COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES GEOLOGY AND GEOPHYSICS

RECORDS:

RECORDS 1967/110

THE GEOLOGY OF THE NORTHERN PART OF THE WISO BASIN

NORTHERN TERRITORY

V. 1.

by

M.A. Randal and M.C. Brown

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SUMMARY

This record deals with the geology of the northern part of the Wiso Basin which occupies a region between the Stuart Highway and the eastern watershed of the Victoria River, and between latitudes 15°S and 18°S in the Northern Territory. The region is of geological interest since, beneath the cover of Mesozoic rocks, Lower Palaeozoic rocks of three sedimentary basins are contiguous: to the south the rocks of the Wiso Basin between Tennant Creek and Tanami; to the north the rocks of the Daly (River) Basin in the Katherine-Darwin Region; and to the east the rocks of the western Barkly Tableland portion of the Georgina Basin.

Precambrian rocks of the Victoria River Group (west), Roper Group (north-east), and Tomkinson Creek Beds (south-east) crop out in the margins and underlie the region. Their extent in the subsurface and their relationships to each other are unknown. The Lower Cambrian Antrim Plateau Volcanics crop out extensively in the western part of the region, and in a small area in the north-east. Scouthole and waterbore data indicate that the Volcanics underlie much of the region, particularly in the northern part. The Volcanics, which are at least 800 feet thick, also occur in the western part of the Wiso Basin and in the Daly (River) Basin; they are probably equivalent to the Helen Springs Volcanics in the western Barkly Tableland.

The Lower Palaeozoic rocks are mainly Middle Cambrian carbonate sequences - the Montejinni Limestone, the Merrina Beds, and the Tindall Limestone. The Montejinni Limestone crops out mainly in the western part of the region where it is divisible into three units - two limestone units separated by a middle mudstone unit. The upper limestone unit is lithologically similar to the Tindall Limestone which occurs extensively in the Daly (River) Basin and in the subsurface along the eastern part of this region. Fossils from both the upper and lower units of the Montejinni Limestone are similar in age to those from the Tindall Limestone. The Tindall Limestone presumably continues to the south-east where it passes laterally into the Gum Ridge Formation and possibly the Anthony Lagoon Beds of the Georgina Basin. The former correlation is supported by fossil evidence (Öpik, 1959). The Montejinni Limestone in the Wiso Basin is probably equivalent to the lower part of the Merrina Beds - a sequence of

dolomite and dolomitic limestone overlain by sandstone.

The Jinduckin Formation crops out in the northern part of the region: it occurs mainly in the Daly (River) Basin to the north, but may extend as far south as the area near Larrimah township. Lower Ordovician fossils have been found near the top of this formation near Claravale in the Daly (River) Basin (Öpik, 1964). No break has yet been found between the Tindall Limestone and the Jinduckin Formation, and it is not known if the latter is entirely Lower Ordovician or partly Cambrian in age. On the preliminary geological sheet the age is shown as Cambrian/Ordovician.

The thickness of the Lower Palaeozoic section increases from the northern part of the Wiso Basin southwards towards the central part of the Basin, and northwards towards the Daly (River) Basin. It is about 200 feet over much of the region but near latitude 18°S may be 600-700 feet, and near latitude 15°S is at least 550 feet. The axis of the basin lies along a slightly curved meridional line through the centre of the region. Structure contours have been drawn on the base of the Lower Palaeozoic succession and the trends suggest positions for the contiguous boundaries of the three basins within this region (see Fig. 6).

Lower Cretaceous non-marine and marine rocks are widespread in the northern and central parts of the region, and contain similar units to those described previously by Skwarko (1966). The succession consists of up to 400 feet of sandstone and claystone.

Thin Miocene limestone units have been mapped in two widely separated localities. The Birdum Creek Beds, west of Larrimah Township, contain freshwater gasteropods and are about 50 feet thick. The Camfield Beds in the eastern part of the Wave Hill Sheet area contain gasteropods, and vertebrate bones, and are about 70 feet thick. There is no apparent connexion between these two units, but they were presumably deposited contemporaneously under similar conditions.

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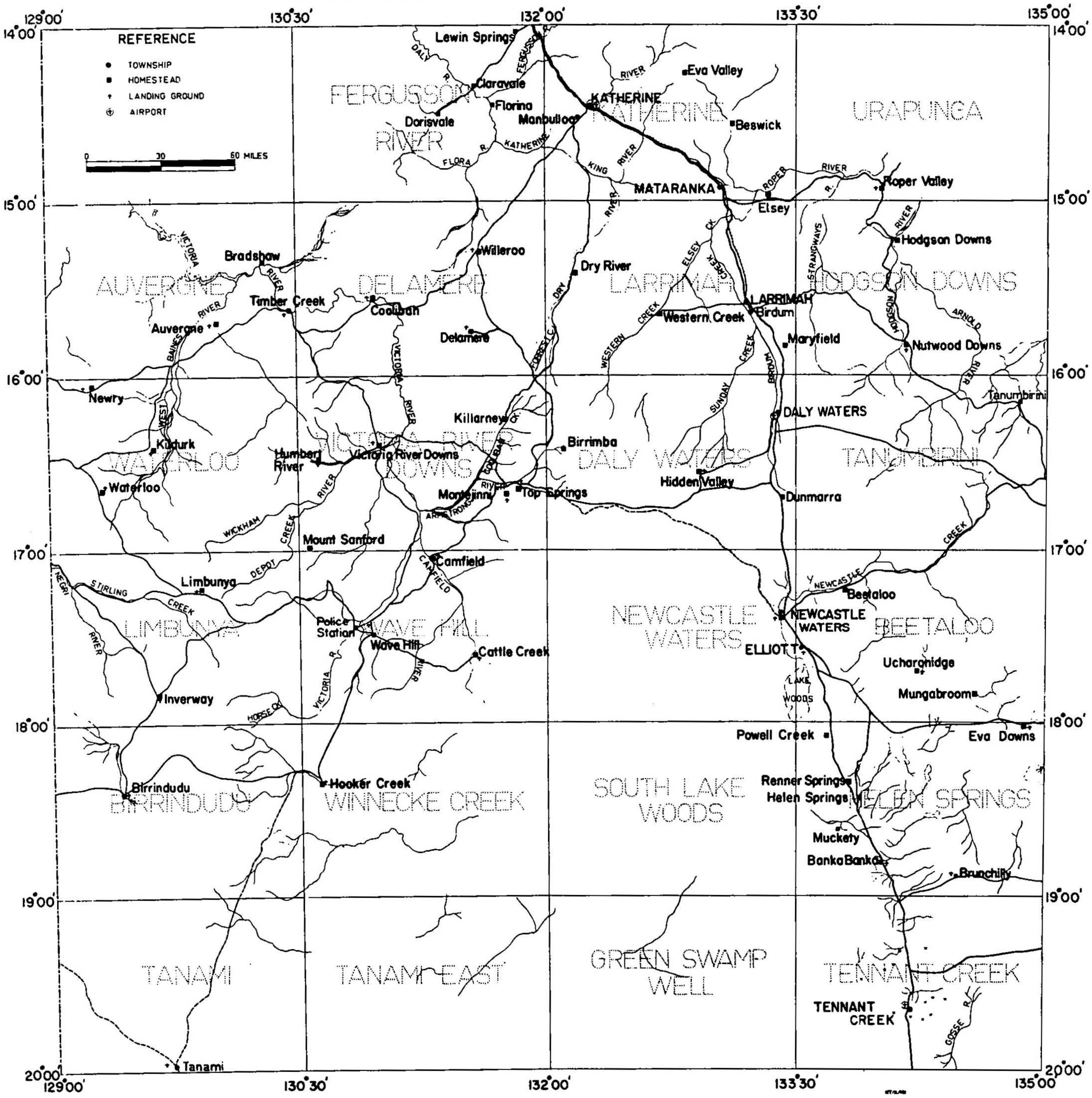
LOCALITY MAP - NORTHERN WISO BASIN

FIG. 1



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INTRODUCTION

Location and Access

This record describes the geology of the region between Lake Woods, Mataranka, Willeroo, and Wave Hill in the Northern Territory of Australia. The region lies between latitudes 15° and 18°S. and west of longitude 133° 30'E: the western boundary is the Camfield and Armstrong Rivers in the southern part, and a line through Delamere and Willeroo Homesteads in the northern part (Fig. 1).

The region is covered by the Newcastle Waters, Daly Waters, and Larrimah 1:250,000 Sheet areas, and the eastern parts of the Wave Hill, Victoria River Downs, and Delamere 1:250,000 Sheet areas. It lies between the two main lines of communication in the northern part of the Northern Territory; the road networks from Katherine to Western Australia via Willeroo and Timber Creek, and via Willeroo and Wave Hill in the west, and in the east the bitumen-sealed Stuart Highway connecting Darwin and Katherine to the southern and eastern states. The western network of roads is at present undergoing considerable alterations: new alignments and stream crossings are currently being constructed prior to sealing on the roads from Willeroo to Top Springs, Willeroo to Timber Creek, Top Springs to Timber Creek, and Top Springs to Wave Hill. During 1966, the road from Katherine to Top Springs via Willeroo was being sealed, and by October 1966 bitumen had been laid to about 20 miles south of Willeroo. A major development road was completed in 1964 and connects Top Springs with Dunmara on the Stuart Highway. This road replaces the historic Murranji Track from Newcastle Waters to Top Springs. Another important development road connects Daly Waters, on the Stuart Highway, to Borroloola near the Gulf of Carpentaria. Other connecting roads and the major station access roads are shown on Figure 1: these are usually impassable in wet weather.

The major settlements are the townships of Daly Waters, which has a large aerodrome and air-navigation aids; Newcastle Waters, which is

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near the intersection of the Barkly, Murranji, and North-South Stock Routes, and Larrimah, the southern terminus of the North Australian Railway. The township of Birdum, formerly the terminus, is now in ruins. Minor settlements are the roadhouse and stock inspector's residence at Top Springs on the Armstrong River, and the Wave Hill Police Station and Welfare Branch Settlement on the Victoria River. Other settlements are Dunmara Roadhouse and the homesteads for several cattle stations: Wave Hill, Camfield, Cattle Creek, Pigeonhole and Moolooloo (Outstations for Victoria River Downs), Montejinni, Birrimba, Killarney, Delamere, Willeroo, Dry River, Western Creek, Maryfield, Daly Waters Station, Hidden Valley, and Newcastle Waters Station. Settlements and stations near the Stuart Highway have a telephone service; the others have radio-communication with either Alice Springs, Wyndham, or Darwin.

Weekly air-services connect Top Springs, Camfield, Cattle Creek, Victoria River Downs, Delamere, and Willeroo to Katherine and Darwin. Daly Waters is served weekly by the two major airlines operating between Adelaide and Darwin.

With the exception of settlements along the Stuart Highway and on the watershed of the Victoria River, there is no habitation in the area south of the Murranji Stock Route; it is a semi-desert with no well-defined watercourses, permanent waterholes, or good grazing lands.

Climate

The climate is mainly semi-arid: rain falls generally under the influence of the north-west monsoon normally lasting from November to March (the Wet Season); the remainder of the year (the Dry Season) normally lacks useful rain. The duration of the rainy season is longest in the northern part and shortest in the south. The average rainfall throughout the region is variable: 24 inches at Willeroo and 27 inches at Larrimah in the north, and 17 inches at Newcastle Waters and 18 inches at Wave Hill in the south*.

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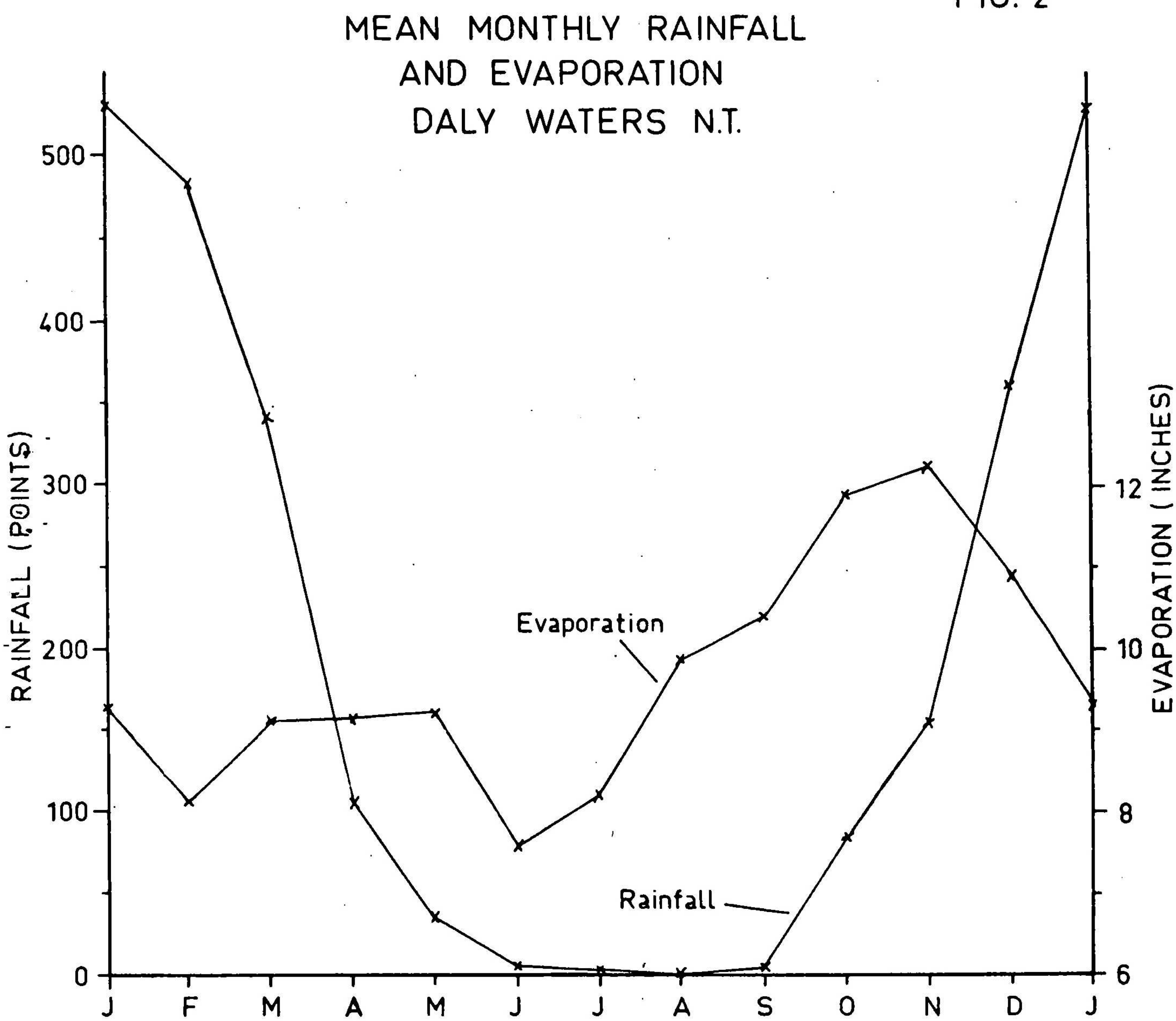
* These figures are for the period 1950-65 inclusive, and were provided by the Commonwealth Bureau of Meteorology.

FIG. 2



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The evaporation in the region is 112 inches per year at Daly Waters decreasing northward to 88 inches per year at Katherine. The mean monthly rainfall and mean monthly evaporation at Daly Waters for the period 1950-1966 are illustrated in Figure 2.

Aerial photographs and maps

The entire region is covered by vertical aerial photographs at a nominal scale of 1:50,000 flown by the R.A.A.F. between 1948 and 1950. The eastern sheet areas - Newcastle Waters, Daly Waters, and Larrimah - are also covered by vertical aerial photographs at a nominal scale of 1:85,000 flown by Adastra Airways Pty Ltd in 1963. New photography over the western part of the region should be available late in 1967.

All the sheets have been published by the Division of National Mapping, Department of National Development, in the 1:250,000 topographic series. The year of publications and year of aerial photography used are listed below:

Larrimah:	published in	1966	from	1950	aerial	photography.
Daly Waters:	"	1966	"	1963	"	"
Newcastle Waters:	"	1965	"	1963	"	"
Delamere:	"	1966	"	1948	"	"
Victoria River Downs:	"	1966	"	1948	"	"
Wave Hill:	"	1965	"	1948 & 1962		"

Photo mosaics and photoscale compilations are available from the Division of National Mapping.

The Department of the Interior carried out third-order instrument levelling in 1964 (supplemented in 1966) along the Stuart Highway, the Murranji Track, the Willeroo - Top Springs Road, and the Top Springs - Wave Hill road. The reduced elevations and the plans showing the locations of the bench-marks are available from the Department of the Interior, Canberra.

Survey Methods

Rivereau (1966) and Perry (1966) prepared photo-geological maps of the region, and these were used in the field and amended as required. Standard methods were used for the preparation of the 1:250,000 scale maps from the photo-scale compilations.

Groundwork was supplemented by 30hours of helicopter traverse. The flight lines are shown on the 1:250,000 geological sheets.

Surface mapping was supplemented by 1130 feet of scout hole drilling and coring with a Mayhew 1000 rig operated by the Bureau of Mineral Resources (Appendix 1). The Water Resources Branch (N.T.A.) and Gorey & Cole Drillers Limited provided considerable information on water-bores, and this is reported where appropriate in both the text and Appendix 2.

The authors were helped during the survey by the following B.M.R. personnel: K.G. Smith, who assisted in the mapping of the Newcastle Waters and Larrimah Sheet areas; W.J. Perry, who assisted in the helicopter survey; S.K. Skwarko, who examined most of the outcrops of Lower Cretaceous rocks (Skwarko, 1967); and C.G. Gatehouse, who mapped fossiliferous Tertiary rocks east of Camfield Homestead, portion of the Wave Hill and Victoria River Downs Sheet areas, and who determined the Cambrian fossils found during the survey. M.D. Plane visited the fossiliferous Tertiary rocks east of Camfield Homestead and collected and determined the fauna (Plane & Gatehouse, 1967).

Barometric work was tied to the instrument-levelled bench marks (Department of the Interior) and supplemented by the barometric elevations of helicopter gravity stations erected by Wongela Geophysical Pty Ltd for the Bureau of Mineral Resources (Flavelle, 1965).

Previous Investigations

After his examination of the Victoria River Region in 1856, A.C. Gregory traversed eastward into this region to the Dry River which he traced to near its confluence with the King River. He turned south-eastward and joined Elsey Creek near the confluence with Birdum Creek, followed the former to the Roper River, and thence journeyed to Queensland via the country south of the Gulf of Carpentaria.

In 1862 Stuart made his successful crossing of the continent from south to north. In this region he travelled along the eastern margin of Lake Woods to Newcastle Waters Creek and Daly Waters Creek. From Stuart Swamp he travelled north-eastward to the Strangway River and thence northwards to Van Diemen Gulf. During 1862 and the unsuccessful attempt in 1861, Stuart made short excursions over Lake Woods, the Ashburton Range, parts of the Murranji track, and Sturt Plain. In 1879, Forrest travelled from Victoria River Downs to Daly Waters via the Dry River during a trip from Port Hedland to Darwin, and in 1896 Hann passed through the northern part enroute from Lawn Hill to the Kimberleys.

H.Y.L. Brown (1895) travelled to the Victoria River Region via Willeroo and Delamere in 1894, and referred to the Cambrian limestones and the basalt outcrops which he believed to be the younger; he later (1909) regarded the volcanics as Mesozoic to Tertiary in age. Towards the end of 1894 he journeyed overland from Darwin to Adelaide along the Telegraph Line noting (1895) Cretaceous rocks and Cambrian limestone between Katherine and Daly Waters.

Wells made preliminary topographic surveys of the Victoria River region and in a short report (1907) referred to the limestone at Mounts William and Wallaston; on a map dated 1908 and used by Brown (1909) he notes limestone along the western edge of the Tableland between Figtree and Bullock Creeks, but none of these localities was visited by Brown (1909) when he journeyed from Pine Creek to Tanami via Willeroo and Wave Hill. This journey was repeated by Jensen (1915).

Chewings (1928, 1931) passed through the south-western part of the region in 1909 during a survey for bore-sites between Barrow Creek and Wave Hill. He referred to the Merrina Beds as the Winnecke Creek Tableland Formation, and considered it was younger than the Montejinni Limestone which he thought was probably Devonian. Most of his observations were made to the south of this region and are referred to by Milligan, Smith, Nichols, & Doutch (1966), who mapped and named the Merrina Beds.

Woolnough (1912) passed to the north and east of the region but commented on some of Brown's (op.cit.) observations, and reproduced his map.

Winters (1915) journeyed along the Telegraph Line from Pine Creek to Newcastle Waters in 1914, and commented on the Cambrian limestone and Cretaceous rocks; he briefly commented on the groundwater environment of the eastern part of the region, and considered it similar to that of the Barkly Tableland. Ward (1926) visited the region in 1925 during a groundwater investigation of the Northern Territory, and selected waterbore sites along the Dry River and Wave Hill Stock Routes.

Hossfeld (1954) used the term Wiso Tableland for the area between Newcastle Waters, Wave Hill, The Granites, and Barrow Creek. He believed the area was underlain by Cambrian sediments which were a continuation of those in the Buldiva Basin* to the north - the whole constituting the Buldiva - Wiso Basin. Recent mapping tends to support this concept in principle.

Between 1949 and 1953 Traves (1955) examined the western part of the region during the geological mapping of the Ord - Victoria Region; he also examined water supply problems on Wave Hill (Traves, 1953). Noakes & Traves (1954) examined rocks along the Stuart Highway during the survey of the Barkly Tableland.

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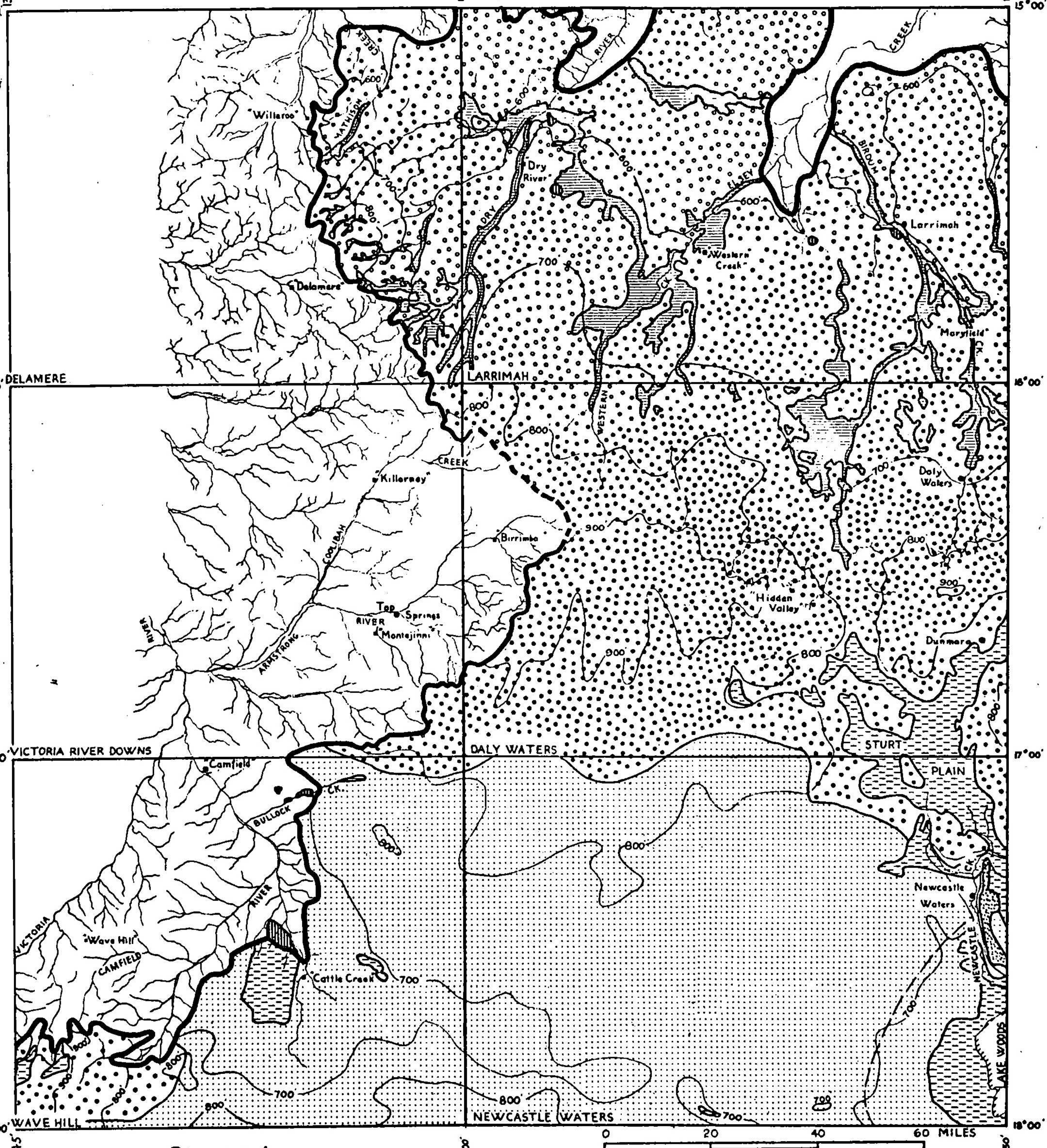
* Referred to by Noakes (1949) as the Daly River Basin, and by subsequent authors as Daly River Basin or Daly Basin.

PHYSIOGRAPHIC UNITS, NORTHERN WISO BASIN

Fig. 3



Dissected Areas

Victoria River Plains and Terraces (also Daly River Basin and Gulf Fall)

Sturt Plateau

- Alluvial Flats
- Black Soil Plains
- Sand (and Travertine) "Desert" Area
- Laterite Areas
- Ashburton Range

Miocene Limestone

- 800 — Form Lines on Sturt Plateau
- Physiographic Boundary, Major
- " " Minor
- "Birrimba" — Homestead
- Larrimah — Township
- Ancient Shoreline of Lake Woods
- Present " " "

Bureau of Mineral Resources Geology and Geophysics, June '67.

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N.J. Mackay (Northern Territory Administration) examined the western part of the region during water supply investigations and commenced mapping the Wave Hill and Victoria River Downs Sheet areas at four-mile scale. The work was not completed, but his maps and unpublished notes were used by Barclay & Hays (1965) during water supply investigations in these sheet areas between 1961 and 1963.

Neumann (1964) describes a reconnaissance gravity survey between Normanton and Daly Waters in 1959-60; and in 1965 Wongela Geophysical Pty Ltd carried out a contract gravity survey for the Bureau of Mineral Resources over the Newcastle Waters, Daly Waters, Wave Hill, and part of the Victoria River Downs 1:250,000 Sheet areas (Flavelle, 1965). This survey will continue over the remainder of Victoria River Downs, and the Delamere and Larrimah Sheet areas during 1967 (Flavelle, B.M.R., pers. comm.).

An airborne magnetometer survey was made for Barkly Oil Co. Pty Ltd by Aeroservices Limited (Hartman, 1964) between the headwaters of the Dry River and the headwaters of Sunday Creek. In 1965, Compagnie General de Geophysique completed an aeromagnetic survey over parts of the Daly Waters Sheet area for Mercure International Petroleum Limited (Leridon, 1966), and S.N.P.A. (1966) prepared a geomorphological study of part of the Daly Waters Sheet area for the same company.

The Bureau of Mineral Resources has mapped at 1:250,000 scale the sheet areas to the north (Randal, 1962, 1963; Dunn, 1963a), to the east (Dunn, 1963b; Paine, 1963; Randal, Brown, & Doutch, 1966), and to the south (Milligan *et al.*, 1966).

PHYSIOGRAPHY

The region contains two major physiographic units: a gently undulating plateau, with sparse surface drainage, in the eastern and central parts; and a dissected area covering most of the western part and portions of the northern part (Fig. 3). The two units are, respectively, parts of the 'Main Plateau' and 'Dissected Margin' of the northern part of the Northern

Territory (Hays, 1967). The plateau in this area has been called the Sturt Plateau by Paterson (in Traves, 1955). It is continuous with the Barkly-Birdum Tableland of Dunn et al. (in prep.). The name Sturt Plateau is used in this Record.

Sturt Plateau

The Sturt Plateau has a maximum elevation of 950 to 1000 feet between Hidden Valley and new Birrimba Homesteads. This high country forms part of a divide between ground sloping southwards to Cattle Creek and Lake Woods, and northwards to the Roper River and Daly River drainage systems. In the northern part of the Larrimah 1:250,000 Sheet area the general level of the plateau falls to about 600 feet. Other notably low areas are the open grass plains around Cattle Creek Homestead at about 650 feet, and the internal drainage basin of Lake Woods also at about 650 feet. South of Wave Hill Homestead the plateau again rises to over 900 feet.

Five subsivisions can be made within the Sturt Plateau, based on topography, superficial deposits, and vegetation. These are shown on Fig. 3.

The laterite areas consist mainly of low rises with a surface of rubbly ironstone and thin patchy soils, and intervening valleys with a thick cover of reddish sandy and loamy soils. These valleys have a system of tributary valleys, but the majority no longer contain active streams. Active streams are most abundant where the general slope of the plateau surface is greatest, and in the north of the region. In the Daly Waters Sheet area, tributary networks at the heads of small streams have eroded headward into the sloping plateau surface, exposing the Cretaceous sedimentary rocks underlying the laterite. Mathison Creek and some of the tributaries of the Dry River also have eroded well below the laterite surface.

Over most of the Newcastle Waters Sheet area and in the eastern part of the Wave Hill Sheet area, the plateau is covered by red sand, with some areas of travertine south and east of Cattle Creek Homestead. South of latitude 17° 30' dunes occur; they are mostly longitudinal although some irregular transverse dunes are present. The dunes have a maximum elevation of about 10 feet and are now fixed by vegetation; they trend at about 112°.

The black soil plains are flat open grasslands with few trees. They are lower than adjacent laterite or sand areas, and have developed on Cambrian carbonate rocks, on Lower Cambrian basic volcanics, and on argillaceous Mullaman Beds. The black soil plain south of Newcastle Waters is marginal to the present Lake Woods, and is bounded by a former strand line; it is probably mainly on old lake alluvium.

The plateau in the Larrimah, Delamere, and the northern part of the Daly Waters Sheet areas also contains areas of dark grey and brown soils. They are shown in Figure 3 as 'alluvial flats', because they are confined to the valleys of former or present-day streams, and appear to be mainly alluvial deposits.

Outcrops of Tertiary (probably Miocene) limestone, the Birdum Creek Beds, occur in valleys on the Larrimah Sheet area, often in the 'alluvial flat' areas, at elevations of a little over 600 feet. Some of the clayey soils of the alluvial flats may be residual weathering products of this limestone.

To the east of Newcastle Waters the low north-south trending ridge of Precambrian sandstone is a northern extension of the Ashburton Range. There the range is only 50 feet to 100 feet above the general level of the plateau. As in areas further south (Randal <u>et al</u>., 1966) the range stands above the level of surrounding flat-lying Lower Cretaceous sediments and was elevated country during their deposition.

Dissected areas

The country marginal to the Sturt Plateau is dissected by tributaries of three major drainage systems; the Victoria River, the Daly River, and the Roper River (Gulf Fall drainage). The areas dissected by the three systems comprise respectively the Victoria River Plains and Terraces (Traves, 1955), the Daly River Basin (Noakes, 1949), and Gulf Fall (Stewart, 1954). Streams south of the divide between Willeroo and Delamere Homesteads drain into the Victoria River; those north of this divide drain into the Daly and Roper Rivers.

The topography is controlled largely by differential erosion. The area covered by Figure 3 is underlain mainly by gently dipping lava flows with interbedded sedimentary rocks, and gently dipping to horizontal sedimentary rocks. Gently sloping plateaux of resistant rocks, and slopes with ledges of resistant rocks are common. Chert bands in the Antrim Plateau Volcanics, and the lower unit of the Montejinni Limestone, form especially prominent plateaux and ledges. South-east and east of Killarney Homestead an extensive near-flat surface at about 730 feet appears to be the exhumed unconformity at the base of the Mullaman Beds. The surface bevels the gently dipping units of the Montejinni Limestone and contains outliers and scree of basal rocks of the Mullaman Beds.

Hays (1967) recognized an ancient erosional plain below the level of the Sturt Plateau, which he called the Wave Hill Surface. From the type area around Wave Hill Homestead he traced it to the north over a large area marginal to the Sturt Plateau. We were not able to either confirm or deny the continuity of the Wave Hill Surface outside the type area because of the abundance of lithologically controlled plateaux and ledges in the dissected areas.

Stream trends in the dissected areas are often controlled by jointing. Many of the small streams on the Antrim Plateau Volcanics, especially in the Delamere Sheet area, trend at about 130°. Some of the long straight reaches of major streams are presumably controlled by fracturing, although this has not been demonstrated in the field.

In the north-eastern corner of the Larrimah sheet area rocks of the Roper Group dip at between 5° and 15°, and form low strike ridges trending at 130° to 150°.

In the Wave Hill Sheet area, outcrops of Miocene limestone (the Camfield Beds) occur below the level of the main plateau at elevations of between 500 and 600 feet. In the type area on Bullock Creek the limestone is about 70 feet thick and its upper surface is about 100 feet below the level of the plateau. Further south near Cattle Creek, where the plateau is lower, the difference in elevation is not so marked. The Camfield Beds are themselves dissected and, near the junction of Bullock Creek and the Camfield River, occur as isolated mesas with their tops up to 70 feet above nearby stream beds. The relationships in the Bullock Creek area show that the Sturt Plateau had been dissected to a depth of about 170 feet before deposition of the Miocene limestone.

STRATIGRAPHY

The region contains rocks of Precambrian, Cambrian, Mesozoic and Tertiary ages, but there is an extensive cover of Cainozoic superficial deposits. A summary of the post-Precambrian stratigraphy is given in Table 1.

The Lower Palaeozoic rocks of the Wiso Basin (Hossfeld, 1954; Milligan et al., 1966), and those of the Daly River Basin (Noakes, 1949; Randal, 1962, 1963) to the north, appear to merge beneath the Mesozoic rocks of this region. The Lower Palaeozoic rocks of the Daly River Basin seem to continue south-eastwards beneath the Mesozoic rocks along the eastern edge of this region, to merge with the Lower Palaeozoic rocks of the Barkly Tableland portion of the Georgina Basin (Smith, 1967; Randal, Brown & Doutch, 1966).

Considerable stratigraphic information was obtained from five scoutholes - DW1, approximately near the centre of the Daly Waters Sheet area; L2, similarly situated in the Larrimah Sheet area; L3, 2.5 miles west of Larrimah Township; L1, 10 miles north-west of the township; and K1, 4 miles north of the region on the road paralleling the Dry River. In addition, several waterbores were drilled during the survey and cuttings from them provided useful stratigraphic information. These were Birrimba Homestead bore, Dry River Stock Route No. 8, and Moorak and Enoanoa Bores (Daly Waters Station) in the Daly Waters Sheet area, Maryfield Homestead Bore in the Larrimah Sheet area, and a series of five Department of Works bores in the Delamere Sheet area along the Willeroo - Top Springs Road. Drillers' logs of other waterbores in the region are mentioned at appropriate places in the text.

PRECAMBRIAN

The Tomkinson Creek Beds crop out in the south-eastern part of the region, the Roper Group in the north-east, and the Victoria River Group in the west.

Tomkinson Creek Beds

The Tomkinson Creek Beds (Randal et al., 1966) crop out along the central eastern margin of the Newcastle Waters Sheet area between Newcastle Creek and Lake Woods. The south-easterly extension of this unit forms the high ridges of the Ashburton Range along which, in the Helen Springs Sheet area, Randal et al. (op. cit.) mapped and renamed the unit. The rocks were previously called the Ashburton Sandstone* (Noakes & Traves, 1954).

In the Newcastle Waters Sheet area the Tomkinson Creek Beds form long strike ridges with narrow intervening valleys, or occur as a dissected sand-covered tableland. The unit consists mainly of medium to coarse-grained quartz sandstone with minor cross-bedding; there are small interbeds

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* This name contravened the Australian Code of Stratigraphic Nomenclature; the history of the name and the reasons for renaming the unit are given in Randal et al. (op. cit.).

of siltstone and pebble conglomerate. The rock types are not as varied as in the main range to the south, where there is, in the Helen Springs Sheet area, a higher proportion of siltstone in the section together with carbonate rocks and altered carbonate rocks. A dolerite sill intruding the top of the sequence in the Helen Springs and Beetaloo Sheet areas is not present in this region.

The unit is the continuation of the upper parts of the Tomkinson Creek Beds from the Helen Springs and Beetaloo Sheet areas.

The unit is extensively folded and faulted. In the Newcastle Waters Sheet area the regional dip is west ranging from 26° to 60°.

The unit is overlain unconformably by Lower Cretaceous sandstone, siltstone, and claystone. Poorly exposed contacts occur to the east of Newcastle Waters Settlement. The Tomkinson Creek Beds are also unconformably overlain by the Middle Cambrian Merrina Beds, but no contacts have been observed. The relationships between the Tomkinson Creek Beds and the Middle Cambrian Tindall Limestone and Anthony Lagoon Beds are discussed in the relevant sections. Probably the Lower Cambrian Antrim Plateau Volcanics also unconformably overlie the unit in the subsurface, and this probability also is discussed later.

There is no information in the Newcastle Waters Sheet area about the rocks beneath the Tomkinson Creek Beds. About 120 miles to the south, the unit overlies the Lower Proterozoic Warramunga Group, but opinions on whether the units are conformable or not differ (Smith, 1967).

The thickness of the unit in this region is unknown. Randal <u>et al</u>. (op. cit.) estimate 50-55,000 feet in the Helen Springs Sheet area; near Lake Woods it is probably much less than 11,000 feet, which is the total thickness exposed in the Tomkinson Creek - Powell Creek and Mucketty - Renner Springs blocks to the south.

The age of the unit is shown on the map as Lower Proterozoic following Smith (1967), who considers the unit to be the same age as the

Hatches Creek Group. Some workers believe the age of both units is Carpentarian because of radiometric ages determined for granites intruding the Hatches Creek Group, but Smith (1967, and in Randal et al., op. cit.) questions the validity of the determinations. A single sample of glauconitic sandstone from near Banka Banka has been dated at 1560 million years (McDougall, A.N.U., pers. comm.) i.e. Carpentarian. However the sample came from a sequence of about 5000 feet of sandstone, siltstone, chert and conglomerate near Banka Banka, which overlies the main bulk of the Tomkinson Creek Beds in that area with a marked angular unconformity. The relationship of this sequence to the Tomkinson Creek Beds of the Tomkinson Creek - Powell Creek and Muckety - Renner Springs blocks in the north is not known, but it could be considerably younger than those and the Beds in the Newcastle Waters Sheet area.

Roper Group

The Roper Group (Dunn, 1963a, b) crops out in a small area in the north-eastern part of the Larrimah Sheet area. It consists of sandstone, siltstone, and dolomite belonging to a widespread Adelaidean sequence which crops out to the north and east in the Carpentaria Proterozoic Province. The Group has been divided into many formations in the adjoining Sheets (Dunn, 1963a, b), but poor outcrop and the lack of detail prevented their certain recognition in the Larrimah Sheet area.

In this region the sandstones crop out as strike ridges, dissected dip slopes, and rubble covered rises, glauconitic dolomite forms low steeply dipping slabs, and siltstone forms either alluviated valleys or, wherever protected by overlying sandstones, rubble-covered slopes on the hill-sides.

The Roper Group is unconformably underlain by the Carpentarian Mount Rigg and McArthur Groups (Dunn, Smith & Roberts, in prep.), and is unconformably overlain by the Antrim Plateau Volcanics, the Middle Cambrian Tindall Limestone, and the Lower Cretaceous Mullaman Beds in the Larrimah Sheet area. In this area the Group is extensively folded and faulted - the regional dip is eastward.

