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PRECAMBRIAN GEOLOGY OF THE WESTMORELAND REGION, NORTHERN AUSTRALIA

PART I: REGIONAL SETTING AND COVER ROCKS

by

I.P. Sweet and P.J. Slater

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SUMMARY

Precambrian rocks occupy the region south and west of Westmoreland station, a pastoral property 300 km north of Mount Isa and adjacent to the Northern Territory/Queensland border.

The oldest rocks are Lower Proterozoic schists (Murphy Metamorphics), which occupy part of an east-northeast-trending belt of basement rocks, the Murphy Tectonic Ridge, which bisects the region. Much of the exposed part of the ridge consists of a thick sequence of Lower Carpentarian acid lavas and ignimbrites (Cliffdale Volcanics) which unconformably overlie the Murphy Metamorphics. The 'Nicholson Granite Complex', a multiphase intrusion of granite and adamellite, intrudes both schists and volcanics.

Unconformably overlying the rocks of the Murphy Tectonic Ridge on its northwestern side are the gently tilted sedimentary and volcanic rocks of the Carpentarian Tawallah Group which occupy the McArthur Basin. The basal unit of the group, the Westmoreland Conglomerate, is a fluvial deposit over 1200 m thick partly derived from the ridge, which was a landmass during much of the Precambrian. Overlying the conglomerate is 1200 m of basic volcanics and minor sediments, the Seigal Volcanics, which are overlain by the upper part of the group - about 1000 m of dolomite, sandstone, and basic and acid volcanics.

South of the Murphy Tectonic Ridge is another Carpentarian sedimentary and volcanic sequence of similar age to the rocks in the McArthur Basin. These rocks ('Tawallah Group equivalents') occupy the 'Lawn Hill Platform', a basin of deposition which was separated from the McArthur Basin during most of the Carpentarian by the Murphy Tectonic Ridge. The volcanics in the sequence range from basalts to rhyolites, and are interbedded with dolomite, sandstone, and siltstone. The sequence is about 1500 m thick, and is overlain unconformably by a sandstone and dolomite sequence about 1000 m thick (Fickling Group) which has been correlated with the Mount Isa Group farther south. The dolomitic rocks of this upper sequence are stromatolitic and oolitic, indicating shallow-water deposition, but a siltstone and shale formation (Mount Les Siltstone) may be a deeper-water deposit.

Unconformable on the Fickling Group are sandstones and siltstones of Carpentarian or Adelaidean age (South Nicholson Group) which occupy the South Nicholson Basin.

Except near faults, the cover rocks (i.e., the rocks overlying those of the Murphy Tectonic Ridge) are gently folded. The main phase of deformation was along an east-northeast-trending axis, and resulted in the development of open folds and

vertical east-northeast-trending faults. A later phase of movement displaced the earlier structures along a set of northwest-trending faults. Most movement took place during the Carpentarian, but there have been minor movements since.

The main mineral deposits in the region are uranium in the Westmoreland Conglomerate and Seigal Volcanics, and lead and zinc in the Fickling Group. Uranium is present as irregular lenses of disseminated primary and secondary minerals in sandstone, and as fillings in faults and shears within volcanics. About 6 tonnes of uranium concentrate were produced from the Seigal Volcanics in the late 1950s. Lead and zinc are present in disseminated sulphide minerals in dolomitic rocks; the deposits are of low grade.

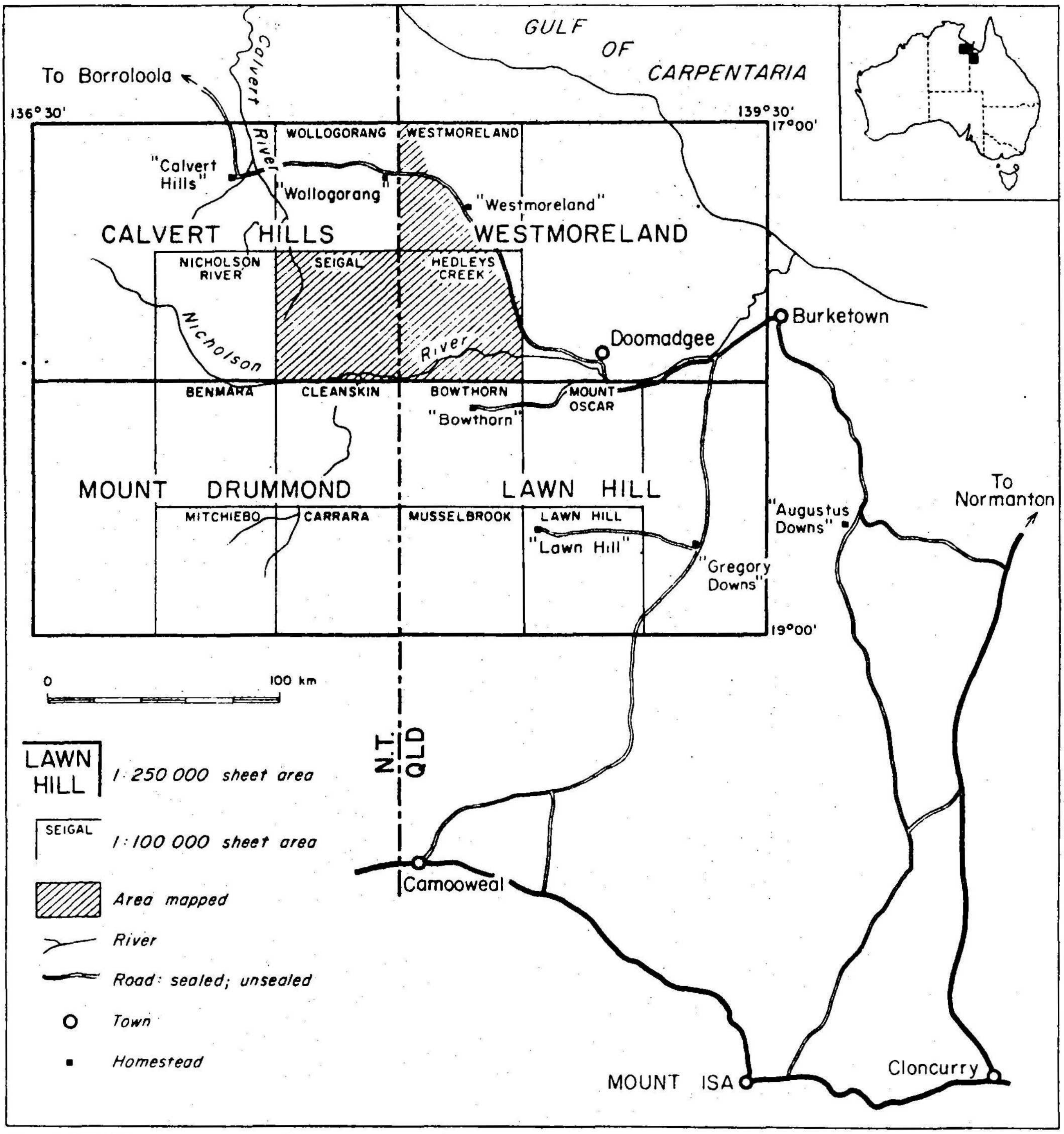

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Fig 1: Location and access map

INTRODUCTION

Aims

The Hedleys Creek, Seigal, and southwestern part of the Westmoreland 1:100 000 Sheet areas, Westmoreland region, were mapped during 1972 and 1973 by I.P. Sweet, J.A. Ingram, J.E. Mitchell, and C.M. Gardner (all BMR), and P.J. Slater (Geological Survey of Queensland). The survey is part of a continuing program to remap, at the 1:100 000 scale, areas of economic interest in Northern Australia. The Westmoreland region was selected for remapping because uranium deposits have been discovered in the area, and because an understanding of the stratigraphy is critical to the search for base metals in the Mount Isa McArthur River region.

Location and habitation

Figure 1 shows the area mapped, which straddles the Northern Territory/Queensland border and is bounded by latitudes $17^{o}30'$S and 18^{o}S and longitudes $137^{o}30'$S and $138^{o}30'$E. Most of the area mapped lies within the drainage basin of the Nicholson River, an east-flowing stream which flows into the Gulf of Carpentaria. Access is by partly sealed roads from Mount Isa to Doomadgee Mission either via Gregory Downs or Augustus Downs and Burketown. Regular air services link these centres about once a week. There are no towns or permanent inhabitants within the area. The nearest settlements are Doomadgee Mission Station, which has a population of about 600, and Burketown, 100 km to the east of Doomadgee, which has a population of about 100. Parts of the Westmoreland, Bowthorn, and Lawn Hill pastoral leases cover the Hedleys Creek Sheet area; here cattle are bred on the open-range system. All of the Seigal Sheet area is Crown Land, and is uninhabitated except for occasional mining activity by a few people at the Norris Copper Mine.

Climate and vegetation

The survey area has a semi-arid to subhumid tropical climate (Slatyer & Christian, 1954). The weather is seasonal, with a short wet summer and a long dry winter. Rain, mainly from thunderstorms and occasional cyclones and tropical depressions associated with a northwest monsoonal influence, amounts to an annual average of 500 to 650 mm; temperatures are moderate to high all year. Annual climatic statistics for Burketown (Table 1) are representative for the region. With increasing distance from the coast, humidity tends to decrease, and temperature extremes and variability become greater.

The annual winter drought of six months or more is an important factor in plant growth, and only species which are drought-resistant occupy the area, except near perennial water-courses. Most of the area is hilly sandstone or acid volcanic country, and supports snappy gum (*Eucalyptus brevifolia*) and spinifex (various *Triodia* spp.). Some soils support dense stands of turpentine shrub (*Acacia lysiphlois*) and other acacias. Other eucalypt species are common in the north, and paperbarks (*Melaleuca* spp.) and ghost gum (*E. papuana*) flank the Nicholson River and perennial waterholes. Perry & Christian (1954) give a detailed summary of the vegetation of the Barkly region, in which the survey area is included.

Topography and drainage

The Westmoreland region lies entirely within the Gulf Fall, a term used by Stewart (1954) to describe the area drained by streams which flow into the Gulf of Carpentaria. About 60 percent of the region is drained by the Nicholson River and its tributaries, and 40 percent by other streams which flow into the gulf (Fig. 2).

The Westmoreland region can be divided into several distinct topographic units (Fig. 2). The coastal plains include both erosional and depositional areas, and rise from sea level to about 50 m in elevation. The main hilly areas, which include most Precambrian rock outcrops, have a local relief of up to 250 m, and merge to the southeast into the Isa Highlands of Twidale (1964). In the west the hilly areas are separated by a high plain underlain by Precambrian granite. The headwaters of the Calvert River in the northwest are eroding a laterite plateau which is at the level of the Barkly Tableland, about 350 m above sea level.

Survey methods

The fieldwork was planned from the first-edition Calvert Hills and Westmoreland 1:250 000 geological maps, and from photo-interpretation of 1:25 000 colour aerial photographs. Ground traverses were undertaken in four-wheel-drive vehicles. Areas not easily accessible by vehicle were examined by helicopter.

Observation points and geological data were plotted onto overlays on the 1:25 000 aerial photographs, and subsequently transferred onto photoscale planimetric sheets prepared by the Division of National Mapping (Seigal Sheet) and the Royal Australian Survey Corps (Hedleys Creek Sheet). The compilations were reduced photographically to the 1:100 000 scale and redrawn for the preliminary maps accompanying this report.

The colour aerial photographs, flown in 1972, and the planimetric bases prepared from earlier photography are available from the Division of National Mapping.

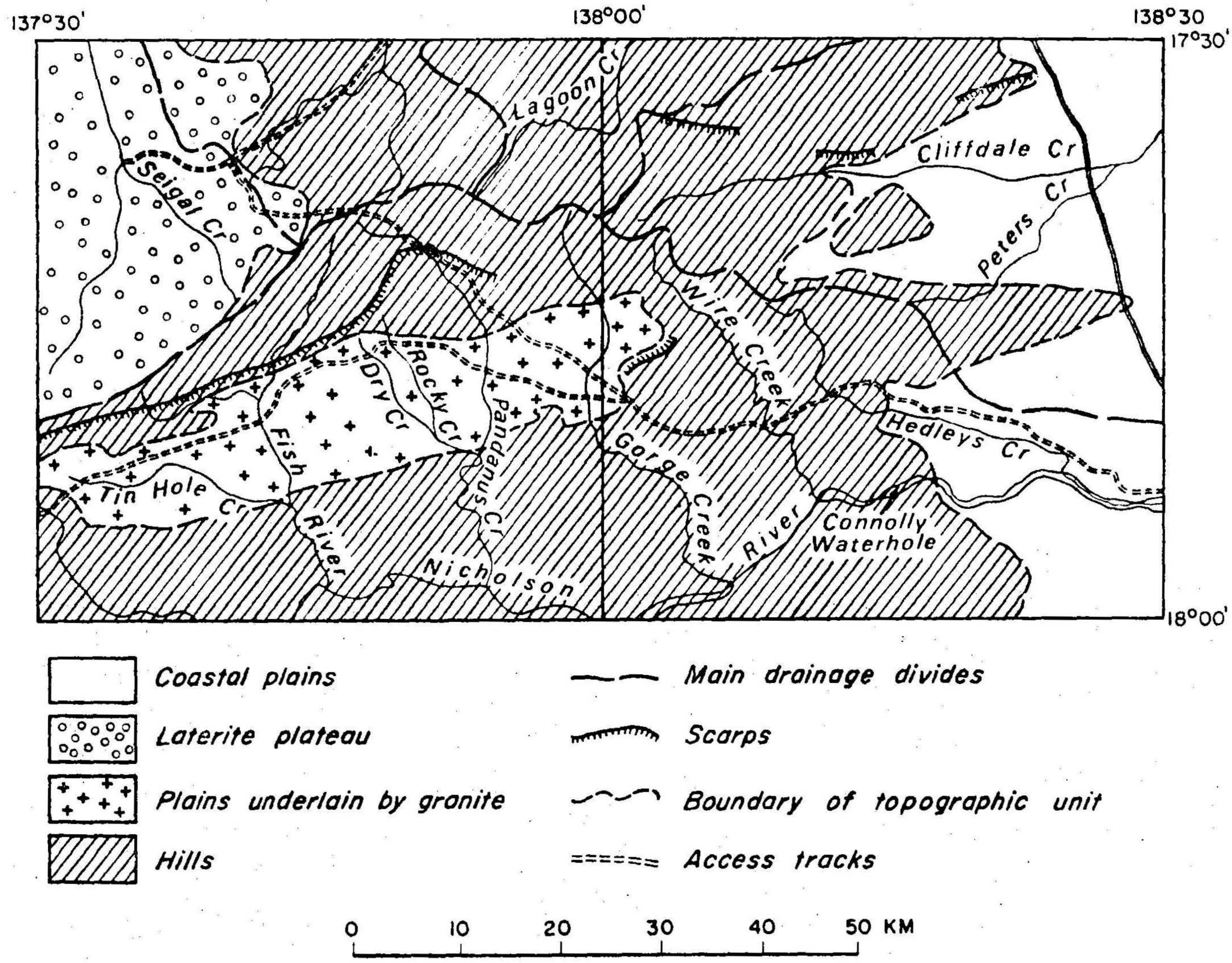

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Fig. 2 Topography and drainage of the Westmoreland region

TABLE 1: Summary of climatic data for Burketown, Queensland.

Weather element	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Year
Rainfall (mm)	206.5	167.7	113.8	28.4	5.3	8.1	0.8	1.0	1.5	11.2	34.8	104.4	683.5
Maximum temp. (°C)	33.9	33.3	33.3	32.9	30.0	27.8	27.7	29.0	31.6	33.8	34.8	34.7	31.9
Minimum temp. (°C)	24.9	24.5	22.8	20.4	16.6	13.9	12.8	14.1	17.3	20.7	23.4	24.7	19.7
Mean temp. (°C)	29.4	28.9	28.1	26.6	23.3	20.9	20.2	21.6	24.4	27.3	30.9	29.7	25.8
Mean relative humidity (%)	66	67	62	48	44	45	40	37	38	42	47	58	50

Previous investigations

A.C. Gregory traversed the region in 1856 and reported the presence of sandstone, basalt, and granite (Gregory, 1857). He probably crossed the Calvert Hills Sheet area near the western end of the China Wall (southwestern Seigal Sheet area), and then followed the Nicholson River to the vicinity of Burketown.

No geological exploration was carried out in the region for over half a century, and maps and surveys by Cameron (1901), Woolnough (1912), and Jensen (1914) indicate that information about rocks in the area (shown as Cambrian or Silurian) was extrapolated from McArthur River to the northwest, and Lawn Hill to the southeast.

The Lawn Hill silver-lead district was discovered by 1887 (Ball, 1911), and it seems likely that prospectors had examined the Westmoreland region by the turn of the century. Copper was discovered at Redbank, in the northeast of the Calvert Hills 1:250 000 Sheet area in 1916.

The first systematic geological survey was by H.I. Jensen in 1939-40 but the results, although available in manuscript form*, were never published. Jensen utilized early RAAF aerial photographs in several traverses adjacent to the Northern Territory/Queensland border. In the first two traverses he examined a strip of country along the border between the Gulf of Carpentaria and the Nicholson River. He observed quartzites and volcanics near Redbank, Cliffdale Creek and Nicholson River, and concluded that they were folded and faulted remnants of the same formations (they are now known to belong to both the basement and younger cover). Jensen also observed carbonate rocks near the Nicholson River and described minor copper and lead prospects in them.

The age of the rocks in the region was still not known, but Jensen, after reviewing the earlier literature (see above), concluded that they were probably of Cambrian age. However, he pointed out the similarity of the rocks to those in the Mount Isa region, which David (1932) had regarded as being of 'Nullagine' (or 'newer Proterozoic') age.

Noakes & Traves (1954) recognized that the rocks were Precambrian, and grouped all the rocks in the Mount Isa and McArthur River provinces as the 'Carpentaria complex' of 'Lower Proterozoic' age.

* A copy of the draft manuscript (without maps or illustrations) is held by the BMR library (see Jensen, 1941 unpubl.).

BMR surveys of the Mount Isa region during the 1950s were extended to include the Westmoreland region, and Carter (1959) and Carter, Brooks, & Walker (1961) produced the first systematic geological maps of the Westmoreland 1:250 000 Sheet area. Carter (1959) designated the rocks as 'Upper Proterozoic' but modified this when surveys west of the border suggested some of the rocks were 'Lower Proterozoic'.

Firman (1959) carried out a reconnaissance of the Calvert Hills Sheet area and traced all units westwards from Westmoreland, but Roberts, Rhodes, & Yates (1963), approaching from the McArthur Basin side, revised his mapping. They subdivided the rocks into 'Lower Proterozoic' and 'Upper Proterozoic', and erected a stratigraphic nomenclature which, with minor modifications, still stands. The report on the McArthur Basin surveys, although never published, is held in BMR as a draft manuscript, and is referred to in this account as Roberts (unpubl. MS).

McDougall et al. (1965) published the first isotopic age results for rocks in the region, and Dunn, Plumb & Roberts (1966) used the data and nominated part of the sequence as the type section for the Carpentarian System in Australia.

Present investigations

During the present survey the units of Roberts et al. (1963) were traced eastwards into the Westmoreland 1:250 000 Sheet area, and units on both sides of the Northern Territory/Queensland border were mapped in more detail. K. Plumb (BMR) and A. Webb (AMDEL) in 1972 collected several suites of samples for further isotopic age determinations. The results are contained in Plumb & Sweet (1974). The present work has been used in Proterozoic correlations across north Australia by Plumb & Derrick (1975).

The reports on the 1972-73 survey are being issued in three parts: Part I (this volume), Part II: the Cliffdale Volcanics, by Mitchell (in prep.), and Part III; the 'Nicholson Granite Complex', by Gardner (in prep.). The information, in summarized form, is being used to compile a second edition of the Westmoreland 1:250 000 Sheet (Grimes & Sweet, in prep.).

Rock nomenclature

Sedimentary rocks have been described using parting and bedding thickness terms after Dunbar & Rodgers (1957). They are:

Bedding partings

Massive	1 m
Blocky	15 cm - 1 m
Flaggy	1 - 15 cm
Fissile	1 cm 1 cm

Bedding thickness

Thick-bedded	30 cm
Medium-bedded	10 - 30 cm
Thin-bedded	1 - 10 cm
Laminated	1 cm

The grainsize scale used for descriptions of sandstones is that of Wentworth (1922) as it appears in Pettijohn (1957). Sandstones are broadly classified as orthoquartzites and lithic sandstones using the criteria laid down in Pettijohn (1957). In addition, the term quartz greywacke has been used to describe sandstones containing few lithic fragments but more than 15 percent matrix.

Carbonate rocks have been described using a combination of the schemes of Folk (1962) and Dunham (1962). Folk's term micrite is not used because recrystallization has altered many primary textures; most finely crystalline carbonates have been called dolomite.

Stratigraphic classification and nomenclature

As mentioned previously, the rocks in the Westmoreland region have been described previously as Silurian, Cambrian, 'Nullagine', 'Lower Proterozoic' and 'Upper Proterozoic'. It was not until BMR and State geological surveys carried out extensive 1:250 000 mapping, and made use of isotopic age determinations, that a reasonably standard classification of the Australian Precambrian came into being. This classification (Dunn et al., 1966) is adhered to in this report (Table 2).

Formal stratigraphic nomenclature for units in the area was introduced by Carter (1959), and Roberts et al. (1963). Table 3 shows the relation between this previous nomenclature and that used in this report.

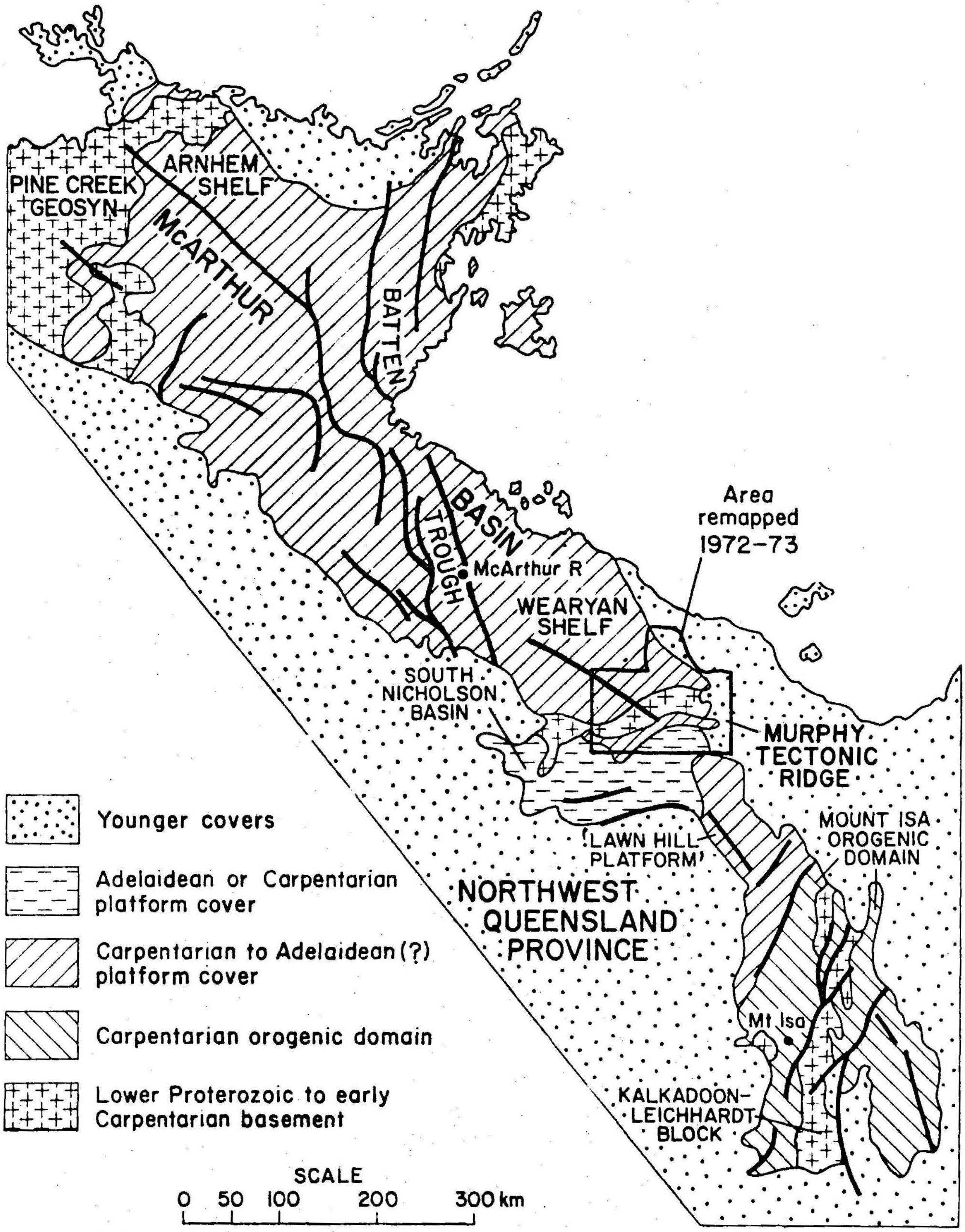

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Fig. 3 Regional tectonic setting

TABLE 2: Australian Precambrian stratigraphic classification (after Dunn et al., 1966, as modified by Plumb, pers. comm., 1974).

AGE (m.y.)		
570	PALAEOZOIC	CAMBRIAN
1400		ADELAIDEAN
1770 ± 20		CARPENTARIAN
2200 - 2250		('Nullaginian') LOWER PROTEROZOIC
	ARCHAEAN	-

REGIONAL TECTONIC SETTING

Figure 3 shows the Westmoreland region in relation to the whole Northwest Queensland Province. The Precambrian rocks in the region are assigned to four main tectonic units (Fig. 4). The stratigraphy of the region is summarized in Table 4.

The Murphy Tectonic Ridge is an east-northeast-trending basement inlier containing metamorphics, acid volcanics, and granite of Early Proterozoic and Carpentarian ages. The 'Nicholson Granite Complex' was previously mapped by Carter (1959) as Nicholson Granite, and by Roberts et al. (1963) as Nicholson Granite (older than Cliffdale Volcanics) and Norris Granite (younger than Cliffdale Volcanics). Because it seems that all phases of granite intrude the volcanics we have reverted to the use of a single name for the granite. During the Carpentarian the Murphy Tectonic Ridge formed a topographic barrier that separated, and provided sediment to, the McArthur Basin to the northwest, and the 'Lawn Hill Platform*' to the southeast.

The McArthur Basin contains a thick, relatively undeformed sequence of sedimentary and volcanic rocks which were laid down on a platform called the Wearyan Shelf (Plumb & Derrick, 1975). The 'Lawn Hill Platform' consists of a sequence of similarly undeformed rocks of the same age as, and of similar lithology to, those in the McArthur Basin. Sandstone and siltstone of the South Nicholson Group were deposited in the South Nicholson Basin

* Tentative name only pending the completion of mapping in the Lawn Hill region.

TABLE 3: Past and present stratigraphic nomenclature for Proterozoic rocks in the Westmoreland region

	Carter (1959)		Roberts, Rhodes, & Yates (1983)		This report	
	North of MTR*	South of MTR*	North of MTR*	South of MTR*	North of MTR*	South of MTR*
COVER ROCKS				South Nicholson Group (Constance Sandstone)		South Nicholson Group (Constance Sandstone)
				Fickling Beds		Fickling Gp (3 fms)
	Gold Creek Volcanics		Tawallah Group: Masterton Fm	Fish River Fm	Tawallah Group: Masterton Fm	Fish River Fm
	Constance Sandstone		Tawallah Group: Wollogorang Fm Settlement Creek Volcanics Aquarium Fm Sly Creek Sandstone McDermott Fm Peters Creek Volcanics	Tawallah Group: Peters Creek Volcanics	Tawallah Group: Wollogorang Fm Settlement Creek Volcanics Aquarium Fm Sly Creek Sandstone McDermott Fm Seigal Volcanics	Peters Creek Volcanics
	Wollogorang Formation					
	Peters Creek Volcanics					
	Westmoreland Conglomerate		Tawallah Group: Westmoreland Conglomerate	Tawallah Group: Westmoreland Conglomerate	Tawallah Group: Westmoreland Conglomerate	Wire Creek Sandstone
BASEMENT ROCKS (IN MTR)						
	Nicholson Granite Cliffdale Volcanics		Norris Granite		'Nicholson Granite Complex'	
			Cliffdale Volcanics		Cliffdale Volcanics	
			Nicholson Granite			
			Murphy Metamorphics		Murphy Metamorphics	

* Murphy Tectonic Ridge

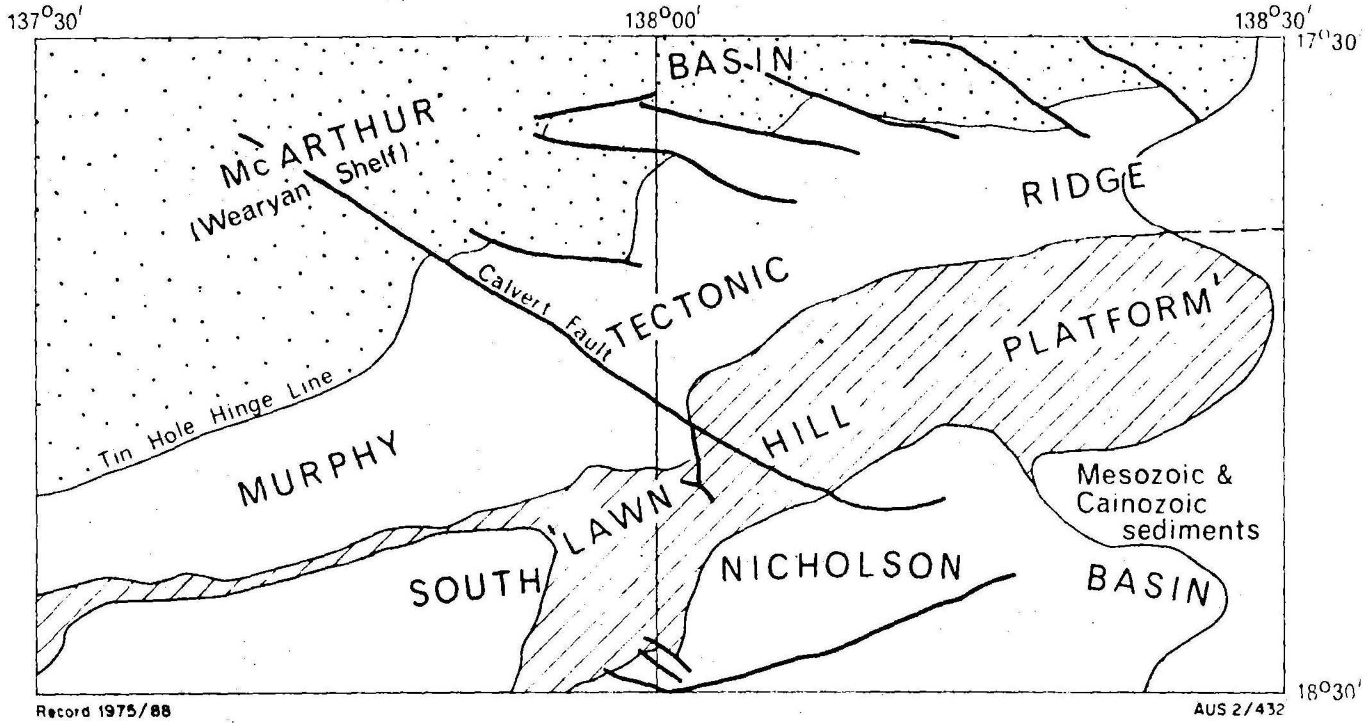

Fig. 4 Tectonic units in the Seigal and Hedleys Creek 1:100 000 Sheet areas

during the late Carpentarian or early Adelaidean. Rocks of the same age were deposited in the McArthur Basin, but no outcrops of these rocks are present within the area mapped.

MURPHY TECTONIC RIDGE

LOWER PROTEROZOIC

Murphy Metamorphics

In the southwestern Calvert Hills Sheet area, Roberts et al. (1963) mapped schists and metavolcanics as the Murphy Metamorphics. They are poorly exposed in the Seigal Sheet area, where they appear to be unconformably overlain by the Cliffdale Volcanics. The contact is not exposed, but the contact relations are inferred from the lack of metamorphism and folding in the volcanics.

The age of the Murphy Metamorphics is inferred to be Early Proterozoic because they are intruded by the 'Nicholson Granite Complex', which is of earliest Carpentarian age. The metamorphics are low-grade greenschist facies quartz-albite-biotite-muscovite/chlorite) schists and quartz-feldspar-muscovite gneisses. Locally they are mixed with granite to form migmatitic contact zones around the 'Nicholson Granite Complex'.

CARPENTARIAN

Cliffdale-Volcanics

The Cliffdale Volcanics were first observed by Jensen (1941, unpubl.) and were named and defined by Carter et al. (1961). Roberts et al. (1963) mapped them in the Calvert Hills Sheet area, and during the present survey they were mapped in detail and are reported in full by Mitchell (in prep.). They consist of at least 4000 m of calc-alkaline rhyolitic to dacitic ignimbrite, rhyolite lava, and minor acid tuff.

The base of the Cliffdale Volcanics is not exposed, a contact mapped by Roberts et al. (1963) may be a fault. The volcanics are overlain with pronounced unconformity by the Westmoreland Conglomerate, which contains many cobbles and boulders derived from the volcanics.

