COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

REPORT No. 90

Middle Proterozoic Volcanic Rocks in the Katherine-Darwin Area, Northern Territory

BY

J. R. STEWART

Issued under the Authority of the Hon. David Fairbairn
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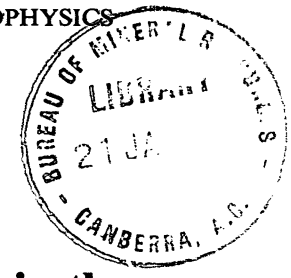

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MINISTER: THE HON. DAVID FAIRBAIRN, D.F.C., M.P.

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SUMMARY

This Report describes the Middle Proterozoic volcanic rocks which crop out in the Katherine-South Alligator River area of the Katherine-Darwin Region, Northern Territory. Other Proterozoic igneous rocks in the area are also described briefly.

Middle Proterozoic Katherine River Group rocks crop out over a wide area but the thickest sections were developed in three depositional basins. The sequence is part of the vast Middle/Upper Proterozoic succession in the McArthur Basin which extends from Arnhem Land to the Queensland border.

Deposition of the Katherine River Group started with the Edith River Volcanics. Flows of basic lava were followed by eruption of ignimbrite over wide areas. The overlying Kombolgie Formation consists of sandstone and minor conglomerate with interbedded volcanics. In the area described the volcanic members of this Formation are confined to the three depositional basins. With the exception of the Plum Tree Volcanic Member in the Mount Callanan Basin, which is largely ignimbritic, the volcanics comprise andesitic and basaltic lavas.

Extensive alteration of these Precambrian ignimbrites is common and no original glass remains. Identification depends on both their field characteristics and study of thin sections. Individual units range up to 1500 feet thick.

The typical ignimbrite of the Edith River Volcanics is red-brown and has a distinct foliation due to the presence of green or red, sub-parallel, lenticular bodies, which probably represent flattened pumice fragments. These fragments, together with phenocrysts of feldspar and quartz, aggregates of chlorite, and rock fragments are set in a fine-grained devitrified matrix which often shows a criss-cross arrangement of quartz laths. The pumiceous fragments are commonly bent around the phenocrysts and the elements of the matrix may show pseudo-flow structure.

The typical ignimbrite of the Plum Tree Volcanic Member does not contain quartz phenocrysts and devitrified vitric fragments cannot usually be identified.

The association of uranium mineralization with the acid extrusives of the South Alligator River area is noted.

INTRODUCTION

This Report summarizes part of a thesis submitted to the University of New England for the degree of Master of Science in 1959. The field work was carried out when the author was a member of Bureau of Mineral Resources field parties in the Katherine-Darwin Region in 1954 and 1955. In each year about five months were spent in geological mapping. The Report supplements the account by Walpole, et al., (1965, in press) on the general geology of the Katherine-Darwin area.

Situation and Access. The Katherine-South Alligator River area, with which this Report is primarily concerned, is in the northern part of the Northern Territory and is part of the larger Katherine-Darwin Region (Noakes, 1948; Walpole, et al., in press; Katherine-Darwin 1:500,000 map). The Katherine-South Alligator River area comprises parts of the Mount Evelyn, Katherine, Pine Creek, and Fergusson River 1:250,000 Sheet areas and includes seven 1-inch Sheet areas and parts of five others (see Pl. 6).

The Stuart Highway, from Darwin to Alice Springs, crosses the area between Pine Creek and Katherine. Vehicle tracks from the Stuart Highway give access to most of it, but with the exception of the road from Pine Creek to El Sherana via Moline, the tracks are virtually impassable during the wet season.

Climate, Vegetation, and Water Supply. The area has a monsoonal climate with a well-defined wet summer and a dry winter. The rainfall ranges from about 35 to 60 inches per annum, almost all of which falls between November and March.

Parts of the rivers contain permanent running water; elsewhere water can be obtained from numerous waterholes and billabongs, many of which are permanent.

The country generally consists of low hills and ridges with broad flat valleys, all of which are covered by open tree growth and grassland. The Middle Proterozoic sandstone forms deeply dissected and extremely rugged, spinifex-covered tablelands and hills.

Settlements. Pine Creek and Katherine are the main townships in the area. Since the discovery of uranium in 1954 various mining settlements have been established; for example, El Sherana and Rockhole (in the South Alligator River Valley), and Sleisbeck and Moline; by 1963 only two, El Sherana and Moline, were still inhabited. The area also contains several small pastoral homesteads.

Previous Work. Previous work on the Middle Proterozoic igneous rocks has been very limited. Brief descriptions have been given by Woolnough (1912), Jensen (1915), Noakes (1949), Carter (1952), Gardner & Rade (1955), and Rattigan & Clark (1955). The only microscopic petrological descriptions are contained in the reports by Carter and Gardner & Rade, but these deal with very limited areas.

REGIONAL GEOLOGY

The volcanic rocks described in this Report are part of the Middle Proterozoic Katherine River Group, a sequence of arenites, rudites, and volcanics which overlie the Lower Proterozoic rocks in the Pine Creek Geosyncline with a marked angular unconformity (Randal, 1963; Walpole, 1962).

The Katherine-South Alligator River area lies in the eastern part of the Lower Proterozoic Pine Creek Geosyncline. The main part of the geosyncline is separated from a marginal trough to the east by a basement ridge of Archaean greenstone and greenstone agglomerate. The principal rock types in the geosyncline west of the ridge are sandstone, ferruginous and carbonaceous siltstones, shale, and chert of the Goodparla Group, overlain by greywacke and siltstone with minor volcanics of the Finniss River Group. The eastern trough contains the South Alligator Group, which comprises a similar sequence to the two Groups in the west. The Lower Proterozoic sediments have been steeply folded but metamorphism has been of low grade only. Before or during folding basic sills and dykes were intruded (Bryan, 1962). The intrusions are up to several thousand feet thick and comprise altered dolerite and gabbro with some granophyric differentiates. After folding, widespread granitic intrusion took place. The largest intrusion in the Cullen Granite in the west of the Katherine-South Alligator River area, and other intrusions include the Malone Creek, Wolfram Hill, and Grace Creek Granites, which are probably genetically related to the Cullen Granite.

The Middle Proterozoic Katherine River Group overlies the eroded surface of the older rocks; it covers the eastern side of the Pine Creek Geosyncline and extends much farther eastwards into Arnhem Land. In the Katherine-South Alligator River area the thickest and best exposed sections were deposited in three basins known as the Edith Falls, Mount Callanan, and Birdie Creek Basins (Fig. 1).

Measured sections from each of the basins are summarized in Figure 2. In the areas between the basins the succession is much thinner and the higher volcanic members are absent.

Deposition of the Katherine River Group started with the Edith River Volcanics. Initially, deposition seems to have been localized; the greywacke, conglomerate, shale, and tuffaceous sediments of the Phillips Creek Member are confined to the western side of the Edith Falls Basin, and lenses of sedimentary breccia, conglomerate, greywacke, and minor acid volcanics constituting the Scinto Breccia Member and the Coronation Hill Member are restricted to the South Alligator River Valley. Subsequent volcanic activity was more widespread and was continuous over most of the area described. In the Edith Falls and Mount Callanan Basins the volcanic activity began with basalt flows, which were followed by acid extrusives, largely ignimbritic, but in the Birdie Creek Basin and the area between the basins the Edith River Volcanics consist entirely of acid extrusives.

The Kombolgie Formation, which consists of sediments and interbedded volcanics, overlies the Edith River Volcanics with local disconformities. The sediments consist mainly of sandstone and minor conglomerate, suggesting, outside the three basins, a stable shelf environment; the relative instability of the basin areas is reflected in the greater thickness of sedimentation and the 'dirtier' character of the sediments, particularly near the base of the formation, in those areas. The sediments show well-developed large-scale current-bedding and extensive ripple-marking. In the Katherine-South Alligator River area the volcanic members of the Kombolgie Formation are confined to the Edith Falls, Mount Callanan, and Birdie Creek Basins and cannot be correlated from one basin to another. With the exception of the Plum Tree Volcanic Member, which is largely ignimbritic, the volcanics comprise andesitic and basaltic lavas. An angular unconformity in the sandstone of the Kombolgie Formation to the east of the South Alligator River may represent a break in sedimentation during the time interval occupied by one or more of the extrusive episodes within the three basins to the south and west.