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Dunn (1963a) states 'the appearance of the Roper Group marks a return to terrigenous sedimentation. This sandstone-shale sequence with subordinate carbonate rocks is the most widespread and lithologically consistent within the McArthur Basin.' He further cites some evidence that the Group was deposited under shallow water conditions.

The thickness of the Roper Group in the Larrimah Sheet area is unknown, but in the adjoining sheet areas it is 6000 feet.

An Adelaidean age is assigned to the Group on the basis of radiometric determinations on dolerite intrusions and glauconitic sediments (Dunn et al., op. cit.).

Victoria River Group

Rocks of the Victoria River Group (Traves, 1955) crop out in the western parts of the Wave Hill, Victoria River Downs, and Delamere 1:250,000 Sheet area. These rocks were not mapped during this survey*.

The rocks of the Group were briefly examined by Perry (1967) during 1966 to check some of the photo-interpretation previously prepared (Perry, 1966).

The Victoria River Group was regarded by Traves (op. cit.) as Upper Proterozoic in age, but further reconnaissance work by companies, mapping by resident geological staff, and 1:250,000 scale mapping in Precambrian areas of Northern Australia suggest the Group may contain rocks of both Carpentarian and Adelaidean ages (P.R. Dunn, B.M.R., pers. comm.).

The Group is unconformably overlain by the Lower Cambrian Antrim Plateau Volcanics, but no contacts with the Middle Cambrian Montejinni Limestone have been seen. The Victoria River Group presumably forms the western Precambrian basement for the sediments of the northern Wiso Basin. No correlation with the Tomkinson Creek Beds and the Roper Group, which form the basement to the east, can yet be made.

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* Mapping of the Victoria River Basin will commence in 1967, and will extend into these three sheet areas in 1968.

PALAEOZOIC

Lower Cambrian

Antrim Plateau Volcanics

The Antrim Plateau Volcanics crop out in a broad north-south trending belt between Wave Hill and Willeroo Homesteads, and in the north-eastern corner of the Larrimah Sheet area; they probably occur in the subsurface throughout the region. The Volcanics are predominantly basalt flows, with interbedded sandstone, chert, limestone, conglomerate, and pyroclastics. They unconformably overlie the Adelaidean Victoria River Group, and are overlain with a slight angular unconformity by the lower Middle Cambrian Montejinni Limestone: they are at least 790 feet thick.

The type area of the Antrim Plateau Volcanics is the Antrim Plateau, a dissected hilly area about 40 miles east of Hall's Creek in Western Australia. The rocks in that area were originally termed the Antrim Plateau Basalts (David, 1932), but Traves (1955) revised the name to 'Antrim Plateau Volcanics' and showed that the Volcanics extended continuously for about 140 miles to the north-east of the type area. The basic volcanic rocks described in this Record form part of a broad outcrop belt extending from Hooker Creek to north of Willeroo and were also mapped by Traves (op. cit.) as the Antrim Plateau Volcanics: they are probably continuous with the Volcanics of the type area below a superficial cover, and have the same relationships with older and younger rocks.

During the 1966 field season basic volcanics regarded as part of the Antrim Plateau Volcanics were mapped in the north-eastern corner of the Larrimah sheet area. These rocks are continuous with outcrops of volcanics in the Katherine Sheet area (Randal, 1963). Basic volcanics were also encountered at 163 feet below a cover of Mesozoic and Cambrian sedimentary rocks in BMR Scouthole L2a near the centre of the Larrimah Sheet area. Drillers' logs suggest that the Volcanics occur from 345 feet to the total depth of 370 feet in the Hidden Valley waterbore near the centre of the Daly Waters Sheet area, and between 156 feet and 234 feet in Burge Bore in the south-east of the Newcastle Waters Sheet area (Fig. 5).

The Volcanics generally form plains and rounded hills and ridges with a good grass cover and scattered low trees. In areas where hard sedimentary rocks are interbedded with lava flows (e.g. south of Moolooloo Homestead) differential erosion has produced prominent ledges and plateaux. Between 4 miles and 10 miles south-west of Camfield Homestead numerous small buttes and mesas of chert overlie basalt.

Basalt is the predominant rock type in the Volcanics: it is usually compact and well crystallized, but the top and bottom of flows are aphanitic and vesicular or amygdaloidal. Vesicles are often filled with banded agate and smoky quartz. The quartz often has inclusions and coatings of native copper, and amygdales are commonly coated with greenish copper carbonate stains. Xenoliths of indurated sandstone and siltstone, sometimes partly melted, are common in some exposures.

Four samples of the igneous rocks were analysed (Table 2) and thin sections were described by officers of Australian Mineral Development Laboratories, Adelaide (In Reports AN 1845/67 and MP 1845/67). Three of the samples were basalts of tholeiitic composition, partly altered, and with a higher than normal content of alkalis; the fourth (66675055) had an unusual chemical composition and was described by G. Williams of A.M.D.L. as a sanidine trachyte.

The sanidine trachyte was collected from locality WV 55, a low hill 1 mile west of the junction of Camfield River and Cattle Creek. Its chemical composition is almost identical to the basalts, except that the sodium and calcium contents are very low, and that for magnesium low: the deficiencies in these elements are made up by an unusually high content of potassium (10.4% K_2O). The iron is almost completely in the ferric state.

The chemistry suggests that the unusual composition has resulted from replacement of most of the calcium and sodium of a tholeiitic basalt by potassium, with the accompanying oxidation of ferrous iron to the ferric state.

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TABLE 2: ANALYSES OF ANTRIM PLATEAU VOLCANICS

Sample No.		6667 1044	6667 2026	6667 3204	6667 5055
		%	%	%	%
Silica	SiO_2	52.6	52.2	52.1	53.4
Aluminium oxide	Al_2O_3	13.6	13.6	12.9	13.7
Ferric oxide	Fe_2O_3	11.5	4.35	11.0	13.4
Ferrous oxide	FeO	3.55	7.20	4.05	0.54
Magnesium oxide	MgO	3.50	5.60	4.00	2.20
Calcium oxide	CaO	5.0	8.30	7.20	0.97
Sodium oxide	Na_2O	2.95	2.70	2.40	0.35
Potassium oxide	K_2O	2.10	1.23	1.73	10.4
Water over 100°C	H_2O^+	1.48	2.02	1.06	1.95
Water at 100°C	H_2O^-	1.00	0.33	0.85	1.25
Carbon dioxide	CO_2	0.13	0.35	0.18	0.23
Titanium oxide	TiO_2	2.10	1.80	2.15	1.32
Phosphorus pentoxide	P_2O_5	0.18	0.10	0.15	0.12
Manganese oxide	MnO	0.07	0.07	0.05	0.04
Copper	Cu	30 ppm	25 ppm	10 ppm	5 ppm

6667 1044; locality DL 44, 6¾ miles east-north-east of Willeroo Homestead

6667 2026; locality L 22, 25 miles north by east of Elsey Cemetery

6667 3204; locality VRD 204, 1¼ miles west-north-west of Top Springs in bed of Armstrong River

6667 5055; locality WV 55, 1 mile west-south-west of junction of Camfield River and Cattle Creek

In the field the sanidine trachyte resembled a fine-grained basalt and was not recognized as a distinctive rock type, so that its extent and relationships to other rock types in the Volcanics is not known.

Traves (1955) did not recognize the presence of the sandstone, chert, limestone and siltstone interbedded with the Volcanics, and interpreted stromatolitic chert at Top Springs and silicified sandstone near Pigeon Hole to be inliers of the Victoria River Group. Mapping during 1966 showed that the chert at Top Springs crops out over many square miles as a sub-horizontal bed. The Armstrong River and Illawarra Creek have cut through the chert and have exposed basalt below (VRD 203, VRD 257). Younger basalt overlies the chert, and contains large chert xenoliths.

Other chert interbeds sometimes associated with limestone have been found west of Top Springs, south and south-west of Camfield Homestead and south and east of Wave Hill Homestead. The known outcrops are shown on the 1:250,000 geological maps of Victoria River Downs and Wave Hill. Three separate beds of chert, separated by basalt flows, form benches in the hills south of Moolooloo Homestead. The middle bed is the most persistent.

Barclay & Hays (1965) found sandstone interbeds in the Volcanics near Pigeon Hole and at other localities in the Victoria River Downs Sheet area, and suggested that some sandstone at the base of the Volcanics was conformable with overlying basalt. Photo-interpretation on the Delamere and Victoria River Downs Sheet areas (Perry, 1966) also suggested the presence of sandstone interbeds in the Volcanics, and field observations during 1966 confirmed this. Photo-interpretation showed that many of the sandstone outcrops have a marked west-north-westerly elongation.
J. Shields (N.T.A. Darwin, pers. comm.) reports sandstone interbeds in the Volcanics from waterbores near the Western Australian border. Cuttings show sandstone interbeds in the Volcanics in waterbore DWH 4 and Dry River Stock Route bore No. 8; chert with associated limestone was also intersected in the latter bore (Appendix 2).

Drillers' and geologists' logs of the bores listed in Table 3 indicate sedimentary rocks are interbedded with the Volcanics.

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TABLE 3: SEDIMENTARY INTERBEDS IN THE ANTRIM PLATEAU VOLCANICS

Bore Name	Registered No.	1:250,000 sheet area	Interval	Rock type
Victoria River Downs No. 14*	2609	Victoria River Downs	306'-340' 420'-440'	sandstone "
" No. 11*	2847	"	102'-180'	"
" No. 22*	3367	"	40'- 45'	"
Coleso bore, Camfield Station	4049	"	10'- 50'	"
Armstrong bore, Montejinni Station	5396	"	174'-190'	chert
Top Springs new town site bore	5444	"	160'-177' (T.D.)	chert, chalcedony, dolomite, limestone
Comet Creek bore, Killarney Station	5461	"	56'- 65' 81'- 92' 305'-315'	sandstone " "quartzite in limestone"
Delamere New Site 1023*	5480	Delamere	45'- 50' 100'-110'	sandstone "
6 Mile Yard Bore, Delamere Station	5551	"	0'-174'	basalt and sandstone
Fred's Yard bore, Delamere Station	5554	"	60'-230'	basalt and sandstone
No. 2 site for No.12 bore, Wave Hill Station	5450	Wave Hill	180'-200'	fine quartz sandstone
Horse Paddock bore Victoria River Downs Station *	3003	" "	40'- 66' 83'-104'	sandstone "
Victoria River Downs No. 7*	2806	" "	146'-147'	shale
			243'-300' 380'-506'	silty sandy shale sandstone and shale
Victoria River Downs No. 5*	2756	" "	185'-300'	red and white sandstone

* BORES not located on the ground.

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The interbedded sandstones are brownish medium to fine-grained, friable to indurated. Two main types can be recognized from the sedimentary structures and probably represent two distinct environments of deposition. The first type is medium-grained and friable, and is characterized by large scale straight cross-beds, in sets commonly 10 feet or more in thickness, usually dipping west to north-west. This type of sandstone has a variable thickness and occurs in outcrops frequently elongated in a west-north-west direction: it was apparently deposited as elongated sand-ridges which were subsequently covered by basalt flows. In places where the contact has been observed (DL 204, WV 202), the basalt rests on a bedding surface. The sandstone is strongly indurated for several inches below the basalt, and the surface of the sandstone has shallow elongated ridges and furrows, apparently caused by viscous drag of the lava moving over the surface. The same features were observed at the contact between a similar sandstone and basalt in the Helen Springs area (Randal et al., 1966)

The second type of sandstone is fine to medium-grained, and is either flat laminated with current lineations on the bedding surface or ripple-bedded. It is commonly interbedded with siltstone and chert.

Thin sections of both sandstones show that the grains are mainly of quartz, rock fragments, and feldspar. The rock fragments include indurated siltstone, ferruginized siltstone, basalt with a glassy groundmass, and basaltic glass. The feldspar is mainly microcline and orthoclase. The grains are coated with brownish iron oxide. Quartz is the commonest cement, but calcite cement is present in some samples, and a barite or celestite cement is present at DL 204 near Pandanus Spring. In the sandstone with large-scale crossbeds the grains are well sorted and the rock fragments and feldspar usually well rounded. In sandstones with current lineations the grainsize is morevariable, and some of the basalt fragments are angular and notably larger than the other clasts. A coarse-grained sandstone with clasts mainly of chert crops out ½ mile south-south-east of Top Springs (VRD 220).

A thin section of an indurated sandstone at the base of a basalt flow (DL 204) shows that the interstices between the grains are filled with quartz containing abundant needles and short prisms of an orthorhombic

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mineral, probably mullite. A similar quartz-(?)mullite intergrowth was found in an indurated sandstone near Helen Springs (Randal et al., 1966) and was interpreted as a product of partial melting and re-solidification of the sandstone. Similar intergrowths, containing sillimanite rather than mullite, have been noted.

Chert occurs as a replacement of limestone and calcareous siltstone. In some outcrops (VRD 211, road crossing of Companion Creek, and WV6 south of Wave Hill Homestead) chert and limestone are closely associated, and laminations in the limestone pass laterally into chert. Thin sections of chert show textures similar to those of the limestones. Ghosts of intraclasts (specimen from VRD 209) and of probable shells and shell fragments (VRD 223) have been recognised.

Part of a specimen from locality VRD 223 is a silicified siltstone, consisting of clasts of altered basalt glass, quartz, and muscovite, with ghosts of probable shell fragments, set in cryptocrystalline silica.

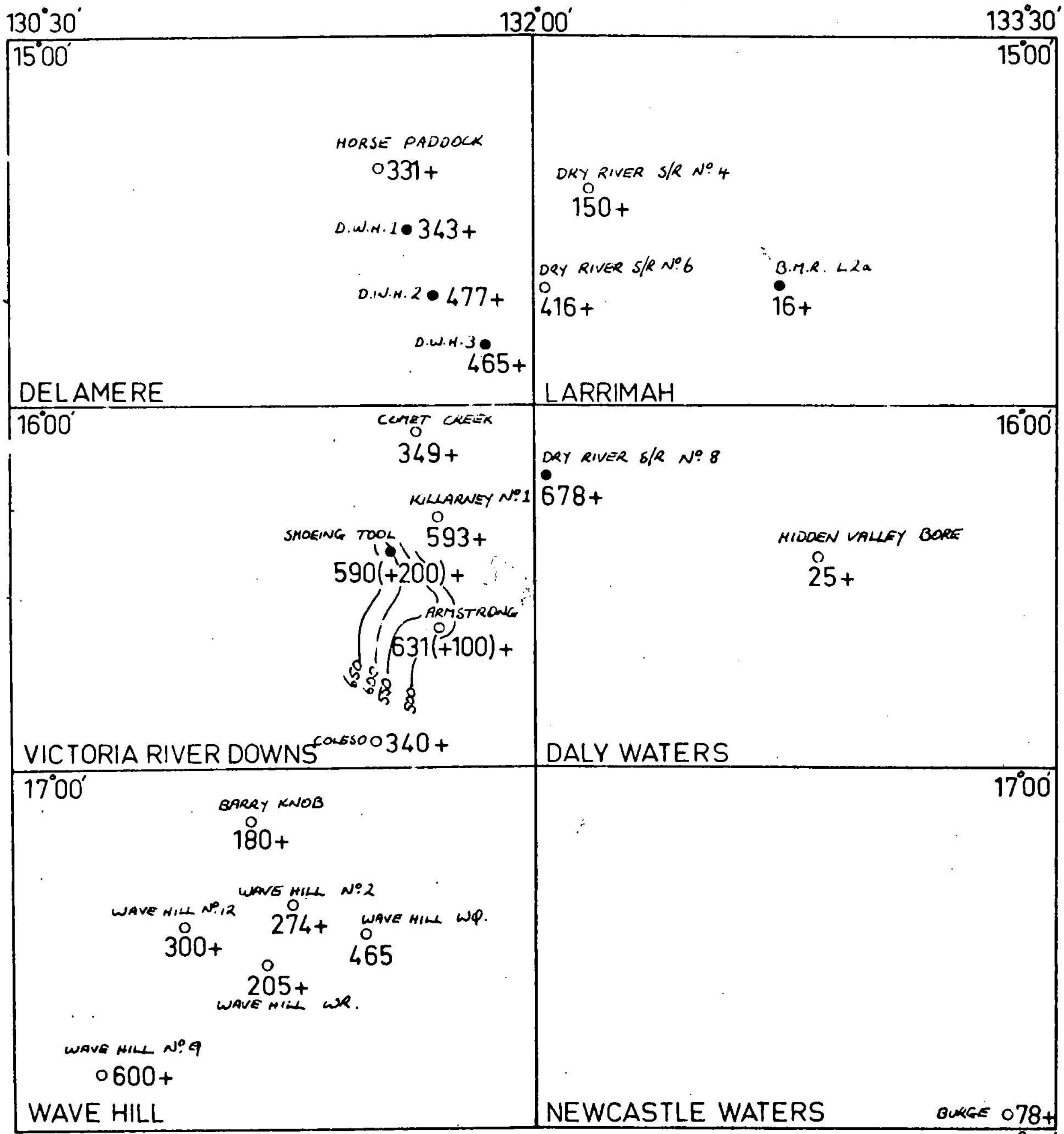
The limestones associated with the chert are laminated microcrystalline with some sand, silt, and clay impurities. The crystals are variable in size and irregular in shape. The limestones examined in thin section appear to have been deposited as laminated carbonate mud and subsequently recrystallized.

At locality DL 206, 6½ miles east of Delamere Homestead, about 50 feet of conglomerate, consisting of basalt blocks in a friable sandstone matrix, is exposed in a small gully. The basalt fragments are up to 18 inches across; some have a chilled margin and vesicular core and may be reworked volcanic bombs or pillows; most are angular fragments without recognisable internal structure. The conglomerate grades upward into a laminated fine sandstone, which is overlain by basalt.

Near Wave Hill No. 3 bore, the Volcanics contain tuffs and agglomerates. Some of the chert may be silicified tuff, but this has not been confirmed. Fragments of basaltic glass, with outlines typical of glass shards, are common in some thin sections of siltstone and chert;

FIG. 4

THICKNESS OF ANTRIM PLATEAU VOLCANICS
STRUCTURE CONTOURS ON A CHERT INTERBED



LEGEND

- o Waterbore, interpretation of driller's log
- ● Waterbore or BMR Scouthole, cuttings examined by geologist

631(+100)+ Minimum thickness from bore data, with additional thickness from outcrop data in brackets

Structure contours on chert interbed cropping out at Companion Creek crossing (control points not shown), 50 foot intervals

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they have presumably been derived from tuffs.

The Volcanics in the main outcrop belt dip very gently, usually to the east, as indicated by the slopes of plateaux and ledges of resistant sedimentary rocks and flows.

The dominant tholeiitic composition of the lava flows is usually regarded as typical of continental subaerial lava fields. The sedimentary rocks interbedded with the basalts indicate that some of the basalt was extruded subaerially (onto sand dunes) and some into shallow water. The sedimentary rocks appear to have been deposited in two main environments; the elongate ridges of sandstone with large scale crossbeds are interpreted as aeolian dunes; the chert, limestone, siltstone, and sandstone with ripple lamination and current lineations, were deposited under marine (intertidal zone) or lacustrine conditions.

The aeolian deposition of the sandstone with large scale cross-beds is inferred from the large scale of the cross-bedding, the very good sorting of the sand grains, and the lack of pebbles, and its occurrence as depositional mounds and ridges. In addition, the sharp and little-disturbed contact between the sandstone and the overlying basalt, and the partial melting of a narrow zone of the sandstone at the contact, indicate that the sediment was dry. Away from the margins of the outcrops, the majority of the cross-beds dip west-north-west, indicating the dominant direction of sand transport to have been in that direction and thus parallel to the trend of the ridges. The ridges are somewhat wider than modern seif dunes, and less regular in shape. They are like the parabolic dunes of McKee (1966). Barclay & Hays (1965) suggested an aeolian origin for some of the sandstone interbeds in the Volcanics.

The intertidal deposition of the chert with algal stromatolites can be inferred by analogy with present-day occurrences of algal stromatolites. Several types of stromatolites are present in the chert exposed around Top Springs. Tall cone-shaped and club-shaped forms are common. Adjacent club-shaped forms are sometimes joined together. The club shapes often developed as a later growth stage of an initial cone type, which latter were referred by Traves (1954) to Collenia frequens Walcott. The club shapes are typical Cryptozoon types. At locality VRD 203, (west of Top Springs), there are club shaped stromatolites 3 feet high and 20 inches across, and cone shapes up to 10 inches basal diameter and of similar height. Club-shaped stromatolites of similar dimensions form reef-like structures in a hypersaline lagoon subject to wave action at the head of Shark Bay, Western Australia (Logan, 1961). The heads of the stromatolites are a few inches above high water mark and their bases are at low water mark.

The cherts (and limestones) with flat or slightly wavy lamination may have been deposited as carbonate mud bound by algal mats. In Shark Bay, and other modern occurrences, flat laminated algal-bound carbonate sediments are characteristic of the intertidal zone in areas normally sheltered from wave attack.

The sedimentary rocks, as a whole, suggest that the basalt was extruded in an area near sea level and subject to marine incursions. Sand, derived from areas of Precambrian sedimentary and igneous rocks and in part from the basalts, was moved along shorelines by longshore drift, and blown off beaches into the hinterland where it accumulated as dunes. Carbonate sediments often bound by algal mats and calcareous silts accumulated in the more sheltered intertidal areas. The ripple-bedded sands and those with current lineations were probably deposited as beach and shallow subtidal sands; the conglomerate at DL 206 could be due to a mixing of littoral sand with fragments derived from wave erosion of a basalt flow. The water-laid sediments could perhaps have been deposited from lakes formed either by warping of the surface of the lava field or by blocking of drainage by lava flows. The climate seems to have been warm and arid, with a dominant south-south-east wind.

The thickness of the Volcanics is difficult to estimate from outcrop data owing to the gentle dips and the lack of accurate levelling. Many waterbores have been drilled partly or entirely in the Volcanics, but none penetrated the complete section from the overlying Montejinni Limestone to the underlying Victoria River Group. Some of the bores, and the thicknesses of Volcanics penetrated, are shown in Figure 4. The thickest known section is in the area of Shoeing Tool Replacement bore near Mooloooloo Homestead (Appendix 2) - 590+feet of Volcanics in the bore and about 200 feet more in nearby hills, giving a thickness in excess of 790 feet. Armstrong bore, about 8 miles west of Top Springs, and surrounding outcrops give a minimum thickness of about 730 feet. The Volcanics become thinner to the south and north of these two localities, (both on the Victoria River Downs 1:250,000 sheet area); they are 465 feet thick at WQ bore in the Wave Hill 1:250,000 Sheet area, and Randal (1962) estimated about 200 feet of Volcanics on the Fergusson River 1:250,000 Sheet area.

The Antrim Plateau Volcanics rest on sedimentary rocks of the Victoria River Group with an angular unconformity. The surface had considerable relief. Traves (1955) states that the Volcanics occur in old valleys, some of them 200 feet deep, along the Victoria River between Coolibah and Willeroo. This was confirmed by Barclay & Hays (1965). Some of the Victoria River Group inliers, such as the one near No. 47 bore, Wave Hill Stock Route, represent hills on the unconformity surface.

The Volcanics are overlain with a slight unconformity by the lower Middle Cambrian Montejinni Limestone. Small scale irregularities, probably due to pre-Montejinni erosion, have been observed at the junction between the two units at Palm Spring (VRD 105). On a regional scale, the Montejinni Limestone appears to rest on lower horizons of the Volcanics at the southern margin of the Victoria River Downs sheet area, than farther north around Companion Creek. The chert at Companion Creek Crossing (VRD 211) is between 150 feet and 200 feet below the base of the Montejinni Limestone. The chert horizon has been traced continuously on air photos, and at the southern margin of the Victoria River Downs Sheet it is apparently overlapped by the Montejinni Limestone.

Traves (1955) regarded the age of the Volcanics as probably Lower Cambrian, because they were overlain, apparently conformably, by the lower Middle Cambrian Negri Group and underlain unconformably by the Upper Proterozoic (Adelaidean) Victoria River Group. The relationships in the northern Wiso Basin are similar, but there is a slight unconformity between the Volcanics and the overlying lower Middle Cambrian limestone.

The stromatolites at Top Springs, now known to be near the top of the Volcanics, were equated with forms from the Upper Proterozoic Belt Series of North America by Traves (1954). Radiometric ages are not available for the Volcanics, but a Rb/Sr age of 666± 56 million years has been determined by V.M. Bofinger for shales about 3,000 feet to 5,000 feet below the unconformity at the base of the Volcanics in the east Kimberly area (Dow & Gemuts, in prep.). If this age is reliable then the Volcanics are almost certainly Lower Cambrian.

Middle Cambrian

Montejinni Limestone:

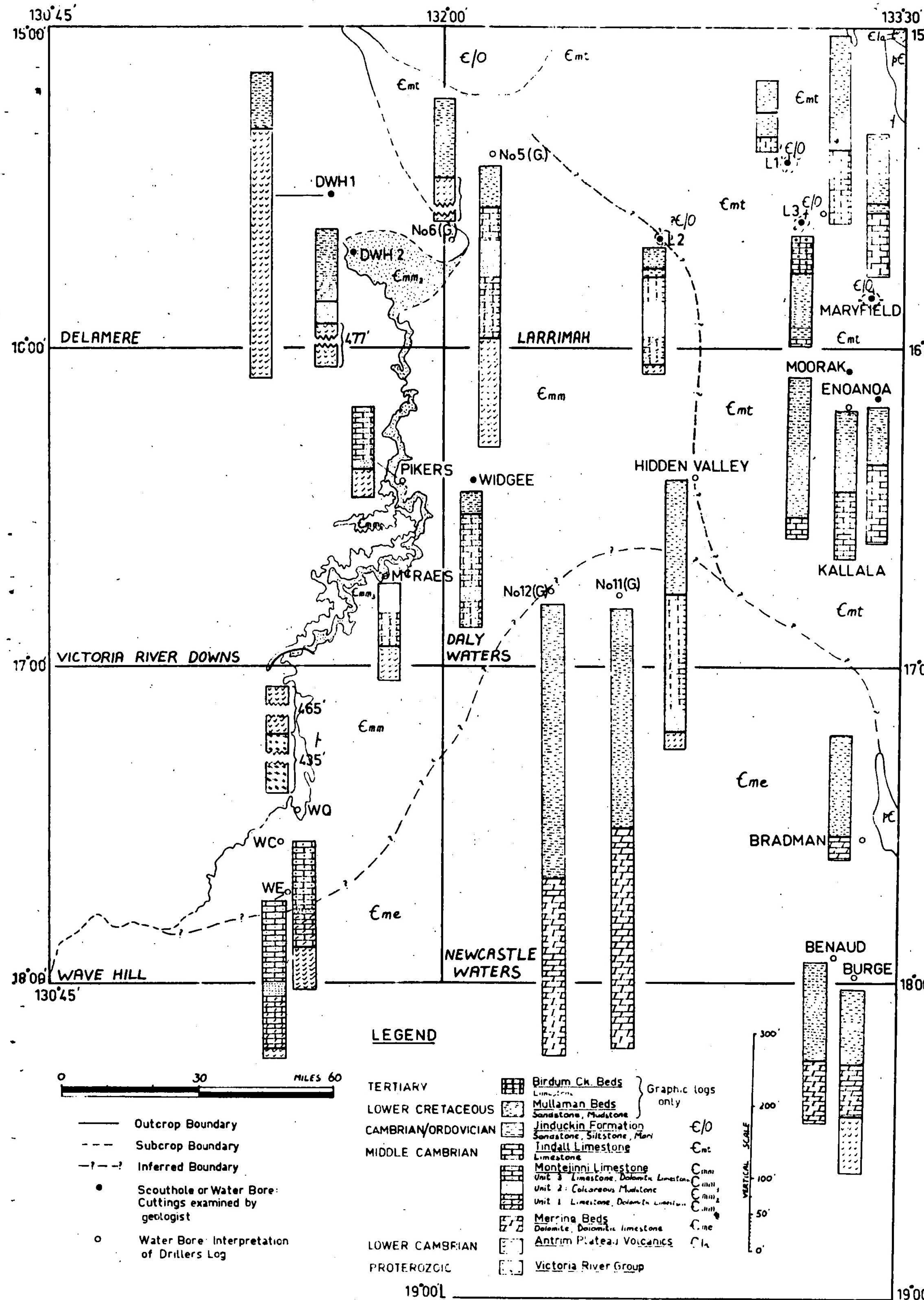
The Montejinni Limestone (Traves, 1955) crops out in the western part of the region. It unconformably overlies the Lower Cambrian Antrim Plateau Volcanics, and is equivalent in part to the Tindall Limestone of the Daly River Basin (Randal, 1962, 1963) and the Merrina Beds in the central part of the Wiso Basin (Milligan *et al.*, 1966). It consists of three units - two limestone units separated by a middle mudstone unit - with a thickness of about 200 feet. The age of the Montejinni Limestone is lower Middle Cambrian. *Redlichia* has been found near the base and near the top of the unit. Fossil lists are given in Appendix 3.

Traves (1955) named the Montejinni Limestone from outcrops of the formation about Montejinni Homestead. Although previous workers had made some brief comments about limestone outcrops in the western part of the region, Traves was the first to map the unit and differentiate it from Precambrian limestone units within the Victoria River Group. Traves believed the formation was Cambrian in age and it had an equivalent in the Daly River Group to the north and in the Negri Group to the west. This could not be proved at the time as the only fossils found in the formation were girvanellids.

Traves (op. cit.) does not describe a type section or locality although he intended that the type area should be 'in the vicinity of

FIG. 5

GENERALIZED BORE LOGS AND SUBCROP MAP



Montejinni Homestead where 30 feet of grey crystalline limestone are exposed in the home paddock'. He also states 'At the bottom of the typical section of the formation are about 40 feet of crystalline limestone, thickly bedded to massive, fine to coarse-grained, grey, cream, and brown, containing abundant chert nodules which are commonly found along the bedding planes. This is overlain by 20 to 40 feet of crystalline limestone, thinly bedded, fine-grained, grey, and with very few, if any, chert nodules'.

The Montejinni Limestone crops out in a long and narrow meridional belt from between Cattle Creek and the headwaters of the Camfield River in the south to east of Delamere Homestead in the north. It flanks the western margin of the large plateau which lies between the Timor Sea drainage to the west and the Gulf of Carpentaria Drainage to the east. In the central part of the meridional belt, the formation forms a rugged dissected terrace flanking the plateau; in the southern part this terrace merges imperceptibly into the plateau. The unit also forms isolated mesas some miles west of the plateau and terrace, and in the north crops out as boulders in grassy plains and woodlands. The Montejinni Limestone passes beneath the Lower Cretaceous cover between Larrimah and Willeroo and appears to re-emerge on the northern and eastern sides of the plateau as beds of the Tindall Limestone. To the south-east it passes beneath the sand cover and re-appears in the central part of the Wiso Basin where it underlies the upper part of the Merrina Beds, but appears to be equivalent to the lower part of this unit (Milligan _et al._, 1966). These aspects are discussed later and are illustrated in Figure 5.

The Montejinni Limestone consists of limestone, dolomitic limestone, dolomite, silty carbonates, and calcareous mudstone or siltstone. In places it contains abundant chert nodules and stringers along bedding planes. Milligan _et al._ (op. cit.) record thin to medium-bedded quartzose, microcrystalline limestone, dolomitic siltstone, and crystalline limestone in the Winnecke Creek Sheet area south of this region. Between Cattle Creek and Delamere Homesteads a three-fold division of the formation has been recognized at several localities and in scouthole and waterbore cuttings - an upper and a lower limestone unit, separated by a middle mudstone unit*. The division is shown on the Delamere and Victoria River

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* The 'typical section' of the Montejinni Limestone described by Traves (op. cit.) apparently refers to the lower limestone unit of this Record.

Downs geological sheets, but because of topography, paucity of outcrop, and scale of mapping, it has not been shown on the Wave Hill geological sheet. The surface and subsurface distribution of the three units is shown in Figure 5.

The following composite section has been estimated from surface exposures north-east of Top Springs:

	Top	
Unit 3	35 feet +	Grey to brownish limestone with stromatolites at base and *Girvanella* and *Biconulites* higher in the section. Contains small patches of dolomite and is partly silicified.
Unit 2	40 feet	Calcareous mudstone, red-brown and yellow-buff. Silty carbonates. Produces red-brown soil with rubble of red travertine. The unit is poorly exposed. A persistent band of silicified rocks occurs at the base.
Unit 1	50-60 feet	Mottled limestone with chert nodules and patches of dolomite, overlain by laminated coarsely crystalline pale limestone producing flat slabs in black and grey soils.

A similar sequence was penetrated in the homestead bore at New Birrimba, 20 miles north-north-east of Top Springs Homestead:

Soil	0-30 feet	Clayey soil and ferruginous material
Unit 3	30-134 feet	Brown microcrystalline limestone and dolomite.
Unit 2	124-155½ feet	Buff calcareous mudstone, some limestone.
Unit 1	155½-165½ feet	Grey and brown calcilutite.

A detailed description of the cuttings is given in Appendix 2. The same divisions occur in a measured section one mile south-east of Palm Springs, on the upper reaches of Townsend Creek:

	Top	
Unit 3	(20 feet	Dark-grey dolomitic limestone with *Redlichia*, *Biconulites*, and *Lingulella*
	(10 feet	Stromatolitic limestone
Unit 2	40 feet	Yellow, white, buff, calcareous siltstone, thin-bedded and laminated.
Unit 1	(10 feet	Stromatolitic limestone
	(60 feet	Thin-bedded light-grey limestone
	(40 feet	Dark grey cherty limestone

The three divisions do extend southward into the Wave Hill Sheet area, but have not been separately mapped. In a sinkhole 23 miles north of Cattle Creek Station the section is:

	3 feet	Pisolitic ironstone
Unit 3	13 feet	Chert rubble, some grey crystalline limestone blocks
Unit 2	(16 feet	Red to buff calcareous siltstone
	(41 feet	Red and chocolate calcareous siltstone
Unit 1	(1½ feet	Dolomitic limestone, stromatolitic
	(1½ feet	Thick chert bands and nodules in dolomitic limestone
	(7 feet	Foetid black and grey limestone with chert nodules
	(	Thick bedded
	(100 feet +	Presumably all limestone in a deeper secondary inaccessible sinkhole(sounded by line and illuminated by torch.)

About another 20 feet of Unit 3 is exposed in adjacent rises. The section dips about 1° in a direction about 100°.

Farther south along the scarp a few thin siltstone beds occur: at WV 25 (8 miles east-north-east of Chungamidgee waterhole) a 5-foot bed of chocolate and yellow calcareous siltstone is underlain by stromatolitic cherty limestone and overlain by light grey crystalline limestone with rare chert nodules. In the scarp east of Chungamidgee waterhole on the road from Wave Hill to Cattle Creek - one of the localities described by Traves (op. cit., p. 33) - the siltstone unit is missing and thick-bedded grey crystalline limestone with abundant chert nodules is directly overlain by thin-bedded light grey crystalline limestone (Unit 1) and overlain to the east by massive karst crystalline limestone and calcilutite (Unit 3). Elsewhere along the scarp Unit 3 contains more chert than it does to the north, and without the intervening siltstone unit the two limestone units cannot be separately identified. The drillers' logs of waterbores WC and WF on Wave Hill Station suggest the presence of all three units (Fig. 5 and Appendix 2).

In the north of the region, the mudstone unit is the most persistent in outcrop. The lower limestone unit (Unit 1) appears to lense out north of Fraynes Knob, and the mudstone (Unit 2) rests directly on the

Lower Cambrian Antrim Plateau Volcanics. The mudstone unit disappears beneath the Lower Cretaceous rocks about 10 miles north-east of Delamere Homestead, and the upper limestone unit is overlapped by the Lower Cretaceous rocks, 25 miles south-east of Delamere Homestead.

However, all three units extend considerable distances to the east under the Mesozoic rocks. Scout-hole L2, 40 miles west of Larrimah, is about 80 miles east of the northern outcrops of the Montejinni Limestone, yet it intersected a similar section from 35 to 162 feet (Fig. 5, and Appendix 1).

Similarly, the Hidden Valley waterbore penetrated 160 feet of Unit 3 underlain by 30 feet of Unit 2, in turn underlain by the Antrim Plateau Volcanics (see Fig. 5, and Appendix 2).

The surface and subsurface distribution of the three units is shown in Figure 5.

The unconformable contact between the Antrim Plateau Volcanics and the Montejinni Limestone is apparent at most places along the western scarp, but the best exposures are at VRD 115 and VRD 113 near Cullenjacky Bore on the Top Springs-Wave Hill road. Contours on the contact between the two units are shown in Figure 6. The contact between the Montejinni Limestone and Precambrian rocks is not exposed. The Limestone is unconformably overlain by the Lower Cretaceous Mullaman Beds (Figure 7) which in the northern part of the region overlap the limestone to rest directly on the Lower Cambrian Antrim Plateau Volcanics.

The upper part of the Montejinni Limestone (Unit 3) appears to be equivalent to part of the Tindall Limestone. Unit 3 can be recognized in discontinuous outcrop and interpreted in bore-hole data as far north as the valley of the Dry River near Bore No. 4, where outcrops of fossiliferous limestone are identical to and contiguous with outcrops of the Tindall Limestone in the Katherine Sheet area. The recognition of Unit 3 in Scouthole L2 in the middle of the Larrimah Sheet area further assists this correlation in the eastern part of the region. A

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similar limestone to Unit 3 in Scouthole L2 occurs in Scouthole L1 in the valley of Birdum Creek. This limestone is identical in lithology and faunal content to outcrops of Tindall Limestone about 20 miles north in the valley of Elsey Creek. Several waterbores as far south as Enoanoa bore near Daly Waters have yielded rock chips similar to the Tindall Limestone and Unit 3 of the Montejinni Limestone (Fig. 5, and Appendices 1 and 2). Although the fauna found in the upper and lower limestone units of the Montejinni Limestone are the same as those found in the Tindall Limestone, the three units of the Montejinni Limestone have not been recognized in the Tindall Limestone. The upper unit of the Montejinni Limestone is identical to rocks of unknown position within the Tindall Limestone, and until more subsurface data can clearly establish the relationship between the two formations it is better to retain different names for them.

Milligan et al. (1966) consider that the Montejinni Limestone in the Winnecke Creek Sheet area is overlain by the upper part of the Merrina Beds, and is equivalent to the lower part of that unit. This relationship could not be checked in the northern part of the Wiso Basin. However, the drillers' logs of waterbores on the Murranji Stock Route are similar to those in the Lake Woods area where outcrops of the Merrina Beds are known. The Merrina Beds presumably occur in the subsurface as far north as the central part of the Murranji Stock Route. On existing evidence they are correlated with the Montejinni Limestone to the west and the Tindall Limestone to the north-east; this latter correlation is by indirect evidence only at this stage.

Traves (1955) reports that the beds of the Montejinni Limestone are generally sub-horizontal, broadly folded and slightly buckled, and the recent survey substantiates this opinion. The regional dip of the rocks in the meridional belt is gently eastward - usually less than 1°. Small folds of local significance occur along the road north from Top Springs and near Cullenjacky Bore on the Top Springs-Wave Hill road. Some of these folds are probably caused by solution collapse, although some folds affect the underlying Antrim Plateau Volcanics. Steepened and reversed dips occur along faults, but these are uncommon.