Table 4: Summary of Proterozoic stratigraphy, Westmoreland region

Tectonic unit and age	Rock Unit and Symbol	Thickness	Lithology	Remarks
SOUTH NICHOLSON BASIN				
Carpentarian or Adelaidean	South Nicholson Group	300+	Quartz sandstone; micaceous siltstone and sandstone; glauconitic sandstone	Most outcrop in WESTMORELAND* is lower-most formation; much thicker in LAWN HILL* and MOUNT DRUMMOND*; unconformable on all units of 'Lawn Hill Platform'
'LAWN HILL PLATFORM'				
Carpentarian	Fickling Group	700+	Oolitic, stromatolitic and intraclast dolomite; dolomitic siltstone and shale; conglomerate and sandstone; chert	Local unconformity within group; minor lead mineralization; conformable on Ptf
	Fish River Formation Ptf	250	Quartz sandstone, conglomeratic near base and top; micaceous siltstone	Unconformable on several older units including 'Nicholson Granite Complex'
	Peters Creek Volcanics Ptp	1500–2000	Alternating sequence of basalt, rhyolite and rhyodacite; possibly some trachyte and andesite; minor tuff, shale, siltstone, sandstone, dolomite, and conglomerate	Seven members mapped; thins westwards or younger units removed by erosion; basal basalt member equivalent to Seigal Volcanics (in lower Tawallah Gp.), and younger acid units probably equivalent to volcanics in upper part of Tawallah Gp., all in McArthur Basin
	Wire Creek Sandstone Pti	50	Quartz sandstone with cobble conglomerate lenses	Nonconformable on 'Nicholson Granite Complex'; equivalent to at least part of the Westmoreland Conglomerate
McARTHUR BASIN (Wearyan Shelf)				
Carpentarian	Tawallah Group	3500	Conglomerate, sandstone, siltstone, dolomite, basalt, and rhyolite	Unconformable on units in Murphy Tectonic Ridge. May be two local unconformities within the group; prominent basal conglomerate formation derived from Ridge. Type section for the Carpentarian System
MURPHY TECTONIC RIDGE				
Carpentarian	'Nicholson Granite Complex' Pgn	-	Porphyritic hornblende – biotite adamellite; finer grained muscovite granite	At least 8 mappable phases; intrudes Murphy Metamorphics and most (possibly all) phases intrude Cliffdale Volcanics
	Cliffdale Volcanics Pcc	4000+	Calc-alkaline ignimbrite, rhyolite, and tuff	Five members mapped; defines base of Carpentarian System
Lower Proterozoic	Murphy Metamorphics	-	Quartz-muscovite schist and quartz-feldspar gneiss	Oldest rocks in area. Unconformably overlain by Cliffdale Volcanics and intruded by 'Nicholson Granite Complex'

* 1:250 000 Sheet areas

McDougall et al. (1965) proposed that the Cliffdale Volcanics be defined as the base of a time-rock unit to be known as the Carpentarian System. Dunn et al. (1966) adopted this proposal in a classification of the whole Australian Precambrian. This was done because of the desirability of having an accurately dated unit at the base of such a system. However it was, of course, realized that the Cliffdale Volcanics could be significantly older than the sedimentary sequence which forms the remainder of the Carpentarian System in the area.

Mitchell (in prep.) has divided the Cliffdale Volcanics into 5 units; the lower 4 of these consist predominantly of ignmibrite, and the youngest unit is a thick, flow-banded rhyolite.

The volcanics show no evidence of regional metamorism, but they do show some effects of thermal metamorphism produced during the intrusion of the 'Nicholson Granite Complex'.

The Cliffdale Volcanics are isotopically dated as 1770 $\pm$ 20 m.y. The younger phases of the 'Nicholson Granite Complex' yield an isochron indistinguishable from that for the Cliffdale Volcanics (A.W. Webb, AMDEL Rep. AN1814/73, unpubl.).

'Nicholson Granite Complex'

Jensen (1941, unpubl.) observed granite near the Northern Territory/Queensland border, and Carter et al. (1961) defined it as Nicholson Granite. They noted that it intrudes Cliffdale Volcanics.

Roberts et al. (1963) mapped the granite in Calvert Hills and, mainly from isotopic age determinations, McDougall et al. (1965) recognized two distinct types. The older type (overlain by Cliffdale Volcanics) they named Nicholson Granite, and the younger type (intrudes Cliffdale Volcanics) they called Norris Granite. Most contact relations of the 'older' granites are difficult to determine, and further isotopic age determinations have been carried out in an attempt to resolve the issue. In the meantime the granite has all been mapped as 'Nicholson Granite Complex', within which five main phases (1, 2, 5, 6, and 8), and four minor ones (3, 4, 7, and 9), have been recognized. Phases 1 and 2, which are coarse-grained porphyritic hornblende-biotite adamellites with locally abundant xenoliths, crop out in the central and southeastern Seigal Sheet area. They are intruded to the north by phases 5 and 6 (medium even-grained granite), and to the west by phase 8 (medium to fine even-grained muscovite granite). Phases 3 and 4 are basic variants associated with phase 1; phase 7 consists of micrograntic dykes associated with phase 5; and phase 9 consists of muscovite microgranite associated with phase 8.

Compared with average granites the 'Nicholson Granite Complex' is distinguished by high potash and total iron, and low uranium, tungsten, and tin. Chemical trends suggest that the degree of differentiation increases from phases 1 and 2 to 5 and 6 to 8, i.e., from the southeastern part of the ridge northwards and eastwards.

The intersection of structural systems within the granite complex is centred around Crystal Hill, the site of the greatest concentration of greisen zones, quartz reefs and tin, tungsten, uranium, and copper mineralization. Elsewhere the granite is largely unmineralized, probably because its upper parts, which are more likely to have been mineralized, have been removed by erosion. An estimated 10 000 m has been eroded from above the oldest part of the complex.

McARTHUR BASIN

The Murphy Tectonic Ridge was uplifted several thousands of metres after the intrusion of the 'Nicholson Granite Complex', as the basal unit of the McArthur Basin sequence, the Westmoreland Conglomerate, overlies probable mesozonal granite in parts of the Seigal Sheet area. Most of the material eroded from the Murphy Tectonic Ridge before this unit was deposited was probably laid down northwest of the area mapped.

CARPENTARIAN

Tawallah Group

Two major rock groups and their correlatives have been mapped in the McArthur Basin (Plumb & Derrick, 1975), but only the older of these, the Tawallah Group, is preserved in the Westmoreland region (Table 5). It was defined by Roberts (unpubl. MS), and described by Roberts et al., (1963). Carter (1959) mapped and named the two oldest formations in the group, the Westmoreland Conglomerate, and Seigal Volcanics (which he included in the Peters Creek Volcanics) but did not recognize any of the overlying units because of poor outcrop. Roberts et al. (1963) recognized 8 formations, and grouped them as the Tawallah Group. During the present survey the boundaries of these formations were extended eastwards into the northern part of the Westmoreland Sheet area.

Table 5: Summary of stratigraphy of the Tawallah Group

Unit name and map symbol	Range of thickness (metres)	Lithology	Stratigraphic relationships	Remarks
Packsaddle Microgranite (Ꝑgr)	-	Pink porphyritic microgranite		
TAWALLAH GROUP				
Masterton Formation (Ꝑtm)		Sandstone, rhyolite, and basalt		Undivided Masterton Fm. does not crop out in area mapped
Hobblechain Rhyolite Member (Ꝑth)	not measured	Feldspar porphyry		Apparently grades northwestwards into Packsaddle Microgranite
Gold Creek Volcanic Member (Ꝑtg)	not measured	Basalt	Intruded by Packsaddle Microgranite west of Seigal Sheet area	Very poor outcrops in low hills in northwestern Westmoreland 1:250 000 Sheet area
Wollogorang Formation (Ꝑto)	not measured	Siltstone and dolomite	Conformable on Settlement Creek Volcanics	As for Gold Cr. Volc. Mbr
Settlement Creek Volcanics (Ꝑte)	not measured	Basalt, siltstone, tuff	Conformable on Aquarium Formation	Only one small outcrop in northwestern Seigal; masked by alluvial deposits in Westmoreland Sheet area
Aquarium Formation (Ꝑtq)	not measured	Glauconitic sandstone and siltstone	Conformable on Sly Creek Sandstone	No outcrops observed in mapped area, but probably present below Bukalara Sandstone in northwestern Seigal Sheet area
Sly Creek Sandstone (Ꝑtl)	170	Fine and medium feldspathic quartz sandstone; pebbly sandstone and cgl*	May lie unconformably on McDermott Formation and the Seigal Volcanics	Resistant to weathering and forms scarp-cappings and plateaux
McDermott Formation (Ꝑtd)	0 - 200	Stromatolitic, sandy, oolitic, and intraclastic dolomite and dolarenite; fine and medium sandstone; laminated shale and siltstone	Conformable on Seigal Volcanics; either lenses out southwestwards or is overlain unconformably by Sly Creek Sandstone	Recessive weathering; forms low hills and scarp slopes with capping of Sly Creek Sandstone
Seigal Volcanics (Ꝑts)	1100 - 1600	Amygdaloidal basalt and massive slightly porphyritic basalt; minor siltstone and fine sandstone beds with scattered bombs in some beds	Appears to be conformable on the Westmoreland Conglomerate	Probably extruded into a marine environment but no pillow lavas observed; volcanics are tholeiitic basalts
Carolina Sandstone Member (Ꝑts$_c$)	10 - 20	Flaggy to massive, fine sandstone with minor siltstone beds in north; cobble cgl in the southwest	Conformable sand sheet between lava flows	Murphy Tectonic Ridge is probable source of sediment - most clasts are of quartz, sandstone, and cgl, and may be derived from Westmoreland Conglomerate
Westmoreland Conglomerate (Ꝑtw) (undivided)		Fine to coarse and pebbly lithic and quartzitic sandstone; pebbly and cobbly throughout; numerous cgl lenses	Unconformable on Cliffdale Volcanics and 'Nicholson Granite Complex'	Shown as such where other units (1-4, C1, C2) cannot be recognized
Conglomerate unit 2 (Ꝑtw$_{c2}$)	100	Pebble cgl with grit interbeds	Conformable member; overlain by Ꝑtw$_4$	Pebbles of quartz and red sandstone; crops out west of Calvert Fault
Conglomerate unit 1 (Ꝑtw$_{c1}$)	240	Pebble and cobble cgl with ferruginous grit matrix	Conformable member	Clasts up to 30 cm of pink sandstone, quartz, chert, and acid volcanics; most outcrop is west of Calvert Fault
Unit 4 (Ꝑtw$_4$)	0 - 200(?)	Coarse quartz greywacke with ferruginous clayey matrix and scattered pebbles; strongly cross-bedded; isolated cgl lenses	Conformable member; lenses out in west; overlain, apparently conformably, by Seigal Volcanics	Can be traced farther west than Units 2 and 3; fairly uniform lithology;
Unit 3 (Ꝑtw$_3$)	200 - 500	Coarse strongly cross-bedded pebbly and cobbly sandstone; cgl lenses common; siltstone and shale lenses in east	Conformable member; base gradational from Unit 2 in places	Characteristic rounded cliffs; strongly jointed; clasts include quartz, quartzite, sandstone, acid volcanics; haematite laminae prominent

TABLE 5: (Contd.)

Unit name and map symbol	Range of thickness (metres)	Lithology	Stratigraphic relations	Remarks
Unit 2 (Ptu_2)	450	Massive medium cross-bedded sandstone with scattered quartz pebbles up to 5 cm across; ferruginous clayey matrix	Conformable member except in eastern Seigal Sheet area where it lies unconformably on Unit 5 of Cliffdale Volcanics	Recessive weathering except where Unit 1 is absent in eastern Seigal Sheet area; scattered volcanic clasts in western part of outcrops
Unit 1 (Ptu_1)	0 - 240	Cobble and pebble cgl lenses at base (clasts of tuff and porphyritic acid volcanics); overlain by fine to coarse argillaceous and quartzitic sandstone and orthoquartzite, some scattered pebbles; ferruginous weathering in some places	Unconformable on Cliffdale Volcanics	Angular clasts up to 1 m; sparse cross-bedding; ripple-marks in fine sandstones; absent in eastern Seigal Sheet area

* cgl = conglomerate

Westmoreland Conglomerate

The Westmoreland Conglomerate was defined by Carter et al. (1961) and named after Westmoreland, the pastoral holding. It is exposed over an area of 800 km^2 in the Seigal and Hedleys Creek 1:100 000 Sheet areas. Additional exposures are in the southern part of the Westmoreland 1:100 000 Sheet area in Queensland, and in the southwestern part of the Calvert Hills 1:250 000 Sheet area in the Northern Territory.

The formation forms a range up to 350 m high extending 100 km southwest from near Westmoreland homestead. From near the Queensland border to 55 km to the southwest, the southern margin of the formation forms a scarp known as the China Wall. North of this scarp, in the western Seigal Sheet area, the formation also forms up to four parallel sandstone ridges between which are valleys formed in less resistant conglomerate. The formation is also exposed in an outlier surrounded by the 'Nicholson Granite Complex', between Tin Hole Waterhole and Fish River in the western part of the Seigal Sheet area.

Stratigraphic relations. The Westmoreland Conglomerate is unconformable on the 'Nicholson Granite Complex' and Cliffdale Volcanics, and is overlain, apparently conformably, by the Seigal Volcanics. Carter et al. (1961) suggested a minor angular unconformity above, but also stated that the discordance might be due to an initial depositional dip in the Westmoreland Conglomerate. Other workers (Jensen 1940; 1941 unpubl.; Morgan, 1965) considered that basal rocks of the Westmoreland Conglomerate had been intruded by the 'Nicholson Granite Complex', but it is now clear that there is a major erosional break above the granite.

Roberts et al. (1963) correlated the Westmoreland Conglomerate with the Yiyintyi Sandstone, which crops out to the northwest, in the Mount Young and Bauhinia Downs 1:250 000 Sheet areas.

Northeast of the Calvert Fault (Fig. 4), four conformable units, (Nos. 1 to 4, have been distinguished within the formation on the basis of rock type and airphoto-pattern. Southwest of the Fault the photopattern characteristic of units 2 and 3 is lacking and the rock-types present are more variable: most of the succession here remains undivided, although unit 1, and two conglomerate lenses and unit 4 have been delineated (Table 5).

Unit 1

Distribution. Unit 1 occurs in a series of disconnected outcrops in the northern part of the Hedleys Creek Sheet area, and in a small outcrop in the core of an anticline east of Battle Creek, in the Westmoreland 1:100 000 Sheet area to the north, and it also forms part of the China Wall in the western part of the Seigal Sheet area.

Reference area. The type section of the Westmoreland Conglomerate nominated by Carter et al. (1961): 2 km southeast of Buck Hill, where Unit 1 dips 35° northwest and is about 230 m thick.

Topographic expression. North of Scrutton Creek the unit occurs as an upstanding strike ridge between the more easily weathered Cliffdale Volcanics and Westmoreland Conglomerate Unit 2. East of the Cliffdale Fault the unit forms escarpments up to 180 m high: locally, where a basal conglomerate is well developed, a smaller subsidiary escarpment is formed in front.

Stratigraphic relations. Unit 1 is the basal unit of the Westmoreland Conglomerate and it lies with angular unconformity on acid lavas and pyroclastics of the Cliffdale Volcanics. Locally the exact position of the contact is masked by extensive scree of volcanic rubble derived from the basal conglomerate of Unit 1. In the west the unit overlies Unit 5 of the Cliffdale Volcanics, but elsewhere it overlies Unit 4.

The contact with the overlying Unit 2 of the Westmoreland Conglomerate is conformable, and is placed above a distinctive quartzite bed.

Lithology. The unit consists typically of a basal conglomerate overlain by a sequence of argillaceous and quartzitic sandstone and orthoquartzite. The basal conglomerate varies both in character and in thickness along strike, and is locally absent.

Conglomerate beds are well exposed in a scarp on the northeast side of the Buck Hill Fault (grid ref. 175645, Westmoreland 1:100 000 Sheet area). Conglomerate composed predominantly of subrounded cobbles of tuff and porphyritic acid volcanics in a matrix of coarse angular sublabile sandstone forms the base of the escarpment. The size of clasts decreases upwards, and within 25 m of the base they decrease from cobbles, through pebble conglomerate, to coarse sandstone with thin pebbly layers. The coarse sandstone is medium bedded and has a light brown weathering surface; thin (5-10 cm) cross-bed sets are common. About 25 m above the highest pebbly bed a white argillaceous sandstone bed about 5 m thick is succeeded by about 200 m of white generally coarse quartzose sandstone and orthoquartzite in which cross-bedding and pebbles of vein quartz up to 5 cm across are common. Grainsize generally is coarse.

North of Scrutton Creek, at grid ref. 126551, the basal conglomerate fills a depression within the Cliffdale Volcanics. Here crudely stratified and unsorted conglomerate consists of subrounded to angular clasts, up to 1 m across, of several types of acid lava and tuff, pink chert, and purple very fine-grained arenite in a matrix of lithic arenite. The conglomerate pinches out within 100 m to the north, where overlying flaggy sandstone and massive orthoquartzite 4 m thick lie directly on Cliffdale Volcanics.

The basal conglomerate is absent 5 km west of the Westmoreland homestead/Doomadgee Mission road (at grid ref. 200587). Here the quartz sandstone sequence is underlain by a sequence of cross-bedded poorly cemented coarse argillaceous sandstones containing thin pebble horizons. These are underlain, at the base of an escarpment, by 2 m of thin coarse arkosic sandstone, quartzitic very fine pebble conglomerate, and pink siltstone lenses up to 5 cm thick.

The sequence of quartz sandstone and orthoquartzite forms the upper part of Unit 1. The orthoquartzites are pink, white, or grey, massive well-cemented, and are fine to coarse. The quartzose sandstones are massive to flaggy, commonly coarse-grained (though fine-grained varieties also occur), quite well sorted, and ferruginous in some places; they are composed of up to 90 percent subangular to subrounded quartz in a matrix of sericite, kaolin, and iron oxides. Small quartz pebbles are common locally in this upper part.

In the northernmost outcrops of Unit 1, east of Battle Creek, the basal conglomerate is absent, and the Cliffdale Volcanics are overlain by medium to coarse pebbly arenite which is ferruginous in places. Medium-scale cross-bedding occurs sparsely in the more massive beds. Ripple marks are present in flaggy fine-grained quartz sandstones at the head of Six Mile Creek (metric grid 209072 on Westmoreland 1:250 000 Sheet) and at a locality 3 km to the north.

Unit 1 has also been mapped in the western part of the Seigal Sheet area, where it extends from the west branch of Rocky Creek, 5 km west of Crystal Hill, west-southwest for 28 km. It consists of grey or pink medium-grained quartzose sandstone and orthoquartzite. Bedding is thin to very thick, ripple-marks are common, and tabular cross-bedding was observed. The lower contact of the unit with the 'Nicholson Granite Complex' is obscured by scree. The area where the unit is absent was probably an area of slightly higher basement, and may have supplied some detritus to the western area of outcrop.

Thickness. An overall thinning of the unit towards the west is apparent. Local relief of tens of metres on the erosional surface of Cliffdale Volcanics accounts for some observed thickness variations. Scree shed from basal conglomerate masks the unconformity in some sections, preventing accurate thickness measurements on the ground.

Estimation of thicknesses have been made from aerial photographs. In the area east-southeast of Buck Hill, the thickness is 240 m ± 40 m and is possibly similar in outcrops 5 km to the south and 15 km to the northeast. The unit thins to about 60 m in the westernmost outcrops in Queensland, and is absent over a distance of 30 km in the eastern Seigal Sheet area. The outcrops in the western part of the Seigal Sheet area are about 150 m thick (Table 6).

Unit 2

Distribution. Outcrops extend over a strike length of 44 km, from 10 km east of the Doomadgee Mission/Westmoreland road westwards to Moogooma prospect in the western part of the Hedleys Creek Sheet area: the unit is exposed on the flanks of an east-northeast-trending anticline near Battle and Six Mile Creeks, and at the head of Moores (Eight Mile) Creek in the Westmoreland Sheet area. In the Seigal Sheet area the unit has been recognized east of the Calvert Fault.

Topographic expression. Unit 2 weathers more easily than adjacent units. Consequently it forms low ground between the strike ridge of Unit 1 and dissected cliffs of Unit 3, and much of it is masked by alluvium and sandy soils. However, in the Seigal Sheet area where Unit 1 is absent, Unit 2 forms upland areas about 100-150 m above the general erosional level of the underlying Cliffdale Volcanics.

Reference sections. The unit is well exposed in the Westmoreland Conglomerate type section of Carter et al. (1961). Other good sections are exposed 13 km east-southeast and 4 km south of the Redtree uranium deposit.

Stratigraphic relations. Unit 2 lies conformably between Units 1 and 3 within the Westmoreland Conglomerate. Where Unit 1 is absent it lies unconformably on Cliffdale Volcanics and the 'Nicholson Granite Complex'.

The lower contact of Unit 2 is placed above the top orthoquartzite bed of Unit 1. East of the Cliffdale Fault the boundary is gradational, and is marked by an upwards decrease in proportion of quartz grains and an increase in grainsize.

Lithology. Unit 2 is a fairly uniform sequence of massive cross-bedded sandstone in which pebbles of vein quartz up to 5 cm across are abundant (Plate 1). The sandstones are not well sorted, and grainsize varies from medium-grained to fine pebble conglomerate and rare boulder conglomerate. The sandstone is commonly grey-brown, but ferruginous outcrops are purple.

The rocks contain between 45 and 75 percent, and less commonly 85 percent, subangular quartz grains set in a matrix of

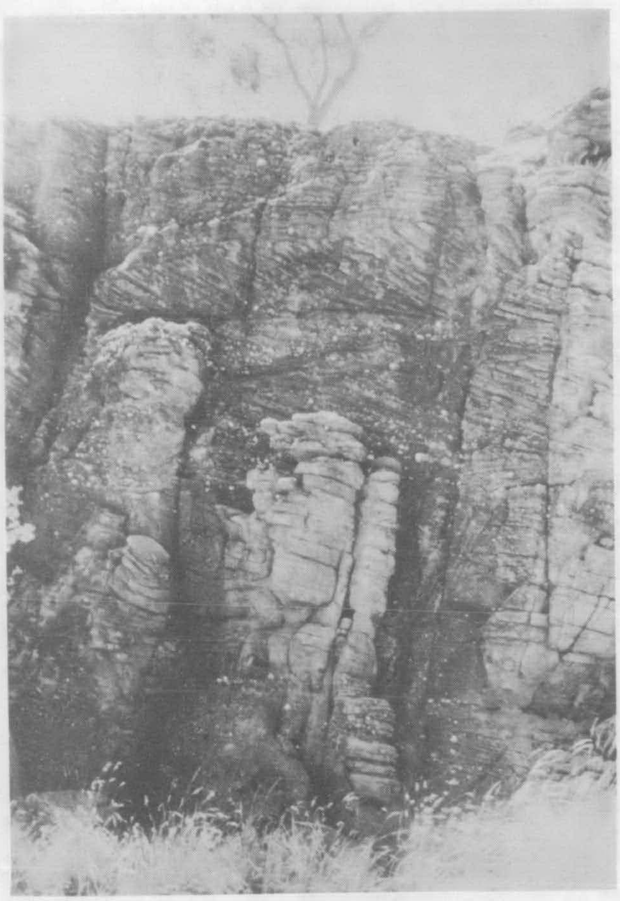

Plate 1: Cross-bedded pebbly and cobbly sandstone in Unit 2 of Westmoreland Conglomerate east of Cliffdale Fault, Hedleys Creek Sheet area (Neg. GAB/7).

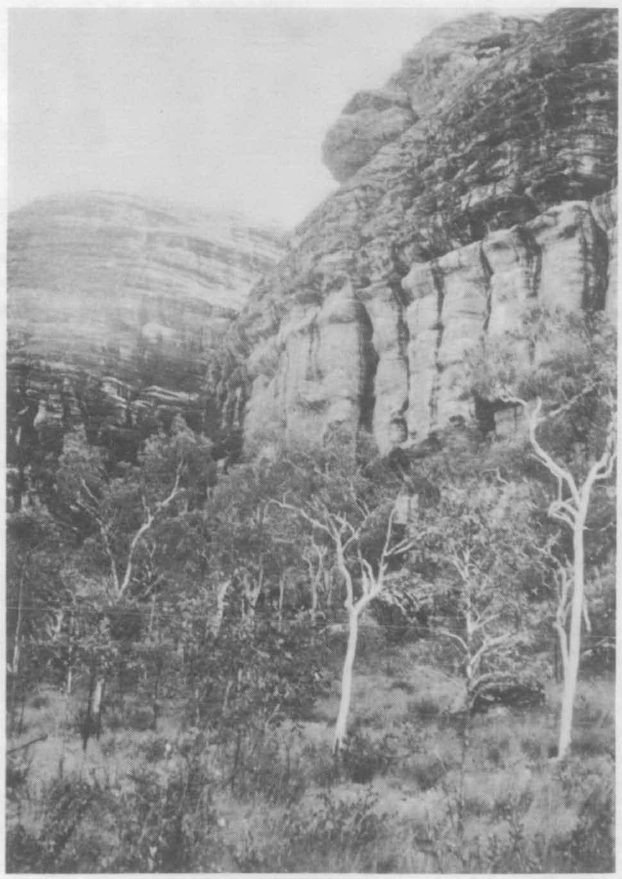

Plate 2: Characteristic outcrop of Unit 3 of Westmoreland Conglomerate at Conglomerate Hill, Westmoreland 1:100 000 Sheet area (Neg. GAB/19).

The rocks contain between 45 and 75 percent, and less commonly 85 percent, subangular quartz grains set in a matrix of sericite, clay, and iron ores. Some quartz grains contain inclusions of muscovite. Pebbles of vein quartz are almost ubiquitous within the unit, and pebbles of porphyritic acid volcanics are common in the western part of the outcrop.

Trough and less common tabular cross-bedding occur throughout the unit. The sets are of medium scale, and are generally thicker than in the enclosing units.

Thickness. Estimation of thickness based on measured and photo-interpreted dips indicate a roughly uniform thickness of 450 ± 100 m. No sections were measured.

Unit 3

Distribution. The unit crops out as a west-southwest-trending belt from Dilldoll Rock in the southeastern part of the Westmoreland 1:100 000 Sheet area, 65 km to the Calvert Fault in the west, in the Seigal Sheet area.

Topographic expression. Where the overlying unit has been eroded, for example near Moores (Eight Mile) Creek, Unit 3 forms rugged uplands which are covered in places with sparse vegetation. It forms conspicuous rounded cliffs above the contact with Unit 2 (Plate 2). Joints and faults cutting Unit 3 are eroded to form deep linear gullies.

Reference areas. The unit is well exposed in the Westmoreland Conglomerate type section, and also 3 km southwest of Redtree uranium deposit.

Stratigraphic relations. The unit is a conformable member within the Westmoreland Conglomerate. The contact with the underlying Unit 2 is generally marked by an abrupt change in slope, due to the more resistant nature of Unit 3, but the strata are locally gradational. The contact with Unit 4 is placed above the last thick boulder or cobble conglomerate bed in Unit 3.

Lithology. Much of the exposed rock is light brown very coarse pebbly or cobbly sandstone in which trough cross-bedding, commonly less than 1 m thick, is outlined by laminations of rounded black hematite grains. Rounded pebbles and cobbles of vein quartz, metamorphic quartz, red orthoquartzite, red fine quartzose arenite, and acid volcanics occur in varying proportions in a matrix of poorly sorted coarse quartzose sandstone.

Polymictic conglomerates up to 30 m thick also occur within the sequence, most commonly near the top of the unit. They contain clasts similar to those in the pebbly sandstones. A boulder conglomerate containing rounded pebbles and boulders all of quartz feldspar porphyry, crops out over a strike length of 1.2 km, 7.5 km southwest of Redtree. At another outcrop, 8 km south-southwest of El Hussen uranium prospect (Plate 3, grid ref. 028 590), a thick conglomerate consisting of pebbles and cobbles of fine-grained red sandstone set in a coarse gritty sandstone matrix forms the top of Unit 3.

In the area of Moores (Eight Mile) Creek, the unit is more varied. Lenses of red siltstone and shale are locally interbedded with poorly sorted coarse sublabile sandstone, pebbly and cobbly sandstone, and lenses of poorly sorted boulder conglomerate. The clasts are composed of vein quartz, orthoquartzite, chert, red porphyritic rhyolite, coarse quartzose arenite, and coarse cross-bedded sandstone with black sand lamination, and are clearly both extraformational and intraformational. Trough cross-bedding is prevalent in the sandstones. Ripple-marks and sandstone dykes occur in the siltstones.

The top of the unit is marked by a laterally extensive conglomerate bed composed of poorly sorted pebbles and boulders up to 80 cm across of vein quartz, red orthoquartzite, red fine-grained quartz sandstone, conglomerate, and rarely quartz-feldspar porphyry, set in a matrix of subangular sand and clay. This bed was observed near El Hussen uranium prospect, 16 km west of the Queensland border (Plate 3), in outcrops west of Buck Hill, and at Conglomerate Hill 10 km southwest of Westmoreland homestead.

Thickness. The maximum thickness is about 500 m, in the area southwest of Buck Hill. The unit appears to thin to the north and west and is probably less than 200 m thick at Conglomerate Hill and in the Seigal Sheet area.

Unit 4

Distribution. Unit 4 crops out along the southern side of the valley of Lagoon Creek, from Battle Creek in the east (Westmoreland 1:100 000 Sheet area) to Branch Creek in the west, and as far south as the west branch of Breakneck Creek (central Seigal Sheet area). South of Battle Creek it crops out in a small east-trending valley known as Long Pocket.

Topographic expression. Owing to erosion along a profusion of joints, the unit has an extremely rugged surface. It forms a resistant dip slope generally of 5 to 10°, but locally of up to 45°.

Reference area. A representative section through the unit is exposed in a gorge where Lagoon Creek cuts through the Westmoreland Conglomerate 2 km east of the Queensland/Northern Territory border.

Plate 3: Massive cobble conglomerate forming the top of Unit 3 of the Westmoreland Conglomerate near El Hussen prospect, Seigal Sheet area (Neg. GAB/21).

Plate 4: Westmoreland Conglomerate, Unit 4, in the western wall of the gorge of Lagoon Creek in the northwestern part of the Hedleys Creek Sheet area. Note the conglomerate beds near the top of the cliff, and large-scale festoon (trough) cross-beds below. (Neg. M/1506, Nos 6A-11A).

Stratigraphic relations. The unit lies conformably on the thick boulder conglomerate at the top of Unit 3. The contact with the overlying Peters Creek Volcanics is conformable and a few metres of shale is exposed at the contact in two costeans 3 km west of the reference area. On aerial photographs the unit appears to lense out against basal lavas of the Seigal Volcanics at its western extremity, but the relation is complicated by probable faulting. Carter et al. (1961) considered that the contact with the volcanics may be unconformable, but we saw no evidence of this.

Lithology. Unit 4 shows little variation in rock type along the whole of its strike length. It is a light grey or brown coarse-grained quartz greywacke composed of subangular quartz grains (60-70%) and subordinate other grains in a matrix of sericite, clay, and iron oxides. About 5 percent of grains are altered to clay and sericite, or replaced by secondary quartz.

Around Redtree the unit is medium to very coarse-grained and contains pebbles of vein quartz, orthoquartzite, and, less commonly, chalcedony in thin discreet layers and dispersed throughout the sandstone. The unit is well exposed in cross-section in the reference area, where it consists of about 150 m of interbedded coarse sandstone lenses, which exhibit trough cross-bedding and minor conglomerate beds (Plate 4). Pebble bands occur sparsely near the base, and a 2 m thick cobble conglomerate bed occurs about half way up the sequence.

Bedding varies from thick to thin, and some medium-grained sandstones have flaggy or fissile partings. Both trough and planar tabular cross-bedding of medium scale are common within the unit. Sedimentary slumping was noted near Moongooma Prospect and also 4 km to the north, and ripple marks were also observed.

Thickness. In the east the unit is estimated from field observation and drilling data to be between 150 m and 250 m thick, but it thins westwards to about 75 m before lensing out abruptly.

Westmoreland Conglomerate west of the Calvert Fault

Lateral facies changes westwards render it impracticable to map Units 2 and 3 of the Westmoreland Conglomerate farther west than about the Calvert Fault. Rocks similar to those of Units 2 and 3 are present west of the Fault, but they intertongue with one another and with other varieties of arenite and rudite which are not common in the succession to the east. Accordingly the sequence west of the fault is mapped as prominent Units 1 and 4 separated by a sandstone sequence containing two conglomerate members.

TABLE 6: Section through Westmoreland Conglomerate northwest from China Wall at Dry Creek, west of Pandanus Creek uranium mine

Unit	Estimated thickness metres	Overlain unconformably by Cretaceous rocks
Unit 4	90	Quartzose Sandstone: light brown to pink, coarse-grained with few granule sandstone beds, few quartz pebbles, cross-bedded, well jointed
Upper Conglomerate	100	Pebble conglomerate with interbedded brown grit: pebbles of fine-grained red arenite and quartz; matrix of coarse angular sand; black sand laminae, trough cross-bedding
Undivided on map	100	Quartzose sandstone: pale brown, fine to medium-grained, thin partings, large-scale cross-bedding, no pebbles
	70	Coarse pebbly grit: light brown to purple; pebbles up to 5 cm across of quartz and fine-grained pink arenite; black sand laminae, trough cross-bedded, very well jointed
	80	Sublabile sandstone: purple to pink, medium-grained; abundant clay matrix; thick bedded, cross-bedded, very few pebbles
Lower Conglomerate	240	Pebble and cobble conglomerate: clasts mainly 10-15 cm (30 cm maximum), of fine grained pink arenite, quartz, minor chert and volcanics; matrix of purple (ferruginous) grit; trough cross-bedded.
Undivided on map	60	Pebbly grit: Purple angular to subangular clasts up to 2 cm; rare boulder beds with acid volcanic clasts
	190	Pebbly grit with interbedded pebble conglomerate: clasts of fine grained pink arenite and quartz; coarse arkosic matrix
	640	Sublabile sandstone: red, grey, or white, medium to coarse, cross-bedded; a few quartz pebbles in lower part of unit.
Unit 1	150	Quartz sandstone: Grey to white, fine to coarse-grained, thick-bedded.
Total:	1720	Underlain nonconformably by 'Nicholson Granite Complex'

Plate 5: Westmoreland Conglomerate in the China Wall west of Pandanus Creek uranium mine, Seigal Sheet area (Neg. GAB/25).

Roberts (unpubl. MS) describes an almost complete section through the Westmoreland Conglomerate along the western branch of the Fish River. The most notable rocks, in a succession of mainly quartzose sandstone with conglomeratic interbeds, are two thick (430 m and 180 m) very coarse arkosic sandstones consisting dominantly of quartz and pink feldspar, 1.2 - 2.5 cm across, enclosed in a white clay matrix. The lower of the two sandstones also occurs in Breakneck Creek north of its junction with the Fish River.

Except in Units 1 and 4, pebble beds occur sporadically within the sequence.

West of Pandanus Creek uranium mine, an almost complete section of the Westmoreland Conglomerate is exposed. The rocks present, and their thicknesses estimated from field dip measurements and aerial photographs, are presented in Table 6, and part of the succession is shown in Plate 5.

