### 1:100,000 Geological Map Series

#### Explanatory Notes

**Anson 4971**

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MAP
1:100 000 Geological map of ANSON (4971) in pocket
Figure 1  Locality map.
ABSTRACT

Geologic mapping of the Anson 1:100 000 map sheet area by the Northern Territory Geological Survey (NTGS) in 1981, using 1:25 000 colour aerial photography, was supplemented by airborne magnetic and radiometric surveys carried out in the same year.

Much of ANSON is of low relief, with Murrenja Hill forming the most prominent feature. The lower reaches of the Daly River meander NW to Anson Bay through extensive floodplains which constitute a major obstacle to access except during the latter part of the dry season.

The map sheet area contains Early Proterozoic low- to high-grade metasedimentary rocks (Unit Ec, Welltree Metamorphics with Ew1, Member) intruded by the 1852±33 Ma Wagait Granite and the 1768±16 Ma Two Sisters Granite. Middle Proterozoic sedimentary rocks (Moyle River Formation) overlie the Wagait Granite with an apparent unconformity. Both the granite and Moyle River Formation have been intruded by the undated, but probably Late Proterozoic, Murrenja Dolerite. Flat-lying, dominantly calcareous, Cambrian sedimentary rocks unconformably overlie the metamorphic and granitic rocks. The Early Permian Kulshill Formation (containing the Sakmarian indicator *Pseudorecticulatispora* (al. *Verrucosisporites* *pseudorecticulatus*), unconformably overlies the Wagait Granite, and consists of arenites and siltstones. The Cainozoic and Quaternary cover consists of mainly unconsolidated sand, silt, clay, and limonite pisolithes.

Metamorphic mineral assemblages show a prograde metamorphic event of greenschist-to amphibolite-facies, followed by a period of retrograde greenschist-facies metamorphism.

The structure of the metamorphic rocks is unknown. During the Late Proterozoic, NE- to SW-directed compressional stresses resulted in folding of the Middle Proterozoic sedimentary rocks, and extensive dextral-oblique slip faulting. The most prominent magnetic feature is a north-trending zone of anomalies attributed to magnetic and pyrrhotitic horizons in the Ew1, member of the Welltree Metamorphics. The radiometrics give little assistance to geologic interpretation.

Exploration for coal, heavy minerals in beach-sands, bauxite, phosphate, base-metals, diamonds and uranium has yielded no positive results.

INTRODUCTION

Location, access and climate

ANSON (Sheet 4971) is centred about 105 km SW of Darwin and covers the area between latitudes 13° 00’S and 13° 30’S and longitudes 130° 00’E and 130° 30’E (Figure 1). The small settlements in the sheet area are: La Belle Downs outstation (Stapleton Station); Bulgal outstation, a coastal settlement on the Wagait Reserve; Nimrod Safaris, a tourist operation at Channel Point; and Litchfield station in the south. With the exception of the tourist venture, cattle grazing is the sole land use.

Access from Darwin is via the Mandorah and Wangi Station roads into REYNOLDS RIVER and thence via the road to the coast. This road follows the boundary between the Wagait Aboriginal Land and Stapleton Station. Minor vehicular tracks lead to Litchfield outstation, Bobs Knob, and the northern part of Murrenja Hill, but graded fence-lines provide most of the vehicle access in ANSON. Much of the sheet area is accessible only during the latter part of the dry season, as the extensive areas of blacksoil plain remain inundated throughout the wet season and are not completely dry until August or September. The Peron Islands, and all of the area south of the Daly River, are part of the Daly River Reserve.

The climate is monsoonal, with the majority of the rain falling between November and March. The sheet area is transected by the 1200 mm isohyet, which lies south of the Daly River mouth, and the 1400-1600 mm isohyets, with the coastal region in the north receiving more than 1400 mm of rainfall per annum. Temperatures range between an annual average maximum of 34°C and an annual average minimum of about 20°C.

Physiography

There are four major physiographic divisions in ANSON: Dissected Uplands, Eluvial Lowlands, Floodplains and the Coastal Region (Figure 2).

Dissected Uplands

The dissected uplands are restricted to Murrenja Hill, which reaches a maximum elevation of 146 m above sea-level and rises about 130 m above the surrounding plains. The hill is rock-strwnn, supports only skeletal soils and its lower slopes are steep. Along the western flank and the central valley, groundwater seepage enables tall eucalypts and a dense undergrowth to flourish.

Eluvial Lowlands

The eluvial lowlands, which occur in the eastern half of ANSON and adjacent to the coast in the north and south, are approximately co-extensive with the ground between the 15 m and 50 m contours.

The lowlands have formed over granitic, metamorphic and sedimentary rocks and, although outcrop of these rocks is very poor, the soils are not exceptionally thick. Tall, medium-density woodland is restricted to areas in the north on lateritic soils underlain by Permian rocks. This may indicate more fertile soils or a higher water table in these areas. *Livistona* palms are dominant in areas underlain by granitic and metamorphic rocks. The drainage pattern developed is a low-density, slightly incised, dendritic system.

*References to 1:100 000 map sheet areas in this report are designated by the use of capital letters.

†In this report the Proterozoic is subdivided as follows:

Early Proterozoic (2700 Ma — 1700 Ma),
Middle Proterozoic (1700 Ma — 1000 Ma),
Late Proterozoic (1000 Ma — 570 Ma).

Australian Bureau of Meteorology, Annual Rainfall (median) 50 percentile map.
Figure 2 Physiographic units in ANSON.

Floodplains
The floodplains form the most extensive physiographic feature in ANSON and, with the exception of the coastal region, occupy virtually all of the ground below the 15 m contour. The plains are broad expanses of black cracking clays which are inundated during the wet season. The Daly River meanders through the plains, and flows into Anson Bay. In contrast, the Reynolds River debouches onto the floodplains, where it forms a chain of large billabongs. The floodplains, which extend NW of Murrenja Hill into FOG BAY, are part of the Finniss River system.

The plains are underlain by estuarine sediments containing shelly material, deposited during the last, Late Pleistocene, sea-level rise (Christian and Stewart, 1953).

Coastal Region
The coastal region includes cheniers, mudflats, cliffs, beaches and laterite shelves. Saline mudflats have developed along the tidal channels which flow into Anson Bay, and as far as 20 km upstream from the mouth of the Daly River, where low ground, flanking the riverbanks, is inundated by tides. The saline mudflats are commonly populated by mangroves. Where low cliffs form the coastline, narrow, sandy beaches form the shore, and north of Channel Point and near Red Cliff, low, laterite benches extend seawards and are exposed at low tide.

Extensive areas of cheniers, with intervening mudflats, have developed along the shore to the south of the mouth of the Daly River. A series of long cheniers and beach ridges, trending parallel to the present coast, lie some 10 km inland from the mangrove flats north of the river mouth, and mark the positions of former shorelines.

The Peron Islands have identical landforms to those of the adjacent mainland. During low tides, they are separated from the mainland by a narrow, deep channel bounded by extensive tidal flats.

Small caves, at the base of conglomerate outcrops at Bobs Knob, may have been formed by marine erosion during the Late Pleistocene sea-level rise.

Previous investigations
The first accounts of the geology of ANSON were given briefly by the South Australian Government Geologist, H.Y.L. Brown, when he observed the coastal sections of Permian rocks during his geologic reconnaissance of the Victoria River and Daly River regions (Brown, 1895; 1906). He subsequently visited ANSON in 1908 when he inspected the South Australian Government Coal Bore being drilled near Cliff Head (Brown, 1908). A further three coal bores were drilled at Redcliff between 1909 and 1911 (Playford, 1911).

Noakes (1949) visited the area as one of a team surveying the Katherine-Darwin region (Christian and Stewart, 1953); he described the “Litchfield Granite” (Wagait and Two Sisters granites) and assigned the rocks of Murrenja Hill to the Brooks Creek Group, a term which he used to describe all of the Early Proterozoic metamorphic rocks in the western part of the Pine Creek Geosyncline. Walpole and others (1968) included the area in a Bureau of Mineral
Resources (BMR) survey of the Katherine-Darwin region. They mapped as Chilling Sandstone the sedimentary rocks at Murrenja Hill, and used the term “Litchfield Complex” to describe the granites. Mundum (1972), and Sweet and others (1974), retained the term “Litchfield Complex” but mapped the rocks at Murrenja Hill as Moyle River Formation. The Cape Scott 1:250 000 sheet area, which includes ANSON, was covered by a reconnaissance helicopter gravity survey of NW Australia, flown by BMR in 1967 (Whitworth, 1970) and by a BMR aerial magnetic and radiometric survey in 1974-1975.*

Company exploration began with the search for heavy-mineral concentrations in beach sands on the coastline of Anson Bay; as a result some uneconomic concentrations of rutile and magnetite were located (Murphy, 1969a and b; Cuttler, 1972; Nixon and Hirst, 1973). The results of exploration for bauxite and phosphate deposits were discouraging (Zimmerman, 1969). Base-metal and uranium exploration has been concentrated in the area east and SE of Murrenja Hill (Berkman, 1978; Nicol and Berkman, 1980; Broken Hill Proprietary Company Limited (BHP), 1976; Boyd and Nicol, 1981); no significant mineralisation has yet been located.

The land units of the Wagait Reserve have been described by Forster (1977); his report includes detailed soil descriptions.

**STRATIGRAPHY**

A summary of the stratigraphy of ANSON is given in Table 1.

