### 1:250 000 GEOLOGICAL MAP SERIES

#### EXPLANATORY NOTES

**HUCKITTA SF53-11**

M.J. FREEMAN

GEOPHYSICS BY P. WOYZBUN

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Government Printer of the Northern Territory

Darwin 1986
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### Map

1:250 000 Geological Map of Huckitta (SF53-11) in pocket
ABSTRACT

The Huckitta 1:250 000 map sheet area, NE of Alice Springs, was remapped during 1980-1983 by geologists of the Northern Territory Geological Survey and the Bureau of Mineral Resources.

The geology on this map sheet area consists of two main units; a basement, in which igneous rocks have intruded metamorphic rocks, and an overlying sequence of sedimentary rocks.

The basement, termed the Arunta orogenic domain, consists of the granulite and amphibolite facies metamorphic rocks which originated as sediments and felsic to mafic volcanogenic rocks in an east-west trough. Severe deformation and metamorphism at about 1.8 Ga was soon followed by extensive granite intrusions.

Cover rocks of the epeiric Georgina Basin were deposited from about 0.9 Ga until the Devonian. Deposition was initially confined to troughs but a subsequent regional transgression resulted in sheet-like accumulations. Palaeozoic sediments were deposited intermittently, culminating in the mainly fluvial and aeolian sands of the Devonian Dulcie Sandstone.

Reactivation of basement faults, and the concomitant generation of retrograde schist-zones up to several kilometres wide, followed. This event is correlated with the Carboniferous Alice Springs orogeny, and resulted in folding and faulting of the sedimentary rocks. During this tectonism there was significant uplift of the rocks in the southern part of the map sheet area. Subsequently only epeirogenic activity occurred.

During Cainozoic time, there were intermittent pluvial periods during which sediments were deposited in localised intermontaine basins and extensive fans formed. Subsequent aridity was accompanied by the spreading of a veneer of sand across lowlands.

Strata-bound copper-lead-zinc mineralization, associated with magnetite-rich rocks and some calcareous rocks, is located at the Jervois Mine, and scheelite-molybdenite mineralization in skarn at the Molyhil Mine. Numerous scheelite prospects in the Bonya Schist are in skarn-like epidote-quartz-garnet rock. Until about 1960 mica was mined from pegmatites within Harts Range Group rocks at the Plenty River Mining Field and in the Harts Range.

INTRODUCTION

The HUCKITTA* map sheet area, bounded by latitudes 22°S and 23°S and longitudes 135°E and 136°30'E, is centred 230 km NE of Alice Springs (Figure 1). Constituent 1:100 000 map sheets are shown on the title page.

There are no townships, and only the Aboriginal settlements at Baikal, Derry Downs and MacDonald Downs have populations in excess of 15. Other habitations include the Molyhil and Jervois mine camps (both currently under care-and-maintenance), nine pastoral lease homesteads, and a miners' homestead at Baikal (Figure 2).

Authorised landing areas are located near the homesteads of Lucy Creek, Jervois and Huckitta and there are landing grounds suitable for light aircraft at the remaining settlements.

The unsealed Plenty Highway is joined to most settlements with formed, gravel roads. All other vehicle tracks are of graded-earth standard.

Climatic statistics within the sheet area are available only for Jervois Homestead (since 1967). Mean diurnal temperature ranges in January are 22.0° C to 37.9° C and in July are 4.7° C to 21.7° C, and with frost on 13 days per annum. Annual average rainfall is 333 mm, of which 211 mm falls in the period December to March. The average 3 PM relative humidity is 13 percent, which, coupled with the high temperatures, results in extremely dehydrating conditions. Alice Springs, the nearest recording station, has an annual average evaporation of 2.9 m (Average for period 1967-1983).

The geology of HUCKITTA was first described in total by Smith (1964a).

Most sedimentary and metamorphic rock terms are based on Bates and Jackson (1980), sandstone names on Pettijohn and others (1973), igneous rock names on Streckeisen (1976) and many of the geomorphological terms used are defined in Twidale (1982). Some elaboration of terms is in Appendix 1. Only geological data available by mid-1984 was included in this report.

PHYSIOGRAPHY

The physiography of central Australia was described by Mabbutt (1962, 1967). His subdivisions have been simplified and modified to produce Figure 3 which illustrates the broad physiographic regions of HUCKITTA. The subdivisions, which correlate well with the underlying bedrock, are described in Table 1.

REGIONAL GEOLOGY

The basement rocks of central Australia consist of crystalline metamorphic and igneous rocks of the Arunta orogenic domain (usage after Geological Society of Australia, [1971], as refined by Rutland, [1981]). This crystalline basement grades into sedimentary rocks, The Granites-Tanami and Tennant Creek orogenic domains. These domains constitute the southern part of the North Australia Orogenic Province of Rutland (1981). Intracratonic Adelaideon (sensu stricto, correlated with the Adelaide Geosyncline sedimentary sequence of late Proterozoic age [Parkin, 1969]) and Palaeozoic marine and terrestrial sedimentary sequences of the Georgina, Ngala and Amadeus basins overlie the basement.

The Arunta orogenic domain is generally considered under both tectonic, or structural, and stratigraphic subdivisions (Figure 4). Under the former, three major east-west Tectonic Zones (the Northern, Central and Southern) are recognised (Figure 5); (Shaw and Stewart, 1976). The zones are separated by deformed belts. In HUCKITTA, the Delny-Mount
Sainthill Fault Zone separates the Northern from the Central Tectonic Zone. Within each of the zones, the rocks have been disrupted into many discrete fault-bound blocks. Where these blocks can be clearly defined they are named, and those in HUCKITTA are shown on the map face and in the inset in Figure 6. Under the stratigraphic classification, there are three Divisions (Figure 4) which are defined on generalised gross lithology and should not be interpreted on a chronostratigraphic basis (Shaw and Stewart, 1975). However, in a broad sense they can be so used, although convergent petrogenetic processes could have produced similar lithological assemblages at different times. The divisions are subdivided into formal and informal lithostatigraphic units under group, formation and member status. Severely deformed rocks, produced in retrograde schist zones by later tectonism, and syntectonic and posttectonic intrusive rocks are not included in the Divisions. The distribution of the divisions in the Arunta orogenic domain is shown in Figure 6.

The Arunta orogenic domain is a medium to high-grade metamorphic terrain which originated as an accumulation of sedimentary and volcanogenic rocks in an east-west trough coinciding with the Central Tectonic Zone of Shaw and Wells (1983). With time, the trough broadened to include the Northern and Southern tectonic zones, and the composition of sediment, which was being supplied to the basin, matured.

Division 1 rocks are felsic and mafic granulites, thought to represent metamorphosed mafic and felsic volcanogenic rocks with a small proportion of pelitic and calcareous sediment. Division 2 rocks are mainly schistose pelitic metasediments and quartzofeldspathic gneisses, some of which are probably meta-acid volcanics, with minor mafic rocks. Division 3 rocks consist of schistose, pelitic metasediments, and metaquartzite. The divisions are separated by unconformities (Shaw and Warren, 1975; Ofte and Shaw, 1983). The generalised distribution of the divisions, and of the rock groupings within, is shown in Figure 5. The increasing maturity in sediment composition reflects the evolution of the basin. This gradation ranged from mafic and felsic volcanogenic rocks with minor calcareous and pelitic sediment, through pelitic, acid and calcareous sediment with lesser volcanogenic components and through to quartzite with shaly and pelitic rocks (Shaw, 1979; Smith, Stewart and Smith, 1961).
Figure 2  Major topographic and cultural features.

Figure 3  Generalised physiographic divisions.
<table>
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<th>FEATURE</th>
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<th>SURFACE COVER</th>
<th>VEGETATION</th>
<th>COMMENTS</th>
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</thead>
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<tr>
<td>Sand plains</td>
<td>Low, parallel to irregular sand dunes; hummocky sand plains</td>
<td>Sand, mostly stabilised; soil in swales ranges from sandy to clayey; unstructured sandy soil exposed in creek bank in NE is over 4 m thick</td>
<td>Spinifex (<em>Triodia</em> spp.) shrubs (especially <em>Cassiea</em> spp.), low trees (esp. blue mallee, <em>Eucalyptus gamophylla</em>)</td>
<td>Includes palaeo-alluvial fans of Plenty-Marshall and Bundey river systems, now masked by sand; includes flood-out areas, floor by grey, expansive clay soils, of Lucy and Ooratippra creeks</td>
</tr>
<tr>
<td>Pediment and plains</td>
<td>Broad, planar to gently curved, sloping surfaces; rare broad shallow valleys with ill-defined watercourses</td>
<td>Soil-covered, soils range from grey, expansive clay-soils to red-brown and sandy red earths; commonly boulder-strewn</td>
<td>Various grasses and herbs with areas of mulga (<em>Acacia aneura</em>) regal wattle (<em>Acacia victoriae</em>) or gidgee (<em>Acacia georgeana</em>) with isolated ghost gums (<em>Euc. papuana</em>), white wood (<em>Alalaya hemigluca</em>), beefwood (<em>Grevillea striata</em>) and corkwood (<em>Hakea suberea</em> and <em>H. eyreana</em>). Red river gums (<em>Eucalyptus camaldulensis</em>) and tea-tree (<em>Melaleuca spp.</em>) along watercourses</td>
<td>Much in W? underlain by Waite Formation equivalent</td>
</tr>
<tr>
<td>Low hills</td>
<td>Low, rounded hills with trellis-type drainage, controlled by joint sets, entrenched to 20 m high, surrounded by plains of low hills</td>
<td>Soil-covered hills with outcrops of limestone, dolostone and sandstone</td>
<td>Various grasses with some areas of spinifex; low trees are mostly gidgee; river red gums and tea-tree along watercourses</td>
<td>Underlying rock is mainly Arrintherunga Formation and Tomahawk beds, but also is Bonya Schist in the Bonya Hills</td>
</tr>
<tr>
<td>Table hills and plateaux</td>
<td>Plateaux and mesas up to 50 m high, surrounded by plains or low hills</td>
<td>Grey, expansive clay soil with gilgai, or red bouldery soil</td>
<td>Various grasses with low shrubs</td>
<td>Underlain by Waite Formation equivalents, much with resistant silcrete capping</td>
</tr>
<tr>
<td>Ridge country</td>
<td>Strike-ridges and valleys with rock faces and steep slopes. Mostly a rugged, higher core surrounded by lower, more rounded hills and ridges, relief is up to 100 m commonly and 150 m in the extreme</td>
<td>Rocky soils with large areas of outcrop. Soils are mostly red and sandy and are confined to valleys</td>
<td>Various grasses in the soil-covered areas with shrubs and spinifex in the areas of outcrop</td>
<td>Underlain by folded sedimentary rocks; silcreted cappings occur on some sandstones; the highest ridges commonly form a dissected bevelled surface; also includes some outcrops of Delny-Mount Sannith Fault Zone</td>
</tr>
<tr>
<td>Ranges</td>
<td>Irregularly distributed hills and valleys, commonly very rugged; relief is mostly up to 80 m, but up to 250 m in the Harts Range; surface slopes commonly approach 30°</td>
<td>Thin, bouldery, sandy, red soils with small areas of grey clay soils, but with rock outcrops predominating</td>
<td>Sparse low trees (mulga, gidgee, whitewood, corkwood) over short grasses and herbs</td>
<td>Basement crystalline rocks of the Arunta underlie this subdivision</td>
</tr>
<tr>
<td>Sandstone ranges</td>
<td>Bold plateaux with severely dissected, high margins. Relief up to 150 m; distinctive, very long, high escarpments</td>
<td>Sandstone outcrops cover most of the surface with sandy red soils locally</td>
<td>Spinifex with shrubs (<em>Cassiea</em> spp.) and limited areas of short grass; stunted ghost gums are widespread</td>
<td>Mostly coincides with Dulcie Sandstone outcrops; the bevelled capping is a former peneplain, at an angle to the dipping bedding</td>
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Figure 4 Structural and stratigraphic subdivisions of the Arunta orogenic domain on HUCKITTA.
In the Central Tectonic Zone, granulites of Division 1 predominate except in the E where amphibolite facies, Division 2 rocks occur. The Southern and Northern tectonic zones consist of Division 2 and Division 3 rocks. Different metamorphic grades were attained in these zones with the Southern Tectonic Zone at amphibolite facies and the Northern Tectonic Zone mostly at the upper greenschist facies but locally at granulite facies.

In the Arunta orogenic domain, an early tectonic event during the middle Proterozoic metamorphosed and dislocated the rocks into many fault-bounded blocks (Figure 6). A later tectonic event, the Carboniferous Alice Springs Orogeny, reactivated these faults. Sedimentation in the Georgina, Ngala and Amadeus basins began in Adelaidean time S of what is now about 21° 30'S. Argillites, arenites, glacigenic sediments and carbonates were deposited along the southern margin of the Georgina Basin. Sedimentation after the Adelaidean, primarily of carbonates and arenites, extended northwards into the Wiso Basin and central Georgina Basin. During the Adelaidean and Cambrian, intermittent elevation resulted in erosion of both the crystalline rocks and previously deposited sedimentary rocks. Sedimentation ceased in the Devonian Period and, except for deposition in local intermontane basins, central Australia has remained an area of erosion.

**STRATIGRAPHY**

The southern one-third of HUCKITTA contains outcrop of deformed Proterozoic crystalline rocks of the Arunta orogenic domain. The northern two-thirds contains outcrop of generally flat, shallow-dipping and only slightly deformed Adelaidean-Palaeozoic sedimentary rocks of the Georgina Basin. At the boundary between these two provinces is an area in which both the sedimentary and crystalline rocks are infolded and faulted together. The stratigraphic sequence is shown on the map face, however it is emphasized that the metasedimentary sequence is tentative except in the few instances where superposition is observed.

**ARUNTA OROGENIC DOMAIN**

Three groupings of rocks, termed divisions by Shaw and Stewart (1975), occur in structural blocks as illustrated and named on the Solid Geology summary on the map face. Each block contains a unique assemblage of rock units and, with the exception of the Bonya Schist, it is difficult to correlate the units between the blocks. The following descriptions of Arunta orogenic domain rocks are based mainly on the full descriptions in Shaw, Warren and others (1984) and unreferenced extractions from this work are here gratefully acknowledged.

**DIVISION 1**

**Strangways Metamorphic Complex**

*Kanandra Granulite* (pēsk)

The Kanandra Granulite is the only unit of the Strangways Metamorphic Complex (Stewart and others, 1980) in HUCKITTA and is confined to the Ambalindum Block and to slivers in the Delny-Mount Sainthill Fault Zone. Dominant rock-types are fine-grained mafic granulite and medium-grained, well-layered, quartzofeldspathic gneiss, much of which is garnetiferous.

Most outcrops are of granulite but the quartzofeldspathic gneiss may be as widespread though less well exposed. Less common rock types include coarse-grained migmatitic garnet quartzofeldspathic gneiss, garnet-biotite gneiss, sillimanite gneiss, hornblende gneiss and rare cordierite-orthopyroxene-quartz rocks.

Much of the outcrop is obscured by Cainozoic deposits. However, the extent of the Kanandra Granulite can be delineated from the characteristic high-intensity and highly variable aeromagnetic contour pattern on the total magnetic intensity maps (TMI; Northern Territory Department of Mines and Energy, 1982).

**Unnamed Metamorphics**

*Unnamed metamorphics S of Mount Baldwin* (pēc)

This unit is restricted to the Delny-Mount Sainthill Fault Zone and its immediate vicinity and consequently some of the gneiss is mylonitised. Well-layered quartzofeldspathic gneiss, with intercalated biotite schist, biotite gneiss, calc-silicate rock and quartzite, outcrops in low hills S to SW of Mount Baldwin. The quartzofeldspathic gneiss is leucocratic and mostly consists of dominant sodic plagioclase with lesser quartz, rutile, kornruperine, biotite and microcline; plagiogopite and clinopyroxene are rare constituents. Calc-silicate rocks consist mainly of plagioclase, quartz, hornblende, clinopyroxene, sphene, secondary clinozoisite and actinolite.

Retrogression has converted some of the kornruperine to tourmaline and phyllosilicates (Warren and McColl, 1983). The unit is assigned to Division 1 because the unit is lithologically similar to the Cadney metamorphics in ALICE SPRINGS and because of its high metamorphic grade.

*Unnamed metamorphics, Jervoïs homestead district* (pēd)

This unit occurs in an unnamed structural block from near, to 35 km E of the Jervoïs homestead. The rocks occur as isolated outcrops surrounded by extensive soil and sand-covered plains. The dominant type is quartzofeldspathic gneiss, which is quartz-rich, and commonly grades into biotite gneiss. Migmatite occurs as concordant and discordant leucosomes in both the quartzofeldspathic and biotite gneiss. Feldspathic quartzite and schistose, muscovite-bearing quartzite are also present and commonly contain tourmaline. Minor rock types include partly schistose, quartz-rich metasediment, biotite schist and layered magnetite-quartz rock. Calc-silicate rock and megacrygistic granitic gneiss occur in restricted areas. Some of the schistose rocks appear to be near fault zones and may be retrogressed gneissic rocks.

Because of their scattered outcrops, no structural interpretation has been made. The rocks are intruded by several plugs of undivided and unnamed granite. Aeromagnetic data indicate that outcrops of this unit which occur in an equant area some 15 km in diameter centred at approximately GR PO240670, are probably underlain at shallow depth by granite.

The unit is tentatively placed in Division 1 because it is inferred to unconformably underlie rocks of the Harts Range Group. Various parts of this unit
Figure 5  Generalised localities of tectonic zones within the Arunta orogenic domain and localities of adjacent tectono-orogenic units.

Figure 6  Generalised geological map of the Arunta orogenic domain showing distribution of Divisions 1-3, granite and major faults, and of structural blocks on HUCKITTA.
(pEd) can be correlated lithologically with the Delny Gneiss, Mapata Gneiss, Chiripee Gneiss (all in ALCOOTA) and the Alberta Metamorphics (ILLOGWA CREEK).

DIVISION 2
Division 2 rock types are predominantly layered quartzofeldspathic rocks and calcareous-metapelitic rocks (Shaw and Stewart, 1975), with subordinate metapsammitic rocks. In HUCKITTA the Harts Range Group is the only Division 2 unit S of the Delny-Mount Sainthill Fault Zone and the remaining units to the N of the fault zone. No age relations are known between the Division 2 units N and S of the fault zone, nor between individual units N of the fault.

Harts Range Group
The group consists (Joklik, 1955) of four apparently concordant formations, namely the Entia Gneiss, Bruna Gneiss, Iridinda Gneiss and Brady Gneiss in ascending sequence. In HUCKITTA, the full sequence is only seen in the SW corner. Much of the outcrop has not been divided into individual formations because of lack of outcrop continuity and of diagnostic rock type assemblages. The mapping of these undivided rocks of the Harts Range Group has been extended from ILLOGWA CREEK (Shaw, Freeman and others, 1982) where the undivided rocks interfinger with both the Iridinda Gneiss and Brady Gneiss. In ALICE SPRINGS, the group overlies the Strangways Metamorphic Complex with a disjunctive boundary which may be a tectonically disrupted unconformity (Shaw, Langworthy and others, 1979), but in HUCKITTA these units are separated by faults.

Dominant rock types in the undivided Harts Range Group (pEh) are biotite gneiss with interlayered calc-silicate rocks (Plate 1), metaquartzite and amphibolite. The biotite gneiss is locally garnetiferous or migmatitic. In JEROIS RANGE the rock types include muscovite-biotite schist, quartz-rich metasediment, biotite gneiss, quartzofeldspathic gneiss and rarer sillimanite-garnet gneiss, sillimanite muscovite gneiss, biotite schist and para-amphibolite. Most of the rocks are intruded by pegmatite.

Entia Gneiss (pEhe)
The Entia Gneiss is restricted to the Harts Range where it occurs on the N flank of the Entia Domal Structure (Shaw, Freeman and others, 1982). The formation consists of interlayered quartzofeldspathic gneiss, layered amphibolite, hornblende gneiss and biotite gneiss. A distinctive feature of much of the formation is the intercalation of the leucocratic and melanocratic rocks. Large compositional variations occur and some rocks grade into others laterally. For example, biotite gneiss and quartzofeldspathic gneiss commonly grade into each other and hornblende gneiss grades into quartzofeldspathic gneiss or into amphibolite.

Bruna Gneiss (pEha)
The Bruna Gneiss is a relatively thin (up to 140 m) sequence of megacrystic quartzofeldspathic gneiss, which apparently conformably overlies the Entia Gneiss. Compositionally it is granitic and consists of K-feldspar megacrysts up to several tens of millimetres across in a quartzofeldspathic matrix; accessory minerals are biotite, hornblende and garnet.

Iridinda Gneiss (pEhi)
The Iridinda Gneiss is a sequence of schistose garnet-biotite-quartz-plagioclase gneiss with layered amphibolite, sillimanite gneiss, calc-silicate rock and quartzofeldspathic gneiss. In general, there is less garnet and layered amphibolite and more biotite and sillimanite than in the type area of the formation in ILLOGWA CREEK. It is the most extensive formation of the group in HUCKITTA.

The garnet-biotite-quartz-plagioclase gneiss is medium-grained to fine-grained with the garnet commonly occurring as porphyroblasts up to 4 mm in diameter. This rock type grades into biotite gneiss. Sillimanite gneiss contains dominant quartz and feldspar with minor sillimanite and minor to nil garnet and biotite. Calc-silicate rock occurs as lenses typically of a flabby, leucocratic, medium-grained rock consisting of phlogopite, scapolite, diopsid plagioclase, calcite and quartz, with accessory sphene and magnetite. Other components may include wollastonite, calcic garnet, clinopyroxene and hornblende in the more melanocratic rocks. Amphibolite, as with the calc-silicate rock, occurs as widespread lenses and pods, but occupies less than 5% of the outcrop area.