The Montejinni Limestone was deposited in the shallow epeiric sea which covered large parts of the Northern Territory during the Middle Cambrian. Sedimentation was quite and slow - probably resulting from chemical precipitation of carbonates assisted by living organisms, together with transportion of terrigenous material from a land surface of Antrim Plateau Volcanics and rocks (including carbonates) of the Victoria River Group. Unit 3, above the basal stromatolite band, contains abundant shelly fossils, suggesting well-circulated water of normal salinity, and abundant Girvanella (filamentous blue-green algae), indicating shallow water probably less than 30 feet deep. The stromatolite beds, which occur at the base of Unit 3 and sometimes at the top of Unit 1, suggest intertidal deposition, probably in water with restricted circulation and high salinity. Unit 1 contains trilobites, suggesting a normal marine environment. Unit 2, a mudstone with dominant red colour and a lack of fossils, suggests an oxidizing environment with restricted circulation of water with above normal salinity. The reason for the change from carbonate sedimentation to terrigenous sedimentation and the return to carbonate sedimentation, is not clear. The patchy dolomitization of the limestones with destruction of original textures by euhedral dolomite rhombs, apparently occurred after consolidation of the sediments.

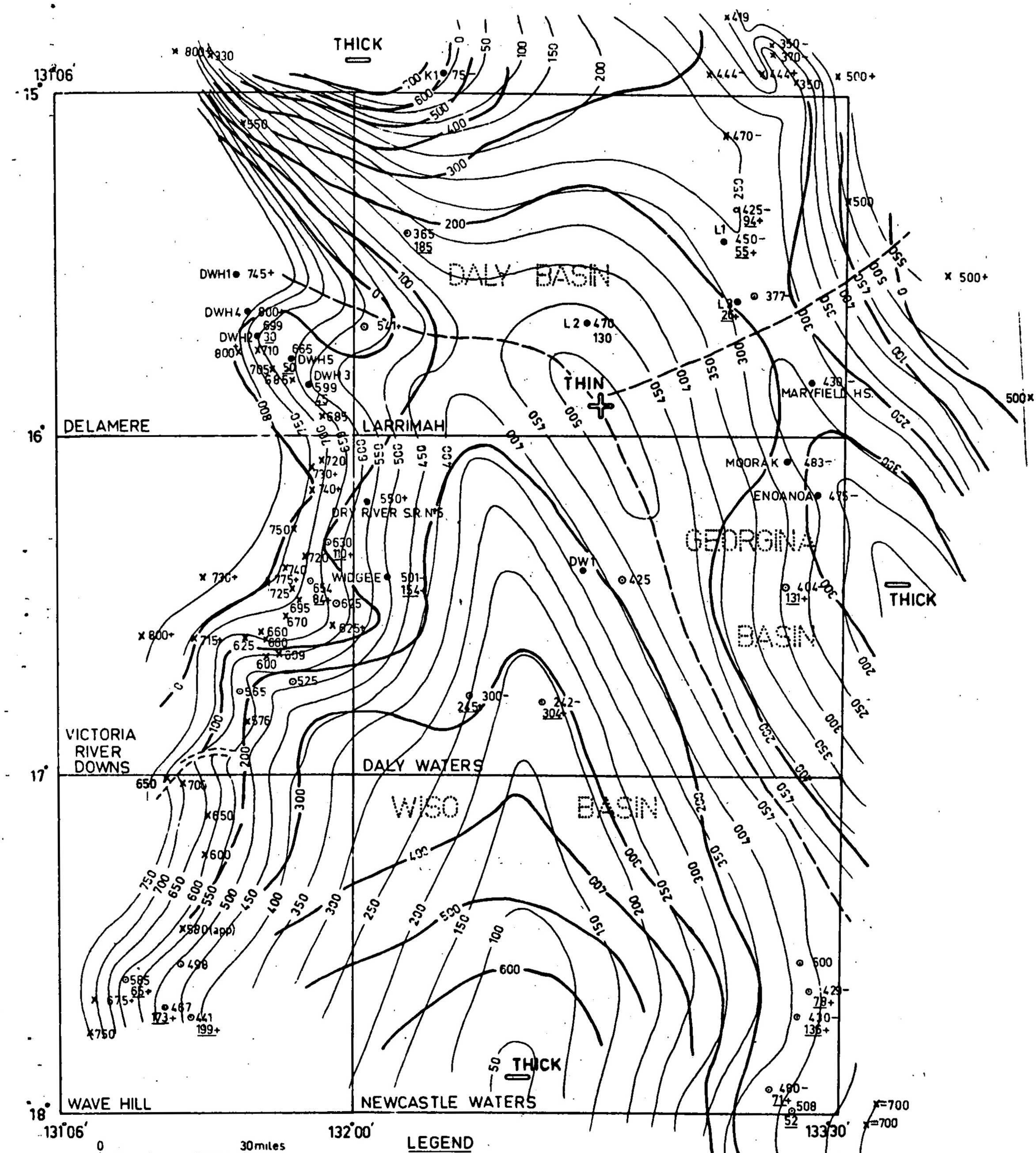
The Montejinni Limestone does not exceed 200 feet in thickness (Figure 6). There is some indication that the thickness of equivalents of the Limestone increases southwards. Milligan et al. (op. cit.) recorded several hundred feet of Merrina Beds in the central part of the Wiso Basin. In the north, the thickness of the Montejinni Limestone is 120 feet in Scouthole L2 and 170 feet in Dry River Stock Route No. 5. It is 190 feet in the Hidden Valley waterbore and in the Top Springs area. It is approximately 200 feet in a sink-hole north of Cattle Creek Homestead and in Wave Hill WE bore south of Cattle Creek Homestead (Fig. 6).

Tindall Limestone:

The Tindall Limestone was named by Randal (1962, 1963; in Walpole et al., 1967) as the basal unit of the Daly River Group (Noakes, 1949): the type locality is about Tindall Aerodrome, seven miles

STRUCTURE CONTOURS BASE OF LOWER PALAEOZOIC SEDIMENTS
ISOPACHS LOWER PALAEOZOIC SEDIMENTARY ROCKS

FIG. 6



LEGEND

× Outcrop data
⊙ Waterbore : interpretation of drillers log
● Scouthole or Waterbore : cuttings examined by geologist
Structure contours, 50 foot intervals
Isopachs, 100 foot intervals
⊙ 405 / 35 Elevation of contoured surface, in feet above sea level / Thickness of Palaeozoic sedimentary rocks, in feet
Structurally high areas
Structurally low areas
Fault
Basin boundary

Isopachs; Structure contours: Klm, €/O, €mn €at €ne, €la, Pu

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south-east of Katherine township in the Katherine Sheet area. The unit occurs in the Pine Creek, Fergusson River, Delamere, Larrimah, Katherine, and Hodgson Downs Sheet areas.

In this region the unit crops out in the valley of Mathison Creek in the Delamere Sheet area, and in the valleys of the Roper River and Elsey and Cattle Creeks in the Larrimah Sheet area. Outcrops of the Montejinni Limestone in the Dry River valley in the north-western part of the Larrimah Sheet area could equally as well be regarded as Tindall Limestone. The Tindall Limestone has been recognized in cuttings from scout-holes L1 and L2 near Larrimah township, and in cuttings from the Maryfield Homestead bore, 22 miles south-east of Larrimah, and from Enoanoa and Moorak bores on Daly Waters station. Drillers' logs suggest it is present in the Hidden Valley waterbore and in No. 5 bore Dry River Stock Route (Fig. 5 and Appendix 2). The unit occurs as scattered blocks in grassy plains or woodlands, as low karst outcrops, or as pavements and banks in watercourses. It crops out on the dissected north-western and north-eastern edge of the Sturt Plateau, and underlies the Mesozoic rocks of the plateau for some distance southward eventually merging with the Merrina Beds and the Montejinni Limestone.

The presence of limestone beneath the superficial deposits and Lower Cretaceous rocks of the plateau is suggested by the extensive pattern of incipient sinkholes - shallow silt-filled depressions with heavy vegetation - which extends over much of the Larrimah Sheet area, and the northern part of the Daly Waters Sheet area.

No sections have been measured in outcrops of this unit; detailed cuttings descriptions of incomplete parts of the unit in the scoutholes are given in Appendix 1. The unit consists of light brown, grey-brown, buff and yellowish calcilutite, fine crystalline limestone, dolomitic limestone, and dolomite. It contains chert nodules and stringers, but these are not as prevalent as in the Montejinni Limestone. The Tindall Limestone is fossiliferous: *Biconulites*, ptychoparioid trilobites, phosphatic brachiopods, obolidae, and cystid plates have been found in the scoutholes, and *Biconulites*, phosphatic brachiopods, obolidae, *Girvanella*, and sponge spicules have been found in outcrop.

The outcrops of the Tindall Limestone in the Delamere Sheet area are on the south-western edge of the Daly River Basin, and dips are gently basinwards - about 1° to the north-east, although higher dips probably caused by collapse or local faulting have been noted. In the north-east of the Larrimah Sheet area the beds are sub-horizontal - some may dip at low angles basinwards to the north, and others south beneath the Cretaceous cover to form the northern part of the Wiso Basin. Along Cattle Creek in the Larrimah Sheet area the dips are clearly westward off the Adelaidean Roper Group and the Lower Cambrian Antrim Plateau Volcanics. The Tindall Limestone unconformably overlies these two units in this area, and unconformably overlies the Antrim Plateau Volcanics in the Delamere Sheet area (Fig. 6). It is unconformably overlain by the Lower Cretaceous Mullaman Beds. Relationships with the Lower Palaeozoic Jinduckin Formation are discussed later.

The relationship of the Tindall Limestone to the Montejinni Limestone and the Merrina Beds has previously been discussed. The Tindall Limestone or some equivalent of part of it probably extends southwards and south-eastwards along the eastern edge of the Ashburton Range to merge with the Middle Cambrian Gum Ridge Formation in the Helen Springs and Tennant Creek Sheet areas, and with other Middle Cambrian units of the Barkly Tableland. A correlation of the Tindall Limestone with the Gum Ridge Formation is indicated by the fauna (Öpik, 1959). The Tindall Limestone may be a correlate of the upper Lower Cambrian or lower Middle Cambrian Top Springs Limestone which underlies the Cretaceous rocks in the Wallhallow Sheet area (Plumb & Rhodes, 1964). The two are similar in lithology, outcrop, and stratigraphic position.

Fossils from the Tindall Limestone in the Daly River Basin clearly indicate a lower Middle Cambrian age (Randal, 1962, 1963).

The depositional environment of the Tindall Limestone is similar to that of the upper unit of the Montejinni Limestone.

The thickness of the Tindall Limestone in this region is at least 100 feet (Fig. 6). In the Daly River Basin to the north it is about 500 feet (Randal, op. cit.).

Merrina Beds:

The Merrina Beds were named by Milligan et al. (1966) from Scouthole WC3 near Merrina Waterhole in the central part of the Wiso Basin, and contain lower Middle Cambrian fossils.

In the northern part of the Wiso Basin the Merrina Beds crop out as scattered boulders and pavements of dolomite near Benaud and Coolibah Bores in the south-eastern part of the Newcastle Waters Sheet area. Chert and lateritized sandstone rubble along the southern margins of the Newcastle Waters and Wave Hill Sheet areas have been included in this unit in conformity with mapping by Milligan et al. (op. cit.) in the adjoining Sheet areas of South Lake Woods and Winnecke Creek. The drillers' logs of waterbores suggest the Merrina Beds extend as far north as the central part of the Murranji Stock Route (Fig. 5).

The unit consists of dolomite, dolomitic limestone, chert, silicified carbonate rocks, and sandstone in the northern part of the basin; Milligan et al. (op. cit.) record crystalline dolomite, dolomitic claystone, siltstone, and fine-grained sandstone with thin dolomite beds overlain by a medium to coarse-grained, cross-bedded sandstone.

The Merrina Beds dip gently basinwards. The relationship between the Merrina Beds and other Middle Cambrian units has been discussed previously. The Beds presumably unconformably overlie the Tomkinson Creek Beds and are unconformably overlain by the Lower Cretaceous Mullaman Beds. Contacts with basement rocks to the west have not been seen in either the central or northern part of the Wiso Basin.

The age of the lower part of the Merrina Beds is lower Middle Cambrian: fossils found in the unit in the central part of the Wiso Basin are Biconulites, Acrotreta, Acrothele, and algae. The age of the upper part is not known but it conformably overlies the Montejinni Limestone. In the northern part of the Wiso Basin no fossils have been found in the Merrina Beds, but the outcrops are probably within the lower part of the unit.

Because of very poor exposure very little about the depositional environment can be deduced from the Newcastle Waters and Wave Hill Sheet areas. Evidence to the south suggests the dolomites were deposited as carbonate muds in warm shallow marine conditions and that dolomitization occurred at a late diagenetic stage. Some elevation of the land surface nearby produced small changes in environment sufficient to produce the siltstone and sandstone parts of the sequence.

The Merrina Beds are at least 450 feet thick in the central part of the basin: drillers' logs of water-bores along the Murranji track suggest the thickness is at least 300 feet (Fig. 5 & 6).

Cambrian/Ordovician

Jinduckin Formation

The Jinduckin Formation was named by Randal (1962) from Jinduckin Creek in the Fergusson River Sheet area of the Daly River Basin. The sequence of sandstone, siltstone, marl, limestone, and dolomite overlies the Tindall Limestone throughout the Daly River Basin.

In this region the Jinduckin Formation crops out in the north-eastern part of the Delamere Sheet area and in the north-western part of the Larrimah Sheet area. It forms isolated mesas and rubble-covered hills sometimes capped by the Lower Cretaceous Mullaman Beds, and occurs on the north-western slopes of the central plateau. Siltstone beds, overlying limestone in scoutholes L1, L2 and L3, and in the Maryfield Homestead bore, are similar to those in the Jinduckin Formation, but it is not proven that the formation extends this far to the south-east.

In this region the Jinduckin Formation consists of interbedded sandstone, siltstone, calcareous siltstone, dolomite and dolomitic limestone. It is thin to medium-bedded, flaggy, and in part silicified. It contains thin chert bands and nodules. Outcrops of sandstone and siltstone are characteristically red, chocolate or buff; the carbonate rocks are frequently pinkish-grey on the weathered surface. The carbonates are microcrystalline to finely crystalline, and contain algal stromatolites. Sandstones are well sorted, and fine to medium-grained, and in a few places they are cross-bedded and cross-laminated; they are occasionally ripple-marked. Halite pseudomorphs occur in both the sandstone and the siltstone beds.

The Jinduckin Formation appears to conformably overlie the Tindall Limestone in the Daly River Basin: no definite contacts between the two were observed in outcrop, but north of Mathison Creek the two formations are concordant in strike and angle of dip. Furthermore in Scouthole K1, 18 miles north of Dry River Stock Route Bore No. 4, the contact between the two formations seems gradational (Appendix 1).

During the mapping of the Daly River Basin, Randal (op. cit.) considered the contact to be conformable and regarded the Jinduckin Formation (and its equivalent, the Manbulloo Limestone Member) as Middle Cambrian in age although no diagnostic fossils were found. In 1964, geologists of Australian Aquitaine Petroleum Pty Ltd discovered trilobites and brachiopods of Lower Ordovician age (Öpik, 1964) in rocks near the top of the Jinduckin Formation near Claravale Homestead in the Fergusson River Sheet area. The position of the Cambrian/Ordovician boundary within the Daly River Basin is not known but presumably is within the Jinduckin Formation or at its base. It is not known if the Formation represents continuous, but slow, sedimentation from lower Middle Cambrian time to Lower Ordovician time, or if there are breaks in the sequence. The only fossils found in the formation in this region were algal stromatolites in the dolomite interbeds.

Randal (op. cit.) estimated the thickness of the Jinduckin Formation at 200 feet; however, at scouthole K1, 355 feet of flat lying interbedded sandstone, siltstone and carbonate rocks were penetrated. At least another 100 feet of the unit is exposed in surrounding hills.

The presence of shelly fossils and algae suggest the formation was laid down under shallow water marine conditions. Halite pseudomorphs in part of the sequence indicate evaporitic conditions - probably in the inter-tidal zone or in lagoons.

The age of the Jinduckin Formation is not accurately known. Lower Ordovician fossils have been found near the top of the unit, but its lower contact with the lower Middle Cambrian Tindall Limestone appears conformable. At present the age is regarded as Cambrian/Ordovician.

MESOZOIC

Lower Cretaceous

Mullaman Beds

Flat-lying sediments of the Lower Cretaceous Mullaman Beds crop out over most of the Daly Waters and Larrimah Sheet areas, and parts of the Newcastle Waters, Wave Hill, Victoria River Downs and Delamere Sheet areas. In this region the rocks are continuous with the 'Mullaman Group' (Noakes 1949), which covers large areas of the Katherine-Darwin Region to the north. Noakes' term has been modified to Mullaman Beds by later workers, and this name has been extended to include all the Lower Cretaceous rocks in the northern part of the Northern Territory*. The name Mullaman Beds has been used in this sense by Skwarko (1966, 1967).

In this region the Mullaman Beds crop out on the plateau which forms the divide between the drainage to the Timor Sea and that to the Gulf of Carpentaria, and along its dissected north-eastern margin. The unit crops out also on isolated mesas to the west of the plateau. The southern limit of the unit is along a line from south of Lake Woods north-

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* Vide relevant explanatory notes to adjoining areas, and Walpole, Dunn, & Randal (1967).

westward to the western edge of the plateau east of Camfield Homestead. On the plateau the Mullaman Beds occur as low rocky knolls or as scattered rubble in the sand and soil, but along the western edge of the plateau the Beds are well exposed as cliffs and escarpments from near Mount Wallaston in the Wave Hill Sheet area to north of Willeroo Homestead in the Delamere Sheet area. In the areas of poor outcrop, information has been obtained from scoutholes and waterbores.

The Mullaman Beds contain saccharoidal sandstone, conglomerate, glauconitic sandstone, claystone, and siltstone. Both marine and non-marine sediments occur in the unit. Skwarko examined the Mullaman Beds in this region during 1966 and the following comments on the sequence within the Mullaman Beds are based on Skwarko's results (Skwarko 1966, 1967).

The lowermost unit exposed on the plateau and along its western margin is a non-marine saccharoidal sandstone with, in places, basal beds of grit, and pebble and boulder conglomerate. It contains abundant impressions of wood fragments and leaves, but no marine fossils have been found. Skwarko reported decreasing grainsize in the rocks from west to east and north-east, and attributes this in part to the effects of distance from the source area; he records at least 15 feet in the west, and at least 45 feet (from scouthole L1) in the east. This sandstone unit is equated with Skwarko's (1966) unit A of the Inland Belt to the north, and with similar rocks in north-western Queensland named Lees Sandstone by Öpik, Carter, & Noakes (1961). The age of the unit is ?Neocomian-Aptian. Skwarko (1967) discusses the possibility that part of the Cretaceous section at Mount Sullivan, 18 miles north-north-east of Top Springs, at present regarded as equivalent to the Lees Sandstone, may contain rocks older than the Lees Sandstone.

In the plateau the equivalent of the Lees Sandstone is overlain by claystone and siltstone, with sandy interbeds, containing marine molluscs of Aptian age and, in DW1, foraminifera. Skwarko (op. cit.) tentatively refers it to Unit 6 of his Coastal Belt (Skwarko, 1966). It is more than 30 feet thick in outcrop on the western escarpment of the Sturt Plateau, but at Scouthole DW1 it is probably 140 feet thick. Along

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the western escarpment this unit is overlain by 15 feet of yellow, brown, or red, medium-grained micaceous quartz sandstone, in places glauconitic. This sandstone is called Unit 6a by Skwarko (1967) and although it is represented in the Coastal Belt it was there included in Unit 6 by Skwarko (1966) because of inadequate definition owing to poor exposures. In Scouthole DW1 Unit 6a is 48 feet thick. The fauna in the unit includes Rhizocorallium, the gastropod Neritokrikus tuberosus, and belemnites: its age is Aptian.

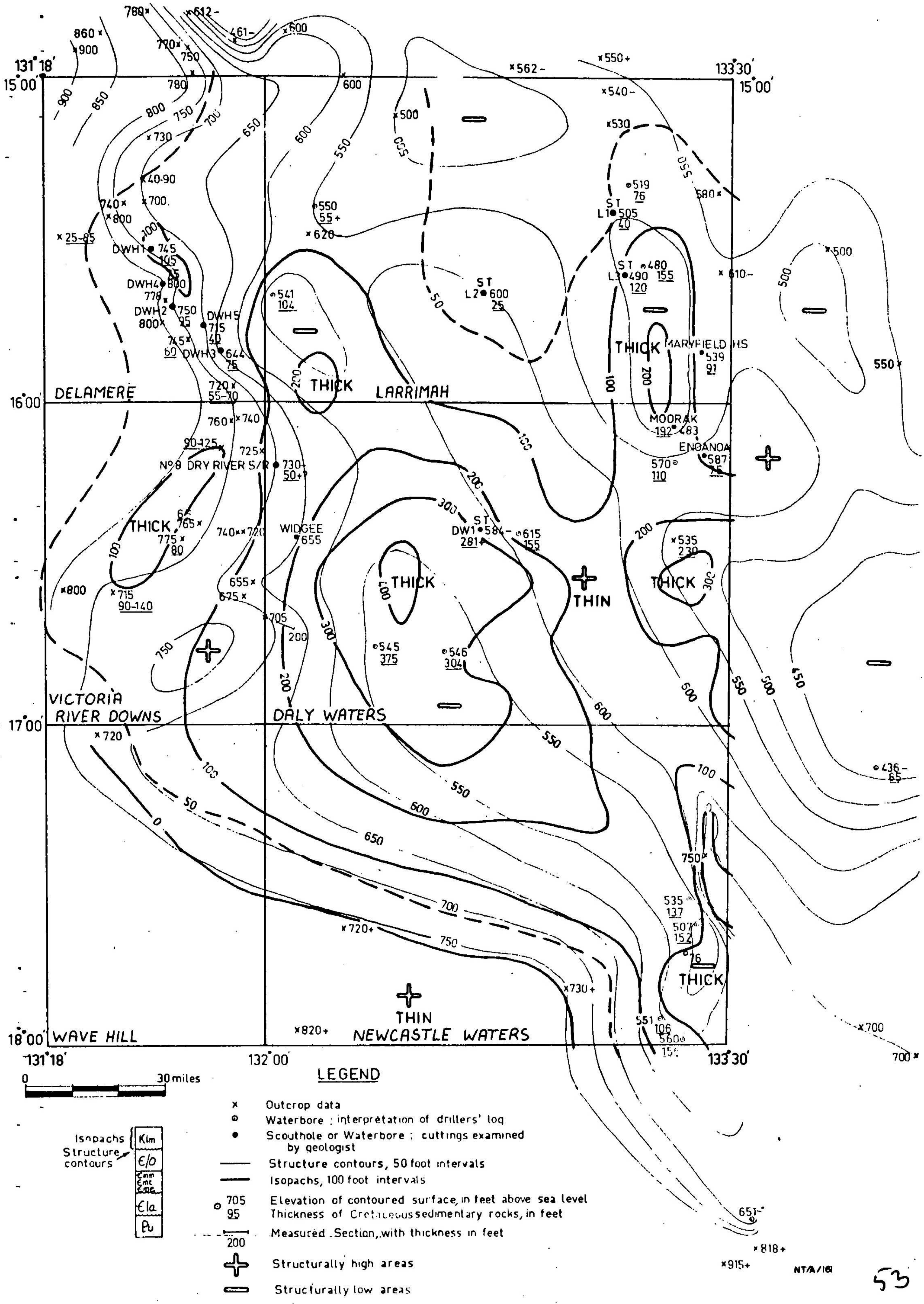
The uppermost subdivision of the Mullaman Beds is a micaceous siltstone and claystone, which in the Victoria River Downs Sheet area contains grit and pebble conglomerate near the top. Skwarko (1967) refers to this subdivision as the Polland Shale of Öpik et al. (1961) which is the same as his Unit C of the Inland Belt. It contains a microfauna of arenaceous foraminifera of Albian age, and rests probably disconformably on Aptian rocks. The list of microfauna from Scouthole DW1, where the unit is about 95 feet thick, is given in Appendix 1.

These four divisions of the Mullaman Beds are not shown on the geological sheets accompanying this record: the outcrop width of the divisions on the western side is too narrow to show at 1:250,000 scale, and on the plateau itself too few outcrops have been visited to delineate the boundaries even approximately. However, because of the relief on the plateau and the generally horizontal attitude of the strata all the divisions should crop out. Most of the Lower Cretaceous outcrops in the central part of the Daly Waters Sheet area are considered Polland Shale, and those in the central and northern part of the Larrimah Sheet are Lees Sandstone equivalent. In the latter area remnants of Unit 6a and 6 may occur, but this has not yet been proved. Heavily lateritized claystone occurs along the Stuart Highway near Larrimah Township, but the cuttings from the waterbores at Maryfield Homestead and on Daly Waters Station (Moorak and Enoanoa) suggest the Polland Shale directly overlies the Lees Sandstone equivalent (Appendix 2). Units 6 and 6a may crop out along the boundary between the Daly Waters and Larrimah Sheet areas and north of Hidden Valley: there the plateau slopes north and the drop in elevation of the land surface may reveal the section which occurs in Scouthole DW1 between the Polland Shale and the Lees Sandstone equivalent.

STRUCTURE CONTOURS BASE OF LOWER CRETACEOUS SEDIMENTS

ISOPACHS LOWER CRETACEOUS SEDIMENTS

FIG. 7



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In the Newcastle Waters Sheet area both saccharoidal sandstone (Unit A) and claystone (Unit 6 or Unit C) occur.

The Mullaman Beds unconformably overlie the Precambrian Tomkinson Creek Beds and Roper Group, the Lower Cambrian Antrim Plateau Volcanics, and all Lower Palaeozoic units of the Daly Basin and the northern part of the Wiso Basin. They are unconformably overlain by the Tertiary Birdum Creek Beds, but have not been found in contact with the Camfield Beds. The Mullaman Beds are overlain by extensive Cainozoic superficial deposits.

The unconformity at the base of the Mullaman Beds is illustrated by structure contours in Figure 7: the contours may show the relief of the land surface at the time immediately before the Lower Cretaceous sedimentation, but the original elevations of the land surface have to some extent been altered by post-depositional warping. The configuration of this surface tends to support Skwarko's (1967) belief that deeper water existed to the east of the western escarpment which was itself close to the Lower Cretaceous shore-line.

The faunal assemblages and correlation of the four subdivisions of the Mullaman Beds with the sequences to the north and north-east indicate the age of the unit ranges from late Neocomian(?) through Aptian to Albian, i.e. Lower Cretaceous. The fossil assemblages and the correlations are reported in detail by Skwarko (1967).

This region falls within the area of Skwarko's (1966, 1967) Inland Belt, and the early Cretaceous sedimentation was in a possibly shallow-water lacustrine environment. Sedimentation was presumably from higher ground to the west, and from the Ashburton Range. During the Aptian the region was flooded by an epeiric sea. During the Albian (i.e. Polland Shale time) the sea may have been continuous with that in which the sediments of the Great Artesian Basin were deposited. Skwarko (1966) correlates the Polland Shale with the 'Lower Wilgunya Formation'*.

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* Vine (B.M.R., pers. comm.) and others have raised the status of the Wilgunya Formation to Sub-group; the 'Lower Wilgunya Formation' in Skwarko's sense is now the Wallumbilla Formation.

Skwarko (1967, p.4) reports at least 165 feet of Lower Cretaceous sediments in sections along the western part of the plateau. The maximum observed thickness at any one point is 281 feet in Scouthole DW1 where all four subdivisions were intersected; but the hole penetrated only the first few feet of the Lees Sandstone equivalent before it was abandoned. The driller's log of No. 12 bore Murranji Stock Route suggests 375 feet of Cretaceous rocks were penetrated in that hole.

Figure 7 illustrates isopachs based on the present thickness of the Mullaman Beds below the plateau surface: the values indicated at the control points are less than the depositional thickness. The interpolation of the structure contours between control points suggests the variation in elevation of the basal unconformity is less than the variation in elevation of the present topography between the Murranji Stock Route and the Hidden Valley waterbore: if the strata are essentially flat lying then they may attain a thickness of about 400 feet in this area.

CAINOZOIC

Tertiary Laterite

Laterite profiles are well-developed on Lower Cretaceous argillaceous rocks and Lower Cambrian basic igneous rocks on the Sturt Plateau. They pre-date Miocene limestone, and are probably Tertiary in age.

Laterite is present over most of the Larrimah and Delamere Sheet areas, and parts of the other four sheet areas. It is largely confined to the Sturt Plateau, but is absent from the plateau over most of the Newcastle Waters Sheet area and the eastern half of the Wave Hill Sheet area. The ferruginous zone of the laterite is exposed along the edge of the Sturt Plateau and in minor low scarps and rises on the plateau surface, but is commonly covered with a variable thickness of red to dark brown, sandy and loamy soils. The laterite areas are timbered, supporting eucalypts and acacias such as Lancewood and Bullwaddy. Tall tropical grasses are present on soil-covered areas, and spinifex grows on exposures of the ferruginous zone.

On the argillaceous Cretaceous sediments, the ferruginous zone of nodular and pisolitic ironstone passes down into a mottled zone of iron-stained and bleached sedimentary rock and then into a pallid zone of bleached rock with thin hematite veins. These relationships can be seen in the scarp of the Sturt Plateau east of Top Springs. Some sections of ferruginous zone material (e.g. at Frew Pond, south of Dunmara) show apparent bedding and size sorting of the ironstone pisolites, and may be in part detrital. At locality WV77, in a sinkhole section, rubbly ferruginous material overlies siltstone of the middle unit of the Montejinni limestone. It may have developed in place on the siltstone or could alternatively be detrital and have developed originally on other rock type. Laterite profiles on the Antrim Plateau Volcanics were not examined in detail during 1966. According to Traves (1955), they lack a definite pallid zone.

Nine samples of ferruginous zone material were analyzed by A.M.D.L. for Fe, Al, Si, Mg, and trace elements Cu, Ni, Mn. Iron contents ranged from 22.9% for a specimen from locality VRD 21, about 5½ miles N.N.E. of WG bore, to 46.4% at WV77. Aluminium contents were low, less than half as abundant as iron, and less abundant than silicon except for two samples; in one of these silicon and aluminium were equal at 10.5% and in the other aluminium content was 11.1% and silicon 11.0%. The lowest aluminium content was 1.5%, in a specimen from near Murranji bore with 44.2% iron.

The laterite cannot be precisely dated in this region. The youngest rocks it overlies are of Lower Cretaceous age. In the Bullock Creek area it seems to be older than the Miocene Camfield Beds. In that area the Miocene limestones rest on a surface eroded almost 200 feet below the laterite. On the Larrimah Sheet area the limestones of the Birdum Creek Beds, probably of the same age as the Camfield Beds, occur in alluviated valleys apparently eroded into the laterite surface: the limestone contain pellets of lateritic material. Traves (1955) suggested that, on the Sturt Plateau, lateritization of rises and alluviation of valleys could have occurred together. If this is so then the Birdum Creek Beds which occur in the alluviated valleys could have formed at the same time as the lateritization.

Highly ferruginous sandstones and conglomerates are sometimes present at the base of the Lower Cretaceous Mullaman Beds, (Mt. Sullivan, Frayne's Knob, VRD 235, DL 212). Some of the rocks beneath the basal unconformity (siltstone at Frayne's Knob, basalt at Mt. Sullivan and DL 212) are also highly ferruginized. Five samples of these ferruginous rocks were analysed for the same elements as the laterite samples. Iron contents ranged from 22.1% for a conglomeratic rock at DL 212 to 42.4% for a rock with arenaceous texture from VRD 235. Aluminium contents were low(1.9 to 4.8%). The amounts of trace elements especially for manganese, were generally much higher than for the Tertiary laterite samples.

Outcrops of ferruginous rocks at the base of the Mullaman Beds could be mistaken for Tertiary laterite in areas where younger parts of the Mullaman Beds have been eroded.

Camfield Beds

The name Camfield Beds is proposed for Tertiary limestone, sandstone, and siltstone which crop out in the eastern part of the Wave Hill Sheet area. The rocks were previously unknown as a distinct Tertiary unit, and had been photo-interpreted by previous workers as part of the Middle Cambrian Montejinni Limestone.

The Camfield Beds crop out in the valley of Bullock Creek, a tributary of the Camfield River south-east of Camfield Homestead, and in the western valley of Cattle Creek from its confluence with the Camfield River upstream to near Cattle Creek Homestead.

The outcrops form mainly mesas in the Bullock Creek area, where they rise up to 70 feet above adjacent stream beds and are about 100 feet below the main surface of the Sturt Plateau. In the Cattle Creek area the unit forms rough low hills with rectangular drainage. In both areas, pavements and low cliffs of limestone occur in and about the watercourses.

The Camfield Beds consist of limestone, siltstone, and minor sandstone. The limestone is partially silicified and contains abundant chert laminae and nodules, and patches of chalcedony. The following is a composite section measured along the valley of Bullock Creek.

	Top
2 feet	Dark-grey hard limestone, thick-bedded
8 feet	Hard and soft buff limestone with vertical burrows, medium-bedded. This section may be underlain by up to 30 feet of non-outcropping strata, underlain by the following sequence:
10 feet	Cherty limestone, massive, with poor bedding
3 feet	Cherty limestone, medium-bedded, containing gasteropods
7 feet	Red-grey gypsiferous siltstone (leached silty limestone) with bone material
4 feet	White-buff limestone, opaline silica, gasteropods and bone material
15 feet	Mottled red and grey calcareous sandy siltstone and silty sandstone.
21 feet	Red calcareous siltstone (may be leached limestone)
10 feet	Basalt (Lower Cambrian Antrim Plateau Volcanics).

The limestone and the siltstone contain flattened polished pebbles of agate, derived from the underlying Antrim Plateau Volcanics. In the Cattle Creek area, where the unit rests mainly on the Montejinni Limestone the agate pebbles are rare. The pebbles are scattered throughout the unit, but are dense near the base. A coarse conglomerate near the base consists of clasts of basalt, chert fragments, and pellets of pisolitic ironstone. The latter is presumably derived from the lateritization of pre-Tertiary rocks: the pellets are similar to those in cemented and loose lateritic gravels which occur in many parts of the region over all pre-Tertiary units.

In the Bullock Creek area, gypsiferous siltstone in the unit is reddish and has a poorly developed box-work fabric, but in the Cattle Creek area siltstone interbeds are greyish-white and are lustremottled by thin laminae of gypsum. Fine to medium-grained sandstones in the same area have a similar fabric, but the weight of the rocks suggests the sulphate mineral is barytes. Algae and stromatolites occur in the limestone parts of the sequence.

The Camfield Beds unconformably overlie the Lower Cambrian Antrim Plateau Volcanics and the lower Middle Cambrian Montejinni Limestone. The unit has not been seen in contact with the Lower Cretaceous Mullaman Beds.

The sequence is about 70 feet thick as indicated by the composite section from the Bullock Creek area previously discussed. The full thickness is not apparent in the Cattle Creek area where only about 20 feet is exposed. The rocks are essentially flat-lying but some pitches and rolls have been caused by slumping and solution collapse. Lack of accurate levelling and indefinite correlation of horizons from outcrop to outcrop prevented an accurate measurement of the section and as indicated earlier up to 30 feet of section may be missing from the estimated thickness. The top of the unit has been eroded and an unknown amount removed.

During the mapping C. G. Gatehouse discovered extensive deposits of bone-beds which were later visited by M.D. Plane (Plane & Gatehouse, 1967, in press) who reports the following material: lung fish teeth, scutes of turtles, crocodile teeth, and post-cranial bones of giant ground birds; and representatives of the families Diprotodontidae and Thylacoleonidae. Freshwater gasteropods occur in the rocks and frequently form rich coquinite beds. The bone-beds have been found only in the Bullock Creek area; only poorly preserved gasteropods have been found in the Cattle Creek area, but as the rock types are similar further search may yield bone material.

Plane (in Plane & Gatehouse, op. cit.) considers that the Beds are middle to late Miocene in age: younger than the Kutjamarpu fauna of the Lake Eyre Basin (Stirton, in press), and older than the Alcoota fauna near Alice Springs (Woodburne, in press).

The presence of algae and stromatolites indicate the sediments were deposited in shallow water. A near-shore environment is supported by the fragmentation of fossil material, the conglomeratic material in the sequence, and the topographic situation of the unit. Deposition may have been in waters normally saline as indicated by the gypsum and barytes, but subject to freshwater flooding which brought in the gasteropods. The environment may have been lacustrine, or associated with lagoons or estuaries frequently flooded by freshwater.

Birdum Creek Beds

The name Birdum Creek Beds is applied to scattered outcrops of previously unknown Tertiary limestone which have been found in the central part of the Larrimah Sheet area between Birdum Creek and the Dry River.

The type locality for the unit is about Scouthole L3 which penetrated about 50 feet of the unit on a low rise on the western side of Birdum Creek, 3 miles west of Larrimah Township.

The Birdum Creek Beds occur as low rubbly rises and as scattered boulders in the black soil plains along Birdum Creek and the Dry River, and in the alluvial flats of the Sturt Plateau (cf. p. 11). No definitive pattern on aerial photographs has been established for this unit, and the outcrops mapped have been the result of chance encounter by ground traverses. The outcrops, which are usually lower than the grass cover cannot be readily seen from the air. The Birdum Creek Beds probably are far more extensive in the Birdum Creek and Dry River valleys, and in the alluvial flats, than is shown on the geological map.

The unit consists mainly of hard, finely crystalline limestone in outcrop, but Scouthole L3 intersected considerable amounts of soft chalky limestone in the interval 0 - 25 feet (Appendix 1). The limestone contains opaline nodules and is in part siliceous; it contained chalcedony in the interval 35 - 50 feet in L3, and abundant quartz sand grains in the interval 25 to 50 feet. No accurate appraisal of bedding can be made, but the boulders are flaggy. The material from the scouthole was massive with little indication of bedding.

The Birdum Creek Beds contain at least two genera of freshwater gasteropods of probable Tertiary age. Although there is no continuity between these Beds and the Camfield Beds on the Wave Hill Sheet area, they probably are contemporaneous and were deposited under similar conditions.

The Birdum Creek Beds are at least 50 feet thick.

Superficial Deposits

Four categories of superficial deposits have been mapped in the region: alluvium (Cza), travertine (Czt), black soils (Czb), and other colluvial deposits and sands (Czs). They have been mapped largely by photo-interpretation, with some ground observations.

The areas mapped as Cza include flood plains and floodouts of streams, lake and swamp areas, and some flat areas of heavy grey and brown soils in old valleys on the Sturt Plateau.

Areas mapped as Czt comprise calcareous terrace deposits of stream valleys in areas of basic volcanics and carbonate rocks, and more extensive areas of travertine on the Sturt Plateau near Cattle Creek which have probably developed on Cambrian and Tertiary carbonate rocks.

Open grassy plains with heavy grey to brown soils have been mapped as Czb. They occur on areas underlain by carbonate rocks, basic volcanic rocks, and claystones and siltstones of the Mullaman Beds. They are probably partly residual deposits and partly alluvial.

Areas mapped as Czs are covered by several additional types of deposits. The deposits are usually red, sometimes brown to yellow. The most extensive is the red sand covering most of the "desert" area of the Sturt Plateau on the eastern part of the Wave Hill Sheet area and most of the Newcastle Waters Sheet area. Much of this sand has probably been reworked by wind; some of it has come from ancient shoreline deposits of Lake Woods, and some has probably been derived from sandstone in the Mullaman and Merrina Beds. Red sandy and loamy soils mapped as Czs occur in valleys in laterite areas on the Sturt Plateau; they may be in part alluvial deposits derived from the laterite. Other deposits mapped as Czs are probably largely colluvial, on various parent rocks. Extensive areas of red soil occur on basal Mullaman Beds in the eastern part of the Victoria River Downs Sheet area.

