatolite beds are very closely associated with sandy and oolitic dolomites and with intraformational breccias. Near No. 7 Bore small hemispherical forms encrust a block of sandstone within fine-grained dolomite.

Figure 35 shows a columnar stromatolite from the area north west of No. 7 Bore. The depression in the laminations contains lenses of coarse detritus, and the laminations thin and pinch out. This is typical of stromatolites formed by trapping of detritus by algal mats as described by Logan (1961) from the Shark Bay area of Western Australia. The following section was measured through the Lloyd Creek Formation near the Bullo track.

Thickness (ft)	Spencei Sandstone
19	No outcrop
9	Dolomite - light grey, blocky. 70% oolites.
68	No outcrop
10	Sandstone: as above, but green-brown with dolomite lenses and interbeds up to 4" thick.
10	Brown, blocky sandstone. Fine-grained, feldspathic.
60	Light grey dolomite - very closely packed oolites.

	Occasional tabular fine-grained dolomite fragments and lenses of more ferruginous material, both of which are more apparent on weathered surface.
15	Above increases in percentage of dolomite and becomes oolitic (up to 80% of rock) Oolitic and non oolitic dolomite are interbedded.
15	As before, but slightly higher percentage of dolomite.
12	Sandstone: grey, blocky, thin-bedded, grains cemented by dolomite up to 3 mm in grain size, and comprising perhaps 5-10% of the rock.
15	Sandstone: white, flaggy, friable, medium-grained halite pseudomorphs.
2	Light grey oolitic dolomite
10	Sandy dolomite: light grey, blocky thin-bedded, medium to coarse-grained.

Pinkerton Sandstone

In other localities dark grey dolomitic siltstone is interbedded with fine-grained well sorted quartz sandstone. Sandy dolomite generally predominates.

Although quartz is the most common detrital mineral, small quantities of feldspar (microcline), tourmaline, zircon, chert, chalcedony, some metamorphic rock fragments, and minor opaque minerals (weathering to limonite) are present.

The Lloyd Creek Formation is nowhere greater than about 250 feet thick. Nine sections were measured in the field, the thinnest, near the centre of the area, was only 95 feet. These sections gave satisfactory thickness data, but little information on lithology, since the formation is generally poorly exposed. The distribution of the sections and their variation in thickness is shown in the fence diagram (fig. 31).

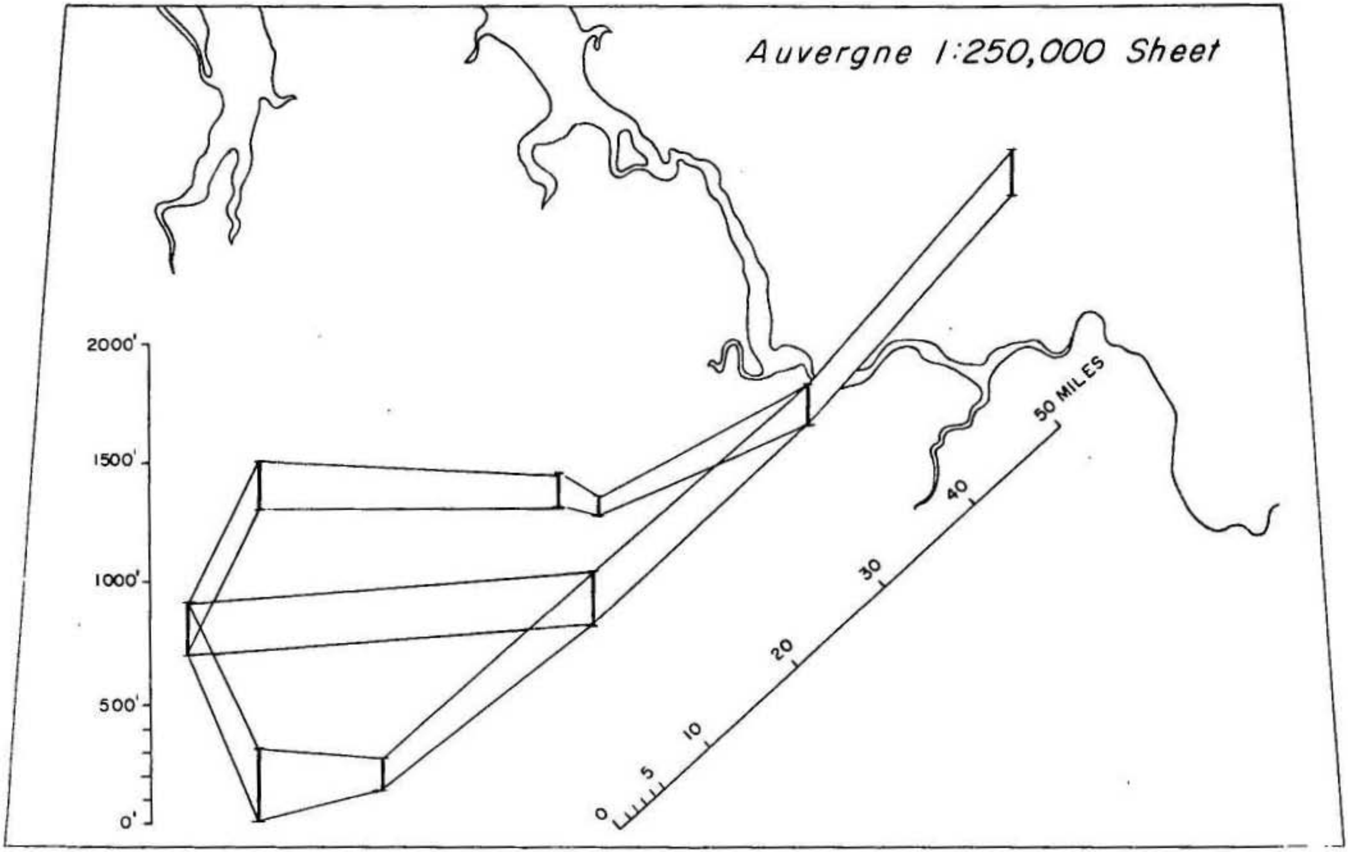


Fig. 31: Stratigraphic Sections through the Lloyd Creek Formation.

Fig.32 "Columnar" Stromatolites from Lloyd Creek Formation 10 miles northwest of Bullo Gorge.
GA/510(I.R.P.)

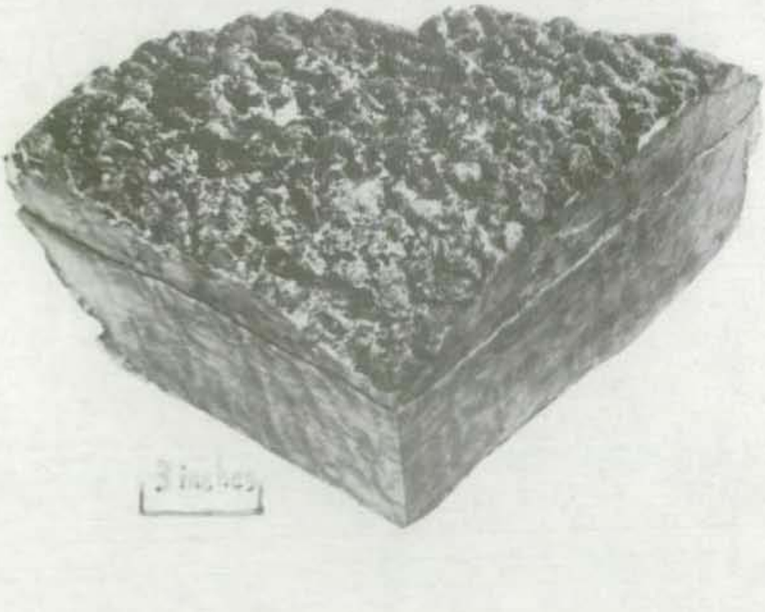


Fig.33 Smaller columnar or digitate stromatolites from Lloyd Creek Formation 3 miles north-northwest of Bullo Gorge. Some branching of columns is evident in the parent outcrop.
GA/852(I.P.S.)

Fig. 34 Section of specimen shown in fig. 33
Most laminations are continuous, and these could also be classified as undulatory stromatolites.

GA/850(I.P.S.)

Fig. 35 Irregular columnar stromatolites from Lloyd Creek Formation. Same locality as fig. 33.

GA/851(I.P.S.)

Fig. 36: Flaggy dolomite and dolomitic siltstone: Lloyd Creek Formation. Locality: 10 miles west of Coolamon, Port Keats 1:250,000 Sheet area.

GA/512 (I.R.P.)

Distinguishing features

The Lloyd Creek Dolomite is the only formation in the Auvergne Group in which oolites and stromatolites are extensively developed.

Palaeogeographic significance

The presence of sand-size particles, oolites, stromatolites, and some intraformational breccia indicate that this formation was deposited in a shallow water fairly high energy environment. Oolites are generally considered to form in agitated water (Eardley, 1938; Rusnak, 1960) although some non-spherical oolites may form in quiet water (Freeman, 1962). Because of their ubiquitous association with current-bedded sand in the Lloyd Creek Formation a wave and current-swept environment is most likely.

From the available evidence (Logan 1961), stromatolitic beds appear to be near-shore deposits, either marine, or in a saline lake. Other fine-grained dolomites in the formation, in association with sand and silt, both support the hypothesis that deposition took place in a shallow-water, stable-shelf environment.

Spencer Sandstone

Distribution

The Spencer Sandstone occurs mainly in the southwest of the Sheet area. It forms a belt up to six miles wide along the central part of the Spencer Range where it forms slopes which dip gently to the north west. Between the Bullo track and the Victoria River Fault, the sandstone follows around the nose and along the limbs of regional fold structures. From this area it can be followed to the south west along the southern side of the Victoria River Fault where it is exposed adjacent to Phanerozoic rocks and the Halls Creek Group.

Derivation of name

This formation is named after Spencer Range in the central part of the Auvergne Sheet area. This unit has not been previously identified or mapped as a separate formation.

Reference area

The unit is best exposed and most readily examined in areas adjacent to the Bullo River Homestead track where it crosses the Spencer and Pinkerton Ranges.

Stratigraphic relationships

The Spencer Sandstone is the middle formation of three which constitute a predominantly dolomitic upper part of the Auvergne Group. The Spencer Sandstone is conformably underlain by the Lloyd Creek Formation and conformably overlain by the Shoal Reach Formation.

The contact with the Shoal Reach Formation is poorly exposed but there is some evidence that it is a transitional contact. The contact is defined at the first outcrop of dolomite sandstone above the underlying quartz sandstone, which being relatively hard, generally causes a change of slope.

The Spencer Sandstone is flat lying over much of its extent and its typical topographic expression is shown in the Figure. 37.

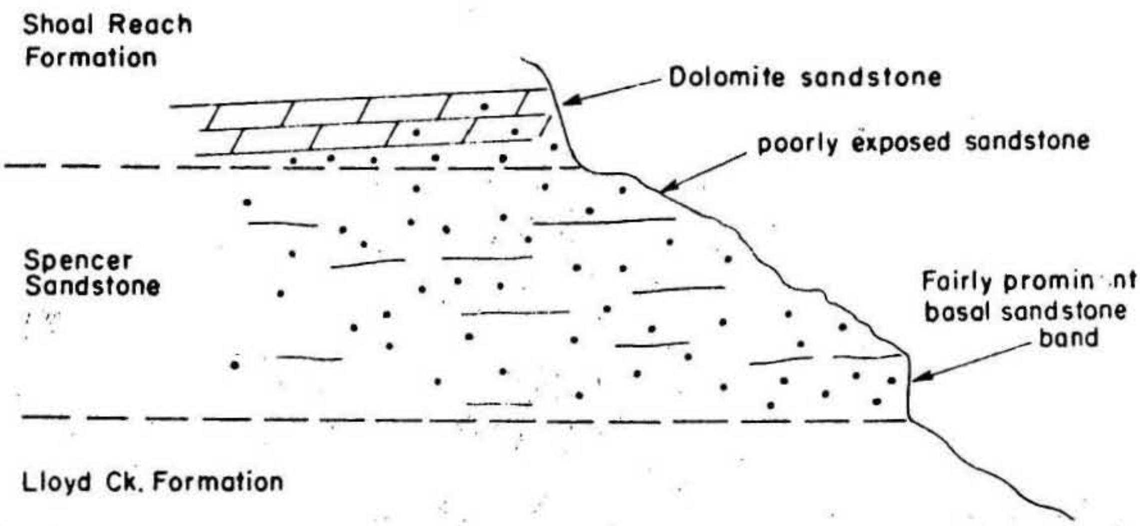


Fig. 37. Diagram showing topographic expression of the Spencer Sandstone and associated formations.

In some places Spencer Sandstone is dolomitic which suggests no significant facies difference from the overlying Shoal Reach Formation. However the considerable areas of distinctive topography formed by the sandstone, notably the basal 'member' and the characteristic change of slope forming its upper contact makes it readily identified on air photos and warrants it being mapped as a distinct Formation.

Lithology and Thickness

The Spencer Sandstone is generally poorly exposed; it forms low rounded hills with shallow dipping slopes covering large areas. Commonly it roughly coincides with the plain where isolated scattered out crops of sandstone are just exposed through sandy areas.

This poor exposure, and the fact that the overlying unit is generally absent makes it difficult to obtain a true thickness of the Spencer Sandstone. Up to 550 ft. of this unit has been measured, but this seems to vary considerably over a fairly short distance.

In most areas the Spencer Sandstone has a basal sandstone member which may measure up to 50 ft thick. (Fig. 38). This is a brown-grey, thin-bedded, flaggy and blocky, fine or medium-grained sandstone. It contains abundant small-scale cross laminations and ripple marks; reddish-purple and green mud flakes are common; pseudomorphs after halite occur in some places. Typically the mud flakes weather out leaving pits in the exposed surfaces.

The following section through Spencer Sandstone four miles south of the Bullo Gorge shows well the lithology of the unit but the thickness shown may not be true due to lack of outcrop and possible strike faulting in the area.

Thickness (ft)	Overlain by Shoal Reach Formation
170	Sandstone, fine-grained, about 2% glauconite
42	Sandstone, grey, fine-grained, friable, up to 10% feldspar
34	no outcrop
100	Sandstone, white, blocky, thin-bedded, medium to coarse-grained, poorly sorted, interbedded with fine fissile feldspathic sandstone.
	Generally poor exposure
200	Sandstone, white, blocky to flaggy, thin-bedded, fine to medium-grained, abundant chocolate and green mud flakes.
Total 546	

Fig. 38 Basal part of Spencer Sandstone. Shows its typical thin-bedded Character which may be massive or flaggy. Three miles N.N.W. Bullo Gorge

GA/586(I.P.S.)

The following section was measured through the Spencer Sandstone on the Bullo River Homestead track, about six miles due south of the Bullo Gorge.

Thickness (ft)	Overlain by Shoal Reach Formation
180	No outcrop
70	Poor outcrop, mainly scattered remnant blocks of white, fine-grained sandstone
170	No outcrop
25	Sandstone: white, blocky to flaggy, thin-bedded, fine to medium-grained. Minor coarse-grained, up 10% feldspar. Interbedded with softer red-weathering fine sandstone which has a sericitic matrix.
5	No outcrop
17	Sandstone: light-brown, blocky, thin-bedded, medium-grained. Up to 5% feldspar. Some fissile, silty interbeds. Contains abundant mud flakes.
Total 467 ft	Probable base of unit

The upper parts of the unit consist of essentially the same sandstone but it is generally far more poorly exposed. The sandstone is generally white (weathering reddish brown), blocky to flaggy, medium to fine-grained, thin-bedded to laminated and commonly friable. It is interbedded with thin fissile silty sandstone. Ripple marks and cross bedding are common.

