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COMMONWEALTH OF AUSTRALIA.

DEPARTMENT OF NATIONAL DEVELOPMENT.

BUREAU OF MINERAL RESOURCES GEOLOGY AND GEOPHYSICS.

RECORDS.

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EXPLANATORY NOTES ON THE CALVERT HILLS 1:250,000 GEOLOGICAL SHEET.

Compiled by

H.G.Roberts, J.M.Rhodes and K.R.Yates.

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Contents

ILLUSTRATIONS

EXPLANATORY NOTES ON THE CALVERT HILLS 1:250,000

GEOLOGICAL SHEET - SE53-8

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INTRODUCTION

The Calvert Hills Sheet is bounded by latitudes 17° and 18°S and by longitudes 136° 30' and 138° E. The Sheet area lies within the Northern Territory and is bounded on the east by the Queensland border.

The main access to the area is by the graded Burketown-Borroloola road, which crosses the north-eastern part of the Sheet area, passing through Wollogorang and Calvert Hills Homesteads, the only permanent settlements in the Sheet area. A vehicle track joins the road 8 miles south-west of Wollogorang and leads southwards to the abandoned Seigals Creek Homestead. From Seigals Creek vehicle tracks lead south to Tin Hole; southeast to Pandanus Creek uranium mine; and east to Westmoreland Homestead in Queensland. The Pandanus Creek uranium mine is linked by vehicle track to the main Burketown-Borroloola road at Corinda Homestead in Queensland.

Rainfall ranges from 20 inches per annum in the south-west to 30 inches per annum in the north-east, and occurs mainly during the period November to April.

Only five people live permanently in the area.

The following air photographs and maps covering the Sheet area were available during the course of the survey :

Calvert Hills air photographs (scale 1:50,000), flown by the Royal Australian Air Force in 1947 and 1952; Calvert Hills controlled photoscale topographic base-maps; Calvert Hills 1:250,000 topographic series - E/53-8, zone 5; and Calvert Hills : uncontrolled photo-mosaic (scale about 4 miles to 1 inch), prepared by the Division of National Mapping, Department of National Development.

The accompanying geological map was compiled on controlled photoscale base maps and reduced subsequently to 1:250,000 scale.

PREVIOUS INVESTIGATIONS

Gregory (1861) made notes on the rock types in the Nicholson River district, but it was not until 1939 that any significant geological work was done in the Sheet area. In 1939 and 1940 Jensen and party made traverses along the Queensland border, and in the Wollogorang district (A.G.G.S.N.A., 1940 a, b, and Jensen, 1942).

The Redbank copper mines, discovered in 1916, were examined during 1939 and 1940 by Blanchard (1940), Jensen (1940), A.G.G.S.N.A. (1940 b), and later by Benedict & King (1948).

In 1947-1948 Noakes & Traves (1954) made regional geological observations in the Sheet area.

The discovery of uranium at Pandanus Creek in 1955 led to greater interest in the area, and during 1956 and 1957 several mining companies explored for uranium in both the Calvert Hills Sheet area and the adjoining Westmoreland Sheet area of Queensland. Bureau of Mineral Resources geologists Lord (1955; 1956) and Walpole (1957) reported on the uranium discoveries, and Livingstone (1957) made an airborne scintillograph survey of the Nicholson River district.

The first systematic geological mapping of the Sheet area was performed during 1956 and 1957 by the Bureau of Mineral Resources (Firman, 1959b). At the same time, Mount Isa Mines Ltd prospected and mapped parts of the area (Battey, 1956; 1958), and Haney (1957). North Australian Uranium Corporation, N.L., was also active in the area during 1956 and 1957 (Newton & McGrath, 1958).

Firman (1959a) reported on the Redbank copper mines, which he examined during 1957.

In 1959 the Bureau of Mineral Resources completed a reconnaissance gravity survey from Burketown, Queensland, to Daly Waters, Northern Territory, crossing the northern part of the Calvert Hills Sheet area en route (Radeski, 1962).

All adjacent Sheet areas - Westmoreland (Carter, 1959a), Mount Drummond (Smith & Roberts, 1962), Robinson River (Yates, 1962), and Walhallow (Plumb & Rhodes, 1962) - have been mapped by the Bureau of Mineral Resources.

During 1961 geologists and prospectors of the Carpentaria Exploration Company were active in the area.

These Notes and the accompanying geological map are based on field work undertaken by the Bureau of Mineral Resources during 1961 which was part of the regional mapping of the Upper Proterozoic Carpentaria Province on the Northern Territory.

Inaccessible parts of the Sheet area were examined by helicopter chartered by the Bureau of Mineral Resources.

PHYSIOGRAPHY

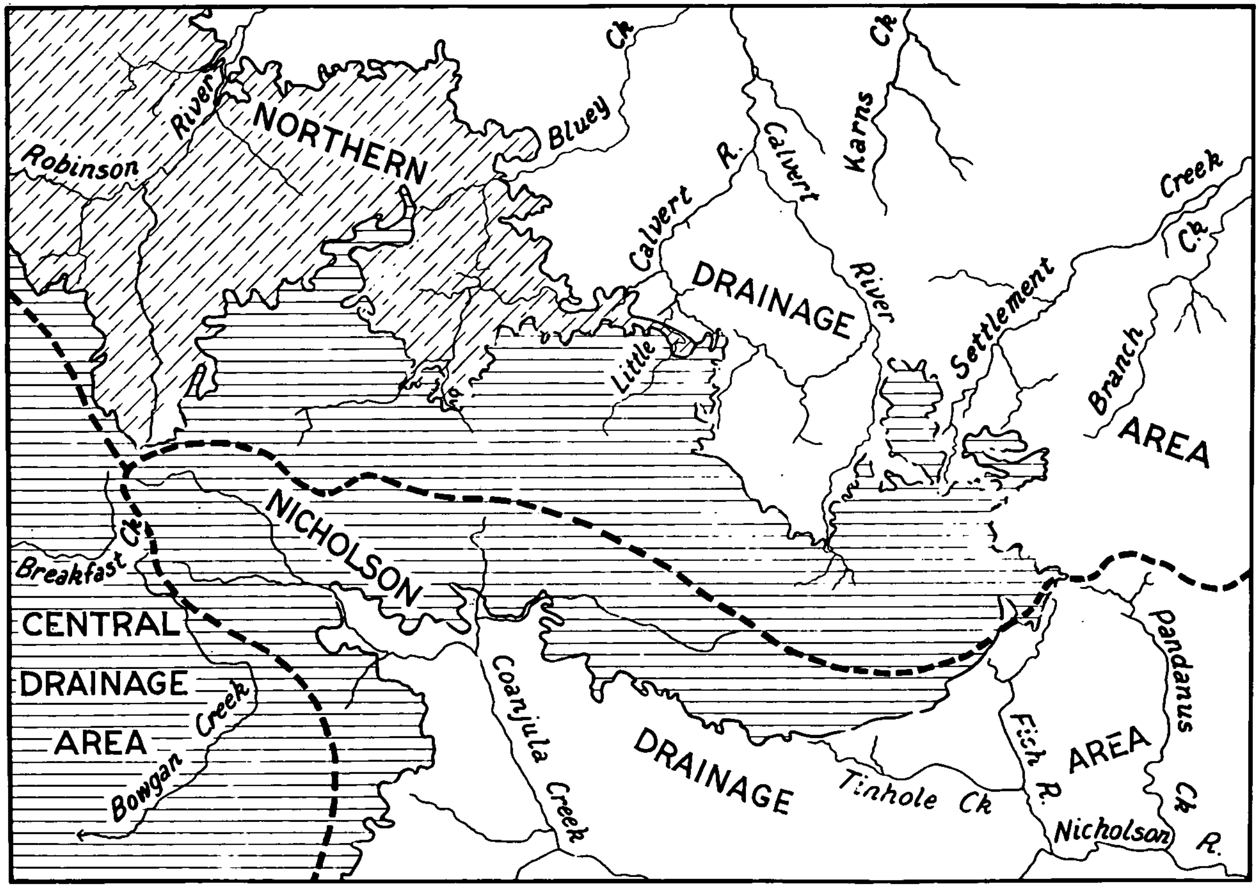
The country surrounding the south-western part of the Gulf of Carpentaria falls into three major physiographic regions, the Barkly Tableland, the Gulf Fall, and the Coastal Plains (Dunn, Smith, & Roberts, 1962). Parts of the Barkly Tableland and Gulf Fall occur in the Calvert Hills Sheet area (see fig.1)

Gulf Fall: The northern, eastern, and south-eastern parts of the area comprise hilly, dissected country drained by streams flowing into the Gulf of Carpentaria, and form part of the Gulf Fall (Stewart, 1954). In the southern part of the area the Gulf Fall is drained by the Nicholson River and its tributaries, an east-flowing drainage system seperated from the dominantly north-flowing streams by the elevated peninsula-like projection of the Barkly Tableland, which extends eastwards to the headwaters of Seigals Creek. East of Tin Hole the 'China Wall' forms a contination of this drainage divide.

Nicholson Drainage Area: In the part of the Gulf Fall drained by the Nicholson River system the most prominent physiographic feature is the 'China Wall', a series of elevated strike ridges of Westmoreland Conglomerate, which form an arcuate belt from the

Fig. 1

PHYSIOGRAPHIC SKETCH MAP – CALVERT HILLS SHEET AREA



Scale

10 0 10 20 30 MILES

Reference

Bukalara Plateau | Gulf Fall | Barkly Tableland

Bureau of Mineral Resources Geology and Geophysics, November 1962

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E53-8-2

Queensland border to the headwaters of the Nicholson River, some 60 miles to the west. The Wall is from 2 to 6 miles wide. Over most of its length a very prominent, almost vertical scarp, up to 400 feet high, separates it from the lower (granite) country to the south.

The less resistant Nicholson Granite and Murphy Metamorphics form low, partly soil-covered areas, and the Norris Granite and Cliffdale Volcanics tend to form rough hilly country.

Along the southern margin of the Sheet area the sub-horizontal Constance Sandstone is incised by super-imposed drainage and forms steep-sided gorges up to 200 feet deep. The Fickling Beds, with a greater range of rock types than the Constance Sandstone, form undulating, broken country with occasional strong strike-ridges.

Northern Drainage Area: In the northern half of the Sheet area the Gulf Fall is traversed by a series of dominantly north and north-east flowing streams, the most important being Branch Creek, Settlement Creek, the Calvert River and its numerous tributaries, and the Robinson and Foelsche Rivers.

In the north-west, the horizontal Bukalara Sandstone forms a broad plateau, which has been dissected by the Foelsche and Robinson Rivers. The plateau, called the Bukalara Plateau (Dunn et al., 1962), lies within the Gulf Fall at an elevation of about 800 feet above sea level, only slightly below the local level of the Barkly Tableland. It is more deeply dissected than the Tableland - in places to a depth of 200 feet. The Plateau extends on to the adjacent Walhallow and Robinson River Sheet areas, and the Bauhina Downs Sheet area, where it is most extensive. In some places within the Plateau the Bukalara Sandstone is entirely removed, and the less resistant underlying strata preferentially eroded by superimposed streams to form undulating lower-lying areas.

In the area north of the Calvert Fault the physiography is dominated by the differential erosion of various strata. The Peters Creek Volcanics are more easily eroded than the Westmoreland Conglomerate and Sly Creek Sandstone, and their topography is more subdued, although quite rugged hills occur in places. The McDermott Formation is exposed in a series of benches below a scarp of the Sly Creek Sandstone.

Branch Creek has been superimposed on the Upper Proterozoic rocks and cuts across the strike of the Sly Creek Sandstone forming steep-sided gorges, and Settlement Creek, which is entrenched along the strike of the poorly resistant Aquarium Formation and Settlement Creek Volcanics, is a subsequent stream. Elevations along the Settlement Creek valley range from 186 feet at Wollogorang to 783 feet two miles south of Aquarium Spring, in the headwaters of the stream.