STRUCTURE

The Proterozoic rocks are more strongly deformed than the Cambrian and Mesozoic cover. The rocks of the Roper Group in the Larrimah Sheet area dip at between 5° and 15° and have a regional strike north-north-west. The Victoria River Group has large areas of uniform gentle dips, and some folds with north-south axial trends. It is also faulted. The Tomkinson Creek Beds in the Newcastle Waters Sheet area have a dominant north to north-north-east strike and dips of up to 60°, mostly to the west. A south-plunging syncline with north-south axis occurs in the southern part of the outcrop. The beds are cut by faults trending north-south. The trends of bedding and faulting are similar to those of the main outcrops of Tomkinson Creek Beds in the Beetaloo and Helen Springs Sheet areas (Randal <u>et al.</u>, 1966).

The Palaeozoic and younger rocks which crop out over most of the region are almost flat-lying. Structure contours, based on outcrop and bore data, have been drawn on the base of the lower Middle Cambrian carbonate rocks (Figure 6) and on the base of the Lower Cretaceous Mullaman Beds (Figure 7). In the dissected areas west of the Sturt Plateau, the present relief of the base of the Montejinni Limestone is about 300 feet. The relief is probably due mainly to post depositional tilting and does not represent the original shape of the surface on which the Montejinni Limestone was deposited: this is indicated by the lateral persistence of thin shallow water units. The absence of Unit 1 (maximum thickness about 100 feet) in outcrop sections north of Frayne's Knob is probably due to deposition of this unit by a sea transgressing on to a gently sloping surface with about 100 feet relief. Deposition of this unit apparently levelled the surface. The subsequent units, deposited probably in water less than 30 feet deep, persist laterally; and there is no evidence of wedging-out against the present high parts of the surface or of changes to a deeper water facies towards the present low areas.

Away from the outcrop area of the Montejinni Limestone, the relative importance of pre-depositional topography and post-depositional tilting in determining the shape of the basal surface is not known, but there is no evidence for important pre-depositional topography.

The configuration of the base of the Mullaman Beds may be controlled significantly by pre-depositional topography over much of the region. The strike ridges of the Ashburton Range existed during deposition of the Beds, and the basal non-marine Unit A and some of the later marine units are variable in thickness (Skwarko, 1967). However, the variations in elevation of the surface in the south-eastern part of the Delamere Sheet area and in the south of the Fergusson River Sheet area are greater than the local thickness of the Beds and sub-parallel to the present plateau surface, and are probably largely due to tilting after deposition.

On a regional scale the base of the Mullaman Beds is notably flatter than the base of the lower Middle Cambrian rocks, indicating that gentle tilting of the Palaeozoic rocks preceded deposition of the Mullaman Beds; this is also indicated by the overlap of the Mullaman Beds on to Lower Cambrian and Proterozoic rocks. Structure contours have also been drawn (Figure 4), over a small area, on a chert bed in the Antrim Plateau Volcanics (the bed exposed at Companion Creek crossing, VRD 111). The structure contours of this bed show a similar spacing to those on the base of the lower Middle Cambrian carbonate rocks, but the trends are different.

The surface of the Sturt Plateau has broad variations in elevation, reflected in the regional drainage pattern. These broad undulations could be attributed to warping of the surface, presumably during the Tertiary. Some Tertiary or later warping must have occurred to form the closed drainage basin of Lake Woods. In the eastern part of the Delamere Sheet area the slopes of the plateau surface and the base of the Mullaman Beds are almost parallel, suggesting the tilting of the Mullaman Beds in that area to have coincided with the warping of the plateau surface, presumably in the Tertiary. Elsewhere there is no obvious relationship between the slope of the plateau surface and that of the base of the Mullaman Beds; either some tilting of the Mullaman Beds occurred before development of the plateau surface or the Beds were deposited on a surface with considerable relief.

In the dissected area west of the Sturt Plateau and south of Willeroo, where there is adequate borehole and outcrop control, the spacing of the structure contours indicates the regional dips of all units are less than about a quarter of a degree. Superimposed on these gentle regional dips there are local areas of dips up to about 35°. Some of these steeper dips occur along minor faults near Mt. Wallaston. Other local steep dips (e.g. in outcrops about 7 miles east-north-east of Top Springs) are of uncertain origin; they occur in the Montejinni Limestone, and are tentatively attributed to collapse following solution of carbonate rocks (either the Montejinni itself or limestone in the Antrim Plateau Volcanics). Below the Sturt Plateau, to the east of the dissected country, both outcrop and bore data are limited. The available data show that the Mullaman Beds are everywhere almost flat-lying, with a maximum thickness perhaps a little over 400 feet. The base of the lower Middle Cambrian carbonate rocks is less well known, but there is no evidence that dips are any greater than in the dissected country.

Contours on the base of both the Mullaman Beds and the lower Middle Cambrian carbonate rocks indicate a structural ridge between the Wiso Basin and the Georgina Basin trending north-north-west from the Precambrian outcrops of the Ashburton Range, and ending near Scouthole L2.

In the north, the base of the lower Middle Cambrian carbonate rocks dips towards the Daly River Basin, indicated by its drop in elevation between Scoutholes L2 and K1.

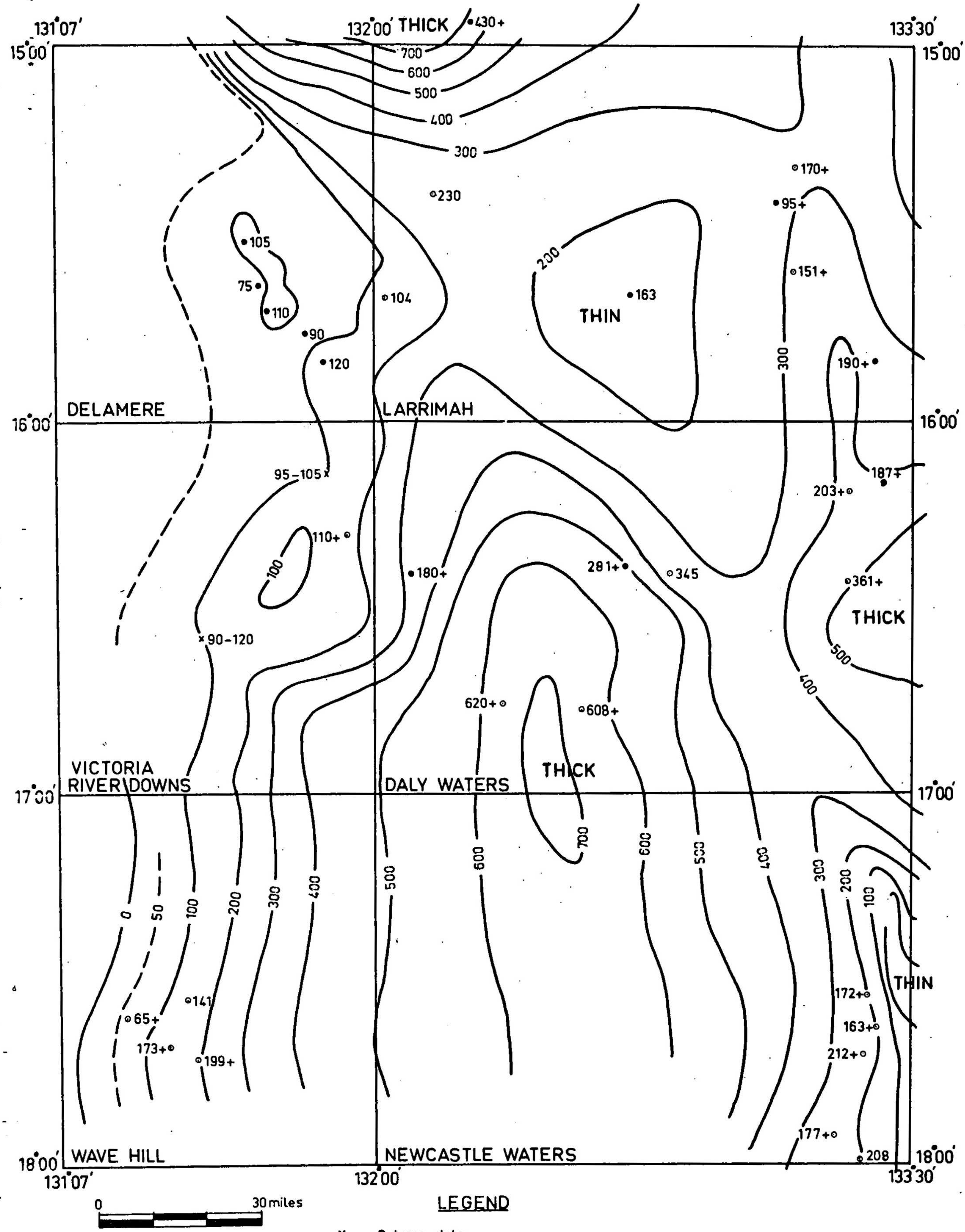
The Antrim Plateau Volcanics and overlying Montejinni Limestone are faulted near Mt. Wallaston. A graben with maximum downthrow of about 100 feet is bounded by parallel faults about a mile apart. This faulting does not appear to displace the Mullaman Beds.

At Gallery Hill a reverse fault, with a curved (concave up) surface dipping west intersects the Mullaman Beds. On the eastern side of the fault the bedding is sub-horzontal and truncated by the fault; on the western side it is parallel to the fault. The dip of the fault surface, and of the beds above it, changes from about 45° near the top of the hill to near-horizontal on the western side of the hill. The razorback ridge of Gallery Hill follows the strike of the upturned beds on the western side of the fault surface. This fault does not seem to continue into the underlying Antrim Plateau Volcanics; it is probably due to eastward gravity sliding of argillaceous Mullaman Beds in the regional dip direction.

Some prominent stream lineaments are probably related to major fractures in the basement. The most prominent lineament extends about 250 miles north-north-east from near Wave Hill Police Station. It is expressed in linear trends of the Victoria River, Coolibah Creek and part of the Armstrong River, Dry River, and part of the King River (in the Katherine Sheet area).

THICKNESS OF POST-LOWER CAMBRIAN SEDIMENTS BELOW PLATEAU SURFACE

FIG. 8



LEGEND

Isopach: Klm, Є/o, Єmm Єmt Єms, Єla, Pu

× Outcrop data

⊕ Waterbore : interpretation of drillers' log

• Scouthole or Waterbore : cuttings examined by geologist

— Isopachs, 100 foot intervals

•75 Thickness of post-Lower Cambrian sedimentary rocks, in feet

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ECONOMIC GEOLOGY

Petroleum

The petroleum prospects in the northern part of the Wiso Basin are not encouraging, although no really reliable assessement of the prospects can be made until adequate subsurface investigations supplement the mapping.

The Cambrian and the Mesozoic sequence contain considerable proportions of marine fossiliferous rocks, which may provide source rocks. But except for the carbonate rocks, which have fracture porosity, there is a lack of porosity other than in the Lees Sandstone equivalent in the Lower Cretaceous, and some sandy interbeds in the Merrina Beds in the south. Furthermore, the maximum thickness of sediments over the Lower Cambrian Antrim Plateau Volcanics at any time was probably less than 1000 feet (Figure 8), which reduce the chance of hydrocarbon accumulation even if hydrocarbons were generated: no prospective traps, either structural or stratigraphic, were recognized during the survey.

The Antrim Plateau Volcanics contain interbeds of sedimentary rocks, some containing algae, but these interbeds are less than 50 feet thick and many are extensively silicified and in part contact metamorphosed. The Volcanics must be regarded as economic basement.

Building materials

Flaggy carbonate rocks and flaggy sandstones have been used for minor building purposes - pathways around homesteads, mounting bore equipment, and as foundations for cattle troughs. Basalt slabs have also been used for these purposes, but suitably shaped stones are not common. For mounting bore equipment the stone is bonded by cement, and its use seems to be more a question of reducing the amount of cement required rather than any superior property over concrete slabs.

The Montejinni Limestone may contain suitable stone for quarrying and dressing, but its distance from any market precludes its use at present.

There are no large deposits of good quality quartz sand on the surface: the ferruginous and silty sand of the desert areas is of doubtful value for building purposes, but it has been mixed with a high percentage of cement for paving floors. A new homestead at Killarney is being constructed from bricks made on the site by mixing cement with silty sand from a nearby creek. Minor pockets of good quality sand occur in streams draining the Tomkinson Creek Beds and the Antrim Plateau Volcanics, but major construction would rapidly deplete those within reasonable hauling distances. The saccharoidal sandstone of the Lees Sandstone equivalent is very friable beneath a surficial silicified skin and weathers to a very pure quartz sand. Deposits from this unit may be discovered at workable depths beneath the silt and lateritic material in the lower parts of the central plateau and along its margins. Similar deposits are worked near the old Manbulloo Aerodrome in the Katherine Sheet area.

The clayey soils of the downs country and over parts of the Antrim Plateau Volcanics make excellent earth tanks for the storage of borewater. The soil becomesplastic and impervious when wet and if the tanks are kept moist and vegetated they are virtually water-tight.

Gravel supplies suitable for road surfacing are widespread, but occur in usually thin and sparse deposits. Along the Dunmarra-Top Springs road the lateritic gravel was scraped and compressed to form the road surface. The same type of gravel is being used as an underlay for the tar-sealing of the Katherine-Top Springs road south of Willeroo. Basalt is being quarried, crushed, and screened near Delamere Homestead for use as aggregate in the hot-mix for this road.

The main roads near Top Springs are composed of compressed gravels obtained by scraping travertinous rubble formed on the calcareous mudstone unit of the Montejinni Limestone. Along all the major roads suitable materials for underlays and aggregates should be found within reasonable hauling distances, but crushing of material will be required along many stretches of road.

Miscellaneous

Over large areas of the Antrim Plateau Volcanics the ground is strewn with semi-precious gemstones of varying quality. Prehnite, chalcedony, amethyst, smoky quartz, calcite, and quartz crystals with inclusions of native copper, and "dusted" with native copper occur in geodes and vesicles in the basalt and some of the chert interbeds, and are weathering out of them. Naturally polished agates form clasts in the basal conglomerate of the Camfield Beds.

Copper mineralization is known in the Antrim Plateau Volcanics. Native copper occurs in geodes in the basalt, and stainings of azurite and malachite are common in vesicles and joints, and on bedding planes in tuffs and agglomerates within the sequence. Some copper stainings have been observed in the basal beds of the Montejinni Limestone immediately above the unconformity with the Volcanics. Geochemical sampling may be useful in locating accumulations of copper mineralization within the Volcanics.

Iridescent iron and manganese stainings in lateritized Mesozoic claystone near Daly Waters have led to erroneous reports of copper mineralization in that and surrounding areas. The highest concentration of copper reported in the laterite samples is 65 ppm i.e. 0.0065% copper.

Several samples of the laterite developed over the Antrim Plateau Volcanics and the Mullaman Beds were analysed for bauxite, but the results were extremely disappointing. The aluminium contents are low, and are less than the silicon in all but two samples; in these two the aluminium and silicon contents were about the same - 10.5 percent in one, and about 11.0 percent in the other. The iron contents of these laterites range from 22.9 percent to 46.4 percent. The samples containing the most iron contain the least silicon, but it is still greater than 7.5 percent in these.

The discovery of large deposits of high grade phosphate in lower Middle Cambrian rocks in north-west Queensland has aroused interest in the Palaeozoic rocks of this region as a possible source of phosphate.

Cuttings and cores from the scout drilling were tested with acidified ammonium molybdate; phosphate contents of those giving a strongly positive reaction were estimated by the semi-quantitative Shapiro test. Some of the cuttings were assayed for P_2O_5 by officers of I.M.C. Development Corporation. A total of 240 outcrop samples from the region, collected from all rock units mapped, were also tested with acidified ammonium molybdate by officers of I.M.C. Development Corporation.

The results of this testing were not encouraging. The highest P_2O_5 contents were 8% from a $\frac{3}{4}$ inch lens of white siltstone from core No. 1 of scout hole K1, and between 1% and 7% for cuttings of a white to buff mudstone from the 120 foot to 130 foot interval of scout hole L3. The former seems to be an isolated occurrence, since channel samples from the core contained less than 1% P_2O_5. The mudstone in scout hole L3 immediately underlies the basal unit of the Mullaman Beds; the phosphate seems to have been concentrated by weathering before deposition of the Mullaman Beds. A similar occurrence of phosphate was found by officers of I.M.C. Development Corporation in cuttings from scout hole HS4 (Helen Springs 1:250,000 sheet area).

The environments of sedimentation for the Phanerozoic rocks are not considered suitable for accumulation of phosphate deposits; the marine sediments have been deposited in extensive shallow seas covering a near-flat sea floor. Bedded cherts are absent. Glauconite (sometimes associated with phosphate) is abundant in some of the Mullaman Beds, but the maximum content of P_2O_5 recorded from these glauconitic sediments was 0.25% in the interval 150' to 160' in scout hole DW1.

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Water

This region contains several cattle stations and there is a consequent heavy demand on its water resources. The demand for water is greatest west of the Sturt Plateau where good quality Mitchell and Flinders grasses grow on pedocalcic soils developed from the Montejinni Limestone and the Antrim Plateau Volcanics. There is some demand for water in the Lake Woods region of Newcastle Waters, and along the Stuart Highway water is required for townships and some stations. Water is required along the stock routes in the region, but since the inception of trucking rather than droving the demand has lessened.

Permanent surface water is not abundant, and is generally restricted to the larger streams in the Victoria River Drainage system. Long pools of permanent water occur in the Victoria River for almost its entire length from Wave Hill Police Station to its mouth; smaller permanent waterholes occur in the Camfield and Armstrong Rivers, and Coolibah Creek. Newcastle Waters Creek contains permanent waterholes between Newcastle Waters Township and Lake Woods, and Stuart Swamp near Daly Waters is regarded as permanent. Waterholes along the north-south stock route, in Birdum Creek, and in the vicinity of Hidden Valley Homestead are regarded as perennial, but may fail if the rainy season is either late or abortive for some years in succession. Numerous waterholes occur in the plateau north of the dissected area in the northern part of the Daly Waters Sheet area, but the chance of their failing is high, even though some are perennial over some years.

Because of the unreliability and sparseness of surface waters, cattle stations and public utilities are dependent on supplies of groundwater. Randal (in prep.) discusses the quality and occurrence of the groundwater of this region in detail, and these comments are taken from that report.

Groundwater has been obtained from aquifers in the Victoria River Group, the Antrim Plateau Volcanics, all the Middle Cambrian carbonate units, and from the Mullaman Beds. There is no evidence that groundwater is being obtained in the Tertiary Camfield Beds or Birdum Creek Beds.

M1

Subartesian water of varying quality is obtained from porous and fractured sandstones and carbonate rocks of the Victoria River Group, but the Group was not mapped during this survey. Newcastle Waters town supply is from a bore probably in the Tomkinson Creek Beds: the supply is only mediocre; the salinity is less than 1000 ppm.

Water occurs in fractures and joints in the basalt of the Antrim Plateau Volcanics, and also in porous sandstone interbeds. Shallow groundwater supplies have been obtained in weathered volcanic debris near watercourses. The risk of failure to obtain adequate supplies in the Volcanics is high: Barclay (in Barclay & Hays, 1965) reports that of the bores drilled soley in basalt on Wave Hill Station 50 percent were dry, 25 percent yielded less than 1000 gallons/hour, and 25 percent yielded between 1000 and 2000 gallons/hour. Hays (in Barclay & Hays, 1965) reports similar disappointing results with bores drilled into the basalt on Victoria River Downs Station. However, in some areas, the thickness of the basalt upsets the economics of drilling through it to exploit aquifers in the underlying Victoria River Group, and mediocre supplies must be accepted as a compromise. Because the occurrence of water in the Volcanics is largely controlled by the size of a joint system and its connexion to a recharge path rather than by storage in a discrete aquifer, considerable random variation in depths to water can be expected. Winari bore on Montejinni station obtains 2000 gallons an hour from a depth of 35 feet; Armstrong bore on the same station obtained a mere 70 gallons/hour at 35 feet, and even on deepening to 631 feet obtained only 800 gallons/hour at 589 feet.

With few exceptions the water from the basalt is of very good quality - less than 1000 ppm of total dissolved solids. Both fluoride and sulphate contents are low. Only three bores on Wave Hill Station and two on Camfield Station produced water of more than 1000 ppm total salinity. In the north-western part of the region the total salinity is generally less than 500 ppm.

Water is obtained from cavities, joints, and fractures in the Tindall Limestone, the Montejinni Limestone, and the Merrina Beds. It may also occur in sandstone interbeds in these rocks, particularly in the

Merrina Beds. Groundwater has also been obtained from the unconformity between the carbonate rocks and the underlying Antrim Plateau Volcanics, and from the unconformity with the overlying Mullaman Beds. Because the solubility of the carbonate rocks is higher than that of the basalt, the movement of groundwater in the former increases the size of the cavities and joints, and hence increases the relative storage. Also the chance of higher recharge (through sink holes etc.) and from a larger area is better than for the basalt. These factors are reflected in the higher rate of successful drilling in the Montejinni and Tindall Limestones. Bores drilled directly into the carbonates need rarely be deeper than 150 feet to obtain adequate supplies: Bauhinia bore on Killarney Station obtains 2400 gallons/hour at a depth of 30 feet, and Dry River Stock Route No. 9 the same supply at about 75 feet. However over much of the area the carbonate sequences are covered by varying thicknesses of non-productive Lower Cretaceous rocks, and deep holes (up to 400 feet) have been drilled to obtain water from the carbonates. Some of the bores along the Murranji Stock Route were drilled to 500 - 600 feet to obtain adequate supplies of water presumably from the Merrina Beds. Figures 6 and 7 which illustrate isopachs on the carbonate rocks and the Lower Cretaceous rocks respectively should be useful guides for the prognoses of proposed waterbores.

The salinity of groundwater in the Montejinni Limestone is less than 1000 ppm and is generally less than 500 ppm. The salinity of water in the Tindall Limestone and Merrina Beds is more variable ranging for the former from 350 ppm along the Dry River Stock Route to about 1500 ppm near Daly Waters. The salinity of water in the Merrina Beds is less tham 1000 ppm along Newcastle Waters Creek and Lake Woods, increasing to over 2000 ppm along the Murranji track to No. 10 bore, but rapidly decreasing again further west.

Because of the inadequacies of the drillers' logs it has not been possible to confirm that bores in this region are drawing water from the Mullaman Beds, although it is certain they are in adjoining areas to the east and south-east. Some of the shallow bores near Lake Woods and along the eastern part of the Murranji track may be drawing from the Mullaman Beds.

REFERENCES

BARCLAY, J., and HAYS, J., 1965 - Minor Investigations by the Northern Territory Resident Geological Section: Water Supply Investigations at Victoria River Downs and Wave Hill, 1963. Bur. Min. Resour. Aust. Rec. 1965/83 (unpubl.)

BROWN, H.Y.L., 1895 - Government Geologists report on explorations in the Northern Territory. Sth. Aust. parl. Pap. 82.

BROWN, H.Y.L., 1909 - Government Geologists report on the Tanami Gold country. Sth. Aust. parl. Pap. 105.

CHEWINGS, C., 1928 - A journey from Barrow Creek to Victoria River. Geogr. J. 76, 316-338.

CHEWINGS, C., 1931 - A delineation of the Precambrian plateau in central and north Australia with notes on the impingent sedimentary formations. Trans. Roy. Soc. S. Aust., 55, 1-11.

DAVID, T.W.E., 1932 - Explanatory notes to accompany a new Geological Map of the Commonwealth of Australia. Sydney Coun. sci. ind. Res.

DOW, D.B., and GEMUTS, I., in prep. - The Precambrian geology of the Kimberley Region. The East Kimberley. Bur. Min. Resour. Aust. Bull.

DUNN, P.R., 1963a - Urapunga, N.T. - 1:250,000 Geological Series. Bur. Min. Resour. Aust. explan. Notes SD/53-10.

DUNN, P.R., 1963b - Hodgson Downs, N.T. - 1:250,000 Geological Series Bur. Min. Resour. Aust. explan. Notes SD/53-14.

DUNN, P.R., SMITH, J.W., and ROBERTS, H.G., in prep. - Geology of the Carpentaria Proterozoic Province, N.T. Part 1: Roper River - Queensland border. Bur. Min. Resour. Aust. Bull.

FLAVELLE, A.J., 1965 - Helicopter Gravity Survey by contract, N.T. and Qld. 1965. Pt. 1. Bur. Min. Resour. Aust. Rec. 1965/212 (unpubl.).

HARTMAN, R.R., 1964 - Airborne Magnetometer Survey over OP 73/3 N.T. Report by Aeroservice Ltd. for Barkley Oil Company Pty Ltd

HAYS, J., (1967) - Land surfaces and laterites in the north of the Northern Territory in JENNINGS, J.N., and MABBUTT, J.A. - LANDFORM STUDIES IN AUSTRALIA AND NEW GUINEA. A.N.U. Press. Canberra.

74

HOSSFELD, P.S., 1954 - Stratigraphy and Structure of the Northern Territory of Australia. Trans. Roy. Soc. S. Aust., 77.

IVANAC, J.F., 1954 - The geology and mineral deposits of the Tennant Creek gold-field, Northern Territory. Bur. Min. Resour. Aust. Bull. 22.

JENSEN, H.I., 1915 - Report on the country between Pine Creek and Tanami. Bull. N. Terr. 14.

LERIDON, J., 1966 - Final report of an Airborne Magnetic Survey over OP 64/3 N.T. Compagnie Generale de Geophysique for Mercure International Petroleum Pty Ltd

LOGAN, B.W., 1961 - Cryptozoon and associate stromatolites from the Recent, Shark Bay, Western Australia. Jour. Geol., 69, 517-533.

McKEE, E.D., 1966 - Structures of dunes at White Sands National Monument, New Mexico (and a comparison with structures of dunes from other selected areas). Sedimentology, 7, 1-69.

MILLIGAN, E.N., SMITH, K.G., NICHOLS, R.A.H., and DOUTCH, H.F., 1966 - The geology of the Wiso Basin, N.T. Bur. Min. Resour. Aust. Rec. 1966/47 (unpubl.)

NEUMANN, F.J.G., 1964 - Normanton to Daly Waters reconnaissance gravity survey, Qld. & N.T. 1959-60. Bur. Min. Resour. Aust. Rec. 1964/131 (unpubl.).

NOAKES, L.C., 1949 - A geological reconnaissance of the Katherine-Darwin region, Northern Territory. Bur. Min. Resour. Aust. Bull. 16

NOAKES, L.C., and TRAVES, D.M., 1954 - Outline of geology of the Barkly Region in Survey of the Barkly Region, 1947-48. Sci. ind. Res. Org. Melb., Land Res. Ser. 3(3), 34-41

ÖPIK, A.A., 1959 - Correlation chart of Cambrian and Ordovician in Australia. Bur. Min. Resour. Aust. Rec. 1959/52 (unpubl.).

ÖPIK, A.A., 1964 - Early Ordovician at Claravale in the Fergusson River area, Northern Territory. Bur. Min. Resour. Aust. Rec. 1964/136 (unpubl.).

ÖPIK, A.A., CARTER, E.K., and NOAKES, L.C., 1961 - Explanatory notes on the Mount Isa 4-mile geological sheet. Bur. Min. Resour. Aust. explan. Notes 20.

PAINE, A.G.L., 1963 - Tanumbirini, N.T. - 1:250,000 Geological Series. Bur. Min. Resour. Aust. explan. Notes SE/53-2.

PERRY, W.J., 1966 - Photo-interpretation of Wave Hill, Victoria River Downs, and Delamere, N.T. Bur. Min. Resour. Aust. Rec. 1966/159 (unpubl.).

M5

PERRY, W.J., 1967 - Notes on a field visit to Delamere, Victoria River Downs and Wave Hill 1:250,000 scale Sheets N.T. (July-August, 1966). Bur. Min. Resour. Aust. Rec. 1967/69 (unpubl.)

PLANE, M.D., and GATEHOUSE, C.G., 1967 - A new vertebrate fauna from the Tertiary of Northern Australia. Aust. J. Sci. in press.

PLUMB, K.A., and RHODES, J.M., 1964 - Wallhallow, N.T., - 1:250,000 Geological Series. Bur. Min. Resour. Aust. explan. Notes SE/53-7.

RANDAL, M.A., 1962 - Fergusson River, N.T. - 1:250,000 Geological Series. Bur. Min. Resour. Aust. explan. Notes SD/52-12

RANDAL, M.A., 1963 - Katherine, N.T. - 1:250,000 Geological Series. Bur. Min. Resour. Aust. explan. Notes SD/53-9.

RANDAL, M.A., in prep. - Groundwater in the northern Wiso Basin and eastern environs. Bur. Min. Resour. Aust. Rep.

RANDAL, M.A., BROWN, M.C., and DOUTCH, H.F., 1966 - The Geology of the Helen Springs and Beetaloo 1:250,000 Sheet areas, N.T. Bur. Min. Resour. Aust. Rec. 1966/110 (unpubl.)

RIVEREAU, J.C., 1966 - Report on photo-interpretation of Newcastle Waters, Daly Waters, and Larrimah, N.T. Bur. Min. Resour. Aust. Rec. 1966/63 (unpubl.).

SKWARKO, S.K., 1966 - Cretaceous stratigraphy and palaeontology of the Northern Territory. Bur. Min. Resour. Aust. Bull. 73

SKWARKO, S.K., 1967 - Cretaceous stratigraphy of the Wiso Basin (Preliminary report). Bur. Min. Resour. Aust. Rec. 1967/47 (unpubl.)

SMITH, K.G., 1967 - The geology of the Georgina Basin. Bur. Min. Resour. Aust. Rec. 1967/61 (Bull. in prep.).

SOCIETE NATIONALE DES PETROLE D'AQUITAINE, 1966 - Geomorphological study of Permit OP 64/3. Report for Mercure International Petroleum Pty Ltd

STEWART, G.A., 1954 - The geomorphology of the Barkly Region in Survey of the Barkly Region, 1947-48. Sci. ind. Res. Org. Melb., Land. Res. Ser. 3, 42-58.

STIRTON, R.A., in press - A Diprotodontid from the Kutjamarpu Fauna, South Australia. Bur. Min. Resour. Aust. Bull. 85.

TRAVES, D.M., 1949 - Preliminary report 1949 Ord-Victoria Region. Bur. Min. Resour. Aust. Rec. 1949/22 (unpubl.).

TRAVES, D.M., 1953 - A study of underground water at Wave Hill Station, N.T. Bur. Min. Resour. Aust. Rec. 1953/91 (unpubl.).

M6

TRAVES, D.M., 1954 - Collenia frequens in Upper Proterozoic rocks of the Northern Territory of Australia. Proc. Linn. Soc. N.S.W., 79 (3-4), 95.

TRAVES, D.M., 1955 - The Geology of the Ord-Victoria region, Northern Territory. Bur. Min. Resour. Aust. Bull. 27.

TRAVES, D.M., 1957 - Upper Proterozoic and Cambrian Geology in north-western Australia, in The Cambrian geology of Australia. Bur. Min. Resour. Aust. Bull. 49.

WALPOLE, B.P., DUNN, P.R., and RANDAL, M.A., 1967 - The geology of the Katherine-Darwin Region, Northern Territory. Bur. Min. Resour. Aust. Bull. 82.

WARD, L.K., 1926 - Report on water supply facilities on stock routes and elsewhere in the Northern Territory of Australia. Comm. Dep. Works and Railways.

WELLS, L.A., 1907 - The Victoria River and adjacent country. Office of the Minister controlling the Northern Territory, Adelaide.

WINTERS, R.J., 1915 - Observations on country between Pine Creek and Newcastle Waters, in Bull. N. Terr. 14.

WOODBURNE, M.O., in press - Three new diprotodontids form the Tertiary of the Northern Territory. Bur. Min. Resour. Aust. Bull. 85.

WOOLNOUGH, W.G., 1912 - Report on the geology of the Northern Territory. Bull. N. Terr. 4.

APPENDIX I

RESULTS OF SCOUT DRILLING

by

M.C. Brown

Summary

Scout holes were drilled at five sites, three in the Larrimah 1:250,000 Sheet area, and one in each of the Katherine and Daly Waters 1:250,000 Sheet areas. A truck-mounted "Mayhew 1000" rig, owned by the Bureau of Mineral Resources, was used. The greatest depth penetrated was 429'6" in K1, the shallowest was 96ft in L1.

Circulation was lost at some stage at all sites and this resulted in the failure to reach target depth at three of the sites. At site DW1 three unsuccessful attempts were made to drill to target depth; at L2 the second attempt was successful, but at both L1 and K1 only one hole was drilled and each failed to reach target depth.

A total of sixteen cores were taken. Recovery was good: 100 percent for 6 of the cores, and greater than 60 percent for the remainder, except for core No. 2 of L1 (about 18 percent).

Cuttings were collected normally at 10-foot intervals, but were taken at 5-foot intervals for the top 70' of L3, and during some of the coring. Dry cuttings blown out during air drilling were bagged without any further treatment at the wellsite. Wet cuttings were washed with clean water and dried at the wellsite before bagging.

Changes in lithology and in rates of penetration were noted during drilling and this information was used in producing the detailed logs.

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Cuttings and cores were examined by hand lens and described at the wellsite and tested for carbonate with 3% hydrochloric acid. Cuttings from sites DW1, L1, and K1 were re-examined in the laboratory using a zoom binocular microscope. Some checks were made on carbonate rocks by staining with Alizarin Red S. to distinguish between dolomite and calcite.

Samples from the four cores taken at site DW1, cores 1, 2 and 3 of K1 and cores 1 and 2 of L1 were submitted for micropalaeontological examination. Cores of suspected Cambrian limestone were submitted for identification of macrofossils.

Seven samples of clayey sediments (five from DW1 and two from K1) were submitted to Australian Mineral Development Laboratories for semiquantitative determination of clay mineralogy.

Phosphate logs were run on cuttings from all holes using the technique of Barrie (1965). Results of the drilling are summarized in Figures 1 and 2 of this Appendix.

Daly Waters (BMR) Scout holes No. 1, 1a and 1b (site DW1)

Location: Latitude 16°24'S. Longitude 132°41'E, in Daly Waters 1:250,000 Sheet area, approximately 18½ miles at a bearing of 306° (true) from Hidden Valley Homestead.

Altitude: 865' (barometric measurement).

Surface Geology: No outcrops occur in the vicinity of the well site, which is in a broad elliptical valley with grey and brown soils, surrounded by higher country capped by Tertiary laterite.

Objective: To penetrate superficial cover and presumed Cretaceous sediments, and to drill as far as possible into Palaeozoic sedimentary rocks thought to underlie the area. Photogeological work by Rivereau (1966) suggested the crest of a broad anticline occurred near the wellsite and it was hoped that the Cretaceous sediments would be thinner there than elsewhere.

History: (a) Hole No. 1: The hole was drilled with a $4\frac{3}{4}$" bit, except for the top 10 feet which was reamed out and cased with 6" casing after drilling to 90 feet.

Loose sands were encountered between 95 feet and 150 feet and the hole was drilled with mud from 150 feet down. At 265 feet a cavity 25 feet deep was encountered resulting in complete circulation loss. As Palaeozoic rocks had not been encountered another hole, No. 1a was drilled 55 yds SSE of bore No. 1

(b) Hole No. 1a: This hole was air-drilled to 120 feet, and below that with bentonite mud. At 130 feet, circulation was completely lost in a cavity and the hole was abandoned.

(c) Hole No. 1b: This hole, about 50 yds east of No. 1, was air-drilled to 281 feet. Drilling with bentonite mud was attempted, but circulation was again lost almost immediately and the hole was abandoned. The percent cuttings log for the section below 140 feet was constructed from descriptions of cuttings from hole No. 1b, which were obtained by air-drilling.

Cores:

Core	Interval Cored	Recovery
Core No. 1 (hole No. 1)	15' - 24'6"	6' (broken core)
Core No. 2 (hole No. 1)	90' - 95'	4'1"
Core No. 3 (hole No. 1)	210' - 219'6"	7'6"
Core No. 1 (hole No. 1b)	258' - 266'	5'

Fossils: No macrofossils were found; samples of representative lithologies from all four cores and from cuttings from 268' to 270' yielded microfaunas of arenaceous foraminifera, similar to microfaunas previously recorded from Lower Cretaceous sediments (Terpstra, 1967).

Water: No groundwater was encountered in the holes.

Superficial Deposits: Grey and brown soil with some ironstone pisolites was drilled to a depth of 8 feet.

Lower Cretaceous (Mullaman Beds): The entire section below the soil cover is referable to the Mullaman Beds of Lower Cretaceous age, on the basis of similarities in lithology and microfauna with outcrops of the Mullaman Beds. Detailed correlation of the scouthole section with surface units cannot be made because of the absence of good index fossils; however general correlations are suggested below.

(1) the coarse sand (280'-281') at the bottom of the hole may correlate with a non-marine sandstone and conglomerate occurring in many localities at the base of the Mullaman Beds (Unit A of Skwarko, 1966).

(2) The purplish, pink, and buff to white claystone, siltstone and fine-grained sandstone between 263' and 280' are lithologically similar to sediments with arenaceous foraminifera at locality VRD1 (16 miles NNE of Killarney Homestead) which appear to underlie white and buff claystones with Mollusca occurring further east. Similar purplish, buff, and white sediments occur below the white to buff siltstone and claystone cappings of Mt. Sullivan, Fraynes Knob and Gallery Hill. Near No. 14 bore (Murranji Stock Route) similar sediments apparently underlie white claystone with Mollusca exposed further east.

(3) The scout hole section between 94'6" and 263' is tentatively correlated with outcrop Units 6a (a greenish-buff sandstone with Rhizocorallium) and 6 (an underlying claystone with Mollusca) of Skwarko (1967). This tentative correlation implies a considerable eastward thickening of the two units from a combined thickness of around 45' along the western margin of the Sturt Plateau to 168'6" at the scout hole. The glauconitic sands and silty clays of the scout hole section are similar lithologically to the sandstone of Unit 6a and the claystone of Unit 6. In the scout hole section the sands and clays are interbedded, so that a boundary between the two units cannot be drawn with certainty. Skwarko (1967) places the base of Unit 6 at about 140' in the scout hole. This would mean that Unit 6 becomes more sandy, as well as thickening, towards the east.

(4) The clay and claystone from 8' to 94'6" in the bores probably represents the uppermost "unit C" (Polland Shale) of Skwarko (1966), which crops out in the main scarp between the well site and Top Springs.

Except possibly for the one foot of coarse sand at the bottom of the hole the sediments are marine, as indicated by the presence of foraminifera and the abundance of glauconite in the sands. The purplish colours in the interval 263' to 280' initially suggested non-marine conditions; however a sample of purplish sandstone from core No. 1 (Hole No. 1b) yielded arenaceous foraminifera, and the purplish sandstones contain some glauconite. There appears to be little difference in grainsize or sedimentary structures between the purplish sediments and the grey, buff, and greenish sediments. The colour change is probably due to a change in state of oxidation of the source material rather than to a marked difference in depositional environment.

If the correlations suggested above are correct then the bottom of hole No. 1b may be not more than 20 feet or so above the basal unconformity. The large cavities encountered in the first two holes are probably due to collapse and upward stoping of caverns in underlying carbonate rocks (presumably Palaeozoic).

Approximate abundances of clay minerals in the minus 10 micron fractions were determined by A.M.D.L. (Report MP 2465-67 by E.C. Stock) for samples of clay from cores Nos. 1, 2 and 3 of hole No. 1 and one sample each of greyish to buff claystone and pink clay from core No. 1, hole 1b. The sample from core No. 1, hole No. 1, gave the following results: kaolin dominant (>50%), random mixed layer smectite-illite subdominant (20% to 50%), illite accessory (5% to 20%). The other samples from lower in the section consisted of smectite, illite, and kaolin; smectite was dominant except for the grey and buff claystone from core No. 1, hole No. 1b, in which smectite, illite, and kaolin were each subdominant. The dominance of kaolin in the sample from core No. 1, hole No. 1, may be a result of weathering; it appears to be within the pallid zone of the Tertiary laterite profile.