The Spencer Sandstone adjacent to the Bonaparte Gulf Basin is similar to that in the Bullo Gorge area. However near Alligator Waterhole in the south-west corner of the Sheet area dolomitic sandstone occurs in the middle part of the formation and is associated with fine-grained sandstone containing halite casts. Five miles south-east of Ernie Lagoon a complete section of the Lloyd Creek Formation, Spencer Sandstone, and Shoal Reach Formation was measured; the Spencer Sandstone comprises:

Thickness (ft)	Overlain by Shoal Reach Formation
16	<u>Feldapthic sandstone</u>: fine, friable
14	<u>Sandstone</u>: grey, flaggy, thin-bedded, fine to medium-grained. Up to 3% green glauconite grains or pellets up to 1 mm. Minor quartz grains of same size.
17	<u>Sandstone</u>: fine-grained, up to 5% feldspar
250	<u>Sandstone</u>: poor exposure, white, blocky to flaggy, fine to medium-grained, limonite-spotted.
8	<u>Sandstone</u>: fine-grained abundant green and brown clay clasts from 2 to 5 mm. across. These preferentially weathered out and give the rock a pocked-marked appearance.
8	No outcrop
150	<u>Sandstone</u>: white, blocky to flaggy, thin-bedded, fine to medium-grained, friable, up to 15% feldspar.
11	<u>Sandstone</u>: basal band, massive to flaggy, white, reddish-brown weathering, fine-grained, friable.
Total 474	

Underlain by Lloyd Creek Formation

<u>Distinguishing features</u>

The basal sandstone unit has a characteristic lithology. The formation is distinguished by its presence as a relatively large area of poorly exposed friable sandstone within the mainly dolomitic sequence of the upper part of the Auvergne Group. These features are well defined on air photos.

Palaeogeographic significance

The conditions of deposition of the Spencer Sandstone represent a minor variation of the environment of deposition of the underlying and overlying dolomitic formations. The fact that dolomite persists in some parts of the unit, and that sand is a common component of the formation above and below indicates the small degree in the change of conditions.

The Spencer Sandstone was most probably deposited under shallow marine conditions in a stable environment. There is evidence that conditions during part of the deposition were sub-aerial.

Shoal Reach Formation

Distribution

The Shoal Reach Formation is extensive in the Spencer Range area. It also follows along the southern margin of the Victoria River Fault for about 80 miles from the Ernie Lagoon area to 10 miles north of the Victoria River. Typically it is poorly exposed; it crops out most continuously where the upper part of the Auvergne Group assumes moderate dips in faulted and folded areas.

Stratigraphically this unit overlies the Lloyd Creek Formation. It is absent however, over large areas of Lloyd Creek Formation in the north-east of the Auvergne Sheet area. Further north, on the Port Keats and Fergusson Sheet areas, the Shoal Reach Formation is preserved in the sequence by overlying Cretaceous sandstone.

Derivation of name

The name is derived from Shoal Reach near the junction of the Bullo and Victoria Rivers, and the Auvergne Sheet area.

Reference area

The Shoal Reach Formation and its relationships are well exposed, adjacent to the Bullo River homestead track, between the Pinkerton Range scarp and the Bullo River Gorge.

Stratigraphic relationships

The Shoal Reach Formation is the upper-most unit in the Auvergne Group. It conformably overlies the Spencer Sandstone and the contact is probably gradational.

The Shoal Reach Formation is almost certainly unconformably overlain by the Black Point Member of the Bullo River Sandstone. This contact is rarely well exposed. However, where it was seen however the contact is distinct and marked by an abrupt change in lithology. The upper Shoal Reach Formation consists of thin-bedded silty dolomite. The overlying Black Point Member is a sandstone: gritty, coarse, felspathic and ferruginous. This abrupt change of facies indicates an abrupt change of the environment of deposition and of provenance and probably indicates a hiatus. In some areas, there is evidence of a slight angular unconformity between the two units.

Lithology and thickness

The Shoal Reach Formation consists mostly of dolomite siltstone and fine-grained sandstone. Intraformational conglomerate also occurs in places.

Up to 350 feet of Shoal Reach Formation were examined east of Ernie Lagoon and 4 miles southeast of Bucket Springs. In these areas the formation is typified by thin lenses and bands of fine, grey dolomite within a predominantly sandstone sequence. The sandstone is commonly dolomitic, white to brown, flaggy to blocky, thin-bedded and medium-grained. Mud flake clasts are common. The dolomite is pink to brown. It forms lenses up to 1 foot long, and interbedded lamellae in the sandstone. (see fig. 39)

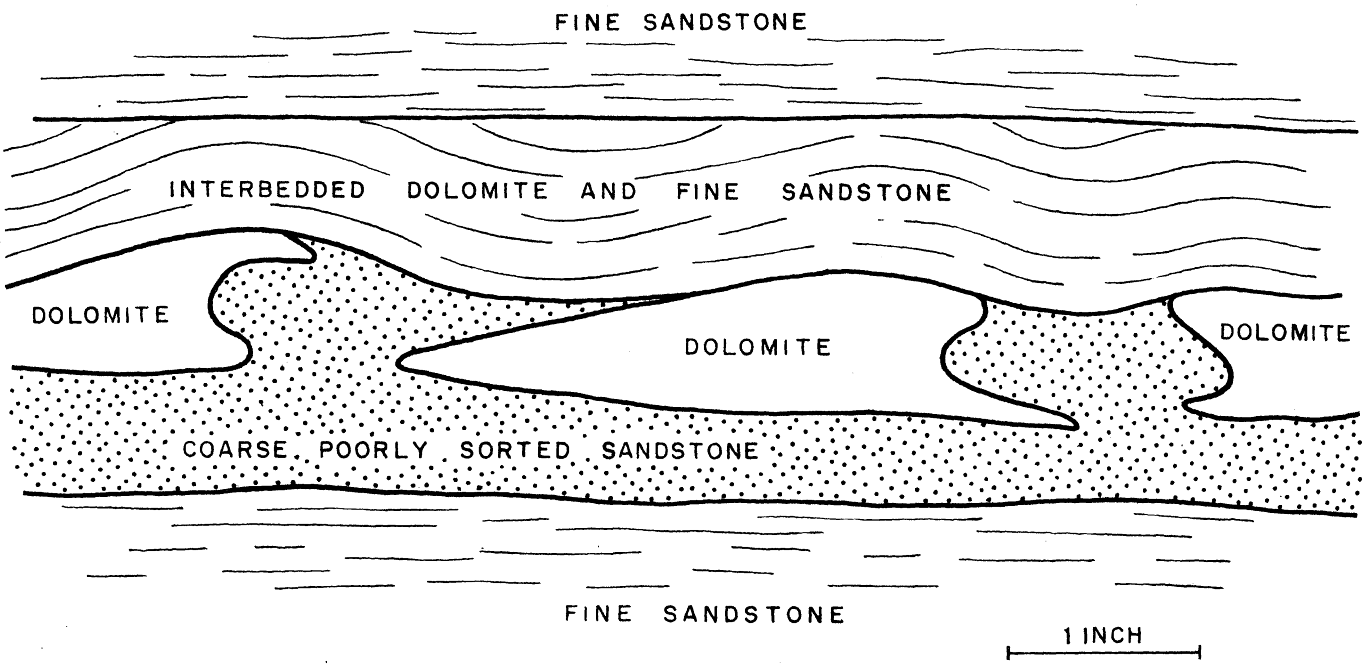


Fig.39: Relationships of dolomite and sandstone in beds within the Shoal Reach Formation.

To accompany Record 1968/117.

D52/A15/19

Near No. 7. Bore and Alligator Waterhole the upper part of the Shoal Reach Formation consists of white - to - grey - weathering, grey-pink silty dolomite. Ripple marks and small-scale cross bedding are delineated by concentrations in the dolomite of sand grains - up to 15% of the rock in places. Features which show sediment movement before consolidation include intraformational breccia, small-scale slumps, microfaults and abrupt cut-off of beds. Whitish siltstone and fine sandstone crop out below the dolomite. A thin bed of chocolate shale containing a net - work of carbonate-filled joints occurs locally.

The following section was measured through the Shoal Reach Formation 6 miles south-east of Bullo Gorge.

Thickness (ft)	Overlain by Black Point Sandstone Member (Bullo River Sandstone)
6	No outcrop
32	Sandy dolomite: grey, blocky to massive, thin to medium-bedded, medium-grained; minor fissile beds. Interbeds of fine dolomite.
29	Sandstone: blocky, some probably dolomitic
25	Dolomitic sandstone: interbedded with siltstone (? dolomitic) which forms up to 60% of the rock
63	Dolomitic sandstone: grey, blocky to fissile, thin-bedded, fine-grained. The fissile beds are mainly silty.
28	Interbedded sandstone, dolomite and dolomitic sandstone.
Total 183	

Underlain by Spencer Sandstone

A maximum of 200 feet of Shoal Reach Formation is poorly exposed within an eight-mile radius of Bullo Gorge. Five miles west of this Gorge the lower 100 feet of the unit consists of siltstone and fine-grained sandstone. Greenish clay lamellae and mud flakes are common. The upper 100 feet is mainly dolomite interbedded with purple dolomite siltstone and minor intraformational conglomerate. This generalisation is typical of the Shoal Reach Formation in this area.

Caliche commonly encrusts the fine-grained blocky to flaggy dolomite in the upper part of the unit. Four miles south of Bullo Gorge intraformational conglomerate forms an essential part of the upper 20 feet of the dolomite toward the top of the unit. This consists of fine-grained grey dolomite pebbles, in a medium-grained poorly sorted dolomite sandstone. The pebbles, up to 4 mm in diameter, are sub-angular to subrounded. This conglomerate forms beds up to 4 inches thick within a dolomitic and silty sequence.

Two miles east of Black Point about 140 feet of the Shoal Reach Formation are exposed, the generalised section is as follows: -

Thickness (ft)	Overlain by Black Point Member (Bullo River Sandstone)
20-30	Dolomite: fine-grained, flaggy
20-30	Dolomitic sandstone: (brecciated at the margins of the exposed part of this section).
up to 100	Flaggy dolomite and greenish shale passing down into dolomitic siltstone and minor dolomite.
	concealed lower contact

The dolomitic sandstone in this area commonly includes intraformational breccia in bands up to 8 inches thick. This consists of medium to coarse-grained (and rarely gritty), poorly sorted sandstone which contains fragments and discontinuous bands of dolomite. It is interbedded with fine-grained pinkish-grey dolomite in bands up to 4 inches thick. The dolomitic sandstone consists mainly of rounded quartz grains of varying size within an extremely fine-grained dolomitic matrix; the approximate proportions are matrix, 6, grains 4. Up to 5% of the grains are carbonate, 1 to 2% are feldspar. Small rounded grains of tourmaline, zircon and opaques are also present.

The quartz grains are mostly clear or dusty single grains. About 10% are composite and probably derived from metaquartzite. Up to 5% appear to have derived from chert, and several fragments of volcanic origin are present.

The grains within the sandstone interbeds show graded bedding. The contact between the bands of dolomite and the base of a sandstone band (relatively coarse-grained) is sharp, the upper contact is gradational.

Two miles south-east of the mouth of Langang Creek the contact between the Shoal Reach Formation and the overlying Black Point Member appears to be transitional. Here, the dolomitic sandstone near the top of the Shoal Reach Formation contains a bed of sandstone, about 3 feet thick, of similar character to the Black Point Sandstone. Overlying this is dolomite, dolomitic intraformational conglomerate, and alternating sandstone and dolomite. The dolomite content decreases upwards, and is finally absent at the contact with the overlying Black Point Member.

In spite of this possible transitional relationships, it is maintained that there is an unconformable relationship between the Shoal Reach Formation and the Black Point Member throughout most of the area.

Distinguishing features

The poor exposure of the Shoal Reach Formation makes it difficult to define any highly characteristic features.

It is perhaps most readily recognised as the predominantly dolomite unit which immediately underlies the highly characteristic Black Point Member of the Bullo River Sandstone.

A carbonate sequence with which it may be confused (if the stratigraphic position is not known) is the Lloyd Creek Formation which, however, contains oolitic dolomite and algal structures. Intraformational conglomerate (or breccia) and alternating sandstone and dolomite bands are more abundant in the Shoal Reach Formation.

Palaeogeographic significance

The composition and distribution of the Shoal Reach Formation, the uppermost unit of the Auvergne Group, indicates that shallow water marine deposition within a stable platform or shelf environment continued throughout the time of formation of the group. The environment of deposition changed rather radically after this. In the Shoal Reach Formation the association of dolomite with sandstone and siltstone which show fine-scale cross bedding, ripple marks, and graded bedding, indicates a shallow, rather protected, environment, but within the influence of wave action.

Dolomite deposition persisted throughout the development of the formation. The influx of sand was spasmodic, and the nature of some sandy bands and lenses in the dolomite suggests that they may be of aeolian origin.

Intraformational breccia (and conglomerate) indicates local instability in the sediments before their final consolidation. This is more abundant in the upper part of the unit and may represent insipient stages of development of the more unstable environment in which subsequent formations were deposited.

BULLO RIVER SANDSTONE

Distribution

The Bullo River Sandstone forms a large tract of inaccessible country (about 250 square miles) in the central and southwestern portion of the Auvergne Sheet area. Several isolated outliers crop out along the Spencer Range and in an area of about 30 square miles on the east bank of the Victoria River, between Holdfast and Shoal Reaches.

Derivation of name

The name is derived from the Bullo River, the upper reaches of which drain most of the large area of sandstone mentioned above.

Reference area

The lower part of the formation is well exposed near Bullo Gorge. In most areas the upper part is removed by erosion, but it is preserved in the core of a large syncline between Bucket Spring and Brolga Swamp. This latter area is therefore nominated as the reference area.

Stratigraphic relationships

The Bullo River Sandstone overlies the Shoal Reach Formation with probable unconformity. It is overlain unconformably by the Moonlight Valley Tillite in the south, and by the Ranford Formation to the north. The base of the Bullo River Sandstone is formed by the Black Point Sandstone Member which has a distinctive photo-pattern.

Lithology

The Bullo River Sandstone is an entirely clastic unit consisting largely of reddish-brown to maroon quartz sandstone with some conglomerate. The bedding is irregular and the sandstone is poorly sorted and heterogeneous. The Black Point Sandstone Member at the base is a distinctive ferruginous feldspathic sandstone.

Above the Black Point Sandstone Member the remainder of the formation consists mainly of quartz sandstone: thin to medium-bedded, cross-bedded, and blocky to massive. Laminations in some beds are marked by varying amounts of iron oxides which outline the cross bedding. Cross bedding is present in most outcrops, and includes festoon, tabular, and, rarely, torrential types. The thickness of individual cross bedded units varies from a few inches to as much as 10 or 15 feet. The largest foreset beds may be several inches thick, and many display primary current lineations.

Most of the sandstone is fine to medium grained (between 0.1 and 1.0 mm), but lenses of coarse sand, granules and fine pebbles are present in most areas, commonly as layers within foreset beds. Sorting is generally poor to moderate; in some samples up to 5% of recrystallized clay matrix occurs.

Most of the grains are sub-angular to sub-rounded. The larger fragments and generally more rounded, and in beds containing a high proportion of pebbles, the pebbles are extremely well rounded.

Quartz forms over 95% of fragments in most specimens. Authigenic quartz growths fill most pore spaces and act as cement. Several types of quartz grains are present; the characteristics of each type are: (i) no inclusions, clear and unstrained, single crystals; (ii) many inclusions - producing a very "dusty" appearance, single crystals; (iii) grains derived from metamorphic rocks, highly sutured on several grain boundaries, highly strained;

Fig.40 Lower grass-covered slopes are formed by Shoal Reach Formation. The dark coloured scarp-slope on the left is the Black Point Member. The top cliff on the right is part of the Bullo River Sandstone.

Nose of syncline, 8 miles WSW Brolga Swamp, Auvergne 1:250,000 sheet area.

GA/517(I.R.P.)

Fig.41 Typical topography of Bullo River Sandstone - Bullo River Gorge.

GA/1295(I.R.P.)

(iv) chert - extremely fine-grained, granules may be chalcedony;
(v) other quartz rock fragments, some with much opaque material, which probably have a volcanic origin.