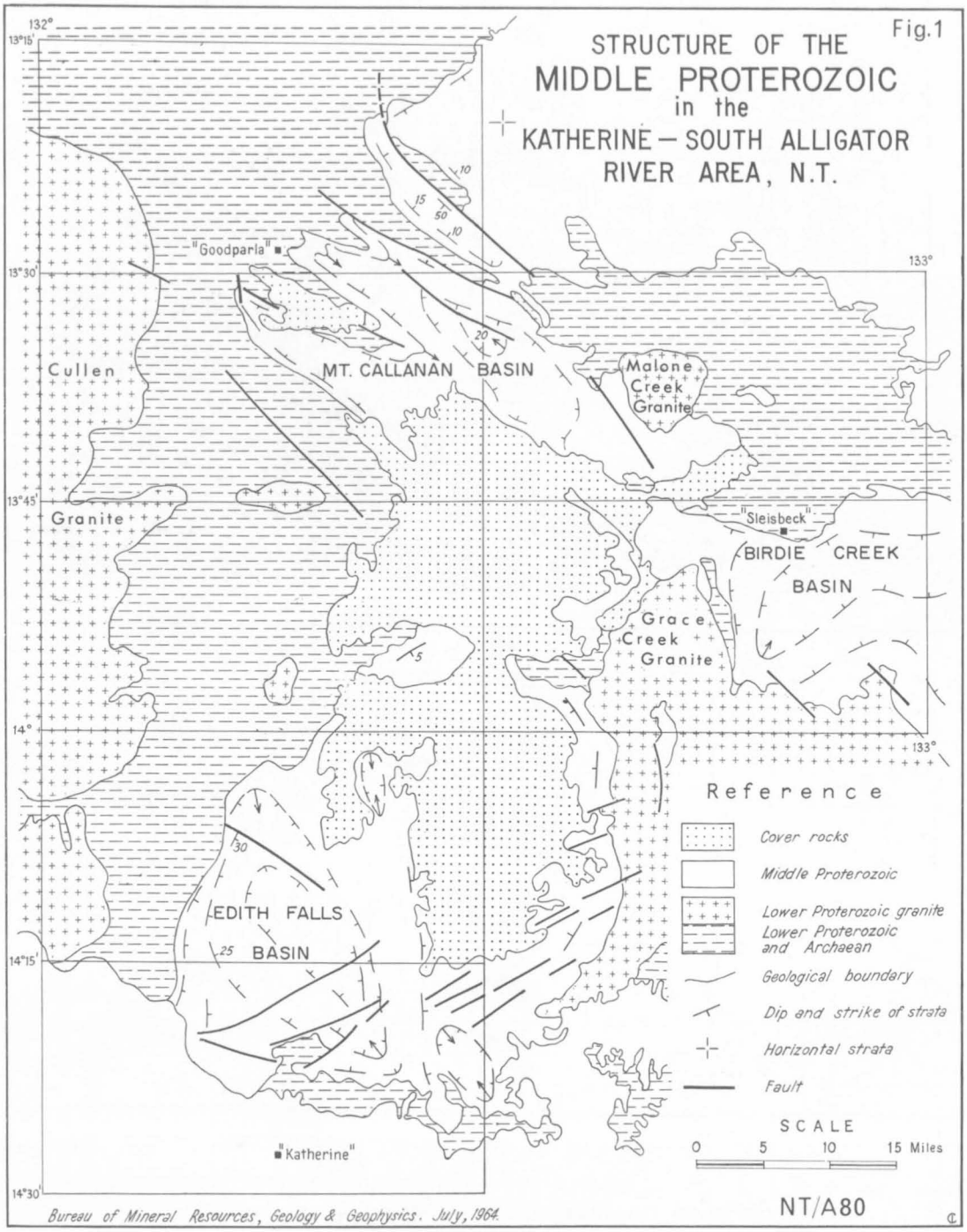
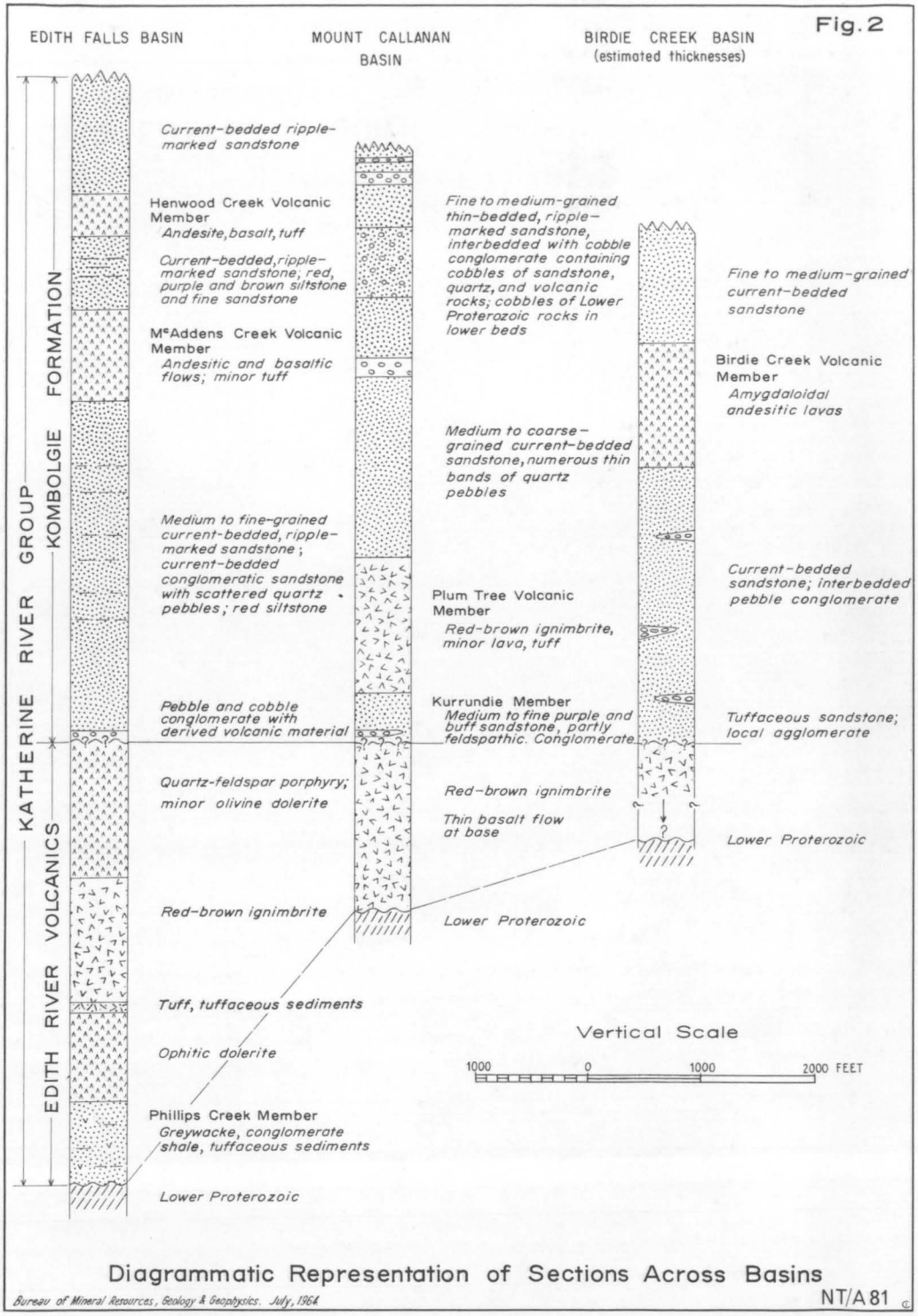


Fig.1
STRUCTURE OF THE
MIDDLE PROTEROZOIC
in the
KATHERINE – SOUTH ALLIGATOR
RIVER AREA, N.T.
132°
13°15'
13°30'
13°45'
14°
14°15'
14°30'
133°
"Goodparla"
Cullen
Granite
MT. CALLANAN BASIN
Malone Creek Granite
"Sleisbeck"
BIRDIE CREEK BASIN
Grace Creek Granite
EDITH FALLS BASIN
"Katherine"
10
15
50
10
20
15
30
25
Reference
Cover rocks
Middle Proterozoic
Lower Proterozoic granite
Lower Proterozoic and Archaean
Geological boundary
Dip and strike of strata
Horizontal strata
Fault
SCALE
0 5 10 15 Miles
Bureau of Mineral Resources, Geology & Geophysics. July, 1964.
NT/A80
©



Diagrammatic Representation of Sections Across Basins

Bureau of Mineral Resources, Geology & Geophysics. July, 1964

NT/A 81

The main structural features of the Katherine River Group in the Katherine-South Alligator River area are the three depositional basins which appear to have developed by accelerated local sagging at the same time as the deposition of the sediments. Their loci have probably been controlled by the discharge of large volumes of magma from the magma chambers underlying the basins.