Cuttings Description:

(a) hole No. 1

0' - 10'	70%	yellow-brown soil
	20%	ironstone pisolites
	10%	claystone; very pale grey, pale purplish, or pinkish with thin hematite veins; some mica flakes.
10' - 15'	10%	yellow brown soil and ironstone pisolites
	90%	claystone; as above
15' - 20'	80%	claystone; as above
	20%	limonitic ironstone
20' - 24'6"	100%	claystone; as above
24'6" - 30'	100%	claystone; as above
	traces	limonitic ironstone
30' - 40'	100%	claystone and clay; white, pale grey, some buff; some hematite and limonite veins; clays are generally soft.
40' - 50'	100%	claystone and clay; light grey and buff; generally soft; some fragments contain ½ mm limonite pellets.
50' - 60'	100%	clay and claystone; light grey, purplish and buff; generally soft; some limonite veining.
60' - 70'	100%	clay and claystone; as above
70' - 80'	100%	clay and claystone; as above
80' - 90'	100%	clay and claystone; as above
90' - 95'	80%	clay and claystone; as above
	20%	silty claystone or clayey siltstone; buff
95' - 100'	90%	sand and friable sandstone; buff fine to very fine, well sorted, quartzose, with glauconite
	10%	clay and claystone; white to light grey.
100' - 110'	80%	sand and friable sandstone; buff, white, purple, very fine to fine, well sorted, quartzose with glauconite pellets.
	20%	claystone; white to light grey.

110' - 120'	90%	sand and friable sandstone; buff to white, very fine to fine, well sorted, quartzose and micaceous, with glauconite.
	7%	claystone; white to grey
	3%	silty and sandy claystone.
120' - 130'	95%	sand (minor friable sandstone); white, very fine grained, quartzose and micaceous with a few glauconite pellets.
	5%	claystone; white to grey
130' - 140'	100%	sand and friable sandstone; white and buff, very fine to fine, quartzose and micaceous, with glauconite.

(b) hole No. 1B

140' - 150'	80%	clay; white and buff, silty
	20%	sandstone and sand; greenish and buff medium grained, with glauconite pellets and quartz grains in a clay matrix; glauconite pellets have rounded and septate shapes.
150' - 160'	40%	clay; as above
	20%	siltstone; light grey to buff, clayey, and micaceous
	40%	sandstone; as above
160' - 170'	90%	sandstone; buff to greenish grey, medium to very coarse grained, with glauconite pellets and quartz in a clayey matrix; glauconites are rounded, septate or mammilated; quartz grains subangular to rounded; some sandstone strongly silicified.
	10%	clay; silty, grey to buff
	traces	claystone; white to pink
170' - 180'	90%	sand; medium to fine grained, with quartz glauconite pellets, muscovite, biotite; some clay matrix.
	10%	clay; white and buff silty
180' - 190'	60%	sand and sandstone; medium to fine grained, with quartz, glauconite, and micas; some buff clay matrix.
	40%	clay; white to grey and buff, silty
190' - 200'	90%	sandstone and sand; as above
	10%	clay; as above

200' - 210'	60%	clay; light grey to buff silty.
	40%	sand and sandstone; as above; some occurs as thin laminae in clay.
210' - 220'	60%	sand and sandstone; as above.
	40%	clay; as above
220' - 230'	70%	sand and sandstone; as above; also some coarse and very coarse quartz grains, and glauconite pellets up to ½ mm.
	30%	clay; as above
230' - 240'	50%	sand and sandstone; very fine and fine-grained with quartz, glauconite, and micas; some clay matrix; some very coarse quartz and chert sand grains.
	50%	clay; light grey to buff, some red, silty, with some fine sand grains.
240' - 250'	90%	clay; buff, light grey, pinkish, with some mica silt and fine quartz sand grains.
	10%	sandstone and sand; white, fine grained, and friable; also fine and very fine-grained with clay matrix; some very coarse quartz grains; glauconite not abundant.
250' - 258'	90%	clay, as above
		sand and sandstone; medium to very fine, glauconitic, with clayey matrix.
258' - 266'	20%	clay; light grey and buff silty
	10%	siltstone; pink, clayey
	70%	sand and sandstone; pinkish, fine and very fine, with quartz, red (clay?) pellets, and micas; also buff, with quartz, glauconite, and micas; clay matrix sometimes present; some loose sand grains are very coarse.
266' - 270'	90%	clay; pink, brown, pale pink, purplish
	10%	sandstone; as above
270' - 280'	80%	clay and claystone; pink, purplish and yellow-buff, silty; also some clayey siltstone
	20%	sand and sandstone; pink and greenish-buff, fine to medium grained, with quartz, glauconite, muscovite, and some clay matrix; pink sandstone contains red (clay?) pellets; buff sandstone contains some coarse grained quartz and glauconite.
280' - 281'	90%	sand; fine to very coarse; with quartz, glauconite, ferruginous pellets, muscovite, tourmaline, chert grains; quartz grains have a discontinous coating of hematite and are occasionally cemented together with iron oxide; glauconites are mainly rounded and septate, but include some replacements of mica.
	10%	clay; buff and pinkish; also clayey sandstone.

Core Descriptions:

Core No. 1 (hole No. 1), 15' to 24'6", recovered 6' of broken core.

The core consists mainly of white to pale grey claystone with thin hematite staining along joints. A steep-dipping vein about 1½" thick of limonite and limonite-stained clay was intersected between about 17'6" and 19'.

Core No. 2 (hole No. 1), 90' to 95', recovered 4'1", including many small fragments.

Down to 2'3" from the top of the core, it consists of soft light grey claystone with thin hematite veins. At 2'3" from top the claystone passes gradationally into a silty and sandy clay with green (probably glauconite) pellets. The colour changes to pinkish and buff at 3' below the top of the core. Between 3'7" and 4'1" from the top of the core it consists of buff glauconitic very fine grained sandstone.

Core No. 3 (hole No. 1), 210' to 219'6", recovered 7'6".

The core consists of greenish-buff fine and very fine grained friable glauconitic and micaceous quartz sandstone containing thin layers and irregular patches of sticky grey clay. Some burrows are present.

Core No. 1 (hole No. 1b), 258' to 266', recovered 5'.

The top 3 feet of the core consists of yellowish-buff very fine-grained micaceous sandstone, with interbeds of greyish to buff laminated claystone. Below this it consists of pink to purplish, medium to very fine-grained sandstone with thin laminae and irregular patches of pink clay. Glauconite occurs in both the buff and purplish sandstone. Burrows are common in the sediments and have caused some mixing of clay and sand.

Larrimah (BMR) Scouthole No. 1 (site L1)

Location: Latitude 15°26'S. Longitude 133°06'E, in Larrimah 1:250,000 Sheet area. Near No. 1 bore Birdum Stock Route, and about 6 miles NNW of old Gorrie Homestead.

Altitude: 545 feet above sea level (barometric measurement).

Surface Geology: The hole was spudded into red sandy soil. Nearest outcrops are of Lower Cretaceous silicified sandstone. A shaft near No. 1 bore and about 100 yds north of the drilling site has spoil containing blocks of Cambrian limestone.

Objective: To penetrate a thin Cretaceous cover and obtain a section in underlying Lower Palaeozoic sedimentary rocks to Precambrian rocks or Lower Cambrian volcanics.

History: The hole was air-drilled to total depth. A $6\frac{5}{8}$" diameter roller bit was used down to 39 feet and the hole was cased with 6" casing to this depth. Below 39 feet the hole was drilled with a $4\frac{3}{4}$" bit. At 94 feet, in limestone, the drill stem dropped 3 feet into a cavity, and again at 98 feet a 1 foot cavity was encountered. Circulation was lost and the hole was abandoned.

Cores:	Core	Interval Cored	Recovery
	Core No. 1	45' - 49'	4'
	Core No. 2	60' - 67'	1'3"
	Core No. 3	86' - 93'	6'8"

Fossils: Limestone from core No. 3 contained abundant shell fragments including some complete trilobite glabellas. C.G. Gatehouse (BMR, pers. comm.) identified the following forms: Biconulites sp., ptychoparioid trilobites, phosphatic brachiopods, obolidae, (?) cystid plates. Samples from cores Nos. 1 and 2 were washed for microfossils, but according to D.J. Belford (BMR, pers. comm.) no organic remains were found.

Water: No groundwater was encountered.

Lower Cretaceous (Mullaman Beds): The medium to coarse-grained sand with pebble bands, from surface to 45 feet, is probably the non-marine Lower Cretaceous "Unit A" of Skwarko (1966).

Cambrian/Ordovician?: The section from 45 feet to about 80 feet shows some lithological similarity to argillaceous sediments of the Jinduckin Formation. Since it overlies fossiliferous limestone resembling Tindall Limestone it could be part of the Jinduckin. It could however be an argillaceous facies of the Tindall Limestone. This material was very likely weathered and perhaps partly reworked by soil-forming processes before deposition of the overlying Cretaceous sands.

Middle Cambrian (Tindall Limestone?): The mottled yellow to grey-brown calcilutite and fine crystalline limestone with shell fragments encountered between 80 feet and total depth is lithologically similar to outcrop samples of Tindall Limestone or the upper limestone unit of the Montejinni Limestone.

The fauna indicates an early Middle Cambrian age, according to C.G. Gatehouse. It is similar to the fauna from outcrops of Tindall Limestone near Katherine.

Cuttings Descriptions:

0' - 45'	100%	sand; medium to coarse grained; grains mostly quartz, generally with an iron oxide coating; some pebbles.
45' - 50'	15%	siltstone; buff to red hematitic and brown limonitic.
	85%	clayey sand; fine to very coarse quartz grains (hematite-stained), and ferruginised siltstone fragments in a white to buff soft clay metrix.

Core No. 3, 86' to 93', recovered 6'8".

The core consists of yellowish to brown calcilutite and fine crystalline limestone. The top 2' of the core contains many solution cavities. Fossils and fossil fragments are abundant.

Larrimah (BMR) Scout holes No. 2 and 2a (Site L2)

Location: Latitude 15°39'S, Longitude 132°40'E, in Larrimah 1:250,000 Sheet area. About ½ mile south of Brolga Waterhole.

Altitude: 625 feet above sea level (barometric measurement)

Surface Geology: Sandy red soil at site. Nearest known outcrops are of silica-cemented sandstone of the Lower Cretaceous Mullaman Beds, about 2 miles east of the hole.

Objective: To penetrate superficial cover and probable Cretaceous sediments and obtain a section in underlying Lower Palaeozoic sedimentary rocks, if possible down to Precambrian rocks or Lower Cambrian Volcanics.

History: (a) Hole No. 2. This hole was air-drilled with a 4¾" bit. No casing was used. At 56 feet in limestone some circulation loss occurred. At 61'6" the drill stem dropped about 3 feet into a cavity, after which few cuttings were returned. After taking core No. 2 (71' - 76'). The hole was plugged with cement from 55 feet to 71 feet. This was allowed to set for 17 hours then reamed out. At 83 feet circulation was lost again and another site was selected nearby.

(b) Hole No. 2a was spudded about 30 yards east of No. 2, and was drilled with air to 171 feet. The hole was drilled to 72 feet using a 7⅜ inch bit. With this large diameter for the upper part of the hole the upward air velocity was insufficient to return cuttings larger than about 2mm. Cuttings larger than this were presumably recirculated near the bottom of the hole until they had been worn small enough to be blown out; this caused a delay in the return of cuttings.

50' - 60'	85%	clayey siltstone (or silty claystone); brownish-buff, buff, white, pinkish; sometimes strongly ferruginised.
	5%	sandstone; fine to very fine, silica-cemented.
	10%	sand; coarse and very coarse quartz grains.
60' - 70'	85%	claystone; silty, pinkish and buff, with occasional quartz sand grains
	5%	chert; white, grey, and buff
	10%	sand; as above
70' - 80'	80%	silty claystone and clayey siltstone; pink, white, buff; some strongly ferruginised; some with quartz sand grains.
	10%	limestone; yellow-brown calcilutite and fine crystalline limestone.
	5%	chert
	5%	sand; as above
80' - 86'	60%	claystone and siltstone; pink, buff, white.
	30%	limestone; brown, yellow, and white calcilutite and fine crystalline limestone; shell fragments (Biconulites sp.?) in some cuttings.
	5%	chert; white, pink, colourless.
	5%	sand; as above
86' - 90'	40%	limestone; yellow, white, pale brown
	20%	chert; white, buff, colourless, pink
	5%	sandstone; very fine grained, silica cement
	20%	sand; as above
	15%	claystone and siltstone; as above
90' - 95'	65%	limestone; light brown to yellow and white calcilutite and fine crystalline limestone; shell fragments abundant in some cuttings.
	5%	chert; white and buff, clear.
	20%	sand; as above
	10%	claystone and clay; as above

Core Descriptions:

Core No. 1, 45' to 49', recovered 4'.

The core consists of buff to pink micaceous siltstone and claystone.

Core No. 2, 60' to 67', recovered about 1'3" of fragments.

The core consists of buff to pink siltstone or claystone, buff sandy clay, and pieces of grey chert up to 2" across. The siltstone or claystone is brecciated and the sandy clay occurs as irregular patches.

From 72 feet the hole was drilled with a $4\frac{3}{4}$ inch bit. Air drilling continued to 171 feet, when circulation was lost. Drilling with bentonite mud was then tried but none returned to the surface. Air-drilling without returns was continued to 175 feet. The bottom hole core was drilled with water, with no returns of cuttings.

Cores:	Core	Interval Cored	Recovery
	Core No. 1 (hole No. 2)	36' - 40'6"	3'
	Core No. 2 (hole No. 2)	71' - 76'	5'
	Core No. 1 (hole No. 2a)	131' - 140'1"	8'10"
	Core No. 2 (hole No. 2a)	175' - 176'3"	1'3"

Fossils: Limestone in core No. 1 (hole No. 2a) shows cross-sections of shell fragments including Biconulites sp.

Water: No groundwater was encountered.

Lower Cretaceous, Mullaman Beds: The sand and clayey sand down to 24 feet is regarded as part of "Unit A" (Skwarko, 1966) of the Lower Cretaceous Mullaman Beds. It is reworked, especially near the surface, by plants and other soil-forming agents.

Cambrian/Ordovician?: Between 24 feet and 35 feet the drill penetrated buff clayey siltstone, in places hardened by limonite. This interval is tentatively regarded as being either part of the Jinduckin Formation or a siltstone unit of the Montejinni Limestone not seen in outcrop.

Middle Cambrian Montejinni Limestone: The section from 35 feet to 162 feet comprises an upper limestone unit, middle unit of buff and brown calcareous mudstone and clayey carbonates, and a lower unit of dolomitic limestone. The lithologies and thicknesses of these three units are very similar to those of the three main units of the Montejinni Limestone in the area around Top Springs, and in both cases the lower carbonate unit is underlain by basalt.

In core No. 1 of hole No. 2 and core No. 1 of hole No. 2a the carbonate rocks contain irregular patches of clayey sand. This appears to be due to filling of solution cavities by a mixture of sand from the Mullaman Beds and clayey material from mudstone and siltstone overlying and interbedded with the carbonate rocks. Cavity-filling material of this type may account for most of the sand and some of the mudstone or siltstone in cuttings from below 35 feet. In drawing-up the detailed lithological log it has been assumed that the sand in cuttings below 35 feet is not part of the sequence. However this is not proven and there may be some sandy interbeds in the carbonate units or the interbedded mudstone.

Lower Cambrian, Antrim Plateau Volcanics: At about 162 feet very hard drilling was encountered, followed by softer drilling to 171 feet. Cuttings over this interval contain some material interpreted as weathered basalt, with dolomitic limestone, mudstone, chert, and sand. Between 171 feet and 175 feet no cuttings were returned but on pulling up at 175 feet cuttings of basalt, silicified basalt and dolomitic limestone were caught up in drilling mud on the bit and drill pipes. Core No. 2 of bore No. 2a recovered partly altered and copper-stained basalt with calcite veins, similar lithologically to outcrop samples of the Antrim Plateau Volcanics.

The position of the junction between carbonate rocks and the Volcanics is not precisely located due to the delay in return of cuttings from depth. In drawing the detailed lithological log it has been assumed that the Volcanics start at about 162 feet and that the hard drilling at 162 feet represents silicified basalt or a quartzite xenolith in the basalt. However the carbonate could continue down closer to 170 feet and the hard drilling at 162 feet may have been in a chert nodule in the carbonate.

Cuttings Descriptions:

(a) hole No. 2

0' - 10'	90%	sand; brownish red, fine grained, silty
	5%	ironstone pellets, 1/16" to 3/16" diameter
	3%	sand; coarse and very coarse quartz grains
	2%	clayey siltstone; buff, partly ferruginised.

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10' - 20'	90%	sand; very coarse to very fine grained, quartzose
	6%	sandstone; with buff clay or silt binding material
	4%	ironstone pellets; as above
20' - 30'	50%	sand; as above
	5%	sandstone; as above
	45%	clayey siltstone, buff; some strongly cemented by limonite.
30' - 36'	80%	clayey siltstone; buff
	10%	chert; buff to dark brown
	10%	limestone; orange-yellow to dark grey-brown calcilutite and fine crystalline limestone, with a few very small vugs.
	traces	coarse sand.
36' - 40'6"	60%	limestone; as above
	20%	sand; quartzose
	20%	sandy clay; buff
40'6" - 50'	80%	limestone; pale yellow-orange to dark grey-brown, microcrystalline to fine crystalline.
	10%	sandy mudstone; buff
	10%	sand; quartzose; some very coarse grains.
	traces	limonite pellets.
50' - 60'	80%	limestone; as above
	10%	mudstone and sandy mudstone; buff to reddish
	8%	sand; as above
	2%	limonite pellets

(b) hole No. 2a

60' - 70'	50%	mudstone; buff, some brown and white, calcareous
	50%	limestone; light brown to yellow calcilutite
70' - 80'	As above, with traces of calcite crystals	
80' - 90'	97%	mudstone; buff and chocolate-brown calcareous.
	3%	chert; light grey, uniform fine texture.
	traces	quartz sand grains, limestone, ferruginised mudstone.
100' - 110'	40%	mudstone; as above
	30%	quartz grains; rounded, medium grain size.
	20%	limestone; pale calcilutite and very fine crystalline limestone
	10%	chert; pale grey, uniform fine texture.
110' - 120'	50%	mudstone; buff, and dark brownish grey, calcareous
	40%	limestone; pale, fine crystalline.
	10%	quartz grains; as above

120' - 130'	45%	mudstone; as above
	45%	limestone; brown to light yellow-brown, possibly in part dolomitic.
	10%	quartz grains; as above
130' - 140'	60%	limestone; pale yellow to buff and brown fine crystalline, dolomitic
	30%	mudstone; yellow, buff, and dark grey-brown, calcareous.
	10%	quartz grains; as above.
	traces	chert
140' - 150'	70%	limestone; white, pale yellow and brown, fine crystalline, dolomitic
	20%	mudstone; buff calcareous
	10%	quartz grains; as above
150' - 160'	70%	limestone; white to yellow fine crystalline, dolomitic
	20%	mudstone; buff to reddish
	10%	quartz grains; as above
160' - 171'	65%	limestone; as above
	10%	mudstone; as above
	10%	basalt; silicified and in part ferruginized
	5%	chert; grey to yellow, fine textured
	10%	quartz grains; as above

Core Descriptions:

Core No. 1 (hole No. 2), 36' to 40'6", recovered 3'3"

The core consists of limestone, with large irregular patches of clayey sand apparently occurring as a cavity filling in the limestone. The limestone is a yellow-brown to dark grey-brown calcilutite with some wavy bands of silty limestone. Shell fragments, including Biconulites sp. are common between 18 inches and 12 inches from the bottom of the core. The limestone contains some calcite veins and vugs lined by calcite crystals.

Core No. 2 (hole No. 2), 71' to 76', recovered 5'

The core consists of calcilutite and calcareous mudstone. The top 1½ inches of the core is a grey-brown calcilutite. Below this down to 1'10" from the top, it consists of buff, white, and limonitic mudstone, calcareous in parts. Below this, down to the bottom of the core, it consists of white to yellow clayey calcilutite with bands and irregular patches of white to buff mudstone.

Core No. 1 (hole No. 2a), 131' to 140'1", recovered 8'10"

The core consists of limestone and dolomitic limestone, with large patches of a massive grey calcareous mudstone. The latter has irregular, sometimes near-vertical, boundaries with the limestone and dolomitic limestone and appears to be a cavity filling. Down to about 2'6" from the top of the core the limestone is a bedded yellow to grey-brown calcilutite with some vugs and patches of calcite spar. Below this it is a laminated yellow to buff dolomitic limestone, in places partially leached and porous. The limestone in the top 2'6" of the core has a dip of about 40°, presumably due to collapse. Below that, laminations are near-horizontal.

Core No. 2 (hole No. 2a), 175' - 176'3", recovered 1'3"

The core consists of brownish partly-weathered basalt with calcite veins. Some small patches of greenish copper carbonate stain are present.

<u>Larrimah (BMR) Scout hole No. 3 (Site L3)</u>

<u>Location:</u> Latitude 15°35'S, Longitude 133°09'E, about 3½ miles west of Larrimah railway station on south side of the track to Brolga Waterhole.

<u>Altitude:</u> 615 feet above sea level (barometric measurement).

<u>Surface Geology:</u> Outcrops and large blocks of white calcilutite with gastropod shells (Tertiary Birdum Creek Beds), in part veined by secondary travertinous calcite. The limestone is overlain in places by a thin cover of sandy black soil.

<u>Objective:</u> To determine the thickness and subsurface lithology of the Birdum Creek Beds and to obtain a section in underlying rocks.

<u>History:</u> The hole was drilled with a $4\frac{3}{4}$ inch bit, except that the top 20 feet 5 inches were reamed out with a $7\frac{3}{8}$ inch bit and cased with 6" casing after initially having drilled to 19 feet, 6 inches. The hole was drilled with air to 120 feet, then continued with bentonite mud to 141 feet, 6 inches. At this depth circulation was lost in limestone. Air drilling was continued to 150 feet. A bottom hole core could not be taken due to the collapse of loose sands into the bottom of the hole.

<u>Cores:</u> Core No. 1, 10 feet to 19 feet 6 inches, recovered 7 feet.

<u>Fossils</u>: None were found.

<u>Water:</u> On returning to air drilling at 141 feet 6 inches, about 500 gallons of water, mud, and sand were blown out of the hole. On pulling up at 150 feet, water could be seen standing at the bottom of the hole. The water level was measured with a sounder at 108 feet 6 inches.

<u>Tertiary, Birdum Creek Beds:</u> The limestone at outcrop continues in depth to 50 feet below the surface. Down to 25 feet the limestone is mainly soft, chalky, and white with a few patches of white to pale yellow calcilutite. Below this depth it is mainly a pale yellow and hard calcilutite. Below 35 feet the limestone contains nodules of white to pale yellow chalcedony. Some pale yellow sandy clay occurs in the cuttings down to 50 feet and also occurs as irregular patches in the limestone in core No. 1. This material may be in part an insoluble residue of the limestone, but it also resembles sandy clay immediately underlying the limestone and could have been squeezed up from below into fractures and solution cavities.

<u>Lower Cretaceous Mullaman Beds:</u> Between 50 feet and 125 feet the section is in sandy sediments referable to the Lower Cretaceous Mullaman Beds. From 50 feet to 60 feet the sediment is a yellow-green soapy textured sandy clay; down to about 85 feet it is fine to coarse-grained quartz sand with white clay binding; below that are loose quartz sands, and fine gravels with quartz and chert pebbles. The loose quartz sand and fine gravel are probably the non-marine "Unit A" of Skwarko (1966) and the overlying clayey sand and sandy clay are correlated with Skwarko's "Unit B".

Cambrian/Ordovician?: Between 125 feet and 140 feet 6 inches, the cuttings contained white to buff soft clayey mudstone and some hard limonite-stained mudstone, in addition to large quantities of sand and gravel which probably represent cavings from higher in the hole. This mudstone, which overlies limestone similar to the Tindall Limestone, may be either an argillaceous facies of the Tindall Limestone, or a remnant of Jinduckin Formation.

The mudstone gave a stongly positive reaction for phosphate when treated with acidified ammonium molybdate solution. Mudstone cuttings picked from the 120 to 130 feet interval gave Shapiro Test colour reactions estimated at between 1% and 7% P_2O_5. Mudstone from lower in the hole gave no Shapiro Test reaction.

Cambrian Tindall Limestone: Limestone was encountered at 140 feet 6 inches and continued in the cuttings to total depth of 150 feet. The cuttings are of light brown to grey-brown calcilutite similar to outcrops of the Tindall Limestone or the upper unit of the Montejinni Limestone.

Cuttings Descriptions:

0' - 1'	80%	dark grey-brown soil
	20%	limestone; pale calcilutite
1' - 5'	95%	limestone; light brown hard calcilutite, and white chalk with a few sand grains.
	5%	sandy clay
5' - 10'	90%	limestone; yellow to brown hard calcilutite, and white chalk with some sand grains.
	10%	clay, sandy clay, and rounded loose quartz grains
10' - 19'6"	90%	limestone; mainly white chalk, some yellow hard calcilutite, both with quartz sand grains.
	10%	yellow-green clay, sandy clay, and quartz grains.
20' - 25'	90%	limestone; mainly white, yellow, and pale brown calcilutite with quartz sand grains, also white chalk.
	10%	clay, sandy clay, quartz grains.
30' - 35'	85%	limestone; white to buff calcilutite with a few quartz sand grains.
	15%	clay, sandy clay, quartz grains.

35' - 40'	90%	limestone; as above, with minor chalky limestone.
	7%	chert; white, buff and light brown, chalcedonic and translucent.
	3%	sandy clay; yellow-green
40' - 45'	80%	limestone; as above
	17%	sandy clay; yellow-green
	3%	chert; white to pale buff
45' - 50'	75%	limestone; white to pale buff calcilutite
	20%	sandy clay; yellowish-green
	5%	chert; white to light grey translucent
50' - 55'	75%	sandy clay; white to light green, with rounded quartz grains up to very coarse grain size.
	10%	limestone; as above
	15%	chert; white, pale grey, pale buff, translucent.
55' - 60'	90%	sandy clay; as above
	5%	limestone; as above
	5%	chert; as above.
60' - 65'	50%	sandy clay; white
	50%	sand; medium to coarse rounded quartz grains.
65' - 70'	80%	sand and granule gravel; rounded to angular quartz grains, larger grains sometimes smoky and pink quartz.
	20%	sandy clay; white
	traces	silica-cemented quartz sandstone, chert.
70' - 75'	75%	sand and granule gravel; as above
	25%	sandy clay
75' - 80'		As above
80' - 90'	80%	sand; fine to very coarse quartz grains, rounded to angular
	20%	sandy clay; white
90' - 100'	90%	sand; mainly very fine to fine quartz grains, some coarse and very coarse.
	10%	clayey sand; fine sand with clayey binding
100' - 110'	95%	sand; mainly medium to coarse, quartz grains, minor very coarse grains and poorly rounded quartz granules.
	5%	clayey sand
110' - 120'	100%	sand; as above
120' - 130'	95%	sand and granule gravel; medium to very coarse quartz sand grains, and poorly rounded granules of grey quartz, pink quartzite, chert.
	5%	mudstone; clayey, white and buff. (This gives strong reaction with acidified ammonium molybdate. Semiquantitative Shapiro phosphate test indicates 1% to 2% P_2O_5).

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130' - 140'	70%	sand and granule gravel; as above
	30%	mudstone; buff and white clayey.
140' - 150'	60%	sand and granule gravel; as above, with a few small quartz pebbles up to 5 mm.
	30%	limestone; light brown to grey-brown calcilutite, with some coarser clear calcite patches.
	5%	chert; (probably in part as pebbles in sand)
	5%	mudstone; buff
	traces	ironstone, white claystone, white calcilutite.

Core Description:

Core No. 1, 10' - 19'6", recovered 7'

The core consists of white chalky limestone, yellowish clay, pale yellow calcilutite, and sandy clay. The clay and sandy clay occur as irregular patches and fracture filling in the limestone, and may represent an insoluble residue of the limestone.

Katherine (BMR) Scout hole No. 1 (Site K1)

Location: Latitude 14°57'S, Longitude 132°17' in Katherine 1:250,000 Sheet area, about 32 miles south of Katherine and $\frac{3}{4}$ mile east of crossing of Gorgon Creek by the road from Katherine to Dry River, on a spur on the western slope of a hill with a trigonometric station.

Altitude: 505 feet above sea level (barometric measurement).

Surface Geology: The hole was spudded into outcrop of red calcareous siltstone of the Jinduckin Formation. The surrounding area has exposures of red siltstone and fine-grained red sandstone, with some surface scree of chert nodules. Dip is locally a few degrees to the south-east. About 150 feet of interbedded sandstone and siltstone, stratigraphically overlying the outcrop at the bore site, is exposed on the slopes of the hill east of the hole.

Objective: To obtain a section in the Jinduckin Formation and, if possible, through the underlying Tindall Limestone to the Lower Cambrian Antrim Plateau Volcanics or Precambrian rocks.

History: The hole was drilled with a $4\frac{3}{4}$ inch bit to total depth, except that at 362 feet the top 20 feet of the hole was reamed out with a $6\frac{5}{8}$" bit and 20 feet of 6" casing was cemented in.

The hole was air-drilled from surface to 145 feet, then from 145 feet to 157 feet 6 inches with water and bentonite mud. From 157 feet 6 inches to 222 feet drilling continued with air and water injection. Below 222 feet abundant groundwater started to flow into the hole and air drilling was continued without water injection. At 420 feet the air compressor could not lift the water column. The remainder of the hole was drilled with bentonite mud. A small quantity only of drilling fluid was returned to surface between 420 feet and 422 feet and none was returned during drilling of the bottom hole core.

The hole was abandoned at 429 feet 6 inches. The uppermost aquifer and the top of the hole were sealed with cement plugs.

Cores:	Core	Interval Cored	Recovery
	Core No. 1	12' - 17'6"	5'6"
	Core No. 2	101' - 105'6"	4'1"
	Core No. 3	375' - 383'6"	8'6"
	Core No. 4	422' - 429'6"	7'6"

Fossils: The limestone of core No. 4 contains abundant shell fragments including some probable Biconulites sp.

Water: A number of aquifers, all producing good quality water, were drilled, and are shown on the log (Fig. 1). They are all porous carbonate rocks, mostly dolomite, but with some dolomitic limestone near the bottom of the hole. Water samples were collected in a plastic container placed beside the hole to catch portion of the water blown out during drilling. Samples were taken at a number of levels and showed some variation in total quantity and proportions of dissolved material. In general the total dissolved solids decreased with depth, from 441 ppm for a sample at 105 feet to 242 ppm for a sample at 300 feet. A small rise to 266 ppm was recorded for a sample from 405 feet.

Water levels were measured at drilled depths of 240 feet, 362 feet, and 384 feet. Measurements varied from 180.2 feet to 180.7 feet.

Some estimates were made of the quantities of water blown out during air drilling. Between 376 feet and 413 feet the flow increased from about 1000 gallons per hour to about 5000 gallons per hour, indicating the porous dolomite and dolomitic limestone in this interval to be the most important aquifer drilled.

The minor aquifer at around 100 to 110 feet is above the standing water level for the lower aquifers.

<u>Cambrian/Ordovician Jinduckin Formation:</u> The hole was spudded in outcrop mapped as Jinduckin Formation, and the base of the Jinduckin is placed at the lowest limit of clastic sediments, at about 355 feet. The section down to this depth is characterized by the presence of calcareous siltstone, including both coarse micaceous and fine clayey varieties. It is mostly red and chocolate brown, but sometimes grey and greenish-grey below 60 feet. Down to 80 feet the siltstone has interbeds and lenses of well-sorted very fine to fine-grained sandstone. Below 80 feet interbeds of dolomite and nodules of chert are present, and sandstone is apparently rare or absent.

The dolomite interbeds are up to 15 feet thick. They are generally microcrystalline to fine crystalline; white, yellow, brown, or grey-brown; and sometimes porous and vuggy. The lowest of these interbeds contains some calcite. The dolomite in core No. 1 is similar to dolomite exposed near the road crossing of Gorgon Creek and mapped as Manbulloo Limestone Member. The dolomite interbeds in the bore are here regarded as tongues of the Manbulloo Limestone Member.

<u>Middle Cambrian Tindall Limestone:</u> Below 355 feet the section consists of carbonate rocks with little terrigenous material. Down to 420 feet the rocks

are dolomite and calcareous dolomite with minor dolomitic limestone; however, core No. 4 (422 feet to 429 feet 6 inches) is a fossiliferous limestone with some dolomitic patches. This limestone is similar in lithology to outcrops mapped as Tindall Limestone and is probably part of that formation. The overlying dolomite is tentatively regarded as dolomitized Tindall Limestone. The Tindall Limestone is in part dolomitic in outcrops to the west and south-west of the bore site.

The dolomite between 355 feet and 420 feet has vugs and intergranular porosity and is an excellent aquifer.

Cuttings Description:

0' - 10'	50%	clayey siltstone; soft, red-brown
	45%	siltstone; coarse micaceous, red-brown some white
	5%	sandstone; very fine-grained, mainly white to greyish.
10' - 20'	30%	clayey siltstone; soft, red-brown
	30%	siltstone; coarse micaceous, red-brown, some white.
	40%	sandstone; very fine to fine-grained well sorted, red-brown, buff, pale grey; some dark patches (?Mn stains)
20' - 30'	50%	clayey siltstone; soft, pink, red-brown, white.
	20%	siltstone; coarse micaceous, red-brown
	30%	sandstone; fine and very fine grained, well-sorted; reddish, white and buff. Porous and friable in part.
30' - 40'	35%	clayey siltstone; pink and red-brown
	60%	micaceous siltstone; red-brown (some white)
	5%	sandstone; as above
40' - 50'	45%	clayey siltstone; as above
	45%	micaceous siltstone; as above
	10%	sandstone; fine grained, reddish to white, well sorted.
50' - 60'	45%	clayey siltstone; as above (some white)
	45%	micaceous siltstone; as above
	10%	sandstone; as above, often micaceous, sometimes strongly silica-cemented. Micas in this and above intervals frequently greenish in colour (?biotite).

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60' - 70'	40%	<u>clayey siltstone</u>; as above
	60%	<u>coarse micaceous siltstone</u>; as above, also some hard and greyish (?dolomitic).
	traces	<u>sandstone</u>; very fine grained, well-sorted.
70' - 80'	20%	<u>clayey siltstone</u>; pinkish, red-brown, pale grey.
	70%	<u>coarse micaceous siltstone</u>; as above
	10%	<u>sandstone</u>; very fine grained, well sorted, light grey
80' - 90'	45%	<u>clayey siltstone</u>; pink, grey, purplish
	40%	coarse <u>micaceous siltstone</u>; red-brown, grey purplish.
	15%	<u>dolomite</u>; microcrystalline, pale grey, brownish-grey, purplish
	trace	<u>chert</u>; brownish translucent.
90' - 100'	30%	<u>clayey siltstone</u>; as above
	40%	coarse <u>micaceous siltstone</u>; as above, coarse biotite flakes common.
	30%	<u>dolomite</u>; pale brownish-grey to buff, microcrystalline and fine crystalline porous.
	traces	<u>chert</u>
100' - 110'	80%	<u>dolomite</u>; pale greyish brown, mostly microcrystalline with small vugs; some fine crystalline granular and porous.
	10%	<u>clayey siltstone</u>; grey, red.
	10%	micaceous siltstone; red-brown, grey, grades into very fine <u>sandstone</u>.
	traces	<u>chert</u>; white and brownish translucent.
110' - 120'	60%	<u>dolomite</u>; pale brown to greyish-brown microcrystalline, a few fragments fine crystalline.
	30%	<u>micaceous siltstone</u>; red-brown and greenish-grey
	10%	<u>clayey siltstone</u>; grey, red-brown
	traces	<u>chert</u>
120' - 130'	60%	<u>micaceous siltstone</u>; about ½ red-brown and ½ grey, traces yellow-green
	35%	<u>dolomite</u>; microcrystalline to fine crystalline, light brown
	5%	<u>clayey siltstone</u>; grey and brown
130' - 135'	50%	<u>dolomite</u>; buff & light brown, generally fine crystalline, some microcrystalline.
	20%	<u>clayey siltstone</u>; red-brown and pinkish, some grey.
	20%	<u>micaceous siltstone</u>; red-brown, some grey; may grade into silty dolomite
	10%	<u>chert</u>; white to brownish, also red and clear banded, and some greenish
140' - 150'	70%	<u>micaceous siltstone</u>; red-brown (a few chips grey).
	10%	<u>clayey siltstone</u>; red-brown (some grey)
	15%	<u>dolomite</u>; light brown microcrystalline and fine crystalline, some grey and silty.
	5%	<u>chert</u>; white and brown; also banded, clear, red, and green

150' - 160'	50%	dolomite; buff, yellowish, light greyish-brown microcrystalline and fine crystalline, also grey silty.
	40%	micaceous siltstone; red-brown (minor grey)
	10%	clayey siltstone; red-brown
	traces	chert
160' - 170'	50%	dolomite; microcrystalline and fine crystalline, buff to pale buff; some light greenish-grey silty.
	40%	micaceous siltstone; red-brown, some grey.
	5%	clayey siltstone; red-brown, grey, greenish-yellow
	5%	chert; orange, clear, light brown, often banded
170' - 180'	70%	dolomite; microcrystalline and fine crystalline, sometimes with small vugs, sometimes silty; buff, grey and grey-brown.
	20%	micaceous siltstone; red-brown, grey, dark grey
	10%	chert; buff, light grey, colourless
180' - 190'	70%	dolomite; as above, also some calcite crystals.
	20%	micaceous siltstone; as above
	5%	clayey siltstone; red-brown and grey, sometimes as intraformational cherts in coarser siltstone.
	5%	chert; brownish and buff.
190' - 200'	90%	dolomite; buff and yellowish, sometimes grey microcrystalline to fine crystalline, sometimes with vugs, some fragments silty.
	5%	micaceous siltstone; red and red-brown
	5%	chert; brown and buff; one chip showing pellet calcarenite textures.
200' - 210'	60%	micaceous siltstone; red-brown and grey, probably grading into silty dolomite.
	10%	clayey siltstone; red-brown and grey.
	20%	dolomite; "clean" yellowish microcrystalline and fine crystalline, some showing pellet calcarenite texture; also grey silty dolomite.
	10%	chert; brown, buff, orange (banded)
	trace	very fine grained sandstone with dolomite clasts.
210' - 220'	40%	micaceous siltstone; red-brown
	20%	clayey siltstone; red-brown and grey (sometimes occurring as clasts in coarse micaceous siltstone).
	30%	dolomite; pale orange, buff and light brown microcrystalline and fine crystalline porous; also grey silty dolomite.
	10%	chert; white, buff, orange, colourless; sometimes showing pelleted textures.
220' - 230'	80%	dolomite; white and pale buff, mainly fine to medium crystalline and friable, some uniformly microcrystalline
	10%	micaceous siltstone; red-brown and grey.
	5%	clayey siltstone; red-brown
	5%	chert; white, buff, orange

230' - 240'	90%	dolomite; white and buff, microcrystalline, fine and medium crystalline with vugs, also a few chips grey silty dolomite.
	10%	siltstone; micaceous and clayey, red-brown, some grey.
	traces	chert; brownish-grey and white
240' - 250'	70%	dolomite; white to pale buff and orange, microcrystalline, fine and medium crystalline, some fragments showing possible pelleted textures; also some grey silty and pyritic dolomite.
	20%	micaceous siltstone; red-brown, some grey, grading into silty dolomite.
	10%	clayey siltstone; red-brown and grey.
	traces	chert
250' - 260'	80%	micaceous siltstone; red-brown, some grey, sometimes with dolomite clasts.
	15%	clayey siltstone; red-brown, some grey.
	5%	dolomite; white to buff, some grey silty.
	traces	calcite crystals
260' - 270'	60%	micaceous siltstone; red-brown and red, some grey.
	20%	clayey siltstone; red-brown and red, some grey, siltstone sometimes has calcite veins.
	15%	dolomite; buff, white, grey, sometimes silty; microcrystalline to fine crystalline, sometimes with pelleted texture.
	5%	chert; orange, white, buff and colourless, sometimes showing pelletal textures.
270' - 280'	50%	micaceous siltstone; red-brown, some grey.
	20%	clayey siltstone; red-brown and grey
	30%	dolomite; white, buff, some grey, fine crystalline to microcrystalline; some pyrite in grey dolomite. calcite crystals abundant, probably veins or vug fillings in siltstone.
280' - 290'	60%	micaceous siltstone; red-brown, some grey
	15%	clayey siltstone; red-brown, some grey.
	5%	sandstone; very fine grained well-sorted, red-brown, some grey; siltstone and fine sandstone sometimes contain intraformational clasts of dolomite and clayey siltstone; also contain calcite crystals and veins.
	20%	dolomite; white, buff, grey; grey variety often silty or sandy and grades into dolomitic siltstone and claystone.
	traces	chert.
290' - 300'	95%	dolomite; light brown and grey-brown with some thin ?bituminous layers; microcrystalline to fine crystalline, sometimes with intercrystalline porosity; some well-preserved felsparite textures; minor grey silty dolomite.
	5%	siltstone; pink and red-brown, some grey
	traces	chert; orange, white

300' - 310'	50%	clayey siltstone; grey and red-brown (sometimes interbanded)
	45%	coarse micaceous siltstone; grey and red-brown, grey siltstone often contains thin pyritic bands
	5%	dolomite; white and buff microcrystalline and fine crystalline.
310' - 320'	60%	micaceous siltstone; red-brown (a few chips grey)
		clayey siltstone; red-brown and grey (sometimes as clasts in micaceous siltstone)
	10%	dolomite; white, buff, greyish; some well preserved intraclastic and pelletal textures, some silty dolomite; some greenish pellets (= glauconite?).
320' - 330'	60%	micaceous siltstone; red-brown
	20%	clayey siltstone; red-brown
	20%	dolomite; white, buff, grey, microcrystalline to fine crystalline, some silty, some ?glauconite
	traces	chert; orange, white.
330' - 340'	35%	micaceous siltstone; red-brown, some grey
	60%	clayey siltstone; red-brown and grey, often mottled (patches of grey in red-brown)
	5%	dolomite; buff and grey
340' - 350'	60%	crystalline limestone and dolomite; light brown, dark grey-brown, buff, and white; mostly fine crystalline and porous, some microcrystalline.
	30%	clayey siltstone; red-brown and grey (sometimes interbanded). Some pyritic bands in grey siltstone.
	10%	chert; orange, white, brown, greenish
	traces	coarse micaceous siltstone.
350' - 360'	70%	limestone and dolomite; brown to dark grey-brown calcilutite; yellow, pinkish, buff and light grey fine crystalline dolomite, calcareous dolomite, and dolomitic limestone.
	20%	clayey siltstone; grey (minor red)
	10%	chert; white, brown, clear, orange, sometimes with chalcedonic banding.
360' - 370'	80%	dolomite, calcareous dolomite, limestone; white, buff, light brown, light grey; fine crystalline, sometimes porous (dolomite dominant).
	10%	chert; white, colourless, light brown, orange. some small banded white-colourless chert nodules occur as vug fillings in crystalline dolomite.
	10%	siltstone; grey clayey, also red clayey and red micaceous
	traces	sandstone; very fine grained friable.