The reddish colour of the Bullo River Sandstone is due mainly to the presence of very fine-grained dissemented hematite in interstices between the quartz grains. Much of it has weathered to limonite which forms irregular masses and red-brown stains throughout the rock.

Clay, or authigenic minerals derived from clays, are present in most rocks, and in a few cases account for 5 to 10% of the bulk of the rock.

Accessory minerals, include well rounded grains of zircon and tourmaline, and a few flakes of micas.

The total thickness of the formation has only been measured in two places, both of them in areas near the major fault zone. One section, 2 miles south-east of Bucket Spring is 1,050 feet thick, and the other, 9 miles to the northeast, 990 feet. These are mimimun figures since the Ranford Formation lies unconformably on the Bullo River Sandstone.

Distinctive Features

The formation is easily recognized on aerial photographs by its distinctive pattern: the basal member forms a minor scarp and smooth bench, while the remainder is very strongly jointed, and forms very rugged terrain. On the ground, the unit is easily recognized by its blocky to very massive nature, and its dark red to purple colour.

Palaeogeographic significance

The Bullo River Sandstone may represent a red bed facies. The red colour alone is not a criterion of a specific environment of deposition but the composition of the unit suggests that it is a non-marine deposit. The abundance of cross bedding of all scales and the presence of numerous conglomeratic beds indicate a fluvial environment with streams of sufficiently velocity to transport coarse sand and pebbles over wide areas.

The lack of interbedded silt and mud is noteworthy. The sorting and rounding characteristics of the sand grains indicate that the sandstone is texturally submature (Pettijohn 1957). The formation has affinities with previously documented redbed deposits, particularly of the Newark-type described by Pettijohn (1957).

Black Point Sandstone Member

Distribution: The Black Point Sandstone Member crops out mainly around the margins of the Bullo River Sandstone outcrop.

Derivation of name

From Black Point, a small headland on the east bank of the Victoria River about 12 miles upstream from Entrance Island.

Type locality

The type locality is adjacent to the Bullo track, 3 miles north-north-west of Big Knob Waterhole.

Stratigraphic relationships

The member is overlain conformably by the remainder of the Bullo River Sandstone.

The lower contact, with the Shoal Reach Formation is sharp, there being an abrupt change in lithology from thin-bedded siltstone and dolomite to the overlying thicker bedded sandstone. It may be an unconformable contact.

Lithology

The Black Point Sandstone Member was first differentiated as a photogeological unit by Perry (1967a), its upper boundary being a prominent bench, and its photocharacter being much smoother and less jointed than the remainder of the formation.

The rock is similar to that in the rest of the Bullo River Sandstone but minor lithological differences are apparent in the field. It contains feldspar - commonly 5% and up to 10% - which is usually quite fresh, and mostly microcline and perthite.

In many places the sandstone is better sorted and slightly less ferruginous than the remainder of the formation. Conglomeratic sandstones are rare, with the exception of the basal few feet.

The base is well exposed at Alligator Waterhole, about 10 miles northeast of No. 7 Bore, where the contact is sharp, and the beds underneath appear to have been truncated. A conglomerate at the base contains a few pebbles of silicified oolitic limestone. The member is extremely massive at this locality and forms very large-scale crossbedded layers up to 15 feet thick.

North and west of Bullo Gorge, a few feet of red brown shale occurs at the base of the member. Both east and west of the gorge the contact between the Shoal Reach Formation and the Bullo River Sandstone is marked by up to three feet of massive concretionary limonite.

The Black Point Sandstone Member appears everywhere to be of the order of 150 feet, but may reach 200 feet in the north.

Big Knob Beds

The Big Knob Beds occur exclusively as swarms of steep-sided knobs (see fig. 43). They have the form of domes or short whalebacks with almost vertical walls on at least two sides (see fig. 45). They are up to 70 feet high and have a similar diameter. They are formed of bare massive rock and large boulders, most with a steep talus slope. On air photos they appear as small dark-toned spots.

Distribution

Three separate swarms occur in the south-west part of the Pinkerton Range. In the largest of these, five miles south-west of Big Knob Waterhole, about 110 knobs occur in ten square miles. One of the two smaller swarms is near No. 7 Bore, and the other is five miles south of Bullo Gorge around Big Knob Waterhole. The swarms have sub-linear branched forms (see fig. 42).

Type locality

The type locality is at Big Knob Waterhole, adjacent to the Bullo track (Grid ref. 242012).

Stratigraphic relationships

The knobs all lie in the stratigraphic level of Shoal Reach Formation or on the Spencer Sandstone; the bases of a few are in the upper part of the Spencer Sandstone. The upper part of some knobs lie in the Black Point Sandstone Member of the Bullo River Sandstone. It is possible that all the knobs were lying discordantly within the Shoal Reach Formation before this was preferentially eroded away.

The contact between the knobs and adjacent formations was not seen because of scree cover.

Lithology and thickness

The knobs consists of ferruginous sandstone, grit and conglomerate. The most common type is sandstone. It is red-brown, massive, thin bedded or nonbedded, medium to coarse grained and poorly sorted. The quartz grains are colourless, white, opalescent blue and yellow: they measure up to $\frac{1}{2}$ cm in diameter and are sub-angular. Both flattened and unflattened mudstone clasts are common. The sandstone contains thin lenses of grit, and some portions contain up to ten percent muscovite. The sorting is moderate to very poor. Grains are sub-rounded to rounded with ferruginous sheaths and siliceous overgrowths. Accessory amounts of chert, quartzite, sericitized rock fragments, tourmaline and zircon are present. A clay and iron oxide matrix forms well under five percent of the rock.

The upper part of some of the knobs consist of conglomerate (see fig. 44). The matrix is very poorly sorted with quartz grains from $\frac{1}{2}$ cm. to 1 cm; the largest grains are angular. The megaclasts form up to 50 percent of the rock. Their size, shape, and composition vary considerably. They are up to one foot long, and rounded or angular. Many of them are tabular. Common rock types are: red-brown, thin bedded siltstone; white, thin-bedded and cross-bedded, medium-grained sandstone poorly sorted with up to ten percent of feldspar grains; red-brown, fine to medium-grained, well sorted sandstone; and small fragments of white micaceous clay.

The rock also contains rounded nodules of very ferruginous well sorted sandstone from 1 cm to about 15 cm across. They do not appear to be discrete bodies but grade into the surrounding sandstone: they generally weather out preferentially. Iron is the main cement with minor quantities of barite: there is no siliceous cement and the grains do not appear to have any siliceous overgrowth. These nodules are particularly common in the upper conglomeratic parts of the knobs but do occur throughout. A generalised and estimated section, typical of knobs near the Bullo track, comprises.

TOP

30 feet	Cobble and boulder <u>conglomerate</u> passing down into <u>sandstone</u> with many cobbles of siltstone and minor sandstone
2 feet	Soft muscovite-rich <u>sandstone</u>
30 feet	Hard <u>ferruginous sandstone</u>

BASE

Boundaries between the sandstone and conglomerate are gradational and very vaguely defined.

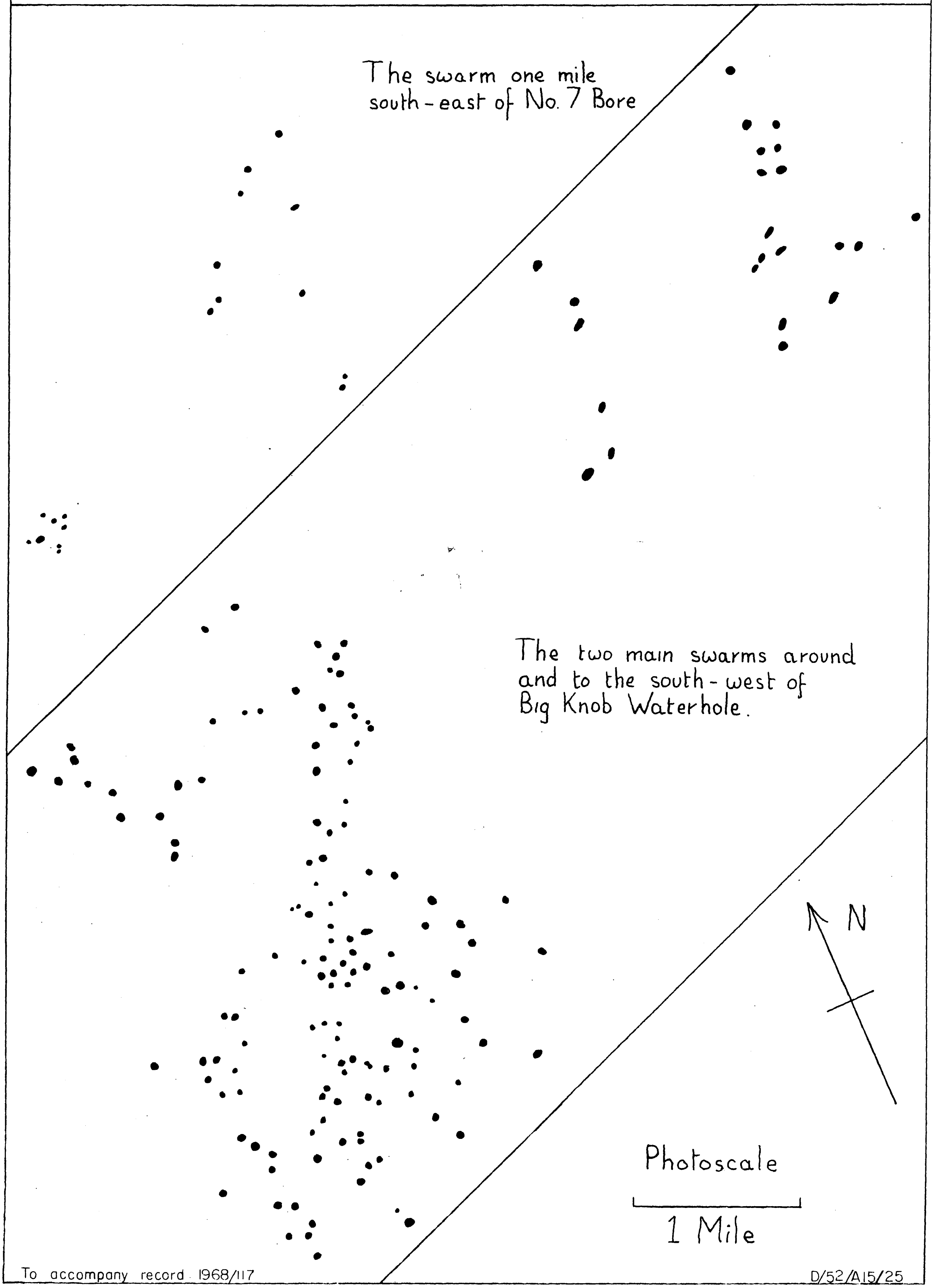
<u>Discussion and correlation</u>

The origin of the knobs is obscure. All the knobs are within the Shoal Reach Formation. However their distribution and very different composition strongly suggest that they were not originally part of this formation.

The Shoal Reach Formation is composed of dolomitic sandstone and one suggestion therefore is that the knobs are composed of sediment which has filled sink holes in this formation. If this is the case the branched sub-linear form of the swarms of knobs may be explained as the reflection of the valley system in which the sink holes formed.

FIG 42

Distribution of outcrop of Big Knob Beds



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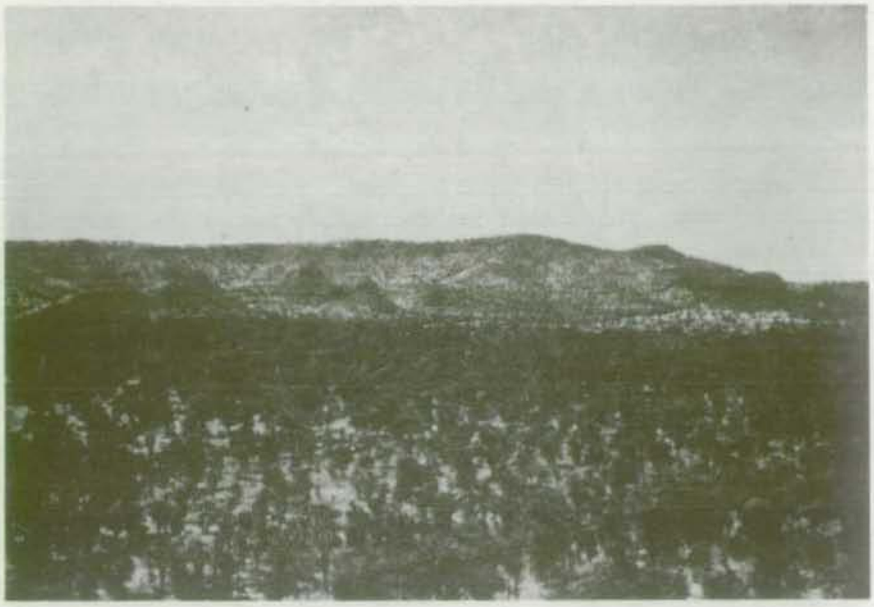


Fig.43 Swarm of Knobs constituting the Big Knob Beds, 7 miles S.S.E. of Bullo Gorge, east of the Bullo track.

GA/527(C.M.M.)

Fig.44 Conglomerate from Big Knob Beds. Ferruginous nodules ringed.

GA/531(C.M.M.)

Fig.45 Typical mode of occurrence of Big Knob Beds near the Bullo Track.

GA/572(C.M.M.)

The sediment forming the Big Knob Beds are most similar to those in the Beasly Knob Member of the Ranford Formation, in the central western part of the Sheet area. This member contains conglomerate and sub-mature ferruginous sandstone with opalescent blue, white and yellow quartz; both rock types are typical of the rock forming the knobs. Thus the Big Knob Beds may be tentatively correlated with the Beasly Knob Member of the Ranford Formation.

Bonte (1963) describes the formation of solution holes in carbonate formations with a sandstone capping. The sandstone collapses into the hole as it is formed. The lithology of the Bullo River Sandstone is similar to that of the Big Knob Beds, so it is also possible that the knobs were formed in this way, the Bullo River Sandstone being the source of these beds.

A second suggestion for the mode of formation of the knobs is that they are the remains of eskers or kames which have consolidated but subsequently been re-eroded by ice. A few linear features which are somewhat similar to glacial striations are exposed on the side of the knob adjacent to Big Knob Waterhole.

It has already been observed that the lithology of the knobs is similar to that of the Beasly Knob Member of the Ranford Formation which is known to be associated with glacials. Further evidence for a glacial origin of the knobs is found in the presence of ferruginous nodules. Similar structures are found in sandstone associated with recent glacial deposits in Scotland. It is thought that there were originally ice - cemented lumps of sand which became incorporated in the sandstone: when the ice melted it was completely or partially replaced by another cement, often iron oxide.

ADELAIDEAN

DUERDIN GROUP

Introduction

A summary of the stratigraphy of the Duerdin Group is given in Table 7.

The formations of this group, originally called the Ord Group (Dow et al 1964) were first recognised in the Ord River Region. In that area they consist of tillites, sandstones, siltstones, and shale. On the Auvergne Sheet area tillites and associated conglomerate, sandstone, and minor dolomite have been divided into three formations and included in the Duerdin Group, these are :-

Ranford Formation
Skinner Glacials
Moonlight Valley Tillite

Both the Ranford Formation and the Moonlight Valley Tillite were defined in the Ord River Region (Dow & Gemuts, 1969) but the relationship of the Skinner Glacials to these formations is not definitely known. It is included in the Duerdin Group because it contains tillite and associated rock types.

The glacial rocks are restricted to the southwestern quarter of the Auvergne Sheet area. They extend onto the Waterloo Sheet area, where their total extent is not yet known.