Petrographic details are based upon descriptions of thin sections by the Australian Mineral Development Laboratories (AMDEI), Central Mineralogical Services, and NTGS personnel (in Hahey and Edgoose, 1984).

**REGIONAL GEOLOGIC SETTING**

The Early Proterozoic Unit Ec and the Welltree Metamorphics (Hickey, 1985; Pietsch, in prep., b) constitute the oldest rocks in ANSON.

The low- to high-grade Welltree Metamorphics, which extend into REYNOLDS RIVER, FOG BAY and BYNOE (Figure 3), are perhaps equivalent to the Hermit Creek Metamorphics which crop out in the southern part of the Litchfield Province and which, in turn, may correlate with the Halls Creek Group of the East Kimberley region (Dundas and others, in prep., a). This implies that the Halls Creek Mobile Zone (Figure 4) may have extended to at least ANSON, as first suggested by Traves (1955), who proposed that it continued to DARWIN.

The synorogenic granites which intruded the Early Proterozoic rocks in ANSON are part of a granitoid batholith that invaded the western margin of the Pine Creek Geosyncline in successive phases of intrusion, beginning at about 1850 Ma (Dundas and others, in prep., a).

Arenites of the Middle Proterozoic Moyle River Formation in ANSON form a northern outlier of the Fitzmaurice Group, which is a thick sequence of shallow-marine sedimentary rocks extending in an elongate belt, up to 45 km wide, from the Western Australia border to GREENWOOD (Sweet, 1977).

The Murrenja Dolerite is correlated with Late Proterozoic dolerites in the Pine Creek Geosyncline, and with dolerite sills which likewise intrude the Moyle River Formation 130 km to the SSW in MOYLE (Fahey, pers. obs.).

The Cambrian sedimentary rocks in ANSON are part of an outlying basin which extends into REYNOLDS RIVER and DALY RIVER, where it is separated from the Daly River Basin by a north-trending belt of Early Proterozoic rocks. Early Permian rocks form the western half of ANSON, and are part of the Bonaparte Basin sequence.

Tom Turners Fault is a dextral-oblique slip fault which merges southwards, from ANSON, into a complex fault zone that extends as far as the East Kimberley region of Western Australia (Figure 4). In ANSON, the fault bifurcates, with the main eastern branch continuing NNE into FOG BAY, BYNOE and DARWIN.

**EARLY PROTERozoic**

**Unit Ec**

This unit, which consists of gneiss, amphibolite, quartzite and schist, does not crop out in ANSON. However, it is inferred to extend as a wedge, bounded by steep faults, into the northern edge of the sheet area from FOG BAY (Figure 5). In FOG BAY, Unit Ec has been defined on limited outcrop, drilling information and geophysics (Hickey, 1985). No further information concerning this unit is available in ANSON.

**Welltree Metamorphics (Bwt)**

The Welltree Metamorphics form an extensive, but extremely poorly exposed unit in the NE of ANSON. The metamorphics, defined in BYNOE (Pietsch, in prep., b), are interpreted to extend into the sheet area southwards from FOG BAY and westwards from REYNOLDS RIVER. In ANSON, apart from some minor outcrop near the eastern edge of the sheet area, all information pertaining to the unit has been derived from the interpretation of NTGS petrologic and geophysical data, and from company drilling and petrologic studies (BHP, 1976; Berkman, 1978; Nicol and Berkman, 1980; Boyd and Nicol, 1981). The metamorphics are composed mainly of partly retrogressed greenschist- to amphibolite-facies schist and some partly retrogressed amphibolite-facies gneiss. The schists and gneisses mainly represent metamorphosed semi-pelitic rocks. However some samples show mineralogy and textures suggestive of metamorphosed tuffs (Berkman, 1978).

Although no contacts are exposed, it is inferred that the Welltree Metamorphics are intruded by the Early Proterozoic Wagait and Two Sisters granites, are faulted against the Early Proterozoic Unit Ec and the Middle Proterozoic Moyle River Formation, and are unconformably overlain by flat-lying Cambrian sedimentary rocks.

These inferred relationships imply a minimum age of 1852±33 Ma for the Welltree Metamorphics, which
<table>
<thead>
<tr>
<th>ERA/PERIOD</th>
<th>GROUP</th>
<th>UNIT, MAP SYMBOL</th>
<th>LITHOLOGY</th>
<th>THICKNESS</th>
<th>COMMENTS, RELATIONSHIPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>QUATERNARY</td>
<td>Qa</td>
<td></td>
<td>Sand, silt, clay</td>
<td>Up to 3 m</td>
<td>Alluvium; transitional into Qcl, Qaf</td>
</tr>
<tr>
<td></td>
<td>Qcl</td>
<td></td>
<td>Sand, silt, clay</td>
<td>Up to 3 m</td>
<td>Colluvium; sheetwash deposits</td>
</tr>
<tr>
<td></td>
<td>Qaf</td>
<td></td>
<td>Black to brown humic soil and clay</td>
<td>Up to 30 m</td>
<td>Floodplain alluvium; transitional into Qa, Qcl</td>
</tr>
<tr>
<td></td>
<td>Qcr</td>
<td></td>
<td>Silt, sand, shelly sand and coral fragments</td>
<td>Up to 3 m</td>
<td>Cheniers and beach ridges; overlies Qaf or Qca</td>
</tr>
<tr>
<td></td>
<td>Qca</td>
<td></td>
<td>Silt, clay, mud</td>
<td>Up to 3 m</td>
<td>Accumulates in the intertidal zone along the coast, and the banks of the Daly River</td>
</tr>
<tr>
<td></td>
<td>Qcb</td>
<td></td>
<td>Poorly consolidated sand, shell and coral fragments and pisolites</td>
<td>Up to 2 m</td>
<td>Cemented beach sand at top of beach lines</td>
</tr>
<tr>
<td>TERTIARY TO</td>
<td>Czs</td>
<td></td>
<td>Unconsolidated sand, silty sand, clayey sand, gravel</td>
<td>Up to 30 m</td>
<td>Eluvial soils developed over all rock types</td>
</tr>
<tr>
<td>QUATERNARY</td>
<td>Czl</td>
<td></td>
<td>Insitu and reworked nodular, concretionary, pisolitic and mottled laterite</td>
<td>Up to 6 m</td>
<td>Developed over Permian, Cambrian and Early Proterozoic rock types</td>
</tr>
<tr>
<td>PERMIAN</td>
<td>Port Keats</td>
<td>Kulshill</td>
<td>Mature to immature (clayey) quartz arenite ± mica ± feldspar, may be friable, porous; interbedded, mottled, siliceous or carbonaceous siltstone; claystone; sandy claystone; conglomerate</td>
<td>Up to at least 375 m, proved in drillhole A.B.1</td>
<td>Uncomfortable on Pgwa; carbonaceous lenses contain algae, spores and pollen which indicate an Early Permian age</td>
</tr>
<tr>
<td></td>
<td>Group</td>
<td>Formation, P</td>
<td></td>
<td></td>
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<tr>
<td>CAMBRIAN</td>
<td>E</td>
<td></td>
<td>Dolomitic siltstone; impure dolomite; fine-grained immature subarkose; quartz arenite, micaceous, ripple-marked, planar-laminated, fine-grained; mudstone; shale</td>
<td>Up to at least 100 m</td>
<td>Unconformable on Pgwa, Bwt</td>
</tr>
<tr>
<td>MIDDLE-</td>
<td></td>
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<td></td>
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<tr>
<td>LATE PROTERZOIC</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Murrenga</td>
<td></td>
<td>Dolerite; minor gabbro</td>
<td></td>
<td>Intrusive into Ezm, Pgwa</td>
</tr>
<tr>
<td></td>
<td>Dolerite,</td>
<td></td>
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<td></td>
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<tr>
<td></td>
<td>Edm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MIDDLE PROTEROZOIC Group</td>
<td>Fitzmaurice Formation, ( \text{P}_\text{zm} )</td>
<td>Moyle River Quartz arenite, siliceous, ferruginous, submature to mature, micaceous, of medium-to granule-grain size, graded, ripple-marked, with planar lamination; sheared schistose quartz arenite; intraformational conglomerate</td>
<td>At least 1750 m</td>
<td>Unconformable on and faulted against ( \text{Egw} ); faulted against ( \text{Pwt} ); intruded by ( \text{Edm} )</td>
<td></td>
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<tr>
<td>EARLY PROTEROZOIC</td>
<td>Two Sisters Granite, ( \text{P}_\text{gts} )</td>
<td>Biotite granodiorite, with biotite schlieren ( 1768 \pm 16 \text{ Ma (R. Page, BMR)} )</td>
<td>Intrudes ( \text{Pwt} )</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wagait Granite, ( \text{Egw} )</td>
<td>Hornblende granodiorite; adamellite; mylonitised adamellite; biotite granite and granodiorite; epidotised granite; sometimes porphyritic ( 1852 \pm 33 \text{ Ma (R. Page, BMR)} )</td>
<td>Intrudes ( \text{Ec, Pwt} ); unconformably overlain by ( \text{Pzm, E, P} ); intruded by ( \text{Edm} )</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Welltree Metamorphics, ( \text{Pwt} )</td>
<td>Schist, gneiss</td>
<td>Intruded by ( \text{Egwa, Pgts} ); faulted against ( \text{Pzm} ); unconformably overlain by ( \text{E} ); relationship with ( \text{Ec} ) unknown</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \text{Pwt}_1 )</td>
<td>Schist with graphitic and magnetitic horizons; metaquartzite with or without garnet and graphite; marble; amphibolite; phyllite</td>
<td></td>
<td>Informal subdivision of ( \text{Pwt} )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \text{Ec} )</td>
<td>Undivided schist, gneiss, amphibolite, metaquartzite</td>
<td></td>
<td>Does not crop out in ANSON; interpreted to extend into ANSON from FOG BAY</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure 3 Regional geologic setting of ANSON.
Figure 4  Regional tectonic setting of ANSON.
is the age of crystallisation of the Wagait Granite (Page and others, 1984).

