Explanatory Notes on the Port Keats Geological Sheet

Compiled by C. M. Morgan

The Port Keats 1 : 250 000 Sheet area lies between latitude 14°00'S and 15°00'S and longitudes 129°00'E and 130°30'E in the northwest of the Northern Territory. The western part is covered by the Timor Sea and the Joseph Bonaparte Gulf.

The land south of the Fitzmaurice River is part of Coolibah Station. The rest, except for a small portion of Elizabeth Downs Station in the northeast corner of the Sheet area, is occupied by the Daly River Aboriginal Reserve. The only permanent settlement is Port Keats Mission, with a population of about 500. The only airstrip is at the mission.

An unformed track runs from Port Keats Mission to the northeast corner of the Sheet area and from there to the Daly River Settlement; the track is rough in places and rarely used. Formed tracks of moderately good quality run from the mission westwards to Injin Beach and south to the Kulshill petroleum exploration well. In the southeast a rough and seldom-used track runs from about 8 km south of the Fitzmaurice River southwards along the Koolendong Valley to Bradshaw Outstation (on the Auvergne Sheet area). A few minor station tracks traverse the northern part of the Sheet area.

The coastal plain west of the Macadam Range is covered by open forest, except for the areas of alluvium, which are mostly open and marshy with scattered pandanus palm and swamp paperbark. Mangroves are common along the coast. The ranges and plains in the east support open forest of stunted eucalypts. Spinifex and cane grass are common on the sandstone ranges. The laterite-capped plateaux in the central-eastern part of the area are densely wooded.

The climate is monsoonal. The average annual rainfall at Port Keats Mission is 2 100 mm, and this falls during the northwest monsoon between October and April. The highest figures are recorded in January and February. The annual mean temperatures are 32.6°C maximum and 20.3°C minimum. June and July are the coolest months and October to December the hottest.

Photographs and maps covering the area are Port Keats K.17 air photographs, approx. scale 1 : 50 000, taken in 1948 by R.A.A.F.; Port Keats R.C.9 air photographs, approx. scale 1 : 85 000, taken in 1967, 1969 by Commonwealth air photography; Port Keats uncontrolled photomosaics at approximate scales of 1 : 63 360 and 1 : 250 000, prepared from K.17 photographs by the Division of National Mapping, from whom all photographs may be obtained.

Photoscale topographic compilations at 1 : 50 000 were prepared by and are available from the Royal Australian Survey Corps; and a topographic map at a scale of 1 : 250 000 has been prepared and printed by Royal Australian Survey Corps.
**Previous investigations**

The coastline was explored and the Fitzmaurice River discovered by Stokes in 1839 (Stokes, 1846), who found fossils (now known to be Permian) in the vicinity of a prominent headland, which he named Fossil Head.

In 1855 Gregory landed in Treachery Bay near Pearce Point (Gregory, 1857) and traversed east across the Macadam Range, then south into the interior.

Brown (1895) investigated the tidal reaches of the Fitzmaurice River and discovered traces of gold and silver in a quartz reef near its mouth. During later visits to the Northern Territory Brown visited and reported on coal boring sites near Port Keats (Brown, 1906). Results of this early drilling and logs have been included in a report by Dickens et al. (1971).

In an early BMR survey of the Katherine-Darwin region Noakes (1949) named the Permian rocks of the area the Port Keats Group. Later BMR work in and adjacent to the area included that of Traves (1955), who mapped the Ord-Victoria Region, and Walpole et al. (1968), who revised and extended Noakes's work.

In 1965 and 1966 Australian Aquitaine Petroleum Pty Ltd drilled three exploratory oil wells (Aquitaine, 1966a, 1966b) in the Port Keats Sheet area, and in 1967, five holes were drilled for Thiess Brothers Pty Ltd in search of coal (Geotechnics, 1968) in Permian rocks.

The most recent BMR surveys are reported by Dickens et al. (in press) on the Palaeozoic and Mesozoic rocks of the area, and by Morgan et al. (1970), and Pontifex et al. (1968) (Auvigerne Sheet Area) on the Precambrian geology. The following notes are compiled mainly from information gained from these recent surveys.