TABLE 7 : SUMMARY OF THE STRATIGRAPHY OF THE DUERDIN GROUP

	Rock Unit	Map Symbol	Thickness (feet)	Lithology	Physiographic Expression	Stratigraphic Relationships	Remarks
Ranford Formation	Ernie Lagoon Member	Por	Up to 35'	Light brown quartz sandstone; Minor grit interbeds	Low steep scarps	Conformably overlies Beasly Knob Member	Occupies the central western part of sheet area; youngest Precambrian unit on Sheet area.
Ranford Formation	Beasly Knob Member	Pob	Variable; over 400' in south-west	Brown quartz sandstone, siltstone, Minor pebble conglomerate and grit. Pink dolomite may be local variant	Prominent Hills	Conformably overlies Moonlight Valley Tillite. Overlaps onto Saddle Creek Formation.	Occupies the central-west part of Sheet area. Correlation of outcrops in central-west with those in south-west of Sheet area not proved.
Ranford Formation	Bucket Spring Member	Pou	Up to 180'	Silstone and micaceous Sandstone	Low rounded hills or gently inclined talus slopes	Overlies Bullo River Sandstone. Unconformity not proved	Occupies the central west of Sheet area. Photopattern identical with that of Moonlight Valley Tillite.
	Moonlight Valley Tillite	Pom	Up to 400'	Probably mainly boulder tillite. Some conglomerate, sandstone and siltstone. Pink laminated dolomite at top	Low, rounded hills or gently inclined scarps where protected by hard caprock	Overlies Auvergne Group and other older rocks with pronounced disconformity Overlain conformably by the Ranford Formation	Outcrop is rare. Main key to recognition as Moonlight Valley Tillite is the thin pink dolomite band observed north of Hungry Billabong yard
	"Skinner Glacials"	Poi	Up to 630'	Boulder tillite, fluvioglacial conglomerate and sandstone.	Steep-sided mesas	Overlies Auvergne Group with pronounced disconformity	Continues into Waterloo Sheet area

The outcrops can be divided into two types. The first, and more extensive type, forms low rounded hills, and has a light grey tone on aerial photos. This is overlain by a few feet of dolomite and several hundred feet of sandstone, and bears a similarity to the Moonlight Valley Tillite in Western Australia. It crops out north and north-west of Newry homestead.

The second type, cropping out east and east-north-east of Newry consists of three, parallel, north-east-trending ridges of sandstone, conglomerate and tillite.

As the tillite sequences are somewhat dissimilar, and the outcrop cannot be traced from one type to the other, two names are used. The first type is called Moonlight Valley Tillite, and the second "Skinner Glacials". Subsequent mapping on Waterloo should result in formal naming of the latter.

Moonlight Valley Tillite

Distribution

The Moonlight Valley Tillite crops out on the south-western quarter of the Auvergne Sheet area. The largest outcrop is one of about 60 square miles between 10 and 20 miles northeast of No. 7 Bore. Several other large outcrops occur north and west of the bore; the northernmost outcrop known is about 14 miles from the bore.

Derivation of name

Previously used in describing glacial rocks in the East Kimberleys (Dow et al. 1964), the name is derived from Moonlight Valley, 90 miles south of Kununurra.

Stratigraphic relationships

On the Auvergne Sheet area, the Moonlight Valley Tillite unconformably overlies a number of Precambrian formations, ranging from the Saddle Creek Formation to the Bullo River Sandstone. It most commonly overlies the Bullo River Sandstone and in places it fills fossil valleys (pre-Duerdin Group) within this formation. The Bullo River Sandstone is the youngest known unit overlain by the tillite. The nature of the unconformity varies from a very pronounced angular discordance, to a disconformity.

The tillite is overlain, apparently conformably, by the Ranford Formation. In Western Australia this is unconformably overlain by Antrim Plateau Volcanics, thus fixing the age of the tillite as Precambrian. About four miles north of Hungry Billabong, dolomite overlies the Moonlight Valley Tillite as it does on the Lissadell Sheet area (op. cit.)

Lithology and thickness

Outcrop of the tillite is rare; there is in fact only one locality known (near Alligator Waterhole in the south-west corner of the Auvergne Sheet area) where "boulder clay" crops out. In the rest of the area, the main evidence for recognizing the presence of tillite, is the presence of boulders, cobbles and pebbles scattered on the surface. The range of sizes is large - from small pebbles up to boulders 6 feet across. Cobbles and small boulders are the most common sizes. The majority of these megaclasts are of light-coloured quartzite or silicified sandstone; less common are siltstone, algal limestone and conglomeratic sandstone. At Alligator Waterhole there are a number of boulders (up to 18 inches) of a coarse-grained, pink-feldspar granite, and dark grey mica schist. Most megaclasts are very well rounded, and many are polished. They are generally ovoid in shape. Several display vague striations, and crescentic fractures are common. Some boulders display a series of parallel fractures. which appear to be non-tectonic in origin. A striated glacial pavement developed on a sandstone band of Saddle Creek Formation was found 10 miles north east of Beasly Knob. (Ref. fig. 46 and 47). Striations are oriented at 200°, but the sense of ice-movement is not known.

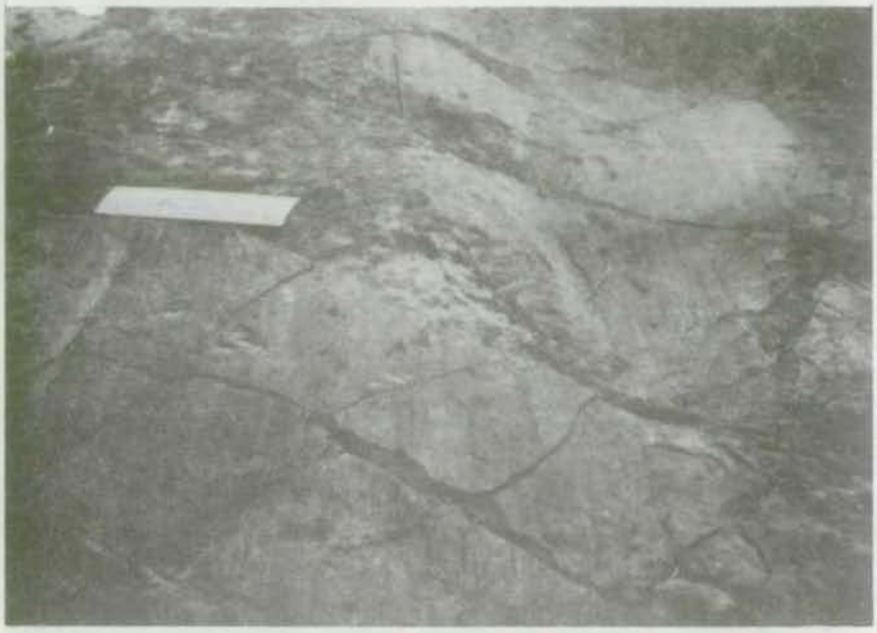


Fig. 46 Remnants of striated pavement developed on Saddle Creek Formation. 10 miles north-east of Beasly Knob.

GA/548(I.P.S.)

Fig. 47 Same pavement as in Fig. 46. Practically all polishing has been weathered away.

GA/544(I.P.S.)

Fig. 48 Striated boulder from Moonlight Valley Tillite, near Hungry Billabong Yard.
GA/577(I.P.S.)

Fig. 49 Residual cobbles from Moonlight Valley Tillite lying on a basement of Bullo River Sandstone. No pavements have been observed on this sandstone.
GA/516(I.R.P.)

The northern extent of these boulder-covered hills is about 7 miles north of Bubble Bubble Spring. One mile west of the spring, there are two interbeds of siliceous siltstone in the tillite. The siltstone is identical to the Bucket Springs Siltstone Member of the Ranford Formation, which crops out to the north and west. This may be the northern limit of the tillite, which could intertongue with the Bucket Springs Member.

Because of the presence of polished, striated and fractured boulders, the rock is believed to be a true tillite rather than a fluvioglacial conglomerate derived from a tillite. By comparison, the conglomerates associated with the "Skinner Glacials" are indurated, and give measurable outcrop due to their resistance to erosion.

Near Bubble Bubble Springs, about 6 feet of pink, thin-bedded to laminated dolomite overlies the tillite. This is one of the important criteria in recognizing the tillite as Moonlight Valley Tillite, as identical dolomites are reported in the same stratigraphic position from adjacent areas in Western Australia by Dow & Gemuts (1969).

The thickness of the tillite is difficult to measure, as it displays no bedding, and is deposited on an irregular surface. Generally its upper limits are not present. However, it is generally more than 100 feet thick, and may be as much as 400 feet. A pre-tillite valley was eroded along a fault zone north-east of Alligator Waterhole, and this was filled in by tillite to about 400 feet.

<u>Distinguishing features</u>

The formation characteristically forms low, rounded, spinifex covered hills. There is a complete lack of indurated outcrop, although the surface is made very rough by the presence of numerous boulders. The drainage pattern is dendritic, reflecting a uniform underlying rock type.

"Skinner Glacials"

Distribution

The "Skinner Glacials" occur in three series of ridges, which all trend in a northeast-southwest direction. The lowest of these is near Saddle Creek Dam, and the most prominent forms the high mesas at Skinner Point. The third series of ridges occurs 6 miles southeast of those at Skinner Point.

Derivation of name

The name comes from Skinner Point, which is the extremity of a prominent mesa $\frac{1}{4}$ mile south of the main Katherine-Wyndham road, and midway between Auvergne and Newry homesteads.

Type locality

None established.

Stratigraphic relationships

Although mapping of this unit is not complete, the Skinner Glacials are known to overlie with pronounced unconformity the Angalarri Siltstone. They also lap onto the Saddle Creek Formation and the Pinkerton Sandstone. They are probably overlain on the Waterloo Sheet area by the Antrim Plateau Volcanics.

Lithology and thickness

The most complete section examined on the Auvergne Sheet area, about $\frac{1}{2}$ mile west of Skinner Point, is as follows:

Thickness (ft)	Top
(6) 100 +	Sandstone: thin to medium-bedded, flaggy to blocky, interbedded with light grey mudstone near base. Sandstone is very argillaceous, but less matrix in upper part.

Thickness (ft)		Top
(5)	75	<u>Tillite</u>: As for (3)
(4)	50	<u>Conglomerate or tillite</u>. Very high proportion of pebbles and cobbles. Most are limestone, some chert, igneous and metamorphics. Small proportion of sandy matrix. May intertongue with slightly conglomeratic coarse cross-bedded sandstone.
(3)	250	<u>Tillite</u>: light grey-green, heterogeneous matrix. Variety of megaclasts, including dolomite, ? limestone, quartzite, igneous and metamorphic rocks. Highly polished and striated cobbles of algal limestone (dolomite?) are the most common. (see fig. 54, 55).
(2)	150	<u>Sandstone and conglomeratic sandstone</u>. Some <u>conglomerate lenses</u>. Large scale cross bedding. Quartz sand - medium to coarse; pebbles and cobbles well rounded, most of quartzite. Some limestone clasts, and cement. (see fig. 56)
(1)	?	<u>Tillite</u>: grey green unsorted matrix; some granite and metamorphic megaclasts, mainly dolomite megaclasts.

Total 628

UNCONFORMITY: -

Angalarri Siltstone

The outcrops 6 miles to the southeast contain no tillite, but consist of interbedded conglomerate and sandstone. The majority of clasts are of dolomite. A few feet of conglomeratic sandstone contains up to 50% of limonite, including some as pseudomorphs after pyrite or magnetite. Overlying this is a massive, extremely friable, yellow, medium-grained argillaceous sandstone. The top of the hill is covered with scattered rounded and polished quartzite boulders, which could be derived from an eroded tillite, or from another conglomerate.

The line of conglomerate to the northwest of the Skinner Point locality (near Saddle Creek dam) contains no true tillite. It is a thick-bedded sequence of coarse, poorly sorted dolomitic sandstone, with numerous pebbles, cobbles, and boulders of quartzite, dolomite, chert, and a few of granite. (fig. 53). One large striated boulder could have been dropped directly from ice. The rocks were obviously deposited by water, and are considered to be fluvioglacial in origin. They are probably less than 200 feet thick in this area.

The outcrops occupy the floor of a present-day valley which must also have been a valley during the Precambrian. They overlap the Auvergne Group, and extend northeastwards onto the Pinkerton Range.

Distinguishing features

The "Skinner Glacials" have no charateristic photo-pattern, and in fact the hard and soft bands result in topography which is almost identical to that associated with the Auvergne Group. They were originally photointerpreted as Auvergne Group for this reason, and were recognized only by ground mapping and examination of lithology and contact relationships.

Palaeogeographic significance

Both sequences of glacial rocks described are believed to be a record of the Moonlight Valley Glaciation described by Dow and Gemuts (1969). Such rocks provide a valuable record of palaeo-climate.

The greater part of the Moonlight Valley Tillite in the Auvergne Sheet area is thought to be a true tillite, formed on land under moving ice. Evidence for this is provided by their composition and the striated glacial pavement found in the west of the area.

Fig. 50 Striated boulder in fluvioglacial sandstone ("Skinner Glacials") GA/594(I.P.S.)

Fig. 51 Mesas of "Skinner Glacials" extending northeast from Skinner Point. Pinkerton Range in the distance. GA/16(I.P.S.)

Fig. 52 Line of small hills arrowed are "Skinner Glacials": occupying a valley formed in the Auvergne Group during the Precambrian.
GA/607(A.G.R.)

Fig. 53 "Skinner Glacials": Boulders of quartzite, granite, and dolomite set in a matrix of dolomitic sandstone (Near Saddle Creek Dam). These are fluvioglacial deposits.
GA/520(I.R.P.)

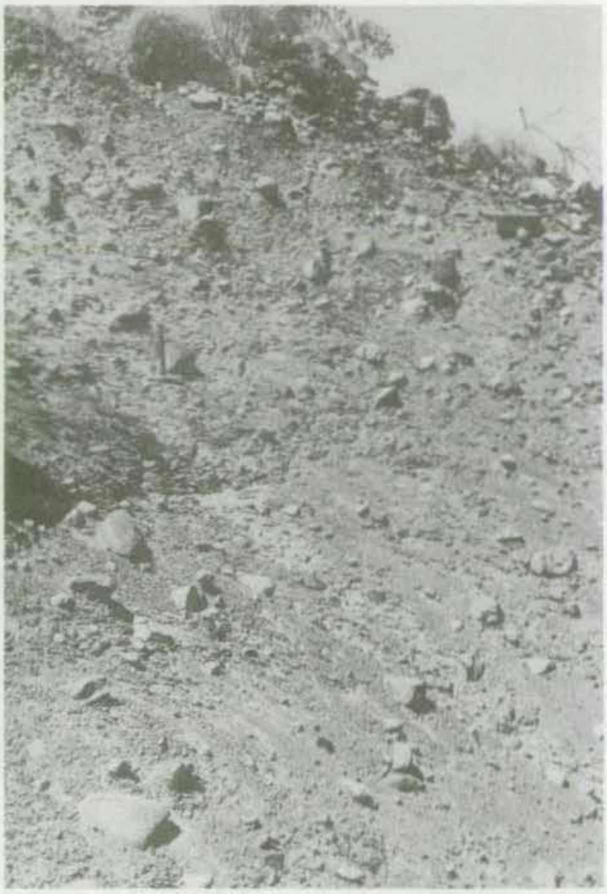


Fig. 54 Outcrop of tillite within "Skinner Glacials". The rounded, polished, and striated boulders are set in a heterogeneous, poorly consolidated clayey and sandy matrix.

Fig. 55 "Skinner Glacials": tillite overlain by poorly sorted conglomerate.