The north-western wall of Settlement Creek valley is steep; resistant dolomitic sandstone beds at the top of the Wollogorang Formation form an erosional buttress, with less resistant beds below. In places the wall rises to 400 feet above the valley floor.

The Gold Creek Volcanic Member crops out as gently undulating to steep-sided hills. The overlying sandstone of the Masterton Formation forms a scarp 200 feet in height. Sandstone of the Masterton Formation forms broad elevated irregular plateaux, dissected rises, and isolated hills protruding through the overlying Karns Dolomite, which forms low undulating, benched hills.

In the Karns Creek area the Karns Dolomite and Masterton Formation are obscured by soil developed on laterite. The area is flat and lies about 600 feet above sea level.

Barkly Tableland: Plains of the Barkly Tableland extend from the west and occupy the south-western and central parts of the Sheet area. The Tableland is drained by the Nicholson River in the south, by the north-flowing river systems in the north, and by the inland-flowing Bowgan, Berakfulla, and Puzzle Creeks in the south west. It lies at an elevation of about 900 feet, is very slightly undulating, and mainly soil-covered, although occasional low exposures of Upper Proterozoic and Mesozoic rocks occur.

Mesozoic beds exposed around the edge of the Tableland are capped by laterite. Most of the Tableland in the Sheet area is covered by soils developed on lateritized Mesozoic rocks. The soils are ferruginous and are termed 'lateritic soils'. Non-ferruginous soil occurs along watercourses, particularly in the western part of the area, where the stream gradients are low. Black soil occurs in the south-west corner, where it may possibly have developed on unexposed Cambrian carbonate rocks, akin to the black soils of the Tableland on the Mount Drummond Sheet area (Smith & Roberts, 1962). However, Plumb & Rhodes (1962) record similar black soils lying on Mesozoic as well as Cambrian rocks in the Walhallow Sheet area.

The highest point in the Sheet area is probably in the district between the headwaters of Coanjula and Berakfulla Creeks. From the limited data available it is deduced to be about 1000 feet above sea level.

STRATIGRAPHY

Table 1 contains a condensed account of the stratigraphy of the Sheet area. The nomenclature used is in accordance with the Australian Code of Stratigraphic Nomenclature, and was approved by the Territories Stratigraphic Nomenclature Committee.

The nomenclature applied to rocks in the Calvert Hills Sheet area by Newton & McGrath (1958), and revised by Firman (1959b), has been further revised, necessitating corresponding revision of the nomenclature used by Carter (1959a) in describing rocks on the adjoining Westmoreland Sheet area.

The nomenclature used will be fully defined and in some cases redefined, by Dunn, et al (1962).

The Mesozoic strata have not been named.

PRECAMBRIAN

Age of the Units: David (1932), in his geological map of Australia, showed areas of 'Permo-Carboniferous' and Precambrian rocks in the Calvert Hills Sheet area. Jensen (1940) regarded the age of the rocks in the Redbank area and along the Northern Territory-Queensland border as most probably Cambrian, although he recognised affinities with the Proterozoic 'Mt. Isa Series'.

Noakes & Traves (1954) considered that the rocks of the Calvert Hills Sheet area were Lower Proterozoic, and termed them the 'Carpentaria Complex'. They discovered rocks in the Robinson River district lying unconformably on rocks of the 'Carpentaria Complex' and referred to them as the 'Robinson Beds', placing them in the Upper Proterozoic. The Beds probably correspond to the present Bukalara Sandstone, which is rather tentatively considered by Dunn (1962) to be of Lower Cambrian age.

Hossfeld (1954) considered the rocks in the area between the Queensland border and Borroloola to be of Middle and Upper Proterozoic age.

Carter & Öpik (1960) described a major unconformity between the folded Lawn Hill Formation, which they assigned to the Lower Proterozoic, and the shallowly dipping Constance Sandstone, which they assigned to the Upper Proterozoic, in the Constance Range area of the Lawn Hill Sheet area of Queensland.

Subsequent mapping of the Westmoreland and the Calvert Hills Sheet areas led Carter (1959a) and Firman (1959b) to conclude that the rocks in these areas were related to the Upper Proterozoic rocks of the Constance Range area. They recognised the unconformity between the Cliffdale Volcanics and the overlying Westmoreland Conglomerate, but were uncertain of its significance and hence uncertain of the age of the Cliffdale Volcanics and of the granite intruding them. They referred them tentatively to the Upper Proterozoic. Carter later revised this opinion and assigned the volcanics to the Lower Proterozoic (Carter, Brooks, and Walker, 1962).

On the Mount Drummond Sheet area, Smith & Roberts (1962) discovered metamorphic rocks (now known as the Murphy Metamorphics) lying unconformably below rocks which they considered equivalent to the Lawn Hill Formation, Ploughed Mountain Beds, and Myally Beds of the Lawn Hill Sheet area.

The Precambrian rocks of the Calvert Hills Sheet area are now considered to represent three major sedimentary epochs separated by two periods of diastrophism and granite emplacement. The two earlier epochs are tentatively referred to the Lower Proterozoic and the third to the Upper Proterozoic.

LOWER PROTEROZOIC

Carter (1959a) on the Westmoreland Sheet area, and Firman (1959b) on the Calvert Hills Sheet area, recognised two rock units older than the Westmoreland Conglomerate. These were the Nicholson Granite and Cliffdale Volcanics. Carter recorded two rock types in the Nicholson Granite, but was unable to establish their relationships, and Firman recorded (unnamed) metamorphic rocks occurring as roof-pendants in the Nicholson Granite.

More detailed work has delineated granites of two ages; the older is now termed 'Nicholson Granite' and the younger is referred to the 'Norris Granite'. The age of the Norris Granite, has been determined at the gerchronology Laboratory, A.N.U., by the Potassium-Argon method to be 1841 million years. This age is within the presently accepted limits of the Lower Proterozoic.

Murphy Metamorphics: The Murphy Metamorphics are the oldest rocks exposed in the Sheet area. They represent geosynclinal pelitic and quartzo-feldspathic sediments and volcanics, which were isoclinally folded, subjected to low-grade regional metamorphism, and intruded by granite. The rocks mostly belong to the quartz-albite-epidote-biotite sub-facies of the greenschist metamorphic facies, and are cut by many thin quartz-microcline veins parallel to the schistosity. In some places anhedral microcline of possible metasomatic origin occurs in patches enclosing many of the rock minerals.

Contacts between the Nicholson Granite and the Murphy Metamorphics are gradational, and it is often difficult to distinguish between the quartz-feldspar-biotite gniess and the adjacent granite. Lit-par-lit injection is common.

Nicholson Granite: The Nicholson Granite intrudes the Murphy Metamorphics, and the two together form an east-trending basement ridge (termed the 'Murphy Tectonic Land') extending across the southern part of the Sheet area. The folding in the Metamorphics parallels the general east-west trend of its exposure.

The lithology of the Nicholson Granite is varied. Probably the most important type in the eastern part of the Sheet area is a coarse-grained porphyritic granite with phenocrysts of potash feldspar up to 4 inches in length. The phenocrysts may be of metasomatic origin. The groundmass contains quartz, potash feldspar, plagioclase, biotite, and minor hornblende. In the Fish River area, near the Granite's contact with the Murphy Metamorphics, the principal type is a fine to medium even-grained muscovite granite with varying amounts of biotite. In some places assimilation of biotite schist has produced melanocratic biotite-rich dioritic rocks.

In the western part of the Sheet area fine to medium-grained leucocratic muscovite granite and adamellite, containing phenocrysts of potash feldspar are the most important types. The rocks are xenomorphic granular and composed of quartz, microcline, plagioclase, and muscovite with occasional biotite or garnet. Tourmaline is an accessory mineral. The potash feldspar phenocrysts may be later than the other minerals and possibly of metasomatic origin.

The Nicholson Granite is considered to be a mesozonal granite.

Dome isolated intrusions of Norris Granite may have been included with the Nicholson Granite on the accompanying map.

Cliffdale Volcanics: In the Fish River district an exposure of Cliffdale Volcanics, part surrounded by poorly outcropping Nicholson Granite, is bounded to the south by exposures of the Murphy Metamorphics. The Volcanics show no sign of having been intruded by the Nicholson Granite, or of having been metamorphosed or isoclinally folded. Although the exposures are poor, it is concluded that the Cliffdale Volcanics are younger than the Murphy Metamorphics and the Nicholson Granite, and were extruded on to an eroded surface of the Granite and Metamorphics.

Lithologically the Volcanics are very uniform. They consist of black, dark grey, and pink hypohyaline, occasionally flow-banded ryhodacite, dacite, and rhyolite. Anhedral to subhedral phenocrysts of feldspar and quartz are common. Thin interbeds of fine tuffaceous sediments and rare volcanic agglomerate occur locally in the Volcanics.

Two separate intrusive phases are represented in the Norris Granite. The initial intrusive mass was itself intruded by a late stage differentiate. The two phases are delineated on the accompanying map, but are termed jointly the Norris Granite.

The dominant rock type in the older part of the Norris Granite is a medium-grained, sub-equigranular to slightly porphyritic granite/adamellite with irregular clusters of ferromagnesian minerals. The rock is mostly leucocratic and contains microcline, microperthite, quartz, plagioclase, biotite and hornblende in decreasing order of abundance.

Near the contacts fine-grained porphyritic varieties occur, indicating more rapid cooling. In some places the contact varieties are very similar to the Cliffdale Volcanics.

In many places the contact is faulted, and the fault zones are generally filled with quartz veins or quartz-feldspar porphyry and granophyric microgranite dyke rocks.

The unfaulted contact is at a low angle. In two places Cliffdale Volcanics cap hills of Norris Granite; so the several isolated exposures of the Granite probably represent the partially exposed roof of an homogeneous epizonal granite mass.

The later granite intrudes the earlier intrusive phase and the Cliffdale Volcanics. Its intrusive relationship to the earlier phase is shown along the northern boundary between the two masses from which radiating aplite veins cut rocks of the earlier phase. Chilled contacts between the two phases are rare, possibly because the earlier granite was still at a high temperature at the time of the late-stage intrusion.

The granite is fine-to medium-grained, pink and leucocratic aplitic in places, and is composed of quartz, feldspar, and very minor ferromagnesian minerals. It is granophyric in places and probably related to an emplaced at the same time as the leucocratic granophyric microgranite dykes which cut the earlier phase of the Norris Granite.

The entire body is extensively fractured and impregnated by quartz-veins and stringers, many of which replace granite, and others occupy pre-existing fractures.

Dyke Rocks: Dyke rocks intrude the Nicholson and Norris Granites, the Murphy Metamorphics, and the Cliffdale Volcanics. Four main types of dykes intersect only Lower Proterozoic rocks. These are :

Griesen Dykes, which cut the Norris Granite and Cliffdale Volcanics, often in sub-parallel north-south swarms, but also as irregular masses associated with quartz blows of granite intrusions. They are fine-grained, equigranular, and composed almost entirely of anhedral quartz and muscovite. They may be related to the late stage of the Norris Granite. Crystal Hill, which is composed of a cassiterite-bearing griesen, occurs at the contact of the two phases of the Norris Granite.

Granophyric Micrognanite Dykes, of pink to grey fine, even-grained granitic rocks which contain quartz, microperthite, plagioclase, biotite, and hornblende. They may be related to the late stage differentiate of the Norris Granite.

Feldspar Porphyry Dykes, of pink to red very fine quartz-feldspar rock, containing small phenocrysts of potash feldspar and plagioclase. Minor hornblende occurs in the groundmass.

Quartz-Feldspar Porphyry Dykes, similar to the feldspar-porphyry dykes, but containing phenocrysts of quartz as well as potash feldspar and plagioclase. Both types may possibly have been feeders for the Cliffdale Volcanics.

UPPER PROTEROZOIC

The Upper Proterozoic sedimentary and volcanic rocks are unconformably overlain by the Lower Cambrian Bukalara Sandstone and overlie Lower Proterozoic rocks with major unconformity.