Uncommon rock types include quartzofeldspathic gneiss which contains muscovite clots and traces of garnet near Prosser Bore, quartz-rich gneiss and quartzite, some of which contains traces of magnetite or hematite, muscovite-biotite schist which contains rare garnet, magnetite quartzite and a biotite gneiss containing irregular feldspar megacrysts.

Brady Gneiss (pEhb)
This formation outcrops in the Harts Range around the flank of the Entia Domal Structure. It is thought to occur beneath the plain N of the range according to interpretation of aeromagnetic data. The northern limit of the formation is probably the Maparta Fault. The sequence, which grades up from the Iridinda Gneiss, consists of biotite gneiss at the base, overlain by partly schistose biotite gneiss containing interlayered calc-silicate rock and rare hornblende gneiss. The formation is considered to have undergone low to middle amphibolite facies metamorphism because of the nearby occurrence (Shaw, Warren and others, 1979) of sillimanite co-existing with muscovite.

Units N of the Delny-Mount Sainthill Fault Zone
Perenti Metamorphics (pE1)
Outcrops of this unit are mostly contained as meta-sedimentary enclaves within the Mount Swan Granite. The unit is formally defined herein (Appendix 2). The Perenti Metamorphics consist of well-layered felsic granulite, quartzofeldspathic gneiss and quartz-sillimanite-biotite-cordierite rock with minor calc-silicate rock and metastolerite. The felsic granulite consists of orthoclase, antiperthite and orthopyroxene. Warren (in Shaw and others, 1984) noted that the pyroxene is partly replaced by hornblende and both are partly replaced by biotite. Though initially metamorphosed to granulite facies, these rocks have subsequen-
Deep Bore Metamorphics (pEv)
This calcareous and pelitic unit (Shaw, Warren and Freeman, 1985) occurs only between the Marshall River and Yam Creek, where it underlies spinifex-covered low hills and ridges.

The dominant rock type is cordierite-bearing quartzofeldspathic gneiss with calc-silicate rock and rare carbonate-bearing rock. These calcareous rocks contain wollastonite and possibly scapolite. Cordierite quartzite is abundant in northern outcrops. Minor to rare rock types include mafic granulite, garnet-bearing quartzose rocks and, in the western outcrops, layered amphibolite. A green tint present, especially in the calc-silicate rocks, is caused by the partial replacement of some components by very fine-grained phyllosilicate minerals.

The structure of the unit is unknown but it does contain prominent, lenticular, compositional layering which may have been derived from the protolith. The Deep Bore Metamorphics are similar to the Bonya Schist and the cordierite-bearing parts of the Deep Bore Metamorphics are similar to the Delmore Metamorphics in ALCOOTA.

Cackleberry Metamorphics (pEv)
The Cackleberry Metamorphics consist of calcareous-pelitic and quartzofeldspathic rocks which outcrop in and west of the Mopunga Range. The formation is well-layered, and different rock types predominate in different outcrop areas.

The most common rock types are calc-silicate rock and quartzofeldspathic gneiss. Minor rock types include cordierite or hornblende-bearing quartzofeldspathic gneiss, layered amphibolite and anthropophyllite-biotite-quartz-cordierite granofels. West of the Mopunga Range, melanocratic sillimanite-cordierite-biotite gneiss is dominant. Amphibolite in some western outcrops is only tentatively assigned to the Cackleberry Metamorphics.

Compositionally it is similar to the Delmore Metamorphics in ALCOOTA (Shaw and Warren, 1975).

Mascotte Gneiss Complex (pEm)
This name was applied by Shaw, Warren and others (1985) to outcrops of various quartzofeldspathic rocks in the western Bonya Hills and in three other small outcrop areas. All outcrops are restricted to the Jervois Block and eastern Jinka Block. The outcrops are typified by irregular, blocky hills with craggy rock-faces and areas of tors. A dissected pediment laps from the W onto the main outcrops.

Granitoid, which occurs in bodies up to 3 km in diameter, is massive, homogeneous, medium-grained, locally foliated and has a distinctive granular texture in which subordinate, grey quartz grains are disseminated in a feldspar-rich matrix. Granitic gneiss is widespread but is particularly common near the southern Charlotte Fault Zone. Pegmatite veins in anastomosing networks are locally common and some are pytymatically folded. Granitic gneiss grades into quartzofeldspathic gneiss where the compositional layering is more distinct and the gneissosity is better developed. Less common rock types include leucogranite, biotite schist, biotite gneiss, amphibolite (some quartz-bearing), and hornblende gneiss. Igneous dykes, some slightly to severely metamorphosed, are common and include tourmaline-bearing aplite dykes up to 50 m wide, which are discordantly intruded into quartzofeldspathic gneiss. A metadolerite dyke, which occurs 2 km NW of the Bonya Mine, has a highly altered margin.

The Mascotte Gneiss Complex is lithologically similar to the Alberta Metamorphics in ILLOGWA CREEK (Shaw, Freeman and others, 1982), and, to a lesser degree, to the Cavenagh Metamorphics (Shaw, Langworthy and others, 1979) in ALICE SPRINGS.

Bonya Schist (pEo)
The Bonya Schist, which occurs within the Bonya Hills and E of the Jervois Range in the Bonya and Jervois structural blocks, overlies the Mascotte Gneiss Complex with a transitional contact.
The formation, defined in Shaw, Warren and Freeman (1985), is divided into five informal units and one formal member, the Kings Legend Amphibolite Member. These units are described in Table 2 and their distribution is shown in Figure 7.

The Bonya Schist consists mainly of muscovite schist and two-mica schist with local occurrences of cordierite, sillimanite, garnet and ?andalusite (Dobos, 1975). Amphibolite is common as thick sequences, such as the Kings Legend Amphibolite Member, or as smaller lenses. Calc-silicate rock is widespread. Metaquartzite beds which mainly occur in the upper part of the formation are locally cross-bedded (Plate 2). Tourmaline is very common and layered quartz tourmalinite occurs as concordant layers up to 0.3m wide. In the Jervois area Cu-Pb-Zn-Ag mineralization is associated with magnetite-bearing layers which range in thickness upwards from millimetre scale (Morgan, 1959).

Unnamed metamorphics (pEș)
Unnamed metamorphics, assigned to Division 2, occur from Molyhil, W for 10 km. The outcrops, typically of quartzofeldspathic gneiss, biotite gneiss and granitic gneiss, underlie smoothly-rounded hills and ridges. The unit occurs in and adjacent to the N edge of the Delny-Mount Sainthill Fault Zone.

Table 2 Units recognised within the Bonya Schist (pEș).

<table>
<thead>
<tr>
<th>Unit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>UNIT 6</td>
<td>3000-4000 m in Bonya Hills. One outcrop near Unca Hill. Distinctive layered actinolite-K-feldspar calc-silicate rock, acid crystal metavolcanic, calcareous meta-pelite (locally with fine magnetite), muscovite-rich schists (some with garnet, sillimanite or andalusite), quartzite (Plate 2) and amphibolite. Top of unit is faulted.</td>
</tr>
<tr>
<td>UNIT 5</td>
<td>1000 m in Bonya Hills, 25000 m in Jervois area (?over-estimate through structural repetition). Fine to medium-grained biotite-muscovite schist, locally with andalusite, cordierite, garnet and tourmaline, garnet-quartz-epidote calc-silicate rock, amphibolite, feldspathic schist and sulphide-bearing quartz-magnetite and quartz-hematite rock. Felsic granular rocks NNE of Jervois Mine. Contains Ag-Pb-Zn-Cu-Bi mineralization at Jervois and W-Cu mineralization widely in the calc-silicate rock.</td>
</tr>
<tr>
<td>KINGS LEGEND AMPHIBOLITE MEMBER (pEșok)</td>
<td>0-900 m, Bonya Hills. Amphibolite with up to 30% plagioclase, glomeroporphyritic, giving a spotty appearance (Plate 3). Minor calc-silicate rock. Contains fine disseminated grains of chalcopyrite-pyrite. Scheelite in calc-silicate rock.</td>
</tr>
<tr>
<td>UNIT 3</td>
<td>0-1500 m in Bonya Hills. A distinctly coarse-grained knotted muscovite schist or andalusite-muscovite schist. Pods and layers of quartz-epidote calc-silicate rock.</td>
</tr>
<tr>
<td>UNIT 2</td>
<td>0-800 m in Bonya Hills. Fine-grained pink quartzofeldspathic rock, hornblende gneiss and quartz-epidote calc-silicate rock; all interlayered in fine-grained muscovite and biotite-muscovite schist. Scheelite occurs in calc-silicate rock.</td>
</tr>
<tr>
<td>UNIT 1</td>
<td>0-500m in Bonya Hills. Amphibolite and layered amphibolite; commonly streaky appearance. Base of unit rests with transitional contact on Mascotte Gneiss Complex.</td>
</tr>
<tr>
<td>UNDIVIDED</td>
<td>An unknown thickness with much soil cover, mostly NE of the Bonya Hills. Muscovite, chlorite and biotite-muscovite schist with megacrystic garnet-biotite schistose gneiss, amphibolite, hornblende gneiss, leucocratic calc-silicate rock. Retrograde schist is common. Its position in the sequence is unknown and may be equivalent to several of the units.</td>
</tr>
</tbody>
</table>
The dominant rock type is a fine to medium-grained quartzofeldspathic gneiss of granitic appearance with distinctive thin, flaggy, quartz-rich layers. The quartzofeldspathic gneiss is locally migmatic and grades into biotite gneiss. A well-layered calc-silicate rock, which occurs at Molyhil, has a complex skarn mineralogy consisting of diopside, quartz, scapolite, microcline, biotite, calcite, sphene, tourmaline, andradite, blue-green hornblende, actinolite, epidote and magnetite and traces of scheelite, chalcopyrite, pyrite and molybdenite. Rare muscovite-biotite gneiss and quartz-rich metasediment occur.

Plugs and apophyses of the Marshall Granite have intruded much of this rock unit. Lithologically pES is similar to parts of the Mascotte Gneiss Complex, but pES has been metamorphosed at a slightly higher grade.

**DIVISION 3**

**Ledan Schist (Elm)**

Ledan Schist outcrops forms low elongate hills near Dnieper homestead and on MacDonald Downs Station. The unit was first named by Shaw and Warren (1975) on ALCOOTA. On airphotos, outcrops are light-toned with distinctive thin lines. The main rock type is biotite-muscovite-quartz schist with accessory tourmaline. Deformed metaconglomerates are present ESE of Dnieper homestead, where graded bedding shows that this unit underlies the Utopia Quartzite. In ALCOOTA the Ledan Schist unconformably overlies the Delmore Metamorphics and is conformably overlain by the Utopia Quartzite.
Utopia Quartzite (Plu)
Several ridge-forming outcrops adjacent to and ESE of Dneiper homestead are assigned to this unit, which was first mapped in ALCOOTA by Shaw and Warren (1975). The ridges are usually sharp, but in HUCKITTA most are capped with the dissected remnant of a Tertiary silcreted surface. The formation consists of metatuffite containing laminae and layers of muscovite and tourmaline.

Unnamed schist and quartzite near Jervois homestead (pEeq)
Near Jervois homestead are discontinuous ridges of metatuffite and low rises of schist which are assigned to this informal grouping. The outcrops show characteristic light tones on airphotos. The metatuffite is muscovite-bearing, medium to fine-grained, and flaggy. Locally it is feldspathic or tourmaline-bearing. The schist is dominantly a muscovite or biotite-muscovite schist with minor tourmaline, apatite, garnet and sillimanite. The schist grades into medium to coarse-grained biotite gneiss.

The interpretation of the stratigraphic position of this unit is difficult. Structurally it underlies the unnamed metamorphics pEd of Division 1. However, the quartzite and schist components are lithologically similar to the combined sequence of Utopia Quartzite and Ledan Schist, which are assigned to Division 3. It is assumed that either the pEeq/pEd sequence is overturned (see for example Shaw, Langworthy and others, 1979, Figure B3) or else there is an as-yet unrecognised structural break between the two units. Alternatively, unit pEeq may be correlated with undivided Harts Range Group to the S on ILLOGWA CREEK which also contains metatuffite and schist.

Intrusive Rocks
Intrusive rocks in HUCKITTA have been grouped under the following headings: granitic rocks; intermediate, basic and ultrabasic rocks; pegmatites and quartz veins. The distribution of intrusive rocks is illustrated in Figure 8.

Granitic rocks
The granites are grouped into formally named units, informal units, which are identified by an individual letter symbol, and undivided granite Eg which includes poorly exposed bodies of uncertain affinity.

Dneiper Granite (Egd)
Smith (1964b) described this unit as a single intrusion extending from Dneiper homestead to Yam Creek dam, but several different granitic rock types, possibly intruded consecutively, are now recognised. The name was restricted (Shaw, Warren and Freeman, 1985) to only one of these types and others are now informal and unnamed.

The Dneiper Granite is a distinctive grey, biotite-rich, gneissic granite which is locally hornblende-bearing. Warren (in Shaw, Warren and others, 1984) reported that the proportion of quartz is low for a granite. Small xenoliths are ubiquitous; most are of biotite-rich rocks but some are of quartzite and calc-silicate rock.

The granite has a foliation which generally is parallel to that in the adjacent metamorphic rocks.

Mount Swan Granite (Egs)
Smith (1964b), allocated the name Mount Swan Granite to a porphyritic, biotite-hornblende granite which outcrops mainly around the Mount Swan homestead and Tower Rock in HUCKITTA and extends into ALCOOTA. It forms tors and extensive sheeted outcrops and has prominent mega-jointing.

The granite is pink and porphyritic. The groundmass consists of quartz, orthoclase, plagioclase (An30), hornblende (ferro-pargasite or hastingsite, partly altered to biotite) and with accessory ilmenite, magnetite, apatite, zircon and allanite. Myrmekite invades the orthoclase. The phenocrysts are of subhedral to anhedral orthoclase and as long as 45 mm, but in the northern outcrops they are up to 100 mm and mostly are aligned, and in the southeastern outcrops they are absent. The granite is schistose adjacent to major faults. It contains many rafts of country rock; the Perenti Metamorphics occur in Mount Swan Granite.

Shaw and Warren (1975) considered the Mount Swan Granite probably intruded Division 3 rocks, but the contact is not exposed in either HUCKITTA or ALCOOTA.

Marshall Granite (Egm)
This name was applied by Smith (1964b) to a pink, slightly foliated granite which outcrops 5-15 km NW of Mount Sainthill. The use of the name now includes outcrops which extend E along the Delny-Mount Sainthill Fault Zone to Molyhil. Outcrops are characterised by steep-sided, spinifex-covered hills, some with Tertiary silcrete cappings.

The dominant rock type is a metamorphosed hornblende granite containing pink perthitic microcline, blue quartz, very pale yellowish-orange plagioclase and dark brown hornblende. A minor rock type in the eastern outcrops is medium-grained and leucocratic and consists largely of pink feldspar and blue quartz.

Dykes and veins of aplite or microgranite, pegmatite and quartz are common. The quartz veins commonly contain large, angular grains of magnetite.

Jinka Granite (Egl)
Joklik (1955) named this unit which underlies the extensive Jinka Plain and extends W and S of the Eucla Range. Small, prominent nubbins, (Tweedale, 1982, p161), occur in the western part of the Jinka Plain, but elsewhere the granite is weathered down to plain level and consists mostly of grus.

The Jinka Granite is a very pale yellowish-orange, coarse and mostly even-grained granite, containing very pleochroic biotite, very pale yellowish-orange to pink K-feldspar, green scirritised plagioclase and rare phenocrysts of K-feldspar. Accessory minerals include magnetite, muscovite, zircon, tourmaline and apatite.
A variant of this granite is a fine to medium-grained, porphyritic granite to granodiorite with a slight gneissic fabric caused by alignment of the biotite and the phenocrysts. Xenoliths of metamorphic rocks, though present, are not common. Numerous quartz veins of the Oorabilla, Reefs cut the Jinkia Granite.

**Jervois Granite (Egn)**

Smith (1964b) applied the name Jervois Granite to isolated outcrops which occur over a large area in SE HUCKITTA.

Outcrops range from low rises to nubbins, and weathering ranges from severe to non-existent.

The most abundant rock type is a fine to medium-grained, even-grained biotite granodiorite. Variations include two leucocratic granites, one of which is medium-grained and contains rare muscovite, and the other is typically coarse and even-grained but locally porphyritic. Roof pendants and rafts of metamorphic rocks are widespread. Late-stage veins of brecciated and re-cemented quartz and specularite trend ENE and ESE across the granite, and have affinities with the Oorabilla Reefs. Black (1980) produced a total-rock Rb/Sr age of 1808 ± 80 Ma for this granite.

**Xanten Granite (Egx)**

This name is assigned (Shaw, Warren and Freeman, 1985) to a hill-forming, leucocratic, silicified granite which outcrops in three fault-bounded blocks at the southern limit of the Jervois Range. It is distinctly devoid of much vegetation except for sparse shrubs and stunted grass. The rock is mostly a two-feldspar, medium to coarse-grained leucogranite. It is distinctly quartz-rich in parts and Farrand (1981) considers some of the quartz to be a post-crystallisation introduction. Saussuritization of the granite is widespread though not intense. The unit is thought to intrude the Maccott Gneiss Complex but relationships are obscured by alluvium. It bears some compositional similarities to the Unca Granite.

**Unca Granite (Egu)**

This new name was assigned (Shaw, Warren and Freeman, 1985), to granite in a triangular area of outcrop 5 km N of the Jervois Mine where it forms a low, rounded hill. A poorly developed NNE-striking foliation is present and a well-developed jointing has a similar strike direction. The Unca Granite is a brown-weathering, even-grained leucocratic granite with a metamorphic texture. It intrudes the Bonya Schist and
is cut by quartz and pegmatite veins. Black (1980) produced a Rb/Sr isochron age of 1459 ± 10 Ma (both mineral and multiple whole-rock data). However it is considered that this age may be erroneous because the foliation suggests the rock is affected by post-crystallisation metamorphism.

**Unnamed assigned granites (Pga.c.f.g.k.l.n.r.y)**

Nine granites were mapped but not named and are assigned to groupings identified by letters. These groupings are described in Table 3 and are listed in alphabetical order because their intrusive ages are poorly known. However granite Eg is severely foliated and is a pre-tectonic, or syntectonic intrusive.

**Unnamed, unassigned granite (Eg)**

Granite Eg is a grouping of a variety of granitic rock types which occur in isolated outcrops across southern HUCKITTA. As such, relationships are poorly known. The granites range in composition from granodiorite to granite, some are porphyritic and many are slightly to well-foliated. One outcrop of this granite, in SW HUCKITTA and which is associated with Kanandra Granulite, is very foliated and texturally similar to the syntectonic Dnieper Granite or the unnamed granite Egg. Details of their mineralogy are contained in Shaw, Warren and others (1984).

**Intermediate, basic and ultrabasic rocks**

**Unnamed meta-quartz norite (Edr)**

A single plug of quartz norite, 200 m across, occurs in the Marshall Granite 2 km NE of Yam Creek Dam. It is a blocky, brown, even-grained rock consisting of plagioclase and biotite with accessory quartz, monazite and opaque grains. The plagioclase is almost completely altered, though relict igneous zoning is still recognizable, and the biotite is extensively altered to chlorite; both features reflect the widespread, low-grade, metamorphism which has affected the Arunta orogenic domain in HUCKITTA.

**Attutra Metagabbro (Eda)**

This unit consists of at least 20 outcrops of gabbro dispersed in an area of 140 km² E of the Jervois Range, and was defined in Shaw, Warren and Freeman (1985). Outcrops generally are low, rounded soil-covered hills, nubbins or tors scattered on plains.

The rock appears to have been dominantly a coarse-grained bytownite-pyroxene gabbro. However the rock is mostly so altered that the igneous petrogenesis is not clear. Farrand (1981) described one specimen in which the pyroxene originally consisted of an augite core with an aegerine rim. In most of the rock examined, the pyroxene grains were altered to amphibole which in turn were chloritised. The plagioclase is replaced by very fine-grained, felted masses of pale green amphibole; biotite is chloritised and quartz is a later introduction into the rock.

In the northern outcrops, despite the extensive alteration, the rock has retained its appearance of a holocrystalline gabbroic rock. In the southern outcrops the metagabbro is medium to fine-grained, with relict megacrysts which now are almost completely replaced by fine-grained amphibole. However these southern outcrops may be of separate intrusives which more altered than the coarser-grained rocks which outcrop to the N. Scattered throughout the outcrops of the Attutra Metagabbro are plugs, up to 50 m across, of very coarse-grained magnetite rocks. Low concentrations of vanadium were identified in these rocks (Wright, 1974). Rafts of melanocratic rocks up to 20 m across are scattered within the gabbro: one is a mafic granulite.

One outcrop of norite, located E of the northern outcrops, is assigned to the Attutra Metagabbro. In the W the metagabbro occurs as stocks, as small as 2.0 m in diameter, within the Bonya Schist. However, larger stocks in the E are separated by up to several kilometres of soil-covered plain, and their continuity under the plains is unknown. It is inferred that the original large mass was disrupted by later tectonism and distributed widely as blocks of varying sizes within the Bonya Schist.

**Ilappa Metadolerite (Edi)**

The Ilappa Metadolerite consists of two north-trending dykes near Cackleberry Bore and was named by Shaw, Warren and Freeman, (1985). Several stocks and dykes exposed near the Mopunga Range may belong to this unit. In outcrop, the rock is fresh, blue-grey and fine-grained. It consists of cummingtonite laths in a groundmass of pale green, actinolitic hornblende, with titaniferous hydrobiotite, intergrowths of chloroisoite and muscovite, and equant opaque grains. The Ilappa Metadolerite intrudes pegmatites in the Cackleberry Metamorphics and is considered to be one of the youngest intrusives in the Arunta orogenic domain in HUCKITTA.

**Unnamed basic rocks (Ed)**

There are many basic stocks and dykes within the Arunta orogenic domain, ranging from small lenses to bodies several hundred metres across. All are now metamorphosed, though in many their holocrystalline texture is still evident in outcrop. The larger bodies were mapped within a general grouping of Ed. The rocks range from gabbroic and noritic to doleritic, but the more altered types now contain coarse to fine-grained amphibole with phyllosilicates and epidote but retain relict igneous textures.