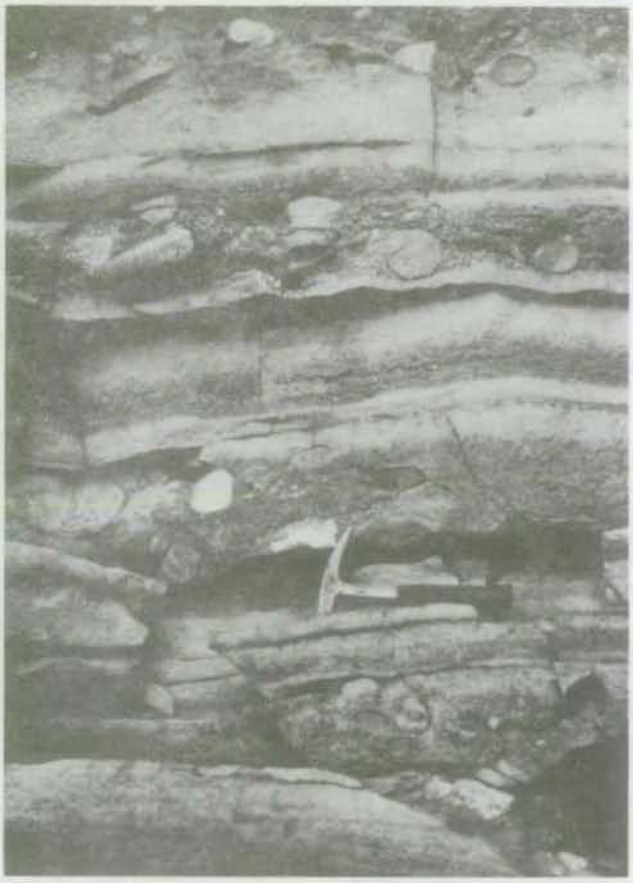


Fig. 56 Fluvioglacial deposits in "Skinner Glacials" at Skinners Point. Pebbles and cobbles in the conglomerate are mostly of sandstone and quartzite, with rare granite and metamorphic clasts. Some beds are crudely graded.

The "Skinner Glacials" were also deposited on land. The conglomerates display strong cross-bedding, linear outcrop, and numerous boulders, and are interpreted as fluvioglacial sediments. Tillite at Skinners Point appears to grade into the fluvioglacial conglomerate at one locality. The linearity of the outcrops is thought to be the result of preservation of the greatest thickness of fluvioglacial and glacial sediments in river or glacial valleys. Since the sediments lap onto the Pinkerton Range northeast of Saddle Creek, the stream must have run from northeast to southwest. However, there are no direct indications regarding ice movement.

The composition of most of the boulders is not of great value in defining the provenance as quartzite or silicified sandstone could be derived from several areas. The nearest granite is in the Halls Creek Mobile Zone, to the west, but an insufficient number of erratics preclude detailed provenance studies. Dow and Gemuts (1969) consider that the Moonlight Valley Tillite came from the north, and there is no evidence on the Auvergne Sheet to contradict this.

The provenance of the limestone or dolomite boulders in the "Skinner Glacials" in unknown. No dolomite or algal stromatolites in the Auvergne Group bears any resemblance to them, nor have similar rocks been seen in the Skull Creek Formation. The Bungle Bungle Dolomite (Dow & Gemuts, 1969) contains similar stromatolites in great abundance. This could provide evidence for a southerly provenance for the Skinner Glacials.

Ranford Formation

The Ranford Formation was defined by Dow et al (1964) as the rocks conformably overlying the Moonlight Valley Tillite in the Ord River Region. The sequence conformably overlying the tillite on the Auvergne Sheet area is equated to the Ranford Formation but because its composition does not correspond closely with that in the Ord River Region the formation has been subdivided into three new members, viz.

Ernie Lagoon Member
Beasly Knob Member
Bucket Spring Member

Bucket Spring Member (new name)

Distribution

The Bucket Spring Member is exposed in the central-western part of the sheet area. Most of it is confined to the core of a syncline south of the Victoria River Fault.

Derivation of name

The member is named after Bucket Spring in the west of the Sheet area.

Type locality

In the core of the syncline 12 miles north-east of Bucket Spring.

Stratigraphic relationships

This member is the lowest unit in the Duerdin Group in the central-western part of the Sheet area. It overlies the Bullo River Sandstone but an unconformable relationship has not been proved. It is conformably overlain by the Beasley Knob Member.

Lithology and thickness

Outcrop of the member is limited to small exposures immediately below the massive Sandstones of the Beasly Knob Member.

The member consists of interbedded grey-green siltstone and fine grained light grey micaceous sandstone. In thin section the rock is moderately sorted with a clay matrix forming over five percent. The grains are apparently sub-angular but quartz over growths mask their original shape. Fresh microcline (5%) and thin flakes of muscovite (2%) are also present with accessory zircon and tourmaline.

The Bucket Spring member is 180 feet thick along the Victoria River Fault. Eight miles south of the fault it is only 100 feet thick: it is not present a few miles further south where the tillites occur.

Distinguishing features

The Bucket Spring Member forms low rounded hills or gently inclined debris slopes where it is capped by the Beasly Knob Member. Typically, these hills show virtually no outcrop, and the absence of trees or scrub growth is distinctive. On aerial photographs the unit has a smooth light tone identical to that of the Moonlight Valley Tillite. In the field it is recognized by its fine and micaceous nature.

Beasly Knob Member (new name)

Distribution

The Beasley Knob Member forms isolated outcrops in the south-west part of the Auvergne Sheet area, and also crops out in the central-western part of the Sheet area.

Derivation of name:-

The member is named after Beasly Knob in the south-west corner of the Sheet area.

Type locality

Near the Victoria River Fault, 8 miles east-north-east of Bucket Spring (Lat. 15°34'S, Long. 129°20'E)

Stratigraphic relationships

The Beasly Knob Member conformably overlies the Moonlight Valley Tillite in the south-west of the Sheet area, and unconformably overlaps the Saddle Creek Formation near the Keep River.

The sandstone and conglomerate separating the Bucket Spring and Ernie Lagoon Members in the central-western area is mapped as Beasly Knob Member, but this correlation is not conclusively proven.

Lithology and thickness

North of the Keep River the Beasly Knob Member consists, principally of sandstone: grey or brown, blocky or massive, thin to thick-bedded, poorly sorted and medium-grained. Green mud flakes are very common. It contains several interbeds of very poorly sorted pebble conglomerate and grit.

The sandstone consists of poorly sorted rounded quartz grains with siliceous overgrowths, and rounded grains of fresh microcline (1%). Tourmaline and sericitised rock fragments are present. Fine zircon, iron oxides, quartz and a little clay form a matrix. (5%). Pebbles in the conglomerate are of fine quartzite.

Near the Victoria River Fault, 8 miles east-north-east of Bucket Spring the Beasly Knob Member is exposed as follows.

Ernie Lagoon Member

Thickness (ft)	
235	No outcrop: possibly a siltstone
2	Pebble conglomerate: very poorly sorted
50	Sandstone: red or grey, massive to blocky medium to thick-bedded, coarse, poorly sorted with granule and minor pebbly interbeds.

Bucket Spring Member

Eight miles further south the upper siltstone(?) and the lower sandstone and conglomerate are both 50 feet thick.

South of the Keep River the member is composed principally of sandstone much of which is very ferruginous. It is light brown, grey or red-brown, massive or blocky, medium or thin-bedded, medium to coarse-grained and generally poorly sorted. Around Skinners Point it is extremely friable possibly due to the leaching out of a carbonate matrix.

The sandstone is composed of sub-angular to rounded quartz grains with secondary siliceous overgrowths. The grains are poorly to very poorly sorted, generally with over five percent of a matrix of iron oxide, clay and fine quartz. Fresh microcline (up to 10%), fragments of fine quartzite, and accessory tourmaline, zircon and muscovite are very common. Grains of micropegmatite and a fine clayey siltstone occur in the sandstone just south of the Keep River.

On Beasly Knob the sandstone is overlain by interbedded siltstone and grit. The siltstone has a patchy development of a ferruginous matrix and resembles the "Zebra stone" in the Ranford Formation of the Lissadell (Dow & Gemuts, 1969) Sheet. The grit is ferruginous and friable.

The siltstone consists of very poorly sorted angular to sub-angular quartz grains with accessory zircon, tourmaline and sericite. A clay matrix or an iron oxide cement form about 50 percent of the rock, the coarser material tending to have the iron cement. These two types are either finely but irregularly interbedded or sporadically distributed. The interbedded grit is very poorly sorted; the larger quartz grains are rounded but the smaller ones are sub-angular. It has a matrix of clay, granular iron oxide and sericite, and patches are cemented by iron oxide.

On Beasly Knob this member consists of 270 feet of sandstone and an overlying 125 feet of interbedded siltstone and grit. The top of the Keep River about 50 feet of the sandstone only one exposed.

Ernie Lagoon Member (new name)

Distribution

The Ernie Lagoon Member is only present in the central-western part of the Auvergne Sheet area, north of the Keep River.

Derivation of name

The name is taken from Ernie Lagoon near the western margin of the Sheet.

Type locality

In the core of the syncline of Bullo River Sandstone, south of the Victoria Fault, 15 miles north-east of Ernie Lagoon.

Stratigraphic relationships

The member conformably overlies the Beasly Knob Member. It is the youngest Precambrian sedimentary unit preserved in the Auvergne Sheet area.

Lithology and thickness

Most of the Ernie Lagoon Member is sandstone: light-brown or purple, blocky, medium to thin-bedded, medium-grained, and siliceous. Some grit and pebble conglomerate interbeds occur in the northeast. The quartz grains in the sandstone are rounded to well rounded with siliceous overgrowths filling the pore spaces. Sorting is moderate to good except in the grit and conglomerate interbeds, which are very poorly sorted. Common accessories are tourmaline and zircon. Fine-grained rock fragments are abundant in the north-east.

Thirty-five feet of this member are preserved in outcrops near the Victoria River Fault in the central-western part of the Sheet area. About 25 feet are present just north of the Keep River. The unit is apparently absent further south.

Distinguishing features

The member forms low steep scarps above the siltstone at the top of the Beasly Knob Member. On air photos it appears as a medium-toned unjointed unit. In the field it is recognised by its well washed and well sorted nature; it tends to weather into rounded boulders.

LOWER(?) CAMBRIAN

Antrim Plateau Volcanics.

The Antrim Plateau Volcanics crop out over an enormous area, extending from the East Kimberley region, in a huge arc around to the Katherine - Daly River area. They overlie rocks in the Victoria River Basin and mask their relationships with rocks in the East Kimberley to the west and the Granites - Tanami area to the south.

As presently known, the volcanics cover an area of about 30,000 square miles, and this must have been considerably greater in the past. Previous work has shown that the basalts vary widely in composition from undersaturated to oversaturated varieties but they are generally considered to form a homogeneous petrographic province of tholeiithic basalts. (Edwards and Clarke, 1940). The thickness is extremely variable, and ranges from less than 200 feet over large areas, to 3,300 feet north of Turner Homestead (Traves, op. cit.).

The Antrim Plateau Volcanics have a limited extent on the Auvergne Sheet area, where they crop out in the south-west corner, covering an area of about 40 square miles. Two areas are recognized: one near Beasly Knob and the other 10 to 15 miles to the north east near No. 7 Bore.

Stratigraphic relationships

Stratigraphic relationships were not determined on the Auvergne sheet. Traves (op. cit.) presents evidence for a Lower Cambrian age for the volcanics as they fill valleys in Adelaidean sediments, and are overlain, apparently conformably, by the Middle Cambrian Negri Group. Numerous examples of extensive erosion of prevolcanic rocks are cited, with basalt occupying valleys. Laing and Allen (1956) also recorded basalts filling valleys in Jasper Gorge Sandstone.

Lithology and thickness

The total thickness of the volcanics on the Auvergne area is unknown, and only about 100 feet can be seen in outcrop. They vary from vesicular basalts near Low Bald Hill in the southwest, to dark green compact basalt 15 miles to the north-east. The vesicular basalt is interbanded with non-vesicular layers, apparently representing a number of flows, each only a few feet thick.

Thin-sections reveal that the basalt contains a single pyroxene, probably pigeonite. The rocks from the Beasly Knob area are fine grained, with over 50 percent unidentifiable ground mass. This may contain pyroxene. The coarser grains are highly altered plagioclase and a pyroxene. In contrast, the volcanics near No. 7 Bore are medium-grained, slightly porphyritic basalt, and are very little altered. The grain size of the plagioclase and pyroxene is from 0.1 to 0.6 mm, with plagioclase phenocrysts up to 2 mm. Only the large grains appear saussuritized. The pyroxene is probably pigeonite, and the plagioclase is labradorite (An_{54}).

Distinguishing features.

The volcanics generally form low hills or plateaux. Scarps can be recognized as containing volcanics by the prominent dark-coloured scree slopes. Jointing is present, and is generally the locus of weathering.

LOWER CRETACEOUS

Mullaman Beds

The Mullaman Beds unconformably overlie rocks of the Auvergne Group in the north-eastern part of the Sheet area. They were identified by correlation with Mullaman Beds of Lower Cretaceous age defined by Skwarko (1966) and Randal (1962) in adjacent areas to the north and east. The beds have been extensively lateritised; the laterite and associated products of silicification typically form a tough cap rock on mesas and other remnants of a dissected plateau. The Mullaman Beds are in most places exposed in profiles underlying the laterite.

The beds consist essentially of sandstone, and since they generally occur below a lateritic profile they are invariably extensively altered. By reference to the work by Skwarko (1966) it seems likely that the unit on this Sheet area consists of marine sediments overlying freshwater sediments, but the composition of the beds and their apparent lack of fossils, gives no indication of this.

CAINOZOIC

Laterite: (Czl)

Remnants of ferruginous laterite and lateritic soil are found in the north-eastern part of the Sheet area. The laterite has formed almost exclusively on the Mullaman Beds, thin remnants of which overlie units of the Auvergne Group - mainly Pinkerton Sandstone. The laterite forms part of the mature Tennant Creek erosion surface of Hays (1967) and is probably a remnant of the Tertiary laterite surface which previously covered most of North Australia. The Pinkerton Sandstone forms a plateau surface immediately below the Mullaman Beds and this seems to be resistant to lateritization. Thin lateritic soils have developed over Jasper Gorge Sandstone in the southern part of the Sheet area.

Undifferentiated gravels (Czg)

Deposits of unconsolidated gravel overlie the Angalarri Siltstone at several localities on the Whirlwind Plains. They are situated on the southeastern side of the plain between the West Baines and Victoria Rivers.

The gravel forms protective cappings on the siltstone and small hills are thereby produced. It consists of subrounded to rounded pebbles and cobbles of sandstone, chert, and jasper up to a few inches in diameter (see fig. 57.). The deposits are no more than about 10 feet thick.

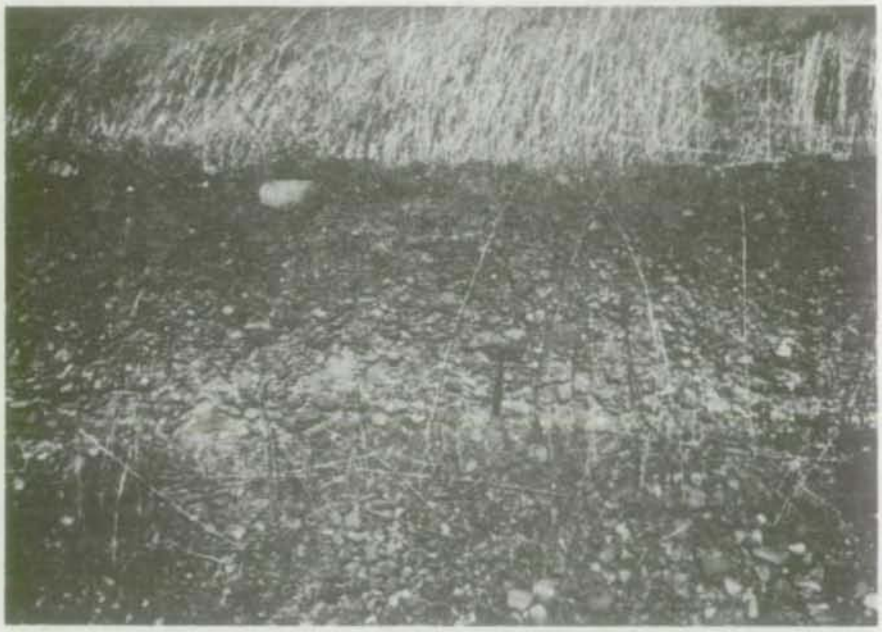


Fig.57 Cainozoic gravels (Czg), 8 miles south-east of Auvergne homestead.
GA/593(I.P.S.)