In 1955 the BMR carried out an airborne magnetometer-scintillometer survey over the eastern part of the Sheet area. The results of this work are shown on BMR maps G 241-1 and G 241-2. In 1958 the western part of the Sheet area was covered by a BMR airborne magnetometer survey and the results are available on BMR map G 250-3. In 1966 Compagnie Générale de Géophysique carried out detailed gravity and seismic surveys over the Mesozoic and Palaeozoic rocks of the western part of the Sheet area (Aquitaine, 1966a, 1966b) and in 1967 BMR included the Sheet area in a regional helicopter reconnaissance gravity survey of Northern Australia (Fig. 4; Whitworth, 1970). In 1968 detailed airborne scintillometer and geological surveys were made in the area by Planet Gold N.L.

**PHYSIOGRAPHY**

The physiography of the area is greatly influenced by lithology and structure. The Sheet area has been divided into three basic physiographic units; the Cambridge Gulf Lowlands, the Litchfield and Cullen Plains, and the extension of the Victoria River Plateau (after Paterson, 1970). The latter has been further subdivided into four informal units (Fig. 1). Some of these units occur on the Auvigerne Sheet area, and are described by Sweet et al. (in prep.).
The Cambridge Gulf Lowlands form a coastal strip up to 55 km wide and are underlain almost entirely by Palaeozoic and Mesozoic rocks of the Bonaparte Gulf Basin. Apart from a few low hills the lowlands mainly consist of flat and low-lying soil and marshy alluvium plains. Much of the coast and river estuaries is bordered by salt flats and at several places low coastal sand dunes support considerable vegetation.

The Litchfield and Cullen Plains in the northeast are underlain by the Litchfield Complex and the Hermit Creek Metamorphics. They consist of soil plains with a dendritic drainage pattern. The granite crops out as isolated piles of large boulders up to 30 m high, and the metamorphics as dissected hills of similar height.

Victoria River Plateau. The Tablelands occupy the southeastern part of the area, and are formed of the gently folded Auvergne Group. They consist of plateaux cut by gorges, cuestas, terraced hills, and areas of undulating hillocks. Relief is locally up to 200 m.

The Inland Plains comprise the Mecway Plane and Koolendong Valley in the southeast, formed in the soft Angalarri Siltstone. They consist of flat soil plains surrounded by steep scarpas.
The ‘Laterite plateaux and mesas’ are flat heavily wooded surfaces underlain by a thin layer of lateritized Cretaceous sediments. The plateaux and mesas are commonly edged by cliffs and steep high slopes, but boundaries with the rugged ridges and plateaux tend to be less abrupt. Elevations of the plateaux range from 275 m in the east to 110 m near Port Keats Mission.

The Rugged ridges and plateaux form a northeast-trending belt up to 40 km wide underlain by deformed and, in some places, metamorphosed sediments and intrusive rocks of the Fitzmaurice Mobile Zone and Pine Creek Geosyncline. The ranges consist of rugged ridges, cuestas, and plateaux predominantly of sandstone, and a few narrow alluvium-filled valleys where softer rocks such as siltstone have weathered out. The ruggedness is enhanced by extensive faulting and the sparseness of vegetation on many hills. Local relief is up to 240 m.

Drainage. The Moyle and the Fitzmaurice are the two principal rivers. The Fitzmaurice flows through gorges up to 60 m deep in the tablelands, meanders across the Meeway Plain, and then cuts across the strike of the rocks in the Rugged ridges and plateaux. It opens out into a wide estuary, and its tidal reaches extend inland to the eastern side of the Meeway Plain. The Moyle River and its tributary Tom Turners Creek have their sources at springs on the Wingate Plateau in the east and descend onto the coastal plain over a series of waterfalls. Other small rivers are also fed by springs on or at the base of the Wingate Plateau and radiate from this feature. The Fitzmaurice and most of the rivers fed by springs flow for most or all of the year; other creeks are dry during the winter months.

STRATIGRAPHY

Details of the rock units in the Sheet area are summarized in Table 1 and briefly discussed below.

Archaean

The Hermit Creek Metamorphics are deeply weathered and poorly exposed, so little is known of their structure or composition. In this Sheet area they consist of sandstones and siltstones, metamorphosed to upper greenschist facies. The Archaean age has been assigned to them on the basis of structural and metamorphic discontinuity with the known Lower Proterozoic rocks (Randall, 1962; Walpole et al., 1968).

Lower Proterozoic

The Finnis River Group consists of sediments and acid volcanics which, in this Sheet area, were the first rocks to be deposited in the Pine Creek Geosyncline. The metamorphic grade is upper greenschist facies, though some retrogressive metamorphism has occurred. Contacts with Carpentarian granite were not observed in this Sheet area, but in adjacent areas the Noltenius Formation has reached hornblendite hornfels facies in contact aureoles. Some outcrops referred to as Meeway Volcanics in the Meeway Plain and Koolendong Valley are intensely sheared and are only tentatively mapped as acid volcanics.