The Upper Proterozoic rocks were deposited in two distinct sedimentary basins: the South Nicholson Basin, lying to the south of the present exposures of Lower Proterozoic rocks, and the McArthur Basin, which extends northwards throughout the coastal region of the Gulf of Carpentaria to Arnhem Land.

The rocks have been divided (on the Sheet area) into three Groups.

Tawallah Group

Rocks of the Tawallah Group are extensively exposed in the Gulf Fall. The group had its maximum development in the northern sector of the Sheet area (in the McArthur Basin), where at most points its thickness is estimated to have exceeded 12,000 feet.

The Westmoreland Conglomerate is the oldest exposed unit in the Upper Proterozoic sequence. In the Northern Territory the base of the unit is usually a medium-grained quartz sandstone, although in an exposure south of Tin Hole an arkose occurs at the base. Very coarse-grained arkose and arkose conglomerate occur within the unit, comprising about half its total thickness; the other half consists of quartz-sandstone, feldspathic sandstone and pebble to cobble conglomerate with pebbles and cobbles of quartz, quartz-feldspar porphyry, and silicified sandstone.

The unit is thought to be stratigraphically equivalent to the Yiyintyi Sandstone of the Mount Young and Bauhinia Downs Sheet areas.

The Peters Creek Volcanics contain a lenticular sandstone bed in the Upper Branch Creek district which has been termed the Carolina Sandstone Member. Below the Carolina Sandstone Member the Volcanics are predominantly andesine basalt containing andesine, augite, chlorite and magnetite. They are cut by several possible feeder dykes of dolerite containing interstitial micrographic intergrowths of quartz and potash feldspar.

Above the Carolina Sandstone Member the Volcanics consist of amygdaloidal basalt, tuff, tuffaceous siltstone, micaceous siltstone and agglomerate.

Near the Kings Ransom Uranium prospect a prominent plug of volcanic breccia intrudes the Peters Creek Volcanics, and dolerite dykes have been recorded by Carter (1959a) cutting the Westmoreland Conglomerate near the Queensland border. These were almost certainly intruded during the extrusion of either the Peters Creek Volcanics or the Settlement Creek Volcanics. Dolerite dykes also cut the Nicholson Granite. They are fine melanocratic rocks consisting of andesine, augite, uralite, and chlorite, with occasional micrographic intergrowths of quartz and potash feldspar, and are almost certainly related to the Peters Creek or Settlement Creek Volcanics.

Firman (1959b) and Carter (1959a) used the name 'Wollogorang Formation' for rocks which are now shown as the McDermott Formation in the Calvert Hills and Westmoreland Sheet areas respectively. On the Westmoreland Sheet area only a few small exposures of the McDermott Formation are believed to occur, north of Lagoon Creek.

The only complete section of the McDermott Formation is exposed in the Branch Creek district, where its thickness is about 500 feet. In the Horse Creek district, where the base of the Formation is not exposed, it is at least 3000 feet thick. In the headwaters of Seigals Creek the unit is missing.

The most common rock type is a grey-green to purple dolomitic siltstone. Dolomites are common and range from pure crystalline dolomite to sandy and silty dolomites. In places they are oolitic, and commonly contain grains of quartz, feldspar, and glauconite. Dolomitic, feldspathic and glauconitic sandstones are abundant in the formation. Algal growths occur mostly in nearly pure dolomite. Isolated crystals of chalcopyrite and pyrite have been found throughout the formation.

Analysis of typical dolomites showed them to contain about 80 percent by weight of dolomite, 3 percent calcite, 1.5 percent siderite, and 15.5 percent residue, which included fine-grained quartz and feldspar.

Firman (1959b) on the Calvert Hills Sheet area, and Carter (1959a) on the Westmoreland Sheet area used the term 'Constance Sandstone' to sandstone beds exposed in the northern parts of both Sheet areas, which have been subdivided and named the Sly Creek Sandstone (lower part) and Aquarium Formation (upper part).

The lithology of the <u>Sly Creek Sandstone</u> is very uniform both laterally and vertically, although towards its top it includes occasional thin ferruginous sandstone interbeds. Ripple marks and cross beds are common. Its thickness is fairly constant over the Sheet area, although it may thin somewhat towards the 'China Wall'. South-west of

Calvert Hills Homestead the unit is 550 feet thick.

The boundary between the Aquarium Formation and the Sly Creek Sandstone is transitional, but it is marked by the appearance of glauconite and a complementary increase in iron-oxide content, imparting a purple coloration to the basal rocks of the Aquarium Formation. The glauconitic sandstone at the base of the unit grades upwards to glauconitic siltstone, which in turn becomes dolomitic. A thin bed of dolomite occurs at the top of the unit. The siltstones and dolomitic siltstones are strongly micaceous, and locally contain abundant halite pseudomorphs.

<u>The Settlement Creek Volcanics</u> consist of a series of basalt flows with occasional interbeds of tuff, siltstone, agglomerate, and volcanic breccia.

The basalts are andesine/basalts containing micrographic intergrowths of quartz and potash feldspar and augite. Magnetite and pyrite are common accessory minerals. The rocks are usually partly or completely altered to an assemblage of chlorite/calcite/and uralitic amphibole.

Vesicular and amygdaloidal varieties occur locally, and the amygdales contain a green mineral, which appears similar to that found to be celadonite (by W.M.B. Roberts, pers. comm.) in the Gold Creek Volcanic Member. Some of the basalts contain quartz-hematite, fibrous amphibole, or serpentine veinlets.

Volcanic breccia and agglomerate occur at the top of the unit at several localities in the Settlement Creek valley. The rocks in places contain blocks of dolomite, suggesting that vulcanism continued locally whilst the Wollogorang Formation was deposited elsewhere. In some places sills appear to have intruded the lowermost beds of the Wollogorang Formation.

Jensen (A.G.G.S.N.A., 1940a) referred to 'limestone' and associated sediments in the Wollogorang-Redbank area as the 'Wollogorang series', and Firman (1959b) applied the name Wollogorang Formation to the dolomitic part of the 'series'.

As Firman's interpretation of the relationships of the Wollogorang Formation to other units has been found by further mapping to be invalid, the term is to be re-defined in Dunn, et al. (1962).

Dolomitic siltstone and sandstone are probably the most important sediments but slightly calcareous dolomite and silty dolomite are common. Beds of feldspathic sandstone, (cemented) dolomite occur near the top of the formation.

The lithology of the formation is laterally uniform : some thin beds are recognizable at points over 100 miles apart. Among these is a dolomitic siltstone bed containing ovoid nodules of dark grey dolomitic limestone. It overlies a similarly distinctive bed of flaggy dolomite characterized by 'wavy' bedding produced by colonial algae. Chemical analyses show that the carbonate/rocks of the formation are generally dolomitic though containing minor amounts of calcium carbonate. Cross-beds, ripple marks, clay pellet impressions, and halite pseudomorphs are common in the sandstone beds at the top of the formation.

The terms 'Masterton Formation ' and 'Golden Creek Formation' were first used by Newton & McGrath (1958). Firman (1959b) used the terms Masterton Sandstone and Gold Creek Volcanics for the same units, but recent work has shown that the Masterton Sandstone or formation, does not constitute a mappable rock unit, and the nomenclature has been revised. The formation consists dominantly of quartz sandstone, feldspathic sandstone, and pebble to cabble conglomerate, but the two volcanic Members become important locally, particularly in the Redbank mine district. The conglomerate, which occurs as small lenses, contains well rounded pebbles and cobbles of pink to white medium-grained quartz-sandstone, vein quartz, acid volcanics, and quartz-muscovite rock.

Cross-beds and ripple marks occur in the sandstones of the unit, but are not prominent.

The <u>Gold Creek Volcanic Member</u> is more than 600 feet thick in the Redbank district, but in the western part of the Sheet are it is usually less than 100 feet.

Vesicular and amygdaloidal basic to intermediate lavas constitute a major part of the unit, but tuffaceous siltstone, lithic sandstone, volcanic breccia and agglomerate are locally well represented.

The lavas are invariably very weathered, making precise determination of their original composition difficult. They are saussuritized and uralitized, the amygdales being characteristically filled with chalcedony, hematite, and celadonite.

Minor sandstone interbeds occur between the volcanic beds. They consist of quartz, quartz sandstone, microcline, and basic volcanic fragments set in a dolomite matrix.

A few small exposures of the Hobblechain Rhyolite Member occur on the Sheet area, but it is best exposed on the Robinson River Sheet area (Yates, 1962). In the Calvert Hills Sheet area it is nowhere more than 200 feet wide and lenses out to the south. The Member consists of rhyolite, porphyritic in quartz and potash feldspar and characterized by a paucity of ferro-magnesian minerals. The rock is partly altered to clay minerals and hydrated iron oxide. Flow banding occurs locally, and is in places, contorted.

The Packsaddle Microgranite intrudes rocks of the Wollogorang Formation and Gold Creek Volcanic Member. The intrusion has domed rocks of the Gold Creek Volcanic Member which dip radially from the contact at angles of up to 20°. Vertical flow-banding occurs at some points along the margins of the intrusion and rocks of the Wollogorang Formation have been recrystallized at the contact.

The Microgranite is similar in composition to the Hobblechain Rhyolite Member, and is distinguishable from it only by virtue of its coarser grainsize and its distinctive joint pattern. The two are probably co-magmatic.

Tawallah Group Equivalents

The lowermost beds of the Fish River Formation consist of poorly sorted, coarse-grained, feldspathic sandstone containing quartz pebbles up to 1 inch in diameter. Tourmaline and zircon occur as accessories. The feldspar content and grainsize diminish gradually upwards from the base.

The volcanics in the unit are amygdaloidal and vesicular basic/to intermediate lavas which lens sharply, and in some places are lacking. Very minor interbeds of fine to medium-grained quartz sandstone occur in the volcanics. Overlying the volcanics is a sequence of white to pink fine-to medium-grained quartz sandstone. The arenites of the Formation are often ripple-marked and cross-bedded, particularly in the upper part of the unit.

The Fish River Formation is probably equivalent to the Masterton Formation of the Tawallah Group.

McArthur Group

Rocks of the McArthur Group are exposed extensively throughout the Carpentaria Region. They were deposited in the McArthur Basin, which is restricted to the northern part of the area.

The Karns Dolomite unconformably overlies the Masterton Formation and in the Robinson River Sheet area (Yates, 1962) is overlain with apparent conformity by rocks of the Roper Group.

The Dolomite was deposited on a dissected surface consisting largely of the Masterton Formation. Strata of the Karns Dolomite, although usually horizontal, dip sharply away from the isolated inliers of sandstone of the Masterton Formation.

The overall superpositional sequence in the Dolomite is difficult to determine. However, the youngest Dolomite beds are probably exposed in the west of the Sheet area.

Dolomite, silty dolomite, and dolomitic siltstone form about two-thirds of the total thickness of the unit; the remainder includes cherty oolitic rocks, siltstone, dolomitic sandstone, chert-breccia and dolomite-breccia.

Algal structures are common in the relatively pure dolomites (silicified in places), and ripple marks, crossbeds and halite pseudomorphs are present locally.

Chemical analyses show the magnesium-calcium ratio in the carbonate rocks to be consistent with the composition of dolomite. Small amounts of theoretically-free calcium carbonate are present.

The Fickling Beds occur only in the South Nicholson Basin. In the Bauhinia Dome, in the northern part of the Mount Drummond Sheet, an incomplete section of the unit is estimated to be over 3000 feet thick (Smith & Roberts, 1962).

Dolomitic and cherty rocks, commonly sandy and oolitic, constitute about one third of the exposed parts of the unit, arenaceous rocks ranging from arkose to quartz sandstone about one third, and the remainder consists largely of micaceous, largely dolomitic siltstone. Chemical analyses show the magnesium-calcium ratio in the carbonate rocks to be consistent with the composition of dolomite. Small amounts of theoretically-free calcium carbonate are present.