Mapping in BYNOE by Pietsch (in prep., b) suggests that the Welltree Metamorphics are equivalent, at least in part, to the Early Proterozoic Burrell Creek Formation of the Pine Creek Geosyncline. The Burrel Creek Formation has a maximum age of about 1880 Ma (P. Stuart-Smith, pers. commun.). However, the Welltree Metamorphics resemble strongly, in both mineralogy and metamorphic history, the schists and gneisses of the Early Proterozoic Hermit Creek Metamorphics found to the south and SSE in GREENWOOD, DALY RIVER, MOYLE and WINGATE MOUNTAINS (Dundas and others, in prep., a and b). These authors propose that the prograde metamorphism of the sedimentary and igneous rocks of the Hermit Creek Metamorphics was probably coincident with the 1920±30 Ma metamorphism in the Halls Creek Mobile Zone (Dow and Gemuts, 1969). This suggested correlation would thus give a minimum age of 1920±30 Ma for the Welltree Metamorphics.

Schist The low- to medium-grade schists are generally fine- to medium-grained, strongly foliated, and may be porphyritic. They sometimes exhibit a weak to distinct banding. Concordant to cross-cutting thin veins composed of quartz or feldspar are common. Some of the quartz veins are pytymatic.

In thin section, the schists have a well developed lepidoblastic texture; granoblastic quartz-feldspar bands with subordinate lepidoblastic mica and interlayered, dominantly micaceous, strongly schistose, bands are common.

Mineral assemblages usually include quartz + muscovite ± feldspar ± biotite ± garnet ± sillimanite or andalusite ± amphibole ± sericite ± chlorite. Accessory minerals include zircon, apatite, rutile, tourmaline and opaques. Typical prograde mineral assemblages are listed in Table 3. Quartz, together with feldspar, commonly forms granoblastic aggregates which may make up to 70% of the rock. The dominant feldspar is primary metamorphic plagioclase (oligoclase where identified) which is sometimes poikiloblastic. Primary metamorphic potash feldspar is rare; however, post-metamorphic secondary potash feldspar, probably adularia, is commonly found in veins, patches and intergrown with biotite. Muscovite is present as strongly aligned flakes and, together with biotite, may form up to 30% of the rock. Garnet occurs as small, disseminated, commonly euhedral, crystals but may be more abundant and larger near quartz veins. Sillimanite is found either as patches of thin fibres or as thin needles enclosed in quartz. Poikiloblastic andalusite and staurolite crystals may form porphyroblasts up to 10 mm across. Most of the schists show some evidence of retrogression to lower greenschist-facies; typical retrograde minerals are sericite, after plagioclase, sillimanite, muscovite, staurolite and andalusite; and chlorite after plagioclase, biotite, garnet and staurolite.

Gneiss The high-grade gneisses are coarse- to very coarse-grained and exhibit a weak- to moderately-strong foliation. They are typically composed of quartz, plagioclase, potash-feldspar, muscovite, biotite, garnet, sillimanite, chlorite and sericite, with accessory zircon and leucocene. Typical prograde mineral assemblages are listed in Table 3. The plagioclase is
andesitic and may form myrmekitic intergrowths with quartz. Muscovite is found as platy grains, intergrown with biotite, or as fibrous aggregates after sillimanite. Garnet may occur as isolated grains or as loosely- to densely-packed crystal clusters. Sillimanite is present as sub-radiating clusters of finely acicular crystals and as fibrous aggregates. The gneisses, like the schists, show evidence of retrograde metamorphism to lower greenschist - facies: retrograde minerals are sericite, after plagioclase, muscovite and sillimanite; chlorite after plagioclase, biotite and garnet, and, more rarely, fibrous muscovite after sillimanite.

\[ Ew_t \]

\[ Ew_t \] consists of schist, with graphic and magnetic horizons, and minor interlayered metaquartzite, marble and orthoamphibolite.

A series of drillholes in the NE of ANSON intersected schist with some interlayered orthoamphibolite and marble (BHP, 1976). The schists are composed of quartz + mica ± amphibole ± garnet ± chlorite ± magnetite ± graphite. Minor to trace minerals are pyrite, chlorapatite, pyrrhotite, sphalerite and galena.

Drilling by A.O.G. Minerals Proprietary Limited (AOG), a few kilometres to the south in the La Belle Downs area, intersected mildly- to strongly-retrogressed schist composed of quartz + muscovite + biotite ± feldspar ± andalusite ± staurolite ± chlorite ± sericite ± graphite (Berkman, 1978; Boyd and Nicol, 1981). Accessory minerals include tourmaline, zircon, apatite and ophases. Where graphic, the metasedimentary rocks may contain mafic sulphides, typically pyritised pyrrhotite. In the same general area are minor outcrops of metaquartzite, with or without garnet and graphite, and phyllite.

The magnetic horizons, and pyrrhotite associated with the graphic horizons, within the schists of \[ Ew_t \], give rise to characteristic magnetic anomalies. Because of the extremely poor outcrop and limited drillhole information, the position of the intraformational boundary between the Welltree Metamorphics and \[ Ew_t \] has been delineated largely on the basis of these magnetic data. Berkman (1980) suggests that the magnetite schists represent regionally metamorphosed, iron-rich sediments and that the associated regional magnetic anomalies, which trend north to NW, reflect the trend of the sedimentary layering.

**Wagait Granite (\( Pgwa \))**

Information obtained from drilling indicates that granite lies at depth beneath much of the mainland area in ANSON. Granite, similar to that exposed in the main outcrop of Wagait Granite in the north-central part of the sheet area, forms small outcrops in the extreme south. This indicates a continuous batholith underlies the alluvium of the central part. The Wagait Granite also extends northwards as subcrop into FOG BAY.

The Wagait Granite was first described by Berkman (1980); previously the granite in ANSON was not distinguished from the Litchfield Complex (Mendum, 1972).

The Wagait Granite is inferred to intrude the Welltree Metamorphics; the contact is nowhere exposed but was penetrated at a depth of 36 m in a water bore SE of Murrenja Hill. The granite is inferred to underlie the Moyle River Formation at both Murrenja Hill, where the contact is poorly exposed at the SW end, and at Bobs Knob, where the contact was penetrated in a nearby water bore. This inferred unconformity is based on field relationships observed in MOYLE, where the Moyle River Formation unconformably overlies a granite of the same age as the Wagait Granite (Edgoose, pers. obs.). Granitic rocks, which are now inferred to be Wagait Granite, were proved below Permian rocks at 158 m depth (drillhole NTGS 82/47) 7 km north of Channel Point, and at 219 m depth in a coal bore, Cliff Head No. 1 (Drummond, 1963).

The Wagait Granite is exposed as boulders and tors on gently undulating plains, and occasionally as isolated tors in swamps. Less commonly, extensive exposures form thickly tree-covered rises.

The rock types are granodiorite, adamellite and granite, most of which are biotite-rich and contain hornblende. The rocks are not foliated, but exhibit considerable variation in texture, and crystallinity ranges from fine to coarse. They include equigranular and porphyritic types, the latter with phenocrysts of feldspar. Typical mineral assemblages include quartz, alkali feldspar (commonly optical microcline with some optical orthoclase), plagioclase, biotite and hornblende. Epidote is the most common accessory mineral, and trace amounts of apatite and zircon occur as inclusions in some quartz crystals. Both species of feldspar form porphyritic crystals, generally about 5 mm, but sometimes up to 10 mm in length, and display varying degrees of micaceous alteration. Some plagioclase is saussuritised. Alkali feldspar is commonly perthitic, and microcline and quartz may form myrmekitic intergrowths. These features, combined with the interstitial nature of much of the quartz, suggest that quartz, and in some cases microcline, were late-stage minerals. Quartz crystals may be up to 5 mm in length. Plagioclase is often highly zoned and generally exhibits poor crystal shape. Biotite is present as individual flakes up to 2.5 mm in length, and in aggregates which may also include hornblende. Biotite is commonly altered to chlorite and epidote. Hornblende is similarly altered to chlorite, and generally displays poorer crystal shape than biotite. It occurs both as individual grains up to 4 mm in length and in clusters. Epidote, in addition to being a product of alteration of other mineral grains, also occurs as a deuteric replacement mineral in veins.

A sample from the bottom of drillhole NTGS 82/47 has been described as a ‘sheared porphyritic rhyolite’ (Fander, in Fahey and Edgoose, 1984). Whereas the possibility exists that this sample may be an acid extrusive rock, and thus may correlate with acid extrusive rocks of the Pine Creek Geosyncline, it has nevertheless been assigned to the Wagait Granite because its texture is not unequivocally extrusive.