The Chilling Sandstone conformably overlies the Finnis River Group and may have an intertonguing relationship with it (Walpole et al., 1968). It reflects a shallowing of the water in the geosyncline and was deposited in an unstable shelf environment. It probably represents the closing stages of sedimentation in the geosyncline. The sandstone has been slightly metamorphosed to a quartzite.
Archaean

The Henschke Breccia is of uncertain age; but it is older than the Moyle River Formation which overlies it with marked angular unconformity. It is limited to one small outcrop, and the proximity of this to the major Tom Turners Fault suggests that it was formed as a wedge of clastics adjacent to an axis of uplift.

Carpentarian or Lower Proterozoic

Basic sills and Ti-Tree Granophyre. The granophyre is probably a differentiate from the magma which supplied the basic sills. No contacts with the Carpentarian granites have been observed, but the granite appears to become finer grained towards contacts with the basic sills, and may therefore be younger; however, a quartz diorite from the bottom of AAP Moyle 1 petroleum exploration well gave K-Ar dates of 1 393 to 1 537 m.y. (Page, 1968). Traces of chalcopyrite are present in the basic rocks.

Carpentarian

The Litchfield Complex has been dated (by the Rb/Sr whole rock isochron method) at 1 760 m.y., but may in part be as old as Archaean (Walpole et al., 1968). The Koolendong Granite is assumed to be Carpentarian. No mineralization associated with the granite has been found in the Sheet area.

Adelaidean or Carpentarian

The Fitzmaurice Group is a thick sequence of sandstone, siltstone, grit, and minor conglomerate (Morgan et al., 1970). The formations all contain some or all of the four rock types and are consequently difficult to differentiate in the field. The group crops out in a major north-northeast-trending synclinorium. On the southeast limb of this structure the three lower formations total about 3 000 m. On the northwest limb, however, they are at least 12 000 m thick. This may have resulted from deposition in a more rapidly subsiding trough in this region, or the thickness may only be apparent owing to repeated measurement of the same units which were laid down as a series of large-scale foreset beds. In the northwest limb the Moyle River Formation contains several interbeds of siltstone up to 460 m thick.

Most contacts between the constituent formations are conformable and gradational.