**Unnamed serpentinite (Ep)**

Deeply weathered, soft, green serpentinite was identified in an area of 3 ha near Middle Dam (GR NQ277843) by Clarke and Woyzun (1978). This was confirmed by later drilling which intersected serpentinite consisting of light and dark green serpentine, talc, magnesite, and phlogopite (Freeman, 1979). The outcrop is intensely weathered (Tla) and is only recognisable by its green colour. Ferricrete and siliceous nodules are common on the outcrop. The serpentinite is in garnetiferous quartzofeldspathic gneiss of the Kanandra Granulite. Its age is unknown. Other similar bodies occur in the general area, including one reported as being in southern MacDonald Downs Station (Cooney, 1973), and one in northern ILLOGWA CREEK (Shaw, Freeman and others, 1982).
<table>
<thead>
<tr>
<th>GRANITE SYMBOL</th>
<th>AREA AND OUTCROP APPEARANCE</th>
<th>LITHOLOGY</th>
<th>RELATIONSHIPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ega</td>
<td>Within and between Delny-Mount Sainthill and Entire Point fault zones; characteristic tors and low hills</td>
<td>Red to red-brown, medium-grained garnet-biotite granite; locally porphyritic; slightly gneissic; retrogressed adjacent to faults</td>
<td>Intrudes Kanandra Granulite; much affected by Tertiary deep weathering</td>
</tr>
<tr>
<td>Egc</td>
<td>Around Yam Creek Dam; tors or low nubbins</td>
<td>Pale creamy-pink granite, with small amounts of biotite; slightly gneissic, K-spar: plagioclase ranges from 1:1 to 2:1; commonly contains xenoliths</td>
<td>Intrudes Cackleberry Metamorphics and granites Egg &amp; Egr; has lithological affinities with granites Egr &amp; Egy</td>
</tr>
<tr>
<td>Egf</td>
<td>Northern Bonya Hills; rough, irregular, sharp-crested hills tite or tourmaline aggregates</td>
<td>Cream-coloured, foliated, muscovite granite; locally it is porphyritic or contains magnetite</td>
<td>Intrudes Bonya Schist and Mascotte Gneiss Complex</td>
</tr>
<tr>
<td>Egg</td>
<td>Mopunga Range; continuous outcrops with layered appearance and</td>
<td>Dark grey, gneissic, biotite granite with local hornblende muscovite; allanite is a common accessory; rarely contains orthopyroxene</td>
<td>Intrudes Cackleberry Metamorphics and is intruded by Marshall Granite and granites Egc, Egl &amp; Egr; possibly equivalent to Dneiper Granite</td>
</tr>
<tr>
<td>Egk</td>
<td>N and NW of Mopunga Range; boulder-strewn low rises</td>
<td>Grey biotite granite; porphyritic and ranges from slightly gneissic to massive; contains abundant myrmekite and minor epidote and fluorite</td>
<td>Intrudes Cackleberry Metamorphics and Dneiper Granite</td>
</tr>
<tr>
<td>Egl</td>
<td>W Mopunga Range; rough hills which commonly are spinifex-covered</td>
<td>Pink leucogranite; medium to coarse-grained with trace of biotite; myrmekite is common</td>
<td>Intrudes Kanandra Granulite, Cackleberry Metamorphics and granites Egg and Egr; grades into schist near retrograde schist zones</td>
</tr>
<tr>
<td>Egn</td>
<td>Northern Bonya Hills; nubbins and isolated tors on plains</td>
<td>Grey, biotite granodiorite to tonalite; slightly foliated; locally hornblende-bearing and contains rare magnetite and apatite</td>
<td>Intrudes Bonya Schist; Black (1980) included it in Jinka Granite but it is lithologically distinct; he determined a Rb-Sr isochron age of 1812±85 Ma</td>
</tr>
<tr>
<td>Egr</td>
<td>South and west of Mopunga Range; low rough hills, mostly covered with spinifex</td>
<td>Pink biotite granite, medium-grained and gneissic with minor muscovite; traces of fluorite present locally</td>
<td>Intrudes Cackleberry Metamorphics and granite Egg; intruded by granites Egc, Egl and Egg; may be equivalent to granite Egg; much affected by deep weathering</td>
</tr>
<tr>
<td>Egy</td>
<td>North of the Mopunga Range; occurs as nubbins or isolated tors on soil plains</td>
<td>Pink to cream-brown, biotite granite; locally it is porphyritic; proportions K-spar: plagioclase ranges 1:2 to 2:1; allanite is a common and fluorite a rare accessory mineral; shows common retrograde effects</td>
<td>Intrudes Cackleberry Metamorphics, Dneiper Granite and granite Egg; may be equivalent to granite Egr</td>
</tr>
</tbody>
</table>
Pegmatites and veins
Two groups of pegmatites and a suite of major quartz veins are recognised in HUCKITTA.

Samarkand Pegmatites (Eps)
Many pegmatites, ranging from small veins to stocks covering up to 50 ha, occur in the Bonya Schist in the Bonya Hills. They were named by Black (1980) and defined by Shaw, Warren and Freeman (1985). The pegmatites are medium to very coarse-grained and consist dominantly of sodic plagioclase with subordinate K-feldspar. Quartz occurs as very irregular, embayed grains with highly undulose extinction. Muscovite, tourmaline, apatite and sphene are common accessory minerals, and beryl is a rare constituent. Rarely, rims of quartz-tourmaline schorl-rock up to 200 mm wide are developed at the pegmatite contact and locally this is partially assimilated into the pegmatite. The pegmatites have a conspicuous grain-size layering (Plate 4). This layering is commonly parallel to the length of the pegmatite body and to the country rock foliation. However in some dykes, layers are folded and locally a folded part is truncated against itself. Cross-cutting relations between dykes indicate that the pegmatites were intruded as several distinct phases.

Harts Range pegmatites
Many small to large pegmatite dykes occur in the Harts Range and Plenty River mining fields (Figure 2). Those in the Harts Range Mining Field outcrop as prominent scars on steep hill-slopes whereas in the Plenty River Mining Field they are poorly exposed. They were well described by Joklik (1955) who studied the geology and mica mining associated with the pegmatites. Some of the pegmatites are well zoned. The dykes range from centimetre scale to over 6 m wide and up to several hundred metres long. Joklik (1955) noted some were zoned, with a quartz core rimmed with feldspar which is in turn rimmed with altered country rock, and concluded that the mica of beter quality was produced from them. However, most zonation is poorly developed and in some pegmatites none is present. The pegmatites intrude the Iridina and Brady gneiss. Riley (1968) obtained a Devonian Rb/Sr age on pegmatite from the Rex Mine in NE ALICE SPRINGS, suggesting it was intruded during the Alice Springs Orogeny.

Oorabba Reefs
The name Oorabba Reefs was first applied by Brown (1896, 1897) to an extensive complex of quartz veins on the Jinka Plain and is restricted to those which intersect or are adjacent to the Jinka Granite. The veins protrude from the plain in outcrops that range from an alignment of quartz boulders to prominent wall-like ribs up to 7 m wide, 15 m high, and 13 km long (Plate 5). They form a criss-cross pattern with trends ranging from west to N. They consist of multi-zoned, vuggy quartz with comb-structures and ribbon-structures and many contain recemented breccia clasts (Plate 6). Specularite is common in the northern veins, and barite and fluorite, with traces of galena, occur in the S and W.

These veins are similar to those which cut the Jervois Granites and which fill many of the faults in the Jervois and Bonya Blocks. Their precise age is unknown, but the period of emplacement was long, possibly ranging from late Proterozoic to Palaeozoic. The youngest rock unit intruded by these quartz veins is the Elkera Formation, implying that some, at least, of the veins may have been intruded during the Huckitta Movement which postdates the Elkera Formation. However many phenoclasts of quartz in the Oorabba Arkose have been derived from the Oorabba Reefs, indicating a much earlier time of emplacement.

The reefs were deposited as fissure veins and stockworks in tensional structures. Internal fabrics, such as brecciation, hydrothermal zoning and extreme ranges in quartz grain-size, permit a local chronology of formation to be established. Multiple phases of fracturing, re-opening and fissure-filling are indicated. Hill (1972) considered the veins to be telethermal-epithermal and to have been introduced during the mid-Palaeozoic.

Late-stage retrograde schist zones (E.Pzr)
Schist zones (E) up to 5km wide are concentrated along the Delny-Mount Sainthill Fault Zone (Warren, 1978) and the Entire Point Fault. The former trends 100° and the latter 060°. The schist zones are, in general, topographically low belts, although localised quartz segregations produce a series of sharp ridges and valleys. Rock types within these zones include muscovite and biotite schists, felsic chloritic schist and rare garnet-chlorite schist, amphibolite and mylonite. The zones also contain slivers of undeformed rock, but many of these, as with rocks adjacent to the fault zones, have undergone hydration and minor metamorphism. In places this has produced indistinct boundaries to the fault zone, though the boundary is generally placed.
where the original fabric of the older units is still observable. These fault zones have been metamorphosed to greenschist or lower amphibolite facies.

There has been recurrent activity during a long period in the retrograde fault zones. Warren (1980) noted that the Delny-Mount Sainthill Fault Zone bears similarities to the Redbank Deformed Zone in ALICE SPRINGS and HERMANNSBURG, which was initiated at about 1620 Ma (Marjoribanks and Black, 1974). Slivers of Mopunga Group rocks are contained within the Delny-Mount Sainthill Fault Zone near Molyhil implying a post-Adelaidean date for the latest activity, which is correlated with the Alice Springs Orogeny of Stewart (1971).

Several younger retrograde-schist zones (Pzr) are located in SE HUCKITTA. These are metamorphosed to the greenschist facies and include sericitic quartzofeldspathic rocks, foliated amphibolite, biotite schist and phyllonite. They are not directly related to the Delny-Mount Sainthill Fault Zone but are similar to greenschist-facies schist zones on ALICE SPRINGS and ILLOGWA CREEK which are regarded as wholly Palaeozoic in age (Stewart, 1971; Iyer and others, 1976) and equated with the Alice Springs Orogeny. Earlier phases of deformation are yet to be documented within these zones (Pzr).

GEORGINA BASIN
The Georgina Basin (Smith, 1965) is a large (325 000 km²), intracratonic sedimentary basin in the Northern Territory and Queensland (Smith, 1965; Smith, Vine and Milligan, 1961). The Georgina Basin includes all the Adelaidean and Palaeozoic rocks (Shergold and Druce, 1980) which rest nonconformably on middle Proterozoic or older rocks.

During Adelaidean time, the sediments were deposited along the S flank of the basin in roughly NW-trending half-grabens (Walter, 1980). These half-grabens have fault-bounded NE margins but on the SW side the sediments lap onto the basement. Some of the
earliest rocks were reworked (for example, the Oorabilla Arkose) demonstrating that depositional areas were more extensive than now recognised and that some of the present basement areas were uplifted during the Adelaidean. From the latest Adelaidean time, (Mopunga Group-time and later) deposition was no longer confined to localised half-grabens and sedimentation extended across HUCKITTA. Thick-

esses vary considerably between the troughs and range from 15 km in the Toko Trough (Harrison, 1980) to 4 km in the Mopunga Trough (Walter, 1980). From the start of deposition of the Mopunga Group, thick-

esses are more uniform regionally and in central HUCKITTA aggregate approximately 2.9 km thick.

Yackah beds (Bay) Outcrops of this unit are restricted to near Mount Cornish in the SE corner of HUCKITTA. The unit consists of a basal subarkose to arkosic granule conglomerate which grades up into quartz arenite to lithic greywacke and this in turn is overlain by very thin-bedded, lenticular, yellow, pink and grey dolos-

tone. The total thickness is 26 m in HUCKITTA. The beds rest unconformably on the Jervois Granite. In HAY RIVER, where this informal unit was first named, the dolostone contains the columnar, branch-

ing stromatolite Acaciella australica and is correlated (Figure 9) with the Bitter Springs Formation (Walter, Krylov and Priess, 1979). Thus the basal clastic rocks of the Yackah beds can be correlated with the Heavitree Quartzite which is interpreted to be younger than 900 Ma (Black and others, 1980).

Mount Cornish Formation (Eac) The Mount Cornish Formation occurs in the SE corner of HUCKITTA and the NW Elua Range. It is a sequence which consists dominantly of poorly-bedded, blue-green diamicite with interbeds of varvite and siltstone. Phenoclasts consist of gneiss, pegmatite, granite, dolerite, orthoquartzite and dolostone; some are faceted and striated. Phenoclasts in the type area are up to 1 m across although Condon (1958) reported blocks up to 12 m across near the Oorabilla Rockholes. The bedding is regular and is laminated in the varvite and ranges from medium to very thick in the diamicite.

In the Elua Range, near the Oorabilla Rockholes, the Mount Cornish Formation occurs as lenses under-

neath Oorabilla Arkose, preserved in depressions in the underlying Jinkra Granite. The lenses, as seen in section, are up to several hundred metres long and 15 m deep. At the type section Walter (1980) recorded 680 m of Mount Cornish Formation. However, there are several faults in the area and the strike of the faults is parallel to the strike of the bedding, so it is possible that this 680 m thickness may include some fault repetition.

After deposition, local erosion followed the mild diastrophic uplift of the Rinkabeen Movement (Walter, 1980).

Regional correlations of the Mount Cornish Formation are shown in Figure 9. The formation is equivalent to the earlier of two extensive Adelaidean glacial units (Priess and Forbes, 1981; Priess and others, 1978), the age of which is about 750 Ma (Thompson, 1980; Webb and Coats, 1980). Preliminary palaeomagnetic work indicates that the unit and its correlatives were deposited at near-equatorial palaeolatitudes (Burek and others, 1979).

Keepera Group The Keepera Group (Walter, 1980) outcrops primarily on HAY RIVER where it consists of the Black Stump Arkose and the Wonmadina Dolomite, although in HUCKITTA it consists only of the Oorabilla Arkose.

Oorabilla Arkose (Eao) This formation, first named by Joklik (1955), was redefined by Walter (1980). Its outcrops are rugged and covered with tors up to 5 m across, many resting upon sheeted outcrops (Plate 7). The distribution of its outcrops is shown in Figure 10a.

The dominant lithology is a poorly sorted arkose to lithic arkose, ranging from medium-grained to pebbly. Phenoclasts up to 200 mm across, are mostly of subrounded milky quartz, some containing rare in-

Plate 7 Oorabilla Arkose outcrop in the type area.
The arkose is typically exposed as tors and sheeted outcrops with exfoliation common as in the foreground. Minimal soil development occurs, as shown especially by the paucity of grass. The valley shape conforms approximately to a gentle syncline (GR NG74908).
Figure 9  Chronostratigraphy and regional correlations of Adelaidean sedimentary sequences in the Georgina, Amadeus and Ngalia basins and the Adelaide Geosyncline.

Plate 8  Dolomitic arkose conglomerate in the Oorabra Arkose.
This typical outcrop contains layered beds at the base, with a scour-channel infilled with corner, unlayered detritus and a reef-quartz block 1.5 m across, in boulder-bearing layer. Scale squares 2 cm (GR PQ044796).
Figure 10  Distribution of outcrops (solid) and interpreted subsurface extent (stippled) of Georgina Basin formations and generalised localities of the Mopunga and Keepera troughs; a, Oorabba Arkose; b, Elyuah Formation; c, Grant Bluff Formation; d, Elkera Formation; e, Mount Baldwin Formation; f, Errarra Formation; g, Arthur Creek Formation.
clusions of galena, fluorite and barite. Bedding is very thick to massive. North of the Jinka Plain (GR NQ890980), arkose lenses up to 200 x 50 m are contained in laminated, dusky red, micaceous siltstone.

The sediment was deposited in half-grabens the inferred positions of which in HUCKUTTA are shown in Figure 10a. In the Mopunga Range, local, abrupt lensing of the arkose is conspicuous on airphotos where, in one case, the unit thins from 1000 m to zero over a strike length of 2.5 km.

Locally, the Oorabara Arkose contains a large range of minor rock types, some exotic. E of SE Elua Range, the Oorabara Arkose contains a poorly bedded, dolomitic, arkosic, sharpstone conglomerate with intraclasts of the same rock. Phenoclasts range up to 1.5 m across (Plate 8). This sediment was intruded by clastic dykes, up to 300 mm across, of siliceous arkose. Scour-channel infillings are present. The arkose in this area has a very irregular contact with the underlying basement. Approximately 2.5 km N of Mount Thring, a basal cobble orthoconglomerate contains phenoclasts with faceted and striated faces. These features are indicative of a glacial origin (Plate 9).

Many rock types are present in the Oorabara Arkose in NE Jervois Range. Here, the formation contains flaggy arkose sharpstone granule conglomerate; pebble to cobble sharpstone conglomerate; fissile, laminated, silty shale; arkosic, pebble sharpstone conglomerate, fissile, micaceous lithic arkose; and cobble to boulder orthoconglomerate. Phenoclasts in the orthoconglomerate consist of milky quartz, dark pink grey stromatolitic limestone (?Yackah beds), and medium grey pebbly limestone and cross-bedded, quartzose, granule conglomerate.

The thickness of the formation, which is restricted to the half-grabens, ranges from 80 m to 1000 m.

The arkose was deposited in a regime of rapid erosion, mass-transport and proximal deposition. Near the Oorabara Rockholes the detritus dropped off the Jinka Granite directly into a fault-bounded trough with minimal attrition as shown by the presence of detrital galena, fluorite and barite. This formation is regarded partly as the product of the later of two extensive Adelaïdean glacial events (Walter, 1980).

Sedimentation ceased with the Toomba Movement, a mild epeiricogenic uplift (Walter, 1980). In the Mopunga Range a very low-angle unconformity truncates the formation.

**Mopunga Group**

The Elyuah, Grant Bluff and Elkera formations comprise the Mopunga Group (Noakes, 1957, redefined by Walter, 1980). Following the localised erosion of the Oorabara Arkose during the Toomba Movement (Figure 9) a transgression occurred across the SW Georgina Basin. The Mopunga Group sediments were then deposited as relatively even-thickness sheets in contrast to the localised half-graben sedimentation which had prevailed prior to that time.

**Elyuah Formation** (Eae)

The Elyuah Formation consists mainly of laminated grey, green or dusky red, fissile shale. It is commonly veneered with colluvium from overlying formations. In many places, a thin basal conglomerate is the only part of the formation to outcrop. The distribution of the formation is shown in Figure 10b.

The basal pebble conglomerate is up to several metres thick and consists mostly of milky quartz, but with minor lithic pebbles in a quartz arenite matrix. Locally the conglomerate appears very similar to the underlying rock (Plate 10) and obscures the basal contact.

Rare laminae of siltstone or sandstone occur in the shale. Mica is common throughout, and at the NE end of the Jervois Range, a rudaceous litharenite contains approximately 30% of mica up to 10 mm in diameter.

Smith (1964b) estimated that the shale averages approximately 90 m in thickness. This compares well with an intersection in cored hole NTGS.HUC3 in the Elua Range where the formation is 100 m thick.

**Grant Bluff Formation** (Eag)

The Grant Bluff Formation overlies the Elyuah Formation with a transitional contact and extends from near the Queensland border, W to ALCOOTA.

The Grant Bluff Formation grades into the overlying Elkera Formation. Lateral facies changes at the upper contact result in a tongue of Grant Bluff Formation sandstone projecting into the Elkera Formation in the middle Elua Range (GR NQ910810). Walter (1980) refined the definition of the Grant Bluff
Formation and included only the sequence between the upper and lower prominently outcropping beds. However the gradational contacts above and below these beds can present difficulties in precisely locating the base and top of the formation.

In outcrop, the unit forms prominent escarpments with conspicuous, laterally continuous beds on the scarp faces (Plate 11).

The Grant Bluff Formation (Figure 10c) consists mostly of undulose laminated to thin-bedded, fine-grained, quartz arenite to sublitharenite, with micaceous partings (Plate 12). However the prominent rock faces consist of well-rounded, medium to coarse-grained quartz arenite with thin to thick beds. Ripple-

marks, up to 350 mm in wavelength, and small-scale trough cross-beds are common, producing the undulose bedding. Infillings of sinuous syneresis (?desiccation) cracks are preserved on many bedding surfaces in ripple-mark troughs. Dewatering structures are common.

In outcrop, the rock is usually orange-brown with slight ferruginous staining. Where fresh, it is light grey to dark grey and contains trace amounts of disseminated, very fine-grained pyrite together with gypsum laminae. Massive aggregates of gypsum, possibly concentrated by surficial processes, have been exposed in the basal Grant Bluff Formation in the overflow channel from Lake Petrocarb.

Plate 11 Typical outcrop of the Grant Bluff Formation, Jervois Range.
The conspicuous beds of sandstone are coarser grained and thicker bedded than the intervening sandstone beds. Colluvium (Qc) on the lower slopes masks Elyuh Formation shale; Bonita Schist outcrops occur in the foreground. Relief is about 150 m (GR PQ257954).
Trace fossils, including narrow curvilinear grooves, are common, particularly on ripple-marked surfaces. Some of these structures could be infillings of syneresis cracks. M. R. Walter (pers. comm.) in 1981 collected traces from the basal Elkera Formation, from near Valley Bore, which he tentatively identified as Planolites burrows associated with surface markings which may be vendotaenid algae.

Mild tectonism of the Huckitta Movement (Walter, 1980) folded the sedimentary sequence and caused erosion of the top of the Elkera Formation (Figure 9). Subsequently the Mount Baldwin Formation arenites were deposited. In the Jervois Range the contact between the two formations is uneven (Plate 14). West of the Elua Range, where the Mount Baldwin Formation is absent, the Elkera Formation is overlain by dolostones of the Errarra Formation.

**Ungrouped formations**

**Mount Baldwin Formation** (Elb)

This is a prominent ridge-forming sandstone, restricted to the Jervois, Johannsen and Elua ranges (Figure 10e), and though reported in drill hole BMR ELK9 on ELKEDRA (Milligan, 1963; Smith & Milligan, 1966) this is now discounted.