West of Murrenja Hill, some outcrops of Wagait Granite show evidence of partial recrystallisation and mylonitisation; these features may be due to movement along Tom Turners Fault.

Zircons in one thin section appear to show detrital features suggesting the Wagait Granite is of anatectic sedimentary origin. However, the presence of hornblende, according to Chappell and White (1974), is indicative of granites derived by partial melting of an igneous source rock. Therefore, the rounded zircons are probably a feature of contamination.
A recent radiometric age determination, using the Rb-Sr whole-rock isochron method, gave a date of 1852±33 Ma for the crystallisation of the Wagait Granite (Page and others, 1984). The granite thus belongs to the group of granitoid bodies which intruded the western margin of the Pine Creek Geosyncline between 1850 Ma and 1840 Ma.

**Two Sisters Granite (Ngts)**
The Two Sisters Granite is a large granitoid body which both subcrops and crops out extensively in FOG BAY, BYNOE and REYNOLDS RIVER (Hickey, 1985; Pietsch, in prep., a and b). The granite is found only in the extreme NE corner of ANSON, where it is a nonfoliated biotite granodiorite with a typical mineral assemblage of plagioclase, quartz, microcline, biotite with traces of muscovite, apatite, calcite and opaque oxides.

Thin sections show some replacement of plagioclase by quartz and microcline, suggesting that these minerals have been introduced at a late stage in the crystallisation of the rock. Biotite clusters or schlieren probably represent partially assimilated xenoliths which have been attenuated by movement of the magma.

A radiometric age-determination, using the Rb-Sr whole-rock isochron method, of samples of the Two Sisters Granite from REYNOLDS RIVER, yielded an age of 1768±16 Ma (Page and others, 1984). Page considers that this date reflects a metamorphic episode and that the date of crystallisation, based on age determinations of samples collected from other granitoids in the Litchfield Province, is more likely to be 1850 to 1840 Ma.

**MIDDLE PROTEROZOIC**

**Moyle River Formation (Rsm)**
The main exposure of the Moyle River Formation in ANSON is at Murrenja Hill, where the moderately- to steeply-dipping sequence forms a prominent hill rising to 130 m above the surrounding plains. There is a smaller outcrop at Bobs Knob, about 6 km south of the eastern extremity of Murrenja Hill; the western part of this outcrop is a large granite body known as granite (Mendum, 1972). Granite was proved by a water bore immediately to the west but is not found at the surface at Bobs Knob.

At Murrenja Hill, the Moyle River Formation is at least 1750 m thick and is composed mainly of medium-grained to coarse-grained micaceous quartz arenites with interbeds of pebble to cobble conglomerates and sheared, sericitic, schistose quartz arenites.

The quartz arenites are largely immature to mature with subangular to rounded quartz grains. They are commonly siliceous, particularly near fault zones where considerable recrystallisation has occurred. Sedimentary features noted are planar lamination, graded bedding and ripple marks.

Quartz arenites in the eastern ‘arm’ of Murrenja Hill tend to be more ferruginous and less mature than those in the more prominent western ridge. Their ferruginous nature, as well as low relief and thicker soil cover, give rise to an unusual and distinct tone on aerial photographs. Similar ferruginous quartz arenites are found on the western side of Bobs Knob.

Plate 1 Sheared, schistose quartz arenite and a thin interbed of submature quartz arenite of the Moyle River Formation, at the northern end of Murrenja Hill.

A = Bedding
B = Foliation

The sheared, schistose quartz arenites are interbedded with orthoquartzites and occur within and near fault zones. The schistose quartz arenites are composed of quartz, muscovite, sericite and minor kaolinite, epidote and opaques. The well-developed schistosity in these quartz arenites generally strikes north to NE and cuts the moderately easterly-dipping beds at a maximum angle of 45° (Plate 1). In some areas, the schistosity is strongly kinked and crenulated. The schistosity and mineralogy are considered to have resulted from shearing of less competent clayey immature quartz arenites during faulting, rather than as a result of regional metamorphism.

Three conglomerate horizons were mapped within the Moyle River Formation in ANSON, but it is likely that more occur throughout the sequence. The lowermost conglomerate at Murrenja Hill occurs on the eastern side of the main western ridge, where it strikes discontinuously for about 3 km. This easterly-dipping bed contains clasts ranging from granules to boulders of angular to subrounded reef quartz and angular to subangular acicular fragments of quartz arenite. A second conglomerate is found near the top of the sequence, towards the northern end of the eastern ‘arm’ of Murrenja Hill, and is composed of angular to rounded, granule- to cobble-sized clasts of reef quartz, coarse-grained siliceous quartz arenite, and granule to pebble conglomerate (Plate 2). Some clasts of quartz arenite feature cross bedding or planar lamination. A third conglomerate crops out at Bobs Knob and is almost identical to those at Murrenja Hill. In places, beds grade from gravelly quartz arenite to pebble conglomerate, but generally the outcrops consist of massive conglomerate. The lithologies of the clasts indicate that all these conglomerates are intraformational.

The lithologies and sedimentary features of the formation indicate a shallow-water depositional en-
environment with fluctuating, but generally high-energy, conditions. The thickness and general uniformity of the sequence (only partially preserved in ANSON, but more complete in GREENWOOD and MOYLE to the south where it is about 5000 m thick) indicate that the sediments were deposited in a basin whose rate of subsidence equalled that of sediment supply.

The unconformity on the west and north flanks of Murrenja Hill, between the Moyle River Formation and the underlying Early Proterozoic Wagait Granite, is nowhere well exposed. The eastern and southern boundaries are complicated by faulting, with the formation being downthrown against both the Welltree Metamorphics and the Wagait Granite. The formation is intruded by the Murrenja Dolerite which, in some places, forms its western boundary.

The maximum age of the formation is defined in ANSON by the 1852±33 Ma date for the crystallisation of the Wagait Granite. Furthermore, the formation has not undergone regional metamorphism and thus post-dates the 1870-1880 Ma orogeny of the Pine Creek Geosyncline (Needham and others, 1980), which was the last regional metamorphic episode to affect the rocks in ANSON.

The minimum age of the formation is less certain. According to Sweet (1977), the Goobaier Formation, which conformably overlies the Moyle River Formation on the south of ANSON, is equivalent to the Angalarri Siltstone of the Auvergne Group. In turn, the Angalarri Siltstone is equivalent to the Golden Gate Siltstone of the Carr Boyd Group. A Rb-Sr whole-rock date on the Angalarri Siltstone yielded an age of 838±142 Ma. However, Sweet (1977) considers that the accuracy of the date should be viewed cautiously. An isotopic age of 1128±110 Ma has been recorded for the Golden Gate Siltstone (Dow and Gemuts, 1969), thus implying a minimum late Middle Proterozoic age for the Moyle River Formation.

These data suggest that the Moyle River Formation should be assigned to the Middle Proterozoic. It is possible that the formation was deposited in the late Early Proterozoic, during 1800 Ma to 1700 Ma. However, this would result in an unacceptably long hiatus before the deposition of the overlying and conformable Goobaier Formation, which, as suggested, may be late Middle Proterozoic to possibly early Late Proterozoic in age.

MIDDLE TO LATE PROTEROZOIC

Murrenja Dolerite (Edm)
The Murrenja Dolerite (new name) occurs below the western flank of Murrenja Hill, where it forms a moderately east-dipping, intermittently exposed sill about 200 m thick. The dolerite slightly transects the bedding of the Moyle River Formation in this area.

The contacts of the dolerite and the Wagait Granite are nowhere exposed, and the contact with the Moyle River Formation is concealed by surficial deposits. The magnetic data suggest a strike-length for the sill of at least 6 km in the SW, but do not indicate whether it continues subsurface to the northern exposure.

Morgan and others (1970), and Sweet and others (1974), acknowledge an intrusive relationship between the dolerite and the Moyle River Formation. However, the former authors nevertheless believe that the dolerite must belong to the group of basic igneous rocks which were intruded by the 1850-1840 Ma granites of the Litchfield Province. However, Dundas and others (in prep., a) demonstrate that the basic rocks of the Litchfield Province are not the result of one phase of intrusion. Basic bodies similar to the Murrenja Dolerite intrude the Moyle River Formation in MOYLE.

The Murrenja Dolerite consists of nonfoliated dolerite and minor gabbro showing only late-magmatic alteration, and is dominantly composed of plagioclase and pyroxene. Much of the plagioclase is anhedral and altered thoroughly to a felt of sericite; less altered crystals are often zoned. Pyroxene occurs as subhedral prisms and interstitial crystals of pigeonite and normal, presumably augitic, clinopyroxene. The central parts of the pyroxene crystals are often altered to chlorite; some crystals are zoned.Opaque iron oxides of probably primary origin are present in accessory amounts.

The age of the Murrenja Dolerite is uncertain. As it intrudes the Moyle River Formation it must have a maximum age of Middle Proterozoic, but there is no evidence in ANSON to suggest its minimum age. However, it is probably equivalent to the youngest basic intrusives of the Pine Creek Geosyncline, which are of Late Proterozoic age.