The paucity of ripple marks, cross-beds, and mud cracks suggests that the sediments were probably deposited in moderately deep water, although the Lalangang Formation does contain some cross-beds. The immaturity of the sediments results from a low energy sedimentary environment with little reworking, and the dark grey shales from periodic stagnant reducing conditions. The high feldspar content in much of the sandstone suggests a relatively close source of sediment supply. It is likely that the group was deposited in a relatively deep water trough in front of a mountain chain. Since it is restricted to an area of intense faulting the trough probably formed between a number of faults which were active at the time of deposition and which uplifted the mountain chain at the same time.
<table>
<thead>
<tr>
<th>Name and Map Symbol</th>
<th>Thickness (m)</th>
<th>Rock Types</th>
<th>Topography</th>
<th>Stratigraphic Relationships</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Carpentarian</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Koolendong Granite Pkg</td>
<td></td>
<td>Even-grained, minor porphyritic, coarse biotite and biotite-hornblende granite, adammellite, granodiorite. In S, adammellite intrudes granodiorite; pegmatite veins abundant</td>
<td>Pavements and boulder piles in soil plains; rugged slopes below sandstone capcings</td>
<td>Unconformably overlain by Pfm. Intrudes Pln and Pfl</td>
</tr>
<tr>
<td>Litchfield Complex Pgl</td>
<td></td>
<td>Coarse even-grained biotite granite, adammellite, granodiorite, tonalite (more acid to W). Mafic xenoliths abundant. Locally porphyritic</td>
<td>Boulder piles up to 30 m high on flat soil plains</td>
<td>Unconformably overlain by Pfm and Mullaman Beds. Intrudes Hermit Creek Metamorphics and (probably) basic sills</td>
</tr>
<tr>
<td><strong>Carpentarian or Lower Proterozoic</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ti-Tree Granophyre Pgl</td>
<td>Sills up to 300 m total 600 m</td>
<td>Pink or grey mesocratic medium granophyre</td>
<td>Valleys. Outcrop restricted to a few small piles of boulders</td>
<td>Sills in Pln. Most relationships concordant</td>
</tr>
<tr>
<td>Basic Sills Pdo</td>
<td></td>
<td>Medium and coarse diorite and gabro. Hypersthene common in W</td>
<td>Low: boulder-strewn hills</td>
<td>Unconformably overlain by Pfm; probably intruded by Litchfield Complex; intrudes Pln and Pfl; most contacts concordant</td>
</tr>
<tr>
<td><strong>Lower Proterozoic</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Henschke Breccia Plg</td>
<td>900</td>
<td>Coarse ferruginous sedimentary breccia and conglomerate with sandstone fragments. Some sandstone interbeds</td>
<td>Massive rugged hills</td>
<td>Unconformably overlain by Pfm. Faulted against granite and Pln</td>
</tr>
<tr>
<td>Chilling Sandstone Pfl</td>
<td>49007</td>
<td>White, blocky or massive medium quartz sandstone. Feldspathic in outcrops NW of Mee-way Plain. Minor tuff</td>
<td>High rugged ridges and plateaux</td>
<td>Conformable on and intertongues with Pln. Intruded by Koolendong Granite and basic sills; interbedded with Pla.</td>
</tr>
<tr>
<td><strong>Archaean</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Berinka Volcanics Pli</td>
<td>850</td>
<td>Grey porphyritic rhyolite and dacite. Minor sandstone and acid intrusives</td>
<td>Valleys with gently undulating floor. Poor outcrop</td>
<td>Interbedded with and intruded into Noltenius Formation</td>
</tr>
<tr>
<td>Noltenius Formation Pin</td>
<td>43007</td>
<td>Low grade metamorphosed greywackes, sandstone, grit, conglomerate. Contact metamorphosed near granites</td>
<td>Rugged ridges and angular hills, some low-lying rocky areas</td>
<td>Unconformable between Ah and Pfm. Intruded by Koolendong Granite, basic sills, Ti-Tree Granophyre. Conformally overlain by Pfl</td>
</tr>
<tr>
<td>Hermit Creek Metamorphics Ah</td>
<td></td>
<td>Ferruginous quartz-muscovite schist, phyllite</td>
<td>Plains, few low hills. Poor outcrop</td>
<td>Intruded by Pgl, unconformably overlain by Pfn</td>
</tr>
</tbody>
</table>
## Table 2: Carpentarian or Adelaidean Stratigraphy