South Nicholson Group

Rocks of the South Nicholson Group are exposed in the southern part of the Calvert Hills Sheet area; extensively in the adjoining Mount Drummond Sheet area; in the western part of the Lawn Hill Sheet area; and in the south-west corner of the Westmoreland Sheet area.

Deposition of the Group is probably restricted to the South Nicholson Basin, and contemporaneous with the deposition of the lower part of the Roper Group in the McArthur Basin (Dunn, et al., 1962).

The type area of the Constance Sandstone is in the Constance Range district of Queensland, where it rests unconformably on Lower Proterozoic rocks (Carter & Öpik, 1961, Carter, Brooks, & Walker, 1962). In the Calvert Hills Sheet area it rests unconformably on both Upper and Lower Proterozoic rocks and occurs only in the south.

Two separate siltstone beds occur within the unit, the lower being termed the Pandanus Siltstone Member, the upper, the Wallis Siltstone Member. These have been differentiated on the Calvert Hills and Mount Drummond Sheets, but were not mapped on the adjoining Queensland Sheet areas, although they are now known to extend there.

A 100-foot bed of medium-to coarse-grained quartz sandstone which underlies rocks of the Pandanus Siltstone Member and surrounds the confluence of the Nicholson River and Pandanus Creek, represents the base of the Constance Sandstone. The bed is mostly obscured by the overlap of younger strata of the Constance Sandstone, particularly along the northern boundary of the Sandstone. The Pandanus Siltstone Member is also overlapped by later beds of the Sandstone.

Resting on the Pandanus Siltstone Member (about 200 feet thick) is a massive to blocky, jointed, coarse-grained quartz sandstone about 600 feet thick, which is in turn overlain by the Wallis Siltstone Member. The Wallis Siltstone Member, generally about 200 feet thick, lenses out to the south (on the Mount Drummond Sheet area), and the underlying and overlying sandstone cannot be distinguished. In the Calvert Hills Sheet area about 1000 feet of sandstone, representing the top of the Constance Sandstone, overlies the Wallis Siltstone Member and underlies the Mullera Formation. In the western part of the Sheet area the Constance Sandstone lenses northwards and is overlapped by the Mullera Formation, which has been observed resting directly on the Lower Proterozoic Murphy Metamorphics.

Cross-beds and ripple marks are common in the Constance Sandstone, particularly in the arenaceous parts of the unit.

Rocks of the <u>Mullera Formation</u> in most places rest conformably on the Constance Sandstone, but in a few localities in the west they rest directly on the Murphy Metamorphics. In the same area the Mullera Formation is thought to lens out northwards, permitting the overlying Mittiebah Sandstone to rest directly on the Murphy Metamorphics. No complete section of the formation is exposed on the Sheet area, but in the Mount Drummond Sheet area the unit is known to be up to 8000 feet thick (Smith & Roberts, 1962).

Ripple marks and cross-beds are common in the more arenaceous beds.

Only a few small exposures of the <u>Mittiebah Sandstone</u> occur in the Sheet area, but it is extensively exposed on the Mount Drummond Sheet area to the south.

The unit rests conformably on the Mullera Formation, and on the Murphy Metamorphics with major unconformity, marked by a coarse-grained arkose at the base of the Sandstone. The unit thickens towards the south; it is about 1500 feet thick near Little Pandanus Creek in the north of the Mount Drummond Sheet area, and 9,000 feet thick in the

Mittiebah Range, in the southern part of the Mount Drummond Sheet area (Smith & Roberts, 1962).

Ripple marks and cross-beds are common in the unit.

PALAEOZOIC

Cambrian

The Bukalara Sandstone unconformably overlies the Precambrian rocks of the Sheet area. Dunn (1962) has found evidence in the Nutwood Downs district (Hodgson Downs Sheet area) suggesting that the Bukalara Sandstone may be of Lower Cambrian age. The formation was deposited on a surface with only minor relief and formed a continuous, almost horizontal blanket, which covered a large part of the Gulf of Carpentaria region.

Conglomerate of the Bukalara Sandstone in the northern part of the Calvert Hills Sheet area and more prominently in the Robinson River Sheet area (Yates, 1962) are exposed on several isolated elongate outcrops, which suggests that it was deposited in the valleys of pre-Bokalara Sandstone streams.

Intense jointing is characteristic of the unit, and cross-beds and ripple marks are very common.

MESOZOIC

Sedimentary rocks of Lower Cretaceous age unconformably overlie the Bukalara Sandstone and the Precambrian rocks. No top to the succession is preserved, but sections up to 200 feet thick occur in places.

Plant-bearing medium-grained quartz sandstone and conglomerate occur locally at the base of the succession, and are overlain by interbedded fine clayey sandstones and siltstones containing shelly fauna. Siltstone is dominant higher in the unit.

Skwarko (1962), with the assistance of M.E. White, identified fossils from three localities in the Sheet area. The localities are shown on the accompanying map by the symbols TT59, TT60, and TT61. The following fossils were recorded:

TT. 59 (About half a mile south-west of Seigals Creek Homestead).

Plants: Microphylloptoris gleichenioides O. and M.

Otozamites bechei Brong.

Conifer foliage and twigs.

TT.60 (About 13 miles south 15° east of Seigals Creek Homestead).

Pelecypoda: Aucellina hughendenensis (Etheridge Snr.) 1872

Brachiopoda: Argiope sp.aff. A. punctata Moore, 1870

Rhynchonella sp.aff. R. solitaria Moore 1870

Cephalopoda: Dimitobelus canhami (Tate) 1879

Plants: Cladophlebis australis

Brachyphyllum stems

TT.61 (Echo gorge, one mile north-west of Prince Copper Mine).

Plants: Conifer fragments indet.

STRUCTURE

LOWER PROTEROZOIC

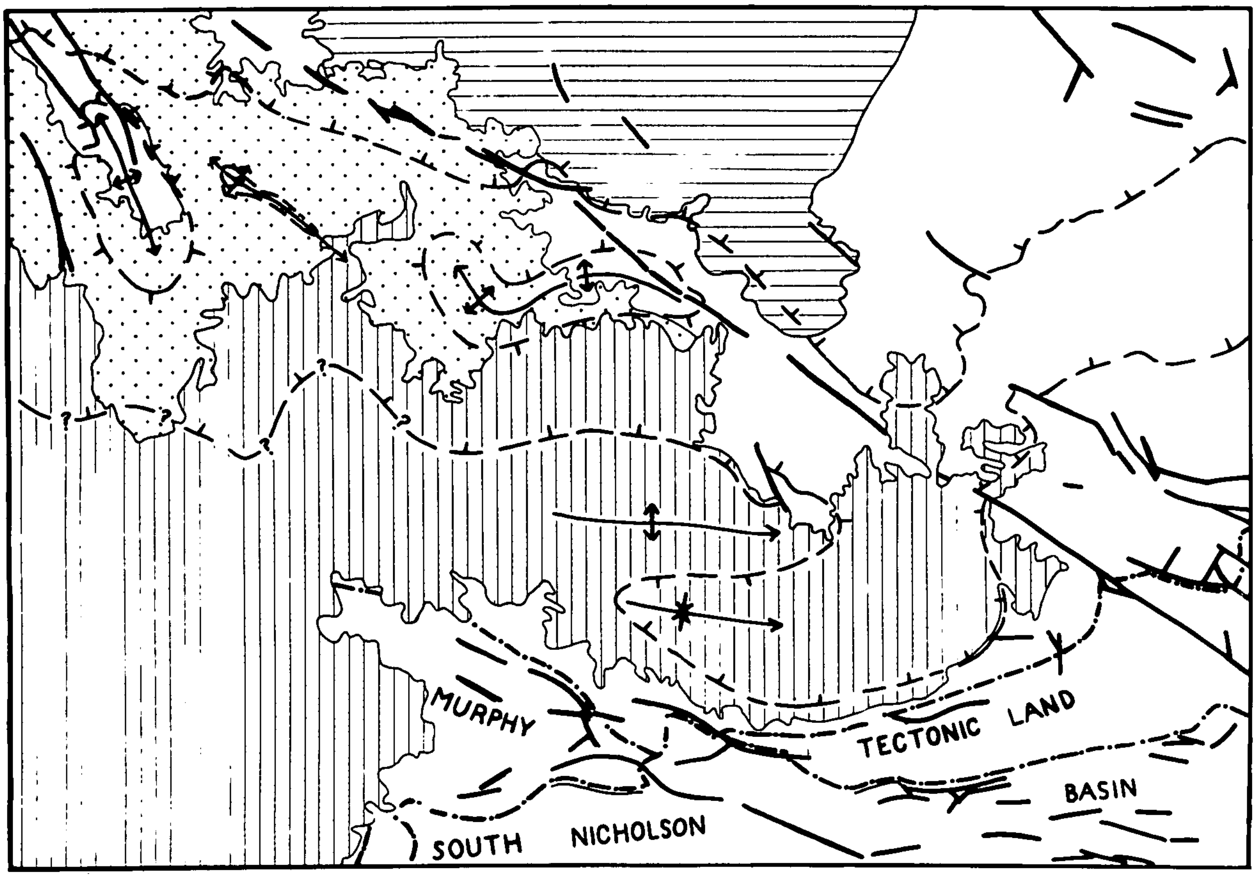
The Murphy Metamorphics are isoclinally folded. Foliation is most pronounced and trends about east in the eastern part of the Sheet area, swinging to the south-west in the west. (Figure 2).

The massive lava flows of the Cliffdale Volcanics seldom dip at more than 30°, but many of the interbedded tuffs and sediments are contorted and appear regularly folded. However, a statistical analysis of bedding planes and fold axes suggests that the contortions are intraformational, and not the result of any regular fold system.

UPPER PROTEROZOIC

The Upper Proterozoic rocks of the Sheet area, although gently flexed, generally retain their initial depositional structure (Figure 2). In the South Nicholson Basin they dip gently southwards away from the Murphy Tectonic Land (see Tectonic History), and in the McArthur Basin, to the north of the Murphy Tectonic Land, the rocks dip gently to the north. At the margins of the Basins the rocks dip more steeply, owing partly to the contemporaneous movements of the Murphy Tectonic Land; partly to the initial depositional dip and partly to post-depositional tectonic adjustments.

TECTONIC SKETCH MAP — CALVERT HILLS SHEET AREA



Scale

10 0 10 20 30 MILES

Reference

Mesozoic

Bukalara Sandstone

Karns Formation

Tawallah Group
South Nicholson Group
Lower Proterozoic

Trend lines in Tawallah Group

Faulting

In the South Nicholson Basin strike faults trend east, parallel to the margins of the Murphy Tectonic Land. Many of the faults are curved, and in some places they were penecontemporaneous with the sedimentation.

In the McArthur Basin the most prominent fault is the Calvert Fault, which comprises a series of parallel wrench faults striking at 305° north. In one locality the rocks north-east of the fault have been displaced (relative to those south-west of the fault) 4½ miles horizontally to the north-west and about 2,500 feet vertically downwards.

In the north-west corner of the Sheet area a series of faults strike between 320° north and 350° north.

Very minor movements along some established faults has occurred since the deposition of the Mesozoic rocks.

Folding

The Upper Proterozoic strata are little folded. The only important folds are four small domes in the central and north-western parts of the Sheet area. The domes are elongate; the long axes are parallel to the faults with which they are associated.

TECTONIC HISTORY

The effects of numerous major and minor tectonic events are preserved in the rocks of the Calvert Hills Sheet area. A summary of the major tectonic events is given in Table 2.

LOWER PROTEROZOIC

The oldest rocks of the area (the Murphy Metamorphics) originated in a Lower Proterozoic geosyncline. Pelitic sediments and volcanics in the geosyncline were isoclinally folded, metamorphosed, and intruded by the Nicholson Granite. After this diastrophision the metamorphics and granite were eroded, the Cliffdale Volcanics were extruded, and the Norris Granite was intruded. Moderate folding, faulting, and uplift, and completed the second diastrophic cycle, and the whole Lower-Proterozoic succession was again eroded.