The top of the Westmoreland Conglomerate 7 km west of Breakneck Creek Gorge is marked by a boulder conglomerate (Btw_{C2}), Unit 4 having lensed out 5 km to the east-northeast. The conglomerate has an open framework with clasts greater than 1 m across of fine red quartzose arenite to pebble conglomerate in a matrix of coarse red grit which has abundant interstitial clay. The boulder bed is about 6 m thick and is underlain by fine to coarse quartzose sandstone and orthoquartzite. A similar boulder conglomerate, about 130 m below the first, is underlain by pebbly grit with conglomerate interbeds, below which is a thick (270 m) quartzose sandstone lying immediately above Unit 1.

Sandstone and overlying basalt cropping out between Tin Hole (at grid ref. 699252) in the west and Fish River in the east are mapped (by Roberts et al., 1963, and the present survey) as Westmoreland Conglomerate and Seigal Volcanics (formerly Peters Creek Volcanics). The sandstone outcrops are the only representative of the Westmoreland Conglomerate on the Murphy Tectonic Ridge, where they are between 20 and 100 m thick. Roberts (unpubl. MS) described the sediments as arkose and feldspathic sandstone, and considered them to be equivalent to the uppermost beds of the Westmoreland Conglomerate in the nearby China Wall outcrops. We observed thick-bedded, flaggy quartz sandstone exhibiting both tabular cross-bedding and ripple-marks and containing scattered pebbles of quartz and pink quartzite. This sandstone is more similar to Unit 1 than to other units of the Westmoreland Conglomerate mapped to the east.

Steeply dipping quartzose and feldspathic pebbly arenite are exposed in a small outcrop adjacent to Tin Hole Creek 3 km south of Tin Hole. The outcrop is surrounded by granite and is thought to be a downfaulted wedge of Westmoreland Conglomerate. Similar small outcrops occur about 1 km north of a track 3 km west of the Fish River.

Discussion

The abundance of very coarse, poorly sorted, trough cross-bedded clastic sediments, and the absence of fine-grained sand and silt, indicate that the Westmoreland Conglomerate is a fluviatile deposit laid down in a high-energy environment, probably from braided rivers. The few palaeocurrent directions measured in the Queensland part of the survey area indicate transportation from the southeast quadrant, and are broadly in agreement with the observations of Carter et al. (1961); more measurements are needed to definitely establish this direction.

The abundant white clay matrix in many coarse sandstones appears to contradict other evidence of a high-energy environment. It is possible that some of the clay was formed from the weathering of feldspar grains broken down after deposition. However, in the type of high-energy environment envisaged, trapped turbid pore-water could deposit significant quantities of silt and clay.

Roberts (unpubl. MS) pointed out that abrupt changes in grainsize within the conglomerate probably reflect violent contemporaneous tectonic adjustments. He introduced the term 'Tin Hole Hinge Line' for an east-northeast-trending zone separating the Murphy Tectonic Ridge from the McArthur Basin to the north. Flexuring or faulting, or both, along this line during the deposition of the Westmoreland Conglomerate permitted the accumulation of more than 1200 m of sediments immediately adjacent to the Ridge, but less than 100 m on the Ridge itself.

The Tin Hole Hinge Line cannot be traced as a line of faulting or flexuring east of Rocky Creek, where the basal beds of Westmoreland Conglomerate flatten out and lie unconformably on Cliffdale Volcanics rather than the 'Nicholson Granite Complex', and we suggest that Rocky Creek may mark an approximate junction between two slightly different depositional environments. Differences in the rock type, structure, and outcrop pattern to the west and east of Rocky Creek are set out in Table 7. The evidence indicates that, in the west, abrupt subsidence took place and that syndepositional uplift was greater than in the eastern part of the Murphy Tectonic Ridge. The provenance of the western area is different from that in the east and reflects the composition of the rocks immediately underlying the conglomerate. This leads to the hypothesis that the Westmoreland Conglomerate in the west was deposited as a series of coalescing fans, possibly bounded to the south by a fault scarp along Tin Hole Hinge Line. Alternatively, the arkosic conglomerates in the west may be locally derived, and the interbedded sandstones may have an easterly provenance similar to that of the formation in the east.

If the Tin Hole Hinge Line extended east of Rocky Creek, it would affect the underlying Cliffdale Volcanics. As this is not the case, it is suggested that in the east the Westmoreland Conglomerate was deposited in a basin adjacent to mountain ranges, but not in the immediate vicinity of a recognizable block bounded by faulting or flexuring. Basement highs in this area could have provided the locally abundant volcanic detritus.

On the west side of Pandanus Creek uranium mine, rocks similar to those mapped both to the east and west, might represent a transition zone which received granitic material from the south and volcanic material from the southeast and east.

TABLE 7: Comparison of Westmoreland Conglomerate east and west of Rocky Creek.

West of Rocky Creek	East of Rocky Creek
1) Outcrop of contact with underlying rocks is linear	1) Contact non-linear; faulted in places
2) Basal rocks have steep dips (up to 60°)	2) Shallow dipping basal rocks with inliers of Cliffdale Volcanics.
3) Faults in basement are parallel to strike	3) Faults in basement also affect Westmoreland Conglomerate
4) Extremely rapid thickening down-dip	4) Thickening not demonstrable
5) Overlies granite	5) Overlies Cliffdale Volcanics
6) Few volcanic pebbles	6) Volcanic pebbles common
7) Feldspar locally abundant	7) Feldspar not common

Environments of deposition. Relief on the pre-Westmoreland Conglomerate depositional surface is of the order of tens of metres, and hollows in this surface are filled by basal conglomerate of Unit 1. The basal facies passes upwards into a quartz-rich sandstone sequence forming the remainder of Unit 1. These sandstones are mainly moderately well sorted, though not particularly well rounded, and show ripple-marks and cross-bedding. Because of the nature of the rest of the formation, they are thought to be fluvial.

Features that are diagnostic in the interpretation of the depositional environment of the basal part of Unit 1, and of Units 2, 3, and 4, are:

1. Predominance of coarse-grained clastic sediments
2. Rarity of interbedded fine-grained sand and silt
3. Lens-shaped sandstone bodies containing medium-scale trough cross-bedding.

Other environmental indicators, such as overall geometry of the formation, are not known, and very few palaeocurrent directions have been measured. Nevertheless, the above features indicate deposition in a fluviatile environment. The high-velocity traction currents necessary to transport the coarse clasts probably occurred in low-sinuosity braided channels, because currents in meandering rivers are generally not powerful enough to transport coarse debris.

Seigal Volcanics

The Seigal Volcanics were included by Roberts et al. (1963) in the Peters Creek Volcanics, which were defined by Carter et al. (1961) from outcrops southwest of the headwaters of Peters Creek, in the Westmoreland 1:250 000 Sheet area. The Seigal Volcanics have been designated a separate unit after the present mapping because:

(1) they crop out only in the McArthur Basin, and are separated (in present-day outcrops) from the type Peters Creek Volcanics (which crop out only on the 'Lawn Hill Platform') by basement outcrops 10-30 km wide, and

(2) they are believed to be equivalent to only the lowermost of the six members constituting the type Peters Creek Volcanics.

Because of the change in nomenclature, Peters Creek Volcanics on the following 1:250 000 Sheets (authors in brackets) should be regarded as Seigal Volcanics: Bauhinia Downs (Smith, 1964), Calvert Hills (Roberts et al., 1963), Mount Young (Plumb & Paine, 1964), and Walhallow (Plumb & Rhodes, 1964).

Type section. In a valley 6 km northwest of the confluence of the Fish River and Breakneck Creek, in the Seigal Sheet area.

The base is at grid reference 797319, on the northern side of the China Wall. The section extends 1 km north across moderately dipping volcanics to the base of a steep sandstone scarp at grid reference 795333.

Stratigraphic relations. The Seigal Volcanics overlie the Westmoreland Conglomerate, probably conformably. Carter et al. (1961) suggested a slight angular unconformity at one locality, but this was not confirmed by our fieldwork.

In the Westmoreland Sheet area and the northeastern part of the Seigal Sheet area, the Seigal Volcanics are overlain conformably by the McDermott Formation. Flow tops in many outcrops are infilled by silt or fine sand, and it is probable that, in this part of the region, sedimentation continued without an erosional break after volcanic activity ceased. However, in most of the Seigal Sheet area the McDermott Formation is absent, and the Seigal Volcanics are overlain by the Sly Creek Sandstone. The McDermott Formation either lenses out southwards, or was partly eroded before deposition of Sly Creek Sandstone.

Topography. Outcrops of the volcanics in the Westmoreland and Hedleys Creek Sheet areas consist of a few small ridges in the soil-covered alluvial plains of Lagoon Creek and its tributaries. In the Seigal Sheet area the volcanics form rugged discontinuous strike ridges where the rocks are massive, and rounded rubbly hills where they are vesicular or weathered.

Lithology. The Seigal Volcanics consist of basic lavas and numerous thin interbeds of siltstone and fine sandstone. Most lava flows are less than 20 m thick. The sedimentary interbeds are less than 1 m thick except for the Carolina Sandstone Member (named by Roberts et al., 1963), which is up to 20 m thick.

In all localities examined except one the base of the Seigal Volcanics is marked by basalt overlying pebbly sandstone. The exception is a costean at grid reference 162583 in the northeastern part of the Seigal Sheet area, where ferruginous shale and siltstone rubble appear to crop out below basalt and above the uppermost pebbly sandstone (Unit 4) of the Westmoreland Conglomerate. Five kilometres to the west, at a poorly exposed contact, basal rubble consisting of unweathered non-vesicular basalt and weathered amygdaloidal basalt lies directly on sandstone.

The Seigal Volcanics below the Carolina Sandstone Member contain few sedimentary interbeds. The lavas, although they are well exposed, are very weathered or altered. Plate 6 shows at least 3 overlapping thin flows. The centres of flows are generally greyish-green or maroon, massive, and weather spheroidally. The upper parts of flows are finer-grained than the centres, are dark red to purple, and contain abundant amygdales and vesicles. The amygdales are of quartz, chalcedony, chlorite, haematite, and celadonite. A flow top at grid reference 900553 (in the Seigal Sheet area) contains small fissures and vesicles filled with fine quartz sand (sample 73762231). One of the few relatively unaltered samples collected from a flow centre (sample 73762232) contains rare labradorite phenocrysts in a groundmass formed of interlocking laths of plagioclase (andesine), colourless subophitic pyroxene, and about 25 percent of iddingsite (after olivine). Some brecciated flow tops are cemented by later quartz (Plate 7).

Thin beds of siltstone and fine sandstone are common above the Carolina Sandstone Member. Volcanic clasts or bombs are common in the fine sandstone beds.

In the type section of the Seigal Volcanics, exposures made up of at least six successive flows of brown to purple, very weathered amygdaloidal basalt are interlayered with thin siltstone beds. One such siltstone bed contains scattered angular blocks of lava up to 10 cm across.

At grid reference 930565, in the Seigal Sheet area, a bed, 60 cm thick of silicified red sandstone contains furrows or striations up to 3 cm wide and several metres long on its upper surface, and is overlain by about 10 m of reddish purple volcanic rock which grades up into brecciated lave cemented by quartz. The sandstone is underlain by 1.5 m of ripple-marked silty sandstone. The striations are interpreted as gouge marks made by blocks of lava in the frontal portion of a flow as it spread across the sandstone. The striae trend at 160°, but the sense of movement is unknown.

Thickness. The Seigal Volcanics are estimated to be about 1600 m thick in the northeastern part of the Seigal Sheet area, where the Carolina Sandstone Member is about 800 m above the base. In the southwestern part of the Seigal Sheet area, at the type section, the volcanics are about 1 100 m thick, and the Carolina Sandstone Member is only 200 m above the base.

Intrusives and eruptive centres. South of the China Wall a northeast-trending dolerite dyke more than 30 m wide can be traced for almost 30 km in the 'Nicholson Granite Complex'. Three kilometres southeast of Tin Hole, 1 km from the nearest Seigal Volcanics outcrops, this dyke is very similar in appearance to the lavas, being composed of red-brown amygdaloidal basalt, and is regarded as a possible feeder for the Seigal Volcanics. Throughout its length the dyke is highly altered and in places is brecciated and silicified.

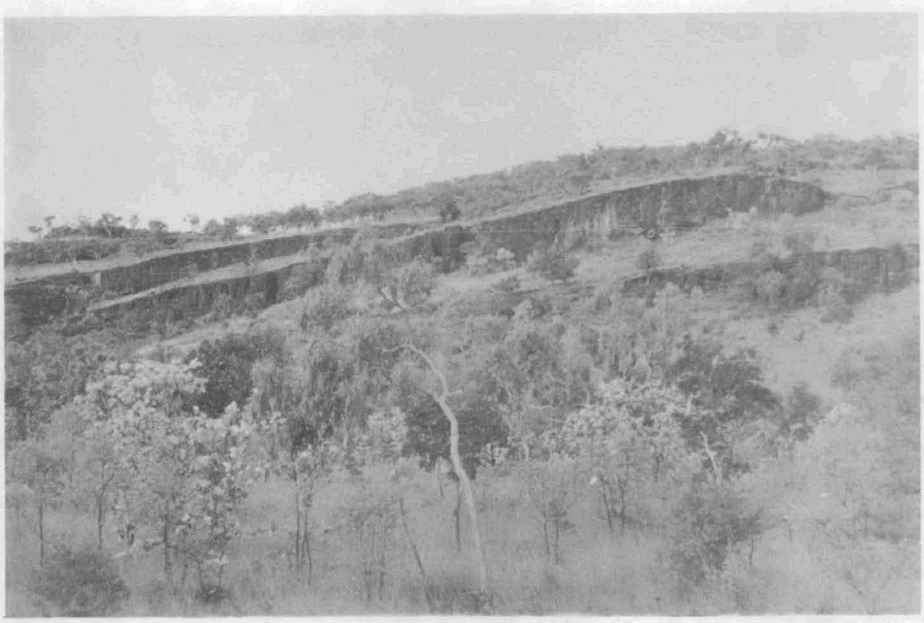

Plate 6: Basalt flows in Seigal Volcanics 3 km north-west of Cobar II uranium prospect, Seigal Sheet area (Neg. M/1506).

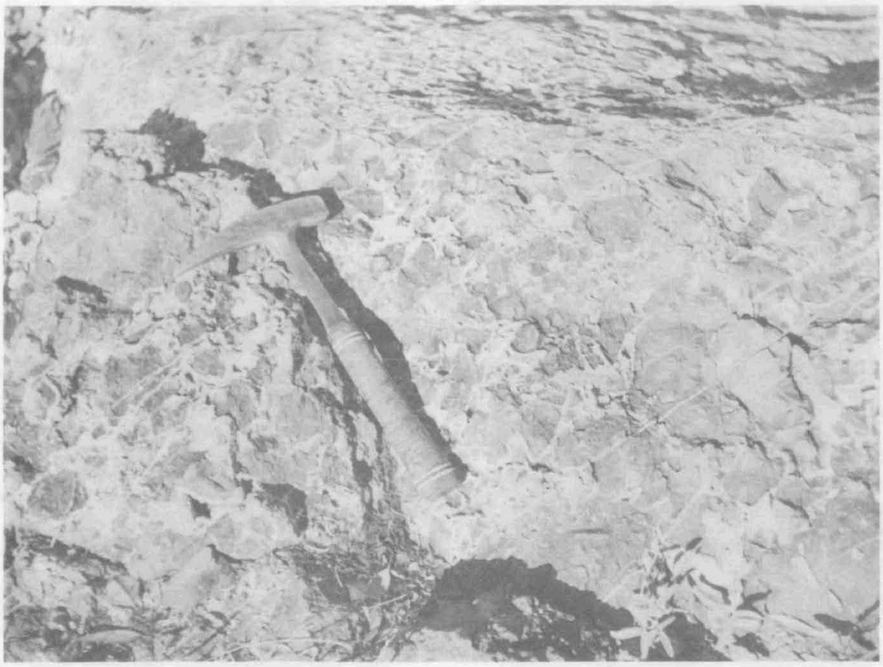

Plate 7: Flow-top breccia cemented by quartz; Seigal Volcanics 9.5 km west of Cobar II uranium prospect Seigal Sheet area (Neg. M/1506).

Numerous northeast-trending dykes intrude the Seigal Volcanics northeast of the Calvert Fault in the Seigal Sheet area, where they are commonly exposed as upstanding walls. Copper mineralization is associated with similar dykes cropping out in the succession below the Carolina Sandstone near Branch Creek. Most of the dykes exposed are brick red in colour, and are brecciated, and cemented with quartz and in places a blueish-green mineral. Horizontal slickensides were seen on a dyke about 1 km northeast of the Doctors Creek road crossing (grid ref. 900553, Seigal Sheet area).

The exposed dykes appear to be composed of almost opaque red-brown ferruginous material containing quartz and radiating clusters of epidote. Relict feldspar laths are faintly visible.

A relatively unaltered dolerite dyke is exposed about 3 km west-southwest of the Branch Creek road crossing. It trends west-northwest, is about 4 m wide, is grey beneath a red-brown weathered skin, and shows spheroidal weathering.

A plug of volcanic breccia 1.5 km northwest of Cobar II uranium prospect forms a steep-sided hill about 60 m high. Much of the rock consists of brecciated fine-grained brick-red amygdaloidal lava. Quartz fills many amygdales and cements blocks of breccia. Pyrolusite coats the surfaces of many joints and lava blocks, some of which contain several percent of specularite.

Petrography. The lavas in the Seigal Volcanics include massive medium-grained basalts with minor glassy mesostasis, and amygdaloidal basalt in which reddish-brown devitrified glass predominates. The amygdaloidal varieties are probably from thin flows, or from the tops and bottoms of relatively thick flows which have massive centres. Most of the rocks are highly weathered, and the following descriptions are based on only 3 thin sections. Specimen 73762232, the freshest examined, contains phenocrysts of plagioclase (1-2 mm) and small euhedral tabular labradorite laths (An_{54}) in the groundmass. Minor olivine is replaced by iddingsite which looks very similar to a reddish-brown fibrous mineral (chlorite?) that replaces devitrified glass. Augite (2V 40^{o}) appears to be the only pyroxene present. In the only other specimen of massive basalt examined, 73762238, the augite is extensively replaced by chlorite: this rock contains some interstitial quartz (containing acicular apatite) and alkali feldspar. Less than 5 percent of opaque oxides are generally present.

The amygdaloidal lavas consist mostly of devitrified glass with scattered euhedral plagioclase laths, and amygdales generally of chlorite and quartz. Sample 73762239 contains granules of opaque oxide and almost opaque glass containing microlites of similar oxides.

The lavas are very similar in composition to those of Unit 1 of the Peters Creek Volcanics, and are probably tholeiitic basalts.

Carolina Sandstone Member

The Carolina Sandstone Member forms a narrow discontinuous strike ridge extending from the northern margin of the Seigal Sheet area west of Branch Creek to the headwaters of the Fish River in the southwest. It was named by Roberts et al. (1963) after the Carolina airstrip (in the Wollogorang 1:100 000 Sheet area), 5.5 km north-northeast of Cobar II uranium prospect. In the Wollogorang Sheet area, an exposure west of a track 4 km north-northwest of Cobar II, is designated as the reference area.

Lithology and thickness. The Carolina Sandstone Member is well exposed in Doctors Creek, in the northern part of the Seigal Sheet area. It is a flaggy to massive fine-grained, dark red-weathering, grey sandstone and interbedded siltstone, and is about 12 m thick. Cross-bedding is common and some ripple-marks and mud cracks are present. A second sandstone bed 4 m thick occurs a few metres below the member in the Doctors Creek area. The Carolina Sandstone is covered by laterite in the headwaters of Doctors Creek. In this general area it consists mainly of silicified lithic sandstone containing scattered detrital groups of both plagioclase and microcline. Nine kilometres to the south, two thin horizons separated by 30 m of volcanics have also been designated as Carolina Sandstone Member (Roberts, unpubl. MS), on the assumption that they are separate tongues of the main body of sandstone.

In the headwaters of the Fish River two sandstone beds are separated by 100 m of volcanics. The upper bed is 2.5 m thick, and consists of fine-grained grey cross-bedded orthoquartzite; the lower bed, 6 m thick, is a pink orthoquartzite containing quartz pebbles up to 7 cm across.

Between 3 and 10 km east of Tin Hole, a prominent sedimentary member within the Seigal Volcanics has also been mapped as the Carolina Sandstone Member. It is a cobble conglomerate, less than 10 m thick, containing clasts up to 25 cm across of fine to medium pink quartz sandstone, quartz, pebble conglomerate, and quartz-cemented sandstone breccia. A fine-grained grey quartz sandstone bed about 3 m thick also occurs in this area within the Seigal Volcanics.

Discussion

The Seigal Volcanics consist of a sequence of thin lava flows and sedimentary beds. Pyroclastics associated with some siltstones indicate that some explosive activity may have taken place, but most breccias are thought to be flow-top breccias, not agglomerates. The siltstones filling and overlying the flow-top breccias are identical to marine siltstones in the overlying McDermott Formation. For this reason it is suspected that at least some of the lavas were extruded into a shallow sea. The Carolina Sandstone Member reflects either renewed uplift in an adjacent area, or a temporary lull in lava extrusion. Uplift almost certainly was important, and sedimentation from the southwest (from the Murphy Tectonic Ridge) is suggested by a decrease in grainsize from boulder conglomerate near Tin Hole to fine-grained sandstone in the northern part of the Seigal Sheet area.

Dolerite dykes probably represent the main feeders to the volcanics. The brick red dykes appear to be of similar composition to the breccia plug near Cobar II mine. No lavas of intermediate or acid composition have been recognized.

McDermott Formation

Distribution. The main outcrops of the McDermott Formation form the slopes of an escarpment north of the valley of Lagoon Creek in the northeast. The escarpment trends west-southwestwards across the headwaters of Branch Creek. These outcrops are in the Westmoreland and Wollogorang 1:100 000 Sheet areas. Scattered outcrops also occur in the northern part of the Seigal Sheet area.

Derivation of name. From McDermott Creek, near lat. 17°25'S, long. 137°49'E, a minor tributary of Branch Creek in the Wollogorang 1:100 000 Sheet area.

Modification of nomenclature. Rocks now mapped as the McDermott Formation were included in a unit called the Wollogorang Formation by Carter (1959) and Firman (1959). Roberts et al. (1963) recognized two main carbonate units in the area, and retained the name Wollogorang Formation for the younger of these units, and renamed the older unit the McDermott Formation.

Type Section. Roberts (unpubl. MS) nominated a 'reference area' 10 km northwest of Carolina airstrip in the Wollogorang Sheet area. This section is presumably preferred to a thicker but incomplete section farther west, because both base and top are exposed.

Stratigraphic relations. The McDermott Formation conformably overlies the Seigal Volcanics. Eighteen kilometres west-southwest of Cobar II mine, the contact is marked by indurated sandstone overlying tuff or a flow top of Seigal Volcanics, and 500 m farther east similar red sandstone contains blocks of basalt.

The McDermott Formation thins southwards and either lenses out against or is truncated by the Sly Creek Sandstone 7 km south of the northern margin of the Seigal Sheet area.

Lithology. The McDermott Formation consists of dolomite, siltstone, shale, and sandstone.

Low ridges of sandstone 21 km west-southwest of Westmoreland homestead are at, or near, the base of the McDermott Formation. The sandstone here is at least 15 m thick, massive, cross- bedded, white, medium-grained, and quartzitic, and has a sparse clay matrix. The contact with the Seigal Volcanics is best exposed 18 km west-southwest of Cobar II mine: tuff or flow-top breccia is overlain by red cross-bedded siltstone, purple shale and medium sandstone, above which is dolomitic siltstone and dolomite.

A well exposed section of McDermott Formation 21 km west of Westmoreland homestead, between Stony and Snake Creeks, consists of alternating dolomite and siltstone. At the base is 25 m of stromatolitic dolomite overlain by 15 m of purplish-brown siltstone, cross-bedded silty dolomite, and dolomitic siltstone and sandstone; these are overlain in turn by 15 m of thick-bedded, cross-bedded brown dolomitic sandstone. The basal stromatolitic dolomite is finely laminated, and the superposition of successive convexly arched continuous laminae gives the false impression of discreet columns growing from a bedding plane. Thus, although the 'columns' may be 20-30 cm high, the synoptic relief of a lamina is seen to be only 1-5 cm.

Near the base of the McDermott Formation about 1 km south of the point where Branch Creek enters a large gorge cut in Sly Creek Sandstone, intraclastic and oolitic gritty dolomite crop out (74760062). Rounded quartz, pink grains (volcanics?), pellets and flakes of green clay or glauconite, intraclasts up to 5 cm long, and ooids are set in a matrix of micrite. The non-carbonate fraction generally makes up less than 50 percent of the rock.

Higher in the sequence, 500 m south of the gorge, the following rocks are exposed:

Thickness (m)	Top
10	Massive, brown stromatolitic dolomite; stromatolite columns 3-5 cm across and 10-30 cm high
30	Dark brownish-purple, intraclastic and wavily laminated, stromatolitic dolomite; several thin, purple shale beds

5 Flaggy, laminated, and thin-bedded silty ferruginous and manganiferous dolomite; intramicrite lens 15 cm thick

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Base

Siltstone and dolomite cropping out around grid reference 578840 in the Seigal Sheet area are overlain and underlain by sandstone. The younger sandstone is Sly Creek Sandstone, but the older one could either be a bed in the McDermott Formation or a tongue of Sly Creek Sandstone. Because outcrops of Cretaceous rocks partly obscure the outcrop this question could not be resolved.

Seven kilometres south of the northwestern corner of the Seigal Sheet area pink dolomite, green shale, and dolomitic siltstone and sandstone are overlain by blocky medium-grained quartz sandstone of the Sly Creek Sandstone. A float boulder of silicified dolomite here contains well defined columnar stromatolites.

Thickness. About 150-200 m of McDermott Formation is preserved in and adjacent to the scarp north of Lagoon Creek in the Westmoreland 1:100 000 Sheet area. In the Seigal Sheet area the formation thins out: it is less than 50 m thick 18 km west-southwest of Cobar II mine, and is absent within 3 km to the south.

The westernmost outcrop of the formation in the Seigal Sheet area is part of a much thicker section, most of which is west of the area mapped. This section has been estimated by Roberts (unpubl. MS) to be about 1000 m thick.

Environments of deposition. The McDermott Formation probably represents near-shore marine and lagoonal environments. The laminated and stromatolitic dolomites within the formation indicate that algal mats were present. Intraclast beds are common, and mainly represent partly lithified beds which have been broken up and redeposited during periods of strong wave activity. That there was an influx of sediment from outside the basin is indicated by the beds of shale and silty and sandy carbonates. Current activity from very slight to quite strong is indicated by the range from laminated shales and cross-bedded silty dolomites to medium-grained, cross-bedded sandstone.

Overall, the facies suggests near-shore, perhaps intertidal, deposition of carbonates. The intraclastic and stromatolitic dolomite were probably the product of high-energy environments, and the laminated dolomites of sheltered (low-energy) ones. The silty and shaly rocks probably include both offshore and lagoonal facies. The presence of mud cracks in one dolomite bed indicates some supratidal carbonate deposition and desiccation.

Sly Creek Sandstone

The Sly Creek Sandstone crops out extensively in the southeastern part of the McArthur Basin, where it was mapped by Yates (1963), and Roberts et al. (1963), Plumb & Paine (1964), Smith (1964). It was previously mapped in the Westmoreland Sheet area by Carter (1959) as Constance Sandstone.

Derivation of name. From Sly Creek, in the Mount Young 1:250 000 Sheet area (Plumb & Paine, 1964).

Distribution. In the area covered by this survey the main outcrops of Sly Creek Sandstone are in the northwestern quarter of the Seigal 1:100 000 Sheet area. Minor outcrops occur in the southwest about 5-8 km north of Tin Hole Creek. A broad plateau of Sly Creek Sandstone extends northeast from the northern margin of Seigal into the Wollogorang 1:100 000 Sheet area and east into the Westmoreland 1:250 000 Sheet area, but outcrops in the plateau were examined only briefly.

Type section. Roberts (unpubl. MS) nominated a reference area 6 km south-southwest of Rosie Creek homestead in the Mount Young Sheet area.

Stratigraphic relations. Roberts et al. (1963) considered the unit to lie conformably on the McDermott Formation and, where the latter is absent, disconformably on the Seigal Volcanics. However, the contact with the McDermott Formation is sharp and may be unconformable. The unit is overlain conformably by the Aquarium Formation.

Topography. The formation is resistant to weathering and forms escarpments and plateaux (Plate 7).

Lithology. The unit consists of white, pink, or grey blocky and massive medium-grained quartz sandstone. It is generally well sorted, contains some feldspar and lithic fragments, has little matrix, and has a silica cement. Current ripples, cross-bedding, clay pellets, and mud cracks are all common sedimentary structures. Climbing ripples were observed in an outcrop in the southwestern part of the Seigal Sheet area.

A small cliff section (about 5 m high), 3 km north of the confluence of Seigal and Agnes Creek, in the northwestern part of the Seigal Sheet area, consists of the following sequence.

Plate 8: Gorge cut by Branch Creek into an escarpment of Sly Creek Sandstone in the Wollogorang Sheet area 14 km north of Cobar II uranium mine (Neg. No. M/1506).

Thickness (m)	Top of cliff
2	Sandstone - massive, gritty, lenticular bedding; festoon cross-bedded
0.3	Conglomerate - subangular and subrounded quartz and sandstone pebbles up to 2 cm diameter
2+	Sandstone - flaggy, medium-grained, well sorted; current ripples and low-angle cross-beds
	Base of cliff

Base of cliff .

Thickness. Dips in the formation in the Seigal Sheet area are low and variable, and, as much of the unit is obscured by flat-lying Cretaceous rocks, no estimate was made of thickness. Roberts et al. (1963) measured a thickness of 550 ft (168 m) to the north, in the Wollogorang Sheet area.

Environment of deposition. The formation is widespread and Roberts (unpubl. MS) considers that it is probably a marine deposit.

'Upper' Tawallah Group - Aquarium Formation, Settlement Creek Volcanics, Wollogorang Formation and Masterton Formation

The Aquarium Formation and Settlement Creek Volcanics crop out in the northwestern corner of the Seigal Sheet area, where they are poorly exposed. They and the two younger formations are well exposed in the Wollogorang Sheet area, and are described briefly by Roberts et al. (1963). All four formations extend from the Wollogorang Sheet area eastwards into the Westmoreland Sheet area, either as subcrop or as low rounded hills with poor outcrops and are shown on the 2nd Preliminary Edition of the Westmoreland 1:250 000 Sheet area. None of the units was examined in detail, and the lithological descriptions given on the accompanying map sheets are based on a few ground observations and the published descriptions by Roberts et al. (1963).

The best exposed unit in the Westmoreland Sheet area is the Hobblechain Rhyolite Member of the Masterton Formation, which is virtually indistinguishable from the Packsaddle Microgranite. The two are regarded as probably comagmatic (Plumb, pers. comm.).

Packsaddle Microgranite

The Packsaddle Microgranite was recognized by Roberts et al. (1963) and Yates (1963) as a feldspar porphyry unit which intrudes some members of the Masterton Formation, but grades eastwards into a rock indistinguishable from the Hobblechain Rhyolite Member.

McDougall et al. (1965) dated a single total-rock sample of the Packsaddle Microgranite as 1470 to 1520 m.y., and Dunn et al. (1966) used this result as a guide to the age of the Tawallah Group when they erected a time-rock classification for the Australian Precambrian. Recent geochronological work, in which no distinction was made between samples collected from the Packsaddle and Hobblechain units, has yielded a Rb/Sr isochron of 1575 $\pm$ 120 m.y. (AMDEL Rep. AN2250/74), which is regarded as the best estimate for the age of the two units and for the younger age limit of the Tawallah Group.

CAMBRIAN

Bukalara Sandstone

The Bukalara Sandstone, which was mapped by Roberts et al. (1963) over much of the northern half of the Calvert Hills Sheet area, extends into the northwestern corner of the Seigal Sheet area. The boundaries shown on the Seigal Sheet were derived from photo-interpretation. This was somewhat difficult because the Bukalara Sandstone is not easily distinguishable from the Cretaceous rocks in the area (both include white medium-grained orthoquartzite).

'LAWN HILL PLATFORM'

CARPENTARIAN

'Tawallah Group Equivalents'

The 'Wire Creek Sandstone', Peters Creek Volcanics, and Fish River Formation, which crop out south of the Murphy Tectonic Ridge, are regarded as equivalent to the Tawallah Group, which crops out only north of the ridge. The stratigraphy of the rocks south of the ridge, including the Fickling Group, which overlies the Fish River Formation, is shown in Table 8.