<table>
<thead>
<tr>
<th>Era</th>
<th>Name and Map Symbol</th>
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</tr>
</thead>
<tbody>
<tr>
<td>PROTEROZONIC</td>
<td>Shoal Beach Formation Pah</td>
<td>60</td>
<td>Brown and greyish green siltstone, minor dolomite and sandstone</td>
<td>Steep slopes bordering plateau and mesas capped by Mullaman Beds</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Spencer Sandstone Pae</td>
<td>60</td>
<td>Fine sandstone, silty sandstone, minor dolomitic sandstone; thin bedded with ripple marks and halite casts</td>
<td>Moderately smooth, slopes bordering plateaux, some low hills terraced</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lloyd Creek Formation Pal</td>
<td>75</td>
<td>Stromatolitic and oolithic dolomite, greyish green siltstone, sandy and silty dolomite</td>
<td>Low hills, smooth or slightly terraced</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pinkerton Sandstone Pap</td>
<td>50</td>
<td>Fine and medium well sorted white quartz sandstone, cross-bedded and ripple-marked; siltstone, minor shale</td>
<td>Caps high scarps, forms plateau, cuestas, and hogbacks</td>
<td>Conformable sequence; faulted against Pfa and unconformably overlain by Mullaman Beds</td>
</tr>
<tr>
<td></td>
<td>Saddle Creek Formation Paa</td>
<td>45-60</td>
<td>Basal sandstone, fine and medium, reddish grey and white, clean washed, large scale cross-beds; overlain by ferruginous siltstone, minor shale</td>
<td>Sandstone forms cliffs in scarps. Siltstone forms slope between sandstone and Pinkerton Sandstone</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Angalarri Siltstone Paa</td>
<td>300?</td>
<td>Greyish green fissile chloritic siltstone, minor shale, dolomitic sandstone, limestone</td>
<td>Undulating plains; steep smooth slopes where sandstone capping remains</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Jasper Gorge Sandstone Paje</td>
<td>110?</td>
<td>Medium grained white and brown well sorted quartz sandstone</td>
<td>Small pavement</td>
<td></td>
</tr>
<tr>
<td>FITZMAURICE GROUP</td>
<td>Legume Formation Pfe</td>
<td>2,100</td>
<td>White, grey, and green poorly sorted fine, medium and coarse sandstone; interbedded grey, white, green, brown fissile laminated siltstone; siltstone and shale increase to north</td>
<td>Gently undulating plains, finely dissected slopes, rounded hills and ranges of hills</td>
<td>Overlies Pfl apparently conformably. Unconformably overlain by Mullaman Beds</td>
</tr>
<tr>
<td></td>
<td>Lalgang Sandstone Pfl</td>
<td>1,850</td>
<td>Fine, medium, and coarse grey feldspathic sandstone, minor grit and pebble beds. One 120m bed of greyish green siltstone S of Fitzmaurice River Valley</td>
<td>Rugged steep ridges up to 150m high. Lower and less rugged hills west of Madjellindi Valley</td>
<td>Apparently conformable between Pfe (above) and Pfl and Pfm</td>
</tr>
<tr>
<td></td>
<td>Goobaheri Formation Pfg</td>
<td>610</td>
<td>Interbedded dark grey shale, grey, and green siltstone, and fine sandstone. Interbeds of medium and coarse white sandstone in upper part</td>
<td>Valleys with gently undulating floors. Coarser sandstone interbeds form ridges, and cliffs in sides of scarps</td>
<td>Conformable between Pfl and Pfg</td>
</tr>
<tr>
<td></td>
<td>Moyle River Formation Pfm</td>
<td>1,100 in SE Posibility up to 11,000 in NW</td>
<td>White fine or medium sandstone with a few thin interbeds of siltstone and coarse sandstone. Several thick up to 500m interbeds of siltstone NW of Madjellindi Valley, Basal conglomerate near Herrickvale Falls</td>
<td>Rugged ridges. Ridges in Macadam Range truncated by Mesozoic peneplain surface</td>
<td>Overlain conformably by Pfg and Pfl. Unconformable on intrusive rocks, Pfm, Finniss River Group, Pfg and Ah</td>
</tr>
</tbody>
</table>

**Unconformity**
The group has been correlated with the Carr Boyd Group, which crops out in the East Kimberley District and has been dated at between 1365 and 900 m.y. by K/Ar dates on ilites (Dow & Gemuts, 1969). Its relationship with the Auvergne Group is not known since all contacts are faulted.

Sandstone, siltstone, and dolomite of the Auvergne Group were laid down on a stable basement block and are only mildly deformed. The Jasper Gorge Sandstone was laid down during a marine transgression over an erosion surface of Bullita Group rocks in areas to the south and east. Cross-bedding indicates that the water was shallow, with considerable current activity. Ripple marks in the Angalarri Siltstone show that this also was deposited in shallow water. The Saddle Creek Formation is a transition between the Angalarri Siltstone and the Pinkerton Formation, which is a mature sandstone deposited in shallow water with considerable current activity. The oolitic dolomites, intraformational conglomerate, stromatolitic growths, and halite casts in the Lloyd Creek Formation, Spencer Sandstone, and Shooi Reach Formation indicate an active shallow marine environment with intermittent subaerial and lagoonal conditions.

Palaeozoic and Mesozoic

The oldest known Phanerozoic rocks in the Sheet area are Devonian and Carboniferous intersected in Kulshill 1 (Aquitaine, 1966b) and Carboniferous sediments in Kulshill 2 exploration well. They probably only underlie the area to the west of the Moyle River Fault. The Devonian and Carboniferous sediments have been divided into two units which probably correspond with the marine Bonaparte Beds and overlying Tannurra Formation in Bonaparte I well (Le Blanc, 1964). The sequences are shown in Figure 2. The unnamed unit overlying the Tannurra Formation contains a mixture of Lower Carboniferous and Lower Permian fossils; its age is therefore uncertain, but it may be a reworked Lower Carboniferous deposit of Lower Permian age.

The Permian and Triassic rocks are poorly exposed, but the oil exploration wells give complete sections of the Lower Permian (Fig. 2). Upper Permian siltstone, sandstone, and conglomerate crop out on the coast between Pearce Point and Injin Beach, southwest of White Cliff Point, and at Port Keats airstrip. Lower Permian limestone, siltstone, and sandstone crop out in the Kuriyippi Hills and at Fossil Head. The sandstone, siltstone, and conglomerate forming Table Hill may be Lower Permian glaciars. The Palaeozoic sequence offshore is much thicker than onshore; information from the Hyland seismic survey (Aquitaine, 1968) indicates at least 5,000 m of Permian and Carboniferous rocks, and offshore drilling at Petrel 1 (50 km north-northwest of Port Keats Mission) penetrated 3,900 m of post-Lower Permian sediments.