CAMBRIAN

UNDIVIDED SEDIMENTARY ROCKS (C)

Flat-lying Cambrian sedimentary rocks are widespread but poorly exposed in the east and SE of ANSON, and extend east into REYNOLDS RIVER and south into GREENWOOD. These sedimentary rocks are concealed beneath blacksoil plains and eluvial soil, with scattered outcrop restricted to small breaks in slope, heads of gullies, stream beds and narrow erosion gullies. Exposed lithologies are calcareous siltstone, fine-grained immature subarkose, micaceous fine-grained quartz arenite, mudstone and shale. Sedimentary structures noted are ripple marks and poorly developed planar laminations.
Percussion drilling by AOG in the SE of ANSON (Berkman, 1978) revealed that the sequence at depth is largely dolomitic siltstone and impure dolomite. None of the drillholes penetrated to basement, but indicated a sequence at least 100 m thick. A diamond drillhole in REYNOLDS RIVER (NTGS 82/42) proved 231 m of Cambrian sedimentary rocks (Pietsch, in prep., a), and therefore, in ANSON, the sequence may be appreciably thicker than 100 m.

The precise age of the unit is conjectural because of lack of fossil evidence. However, fossils, including trilobites, brachiopods, and sponge spicles, discovered to the east in REYNOLDS RIVER, suggest a Middle Cambrian age (Gatehouse, 1968).

The Cambrian sequence unconformably overlies the Early Proterozoic Wagait Granite and Welltree Metamorphics. The contact with the Wagait Granite is nowhere exposed and the position of the boundary is therefore inferred. Similarly, there are no exposures of contacts with the Welltree Metamorphics; the boundary has been determined largely on the basis of percussion drilling by AOG (Boyd and Nicol, 1981).

The lithologies, and textural immaturity, of the sedimentary rocks indicate they were deposited in a quiet, low-energy depositional environment.

PERMIAN
Kulshill Formation (P)
The Permian rocks, that underlie almost all of the western half of ANSON, form the eastern margin of the Bonaparte Basin. A diamond drillhole 7 km north of Channel Point (NTGS 82/47) proved a Permian sequence 158 m thick (Figure 6), and south of the Daly River mouth, coal bores (Cliff Head No. 1 and Anson Bay No. 1) drilled by the South Australian Government in 1909 to 1911 proved thicknesses of 219 m at Cliff Head and more than 398 m at Red Cliff.

Sporadic, low outcrops occur in the north, whereas in the south, Permian rocks are exposed in the cliffs that form the shoreline of Anson Bay (Plate 3). Where the Permian rocks are blanketed by eluvium north of the Daly River, the soils are notably lateritic and deep red in colour. South of the river, sandy surficial deposits predominate, although some laterisation is evident in the soil profiles exposed in the cliff sections.

Drillhole NTGS 82/47 penetrated a sequence (Figure 6) of alternating arenite and siltstone with two thin pebble conglomerate bands (one at 56 m and the other forming a basal bed overlying the igneous basement). The arenite commonly contains thin bands of siltstone which are usually less than 10 mm thick, and which, in the lower part of the sequence, may be carbonaceous. Similarly, the siltstone may contain thin layers and lenses of arenite.

The arenites are medium- to coarse-grained, porous, friable orange-brown feldspathic quartz arenites and subarkoses in which most of the feldspar is replaced by clay minerals. The siltstones are mottled orange-pink to reddish-brown, dominantly siliceous but occasionally carbonaceous, generally ferruginous, and sometimes gritty.

In the north of the sheet area, the exposed Permian rocks are friable, feldspar-rich arenites similar to those encountered in drillhole NTGS 82/47. In addition, they contain a prominent lithic component of quartz arenite, kaolinitic rock, quartzite, and micaceous schist. The coastal cliffs south of the Daly River mouth consist of Permian arenites, siltstones and mudstones, similar in composition and texture to those encountered in drillhole NTGS 82/47.

Palynologic studies (Harris, in Fahey and Edgoose, 1984) of five core samples from drillhole NTGS 82/47 revealed that only one palynomorph event is recorded in the assemblages present (Table 2), the only variation being a deterioration of preservation with depth. The assemblage from 80.02 m contains the Stage 3 index Pseudoreticulatispora (al. Verrucosisporites) pseudo- reticulatus (Plates 4, 5), giving a Sakmarian age. This assemblage can be equated with those assigned to Unit III from the Canning Basin by Kemp and others (1977).

The assemblages are dominated by terrestrially derived spores and pollen, but rare acritarchs indicate that a weak marine influence or brackish conditions existed near the depositional site.

On the basis of the coal bores drilled by the South Australian Government between Port Keats and Cliff Head, Drummond (1963) subdivided the Early Permian sequence, which Noakes (1949) had termed the Port Keats Group, into five unnamed formational units. Australian Aquitaine Petroleum Pty. Ltd. (AAP) divided the Early Permian succession found in
Figure 6  Summary log of drillhole NTGS 82/47.

their oil-exploration wells in KEATS, into two formations, the Sugarloaf Formation above and the Kulshill Formation below (AAP, 1966). The Kulshill Formation (1050 m), found in the Kulshill No. 2 well, consists of tillite and shale, becoming sandy at the top and grading into greywacke with shale interbeds. No coal horizons were intersected. The Sugarloaf Formation (365 m) consists of relatively pure arenites with thin coal beds, passing up into black shales and clays. Drilling by the Utah Development Company during 1972, in GREENWOOD and MOYLE, confirmed that higher proportions of lithic fragments are present in the arenites of the Kulshill Formation than in those of the Sugarloaf Formation (Williams, 1973).

As both drillhole NTGS 82/47 and coal bore Cliff Head No. 1 did not prove any coal or lignite seams before reaching granitic basement, it is likely the above sequences belong to the Kulshill Formation. In addition, the rocks which crop out in ANSON have a lithic component and thus are similar to the rocks of the Kulshill Formation in areas to the south. The coal bore Anson Bay No. 1, however, penetrated lignite seams but did not reach basement; this sequence may belong, in part, to the Sugarloaf Formation.

04/035-2

Total depth 172.8m

Early Permian

Early Proterozoic
Plate 4  Miospores from Early Permian sedimentary rocks intersected in drillhole NTGS 82/47 form core at 80.2m. Photomicrographs from unretouched negatives and prints. DIC, differential interference contrast.

*Microbaculispora tenta*ii Tiwari 1965
1  DIC, median focus
5, 6  proximal and distal foci respectively

*Reteporitites* nigritellas (Luber) Foster 1979
2  DIC, proximal focus

*Breviradites* levii (Balme & Hennelly) Bharadwaj & Srivastava 1969
3, 4  DIC, proximal and distal foci respectively

*Apiculatisporis cornutus* (Balme & Hennelly) Hoeg & Bose 1960
7  mid proximal focus

*Apiculatisporis* sp. A of Foster 1974
8, 9  proximal and distal (DIC) foci respectively
cf. *Granulatisporites confluentes* Archangelsky & Gammero 1979
10  distal focus

*Pseudoreticulatispora pseudoreticulatus*
(Balme & Hennelly) Bharadwaj & Srivastava 1969
11, 12  proximal and distal foci respectively
cf. *Calamospora ubischii* Foster 1979
13, 14  DIC, proximal and distal foci respectively

*Indotriradites* sp. cf. *I. wargalensis* (Balme) Bharadwaj & Tiwari 1977
15, 16  proximal and distal foci respectively

*Indotriradites* sp. A
17  median focus

*Punctatisporites gretenis* Balme & Hennelly 1956
18  median focus

*Densosporites rotundidentatus* Segroves 1970
19  tetrad

20, 21  distal and proximal foci respectively, end member

*Acanthoradites* tetragonulatus Balme & Hennelly 1956
22, 23  distal and proximal foci respectively
29  median focus

*Horridiradites* ramosus (Balme & Hennelly 1956) Bharadwaj & Saluja 1964
24  proximal focus

*Landhladispora* sp.
25, 26  distal and proximal foci only

*Didictritites* sp.
27  proximal focus
28  median focus

*Dictyorradites* sp.
30, 31  proximal and distal foci respectively

*Mehlisphaeridium* sp.
32  DIC, median focus

*Botryococcus* sp. cf. *B. braunii* Kutting 1849
33  median focus

*Quadratisporites horridus* Hennelly ex Potonie & Lele 1961
34  median focus

(Photomicrographs and plate description by W. K. Harris and C.B. Foster, Western Mining Corporation Ltd., Adelaide).
Plate 5 Gymnospermous pollen from Early Permian sedimentary rocks intersected in drillhole NTGS 82/47 from core at 80.2 m. Photomicrographs from unretouched negatives and prints. DIC, differential interference contrast.

*Striatobactites multistratatus* (Balme & Hennelly) Hart 1964
1 proximal focus, note tetrad scar
13 proximo-lateral view
*Protohaploxytonus acutus* Falcon 1978
2, 3 DIC, distal and proximal foci respectively
*Striatopodocarpites cancellatus* (Balme & Hennelly) Hart 1963
4 proximal focus
*Caherniasaccites* sp.
5 median focus
*Marxupipollenites iridatus* Balme & Hennelly 1956
6 median focus
*Cycadoptites folliculatus* Wilson & Webster 1946
7 DIC
*Ephedriotes* sp.
8 note numerous longitudinal striae. The specimen appears superficially as *Praecolpaites sinuosus* (q.v.).
*Praecolpaites sinuosus* (Balme & Hennelly) Bharadwaj & Srivastava 1969
9, 10
*Welwitschipollenites* sp.
11, 12 note longitudinal striae
*Protohaploxytonus* sp. cf. *P. penatus* (Andreyeva) Hart 1964
14 distal focus
15 proximal focus
16 distal focus
17 DIC, proximal focus
*Scheuringpollenites maximus* (Hart) Tiwari 1973
18 mid proximal focus
*?Protohaploxytonus perexiguus* (Bharadwaj & Saluja) Foster 1979
19 note weakly developed proximal striae
*Protohaploxytonus amplus* (Balme & Hennelly) Hart 1964
20 proximal focus
*Plicatipollenites malabarensis* (Potonic & Sah) Foster 1975
21 median focus
(Photomicrographs and plate description by W. K. Harris and C. B. Foster, Western Mining Corporation Ltd., Adelaide).
Table 2 Palynologic assemblages from Early Permian rocks intersected in drillhole NTGS 82/47.