The Edith Falls Basin was named by Rattigan & Clark (1955) and occupies an area about 20 miles square. It is a simple asymmetrical basin which has been modified slightly by transverse faults at its southern end. Dips on the edges of the basin are of the order of 40^{o}, but they become very much flatter in the centre. The axis of the basin trends north-west.

The Mount Callanan Basin is about 30 miles long and 15 miles wide and has been folded into two large synclines separated by a large anticline. Dips range from 60^{o} on the margins of the basin to less than 5^{o} in the centre. The axis of the basin and the axes of the folds trend north-west.

The Birdie Creek Basin occupies an area of about 500 square miles. The major structure is a broad syncline with dips generally between 5^{o} and 10^{o}. The syncline is open to the east and its axis is inflected; the axis trends north-east in the west and turns eastward in the east. The western margin is more intensely folded and dips range up to 85^{o}.

After deposition, the Middle Proterozoic rocks were gently folded into broad anticlines and synclines, particularly in the three basins. The Katherine River Group is cut by minor faults and numerous joints; major faulting was confined to a zone near the Archaean basement ridge in the South Alligator River Valley.

The Middle Proterozoic rocks in the Katherine-South Alligator River area are within the lower part of a vast Middle Proterozoic/Upper Proterozoic sedimentary succession in the McArthur Basin which extends from Arnhem Land to the Queensland Border (Dunn, Smith, & Roberts, in prep.). Acid volcanics, resembling the Edith River Volcanics, are present in most places in the basin where the unconformity between the Middle Proterozoic and older rocks is exposed, e.g. the Scrutton Volcanics (Smith, 1964), the Fagan Volcanics (Plumb & Roberts, 1965), and the Spencer Creek Volcanics (Dunnet, 1965).

Equivalents of the volcanic members of the Kombolgie Formation are also present in other parts of the McArthur Basin, e.g., the Peters Creek Volcanics (Smith, 1964; Plumb & Paine, 1964; Roberts, Rhodes, & Yates, 1963), and the Nungbalgarri Volcanic Member (Rix, 1964; Roberts, 1964).

After the Middle Proterozoic, sedimentation and volcanic activity were mainly confined to the Daly River Basin in the south-west. The Upper Proterozoic Tolmer Group unconformably overlies Lower Proterozoic rocks and the Lower Cambrian Antrim Plateau Volcanics unconformably overlie both Lower and Middle Proterozoic rocks; the limestone and sandstone of the Middle Cambrian Daly River Group unconformably overlie the Tolmer Group and Antrim Plateau Volcanics (Randal, 1962, 1963).

Mesas and tablelands of Lower Cretaceous Mullaman Beds are the remnants of a thin succession (less than 200 feet) of sandstone, siltstone, and shale which covered the whole area (Skwarko, 1964).

The youngest sediments comprise Cainozoic alluvium, sand, gravel, and ferruginous deposits.

MIDDLE PROTEROZOIC VOLCANIC ROCKS

The Middle Proterozoic volcanic rocks in the Katherine-South Alligator River area are typical of the andesite-rhyolite-basalt associations found in continental zones of the earth's crust which have been affected by moderate to strong orogenic movements (Turner & Verhoogen, 1960). The volcanic activity was probably closely related to the later stages of the major orogeny which occurred at the close of the Lower Proterozoic. Tilley (1950) has postulated differentiation of olivine basalt magma and the assimilation of sialic rocks of varied composition to account for the widespread occurrence of acid and intermediate volcanic rocks. The parent magma of the ignimbrites must have contained a relatively high proportion of volatile constituents, presumably as a result of differentiation and assimilation.

Ignimbrites

'Ignimbrite' was originally described by Marshall (1935, p.323) as an acid pyroclastic rock formed from a nuee ardente at such a high temperature that the ash particles were still plastic, and became welded together on settling to give a compact rock resembling a lava. At the International Symposium on Vulcanology in Japan in 1962 R.L. Smith tabled a paper listing twenty-three definitions of ignimbrite, many of them contradictory (Branch, 1962), but it was informally concluded that the term should be retained, although it is synonymous with the general term 'pyroclastic flow'.

The term ignimbrite as used in this Report is equivalent to the 'welded tuff' of Mansfield & Ross (1935) and Gilbert (1938). Mansfield & Ross described welded volcanic tuffs as those 'in which individual fragments had remained plastic enough to become wholly or partly welded... In a few specimens the original forms are unmodified; in others there is flattening, but without obliteration of characteristic ash structure; and in a few, extreme flattening and slight flowage has almost obscured the original structure'. An excellent summary of the nature, occurrence, and nomenclature of ignimbrites has been given by Ross & Smith (1960).

Most of the early descriptions of ignimbrites were of deposits of late Tertiary to Recent age. At the time the work reported here was undertaken only one occurrence of ignimbrite of Precambrian age had been described in the geological literature (although this reference was not available to the writer at the time). This was a description of ignimbrites from the Anti-Atlas region of Morocco (Bouladon & Jouravsky, 1954, 1955). Hjelmqvist (1956) described ignimbrites of Precambrian age in the Dalarna region of central Sweden; and several other occurrences of Precambrian ignimbrites have been reported since: Ross has identified Precambrian ignimbrites in two deep wells in Texas (Ross & Smith, op.cit.), Thompson & Williams (1956) have reported deposits of early Precambrian age in the Sudbury Basin of Canada, and Bentor (1961) has reported the occurrence of alkaline ignimbrites in the Precambrian of Israel.

The Middle Proterozoic ignimbrites in the Katherine-South Alligator River area have the following field characteristics:

(a) Individual occurrences consist of thick homogeneous deposits with a wide areal extent and remarkably constant thickness over considerable distances.

(b) The deposits can be related in only the most general way with particular centres of eruption.

(c) Stratification is commonly absent; there are no interbedded air-fall pyroclastics; and turbulent flow structures are absent.

(d) Columnar jointing, although not common, does occur in places, and as was pointed out by Marshall (1935) such jointing would not be expected to form in acid lava flows.

(e) The upper surface appears to have been roughly horizontal at the time of formation.

(f) The ignimbrites in the three depositional basins usually have a characteristic streaky appearance due to the presence of numerous lenticular fragments which are commonly flattened and bent around the phenocrysts (in thin section the inclusions are seen to consist of devitrified vitric fragments). Outside the depositional basins, recognizable lenticular fragments are generally absent.

(g) The well-compacted varieties are usually red-brown, although minor yellow-brown, buff, grey, pink, greenish, and purple types also occur. The ignimbrites which were originally less well compacted are generally purple in outcrop.

Edith River Volcanics

Edith Falls Basin

The following section of Edith River Volcanics was measured west of Edith Falls, where outcrops are relatively good except for the weathered quartz-feldspar porphyry at the top of the section:

		Thickness (feet)
Top of Section		
Weathered purple quartz-feldspar porphyry with one minor occurrence of olivine dolerite		1200
Red-brown devitrified ignimbrite with well-marked streaks		1100
Tuff and tuffaceous sediments		80
Ophitic dolerite		800
Greywacke, conglomerate, shale, and tuffaceous sediments (Phillips Creek Member)		700
Base of Section	Total	3880

Ophitic Dolerite

Volcanic activity in the Edith Falls Basin began with the eruption of 800 feet of basic lava which crops out for a distance of about six miles along the western margin of the basin. The rock is a rather coarse-grained ophitic dolerite composed of labradorite, augite, magnetite, secondary calcite, and accessory chlorite and apatite.

Devitrified Ignimbrite

The ophitic dolerite flows are succeeded by 80 feet of purple tuff and tuffaceous sandstone, which are overlain by red-brown ignimbrite. The ignimbrite crops out almost continuously around the margin of the Edith Falls Basin.