The Palaeozoic and Mesozoic units are not all formally defined; parentheses, in Figure 2, show the origin of informal names (V & R—Veevers & Roberts, 1968; AAP—Aquitaine, 1966b).
<table>
<thead>
<tr>
<th>Era</th>
<th>Period</th>
<th>Name and Map Symbol</th>
<th>Thickness (m)</th>
<th>Rock types</th>
<th>Stratigraphic relationships</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAINozoic</td>
<td>Quaternary</td>
<td>Qa</td>
<td></td>
<td>River silt, sand, gravel</td>
<td>Superficial: river banks and flood-plains</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Mud, silt, evaporites</td>
<td>Superficial: salt flats, mangrove thcotts</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Sand partly stabilized by vegetation</td>
<td>Superficial: low dunes</td>
</tr>
<tr>
<td></td>
<td>Cretaceous</td>
<td>Czs, Czl</td>
<td>Up to 6</td>
<td>Sand, soil, colluvium. Black soil</td>
<td>Invariably formed on Mullaman Beds</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Laterite: pisolithic ironstone mostly with</td>
<td>motiled and pallid zones</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>high silica content. Underlain by</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Superficial: scrub-covered plains</td>
</tr>
<tr>
<td></td>
<td>Cretaceous</td>
<td>Mullaman Beds Kim</td>
<td>Up to 30</td>
<td>Friable sandstone, siltstone and conglomerate, Mostly lateritised</td>
<td>Unconformable on all older units as mesa cappings</td>
</tr>
<tr>
<td></td>
<td>Triassic</td>
<td>TR</td>
<td>1850?</td>
<td>Siltstone, silty sandstone; minor limestone, Basal conglomerate, diamictite</td>
<td>Overlies Permian possibly with unconformity. Unconformably overlain by Mullaman Beds</td>
</tr>
<tr>
<td></td>
<td>Permian</td>
<td>P</td>
<td>1830+</td>
<td>Shale, sandstone, siltstone, minor limestone</td>
<td>May be unconformable on Carboniferous</td>
</tr>
<tr>
<td></td>
<td>Lower Carboniferous</td>
<td>C</td>
<td>1830+</td>
<td>Subsurface only.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Devonian</td>
<td>D</td>
<td>610+</td>
<td>Shale, sandstone, limestone</td>
<td></td>
</tr>
</tbody>
</table>
Lower Cretaceous

Lower Cretaceous belemnites are present at Mount Greenwood (Cape Scott Sheet area), but have not been recorded from the Port Keats Sheet Area (Dickins et al., in press). The sediments are probably mostly marine, but freshwater sediments have been found at the base of the Mullaman Beds in the Fergusson River Sheet area to the east and may be present in this Sheet area. The beds were deposited on a relatively flat surface which probably sloped gently towards the west.
Cainozoic

The Mullaman Beds are almost invariably capped by laterite which has formed from them, probably during the Tertiary. The pallid zone extends most of the way down through the beds and is probably up to 30 m thick. The ferruginous zone is only about 3 m thick and contains high percentages of silica.

Shallow residual soils and alluvium are common as valley fills between outcrops of Precambrian rocks; the hills generally have a very thin patchy soil cover. On the coastal plains thicker deposits of soil and alluvium overlie the Phanerozoic rocks.

STRUCTURE

Three tectonic units are distinguished in the Sheet area: the Fitzmaurice Mobile Zone, the Sturt Stable Block, and the Bonaparte Gulf Basin (Fig. 3). Stratigraphic units are mostly confined to one tectonic unit. The Cretaceous Mullaman beds conceal the structure in the Sheet area.

Figure 3. Structural and tectonic sketch map.
The Fitzmaurice Mobile Zone consists of thick moderately folded and intensely faulted sediments, the Fitzmaurice Group, within which are windows of Lower Proterozoic and Archaean rocks. The zone is bordered on the west by the Moyle River Fault and on the east by the Victoria River Fault which downthrow to the west and east respectively.

Archaean basement crops out in the northeastern part of the zone. The major structural trends in the zone are north-south to northeast-southwest. Metamorphism in the area reached the almandine-amphibolite facies.