UPPER PROTEROZOIC

The lithology, thickness and distribution of the Upper Proterozoic rocks in the Sheet area were greatly influenced by an east-trending ridge of Lower Proterozoic rocks (the Murphy Tectonic Land) which remained sub-aerial, by virture of its repeated uplift, during most of the Upper Proterozoic sedimentary epoch.

To the north of the Murphy Tectonic Land the McArthur Basin subsided continuously during the deposition of the Tawallah Group (15000'), but subsequently the Basin was relatively more stable and received only thin beds (300'+) representative of the McArthur Group, which in the Bauhinia Downs Sheet area is up to 15000 feet thick.

To the south of the Murphy Tectonic Land the South Nicholson Basin did not subside significantly until, after most of the Tawallah Group was deposited in the McArthur Basin, 3000 feet of the Fickling Beds were deposited. The subsequent deposition of the South Nicholson Group (up to 20,000 feet thick on the Mount Drummond Sheet area) marked the most active phase of sedimentation in the South Nicholson Basin.

ECONOMIC GEOLOGY

History of Mining Activity

Copper was first reported from the Settlement Creek area in 1899, but it was not until 1912 that any significant mining began. In that year, the Branch Creek, Diorite Cliffs, and Bindi Bindi Mines were opened up by the Wollogorang Copper Company on copper showings in the Peters Creek Volcanics at the headwaters of Branch Creek. At the same time E. Thomas, on behalf of Moffat & Linedale of Irvinebank, Queensland, discovered the Packsaddle and Bauhinia Lodes in close proximity to Wollogorang Homestead. None of these mines were located during the mapping of the Sheet area.

W. Masterton, a later owner of the Bauhinia Lode, discovered the Redbank Lode in 1916. From then until his death in 1961, Masterton discovered and developed to varying degrees the mines within the Redbank Copper Field.

In 1953, R.T. Norris began prospecting the area at the headwaters of Pandanus Creek and pegged five leases for copper, from which small amounts of radioactivity were recorded in 1955.

Uranium was discovered at Cobar II by A.R. Blackwell in 1956 and in the same year a 2,000 square mile Authority to Prospect was taken out by North Australian Uranium Corporation. All the important uranium occurrences within the Peters Creek Volcanics were discovered soon after by prospectors employed by this company. Costeaning, shaft-sinking, and diamond drilling were carried out on the larger deposits.

As a result of these discoveries, the Bureau of Mineral Resources undertook an airborne scintillograph survey of the Nicholson River Region late in 1956 and a number of previously undiscovered anomalies were revealed. These anomalies were principally within the Cliffdale Volcanics and Westmoreland Conglomerate. The Eva Prospect, now known as the Pandanus Creek Uranium Mine, was discovered by Eva Clark, a niece of R.T. Norris, in June 1958. Late in the same year Broken Hill Proprietary Limited took option over several of Norris' prospects. These included the Eva Prospect and Crystal Hill. This company put down a total of 139 wagon drill holes and four diamond drill holes to test the vertical and horizontal extension of the uranium field.

Broken Hill Proprietary Limited did not exercise option over the Eva Prospect and the lease was taken up by South Alligator Uranium Ltd. and Aberfoyle Tin N.L. in 1960 as a joint venture, with a contract to be fulfilled by the end of 1961.

Late in 1961 the only mines in operation were the Pandanus Creek Mine, Crystal Hill, and Norris' Copper Mine, which later was being worked intermittently by two miners. Mount Isa Mines Ltd were employing prospectors to investigate the outcrops of granite and volcanics south of the Westmoreland Conglomerate.

Uranium

Uranium mineralization was found within the Cliffdale Volcanics, Peters Creek Volcanics, and Westmoreland Conglomerate. Production of uranium ore is recorded from two mines, Pandanus Creek and Cobar II.

Pandanus Creek Mine

The main orebody is localized within a zone consisting of two parallel shears, striking east and dipping 70 degress north in Lower Proterozoic Cliffdale Volcanics just below the unconformity with the Upper Proterozoic Westmoreland Conglomerate. Between these two shears are three smaller more gently dipping shears. The ore occurs as pods and lenses within these shear zones, and little occurs in the intervening altered volcanics. Granite has been intersected below the orebody in diamond drill holes and a small body of granite outcrops 300 yards to the south-west of the mine. The ore consists predominantly of gummite with some uranophane and sklodowskite. Pitchblende occurs locally and constitutes about 0.7 per cent of all ore mined.

The workings consist of three shafts with levels at 25, 45, 66 and 83 feet. The deposit has been mined over a length of 70 feet at the 66 foot level. Removal of ore has been selective and to October 1961 about 215 tons of ore were mined, the average grade being 8 to 9 percent eU_3O_8. The Director of Mines, Darwin, records the production of 18 tons of ore yielding 2,140 lbs. of concentrate by B.H.P. in 1959-60.

Cobar II Mine

The uranium mineralization consists of a shoot of primary ore which pitches 40° south in a vertical north-striking shear. The orebody has a strike length of 400 feet, a maximum composite width of 20 feet, and a possible depth of 320 feet. Pitchblende occurs in intimate association with fine-grained hematite and gangue minerals, mainly quartz, in veins within the ore shoot. Chalcopyrite, pyrite, arsenopyrite, galena, and gold occur in minor amounts.

McAndrew & Edwards (1957a) state that the uraninite occurs largely as irregular patches and seams 5 to 15 mm. long and 1 to 2 mm. broad within the hematite bands. It is replaced by hematite and in part deposited simultaneously. Sklodowskite, saleite, carnotite, and a mineral isostructural with phosphuranylite were identified from the oxidized zone by McAndrew (1958). The association of hematite and carbonate led McAndrew & Edwards (1957a) to suggest that the temperature of the mineralizing solutions was above 125°C.

The mine was opened to a depth of 133 feet, by means of a 260 foot adit intersecting the base of a 76 foot shaft. A winze 120 feet from the adit entrance was excavated to a depth of 57 feet. From the bottom of the winze a sub-level was driven 120 feet to the south. Seven diamond drill holes were emplaced by North Australian Uranium Corporation.

Production from 1957 to 1959, when mining ceased, totalled 12,795.85 lbs. of uranium concentrate.

Exploratory mining, costeaning and surface stripping was carried out at the El Hussen, Kings Ransom, Old Parr, and McGuinness Prospects, and 13 diamond drill holes were employed to test the El Hussen Prospect. They were all abandoned when mineralization within them was found to be below economic concentration.

Copper

The most important copper deposits occur in the Redbank Copper Field, the largest producers being the Redbank, Azurite, and Prince Mines. The mineralization in these deposits occurs as ill-defined bodies of secondary copper minerals within gently dipping kaolinized volcanic rocks of the Gold Creek Volcanic Member. There is no pronounced structural control to the mineralization.

The ore consists of secondary copper minerals, malachite, chrysocolla, azurite, and chalcocite in that order of abundance. No primary sulphides have been determined from any of the orebodies within the field. The grade of ore produced ranged from 25 to 52 percent copper.

The orebody at the Redbank Mine has a surface outcrop area of 40,000 square feet. It has been mined from 12 pits and 5 shafts to a maximum depth of 70 feet. The workings at the Azurite Mine consist of an open cut 150 feet long and 30 feet wide at the surface. This open cut contains copper mineralization over its entire extent and has not revealed the full areal distribution of the lode. Three shafts were sunk at the boundaries of the open cut, the deepest being 60 feet on the western side.

The exact production of copper ore from the Redbank Field is indeterminable, as records vary. Firman (1959) quotes production to 1955-56 as 932.3 tons of ore. Northern Territory Administration Reports indicate a total field production of about 1000 tons. About half of this production has come from the Azurite Mine.

Norris' Copper Mine was discovered between 1953 and 1954 by R.T. Norris and 5 tons of copper ore were produced in 1954-55. A small amount of ore was produced during 1961.

The orebody is localized in a minor quartz reef which branches from the main Calvert Fault line. The reef strikes at 93° and dips 80° south in Cliffdale Volcanics at their contact with a small body of Norris Granite. Workings consist of two costeans, a pit and a 40 foot shaft at the base of which the lode is three feet wide. The primary ore consists of massive chalcopyrite which has been brecciated and altered along fractures to digenite and hydrated iron oxide. (Lord (1955) reported traces of autunite and torbernite from this lease).

Minor Lower Proterozoic copper mineralization also occurs in the contact rocks of the Norris Granite at Chapman's Prospect and in the Cliffdale Volcanics three miles to the south.

Copper was mined from the Peters Creek Volcanics at the beginning of the century, and the Vulcan Prospect represents copper mineralization discovered during the more recent prospecting of the same formation.

Disseminated chalcopyrite occurs in laminated dolomite within the Karns Dolomite near Calvert Hills Homestead. The chalcopyrite appears to be confined to specific beds within the formation. Detailed prospecting with special reference to this control may reveal the mineral in greater concentration.

Tin

Cassiterite is associated with quartz veins and druses in greisenized granite related to the quartzo-feldspathic late differentiate of the Norris Granite. The two major occurrences are at Crystal Hill and Tracey's Table.

The deposits at Crystal Hill were tested by bulldozing, costeaning, and drilling in 1958 by Broken Hill Proprietary Limited.

Eluvial tin at the base of the hill is now being worked by Mrs. Norris and associates and 160 lbs. are reported to have been extracted from 6 tons of eluvium.

Alluvial tin has been found in creeks draining from areas of granite outcrop.

Wolfram

Wolframite occurs in a quartz vein adjacent to a small body of Norris Granite about one mile south of Chapman's Prospect. In 1954-55, 1.5 tons were produced and in 1957-58, 0.20 tons of 66 percent ore were raised.

Lead

Galena also occurs as syngenetic disseminations within the Karns Dolomite near Calvert Hills Homestead. It shows similar field relationships to the disseminated chalcopyrite, but it is absent from the bed which contains the copper mineralization.

In polished section the galena shows elongation parallel to the bedding and a grainsize up to 1.3 mm. There are no other associated sulphides.

The lead mineralization within this formation possesses similar exploratory possiblities to the disseminated chalcopyrite.

Jensen (1942) reports two shallow shafts in the bed of Gorge Creek in 'cherty limestone' of the Fickling Beds on the adjoining Westmoreland Sheet. At this locality the mineralization consists of veins of galena and copper carbonate stains. Veins of coarse-grained galena occur elsewhere within dolomite of the Fickling Beds.

Manganese

Small manganese deposits occur within the Karns Dolomite within a twenty-mile radius of Calvert Hills Homestead. The mineral constituents are pyrolusite, cryptomelane, and wad, assaying from 30 to 40 percent manganese. The deposits are too small to be of economic importance.

Gold

Prospectors have reported small amounts of free gold in the Tin Hole Creek and Gold Creek areas. Small quantities of free gold occur in the ores of the Pandanus Creek and Cobar II Mines.

Oil

A sample of dark grey shale from the Fickling Beds was found to have an average porosity of 20 percent, a residual water saturation of 12.4 percent of the porosity, and a residual oil saturation of 1.8 percent of the porosity.

Groundwater

There is one water bore in the Sheet area at Wollogorang Homestead, where plentiful potable water has been obtained from the Aquarium Formation. Surface water in the form of waterholes and springs on the major streams is adequate for present needs.

BIBLIOGRAPHY

A.G.G.S.N.A., 1939 - Report for period ended 30th June, 1939. Aer.Surv.N.Aust.

A.G.G.S.N.A., 1940a- Report for period ended 31st December, 1939. Ibid.

A.G.G.S.N.A., 1940b- Report for period ended 30th June, 1940. Ibid.

BATTEY, G.C., 1956 - Calvert Authority to Prospect. Final report 1956 field season. Mt Isa Mines Ltd, Tech. Rep. (unpubl.)

BATTEY, G.C., 1957 - Final report on the "Mucpa" Authority to prospect No.78M. Mt Isa Mines Ltd, Tech. Rep. 9:15 (unpubl.)

BATTEY, G.C., 1958 - Final Report "Calvert" Authority to Prospect No.511. Mt. Isa Mines Ltd, Tech. Rep. 9.19 (unpubl.)