Smith's (1964b) original definition was redefined by Walter (1980) and is now further modified (Appendix 2) to exclude a quartzose pebble conglomerate which outcrops in northern Jervois Range.

The formation consists of grey to dusky red to very dark red-brown, medium to fine-grained quartz arenite to sublitharenite. Locally it is coarse-grained and tends towards a subarkose which commonly produces vuggy weathering surfaces. Rare granule-bearing beds are present. Pebble-sized claystone intraclasts occur in some beds. Prominent hill-capping beds are medium to

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**Elkera Formation** (Eak)

Walter (1980) applied this name to the recessive component of the Mopunga Group that overlies the Grant Bluff Formation. The formation consists mainly of silstone and sandstone, capped with a distinctive stromatolitic dolostone marker horizon. In the Jervois Range, this dolostone does not occur at the top of the Elkera Formation, and the formation is now redefined (Appendix 2) in order to include an additional 43 m of silty sandstone and a granule orthoquartzite bed. This redefinition does not affect the formation boundaries in other outcrops elsewhere. The formation occurs in both HUCKITTA (Figure 10d) and ALCOOTA.

The Elkera Formation consists mainly of dusky red to brown silstone, medium-grained quartz arenite, sublitharenite, dark brown dolostone, which is restricted to eastern HUCKITTA, and laminated mudstone, with a distinctive blue-grey colour. Much of the formation is micaceous. In the eastern half of HUCKITTA the unit contains conspicuous quartz granules which are dispersed in both clastic and carbonate beds. Halite pseudomorphs (Plate 13) are present, though rare, in the argillaceous beds in western HUCKITTA. The stromatolitic dolostone marker, which is yellow-brown, thin to medium-bedded and contains the unique columnar, branching stromatolite *Georgina howchini* (Walter, 1972), is absent in the Elua Range. In the Jervois Range, the top of the formation is marked by lenticular outcrops of medium to very thick-bedded, feldspatic, pebble-bearing orthoquartzite, which cap a dusky red, silty sandstone sequence.

Bedding in the Elkera Formation ranges from very thin to very thick. Parallel orientation of detrital micas imparts a prominent fissility along bedding planes. Bedding is mostly planar, but low-angle alpha cross-stratification (Allen, 1963) is common.

The thickness of the Elkera Formation ranges from 70 m in the Elua Range to 270 m in the Jervois Range, and appears to be less than 100 m west of the Mopunga Range.

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**Plate 13** Halite pseudomorphs, Elkera Formation.

These casts are preserved in dusky red mudstone and are closely associated with desiccation-cracked mudstone and ripple-marked sandstone. Scale in cm (GR NR094253).

**Plate 14** Disconformity between the Elkera and Mount Baldwin formations.

The figure is standing on a lens of orthoquartzite at the top of the Elkera Formation. Mount Baldwin Formation sandstone rests on the disconformity surface (A-A) with its bedding (B-B) forming an angle of about 5° to the disconformity (GR PR312054).
clastic sedimentary rock which Walter (1980) had regarded as being in the top of Mount Baldwin Formation. An erosional surface occurs between the two formations at the now-defined contact.

In the holostratotype (DDH.NTGS.HUC1), the formation consists of a basal sandstone (3 m), grading upward through silty shale into a white dolostone-silty dolostone unit (23 m) which in turn is overlain by a silty sandstone to siltstone unit (36 m) and on top is a limestone and dolostone unit which contains beds of sandy carbonate (67 m).

In and W of the Elua Range the dominant outcrops are thick to very thick-bedded, light brown to pink dolostone, interbedded with laminated silty dolostone and siltstone. Micro cross-laminations are common, especially in a basal silty dolostone in the Mopunga Range.

In the northern Jervois Range, outcrops are mostly of the lower clastic part of the formation, and consist of a basal quartz-pebble conglomerate over lain by friable, ripple-marked subarkose to sublitharenite containing concretionary, pseudo-bedded chert nodules. Trace fossils and bioturbated rock are present. The formation is locally indurated by Tertiary laterite and silcrete, and deeply weathered outcrops of this formation along the flank of the Jervois Range are mapped as Tla. The dolomitic parts of the formation do not

very thick-bedded, (Plate 15) but less resistant parts in general are thinner-bedded and more fissile. The formation is prominently cross-bedded on all scales. In places it is distinguished from the Grant Bluff Formation only with difficulty, but in general the Mount Baldwin Formation has thicker and more even bedding.

The Mount Baldwin Formation is regarded by Walter (1980) as earliest Cambrian on the basis of its trace fossils. In the SE Elua Range, networks of fine, branching burrows occur near the base of the formation, and several varieties of trace fossils have been reported in eastern Jervois Range. Body fossils have not yet been reported.

In the Jervois Range, the formation lies on a disconformity (Plate 14) which is evident on air photographs. In the Elua and Johannsen ranges the base of the Mount Baldwin Formation is, in places, obscure because of the similarity of rock types above and below the disconformity.

**Errarra Formation** (new name) (Ele)
This is defined in Appendix 2. It consists of the various dolostones which were originally included in the Mount Baldwin Formation by Smith (1964b), and later separated, but left undefined, by Walter (1980). The Errarra Formation also includes a minor amount of

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**Plate 16** Hyoliths in the Errarra Formation.
The current-aligned hyoliths are pseudomorphed by barite, and the enclosing dolostone contains dispersed very coarse euhedral of barite as at the top of the photograph. Scale squares 1 cm (GR NQ841851).
Figure 11 Chronostratigraphy and regional correlations of Palaeozoic sedimentary sequences in the southwest Georgina Basin and in the Amadeus and Ngalia basins.

outcrop near the Jervois Range, but the upper clastic beds occur in a single mesa (GR PR347105). Along the NW flank of the Jervois Range and the N Johanssen Range, deeply weathered siltstones of the Arthur Creek Formation rest on Mount Baldwin Formation outcrops and the Errarra Formation is absent (Figure 10f). In the holostratotype the formation is 129.2 m thick, but thins westward to the order of 20-30 m thick in the Mopunga Range.

Faunas are prolific. Near Gap Bore the basal beds contain indeterminate stromatolites with columns up to approximately 150 mm in diameter. Hyoliths, aligned by current activity and partly replaced by barite, (Plate 16) occur nearby. Archaeocyaths are common, and are described by Kruse and West (1980) who concluded that the fauna correlates with Fauna 2 of Daily (1972) and hence was middle to late Early Cambrian. Other faunas include inarticulate brachiopods, tommotiids, and indeterminate phosphatic tubes and sponge spicules (Laurie, in Freeman and others, in prep).

The Errarra Formation overlies the Mount Baldwin Formation with a disconformity or paraconformity (Figure 11). E of the Mopunga Range. In the Mopunga Range the Errarra Formation overlies the Elkera Formation with a disconformity and the two formations are distinguished by the change from the underlying yellow-brown stromatolitic dolostone upsequence into brown, laminated silty dolostone.

Arthur Creek Formation (Ema)

This formation was originally named Arthur Creek beds by Smith (1964b). It was left informal because of poor outcrop and suspicions of a break in the sequence. The formation is formally defined in Appendix 2.

In the composite stratotype in cored holes NTG-S.HUC1 and HUC2, the formation consists of a lower 363 m-thick sequence of fossiliferous calcareous siltstone, the upper one-third of which contains very thick limestone beds, overlain by 54 m of quartzose limestone packstone. The siltstone is organic-rich, dark grey to black, laminated, calcareous and contains disseminated very fine-grained pyrite. The laminations is usually undulose; flaser bedding is common. Numerous bedding-parallel laminae of calcite occur. The organic content results in oil slicks on circulating water during drilling operations and probably was the source of the 'oil' in the Exoil Huckitta 1 oil well. The formation extends across HUCKITTA (Figure 10g).

The siltstone facies readily weathers and is rarely exposed. In the area W of the Elua Range, the Arthur Creek Formation is known solely at GR NQ552973. Elsewhere in western HUCKITTA the formation is marked by prominent lines of white to grey silcrete which formed during the Tertiary as a siliceous replacement of the original rock; this is conspicuous on aerial photographs. Cored hole DDH.NTGS.HUC7, in the Mopunga Range, intersected the fresh siltstones 50 m below silicified outcrop.
The limestone beds within the upper one-third of the siltstone consist of faintly laminated medium to dark grey micrite with very thinly interbedded siltstone. The upper facies is a calcareous quartz arenite to quartzose limestone. The detrital grains consist of subangular, fine to medium-grained quartz with subordinate plagioclase, K-feldspar, apatite, zircon, glauconite and opaque grains. The calcite matrix is completely recrystallised with dispersed to close-packed detrital sand grains. Rarely the calcareous matrix contains relict textures displaying ghost detrital calcite grains. Bedding ranges from laminated to thin-bedded, rarely to thick-bedded, with common low to high-angle cross-beds.

The Arthur Creek Formation is 418m thick in its stratotype, but thins rapidly westward. Only 30m were intersected in cored hole HUC6 in the Elua Range. The siltstone and limestone contains an abundant fauna, especially inarticulate brachiopods, including Micromitra sp. and Acrotheca sp., and trilobites including Xystriidura sp., Psychagnostus sp., Peronopsis sp. and Pagetia sp. (Laurie in Freeman and others, in prep.). The fossil assemblages present suggest an age of early Middle Cambrian.

Arrinthuranga Formation (Eua)
Smith (1964b) applied the name Arrinthuranga Formation to a thick sequence of dolostone and limestone with minor siliciclastic rocks. This formation is observed extensively in HUCKITTA and also in HAY RIVER, TOBERMORY, ELKEDRA and MOUNT WHelan. The sequence is well-bedded and has a conspicuous layered appearance on airphotos. Where the formation is folded it produces rounded hills and where flat-lying, it occurs as soil-covered areas of low relief, or as areas of moderate relief commonly dissected by narrow, deep, joint-controlled ravines.

Kennard (1980, 1981) recognised eight lithofacies which are summarised in Table 4. The numbering of these units bears no relation to their order of superposition and they interfinger laterally. Beds range from medium to thick-bedded and are consistent and regular (Plate 17). Large-scale tepee-like structures are common. However many do not have the typical polygonal outline of tepee structures (Assereto and Kendall, 1977), are very elongate and have parallel crests. Thus these are probably tectonic folds with broad, gentle synclines and sharp, angular anticlines with crenulated fold lines.

Unit 4 of Kennard's (1981) lithofacies is the Eurowie Sandstone Member. South of the Dulcie Range this member thins significantly and cannot be differentiated from other sandstones within the formation. Two outcrop areas of possible Eurowie Sandstone Member, between 5 to 30 km N of Lucy Creek homestead, are on opposite flanks of a gently S-plunging anticline. However to relate these to other outcrops of the Eurowie Sandstone Member it is necessary to infer faulting or folding, neither of which is evident, and so the outcrops could be a separate bed not correlatable to the Eurowie Sandstone Member.

The thickness of the formation is 975 m at the holostratotype (Smith, 1964b, located at and north of GR NO701903) and is 940 m thick in the Mopunga Range, but thins to 715 m in the Huckittita oil well. No measurements are known in the northern part of the sheet area but thicknesses of 434 m have been measured in ELKEDRA (Smith and Milligan, 1966) and 777 m to 914 m in TOBERMORY (Kennard, 1980).

Body fossils are rare, and are limited to a few trilobite fragments. Stromatolites are common. Their internal fabrics are highly variable, ranging from smooth-laminated to undulose-laminated, and through to irregular, fenestral, pustular mats. Many of the bioherms have clotted thrombolitic fabrics possibly caused by emergence and desiccation (Aitken, 1967; Monty, in Walter, 1976). Branching, subhorizontal grazing trails are common in the lime-mudstone lithology and also in the Eurowie Sandstone Member.

The age of the Arrinthuranga Formation is bracketed between the early Middle Cambrian of the Arthur
Creek Formation and the latest Cambrian of the Tomahawk beds. The succession is conformable on the Arthur Creek Formation and the contact is at the change from either poorly outcropping calcareous siltstone or cross-bedded quartz-arenaceous limestone into chert-bearing, well-bedded limestone or dolostone.

**Tomahawk beds (EO)**

The Tomahawk beds consist of a sequence of sandstone, siltstone, dolostone and limestone, and outcrops extensively in NE HUCKITTA and along the flanks of the Dulcie Range. Smith (1964b) informally named the unit after Tomahawk yard, but could not define a type area. It remains informal because where the succession appears to be most complete it is structurally complex (Smith, 1972) and a type section has not yet been defined. Elsewhere, the section is incomplete because it has an erosional upper surface.

The sandstones are mostly well-sorted, fine to medium-grained quartz arenites with minor quartzwacke, subarkose and sublitharenite. Cements mostly are silica with lesser clay and calcite. The quartzwackes have angular grains in a matrix of very fine-grained quartz and the subarkoses contain plagioclase, microcline and perthitic feldspars. Glaucocite is a common accessory mineral. Dolostone and limestone outcrops occur along the southern flank of the E Dulcie Range and in the NE corner of HUCKITTA. These outcrops consist of medium to thick beds of limestone or dolostone, commonly containing poorly sorted quartz sand, accessory glaucocite and traces of tournamaline. Some grains of tourmaline appear to have authigenic overgrowths on rounded detrital grains. Most of this rock petrologically is a quartz-arenaceous dolostone. Extensive medium-bedded flat-pebble conglomerate, with carbonate-rich intraclasts in a quartz-sand-rich matrix, occur S of the Dulcie Range. Near the NE corner of HUCKITTA, an outcrop of quartzose granule sharpstone conglomerate displays large, low-angle cross-beds up to 3 m thick.

Sandstone outcrops in NE HUCKITTA are mostly poorly defined structural basins, some having a siliceous or ferruginous capping. This deformed sandstone grades laterally into undeformed planar bedded quartz-arenaceous dolostone (Plate 19), consisting of prominent, grey, thin to thick beds, interbedded with recessive, grey, fissile, laminated, micaceous siltstone. This lateral gradation is further discussed under Collapse Structures. Outcrops of Tomahawk beds in N HUCKITTA are kaolinated, appear to be affected by a Tertiary deep-weathering event and therefore could be regarded as unit T1a.

Smith (1972) measured 200 m of Tomahawk beds in a section S of the Dulcie Range but an accurate maximum thickness is not known.

There is much bioturbated rock, characterised by medium beds containing irregular disruption of the sediment. Trace fossils are common, mostly consisting of straight to curved burrows confined to bedding planes, or vertical straight burrows (Seilacher, 1967; Pemberton and Frey, 1982). Body fossils are common and include trilobites, molluscs, brachiopods, gastropods and conodonts. Several extensive studies of the body fossils have been completed; on trilobites by Casey and Gilbert-Tomlinson (1956); on conodonts by Jones and others (1971); and on the rostroconchs by Pojeta and others (1977). Laurie (in Freeman and others, in prep.) noted various hyoliths, bivalves and gastropods. The Tomahawk beds range in age from Late Cambrian to Early Ordovician (Shergold and Druce, 1980).

Correlations of the Tomahawk beds are shown in Figure 11. Webby (1978) recognised a hiatus in the Kelly Creek Formation, ascribed to his Kelly Creek Movement, which may occur either in the Tomahawk beds or between the Tomahawk beds and the overlying Nora Formation. The Dulcie Sandstone rests disconformably on the Tomahawk beds with an angular discordance of up to 5°. This break is caused by erosion following the Rodigan Movement of the Amadeus Basin (Wells and others, 1970).

**Nora Formation (Ol)**

The Nora Formation outcrops rarely below the escarpment of the Dulcie Sandstone around the SE Dulcie Range; most of the outcrop area is concealed by colluvium.

The formation, which was named by Casey (in Smith 1963), consists of green-grey siltstone, red coarse-grained sandstone and dark red, oolitic ironstone. Bedding is thin to thick and cross-beds are common in the sandstone. Smith (1972) reported 25.7% Fe₂O₃ in the ironstone.

The maximum thickness of the Nora Formation in the Dulcie Range is 113 m (Smith, 1972), but it thins westward and is absent within several kilometres E of Mount Ultim. Rodigan Movement (Wells and others, 1967) uplift resulted in the bevelling of the Nora Formation in the W, with the maximum erosion occurring in NW HUCKITTA.

The formation probably originated largely in a shallow marine or subtidal environment (Shergold, 1976). Kimberley (1979) concluded that oolitic iron formations are formed when normal carbonate ooliths

![Plate 19 Dolostone in the Tomahawk beds. Typical planar and even-bedded, bioturbated quartz-arenaceous dolostone from NE HUCKITTA. Scale squares 2 cm (GR PR480659).](image-url)
Table 4  Lithofacies of the Arrinhrunga Formation.

<table>
<thead>
<tr>
<th>LITHOFACIES</th>
<th>FOSSILS</th>
<th>DEPOSITIONAL ENVIRONMENT</th>
<th>DISTRIBUTION AND STRATIGRAPHIC RELATIONSHIPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Very fine grainstone and lime-mudstone. Thin-bedded very fine peloid grainstone and lime-mudstone giving a 2-tone fabric; grainstone is dolomitic limestone with dolomitised peloids and lime-mudstone is calcareous dolostone; includes flat-pebble conglomerate, fine-grained sandstone, siltstone, shale, minor algal boundstone</td>
<td>Stromatolites; trilobite fragments; rare worm trails</td>
<td>Moderately shallow water, low turbulence, normal salinity; a weakly tidal extensive shallow shelf</td>
<td>The basal unit of the formation, overlain by lithofacies 2</td>
</tr>
<tr>
<td>2. Algal mound lithofacies. Thrombolitic algal boulderstone in lenticular bioherms tabular biostromes, with flanking beds of peloid and oolite; minor flat-pebble conglomerate, lime-mudstone and fine-grained sandstone; intercolumnar silt is present</td>
<td>Stromatolites; rare trilobite fragments in peloidal and intraclastic grain-stones</td>
<td>Shallow water, moderate turbulence and elevated salinity; a reticulated maze of domed algal bioherms, inter-biothermal rippled peloid-oolid sands migrating peloid-oolid shoals</td>
<td>The most widespread unit; onlaps Eurowie Sandstone Member and a lens of lithofacies 5; overlain by lithofacies 3 and 6</td>
</tr>
<tr>
<td>3. Mixed oolitic-quartz sandstone. Interbedded, cross-stratified ooid carbonate and mixed carbonate-siliciclastic sandstones, minor peloidal carbonate, flat-pebble conglomerate and algal bioherms</td>
<td>Stromatolites; trilobite fragments in oolitic carbonates, common in cores of ooliths</td>
<td>Shallow water, highly turbulent environment; local areas of low turbulence and hypersalinity; ooid and quartz shoals close to terrigenous shoreline; periodic wash-over of sands into lime-mud lagoons</td>
<td>Overlies lithofacies 2 and is overlain by the Eurowie Sandstone Member; up to 130 m thick</td>
</tr>
<tr>
<td>4. Eurowie Sandstone Member. Rippled and cross-laminated, fine to medium-grained quartz arenite, siltstone and shale with cubic hopper-casts after halite; rare granule conglomerate in south</td>
<td>Rare worm trails</td>
<td>Intermittently emergent shoreline dominated by quartz sand; evaporitic conditions wide-spread</td>
<td>Possibly correlates with top of lithofacies 3 south of Dulcie Range; elsewhere overlies lithofacies 3; overlain by lithofacies 2 or onlapped by lithofacies 5; up to 30m thick and occurs in about the middle of the formation</td>
</tr>
<tr>
<td>5a. Undulosal-laminated algal boundstone. Fenestral undulosal-laminated algal boundstone, fine-grained dolostone, and minor very fine-grained sandstone. Also minor amounts of peloidal carbonates and flat-pebble conglomerate. Dolomitisation is widespread and has commonly destroyed primary rock textures</td>
<td>Stromatolites</td>
<td>Intermittently emergent, very shallow water, hypersaline with periodic high wave energy; algal mats, desiccated hard grounds and aeolian-derived quartz sand</td>
<td>Thin lenses at several stratigraphic intervals in the Arrinhrunga Formation</td>
</tr>
<tr>
<td>5b. Pustular-laminated algal boundstone. Fenestral pustular and undulosal-laminated algal boundstones with minor interbeds of cross-stratified peloidal dolostone; finely dolomitised throughout and has a vuggy porosity; gypsum crystals and pseudomorphs after anhydrite (Plate 18)</td>
<td>Stromatolites</td>
<td>Very shallow, hypersaline waters and emergent or near-emergent conditions which were too arid to support the development of the more regular algal laminae of lithofacies 5a</td>
<td>Restricted to the basal part of the sequence; it has a maximum thickness of about 100 m and overlies lithofacies 7; probably interfingers with lithofacies 1</td>
</tr>
</tbody>
</table>
Table 4 (continued).

<table>
<thead>
<tr>
<th>LITHOFACIES</th>
<th>FOSSILS</th>
<th>DEPOSITIONAL ENVIRONMENT</th>
<th>DISTRIBUTION AND STRATIGRAPHIC RELATIONSHIPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>6. Oolitic dolostone lithofacies. Cross-stratified, thin and medium to course-grained oolitic dolostone and minor cross-laminated fine quartz sandstone and flat-pebble conglomerate; minor amounts of peloids, intraclasts, quartz and glauconite; dolostones are largely recrystallised, with relict ooid structures. Peloidal grainstone lithofacies. Cross-stratified medium and thickly bedded fine-to coarse-grained peloid-clast-ooid grainstone.</td>
<td>Shallow water, high turbulence and hypersalinity; ooid shoals close to a terrigenous shoreline and some aeolian derived quartz sand.</td>
<td>An extensive sheet at the top of the formation. 130 m thick near Mopunga Range; overlies lithofacies 2.</td>
<td>Moderately shallow water, high wave and current action and normal salinity; a prograding peloid shoal or barrier bar.</td>
</tr>
</tbody>
</table>

are replaced by iron oxides in organic-rich muds by pore water interaction; this may have occurred in the Nora Formation.