<table>
<thead>
<tr>
<th>PALYNOMORPHS</th>
<th>DEPTH DOWN HOLE (m)</th>
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<tbody>
<tr>
<td></td>
<td>80.02</td>
</tr>
<tr>
<td><strong>SPORES AND POLLEN</strong></td>
<td></td>
</tr>
<tr>
<td>Alisporites sp.</td>
<td>x</td>
</tr>
<tr>
<td>Apiculatisporis cornutus</td>
<td>x</td>
</tr>
<tr>
<td>Breviriletes levis</td>
<td>x</td>
</tr>
<tr>
<td>Calamospora sp.</td>
<td>x</td>
</tr>
<tr>
<td>C. diversiformis (Balme &amp; Hennelly)</td>
<td>x</td>
</tr>
<tr>
<td>Cycadopites cymbatus (Balme &amp; Hennelly)</td>
<td>x</td>
</tr>
<tr>
<td>Cyclogranisporites sp. (reworked)</td>
<td>x</td>
</tr>
<tr>
<td>Densoisporites rotundidentatus (Segroes)</td>
<td>x</td>
</tr>
<tr>
<td>D. solidus (Segroes)</td>
<td>x</td>
</tr>
<tr>
<td>Grandispora sp. A of Segroes</td>
<td>x</td>
</tr>
<tr>
<td>Granulatisporites frustuliferis</td>
<td></td>
</tr>
<tr>
<td>Balme &amp; Hassell (reworked)</td>
<td>x</td>
</tr>
<tr>
<td>G. sp. cf. micronodosus (Balme &amp; Hennelly)</td>
<td>x</td>
</tr>
<tr>
<td>Krauselisporites sp.</td>
<td>x</td>
</tr>
<tr>
<td>Latisporites collinsi (Balme &amp; Hennelly)</td>
<td>x</td>
</tr>
<tr>
<td>Leiotriletes directus (Balme &amp; Hennelly)</td>
<td>x</td>
</tr>
<tr>
<td>aff. Limitisporites sp.</td>
<td>x</td>
</tr>
<tr>
<td>Lophotriiletes scotinus (Segroes)</td>
<td>x</td>
</tr>
<tr>
<td>Marsupipollenites aff. M. striatus</td>
<td>x</td>
</tr>
<tr>
<td>(Balme &amp; Hennelly)</td>
<td></td>
</tr>
<tr>
<td>M. striatus (Balme &amp; Hennelly)</td>
<td>x</td>
</tr>
<tr>
<td>Microbacilispora tentula (Tiwari)</td>
<td>x</td>
</tr>
<tr>
<td>Plicatipollenites sp.</td>
<td>x</td>
</tr>
<tr>
<td>P. gowdwanensis (Balme &amp; Hennelly)</td>
<td>x</td>
</tr>
<tr>
<td>Potoniesporites sp.</td>
<td>x</td>
</tr>
<tr>
<td>Praecolpatites sp. aff. P. sinusosus</td>
<td>x</td>
</tr>
<tr>
<td>(Balme &amp; Hennelly)</td>
<td></td>
</tr>
<tr>
<td>Protohaploxypinus amplus (Balme &amp; Hennelly)</td>
<td>x</td>
</tr>
<tr>
<td>P. linpidus (Balme &amp; Hennelly)</td>
<td>x</td>
</tr>
<tr>
<td>P. rugatus (Segroes)</td>
<td>x</td>
</tr>
<tr>
<td>Pseudoreticulatispora (al. Verrucostisporites) pseudoreticulatus (Balme &amp; Hennelly)</td>
<td>x</td>
</tr>
<tr>
<td>Punctatisporites gretensis</td>
<td>x</td>
</tr>
<tr>
<td>(Balme &amp; Hennelly)</td>
<td></td>
</tr>
<tr>
<td>Scheuringipollenites maximus (Hart)</td>
<td>x</td>
</tr>
<tr>
<td>Striatobaeites multiatriatus</td>
<td>x</td>
</tr>
<tr>
<td>(Balme &amp; Hennelly)</td>
<td></td>
</tr>
<tr>
<td>Stratopodacarphites aff. S. phaleratus</td>
<td>x</td>
</tr>
<tr>
<td>(Balme &amp; Hennelly)</td>
<td></td>
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<tr>
<td><strong>ALGAE</strong></td>
<td></td>
</tr>
<tr>
<td>Botryococcus sp.</td>
<td>x</td>
</tr>
<tr>
<td>aff. Cymatosphaera sp.</td>
<td>x</td>
</tr>
<tr>
<td>Quadrisporites horridus (Balme &amp; Hennelly)</td>
<td>x</td>
</tr>
<tr>
<td>Tetraporina sp.</td>
<td>x</td>
</tr>
</tbody>
</table>

CAINozoic

Cainozoic sediments cover much of ANSON and consist of eluvial soils (Czs), laterite (Czl) and various Quaternary nonmarine and marine deposits, including river and creek alluvium (Qa), colluvium (Qcl), floodplain alluvium (Qaf), cheniers and beach ridges (Qcr), coastal alluvium (Qca) and beach rock (Qcb). Eluvial soils (Czs) cover most of the 'lowlands' physiographic subdivision. Much of ANSON is at an advanced stage in the erosional cycle and substantial soil profiles have developed, except on Murrenja Hill which is mainly rocky outcrop with some skeletal soils. Descriptions of the major soil types are given by Christian and Stewart (1953).

The eluvial soils, developed over the Cambrian sedimentary rocks, are composed of light-grey silt to fine sand with some subangular to pisolithic limonitic granules and pebbles. The soils, formed over the Early Proterozoic metamorphics and granites, are typically silt to medium quartz sand, with varying proportions of coarser quartz and rock fragments, limonitic granules and pebbles.

Medium quartz sand with limonitic granule scree, ferruginous rubble, and minor patches of ferricrete, typically overlie Permian sedimentary rocks, particularly in the northern half of ANSON.

Laterite (Czl) comprises in situ and reworked nodular, concretionary, pisolithic and mottled varieties. Mapp-
able sheets of cemented laterite are confined to small areas on the eluvial soils over the Cambrian sequence and along the coast. Smaller laterite sheets, reworked ferruginous rubble, and subangular to pisolithic limonitic scree, are common on the eluvial rises.

QUATERNARY

Floodplain alluvium (Qaf) consists of black to brown humic soil and clay, and forms extensive blacksoil plains. These plains represent the infilled lower valleys of the Daly, Reynolds and Finniss rivers, which were drowned by the Late Pleistocene sea-level rise (Christian and Stewart, 1953) to a maximum level of about 15 m above the present sea-level. A subsequent fall in sea-level during the Holocene exposed the estuarine deposits. One or two metres of freshwater clays, which have been deposited by seasonal floodwaters over the estuarine sediments, characteristically shrink and crack into coarse polygons during the dry season. Drilling (BHP, 1976) in FOG BAY shows a typical sequence to be about 2 m of black clayey soil underlain by about 28 m of grey-green clays containing pyrite, shell fragments, and nodular manganese oxides, overlying weathered bedrock.

Alluvium (Qa) consists of sand, silt and clay deposited along defined drainage channels, and is of restricted occurrence in ANSON.

Colluvium (Qcl) consists of silt and muddy sand, which is deposited by sheetwash on the gentle slopes between the eluvial rises and low-lying blacksoil plains, and in broad drainage areas that have no defined channels.

Cheniers and beach ridges (Qcr) consist of silt, sand, shelly sand and coral fragments, and are found both on the coastal fringe and up to several kilometres inland. A chenier plain has developed on the southern side of the Daly River mouth; it extends about 3 km inland and represents a NW-prograding shoreline. The subparallel chenier ridges, which are perched on low silt-marsh areas, form cuspatate features that are deflected upstream at the Daly River estuary channel margin.

Similar chenier ridges have formed along the coastal fringe both north and south of the Daly River mouth. Some ridges are found up to 10 km inland, representing the successive positions of former shorelines. A prominent sand spit, that forms the western and southern margin of Peron Island North, has been included in this unit.

Coastal alluvium (Qca) consists of unconsolidated mud, clay and silt, and is found in the intertidal zone along the coast and the banks of the Daly River. The sediments accumulate on both the mangrove-covered mud flats, which are regularly inundated by normal tides, and on the salt flats, which are intermittently flooded by very high tides (Christian and Stewart, 1953). To the NW of the Daly River mouth the flats extend up to 5 km inland.

Beach rock (Qcb) consists of weakly- to strongly-consolidated sand, shell and coral fragments, and pisolithes. It was noted in minor outcrops along the mainland coast in ANSON; a small area was also mapped on Peron Island South.