BENEDICT, P.C., and KING, H.F., 1948 - The Wollogorang - Redbank Area. Zinc Corp. Ltd (unpubl.)

BLANCHARD, R., 1940 - Report on Wollogorang - Redbank Copper District, Northern Territory. Australian Mining and Smelting Co.Ltd (unpubl.)

CARTER, E.K., 1959a- Westmoreland - Bur.Min.Resour.Aust. Explan.Note Ser., 14.

CARTER, E.K., 1959b- New stratigraphic units in the Precambrian of north-western Queensland. Qld Govt Min.J., 60,437-441.

CARTER, E.K., and BROOKS, J.H., 1960 - The Precambrian of north-western Queensland. J.geol.Soc.Aust., 7,21-62.

CARTER, E.K., BROOKS, J.H., and WALKER, K.R., 1962 - The Precambrian mineral belt of north-western Queensland. Bur.Min.Resour.Aust.Bull.51.

CARTER, E.K., and ÖPIK, A.A., 1961 - Lawn Hill 4-mile Geological Series Sheet E54-9. Bur.Min.Resour.Aust. Explan.Note, Ser. 21.

C.S.I.R.O., 1950 - Survey of Barkly region, 1947-48. Sci.ind.Res.org.,Melb., Land Res.Ser.3.

DAVID, T.W.E., 1932 - EXPLANATORY NOTES TO ACCOMPANY A NEW GEOLOGICAL MAP OF THE COMMONWEALTH OF AUSTRALIA. Melbourne, C.S.I.R.

DIXON, L.H., 1957 - Geological studies on Calvert Hills Station, N.T. Frome report No.5300-G-10 (unpubl.)

DUNN, P.R., SMITH, J.W., and ROBERTS, H.G., 1962 - Geology of the Carpentaria Upper Proterozoic Province Part I: Roper River to the Queensland-Northern Territory Border. Bur.Min.Resour.Aust.Bull. (in preparation).

FIRMAN, J.B., 1959a- The copper deposits of the Redbank Copper Field, Northern Territory, Bur.Min.Resour.Rec. 1959/48 (unpubl.)

FIRMAN, J.B., 1969b- Notes on the Calvert Hills 4-mile geological sheet E53-8. Bur.Min.Resour. Rec.1959/50 (unpubl.).

GREGORY, A.C., 1961 - North Australian expeditions. S.Aust. parl. Pap., 3, (No.170)

HANEY, T.H., 1957 - Final Report on "Robinson River" Authority to Prospect No. 545, Northern Territory. Mt Isa Mines Ltd, tech Report 9.16. (unpubl.)

JENSEN, H.I., 1940 - The Redbank (or Wollogorang) copper field Northern Territory. Aer.Surv.N.Aust.,

JENSEN, H.I., 1942 - Report on portion of North-western Queensland adjacent to Northern Territory border. Ibid, Qld Rep. 47 (unpubl.)

KRIEWALDT, M., 1957 - "Bauhinia" Authority to Prospect. No. 510, joint agreement. Mt Isa Mines Ltd, tech. Rep. 9-17 (unpubl.).

LIVINGSTONE, D.F., 1957 - Airborne scintellograph survey of the Nicholson River region. Northern Aust. Rec. Territory and Queensland. Bur.Min.Resour Aust. Rec. 1957/57 (unpubl.).

LORD, J.H., 1955 - Report on an inspection of a uranium find of Pandanus Creek, Northern Territory. Bur.Min.Resour.Aust.Rec. 1955/63 (unpubl.).

LORD, J.H., 1956 - Report on an inspection of uranium discoveries in the Calvert Hills area, Northern Territory. Bur.Min.Resour.Aust. Rec. 1956/115 (unpubl.).

MANSER, W., 1957 - "Calvert Authority to Prospect No.511. Progress report No.1. Period 30/4/57 to 31/5/57. Mt. Isa Mines Ltd (unpubl.)

McANDREW, J., and EDWARDS, A.B., 1957a - Radioactive ore from Milestone, North-west Queensland. Sci.ind.Res.Org., Melb., Mineragr.Inv.Rep. 680

McANDREW, J., and EDWARDS, A.B., 1957b - Radioactive specimens from the Milestone lease, North-west Queensland. Ibid., 721.

McANDREWS, J., 1958 - Sklodowskite from Cobar No. 2 prospect, Northern Territory. Proc.Aust.Inst.Min. Metall., Stillwell Anniversary Volume, 169-175.

MURRAY, K.J., 1953 - Calvert Hills - manganese deposits. Australian Mining and Smelting Co.Ltd. (unpubl.)

NEWTON, H.J., and McGRATH, M.G., 1958 - The occurrence of uranium in the Milestone Authority to Prospect, Wollogorang district, Northern Territory Proc.Aust.Inst.Min.Metall.,Stillwell Anniversary Volume, 177-184.

NOAKES, L.C., 1956 - Upper Proterozoic and Sub-Cambrian rocks in Australia. In EL SISTEMA CAMBRICO, SU PALAEOGEOGRAFIA Y EL PROBLEMA DE SU BASE, 2,1-24. 20th int. geol. Cong. Mexico.

NOAKES, L.C., and TRAVES, D.M., 1954 - Outline of the geology of the Barkly region. In SURVEY OF BARKLY REGION, 1947-48. Sci.ind.Res.Org., Melb., Land Res.Ser.3.

PHILLIPS, D.W., and LAWRENCE, L.J., 1957 - New South Wales University of Technology, unpublished data.

SKWARKO, S.K., 1961 - Progress report on the field activities in the Northern Territory during the 1961 field season. Bur.Min.Resour.Aust.Rec. 1961/153 (unpubl.)

SKWARKO, S.K., 1962 - Notes on Australian Lower Cretaceous Palaeogeography. Bur.Min.Resour.Aust. Rec. 1962/11 (unpubl.)

SMITH, J.W., 1962 - Bauhinia Downs 1:250,000 Geological Series Sheet Se 53-3. Bur.Min.Resour. Aust. Rec. 1962/111 (unpubl.).

SMITH, J.W., and ROBERTS, N.G., 1962 - Mount Drummond 1:250,000 Geological Series SE 53-12. Bur.Min. Resour. Aust. Rec 1962/113 (unpubl.)

STEWART, C.A., 1954 - Geomorphology of the Barkly region. In SURVEY OF BARKLY REGION, 1947-48. Sci.ind.Res.Org., Melb., Land Res.Ser.3, 42-58.

WALPOLE, B.P., 1957 - Report on inspection of uranium occurrences and airborne radiometric anomalies, Westmoreland area, North-west Queensland. Bur.Min.Resour.Aust.Rec. 1957/40. (unpubl.)

YATES, K.R., - Robinson River 1:250,000 Geological Series Sheet Se 53-4. Bur.Min.Resour. Aust. Rec. 1962/119 (unpubl.).

TABLE I STRATIGRAPHY OF THE CALVERT HILLS SHEET AREA

ERA	PERIOD	GROUP	STRATIGRAPHIC UNIT	MAP SYMBOL	LITHOLOGY	THICKNESS IN FEET	PHYSIOGRAPHIC EXPRESSION	DISTRIBUTION	ECONOMIC GEOLOGY	REMARKS
CAINOZOIC	QUATERNARY			Qa	Alluvium		Level to gently sloping plains along main watercourses.	Mainly in north-east and south east.	Contains cassiterite in south-east.	Differentiated on map only where aerially important.
				Czs	Soil, sand ferruginous cemented detritus		Thin veneers on hill-slopes; plateaux; plains.	Universal		
				Czb	Black soil		Plains	Barkly-Beetaloo Tableland		Possibly developed on Cambrian carbonate rocks.
				Czl	Lateritic soil, laterite		Plains	Mainly on Barkly-Beetaloo Tableland.		May be of two ages.
MESOZOIC	LOWER CRETACEOUS		Not named	Kl	Siltstone, sandy siltstone, quartz sandstone, pebble to boulder conglomerate.	Maximum observed: 200, (top not exposed).	Broad plateaux; where dissected - mesa topography	Widespread, but mainly in the headwaters of Gulf bound streams.		Contains both shelly and plant fossils. Unconformable on Bukalara Sandstone.
PALAEOZOIC	(?)LOWER CAMBRIAN		Bukalara Sandstone	Ꞓlb	Feldspathic sandstone, quartz sandstone, pebble and cobble conglomerate.	Maximum observed: 300, (top not exposed).	Dissected plateau in north-west; outcrops poorly in south.	Bukalara Plateau. Scattered exposures in south.		Unconformable on Upper Proterozoic rocks. Jointed.
PRECAMBRIAN	UPPER PROTEROZOIC	SOUTH NICHOLSON	Mitticbah Sandstone	Bsi	Quartz sandstone, feldspathic sandstone, arkose.	Ranges from 0 to 1500. Up to 9,000 on Mount Drummond Sheet area.	Low strike ridges	South Nicholson Basin. Only few small exposures in south-west of Sheet area.		Extensively exposed on Mount Drummond Sheet area.
			Mullera Formation	Bsl	Micaceous siltstone, shale; quartz sandstone, glauconitic sandstone, ferruginous sandstone and siltstone, ironstone.	Ranges from 0 to 1000 (top not exposed). Up to 8,000 on Mount Drummond Sheet area.	Rounded hills and rubble-covered rises.	South Nicholson Basin	Contains minor ironstone beds.	Contains Constance Range iron deposits (Lawn Hill Sheet area).
			Constance Sandstone	Bsa	Exluding Members: medium grained quartz sandstone, very minor siltstone interbeds	Maximum observed: 1700, (including Members).	Resistant, dissected plateaux; marked by strong scarps where less resistant Members present. The Members are poorly exposed in valleys.			Members differentiated on Mount Drummond Sheet area, but not on Westmoreland or Lawn Hill Sheet areas. Unconformably overlies Fickling Beds. Jointed
			Wallis Siltstone Member	Bsw	Micaceous siltstone, glauconitic siltstone. Minor fine grained sandstone interbeds.	Maximum observed: 250 Unit is lenticular.				
			Pandanus Siltstone Member	Bsp	Micaceous siltstone, minor medium grained quartz-sandstone interbeds.	Maximum observed: 200				
		McARTHUR	Karns Dolomite	Bmk	Dolomite, algal dolomite, dolarenite; laminated, oolitic and algal chert; dolomitic siltstone and sandstone, silty and sandy dolomite, oolitic chamosite-dolomite.	Maximum observed: 300, (top not exposed). Probably about 500.	Low, undulating hills with dendritic drainage and pronounced resistant benches.	McArthur Basin. Northern part of Sheet area.	Contains disseminated galena and chalcopyrite in Calvert Hills district.	Unconformably overlies Masterton Formation.
			Fickling Beds	Bmf	Dolomitic sandstone, quartz-sandstone, siltstone, oolitic chert, banded chert, dolomitic siltstone, dolomite, quartzitic feldspathic dolomite, feldspathic sandstone, chert breccia, pebble conglomerate.	Maximum observed 3,000, (top not exposed, base not exposed).	Varies according to lithology and structure. In general rugged low hilly country with resistant ridges and benches.	South Nicholson Basin.	Contains galena and copper minerals near Queensland border.	Formerly mapped (Firman, 1959b and Carter, 1959a) as "Wollogorang Formation". Locally unconformable on Fish River Formation.
		TAWALLAH GROUP	Fish River Formation	Btf	Feldspathic sandstone, quartz sandstone, basic to intermediate lavas.	Ranges from 250 to 700. Lavas lens out in places.	Cuestas and hogbacks.	South Nicholson Basin. South eastern part of Sheet area.		Locally unconformably overlain by Fickling Beds. Rests unconformably on Peters Creek Volcanics.
			Packsaddle Microgranite	Bgr	Pink porphyritic microgranite.	-	Resistant, elevated, dome-like ridge, partly dissected	North-east corner		Intrudes Gold Creek Volcanic Member. Possibly emplaced during extrusion of Hobblechain Rhyolite Member.