The ignimbrite is homogeneous from bottom to top and no amygdaloidal or scoriaceous horizons, such as occur at the top or bottom of acid lava flows, were observed. No centres of eruption have been found. Although massive in outcrop, the rocks generally show a distinct foliation owing to the presence of dark green sub-parallel lenticular bodies which probably represent flattened pumice fragments.

Measurements of rock magnetism on samples of the ignimbrites from the Edith Falls Basin and South Alligator River area show that they were almost certainly laid down on a nearly horizontal surface, and were later tilted. The positions of the palaeomagnetic poles in the two areas coincide when corrected for structural dip (E. Irving, Australian National University, pers. comm.).

Petrography. The ignimbrite is a characteristic dark red-brown colour with streaky patches of dark green material. The rock is porphyritic with phenocrysts of pink feldspar up to 3 mm in length.

Under the microscope, the rock is seen to contain phenocrysts of alkali feldspar, plagioclase, and quartz. Aggregates of chlorite and abundant fragments of igneous rocks are also present. The fine-grained matrix consists mainly of quartz and alkali feldspar, with small amounts of chlorite, sericite, magnetite, hematite, calcite, and zircon. Some sections show flattened fragments bent around the phenocrysts, and one section contains pseudomorphs of a carbonate mineral and hematite after olivine. The olivine fragments are probably xenocrystic in origin.

The feldspars are commonly corroded and altered to calcite, sericite, and chlorite, but when the minerals can be identified, phenocrysts of orthoclase predominate over plagioclase. The plagioclase is probably andesine with a composition about An_{40}. Most thin sections show a few small phenocrysts of quartz. Aggregates of chlorite are commonly present; in one section the chlorite is associated with calcite, and in another, it includes small crystals of zircon surrounded by relict pleochroic haloes.

Rock fragments form an important constituent of some of the devitrified ignimbrites. The xenoliths consist mainly of altered intermediate or basic igneous rocks, but one section contains a large fragment of an altered acid igneous rock.

The matrix includes roughly circular areas containing a criss-cross network of lath-like quartz rods in optical continuity. The diameter of the circular areas ranges from

0.1 to 0.5 mm and is generally between 0.1 and 0.2 mm. The quartz laths range from 0.05 to 0.1 mm in length, and the interstices between them are filled with alkali feldspar. Irregular flakes of chlorite encircle many of the clusters of quartz laths, forming a ragged, corona-like structure (see Pl. 1). The matrix of the ignimbrite originally consisted of finely comminuted glass. The glass probably began to crystallize at a high temperature to form a network of criss-crossed rods of tridymite, and at a lower temperature the tridymite was completely converted to quartz.

In some of the rocks the flattened, devitrified, vitric fragments in the matrix are bent around the phenocrysts. It is of interest to note that the quartz laths in places cross the boundaries of the devitrified vitric fragments. In one section the rows of magnetite grains (partly altered to hematite), in a large devitrified vitric fragment, probably represent pore fillings in original pumiceous material.

Quartz-Feldspar Porphyry

The quartz-feldspar porphyry at the top of the Edith Falls section is 1200 feet thick. The porphyries, which are poorly exposed and invariably deeply weathered, are distinguished by their purple colour. Similar purple weathered porphyries occur in the South Alligator River area.

The porphyries contain phenocrysts of completely sericitized feldspar and quartz. Subrounded xenocrysts of olivine, which are completely replaced by aggregates of granular quartz and traversed by irregular cracks filled with hematite, are also present. The fine-grained groundmass is composed of quartz, sericite, hematite, and chlorite.

The rocks have been classified as quartz-feldspar porphyries, but their original mineral composition and mode of formation are uncertain. Although no pumice fragments have been recognized, their wide areal extent and the absence of flow structures suggest that they may be highly altered ignimbrites. As discussed in the section dealing with the Plum Tree Volcanics, there is reason to believe that these purple-coloured quartz-feldspar porphyries represent ignimbrites which were originally less perfectly welded than the red-brown varieties.

Olivine Basalt

A small outcrop of olivine basalt occurs within the quartz-feldspar porphyry. The rock is an albitized porphyritic olivine basalt with phenocrysts of olivine - which has been completely replaced by calcite, quartz, and hematite - and augite. The fine-grained groundmass is composed of albite, labradorite, calcite, augite, hematite, biotite, and altered olivine. It is not known whether the rock represents a small flow of basaltic lava, or whether it is intrusive into the porphyries. The presence of altered olivine xenocrysts in the quartz-feldspar porphyry suggests that the acid and basic rocks were derived from the same source.

Mount Callanan Basin

In the South Alligator River area, on the eastern margin of the Mount Callanan Basin, the Edith River Volcanics rest unconformably on Lower Proterozoic rocks. The surface of unconformity is irregular, with local relief up to 300 feet. The Edith River Volcanics are well exposed between the western boundary of the Malone Creek Granite and the South Alligator River. The section consists of 1500 feet of red-brown ignimbrite with a thin bed of dolerite at the base. The only variation noted in the ignimbrite was a minor occurrence of a yellow-brown type.

Three centres of eruption have been identified in the South Alligator River area. At Coronation Hill, a vent 60 feet in diameter was exposed during mining operations (see Shepherd, 1962). The vent is filled with agglomerate composed of fragments up to several feet long, of acid and basic volcanic rocks and Lower Proterozoic sediments. Similar agglomerates occur at Pul-Pul, and about four miles east-south-east of Coronation Hill.

Extrusive Dolerite

Extrusive dolerite crops out at the base of the Edith River Volcanics along the western side and near the south-eastern corner of the Malone Creek Granite. It is not nearly as extensive or as thick as the dolerite lava near the base of the Edith River Volcanics on the western side of the Edith Falls Basin. The dolerite consists of plagioclase (which may show alteration to sericite), chlorite, augite, and magnetite or hematite. Cavities and amygdales are filled with chlorite. In places, chalcedony and epidote are present, and calcite has also been noted.

Devitrified Ignimbrite

In the 500 feet of red-brown ignimbrite between the western boundary of the Malone Creek Granite and the South Alligator River stratification is absent, and the ignimbrite appears to consist of a single thick flow. No volcanic breccias or interbedded sedimentary rocks were seen in the section. The ignimbrite forms massive outcrops, and good sections are exposed in the beds of the creeks crossing the strike.

Towards the headwaters of the South Alligator River, the ignimbrite passes laterally into tuff, ashstone, and feldspathic sediments. Ignimbrite has also been recognized in the Edith River Volcanics in the north-western corner of the Mount Callanan Basin near Goodparla Homestead, but is subordinate to tuff and tuffaceous sediments. Along the western margin of the Mount Callanan Basin the Edith River Volcanics are very poorly developed, and are represented by a few small valley-fill occurrences of rhyolitic lava, conglomerate, and tuffaceous sandstone.

Petrography. The Edith River Volcanics in the Mount Callanan Basin are mainly composed of ignimbrite. In hand-specimen this rock type is usually dark red-brown, with a characteristic streaky appearance. Phenocrysts, up to 4 mm long, of feldspar, quartz, and in places a dark ferromagnesian mineral, are set in a fine-grained matrix. The streaky appearance of the ignimbrite is due to the presence of sub-parallel dark green or red streaks some of which are bent around the phenocrysts. The streaks may be 5 cm or more long, but are usually smaller. Rock fragments of different types, up to about 5 mm long, may also be present. The most important colour variant is purple, but yellow-brown and grey types also occur.

In thin section the phenocrysts are seen to form 5 to 25 percent of the rock. They consist of alkali feldspar, quartz, and plagioclase, and aggregates of chlorite. The dark green and red streaks seen in the hand specimen are devitrified vitric fragments. These fragments and xenoliths of different types may each constitute up to 50 percent of the rock in different places. These larger fragments are set in a very fine-grained devitrified matrix composed of quartz, iron-stained feldspar, chlorite, calcite, and sericite. Small amounts of magnetite (partly altered to hematite), zircon, epidote, and fluorite may also be present.

Most of the lineation in the ignimbrites is due to the parallelism of the streaky devitrified vitric fragments. Some of the components of the matrix are sometimes bent around the phenocrysts in such a way as to simulate the flow structure in lavas.