370' - 380'	90%	dolomite; white to pale buff fine crystalline, often porous, some calcite crystals; a few fragments grey silty dolomite.
	10%	siltstone; red and red-brown clayey, and coarse micaceous.
380' - 390'	95%	dolomite; white, pale yellow and buff, generally fine crystalline porous, some microcrystalline; small proportion of crystalline calcite in some chips.
	5%	siltstone; red and brown clayey and micaceous; some grey clayey.
390' - 400'	100%	dolomite; white to pale buff, mostly fine crystalline with inter crystalline porosity and some calcite.
	traces	chert, siltstone (red and grey)
400' - 410'	100%	dolomite; as above
	traces	chert, siltstone
410' - 420'	100%	dolomite, calcareous dolomite, dolomitic limestone; white and pale buff, some grey, pinkish; microcrystalline to fine crystalline, often porous.
	traces	chert, siltstone.

Core Descriptions:

Core No. 1, 12' - 17'6", recovered 5'6"

The core consists of fine grained calcareous sandstone, coarse micaceous calcareous siltstone, and clayey calcareous siltstone. The rocks are predominantly red to red-brown; some of the sandstone is yellowish-buff. The sandstones show ripple bedding. Thin laminae of sandstone and siltstone are frequently broken and disturbed.

Core No. 2, 101' - 105'6", recovered 4'1"

The core consists of laminated grey, grey-brown, and yellowish microcrystalline to fine crystalline dolomite with a variable content of terrigenous silt and clay. In the uppermost 2'6" of the core the laminae are often wavy and the dolomite splits easily along the laminae.

Core No. 3, 375' - 383'6", recovered 8'6"

The core consists of buff to pale yellow microcrystalline to fine crystalline dolomite. The dolomite in places has abundant small vugs about $\frac{1}{4}$" across, and also has some intercrystalline porosity. In places there are undulating laminations in the dolomite, suggesting stromatolites.

Core No. 4, 422' - 429'6", recovered 7'6"

The core consists of brownish calcilutite and fine crystalline limestone, with small patches of yellow fine crystalline dolomite and dolomitic limestone. Shell fragments, including probable Biconulites sp., are common.

Abundances of clay minerals in the minus 10 micron clay fractions of specimens from cores Nos. 1 and 2 were determined by A.M.D.L. (Report MP 2465-67 by E.C. Stock). Results are as follows:

Specimen from core No. 1: Illite dominant (> 50%) random mixed-layer smectite-chlorite subdominant (20% to 50%), chlorite accessory (5% to 20%)

Specimen from core No. 2: Illite subdominant, regular mixed-layer smectite-chlorite subdominant.

REFERENCES

BARRIE, J., 1965 - Notes on some phosphate test procedures. Bur. Min. Resour. Aust. Rec. 1965/77 (unpubl.).

RIVEREAU, J.C., 1966 - Report on photo-interpretation of Newcastle Waters, Daly Waters, and Larrimah 1:250,000 scale sheets, Northern Territory. Bur. Min. Resour. Aust. Rec. 1966/63 (unpubl.).

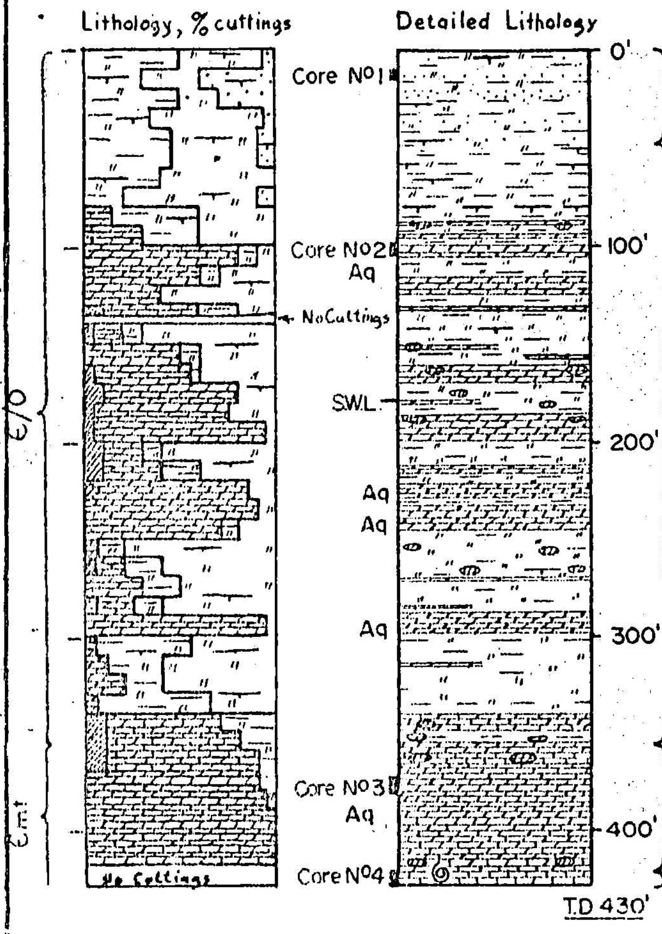
SKWARKO, S.K.R., 1966 - Cretaceous stratigraphy and palaeontology of the Northern Territory. Bur. Min. Resour. Aust. Bull. 73

SKWARKO, S.K.R., 1967 - Cretaceous stratigraphy of the Wiso Basin, Northern Territory (Preliminary Report). Bur. Min. Resour. Aust. Rec. 1967/47 (unpubl.).

TERPSTRA, G.R.J., 1967 - Report on the micropalaeontological examination of scout holes D.W.I. and D.W.IB. Bur. Min. Resour. Aust. Rec. 1967/45 (unpubl.).

Fig. 1.

Katherine (BM.R.) Scout hole No1



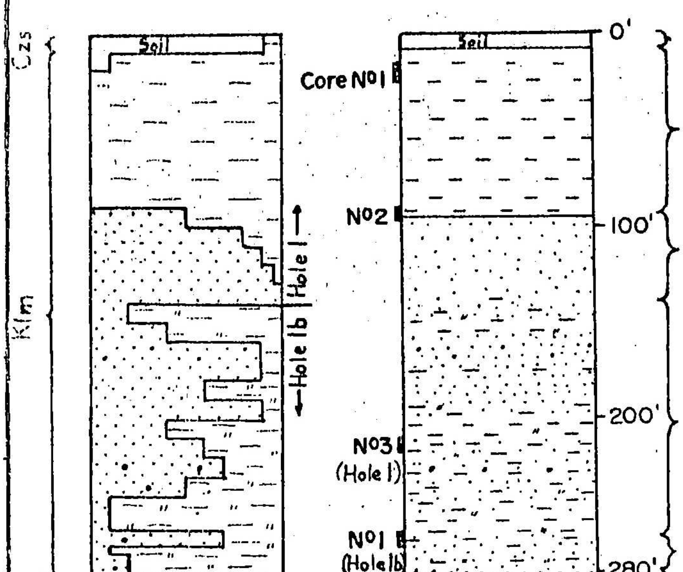
Interbedded sandstone and siltstone
Sandstone: very fine to medium grained well sorted, white, buff, brown
Siltstone: clayey and coarse silty micaceous, calcareous chocolate brown and red

Siltstone with dolomite interbeds up to 15' thick and chert nodules.
Siltstone: clayey and coarse silty micaceous and calcareous, chocolate – brown, red, grey, greenish-grey.
Dolomite: grey silty; grey-brown, light brown and yellowish microcrystalline to fine crystalline.

Dolomite, dolomitic limestone: light buff, pale yellow, white, fine crystalline, often leached porous and vuggy

Limestone: grey – brown calcilutite with yellow crystalline patches, abundant shell fragments

Daly Waters (B.M.R.) Scout hole No I and Ib



Black soil overlying yellow – brown clay with ironstone pisolites

Claystone and clay: predominantly white and hard at top, becoming light grey and soft in depth, also buff and pink; hematite and limonite veins common.

Sand and friable sandstone: buff, fine grained glauconitic; and white very fine grained micaceous

Interbedded sandstone, silty clay
Sandstone; very fine to fine, buff to greenish, friable, glauconitic, some with clay matrix; minor coarse sand 220'-230'
Clay; light grey, buff, some purplish, soft.

Silty clay and medium to very fine glauconitic sandstone, purplish, pink, buff, and grey
Medium to coarse sand at 280'-281'

For Legend, See Fig.2.

Bureau of Mineral Resources, Geology and Geophysics, May 1967

To Accompany Records 1967/110 Appendix I

NT/A/170

G.S.

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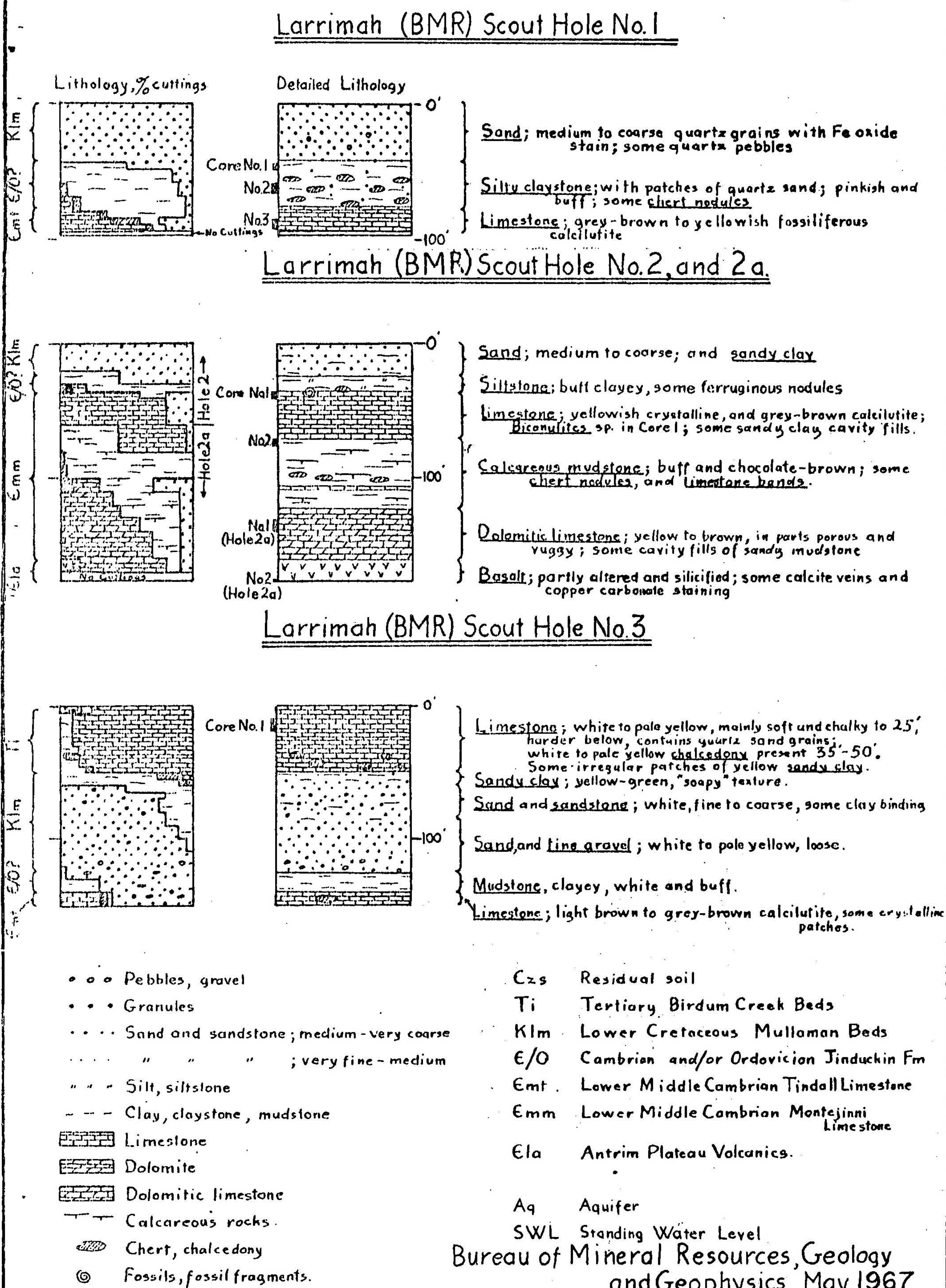
Fig. 2.



Bureau of Mineral Resources, Geology and Geophysics, May 1967

To Accompany Records 1967/110 Appendix 1

D53/A13/2

M.C.B.

APPENDIX 2

NOTES ON WATER BORES, NORTHERN WISO BASIN

by

M.C. Brown

Introduction

Cuttings from some water bores in the area were made available by arrangement with Water Resources Branch, Northern Territory Administration, Darwin; and some were obtained from pastoralists and drillers. They were examined with a hand lens and binocular microscope, tested for carbonate with dilute acid, and some carbonate rocks were stained with Alizarin Red S to distinguish between dolomite and calcite.

The intervals are variable, and the methods and reliability of the sampling are not known. However most of the cuttings can be matched with rock units mapped in outcrop, and they provide useful stratigraphic information.

The cuttings descriptions for the individual bores are preceded by locality data and a brief discussion of the rock units recognized from the cuttings.

Drillers logs are available for some water bores. Those for which the driller's description can be matched with outcrop units have also been used to assist interpretation of subsurface geology. Details of these bores are summarized following the descriptions of bores for which cuttings were available.

Bores DWH1 to DWH 5

Localities: These bores are in the south-eastern part of the Delamere 1:250,000 Sheet area, and were drilled beside the Willeroo-Top Springs

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road to provide water for road construction. Latitudes and longitudes, and elevations of the 5 bores follow:

Bore	Latitude	Longitude	Elevation
DWH1	15°32'S	131°39'E	850'
DWH2	15°43'S	131°42'E	810'
DWH3	15°51'S	131°51'E	720'
DWH4	15°38'S	131°40'E	875'
DWH5	15°46'S	131°48'E	755'

Summary of rock units penetrated: All of the bores spudded in lateritic soils overlying Lower Cretaceous Mullaman Beds, and bottomed in Lower Cambrian Antrim Plateau Volcanics. Between the Cretaceous rocks and the Volcanics the southernmost three of the bores penetrated the argillaceous middle unit of the lower Middle Cambrian Montejinni Limestone. The sections in the bores are similar to outcrop sections in the scarp to the west of the road. The Cretaceous sedimentary rocks are white to buff, sometimes purplish, clayey and sandy siltstone; with some medium to coarse sand and sandstone, often with a clayey matrix. The middle unit of the Montejinni Limestone is represented by brownish-red and dark red siltstone or mudstone, usually calcareous, and containing chert and argillaceous limestone bands. The Antrim Plateau Volcanics are basalts, with some interbeds of well-sorted brownish sandstone in DWH4. The approximate intervals of the units in the 5 holes are tabulated below.

Unit	DWH1	DWH2	DWH3	DWH4	DWH5
Superficial, ferruginous rubble	0'-9'	0'-10'	0'-8'	0'-14'	0'-10'
Lower Cretaceous Mullaman Beds	9'-105'	10'-60'	8'-75'	14'-75'	10'-40'
Lower Middle Cambrian, Montejinni Limestone (middle unit)	absent	60'-110'	75'-120'	absent	40'-90'
Lower Cambrian Antrim Plateau Volcanics	105'-448' (t.d.)	110'-602' (t.d.)	120'-585' (t.d.)	75'-411' (t.d.)	90'-327' (t.d.)

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Cuttings description, DWH No. I bore:

0' - 5'	60%	lateritic nodules, equidimensional and well-rounded; the nodules contain well-rounded quartz sand grains about 0.5 mm in diameter.
	40%	siltstone, white and yellow-brown in colour, quartz sand grains about 0.5 mm in diameter, non-calcareous.
5' - 9'		As above, siltstone fragments up to 20 mm in diameter with oxidized surface layer.
9' - 35'	95%	sandy siltstone, white and buff coloured, of which 20% is poorly sorted sand, quartz grains well-rounded.
	5%	chert fragments, well rounded, quartz grains up to 3 mm diameter also rounded.
35' - 37'	80%	siltstone with quartz sand grains, white to yellow in colour.
	20%	silicified sandstone with angular to subrounded quartz grains.
37' - 45'	80%	siltstone white and yellow with well rounded quartz sand grains.
	20%	ferruginous material, angular fragments up to 4 mm in diameter.
45' - 105'	80%	siltstone as above with nodules of sandstone up to 8 mm in diameter.
	15-20%	silicified sandstone as at 35-37 feet.
	< 5%	quartz crystals, probably from the basalt. Rare fragments of ferruginous material as nodules.
105' - 127'		weathered basalt with green cupriferous staining. rare fragments of quartz.
127' - 144'		weathered basalt, some cupriferous stainings.
144' - 292'		unweathered basalt.
292' - 415'		unweathered basalt, with rare fragments of quartz.
415' - 420'		unweathered basalt, amygdaloidal, geodes of quartz with native copper and iron pyrites.
420' - 448'		as above.

Cuttings description, DWH No. 2 bore:

0' - 10'		nodules of lateritic material enclosing well-rounded sand grains.

10' - 32'	70%	sandy siltstone, brown in colour with white siltstone flecks.
	20%	lateritic nodules
	10%	white sandy siltstone
32' - 45'	100%	purple and white micaceous siltstone with rare quartz sand grains.
45' - 89'	70%	micaceous sandy siltstone, non-calcareous.
	30%	dark red siltstone, no sand grains apparent, calcareous. Fragments of white siltstone present.
89' - 102'	50%	dark red siltstone with black or near black flecks, occasional angular quartz sand grains.
	40%	light brown limestone; crystalline in patches.
	10%	chert; pale blue, red and grey.
102' - 127'	70%	basalt; weathered, brown to grey colour.
	25%	calcareous siltstone; red.
	5%	chert. The rock fragments were supported in a dark red clay.
127' - 157'	95%	basalt; weathered.
	5%	non-calcareous red siltstone.
157' - 268'		fresh basalt contaminated from up-hole with chert, Cretaceous siltstone and lateritic nodules.
268' - 428'	100%	basalt; fresh, blue-grey colour with some green fragments.
428' - 437'	100%	basalt; fresh, red, blue-grey, green fragments.
437' - 520'	100%	as above
520' - 602'	100%	as above

Cuttings description, DWH No. 3 bore:

0' - 8'	60%	ironstone (ferruginized fine sediment)
	20%	siltstone and claystone; white to buff
	20%	quartz sand; medium to coarse.
8' - 50'	10%	ironstone ferruginized fine sediment)
	80%	siltstone and claystone; white to buff.
	10%	quartz sand; medium to very coarse.
52' - 102'	50%	claystone and siltstone; white to buff
	30%	mudstone; red, calcareous, high clay content
	20%	chert; light brown to grey, fine texture.
	trace	ironstone pisolites.

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102' - 120'	95%	mudstone; red (as above) also buff to light grey silty and calcareous
	5%	chert
	traces	white claystone
120' - 130'	100%	basalt; partially altered, aphanitic to ophitic texture, some amygdales with chalcedonic silica filling.
130' - 140'	100%	basalt;
	traces	chert (one piece, grey-brown).
140' - 202'	100%	basalt; grey, with few vesicles or amygdales.
202' - 247'	100%	basalt, as above.
247' - 252'	100%	basalt; fine to aphanitic, with vesicles.
252' - 267'	100%	basalt; mainly grey ophitic and massive.
267' - 368'	100%	basalt; grey, ophitic, massive.
	traces	quartz crystals.
368' - 380'	100%	basalt; as above
380' - 492'	100%	basalt; as above, also some brownish, aphanitic, with amygdales.
492' - 507'	100%	basalt; fine textured, brownish with vesicles.
507' - 585'	100%	basalt; with some amygdales.

Cuttings description DWH No. 4 bore:

0' - 14'	80%	ironstone; pisolites and angular fragments, ferruginized fine sediment.
	20%	claystone; white, some iron staining.
14' - 27'	50%	claystone and sandy claystone; white to buff.
	30%	sandstone; white, fine-grained friable.
	20%	ironstone (ferruginized fine sediment)
27' - 37'	100%	sandy claystone and clayey sandstone; white, fine to coarse quartz grains.
37' - 55'	30%	claystone and sandy claystone; white
	70%	claystone and sandy claystone; strongly ferruginized.
55' - 60'	100%	sandstone; medium to very fine grained, quartz grains in clayey matrix, white to buff.

60' - 95'	30%	sandstone; fine to coarse quartz grains in clayey matrix (mainly fine grained).
	65%	basalt; buff, strongly weathered, with traces of copper staining.
	5%	ironstone.
95' - 147'	100%	basalt; weathered brown massive, and brown vesicular.
147' - 153'	95%	sandstone; brown, medium to fine grained, quartz and basalt grains, moderately to strongly silica-cemented.
	5%	basalt; weathered
153' - 164'	95%	basalt; weathered and copper-stained, also brown aphanitic and vesicular
	5%	sandstone; as above.
164' - 305'	100%	basalt; dark grey, massive, with ophitic texture.
305' - 329'	95%	basalt; dark grey and dark brown.
	5%	quartz sand; medium to fine grained
329' - 372'	100%	basalt; dark grey, massive, ophitic texture.
372' - 382'	98%	basalt; grey and brown fine textured, some vesicles.
	2%	sandstone; brown, well sorted, porous.
382' - 411'	95%	basalt; dark grey, ophitic.
	5%	sandstone; brown, medium to fine grained with quartz grains, occasional basalt grains.

Cuttings description, DWH No. 5 bore:

0' - 10'	100%	ironstone and ferruginized fine sediments (ferruginized claystone and clayey fine grained sandstone)
10' - 25'	80%	claystone; white and buff, some silty and sandy.
	20%	ferruginized claystone.
	traces	quartz sandstone; fine grained, with silica cement.
25' - 40'	90%	sandy claystone, clayey sandstone, fine grained sandstone; buff and white
	5%	coarse and very coarse quartz sand grains; rounded and angular.
	5%	ferruginized claystone.
40' - 55'	80%	clayey siltstone; dark brownish-red, soft.
	15%	chert; grey to buff, fine textured.
	5%	claystone and sandy claystone; white and buff.
55' - 70'	75%	clayey siltstone; dark brownish-red.
	25%	claystone, silty and sandy claystone; white and buff.

70' - 90'	70%	clayey siltstone; dark brownish red
	20%	claystone, silty and sandy claystone; white and buff
	5%	basalt; coarse textured, grey
	5%	crystalline quartz aggregates (?) silicified limestone.
90' - 128'	90%	basalt; largely altered to clay minerals and serpentine, with white vein calcite.
	10%	clayey siltstone; dark brownish red (as above)
	traces	chert
128' - 135'	100%	basalt; grey and brown, coarse textured, partly altered, some copper carbonate stain.
135' - 272'	100%	basalt; grey, well-crystallized, with some small plagioclase phenocrysts.
272' - 283'	100%	basalt; as above
283' - 327'	100%	basalt; greenish-brown, well crystallized with fresh plagioclases and altered ferro-magnesian mirerals (brown and greenish alteration products), a few amygdales of a white mineral with acicular habit are present.

Dry River Stock Route No. 8 bore

Locality: On west side of old Katherine-Top Springs road, 9 miles north of Nelly Waterhole. Latitude 16°12'S, longitude 132°02'E, altitude 780'; on Daly Waters 1:250,000 Sheet area.

Rock units penetrated, summary: The hole was spudded in soil and ferruginous rubble overlying Lower Cretaceous Mullaman Beds, and terminated in basalt of the Antrim Plateau Volcanics. No cuttings were returned over the 50' to 230' interval. The section below this is Antrim Plateau Volcanics. The section above 50' is anomalous; basalt cuttings occur in the 18' to 50' interval, higher than expected, and there is no trace in the cuttings of any basal Mullaman Beds sandstone or of Montejinni Limestone.

Lower Cretaceous Mullaman Beds (0-50'?): The white to buff and pinkish clayey siltstone and silty claystone from near surface to 50' are probably Unit 6 of Skwarko (1966). Similar claystones at two localities about 2½ miles north and south have yielded mollusc faunas.

Lower Cambrian Antrim Plateau Volcanics (50'?-908'): Basalt predominates; but the interval 484' to 502' consists mainly of chert and siliceous limestone, and the interval 280' to 302' contains well-sorted brownish sandstone.

Cuttings description:

0' - 3'	90%	limonitic ironstone; mostly as rounded pisolites about $\frac{1}{4}$" diameter
	10%	silty claystone; white and buff
3' - 5'	100%	clayey siltstone, silty claystone; white and buff, some pinkish
5' - 7'		as above
7' - 10'		as above
10' - 18'		as above
18' - 50'	90%	clayey siltstone, silty claystone; as above
	10%	basalt; grey, well crystallized
	traces	large calcite crystal
50' - 230'		no cuttings, lost circulation
230' - 280'	100%	basalt; grey and brown well-crystallized, occasional small feldspar phenocrysts
280' - 310'	60%	basalt; brownish, coarse textured with fairly abundant small feldspar phenocrysts, and altered ferromagnesian minerals
	40%	sandstone; brown, well sorted medium to fine grained with abundant quartz; some probable basalt fragments
310' - 360'	100%	basalt; grey and brown, well crystallized, some feldspar phenocrysts, brown and greenish alteration of ferromagnesians common
360' - 472'	100%	basalt; grey and brown, well crystallized
472' - 476'	100%	basalt; brown, greenish, and grey; mostly altered
476' - 484'	100%	basalt; fine textured with some feldspar phenocrysts and amygdales; extensively altered, with abundant chlorite aggregates; some clear quartz amygdales.
484' - 502'	75%	chert; white, orange, pink, buff, clear, sometimes with uniform fine texture, sometimes with irregular laminations and bands
	10%	limestone; white, grey, brown, crystalline; sometimes contains quartz sand grains, and grades into calcareous sandstone; contains abundant cryptocrystalline silica
	15%	basalt; grey, aphanitic texture, some small feldspar laths, some quartz amygdales.

502' - 728'	100%	basalt; brown, well-crystallized with altered ferro-magnesian minerals
728' - 752'	100%	basalt; grey-brown, well-crystallized, with chlorite films along joint surfaces
752' - 860'	100%	basalt; greenish-brown, well-crystallized; ferro-magnesian minerals altered to greenish (?)chlorite
	traces	ironstone pisolites, buff silty claystone (?contamination)
860' - 908'	100%	basalt; grey-brown, well-crystallized

Widgee Bore (Birrimba Homestead)

Locality: At new Birrimba Homestead. Latitude 16°25'S, longitude 132°06'E, altitude 685 feet. On Daly Waters 1:250,000 Sheet area.

Lower Cretaceous Mullaman Beds (0'-30'): Red clayey soil with fragments of ferruginous material, claystone, and quartz sand, is present to a depth of 30'. This probably represents a pocket deposit of reworked Mullaman Beds.

Lower Middle Cambrian Montejinni Limestone (30'-166'6"): All three units of the Montejinni Limestone are present; the upper unit of limestone and dolomitic limestone is present from 30' to 134', the middle unit (buff calcareous clay or silt) from 134' to 155'4", and the lower unit (limestone) from 155'4" to total depth.

Cuttings description:

0' - 10'	50%	red clayey soil
	25%	ironstone (ferruginized fine sediments), angular and rounded pieces.
	20%	claystone; white to buff
	5%	quartz sand grains; medium grain size, rounded.
10' - 30'	50%	red clayey soil
	25%	ironstone
	15%	quartz sand grains; medium to very fine grain size.
	traces	white limestone

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30' - 62'	85%	limestone; white to light brown dolomitic (Cuttings mainly limestone, fine powder mainly dolomite)
	5%	clay or silt; white to buff
	10%	quartz sand grains; medium to very fine grain size
62' - 129'	100%	limestone; white to light brown calcilutite, contains some dolomite, and buff clay impurity.
129' - 134'	100%	limestone and dolomite; cuttings brown microcrystalline (?partly dolomitic) limestone, fine powder mainly dolomite.
134' - 155'4"	25%	limestone; grey to brown calcilutite
	75%	clay (and/or fine silt); buff, calcareous.
155'4" - 165'6"	100%	limestone; grey to brown calcilutite, with some clear crystalline patches, sometimes well-laminated.

Shoeing Tool Replacement Bore

Locality: About 6 miles south-east of Moolooloo Outstation. Latitude 16° 24'S, Longitude 131°34'E, Altitude 505'. On Victoria River Downs 1:250,000 Sheet area.

Lower Cambrian Antrim Plateau Volcanics (0-590'): The section below the 3' of surface soil to total depth of 590 feet is in basalt of the Antrim Plateau Volcanics. No interbedded sedimentary rocks were recorded.

Cuttings Description:

0' - 3'	70%	clayey soil with root fragments
	30%	chert fragments, and quartz crystals from the basalt.
3' - 46'	90%	basalt; unweathered, with crystals of quartz attached to some chips.
	10%	weathered basalt; blue-green and red, fine grained, olivine-rich.
46' - 51'		basalt; vuggy and amygdaloidal, olivine-rich, with vugs partially filled with crystalline quartz and native copper spheres in the quartz. Partially weathered.
51' - 66'		basalt; unweathered, no amygdales or vugs visible, greenish in colour.

66' - 197'		basalt; unweathered, with very small amygdales, some fragments with very thin quartz veins running through them; copper stained fragments present.
197' - 226'		basalt; unweathered, amygdaloidal, copper stained, with some crystalline quartz.
226' - 255'		basalt; unweathered, with amygdales and partially filled amygdales. Infillings of quartz and a crystalline green mineral - olivine?
255' - 275'	60%	basalt; unweathered, copper stained.
	40%	crystalline quartz.
275' - 285'		basalt; unweathered, a few amygdales filled with quartz? or some other white mineral.
285' - 302'		as above
302' - 310'		basalt; unweathered, copper stained, with quartz from vesicles, and amygdales filled with a green mineral, basalt red and green.
310' - 331'	90%	red basalt, with amygdales.
	10%	blue-green basalt
331' - 380'		as above
380' - 408'		amygdaloidal basalt; unweathered, blue-green in colour with rare crystalline calcite fragments.
408' - 421'		basalt; unweathered, no amygdales.
421' - 430'		as above
430' - 444'		as above
444' - 466'		amygdaloidal basalt; unweathered with calcite crystal rhombs. Blue-green colour.
466' - 490'		unweathered basalt; blue-green colour.
490' - 590'		unweathered basalt; red fragments and blue-green fragments, amygdaloidal.

Waterbag Bore

Locality: Near crossing of Waterbag Creek by Top Springs - Timber Creek road. Latitude 16°22½'S, Longitude 131°25'E. On Victoria River Downs 1:250,000 Sheet area.

Antrim Plateau Volcanics (and superficial deposits)(0'-16'): Cuttings from 0'-16' consist of limestone (probably surface travertine); and weathered basalt, chert, and agate (probably Antrim Plateau Volcanics).

Victoria River Group (16' - 173' total depth): The section from 16' to 173' (total depth) consists of sedimentary rocks of the Victoria River Group. They consist of red, green, and purple, dolomitic siltstone and sandstone.

Cuttings description:

0' - 16'	50%	limestone, very light brown, porous, soft.
	20%	basalt, weathered.
	20%	limestone; light brown, non-porous, conchoidal fracture, hard.
	10%	chert, agate; red, with conchoidal fracture.
16' - 28'		siltstone; micaceous, red with white spots, quartz sand grains uncommon, dolomitic.
28' - 49'		purple, pale green to white micaceous siltstone; sandy, dolomitic, sand grains mostly angular. rare fragments of basalt and chert.
49' - 54'	90%	red silty sandstone; quartz grains well rounded, equidimensional, poorly sorted, well-cemented, dolomitic.
	10%	basalt; weathered; and rare fragments of chert, red and white; siltstone; and limestone.
54' - 109'	60%	sandy siltstone; red, dolomitic, well cemented, micaceous, thinly laminated.
	40%	purple and green siltstone; dolomitic, thinly laminated.
109' - 111'6"	40%	silty sandstone; quartz grains well rounded, poorly sorted, well-cemented; dolomitic.
	15%	green sandy siltstone; dolomitic; quartz grains angular.
	15%	red sandy siltstone; dolomitic; quartz grains rounded.
	30%	mottled purple and green thinly laminated siltstone; dolomitic; well cemented; quartz grains small, angular and rounded, equidimensional.

111'6" - 130'	80%	siltstone, sandy, micaceous; thinly laminated.
	10%	purple and green sandy siltstone; micaceous; dolomitic.
	10%	silty sandstone, some mica; well-cemented; dolomitic.
130' - 136'	95%	red, purple and green siltstone; as above.
	5%	limestone and chert.
136' - 138'	95%	red, purple sandy siltstone; dolomitic.
	5%	limestone
138' - 148'	90%	purple, green and red mottled siltstone; thinly laminated, micaceous, dolomitic.
	10%	red silty sandstone as above
148' - 150'	80%	green sandy siltstone; slightly mottled, dolomitic
	20%	red sandy siltstone; micaceous, dolomitic.
150' - 160'	70%	red sandy siltstone, micaceous, dolomitic.
	20%	purple green sandy siltstone with muscovite and a dark green mica (biotite); dolomitic.
	10%	red silty sandstone; well-cemented; dolomitic.
160' - 173'		as above

Maryfield Homestead Bore

Locality: At new Maryfield Homestead. Latitude 15°50'S, longitude 133°24'E, altitude 610' (estimated). On Larrimah 1:250,000 Sheet area.

Superficial Deposits (0-20'): From surface to 20' the section is in red clayey sand with ironstone fragments, probably representing material reworked from Cretaceous sediments and Tertiary laterite.

Lower Cretaceous Mullaman Beds (20'-91'): The section from 20' to 91' is in Mullaman Beds. The section is typical of the "Inland Belt" of Lower Cretaceous rocks (Skwarko, 1966) and is similar to that of B.M.R. Scout Hole B1 and Beetaloo No. 1 water bore on the Bettaloo 1:250,000 Sheet area (Randal et al., 1966). It can be subdivided into an upper "Unit C" of white, buff, and pinkish claystone and silty claystone (20'-50'), an intermediate "Unit B" of mixed sandy and clayey sediments (50'-65') and a lower "Unit A" of loose and friable medium to very coarse grained quartz sand (65'-91').

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Cambrian? (91'-104'): The calcareous siltstone between 91' and 104' is probably Lower Palaeozoic and may be either an argillaceous facies of the underlying Tindall Limestone or a thin remnant of Jinduckin Formation.

Lower Middle Cambrian Tindall Limestone (104'-190'): The carbonate rocks from 104' to 190' (total depth) are regarded as Tindall Limestone. Dolomite is abundant down to 119', below that is limestone; a light buff and grey-brown calcilutite, sometimes containing shell fragments.

Cuttings description:

0' - 10'	30%	ironstone; both as rounded pisolites and large fragments of ferruginized clayey coarse grained sandstone
	70%	clayey sand; coarse rounded quartz grains in red clayey and silty matrix
10' - 20'		cuttings as above
20' - 30'	80%	claystone, clayey siltstone; white, buff, pink
	5%	sandstone; white and buff fine to very fine grained, sometimes with clay matrix
	10%	ironstone; as above
	5%	quartz sand; loose coarse and very coarse grains
30' - 39'	100%	claystone; clayey siltstone; as above
	traces	ironstone pisolites, quartz sand
39' - 41'		as above
41' - 61'	60%	claystone, silty claystone; buff, yellow, some white
	40%	sand and sandstone; fine to very coarse quartz sand grains, also buff sandstone with limonitic clay matrix, minor sandstone with white clay matrix
61' - 62'	80%	claystone, silty claystone; white, yellow and buff, sometimes hard and limonite-stained
	20%	sandstone and sand; white and buff fine grained quartzose sandstone; loose medium to very coarse quartz grains
62' - 65'	60%	claystone, silty claystone; as above
	40%	sand and sandstone; friable medium grained sandstone and loose medium to coarse quartz grains
65' - 91'	95%	sand; loose, medium to very coarse angular and rounded quartz and chert grains
	5%	claystone, silty claystone
	traces	limonite pellets

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91' - 104'	90%	siltstone; buff, slightly calcareous; some chips have small cylindrical cavities (? sponge spicule moulds)
	10%	sand; as above
104' - 110'		calcareous dolomite, dolomitic limestone, leached porous dolomite; light buff, and brownish, microcrystalline to fine crystalline
110' - 119'		cuttings as above; dolomite dominant
119' - 176'	90%	limestone; light buff and light greyish-brown calcilutite, minor dolomite replacement
	10%	dolomite, calcareous dolomite; microcrystalline to fine crystalline, sometimes leached porous
		N.B. Some very large cuttings may represent material broken from cavities in limestone
176' - 178'		limestone; light buff and light grey-brown calcilutite with shell fragments. Cavities of various sizes are present
178' - 190'	(t.d.)	limestone, dolomitic limestone, dolomite; light grey-brown and buff; limestone is calcilutite with scattered dolomite crystals; dolomite is microcrystalline to fine crystalline, sometimes leached and porous.