TABLE I STRATIGRAPHY OF THE CALVERT HILLS SHEET AREA (Continued)

ERA	PERIOD	GROUP	STRATIGRAPHIC UNIT	MAP SYMBOL	LITHOLOGY	THICKNESS IN FEET	PHYSIOGRAPHIC EXPRESSION	DISTRIBUTION	ECONOMIC GEOLOGY	REMARKS
PRECAMBRIAN	UPPER PROTEROZOIC	TAWALLAH	Masterton Formation	Btn	Excluding Members: Red medium grained quartz sandstone, locally feldspathic and with polymictic conglomerate lenses; white, medium grained, feldspathic sandstone.	Ranges from about 500 to 1,500 (including Members).	Resistant elevated plateaux; rounded hills protruding through Karns Dolomite	McArthur Basin. Northern parts of Sheet area.		Unconformably overlain by Karns Dolomite. Jointed.
			Nobblechain Rhyolite Member	Bth	Porphyritic rhyolite	Maximum observed: 200 Lenses out to south.	Exposed as horizontal bench	McArthur Basin. North east part of Sheet area.		Conformably overlies the Gold Creek Volcanic Member.
			Gold Creek Volcanic Member	Btg	Basalt, trachyte, volcanic agglomerate and breccia. Tuffaceous siltstone, tuffaceous sandstone, dolomitic lithic sandstone.	Measured: 430 Variable. Thickest in east.	Where dissected forms roughly rounded hills.	McArthur Basin. Northern parts of Sheet area.	Contains copper minerals, mined in Redbank district.	Forms base of Masterton Formation in Redbank district.
			Wollogorang Formation	Bto	Dolomitic siltstone, dolomite, algal dolomite, silty and sandy dolomite, dolomitic feldspathic sandstone.	Measured: 600 (Wollogorang district). Thins to about 300 in west.	Poorly resistant, except for upper (sandstone) beds. Usually occurs in scarp with minor benches.	General within the McArthur Basin	Contains occasional scattered crystals of chalcopyrite.	Basal beds may have been, in places, intruded by sills (mapped as Settlement Creek Volcanics).
			Settlement Creek Volcanics	Bte	Andesine-basalt, minor volcanic agglomerate, tuffaceous siltstone, tuff.	About 500.	Poorly resistant. Occupies valleys; outcrops poorly as low, rounded hills.			Probably contains numerous sills and dykes.
			Aquarium Formation	Btq	Medium grained, purple, ferruginous glauconitic sandstone, green micaceous glauconitic siltstone, glauconitic dolomitic siltstone, dolomitic siltstone, dolomite.	Measured: 550 (south-west of Calvert Hills Homestead). Constant.	Less resistant than Sly Creek Sandstone, usually preserved only on dip slopes of Sly Creek Sandstone			Formerly mapped (Firman, 1959b and Carter, 1959a) as "Constance sandstone". Occasional joints.
			Sly Creek Sandstone	Btl	Medium grained, flaggy quartz sandstone, very minor feldspathic sandstone.	Measured: 565 (south-west of Calvert Hills Homestead). Constant.	Broad cuestas. Resistant, forms steep sided gorges where dissected.			
			McDermott Formation	Btd	Dolomitic siltstone, silty and sandy dolomite, oolitic dolomite, glauconitic sandstone, dolomitic sandstone, quartz sandstone, dolarenite, dolutite.	Maximum observed: 3,000 (base not exposed). Lenses out to south-east.	Benches when horizontal; low undulating country when dipping. Less resistant than Sly Creek Sandstone.		Contains occasional scattered crystals of chalcopyrite.	Formerly mapped (Firman, 1959b and Carter, 1959a) as "Wollogorang Formation".
			Peters Creek Volcanics	Btp	Andesine basalt, volcanic agglomerate, tuff, tuffaceous siltstone.	Estimated maximum: 3,400.	Rounded to benched hills, more prominent near base.	Southern part of McArthur Basin	Strong uranium mineralisation near base of unit (e.g. Cobar II).	In McArthur Basin overlain conformably by McDermott Formation. To south unconformably overlain by Fish River Fm.
			Carolina Sandstone Member	Btc	Fine to medium grained feldspathic sandstone.	Estimated maximum 200. Lenses out in places.	Cuestas and hogbacks	Minor exposure 10 miles north of Nicholson River near Queensland Border		
			Westmoreland Conglomerate	Btw	Quartz-sandstone, arkose, feldspathic sandstone, conglomerate.	Estimated maximum: 5,400 in Fish River gorge.	Series of prominent strike ridges. Basal scarp up to 400 feet high.		Weak uranium mineralisation near top. Numerous areas of anomalous radioactivity within.	Unconformably overlies Cliffdale Volcanics. Jointed.
	LOWER PROTEROZOIC		Norris Granite	Bgo	Late-stage: fine- to medium-grained pink leucocratic granite, aplitic in places. Early-stage: medium-grained biotite granite and adamellite.	-	Rough hills	South-eastern part of Sheet area	Contains cassiterite, mined at Crystal Hill.	Intrudes Cliffdale Volcanics. Intruded in two stages.
			Cliffdale Volcanics	Blc	Dark grey to pink hypohyaline dacite, rhyodacite and rhyolite porphyritic in feldspar and quartz; minor tuff, agglomerate.	No estimate possible	Prominent rounded hills with dendritic drainage.		Contains copper minerals (Norris' Mine), uranium minerals (Pandanus' Mine) wolfram, cassiterite.	Unconformably overlies Murphy Metamorphics, intruded by Norris Granite. Unconformably overlain by Westmoreland Conglomerate.
			Nicholson Granite	Bgn	Coarse grained porphyritic biotite granite, fine to medium even grained muscovite granite	-	Low-lying, largely soil covered areas.	East-west trending belt north and west of the Nicholson River.	No known mineralisation, but little prospected in west of area.	Intrudes Murphy Metamorphics.
			Murphy Metamorphics	Blm	Red muscovite haematite schist, quartz-muscovite-biotite schist, quartz-potash feldspar-biotite gneiss.	No estimate possible	Low, undulating rises in west, very poorly exposed in east.			Isoclinally folded. Unconformably overlain by Cliffdale Volcanics.

TABLE 2

TECTONIC HISTORY - CALVERT HILLS SHEET AREA

CAINOZOIC	EROSION, Development of SOILS, ALLUVIUM, possibly some LATERITE
	Epeirogenic UPLIFT
	LATERITE FORMATION
	Slow epeirogenic UPLIFT, MARINE REGRESSION, PENEPLANATION
LOWER CRETACEOUS	ARENITE-LUTITE DEPOSITION : Local freshwater deposition initially, then general marine deposition. (120'+) ✱
	Epeirogenic SUBSIDENCE, MARINE TRANSGRESSION
	EROSION
	Epeirogenic UPLIFT, JOINTING, FAULTING, MARINE REGRESSION
LOWER CAMBRIAN	ARENITE DEPOSITION : Bukalara Sandstone (300'+)
	Epeirogenic SUBSIDENCE, MARINE TRANSGRESSION

		(SOUTH NICHOLSON BASIN)	(MURPHY TECTONIC LAND)	(McARTHUR BASIN)
UPPER PROTEROZOIC		MARINE REGRESSION, FOLDING, FAULTING, UPLIFT, EROSION		
	SOUTH NICHOLSON GROUP	LUTITE DEPOSITION?	Slow EROSION	Slow EROSION
		ARENITE DEPOSITION: Mittiebah Sandstone (1500'+)		
		ARENITE-LUTITE DEPOSITION: Mullera Formation (1000'+)		
		ARENITE DEPOSITION: Constance Sandstone (1700'+)		
		SUBSIDENCE, MARINE TRANSGRESSION		
	McARTHUR GROUP	EROSION	STABLE	STABLE. MARINE REGRESSION
		UPLIFT	Slow EROSION	CARBONATE DEPOSITION: Karns Dolomite (300')
		CARBONATE DEPOSITION: Fickling Beds (3000'+)		STABLE. MARINE TRANSGRESSION
		SUBSIDENCE		EROSION
		EROSION		UPLIFT, probably FAULTING
		UPLIFT, FAULTING		
	TAWALLAH GROUP AND EQUIVALENTS	ARENITE DEPOSITION: AND VULCANISM: Fish River Formation (400')		ARENITE DEPOSITION, VULCANISM: AND INTRUSION: Masterton Formation (1000'); Packsaddle Microgranite
		SUBSIDENCE, MARINE TRANSGRESSION		CARBONATE DEPOSITION: Wollogorang Formation (600') VULCANISM: Settlement Creek Volcanics (500') ARENITE-LUTITE DEPOSITION: Aquarium Formation (550') ARENITE DEPOSITION: Sly Creek Sandstone (550') CARBONATE DEPOSITION: McDermott Formation (3000')
		Slow EROSION		
		Slow UPLIFT	Slow UPLIFT	
		VULCANISM: Peters Creek Volcanics (200'+) ARENITE DEPOSITION: Upper parts of Westmoreland Conglomerate (350')	VULCANISM: Peters Creek Volcanics (300'+) ARENITE DEPOSITION: Upper parts of Westmoreland Conglomerate (350')	VULCANISM: Peters Creek Volcanics (3400')
		Slight SUBSIDENCE, MARINE TRANSGRESSION	Slight SUBSIDENCE; MARINE TRANSGRESSION	
		Periodic slow and rapid EROSION	Periodic slow and rapid EROSION	
		Periodic UPLIFT	Periodic UPLIFT	SUBSIDENCE, MARINE TRANSGRESSION

LOWER PROTEROZOIC	EROSION
	UPLIFT, moderate FOLDING, FAULTING
	INTRUSION : Norris Granite
	VULCANISM : Cliffdale Volcanics
	EROSION
	OROGENY : INTRUSION : Nicholson Granite FOLDING and METAMORPHISM : Isoclinal folding of the geosynclinal rocks, producing the regionally metamorphosed Murphy Metamorphics.
	DEPOSITION : Geosynclinal sediments and volcanics.

✱ Thicknesses of the various stratigraphic units, (shown in parenthesis) are the maximum observed on the Sheet area.