**Dulcie Sandstone (Dud, Dud₁ & Dud₃)**

The Dulcie Sandstone is exposed as a prominent scarp-forming unit in the Dulcie Range (Plate 20) and extends to the NW corner of HUCKITTA. It was first described by Tindale (1931). Following some confusion in earlier descriptions, Smith (1964b) rationalised the definition, restricting the name only to rocks of the Devonian Period.

The Dulcie Sandstone consists of prominently cross-bedded, medium to very thick-bedded quartz arenite, with rare beds of pebble orthoconglomerate and calcareous silty quartz sandstone. Airphoto interpretation was used to divide the Dulcie Sandstone into two facies near Tent Hill (GR NR152330). The principal difference between the facies is that the lower (Dud₁) is less resistant and outcrops as a series of thinner beds separated by more weathered rock, whereas the upper (Dud₃) is more resistant and consists of prominent thicker beds which produce escarpments up to 50 m high. The contact between these facies was traced laterally around the Dulcie Sandstone outcrops. However, the distinction is less obvious in the eastern and northern outcrops. It is thought that Dud₁ is largely clay-cemented, whereas Dud₃ may be silica-cemented. Cross-bed cosets, both small and large scale, have planar to curved laminae. There is a large range in styles including alpha, gamma, epsilon, nu and xi-cross-stratification (Allen, 1963).

The formation contains rare thelodont fish, Bothriolepis sp. and Phyllolepis sp., mostly consisting of small areas of scales (Gilbert-Tomlinson, 1968). Rare trace fossils of sinuous shallow grooves and vertical tubes are also present. Gilbert-Tomlinson (1968) has suggested that the Dulcie Sandstone consists of an

Plate 20 Typical outcrop, Dulcie Sandstone.

Quartz arenite forms the 50 m-high escarpment and underlies the valley base but silty, calcareous sandstone, an uncommon rock in the Dulcie Sandstone, occurs in the lower slopes. An older bevelled land surface is preserved at the top of the escarpment (GR NR585105).
Figure 12 Location of extensive palaeo-alluvial fans in and near HUCKITTA.

Upper Silurian to Lower Devonian basal sequence overlain by an Upper Devonian sequence, separated by a paraconformity. However this break appears to be within the lithostratigraphic unit Ddu, and was not located during the mapping.

Smith (1964b) measured a 621 m-thick stratotype, 13 km E of the abandoned Huckitta homestead. The formation appears to be about 250 m thick in NW HUCKITTA, where accurate measurements have yet to be made.

The Dulcie Sandstone has been correlated (Figure 11) with the Cravens Peak Beds of western Queensland (Gilbert - Tomlinson, 1968), the Merenie Sandstone of the Amadeus Basin (Wells and others, 1970), and the Lake Surprise Sandstone of the Wiso Basin to the NW (Kennewell and Huleatt, 1980).

EROMANGA BASIN

Hooray Sandstone (JKh)
The once-extensive sediments of the Eromanga Basin are now restricted, in HUCKITTA, to isolated remnants. Initially Smith (1964b) assigned these rocks to the Triassic Tarlton Formation, but Senior and others (1978) have renamed them as the Hooray Sandstone.

The Hooray Sandstone forms several mesas in valleys within and along the flanks of the Dulcie Range, and low hills E of the Jervois Mine are tentatively mapped as Hooray Sandstone. One mesa 2.5 km S of Pound Spring consists of approximately 60 m of cross-bedded, white, kaolinitic sandstone (Smith, 1964b).

Other sections are much thinner. All outcrops are truncated by erosion and many have ferruginised or silicified cappings up to 5 m thick.

CAINozoic UNITS

The informal subdivisions of this Era are summarised in Table 5 and their relationships are shown on the map face. The units consist of laterite, silcrete or deeply weathered profiles superimposed on older rocks and of sediments, and are tabulated under each of these categories.

The Waite Formation was defined by Woodburne (1976a) as occurring only in the localised basin along the Waite River in ALCOOTA. Outcrops of the equivalent lithostratigraphic unit in HUCKITTA are separated from this Waite River basin by a basement high, do not, therefore, comply with the definition of the formation, and hence are termed ‘Waite Formation equivalents’.

Cainozoic sediments up to 40 m thick were intersected in water bores along the Bundey River. The sediment consists of silt and clay with interbedded sandy and pebbly beds. Drilling by the NTGS in 1982 intersected chaledonic limestone at shallow depths and so much of the sediment in the water bores may be regarded as Waite Formation equivalents. However, cored hole NTGS. HUC11 intersected silt, some of which is carbonaceous, with sand and calcarceous silt to a bottom depth of 127 m. This thickness exceeds that
<table>
<thead>
<tr>
<th>AGE</th>
<th>UNIT SYMBOL, LITHOLOGY</th>
<th>DISTRIBUTION</th>
<th>COMMENTS, THICKNESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recent</td>
<td>Qa; Alluvial soil, aeolian sand, silt, clay, local gravel</td>
<td>Throughout</td>
<td>Probably underlies much Qo; larger channels date from previous pluvial periods;</td>
</tr>
<tr>
<td></td>
<td>deposits especially in creek channels</td>
<td></td>
<td>thickness up to 10 m though may be thicker in some valleys</td>
</tr>
<tr>
<td>Quaternary</td>
<td>Qe; Eluvial soil veneer over Arunta domain rocks with</td>
<td>Between Marshall &amp;</td>
<td>Much may overlie Waite Formation equivalents; characteristic arcuate groves of</td>
</tr>
<tr>
<td></td>
<td>common scattered small outcrops</td>
<td>Plenty rivers</td>
<td>Mulga (Acacia aneura)</td>
</tr>
<tr>
<td></td>
<td>Qr; Red-earth soil, local sand and silt</td>
<td>Western one-third</td>
<td>Flood-out areas; inundated in wet periods</td>
</tr>
<tr>
<td></td>
<td>Qp; Clay soil, dark grey, expansive</td>
<td>NE quarter</td>
<td>Much is probably underlain by Qa</td>
</tr>
<tr>
<td></td>
<td>Qs; aeolian sand; sheet sand and stabilised dunes</td>
<td>N and NW and along</td>
<td>Scree slopes on steeper hills, some outwash fans</td>
</tr>
<tr>
<td></td>
<td>Qc; Sand and gravel, colluvium, fanglomerite; some eluvium</td>
<td>Marshall/Plenty river</td>
<td></td>
</tr>
<tr>
<td>Mio-pliocene</td>
<td>Waite Formation equivalents Twchalcadonic limestone</td>
<td>Southwest</td>
<td>Lacustrine deposits; vertebrate fauna on ALCOOTA (Woodburne, 1967a,b; Lloyd, 1968);</td>
</tr>
<tr>
<td></td>
<td>cappings over argillaceous sediments; minor conglomerate</td>
<td></td>
<td>40 m.</td>
</tr>
<tr>
<td>Palaeocene</td>
<td>Carbonaceous argillaceous sediment</td>
<td>DDH.NTGS.HUC11</td>
<td>One intersection from 250 m to 127+ m depth; tentative identification by Truswell</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(BMR, pers. comm.) indicates Palaeocene age</td>
</tr>
<tr>
<td>Cainozoic</td>
<td>Czs; Black soil, expansive, clay-rich soil</td>
<td>NE DNEPER</td>
<td>On relatively elevated plain; overlies laterite, now being eroded on east;</td>
</tr>
<tr>
<td>undivided</td>
<td></td>
<td></td>
<td>conspicuous Mitchell grass cover; 5 m</td>
</tr>
<tr>
<td></td>
<td>Czc; Fanglomerate, conglomerate, soil and sand</td>
<td>SW JINCA especially</td>
<td>Outwash deposits (pediments) around ranges, deposited before or during dune</td>
</tr>
<tr>
<td></td>
<td></td>
<td>small occurrences</td>
<td>formation, now being actively dissected; up to 10m</td>
</tr>
<tr>
<td></td>
<td></td>
<td>elsewhere</td>
<td>Undulating peneplain, now being eroded</td>
</tr>
</tbody>
</table>

### SURFICIAL-ALTERATION PROFILES

<table>
<thead>
<tr>
<th><strong>7 Palaeocene to Miocene</strong></th>
<th><strong>Ts</strong>; Silcrete, silicified rock well described by Milnes &amp; Twidale (1983)</th>
<th><strong>DNEPER and nearby JINCA</strong>; a few outcrops near Lucy Creek homestead</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early Tertiary or older</td>
<td>Tf; Ferricrete, highly to moderately ferruginised rock</td>
<td><strong>Throughout</strong></td>
</tr>
</tbody>
</table>

Widespread deep-weathered profile; some related to **Tf±Ts**; Indur & Senior (1978) suggest latest Cretaceous to Early Paleocene age
of any other known Tertiary sequence in HUCKITTA. Preliminary palynological determination by E. M. Truswell (pers. comm.) indicates that the sediments accumulated during the Palaeocene.

A more pluvial climate prevailed during relatively recent times (Bowler, 1982), resulting in the major watercourses carrying far greater flows than at present. C. J. Simpson (pers. comm.) noted that the Marshall-Plenty rivers developed a large fluvial fan some 100 km across, starting in SE HUCKITTA. A second has now been located on the Bundey River downstream (northwards) from where it crosses the Dulcie Sandstone (Figure 12).

Quaternary units are only a superficial veneer and none are thought to be present in any great thickness.

### METAMORPHISM

The general distribution of metamorphic facies is illustrated in Figure 13.

Black and others (1983) have documented five metamorphic events in the Arunta orogenic domain, ranging 1800-1000 Ma. The events which affected HUCKITTA are listed in Table 6. The earliest, the Strangways Event, is considered to be the most

**Plate 21** Sitstone outcrops of the Errarra Formation, affected by Tertiary deep weathering (Tia).

The basal siltstone of the formation is well indurated through a severe weathering event and now forms erosional remnants along the flank of the Jervois Range. Mount Baldwin Formation sandstone outcrops occur in the foreground and hidden behind the Tia. The case is about 3 m high (GR FR40640).
significant for HUCKITTA (Shaw, Langworthy and others, 1979). The two later hydration events are only tentatively correlated with the Aileron and Anmatjira events.

Hydration of many of the granites has occurred. Some may be deuteritic, but probably some, at least, may reflect a separate metamorphic event correlatable with hydration of the metamorphic rocks.

Late-stage dynamometamorphic effects were concentrated along the retrograde schist zones; particular examples are the Delny-Mount Sainthill Fault Zone, and several isolated outcrops in southern Jervois Range. The Delny-Mount Sainthill Fault Zone was probably initiated during the earlier events described in Table 6 and remodelled during the Carboniferous Alice Springs Orogeny. In contrast retrograde schist (Pzr) in several outcrops in SE HUCKITTA are considered to be wholly related to the Alice Springs Orogeny. Granular crystalline and sedimentary rocks can be traced into the schistose zones and which contain slivers of little-deformed or undeformed rocks. Retrogression has generally occurred on greenschist facies, though in some places it was at the amphibolite facies. Mylonitic quartz veins within the schist zones are multiply folded, indicating an extended history of polyphase deformation and mylonitisation.

STRUCTURE AND TECTONICS

Two periods of major tectonism are recognised in HUCKITTA. In addition, minor activity occurred between and after the major tectonic events, and an episode of carbonate dissolution was accompanied by widespread collapse-structure formation.

EARLY DEFORMATION IN THE ARUNTA OROGENIC DOMAIN

The first major deformation in HUCKITTA probably accompanied the Strangways Event at 1800 Ma (Black and others, 1983) and affected the whole domain. Subsequent Proterozoic metamorphic events have deformed the rocks to a lesser degree and their effects are either localised or have not been correlated with individual deformational events.

Detailed structural analysis in the S and W parts has not been done for this report. In outcrops of the Harts Range Group in this area, the foliation is folded apparently into a W-trending synform with a closure S of Mount Thring.

Outcrops of Arunta orogenic domain rocks in the Mopunga Range and extending E to the Jervois Mine area are more continuous. The foliation in the Deep Bore and Cackleberry metamorphics trends generally WNW. Small-scale folds are locally present but are, as yet, to be evaluated in detail. Some premetamorphic folds have no associated penetrative fabric, but in other areas a well-defined lineation is present.

In the Bonya Schist, folding is better known than in other areas. In the Jervois Mine area the earliest phase is an isoclinal folding of the compositional layering (probably original bedding) and the regional foliation is axial planar to this folding. This phase was followed by the formation of a dominant, early crenulation cleavage which is vertical, strikes approximately at right-angles to the foliation and is axial planar to warping of the foliation. The third phase was the formation of a poorly developed crenulation cleavage which is axial planar to the regional north-striking, near-vertically plunging antcline, known locally as the 'J-fold'. Subsequently a vertical, east-striking fracture cleavage set was formed.

In the Bonya Hills a major east-plunging syncline appears to merge westward across a pitch reversal into a west-plunging fold. However rock distributions suggest the two folds have contradictory facings, so the folds may be separated by an as yet unrecognised fault which strikes at a low angle to the axial-plane traces. Crenulation cleavages near the axis of the east-plunging syncline have diverse orientations and details of the deformation in this area are yet to be evaluated.

During this early orogenesis, the basement rocks were fractured into discrete structural blocks separated by faults as illustrated in the Solid Geology inset on the map face and in Figure 5.

The Ambalindum Block, which contains the Kanandra Granulite, at the W end, and the Harts Range Group, occupies the area S of the Delny-Mount Sainthill Fault Zone. The eastern end of the Ambalindum Block was defined by Warren (1980) as the Mount Baldwin Lineament, which is a prominent LANDSAT lineament and which approximately coincides with the NE side of the Lake Caroline Gravity Ridge (Lonsdale and Flavelle, 1968). The lineament cannot be recognised on later TM1 maps although a significant break, trending SSE, is apparent further E, coinciding with the easternmost outcrops of the Harts Range Group. This is preferred as the eastern boundary of the Ambalindum Block.

Near the W boundary of HUCKITTA and N of the Delny-Mount Sainthill Fault Zone is a wedge-shaped area which extends into ALCOOTA. This area appeared to be a single structural block and was named the Mount Skinner Block by Shaw and Warren, (1975). This block is cut by several parallel faults trending NW, and has extensive Cainozoic cover so its integrity is in doubt and use of the name has been discontinued.

Further E from this former Mt. Skinner Block are the Jinka, Bonya and Jervois blocks, (Shaw and others, 1984). The southern margin of the Bonya Block is problematical, but is probably an ENE-trending branch of the Delny-Mount Sainthill Fault Zone. The Jervois Block is separated from the Bonya Block by the quartz-filled Bonya Fault (Figure 6) in the S and a wedge of sedimentary rocks in the N. Aeromagnetic data shows a major break in the basement rocks across a NNE extension of this fault (termed the Jervois Fault), coinciding with the present eastern limit of the sedimentary rocks. Further northwards the extension of the Jervois Fault may be represented by a line of disruption within the sedimentary rocks in the Jervois Range. Beyond the range the projection line marks the SE limit of sandstone outcrops which are tentatively correlated with the Eurowie Sandstone Member. Thus the Jervois Fault may have been active during the Late Cambrian.

The remaining block in SE HUCKITTA, extending E from the Ambulindum Block possibly as far as the Tarlton Fault in TOBERMORY, is left unnamed. Within the block are outcrops of unnamed metamorphics (red) and two Palaeozoic retrograde-schist zones which could represent major structural features which further divide this block.
<table>
<thead>
<tr>
<th>UNIT</th>
<th>PRE-STRANGWAYS</th>
<th>STRANGWAYS (1790±35Ma) PROGRADE ASSEMBLAGES, COMMENTS</th>
<th>HYDRATION I (TAILERON EVENT, 1700-1650 Ma) RETROGRADE ASSEMBLAGES, COMMENTS</th>
<th>HYDRATION II (ANMATJIRA EVENT 1400 Ma) RETROGRADE ASSEMBLAGES, COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kanandra Granulite</td>
<td>Migmatite</td>
<td>Or-opx zone of granulite facies; opx+cpx+plag; gt+di+plag; scp+wol+di+cc; gt+or±opx±bi</td>
<td>Amphibolite facies; bi after gt+opx; hb [pargasite] after opx; sill+biot after gt+or</td>
<td>Amphibolite facies; bi after gt+opx; hb [pargasite] after opx; sill+biot after gt+or</td>
</tr>
<tr>
<td>Unnamed unit pEc</td>
<td>Not recognised</td>
<td>Amphibolite transitional to granulite facies; kornjerupine indicates moderate to high temperatures (Werding and Schreyer, 1978)</td>
<td>Not recognised</td>
<td>Greenschist facies (Clt after kornjerupine)</td>
</tr>
<tr>
<td>Unnamed unit pEd</td>
<td>Not recognised</td>
<td>Amphibolite facies; migmatitic quartzofeldspathic gneiss; knotted schist (Indications are imprecise, Membert, 1968).</td>
<td>Amphibolite facies; knotted schist, with muscovite clots after ?andalusite.</td>
<td>Not recognised</td>
</tr>
<tr>
<td>Irindina Gneiss pEhi</td>
<td>Not recognised</td>
<td>Upper amphibolite; (N outcrops &amp; S DNEPER) sill-or zone; K-spar+sill +qtz; gt+biot+plag+qtz+sill; hb+plag+qtz+di; scp+di+plag+qtzphlog); middle amphibolite (SW JVSIA) sill-musc zone (sill+ musc+qtz)</td>
<td>Granite</td>
<td>Granite</td>
</tr>
<tr>
<td>Perenti Metamorphics pEt</td>
<td>Not recognised</td>
<td>Granulite facies cpix+opx+plag; opx+K-spar; antiperthite</td>
<td>Not recognised</td>
<td>Granite</td>
</tr>
<tr>
<td>Cackleberry Metamorphics pEv</td>
<td>Not recognised</td>
<td>Transitional hornblende-granulite facies; cord+K-spar; opx+cpx+plag; severely overprinted by later event</td>
<td>Amphibolite; cord+anth after opx; chl+ep; green hb+cum</td>
<td>Not recognised</td>
</tr>
<tr>
<td>Deep Bore Metamorphics pEp</td>
<td>Not recognised</td>
<td>Granulite facies opx+cpx+plag(An 80)+hb; high-T hb with 2.1% TiO₂ indicating 810°C [Wood &amp; Banno, 1973; Wells, 1977]</td>
<td>Amphibolite facies cord+biot+qtz pseudomorph gt; hb after opx</td>
<td>Transitional amphibolite - greenschist facies; plag replaced by ep+phyl</td>
</tr>
<tr>
<td>Mascotte Gneiss Complex pEm</td>
<td>Not recognised</td>
<td>Amphibolite facies; migmatitic quartzofeldspathic gneiss</td>
<td>Not recognised</td>
<td>Not recognised</td>
</tr>
<tr>
<td>Location</td>
<td>Facies Description</td>
<td>Facies Description</td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------------------</td>
<td>------------------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bonya Schist p&lt;sub&gt;0&lt;/sub&gt;</td>
<td>Low pressure and-sill amphibolite facies, 520-600°C, 0.2-0.3 GPa (Dobos, 1978); qtz+musc+m+t±biot±and±cord±chl; qtz+musc+m+biot±sill; qtz+ai±m±biot±staur±and±biot; qtz+m±sp±ch±staur; hb+plag±ep±qtz; transitional greenshist-amphibolite facies; qtz+plag+b+m±k±spar±ep; enclave near Bonya Bore</td>
<td>Amphibolite facies musc after and; musc after cord; both giving widespread knotted schist</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unnamed unit p&lt;sub&gt;e&lt;/sub&gt;s</td>
<td>?Amphibolite facies; no diagnostic assemblages but contains quartzofeldspathic gneiss</td>
<td>Not recognised</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ledan Schist p&lt;sub&gt;hn&lt;/sub&gt;</td>
<td>Lower amphibolite facies; qtz+musc+biot, schist</td>
<td>Not recognised</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dneiper Granite E&lt;sub&gt;gd&lt;/sub&gt;</td>
<td>Development of foliation</td>
<td>Greenschist facies; clt+opaque after biot</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mount Swan Granite E&lt;sub&gt;gs&lt;/sub&gt;</td>
<td>Not recognised</td>
<td>Greenschist facies; biot after hp; phyl after plag; myrmekite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jinka Granite E&lt;sub&gt;gj&lt;/sub&gt;</td>
<td>Not recognised</td>
<td>Greenschist facies; biot after hp; phyl after plag; myrmekite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unca Granite E&lt;sub&gt;gu&lt;/sub&gt;</td>
<td>Not recognised</td>
<td>Greenschist facies; biot after hp; phyl after plag; myrmekite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unnamed granite E&lt;sub&gt;gc&lt;/sub&gt;</td>
<td>Not recognised</td>
<td>Greenschist facies; biot after hp; phyl after plag; myrmekite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unnamed granite E&lt;sub&gt;gf&lt;/sub&gt;</td>
<td>Development of foliation, adjacent granite E&lt;sub&gt;gn&lt;/sub&gt; has Rb-Sr age of 1750 Ma (Black, 1980) indicating P&lt;sub&gt;e&lt;/sub&gt; was metamorphosed before 1750 Ma.</td>
<td>Greenschist facies; biot after hp; phyl after plag; myrmekite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attutra Metagabbro P&lt;sub&gt;da&lt;/sub&gt;</td>
<td>Not recognised</td>
<td>Greenschist facies; clt after biot and hb</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unnamed meta-quartz norite E&lt;sub&gt;dr&lt;/sub&gt;</td>
<td>Not recognised</td>
<td>Greenschist facies; clt after biot and hb</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

act = actinolite; cord = cordierite; hb = hornblende; phl = phlogopite; spess = spessartine; aim = almandine; cpx = clinopyroxene; K-spar = K-feldspar; phyl = phyllosilicates; staur = staurolite; andl = andalusite; cum = cummingtonite; musc = muscovite; plag = plagioclase; wot = wollastonite; biot = biotite; calc = calcite; ep = epidote; opx = orthopyroxene; scp = scapolite; clt = chlorite; gr = garnet; or = orthoclase; sll = sillimanite;
In the northern part of HUCKITTA, there are well-defined, fault-bounded blocks with a cover of sedimentary rocks, but no attempt has yet been made to classify or name them.