Moorak Bore, Daly Waters Station

Locality: 13 miles at a bearing of 345° from Daly Waters township. Latitude 16°05'S, Longitude 133°20'E, Altitude 675 feet. On Daly Waters 1:250,000 Sheet area.

Superficial Deposits (Tertiary Laterite)(0'-35'): The rubbly ferruginous material at the surface continues to about 35'.

Lower Cretaceous Mullaman Beds (35'-191'): The section from about 35' to 191' is in Mullaman Beds. It consists dominantly of white, buff, and pinkish silty claystone referable to "Unit C" of Skwarko (1966). Basal sand and sandstone are present in small amounts in cuttings below 191'.

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Lower Middle Cambrian Tindall Limestone (191'-220'): The section from 191' to 220' (total depth) is in limestone regarded as Tindall Limestone. It is dominantly a grey to brownish calcilutite, containing some shell fragments. Some disrupted calcilutite and silicified oolitic limestone are present.

Cuttings description:

0' - 26'		lateritic material; seems to have been originally rubbly in nature; most fragments have rounded surfaces.
26' - 40'	60%	ferruginous material in chips up to ¾" across, showing no original rock textures.
	40%	silty claystone; white to pinkish, buff, or red hematitic; white claystone generally soft; claystones contain some silt-size quartz and muscovite.
40' - 100'	15%	ferruginous material
	85%	white and buff claystone, with some silt-size muscovite and quartz.
100' - 103'	100%	claystone; as above, mostly soft.
103' - 140'	100%	claystone; as above.
140' - 170'	100%	claystone; as above; plus about 5% ferruginous material.
170' - 191'	95%	claystone; as above, a few chips with fine to very fine sand grains.
	5%	ferruginous material.
191' - 196'	15%	claystone; as above
	5%	fine sandstone; fairly friable, some poorly sorted.
	5%	chert; mainly silicified oolite, some laminated fine textured chert.
	75%	limestone, grey to brownish, includes calcilutite (dominant), disrupted calcilutite (dismicrite), and some "intramicrite" (intraclasts in calcilutite matrix). Calcilutite contains some spar-filled shells including (?) small Biconulites sp.
196' - 204'	70%	limestone, similar to above.
	5%	chert, mainly silicified oolite.
	15%	white-pink claystone
	5%	yellow-buff mudstone (soft)
	5%	ferruginous material
	traces	fine sandstone, loose quartz grains up to about 1½mm.
204' - 220'	100%	limestone; grey (some brownish - buff), dominantly calcilutite.
	traces	buff mudstone and ferruginous material.

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Enoanoa Bore, Daly Waters Station

Locality: About 1/10 mile west of Stuart Highway, $8\frac{3}{4}$ miles north of Daly Waters turnoff. Latitude 16°10'S, Longitude 133°25'E, Altitude 656'.

Superficial deposits, Tertiary Laterite (0'-40'): About 40' of lateritic ironstone is present below the surface.

Lower Cretaceous Mullaman Beds (40'-75'): The section from 40' to 75' can be subdivided into an upper unit of buff, white, and pinkish claystone and siltstone from 40' to about 55'; and a lower unit of fine to very coarse grained friable sandstone and loose sand (55' to 75'). The two units represent Units C and A of Skwarko (1966). A thin transition zone (Unit B) may be present.

Lower Middle Cambrian Tindall Limestone (75'-187', total depth): The section below 75' is in limestone, mainly a light grey, yellow, and brown calcilutite with shell fragments. Some shell fragment calcarenite is present. The limestone is regarded as Tindall Limestone.

Cuttings description:

0' - 45'	75%	ironstone (ferruginized siltstone)
	25%	siltstone; white to buff with quartz and mica grains, variable clay matrix.
45' - 58'	80%	claystone (or clayey siltstone); buff and white.
	10%	ironstone
	10%	quartz sand grains; medium grain size
	traces	limestone
58' - 63'	20%	claystone (or clayey siltstone); buff, white, and pinkish
	20%	sandstone; buff, well-sorted, fine grained, friable
	60%	quartz sand; medium to very coarse grain size
63' - 75'	80%	quartz sand; medium to very coarse grain size
	20%	sandstone buff, well-sorted fine grained, friable

75' - 144'	90%	limestone; (large fragments probably broken from cavernous limestone) light yellow to brown calcilutite with shell fragments and (?) echinoderm ossicles; also one piece of shell fragment calcarenite.
	10%	sandstone; medium to coarse quartz grains and mudstone fragments with clayey binding (attached to limestone, probably a cave fill)
144' - 168'	95%	limestone
	5%	claystone or silty claystone; buff
	traces	ironstone
168' - 187'	90%	limestone; light grey, yellow, and light brown calcilutute with some shell fragments (not abundant)
	5%	sandstone; buff, well sorted fine-grained friable
	5%	claystone or silty claystone; buff
	traces	sandy white claystone.

INTERPRETATION OF SELECTED DRILLERS' LOGS

Newcastle Waters 1:250,000 Sheet area

Bradman Bore

	Log	Geological Interpretation
0' - 10'	Black Soil	
8' - 72'	Limestone clay	Lower Cretaceous Mullaman Beds. (Compact mudstone frequently termed limestone by drillers).
72' - 115'	Limestone boulders	
115' - 137'	Yellow limestone, clay and boulders	
137' - 146'	Limestone	Middle Cambrian Merrina Beds.
146' - 172'	Water bearing country with very hard bars	

Benaud Bore

	Log	Geological Interpretation
0' - 2'	Black soil	
2' - 12'	Red sandy clay	
12' - 38'	Yellow clay	Lower Cretaceous Mullaman Beds.
38' - 71'	Red clay	
71' - 76'	White sand clay	
76' - 87'	Yellow clay	
87' - 106'	Yellow clay and boulders	
106' - 137'	Very hard limestone, quartz and ribbon stone	Middle Cambrian Merrina Beds.
137' - 139'	Water, small supply	
139' - 156'	Very hard quartz and ribbon-stone	
156' - 163'	Water bearing country	
163' - 165'	Limestone	
165' - 168'	Water bearing	
168' - 175'	Limestone	

Burge Bore

	Log	Geological Interpretation
0' - 6'	Black soil	
6' - 9'	Red clay and sand	Mullaman Beds
9' - 37'	Yellow clay and sand	
37' - 60'	Red clay and sand (small supply of water)	
60' - 104'	Yellow clay and sand	
104' - 121'	Red clay and gravel water-bearing country	Mullaman Beds or Merrina Beds.
121' - 132'	Red clay	
132' - 156'	Yellow clay	
156' - 234'	Blue Limestone or Basalt	Merrina Beds or Antrim Plateau Volcanics.

Daly Waters 1:250,000 Sheet area

Hidden Valley Bore

0' - 10'	Brown clay	
10' - 40'	Red laterite material, slightly calcareous	Lower Cretaceous Mullaman Beds.
40' - 60'	Yellow brown clay rich shale	
60' - 140'	Yellow brown ferruginized sandstone	
140' - 155'	Light red, slightly calcareous sandstone	
155' - 233'	Yellow slightly impure limestone	Middle Cambrian Tindall Limestone or Unit 3 of Montejinni Limestone
233' - 285'	Light-brown limestone	
285' - 298'	Pale grey limestone	
298' - 315'	Light brown silty limestone	
315' - 345'	Dark, reddish brown leached limestone	Unit 2 of Montejinni Limestone
345' - 370'	Dark grey basalt	Lower Cambrian Antrim Plateau Volcanics

Murranji Stock Route No. 11

0' - 20'	Soil	
20' - 85'	Clay and sandstone	Lower Cretaceous Mullaman Beds
85' - 130'	Yellow sandstone	
130' - 304'	Red clay, yellow sandy clay	
304' - 342'	Yellow limestone	Middle Cambrian Merrina Beds
342' - 350'	Red clay	
350' - 540'	Yellow limestone	
540' - 580'	Volcanic rock	
580' - 608'	Hard limestone, caves, honey-comb and hard limestone	

Murranji Stock Route No. 12

0' - 2'	Sandy soil	
2' - 25'	Sandy clay	Lower Cretaceous Mullaman Beds
25' - 60'	Red sandstone	
60' - 375'	Red and yellow clay siltstone and sandy clay	
375' - 540'	Yellow limestone	Middle Cambrian Merrina Beds
540' - 585'	Red clay	
585' - 620'	Limestone, gravel and water country	

House bore, Kallala Homestead

0' - 30'	Porous sandstone	Lower Cretaceous Mullaman Beds
30' - 83'	Red and yellow clay	
83' - 110'	Slippery back, soft clay	
110' - 263'	Limestone	Middle Cambrian Tindall Limestone

Larrimah 1:250,000 Sheet area

Dry River Stock Route No. 5

0' - 37'	Sandy clay	Lower Cretaceous Mullaman Beds
37' - 55'	Ferruginous quartzite	
55' - 99'	Brown limestone	Unit 3 Middle Cambrian Montejinni Limestone
99' - 150'	Calcareous siltstone and limestone	Unit 2 Middle Cambrian Montejinni Limestone
150' - 182'	Brown limestone	Unit 1 Middle Cambrian Montejinni Limestone
182' - 230'	Chocolate limestone and siltstone	
230' - 340'	Basalt	Lower Cambrian Antrim Plateau Volcanics
340' - 371'	Vesicular basalt	
371' - 382'	Angular sandy material with fragments of basalt	

Dry River Stock Route No. 6

0' - 61'	Clay, ironstone, shale	Lower Cretaceous Mullaman Beds
61' - 104'	Ironstone and basalt	Lower Cambrian Antrim Plateau Volcanics
104' - 521'	Basalt	

Victoria River Downs 1:250,000 Sheet area

McCraes Bore, Montejinni Station

0' - 10'	Red soil	Unit 2 Middle Cambrian Montejinni Limestone
10' - 40'	Limestone in clay	
40' - 95'	Limestone	Unit 1 Montejinni Limestone
95' - 141'	Basalt	Lower Cambrian Antrim Plateau Volcanics

Pikers Retreat, Killarney Station

0' - 4'	Black soil	
4' - 71'	Limestone and layers of clay	Unit 3 Middle Cambrian Montejinni Limestone
71' - 84'	Puggy clay	Unit 2 Middle Cambrian Montejinni Limestone
84' - 124'	Fine-grained basalt	Lower Cambrian Antrim Plateau Volcanics

Wave Hill 1:250,000 Sheet area

No. 37 (WE) bore, Wave Hill Station

0' - 2'	Surface soil	
2' - 48'	Limestone	Unit 3 Middle Cambrian Montejinni Limestone
48' - 51'	Quartzite	
51' - 111'	Hard limestone	
111' - 119'	Sandy clay	Unit 2 Montejinni Limestone
119' - 123'	Puggy clay	
123' - 131'	Hard shale	
131' - 199'	Hard limestone	Unit 1 Montejinni Limestone
199' - 204'	Puggy clay	
204' - 217'	Quartzite and washed sand	Lower Cambrian Antrim Plateau Volcanics

APPENDIX 3

REPORT ON FOSSILIFEROUS MATERIAL FROM THE DELAMERE, KATHERINE, LARRIMAH, VICTORIA RIVER DOWNS AND WAVE HILL 1:250,000 SHEET AREAS

by

C.G. Gatehouse

Summary

The oldest known fossils in the area are *Collenia* cf *frequens* (Walcott, 1906) from a locality 0.6 miles south-east of Top Springs and also from near Moolooloo Outstation in the Victoria River Downs Sheet area. They were first recognized by Traves (1954) who regarded them as of Pre-cambrian age.

Before 1966 the only known fossils from the Montejinni Limestone were 'girvanellids' (Traves, 1955). The 1966 field collections by C.G. Gatehouse, M.A. Randal, and M.C. Brown have yielded *Redlichia*, *Biconulites*, *Lingulella*, *Chancelloria* and *Girvanella*. The *Redlichia*, which has a 'sand-paper' ornament, was first observed in chert nodules near the base of the Montejinni Limestone at locality WV 122 on Bullock Creek; it also occurs near the top of the formation at locality VRD 111 near Winari Spring. Thus the age of the Montejinni Limestone is the time of *Redlichia* in early Middle Cambrian times.

Two fossil localities in the Delamere Sheet area have yielded *Acrothele*, *Acrotreta*?, *Lingulella*, and Obolids? These fossils indicate a Cambrian age for the Tindall Limestone from which they were collected.

A silicified clean quartz sandstone containing fossil plant fragments was collected from the Larrimah and Katherine Sheet areas. S.K. Skwarko (B.M.R., pers. comm.) regards these outcrops as equivalent to Unit A of the Mullaman Beds and of ?Neocomian-Aptian age. Foraminifera were recognized in VRDI, 11 miles north-east of Killarney Homestead. D.J. Belford (B.M.R. pers. comm.) has identified them as *Ammobaculites* and *Milliammonia* which indicates a marine Lower Cretaceous age for the silt-stone at VRDI.

The Camfield Beds at Bullock Creek contain the bones of several types of vertebrates and portion of the carapace of a tortoise; two genera of gastropods are also recognizable. The age of these beds is Tertiary; the vertebrates are dated as middle Miocene by M.D. Plane (Plane & Gatehouse, 1967).

Delamere 1:250,000 Sheet area

Locality DL 13 — Mathison Creek, 0.3 miles south-east of crossing of the new Willeroo-Katherine road.
Fossils — Lingulella
Acrothele
Obolids?
Unit — Tindall Limestone
Age — Early Middle Cambrian

Locality DL 15 — Mathison Creek, 4 miles north-west of crossing of Willeroo-Katherine road.
Lithology — Limestone
Fossils — Acrotreta?
Phosphatic brachiopod fragments.
Unit — Tindall Limestone
Age — Early Middle Cambrian

Katherine 1:250,000 Sheet area

Locality K 203 — About 1.5 miles south of Helling Siding.
Lithology — Silicified clean quartz sandstone
Fossils — Indeterminate plant fragments
Unit — Mullaman Beds, Unit A
Age — ?Neocomian-Aptian

Larrimah 1:250,000 Sheet area

Locality L 10 — Bore No. 4 on the Dry River Stock Route, at the Dry River Crossing.
Lithology — Chert nodules with salt pseudomorphs in limestone
Fossils — Indeterminate phosphatic brachiopods
Unit — Montejinni Limestone
Age — Early Middle Cambrian

Locality L 16 — 2.8 miles west-south-west of Larrimah
Lithology — White siliceous limestone
Fossils — Gastropoda
Unit — Birdum Creek Beds
Age — Tertiary

Locality L 17 — 20 miles west by south of Larrimah
Lithology — White silicified limestone
Fossils — Gastropoda
Unit — Birdum Creek Beds
Age — Tertiary

Locality L 19 — 2.5 miles east by north of Brolga Waterhole
Lithology — Silicified clean quartz sandstone
Fossils — Indeterminate plant fragments
Unit — Mullaman Beds, Unit A
Age — ?Neocomian-Aptian

Locality L 20 — 1.7 miles south of Blue Waterhole
Lithology — Silicified clean quartz sandstone
Fossils — Indeterminate plant fragments
Unit — Mullaman Beds, Unit A
Age — ?Neocomian-Aptian

Locality L 22 — 21 miles at 118° from No. 5 Bore Dry River Stock Route
Lithology — White limestone
Fossils — Gastropoda
Unit — Birdum Creek Beds
Age — Tertiary

Locality L 202 — About 5 miles south of No. 4 Bore on the Dry River Stock Route.
Lithology — Nodular chert
Fossils — Gastropoda (2 genera)
Unit — Birdum Creek Beds
Age — Tertiary

Victoria River Downs 1:250,000 Sheet Area

Locality VRD 1 — On track to Killarney, 4 miles from Katherine-Top Springs road.
Lithology — Multicoloured laminated siltstones; purple, brown, white and grey in colour
Fossils — Foraminifera -*Ammobaculites*
-*Milliammonia*
(D. Belford pers. comm.)
Unit
Age — Lower Cretaceous

Locality VRD 5 — 1.5 miles east of Bauhinia Bore, Killarney Station.
Lithology — Grey bituminous limestone with chert nodules
Fossils — *Redlichia*
Biconulites
Unit — Montejinni Limestone
Age — Early Middle Cambrian, *Redlichia*-time

Locality VRD 6 — 7.3 miles north of Peartree (Figtree) Creek on the Katherine-Top Springs road
Lithology — Grey bituminous limestone with chert patches
Fossils — Redlichia
Biconulites
Girvanella
Unit — Montejinni Limestone
Age — Early Middle Cambrian, Redlichia-time

Locality VRD 108 — 3 miles south-east of Palm Spring
Lithology — Grey bituminous limestone with pink dolomitic patches
Fossils — Redlichia pygidium
Biconulites
Lingulella
Indeterminate phosphatic brachiopods
Unit — Montejinni Limestone
Age — Early Middle Cambrian

Locality VRD 111 — Near Winari Spring
Lithology — Grey bituminous limestone with pink dolomitic patches
Fossils — Redlichia fragments
Unit — Montejinni Limestone, near the base of upper limestone unit.
Age — Early Middle Cambrian

Locality VRD 220 — 0.6 miles south-east of Top Springs
Lithology — Chert
Fossils — Collenia of frequens (Walcott, 1906)
Unit — Antrip Plateau Volcanics
Age — Lower Cambrian

Locality VRD 224 — About 4.5 miles south of Moolooloo Outstation
Lithology — Chert
Fossils — Collenia of frequens (Walcott, 1906)
Unit — Antrim Plateau Volcanics
Age — Lower Cambrian

Locality VRD 231c — About $1\frac{1}{4}$ miles east of the junction of the Dunmara-Timber Creek road and the Willeroo-Top Springs road (about 7 miles east of Top Springs, near McGaskills Bore).
Fossils — Algal stromatolites
Unit — Montejinni Limestone
Age — Early Middle Cambrian

Locality VRD 14/33/1B — 2.5 miles east-south-east of Winari Spring.
Lithology — Limestone
Fossils — Algal stromatolites
Unit — Montejinni Limestone (Top unit)
Age — Early Middle Cambrian

Locality VRD 10/62/1 1.5 miles south-west of the crossing of the new Dunmara-Top Springs road and Illawarra Creek.
Lithology Chert
Fossils Algal stromatolites
Unit Antrim Plateau Volcanics
Age Lower Cambrian

Wave Hill 1:250,000 Sheet Area

Locality WV 15 On track from Cattle Creek Outstation to new Dunmara-Timber Creek road, 9.5 miles north-east of Cattle Creek Outstation.
Lithology Limestone
Fossils *Biconulites*
Unit Montejinni Limestone
Age Early Middle Cambrian

Locality WV 53 On east-west trending fence, 6.5 miles east of the Camfield River-Cattle Creek junction.
Lithology Limestones
Fossils *Redlichia* with lineo-punctate test
Unit Montejinni Limestone
Age Early Middle Cambrian

Locality WV 113 Four miles east-north-east of Horse Bore, on Bullock Creek.
Lithology White limestone with opaline silica
Fossils Mammalian bones, gastropoda, teeth, tortoise shells
Unit Camfield Beds
Age Tertiary

Locality WV 114 0.5 miles south-east of Horse Bore, Camfield Station.
Lithology Buff porcellanite, partially silicified
Fossils Gastropoda
Unit Camfield Beds
Age Tertiary

Locality WV 118a 4 miles east of the Camfield River and 8 miles south-east of Sailor Jack Bore.
Lithology Pink, porous limestone
Fossils Gastropoda (2 genera)
Unit Camfield Beds
Age Tertiary

Locality WV 122	In Bullock Creek about 3 miles upstream from Horse Bore.
Lithology	Chert nodules in creek, traced to base of Montejinni Limestone
Fossils	Redlichia cranidia Biconulites
Unit	Montejinni Limestone (at the base)
Age	Early Middle Cambrian, Redlichia-time

Locality WV 204	1.5 miles south-south-east of Wave Hill Police Station.
Lithology	Limestone
Fossils	Algal stromatolites
Unit	Victoria River Group
Age	Proterozoic

REFERENCES

PLANE, M.D., and GATEHOUSE, C.G., 1967 - A new vertebrate fauna from the Tertiary of Northern Australia. Aust. J. Sci. in press.

TRAVES, D.M., 1954 - Collenia frequens in Upper Proterozoic Rocks of the Northern Territory of Australia. Proc. Linn. Soc. N.S.W., 79(3-4), 95.

TRAVES, D.M., 1955 - The Geology of the Ord-Victoria Region, Northern Australia. Bur. Min. Resour. Aust. Bull. 27.

TABLE 1 POST-PRECAMBRIAN STRATIGRAPHY NORTHERN WISO BASIN

ERA	PERIOD	STRATIGRAPHIC UNIT	DISTRIBUTION	LITHOLOGY	MAXIMUM KNOWN THICKNESS	TOPOGRAPHY	REMARKS
CAINOZOIC		Superficial deposits Cza, Czb Czt, Czs	widespread	Alluvium Black soil, travertine sand, sandy soil	20 feet	various	
CAINOZOIC	TERTIARY	Birdum Creek Beds Ti	Central part of Larrimah Sheet area	Calcilutite and chalcedony	50 feet	Low hills and rubble in black soil	Thickness from Scouthole L3
CAINOZOIC	TERTIARY	Camfield Beds Tc	North-eastern Wave Hill Sheet area	Conglomeratic limestone and calcilutite with chalcedony, siltstone, sandstone	70 feet	Low hills and mesas	Contains vertebrate bones and gasteropods
CAINOZOIC	TERTIARY	Laterite Tl	widespread	Lateritized material of parent rock; cemented pisolitic ironstone gravels	30 feet?	Bevelled plateau surfaces dissected on margins.	Developed on all units where suitable rock types occur.
MESOZOIC	LOWER CRETACEOUS	Mullaman Beds Klm	Widespread in central and eastern parts of region	Sandstone, mudstone, claystone	400 feet	Escarpments of main plateau and rock knolls on plateau, some mesas	Contains lower non-marine unit overlain by marine units.
PALAEOZOIC	ORDOVICIAN ?CAMBRIAN	Jinduckin Formation Є/O	Northern parts of Delamere and Larrimah Sheet areas	Sandstone, siltstone, dolomite	455 feet	Mesas and rocky hills on northern margin of plateau underlies plateau in north	Maximum known thickness in Scouthole K1.
PALAEOZOIC	MIDDLE CAMBRIAN	Merrina Beds Єme	Southern part of region	Dolomite, dolomitic limestone, sandstone	May attain 600 feet	Presumably underlies desert area in south of region	Very few outcrops: presence over large area in southern part of region inferred from drillers' logs and geology of areas to the south.
PALAEOZOIC	MIDDLE CAMBRIAN	Tindall Limestone Єmt	Northern part of region	Limestone, dolomitic limestone, dolomite	200 feet but 500 feet to north	Karst topography	Equivalent to upper unit of Montejinni Limestone
PALAEOZOIC	MIDDLE CAMBRIAN	Montejinni Limestone Єmm	Western part of region	Unit 3: limestone and dolomite, minor chert. Unit 2: Calcareous siltstone mudstone Unit 1: Limestone with chert nodules and stringers, dolomite	100 feet 60 feet 100 feet	Karst topography or savannah woodlands on plateau and margins	Maximum thicknesses of units not everywhere present. Maximum observed thickness of formation is about 200 feet.
PALAEOZOIC	LOWER CAMBRIAN	Antrim Plateau Volcanics Єla	Western and north-eastern part of region. Probably in subsurface throughout	Basalt, tuff, agglomerate sandstone, limestone, chert beds.	Extremely variable; at least 790 feet in central west	Rounded blocky hills: silicified sediments form ill-defined plateaux and mesas.	

AUSTRALIA 1:250,000 GEOLOGICAL SERIES

DALY WATERS

NORTHERN TERRITORY

SHEET SE 53-1

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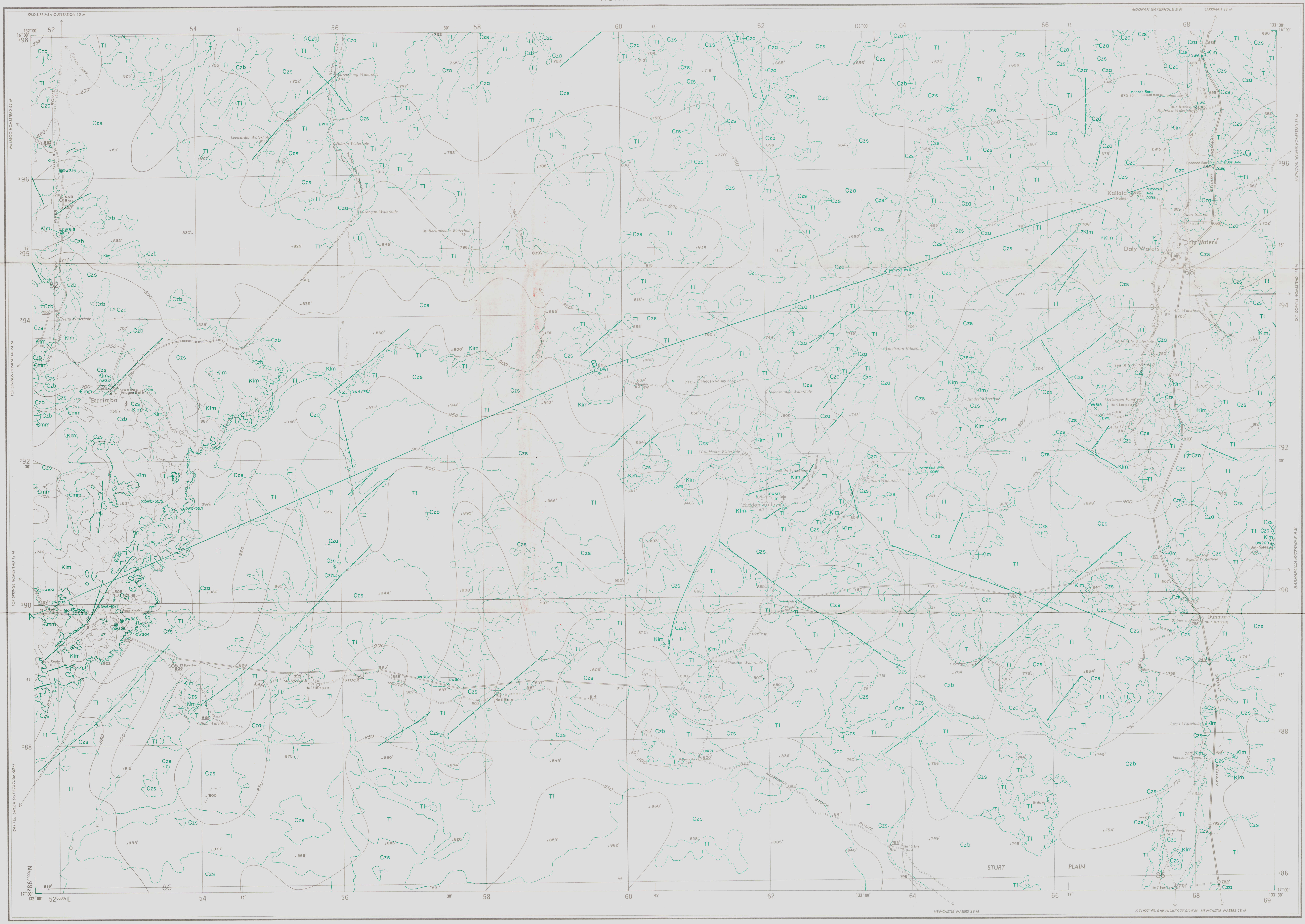


Reference

CAINOZOIC			Cza	*Alluvium; some black soil*
			Czb	*Dark grey and brown clayey soil*
			Czs	*Red, yellow and brown clayey soil; residual sand; some ferruginous rubble*
	TERTIARY		Tl	*Laterite; ferruginous rubble; some soil and sand cover*
MESOZOIC	LOWER CRETACEOUS	Mullaman Beds	Klm	*White, buff and pink claystone and siltstone; glauconitic sandstone with burrows; ferruginous sandstone and siltstone; quartz sandstone*
PALAEOZOIC	MIDDLE CAMBRIAN	Montejinni Limestone	€mm	*Grey-brown fossiliferous calcilutite with small dolomite patches; some dolomite; some calcareous mudstone (not in outcrop)*
		Tindall Limestone	€mt	*Brown fossiliferous calcilutite* (Section only)
	LOWER CAMBRIAN	Antrim Plateau Volcanics	€la	*Basalt; some sandstone, chert, limestone* (Section only)

Geological boundary, position approximate

Fault or lineament } *Air – photo interpretation*

Trend of bedding } *Air – photo interpretation*

Bedding scarp } *Air – photo interpretation*

Sinkholes

Macrofossil locality

X DW9, X DW5/55/1 *Text reference to specimen locality*

Ø St DW1 *Scout hole (B.M.R.)*

Bore

Abandoned bore

Tank

Windpump

Well

Dam on stream

Waterhole

Highway

Road

Vehicle track

Fence

Telephone line

"Daly Waters" *Homestead*

Aerodrome

Landing ground

Yd *Yard*

Trigonometrical station

Astronomical station

• 748 *Height in feet, instrument levelled; datum: mean sea level*

• 763 *Height in feet, barometric; datum: mean sea level*

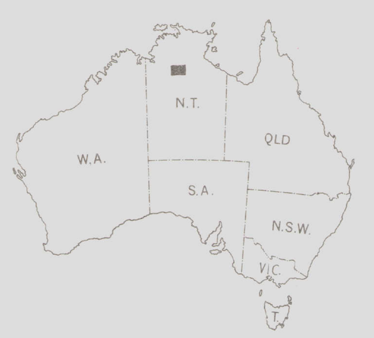
750 *Topographic form lines at intervals of 50 feet*

P.D. *Position doubtful*

I.D. *Identification doubtful*

Compiled and issued by the Bureau of Mineral Resources, Geology and Geophysics, Department of National Development. Topographic base compiled by the Division of National Mapping, Department of National Development. Aerial photography by Adastra Airways Pty. Ltd.; complete vertical coverage at 1:85,000 scale.
Transverse Mercator Projection

Geology; 1966, by: M.A. Randal, M.C. Brown, W.J. Perry and S.K.R. Skwarko
Compiled; 1966, by: M.C Brown
Cartography by: Geological Branch B.M.R.
Drawn by: R.G. Winchester and G.J. Squire



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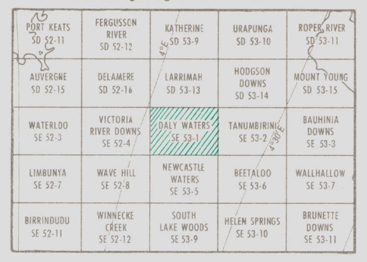
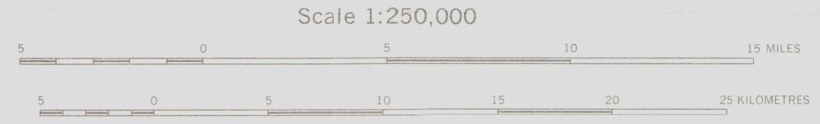


ANNUAL CHANGE 30'E

Scale 1:250,000



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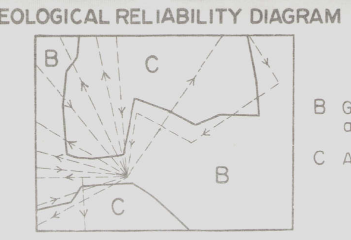
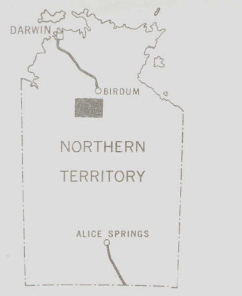


B General reconnaissance and air-photo interpretation
C Air-photo interpretation

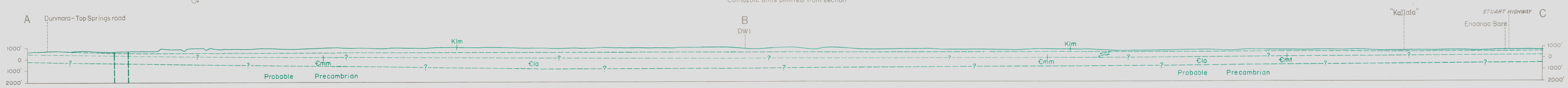
Helicopter traverse



Section

Scale V/H = 4

Cainozoic units omitted from section



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SHEET SE 53-1

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DELAMERE

NORTHERN TERRITORY

SHEET SD 52-16

PRELIMINARY EDITION, 1968

SUBJECT TO AMENDMENT

REFERENCE

Photogeological Character		Possible Geological Equivalent		
	Qa	Alluvium	QUATERNARY	CAINOZOIC
	Qs	Sand	QUATERNARY	CAINOZOIC
Light grey toned, soft appearance	Qt	Terrace deposits	QUATERNARY	CAINOZOIC
	CP	Clay pan	QUATERNARY	CAINOZOIC
Medium grey toned	Czs	Sand, soil	UNDIFFERENTIATED	CAINOZOIC
Medium toned, poorly bedded	Czd	Consolidated detritus	UNDIFFERENTIATED	CAINOZOIC
Dark toned, forms low scarp	Cz	Laterite	UNDIFFERENTIATED	CAINOZOIC
Light toned, soft	K	Mullaman Beds	CRETACEOUS	MESOZOIC
Mottled pattern, flat lying	€m	Daly River Group	MIDDLE CAMBRIAN	PALAEOZOIC
Mottled pattern	€m2	Montejinni Limestone	MIDDLE CAMBRIAN	PALAEOZOIC
Light to medium toned, smooth surface	€la	Antrim Plateau Volcanics	LOWER CAMBRIAN	PALAEOZOIC
Medium toned, rough surface	€l	Sediments associated with €la?	LOWER CAMBRIAN?	PALAEOZOIC
Medium toned, bedded, scarp forming	Puy	Yambarra Beds ("Pinkerton Beds")	PROTEROZOIC	PRECAMBRIAN
Light to medium toned, soft, bedded	Pua	Angalarri Siltstone ("Auvergne Shale")	PROTEROZOIC	PRECAMBRIAN
Light toned, soft	Pua3		PROTEROZOIC	PRECAMBRIAN
Dark toned, forms low scarp	Pua2		PROTEROZOIC	PRECAMBRIAN
Medium toned, low relief	Pua1		PROTEROZOIC	PRECAMBRIAN
Light to medium toned, bedded; well jointed in places; forms prominent scarp	Puj	"Jasper Gorge Sandstone" (Pj, Puc where undifferentiated)	PROTEROZOIC	PRECAMBRIAN
Dark toned, soft; bedding visible in places	Pj	Soft sediments	PROTEROZOIC	PRECAMBRIAN
Soft, dark toned on steep slopes	Puc	"Coolibah Formation"	PROTEROZOIC	PRECAMBRIAN
Light to medium toned, bedded, scarp forming	Puja	Sandstone	PROTEROZOIC	PRECAMBRIAN
Medium toned, soft	Pr	Sediments	PROTEROZOIC	PRECAMBRIAN
Light toned, thin bedded	Pus	"Skull Creek Limestone"	PROTEROZOIC	PRECAMBRIAN

Formation names in inverted commas are unpublished names from Laing & Allen, 1956

- Lithological boundary
- Probable lithological boundary
- Anticlinal axis
- Synclinal axis
- Fault
- Probable fault or lineament
- Edge of bed
- Probable edge of bed
- Edge of bed expressed as scarp

Estimated dips

- Horizontal
- Very low
- Low
- Medium
- Steep
- Vertical
- Trend line
- Joint pattern
- Topographic scarp
- Sink holes

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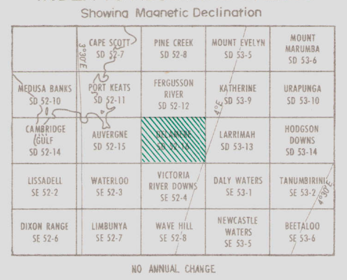

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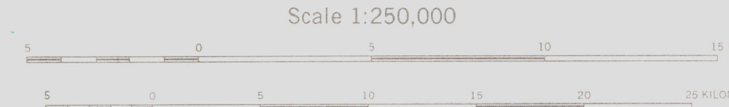
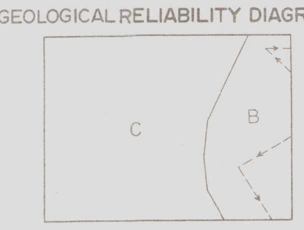


GEOLOGICAL RELIABILITY DIAGRAM



B General reconnaissance and air-photo interpretation

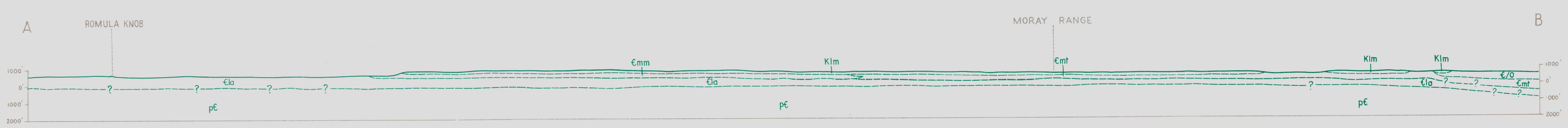
C Air-photo interpretation

---- Helicopter traverse

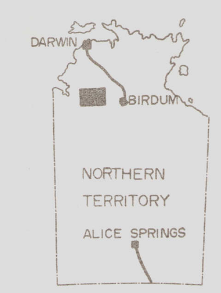
Section

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

Cainozoic sediments omitted from section



Geology, 1966 by: M.A. Randal, M.C. Brown and W.J. Perry
Photo-geological interpretation, 1966, by: W.J. Perry
Compiled 1966, by: M.A. Randal, M.C. Brown
Cartography by: Geological Branch, B.M.R.
Drawn by: G.J. Squire



Reference

MESOZOIC CAINOZOIC			Cza	Alluvium
MESOZOIC CAINOZOIC			Czs	Sand, red and yellow soils, some ferruginous rubble
MESOZOIC CAINOZOIC	TERTIARY		Tl	Laterite, ferruginous rubble, discontinuous soil cover
MESOZOIC CAINOZOIC	LOWER CRETACEOUS	Mullaman Beds	Klm	White, buff and pinkish claystone and siltstone, quartz sandstone, conglomerate. Plant fossils
PALAEOZOIC	CAMBRIAN OR ORDOVICIAN	Jinduckin Formation	€/0	Sandstone, siltstone, marl, conglomerate rocks
PALAEOZOIC	MIDDLE CAMBRIAN	Tindall Limestone	€mt	Fossiliferous limestone and dolomitic limestone
PALAEOZOIC	MIDDLE CAMBRIAN	Montejinni Limestone	€mm	Light grey and brown fossiliferous limestone, some dolomite
PALAEOZOIC	MIDDLE CAMBRIAN	Montejinni Limestone	€mm	Red and buff calcareous mudstone, argillaceous limestone; siliceous breccia at base
PALAEOZOIC	MIDDLE CAMBRIAN	Montejinni Limestone	€mm	Mottled calcilutite, overlain by thin-bedded calcarenite; some dolomite. Not exposed in this sheet area
PALAEOZOIC	LOWER CAMBRIAN	Antrim Plateau Volcanics	€la	Cross-bedded sandstone, chert, conglomerate
PALAEOZOIC	LOWER CAMBRIAN	Antrim Plateau Volcanics	€la	Basalt, some sandstone and chert, pyroclastics
PRECAMBRIAN			p€	Section only. May contain rocks of the Victoria River Group