The tabular alkali feldspar phenocrysts are mainly microperthite. The alteration products include calcite, chlorite, kaolin, sericite, and epidote. The quartz grains are commonly rounded and corroded, and in places they have been recrystallized into a granular mosaic of secondary quartz showing undulose extinction. The plagioclase phenocrysts are invariably altered to sericite. Calcite and chlorite are also present as alteration products in several specimens. The plagioclase is probably andesine with a composition of about An_{35}.

The sub-parallel devitrified vitric fragments are generally between 0.5 and 15 mm long. They are invariably elongated, and many are bent around the phenocrysts. They consist of granular aggregates of quartz, iron-stained feldspar, chlorite, calcite, and sericite in varying proportions. The grainsize ranges from 0.01 to 0.2 mm. One thin section (Specimen R7663) shows a pectinate type of devitrification (see Marshall, 1935, p.345).

Rock fragments, where present, appear to be mainly of two types. The first is an intermediate or basic igneous rock with a pilotaxitic texture, and chlorite in the interstices between the feldspar laths. The fragments show no sign of reaction with the matrix. The second type of inclusion appears to be a quartz-feldspar porphyry, which in one observed case has developed a spherulitic texture and has been altered by the introduction of calcite.

The matrix, which sometimes has a pseudo-flow structure, is composed of a very fine-grained aggregate of quartz, iron-stained feldspar, chlorite, calcite, and sericite (i.e. the same minerals as those which make up the devitrified vitric fragments). Small amounts of magnetite (partly altered to hematite), epidote, fluorite, and zircon may also be present. The matrix is extremely fine in grain - commonly less than 0.01 mm - and is believed to have been formed by devitrification of finely comminuted vitric material. Some thin sections also show evidence of the introduction of secondary silica.

The ignimbrite of the Mount Callanan Basin is similar to the devitrified ignimbrite described by Oliver (1954, p.47) from the English Lake District.

Photomicrographs of typical specimens of the devitrified ignimbrite from the Mount Callanan Basin are shown in Plate 2, Figures 1 and 2, and Plate 3, Figure 2. The devitrified ignimbrite illustrated in Plate 3, Figure 2 contains a significant proportion of rock fragments.

Ignimbrite or Tuff

The rocks which crop out around the southern margin of the Malone Creek Granite are distinguished by the presence of abundant rock fragments. They are probably ignimbrite, but it is possible that they represent normal ash-fall tuff deposits. They are red-brown, grey, purple, or greenish. The phenocrysts include kaolinized alkali feldspar, sericitized plagioclase, and rounded grains of quartz. Aggregates of chlorite and numerous rock fragments are also present. The matrix is extremely fine-grained. The most common inclusions are of an intermediate or basic igneous rock with a trachytic or pilotaxitic texture. The fragments commonly contain epidote, and in some specimens the inclusions have been completely replaced by epidote. Occasional fragments of sedimentary rock also occur.

Quartz, chlorite, and calcite are present in the matrix, but feldspar could not be identified with certainty. In one specimen the matrix is partly spherulitic; and in another, the elongated iron-stained areas, which are bent around the phenocrysts and rock inclusions, probably represent devitrified glassy fragments.

Dolerite

A prominent intrusion of dolerite, about half a mile long and a hundred feet wide, occurs eight miles south-south-east of Coronation Hill. Although conclusive field evidence is lacking, the dolerite appears to be intrusive into the ignimbrite, but it is probably genetically related to the Edith River Volcanics. It is composed of irregularly sericitized and chloritized plagioclase (?andesine), chlorite, and augite, with a little calcite, pyrite, and quartz. Grainsize decreases markedly from the centre of the intrusion towards the margins. The coarser varieties have an ophitic texture and a mottled appearance due to white spots of almost completely sericitized plagioclase.

About six miles east of Goodparla Homestead, a porphyritic olivine dolerite crops out in the Edith River Volcanics, but its relationships are not known.

Pul-Pul Rhyolite Member

In the Coronation Hill area on the eastern side of the Mount Callanan Basin, the Edith River Volcanics have been divided into three members:

Pul-Pul Rhyolite Member - rhyolite with some tuffaceous sediments

Scinto Breccia Member - siliceous sedimentary breccia, greywacke conglomerate, conglomerate, etc.

Coronation Hill Member - valley-fill lenses of conglomerate, greywacke conglomerate, greywacke, sedimentary breccia, and acid volcanics.

The Pul-Pul Rhyolite Member crops out well in the neighbourhood of El Sherana, and can be traced for about 19 miles to the north-west, but to the south of Pul-Pul the three-fold division cannot be recognized.

In hand-specimen the rocks are mottled purple and white. They contain quartz crystals and irregular patches of whitish material, up to 2 cm long, set in a fine-grained purple matrix. One iron-stained variety is red with pink patches. Under the microscope the rounded quartz phenocrysts invariably show secondary rims of dusty quartz. The silicified groundmass consists almost entirely of very small quartz grains with a little sericite and hematite. Numerous cognate xenoliths from 1 mm to 1 cm in length are present. They contain quartz phenocrysts set in a groundmass of quartz, and a little sericite and hematite. The groundmass of the xenoliths is considerably coarser in grain than the matrix of the host rhyolite.

These rocks have been tentatively identified as rhyolite. No pumice fragments or other characteristic features of ignimbrites were observed and the flows are of small areal extent compared with the ignimbrites.

Birdie Creek Basin

Extrusive Quartz-Feldspar Porphyry

A relatively thin sheet of Edith River Volcanics originally extended over almost the whole of the Mount Stow 1-mile Sheet area, but the porphyry is now preserved only where it is protected from erosion by the overlying sediments of the Kombolgie Formation. The quartz-feldspar porphyry rests unconformably on the Grace Creek Granite and is overlain conformably by the Kombolgie Formation. Except in the area south-west of Sleisbeck, the quartz-feldspar porphyry does not appear to be more than 50 feet thick.

The Mount Stow 1-mile Sheet area was mapped in less detail than elsewhere, owing mainly to the deep weathering of most exposures of the Edith River Volcanics. However, the uniform thickness and composition of the porphyry over wide areas and the absence of flow structures suggests that it is an ignimbrite. It is similar in appearance to the quartz-feldspar porphyry which occurs in the Edith Falls Basin.

The porphyry is generally purple, but red-brown and buff varieties also occur. The phenocrysts of feldspar are commonly corroded and completely replaced by sericite. In places the rock has been extensively silicified, and the feldspar has been replaced by very fine-grained aggregates of quartz and sericite. The rounded quartz phenocrysts in places show secondary growth rims. Phenocrysts of kaolinized microperthite were seen in one thin section, and partly uralitized augite xenocrysts in another. The groundmass consists of quartz, sericite, minor hematite, and accessory zircon. The groundmass is usually very fine-grained, but where strongly silicified it becomes coarser-grained owing to the enlargement of the quartz grains by secondary growth. The silicification is believed to be associated with the formation of the duricrust in Northern Australia.

Nine miles west of Sleisbeck there is an occurrence of red-brown devitrified ignimbrite. The rock contains phenocrysts of altered feldspar set in a fine-grained matrix showing a marked lineation due to the presence of chloritic streaks. The quartz laths in the groundmass have a well-developed criss-cross structure.

(?)Intrusive Quartz-Feldspar Porphyry

In the Birdie Creek area dyke-like bodies of quartz-feldspar porphyry occur along major joint planes in the Grace Creek Granite. Similar joints in the same area are occupied by dolerite dykes. The porphyry may represent some of the feeder dykes of the Edith River Volcanics in the Birdie Creek Basin, or alternatively may be extrusive flows filling weathered out joint planes in the eroded surface of the granite. The rocks are similar to the extrusive quartz-feldspar porphyry in colour and texture.

Plum Tree Volcanic Member

The Plum Tree Volcanic Member of the Kombolgie Formation crops out in a rectangular area measuring about 30 by 15 miles in the Mount Callanan Basin. Fairly good outcrops of volcanics occur in the broad synclines and anticlines south-east of Goodparla Homestead. The Plum Tree Volcanic Member is 1100 to 1200 feet thick.

In the South Alligator River Valley area the Plum Tree Volcanic Member consists of fine-grained red-brown or purple devitrified ignimbrite containing phenocrysts of feldspar and a dark mineral. The middle parts of the ignimbrite are generally red-brown, but the topmost hundred feet or so is usually purple; and the only exposure of the base seen was also purple. The purple variety is invariably more decomposed than the red-brown type and it seems probable that it represents the upper and lower parts of the ignimbrite sheet where the rock was less completely welded. A thin band of amygdaloidal material occurs 100 feet below the top of the formation two and a quarter miles south-south-east of El Sherana, and a circular mass of blue-grey epidote-bearing volcanic rock occurs nearby.