Table 8: Summary of stratigraphy of units in the 'Lawn Hill Platform'

	Rock Unit and Symbol	Thickness (metres)	Lithology	Stratigraphic relations	Remarks
FICKLING GROUP	'Doomadgee Formation' Pfd$_3$	50 – 400	Grey and brown, laminated fine sandstone; dolomite, dolomitic sandstone and conglomerate	Overlain unconformably by Constance Sandstone	Greatest thickness is in Mt Drummond 1:250 000 Sheet area
	Pfd$_2$	30	Dark grey shale and siltstone with white claystone (tuff?) interbeds	Conformable member	Tuff? beds are predominantly orthoclase
	Pfd$_1$	60	Fine to coarse sandstone; pebble and locally cobble conglomerate at base	Rests disconformably on 'Mount Lee Siltstone'	
	'Mount Lee Siltstone' (Pfl)	55 – 90	Dolomitic siltstone and shale with flaggy dolomite interbeds	Conformable on 'Walford Dolomite'; overlain disconformably by 'Doomadgee Formation'	Minor lead mineralization
	'Walford Dolomite' (Pfw)	250 to more than 400	Oolitic, stromatolitic, and intraclastic dolomite; minor shale and dolomitic, glauconitic sandstone	Contacts are conformable	Minor scattered lead, zinc and copper mineralization (sulphides), mainly near the top
	Pfw$_c$	-	As for Pfw, but silicified	-	A surface silicification feature; may be related to development of laterites during the Cretaceous or Tertiary
	Basal member (Pfw$_b$)	10 – 20	Leached shale, siltstone, and fine dolomitic? sandstone	Conformable on Fish River Formation	Is a transitional unit from clastics of the Fish River Formation to dolomite above; contains a lignite bed which may be a weathered pyritic shale; recognized only in Hedleys Creek
	Fish River Formation (Ptf)	10 – 250	Quartz sandstone, conglomerate lenses at base and top; fine sandstone and siltstone with shale partings	Unconformable on Peters Creek Volcanics, 'Wire Creek Sandstone' and 'Nicholson Granite Complex'	Prominent siltstone member in middle of unit in Hedleys Creek
EQUIVALENTS	Peters Creek Volcanics	About 1800 in type section	Basalt, andesite and other intermediate volcanics, rhyodacite and rhyolite, siltstone, dolomite, conglomerate, tuff	Conformably overlies Wire Creek Sandstone, and unconformably overlain by Fish River Formation	Divided into 7 members and one "dome" unit as shown below; probably thins westwards
	Unit 7 (Ptp$_7$)	200	Massive reddish brown rhyolite	Conformably overlies Unit 6 and Ptp$_d$ in easternmost outcrops; overlain unconformably by Fish River Formation	Very similar in lithology to Ptp$_d$
	The "dome" unit (Ptp$_d$)	-	Flow-banded reddish-brown rhyolite with minor siltstone at top	Appears to intrude Unit 6 and be overlain by Unit 7	Shape and contact relations of the body suggest that it is a lava dome
	Unit 6 (Ptp$_6$, $_{6i}$ and $_{6r}$ and $_{6s}$)	330	Vesicular and amygdaloidal intermediate and acid volcanics, sandstone, conglomerate, tuff and possibly stromatolitic chert	Conformable member of Peters Creek Volcanics; appears to be intruded by Ptp$_d$; overlain unconformably by Fish River Formation	Thin flows of lavas of various compositions; intermediate varieties predominate; clasts in conglomerate lens indicate erosion of underlying flows
TAWALLAH GROUP	Unit 5 (Ptp$_5$)	200 – 350	Highly porphyritic, flow banded reddish-brown rhyodacite	Conformable member of Peters Creek Volcanics; overlain unconformably by Fish River Formation	Contains higher proportion of phenocrysts than other acid units (i.e. than Unit 2 and parts of Unit 4)
	Unit 4 (Ptp$_4$)	60	Vesicular and amygdaloidal basalt and brecciated rhyodacite(?); some flow tops infilled by siltstone and sandstone	Conformable member of Peters Creek Volcanics	Basic rocks are similar to those in unit 1; overlies Unit 2 in western Hedleys Creek where Unit 3 is absent
	Unit 3 (Ptp$_3$)	0 – 180	Laminated mudstone and siltstone overlain by oolitic and stromatolitic dolomite and ripple-marked silty dolomite	Conformable member of Peters Creek Volcanics	Possible equivalent of Wollogorang Formation north of Murphy Tectonic Ridge; malachite stained in type section; lenses out westwards
	Unit 2 (Ptp$_2$)	300 – 500	Massive, pink and reddish-brown porphyritic rhyolite	Conformable member of Peters Creek Volcanics	Single? massive flow in eastern Hedleys Creek Sheet area; at least 4 flows in west
	Unit 1 (Ptp$_1$)	300 – 600	Vesicular and amygdaloidal basalt; massive porphyritic basalt; brecciated flow tops with siltstone infillings	Conformable on 'Wire Creek Sandstone'	
	Unit 1, sandstone (Ptp$_{1s}$)	1 – 5	Fine and medium, feldspathic and glauconitic sandstone	Conformable lenses between basalt flows of Unit 1	At least 2 lenses; younger one may be equivalent to the Carolina Sandstone Member in the Seigal Volcanics
	Unit 1, basalt (Ptp$_{1b}$)	10 – 50	Massive, slightly porphyritic, fresh basalt		Probably flow centre basalts
	'Wire Creek Sandstone' (Ptl)	0 – 70	Coarse and gritty sandstone with scattered quartz pebbles; cobble and boulder conglomerate lenses	Unconformable on 'Nicholson Granite Complex' and Cliffdale Volcanics	Thickness is variable in east – probably thicker where conglomerates are present; clasts are of quartz and quartzite

The 'Tawallah Group equivalents' will not be given a formal group name until mapping of the 'Lawn Hill Platform' is completed.

'Wire Creek Sandstone'

A belt of sandstone which extends westwards from the headwaters of Peters Creek, in the Hedleys Creek Sheet area, was mapped as Westmoreland Conglomerate by Carter (1959). Roberts et al. (1963) mapped the same belt of rocks in the Calvert Hills 1:250 000 Sheet area and retained the same nomenclature.

During the present survey the sandstone was mapped more accurately because of the use of larger-scale photography, and was shown to be a continuous bed - not two unconnected lenses in basement hollows as implied by Carter (1959).

The unit, although inferred to be equivalent to the Westmoreland Conglomerate, has been named 'Wire Creek Sandstone' because all its outcrops are separated from the 'type' Westmoreland Conglomerate by a basement ridge (Murphy Tectonic Ridge), and it cannot be proved that the unit ever extended across the ridge. On the contrary, it can be shown that some of the material in the unit was derived from the ridge.

Type section. A small gorge where Wire Creek intersects the unit. The base is at metric grid reference 907367, and the section extends east-southeastwards along Wire Creek for a distance of 1 km.

Stratigraphic relations. The 'Wire Creek Sandstone' overlies the 'Nicholson Granite Complex' with pronounced nonconformity. The contact is rarely exposed, but, at grid reference 137271 in the Seigal Sheet area, highly weathered granite is exposed in scree slopes below arkosic sandstone which was probably partly derived from the granite.

In the east the sandstone overlies, with angular unconformity, the Cliffdale Volcanics, and contains numerous rounded clasts derived from the volcanics.

The sandstone is overlain conformably by Unit 1 of the Peters Creek Volcanics. The contact is sharp, and the sandstone immediately beneath the volcanics appears baked, but there is no evidence of a hiatus.

Lithology. At its easternmost outcrops, the 'Wire Creek Sandstone' forms low rounded rubble-covered ridges, and consists of cross-bedded quartz sandstone resting unconformably on highly-weathered Cliffdale Volcanics. Similar outcrops extend westwards for about 30 km from the western bank of Peters Creek. At grid

Plate 9: Interbedded boulder and cobble conglomerate, grit, and coarse sandstone in the Wire Creek Sandstone near 'One Hen' tin prospect, Hedleys Creek Sheet area (Neg. M/1375).

reference 067443 conglomeratic sandstone about 20 m thick forms a ridge about 30 m high. This rock contains tabular clasts of thin-bedded brown quartzite up to 30 cm across enclosed in a matrix of clayey and gritty sandstone; quartz, quartzite, and volcanic grains were observed in the matrix. About 3 km to the east this sandstone is less than 2 m thick.

Good exposures occur southwest of the 'One Hen' tin prospect in the central Hedleys Creek Sheet area, where a boulder conglomerate contains clasts of quartz and quartzite up to 30 cm across in a quartz sand matrix (Plate 9). Five kilometres southwest of the prospect, medium to coarse and gritty cross-bedded sandstone contains well rounded scattered cobbles of acid volcanics.

No conglomerates were observed south of the type section, where the unit consists of medium to coarse and gritty, poorly to moderately sorted sandstone which contains subangular to subrounded grains with secondary quartz overgrowths set in a clay matrix. Although quartz clasts predominate, a few rock fragments are recognizable; these include acid volcanics, vein quartz, muscovite schist, and chert or quartzite (Table 9). Most larger grains and the scattered pebbles are of vein quartz. Although the sandstone at most outcrops appears to be arkosic, fresh feldspar was found only at the most westerly one, near Fish River (grid ref. 911195). White clay grains present in the sandstone east of this locality may have been feldspar originally, but such grains are few, and most of the clay is interstitial.

The most common accessory minerals are hematite and limonite which occur as fine grains and stains in the clayey matrix.

Thickness. The 'Wire Creek Sandstone' is estimated to be between 50 and 70 m thick between Pandanus Creek in the west and Wire Creek in the east, and it varies between 1 and 20 m farther east. It is generally poorly exposed, and may be thicker than 70 m locally. West of Pandanus Creek, where the formation is affected by faulting, the thickness has not calculated, but it is estimated to be about 30 m thick 8 km west of Pandanus Creek, where it is overlain by Peters Creek Volcanics. West of the Fish River it is absent: it was either eroded away or was never, deposited, because the Fish River Formation, which is younger than 'Wire Creek Sandstone', lies directly on granitic basement.

Depositional environments. Most of the formation, such as that depicted in Plate 9, was almost certainly deposited in high-energy streams channels. Crude graded bedding indicates deposition in decreasing energy conditions, probably following floods.

Table 9: Thin-section descriptions, Wire Creek Sandstone

BMR registered no. and field no.	Rock name and generalized description	Constituents	Description
74760001 HC7/79/1	Purple medium-grained quartz sandstone LITHIC SANDSTONE (PROTOQUARTZITE)	Quartz 90%	0.2-0.4 mm, subrounded to rounded; cemented by syntaxial quartz overgrowths
		Clay 5%	Some forms fine coatings on quartz grains, but most forms detrital grains; illite and/or montmorillonite - probably altered rock fragments
		Rock fragments	A few grains only; acid volcanics
		Iron oxides 5%	Interstitial; cements some grains - now mostly limonite but may have been hematite (No feldspar or heavy minerals other than iron oxides are present)
74760002 HC7/79/3	Coarse to gritty, poorly sorted sandstone LITHIC SANDSTONE (PROTOQUARTZITE)	Quartz 80%	Subangular grains 1 mm; some 4 - 5mm; biotite inclusions are common
		Rock fragments 15-20%	Acid volcanic grains: 1 mm, subrounded; about 10%; light-coloured quartz/sericite/clay grains and some strained metamorphic quartz; 5-10%
		Iron oxides	Interstitial - from rock fragments (No feldspars are present)
74760003 S9/97/1	White clayey medium to coarse sandstone LITHIC SANDSTONE (PROTOQUARTZITE)	Quartz 80%	Subangular to subrounded; 1-2 mm with some coarser grains; 5-10% of strained composite grains
		Rock fragments and matrix 15%	Patches of fine-grained low birefringence clay; some are detrital grains, some is matrix; a few are acid volcanics
		Muscovite 1%	Several flakes and grains
		Voids 5%	May be due to weathering out of clay grains

TABLE 9: (Contd.)

BMR registered no. and field no.	Rock name and generalized	Minerals present	Description
74760004	Reddish, clayey, coarse, gritty and pebbly sandstone LITHIC SANDSTONE (PROTOQUARTZITE)	Quartz 90%	Subrounded, 0.5–1.5 mm (one 10 mm) Cemented by syntaxial overgrowths
		Rock fragments 10%	Composite grains of quartz showing highly sutured contacts; siltstone; very fine, equigranular mosaics (chert or clay minerals)
		Iron oxide	Interstitial staining
		Matrix	Scattered clay
		Accessories	A few grains of zircon
74760005 S11/23/15	White, medium to coarse arkosic sandstone FELDSPATHIC SANDSTONE	Quartz 75–80%	Subangular to subrounded
		Feldspar 5%	Abundant microcline, some scattered untwinned grains
		Rock fragments } 15–20%	Scattered altered acid volcanic grains
		Matrix } 15–20%	Silt and clay with some fine sand, rare muscovite

Between Wire and Pandanus Creeks, sandstone with scattered pebbles is either thick-bedded and structureless, or shows trough cross-bedding and rare ripple-marks. These rocks were laid down in a slightly lower-energy environment than the eastern outcrops, but still in a fluvial environment. The complete lack of fine-grained sediments tends to rule out a meandering river system. The poor to moderate sorting, and the presence of interstitial clay indicates rapid deposition from the water-body carrying the sediment. These factors all support the idea of deposition by a series of braided streams which perhaps formed small coalescing alluvial fans.

The presence of feldspar in the westernmost outcrop of sandstone indicates close proximity to granitic source rocks. Elsewhere, in the Seigal Sheet area, despite overlying the 'Nicholson Granite Complex', the sandstone does not contain feldspar. This may indicate either that feldspar was broken down to clay in a humid climate, or that much of the sand was not locally derived.

Palaeogeography. The Murphy Tectonic Ridge and its easterly extension were probably the source areas for both the 'Wire Creek Sandstone' and Westmoreland Conglomerate, and it is probable that the two units have always been separated by a narrow strip of basement rocks.

Peters Creek Volcanics

Distribution. The Peters Creek Volcanics crop out in a west-trending belt up to 10 km wide in the central part of the Hedleys Creek Sheet area, and several isolated outcrops, bounded by faults and unconformities are present to the west, in the Seigal Sheet area. The westernmost outcrop is 2 km east of the confluence of Tin Hole Creek and Fish River.

Outcrops previously described by Roberts et al. (1963) as Peters Creek Volcanics in the northern Seigal Sheet area are now named Seigal Volcanics and are described elsewhere in this report.

Type section and nomenclature. Carter et al. (1961) nominated a type section (retained by us) in the main outcrop belt. They described the unit as a sequence of acid to intermediate lavas with agglomerate, tuff and sediment interbeds.

During the present mapping the formation was subdivided into seven members, informally called Units 1 to 7 (numbering from the oldest to youngest). The type section includes good exposures of all but Unit 1, which is better exposed to the west, near Wire Creek.

Stratigraphic relations. The formation overlies 'Wire Creek Sandstone', apparently conformably, and is overlain with angular unconformity by the Fish River Formation.

Unit 1

Distribution. Unit 1 forms an arcuate belt up to 4 km wide which trends west from the headwaters of Peters Creek to within 3 km of the Northern Territory border. Five smaller outcrops occur along a west-southwest-trending fault zone farther west, in the Seigal Sheet area.

Reference area. No type section is nominated for Unit 1, which, however, is well exposed along and near the banks of Wire Creek, from grid reference 916366 (base), to 935342 (top), in the Hedleys Creek Sheet area.

Stratigraphic relations. The volcanics overlie 'Wire Creek Sandstone' with what is assumed to be a conformable contact. The contact is rarely exposed, but where it is there is no evidence of discordance; it is well exposed at grid reference 143257 in the southeastern Seigal Sheet area, where the upper surface of the 'Wire Creek Sandstone' is silicified and ferruginized.

The contact of Unit 1 with Unit 2 is concordant, and is assumed to be conformable. At several localities in the Seigal Sheet area, the Fish River Formation truncates Unit 2 and lies directly on Unit 1 with angular unconformity.

Topography. Much of the eastern area underlain by Unit 1 is nearly flat, and has a mantle of soil or sediment. Some lava flows and a sandstone bed near the top of the unit form cuestas and hogbacks between 20 and 200 m high. The western outcrops consist of part of a west-southwest-trending irregular hogback ridge up to 100 m high.

Lithology. Unit 1 of the Peters Creek Volcanics consists of a series of thin (10m) basic lava flows, at least two flows which may be greater than 30 m thick, and some sedimentary interbeds.

The best exposures in the easternmost outcrops, between 1 and 10 km west of Peters Creek, are near the top of the unit. In a moderately dipping sequence at grid reference 163418, near a probable fault zone, parts of two flows of basalt and an overlying bed of quartz sandstone can be seen. The top 3 m of the older flow, composed of highly vesicular and amygdaloidal basalt, is exposed. The younger flow is 10 m thick and consists of massive, slightly vesicular lava in its lower and middle portions. The number of amygdales increases towards the top, and the uppermost portions consist predominantly of amygdales of quartz and dark bluish green chlorite (e.g., sample 74760006).

The basalt around many of the amygdales has weathered away leaving a rock of nodular or pisolitic appearance. Irregularities in the brecciated flow top are infilled with micaceous and quartz siltstone which has penetrated and filled fractures in, and interstices between, blocks or tongues of lava. The uppermost 1 m of the overlying sandstone bed contains numerous spherical cavities, up to 2 cm across, lined by quartz crystals; these cavities become more numerous upwards, and may have resulted from baking of the sandstone by an overlying basalt flow.

Near the base of Unit 1, at grid reference 160450, a flow-top consisting of irregular blocks and tongues of vesicular basalt 10-50 cm across is cemented and infilled with quartz. It is overlain by a massive dark greyish green non-vesicular rock which was tentatively mapped as a dolerite sill because of its unaltered and non-vesicular nature. However, this rock has a grainsize within the range of basalts (sample 74760009), and might be the centre of a thick flow. The problem of distinguishing lava flows from dolerite sills is well known (e.g. Poldevaart, p. 9) and coarse flow centres are common in basalt lavas of the Antrim Plateau Volcanics, which are petrographically similar to Unit 1 of Peters Creek Volcanics (R. Bultitude, pers. comm., 1975). Above the possible sill there is a silicified, fine to medium-grained feldspathic sandstone bed less than 5 m thick.

A well exposed section of Unit 1 at Wire Creek consists of numerous flows with massive centres and vesicular tops. Near the top of the sequence a pink fine-grained silicified sandstone bed can be traced along strike throughout the Hedleys Creek Sheet area. The unit here dips southeast at 10 - 15°, and is at least 600 m thick, about twice as thick as it may be in its easternmost outcrops. Southwest of the outcrops near Wire Creek Unit 1 is cut by the Calvert Fault and associated faults.

In the Seigal Sheet area, at Gorge Creek, a sequence of 200 m of dark red amygdaloidal basalt is capped by about 2 m of medium-grained well sorted feldspathic sandstone. This sequence is faulted against paler red volcanics to the south which are tentatively assigned to Unit 2. Between 1 and 5 km west of Gorge Creek, Unit 1 is estimated to be between 100 m and 200 m thick. At grid reference 143257, the upper surface of the 'Wire Creek Sandstone' appears baked and ferruginized, and is overlain by highly weathered basalt, which shows structures that are either pillows or an unusual form of spheroidal weathering; they consist of ovoid masses of basalt up to 50 cm across and 30 cm high bounded by curved joint surfaces. Vesicle patterns could not be seen, perhaps because the rock is so weathered, and the origin of the structures remains a mystery.

Three of the four outcrops of Unit 1 farther west in the Seigal Sheet area were mapped by Roberts et al. (1963) as basalt flows within the Fish River Formation. Our mapping has shown that all the basalt belongs to Unit 1 of the Peters Creek Volcanics, and the sandstone below them is 'Wire Creek Sandstone'. The flows consist of highly weathered vesicular and amygdaloidal basalt in which quartz and chlorite are common amygdale minerals. At the westernmost outcrop, Unit 2 of the Peters Creek Volcanics is faulted against Unit 1. The Peters Creek Volcanics are absent farther west, where the overlying Fish River Formation, is unconformable on basement rocks. However we consider that the Peters Creek Volcanics were originally present farther west and were removed by erosion before the Fish River Formation was deposited.

Petrography. A summary of samples examined is given in Table 10. The lavas in Unit 1 are virtually identical to those in the Seigal Volcanics, and include well crystallized, slightly porphyritic varieties (such as 74760009) and glassy, amygdaloidal varieties. The ccurrence of small quantities of pigeonite (2V = 0^{o}) in 74760009* indicates the tholeiitic affinities of the suite.

Unit 2

Distribution. Unit 2 crops out in an arcuate belt 2-3 km wide which extends from the Westmoreland/Doomadgee track and the headwaters of Peters Creek in the east, to the Northern Territory border in the west. There are also four small outcrops in the southeastern part of the Seigal Sheet area, the most westerly one being 3 km east of the confluence of Tin Hole Creek and Fish River.

Reference area. The unit is fairly uniform in composition, and therefore any section would give an accurate impression of its lithology. For convenience, the section where Wire Creek cuts the unit (base at grid reference 935342) is nominated as a suitable reference section. The type section nominated by Carter et al. (1961) for the whole formation includes good exposures of Unit 2.

Stratigraphic relations. The contact with Unit 1 of the Peters Creek Volcanics is generally hidden by scree. In a tributary of Peters Creek, at grid reference 148419, the upper part of Unit 1, consisting of about 10 m of thin-bedded and laminated fine sandstone and siltstone overlain by a 1 m thick flow of vesicular basalt, is overlain by more siltstone and a breccia containing clasts of slightly vesicular acid volcanics, representing Unit 2. The volcanics in the breccia are thought to represent agglomeratic material, and their presence indicates the continuity of volcanism between Units 1 and 2.

* See Appendix for silicate analyses

Table 10: Thin section descriptions Peters Creek Volcanics (Unit 1).

BMR registered No. and field No.	Rock name and generalized description	Description and comments
74760006 HC5/87/1	Amygdaloidal basalt	Purple, weathered, fine-grained rock with numerous small (< 5 mm) amygdales containing bluish green chlorite, some lava clasts cemented by quartz; one vesicle contains silty sediment (flow-top basalt)
74760007 HC5/87/1	Leached or altered siltstone or shale with nodular surface	White to purple fine-grained rock cut by numerous thin limonite veins: baking indicated by development of chlorite and nodules
74760008 HC5/89/1	Amygdaloidal basalt(?)	Probably all devitrified glass plus quartz amygdales; light brown
74760009 HC5/89/5B	Medium-grained slightly porphyritic basalt	Fresh clinopyroxene, plagioclase, and minor pigeonite; interstitial chlorite and calcite; tholeiitic affinities
74760010 HC5/89/13A	Vesicular basalt in contact with baked siltstone or shale	Basalt is highly altered; sediment is pinkish-brown and indurated
74760011 HC5/89/13B	Vesicular basalt	Greyish purple altered rock with light pink feldspar laths set in devitrified glass
74760012 HC7/81/6	Subgreywacke	Purple medium sandstone-quartz (60%), feldspar (10%), rock fragments (20+%), glauconite/chlorite (10%), minor matrix; thin interbed near top of unit 1.
74760013 HC7/81/8	Altered amygdaloidal basalt	Sericitized plagioclase (60%) glass (20%), amygdales of fibrous green chlorite (20%).

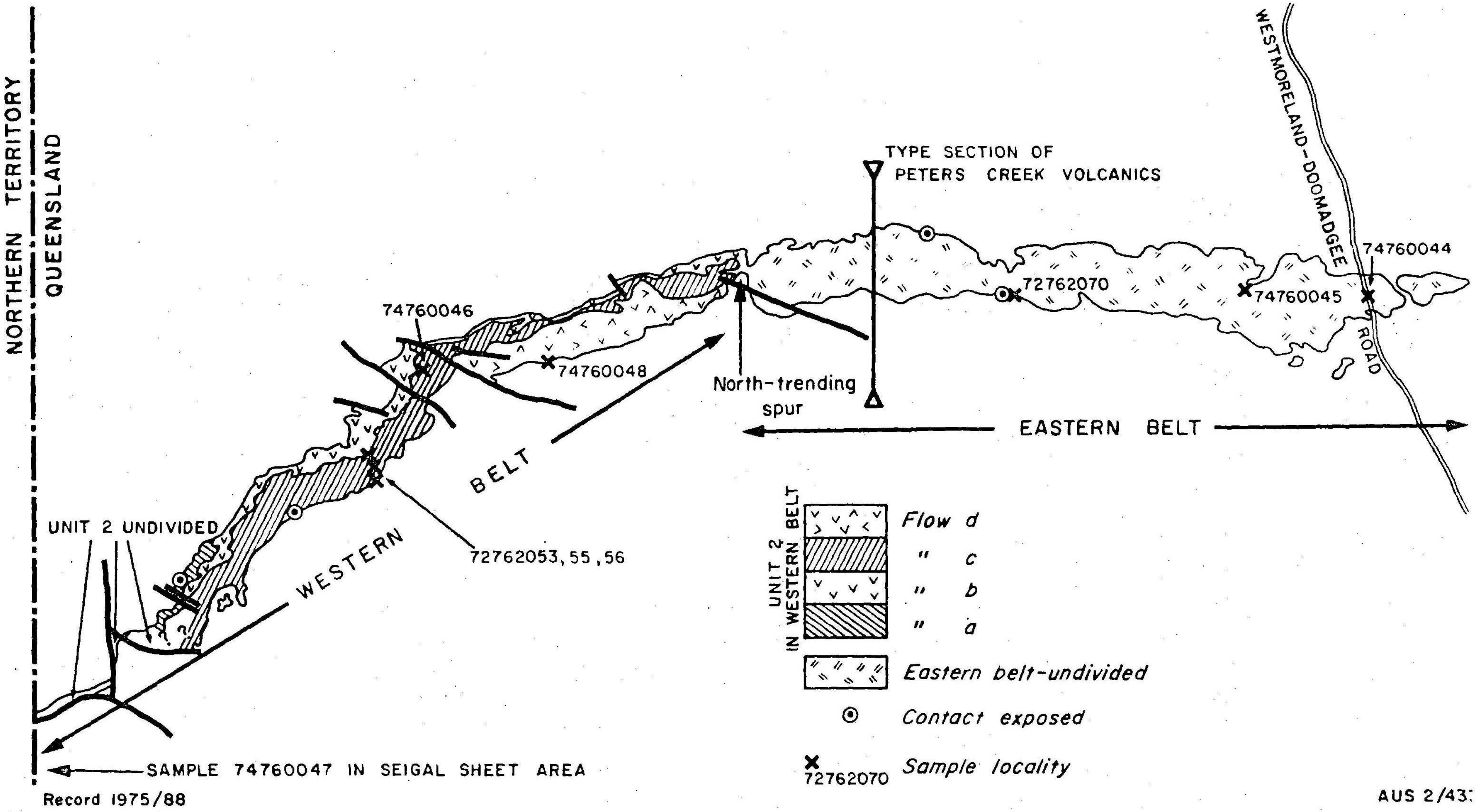


Fig. 5 Distribution of Unit 2 of the Peters Creek Volcanics in the Hedleys Creek 1:100 000 Sheet area

The upper contact is poorly exposed except at grid reference 180397, where Unit 2 is overlain by finely laminated siltstone.

Topography. In the Hedleys Creek Sheet area Unit 2 forms a rounded ridge up to 100 m high. Much of the surface is bare rock, and in parts is strewn with rounded boulders and cobbles.

Description of outcrops. The unit consists of massive light pink to reddish brown feldspar porphyry. Figure 5 shows the main outcrop of the unit and the sites of samples collected. The rocks east of the north-trending spur, the eastern belt, are more massive, and possibly more siliceous, than those to the west.

Both the lower and upper surfaces of the eastern belt dip south at 5-15^{o}, but no internal bedding or banding has been seen. The rocks are light pink quartz feldspar porphyries; the matrix is fine grained and shows granophyric texture (74760044 and 0045). Rocks at the base of the unit appear to be slightly finer-grained than those in the centre. In an exposure of the upper contact at grid reference 180397, massive porphyry is overlain by 1 m of vesicular volcanics (light brown, altered, with vesicles lined by quartz crystals), then 30 cm of similar rock containing an unidentified acicular mineral, and, at the top of Unit 2, by 1 m of very fine-grained volcanic rock containing sparse feldspar phenocrysts. Here the unit is overlain by finely laminated siliceous siltstone of Unit 3. That the porphyries are massive may indicate that they are part of a high-level sill; the granophyric textures in samples 74760044 and 74760045 support this contention. However, porphyries in the western belt which are obviously extrusive show similar textures, and are capped by similar sediments. It thus seems likely that the porphyry in the eastern belt is also extrusive, possibly part of a very thick flow.

In the western belt (Fig. 5), at least three small scarps within the outcrops of Unit 2 can be traced for 5-30 km along strike and are believed to be due to differential erosion at flow boundaries. Here it seems likely that there are four distinct flows designated a to d (Fig. 5). The oldest, flow a, is separated from underlying highly amygdaloidal basalt by 5 cm of pink, fine-grained ashstone.

Flow b is well exposed over the whole of the western belt. At Wire Creek it consists of orange-brown massive feldspar porphyry, which displays a regular flow? parting dipping 16-20^{o} southeast. The thickness of the flow, based on the dip of the parting, is estimated at 120 to 160 m. The top of flow b is exposed 3 km northeast of Wire Creek at grid reference 956367, where it displays ropy flow structures.

Flow c is also present throughout the western belt. At its base at grid reference 877288 at least 3 m of purple finely laminated ashstone is overlain by massive pink scoriaceous lava, above which is massive feldspar porphyry (samples 72762053, 2055, 2056, 74760046). This porphyry is a darker reddish brown than flow b, and contains specks of iron oxide and small white patches of clay or sericite. Ropy flow structures similar to those on flow b are preserved on the upper surface of flow c at grid reference 916317 (Plate 10).

Flow d occurs only between Wire Creek and the spur separating the eastern and western belts. It is thicker than the other flows, but it appears to have a virtually identical composition (74760048).

Four isolated remnants of very weathered reddish brown volcanics in the Seigal Sheet area are mapped as Unit 2 as they appear to be feldspar porphyries rather than amygdaloidal basic rocks. A sample from the westernmost outcrop (3 km northeast of the Fish River/Tin Hole Creek confluence) consists of devitrified glass with scattered feldspar phenocrysts (74760047), and is similar in appearance to samples from the western outcrop belt.

At a small outcrop at grid reference 090237, in the Seigal Sheet area, a sequence mapped as Unit 2 is faulted against both Unit 1 of the Peters Creek Volcanics and Fish River Formation. The following succession is exposed:

Top

10+ m	White orthoquartzite (Fish River Formation)
6 m	Agglomerate or conglomerate - round and angular porphyry fragments up to 30 cm set in silty and sandy matrix with 10-20% quartz grains
5 m(?)	Brown siltstone
10 m	Calcrete at surface - probably dolomitic sediments beneath
3 m	Reddish sandstone
10+ m	Massive red feldspar porphyry

Base

This sequence is mapped as Unit 2 because of the presence of porphyry, although the siltstone, sandstone, and carbonate rocks are similar to those of the McDermott Formation in the northern part of the Seigal Sheet area.

Plate 10: Ropy flow structure at the top of Unit 2 of the Peters Creek Volcanics 3 km west-south-west of Wire Creek, Hedleys Creek Sheet area (Neg. GAB/10).

TABLE 11: Thin-section description, Peters Creek Volcanics (Unit 2)

BMR Registered no. and field no.	Rock name	Description and comments
74760044 HC6/99/1	Quartz-feldspar porphyry	Light pink, medium-grained; feldspar phenocrysts up to 3 mm; quartz phenocrysts are embayed, surrounded by intergrowths of quartz/feldspar; granophyric groundmass; minor Fe oxides, pyroxene?
74760045 HC6/99/3	Quartz-feldspar porphyry	Pink-brown, medium-grained; oligoclase phenocrysts up to 5 mm; embayed quartz phenocrysts; partly granophyric groundmass; groundmass feldspars are simply twinned laths, probably of orthoclase; accessory tourmaline, zircon, epidote?, goethite, magnetite?, sphene
72762055 HC7/81/2	Rhyolite	Holocrystalline, but poorly defined grain boundaries; feldspar phenocrysts; spherulitic and granular quartz/feldspar groundmass (not granophyric); minor anatase and sericite; from base of flow c.
72762056 HC7/81/3	Rhyolite	Dark red-brown; as for 72762055, except that spherulites increase in grainsize outwards, and their rims are granophyric
74760046 HC7/81/4A	Rhyolite	Similar to 72762055; feldspar phenocrysts are highly ferruginized; accessory epidote and zircon; anatase and sericite as alteration products; from base of flow c
74760048 HC7/84/1	Rhyolite	Phenocrysts of plagioclase (altered to green sericite), potash feldspar (altered to opaques and clays), and umembayed quartz; spherulitic semi crystallized highly ferruginous groundmass; phenocrysts commonly fragmented; accessory epidote and chlorite; from top of flow d.

TABLE 11 (continued)

74760047 S11/22/1	Rhyolite	Feldspar (oligoclase?) phenocrysts ferruginized and altered, and rimmed by feldspar laths (due to devitrification?); groundmass consists of radiating feldspar laths and quartz.
72762053 HC8/69/1	Rhyolite	Anhedral quartz 'overprinted' by random feldspar laths; most crystal boundaries indistinct (incompletely crystallized); rare phenocrysts blackened by opaques; from top of flow c.

Thickness. Accurate measurements of Unit 2 of the Peters Creek Volcanics cannot be made because of the lack of measurable dips, but assuming that the unit is concordant with the enclosing units, which dip south at 5-15^{o}, it is between 300 and 500 m thick. The western belt is probably about 400 m thick over most of its length, but may be thinner at its western end. At the isolated outcrops in the Seigal Sheet area the unit does not exceed 100 m in thickness.

Petrography. Table 11 is a summary of thin-section data of samples from Unit 2.* Spherulitic crystallization is present in samples 74760046, 0047, 0048, 72762055, and 2056, and is interpreted as a devitrification feature. Interstitial to the spherulites in all samples except 0048 is a quartz-feldspar granophyric intergrowth which is interpreted as a recrystallization feature. A range of recrystallization textures can be observed: 0048 is the least recrystallized, and is composed entirely of spherulites plus phenocrysts; 2053, 2055, 2056, 0046, and 0047 are partly recrystallized; and 0044 and 0045 are fully recrystallized and are coarse enough to be termed 'microgranites'. Sample 72762056 shows best the progression outwards from spherulites to granophyric intergrowths.

Unit 3

Unit 3 of the Peters Creek Volcanics was mapped by Carter (1959) as outliers of a younger formation lying unconformably on Peters Creek Volcanics. However, it is now known to be a tabular body dipping southwards below Units 4 to 7 of the Peters Creek Volcanics.

Distribution. Unit 3 is poorly exposed in an east-trending valley about 1 km wide and 20 km long in the eastern part of the Hedleys Creek Sheet area. It lenses out to the west.

Reference section. The type section of the Peters Creek Volcanics passes through the best outcrop of Unit 3 (at grid ref. 130390).

Stratigraphic relations. The lower contact is exposed at grid reference 180397, where finely laminated siltstone of Unit 3 overlies feldspar porphyry of Unit 2.

Topography. The unit forms the floor of a valley, and exposures are generally restricted to creek banks. The exceptions to this are two small conical hills which rise about 50 m above the valley floor; one is the reference section, and the other is 13.5 km to the east. The valley is bounded to the north by a dip slope of the underlying unit, and to the south by a scarp slope of the overlying unit.

Lithology. Unit 3 consists of shale and siltstone overlain by dolomitic siltstone and dolomite.

The shale and siltstone crop out at, and 5 km east of, the type section. Fine laminae of clay minerals alternate with laminae of quartz silt and silty clay. In the eastern outcrop small radiating aggregates of stilpnomelane have developed in ferruginous clay bands (sample 72762070), possibly due to thermal metamorphic effects of adjacent flows. Sedimentary structures in shale at the type section include load casts and a possible poorly preserved halite cast.