LATE PROTEROZOIC DEFORMATION
Several episodes of minor deformation occurred between the two major orogenies of the middle Proterozoic Strangways Event and the Carboniferous Alice Springs Orogeny.

Evidence of epeirogenesis during this period is preserved in the Georgina Basin sedimentary sequence. Initially, NW-trending rifts developed as half-grabens during the Adelaidean, and concomitant sedimentation occurred within them. Subsequent sedimentation extended completely across the basin. Local and regional breaks occur at various levels in the sequence. Walter (1980) documented four significant breaks and named some of the corresponding movements (Figures 9 and 10). Of these, only the latest Adelaidean Huckitta Movement caused folding. In the Jerrold Range, the Mopunsa Group was folded prior to deposition of Mount Baldwin Formation sediments.

Several parallel NW-trending faults in the Bonya Schist, S of the Johannsen Range, are reactivated into a WNW orientation on penetrating the cover rocks. The amount of displacement across the faults decreases from a maximum of several hundred metres in the Elyuah Formation to nil in the Mount Baldwin Formation, indicating the faulting was contemporaneous with deposition of the Mopunsa Group (Simpson, 1980).

ALICE SPRINGS OROGENY
The second orogenesis in HUCKITTA is correlated with the Alice Springs Orogeny and involved reactivation of basement structures and moderate deformation of the cover rocks.

Extensive areas have rocks referred to as retrograde-schist zones which are generally related to the Delny-Mount Sainthill Fault Zone (Warren, 1978) and are described herein as Late Stage Retrograde Schist Zones. This fault zone is up to 5 km wide and though it is well-defined on the TMI maps, its boundary is difficult to define precisely in outcrops. Many splays occur and those extending NW from the fault zone have influenced the present form of the Elua Syncline (Figure 14). The fault zone is a high-angle reverse fault with near-vertical S dips, and lineations in the fault rocks indicate that movement has been essentially vertical. Slivers of little-deformed rock occur within the fault zone. One of these, WSW of Mount Baldwin, contains the high-temperature indicator boron-bearing kornrunite (Warren and McColl, 1983) and has probably been displaced upwards to lie within lower grade metamorphic rocks. Slivers of Adelaidean sedimentary rocks in the fault zone, near Molyhill, are tectonically intercalated with Arunta orogenetic domain rocks, having been translated downwards and rotated from horizontal to vertical within the fault zone. Early-formed mylonite (Bell and Etheridge, 1973) has been intensely folded by later deformation. The duration of movement is unknown, but this fault zone is thought to be an older structure which was reactivated several times (Warren, 1978; Black, 1980). Its last phase post-dates the Late Cambrian Arrintherunga Formation and is correlated with the Carboniferous Alice Springs Orogeny (Stewart, 1971).

Other faulting in the basement is mostly along well-defined planes, some extending into cover rocks or separating basement from cover rocks. In many instances the faults grade into monoclinal or zones of complex deformation referred to as fault zones on the Solid Geology inset on the map face. Particular features are discussed below.

One example of these faults is the Charlotte Fault Zone which ranges from a single, quartz-filled fault to twin faults, 1 km apart separated by either basement or cover rocks. Severe movement within the zone has rotated slivers of cover rock and juxtaposed various formations out of stratigraphic sequence (Figure 15).

Near the W boundary of HUCKITTA are four WNW-trending ridges of the lower Mopunsa Group, separated by basement rocks. The cover rocks have a shallow northward dip, though locally they are folded and faulted. It is interpreted that the basement rocks are thrust on the cover rocks and form a series of N-dipping thrust slices in an imbricate stack (Butler, 1982) with the sediments preserved in horses. The individual thrust surfaces merge to form a NE-trending branch line (Boyer and Elliott, 1983) which is evident on the TMI map and shown by sparse outcrops of severely deformed Grant Bluff Formation to extend NE from Dnieper Homestead.

Cover-rock faulting has occurred over steeply dipping faults in the basement. Notable examples of these are NNW-trending faults with E-side-down movement (Ooratipima, Mount Playford, Lucy Creek and Picton fault zones), and a N-trending fault with E-side-up movement (Putta Putta Fault Zone). These fault zones occur as a series of faults and monoclines and smaller scale anticlines, synclines, joints, brecciated surfaces and ferricrete. Fault zone margins are commonly sharp; for example, bedding dips in monoclines change from vertical to horizontal in 10 to 20 m (Plates 22, 23). Although vertical movements predominate, other features, such as the NE splaying at the northern end of the Lucy Creek Fault Zone, could indicate a strike-slip component.

Simpson (1980) noted that some of the Palaeozoic faults along the basement-cover boundary may be of a transverse strike-slip type. In particular, strike-slip faults and reverse faults E of the Mopunsa Range have a style similar to that of the Toomba Fault, located some 250 km ESE of HUCKITTA (Bureau of Mineral Resources, 1978). In HUCKITTA, there are six NW-trending faults, which displace the basement-cover contact further to the N in a major dextral fault system similar to, though possibly including a greater strike-slip component than, the Toomba Fault (Harrison, 1980).

The sedimentary cover is mildly affected by broad, gentle folding, most of which can be related to faults in the underlying or adjacent basement. Such broad-scale folds include the WNW-trending Dulcie Syncline, a shallow S-plunging syncline E of the Lucy Creek homestead, and an ill-defined very shallow north-plunging anticline/syncline fold-pair between Lucy Creek homestead and the Dulcie Range.

The Elua Syncline, in the Jinka Block, is asymmetric with the N limb having a 7° S dip, and the southern limb nearly vertical. This southern limb is dismembered into several fault-bound slivers and has an incomplete stratigraphic sequence. The Jinka Block has rotated with the N-side-up, adjacent to the
Figure 14  N-S cross-section through the Jinka Block showing relative movement across faults and the minimum amount of movement at the Oomoozilla Fault.
Figure 15  Schematic cross section through the Charlotte Fault Zone at GR PQ005915.

Oomoomilla Fault, and the S-side-down, adjacent to the Delny-Mount Sainthill Fault Zone. NW-striking splays from this fault zone have combined with fault drag to produce the Elua Syncline (Figure 14). By projecting the bedding northwards from the Elua Syncline to the Oomoomilla Fault, a relative vertical movement of 3500 m is indicated at the Oomoomilla Fault.

Extensive areas of the Tomahawk beds which outcrop S of the Dulcie Sandstone have macroscopic kink folds (Plate 24) as illustrated diagrammatically on the map face. The fold axes commonly are of the order of 50-100 m apart, trend consistently at about 305° and form an angle of 30° to 60° to the bedding strike direction. In the area extending from approximately 3 km E of Exoil Huckitta 1 oil well SE to the Oomoomilla Fault, the axial planes of the kink folds dip northward, resulting in monoclines. Both the underlying Arrinhrunga Formation and the overlying Dulcie Sandstone are not folded to the same degree suggesting there should be surfaces of detachment above and below the folded rocks to facilitate the differential foreshortening (R. D. Shaw, pers. comm., 1983). No field evidence of these surfaces has yet been observed although airphoto interpretation indicates that W of the abandoned Old Huckitta homestead are E-trending faults which are deflected along the contacts between the Tomahawk beds and both the Arrinhrunga Formation and the Dulcie Sandstone respectively. Both of these fault sets may be splays from décollements along the bottom and top of the Tomahawk beds and, if so, indicates that there was a westward over-riding component present in the movement. The latest movements have affected Devonian rocks and therefore can be correlated with the Alice Springs Orogeny. Prominent jointing is widespread and associated with the faulting and folding. In the Jervois Range, E-W vertical joints within the Mount Baldwin Formation are up to 0.5 m wide. Within the structure the rock has been broken into vertical slivers and sheets which are up to 40 mm thick. The extensive soil-covered Arrinhrunga Formation N of the Johanssen Range is cut by gently arcuate E-trending joints many kilometres long (Plate 25).

Plate 22  Homoclinc near Oomoomilla Fault. Subhorizontal and undeformed bedding to the right contrasts markedly with the vertical drag-folded bedding to the left which extend some 300 m to the Oomoomilla Fault. This limit of deformed rock is commonly well-defined and is typical of many of the larger fault zones in N and E HUCKITTA. Scale squares 2 cm (GR NQ694914).
The latest movements have affected Devonian rocks and therefore can be correlated with the Alice Springs Orogeny. Even younger movements have been reported (Warren, 1981), but are of a minor nature. However they indicate the structures have had long histories.

**COLLAPSE STRUCTURES**

In an area of approximately 400 km² in NE HUCKITTA (Figure 16) deformed Eurowie Sandstone Member overlies undeformed Arrinthunga Formation; deformed Tomahawk beds overlie undeformed Arrinthunga Formation; and deformed Tomahawk beds overlie undeformed Tomahawk beds.

This complexity is attributed to gravity collapse of lithified beds overlying carbonate beds that were being dissolved by groundwater. One of these structures is illustrated in Figure 17, where open to isoclinaly folded siltstone and sandstone is embayed within hollows as deep as 10 m in dolostone. In some instances the hollows are elongate parallel to the regional jointing.

The interface between the overlying deformed and underlying undeformed rock is commonly marked by a zone, up to 0.5 m wide, of ferricrete consisting of dense, locally colloform, dark brown to black, hydrated iron oxides which grade into the carbonate rock. The ferricrete contains lineations which plunge down the dip of the contact. Locally this lineation grades into slickenside.

The absence of any deformation in the underlying rocks, the lack of any evidence for low-angle thrust surfaces and the highly undulatory contact, leaves solution of the carbonate rocks the most plausible mechanism. It is thought that this reaction occurred progressively along a sub-horizontal surface permitting the overlying rocks to slowly subside while retaining much of their bedding integrity.

Similar features occur E of the Ooratippra Fault Zone (GR PR397580), where the deformed Tomahawk beds rocks rest discordantly on horizontally bedded Arrinthunga Formation. The relations between these two units are the same as for the Arrinthunga Formation — Eurowie Sandstone Member, and it is concluded that a similar mechanism has operated here. Kennard (1981) considered that a karst erosion surface formed on the Arrinthunga Formation before deposition of the Tomahawk beds, but this is now considered untenable (Wright, 1982) because the overlying unit was indurated before collapse occurred.

Further east, most Tomahawk bed outcrops are of mottled light brown to white, slightly calcareous and kaolinitic sandstone which is mesoscopically to macroscopically folded. The folds have highly contrasting fold styles, superimposed folds and random orientations of axes. In places the appearance is that of large-scale slump-folding. On the N boundary of the sheet is a second outcrop type (GR PR485670). This consists of horizontally bedded, even-bedded quartz arenaceous dolostone (Plate 19), occurring as prominent hills in a restricted area. The contact between these two lithologies is a zone in which the quartz arenaceous dolostone progressively loses its dolomite component over thicknesses of about 5 to 10 m and grades into the kaolinitic sandstone. The contact varies from near-
Plate 25 Megajoints in the Arrinhrunga Formation, NE HUCKITTA.
A high-oblique airphoto looking east across shallowly west-dipping carbonate rocks. In this area of low relief, the joints, some of which can be traced for 10 km, are emphasised by elongate groves of gidgee (Acacia georgiana) but in areas of greater relief they are eroded into clefts (GR PR050300).

Figure 16 Distribution of deformed Tomahawk beds and Eurowie Sandstone Member overlying little-deformed Tomahawk beds and Arrinhrunga Formation.
Figure 17  Schematic plan and section of a collapsed Eurowie Sandstone Member on and within horizontally bedded Arrinthurunga Formation.
vertical to inclined and from flat to convex upwards. In all observed instances the carbonate-leached rock is uppermost. At one site where the bedding can be traced from the quartz arenaceous, dolostone to sandstone over 50 m, the gradation is accompanied by down-turning of bedding suggestive of a collapse structure boundary (Plate 26).

It is thought that the folded Tomahawk beds rock in NE HUCKITTA was produced by solution of the dolomite component in the underlying rocks. This dissolution, and the consequent volume decrease, resulted in progressive collapse of overlying rocks, and the rocks which still contain primary dolomite were below the maximum depth at which the carbonate dissolution occurred. Erosion has subsequently exposed these rocks. The carbonate-deficient rock has undergone an early-middle Tertiary deep weathering event, which suggests that the dissolution event may have occurred in the late Cretaceous to mid-Tertiary.

Smith and others (1961) noted these collapse structures on TOBERMORY and concluded it was caused by solution of the carbonate matrix during laterisation.

**GEOLOGICAL HISTORY**

The oldest rocks in HUCKITTA are those of Division 1 of the Arunta orogenic domain, and represent acid and basic volcanics plus minor argillaceous and calcareous sediments which were deposited in an E-W trough. Division 2 rocks were subsequently deformed by a broader area. These rocks S of the Delny-Mount Sainthill Fault Zone, consisted of the Harts Range Group of argillaceous and calcareous sediments, with minor acid and basic volcanics. N of the fault zone, argillaceous and calcareous sediments of the other formations in Division 2 were deposited possibly diachronously in local subbasins. Arenaceous and argillaceous sediments then accumulated above a disconformable contact and gave rise to Division 3 rocks. Deep burial followed and the accompanying metamorphism, ranging from lower amphibolite to granulite facies, was accompanied by folding and faulting. This metamorphism is correlated with the Strangways Event at about 1800 Ma (Black and others, 1983). Syntectonic acid and basic igneous rocks were intruded. Posttectonic granites, dated at 1775 Ma (Black, 1980; see also Compston and Arriens, 1968; Hurley and others, 1961; Webb, 1972), were intruded followed by at least two hydration events. Later, dolerite dykes were intruded.

The Georgina Basin was initiated during the Adelaidean with the development of a series of troughs or half-grabens trending NW to NNW. Sedimentation began with thin sands andstromatolitic dolostone of the Yakka beds accumulating in a fluvial to shallow marine environment. Uplift, accompanying the Areymonga Movement (Wells and others, 1970), was followed by planation of the Yakka beds except in the Keepera Trough in SE HUCKITTA. The troughs subsided and glaciocene sediments of the Mount Cornish Formation were deposited. Uplift accompanying the Rinkabeena Movement resulted in the partial erosion of the previously-deposited sediments. The Oorabra Arkose was then deposited, probably in a subaerial environment, with the half-grabens being sites of rapid localised subsidence. Glaciocene sediments were deposited and preserved at one site; elsewhere arkose was deposited with very little weathering or attrition. The Toomba Movement interrupted sedimentation and caused erosion of some of the recently deposited sediments. This ended the activity of the half-grabens.

A widespread transgression then occurred throughout HUCKITTA with accompanying sheet-like deposition of the Mopunga Group in a shallow marine environment. Initially, argillites were laid down in a relatively quiet environment, followed in sequence by arenites, in a shallow wave-dominated environment, and siltstones, in quieter conditions. Uplift and minor folding during the Huckitta Movement caused erosion of the top of the Mopunga Group.

The Early Cambrian Mount Baldwin Formation was deposited in a fluvial fan or deltaic environment in the central and eastern parts of HUCKITTA. A transgression then resulted in a basal clastic sequence
being deposited, though restricted to the Jervois Range, overlain by a widespread archaeocyath-bearing carbonate (Errarra Formation). Deepening of the marine environment and a change to anoxic conditions in the Middle Cambrian accompanied deposition of the silty limestone of the Arthur Creek Formation. During deposition of the uppermost Arthur Creek Formation, conditions again shallowed and arenaceous detritus was incorporated with the calcareous sediment. Extreme shallowing of the marine environment during the Late Cambrian, when marine circulation became restricted, produced extensive carbonate banks and shoals, algal bioherms grew, and local emergence led to the formation of evaporite pans (Arrinthuranga Formation). During latest Cambrian there was a reversion to more open marine conditions and a prolific fauna developed. Dolostone and glauconitic calcareous quartz sand of the Cambro-Ordovician Tomahawk beds were deposited widely. Finally the Nora Formation was deposited as a subtidal accumulation of silt, sands and oolitic ironstone; the ironstone possibly reflecting a lacustrine palaeo-environment.

During the Late Ordovician Rodingan Movement (Wells and others, 1970), uplift, especially in western HUCKITTA, resulted in planation of the Nora Formation and, in the west, the uppermost Tomahawk beds.

Aeolian, fluvial, lacustrine and marine sheet sands (Dulcie Sandstone) were deposited extensively during the Devonian.

The Carboniferous Alice Springs Orogeny caused reactivation of block faults within the basement rocks together with the formation of low-grade retrograde schist zones in the Delny-Mount Sainthill Fault Zone plus folding and faulting of the Georgina Basin sequence.

Erosion dominated until the Jurassic. The subsequent fluvial sheet sands of the Jurassic-Cretaceous Hooray Sandstone were then deposited, although in HUCKITTA most was subsequently eroded.

Deep weathering and laterisation occurred during the latest Miocene to Pliocene, followed by accumulation under pluvial conditions, of sand, lime mud and carbonaceous clastics in intermontane lakes and swamps in W HUCKITTA (Waite Formation equivalents). In later Tertiary times the lacustrine sediments were uplifted and their erosion is still proceeding. This uplift was accompanied by deflection of streams, modification of drainage patterns and the formation of very extensive alluvial fans by the Plenty-Marshall and Bundey rivers. Outwash fans formed at the foot of the higher hills. In the Pleistocene, a return to arid conditions produced sand plains, locally with dunes. Since then amelioration of aridity has resulted in vegetating of the sand, with resultant dune stabilisation. Erosion of the outwash fans continues in areas of greater relief.

**METEORITES**

Two features of meteoric origin are known in HUCKITTA; these are the Boxhole Crater and the Hukitta Meteorite.

The Boxhole Crater (GR NQ199992) has a classical crater shape, 175 m in diameter, up to 16 m from floor to rim-crescent and with the rim-crescent between 2.9 and 4.9 m above the adjacent plain (Madigan, 1937). The crater is excavated on the edge of a ridge of reef quartz and deeply weathered ?Cackleberry Metamorphics. Both McCall (1973, p52) and Krinov (1963) regard the excavation as an explosion crater.

Only a moderate amount of meteoric debris has been collected. Madigan (1940) reported that 82 kg was acquired for the British Museum in 1938 and Corbett (1968) itemised six fragments aggregating 178.3 kg which are held in the South Australian Museum.

The meteoric iron is classified as a medium octahedrite with the following composition as determined by Alderman (in Madigan, 1940):

<table>
<thead>
<tr>
<th>Element</th>
<th>Fe</th>
<th>Ni</th>
<th>Co</th>
<th>P</th>
<th>S</th>
<th>C</th>
<th>SiO₂</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>91.77</td>
<td>7.80</td>
<td>0.44</td>
<td>0.08</td>
<td>0.03</td>
<td>0.049</td>
<td>0.01</td>
<td>100.18</td>
</tr>
</tbody>
</table>

Kohman and Goel (1963) reported a radiocarbon age-dating of 5.4 ± 1.5 ka as the time of the fall. Milton (1972) suggested that the Boxhole Meteorite was co-genetic with the Henbury Meteorite which fell some 120 km SSW of Alice Springs.

The Hukitta Meteorite (GR NR776350) was found in the late 1930's (Madigan, 1939), on the edge of a bare area on an extensive plain; no sign of a crater existed. After removal from the soil, the 1.35 m-long body had a mass of 1415 kg; 927 kg of iron-shale was then removed from the soils underlying the meteoric iron. The main mass is now held in the South Australian Museum.

The Hukitta Meteorite is classified as a pallasite (stony iron meteorite) and Alderman (in Madigan, 1939) made the following analyses of the separated 'stony' and 'iron' components:

<table>
<thead>
<tr>
<th>Component</th>
<th>SiO₂</th>
<th>FeO</th>
<th>MgO</th>
<th>CaO</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Olivine</td>
<td>40.21</td>
<td>12.57</td>
<td>47.49</td>
<td>0.20</td>
<td>100.47</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Element</th>
<th>Ni</th>
<th>Fe</th>
<th>Co</th>
<th>S</th>
<th>C</th>
<th>SiO₂ &amp; Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ni-Fe alloy</td>
<td>89.36</td>
<td>8.98</td>
<td>0.45</td>
<td>0.02</td>
<td>0.13</td>
<td>0.47</td>
</tr>
</tbody>
</table>

The time of impact is unknown although it is likely to have been a considerable period ago because there is no trace of an impact structure and because of the large amount of iron-shale formed by weathering of the meteoric iron.

**ECONOMIC GEOLOGY AND MINERALISATION**

Mineralization is widespread in HUCKITTA and production during the last several years has been from open pits at the Jervois and Molyhil mines. The mineralization is discussed in genetic groupings and generally in decreasing order of importance; a list of the various minerals/elements and the headings under which they are mentioned is given in Table 7.

**JERVOIS MINING AREA**

Secondary copper mineralization was located at this site in 1929 (Hossfeld, 1931) and subsequently described by several workers (Bell, 1938; Blanchard, 1939; Sullivan, 1950; Casey and Noakes, 1953; Catley, 1955; Robertson, 1959; Hughes and Ward 1961; Grainger, 1967; Fruzzetti, 1970). Minor development proceeded until the late 1970's (Plate 27). Diamond drilling and geophysical surveys by Consolidated Goldfields resulted in their locating significant occurrences of both copper and also lead-zinc-silver mineralization (Catley, 1965). Union Corporation (Wright, 1974), and Petrocarb Exploration Ltd, subsequently drilled to
determine reserves. Ypma (1983) quoted calculations by Petrocarb of 3.66 Mt (megatonnes) at 2.8% Cu and 60 ppm Ag, including 0.3 Mt also containing 9.0% Pb and 3.0% Zn, as well as calculations by Wilstead and Associates of open-cut probable and possible primary reserves of 0.8 Mt at 3.1% Pb, 1.1% Zn, 2.3% Cu and 100 ppm Ag. Additional reserves exist at depth. In the oxidised zone Holmes (1972), reported bismuth concentrations of up to 0.01%. The Plenty River Mining Company recommenced mining at the Green Parrot orebody in 1982, although at the time of writing the mine is on a care and maintenance basis.