The gravels could be piedmont deposits, eroded rapidly by minor streams from the nearby Newcastle Range. Alternatively, they may have been deposited by the Victoria and Baines Rivers during an earlier erosional and depositional cycle.

The deposits include an area near the Victoria River mapped by Traves (1955) as possible Weaber Group of Palaeozoic age. There is nothing to substantiate this, and it seems much more likely that the deposits are of Cainozoic age.

Black soil: (Czb)

Areas of black soil occur on the Baines - Angalarri Plains and on the Cambridge Gulf Lowlands. It forms typical rough surfaces with gilgais and desiccated cracks. Much of this soil appears to be derived from underlying carbonate rocks.

Superficial soils: (Czs)

Superficial sand, residual soils, eluvium and minor travertine occur throughout the Sheet area. Sand occurs on the tops of sandstone plateaux and as valley deposits adjacent to sandstone ranges, commonly associated with scree and gravels. A widespread blanket of sand also covers much of the Cambridge Gulf Lowlands. Many scarp slopes and some velley and plain pavements shown on the map, as Angalarri Siltstone, Lloyd Creek Formation, and Spencer Sandstone, are in fact covered by thin sand and scree deposits.

Terrace deposits: (Czt)

Terrace deposits consist of river deposited mud, silt and evaporites along the banks of the Victoria River down stream of Timber Creek. They were not closely examined but their distribution and land form lead Perry (1967a) to interpret them as alluvial-terrace deposits.

River alluvium: (Qa)

Deposits of Quaternary sediments have been, and still are being deposited along all major streams in the Sheet area. Up to 30 feet of sand, silt, clay and gravel have been found along the banks of the Victoria, Keep, and Bullo and Baines Rivers.

Most streams are now being entrenched into their own alluvial deposits. Stony creek beds are common in the hilly areas.

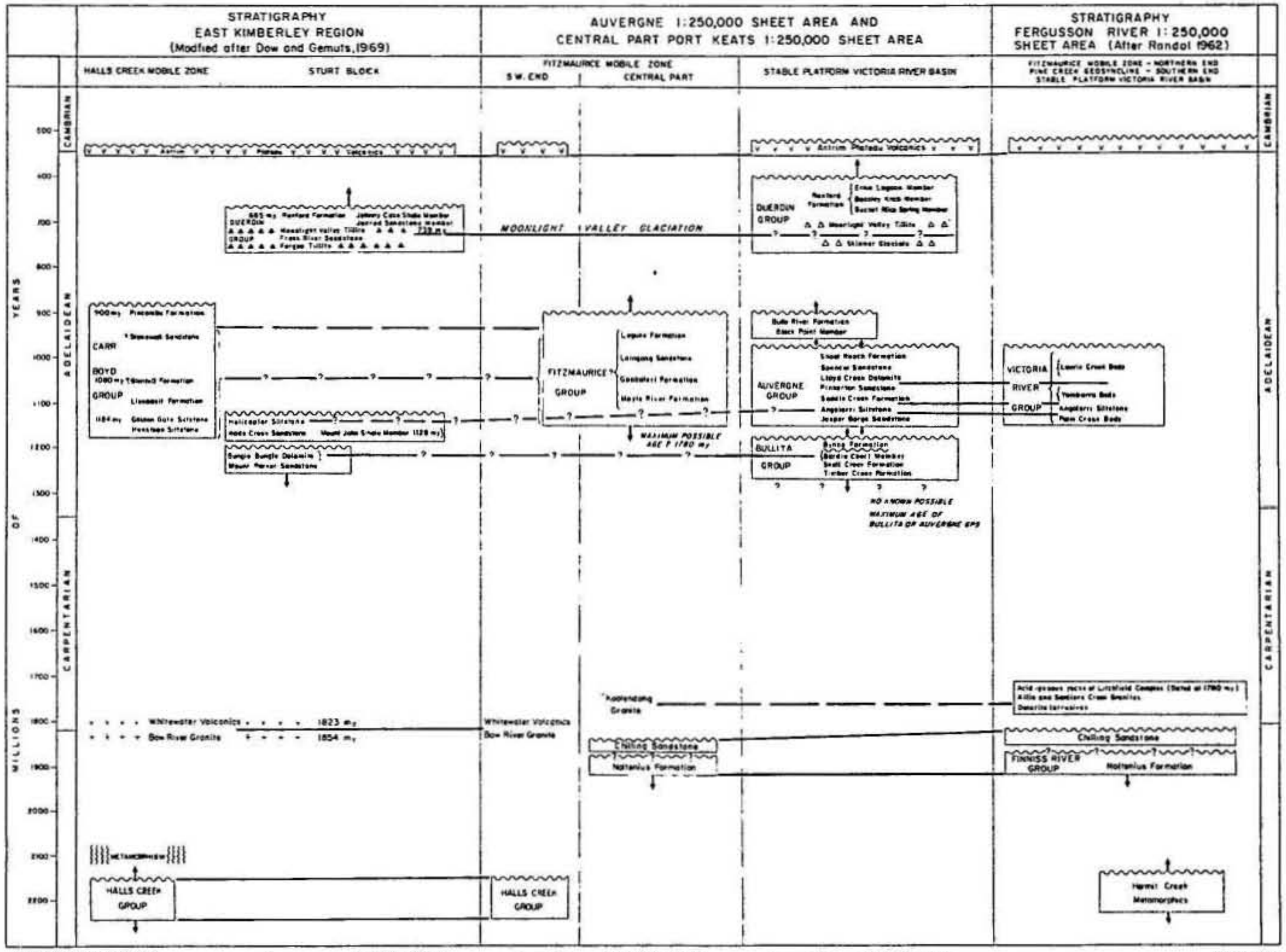
Coastal alluvium: (Qac)

Deposits of coastal mud, silt and evaporites are being deposited on the low-lying tidal flats bordering the estuaries of the Victoria and Keep Rivers, and minor coastal streams in the north of the Sheet area. The lower areas are subjected to tidal and seasonal inundation and these grade inland into emerged salt flats subject only to seasonal flooding. These emerged coastal and river flats are now being encroached on by deposits of Recent river alluvium.

STRATIGRAPHIC CORRELATIONS

It will not be possible to confidently correlate the stratigraphy if the Auvergne Sheet area with adjoining regions, both within and without the Victoria River Basin, until the mapping programme in the Basin is complete. Radiometric age determinations are also desirable. Table 8 sets out probable correlations, at the present state of knowledge, between the stratigraphy of the Auvergne Sheet area and the established stratigraphy in the East Kimberley (Dow and Gemuts, 1969) immediately to the south-west, and in the Katherine-Darwin region (Randal, 1962), immediately to the north-east. The correlation between the Adelaidean units in the East Kimberley is supported by radiometric age determinations by Bofinger (1967).

The only confident correlations which can be made with rocks in the Kimberley Region, to the south-west, are with those rocks which are essentially contiguous i.e. the basement rocks (Halls Creek Group and Lamboo Complex); Whitewater Volcanics and the younger Duerdin Group. Since these units have all been radiometrically dated in the East Kimberley they provide definite lower and upper limits to the age of the other Proterozoic rocks of the Auvergne Sheet area (Table 8).



To accompany Record 1968/117 — Correlation definite — Correlation probable —?— Correlation possible D52/A/125

Table 8.- Correlation between stratigraphy established 1967, Auvergne and Port Keats 1:250,000 Sheet Areas and stratigraphy previously established in East Kimberley Region and Fergusson River 1:250,000 Sheet Area

In the central and northern part of the Fitzmaurice Mobile Zone, in the Port Keats Sheet area, the Fitzmaurice Group overlies the Chilling Sandstone and Noltenius Formation, established in the Katherine-Darwin area as being of Lower Proterozoic age. Granites of the Litchfield Complex intrude the Lower Proterozoic units and are dated at about 1800 m.y. (Compston & Arriens, 1968). It is likely that the granites can be correlated with the Koolendong Granodiorite, just north of the Auvergne Sheet area. The Fitzmaurice Group unconformably overlies the grandiorite, implying a maximum possible age for the Group.

Traves (1955) assigned the Proterozoic sediments of both the Sturt Block and the Fitzmaurice Mobile Zone (his Halls Creek Mobile Zone) to his Victoria River Group. Harms (1959) considered the rocks of the Mobile Zone (Macadam Range Beds) to be older than the rest of the Victoria River Group. He equated them to the Chilling Sandstone and suggested a correlation with the Carr Boyd Ranges (Carr Boyd Group - Plumb and Veevers 1965) of the East Kimberley. Dunn (1965) tentatively correlated the present Auvergne Group with the Helicopter Siltstone and Wade Creek Sandstone of Dow et al (1964) and the present Bullita Group with the Bungle Bungle Dolomite. Dunn further suggested that the sediments of the Mobile Zone equated with the Carr Boyd Group but assigned them to the Carpentarian on the basis of views then held by Dow et al (1964).

Radiometric age determinations by Bofinger (1967) allowed the positioning of the East Kimberley rocks in the time - scale for the first time (see Table 8, this report). The Wade Creek Sandstone and Helicopter Siltstone fell within the overall time - span occupied by the Carr Boyd Group although specific correlation of formations is not possible. The age of the Bungle Bungle Dolomite and the conformably underlying Mount Parker Sandstone has not been satisfactoryily determined.

Dow and Gemuts (1969) equate the Wade Creek Sandstone with the Hensman Sandstone, Golden Gate Siltstone and Lissadell Formation, on the basis of correlating ferruginous beds in the Mount John Shale Member (1128 m.y.), with iron ore in the Golden Gate Siltstone (1184 m.y.).

The Bungle Bungle Dolomite was considered older than the Carr Boyd Group (and rightly shown as Adelaidean or Carpentarian on maps). Dow and Gemuts did not account for a sandstone, identified as Mount Parker Sandstone in the Lissadell Sheet area, which overlies Golden Gate Siltstone, thus raising the possibility that the Bungle Bungle Dolomite is equivalent to the Carr Boyd Group (Plumb and Dunnet 1968). The correlation chart of Bofinger (1967) is preferred to Dow and Gemuts (1969).

Current mapping shows a striking similarity between the Pincombe Formation of the Carr Boyde Group and the Legune Formation. They are similar in lithology and mode of outcrop; their structural setting is consistent with their forming a faulted, north-pitching syncline; both lie at the top of their successions and are unconformably overlain by Palaeozoic rocks of the Bonaparte Gulf Basin. Lithologies, general order of thicknesses, and tectonic setting of the rocks in the Fitzmaurice Group are all consistant with correlation with the Carr Boyd Group although facies changes in the Carr Boyd Group exclude correlation of specific formations.

There is no reason at this stage to doubt Dunn's correlation of rocks on the Sturt Block so it can be tentatively concluded that sedimentary rocks of the Sturt Block and Fitzmaurice Mobile Zones are of similar age and correlate with surrounding regions as shown in Table 8.

STRUCTURAL GEOLOGY (REFER FIG. 59)

INTRODUCTION:

The Auvergne 1:250,000 Sheet area is divided into three major tectonic units: the stable Sturt Block in the central south-east; the Fitzmaurice Mobile Zone trending north-east across the centre of the Sheet area; and the Bonaparte Gulf Basin in the north-west.

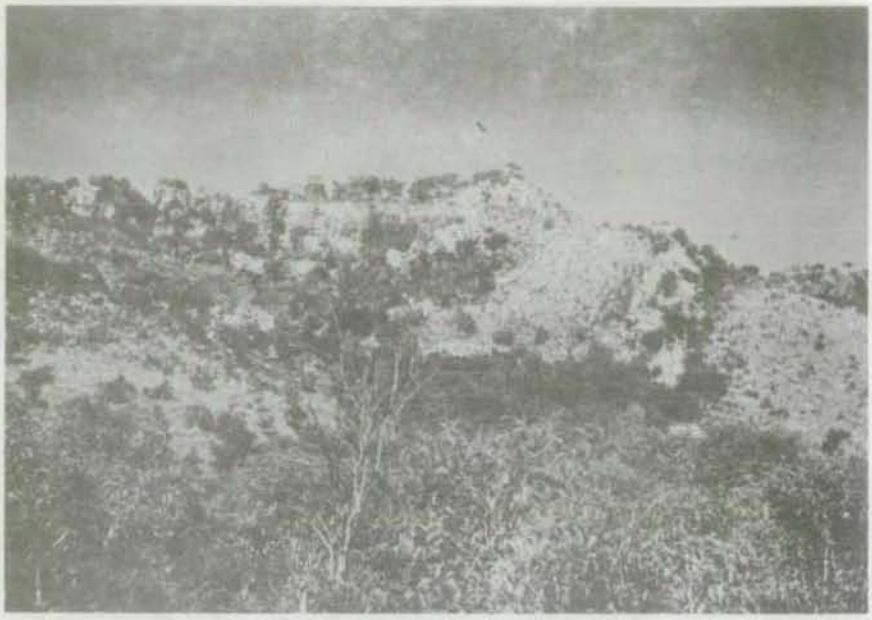
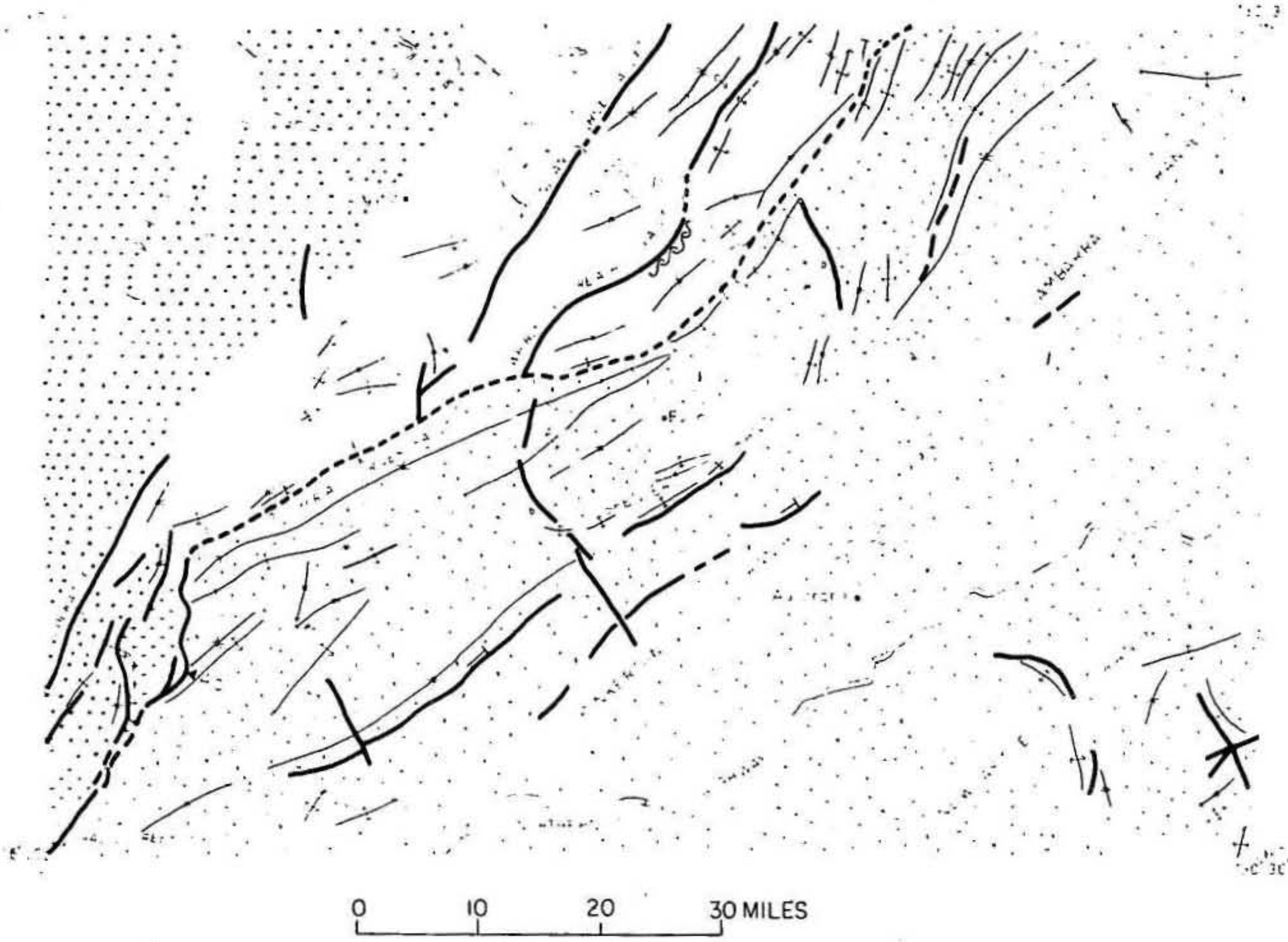


Fig.58 Siltstones and sandstones of the Ranford Formation upturned against the Victoria River Fault (to right of photo).