The overlying dolomitic rocks are thin-bedded to medium-bedded, and include oolitic, laminated, and stromatolitic dolomite, ripple-laminated silty dolomite, and dolomitic siltstone. The carbonate is recrystallized to varying degrees, and in some places the recrystallisation has obliterated sedimentary structures. An oolitic band 10 cm thick in the type section contains patches of malachite which probably makes up less than 1% of the rock (sample 74760050)*. Dolomitic rocks in the east (grid ref. 265373) contain stromatolites forming hemispherical structures up to 50 cm across and high, and columnar structures. The latter consist of finely laminated columns of chert 5-10 mm across and up to 5 cm high, and intercolumn partly recrystallized dolomite with detrital quartz, muscovite flakes, and clay minerals; no laminae are visible. Detrital grains are absent from the stromatolites. The chert may be early diagenetic or perhaps even primary.

The westernmost exposure of dolomitic sediments is on the western slope of the spur 5 km west of the type section, where laminated silty dolomite is overlain by fine sandstone assigned to Unit 4. Unit 3 may extend farther west as a thin layer beneath basalt and volcanogenic sandstone of Unit 4.

Thickness. Unit 3 is about 180 m thick at the type section, and is probably a similar thickness to the east. Less than 1 km to the west it appears to be less than 100 m thick, and it may lens out on the western side of the spur at grid reference 080400.

Petrography. This is summarized in Table 12.

* Analysis by AMDEL (Rept. AN 2882/75) showed sample contained 0.83 percent copper.

TABLE 12: Thin-section descriptions, Peters Creek Volcanics (Unit 3)

BMR registered no. and/or field no.	Rock name	Description and comments
72762070 HC6/03/2C	Laminated siltstone and mudstone	Silicified; wavy laminae; quartz silt bands alternate with thin clay bands containing stilpnomelane
HC6/07/2	Dolomite	Dark grey organic-rich dolomite; fine laminae; whole rock recrystallized to medium-grained carbonate
HC6/07/3A	Recrystallized oolitic dolomite	Oolites about 1 mm across stand out on weathered surface; oolites sparse (10%) in medium to coarse recrystallized, light grey dolomite matrix
74760050 HC6/07/3B	Recrystallized oolitic dolomite	As for HC6/07/3A, but oolites almost obliterated by recrystallization; blebs (1-2 cm) of malachite and iron oxides
HC6/09/2	Intraclast dolomite	Tabular clasts of dolomite in finely crystalline matrix
HC7/94/3A & B	Dolomite	Very finely crystalline pinkish grey dolomite with thin (2-15 mm) lenses of finely laminated grey chert possibly replacing stromatolites
74760051 HC7/94/3C	Stromatolitic dolomite	Partly recrystallized dolomite with small columnar stromatolites now composed of chert

Unit 4

Unit 4 of the Peters Creek Volcanics forms a scarp up to 50 m high in the Hedleys Creek Sheet area. The scarp is due to the greater susceptibility to erosion of the intermediate and basic lavas of the unit, than that of the massive rhyolite in the overlying unit.

Stratigraphic relations. Lavas and sandstone of Unit 4 overlie dolomite of Unit 3 in the east and rhyolite of Unit 2 in the west, and underlie massive rhyolite of Unit 5 throughout the outcrop area; both upper and lower contacts are believed to be conformable.

Lithology. The characteristic lithology of Unit 4 is an intermediate or acid volcanic rock, possibly rhyodacite, but some tuff, sandstone, and basalt are also present. These rocks, and the underlying Unit 3, represent a phase of mixed sedimentary and igneous activity between the outpourings of massive rhyolite of Units 2 and 5.

The contact between Units 3 and 4 has not been observed, as both units are soft and weather easily, and are poorly exposed. The boundary has been photo-interpreted along a change in soil colour from greyish to reddish-brown. At, and east of, the type section of the formation, basalt (sample 74760049) containing chlorite amygdales and geodes of amethyst and smoky quartz crops out. It is overlain by 2 m of fine purple feldspathic sandstone, then light brown amygdaloidal lava of intermediate or acid composition.

At Wire Creek, dark brown brecciated lava contains vesicles and vugs from 0.5 to 10 cm across (72742054). Similar brecciated lava 3 km to the southwest (74760054) overlies finely laminated tuff (74760053) which lies on a well exposed pavement of Unit 2 displaying ropy flow-top structures.

In the westernmost exposure of Unit 4 only scree of lithic sandstone is visible, but the photo-pattern suggests that intermediate or basic lavas are present.

Thickness: Unit 4 is the thinnest member in the Peters Creek Volcanics, and probably does not exceed 60 m.

Petrography. Table 13 summarizes thin-section data for Unit 4.

TABLE 13: Thin-section descriptions, Peters Creek Volcanics (Unit 4)

BMR registered no. and field no.	Rock name	Description and comments
74760049	Probably intermediate or basic volcanic	Dark purple fine-grained rock; almost completely oxidized and stained with opaque oxide; vaguely visible feldspar laths with minor interstitial quartz and ironstained sericite?; flow structures visible small vesicles contain chlorite or ironstained sericite, probably basaltic or andesitic
74760053 HC8/69/6B	Tuff	Finely laminated rock with quartz stringers; bulk of rock is very fine-grained; contains scattered euhedral and subhedral quartz and fragments of other crystals; laminae drape over the quartz crystals.
74760054 HC8/69/6C	Rhyodacite?	Dark brown, fine-grained volcanic rock; trachytic texture formed by subparallel oligoclase laths; rare alkali feldspar phenocrysts; accessory apatite and epidote
72762054 HC8/69/2	Rhyodacite?	Similar to 74760054 - both alkali feldspar (large anhedral grains) and subhedral plagioclase present; also interstitial quartz; patches of granular opaque oxide, sericite, chlorite, epidote, and

TABLE 13 (continued)

	clay; some of these patches are euhedral and many be after pyroxene; accessory apatite

Unit 5

Unit 5 of the Peters Creek Volcanics is the second of three massive or poorly banded members in the Peters Creek Volcanics. Its outcrop extends across the Hedleys Creek Sheet area as a belt up to 3 km wide and is truncated by the Fish River Formation 8 km east of the Northern Territory border.

Stratigraphic relations. Both upper and lower contacts of Unit 5 are conformable.

Lithology. Unit 5 consists of reddish brown massive feldspar porphyry with minor amygdaloidal even-grained rocks at the top and base.

The base is exposed in the type section, at grid reference 130382, where pinkish-brown porphyry with scattered feldspar phenocrysts, basalt, and sediments of Unit 4 are overlain by several metres of purplish brown feldspar porphyry which has a high percentage of opaque minerals. (up to 10% in 74760067). This porphyry grades into massive reddish brown feldspar porphyry, the main constituent of the unit at all localities. This last rock is a reddish-brown porphyry containing up to 30 percent phenocrysts, a much higher percentage than the rhyolites of Unit 2. The phenocrysts are from 1 to 5 mm across, are highly altered, euhedral, and many are fragments of larger crystals. The outcrops display very faint probable flow-banding which is highly variable in direction, but invariably steeply dipping. Some samples contain voids or completely filled with quartz, chalcedony, and micaceous minerals (e.g., 74760064, 65).

The upper surface of Unit 5 is uneven, and may have had relief of 50 metres or more when the lavas of Unit 6 were extruded. The uneven surface probably results from the sluggish extrusion and flow of very viscous lavas. No individual domes, tholoids, or necks have been recognized in the unit.

Thickness. The thickness of the unit varies because of the uneven upper surface, and it probably varies between 200 and 350 m.

Petrography. Table 14 summarizes the thin section data for Unit 5*.

TABLE 14: Thin-section descriptions, Peters Creek Volcanics (Unit 5)

BMR registered no. and field no.	Rock name	Description and comments
74760064 HC7/90/9	Rhyodacite?	Groundmass - oxidized, cryptocrystalline quartz-feldspar-opaques; flow texture outlined by variable oxidation in groundmass; rounded to irregular cavities (40% of rock) filled zonally with quartz, opaque oxides, iron-stained chlorite, and clay Feldspar (10%) - anhedral phenocrysts replaced by sericite, chlorite, clay, and groundmass; original composition unknown
74760065 HC6/03/5B	Rhyodacite?	Groundmass similar to 74760064; hematite needles form circular patterns around phenocrysts and cavities; altered euhedral phenocrysts were probably alkali feldspar; cavities - some contain high-birefringence, apparently uniaxial? chlorite.
74760066 HC8/69/4		Groundmass - mottled (variable oxidation) and cryptocrystalline Phenocrysts: (a) euhedral, albite-twinned plagioclase (oxidized) (b) alkali feldspar altered to opaques, chlorite, sericite, and clays (c) scattered quartz. Also pseudomorphs of opaques and chlorite probably replacing amphiboles.

* See Appendix for silicate analyses.

TABLE 14 (continued)

74760067 HC6/05/2	Rhyodacite?	Groundmass - cryptocrystalline feldspar, less quartz and not as oxidized as 0064, 0065, 0066, but some hematite veins Phenocrysts - probably alkali feldspar; also veined by hematite; patches of relict mafics, apatite, and chlorite

Unit 6

Unit 6 of the Peters Creek Volcanics consists of a series of thin flows of basalt, andesite, and rhyolite, and at least two sedimentary interbeds. It can be recognized on aerial photographs from its dark brown banded pattern, and generally subdued topography.

Stratigraphic relations. Andesitic lavas overlie and infill the uneven upper surface of Unit 5. The uppermost rocks of the unit, which are basalt, are overlain by rhyolite of Unit 7. Both upper and lower contacts are assumed to be conformable. The relations between Unit 6 and the 'dome' Unit, Btp_d, are not well understood.

Lithology. Flows of andesitic volcanics, some less than 2 m thick, overlie the massive highly porphyritic rhyodacites? of Unit 5. At grid reference 195369 several metres of strongly jointed dark brown non-porphyritic fine-grained dacite or andesite (Table 15) (72762061) overlies Unit 5 rocks, and is overlain by light brown highly vesicular lava (trachyte?, 72762062). The vesicles contain quartz and bright green chlorite, and form pipes up to 4 cm long which rise vertically, or are curved, from the base of the flow. They are most numerous at the base, and are more scattered, although larger, 2 to 3 metres above. Three kilometres to the west the basal flow is also a dark brown fine-grained volcanic rock which grades upwards into vesicular lava. Quartz and chalcedony occupy some of the vesicles, but most of them are empty. A topographic bench a few metres above is either the brecciated top of the flow, or an agglomerate. It consists of amygdaloidal volcanic clasts in a fine-grained purple matrix; the boundaries between clasts and matrix are difficult to determine. In the centre of the unit, at grid reference 130358, a lens of sandstone and conglomerate has a maximum thickness of about 50 m. Near their base these rocks are fine-grained and laminated, and may be tuffaceous. The clasts in the conglomerate are up to 10 cm across; most are of rhyolite or rhyodacite, although a few well rounded quartzite and quartz pebbles are also present. Matrix is sparse, and consists mostly of volcanic detritus. A slight upward trend towards better rounding and sorting is evident. Several poorly exposed andesitic flows (Table 15, 72762068) and thin sandstone beds are present above the conglomerate; the lavas contain geodes of smoky quartz and jasper.

Near the top of the Unit 6, at grid reference 131354, in the Hedleys Creek Sheet area, two thin light-coloured interbeds are present in volcanics. The lower one is probably a rhyodacite flow, and the upper one is a brecciated finely laminated siliceous sedimentary rock which may be a tuff.

An isolated outcrop of stromatolitic chert overlying rhyolite of Ptp_d, at grid reference 179358, is tentatively assigned to Unit 6.

Thickness. The greatest preserved thickness of Unit 6, assuming a 10° dip, is 330 m in the type section of the Peters Creek Volcanics.

Petrography. Thin section data for Unit 6 is summarized in Table 15*. Because the rocks are highly altered it is not possible to assign specific names to most of them. However they are mostly of intermediate and basic composition.

TABLE 15: Thin-section descriptions, Peters Creek Volcanics (Unit 6)

BMR registered no. and field no.	Rock name	Description and comments
72762057 HC8/69/5	Dacite or andesite	Fine-grained partly crystalline highly ferruginized groundmass consists of random plagioclase laths with quartz, opaques, chlorite, and mafics; cavities 1-5 mm across filled with quartz and chlorite
72762061 HC7/93/10A	Dacite or andesite	Similar to 72762057 but more vesicular. Fine-grained groundmass contains plagioclase laths, chlorite, hematite, and relatively abundant apatite

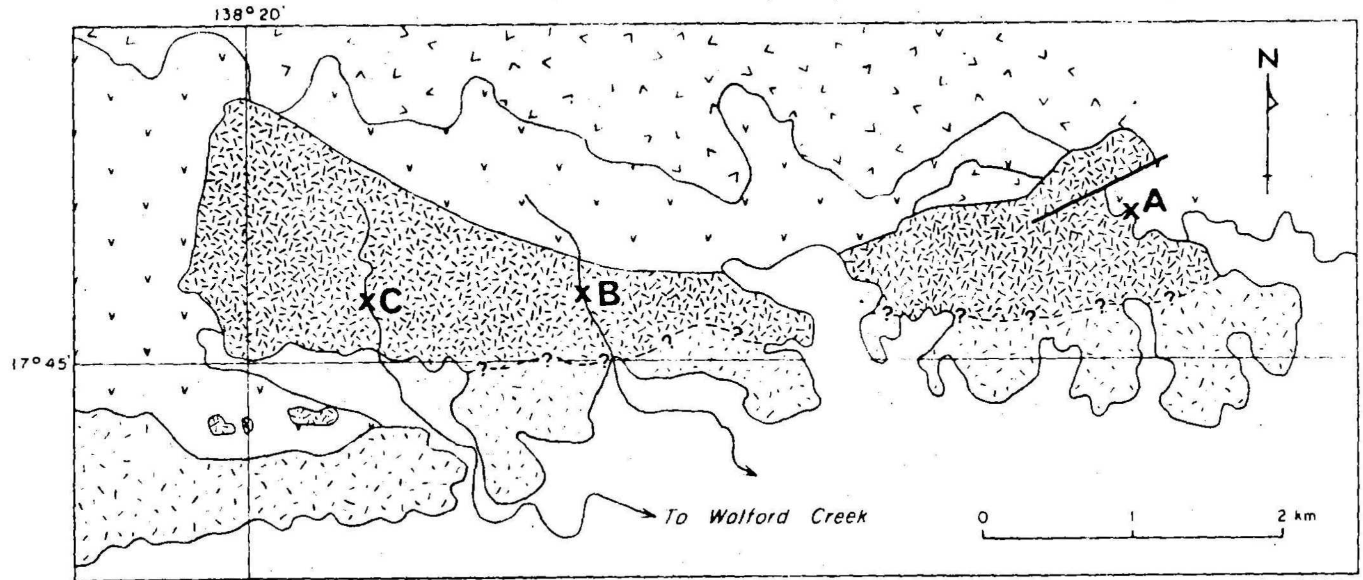
* See Appendix for silicate analyses.

TABLE 15 (continued)

72762062 HC7/93/10B	Trachyte?	Uniformly fine-grained holocrystalline rock consisting of plagioclase laths, an interstitial alkali feldspar, opaques, quartz, apatite, clay, chlorite, and iron staining
72762063 HC7/93/11	Intermediate volcanic	Plagioclase laths plus minor alkali feldspar; trachytic texture; pseudomorphs of chlorite and/or opaques
72762068 HC7/91/19B	Intermediate volcanic	Similar to, but fresher than, 72762063. Holocrystalline, fine-grained; plagioclase and alkali feldspar, abundant opaques, and calcite; possible pseudomorphs after hornblende or pyroxene; interstitial chlorite
74760068 HC7/89/20B	Volcanigenic conglomerate	Rounded sand-sized grains of rhyolite or rhyodacite and clear unstrained quartz set in a fine siliceous matrix; scattered muscovite flakes
74760071 HC7/91/23	Sandy siltstone (tuffaceous ?)	Coarse silt particles, with scattered angular quartz sand and muscovite flakes; quartz/clay matrix; many thin discontinuous bands of brown-stained chalcedony

Unit Ptp_d

Ptp_d of the Peters Creek Volcanics is so labelled because it is the only rhyolite body within the formation that can be recognized as part of a lava (or cumulo-) dome. All other rhyolite bodies seen are tabular and probably consist of one or more lava flows of unknown extent.



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Peters Creek Volcanics	Unit 7	*Red porphyritic rhyolite*
	Ptp$_d$	*Red porphyritic rhyolite*
	Unit 6	*Andesite and other intermediate volcanics, some sediments*
	Unit 5	*Reddish-brown porphyritic rhyodacite*

Fig 6: Distribution of Ptp$_d$

Stratigraphic relations. Figure 6 shows the distribution and stratigraphic relations of Ꝑtp$_d$. The unit may be a lava dome that was extruded before Unit 6 and formed a topographic high around which younger lavas and sediments were laid down; more probably, it was extruded after Unit 6 was deposited, as it appears to be of similar composition to Unit 7.

Unit 7 and Ꝑtp$_d$ are virtually identical lithologically, and a boundary between them has been drawn, somewhat arbitrarily, along a slight topographic depression.

Lithology. Unit Ꝑtp$_d$ consists of massive reddish brown feldspar porphyry, and quartz porphyry which shows prominent flow-banding at some localities. It has a lower proportion of phenocrysts than the porphyry of Unit 5. The best exposures of Ꝑtp$_d$ are at localities B and C (Fig. 6), where creeks cut across the unit. At both exposures massive porphyry with euhedral and subhedral feldspar phenocrysts up to 3 mm across grades into flow-layered porphyry. The layering is indicated by the presence of small aggregates of quartz grains. These aggregates vary from small spherical blebs up to 1 mm across (sample 72762065) to lens or rod-shaped structures up to 5 mm long and 3 mm across (72762059). They may be infillings (amygdales) in vesicles and flow structures. Most of the flow-layering is steeply dipping and curved, as is typical of rhyolite flows.

Irregular networks of greyish-green, fine-grained sediments form 'dykes' up to 20 cm across in some parts of the lava. Because of the similarity of these sediments to siltstones in Unit 6, it is possible that they are remnants of that unit included in Ꝑtp$_d$ during extrusion. However, as clasts of basic and intermediate lavas are not equally as common, the sediments may be later fillings in open fractures formed as the lava congealed.

Petrography. The lava is apparently of similar composition to the other acid varieties of the Peters Creek Volcanics, such as those of Units 2 and 7*. The samples examined (Table 16) have a fine-grained limonite-stained devitrified groundmass with a vague spherulitic structure. Scattered euhedral and subhedral feldspar phenocrysts are invariably altered to kaolin? and chlorite; opaque minerals are rare.

* See Appendix for silicate analyses.

TABLE 16: Thin-section descriptions, Peters Creek Volcanics (Ptp_d)

BMR registered no. and field no.	Rock name	Description and comments
72762058 HC7/91/9A	Porphyritic rhyolite	Dark reddish-brown rock with euhedral altered feldspars; scattered secondary quartz; groundmass shows devitrification textures - some vaguely spherulitic structures in a mosaic of equant vaguely defined ironstained grains; scattered chlorite or sericite associated with iron oxide grains may be alteration product of pyroxene?
72762059 HC7/91/9B	Rhyolite	Pale pinkish brown rock consisting of 20-30% by volume of quartz amygdales up to 1 mm across; groundmass is a fine-grained mosaic, not as ferruginous as 72762058, nor is a spherulitic texture developed
72762060 HC7/91/9C	Siltstone 'dyke' rock	20-30% quartz and up to 10% muscovite and chlorite flakes in kaolinite/chert matrix; accessory tourmaline; chalcedony fills numerous voids up to 0.5 mm
72762065 HC7/91/18A	Rhyolite	Virtually identical to 72762059 except that it contains scattered pseudomorphs of chlorite/iron oxide/quartz aggregates after feldspar
72762066 HC7/91/18B	Siltstone 'dyke' rock	Similar to 72762060; contains a micaceous mineral (chlorite?) forming radi-

TABLE 16 (continued)

		ating clusters in small (1 mm) voids (yellow to brown pleochroic, high (2nd order) birefringence); a similar chlorite? has been observed in several of the rhyolite units
72762069 HC7/91/21	Tuffaceous? cherty siltstone 'dyke' rock	Similar to 72762060 and 72762066; scattered muscovite and quartz grains in a clay/chert matrix; same euhedral quartz grains and sand-sized clay grains
74760073 HC7/93/8B	Porphyritic rhyolite	Dark reddish-brown porphyry; vaguely spherulitic devitrified groundmass; a few thin quartz veins; rare chlorite associated with altered feldspar phenocrysts.

Unit 7

Unit 7 of the Peters Creek Volcanics is a dark reddish-brown rhyolite closely similar to some of the rhyolite in Ᵽtp$_d$. It crops out in a narrow east-trending belt between Hedleys Creek and the Domadgee-Westmoreland road, a distance of about 20 km.

Stratigraphic relations. Unit 7 overlies basalt of Unit 6, apparently conformably, and is unconformably overlain by the Fish River Formation. It overlies, and may merge with Ᵽtp$_d$.

Lithology and petrography. The rhyolite is a feldspar porphyry in which the phenocrysts are invariably completely altered to white clay. The groundmass displays spherulitic devitrification texture, in which spikey grains of quartz and feldspar are set in a strongly ironstained mosaic of unidentified equant grains (sample 74760072 - the only thin section examined). Exposures are massive to flaggy, and only at grid reference 143346 was contorted flow-banding observed. Units 7 and Ᵽtp$_d$ may be part of the same extrusive body; if so, Ᵽtp$_d$ is probably the eruptive centre.

Thickness. Unit 7 is about 200 m thick in the type section of the Peters Creek Volcanics. This is the greatest known thickness of the unit.

Fish River Formation

The first specific mention of the rocks in the Fish River Formation was made by Jensen (1941, unpubl.), who noted that 'red tuffy quartzites occur overlying the volcanic rocks'. However, the 'quartzites' were not mapped as a separate unit by Carter (1959), who included them in his 'Wollogorang Formation'. Roberts et al. (1963) recognized the Fish River Formation as a mappable unit in the Calvert Hill Sheet area, and, based on their description of its stratigraphic relations, Taylor (1970) recognized the unit east of the Northern Territory border in the Westmoreland Sheet area.

Roberts et al. (1963) described the unit as a sequence of pebbly feldspathic sandstone overlain in some places by lavas, and capped by quartz sandstone. Our mapping has shown that the feldspathic sandstones are 'Wire Creek Sandstone' and that the lavas are Peters Creek Volcanics. These two units are overlain with angular unconformity by the quartz sandstone, for which we retain the name Fish River Formation. The easternmost outcrop of the Fish River Formation in the Calvert Hills Sheet area was mapped as such by Roberts et al. (1963), and its unconformable relation with the two older units is shown at grid reference 625757, on the Calvert Hills map.

Distribution. The unit forms a series of disconnected ridges trending east-northeast across the southern part of the Seigal Sheet area, and crops out in a belt up to 4 km wide with similar trend in the central part of the Hedleys Creek Sheet area.

Derivation of name. From Fish River, a south-flowing tributary of the Nicholson River in the southern Seigal Sheet area.

Type section. Roberts et al. (1963) nominated a reference section in the Seigal Sheet area, but, since this has not been published as a type section, a complete well exposed section in and adjacent to Wire Creek is nominated as the type section. The base of the section is in the east bank of Wire Creek at grid reference 957314. The section runs southeast along the creek bank for 1.3 km to a cliff, then for a distance of 0.7 km due east to the top of the formation at grid reference 974305.

Stratigraphic relations. The Fish River Formation unconformably overlies progressively older rocks from east to west. In the eastern part of the Hedleys Creek Sheet area it overlies Unit 7 of the Peters Creek Volcanics; in the western part it overlies Units 1 and 2. The formation is unconformable on 'Wire Creek

Sandstone' in the eastern part of the Seigal Sheet area, and on the 'Nicholson Granite Complex" and Murphy Metamorphics in the western part.

Although the upper boundary of the Fish River Formation is sharp, and is an easily recognized photogeological boundary, there is no evidence of an unconformity between it and overlying rocks of the Fickling Group. Roberts et al. (1963) stated that the contact is locally unconformable, but did not present any evidence of this.

The formation is subdivided into three informal units (shown as Ptf_1, Ptf_2, and Ptf_3) in the Hedleys Creek Sheet area, but is undivided (Ptf) in Seigal.

<u>Lithology</u>. The Fish River Formation consists of fine to medium-grained quartz sandstone, with minor lithic sandstone, conglomeratic sandstone, siltstone and shale. A lens of siltstone and shale (Ptf_2), has been mapped in the Hedleys Creek Sheet area, and divides the lower (Ptf_1) and upper (Ptf_3) sandstones in the unit.

<u>Unit Ptf_1</u>. The base of the Fish River Formation is well exposed, and is marked locally by a basal conglomerate. In the type section a 0.5-1 m bed of conglomerate with an uneven base on Peters Creek Volcanics contains well rounded quartzite clasts and subangular to subrounded volcanic clasts; although some clasts are cobbles (up to 20 cm) most are pebbles about 5 cm across. The conglomerate is overlain by a 1 m bed of conglomeratic sandstone containing pebbles up to 2 cm across and medium-grained purple cross-bedded sandstone. The cross-beds are tabular, in units 10-30 cm thick, and indicate a depositional current from the south.

In the easternmost outcrop of the unit, the basal beds include massive to blocky, medium-grained to gritty sandstone, but no conglomerate. A fault separates this outcrop from the younger part of the unit, which here includes about 4 m of poorly sorted conglomerate containing rounded rhyolite clasts up to 5 cm across.

In the Seigal Sheet area (Ptf undivided) the lowermost beds are well sorted sandstones, with only rare pebbly lenses. Four kilometres west of the Northern Territory border massive and blocky, pink, medium-grained sandstone contains rare lenses of weathered volcanic pebbles up to 1 cm across; the sandstone shows ripple-marks and mud cracks. Higher in the unit at this locality medium-grained, well sorted orthoquartzite is cross-bedded on a large scale (sets are 2-3 m thick and foresets are several metres long).

At grid reference 888183, where the Fish River intersects the unit in the Seigal Sheet area massive and blocky, well sorted quartz sandstone is cross-bedded in small tabular units, contains mudflakes 0.5-1.0 cm across, and shows three sets of current ripples in different orientations. Herringbone cross-bedding here indicates current reversals during deposition (Plate 11).

Ten kilometres west of the Fish River, basal cobble conglomerate containing rounded quartzite clasts overlies highly weathered granite. The conglomerate grades up into white orthoquartzite which in turn is capped by porous clayey coarse sandstone; ripple-marks and mud cracks are preserved in the sandstone. Three kilometres farther west a thinner sequence of massive and blocky cross-bedded medium-grained sandstone shows ripple-marks, mud cracks, and numerous cavities where mudflakes on bedding planes have been weathered out.

Unit Ɛtf$_2$. This unit has been mapped only in the Hedleys Creek Sheet area, and probably lenses out in the eastern Seigal Sheet area. It forms a scarp slope up to 50 m high capped by the upper unit of the Fish River Formation, and is easily recognized on aerial photographs.

At the type section of the formation this unit consists of thinly interbedded and laminated purple and green shale, and wavy beds up to 2 cm thick of pinkish siltstone and fine sandstone. At grid reference 855268, in the westernmost exposure of the unit, it consists of thin-bedded and flaggy very fine-grained purple sandstone with clayey matrix and micaceous bedding parting-planes. At both localities the thin sandstone beds have abundant skip and prod casts on their undersurfaces, representing small grooves in underlying silt and mud laminae, the grooves being produced by current scour (M.R. Walter, pers. comm.). The unit may grade into ferruginous sandstones noticed farther west in the Seigal Sheet area.

Unit Ɛtf$_3$. In the Hedleys Creek Sheet area Unit Ɛtf2 is overlain by Unit Ɛtf$_3$, which consists of well sorted medium-grained orthoquartzites except in an area 10-11 km east of Wire Creek, where conglomeratic lenses are also present. The conglomerate contains subangular to well rounded cobbles and boulders up to 30 cm across of silicified fine to medium feldspathic sandstone. East of Wire Creek the uppermost bed of the Fish River Formation is a distinctive coarse ferruginous sandstone in which pink grains of weathered rhyolite are prominent (e.g. sample 7476077, Table 17).

Thickness. At the type section near Wire Creek the Fish River Formation is about 250 m thick (Ɛtf$_1$ = 100 m, Ɛtf$_2$ = 50 m, Ɛtf$_3$ = 100 m). Taylor (1970) considered that the thickness may vary along strike because the conglomerate beds in the upper part of

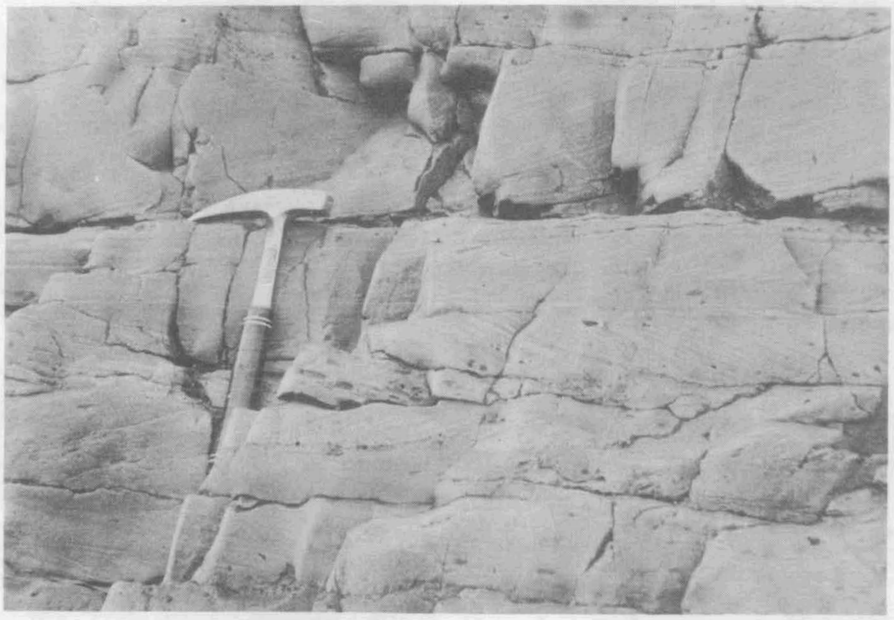

Plate 11: Herringbone cross-bedding in the Fish River Formation in outcrops where the Fish River cuts across the formation in the Seigal Sheet area (Neg. M/1506).

TABLE 17: Thin-section descriptions, Fish River Formation

BMR registered no. and field number	Rock name	Minerals present	Texture of rock and comments
74760074 HC7/93/4A			Medium moderately sorted subgreywacke
		Quartz (70+%)	0.2-0.5 mm, rare larger grains; limonite/goethite-stained rims; moderately to well rounded but enveloped in syntaxial growths
	SUBGREYWACKE	Rock fragments (20+%)	Most appear to be grains of devitrified matrix of rhyolite - i.e., composite grains of indistinct crystals; some chert, siltstone?, and clay grains; no feldspar
		Matrix (5+%)	Quartz silt and clay minerals
		Accessories	Rounded tourmaline, zircon
		Cement	Syntaxial quartz.
74760075 HC8/69/5			Purple, medium sandstone with scattered coarse grains
		Quartz (70+%)	Rounded, well sorted fine-medium (0.1-0.3 mm); syntaxial overgrowths.
		Feldspar (5%)	Several grains of orthoclase, one of microcline
	PROTOQUARTZITE	Rock fragments (25%)	Heavily ironstained rhyolite, minor chert
		Accessories	Rounded fractured tourmaline; some chlorite
		Cement	Syntaxial quartz
74760076 HC8/67/4			White medium to coarse quartz sandstone
		Quartz (95+%)	Bimodal - larger grains up to 1.0 mm in fine to medium sand
	ORTHOQUARTZITE	Rock fragments	Chert, composite quartz grains, one shale or siltstone; rhyolite (as for 0075)
		Accessories	One small rounded tourmaline
		Matrix	Sparse - some clay and quartz silt
		Cement	Syntaxial quartz

TABLE 17: (Contd.)

BMR registered no. and field number	Rock name	Minerals present	Texture of rock and comments
74760077 HC8/67/13B	SUBGREYWACKE		Poorly sorted medium to coarse sandstone; grainsize 0.2-1.0+ mm.
		Quartz (60+%)	
		Rock fragments (30+%)	Most are rhyolite, but a few are chalcedony, chert, and composite quartz grains.
		Cement	Syntaxial quartz overgrowths.
		Matrix	Scattered limonite - assumed to be secondary
		Voids (5-10%)	Very common
74760078 S10/95/1B	ORTHOQUARTZITE		Porous sandstone with mudflake voids
		Quartz (40+%)	Subrounded to well rounded
		Rock fragments (5%)	
		Accessories	Well rounded zircon
		Matrix	Minor clay and quartz silt
		Cement (40+%)	Chalcedony and chert
		Voids (10%)	Very common
74760079 S10/11/6	ORTHOQUARTZITE		Well cemented quartz sandstone with scattered mudflakes
		Quartz (95%)	Bimodal - well rounded grains
		Rock fragments (5%)	Most are probably rhyolite; may be fine-grained siliceous fragments; no feldspar
		Accessories	Rounded tourmaline
		Matrix	Rare - very minor clay and quartz silt, some iron oxide
		Cement	Syntaxial quartz growths
		Voids	Rare
74760080 HC9/03/5	PROTOQUARTZITE		Fine-grained purple quartz sandstone with shale clasts or lenses
		Quartz (90+%)	0.1-0.3 mm, well sorted, syntaxial growths
		Rock fragments (5+%)	Chert, shale?, rhyolite; rare fresh feldspar grains

TABLE 17: (Contd.)

BMR registered no. and field number	Rock name	Minerals present	Texture of rock and comments
74760080 HC9/03/5		Accessories	Rounded tourmaline common; one rounded zircon
	PROTOQUARTZITE	Matrix	Sparse - iron oxide rimming quartz grains
		Cement	Syntaxial quartz overgrowths
		Voids	Minor, scattered.

the formation contain volcanic clasts and indicate a bedrock relief of at least 30 m. However, there is no evidence for such relief on the upper surface of the Peters Creek Volcanics in the Hedleys Creek Sheet area. The thickness varies widely in the Seigal Sheet area: near Gorge Creek the formation is more than 200 m thick, but to the west, between Pandanus Creek and the Fish River it is only 50-70 m thick. It is about 170 m thick between 8 and 12 km west of the Fish River. The thickness decreases rapidly farther west, and is probably only 10-20 m at the western margin of the Seigal Sheet area.