In the Goodparla North and Goodparla South 1-mile Sheet areas the Plum Tree Volcanic Member consists of a series of lava flows (in places amygdaloidal), tuffs, and tuffaceous sandstones with conglomerate lenses. Some ignimbrite is probably also present, and examination of a collection of specimens from near the Mary Junction Mine showed that three distinct types are represented: (a) the characteristic red-brown ignimbrite with phenocrysts of pink feldspar and occasional crystals of quartz, (b) a grey amygdaloidal lava, and (c) a tuff or tuffaceous sandstone.

In the north-eastern quadrant of the Goodparla South 1-mile Sheet area there are extensive outcrops of the typical red-brown ignimbrite with phenocrysts of pink feldspar and a dark ferromagnesian mineral.

Specimens collected at 50-foot intervals during a traverse across the Plum Tree Volcanic Member two miles south of Dinner Creek were all found to be devitrified ignimbrite with the possible exception of those from the bottom and topmost hundred feet. Some of the specimens are considerably altered.

Petrography. Some of the ignimbrites have a distinct lineation in the hand specimen. They contain phenocrysts of altered plagioclase and alkali feldspar, and pseudomorphs of chlorite after hornblende or biotite set in a fine-grained matrix of quartz and alkali feldspar. The accessories include zircon, apatite, and sphene, and variable amounts of chlorite, sericite, calcite, and hematite are also present. The proportion of phenocrysts to matrix varies considerably.

The feldspar phenocrysts are generally pink or white and less commonly green. They range up to 1 cm in length with the majority in the range 1 to 5 mm. In most slides the plagioclase phenocrysts have been completely replaced by aggregates of iron-stained sericite, but occasional crystals with the composition of andesine have been noted. The microperthite or orthoclase phenocrysts are partly altered to kaolin with a little chlorite, quartz, calcite, sericite, and epidote. The original mafic minerals are represented by pseudomorphs of chlorite, but occasional remnants of biotite can be seen. In the highly altered rocks, calcite, quartz, and sericite occur in association with the chlorite.

The alkali feldspar in the fine-grained matrix is in many specimens completely replaced by sericite with subordinate chlorite, hematite, and calcite. In one thin section the chlorite forms coronas around the quartz laths (see Pl. 5, Fig. 2) as in the ignimbrite of the Edith Falls Basin.

The clear quartz laths in the matrix stand out in bold relief against the iron-stained feldspar (Pl. 1, Fig. 2). They are believed to represent crystals of tridymite which have inverted to quartz. The laths are generally arranged in a criss-cross pattern (cf. Pl. 4, Fig. 1 and Pl. 5, Fig. 1) but around the phenocrysts many have a sub-parallel alignment simulating the flow structure of the feldspar microlites in trachytes (Pl. 1, Fig. 2). The pseudo-flow structure in the ignimbrites is believed to be due to compaction under the weight of the overlying material. The quartz laths are generally optically continuous over circular

areas ranging from 0.2 to 0.3 mm in diameter as shown in Plate 5, Figure 2. This texture is believed to be due to devitrification, but in places large amounts of silica have been introduced into these rocks, and the criss-cross lath texture has been obliterated and the phenocrysts extensively altered.

Two of the specimens collected two miles south of Dinner Creek are especially interesting. One is a pinkish grey rock with pink feldspar phenocrysts, up to 2 mm long, set in a very fine-grained grey matrix with numerous sub-parallel devitrified glass shards. The rock has a rough, but distinct, lineation on cut surfaces. The devitrified glass shards, which range up to 5 mm long and 1 mm wide, consist of a granular aggregate of quartz surrounding a central zone of radially dispersed fibres of a mineral resembling chlorophaeite. The outlines of the shards are unmistakable. The altered shards and feldspar phenocrysts are set in a fine-grained matrix of sericite, quartz, and hematite (see Pl. 3, Fig. 1). In the other specimen, which is purple, the central parts of the shards are filled with chlorite displaying a pectinate arrangement of the fibres (Marshall, op.cit. p.345).

Two amygdaloidal types were examined from the same area. They contain completely sericitized feldspar phenocrysts set in a groundmass of quartz, sericite, hematite, and accessory zircon. The prominent amygdales are filled with quartz, chalcedony, and sericite.

In two other specimens, believed to represent tuff, fragments of quartz and sericitized feldspar are set in a fine-grained matrix of quartz, feldspar, and sericite. These were the only specimens from the Plum Tree Volcanic Member in the South Alligator River area containing quartz grains of phenocrystic dimensions.

McAddens Creek Volcanic Member

The McAddens Creek Volcanic Member of the Kombolgie Formation crops out in shallow strike valleys outlining the major structure on the plateau surface of the Edith Falls Basin. It reaches a maximum thickness of 800 feet at the A.B.C. uranium prospect, but exposures are generally poor. According to Gardner & Rade (1955) the McAddens Creek Volcanic Member can be roughly divided into three parts. In the lower part of the section, which is at least 200 feet thick, the volcanics are partly amygdaloidal and aphanitic and partly non-amygdaloidal and fine-grained or aphanitic. The middle part of the section consists of amygdaloidal basalt, and the upper part comprises three or more flows of fine-grained basalt each of which is amygdaloidal near its top.

A thin bed of fine-grained tuff, about 10 feet thick, occurs about 180 feet above the base of the McAddens Creek Volcanic Member, and all uranium mineralization in the A.B.C. prospect area occurs in or near this horizon. The rock is now considered to be a fine-grained tuff, and not a rhyolite, as originally suggested by Gardner & Rade (1955). Several other minor occurrences of fine-grained siliceous rocks at various horizons in the McAddens Creek Volcanic Member are described by Gardner & Rade as rhyolitic intrusives.

W.B. Dallwitz (in Gardner & Rade, op.cit.) has described a series of drill cores obtained at the A.B.C. prospect in 1954-55. He described the rocks as altered basalts and distinguished three groups: (a) chloritized amygdaloidal basalts, in places silicified or hematitic; (b) chloritized basalts in which amygdales are scarce or absent; and (c) chloritized basalts rich in feldspar which may be bordering on intermediate in composition. Dallwitz also states that some of the basalts appear to have contained olivine.

The author briefly re-examined the slides described by Dallwitz as well as some newly collected material. The lavas consist mainly of altered plagioclase, penninite, and another, non-pleochroic, variety of chlorite. Pyroxene, altered olivine, and a little magnetite are present in some specimens. Most of the plagioclase is altered to epidote and kaolin, but the optical properties of occasional unaltered crystals indicate that the rocks range from andesite to olivine basalt.

Henwood Creek Volcanic Member

The Henwood Creek Volcanic Member is 370 feet thick and crops out in a shallow valley in the plateau surface of the Edith Falls Basin. Outcrops are scarce and mostly deeply weathered. Continuity of this Member around the Edith Falls Basin has not been proved.

The Member appears to consist of amygdaloidal and non-amygdaloidal altered andesite and basalt. No pyroclastics were seen by the author, but they have been reported by Rattigan & Clark (op.cit.). A thin section was cut from the least weathered material available and was found to consist of plagioclase (showing extensive alteration to pale green (?)epidote and a little kaolin), chlorite, and augite. Minor constituents are (?)alkali feldspar, sphene, and magnetite. Microamygdales of irregular shape are filled with quartz surrounded by a rim of chlorite.

Birdie Creek Volcanic Member

The Birdie Creek Volcanic Member occupies a series of valleys around the margins of the Birdie Creek Basin. Outcrops are sparse and the rocks are commonly deeply weathered. The volcanics are about 1100 feet thick and consist of a succession of altered amygdaloidal andesites and possibly basalts.

The dark grey, least altered rocks grade into red-brown, pink, and green epidote-rich varieties. All specimens collected proved to be amygdaloidal. The main constituents are altered plagioclase and chlorite. The plagioclase is altered to iron-stained kaolin, epidote, chlorite, and sericite, but in one specimen the composition was found to be andesine. Some epidote is also commonly present, and two of the less altered rocks contained augite. The amygdales are filled with quartz, chalcedony, chlorite, calcite, and epidote.