Not in stratigraphic sequence

Subdivisions not shown in section

- Geological boundary
- Fault or lineament: air-photo interpretation
- Where location of boundaries and faults is approximate, line is broken; where inferred, queried; where concealed, faults are shown by short dashes
- Strike and dip of strata
- Joint pattern: air-photo interpretation
- Macrofossil locality
- Plant fossil locality
- ×310 Text reference to specimen locality

Text reference prefixed by DL

- Bore
- Abandoned bore
- Well
- Windpump
- Tank
- Dam on stream
- Waterhole; waterhole on stream
- Sinkhole
- Spring
- Road
- Vehicle track
- Landing ground
- "Willeroo" Homestead
- Yd Yard
- Fence
- Trigonometrical station
- Astronomical station
- ·625 Height in feet, barometric; datum: mean sea level
- Topographic form lines

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LARRIMAH

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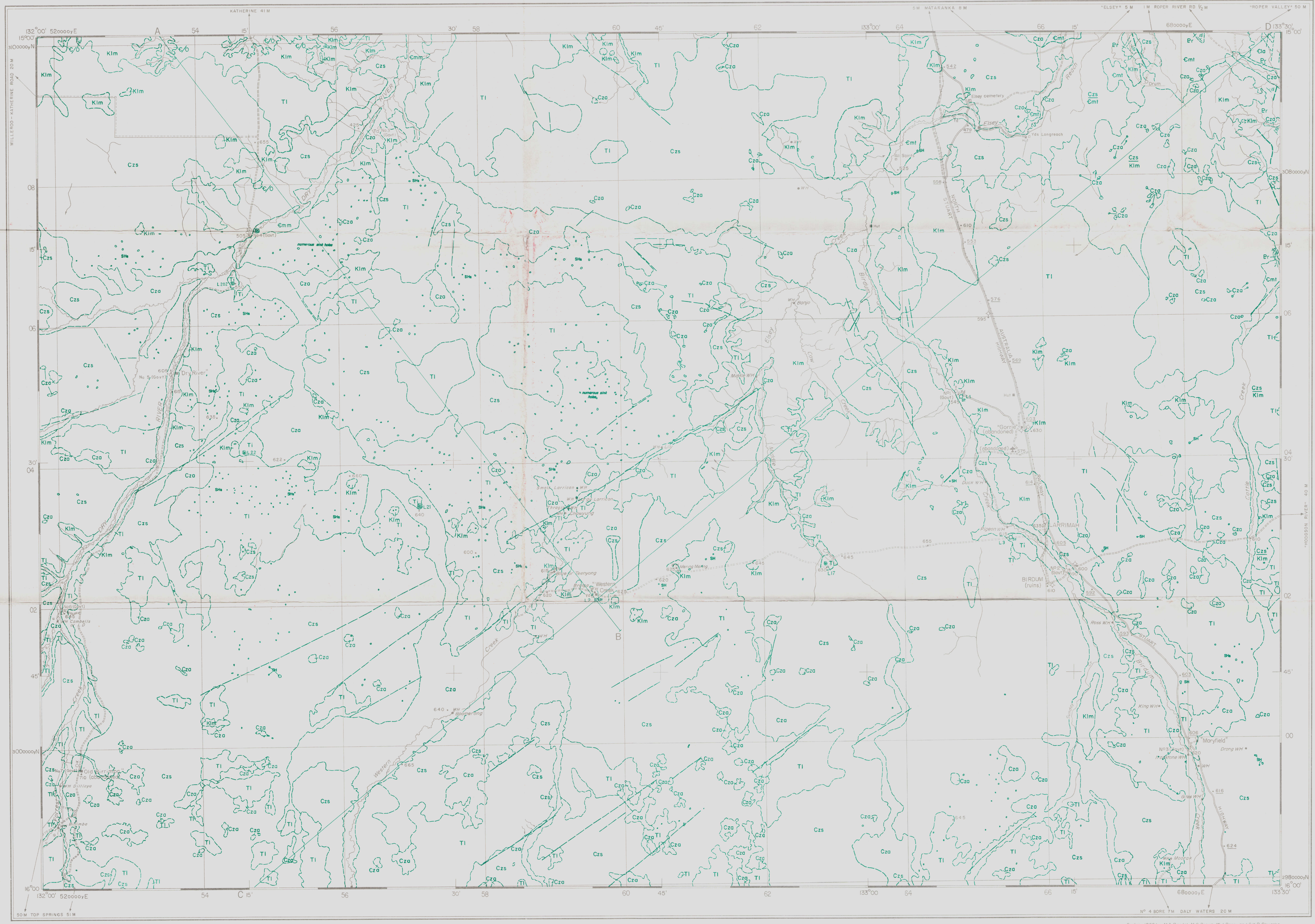

CAINOZOIC			Cza	Alluvium, some black soil and sandy soil
			Czs	Sand, sandy and loamy soils, gravel, some lateritic material
	TERTIARY	Birdum Creek Beds	Ti	Limestone, some chert; fossiliferous
			Tl	Laterite, ferruginous rubble, some sand
MESOZOIC	LOWER CRETACEOUS	Mullaman Beds	Klm	Quartz sandstone, siltstone, mudstone
PALAEOZOIC	CAMBRIAN OR ORDOVICIAN	Jinduckin Formation	€/O	Sandstone, siltstone, marl, carbonate rocks
	MIDDLE CAMBRIAN	Tindall Limestone	€mt	Limestone, dolomitic limestone, siltstone; fossiliferous
		Montejinni Limestone	€mm	Limestone, dolomitic limestone, mudstone; fossiliferous
	LOWER CAMBRIAN	Antrim Plateau Volcanics	€la	Basalt
PRECAMBRIAN ADELAIDEAN		Roper Group	Pr	Quartz sandstone, siltstone, glauconitic dolomitic limestone

Geological boundary, position approximate
Fault, position approximate
Lineament or fault, air-photo interpretation
15 Strike and dip of strata
Joint pattern, air-photo interpretation

Macrofossil locality
L202 Text reference to specimen locality
St Stratigraphic scout hole (BMR)

Bore
Abandoned bore
Well
WH Waterhole
T Tank
Windpump
SH Sink hole

HIGHWAY Highway
Road
Vehicle track
Railway with station
Fence
"Maryfield" Homestead
Landing ground
Yd Yard
603 Height in feet, instrument levelled; datum: mean sea level
630 Height in feet, barometric, datum: mean sea level

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Transverse Mercator Projection

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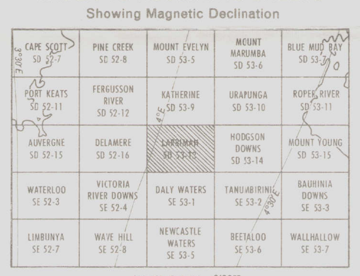

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Compiled, 1966 by: M.A. Randal
Cartography by: Geological Branch, B.M.R.
Drawn by: G.J. Squire

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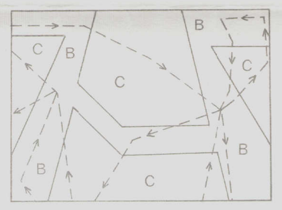
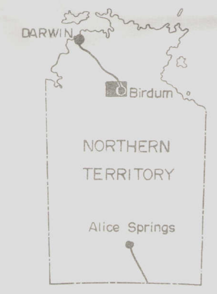
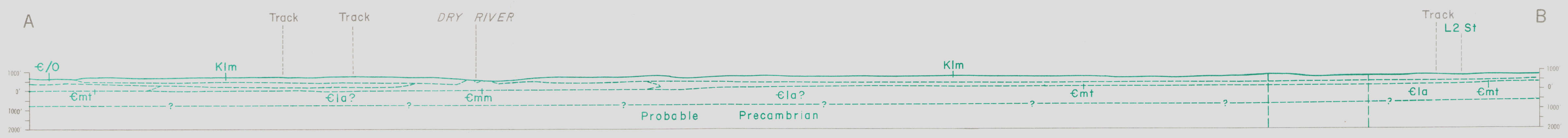


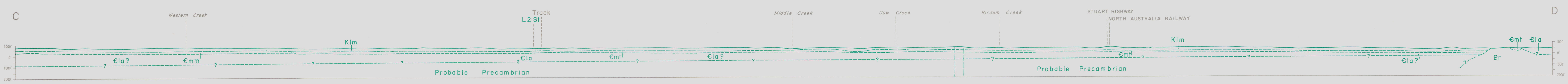
B General reconnaissance and air-photo interpretation
C Air-photo interpretation
← Helicopter traverse



Sections

Cainozoic sediments omitted from sections





LARRIMAH

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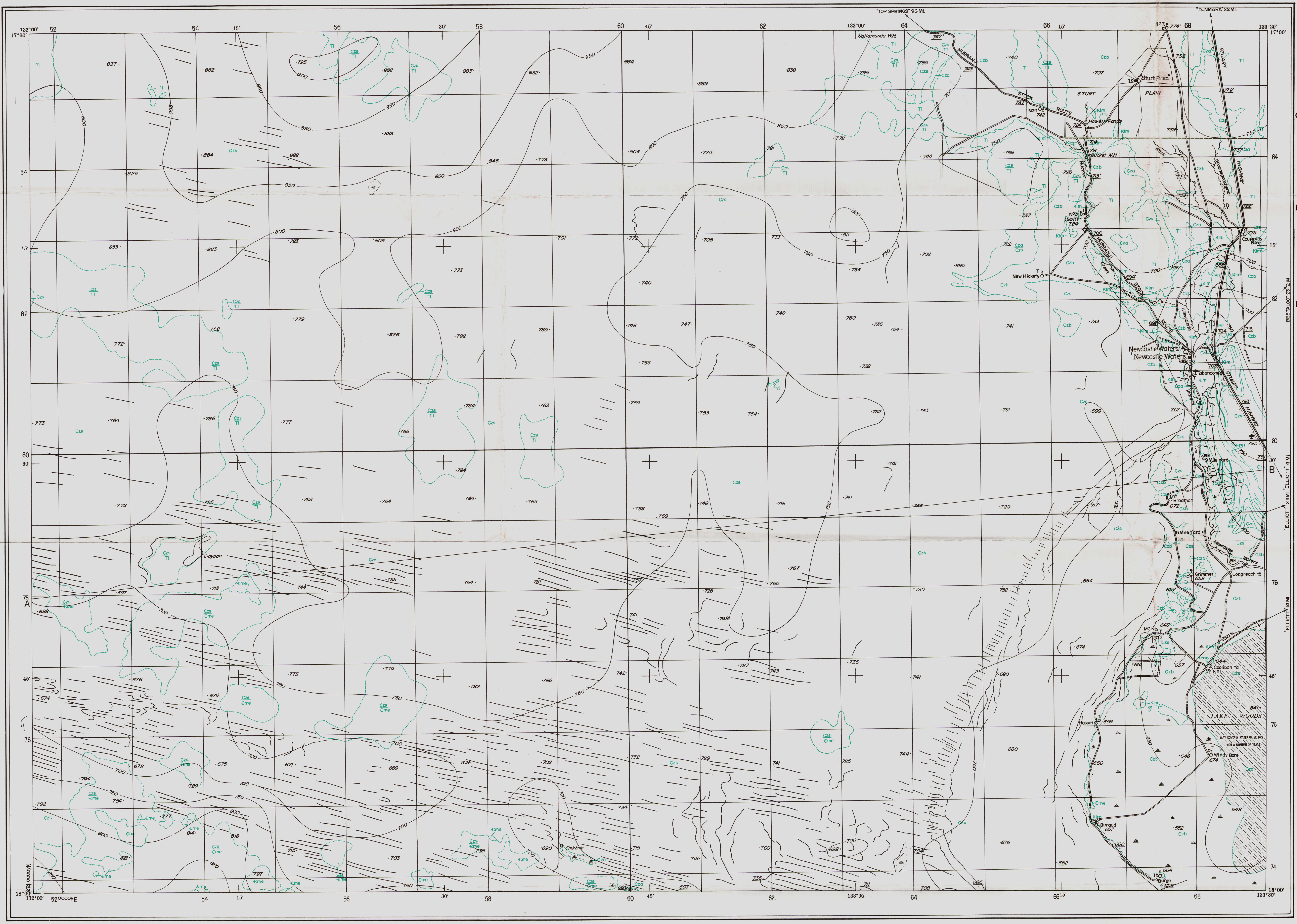
NORTHERN TERRITORY

SHEET SE 53-5



Reference

CAINOZOIC		Cza	Alluvium, some black soil.
		Czb	Black and grey clayey soils, some sand and gravel.
		Czs	Sand, sandy and loamy soils, some lateritic material
TERTIARY		Tl	Laterite, ferruginous rubble, some sand
MESOZOIC LOWER CRETACEOUS	Mullaman Beds	Klm	Quartz sandstone, some pebbles and cobbles, siltstone, siliceous siltstone and claystone with radiolaria.
PALAEOZOIC MIDDLE CAMBRIAN	Merrina Beds	€me	Dolomite, dolomitic limestone, chert, silicified carbonate rocks
	Montejinni Limestone	€mm	Limestone, dolomitic limestone, siltstone (Section only)
LOWER CAMBRIAN	Antrim Plateau Volcanics	€la	Basalt and tuffaceous sediments (Section only)
PRECAMBRIAN LOWER PROTEROZOIC	Tomkinson Creek Beds	Elt	Medium to coarse-grained quartz sandstone with minor cross-bedding, minor siltstone and pebble conglomerate

- Geological boundary, approximate.
- Fault
- Strike and dip of strata
- Trend lines
- Bore, abandoned
- Bore (O Nº9)
- Waterhole (WH)
- Tank (T)
- Windpump
- Swamp boundary
- Sand dune
- Highway
- Track
- Telephone line
- Fence
- Homestead ("Sturt Plain")
- Landing ground
- Yard (Yd)
- Trigonometrical station
- 795· Height in feet, instrument levelled; datum: mean sea level.
- 644· Height in feet, barometric; datum: mean sea level.
- 700 Topographic form lines, interval fifty feet.

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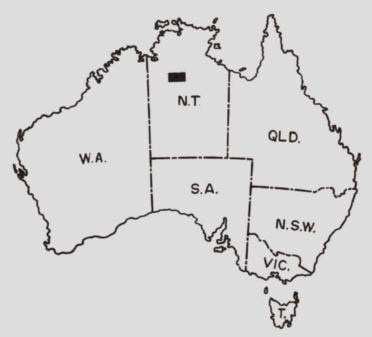
Transverse Mercator Projection.



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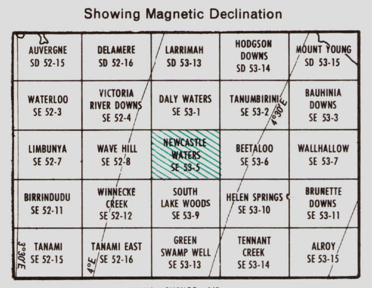
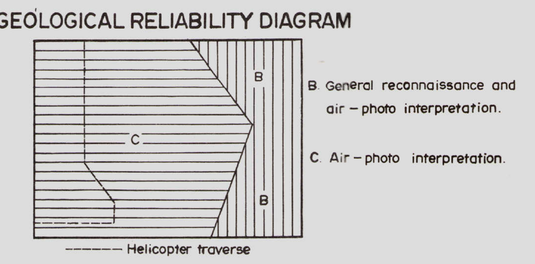


Scale 1:250,000

5 0 5 10 15 MILES

5 0 5 10 15 20 25 KILOMETRES

GEOLOGICAL RELIABILITY DIAGRAM



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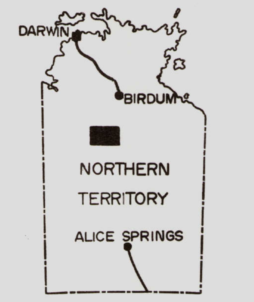
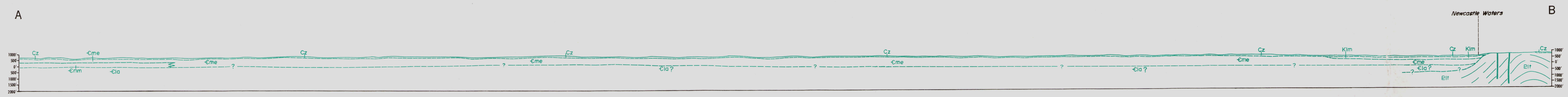
Compiled, 1966, by: K.G.Smith and G.J.Squire.
Cartography by: Geological Branch B.M.R.
Drawn by: G.J.Squire.



Section

Cainozoic sediments shown as Cz

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



NEWCASTLE WATERS

SHEET SE 53-5

PRELIMINARY EDITION, 1967

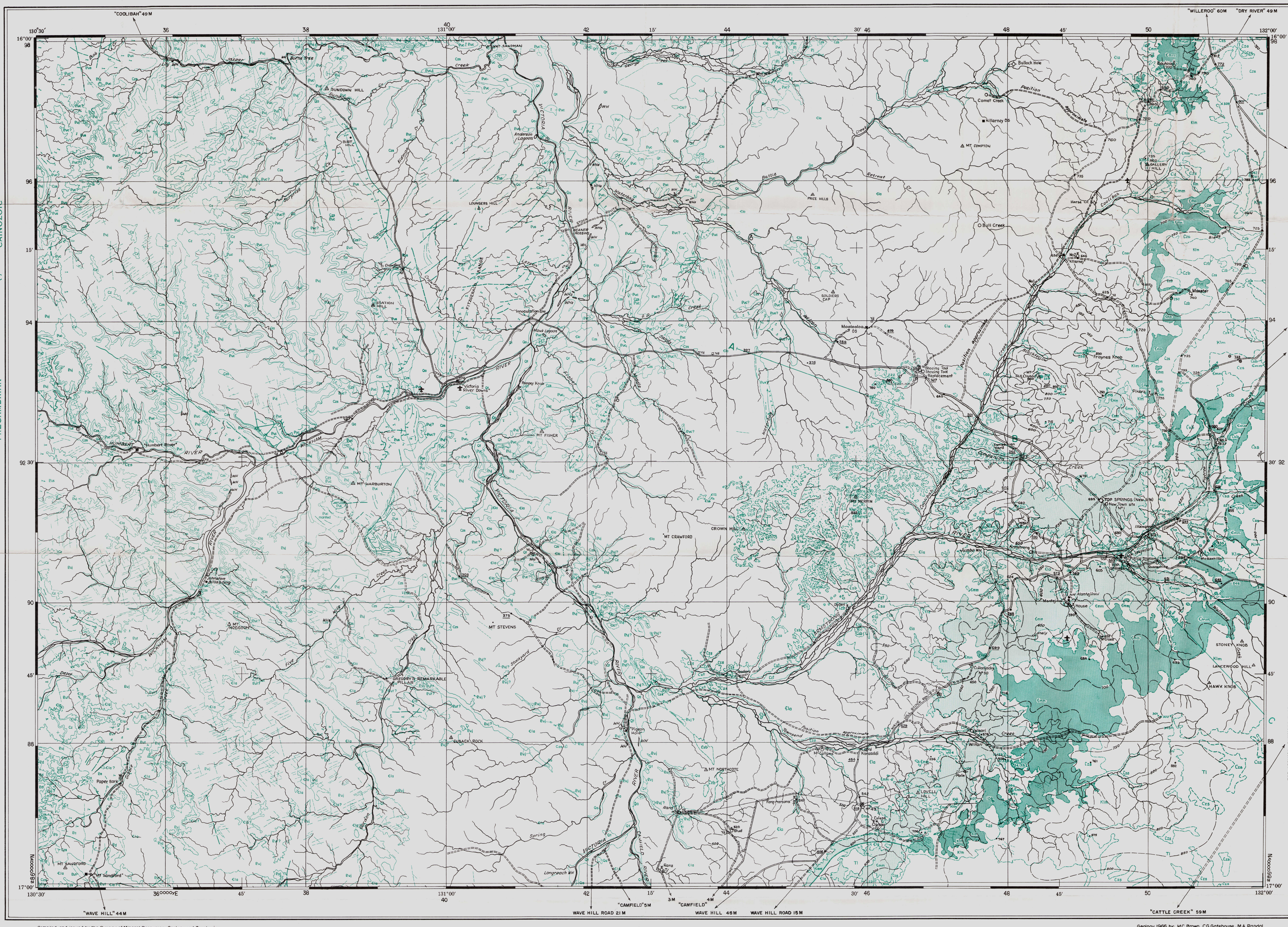
SUBJECT TO AMENDMENT

AUSTRALIA 1:250,000 GEOLOGICAL SERIES

VICTORIA RIVER DOWNS

NORTHERN TERRITORY

SHEET SE 52-4



Reference

Photogeological Character		Possible Geological Equivalent	
	Qa	Alluvium	QUATERNARY — CAINOZOIC
Light grey toned, soft appearance	Qt	Terrace deposits	QUATERNARY — CAINOZOIC
Medium grey toned	Czs	Soil, sand	UNDIFF. — CAINOZOIC
Dark toned, mesa-form	Cz	Laterite	UNDIFF. — CAINOZOIC
Medium toned, smooth surface	€la	Antrim Plateau Volcanics	PALAEOZOIC
Light to medium toned, bedded; very well jointed in places	Puj	"Jasper Gorge Sst" (May also include some Lower Cambrian sandstone in places)	PROTEROZOIC — PRECAMBRIAN
Medium toned, bedded; soft, with prominent hard bed near base	Pj		PROTEROZOIC — PRECAMBRIAN
Soft, dark toned on steep slopes	Puc	"Coolibah Formation"	PROTEROZOIC — PRECAMBRIAN
Dark toned, forms low scarp	Puc1	Marker bed	PROTEROZOIC — PRECAMBRIAN
Soft light toned in gently sloping areas			PROTEROZOIC — PRECAMBRIAN
Light toned, thin bedded	Pus	"Skull Creek Limestone" (Lateral Equivalents)	PROTEROZOIC — PRECAMBRIAN
Medium to light toned, thin bedded	Put	"Timber Creek Formation" (Lateral Equivalents)	PROTEROZOIC — PRECAMBRIAN
Dark toned, with smooth surface	Pe		PROTEROZOIC — PRECAMBRIAN
Dark toned, with dendritic drainage pattern	Pd		PROTEROZOIC — PRECAMBRIAN
Soft, light toned, well bedded	Pc		PROTEROZOIC — PRECAMBRIAN
Medium-toned, well bedded	Pb		PROTEROZOIC — PRECAMBRIAN
Medium toned, hard appearance	Pa		PROTEROZOIC — PRECAMBRIAN

Lithological boundary
Probable lithological boundary
Anticlinal axis
Synclinal axis
Fault
Probable fault
Edge of bed
Probable edge of bed
Edge of bed expressed as scarp

Estimated dips
Horizontal
Very low
Low
Medium
Steep
Vertical

Trend line
Joint pattern

Reference

CAINOZOIC			Cza	Alluvium
CAINOZOIC			Czb	Grey and dark brown clayey soils
CAINOZOIC			Czs	Sand, red and yellow soils, some ferruginous rubble
CAINOZOIC			Czt	Travertine
CAINOZOIC	TERTIARY		Tl	Laterite, ferruginous rubble, discontinuous soil cover
MESOZOIC	LOWER CRETACEOUS	Mullaman Beds	Klm	White, buff, and pinkish claystone and siltstone, glauconitic sandstone with burrows, ferruginous siltstone and sandstone, ferruginous conglomerate with plant fossils
PALAEOZOIC	MIDDLE CAMBRIAN	Montejinni Limestone	€mm	Light brown and grey fossiliferous calcilutite with pink and yellow dolomite patches, persistent stromatolite band at base
PALAEOZOIC	MIDDLE CAMBRIAN	Montejinni Limestone	€mm	Red and buff calcareous mudstone, argillaceous limestone, some chert nodules, siliceous breccia at base
PALAEOZOIC	MIDDLE CAMBRIAN	Montejinni Limestone	€mm	Mottled calcilutite overlain by thin-bedded calcarenite, chert nodules near base, some dolomite
PALAEOZOIC	LOWER CAMBRIAN	Antrim Plateau Volcanics	€la	Chert, limestone, laminated sandstone, calcareous siltstone; some stromatolites in chert
PALAEOZOIC	LOWER CAMBRIAN	Antrim Plateau Volcanics	€la	Basalt, some laminated sandstone, chert, (?)pyroclastics
PRECAMBRIAN	PROTEROZOIC	Victoria River Group	Puv	
PRECAMBRIAN			p€	Section only

Not in stratigraphic sequence (€la)

Subdivisions not shown in section (€mm, €la)

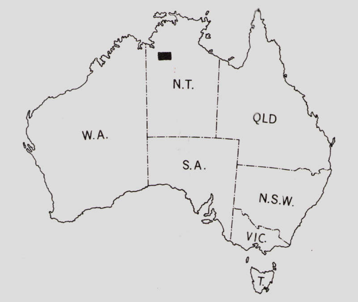
Geological boundary
Fault
Where location of boundaries and faults is approximate, line is broken; where inferred, queried; where concealed, faults are shown by short dashes
Strike and dip of strata
Joint pattern — air-photo interpretation

Fossil locality
Macrofossil locality
Microfossil locality
Plant fossil locality
Text reference to specimen locality
} Text reference prefixed by "VRD"

Bore
Abandoned bore
Well
Windpump
Tank
Dam on stream
Waterhole; waterhole on stream
Sinkhole
Spring

Road
Vehicle track
Landing ground
Homestead; O.S. — outstation
Yard
Fence
Trigonometrical station
Astronomical station
Height in feet, instrument levelled
Height in feet, barometric
} datum: mean sea level
Topographic form lines

Compiled and issued by the Bureau of Mineral Resources, Geology and Geophysics, Department of National Development. Topographic base compiled by the Division of National Mapping and the Bureau of Mineral Resources, Geology and Geophysics, Department of National Development. Aerial photography by the Royal Australian Air Force; complete vertical coverage at 1:46,000 scale. Transverse Mercator Projection.



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Showing Magnetic Declination

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CAMBRIDGE GULF SD 52-14	AUVERGNE SD 52-15	DELAMERE SD 52-16	LARRIMAH SD 53-13	HODGSON DOWNS SD 53-14
LISSADELL SE 52-2	WATERLOO SE 52-3	VICTORIA RIVER DOWNS SE 52-4	DALY WATERS SE 53-1	TANUMBIRINI SE 53-2
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ANNUAL CHANGE 0°25'E

Scale 1:250,000

5 0 5 10 15 MILES

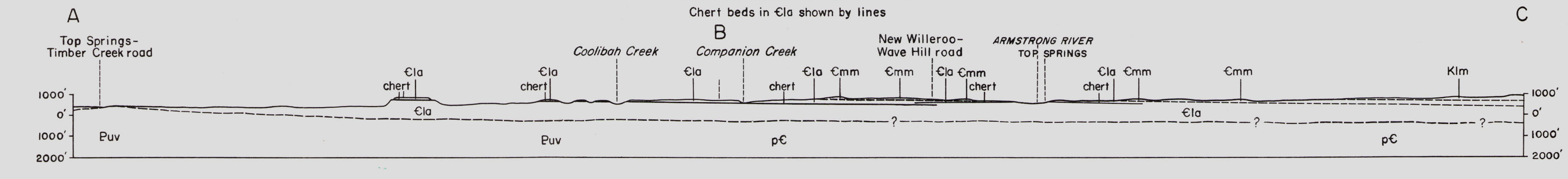
5 0 5 10 15 20 25 KILOMETRES

Section

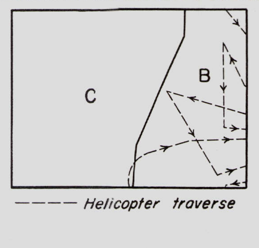
Scale V/H = 4

Cainozoic sediments omitted from section

Chert beds in €la shown by lines



GEOLOGICAL RELIABILITY DIAGRAM

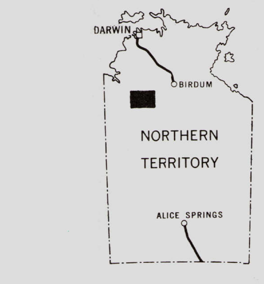


B General reconnaissance and air-photo interpretation

C Air-photo interpretation

Helicopter traverse

Geology, 1966, by: M.C. Brown, C.G. Gatehouse, M.A. Randal, W.J. Perry and S.K.R. Skwarko
Photo-geological interpretation, 1966, by: W.J. Perry
Compiled by: M.C. Brown, C.G. Gatehouse and J.M. Fetherston
Drawn by: G.J. Squire, D.M. Pillinger



VICTORIA RIVER DOWNS

SHEET SE 52-4

Complimentary

WAVE HILL

NORTHERN TERRITORY

AUSTRALIA 1:250,000 GEOLOGICAL SERIES

SHEET SE 52-8

PRELIMINARY EDITION, 1967

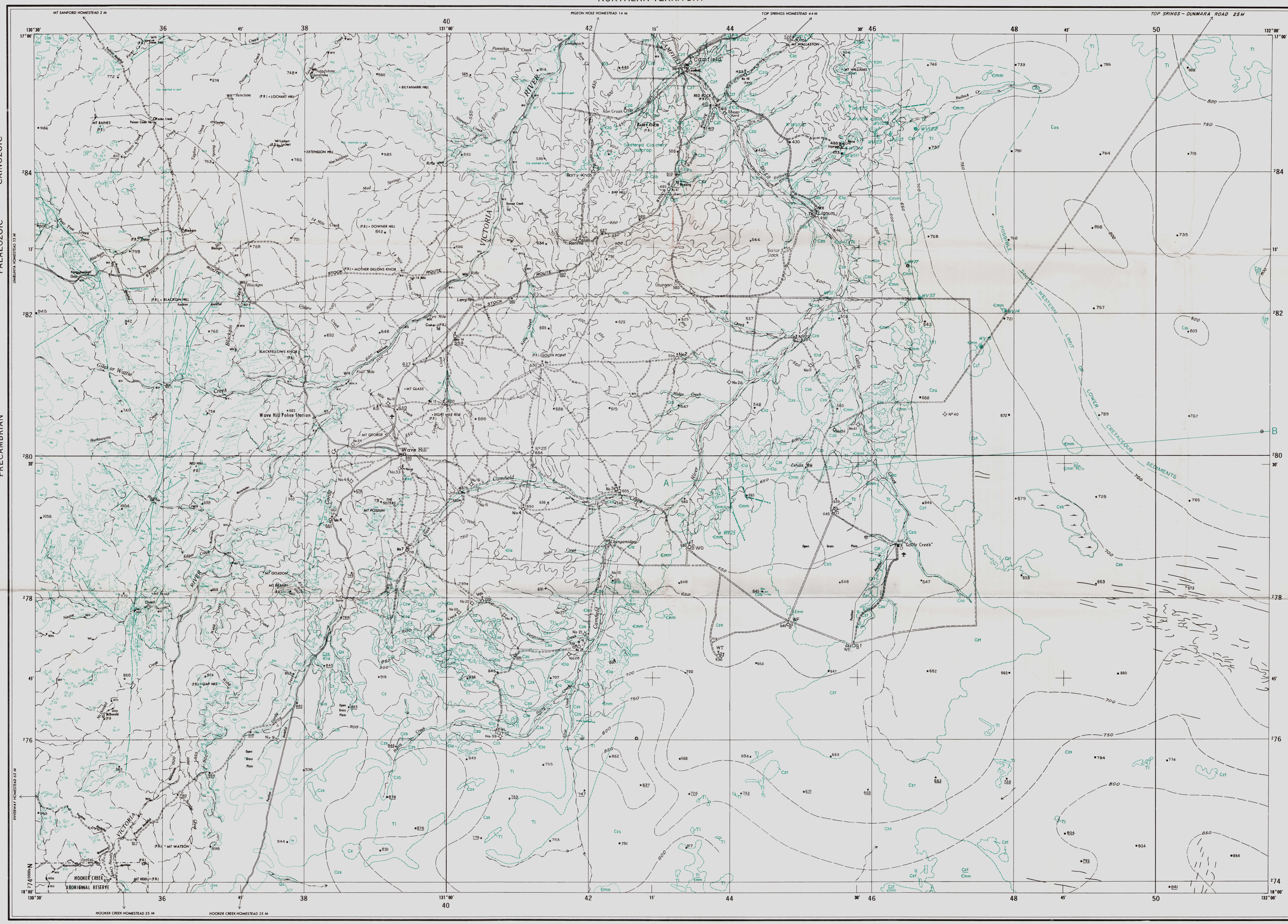
SUBJECT TO AMENDMENT

Reference

Photogeological Character		Possible Geological Equivalent		
	Qa	Alluvium	QUATERNARY	CAINOZOIC
	Qs	Sand	QUATERNARY	CAINOZOIC
Light grey toned, soft appearance	Qt	Terrace deposits	QUATERNARY	CAINOZOIC
Dark toned	Czw	Slope wash	UNDIFFERENTIATED	CAINOZOIC
Medium grey toned	Czs	Soil, sand	UNDIFFERENTIATED	CAINOZOIC
Light toned, forms treeless plain	Czb	Older alluvium	UNDIFFERENTIATED	CAINOZOIC
Dark toned, mesa-form	Cz	Laterite	UNDIFFERENTIATED	CAINOZOIC
Medium toned, smooth surface, characteristic mottled texture where soil covered	€la	Antrim Plateau Volcanics	LOWER CAMBRIAN	PALAEOZOIC
Medium toned, flat lying	Puu		PROTEROZOIC	PRECAMBRIAN
Light and dark toned interbedded units	Pu9	"Wave Hill Beds"	PROTEROZOIC	PRECAMBRIAN
	Pu8			
	Pu7			
	Pu6			
Soft light toned, well bedded	Pu5			
Medium to dark toned, bedded; jointed in places	Pu4	Bedded sedimentary rocks		
Medium to dark toned, bedded; forms distinctive scarp in places	Pu3			
Medium to dark toned, bedded, jointed	Pu2			
Medium grey toned hard unit	Pu1			
	Pu	Undifferentiated		
Scarp forming; dendritic drainage pattern	P7	Bedded sedimentary rocks		
Medium to dark toned; more resistant than P5	P6			
Soft light toned massive unit	P5			
Medium grey toned, scarp forming	P4			
Soft light toned unit, bedding indistinct	P3			
Striated pattern with generally lighter tone than P1	P2			
Medium to dark toned, bedded; fairly resistant	P1			
Light to medium toned, bedded; very well jointed in places	Puj	"Jasper Gorge Sandstone"		
Medium toned, bedded, jointed	Put	"Timber Creek Formation"		
Medium toned, low relief	P	Undifferentiated sediments		

Lithological boundary
Probable lithological boundary
Anticlinal axis
Synclinal axis
Fault
Probable fault or lineament

Estimated dips
Horizontal
Very low
Low
Medium
Steep
Vertical
Trend line
Joint pattern
Sink holes



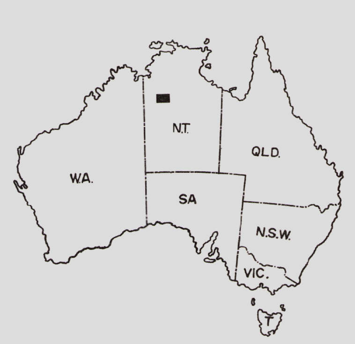
Reference

CAINOZOIC			Cza	Alluvium, some clayey soils
			Czb	Dark grey and brown clayey soils
			Czs	Residual sand, red and yellow clayey and sandy soils, some ferruginous rubble
			Czt	Travertine, some sand and clayey soil
	TERTIARY	Camfield Beds	Tc	Limestone, chalcedonic limestone, calcareous sandstone, siltstone
			Tl	Laterite, ferruginous rubble, some soil and sand cover
MESOZOIC	LOWER CRETACEOUS	Mullaman Beds	Klm	Sandstone, siltstone and claystone
PALAEOZOIC	MIDDLE CAMBRIAN	Merrina Beds	€me	Silcrete and chert rubble at surface, sandstone and carbonate rocks subsurface
		Montejinni Limestone	€mm	Fossiliferous calcilutite, calcarenite, dolomitic limestone, dolomite, calcareous mudstone and siltstone
	LOWER CAMBRIAN	Antrim Plateau Volcanics	€la	Chert; silicified carbonates, tuff and agglomerate, sandstone, minor basalt (Not in stratigraphic sequence)
			€la	Basalt, pyroclastics, chert (Not in stratigraphic sequence)
PRECAMBRIAN	PROTEROZOIC		Pu5	Dolomite, sandstone, siltstone
			Pu	Section only
			p€	Section only

Geological boundary, position approximate
Fault, position approximate, short dashes where concealed
Trend of bedding
Strike and dip of strata
Macrofossil locality
Vertebrate fossil locality
xWV14 Text reference to specimen locality
Measured section
Bore
Abandoned bore
Well
Tank
Windpump
Waterhole
Spring
Rock hole
Sink hole
Swamp
Sand dunes

Road
Vehicle track
Fence
"Camfield" Homestead
Landing ground
Yard
Astronomical station
•365 Height in feet, instrument levelled; datum: mean sea level
• 365 Height in feet, barometric; datum: mean sea level
—250— Topographic form lines; interval 50 feet
P.D. Position doubtful

Compiled and issued by the Bureau of Mineral Resources, Geology and Geophysics Department of National Development. Topographic base compiled by the Division of National Mapping, Department of National Development. Aerial photography by the Royal Australian Air Force; complete vertical coverage at 1:50,000 scale. Transverse Mercator Projection.



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Annual Change 0°25'E

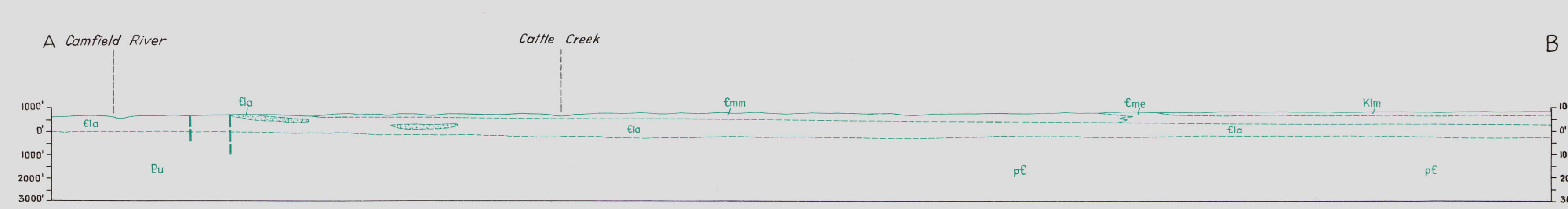
Scale 1:250,000

5 0 5 10 15 MILES

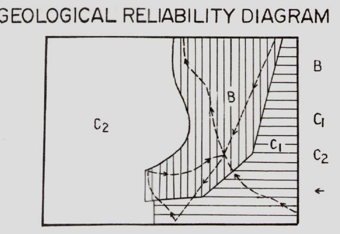
5 0 5 10 15 20 25 KILOMETRES

Section
Cainozoic sediments omitted from section

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



GEOLOGICAL RELIABILITY DIAGRAM



B General reconnaissance and air-photo interpretation
C1 Air-photo interpretation
C2 Photogeology only
← Helicopter traverses

Geology, 1966 by: M.A. Randal, C.G. Gatehouse
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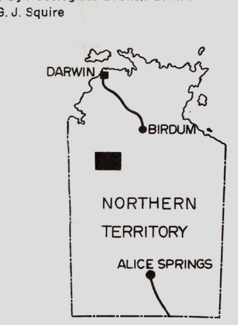

WAVE HILL

SHEET SE 52-8

Complimentary