Petrography. Table 17 summarizes the features of 7 sandstone samples collected from the Fish River Formation; the samples range from lithic sandstone with up to 30 percent rock fragments (subgreywacks in the Pettijohn, 1957 classification) through to orthoquartzite. Feldspar is rare or absent in most samples. The rock fragments are mainly of rhyolite derived from the porphyries in the underlying Peters Creek Volcanics and possibly to Cliffdale Volcanics. A few composite quartz grains, and grains of sedimentary rocks, are also present. Minor clay matrix is present, but most of the interstices are occupied by quartz cement which is invariably in optical continuity with adjacent grains. The heavy mineral suite consists of rare well rounded grains of tourmaline and zircon. The quartz grains and rounded heavy minerals were probably derived from older sediments, such as the 'Wire Creek Sandstone' and Westmoreland Conglomerate.

Depositional environments. The unit is thinner to the west of Pandanus Creek than it is to the east, with the exception of one thick section west of the Fish River. There is no definite trend in grainsize, but the presence of conglomerate lenses in the east suggests that material was eroded from nearby areas. In the east no north-south changes in thickness can be observed, and it therefore cannot be shown whether or not the unit extended onto or across the Murphy Tectonic Ridge. In the west it does extend onto the ridge, but is very thin (10 m or less). This suggests that the ridge was a positive area at the time of deposition, and probably supplied some detritus to the formation.

Small and medium-scale moderate-angle foreset cross-bedding, abundant mudstone flakes, and presence of mudcracks and local conglomerates suggest a fluvial rather than a marine environment. If this is so the current directions noted (from the south and southwest) may indicate a provenance to the south, under what is now occupied by the South Nicholson Basin. Further detailed studies would be needed to resolve this question.

Fickling Group

Jensen (1941, unpubl.) examined what is now called the Fickling Group when he made reconnaissance traverses across the Westmoreland 1:250 000 Sheet area; he reported the presence of 'chertified calcareous rocks, limestone, slate and calcareous quartzite'. Carter (1959) assigned the rocks to the Wollogorang Formation, with a type area near Wollogorang homestead in the Northern Territory. Roberts et al. (1963) realized that the Wollogorang Formation in its type area is older than the carbonate rocks in the southern part of the Westmoreland 1:250 000 Sheet area, and renamed the latter the Fickling Beds. Taylor (1970) informally subdivided the Fickling Beds into five members, which form the basis for the present subdivisions (Table 18).

Distribution. The main outcrops of the Fickling Group are in a roughly triangular area of 320 km^2 in the southwestern part of the Hedleys Creek, southeastern part of the Seigal, and northeastern part of the Cleanskin 1:100 000 Sheet areas. Minor outcrops occur farther west in the Seigal Sheet area. Roberts et al. (1963) and Smith & Roberts (1963) also mapped the group in the southeastern part of the Nicholson River 1:100 000 Sheet area, and in the Bauhinia Dome, in the Benmara 1:100 000 Sheet area. The group must occur in the subsurface to the south, beneath the South Nicholson Group, and to the east and southeast, beneath Mesozoic sediments of the Carpentaria Basin.

Derivation of name. From Fickling Creek, a south-flowing tributary of the Nicholson River near the southern margin of the Calvert Hills 1:250 000 Sheet area.

TABLE 18: Comparison between past and present nomenclature of the Fickling Group

Taylor (1970)	This report
Sandstone Member	'Doomadgee Formation'
Siltstone Member	'Mount Les Siltstone'
Shale-dolarenite Member	'Walford Dolomite'
Oolite Member	
Basal Member	

Type area. In the southwestern corner of Hedleys Creek Sheet area, which is the only place where the whole group is exposed. Separate type sections have been nominated for the individual formations in the group.

Stratigraphic relations. The group lies conformably on the Fish River Formation and is overlain unconformably by the South Nicholson Group. The unconformable relation is not always apparent in individual exposures, as the angular discordance is slight or lacking, particularly in the east. However, it is evident near Pandanus Creek, where Constance Sandstone of the South Nicholson Group overlies all three formations of the Fickling Group.

Within the group there appears to be a disconformity between the 'Mount Les Siltstone' and the 'Doomadgee Formation'.

Lithology. The three formations have been combined as a group because they have in common the occurrence of dolomite. Despite the possible disconformity above the 'Mount Les Siltstone', the group represents a long period in which conditions were favourable for the deposition of shallow-water carbonates. Variable influx of clastic sediments led to the deposition of dolomite shale, siltstone, and sandstone interbeds.

Thickness. Only in the southwestern part of the Hedleys Creek Sheet area are all three formations preserved in sequence, and their thickness here is estimated at about 700 m. Elsewhere the units are bounded by faults or truncated by the South Nicholson Group. Smith & Roberts (1963) report a thickness of 3500 ft (1070 m) for the Fickling Beds in the Bauhinia Dome.

'Walford Dolomite'

Derivation of name: From Walford Creek, an east-flowing stream which drains about 200 km^2 of country in the eastern part of the Hedleys Creek Sheet area.

Distribution. The formation is well exposed in the southwestern part of the Hedleys Creek Sheet area and eastern part of the Seigal Sheet area between Wire and Pandanus Creeks, where it crops out over about 100 km^2. West of Pandanus Creek it forms a series of disconnected fault-bounded outcrops trending west-southwest.

Type section. The base of the type section is at grid reference 860249, 2 km north-northwest of the Galena Pits prospect, in the southwestern Hedleys Creek Sheet area. The section runs 2.3 km on a bearing of 170° (true); the upper 0.5 km is along a small creek, and the top is about 200 m southwest of Galena Pits, at grid reference 864228. A diamond-drill hole (DDH10) 2 km southwest of the type section penetrated 347 m of the formation (Taylor, 1970), and provides the best section through most of the unit.

Stratigraphic relations. The 'Walford Dolomite' appears to conformably overlie the Fish River Formation, and it is overlain conformably by the 'Mount Les Siltstone'. In the Hedleys Creek Sheet area the basal 10-20 m of the formation consists of recessively weathering, leached shale, siltstone, and fine sandstone which are probably dolomitic at depth. These rocks probably represent the transition from the predominantly sandy Fish River Formation below, to the predominantly dolomitic 'Walford Dolomite' above.

Topography. In comparison with nearby sandstone units, such as the Fish River Formation and Constance Sandstone, the 'Walford Dolomite' is readily eroded. Areas underlain by dolomite are flat or gently undulating, and areas of chert and dolomitic sandstone consist of cuestas up to 50 m high.

Lithology. Dolomite predominates in the formation, as the name implies, but the most common rock exposed is chert. Results of diamond drilling by Carpentaria Exploration Company (Taylor, 1970) show that this is a surface feature only, and that in all instances fresh, non-silicified dolomite is present less than 10 m below the surface. DDH10, which was spudded in 'Mount Les Siltstone', penetrated 'Walford Dolomite' at a depth of 19 m; no chert was present, although it is exposed within 300 m on both sides of the drill-hole locality.

The basal member (Bfw$_b$) of the 'Walford Dolomite' crops out between Wire and Hedleys Creeks and to the east. To the west, near the Queensland border, it has been tentatively recognized, but in the Seigal Sheet area, where the base of the formation is poorly exposed or faulted, it has not been recognized. In the best exposure 11.7 km east-northeast of Gorge Waterhole, a 2-3 m bed of concretionary limonite overlying the uppermost gritty sandstone of the Fish River Formation is overlain by up to 10 m of mudstone and leached, porous fine clayey sandstone (sample 74760094). Although no dolomite was found in thin section, the porous nature of the sandstone suggests that it may have been present originally. Limonite concretions were noted in other exposures of the member, but no bedding structures are present. The limonite bed may be either a ferruginous weathering horizon developed during a period of non-deposition, or the weathering product of a highly ferruginous sediment such as pyritic shale. The second interpretation seems more likely, as the sandstone immediately below (in the Fish River Formation) is unlikely to form highly ferruginous laterite, and it does not appear to be strongly weathered. The remainder of the basal member consists of brown shale or mudstone (e.g. sample 74760095).

The bulk of the 'Walford Dolomite' above the basal member consists of dolomite with minor black shale and glauconitic, dolomitic sandstone. At or near the base of the dolomite is a distinctive bed of stromatolitic dolomite in which individual columns are 10 - 30 cm high and generally less than 1 cm across. This bed is always silicified, and in the east forms a scarp-capping above the poorly outcropping basal member. Taylor (1970) called this bed the 'lower collenia marker bed'. A similar bed observed at and west of Fish River in the Seigal Sheet area overlies at least 50 m of laminated dolomite and siltstone. At the exposure of silicified stromatolitic dolomite shown in Plate 12, there are thin and medium beds consisting of parallel unbranched columns about 1 cm across and 2 - 10 cm high, and a few interbeds of oolitic dolomite up to 20 cm thick.

Oolitic, intraclastic, and laminated dolomites are common throughout the formation, and drill-hole data presented by Taylor (1970) shows that many bands of black shale, mainly less than 2 m thick, are also present. Taylor's DDH10 (Hedleys Creek Sheet, grid ref. 847220) penetrated nearly 30 m of black shale in the upper part of the formation. In the middle of the shale is a prominent stromatolitic dolomite bed (Plate 13) which Taylor called the 'upper collenia marker bed', and which he recognized at the surface over a distance of 7 km adjacent to Gorge Creek. The 'upper marker' at the type section of the formation, near Galena Pits, is somewhat different from that intersected in DDH10, 2½ km to the southwest, for it is capped by dolomite, not shale. Stratigraphically below the marker there is a dark soil zone which may be developed on shale, although none crops out.

Some oolitic dolomite occurs above the 'upper marker', but the most common rock type is intraclastic wackestone.

Within 1 km of the Northern Territory/Queensland border, ferruginous and manganiferous breccia are developed on beds adjacent to the 'upper marker', possibly on black shales. The 'upper marker' is generally partly silicified, resulting in the more resistant cherty portions forming characteristic rubble.

In the Seigal Sheet area most outcrops of 'Walford Dolomite' are fault-bounded on at least one side, and a complete sequence is exposed at only one locality. However, the carbonates exposed are similar to those in the east: laminated stromatolitic dolomites, and intraclastic and oolitic beds. The uppermost beds, where exposed, are silicified to white chert in which the original carbonate textures are well preserved (sample 74760085). The whole formation is exposed 8 km west-southwest of Fish River, where it consists of limonite-stained laminated and brecciated chert about 250 m thick.

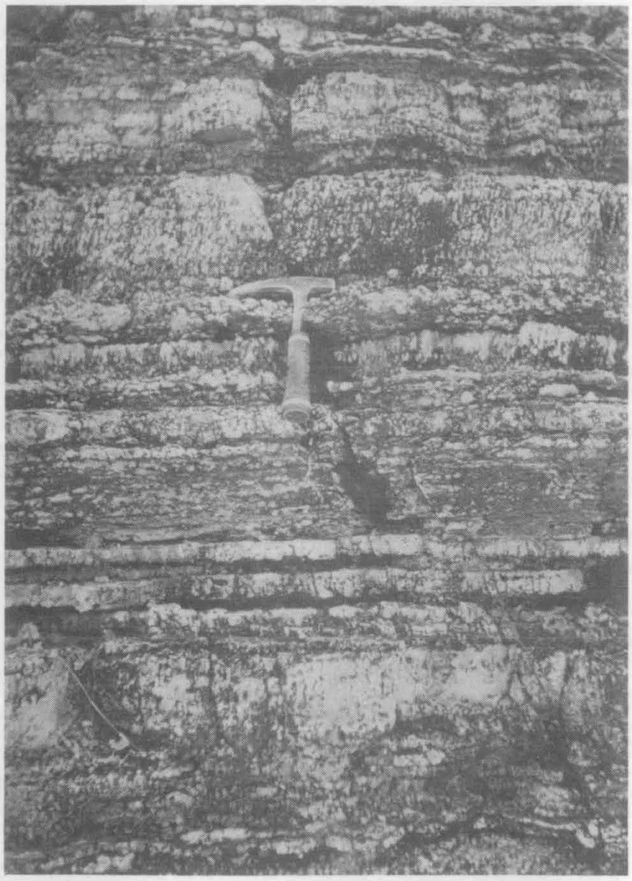

Plate 12: Beds of stromatolitic dolomite replaced by chert - 'Walford Dolomite' 1.5 km west of the western margin of the Seigal 1:100 000 Sheet area (Neg. No. GAB/32).

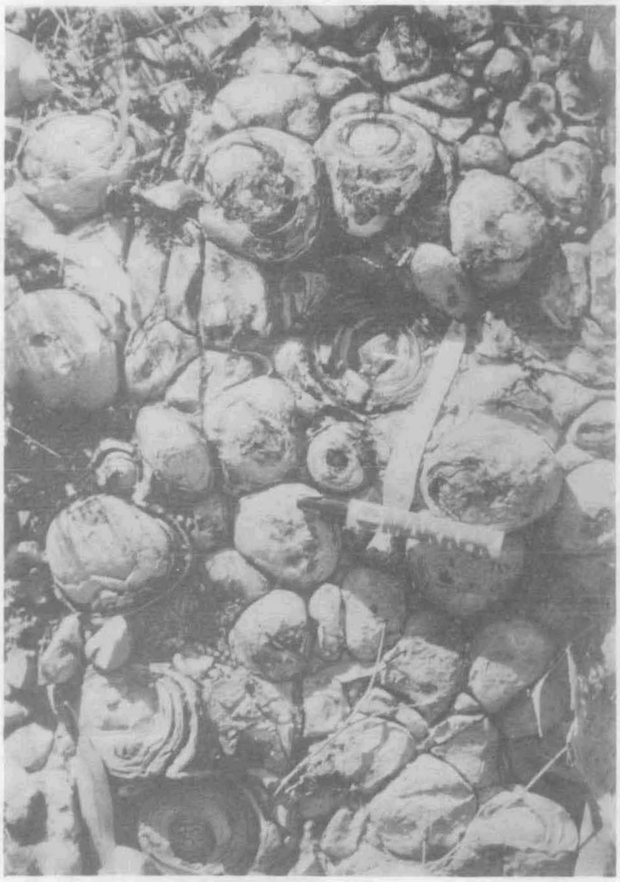

Plate 13: Columnar stromatolites weathered out on a bedding plane of 'Walford Dolomite' 0.5 km south of Gorge Creek at grid reference 835225 in the Hedleys Creek 1:100 000 Sheet area (Neg. no. GAB/33).

Scattered sand grains were noted in dolomite in the western part of the Seigal Sheet area. Just west of the Sheet area boundary, 7 km southwest of Tin Hole, rocks previously mapped as Fickling Beds (by Roberts et al., 1963) consist partly of Fish River Formation - the basal few metres of coarse sandstone; and partly of 'Walford Dolomite' - the overlying silicified interbedded fine-grained dolomite? and sandstone.

Thickness. The only complete, unfaulted sequence of 'Walford Dolomite' in the Seigal Sheet area, near the Fish River, is 250 m thick. In the Hedleys Creek Sheet area, near the type section locality, DDH10 penetrated 347 m without passing into the underlying formation. The thickness at the type section, estimated from aerial photographs and measured dips, is in excess of 400 m. Sequences farther east are affected by faulting.

Petrography. Table 19 summarizes the mineralogy and texture of samples from the 'Walford Dolomite'. The nomenclature is a combination of that used by Dunham (1962) and Folk (1962). The dolomitic rocks are either silicified or partly recrystallized, but fresh rocks probably had a matrix of micrite. The laminated micrites are mostly boundstones (bound by algae; that is stromatolitic). Intraclast rocks range from arenites to rudites in grainsize, and ooids are present in most specimens.

The sandstones examined are glauconitic, and contain rock fragments indicating a mixed igneous (plutonic and volcanic) and sedimentary source. Rhombs of authigenic feldspar, probably albite, are present in some samples.

Environment of deposition and palaeogeography. Most of the 'Walford Dolomite' was deposited in shallow warm marine water. The glauconitic sands indicate marine conditions; so too do the stromatolites, which also indicate intertidal or shallow subtidal environments. Indications of higher-energy environments are provided by the presence of oolitic and intraclastic rocks, in some of which the clasts are several centimetres long. Taylor (1970) reports the presence of halite casts; hence some of the dolomites and muds may be supratidal (sabkha-type) deposits.

The formation appears to thicken eastwards. The presence of feldspar in the sandstones is surprising, especially since there is very little feldspar in the underlying Fish River Formation. Perhaps the sandstones in the 'Walford Dolomite' were mainly derived from granitic basement, whereas the Fish River Formation was mainly derived from the Peters Creek Volcanics, or perhaps the climate changed from humid (feldspar-destroying) to more arid, resulting in better preservation of fresh feldspars.

Table 19: Thin-section descriptions, Walford Dolomite

BMR registered no. and field no.	Rock name and general description	Mineral present	Remarks
74760083 S10/11/7	Wavily laminated chert	Thin silica laminae	Chert (was dolomite); probably micrite
	SILICIFIED SANDY WACKESTONE	Thicker silica laminae	Pellets, ooids, and detrital grains Pellets - no concentric structures, shape variable; 0.2-0.5 mm, some up to 1 mm Ooids - similar size to pellets but vague concentric structure Quartz - scattered subrounded grains up to 0.5 mm
		Matrix	Chalcedony and 'sparry' quartz between former carbonates
74760084 S10/14/9	SANDY INTRA-CLASTIC DOLOMITE	Dolomite 95%	Intraclasts up to 1 cm thick and several cm long of finely laminated carbonate; matrix of partly recrystallized carbonate
		Quartz } 5%	0.5-2.0 mm; strongly embayed by carbonate
		Feldspar } 5%	Detrital grains of microcline (some perthitic, some twinned); commonly with overgrowths of clear feldspar (probably albite)
74760085 S10/16/7A	Chert or sandy rock containing grains up to 5 mm across SILICIFIED OOLITIC INTRACLASTIC PACK-STONE	Rather chaotic mixture of siliceous sand grains, overgrowths, matrix, and clasts	Most clasts are probably silicified carbonate with some ooids bound by fine-grained silica matrix
		Muscovite	Scattered flakes
74760086 S10/18/4C	Grey dolomite with some pink and green laminae SANDY, CLAYEY DOLOMITE	Dolomite (90%)	Varies from very fine-grained to coarse recrystallized
		Quartz } 10%	In some laminae; up to 0.5 mm diam., embayed
		Clay } 10%	Green, fine grained; some chert and chalcedony

TABLE 19: (Contd.)

BMR registered no. and field no.	Rock name and general description	Mineral present	Remarks
74760087 S10/20/2A	INTRACLASTIC PACKSTONE	Dolomite (95%)	Intraclasts 1-3 mm set in recrystallized matrix; slightly silty
		Quartz	Scattered medium sand; much embayed.
74760088 S10/20/2B	FELDSPATHIC, GLAUCONITIC, DOLOMITIC SANDSTONE	Quartz 80%	0.1–0.3 mm and some coarser overgrowths; embayed;
		Feldspar 5%+	Tabular untwinned and twinned microcline some authigenic
		Glauconite 5%	Green, fine-grained, small well rounded pellets
		Chert 5%	Well rounded grains
		Matrix/cement dolomite	Crystalline; also some intraclasts up to 1 cm
74760089 S11/31/4	CHERT (SILICIFIED DOLOMITE)	Quartz 100%	Granular chert and fibrous chalcedony in thin laminae
74760090 S11/33/12A	OOLITIC, SANDY DOLOMITE	Dolomite 95%+	Alternating micrite-cemented oolitic bands and pure micrite bands
		Quartz	Scattered sand, silt and chert
		Mn oxides	Minor, interstitial, opaque
74760091 S11/33/12B	LITHIC SANDSTONE	Quartz 80–90%	0.3–0.5 common; some 1 mm; 2 generations syntaxial cement
		Rock fragments 10–20%	Acid volcanics, composite quartz, chert, silicified ooids
		Accessories	Rounded tourmaline, zircon?, interstitial limonite
74760092 S11/33/13B	DOLOMITE	Dolomite 99%	Very fine-grained, except for lens-shaped areas of coarsely recrystallized carbonate
		Chert, limonite	Minor constituents

TABLE 19: (Contd.)

BMR registered no. and field no.	Rock name and general description	Mineral present	Remarks
74760094 HC8/63/11B	Porous, leached (?) fine LITHIC SANDSTONE	Quartz 50%	Angular, fine sand-size
		Rock fragments 20%	Composite quartz, acid volcanics, chert, claystone grains
		Matrix 30%	Low birefringence - similar clay to that in grains
74760095 HC8/63/13A	PARTLY SILICIFIED MUDSTONE	Clay	Very low birefringence
		Quartz	Very fine silt sizes
		Limonite	Fine staining throughout
74760096 HC10/21/1	INTRACLASTIC WACKESTONE	Dolomite 100%	Recrystallized, with coarse, spar-like grains between irregular, fine carbonate intraclasts 0.5-3.0 mm long.
74760098 HC10/22/10	LAMINATED, SILTY MICRITE	Dolomite 80-90%	Very fine laminae alternate with coarser (silt-size) laminae
		Quartz 10-20%	Silt-sized, in coarser laminae, strongly embayed
		Muscovite	Scattered flakes
		Feldspar	Scattered detrital grains
74760099 HC10/22/11	LITHIC SANDSTONE (feldspathic, glauconitic)	Quartz 70%+	0.1-0.3 mm; syntaxial overgrowths
		Rock fragments 15-20%	Mostly rounded shale clasts
		Feldspar 5-10%	Fresh, microcline and tabular untwinned grains; authigenic grains common
		Glauconite 5%	Scattered, rounded, fine aggregates in pellets
		Accessories	Muscovite, well-rounded tourmaline and zircon
74760100 S11/23/9A	LAMINATED MICRITE	Dolomite 99%+	Light and dark laminae; these correspond to coarse and very fine carbonate respectively
		Quartz	Minor silt

It seems likely that the Murphy Tectonic Ridge was a landmass, or stable area, during the deposition of the 'Walford Dolomite', and provided at least some detritus to the formations.

'Mount Les Siltstone'*

Derivation of name. From the Carpentaria Exploration Company's Mount Les prospect, located at grid reference 857222, in the Hedleys Creek Sheet area.

Distribution. The 'Mount Les Siltstone' crops out in a belt extending from Wire Creek in the east to Pandanus Creek in the west. The belt is generally about 1 km wide, and covers a total area of about 30 km^2.

Type section. Along a geophysical line cut by Carpentaria Exploration Company. The base is at grid reference 906243, about 5 km east-northeast of the Mount Les prospect; from here the section runs 450 m in a southeasterly direction. A diamond-drill hole (DDH 3, grid ref. 906243), provides a good section of the lower part of the unit.

Stratigraphic relations. The contact with the underlying 'Walford Dolomite' is conformable and gradational, and the boundary is placed above the last major dolomite or chert bed. The upper contact is sharp and probably disconformable.

Topography. The formation forms gentle, slightly terraced slopes and low, rounded hills less than 30 m high.

Lithology. Most outcrops of the 'Mount Les Siltstone' are highly weathered, and bear little resemblance to drill-hole samples. At the type section the unit consists of a uniform sequence of light brown to purple fissile and flaggy finely laminated mudstone with a few thicker beds, probably of siltstone.

In outcrops near the Mount Les prospect the formation consists of white and pale green, massive and blocky structureless claystone. Vague laminae are present within the claystone, and quartz and carbonate silt are scattered within it (sample 72762073). Before weathering the rock was probably a dolomitic silty shale.

At the type section DDH3 penetrated 51 m of shale and siltstone before entering massive dolomite of the underlying formation; the uppermost 15 m is highly weathered siltstone, and overlies 19 m of black dolomitic siltstone and 17 m of interbedded black and white shale. Similar rocks were observed in other drill holes such as DDH7 (grid ref. 965268) in which 64 m of 'Mount Les Siltstone' were penetrated including two green shale layers totalling 19 m in thickness.

* NB - shown incorrectly on the accompanying Hedleys Creek 1:100 000 Sheet as 'Mount Les Formation'.

TABLE 20: Thin-section descriptions, 'Mount Les Siltstone'

BMR registered no. and field no.	Rock Name	Mineral present	Remarks
72762073 HC10/21/5E	DOLOMITIC SHALE	Clay 50%+	Very low birefringence; very fine-grained
		Dolomite 40%+	Small grains of silt/clay-size
		Quartz	Scattered silt grains
74760123 HC10/21/6	CLAYEY QUARTZ SILTSTONE	Quartz 50%	Coarsest silt-size; angular
		Mica 10-20%	Flakes with yellow-orange birefringence, may be illite or sericite
		Clay 20-40%	Kaolinite (?) very fine-grained
74760137 S10/16/5B	Pinkish brown dolomite with radiating crystals up to 5 cm long	Dolomite 90%+	Recrystallized - the radiating clusters are formed of elongate calcite crystals.
	RECRYSTALLIZED DOLOMITE	Clay/quartz 10%	Thin films between calcite crystals

The westernmost outcrops of 'Mount Les Siltstone' are in the southeastern part of the Seigal Sheet area, between Pandanus Creek and the Queensland/Northern Territory border. The base of the unit is taken as immediately above massive white chert assigned to the 'Walford Dolomite'. The formation is well exposed 2 km west of the Queensland border, 7.5 km southwest of the Mount Les prospect. Here fissile, leached siltstone is interbedded with flaggy, laminated dolomite beds, up to 20 cm thick, which contain clusters up to 3 cm long of limonite pseudomorphs after pyrite. Above are finely laminated brown to grey siltstone and shale.

About 6 km to the northwest a scree slope below a mesa of 'Doomadgee Formation' consists entirely of massive white siliceous claystone, which is assumed to be 'Mount Les Siltstone'. At the base of the slope there is some pink crystalline dolomite made up of radiating clusters of thin fibrous crystals up to 5 cm long (74760137).

West of Pandanus Creek the southern boundaries of most 'Walford Dolomite' outcrops are faults or unconformities, and the 'Mount Les Siltstone' is absent. In the east the 'Mount Les Siltstone' is well exposed at the Lead Hill prospect, where Wire Creek has a high eastern bank. The exposure here consists of fissile to flaggy white and pale brown siltstone beds 1-20 cm thick, and thin interbeds and laminae of green shale. These rocks are capped by chert conglomerate of the 'Doomadgee Formation' 300 m south of the prospect. At the Lead Hill prospect the 'Mount Les Siltstone' is about 55 m thick, of which the lower 30 m was penetrated in DDH5 (grid ref. 966290).

Thickness. Several diamond-drill holes have penetrated the 'Mount Les Siltstone', including DDH7, which intersected 64 m of the formation. The estimated thickness for the whole formation varies from 55 m at Lead Hill to about 90 m at the type section.

Petrography. Thin section descriptions are summarized in Table 20.

Environment of deposition. The shales and siltstones include both black and green varieties (Taylor, 1970), and are thinly laminated. Several dolomite beds occur in the unit, but they are recrystallized micrites, and do not appear to have contained ooids, intraclasts, or algal laminae. Pseudomorphs after pyrite are present at one locality. The presence of pyrite and black shales may indicate both reducing conditions and deeper water than during the deposition of the 'Walford Dolomite'. The 'Walford Dolomite' and 'Mount Les Siltstone' may also represent a transgressive sequence, so that at least some of the siltstone and shale of the latter formation may be contemporaneous with the shallow-water facies of the 'Walford Dolomite'.

'Doomadgee Formation'

Derivation of name. From Doomadgee Mission Station, a settlement near the Nicholson River about 30 km east of the eastern margin of the Hedleys Creek Sheet area.

Distribution. The 'Doomadgee Formation' crops out in a southwest-trending belt up to 2 km wide in the Hedleys Creek Sheet area. Most of the outcrops are southwest of Hedleys Creek, but a few, totalling about 10 km^2, are present northeast of the creek. In the Seigal Sheet area the formation crops out over about 100 km^2 in the southeastern corner, and extends southwards into the Cleanskin 1:100 000 Sheet area.

Type section. Runs southeasterly, parallel to and 1 km northeast of Gorge Creek, in the Hedleys Creek Sheet area. The base of the section is at grid reference 878225, and the top is 1.6 km to the southeast, at 890214.

Stratigraphic relations. The contact with the underlying 'Mount Les Siltstone' is sharp, and the basal beds of the 'Doomadgee Formation' include conglomerates containing chert and silicified claystone granules and pebbles. This is thought to indicate erosion of the 'Mount Les Siltstone' and 'Walford Dolomite', and thus a disconformity at the base of the 'Doomadgee Formation'.

The 'Doomadgee Formation' is overlain disconformably in the east, and with angular unconformity in the west, by the Constance Sandstone.

Lithology. The 'Doomadgee Formation' includes conglomerate, sandstone, siltstone, shale, and dolomitic rocks, unlike the two older formations in the Fickling Group, which are dominantly dolomite and siltstone.

At the basal contact exposed 2 km northeast of Lead Hill, about 20 cm of sedimentary breccia, made up of angular chert clasts 5-10 cm across in a very sparse matrix, is present. The breccia is overlain by 1 m of laminated light greenish grey fine sandstone, which is succeeded by a thin conglomerate bed containing smaller clasts and more matrix than the basal breccia. The clasts are of grey and white chert; some are laminated and indistinguishable from silicified 'Walford Dolomite', and others may be silicified claystone derived from the 'Mount Les Siltstone'.

An exposure near the Northern Territory border consists of coarse sandstone with lenses of cobble conglomerate. Well rounded cobbles of white and greenish orthoquartzite, as well as subangular clasts of white laminated and oolitic chert, are present. The clasts are up to 20 cm across.

Plate 14: Poorly sorted basal conglomerate of the 'Doomadgee Formation' 7 km southeast of the confluence of Pandanus and Rocky Creeks, Seigal Sheet area (Neg. no. GAB/5).

At some localities conglomerate is not present at the base of the unit. For example, 2 km south of the 'First Up' lead prospect, pink ferruginous dolomite of the 'Mount Les Siltstone' is overlain by thin-bedded clayey sandstone, coarser bimodal sandstone with chert and quartz grains, siltstone, and fine-grained flat-bedded and cross-bedded sandstone of the 'Doomadgee Formation'.

At its westernmost outcrops the basal 'Doomadgee Formation' forms mesa cappings similar to those of the nearby Constance Sandstone. Because of this similarity, part of the 'Doomadgee Formation' east of Pandanus Creek was mapped as Constance Sandstone by Roberts et al. (1963). In these cappings beds of conglomerate over 2 m thick contain well-rounded orthoquartzite cobbles and subrounded ones of chert (Plate 14).

The remainder of the lower part of the 'Doomadgee Formation' (shown as Bfd_1 on the accompanying maps) consists of fine-grained, thin-bedded, flaggy quartz sandstone with some pebbly, silty and ferruginous layers. Some of the sandstone may be dolomitic, and one lens of gritty dolomite was noted in the southeastern part of the Seigal Sheet area.

The middle part of the 'Doomadgee Formation', mapped as Bfd2, is well exposed in undercut bluffs in creek banks. It consists of dark grey highly fissile shale with some silty shale and flaggy siltstone interbeds, (Table 21, no. 74760134). In the type section of the formation, green and red shale beds are present. In exposures near Wire Creek and in the type section. flaggy interbeds up to 30 cm thick consisting of white silt or clay composed of quartz or clay minerals have spherical spots of limonite 0.5-3 mm across (Table 21, no. 72762071). In some of the interbeds, the limonite is weathered out, leaving vaguely cubic holes, which indicate that the patches are alteration products, perhaps after pyrite.

Taylor (1970) noted the presence of the black shale unit, and recorded minor sphalerite occurrences in ferroan dolomite nodules within it. An IP anomaly over the black shale was considered by Taylor to be too large to be explained by the relatively small amounts of lead and zinc in the unit, and he concluded that the anomaly was probably caused by carbon in the black shale.

The upper part of the 'Doomadgee Formation' (Bfd_3) is variable, and ranges from pebble conglomerate to dolomite. In the type section, and in outcrops up to 4 km along strike to the northeast, it consists of distinctive reddish brown recrystallized dolomite interbedded with dolomitic conglomerate, overlain by flaggy, fine to very fine-grained sandstone which is capped unconformably by the Constance Sandstone. The conglomerate interbeds consist of poorly sorted quartz sand grains, flakes or clasts of green clay or siltstone, and dolomite intraclasts set in a matrix of micritic dolomite (Table 21, no. 74760124). The weathered outcrop is manganese-stained.

Ten kilometres southwest of the type section black micaceous silty shale of Bfd_2 grades upwards into very fine-grained thin-bedded and laminated brown-weathering silty sandstone of Bfd_3. The bedding is wavy owing to low-angle cross-beds or ripple-marks, and a manganese bloom coats joint surfaces.

Northeast of Wire Creek, Bfd_2, photo-interpreted as forming a soft-weathering scarp slope, is capped by a resistant siliceous rock, which is assumed to be basal Bfd_3. This siliceous rock also forms several fault-bounded cuestas east of Wire Creek. The siliceous rock, although sandy, is not now a sandstone, but a chert with relict outlines of grains or intraclasts (Table 21, nos. 74760135, 136). It is thin bedded to laminated, and may have been a sandstone/siltstone facies, or alternatively a sandy laminated dolomite micrite which has been silicified. The beds above are, like those in the southwest, manganese-stained fine-grained laminated sandstone (Table 21, no. 74760133).

The most complete sections of Bfd_3 are in the south-eastern corner of the Seigal Sheet area, and in the adjoining Mount Drummond 1:250 000 Sheet area. The sequence is well exposed in a series of topographic benches 2 km northwest of the confluence of the South Nicholson and Nicholson Rivers. Here dolorudite containing chert clasts grades up into dolomitic sandstone which is trough cross-bedded on a large scale (sets 2-5 m across). An overlying second dolorudite bed is capped by several metres of orthoquartzite, which in turn is overlain by fissile to flaggy fine-grained sandstone with prominent primary current lineations.

In the Mount Drummond 1:250 000 Sheet area, Bfd_3 is exposed in an anticline which closes to the south. Here it was mapped as Fickling Beds by Smith & Roberts (1963). The oldest exposed beds are massive, white-weathering fine clayey sandstone; these are overlain by white quartz sandstone, manganese-stained laminated sandstone, and dolomite. No prominent shale unit was noted, and the whole sequence, which is 400 m thick, is considered to be Bfd_3, which is therefore much thicker here than in the type section.