OTHER PROTEROZOIC IGNEOUS ROCKS

Other Proterozoic igneous rocks in the Katherine-South Alligator River area include the Grace Creek and Malone Creek Granites, the acid porphyry dykes to the east of the Cullen Granite, the acid volcanics and dykes near the Fergusson Siding, and dolerite dykes. The Grace Creek and Malone Creek Granites are in physical contact with the Edith River Volcanics. They are believed to be late Lower Proterozoic in age, and are probably related to the Cullen Granite batholith. The acid volcanics and dyke rocks near Fergusson Siding are probably closely related to the Edith River Volcanics. The dolerite dykes are intrusive into the Middle Proterozoic succession but their exact age is not known.

The Grace Creek Granite occupies an area of 600 square miles to the south of Sleisbeck (on the Mount Stow and Mount Harvey 1-mile Sheet areas). Texture and composition

remain more or less constant over most of its area of outcrop. The age of the Grace Creek Granite is not precisely known. No contact metamorphism has been observed in the Edith River Volcanics or the Middle Proterozoic sediments, both of which rest directly on the granite. It is therefore regarded as late Lower Proterozoic, and the Middle Proterozoic sediments and volcanics are considered to rest unconformably on it. It is probably genetically related to the Cullen Granite.

Near Birdie Creek, elongated dyke-like bodies of Edith River Volcanics appear to be intrusive into major joint planes in the granite. The mineralogical composition and texture of the dykes, which probably represent feeder channels for the overlying Edith River Volcanics, are distinct from those of the Grace Creek Granite.

The Grace Creek Granite is a porphyritic granophyre or microgranite with a fine-grained micrographic groundmass. The granite is uniform in texture, but a chilled marginal phase and a pegmatitic variety were noted in the Turnoff Creek area. The granite generally consists of phenocrysts of corroded qartz, partly kaolinized orthoclase, sericitized andesine, and pseudomorphs of chlorite set in a groundmass composed almost entirely of micrographic intergrowths of partly kaolinized alkali feldspar and quartz. Accessory minerals are biotite, magnetite, and zircon. Subordinate chlorite and calcite are also present.

The Malone Creek Granite crops out over about 30 square miles to the south-east of Coronation Hill. It is intrusive into the Lower Proterozoic siltstone, which has been converted locally into hornfels, but no contact metamorphic effects have been observed in the overlying Edith River Volcanics. A thin bed of arkose, presumably of Middle Proterozoic age, rests on the north-western corner of the granite.

The granite is a quartz-rich alkalic variety. The essential constituents are kaolinized and sericitized microperthite, quartz, and biotite, with accessory purple fluorite and zircon. A poorly developed micrographic texture is present in places, and near the margins of the intrusion a porphyritic variety may occur. Greisens have also been noted.

The Malone Creek Granite and other small isolated intrusions such as the Wolfram Hill Granite probably represent cupolas rising from the underlying Cullen Granite batholith which on its eastern side has a metamorphic aureole ten miles wide.

Acid Porphyry Dykes. The Lower Proterozoic sediments in the Ranford Hill 1-mile Sheet area have been intruded by dykes of acid porphyry trending between north-east and north-west. The largest dyke is four and a half miles long. In the Phillips Creek/ Helling Siding area Rattigan & Clark (1955) mapped similar porphyry dykes which range up to two and a half miles long and 30 feet thick, and are probably closely related to the volcanics near Fergusson Siding.

The porphyry contains phenocrysts of kaolinized orthoclase, sericitized andesine, and subordinate quartz, set in a groundmass of the same minerals which may show micrographic intergrowths. Other minerals present include biotite, chlorite, epidote, pyrite, calcite, sericite, hematite, and zircon. These Precambrian acid dykes have almost invariably been so extensively altered that it is impossible to determine the original composition of the feldspars in the groundmass.

Volcanics near Fergusson Siding. The volcanic rocks near Fergusson Siding rest unconformably on Lower Proterozoic rocks and are overlain unconformably by Cambrian sediments. They are probably Middle Proterozoic in age, but there is no direct means of correlating them with the Middle Proterozoic volcanics in other areas. Randal (1962) considered them to be part of the Edith River Volcanics.

Carter (1952) gave the name 'Fergusson Toscanite' to a flow of lava and its associated intrusions in the area around the Fergusson railway siding. The lava flow covers an area of 22 square miles and has a maximum thickness of 350 feet. It is commonly flow-lined, and is chilled near its base, but in the central part of the flow the groundmass is relatively coarse-grained. Rattigan & Clark (1955) renamed these acid lavas and associated hypabyssal rocks the 'Fergusson Volcanics', and stated that the dykes range from narrow veinlets near the Yenberrie and Tennyson's uranium prospects to large dykes up to 30 feet thick. The large dykes have chilled margins.

The intrusive and extrusive varieties are similar in mineralogical composition, but the lavas have a finer-grained groundmass, are mostly darker, and may show well-developed flow lines. The rocks contain phenocrysts of partly kaolinized orthoclase or microperthite, sericitized andesine, corroded quartz, and aggregates of chlorite, epidote, and magnetite which probably represent pseudomorphs after hornblende. The groundmass consists mainly of kaolinized orthoclase and quartz, with a little sericitized andesine, chlorite, epidote, magnetite, hematite, and zircon.

Dolerite Dykes. Dolerite dykes occur in the Grace Creek Granite, and basic dykes, up to two miles long and 15 feet thick, have been described by Rattigan & Clark (op. cit., p.14) in the Edith River/Katherine River area. The latter are intrusive into Lower Proterozoic sediments, the Cullen Granite, the Edith River Volcanics, and the lower three units of the Kombolgie Formation. Small outcrops of dolerite also occur in the Birdie Creek Volcanic Member about two and a half miles south-west of Sleisbeck. The dolerites may be intrusive into the volcanics, but their precise relationships are uncertain. Both the dolerites in the Birdie Creek Volcanic Member and the dolerite dykes in the Grace Creek Granite have ophitic textures. They are composed of plagioclase, augite, chlorite, quartz, alkali feldspar, magnetite, and apatite. Stilpnomelane and chalcedony are also present. The plagioclase is labradorite showing alteration to sericite, chlorite, and epidote.

URANIUM MINERALIZATION

The author believes that the uranium mineralization in the South Alligator River Valley area originated from the same magmatic source as the acid extrusives of the Edith River Volcanics. This view is also held by Shepherd (op.cit.) and Dallwitz (pers. comm.).

The Edith River Volcanics, and especially the Pul-Pul Rhyolite Member, commonly show abnormally high radioactivity. Airborne surveys suggest that high radioactivity tends to be patchy in the volcanics, but insufficient work has been done to confirm this. On the ground the volcanics always give a higher-than-background reading.

The radioactivity in these rocks is very hard to pinpoint. A study of autoradiographs made of thin sections of specimens from the Pul-Pul Rhyolite Member suggested that it is not due to minerals such as zircon, but probably emanates from minute grains or intergranular films of uranium minerals.

Several uranium prospects occur within volcanic rocks, e.g. Chavat's in the South Alligator River area, and the A.B.C. near Katherine. In both places there is a local concentration of secondary uranium minerals. All the uranium deposits and prospects in the South Alligator field occur within the general area of outcrop of the Edith River Volcanics.

A close association between rhyolite and uranium mineralization has been noted elsewhere in the world, e.g., the Marysvale area of Utah, U.S.A. (Gilbert, 1957).

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Fig.1. Devitrified ignimbrite showing flattened and devitrified vitric fragments bent round the feldspar phenocrysts. The dark minerals are chlorite and magnetite. Edith River Volcanics, Edith Falls Basin. Ordinary light, X35. Specimen R7647.