METAMORPHISM

The mineral assemblages of the schists and gneisses of the Welltree Metamorphics are detailed in Table 3. The assemblages in the schists indicate that metamorphism ranged from green schist- to amphibolite-facies under conditions of low to medium pressure. The assemblages in the gneisses (Table 3) indicate amphibolite-facies metamorphism. There is evidence of retrogression in both the schists and gneisses: retrograde minerals are sericite, after feldspar, staurolite, sillimanite and muscovite; muscovite after sillimanite; chlorite after biotite, feldspar, garnet and staurolite. There is a gradual increase in metamorphic grade from low- to medium-grade schist in the east of ANSON to high-grade gneiss near Murrenja Hill (Berkman, 1978).

There are two interpretations of the metamorphic history of the Welltree Metamorphics. A petrologic report (in Berkman, 1978), suggests that the schists and gneisses underwent an initial regional low-grade (green schist-facies) metamorphism, followed by a patchy low- to medium-grade thermal metamorphism. Berkman (1980) again concludes that the metamorphism had undergone two periods of metamorphism, an older regional phase and a younger thermal phase. However, petrologic studies by NTGS, and AOG (Boyd and Nicol, 1981; Nicol and Berkman, 1980), suggest that the metamorphics have undergone prograde metamorphism ranging from green schist- to amphibolite-facies, followed by greenschist-facies retrograde metamorphism. The latter interpretation is similar to that proposed for the Hermit Creek Metamorphics (Dundas and others, in prep., a and b) which lie to the south and SE of ANSON. It is possible that the metamorphic events were synchronous in the two areas. Dundas and others (in prep., a and b) suggest that the medium- to high-grade metamorphism occurred during the 1920±30 Ma event in the Halls Creek Mobile Zone (Dow and Gemuts, 1969), and the low-grade retrogressive metamorphism coincided with the 1870-1800 Ma orogeny in the Pine Creek Geosyncline (Needham and others, 1980).

Finally, vein adularia is common in many thin sections and clearly represents a low-grade hydrother-
mal event which may have been associated with the later intrusion of the Wagait and Two Sisters granites.

The schistose quartz arenites of the Middle Proterozoic Moyle River Formation, which are usually found within or near fault zones, are the product of shearing of less competent clayey immature quartz arenites during faulting; they are not of regional metamorphic origin.

**STRUCTURE**

The Welltree Metamorphics have undergone two periods of metamorphism, but because of paucity of outcrop little is known about the style of deformation that may have accompanied these events. An airborne magnetic survey over the Welltree Metamorphics indicates that bedding trends about north (Berkman, 1980). Steeply dipping foliation was noted in some drill cores.

Tom Turners Fault, which is the principal structural feature in ANSON, is a dextral-oblique slip fault which can be traced from MOYLE in the south to DARWIN in the north (Figure 4). In ANSON, the fault is concealed beneath surficial deposits in the south, but further north its trace is preserved at Bobs Knob and Murrenja Hill. At the southern end of Murrenja Hill, Tom Turners Fault splits into an east and a west branch; the western branch has an easterly-dipping sequence of Moyle River Formation preserved on each side. Further north, the western branch bisects a synclinal structure in Moyle River Formation at the ridge north of Peaked Hill in FOG BAY. The eastern branch continues NNE through BYNOE into DARWIN. Subsidiary faults diverge at the southern as well as at the northern end of Murrenja Hill, where Unit Ec is bounded by faults.

Evidence for vertical displacement occurs where the eastern branch of Tom Turners Fault is exposed at Murrenja Hill. Here, Middle Proterozoic Moyle River Formation to the west of the fault has been downthrown against Early Proterozoic Welltree Metamorphics to the east. A similar, westerly downthrow on Tom Turners Fault occurs to the south in GREENWOOD and MOYLE (Dundas and others, in prep., b). In ANSON, a vertical offset of at least 2000 m is indicated by displacement of Moyle River Formation across the eastern branch of Tom Turners Fault.

The moderately to steeply south-plunging, north-facing, upright syncline, in the northern part of Murrenja Hill, is probably the result of drag during dextral movement along Tom Turners Fault. The fold is restricted to the western side of the fault and occurs within a sequence that, regionally, dips and faces consistently eastwards. This regional easterly dip indicates that Murrenja Hill probably represents the western limb of a synclinorium that was truncated to the west of, and subparallel to, its axis by the eastern branch of Tom Turners Fault. Similar truncated structures in Moyle River Formation are found along Tom Turners Fault in areas to the south and north.

At Bobs Knob, an offset across Tom Turners Fault of the NW-dipping Moyle River Formation, indicates easterly, rather than westerly, downthrow. This anomaly can be explained by a local "scissors" style of faulting, or alternatively, Bobs Knob may be an isolated downthrown block within a broad zone of faulting.

The Moyle River Formation may have been folded in response to the same stress-field that resulted in the dextral transcurrent movement along Tom Turners Fault. Folding probably commenced prior to the faulting and both then proceeded simultaneously.

The Wagait Granite is sheared locally over a broad zone west of Murrenja Hill. This shearing, in addition to the multiple fault traces and the branching of Tom Turners Fault near Murrenja Hill, suggests that movement along Tom Turners Fault affected a broad zone.

Tom Turners Fault may have been active about the same time as the Giants Reef Fault, which is similarly a dextral wrench fault of considerable length (Figure 4), and which Dundas and others (in prep., a) show had ceased to be active by the mid-Late Proterozoic. It is also possible that intrusion of the Murrenja Dolerite may have occurred during movement along the fault.

In the SE of ANSON an extensive NE-trending lineament, evident on Landsat imagery, coincides with a sinistral offset of the north-trending zone of magnetic anomalies associated with Ew11. This offset occurs near the margin of ANSON and REYNOLDS RIVER, and probably represents sinistral wrench faulting. In the NE of the sheet area, another sinistral offset of the magnetic zone associated with Ew12 occurs. Given the sense of movement and strike direction of these probable faults, it would appear that a previously unrecognised major period of faulting, distinct and separate from that which produced Tom Turners Fault, affected the Proterozoic rocks in ANSON.

The Palaeozoic rocks in ANSON are undeformed and virtually flat-lying, although the Permian rocks show localised, gentle westerly dips.

**GEOPHYSICS**

The geophysical data presented in this report have been obtained from an airborne magnetic and radiometric survey carried out by Austirex International Ltd. for the NTGS in 1981. Lines were flown north-south with a 500 m spacing and at a mean altitude of 100 m AGL. The radiometric survey was carried out using a 50 litre NaI crystal. The data are available as 1:250 000 and 1:100 000 total magnetic intensity (TMI) and total count radioelement contour maps, 1:100 000 flight path plans, 1:100 000 multiplots, and as profiles and digital records on magnetic tape. The geophysical interpretation is by T.L.R. Findhammer, NTGS.

**Magnetics**

Total magnetic intensity contours of ANSON are presented in Figure 7. Most of the sheet area is characterised by broad areas of very little magnetic relief, with only a few, isolated occurrences of higher magnetic intensity.

The major magnetic feature is a zone of anomalies located at the NE edge of the sheet area, and which extends northwards and eastwards into FOG BAY, BYNOE and REYNOLDS RIVER. The zone trends almost due north, and is characterised by narrow highs of up to 1260 nT above background, flanked by somewhat wider lows to 250 nT below background. The shapes of these anomalies clearly indicate the close proximity of their sources to the surface. Depth estimates of 10 m to 50 m are typical for this type of anomaly in the Pine Creek Geosyncline (Tucker and
others, 1980). In the anomalous zone, drilling has intersected schist with graphitic and magnetitic horizons, and minor interlayered metaquartzite, marble and orthoamphibolite (Ewt, of the Welltree Metamorphics). Where graphitic, the metasedimentary rocks may contain iron sulphides, typically pyrrhotite, and this, in conjunction with the magnetitic horizons, satisfactorily explains the magnetic anomalies. The northern part of this zone, which extends into FOG BAY, appears offset to the SW, indicating the possibility of a NE-trending sinistral fault in this area. About 10 km north of the southern end of this magnetic zone, there appears to be another sinistral fault which coincides with a lineament mapped from Landsat imagery. The zone of high magnetic relief ends quite abruptly to the south, indicating either a contact, or possibly the closure of a geologic structure.

A curvilinear magnetic anomaly is located across the mouth of the Daly River. The amplitude ranges from 100 to 250 nT, which is typical of similar anomalies reported throughout the Pine Creek Geosyncline (Tucker and others, 1980). Further to the west, at the edge of the survey area, part of what could be a similar magnetic feature is indicated.

Where such curvilinear anomalies occur in the Pine Creek Geosyncline, they are often found over Early Proterozoic rocks adjacent to granitic intrusions (Tucker and others, 1980). In ANSON, a similar cause is proposed; that is, the anomalies are considered due to rafts of metasedimentary rocks within the Wagait Granite.

A small anomaly, ranging from 100 to 230 nT, is located close to the NW corner of the sheet area. This anomaly appears to be the southern end of a zone of anomalies which, in FOG BAY, strikes 030°. This zone is offset to the west in ANSON, possibly by a small, roughly WNW-trending, dextral fault. As the subcropping Early Permian sedimentary rocks are non-magnetic, the source of the anomaly is attributed to the underlying Early Proterozoic metamorphic rocks, as in FOG BAY (Hickey, 1985).