Thickness. The thickness of the 'Doomadgee Formation' in the type section is about 180 m, of which Bfd_1 = 60 m, Bfd_2 = 30 m, and Bfd_3 = 90 m. No thicknesses were estimated northeast of the type section, as the sequence here is complicated by faulting. Unit Bfd_3 is over 100 m thick southwest of a zone of faulting in the adjacent corners of the Hedleys Creek and Seigal Sheet areas, beneath the Constance Sandstone, and is at least 400 m thick in the northern part of the Mount Drummond Sheet area.

Petrography. Descriptions of thin sections of the 'Doomadgee Formation' are summarized in Table 21, and illustrate the variable nature of the unit. The lower part of the unit (Bfd_1) is not very dolomitic, but contains clasts and grains of silicified carbonate and claystone. Similar clasts occur in Bfd_3, and it seems likely that erosion of the 'Mount Les Siltstone' and 'Walford Dolomite' took place during the deposition of the 'Doomadgee Formation', and that much of the material in the formation was derived from these lower units.

Dolomite is common in Bfd_3, and most is authigenic rather than detrital. Dolomite clasts may be derived from within the unit, but the silicified oolitic rock fragments were probably derived from the underlying units.

The presence of fresh microcline grains in some samples suggests that the granitic basement forming the Murphy Tectonic Ridge was probably exposed during deposition of the 'Doomadgee Formation'. Authigenic rhomb-shaped crystals of feldspar in several samples are probably albite. The authigenic feldspar occurs both as overgrowths on detrital feldspar grains, and as separate small crystals up to 0.1 mm across.

Environments of deposition and palaeogeography. The lower units of the Fickling Group are considered to have been exposed during a period of uplift, and were partly eroded and redeposited as the basal 'Doomadgee Formation' during a new transgression. The environment was a high-energy one, as is shown by the presence of conglomerate, and deposition must have been rapid, because the grains are generally not well sorted or rounded. As the transgression proceeded, shales (Bfd_2) were deposited in deeper water, over shallow-water conglomerate and sandstone. A later phase of uplift caused a renewed influx of coarse detritus and perhaps a shallowing of the sea, so that clastic sediments and shallow-water dolomitic sediments were deposited.

The 'Doomadgee Formation' appears to thicken south of the Seigal Sheet area, but it is not known whether this is a primary thickening, or due to local preservation of more of the original thickness. Similarly, it is not known whether the two older formations of the Fickling Group were eroded from the western part of the Seigal Sheet area before the deposition of the 'Doomadgee Formation'.

TABLE 21: Summary of thin section data for the 'Doomadgee Formation'

BMR Registered number and field number	Rock name and brief description	Minerals present	Remarks
72762071 HC9/07/1C	White CLAYSTONE with limonite spots	Clay 70%	White, very low birefringence (kaolinite?)
		Limonite	Forms patches 0.5-2.0 mm across; appear circular in thin section but may originally have been cubes (? pseudomorphs after pyrite)
72762072	QUARTZ SILTSTONE	Quartz 80%	Angular interlocking grains of coarse silt-size
		Feldspar 5%	Rhombs scattered throughout; albite? - authigenic
		Clay 10%	As grains: cloudy, low-moderate birefringence; also as matrix
		Mica 5%	Detrital muscovite flakes; also some chlorite
		Accessories	Tourmaline, zircon
74760125 S12/62/4B	RECRYSTALLIZED SILTY DOLOMITE	Dolomite 50%	Recrystallized 'nodules' 3-5 mm across of radially oriented stained or fibrous dolomite. Where two 'nodules' meet the crystals or fibres are intergrown; some are curved
		Quartz, Muscovite and clay } 50%	Patches with partly recrystallized dolomite between nodules
74760126 S13/68/1A	DOLOMITIC SEDIMENTARY BRECCIA	Matrix	Fine-grained angular to subrounded quartz grains and coarsely crystalline dolomite
		Clasts	Chert, chalcedony (some replacing dolomite), oolitic dolomite, glauconite flakes, fine-grained clastics

TABLE 21: (Contd.)

BMR Registered number and field number	Rock name and brief description	Minerals present	Remarks
74760124 HC9/04/1	Poorly sorted dolomitic sandstone LITHIC SANDSTONE	Quartz 50%	Poorly sorted, subrounded syntaxial overgrowths; 0.2-1.0+ mm
		Rock fragments 45%+	Dolomite: irregular, tabular clasts 1-3 mm common; silt and sand-size carbonate grains Others: acid volcanics, chert, chalcedony (partly authigenic)
		Feldspar 1%	Scattered microcline grains
		Matrix/cement	Syntaxial quartz, chalcedony, recrystallized dolomite with opaque staining along cleavages
74760131 HC9/05/17B	Gritty sandstone LITHIC SANDSTONE	Quartz 50%	Most grains are 0.5 mm; also syntaxial overgrowths;
		Rock fragments	Mostly chert, chalcedony, dolomite (includes single ooids, and one of oolitic wackestone), and claystone grains
		Matrix	Scattered dolomite (detrital?)
74760133 HC8/66/7	Porous quartz SANDSTONE	Quartz	0.1-1.0 mm (bimodal); subrounded to well rounded; not syntaxial quartz
		Rock fragments	Silty shale, rounded chalcedony
		Accessories	Tourmaline, zircon
		Cement 20%	Chert/chalcedony - may be secondary silification
74760134 HC9/07/1A	Dark grey laminated SHALE	Quartz	Scattered grains and laminae of coarse silt.
		Clay minerals	Illite or sericite, scattered detrital muscovite flakes
		Limonite (?)	Scattered opaque spots (after pyrite?), dark brown staining
74760135 HC9/07/9B	Poorly sorted sandy (?) chert SILICIFIED? DOLOMITIC SANDSTONE	Quartz 50%	Scattered grains in chert and chalcedony. Some laminae of fine quartz sandstone
		Acessories	Rounded tourmaline, zircon

TABLE 21: (Contd.)

BMR Registered number and field number	Rock name and brief description	Minerals present	Remarks
74760136 HC9/08/3	As for 74760135		As for 74760135 except that scattered specks of dolomite are present throughout and many quartz grains are strongly embayed by chert
74760140 S13/68/1B	SANDY DOLOMITE	Dolomite 70%+	Partly recrystallized; also some clasts (micritic)
		Quartz	Medium to coarse sand grains, well rounded; numerous composite grains
		Rock fragments	One grain of marl, two of acid volcanics
74760141 S13/72/2B	SANDSTONE with chalcedonic matrix		Brown, slightly limonitic carbonate (micrite) grains, together with fine quartz grains, set in chalcedony
74760142 S13/72/2C	BRECCIATED STROMATOLITIC? DOLOMITE	Dolomite 80%+	Circular patches of laminated micrite and recrystallized carbonate 2-5 mm across - brecciated stromatolite laminae or oncolites
		Chalcedony 20%	Line or fill interstices between dolomite
74760144 S12/62/1	Grey sandstone with limonitic patches up to 1 cm across LITHIC SANDSTONE	Quartz 75%?	0.1-0.6 mm, poorly sorted or bimodal, subrounded with syntaxial overgrowths;
		Feldspar 5-10%	Partly altered K feldspar (no twinning) grains; some authigenic crystals (albite?)
		Rock fragments 10-15%	Composite quartz grains, chert, chalcedony, one silicified ooid, silty claystone
		Concretions?	Patches of quartz grains cemented by limonite-stained carbonate (siderite?)

SOUTH NICHOLSON BASIN

CARPENTARIAN OR ADELAIDEAN

South Nicholson Group

Rocks of the South Nicholson Group form a prominent escarpment west of Lawn Hill Creek. Cameron (1901) noted that quartzites and limestones of the Constance Range are unconformable on fine-grained sandstone, shales, and mudstones (the latter belong to the Lawn Hill Formation). Jensen (1941) reviewed the early literature of these rocks and also (Jensen, 1941 unpubl.) discussed the age and correlation of them in the Lawn Hill and Nicholson River areas. He named them the Constance Range Series and Nicholson limestone and Quartzites respectively and regarded them as part of the same sequence. This was confirmed by Carter (1959), Carter & Opik (1961) and Carter et al (1961), who formally named the rocks the Constance Sandstone and Mullera Formation. Roberts et al. (1963) and Smith & Roberts (1963) showed that these units extend to the west and northwest, and are part of what they named the 'South Nicholson Group'.

Sandstone mapped as Constance Sandstone by Carter (1959) in the northern part of the Westmoreland 1:250 000 Sheet area has since been shown to belong to the older Tawallah Group (Roberts et al., 1963).

Distribution. The South Nicholson Group in the Westmoreland region occupies most of the southern quarter of the Seigal Sheet area, and the southern one third of the Hedleys Creek Sheet area, and it also crops out in the Bowthorn 1:100 000 Sheet area (Fig. 1), the northern quarter of which was mapped during the recent survey.

Derivation of name. From the South Nicholson River, in the Mount Drummond 1:250 000 Sheet area.

Constituent units. Two formations of the South Nicholson Group are present in the region - the Constance Sandstone and the Mullera Formation (Table 22). Three siltstone members - the Pandanus, Wallis, and Bowthorn Siltstone Members are recognized within the Constance Sandstone: the two lower members were defined by Roberts et al. (1963), but the 'Bowthorn Siltstone Member' is a new unit.

Stratigraphic relations. The Constance Sandstone, the oldest formation of the group in the area, lies disconformably and unconformably on the Fickling Group in the Hedleys Creek and

TABLE 22: Summary of stratigraphy of the South Nicholson Group

Rock unit and symbol	Thickness (metres)	Lithology	Remarks
MULLERA FORMATION (Bsl)	-	Micaceous siltstone and fine sandstone; shale	Observed in only one exposure. Conformable on Bsa_3 in Seigal Sheet area
CONSTANCE SANDSTONE Bsa	100 - 300	Medium quartz sandstone	Designated as such where one or more of the siltstone members is absent
Bsa_4	140	Medium quartz sandstone	
'Bowthorn Siltstone Member' (Bsa_b)	200	Micaceous siltstone with medium quartz sandstone beds	May be a tongue of Mullera Formation
Bsa_3	100 - 160	Medium and coarse quartz sandstone	Overlain by Mullera Formation in Seigal Sheet area, but by Bsa_b, Bsa_4 in Hedleys Creek Sheet area
Wallis Siltstone Member (Bsa_w)	0 - 100	Micaceous fine sandstone and siltstone; quartzose and glauconitic	Variable thickness; absent in western and southeastern parts of Seigal Sheet area
Bsa_2	120 - 320	Medium-grained cross-bedded orthoquartzite	
Pandanus Siltstone Member (Bsa_p)	0 - 130	Fissile and flaggy coarse micaceous siltstone, shale, and fine sandstone	Lenses out in southeastern part of Hedleys Creek Sheet area
Bsa_1	1 - 90	Medium and coarse sandstone; pebble and cobble conglomerate lenses	Angular chert (silicified dolomite) clasts predominate. Disconformable and unconformable on Fickling Group

Seigal Sheet areas, and on Lawn Hill Formation and Ploughed Mountain Beds in the Bowthorn Sheet area. The group is overlain with marked angular unconformity by Lower Cretaceous rocks.

Topography. The group, consists mostly of sandstone which forms rugged plateaux where it is flat-lying, and cuestas or hogbacks where it has been tilted or folded. The Mullera Formation, however, which consists mainly of siltstone, is more easily weathered and forms rounded hills.

Lithology. The Constance Sandstone consists of medium-grained orthoquartzite with conglomeratic lenses at the base and several micaceous siltstone interbeds. The Mullera Formation consists of siltstone similar to the interbeds below it, but to the south it also includes highly ferruginous sandstone beds which are sufficiently rich in iron to be classed as iron ore (Carter & Zimmerman, 1960; Harms, 1965).

Constance Sandstone

Derivation of name. From the Constance Range, a prominent north-trending escarpment up to 200 m high in the western part of the Lawn Hill 1:250 000 Sheet area.

Distribution. The formation underlies a large area in the Calvert Hills, Westmoreland, Mount Drummond, and Lawn Hill 1:250 000 Sheet areas. Only the outcrops in the first two named Sheet areas are described in this report.

Type section. The type section, nominated by Carter et al. (1961), is in the western part of the Lawn Hill Sheet area about 39 km south of Bowthorn homestead. It extends 'from lat. 18°27'35"S, long. 138°17'00"E, east-southeast about 4 miles to the base of the formation'.

Stratigraphic relations. The Constance Sandstone in its type area overlies Lawn Hill Formation and Ploughed Mountain Beds with marked angular unconformity, and farther south it is overlain unconformably by Camooweal Dolomite (Carter et al., 1961).

In the Hedleys Creek Sheet area the Constance Sandstone disconformably overlies 'Doomadgee Formation', but to the west, in the Seigal Sheet area, where the older rocks are more folded, it overlies the three formations of the Fickling Group with angular unconformity. In the western part of the Seigal Sheet area the Constance Sandstone overlies the 'Walford Dolomite', and farther west it is unconformable on Murphy Metamorphics (Roberts et al., 1963).

Topography. The Constance Sandstone forms a rugged, partly dissected plateau in the southern parts of the Hedleys Creek and Seigal Sheet areas. Where the rocks are faulted or steeply dipping the softer and more easily weathered siltstone members have been eroded to form valleys, and the sandstones between them form cuestas or hogback ridges.

Lithology. The Constance Sandstone consists mainly of medium-grained cross-bedded orthoquartzite with some coarse and pebbly beds. The three siltstone members consist of micaceous siltstone and fine sandstone.

Figure 7 shows the relative proportions of sandstone to siltstone. Mapping has not been completed in the Bowthorn Sheet area, where there is at least one siltstone unit above Bsa_4, whereas in the southern part of the Seigal Sheet area Bsa_3 is overlain by Mullera Formation.

Unit Bsa_1

Near Fickling Creek, 3 km west of the western margin of the Seigal Sheet area, an exposure of 5 m of flaggy to blocky fine to medium quartz sandstone is mapped as Bsa_1. Three kilometres to the northwest, sandstone tentatively mapped as Bsa_1 consists of medium-grained subarkose (Table 23, sample 74760155), and is the only arkosic sample noted in the unit. These two exposures of the Unit are the most western mapped.

Between the western margin of the Seigal Sheet area and the Fish River, a distance of 25 km, Bsa_1 is less than 10 m thick and consists of poorly sorted conglomerate containing angular chert clasts (Table 23, sample 74760145) and minor well sorted fine sandstone (sample 74760146). The unit is less than 1 m thick 16 km west of the Fish River, where it consists of indurated chert conglomerate with sparse matrix overlying silicified 'Walford Dolomite', from which it is difficult to distinguish. Bsa_1 thickens eastwards and near Pandanus Creek it consists of about 20 m of flaggy and blocky, cross-bedded and ripple-marked medium and coarse quartz sandstone with some chert grains; some cross-bed sets are up to 1 m thick, but most are small scale, and most ripple marks are linguoid (Plate 15). These ripple-marks and cross-beds indicate currents from the north-northwest.

Bsa_1 is thickest in the Hedleys Creek Sheet area, and appears to reach a maximum thickness of about 90 m between Hedleys and Wire Creeks. In this part of the area a flat-lying basal conglomerate 1 m to over 10 m thick contains well rounded pebbles and cobbles of white quartz and quartzite, and subangular to subrounded clasts of chert showing relict stromatolitic and oolitic structures. The conglomerate is generally massive, but displays some faint internal bedding. It is overlain by strongly

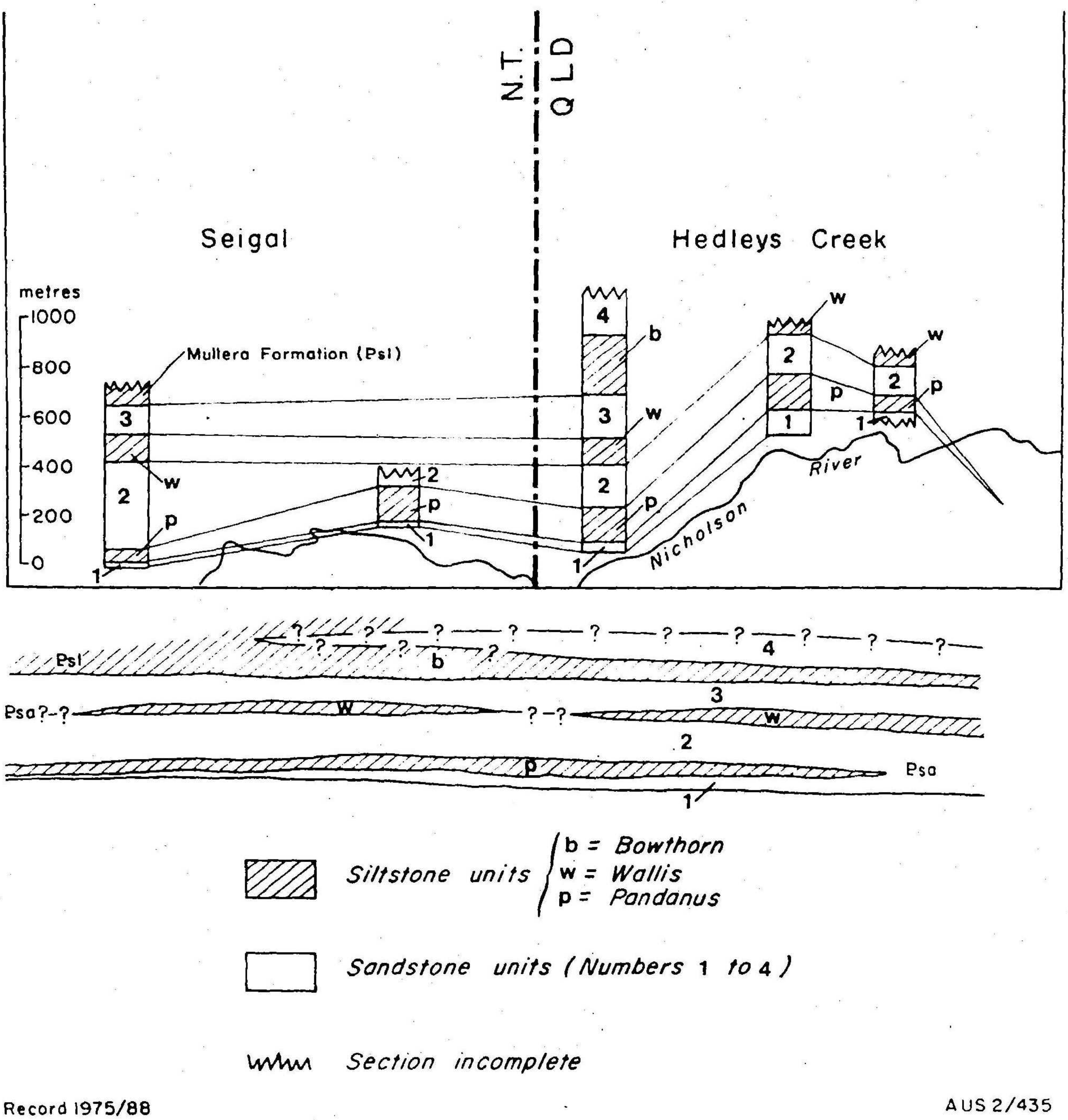

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Fig. 7 Measured sections of the Constance Sandstone and a schematic representation of the units within the formation in the Hedleys Creek and Seigal 1:100 000 Sheet areas.

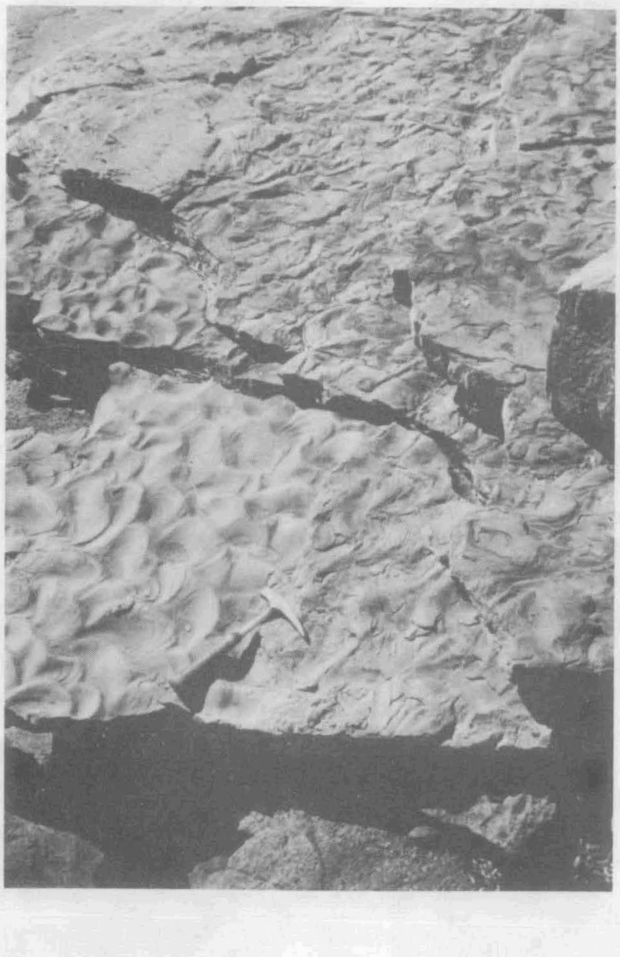

Plate 15: Linguoid ripple-marks on a bedding-plane of Constance Sandstone in the southern bank of Pandanus Creek, Seigal Sheet area (GA/9995).

cross-bedded friable sandstone which contains small pebbles and grit grains, and a sparse clay matrix. South of the Nicholson River in the eastern Hedleys Creek Sheet area, where the Pandanus Siltstone Member is absent, Bsa_1 is not distinguished from Bsa_2, both being labelled Bsa on the map. Here they consist of white, cross-bedded sandstone, some of which contains abundant rock fragments and matrix (Table 23, sample 74760148).

Pandanus Siltstone Member (Bsa_p)

The member was defined by Roberts (unpubl. MS), and was mapped in the Calvert Hills and Mount Drummond 1:250 000 Sheet areas by Roberts et al. (1963) and Smith & Roberts (1963) respectively. It was not distinguished in the Westmoreland 1:250 000 Sheet area by Carter (1959), although it forms a prominent valley between cuestas of sandstone in the Hedleys Creek Sheet area.

Type section. Roberts nominated a reference area around lat. 17°56'S, long. 137°52'E, about 5 km northwest of the confluence of Pandanus Creek and the Nicholson River. This is retained as a type section.

Stratigraphic relations. Both the lower and upper contacts of the Pandanus Siltstone Member, with Bsa_1 and Bsa_2 respectively, are conformable. Roberts (unpubl., MS) considered that the member formed the base of the Constance Sandstone in parts of the Calvert Hills Sheet area, but our mapping has shown that there is always at least a thin veneer (as little as 1 m) of Bsa_1 below it.

Lithology and thickness. The Pandanus Siltstone Member consists of fissile and flaggy, green, purple and reddish brown, coarse micaceous siltstone (e.g. 74760156) with shaly partings and thin interbeds of very fine sandstone. A prominent blocky sandstone bed is present in about the middle of the member in much of the Seigal Sheet area. Most exposures are in scarps capped by Bsa_2, and consist of weathered ferruginous rubble. The blocky sandstone bed is well exposed between 1 and 7 km east of Wallis Creek (grid ref. 685110). One kilometre east of the creek it comprises 2 m of cross-bedded, reddish, fine to medium quartz sandstone overlain by 2 m of blocky white fine-grained orthoquartzite. Six kilometres to the northeast the unit is about 5 m thick and consists of flaggy fine-grained sandstone showing low-angle cross-bedding, primary current lineations, mud clasts, and sandstone concretions (Table 23, 74760153, 0154). The sandstone forms a slight bench in a scarp in the type section, but was not observed farther east.

In the southwestern part of the Hedleys Creek Sheet area, the member is poorly exposed, as it is partly masked by Lower Cretaceous rocks. East and southeast of Wire Creek the upper part of the member crops out in low scarps, and the lower part is poorly exposed in valleys. Fine-grained labile sandstone beds and lenses are common here, interbedded with micaceous siltstone.

The Pandanus Siltstone Member increases in thickness from about 50 m in the west to at least 120 m at the type section.

It is estimated to be 130 m thick at Wire Creek, but it thins southwards, and is only 60 m thick near the Nicholson River 4 km southeast of Connolly Waterhole. Farther to the southeast the Pandanus Siltstone Member appears to have lensed out. The member is definitely absent in the Bowthorn Sheet area to the south, where the entire Constance Sandstone is well exposed.

Unit Ƀsa$_2$

Sandstone Ƀsa$_2$, between the Pandanus and overlying Wallis Siltstone Members, is the thickest unit in the formation. It forms rugged plateaux and cuestas, and is prominently jointed. It can only be identified as Ƀsa$_2$ where the two siltstone members are present; elsewhere it is included in Ƀsa.

In most of the Westmoreland region the unit consists of medium-grained white, pale grey, or brown quartz sandstone with minor matrix and quartz cement (e.g. 74760152). Most exposures display prominent tabular cross-bedding, but at some the sandstone is massive or shows only vague bedding. A characteristic feature of sandstone in the lower part of the unit is irregular silicification resulting in knobby exposures. At most exposures the sandstone contains scattered grains and thin beds of coarse sand and grit. Tourmaline as rounded grains is the most common accessory mineral.

At the base of Ƀsa$_2$ in the western part of the Seigal Sheet area there is a layer a few metres thick of ferruginous flaggy sandstone (Table 23, 74760150, 151) which appears to be transitional from the Pandanus Siltstone Member. Some apparent intertonguing with this member is seen in the east, 1 km north of the Nicholson River, where flaggy grey to brown fine to medium sandstone contains several thin shale interbeds.

The estimated maximum thickness of Ƀsa$_2$ is about 320 m, 3 km west of the Fish River; from here the unit thins progressively eastwards (Fig. 7).

Table 23: Thin-section descriptions, Constance Sandstone

BMR registered no., field no. and symbol of member	Rock name and/or general description	Minerals present	Remarks
74760145 S12/40/1A Bsa_1	Poorly sorted chert conglomerate LITHIC SANDSTONE	Quartz 95%+ in several forms	Scattered large (4 mm) grains set in sandy and silty matrix. Clasts are of chert and chalcedony, claystone, and silicified oolitic dolomite
74760146 S11/31/16 Bsa_1	Well sorted fine sandstone PROTOQUARTZITE	Quartz 85%	0.1–0.2 mm; rounded to well rounded grains; syntaxial quartz cement
		Rock fragments 10%	Mostly chert and chalcedony
		Feldspar 5%	Scattered rounded tabular grains; rare authigenic albite
		Accessories	Muscovite, tourmaline
74760148 HC12/71/1 Bsa	Grey-brown medium sandstone with white matrix SUBGREYWACKE?	Quartz 50–60%	
		Rock fragments 30–40%	Mostly acid volcanics
		Matrix 10%	Recrystallized to sericite
74760149 S10/09/2 Bsa_1	Chert conglomerate with white matrix LITHIC SANDSTONE	Quartz	
		Rock fragments	Sutured quartz, chert, chalcedony, claystone, acid volcanics?
		Feldspar	Scattered rhombs - authigenic albite
		Glauconite	Scattered rounded pellets
		Accessories	Limonite staining, tourmaline, rutile?
74760150 S10/09/1A Bsa_2	Mauve medium sandstone QUARTZ GREYWACKE?	Quartz 70–80%	0.2–0.5 mm with syntaxial overgrowths
		Matrix 20–30%	Clay and/or chlorite; some silt-size quartz
		Accessories	Fibrous limonite (after hematite?), tourmaline
74760151 S10/13/2B Bsa_2	Poorly sorted sandstone LITHIC SANDSTONE	Quartz 60%+	mainly grains 0.1–0.5 mm across
		Rock fragments 30%+	Acid volcanics?, chert
		Feldspar	Tabular, altered, detrital grains
		Accessories	Tourmaline

TABLE 23: (Contd.)

BMR registered no., field no. and symbol of member	Rock name and/or general descriptions	Minerals present	Remarks
74760152 S11/23/10 Bsa_2	Medium porous friable quartz sandstone ORTHOQUARTZITE		Well sorted, close packed grains
		Quartz 95%+	Few quartz overgrowths
		Matrix 5%	Small patches of quartz silt and clay
		Accessories	Tourmaline, Fe oxides
74760153 S11/31/10A Bsa_p	Fine SANDSTONE	Quartz 80%	Well sorted; 0.05-0.15;
		Opaques 10%	Skeletal, altered; ilmenite?
		Accessories	Much tourmaline, rutile
74760154 S11/31/10C Bsa_p	Fine sandstone with concretions of well cemented sandstone up to 2 cm across LITHIC SANDSTONE (PROTOQUARTZITE)	Quartz 90%+	
		Opaques 5%+	? May be altered volcanics
		Rock fragments 5%	Numerous cloudy, composite grains
		Accessories	Tourmaline, zircon?
74760155 S12/38/2 Bsa?	Well sorted, medium sandstone SUBARKOSE	Quartz 85%	Subrounded to rounded grains 0.3-0.5 mm; syntaxial cement
		Feldspar 10%+	Fresh microcline and orthoclase; authigenic rhomb-shaped overgrowths
		Rock fragments 5%	Sericitic rock, silicified ooid, claystone, siltstone, scattered opaques
74760156 S12/40/4 Bsa_p	Purple ferruginous micaceous siltstone COARSE SILTSTONE	Quartz 40-50%	Coarse silt to fine sand; angular grains
		Muscovite 5-10%	Very thin flakes
		Iron oxides 40%	Mostly limonite (after hematite?)
		Chlorite	Yellowish-green, associated with Fe oxides.
74760157 S12/48/1A Bsa_w	Greenish-grey quartz mica SILTSTONE	Quartz 50%	Coarse angular silt grains
		Muscovite) 50%	Thin flakes
		Chlorite) 50%	Flakes and fine-grained aggregates
		Glauconite) 50%	Scattered pellets
		Accessories	Scattered opaques and interstitial limonite in some laminae

TABLE 23: (Contd.)

BMR registered no., field no. and symbol of member	Rock name and/or general descriptions	Minerals present	Remarks
74760158 S12/48/2A Bsa_w	Purple-brown micaceous SILTY SHALE	Quartz 20-30%	Coarse silt grains
		Clay 70%+	Limonite-stained, fine-grained
		Muscovite	Large thin flakes
74760159 S12/48/2B Bsa_w	Glauconitic SAND-STONE AND SILTSTONE	Quartz 20%	Coarse silt and fine sand angular grains in abundant clay matrix
		Clay 70%	
		Glauconite 10%?	In coarser laminae; fine sand-size pellets
		Accessories	Scattered opaques and limonite
74760160 S12/48/2C Bsa_w	GLAUCONITIC SANDSTONE	Quartz 60-70%	Fine sand and some coarse silt grains
		Glauconite 20%+	Very fine-grained pellets
		Accessories	Scattered muscovite, chlorite, opaques, tourmaline, and zircon
74760161 S12/48/2D Bsa_w	ORTHOQUARTZITE	Quartz 95%+	Fine to coarse sand grains;
		Rock fragments 5%	Acid volcanics?, claystone?
		Tourmaline	Scattered grains
74760163 S13/84/1A Bsl	SHALE	Quartz 10-20%	Silt-size grains
		Sericite 80%+	Probably reconstituted clays;
		Detrital muscovite 1%	Scattered flakes

Wallis Siltstone Member (Esa_w)

This member was defined by Roberts (unpubl. MS) and was mapped by Roberts et al. (1963) in the Calvert Hills 1:250 000 Sheet area. It is also present in Mount Drummond, Westmoreland, and Lawn Hill 1:250 000 Sheet areas, but was not delineated on the 1st editions of those sheets.

Type section. Roberts (unpubl. MS) nominated a 'reference area..... around 17°56'S, longitude 137°40'E' in the Calvert Hills Sheet area. The type section nominated by us is in a scarp in that general area, at long. 137°41'E.

Stratigraphic relations. The upper and lower contacts of the member are both conformable.

Thickness. The member is 96 m thick at the type section and probably has a similar thickness for about 10 km westwards along strike. It thins rapidly between 10 and 15 km west of the type section, and is absent farther west in the Seigal Sheet area. However, Roberts et al. (1963) mapped the member in the western part of the Calvert Hills Sheet area. East of the type section the member has a constant thickness in an easterly direction, but it thins southwards, and lenses out just south of the southern margin of the Seigal Sheet area. However, a siltstone unit mapped as the Wallis Siltstone Member is present in the Hedleys Creek Sheet area, and is assumed to have been connected to the outcrops to the west before folding, faulting, and erosion.

Lithology. The dominant lithologies in the Wallis Siltstone Member are flaggy and fissile greyish-green and reddish brown micaceous siltstone and fine sandstone. In the type section, interbeds of fine micaceous sandstone and glauconitic sandstone are interbedded with siltstone. One kilometre to the east similar thin sandstone beds show ripple laminations, shaly partings, primary current lineations, and skip casts, and thicker sandstone beds show pillow structures.

The rock types exposed in the Hedleys Creek Sheet area are identical to those in the type section, and include glauconitic sandstone. The thickness exposed in one section in the southwestern part of the Hedleys Creek Sheet area is 90 m, or almost the same as that in the type section.

Unit Esa_3

Overlying the Wallis Siltstone Member is another sandstone unit, which, in the southwestern part of the Hedleys Creek Sheet area and the adjacent part of the Bowthorn Sheet area, is strongly jointed and forms rounded tors and bare rock outcrops up to 10 m high (Plate 16). Here the unit consists of reddish-brown

Plate 16: Stereoscopic pair of aerial photographs showing weathering pattern of Unit Ƥsa$_3$ of the Constance Sandstone at the confluence of Border Creek (centre) and the Nicholson River (top), in the southwestern part of the Hedleys Creek 1:100 000 Sheet area (From 1:25 000-scale colour photographs Bowthorn Run 1, Nos. 0035, 0036).

cross-bedded friable medium sandstone with a clayey matrix, and the erosion forms are attributed to the uniform composition and induration of the sandstone. In other exposures the unit has a similar lithology, but also includes some coarse sand and gritty lenses in foreset beds. Black specks visible in some samples are probably tourmaline grains.

Ɛsa$_3$ dips gently southwards in the Seigal Sheet area, and is probably about 100 m thick. It thickens eastwards, and is at least 160 m thick in the southwestern part of the Hedleys Creek Sheet area.