At the Jervois Mine, the ore occurs in several bodies (Reward, Attutura, Marshall, Green Parrot, Hanlon, Sykes) occasionally grouped under the title of Attutura (e.g. Watson, 1975). These bodies occur along a strike length of approximately 1.2 km and a width of 600 m and, in addition to those named, there are many smaller mineralised bodies.

These accumulations occur in the Bonya Schist in noses of isoclinal folds which were subsequently re-folded. Because the limbs of the folds are attenuated and because of the re-folding, many of the bodies appear unrelated to each other.

The copper mineralization is associated with magnetite-bearing schist layers, which grade into magnetite-quartzite layers (banded iron formation). This has enabled magnetics to be used to locate other mineralization (Douglas and Maranzana, 1963). The total strike-length of the mineralized zone is about 12 km and is folded to define a major regional anticline known as the 'J-fold'. At the far SW end of the mineralised zone, the oxidised copper mineralization has been mined at the Bellbird deposit. Watson (1975) noted that here, in the primary zone, the copper mineralization occurs as massive chalcopyrite-borneite-pyrite-pyrrhotite disseminations in magnetite-bearing schist and quartzite. He suggested that the type of magnetite-quartzite banded iron formation which is present could be related to possible crystal tuff E of Jervois. However it was emphasised by him that there is no direct evidence that the mineralization was produced by a volcanic exhalative source.

At the Jervois mine the lead-zinc mineralization is localised in calc-silicate rock, some of which is layered and some is massive and appears skarn-like. In these rocks galena + sphalerite + bornite + pyrite ± scheelite mineralization is contained in a quartz-epidote-garnet-diopside-amphibole-fluorite ganguet. It occurs in outcrop at two localities at Jervois; W of the lobes at Green Parrot (at the southern end) and E of the lode at Reward North (at the northern end).

Tourmalinite, layers of fine grained tourmaline-quartz rock, is common within and around the mineralised rocks.

**Molyhil Mine**

Scheelite mineralization was located in 1971 in a small, layered, calc-silicate outcrop, termed the Pinnacle, by local prospectors using UV lamps. Prospecting assistance was given by the N.T. Department of Mines and Energy (Fruzzetti, 1975, Barraclough, 1979a), and concealed mineralization was located some 200 m E of

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**Table 7** Minerals and the text headings under which they are discussed.

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Heading</th>
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<tbody>
<tr>
<td>Barite</td>
<td>Barite-fluorite veins</td>
</tr>
<tr>
<td></td>
<td>Stratabound barite-galena in the Arrinhrunga Formation</td>
</tr>
<tr>
<td>Bismuth</td>
<td>Jervois mining area</td>
</tr>
<tr>
<td>Copper</td>
<td>Jervois mining area</td>
</tr>
<tr>
<td></td>
<td>Scheelite in the Bonya Hills</td>
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<tr>
<td></td>
<td>Minor mineralisation</td>
</tr>
<tr>
<td>Fluorite</td>
<td>Barite-fluorite veins</td>
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<td></td>
<td>Scheelite in the Bonya Hills</td>
</tr>
<tr>
<td>Groundwater</td>
<td>Groundwater</td>
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<tr>
<td>Hydrocarbons</td>
<td>Hydrocarbons</td>
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<tr>
<td>Iron</td>
<td>Minor mineralisation</td>
</tr>
<tr>
<td>Lead-Zinc-Silver</td>
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</tr>
<tr>
<td></td>
<td>Stratabound barite-galena in the Arrinhrunga Formation</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>Molyhil Mine</td>
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<td>Nickel</td>
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<td>Tin</td>
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<td>Tantalite</td>
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<td>Tungsten</td>
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<td></td>
<td>Scheelite in the Bonya Schist</td>
</tr>
<tr>
<td>Vanadium</td>
<td>Minor mineralisation</td>
</tr>
</tbody>
</table>

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**Plate 27** Jervois Mine, view southwards.

Gossanous ironstone of the Reward body occurs in the foreground. The small open cut across the creek is in the Marshall body. The Green Parrot open cut (commenced 1981) is obscured behind the large water tanks. Typical hills of Bonya Schist occur on the horizon.
the discovery site. Subsequent mining and development has occurred in this newer area. Subsurface exposures have demonstrated that the scheelite is accompanied by economic molybdenite concentrations. Drilling by Petrocarb Exploration N.L. has outlined reserves, available for open cut mining, of 1.8 Mt at 0.6% WO₃ and 0.3% MoS₂ (Petrocarb, 1983). Mining was stopped in 1982 pending a re-evaluation of the reserves and a return to higher metal prices.

Scheelite-molybdenite-magnetite-chalcopyrite-pyrite mineralization occurs both disseminated and massive in calc-silicate rock which forms a raft or roof pendant in leucogranite. This leucogranite is now correlated with the Marshall Granite, though it bears similarities to the nearby Jinka Granite. The calc-silicate rock varies from layered to massive, and consists of epidote, quartz, chlorite, garnet, hedenbergite, scapolite, sphenite and a broad range of minor minerals. Both gangue and ore locally are very coarsely-grained. Scheelite aggregates up to nearly 1 tonne, molybdenite rosettes up to 70 mm in diameter and hedenbergite crystals up to 400 mm long have been extracted. Barraclough (1979b) described a sequence of various lithological units in the calc-silicate rock.

It is thought to be a true skarn occurrence. Further exploration in the area has so far failed to locate other mineralization (e.g. Mason, 1978; Barraclough, 1979b; Woyzben, 1980).

**Scheelite in the Bonya Schist**

Many occurrences of scheelite in calc-silicate rocks are known in the Bonya Schist. Wells' Show (GR PQ017909), initially a copper prospect, was the first occurrence of scheelite recognised (Nye and Sullivan, 1942; Morrison, 1968).

During the 1960's and 1970's (Bowen and others, 1978) intensive prospecting resulted in many occurrences being located.

Although ore was produced from several prospects it was used mainly for metallurgical trials, and mining was conducted at only the Jericho and Ultra Violet open cuts (L.A. Johanssen, pers. comm., 1982). The scheelite occurs in bodies of layered calc-silicate rock and skarn-like, massive, calc-silicate rock, both of which are elongate and parallel to the regional foliation and compositional layering and occur up to several hundred metres long and 20 m wide.

The ore consists of scheelite, with minor amounts of powellite and malachite, in a gangue consisting mainly of quartz-epidote-garnet rock, but with a large range of other minerals including clinzoisite, vesuvianite, calcite, diopside, hornblende, tremolite, chlorite and fluorite. Grain-size is very variable with some individual crystals up to 30 cm across. The rocks are characterised by having localised, large, monomineralic patches. Well-defined layering parallel to their length occurs in some of the bodies, though this layering is rarely present in garnet-rich rock. There is much thinly layered quartz-epidote rock which can, in places, be traced across chemical fronts into marble-rich metasediments (Plate 28). In other places there is a more pervasive alteration of marble (Plate 29).

The genesis of these bodies is, as yet, unclear. Metasomatic replacement is thought to have altered calcareous metasediments, producing garnet or epidote and a broad range of calcareous minerals, and introducing the scheelite. Bowen and others (1978) noted that the scheelite-bearing rock is mostly within 400 m of

**Plate 28** Marble (dark grey, top) altered to thinly layered, quartz-epidote calc-silicate rock (lighter grey, bottom) in Bonya Schist.

The chemical front, across which the reaction occurred, is preserved between the two rock types and is about 2 cm wide. Scale squares 1 cm (GR NO996944).

**Plate 29** Megacrysts of garnet within marble, Bonya Schist.

In contrast to Plate 28, alteration of this marble has produced a skarn-like rock which, elsewhere in the Bonya Schist, typically contains scheelite mineralization. Scale square 2 cm (GR PQ099903).
pegmatite bodies, although the widespread occurrence of pegmatite in the Bonya Schist reduces the importance of this correlation.

In the Jervois area, there is a discontinuous horizon of siliceous quartz-epidote rock up to 2 m wide and about 8 km long which contains scheelite mineralization. The horizon occurs approximately 2 km E of the lode horizon, and follows it around the nose of the 'J-fold'. Sporadic banded quartz-magnetite outcrops are associated with this horizon. In contrast to the very altered appearance of the host rocks in the Bonya Hills, this quartz-epidote rock does not appear to have undergone any significant alteration other than the regional metamorphism. About 5 km SW of the Jervois Mine there are several occurrences of scheelite in calc-silicate rocks, some of which are monomineralic plugs of vesuvianite up to 20 m across.

**Barite-Fluorite Veins**

The Oorabara Reefs, consisting of brecciated and recemented, hydrothermal quartz, occur within the Jinka Granite. They commonly contain fluorite, barite and galena. Central Pacific Minerals (1972) conducted extensive exploration of these to determine the quantity and quality of fluorite available for mining (Ransom, 1970; Pietsch, 1973). Hill (1972) quoted reserves of 0.25 Mt at 37% CaF₂ to a vertical depth of 30 m in three reefs (titled A, B, and E). Brown (1971) considered the veins were emplaced hydrothermally.

Additionally, barite occurs as veins in the Oorabara Arkose near Thring Creek along the southern part of the Jinka Granite (GR PQ029768), and both pseudomorphing the hyolite Bicondulites, and as coarse crystals replacing dolostone in the Errarra Formation near Gap bore (GR NS041851) (Plate 16).

Barite veins up to 0.5 m wide and several tens of metres long occur in the Mopunpa Range where they are concentrated in the deformed rock of the Delny-Mount Sainthill Fault Zone. Traces of fluorite, as fine to medium grains, are disseminated in meta-acid volcanic in the Bonya Hills (GR PQ187892).

**Stratified-bound Barite-Galena in Arrinthurunga Formation**

Near Boxbore bore (GR NR780325 to GR NR803285), barite-galena mineralization occurs in a stromatolitic dolostone horizon of the Arrinthurunga Formation (Sturmfels, 1960; Woolley and Rochow, 1961; Hentschel, 1973; Hughes and O'Sullivan, 1973). Stratigraphically it occurs just above the Eurowie Sandstone Member.

The mineralization is confined to a dolostone bed, up to 2 m thick, containing disseminated to massive, coarse to very coarse-grained barite and galena. Locally, barite replaces the columns of stromatolite bioherms (Plate 30). There are small areas of a homogeneous, grey-brown dolostone which is completely recrystallised and appears to be extensively altered. These areas are commonly located on small E-W faults which may have provided conduits for mineralizing fluids. At the southern end of the outcrop it is a considerable amount of associated quartz. It is thought that this quartz is secondary and related to pedogenic silification.

Approximately 15 t of lead ore, which were hand-sorted in 1960, contained 65-70% lead and 60 ppm of silver (Phillips, 1960). Drilling, mapping and geophysical exploration has since been conducted but the mineralization has so far only been located at shallow depths (Vanadium, 1970; Reid, 1975; BHP1977a-e) at the one site (Goudie and Hallof, 1970).

Similar mineralization has been located on Ooratippra Station adjacent to the northern boundary of HUCKITTA (Cotton, 1973a and b). Though the mineralization was reported as occurring in ironstones in the Tomahawk beds, the galena is probably from within the Arrinthurunga Formation carbonates and the ironstone may be related to the Tomahawk beds - Arrinthurunga Formation solution collapse structures (described earlier under Structure and Tectonics). Nenke (1977a and b) described unsuccessful exploration for this mineralization elsewhere in HUCKITTA. Draper (1978) compared this mineralization with the Mississippi Valley type. However, Ypma (1984), conducted some fluid inclusion studies, and interpreted that the Boxbore Bore mineralization was deposited at 495°-520° C and 70 MPa. He concluded that, when deposited, the mineralisation was confined by normal lithostatic pressure as would have been expected in post-Devonian times.

**Plenty River and Harts Range Mica Fields**

Mica-bearing pegmatites occur throughout the Irindina Gneiss and Brady Gneiss. Mining was first commenced in ILLOGWA CREEK in the 19th century, and was stopped in 1961 following cessation of the Commonwealth Mica Pool (Commonwealth, 1960). Mining had been conducted by individuals or small groups of prospectors; the nature of the occurrences was not conducive to development by companies because the small and patchy occurrences are not economic large-scale exploration targets (Tate, 1958).

The pegmatites, as described (Hossfeld, 1931; Owen, 1939; Jensen, 1943, 1944, 1947; Mount Isa
Mines 1951; Tomich, 1952; Armstrong and Jones, 1954; Joklik 1955; Horvath, 1957; Woolley, 1959 and Rowchow, 1962), have a large range in size, shape, mineralogy and relationships with country rock. Joklik (1955, p178) noted that well zoned, extremely coarse-grained pegmatites, in which a core of quartz was surrounded by a rim of plagioclase, contain the better quality mica. These pegmatites also contain a minimum amount of graphic intergrowths and biotite, are discordant to local country rock layering, and contain traces of beryl, apatite, amphiboles and tourmaline which are of value to fossickers.

MINOR MINERALISATION
Other occurrences of interest include vanadium, copper, tin, tungsten, nickel, apatite, t alc and quartz. The Attuura Metagabbro contains bodies of very coarse-grained magnetite. Union Corporation (Australia) Pty Ltd, located traces of vanadium within these (Wright, 1974), with concentrations of 1.1% V and 1.4% Cu being obtained in chip samples. However the bodies are too small to warrant further exploration.

Copper in quartz veins or ironstones is known at several sites. Several tens of tonnes of oxidised copper ore was mined from the Bonya Copper Mine in the 1950's and 1960's. The ore minerals, comprising malachite with minor azurite, and chrysocolla, occur in a discordant quartz vein in silimanite-muscovite and migmatic quartz-feldspar-muscovite schist. At Xanten, malachite-rich ironstone totalling approximately 50 t was extracted from a shallow shaft (L. A. Johansen, pers. comm., 1983). Here, earthy malachite is concentrated in ironstone up to 1 m wide which is located on a vertical, NE-trending fault. This type of mineralization is common within the Bonya Schist but is of minor importance. Several occurrences are known from the western part of HUCKITTA, but are also small.

Disseminated pyrite and chalcopyrite occur in the Kings Legend Amphibolite Member. At several sites near the E boundary of JINNA, the extent of malachite, derived from oxidation of the chalcopyrite, has been tested with small pits. These occurrences are small except for at Green Hoarde, where, however, the relationships are complicated because the mineralization is also associated with a malachite-scheelite-bearing, massive, calc-silicate body. The primary mineralization in the member is of a low grade and it is doubtful if it occurs in economic concentrations near the surface. Moore (1976) noted the occurrence of copper at Dnieper Station.

Cassiterite has been reported in small amounts in the Mount Swan Granite N of Dnieper homestead (Harvey, 1982). The Delny wolframite occurrence in ALCOOTA (Freeman and Wyche, 1982) is in a large raft of Perenti Metamorphics within the Mount Swan Granite near the Utopia Tantalle prospect and therefore similar Sn-Ta-W mineralization may be an exploration target in HUCKITTA.

Mineral claims at Middle Dam were initially on a site of interest for nickel (Clarke and Wozybun, 1978), similar to other occurrences reported in the area (Tham, 1971; Cooney 1973; Hosking, 1972; Barraclough, 1978; and Shaw and others, 1982). Drilling by the NTGS in 1978 indicated that the nickel occurs in a small pipe-like serpentinite body (Freeman, 1979), described in this report as unnamed serpentinite (Ep).

Small pisolitic ironstone deposits occur in the Nora Formation in the southern and eastern Dulcie Range (Vine, 1959).

Daly and Dyson (1956) were unsuccessful in their brief search for radioactive minerals in Harts Range pegmatites and Flack (1970) described a similar search in the Plenty River pegmatites. Exploration for radioactive minerals was also conducted by Uranerz (Fergusson, 1975) and Otter Exploration (Kojan, 1980a, b; 1982a-c).

Non-metallic minerals, which are of minor interest, are restricted to apatite, which occurs as coarse-grained crystals in a quartz vein in the Delny-Mount Sainthill Fault Zone (GR NQ736832), and talc, which occurs in a plug 50 m across associated with coarse euohedra of grossular and clinozoisite in the Bonya Schist (GR PQ339987). Citrine or yellow quartz, some of cutting quality, is available from an area of borrow pits developed for road gravel near the Plenty Highway (GR NQ662619) (Moore, 1979).

HYDROCARBONS
Only one oil exploration well has been drilled (Huckitta No.1). A closed, domal structure was tested by Exxon Oil Co. Ltd., in 1966. The well was collared in the Arrirthunga Formation and completed in crystalline basement at a depth of 1700 m. An oil froth was noted while drilling in the Arthur Creek Formation (Pemerton, 1966). Similarly, stratigraphic drilling by the BMR (Milligan, 1963), and the NTGS, into the Arthur Creek Formation produced petrolierous oil and an oily scum on the circulating water, and this formation is probably an excellent potential source rock. Other hydrocarbon prospects are discussed by Draper and others (1978).

GROUNDWATER
Attempts to locate usable supplies of potable groundwater have commonly been unsuccessful in Arunta orogenic domain rocks. The few successful bores appear to be sited in zones of jointing or faulting. Similarly, in the Adelaidian sedimentary rocks, attempts to locate groundwater have been unsuccessful, either because of poor yields or excess salinity. The Phanerozoic rocks of the Georgina Basin are mostly good aquifers. The cavernous carbonate rocks such as the Errarra, Arrirrunga and Arthur Creek formations, yield good supplies, although high concentrations of magnesia or nitrate have been recorded in some water from them. The Tomahawk beds have moderate to good aquifers and the Dulcie Sandstone has an excellent interstitial porosity and is an extremely good aquifer, providing large yields of excellent water. Valley-filling Cainozoic units are commonly good aquifers, although supply is unreliable in slightly elevated areas. Water of good quality can be located along the valleys of the Plenty, Marshall and Bundey Rivers in the alluvium or in the underlying bedrock, but supplies are usually only small to moderate.

Depths to the water table range from approximately 20 m along the larger rivers to over 100 m in the sedimentary rocks along the northern margin of HUCKITTA.
HUCKITTA has been covered by a number of regional geophysical surveys using various techniques and methods (Wells and Milsom, 1965; Wells and others, 1966; Barlow, 1966; Lonsdale and Flavelle, 1968; Tucker and others, 1979).

In 1959-61, the BMR carried out a reconnaissance gravity survey. The results of this were published as a Bouguer anomaly contour map at a scale of 1:500 000. In 1964, the BMR flew an airborne magnetometer survey with E-W lines spaced at approximately 3 km intervals and at an altitude of about 600 m above sea level. A contour map of Total Magnetic Intensity (TMI) was published at 1:250 000 scale.

In 1981, the Northern Territory Department of Mines and Energy carried out a more detailed survey of the southern half of the sheet. Both TMI and gamma ray spectrometer data were recorded. The survey was flown by E.G.& G. GeoMetrics International Corporation. The lines were flown in a N-S direction at 500 m spacing and at a nominal terrain clearance of 100 m. The results, which are obtained through the Department of Mines and Energy, are available in digital form on magnetic tape, and as contour maps of both TMI and Total Count Radiometrics at scales of 1:250 000 of HUCKITTA and at 1:100 000 of DREDIP, JINNA and JERVOS RANGE. The data is also available in the form of multipoint profiles for each flight line and these profiles contain terrain clearance, TMI (fine and coarse scale), and data from the gamma ray spectrometer, in the form of total count, uranium, (U), thorium (Th) and potassium (K) channels as well as U/Th and U/K ratios.

A preliminary interpretation of this data was conducted and the results included on the Solid Geology inset on the map face. These results include lineaments, interpreted faults and geological boundaries. Whatever the geophysically interpreted features coincide with known geological features, only the latter are shown.

The distance between gravity observations (approximately 10 km) is too great to allow a detailed interpretation, though a Bouguer anomaly contour map is shown in Figure 23.

Gravily and magnetics

The results from the magnetic and gravity surveys correlate well with the known geology. For example, the Kanandra Granulite between the Delny-Mount Sainthill and Entire Point faults is reflected in magnetic and gravity highs and the Jinka Granite has coincident gravity and magnetic lows.

The Delny-Mount Sainthill Fault is well defined on the Bouguer anomaly and TMI maps, but only as far E as its intersection with the Charlotte Fault Zone. At this intersection there exists a 'thumb print' magnetic high which is thought to be caused by an intrusive body, the composition of which is unknown but probably is basic. There seems to be no geophysical indication that the Delny-Mount Sainthill Fault Zone continues beyond this magnetic high. However it may divide into a number of smaller faults, and there is an indication of some being weakly delineated by the magnetics. The Lake Caroline Gravity Ridge, which extends from HUCKITTA to SIMPSON DESERT NORTH (Lonsdale and Flavelle, 1968), is truncated in the NW by the Delny-Mount Sainthill Fault Zone. This gravity ridge may have one of these divided faults on its NE boundary, at least in HUCKITTA. Warren (1980) noted that the Mount Baldwin Lineament, a prominent LANDSAT lineament, which extends SE from Mount Baldwin, may coincide with the northern boundary of the Lake Caroline Gravity Ridge. However, there is little support for this feature on the TMI maps. Alternatively, the prominent magnetic lineament extending SSE from near Mount Thring may better delineate the boundary of the Lake Caroline Gravity Ridge.

The Jervois Fault (Figure 7) lineament can be traced on the TMI map to the NNE to beyond the Ooratippra Fault Zone, as shown on the solid geology inset. Beyond the Ooratippra structure the fault runs between a gravity low to the E and a gravity high to the W. The gravity high is thought to indicate a basement uplift between the Jervois Fault and the Putta-Putta Fault Zone to the W. This is confirmed by the sense of displacement along the Putta-Putta, Lucy Creek and Ooratippra fault zones.