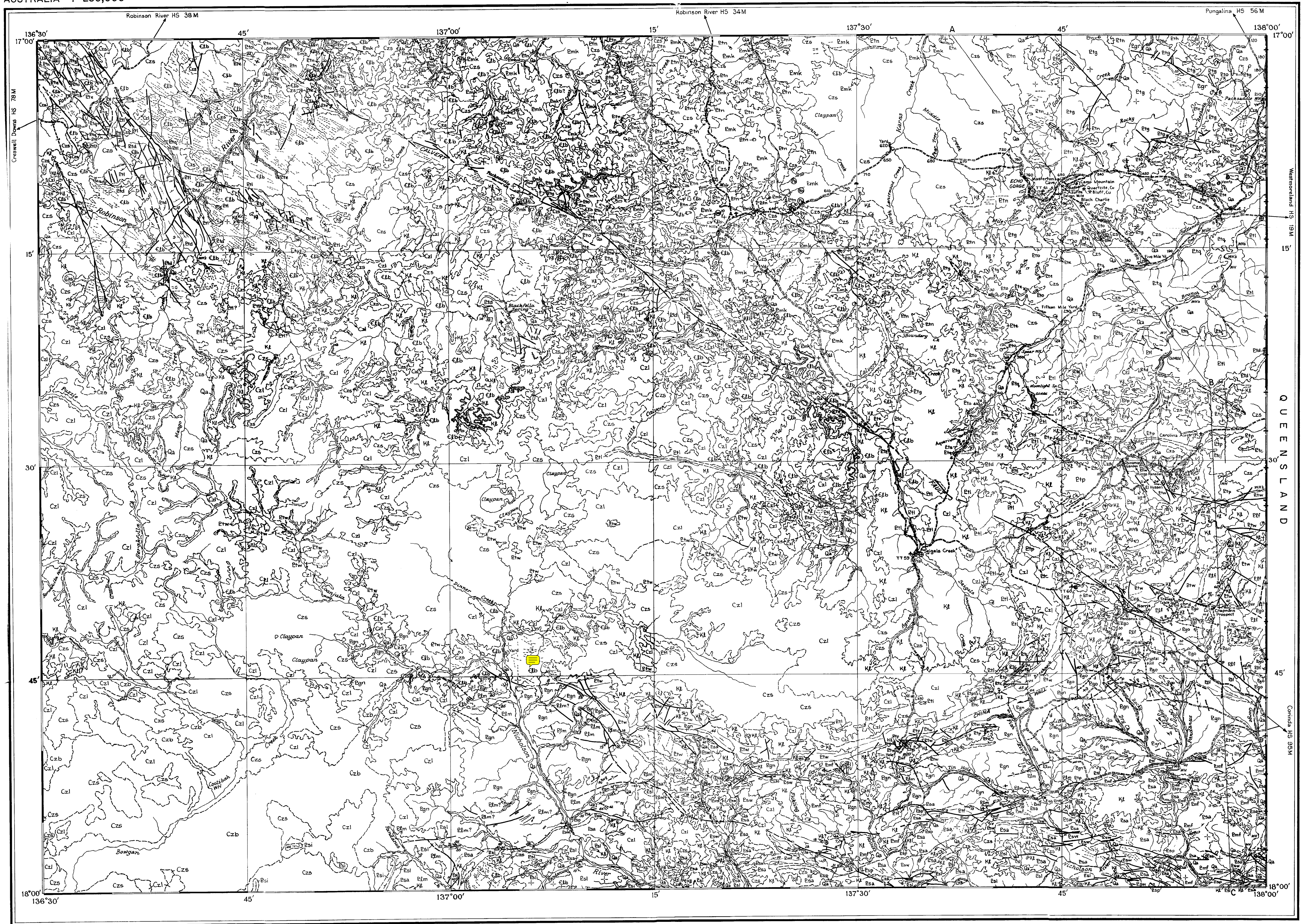
PRELIMINARY EDITION, 1962
SUBJECT TO AMENDMENT

CALVERT HILLS

NORTHERN TERRITORY

AUSTRALIA 1:250,000

1:250,000 GEOLOGICAL SERIES SHEET SE 53-8



Reference

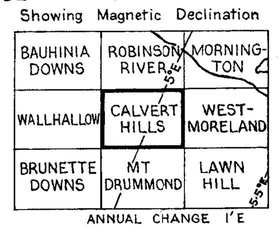
CAINOZOIC	QUATERNARY		Qa	Alluvium
	UNDIFFERENTIATED		Czs	Soil, sand, ferruginous cemmented detritus
			Czb	Black soil
			Czl	Lateritic soil, laterite
PALAEOZOIC MESOZOIC	LOWER CRETACEOUS		Kl	Siltstone, sandy siltstone, quartz sandstone, pebble to boulder conglomerate
	LOWER CAMBRIAN	Bukalara Sandstone	€lb	Feldspathic sandstone, quartz sandstone, pebble to boulder conglomerate
PRECAMBRIAN	UPPER PROTEROZOIC	South Nicholson Group: Mittiebah Sandstone	Psi	Quartz sandstone, feldspathic sandstone, arkose
		Mullera Formation	Psl	Micaceous siltstone, shale; quartz sandstone, glauconitic sandstone, ferruginous sandstone and siltstone, ironstone
		Constance Sandstone	Psa	Medium-grained quartz sandstone, very minor siltstone interbeds
		Wallis Siltstone Member	Psw	Micaceous siltstone, glauconitic siltstone. Minor fine-grained sandstone interbeds
		Pandanus Siltstone Member	Psp	Micaceous siltstone, minor medium-grained quartz sandstone interbeds
		McArthur Group: Karns Dolomite	Pmk	Dolomite, algal dolomite, dolarenite; laminated, oolitic and algal chert; dolomitic siltstone and sandstone, silty and sandy dolomite, oolitic chamosite-dolomite
		Fickling Beds	Pmf	Dolomitic sandstone, quartz sandstone, siltstone, oolitic chert, banded chert, dolomitic siltstone, dolomite, quartzitic feldspathic dolomite, feldspathic sandstone, chert breccia, pebble conglomerate
		Packsaddle Microgranite	Pgr	Pink porphyritic microgranite
		Tawallah Group: Fish River Formation	Ptf	Feldspathic sandstone, quartz sandstone; Basic to intermediate lavas
		Masterton Formation	Ptn	Red medium-grained quartz sandstone, locally feldspathic and with polymictic conglomerate lenses; white medium-grained, feldspathic sandstone
		Hobblechain Rhyolite Member	Pth	Porphyritic rhyolite
		Gold Creek Volcanic Member	Ptg	Basalt, trachyte, volcanic agglomerate and breccia. Tuffaceous siltstone, tuffaceous sandstone, dolomitic lithic sandstone
		Wollogorang Formation	Pto	Dolomitic siltstone, dolomite, algal dolomite, silty and sandy dolomite, dolomitic feldspathic sandstone
		Settlement Creek Volcanics	Pte	Andesine basalt, minor volcanic agglomerate, tuffaceous siltstone, tuff
		Aquarium Formation	Ptq	Medium-grained, purple, ferruginous glauconitic sandstone, green micaceous glauconitic siltstone, glauconitic dolomitic siltstone, dolomitic siltstone, dolomite
		Sly Creek Sandstone	Ptl	Medium-grained, flaggy quartz sandstone, very minor feldspathic sandstone
		McDermott Formation	Ptd	Dolomitic siltstone, silty and sandy dolomite, oolitic dolomite, glauconitic sandstone, dolomitic sandstone, quartz sandstone, dolarenite, delutite
		Peters Creek Volcanics	Ptp	Andesine basalt, volcanic agglomerate, tuff, tuffaceous siltstone
		Carolina Sandstone Member	Ptc	Fine to medium-grained feldspathic sandstone
		Westmoreland Conglomerate	Ptw	Quartz sandstone, arkose, feldspathic sandstone, conglomerate
	LOWER PROTEROZOIC	Norris Granite	Pgo	Fine to medium-grained pink leucocratic granite, aplitic in places; White medium-grained biotite granite, and adamellite
		Cliffdale Volcanics	Plf	Dark grey to pink dacite, rhyodacite and rhyolite with feldspar and quartz phenocrysts; Minor Minor tuff, agglomerate
		Nicholson Granite	Pgn	Coarse-grained porphyritic biotite granite, fine to medium, even grained muscovite granite
		Murphy Metamorphics	Plm	Red muscovite haematite schist, quartz-muscovite-biotite schist, quartz-potash feldspar-biotite gneiss

Geological boundary
Fault
Anticlinal axis, showing plunge
Synclinal axis
Where location of boundaries, faults and folds is approximate, line is broken; where inferred, queried; where concealed, boundaries and folds are dotted, faults are shown by short dashes.
Dome
24 Strike and dip of strata
Vertical strata
Horizontal strata
Trend of bedding showing direction of dip / Horizontal strata / Joint pattern — air-photo interpretation
30 Generalised strike and dip of strata
70 Strike and dip of cleavage
Strike of cleavage, dip indeterminable
Strike and dip of foliation
Vertical foliation
70 Strike and dip of joints
Vertical joints
Plunge of dragfold
Dyke or vein: d-dolerite m-microgranite p-porphyry q-quartz

Macrofossil locality
Plant fossil locality
TT50 Text reference to fossil locality
x1 Age determination sample locality
Mine or prospect
Cu Copper
Mn Manganese
Pb Lead
Sn Tin
U Uranium
W Wolfram
(Circle around symbol denotes unexploited deposit)
Extinct volcanic vent
Vehicle track
Homestead
Yd Yard
WH Waterhole
S Spring
B Bore with windpump
Fence
Landing field
Scarp
Astro station
310 Spot height in feet, barometric (datum: mean sea level)
U147 Trig. Station, height in feet

Compiled and published 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.

INDEX TO ADJOINING SHEETS
Showing Magnetic Declination



Scale 1:250,000

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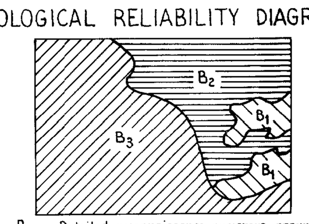
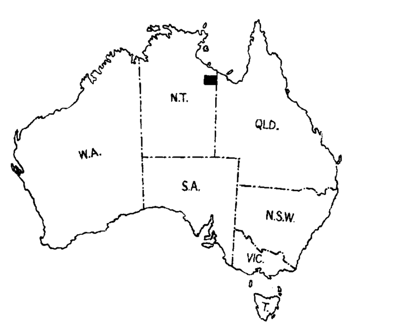
5 0 5 10 15 20 25 KILOMETRES

GEOLOGICAL RELIABILITY DIAGRAM



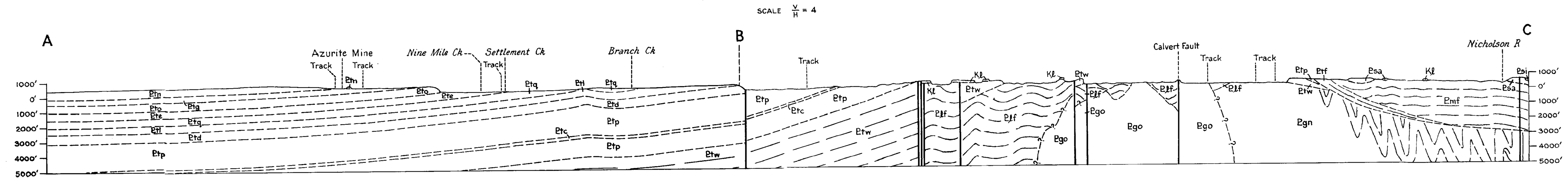
B_1 Detailed reconnaissance, numerous ground traverses, with air-photo interpretation.
B_2 Ground traverses, with air-photo interpretation.
B_3 Helicopter traverses, with air-photo interpretation.

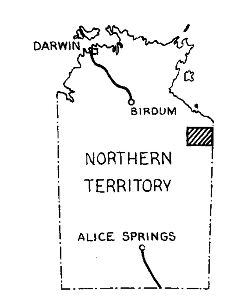
Geology, 1957-1961, by: J.B.Firman, M.C.Johnstone, H.G.Roberts, K.A.Plumb, A.G.L.Paine, J.M.Rhodes, K.R.Yates.
Compiled, February 1962, by: K.R.Yates, J.M.Rhodes, F.J.Roberts, A.S.Mikolajczak.
Drawn, May 1962, by: F.J.Roberts.



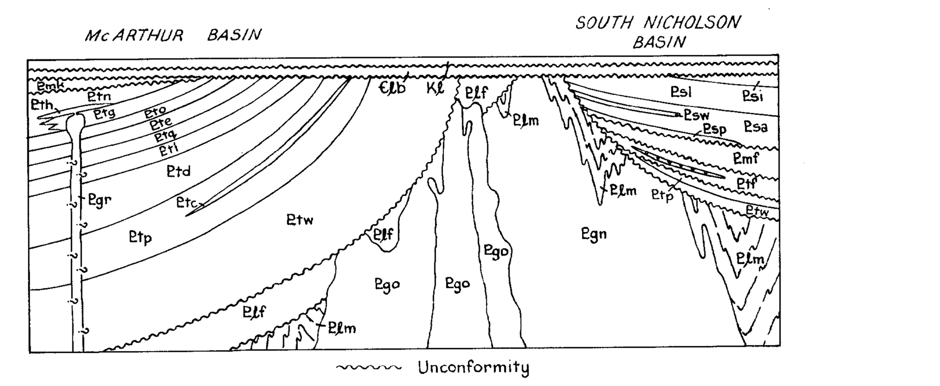
Section

Folding schematic
(Cainozoic units omitted from section)





DIAGRAMMATIC RELATIONSHIP OF ROCK UNITS



Unconformity

CALVERT HILLS
SHEET SE 53-8