The Pine Creek Geosyncline and its associated intrusive igneous rocks are the southwestern part of a geosynclinal unit which crops out extensively in the Katherine-Darwin area. It is thought by Walpole et al. (1968) to be a para-geosynclinal or intracratonic basin, rather than a major geosyncline. The unit is strongly folded, with axes aligned parallel to the major regional boundary faults. The rocks on the western edge of the Meeway Plain and Koolendong Valley are intensely sheared, possibly owing to the proximity of the Victoria River Fault. Metamorphic grade in the sediments reaches greenschist facies, but contact metamorphic effects associated with the intrusives have raised this locally.

The Fitzmaurice Group forms a large synclinorium whose axis trends north-northeast and whose gently dipping western limb is considerably thicker than the steeply dipping eastern limb. Two major fault sets affect the Fitzmaurice Group. The later minor east-trending set displaces the earlier major north to northeast-trending set.

The regional gravity survey (Whitworth, 1969) of the Sheet area shows that the Fitzmaurice Mobile Zone corresponds to a positive anomaly (Fig. 4) termed the Wangites Gravity Ridge. This 'ridge' is thought to be caused by the densification of crustal rocks by metamorphism and to die out to the south.

On the northeastern margin of the Sheet area there are small positive aeromagnetic anomalies over the outcrop of basic rocks (Grid Ref. 660439) and over Archaean rocks about 9 km farther to the west further anomalies occur over an elongate north-northeast-trending granite intrusion northwest of the Meeway Plain (Grid Ref. 632397).

Sturt Stable Block is a sequence of Adelaidean or Carpentarian sediments, the Auvergne Group, which were deposited on a stable cratonic area and subsequently have been gently deformed. The dominant structure of the unit on this Sheet area is a shallow syncline whose axis trends approximately north-northeast. There are also several minor folds which may reflect basement discontinuities. Dips rarely exceed 10°. The block was probably stable during the Lower Proterozoic, forming a 'foreland' of the Pine Creek Geosyncline.

The regional gravity survey (Whitworth, 1969) shows that the 'Victoria River Gravity Shelf', which corresponds to the Sturt Stable Block, is a vaguely defined area with small gravity variations but no dominant trend.

Bonaparte Gulf Basin is a deep structural and sedimentary basin containing thick Palaeozoic and Mesozoic sediments. These are known to be at least 4 400 m thick (Kulshill 1 well). Detailed gravity work (Aquitaine, 1966a) has located the centre of the basin near Port Keats Mission. Regional gravity work has shown an
intense ridge to the west of the basin (Fig. 4). However, the Palaeozoic sequence is still extremely thick in this area (Aquitaine, 1968). Aeromagnetic, seismic, and gravity data show a major discontinuity at the position of the Moyle River Fault indicating a downthrow to the west of at least 3,000 m; but Palaeozoic sediments overlap the Fitzmaurice Mobile Zone for up to 48 km to the east. Probably the Moyle River Fault has been the site of repeated movements.

![Map showing Bouger anomalies and gravity features](https://via.placeholder.com/150)

**Figure 4.** Bouger anomalies and gravity features.

The Hyland marine seismic survey (Aquitaine, 1968) showed a number of very broad anticlines and synclines in the offshore sequence, and delineated several intrusive bodies such as the one shown west of the Victoria River Fault, in the geological cross-section. The nature of these bodies is not known, but the presence of a pronounced gravity high in the area suggests that they could be igneous intrusions rather than diapiric structures.