Younger members in the Constance Sandstone

The Mullera Formation overlies Ɛsa$_3$ in the Seigal Sheet area, but in the Hedleys Creek and Bowthorn Sheet areas unit Ɛsa$_3$ is overlain by a siltstone member which is overlain in turn by more sandstone. The siltstone has been tentatively called the 'Bowthorn Siltstone Member' of the Constance Sandstone. It will be defined formally after mapping of the Bowthorn Sheet area is complete. The siltstone is virtually identical to the two lower siltstone members of the Constance Sandstone, and also to siltstone beds in the Mullera Formation, and it seems likely that the Constance Sandstone and Mullera Formation intertongue (Fig. 7). In the southwestern part of the Hedleys Creek Sheet area the 'Bowthorn Siltstone Member' is about 200 m thick, and is overlain by sandstone unit Ɛsa$_4$, about 140 m thick.

Mullera Formation

Fine grained silty micaceous sandstone and siltstone, and dark grey to black shale crop out in the southern Seigal Sheet area, where they overlie Ɛsa$_3$. They crop out extensively in the Mount Drummond 1:250 000 Sheet area to the south (Smith & Roberts, 1963) and are assigned to the Mullera Formation. They were not examined in detail during this survey.

Petrography

Sixteen thin sections of the Constance Sandstone, including some of siltstone samples, have been examined, and their descriptions are tabulated in Table 23. The sandstones range from orthoquartzites to lithic sandstones (mostly protoquartzites in the classification of Pettijohn, 1957). One sandstone designated 'quartz greywacke' (74760150) is so named because it has a high proportion of matrix but contains only quartz clasts (i.e., no rock fragments). Most samples contain rock fragments, most of which may be derived from the underlying Fickling Group. Scattered feldspar grains are present, mostly fresh microcline, indicating granite outcrops in the source area - probably the Murphy Tectonic Ridge. Although some opaque grains may be altered acid volcanics, only one sample, 74760148, from the eastern part of the Hedleys Creek Sheet area, contains grains identified as acid volcanics.

Depositional environments and palaeogeography

Both the sandstones and siltstones in the Constance Sandstone show shallow water sedimentary structures - cross-bedding, ripple marks, primary current lineations, and skip casts. Clay pellets were observed in some beds, but no mud cracks were seen. The rocks were probably laid down in shallow-water marine environments - the sands in nearshore high-energy environments, and the silts in either offshore (deeper water) or nearshore low-energy environments. The presence of glauconitic sands in the Wallis Siltstone suggests that on offshore environment is more likely, as glauconite forms most commonly in neritic environments. Deposition probably took place during several transgressions and regressions.

The formation appears to thicken eastwards (Fig. 6), and an examination of the aerial photographs suggests that a thick sandstone sequence is also present in the southeast, in the Bowthorn Sheet area. This might imply that the sand was supplied from the east. However, the presence of microcline, tourmaline, and acid volcanic grains also suggests that the Murphy Tectonic Ridge may have supplied some sediment.

STRATIGRAPHIC CORRELATIONS

The correlations made between rocks in the McArthur Basin and those in the 'Lawn Hill Platform' are summarized in Figure 8, and their regional significance is discussed by Plumb & Sweet (1974). The main feature of the correlation is that the Peters Creek Volcanics in its type area in the 'Lawn Hill Platform' is the time equivalent of virtually all of the Tawallah Group. Previously the Peters Creek Volcanics had been regarded as equivalent to only the Seigal Volcanics. The evidence used in coming to the conclusions shown in Figure 8 was the marked similarity between the Seigal Volcanics and Unit 1 of the Peters Creek Volcanics; between the Wollogorang Formation and Unit 3 of the Peters Creek Volcanics; and between the volcanic members of the Masterton Formation and the upper units of the Peters Creek Volcanics.

If these correlations are correct, they indicate that the McDermott Formation, Sly Creek Sandstone, and Aquarium Formation probably lensed out against the Murphy Tectonic Ridge, and were not deposited in the 'Lawn Hill Platform'.

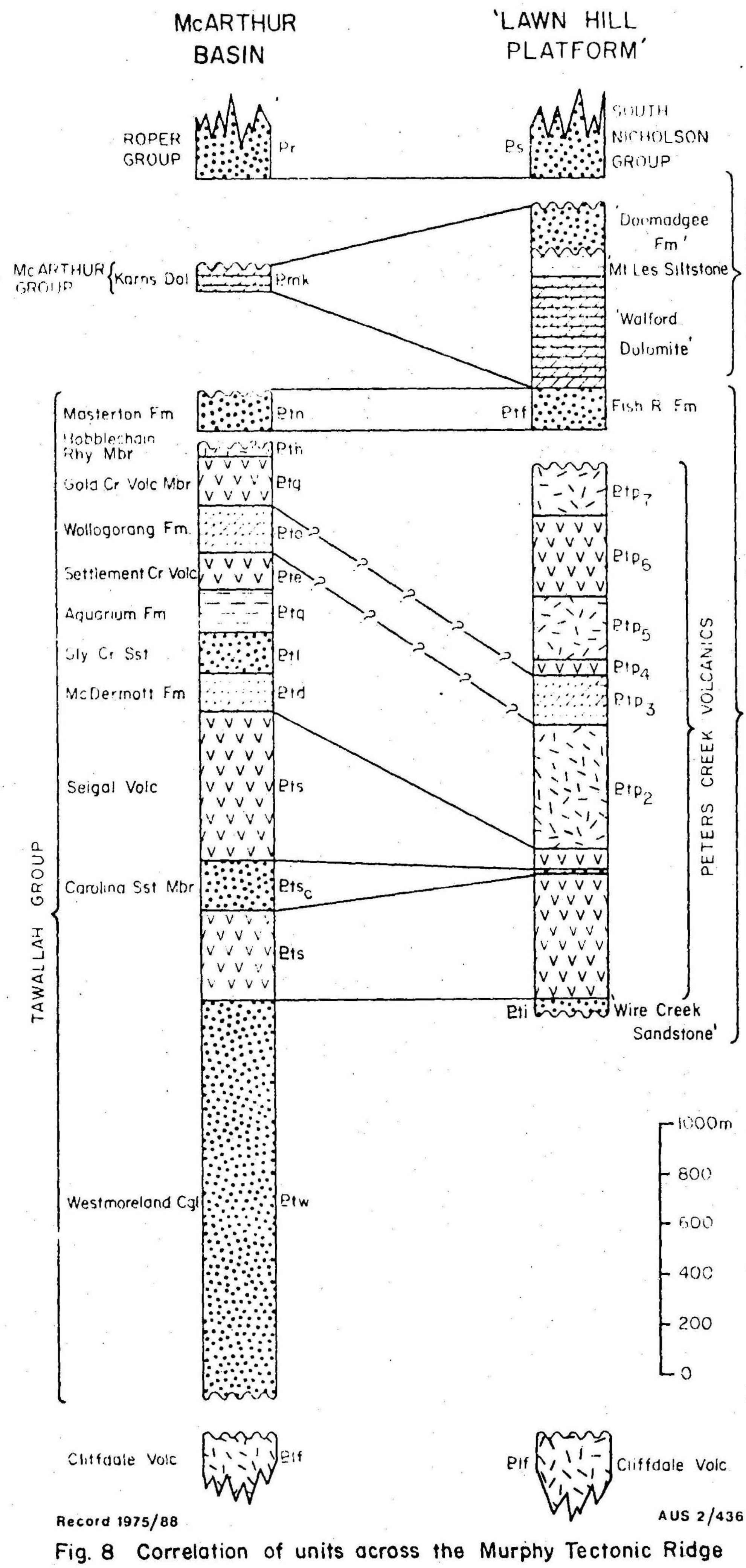

Fig. 8 Correlation of units across the Murphy Tectonic Ridge

Reconnaissance traverses in the Lawn Hill 1:250 000 Sheet area were carried out in an attempt to correlate the rocks there with those in the Westmoreland region, a vital link with the correlation of the McArthur and Mount Isa Groups, both of which contain major base metal deposits (Plumb & Sweet, 1974).

The Ploughed Mountain Beds and Lawn Hill Formation bear some similarity to the Fish River Formation and Fickling Group, and possible equivalents are shown in Table 24. Future mapping in the Lawn Hill Sheet area will be directed towards confirming or refuting the tentative correlations shown. The proposed four-fold subdivision of the Ploughed Mountain Beds is based on reconnaissance traverses east and southeast of Lawn Hill, and is only tentative.

TABLE 24: Tentative stratigraphic correlations within the 'Lawn Hill Platform'

Westmoreland Region	Lawn Hill Sheet Area
'Doomadgee Formation'	Lawn Hill Formation
	'Sandstone unit'
'Mount Les Siltstone'	'Shale and siltstone unit'
'Walford Dolomite'	'Dolomite unit'
Fish River Formation	'Basal sandstone unit'
———unconformity———	———unconformity———
Peters Creek Volcanics	Acid volcanics (mapped as Myally Beds by Carter & Opik, 1961)

GEOPHYSICAL SURVEYS

A BMR airborne radiometric survey was carried out in the Westmoreland region in 1956 (Livingstone, 1957). A number of anomalies were located and follow-up work revealed uranium mineralization in the Westmoreland Conglomerate 25 km southwest of Westmoreland homestead (Walpole, 1957).

Gravity surveys have been carried out by BMR in both the Calvert Hills and Westmoreland 1:250 000 Sheet areas. An aeromagnetic and radiometric survey of the Westmoreland 1:250 000

Sheet area carried out in 1973 is reported by Tucker (in prep.). This survey revealed that the trend of magnetic anomalies reflects the structural trends in the Precambrian rocks, and shows up most strongly in Unit 1 of the Peters Creek Volcanics. Because of its prominent anomaly pattern this unit can be traced eastwards under Cainozoic sediments. Several other features, including faults and possibly dykes, can be interpreted from the aeromagnetic profiles. Most radiometric anomalies recognized during the 1973 survey were due to potassium, but the known uranium mineralization in the Westmoreland Conglomerate also gave good anomalies. Tucker (in prep.) considers that broad gravity lows in the region correspond roughly to the thick sedimentary sequences of the McArthur River and South Nicholson Basins. Separating these lows is an east-northeast-trending gravity high which lies about 10 km south of the Murphy Tectonic Ridge, which lies on the flank of the gravity high and does not have any expression in gravity terms.

STRUCTURE

The cover rocks described in this Record form a broad east-northeast-trending anticlinal arch, at the core of which is the exposed basement of the Murphy Tectonic Ridge (Fig. 9). Several northwest to west-northwest-trending faults cut the basement and cover, and there are also some northeast to east-northeast-trending faults.

Early phases of deformation

The primary folds have east-northeasterly trends, and give rise to a northwesterly dipping homocline in the rocks north of the Murphy Tectonic Ridge, and to southerly dips in the rocks south of the ridge. The only exceptions to these uniform dips are folds in the Westmoreland Conglomerate between 6 and 20 km south of Westmoreland homestead, and minor reversals of dip in the Constance Sandstone near the Nicholson River.

Faulting associated with this first phase of movement is common in the Westmoreland Conglomerate, and is most obvious at and northeast of the main uranium deposits (Redtree, etc., around grid reference 920610), where a highly altered basic dyke occupies the fault zone, which is marked by a narrow gully. Movement along this zone is probably less than 100 m.

At least two other northeast-trending lineaments probably belong to this first phase. One of these in the Tin Hole Hinge Line (Roberts, unpubl. MS; Fig. 9), which forms the northern boundary of the Murphy Tectonic Ridge in the western part of the Seigal Sheet area. There is no obvious evidence of

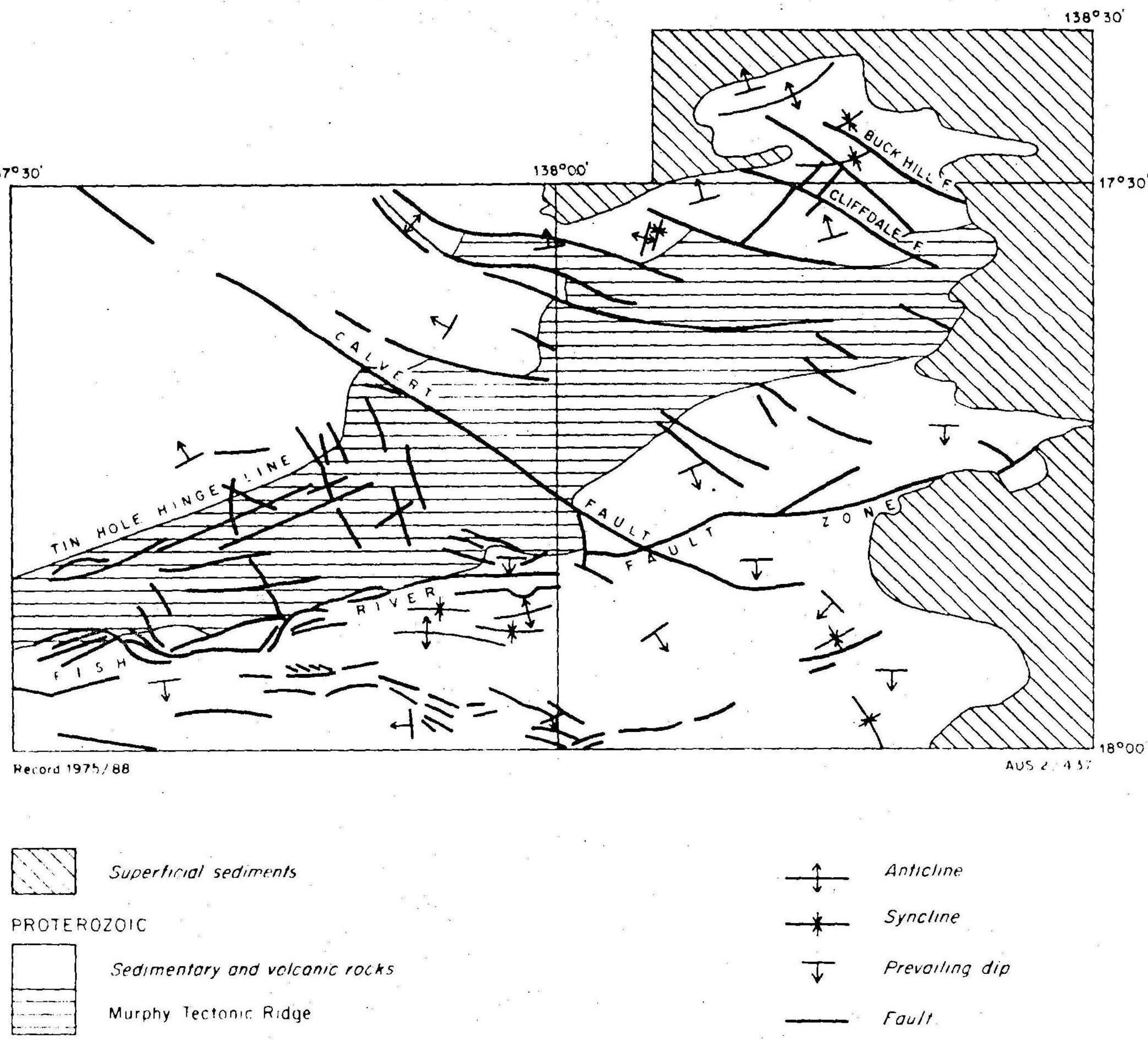

Fig. 9 Structural sketch map of the Seigal, Hedleys Creek, and part of the Westmoreland 1:100 000 Sheet areas

faulting along the lineament, which Roberts considered to be a zone of flexure during sedimentation in the McArthur Basin. Dips are uniformly steep (greater than 60^{o}) in the Westmoreland Conglomerate along the hinge line, but flatten to the northwest, indicating that some postdepositional flexuring or faulting, or both, took place.

The other northeast-trending lineament that probably belongs to the first phase of deformation is the Fish River Fault Zone, which forms the boundary between the Murphy Tectonic Ridge and the Lawn Hill Platform', in the Seigal Sheet area but is entirely within the 'Lawn Hill Platform' in the Hedleys Creek Sheet area. Some syndepositional faulting may have taken place along this zone, as it may be a fundamental lineament marking the southern edge of the Murphy Tectonic Ridge, which was a persistent topographic high during the Precambrian. Displacements along the zone are probably almost vertical (suggested by steep dips adjacent to faults), and a displacement of about 500 m is inferred, downthrown to the south.

A series of minor faults in the Constance Sandstone form an east-northeast-trending zone which is followed in places by the Nicholson River. Displacements are of the order of a few tens of metres, but may be much greater at depth. Tucker (in prep.) discusses a magnetic anomaly which trends eastwards in the vicinity of the fault zone. Interpreted depths to the magnetic source vary from about 900 m in the west to 1600 m in the east. The only rocks known to be strongly magnetic are the Peters Creek Volcanics, and it is possible that they cause the anomaly. A possible interpretation of the geology here, showing Peters Creek Volcanics adjacent to the fault at depths of about 1000 m, is given in the cross-section on the Hedleys Creek Sheet (in folder).

Age of deformation. Although some movements may have occurred during sedimentation in the McArthur Basin and 'Lawn Hill Platform', the main northeast-trending folding and faulting took place later. However, the lack of major displacements in the South Nicholson Groups indicates that the main movements took place before this group was deposited; hence most of the deformation was probably late Carpentarian.

Later phases of deformation

Later structures affecting the cover rocks include a series of northwest-trending faults which are most apparent in the Westmoreland Conglomerate, cross folds causing reversals in plunge of the earlier folds, and a prominent faulted anticline in the Westmoreland Conglomerate in the northern part of the Seigal Sheet area, between El Hussen and Cobar II uranium prospects.

The northwest-trending faults displace the earlier northeast-trending faults cutting the Westmoreland Conglomerate. Although horizontal separations of several thousands of metres are apparent, these could be due to the effect of vertical movements of less than 1000 m on gently dipping strata.

The Calvert Fault is the most prominent of the northwest-trending faults, and, according to Roberts et al. (1963), it displays left-lateral movement of up to '4½ miles'. This may be so in the basement rocks, but is difficult to prove, and is most unlikely in the cover rocks. The horizontal separation of the Carolina Sandstone Member of the Seigal Volcanics along the fault is about 1000 m, but this can be explained by a vertical movement of about 100 m, downthrown to the southwest.

Age of deformation. The northwestern faults, particularly the Calvert Fault, have a much greater effect on the basement rocks than on the cover, and it seems that there were several periods of movement along them, including some movements which took place after the intrusion of the 'Nicholson Granite Complex', but before the deposition of the Westmoreland Conglomerate. Although the movements along these faults which affected the cover rocks were later than movements along the northeast-trending faults, they were probably also Carpentarian in age. This is indicated by the Calvert Fault, which has caused virtually no displacement of the South Nicholson Group, the youngest Proterozoic group in the region.

Recognition of faults

Most faults are recognizable on the ground by brecciated zones infilled by quartz and minor hematite. Some faults, such as the Calvert Fault, form small ridges, and others form depressions. They can be readily recognized on aerial photographs.

Joints

Units 3 and 4 of the Westmoreland Conglomerate have prominent joints with a dominant trend of about 120^{o}. The joints in Unit 3 form linear valleys and gullies. In Unit 4 closely spaced joints show up on aerial photographs because of the relative dense vegetation cover along joint traces. A second set of joints trends at 040^{o}, and there are some other joints with different trends.

The joint system in the Constance Sandstone, like that in the Westmoreland Conglomerate, shows up prominently owing to differential weathering.

GEOLOGICAL HISTORY

At the beginning of the Carpentarian a thick sequence of acid lavas and ignimbrites were poured out onto a land surface formed of Lower Proterozoic metasediments. These volcanics were intruded by several phases of granite, some of which may have been co-magmatic with them.

A belt of the granite and volcanics at least 20 km wide and trending east-northeast across the Westmoreland region was uplifted during the early Carpentarian to form the Murphy Textonic Ridge. Detritus from this belt was carried westwards and northwestwards into the McArthur Basin, where it was deposited as fluvial gravels and sands. Some may also have been transported southwards, to form the thin veneer of sandstone preserved on the 'Lawn Hill Platform'.

Basic lavas were extruded onto the basal sandstone and conglomerate, probably from fissures represented by east-northeast-trending dykes within the ridge. The sea encroached in the northwest, and the lavas were succeeded by marine sediments in the McArthur Basin. On the Lawn Hill Platform, volcanicity continued later than in the McArthur Basin, and massive rhyolite and rhyodacite flows followed the basic lavas.

During the mid-Carpentarian the sediments and volcanics in the 'Lawn Hill Platform' were tilted, faulted, and partly eroded, uplift being most pronounced in the west. A marine transgression followed, during and after which an extensive blanket of sand and dolomitic sediments were laid down, and a thin dolomitic sequence was deposited on the western part of the Murphy Tectonic Ridge. The sediments deposited at this time were shallow-water deposits, and contain stromatolites, oolites, and, rarely, mud cracks. A short period of uplift in the southeast led to erosion and redeposition of some of the sedimentary rocks, and conglomerates with dolomite clasts were laid down.

Towards the end of the Carpentarian the Westmoreland region was uplifted and eroded. Downwarping in the south caused the sea to transgress here, and sand and silt of the South Nicholson Group were deposited in the South Nicholson Basin. Sedimentation may have continued here into the Adelaidean.

Fold and fault movements probably affected the rocks of the McArthur Basin and 'Lawn Hill Platform' before the South Nicholson Group was deposited; since it was deposited only minor faulting and tilting have occurred, and the region has remained stable to the present day.

MINERALIZATION

The Westmoreland region was probably examined by prospectors in the 1890s, after the discovery in 1887 of lead-silver deposits near Lawn Hill, 100 km to the south. Copper was discovered in 1911 at Settlement Creek, near the northern margin of the area, and the nearby Redbank lode was discovered in 1916 (Roberts et al., 1963). Redbank was the only prospect to be exploited commercially until the upsurge in uranium exploration in the 1950s led to the discovery of copper, tin, and uranium in basement rocks of the Murphy Tectonic Ridge. Since 1954 copper has been mined intermittently from Norris Copper mine. Uranium was produced from Pandanus Creek and Cobar II mines in the late 1950s, and tin was won from Crystal Hill.

The mineral deposits and prospects of the region can be divided into three groups:

(1) Mineralization in basement rocks - uranium at Pandanus Creek, copper at Norris, and tin at Crystal Hill, and tin, copper, and tungsten at several minor prospects. The nature of the mineralization is described by Mitchell (in prep.).

(2) Mineralization in the McArthur Basin - several uranium ore bodies in the Westmoreland Conglomerate in the Redtree area (25 km southwest of Westmoreland homestead) and relatively minor uranium and copper occurrences in the Seigal Volcanics near the Northern Territory/Queensland border.

(3) Mineralization in the 'Lawn Hill Platform' - small prospects of lead, zinc, and copper in the Fickling Group between Hedleys Creek and the Queensland/Northern Territory border.

Mineralization in the McArthur Basin

Uranium

Uranium mineralization in the Westmoreland Conglomerate was discovered in 1956 by Mount Isa Mines Ltd (MIM) (Lord, 1956; Walpole, 1957; Brooks, 1958), following an airborne scintillometer survey by BMR (Livingstone, 1957). MIM sank several pits in the area and carried out 900 feet of wagon-drilling until the end of 1958 (Brooks, 1960). The company discovered low-grade mineralization (probably less than 0.05% U_3O_8) consisting of disseminated interstitial grains of metatorbernite and carnotite in coarse feldspathic sandstone. MIM carried out more drilling on their leases (Redtree I, II, and III) in 1969, but no estimates of reserves have been announced.

Queensland Mines Ltd took out authorities to prospect around MIM's Redtree leases in 1967, and between 1968 and 1972 drilled over 37 000 m of percussion and diamond drilling (Brooks, 1972). Reserves of 12 700 tonnes of U_3O_8 (of grade greater than 1.25 kg/tonne) were announced in 1970, but revised estimates of probable reserves were later given as 4170 tonnes U_3O_8 in 1.9 million tonnes of ore.

Brooks (1972) and Hills & Thakur (1975) have described the deposits, which are in the northeast-trending Namalangi joint zone in Unit 4 of the Westmoreland Conglomerate. The joint zone contains a highly altered dyke of intermediate composition. Mineralization consists of pitchblende and brannerite in the Garee lens, southeast of the joint zone, and carnotite and metatorbernite in the Langi and Jack lenses northwest of the joint zone. Smaller deposits have been proved in the nearby Moongooma, Long Pocket, and Tjuambi prospects.

Several thousand metres of drilling was carried out by Broken Hill Proprietary Co. Ltd and AFMECO drilled several thousand metres in an authority to prospect in the northeastern outcrops of the Westmoreland Conglomerate (between the Redtree area and Westmoreland homestead), and although some mineralization was located no results have been announced.

Uranium in the Seigal Volcanics. In 1956, A.R. Blackwell discovered uranium in the northeastern part of the Seigal Sheet area (Roberts et al., 1963). The prospect, known as Cobar II, and several others subsequently discovered, were tested by costeaning, tunnelling, and drilling by the North Australian Uranium Corporation NL in 1956 and 1957 (Newton & McGrath, 1958). The mineralization is located in shears and faults within the Seigal Volcanics adjacent to their contact with the underlying Westmoreland Conglomerate, which here forms a northwest-trending anticline. Newton & McGrath recognized three modes of occurrence of mineralization.

Type A: associated with steeply dipping compression shears in basalt. Cobar II and parts of El Hussen are the best examples (also Old Parr and Kings Ransom).

Type B: associated with steeply dipping tension fractures filled with quartz. These are minor prospects and are not shown on the accompanying Seigal Sheet.

Type C: gently dipping shear at the contact between Seigal Volcanics and Westmoreland Conglomerate. El Hussen is the best example. The mineralization is sparse, and economic grades are present only where the contact is intersected by Type A shears.

McAndrew & Edwards (1957a) described the mineralization from Cobar II as uraninite associated with hematite occupying veinlets in brecciated olivine basalt. Secondary minerals, including carnotite and saleeite, are also present at some prospects (McAndrew & Edwards, 1957b). Sklodowskite is also present at Cobar II (McAndrew, 1958).

Production. Pandanus Creek (in basement rocks) and Cobar II are the only two prospects from which ore has been mined and sold. According to Roberts et al. (1963), 5800 kg of uranium concentrate were produced from Cobar II between 1957 and 1959. At Pandanus Creek 312 tonnes of ore containing 8.37 percent U_3O_8 was mined by South Alligator Uranium NL and trucked to the Rum Jungle treatment plant. A spoil dump at the mine contains about 3000 tonnes of ore averaging over 1 percent U_3O_8 (Morgan, 1965).

Origin of the Uranium. Newton & McGrath (1958) thought that the 'Nicholson Granite Complex' intruded the Westmoreland Conglomerate, and that hydrothermal fluids emanating from the granite carried the uranium. Carter (1959) and later workers recognized that the granite is overlain unconformably by the Westmoreland Conglomerate, and that an alternative explanation for the emplacement of the uranium minerals was necessary.

The deposits in the Westmoreland Conglomerate are adjacent to a dyke intruding the conglomerate, and it had been thought that the uranium was introduced when the dyke intruded. However, the uranium may have been leached from granitic basement rocks and deposited by ground-water in the conglomerate; thus the proximity of the dyke may be fortuitous. Alternatively, uranium minerals might have been eroded from basement rocks, laid down as heavy minerals in sand and gravel lenses within the Westmoreland Conglomerate, and later remobilized by groundwater. The deposits are similar to some in Canada and the United States where most reserves are in conglomerate and sandstone formations (Robertson & Douglas, 1970).

The uranium prospects in the Seigal Volcanics appear to be related to a northwest-trending anticline and associated faults. These structures are related to a minor phase of deformation which may have caused mobilization and enrichment of uranium already deposited at the contact of the Seigal Volcanics and Westmoreland Conglomerate.

Copper

Newton & McGrath (1958) show several copper prospects in the Seigal Volcanics about 8 km southwest of the Cobar II mine. At these prospects, which were located during the present survey, malachite and azurite staining is associated with faults and acid dykes cutting the Volcanics. The prospects have been tested by short drives and costeans, and do not appear to contain significant amounts of ore.

Mineralization in the 'Lawn Hill Platform'

Lead mineralization was discovered in the Gorge Creek area in the southwestern Hedleys Creek Sheet area, probably by about the turn of the century. Jensen (1941, unpubl.) examined some of the prospects, but by that time several shafts were filled with alluvial sediments from Gorge Creek. Taylor (1970) reported a comprehensive exploration program by Carpentaria Exploration Company Pty Ltd (CEC) between 1961 and 1970, which located at least 20 minor occurrences of copper, lead, and zinc within the Fickling Group; only the larger occurrences are shown on the accompanying Hedleys Creek Sheet. Visible mineralization consists mostly of finely disseminated galena, chalcopyrite, sphalerite, and pyrite in silicified dolomite at the top of the 'Walford Dolomite'. The minerals are leached in some outcrops, and Taylor (1970) used the presence of jarosite-staining on the rocks to indicate the former presence of sulphides.

The most southwesterly group of prospects includes Gorge Creek, Mount Les and Galena Pits, in the Hedleys Creek Sheet area, where galena is present in small crystals (1 mm) and in some larger aggregates (rarely up to 5 cm) in chert. Two diamond-drill holes put down at Mount Les (CEC's DDH1, grid ref. 857228, and DDH2, grid ref. 861227) intersected lead and zinc values generally of less than 0.1 percent.

At the First Up prospect the only surface sign of mineralization is a massive outcrop of ferruginous chert containing minor cerussite and pyromorphite, and a drill hole (DDH6) indicated even lower values of lead and zinc than at Mount Les. Copper values were somewhat higher, being about 400 ppm.

Lead Hill is the richest prospect in the 'Lawn Hill Platform', but is regarded as being too small to be worked economically, even on a small scale. The prospect is a vertical zone of breccia in 'Mount Les Siltstone' exposed in the eastern bank of Wire Creek. The zone is about 15 m high and 3 to 4 m wide, and contains scattered irregular blocks of galena weighing up to several kilograms. Taylor (1970) quotes an average grade of 10 percent lead in the outcrop. A drill hole (DDH5) placed 60 m southwest of the outcrop to intersect the line of mineralization penetrated 2 m of 2.1 percent lead and 1.2 percent zinc. Taylor considered the Lead Hill deposit to be a mineralized collapse breccia; the lead and zinc were presumably leached from the adjacent siltstone and dolomite. The deposit appears to have no geochemical expression, and it is fortuitous that it has been exposed by erosion by Wire Creek. Other such deposits might occur in both the 'Walford Dolomite' and 'Mount Les Siltstone', but would be difficult to locate.

Taylor (1970) reported minor sphalerite from a ferroan dolomite in the 'Doomadgee Formation'. The dolomite is distinctive in appearance and was observed at the top of Ƀfd$_2$ in the type area (Table 21, sample 74760125), but is absent farther southwest.

No prospects are known in the rocks of the South Nicholson Basin, although United Uranium NL explored for uranium in the Constance Sandstone where it is intersected by the Fish River.

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APPENDIX

Major element silicate analyses were carried out by AMDEL (Report AN2882/75) on 14 samples from the Peters Creek Volcanics; the results are shown in Table A.

The silica contents of the rocks confirm the validity of the names assigned to most of the rocks on the basis of thin section examination. The exceptions are the samples from Unit 6, which were thought to be of intermediate composition - sample 74760070 shows that basic varieties are also present. The presence of quartz in amygdales may have influenced silica values for samples 74760011 and 74760013 from Unit 1.

The FeO/Fe_2O_3 of the samples suggests that few of the rocks are fresh, and the lack of CaO in the basic rocks bears this out. Alkalis are also affected, Na_2O being virtually absent, and K_2O being extremely highly in all samples.

TABLE A: SILICATE ANALYSES OF SAMPLES OF VOLCANICS FROM THE PETERS CREEK VOLCANICS, WESTMORELAND REGION

	74760009 Ptp_1	74760011 Ptp_1	74760013 Ptp_1	74760055 Ptp_1	74760044 Ptp_2	74760046 Ptp_2	74760047 Ptp_2	74760064 Ptp_5	74760065 Ptp_5	72762063 Ptp_6	74760070 Ptp_6	72762058 Ptp_d	72762059 Ptp_d	72762065 Ptp_d
SiO_2	47.86	56.34	54.70	52.94	77.48	73.26	76.17	72.29	68.43	56.45	52.16	75.43	80.46	79.17
TiO_2	1.05	1.84	1.39	1.37	0.28	0.39	0.39	0.56	0.65	2.57	2.25	0.32	0.26	0.25
Al_2O_3	15.17	11.56	13.32	13.01	11.48	11.78	12.34	10.51	11.88	13.31	13.41	11.82	9.61	9.61
Fe_2O_3	1.92	18.21	2.31	3.76	0.17	3.69	0.84	5.79	7.30	11.64	17.52	2.01	0.18	1.70
FeO	8.25	0.25	6.15	6.25	0.20	0.20	0.15	0.25	0.50	0.50	0.50	0.15	0.20	0.30
MnO	0.18	0.19	0.12	0.22	0.01	0.01	0.01	0.01	0.03	0.02	0.02	0.01	0.01	0.01
MgO	7.63	0.81	9.72	6.43	0.07	0.10	0.02	0.40	0.48	0.83	0.51	0.08	0.01	0.14
CaO	8.56	0.16	0.31	4.09	0.04	0.06	0.03	0.19	0.18	0.92	0.08	0.03	0.02	0.03
Na_2O	1.32	0.04	0.06	2.83	0.16	0.28	0.23	0.09	0.14	0.09	0.03	0.12	0.11	0.10
K_2O	3.37	8.50	5.26	2.99	9.45	9.22	8.91	7.95	9.12	9.59	10.46	9.15	8.04	7.43
P_2O_5	0.19	0.11	0.15	0.15	0.02	0.07	0.01	0.16	0.15	0.79	0.17	0.01	0.03	0.02
H_2O+	3.15	1.33	5.47	3.47	0.41	0.62	0.84	1.21	0.97	1.82	1.40	0.82	0.28	0.92
H_2O-	0.27	0.25	0.43	0.07	0.07	0.12	0.04	0.15	0.07	0.30	0.18	0.06	0.04	0.06
TOTAL	98.92	99.59	99.39	97.57	99.82	99.80	99.97	99.57	99.91	98.82	99.13	99.98	99.21	99.72

SAMPLE LOCALITIES (metric grid references)								
	74760009	HC 103441	74760044	HC 313391	74760065	HC 208380	72762059	HC 196361
	74760011	HC 070432	74760046	HC 957367	72762063	HC 202378	72762065	HC 190359
	74760013	HC 934366	74760047	S 927200	74760070	HC 172350		
	74760055	HC 968411	74760064	HC 159377	72762058	HC 196361		