GA/568 (C.M.M.)

FIG 59 STRUCTURAL SKETCH MAP — AUVERGNE 1:250,000 SHEET AREA



Bonaparte Gulf Basin

Mobile Belt { Fitzmaurice Group and Legune Formation / Lamboo Complex

Sturt Stable Block

Anticline } with direction of plunge

Syncline } with direction of plunge

Dip of Beds

Dip of Overturned Beds

Horizontal Bedding

Monocline

Fault with direction of downthrow

Shear Zone

Vertical Cleavage

Geological Boundary

Thrust Fault with overthrust block marked

Reverse Fault

BONAPARTE GULF BASIN

The Bonaparte Gulf Basin contains over 10,000 feet of Palaeozoic sediments, largely covered by alluvium. Its composition and structure are described in detail by Veevers and Roberts (1966).

STURT BLOCK

The Sturt Block is a stable platform to the south-east of the Victoria River Fault. It is covered by the Bullita, Auvergne and Duerdin Group sediments. Movements have been essentially epeirogenic; the sediments are generally undisturbed over most of the area, with a gentle regional dip to the north-west, but they become more deformed adjacent to the Victoria River Fault.

Folding

Regional dips in the Jasper Gorge Sandstone and Skull Creek Formation, in the south-east corner of the Sheet area, are of the order of 5° to the north-west; this increases to about 10° in the Auvergne Group of the Pinkerton, Spencer and Yambarra Ranges.

Between these ranges and the Victoria River Fault the sediments are folded into broad folds; limbs dip mostly at 5° to 10°. In the Koolendong Valley however the sediments are almost horizontal. The folded belt is bounded to the south-south-east by a lineament comprising a fault (possibly a thrust fault), a monocline, or both. The fault or monocline runs parallel to the Victoria River Fault from No. 7 Bore in the south-west and dies out towards the north-east margin of the sheet. Bedding dips along the structure range from shallow to vertical. A similar lineament occurs 8 miles west of Bullo Homestead.

The strata adjoining the Victoria River Fault are severely folded; they are overturned along most of the length of Sandy and Paperbark Creeks.

Faulting

Faulting in the Sturt Block is not severe. Faults in the Newcastle Ranges have small throws although one north-east-trending fault has produced local bedding dips of up to 90°. Mount Dempsey is the focus of several radiating faults.

Faulting is more common in, and to the north-west of, the Pinkerton and Yambarra Ranges. Most faults trend either, north-east, parallel to the Victoria River Fault, or, roughly north-west. The north-westerly faults are the more prominent.

The north-east trending faults displace rocks of the Auvergne Group but some do not appear to displace the Duerdin Group sediments. The low-angle-reverse fault which runs north-east from No. 7 Bore brings the Saddle Creek Formation into contact with the Bullo River Sandstone, involving an uplift to the north-west of about 1600 feet; it does not cut the overlying Duerdin Group. Faulting probably took place within the Angalarri Siltstone or siltstones in the Saddle Creek Formation. The fault dies out near the Bullo Track but reappears to the north-east.
North-east of the Victoria River the fault is associated with a steep monocline, and in the region of Mussel Hole Yard there is an upthrow of about 500 feet to the west. Another low-angle reverse fault occurs about six miles south-east of this fault zone, and about 8 miles north-west of Auvergne Station.

The north-west trending faults are much more numerous than the north-east trending ones. They are vertical or nearly so and displace all units of the Duerdin and Auvergne Groups as well as the fault which runs north east from No. 7 Bore and, in one case, the Victoria River Fault. They produce upthrows, generally to the north-east, of up to 600 feet.

FITZMAURICE MOBILE ZONE

The Fitzmaurice Mobile Zone is a belt of relatively highly deformed rocks, running paralled to, and separated from the Sturt Block by the Victoria River Fault. It is an extension of the Halls Creek Mobile Zone of the East Kimberley and connects it with the Pine Creek Geosyncline to the north-east. It differs from both of these in that the great majority of rock exposed is unmetamorphosed sediment rather than the older igneous and metamorphic rock. Lateral displacements on faults are apparently much less than in the Halls Creek Mobile Zone (Dow & Gemuts, 1969).

The rocks within the Fitzmaurice Mobile Zone are principally of the Fitzmaurice Group and Legune Formation, with minor amounts of the underlying Halls Creek Group and Lamboo Complex, in the south-west. These units are overlapped in the south west corner by Palaeozoic rocks of the Bonaparte Gulf Basin, some of which are also highly deformed. The exposed width of the mobile zone, much of which is covered in the north-west by alluvium, varies from about six miles in the south-west to around twenty miles in the north-east.

The phyllites of the Halls Creek Group have a cleavage sub-parallel to the main Victoria River Fault. Older structure has probably been obscured by movement along this fault. The Lamboo Complex is poorly exposed but the structure appears to be similar to that in the Halls Creek Group.

Deformation of the Fitzmaurice Group and Legune Formation is predominantly by faulting. Folds are generally broad with bedding dips rarely greater than 45°; vertical bedding is locally common near major faults. Overtuned strata occur only along the Victoria River Fault. Two small basinal synclines occur 6 miles and 18 miles south of Legune homestead respectively; they are probably controlled by two sets of intersecting faults.

Faulting

Minor Faults:

The mobile zone is lacerated by numerous faults a few miles long. The faults are recognised by change in lithology and photopattern, truncation of bedding and small drag folds, but displacements are difficult to estimate due to the monotonous and repetitive lithology of the sediments. Apparent horizontal movements of a few hundred feet are common. The faults have no dominant trend but many are sub-parallel to the major faults.

Major Faults:

The Indian Hill Fault runs north-northeast from a point near Nap Springs, 10 miles south-west of Legune homestead, and separates the Moyle River Formation from the Legune Formation. At the northern margin of the Sheet it has an apparent upthrow to the east of at least 3500 feet. To the south-west of Nap Springs the fault merges with a complex fault zone extending down to the Victoria River Fault.

The Whirlpool Reach Fault follows a sinuous north-easterly course from a point on the Victoria River Fault some 12 miles west-northwest of Bullo River homestead to the northern margin of the Sheet area. In the north it separates the Lalngang Sandstone from the Moyle River Formation which involves an apparent downthrow to the west of at least 2000 feet. Immediately south of the Victoria River the fault is represented by a shear zone about half a mile wide, in which some or all of the Goobaieri Formation has been sheared out. Near the Victoria River Fault the Moyle River Formation is faulted against Legune Formation which involves an apparent downthrow to the east of about 4000 feet.

This fault truncates the eastern limb of a north-plunging syncline in the north of the Auvergne Sheet area, and the western limb of a similar fold in the south of the Port Keats Sheet 10 miles to the north. The similarity of the synclines suggests that they are the same fold displaced by a sinistral movement in the Whirlpool Reach Fault.

The Victoria River Fault is part of a 500-mile long fault zone extending from south of Halls Creek to near Darwin. In the East Kimberley Region it is known as the Halls Creek Fault which runs along the eastern side of the Halls Creek Mobile Zone and shows large dextral horizontal displacements. The Halls Creek Fault branches near the Western Australia/Northern Territory border. One branch is the Victoria River Fault, and its possible extension in the Katherine - Darwin area, the Giants Reef Fault. The Giants Reef Fault extends to the north of Rum Jungle and shows a sinistral horizontal movement. The other, and possibly major, branch is the Cockatoo Fault which is concealed over most of its length but probably separates the mobile zone from the Bonaparte Gulf Basin. In the Auvergne Sheet area the Victoria River Fault separates the mobile zone from the Bonaparte Gulf Basin. In the Auvergne Sheet area the Victoria River Fault separates the mobile zone from the Sturt Block.

In the south-west the Victoria River Fault is vertical and separates phyllites of the Halls Creek Group from tillite of the Duerdin Group; the tillite is dragged into a vertical attitude against the fault, (see fig. 58). The quartz-filled fault plane produces several prominent hills including Beasley Knob.

To the north of these hills the Fault is covered by soil, but ten miles to the north-east a major fault reappears dipping 45° to the north-west and separating the Auvergne Group from Legune Formation and Halls Creek Group. Further north the fault is not exposed but its existance is deduced from the lithology changes and structures in the surrounding rocks. There is very little quartz veining associated with the fault.

The fault follows a sinuous northerly trend for ten miles then turns sharply to follow a general east-northeasterly trend till it meets the Victoria River. Along this stretch the fault is probably a low-angle thrust fault, the northern block having been thrust over the southern. Rocks of the Auvergne and Duerdin Groups dip steeply to the south-east or are overturned to dip to the north-west; an overturned dip of 34° was recorded near Bucket Springs.

Near the Victoria River the fault turns and strikes north-east but is still not exposed. The Auvergne Group is only slightly disturbed; the Fitzmaurice Group to the north-west forms a steep-sided syncline.

Correlation of rocks to the south and north of the fault is uncertain so it is impossible to confidently estimate the displacement on the Fault. It is possible that the Auvergne and Bullita Groups are approximate stratigraphic equivalents of the Fitzmaurice Group and Legune Formation, in which case the throw might not be more than two or three thousand feet.

The thrusted part of the Victoria River Fault is bounded to the south-east by the Angalarri Siltstone. It is likely that the thrusting has taken place along this incompentant unit.

AGE OF FAULTING

Evidence for the age of faulting on this Sheet is not as complete as it is in the neighbouring East Kimberley Region. Some of the faults cutting the Lamboo Complex and Halls Creek Group do not displace the overlying Devonian sediment. The north-east-trending fault near No. 7 Bore does not displace the Duerdin Group. Most faults however cut all the Precambrian units, and Carboniferous and Devonian units are severely affected by faulting.

In the East Kimberley Region (Dow & Gemuts 1969) it is known that the faulting started at least in early Carpentarian time and continued with decreasing vigour into the Palaeozoic. In the Port Keats Sheet area to the north the Lower Permian is faulted whereas the Upper Permian is hardly affected.

AGE OF FOLDING

Most of the folds in the Mobile Zone and and in the Sturt Block have their axes parallel to the major faults. It is reasonable to suppose they formed concurrently with the faulting.

Regional unconformities in the succession in the Sturt Block may represent periods of very slight folding or epeirogneic movement. These are found:

(i) below the Jasper Gorge Sandstone; (ii) possibly between the Bullo Sandstone and Shoal Reach Formation; (iii) below the Duerdin Group; (iv) below the Antrim Plateau Volcanics. The Proterozoic strata were tilted to the north-west before deposition of the Antrim Plateau Volcanics.

GEOLOGICAL HISTORY

It is not possible to present a detailed geological history of the Auvergne Sheet area, since this will not be fully appreciated until mapping of the whole basin has been completed. The following comments however are relevant to the history of formation of the rock sequences.

The stable Sturt Block and the Fitzmaurice Mobile Zone are two basic geotectonic units inherent to the evolution of the Victoria River Basin. They developed during Archaean and possibly Lower Proterozoic time and the distribution and nature of the facies in the area indicates that they persisted throughout the history of formation of the Basin, (fig. 60).

The sediments in the Fitzmaurice Mobile Zone, are represented by the Fitzmaurice Group and the Legune Formation. These rocks were deposited in an unstable trench or orogenic trough, which was fairly rapidly subsiding, along the margin of the stable Sturt Block.

The greatest instability is indicated in the lower part of the sequence. The rocks are labile sandstone, grit, and pebble beds, and rarely subgreywake and feldspathic sandstone.

In the Legune Formation, at the top of the sequence, the sediments are more homogeneous and mature, and orthoquartzites and interbedded siltstones predominate. Folding and faulting is less intense in this formation and various sedimentary features indicate that it was deposited in more stable conditions than the underlying sediments.

The sediments which accumulated on the Sturt Block are a relatively undisturbed sequence of alternating sandstone, siltstone and dolomite which form the Bullita and Auvergne Groups. They may be considered as stable facies by comparison to the orogenic facies of the marginal Fitzmaurice Mobile Belt. Minor glacial and fluvioglacial deposits and associated sandstone were formed on top of this sequence during the late Adelaidean (Duerdin Group).

The Bullita and Auvergne Group sediments were deposited in a marine environment on a stable epicontinental shelf or platform. The depth of water fluctuated between the intertidal and neritic zone. Isolated shallow basins of deposition almost certainly developed on the platform from time to time but no organic reef-type environments have been recognised.

The following features provide evidence for the interpretation of these conditions of deposition.

1. The sediments form relatively thin units of distinctive composition (i.e. predominately sandy, silty or carbonate facies). These units are essentially homogeneous and have a fairly consistent thickness throughout the area.

2. Lateral facies changes in the units are very gradual. Vertical facies changes while commonly abrupt are within the range of conditions expected within complex mixed environments of shallow water deposition.

3. The rock sequence is for the most part flat lying or gently dipping.

4. The rock-types themselves, and their primary sedimentary features which include;

(a) the fact that most of the sandstone units are mature, clean sediments, they are mainly orthoquartzites. Many are glauconitic.

(b) stromalolites are common in most dolomitic formations; oolites occur in some.

(c) ripple marks, current bedding, current-lineations, mud cracks, festoon cross-laminations, and pseudomorphs after halite are seen in almost all formations.

The relatively quiet, stable conditions of deposition ended at the top of the Auvergne Group after which there was an apparent rejuvenation of weathering, with the consequent deposition of the texturally immature Bullo River Sandstone. This formation is a non-marine deposit, largely fluviatile.

The Bullo River Sandstone was followed by the deposition of glacial and fluvioglacial sediments which are the northern-most remnants of extensive glacial deposits previously mapped in the Kimberley region, and established as late Adelaidean (Dow & Gemuts, 1969). They appear to be restricted to areas overlying the Bullo River Sandstone and to elongate zones, possibly glacial valleys, which were carved into the soft, flat-lying Angalarri Siltstone. Some lapped up onto the more resistant units higher in the Auvergne Group.

The relative time of deposition of sediments in the mobile zone and on the stable platform is not known. Deposition possibly commenced in the mobile zone before it did on the adjacent platform but most of the sediments probably accumulated simultaneously in their respective environments. The situation may have been as diagrammatically shown in Fig. 60.

The direction from which the sediments were derived is not known. If the relationships shown in fig. 60 are correct, it is most likely that the source was from a generalised northwesterly direction relative to the basin. The boundary between the mobile zone and stable platform acted as a plane for the formation of a thrust fault after the deposition of the Duerdin Group.

ECONOMIC GEOLOGY

The only minerals currently produced from the Auvergne Sheet area are road building materials and water; in the past small quantities of ochre have been mined. The mapping by the Bureau of Mineral Resources provided no positive indication of potentially economic metal or petroleum deposits. Exploration has been carried out in parts of the Sheet area from time to time, and comments on this work and on known showings of various minerals in the area are given below.

Petroleum

The petroleum potential of the Palaeozoic rocks on Auvergne Sheet area has been discussed by Veevers and Roberts (1968). Gas has been found in these rocks (Bonaparte No. 2 Well on Cambridge Gulf Sheet area flowed 1.5 million cu. ft. a day but was abandoned).