### GEOLOGICAL HISTORY

During Archaean time a series of sediments was laid down and then intruded by basic rocks and folded and metamorphosed (Hermit Creek Metamorphics). After a period of uplift and weathering the land was submerged in Lower Proterozoic times and a trough formed. Turbidites, silt, and acid volcanics (Finnis River Group) were deposited in this trough and overlain by a thick sequence of sandstone (Chilling Sandstone). The sediments were then intruded by basic and acid magmas, and folded and metamorphosed. The Litchfield Complex to the north of the area is surrounded by migmatites and was probably an early deep-level granite, whereas the Koolendong Granite is strongly discordant with the country rock and was probably a high-level granite. The area was once again uplifted and eroded. Later, probably during the late Carpentarian or early Adelaidean, a series of fault troughs formed in the Fitzmaurice Mobile Belt and were filled with a thick sequence of sediments while they subsided. The sediment
was supplied from a close source, probably to the northwest, as the sediments thicken in this direction (Fitzmaurice Group). A large shallow sea developed over the Stable Block and dolomite, siltstone, and sandstone were deposited (Auvergne Group). At the end of the Proterozoic the eastern part of the area was uplifted, but the area west of the Moyle River Fault subsided and a thick sequence of Palaeozoic and Mesozoic sediments was deposited in the Bonaparte Gulf Basin; on the land area Lower Permian glacial deposits were formed (Dickins et al., in press). Faulting was active in the Mobile Zone till about Middle Permian time. The Palaeozoic rocks were gently folded and faulted, and intrusive bodies injected into the sequence. In the Lower Cretaceous the land in the east was submerged and marine sediments were deposited over what was by then a peneplaned surface. The whole area was once again uplifted and the sea retreated at least as far as its present position. In Tertiary time laterite developed on the Cretaceous sediments. Since then there has been slight warping of the area; rivers which developed on the Cretaceous surface have been superimposed on the underlying structure.

ECONOMIC GEOLOGY

No deposits of minerals or hydrocarbons of commercial value have yet been found in the Port Keats Sheet area. Occurrences of hydrocarbons, coal, gold, silver, copper, and radioactive minerals have, however, been investigated.

Petroleum

Three exploratory oil wells (Kulshill 1, Kulshill 2, and Moyle 1) were drilled by Australian Aquitaine Petroleum in 1965-1966. They were sited in the Palaeozoic rocks of the Bonaparte Gulf Basin to the south and east of Port Keats Mission. No commercial reserves were proved, although traces of oil, gas, bitumen, and fluorescence were encountered in both the Kulshill wells. The hydrocarbons occur in the Lower Permian 'Kulshill Formation' (Aquitaine, 1966b), and in the upper part of the Lower Carboniferous (Tannurna Formation and Milligans Beds units 1 and 3). All shows were in rocks of low permeability.

Coal

Coal seams have been intersected in bore holes in Permian rocks between the mouths of the Fitzmaurice and Daly Rivers on the Port Keats and Cape Scott 1 : 250 000 Sheet areas. They were originally found in bores drilled by the government between 1905 and 1909. In 1965-66 coal seams were intersected by the Kulshill 2 well at 1 300 feet. In 1967 five shallow bores, Kuriyippi 1-5, were drilled for Thiess Bros Ltd in an attempt to find commercial quantities of coal (Geotechnics, 1968). Carbonaceous material was intersected in four of the holes, but no thick coal seams of wide lateral extent were found within 1 000 m of the surface. Furthermore the coal was of poor quality.

The coal occurs in two horizons in the Lower Permian 'Sugarloaf Formation' (Aquitaine, 1966b) — the 'Sugarloaf shale' (upper coal measures) and 'Sugarloaf sandstone' (lower coal measures) (Geotechnics, 1968). In the upper coal measures the coal is interbedded with black clay, shale, or fine to coarse-grained grey sandstone. In the lower measures the coal is mostly in medium to coarse-grained friable
porous sandstone. The coal occurs as small fragments, interspersed grains, thin lenses, and seams. The only seam of any lateral extent was 60 cm thick. All other seams were less than 20 cm thick.

Radioactive Anomalies

A reconnaissance with an airborne scintillometer was made over the eastern half of the Sheet area by BMR in 1955. A number of radioactive anomalies were discovered (BMR Map G241-1 and G241-2). A more detailed airborne scintillometer survey was made in the area by Plant Gold N.L. in 1968.

Of the anomalies found by the BMR 85 percent are situated on laterite overlying the Mullaman Beds, and 15 percent near outcrops of laterite. Most but not all of the anomalies are in the area occupied by the mobile belt.

Silver and Gold

In 1895 H. Y. L. Brown assayed a quartz reef in sediments (probably of the Fitzmaurice Group) near the mouth of the Fitzmaurice River. One sample showed 56.6 grams of silver to the metric ton. Another showed traces of gold.

Copper

Traces of chalcopyrite have been found in the basic sills in the northeastern part of the Sheet area.

Iron

Pyrrhotite has been found in the Ti-Tree Granophyre in an outcrop a few kilometres east of the Port Keats Sheet area (Morgan et al., 1970).

Water Resources

Nine water-bores have been drilled, all in the vicinity of Port Keats Mission. Most of them struck small quantities of water at shallow depths. Good quantities of water can be obtained from rivers fed by springs on or at the base of the Mullaman Beds, in particular the Moyle River and Tom Turners Creek.
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