Two lineaments, which cross the Dulcie Syncline and extend to the NE to the edge of HUCKITTA, are considered to be possible basement faults which may have had some effect on the overlying sediments although no effects have yet been reported. Unfortunately this part of the area is not covered by the recent more detailed magnetometer survey and as a consequence the interpretive work is not as confident.

Magnetics in the southern part of HUCKITTA are characterised by the existence of many elongated lows of considerable linear extent. One of these exists near and around the 'J-fold' in JERVOS RANGE. This is considered to be caused by granitic rocks. From the shape of the closures it is concluded that the granite is more likely to be a sill rather than a stock.

Similar comments can be made about the oval dome-like group of magnetic highs and lows in the S-central part of JERVOS RANGE. Elongated lows surround a dome and are considered to be caused by near-outcropping granitic rocks. Here, a granitic sill is thought to underlie the whole of the dome and although the rocks are assigned to unit pEd, the area probably consists of pEd over Eg.

In the same area, two geophysical lineaments have been indicated on the solid geology map. These trend ENE near the Mount Baldwin Lineament across the Lucy Creek Fault Zone where they are displaced to the S. They are considered to be faults and, if so, then they must be older than the Lucy Creek Fault Zone.

On JINNA the magnetics and gravity clearly delineate the Jinka Granite. From the shape of the magnetic anomalies and the shape and magnitude of the gravity anomaly, the granite is considered to be a pluton. Linear magnetic highs coincide with the larger quartz reefs of the Oorabra Reefs (Figure 14), and indicates the reefs contain a significant magnetic component.

Several rock type boundaries have been interpreted from the magnetics though little interpretation of rock compositions has been attempted (Horsfall, 1981).

In SW JINNA, two sub-parallel lineaments extend N from the edge of the sheet to the Delny-Mount Sainthill Fault Zone. These are very pronounced in the areas of high magnetic relief but far less distinct elsewhere. It is considered that they represent probable faults in their southern part and possible faults to the N. In the N, they interrupt the elongate magnetic lows S of the Delny-Mount Sainthill Fault Zone. These lows are
interrupted by another pair of subparallel lineaments in the eastern part of Dnieper. This well-defined belt of elongated lows is parallel to the Delny-Mount Sainthill Fault Zone between E of Jinka and the Maparta Fault in the W. The origin of these lows is not clear. They are considered to be related to magnetic highs to the N as remnant magnetised bodies. They are possibly due to some granitoids at depth injected along a feature associated with the Delny-Mount Sainthill Fault Zone. If so, it is conceivable that all of the magnetically quiet zone S of this major fault could be underlain by granite.

An E-W pair of subparallel magnetic lineaments, which converge eastward, extend between the Maparta Fault and the geophysically interpreted geological boundary near the south-central part of Jinka. In between the paired feature are four lineaments which trend at approximately 315° in an en-échelon pattern which suggest that the E-W lineaments might be faults with relative horizontal movement of some 5-7 km. The en-échelon features are similar to each other because each has one or more magnetic high-low anomaly patterns associated with it. The bodies causing the anomalies appear to be shallow-seated, plug-like and to have a relatively high magnetic content; they are thus presumably basic or ultrabasic in composition and may have been intruded along oblique tension fractures.

To the N of the Dulcie Syncline, a gravity low, coinciding with an increase in depth to magnetic basement, resulted, in the recognition of the Ammaroo Sub-Basin by Barlow (1966).

**Figure 18** Bouguer anomaly contour map.

**Radiometrics**

The Total Count contour maps, obtained from the gamma ray spectrometer survey, delineate large areas of relatively high response over areas of outcrop. This is particularly true over the Jinka and Bonya blocks. The high radiometric responses in these blocks reflect the abundance of potassium in the granites. Similar high responses were recorded in the extreme NE corner of Dnieper. The extensive elongated radiometric highs, which coincide with watercourses, are considered to be caused by potassium-rich feldspar-rich detritus being eroded from granitic outcrops. However the elevated radioactive levels in the detritus of the northern tributaries of the Marshall River are unexpected because the formations being eroded, particularly the Tomahawk beds and Arrinthunga Formation, are not feldspar-rich. A ring of low-order radiometric highs coincides with outcrops of the Tomahawk beds adjacent to the Dulcie Sandstone fringing the Dulcie range, and adjacent to the Arrinthunga Formation near the Oomoomilla Fault. On the multiplot profiles, the primary source of the radiation is indicated to be potassium with a minor contribution from thorium. The cause of the elevated radioactivity is unclear but may partly be a rock type effect and partly because of movement of the radioisotopes in groundwater and their fixing in favourable rock types within the unit.

The remainder of the area surveyed shows a consistently low total count with some isolated highs; all these are small in area and have only moderately elevated, total-count values.
The extensive lows, particularly across S HUCKITTA, reflect areas of extensive soil and sand cover or areas where the rocks are devoid of any radioactive components. The small, isolated, radiometric highs, within the extensive areas of low response, probably reflect residual soils or subcrops of rocks slightly more radioactive than the surrounding plains. Only one of these highs, situated in the extreme NE corner of JINKA, was investigated on the ground; it was a false anomaly produced by a malfunction of the recording equipment.

The Elua Syncline is well-delineated on the Total Count maps as an extensive low surrounded by higher levels caused by the Jinka Granite.

The Ooomomilla Fault and, over much of its length, the Delny-Mount Sainthill Fault Zone, are well-defined in the radiometric and magnetic data.

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### APPENDIX 1

#### ROCK NOMENCLATURE

Metamorphic rock names are based on field identification, using the criteria of dominant mineralogy, texture and grain size. Igneous rock terminology is based on that of Streckeisen (1976) and sedimentary rock terminology on Bates and Jackson (1980).

*Amphibolite:* essentially hornblende (30-80%) and plagioclase and possibly retrograde assemblages (actinolite, chlorite, biotite).

*Biotite gneiss:* field term for gneiss containing quartz, feldspar, and 10% or more of biotite. Many of these gneisses are of granodiorite composition, but the more biotite-rich varieties are considered to be pelitic metasediments.

*Biotite schist:* schist, with 20% or more biotite, and little or no muscovite.

*Calc-silicate rock:* consists mainly of calcium-bearing silicate minerals such as epidote, grossularite, plagioclase, diopside and formed by metamorphism of impure limestone or dolostone (Bates and Jackson, 1980).

*Coarse-grained:* metamorphic and igneous rock, grain sizes in the range 5-30 mm; sedimentary rock grain sizes in the range 0.5-1.0 mm.

*Cordierite gneiss and sillimanite-cordierite gneiss:* granular rocks containing cordierite, or cordierite and sillimanite. Cordierite-sillimanite metapelites contain the assemblage cordierite-feldspar-sillimanite-biotite-quartz. Cordierite anthophyllite rocks contain the assemblage cordierite-anthophyllite±quartz±spinel. Cordierite quartzite is a granular orthopyroxene-cordierite-quartz rock.

*Deformed rock:* a field term for highly strained or brecciated rocks such as mylonite, cataclasite, and highly foliated rocks.

*Dolerite:* includes unaltered dolerite, metadolerite and microronite.

*Felsic granulite:* nongenetic field term for hypersthene-bearing metamorphic rock with a colour index less than 50.

*Ferricrete:* a non-genetic term for a rock which consists partly or wholly of hydrated iron oxides.

*Fine-grained:* metamorphic and igneous rock grain sizes less than 1 mm, but with grains resolvable; sedimentary rock grain sizes in the range 0.125-0.25 mm.
Gneiss: medium to coarse-grained, irregularly layered or banded and foliated rock and which is only weakly schistose because micas are present in only minor amounts.

Granite: rocks of either granite or adamellite composition, having a mafic content of about 10 per cent, and a hypidiomorphic texture. Some metamorphically retrogressed equivalents are included in the same category.

Granitoid: large bodies with granite composition and allotriomorphic texture.

Granitic gneiss: macroscopically (i.e. map-scale) heterogeneous gneiss of broadly granitic mineralogy. The rock is commonly texturally or compositionally layered on a small-scale (outcrop to hand specimen). Differs from quartzofeldspathic gneiss in forming large, roughly equant to irregular bodies more than about 50 m across rather than lenticular bodies within a compositionally layered sequence, and differs from garnet texturally.

Garnet-biotite gneiss: schistose gneiss containing garnet, and with biotite in excess of 10%. Also contains plagioclase and quartz, but mostly lacks K-feldspar.

Hornblende gneiss: gneiss of acid to intermediate composition containing hornblende. Typically could be biotite-hornblende-quartz-plagioclase gneiss.

Laminated: bedding less than 1 mm thick.

Layered amphibolite: compositionally layered amphibolite, rarely of calc-silicate rock with colour index over 20, and for amphibolite with anomalous mineral constituents.

Leucogranite: granite with nil or negligible ferromagnesian minerals.

Mafic granulite: nongeneric field term for hypsthene-bearing metamorphic rocks in which the colour index exceeds 50. Typically, they consist of orthopyroxene + clinopyroxene + plagioclase + amphibole.

Medium-beded: bedding in the range 10-30 cm.

Medium-grained: igneous and metamorphic grain sizes between 1 and 5 mm; sedimentary grain sizes between 0.5-1.0 mm.

Megaecrystic gneiss: gneiss containing megacrysts (porphyroblasts or porphyroclasts) of feldspar or garnet. Matrix may be quartzofeldspathic gneiss or biotite gneiss.

Meta-ultramafic rocks: such as metapyroxenite, metabasalt; it does not necessarily imply a metamorphosed igneous rock.

Migmatite: rock consisting of a metamorphic matrix with igneous or pseudo-igneous components which are megascopically distinguishable. The igneous component is of pegmatitic, aplitic or granitic composition with a generally plutonic appearance (Monhert, 1968).

Mylonite: layered and lineated, very severely strained, metamorphic rock without the genetic connotation that mylonites are a product of brittle deformation (Bell & Etheridge, 1973).

Quartz-rich metasediment: ‘metasandstone’ with a small proportion of either intergranular or interlayered metapelitic component. It is a granular micaceous gneiss with over 50% quartz.

Quartzofeldspathic gneiss: granular gneisses having a colour index of about 10 or less that form layers or lenticular bodies. They have a distinctive brownish-yellow colour on coloured aerial photographs. Typically of granite, or granodiorite composition. The gneiss commonly forms part of a layered sequence and shows internal compositional layering.

Retrogressed rock: field term for a wide variety of rocks which have been retrogress metamorphosed generally to the greenschist facies.

Schist: a schistose or cleavable rock, in which the individual grains are visible to the naked eye, containing both muscovite and biotite. Mineralogical qualifiers (e.g. andalusite schist) imply micaceous schist matrix with megacrysts of the mineral.

Thick-beded: bedding in the range 30-100 cm.

Thin-beded: bedding in the range 3-10 cm.

Thin-laminated: bedding less than 3 mm thick.

Tor: spherical to ellipsoid-like, block to boulder of graniite rock; a weathering-rounded quadrangular joint block. Syn: core-stone, though lacking enclosing grus.

Very thin-beded: bedding in the range 1-3 cm.

APPENDIX 2

DEFINITION OF ROCK UNITS

Perentiti Metamorphics (New name, partly defined, formal)
Symbol: pEt
Proposers: R.G. Warren & M.J. Freeman

Derivation of name: Perentiti copper prospect, locality at approximately GR NR033104.

Distribution: In HUCKITTA, near western edge of sheet area and in ALCOOTA, near eastern boundary of sheet. Mostly as outcrops isolated from each other by granite.

Type area: Generally along a traverse 2 km west of Tower Rock, from GR NR067148 to GR NR067156 in HUCKITTA. A stratotype cannot be defined because the structure, and hence sequence, of the unit, is not defined and the top and base are not known.

Topographic expression and air photo characteristics: Generally forms low ridges within the Mount Swan Granite. Distinguishing features are a lighter tone on air photo, and the presence of pronounced layering.

Lithology: Quartzofeldspathic gneiss, felsic granulite, quartz-sillimanite-biotite-cordierite rock, calc-silicate rock, metadolerite. Felsic granulite consists of orthoclase, antiperthite and orthopyroxene; calc-silicate rocks consist of diopsidite, calcic plagioclase and quartz with lesser orthopyroxene, sphene and apatite; metadolerite is fine-grained, consists of hornblende-orthopyroxene-clinoxyroxene and has a granulite texture. Generally consists of mineral assemblage with granulate metamorphic grade, later partly retrogressed to amphibolite facies and subsequently hydrated at a still lower grade.

Correlation and age: No definite correlate known but assigned to Division 2 of the Arunta orogenic domain because of its dominantly felsic composition. The age is unknown but is inferred to be early Proterozoic and older than about 1.8 Ga.

Distinguishing features: Outcrops of generally felsic gneiss or granulite mostly associated with or occurring as rafts within the Mount Swan Granite. Pronounced layering is present in most outcrops.

Elkera Formation (Pak)
This unit was named by Walter (1980) who nominated a holostratotype in Section 10 of Smith (1964) in SW Jervois Range. Based on regional geological considerations, Walter regarded the top of a dolostone bed, which contains the stromatolite Georginia howehini Walter, as the top of the Elkera Formation.

In the Jervois Range, additional section occurs above this dolostone bed and below the disconformity surface which separates the Elkera and Mount Baldwin formations. This upper section is now included in the Elkera Formation.

The extant holostratotype cannot be extended because of faulting. An alternative additional section is now proposed 8.0 km north of Valley Bore, from GR PQ259965 to GR PQ254965. It consists of 37 m of deep brown-red, fine-grained sandstone with interlaminated siltstone which overlies the dolostone containing the Georginia howehini. The sandstone is overlain by 6m of grey, granule-bearing
orthoquartzite, which is in turn overlain disconformably by sandstone of the Mount Baldwin Formation. The orthoquartzite bed is lenticular beneath the disconformity, erosion having selectively removed parts before the onset of Mount Baldwin Formation sedimentation.

**Mount Baldwin Formation** (Redefinition of unit) Walter (1980) redefined the original definition of Smith (1964b). As a result of drilling by the NTGS in 1982, a refinement is now added. In NE Jervois Range, a disconformity exists between the Mount Baldwin Formation and the overlying Errarra Formation. It is recognised by the occurrence of a pebble conglomerate in outcrop and in the cored hole DDH.NTGS.HUC1, commencing at a depth of 372.52 m. The sandstone overlying this disconformity is now assigned to the Errarra Formation.

**Errarra Formation**

**Symbol:** Ele

**Proposer:** M.J. Freeman

**Derivation of name:** Errarra is the Aboriginal name for Marshall Well (abn) on Marshall River, at approx. GR NQ858660.

**Distribution:** In HUCKITTA, from the Jervois Range to the Mopunga Range. Apparently absent from the N flank of the Johannsen Range and possibly the SW Jervois Range.

**Holosтратotype:** In cored hole DDH. NTGS. HUC1, between 243.37 m and 372.52 m. Collar locality Lat.22°31'50"S, Long. 136°15'4"E (GR PR273072). Core will be stored in the NTGS Core Library (Alice Springs).

**Lithology:** In the holosтратotype, it consists, from the top, of:
- 67.4 m (243.37 m-310.73 m) Pale grey dolostone and limestone with some quartz arenite locally and intraclasts abundant in some beds.
- 36.2 m (310.73 m-346.9 m) Green-grey, silty sandstone; brown, friable, medium to coarse grained sandstone; and sandstone, white, very porous with green siltstone interlaminations. Discordant patches of chert occur near the top. 22.6 m (346.9 m-369.5 m) Dolostone, white to red, vuggy, with archaeocyaths, local silt laminae and dolostone intraclasts and dispersed rare grains of glauconite.
- 3.0 m (369.5 m-372.52 m) Fining-up sequence, basal granule conglomerate, with peloids of metamorphic and sedimentary origin; grades up to silty shale with graded beds. Rests with sharp, erosional contact on grey, quartz arenite to subarkose of Mount Baldwin Formation.

In outcrop, only the sandstone and basal conglomerate occur in the NE Jervois Range. The dolostone is thought to be absent in outcrop in this area because of weathering, though present in the subsurface. Elsewhere, from the Elua Range to the Mopunga Range, only the lower dolostone facies crops out. This dolostone is archaeocyath-bearing, light brown to grey and micritic with interbeds of micro-cross-laminated silty dolostone and rare siltstone. The calcite rocks are ripple-marked red-brown silty sandstone which outcrop poorly. Conglomeratic pseudo-beded chert nodules occur rarely. The basal conglomerate is a subarkose to quartz arenite with granules to pebbles of well-rounded milky quartz. Most of the outcrop is deeply weathered and generally unrecognizable.

In 1982 drilling, only the ?lower dolostone facies was intersected in the Elua Range (DDH. NTGS. HUC6) and only the lower dolostone and lower clastic facies E of the Mopunga Range (DDH. NTGS. HUC7). However in contrast to this latter intersection, the lower clastic facies is absent in an outcrop section about 1.5 km E of the drill hole collar.

**Thickness:** 129.2 m in holosтратotype. Available data indicates this is consistent across HUCKITTA.

**Relationships and boundary criteria:** Disconformably overlies the Mount Baldwin Formation in the Jervois and Elua ranges. In the Jervois Range, as in the stratotype, the base is placed at the erosional surface between quartz arenite of the Mount Baldwin Formation and the overlying basal pebble to granule conglomerate. In the Elua Range it is the contact between the Mount Baldwin Formation quartz arenite and the overlying dolostone and dolomitic siltstones. In the Mopunga Range, yellow-brown dolostone of the Errarra Formation overlies the stromatolithic *(Georginia howchini)* dolostone of the Elkera Formation. The upper contact is marked by the change from either siltstone or dolostone of the Errarra Formation to the distinctive, grey, calcareous siltstone of the Arthur Creek Formation.

**Fossils and Age:** The Errarra Formation contains a distinctive archaeocyathan faunal assemblage, described by Kruse and West (1980), including *Aldanocysthus greeni*, *Cosinocyathus bilateralis*, *Dicyocysthus*, *Aruntecyathus toddii* and *Radiocyathus minor*. Preliminary evaluation of remaining faunas, by Laurie (pers. comm.) indicates the presence of inarticulate brachiopods, tommotitides, hyoliths and indeterminate phosphatic tubes and sponge spicules. Kruse and West (1980) concluded that the archaeocyathan fauna indicated a correlation with the Atedaban to possibly early Lennian stages of Siberia, i.e. middle to late Cambrian. Stromatolites are locally present.

**Correlatives:** Correlated with the Red Heart Dolomite which occurs 100-200 km E of the Jervois Mine along the southern margin of the Georgina Basin (Walter and others, 1979). Also the equivalent of the Todd River Dolomite of the Amadeus Basin (Wells and others, 1970), and of the Ajax, Wilkawillina and Kulpara Limestones of South Australia (Parkin, 1969).

**Synonymy:** Included in the upper Mount Baldwin Formation by Smith (1964b) and subsequent authors. Definition alluded to by Walter (1980) who excluded the dolomitic section from the Mount Baldwin Formation but had left it unnamed.

**Arthur Creek Formation** (elevation of status) Originally defined by Smith (1964b) as Arthur Creek beds because of its poor outcrop and a suspected break in the sequence. Following stratigraphic diamond drilling in 1982 it is now desirable to elevate the unit to formation status; no significant break in the section has been recognised.

**Proposer:** M.J. Freeman

**Distribution:** HUCKITTA; extensive outcrops W of Lucy Creek Homestead. Poor outcrops elsewhere.

**Lectostratotype:** In two, overlapping, continuously-cored holes: DDH. NTGS. HUC2, for upper part, from 20.35 m to 203.76 m depth and DDH. NTGS. HUC1, for lower part, from 9.17 m to 243.37 m depth. Core will be stored at the Alice Springs Core Library of the Northern Territory Geological Survey. Correlation between the two drill holes was established in the lowest occurrence of limestone beds, a distinctive marker within the formation. Lateral facies variations may result in minor imprecision of the correlation. (HUC1 is located at Lat. 22°31'50"S, Long. 136°15'4"E, GR PR273072, HUC2 at Lat. 22°23'7"S, Long. 136°15'4"E, GR PR222241.)

**Lithology:** In the lectostratotype it consists of three parts, listed in order from the top, as below:
- 54.4 m (in HUC2, 20.35-74.73 m) Calcareous quartz arenite, planar and trough cross-beds.
- 129.0 m (in HUC2, 74.73-203.76 m) Grey, laminated, calcareous siltstone with pyrite and flaser-bedded, black, very thin interlaminations of organic-rich clay. Contains thin interbeds of grey limestone.
- 234.2 m (in HUC1, 9.17-243.37 m) Laminated calcareous siltstone as in interval above. (Overlies Errarra Formation).
In outcrop, the uppermost unit is hill-forming between about GR PR250230 and GR PR200030, absent elsewhere. Only limestone beds outcrop in the middle unit, as rubbly lines of grey limestone blocks. Outcrop of the lowest unit is very poor and mostly is bleached, white, porous and friable silstone. Outcrops of the fresh rock are rare. Only located north of the Jervois and Johannsen Ranges and one outcrop in the Mopunga Range (GR NQ552973). Elsewhere it is known only from drill hole intersections because it is readily weathered. Only the lowest unit is known to occur away from the type area outcrops.

Relationships and boundary criteria: Gradational at top with dolostones of the Arrinthuranga Formation and at the base with green-grey silty sandstone and siltstone in the Errarra Formation; in both cases over intervals of approximately 1-2 m.


The assemblages present suggest an age ranging between Floran or slightly older and late Undillian which places it in middle Cambrian.

Thickness: 417.6 m in stratotype but thinner elsewhere; 30 m in the Elua Range and 50m in the Mopunga Range drill hole intersections.

Correlatives: Partly equivalent to the Sandover beds on ELKEDRA (Smith, 1972) to the north and to the Marqua beds on TOBERMORY to the east (Walter and others, 1979).

Synonymy: Now excludes the dolostone, in S and E Mopunga Range, which Smith (1964b) included in the Arthur Creek beds. This dolostone is now assigned to the Arrinthuranga Formation on lithological grounds.