The petroleum potential of the Proterozoic rocks in the Auvergne Sheet area were investigated in 1956 (Laing and Allen, 1956). No drilling was carried out. This investigation was based on reported oil seeps in the area. The validity of these reports is doubtful and the localities recorded are vague; as far as can be ascertained no reports of oil see pages in Proterozoic rocks in the area can be substantiated. The Proterozoic rocks do not appear to be a likely prospect for the discovery of petroleum.

Metals

Accessory amounts of pyrite were found in places in the Angalarri Siltstone and in dolomites of the Skull Creek Formation; several grains of copper sulphide were found in dolomitic siltstone of the Coolibah Formation near Bullita Station, just south of the Sheet area.

The genetic relationship of finely disseminated sulphide with dolomite and associated evaporites, which in some parts of the world is associated with syngenetic ore bodies, suggests that the Timber Creek, Skull Creek, and possibly, the Lloyd Creek Formations may be considered potential targets for exploration for this type of mineralization.

To date, however, there is no evidence of economic sulphides in these units. It is unlikely that they can be correlated in age with known Proterozoic deposits of this type; e.g. the McArthur River lead deposit is probably older (Carpentarian) than the carbonate deposits in the Victoria River Basin (probable Adelaidean).

Several airborne radio-active anomalies were found in the Fitzmaurice Mobile Zone, in the adjacent Port Keats Sheet area, during reconnaissance survey by the Bureau of Mineral Resources in 1956. The survey did not extend into the Auvergne Sheet area but it is likely that similar results would be found here. No radio-active mineral deposits are known from either Sheet area however.

Copper minerals are known in the Antrim Plateau Volcanics in some districts but no traces were found in the Auvergne Sheet area.

Non-metals

A small quantity of red ochre has been mined from a deposit at the top of a hill 8 miles east of Alligator Spring and 2 miles north of the Legune track. The workings consist of an open cut about 15 feet deep and 10 feet wide. At least thirty, 44 gallon drums of ochre were stock piled at the mine in 1967. No estimates of the reserves were made but considering the current low demand for red ochre the deposit is not likely to be of any significant economic value.

Small pods and veins of barytes were found in the Angalarri Siltstone. A lense of up to 20 feet long and 5 feet wide was found one mile north-west of Saddle Creek Dam. Similar occurrences have been found in the Coolibah Formation in adjacent areas.

Readily accessible deposits of <u>sand</u> and <u>gravel</u>, and <u>sandstone</u> suitable for aggregate are available near Timber Creek and most other parts of the Sheet area. Material suitable for road and air strip foundations is readily available mainly as sandstone, silicified sandstone, and eluvial gravels at the base of sandstone ranges. Road metal of reasonable quality, predominantly dolomitized-limestone, limestone and dolomite is available mainly in the south east of the area, but also to a limited extent in the poorly accessible range country, generally at least 20 miles from the present main highway. Chert and volcanic rocks suitable for this purpose are available and accessible in the east and west parts of the Sheet area respectively.

<u>Glauconite</u> is a common mineral in several formations in the Auvergne Group. Although this is a mineral from which potash may be derived,
the potash minerals of current commercial value are of evaporitic origin. The glauconite appears to be too disseminated to be of economic interest.

<u>Water</u>

<u>Underground water</u> is required for stock and very minor domestic use: the areas having greatest demand are in the grazing country on the Baines - Angalarri Plains; in the vicinity of Legune; and in isolated areas near Bullo River.

On the Baines-Angalarri Plains some underground water is obtained from bores; most water however is drawn from permanent waterholes, perennial springs and dams.

Laws (1967) considers that the <u>Jasper Gorge Sandstone</u> has excellent potential as an artesian aquifer. The overlying Angalarri Siltstone and Cainozoic sediments are poor; most of the "dry bores" on the Auvergne pastoral lease have bottomed in these units. Had they penetrated the Jasper Gorge Sandstone they would almost certainly have been successful. The depth of this aquifer increases from zero near its outcrop to greater than 900 feet along a north-east trending line passing through Bradshaw.

The successful Argument Camp Bore near Skinners Point, intersected Jasper Gorge Sandstone at 827 feet.

Laws (op cit.) has studied the saline coastal alluvium near Legune station; the alluvium underlies grassed, treeless plains only a few feet above the tidal mud flats. Bores down to 1000 feet yield good flows of water too saline for most purposes (10,000 to 60,000 ppm dissolved salts). Several bores sited on the foot hills of "sand islands" have obtained freshwater from "freshwater lenses" floating on the surface of salt water. The Spirit Hill No. 1 oil exploration well, south of Legune, produced an artesian flow of good water at 100 gallons per hour (Veevers and Roberts, 1968).

One bore near Bullo River Homestead produces saline water suitable only for stock. Prospects in this area are probably better near hilly country away from salt-water contamination.

Surface water of good quality is available from permanent waterholes in most major rivers and creeks above the tidal limit. Several perennial springs occur at the base of the Pinkerton Sandstone. Fault zones within coarse sandstone in the Fitzmaurice Group, and in the Pinkerton and Spencer Sandstones, give rise to perennial springs. Water in these areas is not in great demand because of the poor access and the poor grazing.

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AUSTRALIA 1:250 000 GEOLOGICAL SERIES

AUVERGNE

NORTHERN TERRITORY

SHEET SD 52-15

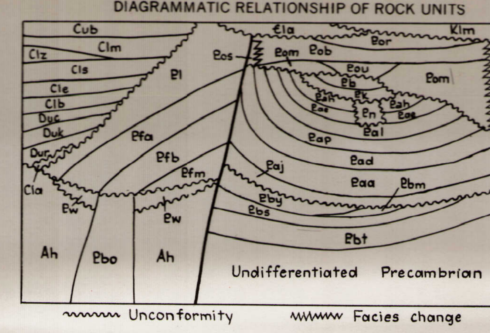
Reference

- Geological boundary
- Anticline showing plunge of fold axis
- Syncline showing plunge of fold axis
- Fault (D, U indicate relative movement down, up) (⇌ Relative horizontal movement)
- Fault showing low angle thrust
- Lineament
- 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
- Measured strike and dip of strata
- Prevailing strike and dip of strata
- Overturned strike and dip
- Horizontal strata
- Vertical strata
- Dip < 5° — Air-photo interpretation
- Dip 5°-15° — Air-photo interpretation
- Dip 15-45° — Air-photo interpretation
- Dip > 45° — Air-photo interpretation
- Trend lines — Air-photo interpretation
- Joint pattern — Air-photo interpretation
- Dip slope
- Measured strike and dip of cleavage
- Prevailing strike and dip of cleavage
- Strike of vertical cleavage
- Strike of vertical joints
- Glacial striae
- Mine
- Oil exploration well: abandoned dry
- Oil exploration well: St—stratigraphic hole
- Water bore
- Abandoned bore
- Wind pump
- Earth tank or dam
- Waterhole
- Waterhole on stream
- Sink hole
- Spring
- Swamp
- Highway
- Track
- Landing ground
- "Bradshaw" Homestead
- Building
- Yard
- Astronomical station
- Height in feet, instrument levelled — Datum: mean sea level
- Height in feet, barometric — Datum: mean sea level
- (PD) Position doubtful
- Margin Bonaparte Gulf Basin

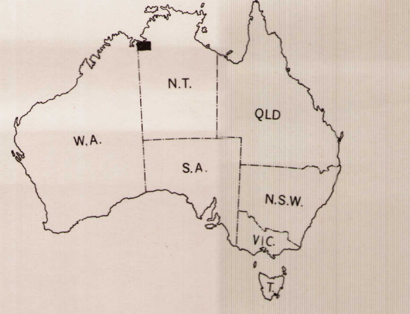
Reference

CAINOZOIC	QUATERNARY		Qac	Coastal deposits: mud, silt, evaporites
			Qa	Alluvium
	UNDIFFERENTIATED		Czt	Terrace deposits: mud, sand, gravel
			Czs	Sand, soil, colluvium
			Czb	Black soil
			Czg	Sand, gravel, colluvium
			Czl	Laterite, lateritic soil
MESOZOIC	CRETACEOUS	Mullaman Beds	Klm	Friable and ferruginous sandstone, lateritic soil
PALAEOZOIC	UPPER CARBONIFEROUS	Border Creek Formation	Cub	Quartz sandstone, conglomerate, siltstone
	LOWER CARBONIFEROUS	Milligans Beds	Clm	Silty shale (sub-surface only)
		Zimmermann Sandstone	Clz	Quartz sandstone and siltstone
		Septimus Limestone	Cls	Limestone, minor calcareous sandstone
		Enga Sandstone	Cle	Calcareous quartz sandstone
		Burt Range Formation	Clb	Limestone, minor shale and sandstone
	UPPER DEVONIAN	Cockatoo Formation	Duc	Sandstone conglomerate
		Kellys Knob Sandstone Member	Duk	Quartz sandstone
		Ragged Range Conglomerate Member	Dur	Conglomerate, sandstone
	LOWER(?) CAMBRIAN	Antrim Plateau Volcanics	Єla	Basalt
PROTEROZOIC	ADELAIDEAN	Duerdin Group: Ranford Formation	₽os	Massive red brown ferruginous sandstone
		Ernie Lagoon Member	₽or	Light brown quartz sandstone; minor granule sandstone interbeds
		Beasly Knob Member	₽ob	Brown quartz sandstone; minor conglomerate and granule sandstone
		Bucket Spring Member	₽ou	Siltstone and micaceous sandstone
		Moonlight Valley Tillite	₽om	Tillite overlain by dolomite
		"Skinner Glacials"	₽oi	Tillite, conglomerate, pebbly sandstone, sandstone
		Bullo River Sandstone	₽b	Reddish brown pebbly quartz sandstone; minor conglomerate
		Black Point Sandstone Member	₽k	Reddish brown feldspathic quartz sandstone; minor conglomerate
		Big Knob Beds	₽n	Reddish brown ferruginous sandstone, granule sandstone and conglomerate
		Auvergne Group: Undifferentiated	₽ax	Dolomitic siltstone, silty dolomite, dolomite, siltstone, minor sandstone, includes ₽ah, ₽ae, ₽al
		Shoal Reach Formation	₽ah	Dolomite, sandy and silty; minor siltstone and shale
		Spencer Sandstone	₽ae	Quartz sandstone, silty sandstone, minor dolomitic sandstone
		Lloyd Creek Formation	₽al	Dolomite, oolitic and stromatolitic; sandy and silty dolomite; siltstone
		Pinkerton Sandstone	₽ap	Massive quartz sandstone, siltstone, minor shale
		Saddle Creek Formation	₽ad	Basal crossbedded sandstone: upper siltstone, minor shale and oolitic dolomite
		Angalarri Siltstone	₽aa	Siltstone, grey-green shale; minor dolomitic siltstone, limestone
		Jasper Gorge Sandstone	₽aj	Massive quartz sandstone, minor conglomerate, siltstone; Basal conglomerate
		Bullita Group: Bynoe Formation	₽by	Purple and green massive siltstone, grey sandstone and dolomite
		Skull Creek Formation	₽bs	Dolomite, limestone, carbonate rich siltstone and fine sandstone
		Bardia Chert Member	₽bm	Massive laminated chert, brecciated chert
		Timber Creek Formation	₽bt	Siltstone, dolomitic siltstone, fine sandstone, dolomite
		Legune Formation	₽l	Interbedded quartz sandstone, siltstone, minor shale
		Fitzmaurice Group: Laingang Sandstone	₽fa	Quartz sandstone, granule sandstone, conglomerate; minor siltstone
		Goobaieri Formation	₽fb	Basal quartz sandstone, overlain by sandstone and siltstone
		Moyle River Formation	₽fm	Quartz sandstone; minor siltstone, pebble conglomerate
	CARPENTARIAN	Lamboo Complex: Bow River Granite	₽bo	Coarse grained and porphyritic biotite granite
		Whitewater Volcanics	₽w	Acid lavas, tuffs, intrusive quartz-feldspar porphyry
ARCHAEAN OR LOWER PROTEROZOIC		Halls Creek Group	Ah	Slate, green schist, mica schist, andalusite schist

DIAGRAMMATIC RELATIONSHIP OF ROCK UNITS



Compiled by the Bureau of Mineral Resources, Geology and Geophysics, Department of National Development. Issued under the authority of the Hon. David Fairbairn, Minister for National Development. Base map compiled by the Division of National Mapping, Department of National Development. Commonwealth aerial photography, complete vertical coverage 1:50000 scale
Transverse Mercator Projection



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DRYSDALE SD 52-9	MEDUSA BANKS SD 52-10	PORT KEATS SD 52-11	FERGUSSON RIVER SD 52-12	KATHERINE SD 53-9
ASHTON SD 52-13	CAMBRIDGE GULF SD 52-14	AUVERGNE SD 52-15	DELAMERE SD 52-16	LARRIMAH SD 53-13
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LANSDOWNE SE 52-5	DIXON RANGE SE 52-6	LIMBUNYA SE 52-7	WAVE HILL SE 52-8	NEWCASTLE WATERS SE 53-5

ANNUAL CHANGE 08"W

Scale 1:250,000

5 0 5 10 15 MILES

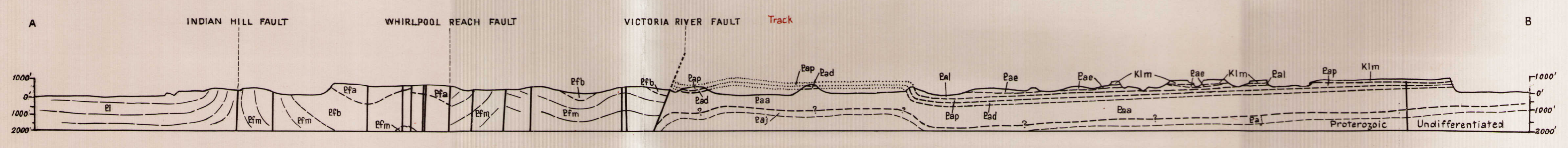
5 0 5 10 15 20 25 KILOMETRES

Sections

Folding schematic

Scale: $\frac{V}{H} = 4$

Cainozoic sediments omitted from sections



Geology, 1966, by: J.J. Veevers, J. Roberts, J.A. Kaulback
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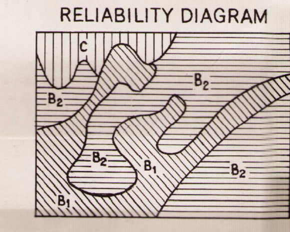
Cartography by: Geological Branch BMR
Drawn 1968 by: I.E. Martin, A. Tatarow

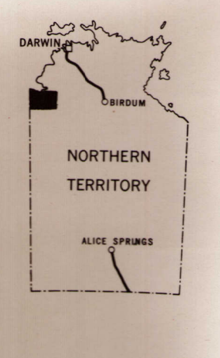
RELIABILITY DIAGRAM

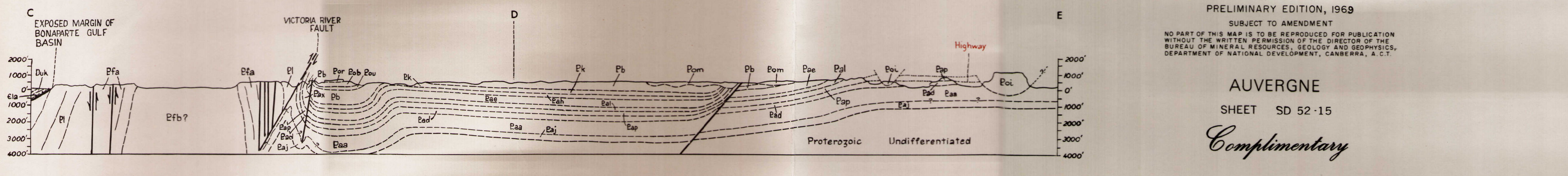


Geology B_1 Detailed reconnaissance, numerous traverses and air-photo interpretation

B_2 General reconnaissance, some traverses and air-photo interpretation

C Air-photo interpretation





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SHEET SD 52-15

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