Five kilometres to the SE of this anomaly is a subtle NE-trending feature of low amplitude. Similarly subtle features are located 15-20 km further to the SE and at the mid-western and southern ends of the sheet area. The source could be either small rafts of metasedimentary rocks in the granite or a minor basic intrusion. The dolerite sill, which intrudes the Moyle River Formation at Murrenja Hill, produces a north-trending magnetic anomaly of a similarly low amplitude.

Radiometrics
The total count radioelement contours are shown in Figure 8. ANSON has a low count over practically all of its area and thus the results of the radiometric survey offer little assistance for geologic interpretation.

The course of the Daly River and its tributaries, the area drained by the Reynolds River and the floodplains that are inundated regularly, are characterised by a zero to very low total count. Other areas of very low count coincide with exposures of sedimentary rocks, for example, Murrenja Hill. The eluvial lowlands, which occupy relatively high ground between the 15 m and 50 m contours, generally have a slightly higher count.
In the north-central part of ANSON is an area of well exposed Wagait Granite which has the highest relative uranium values. These higher values reflect an inhomogeneous distribution of radioactive minerals within the granite.

To the east of this area, and also in the southern part of ANSON, spurious occurrences of somewhat higher count are noted over some floodplain areas. These anomalies are interpreted to be due to the presence of material, transported from the east, which contains higher proportions of radioactive minerals.

**Gravity**

Very little gravity information is available for ANSON. Apart from one roughly east-west road traverse by the BMR in the northern part of the sheet area, readings exist only for 23 widely spaced stations (Tucker and others, 1980). Company-derived data is non-existent and detailed surveying has not been undertaken by the NTGS.

The dominant feature is the central ridge which trends north-south, and consists of two highs of 380 $\mu$m/sec$^2$ separated by a minor low of 350 $\mu$m/sec$^2$. The ridge lies over the Wagait Granite and extends southwards through GREENWOOD and well into MOYLE. Northward, the ridge probably continues into the westerly of two ridges which exist in FOG BAY (Hickey, 1985). The ridges are collectively designated as the Litchfield Gravity High.

The steep gradient observed on most of the eastern flank of the ridge is probably related to Tom Turners Fault, which separates denser material of the ridge from lighter material to the east. The gradient on the western flank of the ridge is steeper than that on the eastern.

There are two major explanations for the existence of the Litchfield Gravity High. The first requires that the basement of the Litchfield Province has the same density as that of the Pine Creek Geosyncline. In this case, the gravity high would most logically be caused by a thick sequence of metasediments and possible mafic rocks within a rift-like structure surrounded by less dense basement. Outcropping granitoids (Wagait Granite) would have intruded the metasediments from even lower basement or alternatively would be of anatectic origin.

The second explanation assumes that the basement of the Litchfield Province has a higher density (2.8 t/m$^3$) than that of the Pine Creek Geosyncline, perhaps similar to known metasediments within the province. In this case, the Litchfield Gravity High would represent a basement high, with the granitic bodies being sheet-like in nature and of limited depth extent. Where granites do not crop out, metasediments may represent basement.

**GEOLOGIC HISTORY**

The earliest geologic event recorded in ANSON is the deposition of arenaceous, argillaceous and calcareous sediments that were later metamorphosed to schist, gneiss, metaquartzite, amphibolite and marble of the Welltree Metamorphics. Some of the amphibolites are considered to be of igneous origin thus implying basic igneous activity prior to metamorphism and folding.
This initial period of metamorphism may have been synchronous with the 1920±30 Ma metamorphism of the Halls Creek Group in the Kimberley region and with that of the Hermit Creek Metamorphics south and SE of ANSON.

A second period of regional metamorphism, probably coincident with the 1870 - 1800 Ma orogeny in the Pine Creek Geosyncline, partly retrogressed the Welltree Metamorphics. The synorogenic Wagait Granite and Two Sisters Granite were then emplaced. Erosion exposed the Wagait Granite before deposition of the Middle Proterozoic Moyle River Formation, in a sedimentary basin whose rate of subsidence equaled the rate of sediment supply. This basin was probably continuous with that in which the Moyle River Formation was deposited in GREENWOOD, MOYLE, other sheet areas to the south, and FOG BAY to the north. After lithification of the sediments, a period of NE- to SW-directed compressional stress caused folding, north- to NNE-trending, dextral wrench faulting (Tom Turners Fault), and localised shearing.

Erosion preceded the development of a Cambrian shallow-marine basin in which were deposited dominantly carbonate sediments. As Cambrian sedimentary rocks are unknown west of Tom Turners Fault, this area may have formed the exposed western margin of the Cambrian basin.

There is no record in ANSON of deposition following the Cambrian and prior to the Early Permian, when terrestrial to shallow-marine sediments were deposited.

Although no remnants of Cretaceous sedimentary rocks are found in ANSON, it is highly probable that thin sheets of Cretaceous shallow-marine or estuarine sediments were deposited over much of the sheet area prior to being removed by Cainozoic erosion (Figure 3 in Skwarko, 1966).

The rise in sea-level during the Late Pleistocene drowned the lower valleys of the Daly, Reynolds and Finniss rivers. During the Holocene, a subsequent small drop in sea-level exposed the estuarine deposits (Christian and Stewart, 1953). The positions of former Holocene shorelines are marked by cheniers and beach ridges which lie up to 10 km inland from the present coast, and by a probable wave-eroded cliff in the Moyle River Formation at Bobs Knob.

**ECONOMIC GEOLOGY**

No minerals of potential economic significance are known in ANSON. Exploration for coal, heavy minerals in beach-sand, bauxite, phosphate, uranium and base-metals has failed to locate more than traces or minor occurrences of these minerals. Exploration for diamonds has been similarly unsuccessful. Numerous bores have been sunk for water.

**Coal**

In the early 1900s, the South Australian Government drilled the Permian sequence at Cliff Head and Red Cliff, as part of a regional exploration program for coal (Playford, 1911). The borehole at Cliff Head, Cliff
Head No. 1, reached granite basement at 219.5 m (Herbert, 1909) without penetrating any seams of coal or lignite. At Red Cliff, three thin seams (all less than 75 mm) of lignite were penetrated before the hole was completed at 398.3 m without reaching the base of the Permian (Cunnew, 1911).

**Heavy-mineral beach-sand**

In the late 1960s and early 1970s, the beach sands of Anson Bay were prospected for concentrations of heavy minerals (Murphy 1969a and b; Cutler, 1972; Nixon and Hirst, 1973). Samples were collected by hand-augering and surface-sampling, and the heavy fraction separated by sieving and heavy-liquid separation. Some high values were obtained from the surface samples (47%, 68%), but generally the grades were below 1%, and most heavy fractions were composed dominantly of iron oxides and magnetite.

**Bauxite and phosphate**

In the late 1960s, exploration by surface-sampling for bauxite deposits within laterite, and by assays of drill core for phosphate in the Cambrian sequence (Zimmerman, 1969), was unsuccessful with only trace amounts being located.

**Uranium, base-metals and diamonds**

Limited base-metal exploration was undertaken in conjunction with the bauxite and phosphate exploration program. Assays of soil and stream sediment samples, collected over the Murrenja Dolerite and from the eastern side of Murrenja Hill, registered only background base-metal values (Zimmerman, 1969).

Between 1975 and 1981, several companies explored the Early Proterozoic rocks and Palaeozoic cover rocks east and SE of Murrenja Hill for uranium and base-metal deposits (BHP, 1976; Berkman, 1978; Boyd and Nicol, 1981). Auger, percussion and diamond drilling programs were undertaken to investigate anomalies detected by airborne and ground radiometric and magnetic surveys, but only minor traces of uranium and base-metals were discovered (BHP, 1976; Boyd and Nicol, 1981).

In the east of ANSON, exploration for diamonds was undertaken by Ashton Mining Limited (1983) who used aeromagnetic data to assess the kimberlite potential of the area. This potential proved to be limited.

**Water**

Twenty-one bores have been drilled for water in ANSON, 19 of which were successful (Fahey and Edgoose, 1984). Water suitable for human consumption was located in eight; the remaining bores striking either salty water, or water suitable only for stock. The Daly River, for the length of its course in ANSON, is tidal. Some large billabongs lie in the eastern half of the mainland area, but elsewhere there are broad expanses of plains which lack standing water for a large part of the dry season. Most bores in these areas, which have been sunk to supply water to stock, have struck salty water.

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**REFERENCES**


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**APPENDIX**

**MURRENJA DOLERITE** (J. E. Fahey, C. J. Edgoose).

*Derivation of Name:* Murrenja Hill in the Anson (4971) 1:100 000 sheet AMG 503539 (Latitude 13°05'S, Longitude 130°23'E).

*Distribution:* Occurs at and along the western side of Murrenja Hill.

*Type Area:* Type area bound by AMG 486489 (Latitude 13°07'20''S, Longitude 130°22'12''E), AMG 488489 (Latitude 13°07'20''S, Longitude 130°22'19''E), AMG 486487 (Latitude 13°07'26''S, Longitude 130°22'12''E), AMG 488487 (Latitude 13°07'26''S, Longitude 130°22'19''E).

*Rock Type:* Dolerite, minor gabbro. Medium-grained.

*Mineralogy:* Plagioclase, pyroxene, chlorite, opaque oxides.

*Thickness:* Approximately 200 m.

*Age:* Minimum age of late-Middle to Late Proterozoic.

*Relationships:* Intrudes the ?Middle Proterozoic Moyle River Formation and the Early Proterozoic Wagait Granite.