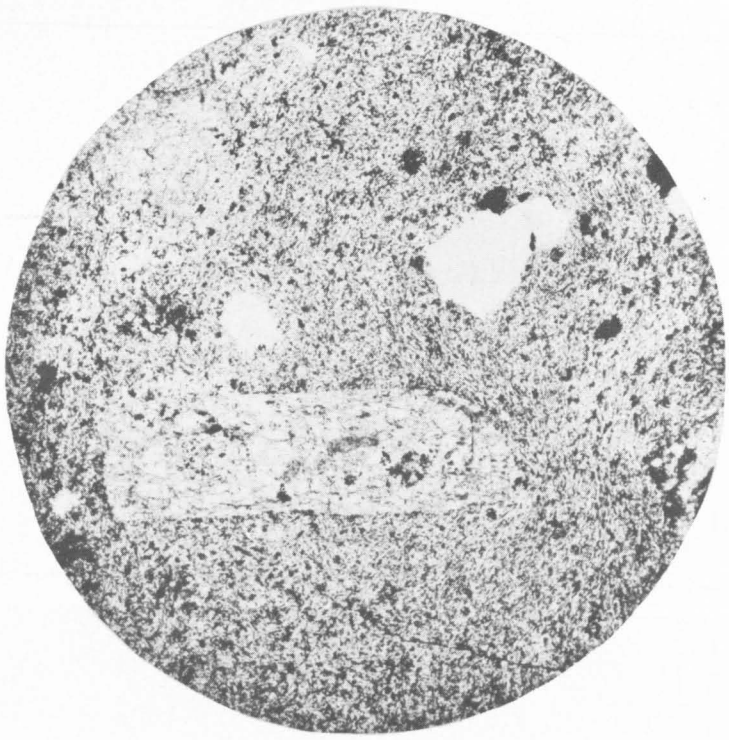


Fig.2. Devitrified ignimbrite showing pseudo-flow texture of quartz laths round a feldspar crystal. Plum Tree Volcanic Member, Mount Callanan Basin. Ordinary light, X35. Specimen R7743.

Plate 2

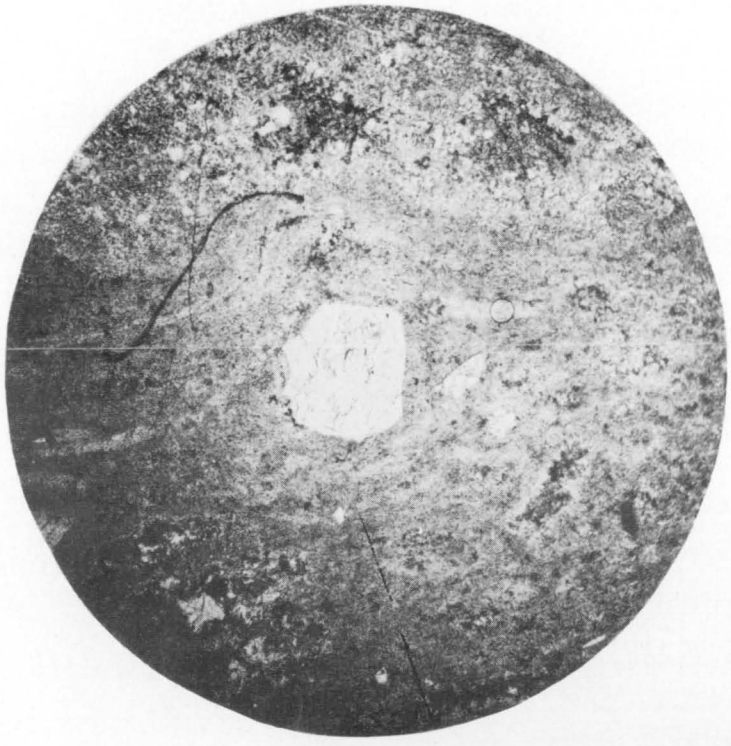


Fig.1. Devitrified ignimbrite showing devitrified vitric fragments bent round a quartz phenocryst. Larger, more coarsely crystalline fragments are visible at the top and bottom of the photograph. Edith River Volcanics Mount Callanan Basin. Ordinary light, X35. Specimen R7661.

Fig.2. Devitrified ignimbrite showing devitrified vitric fragments bent round quartz phenocrysts. Part of a large rock fragment is also visible. Edith River Volcanics, Mount Callanan Basin. Ordinary light X35. Specimen R7672.

Fig.1. Devitrified ignimbrite showing former glass shards now replaced by fibrous, radiating chlorophaeite surrounded by a rim of quartz grains. The phenocryst is altered feldspar. Plum Tree Volcanic Member, Mount Callanan Basin. Ordinary light, X35. Specimen R7725.

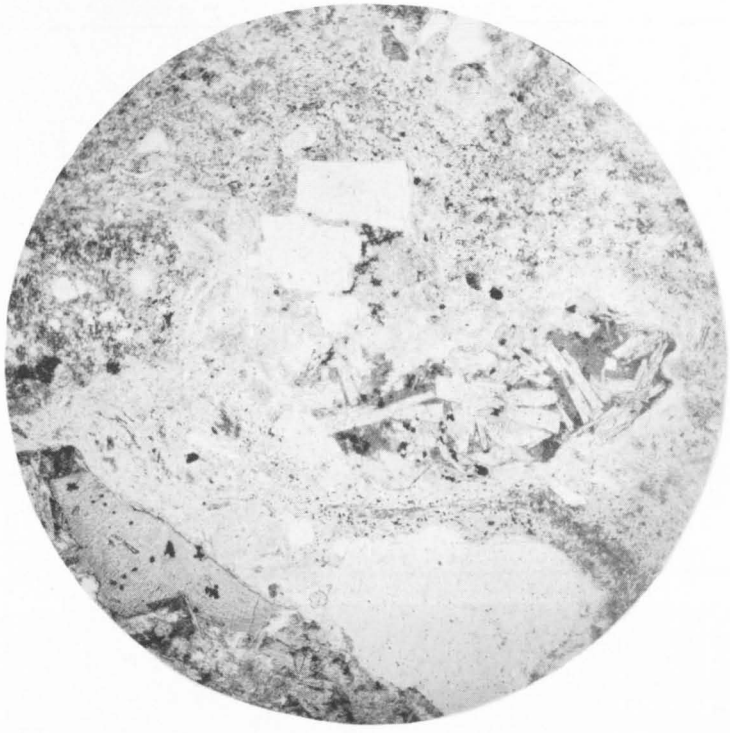


Fig.2. Devitrified ignimbrite showing phenocrysts of quartz and feldspar, one small rock fragment, and part of a large rock fragment. Edith River Volcanics, Mount Callanan Basin. Ordinary light, X35. Specimen R7668.

Plate 4

Fig.1. Devitrified ignimbrite showing well-developed criss-cross lath texture. Opposite the feldspar crystal is a grain of zircon. Edith River Volcanics, Birdie Creek Basin. Crossed nicols, X60. Specimen R7692.

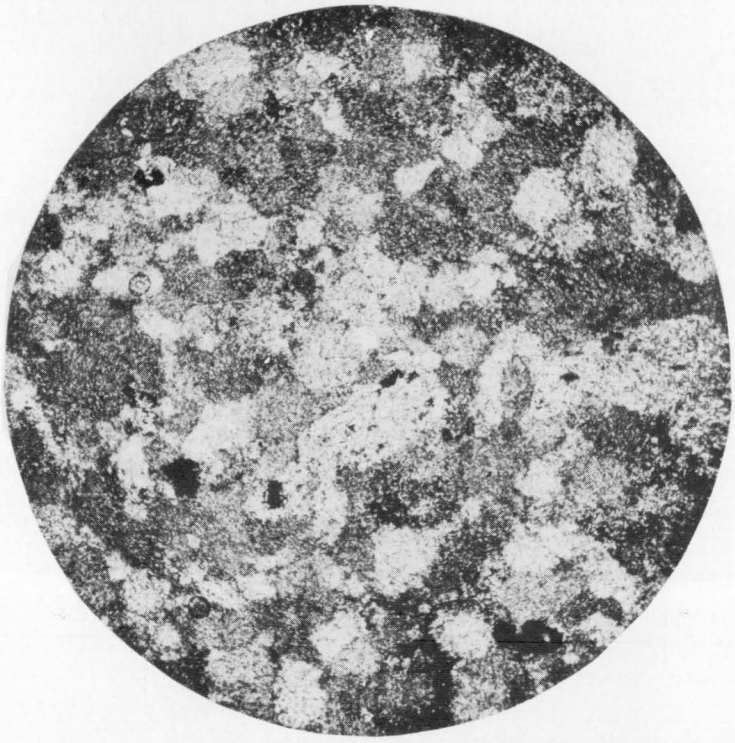


Fig.2. Feldspar porphyry showing the effect of devitrification and silicification of the groundmass. Edith River Volcanics, Birdie Creek Basin. Crossed nicols, X35. Specimen R7695.

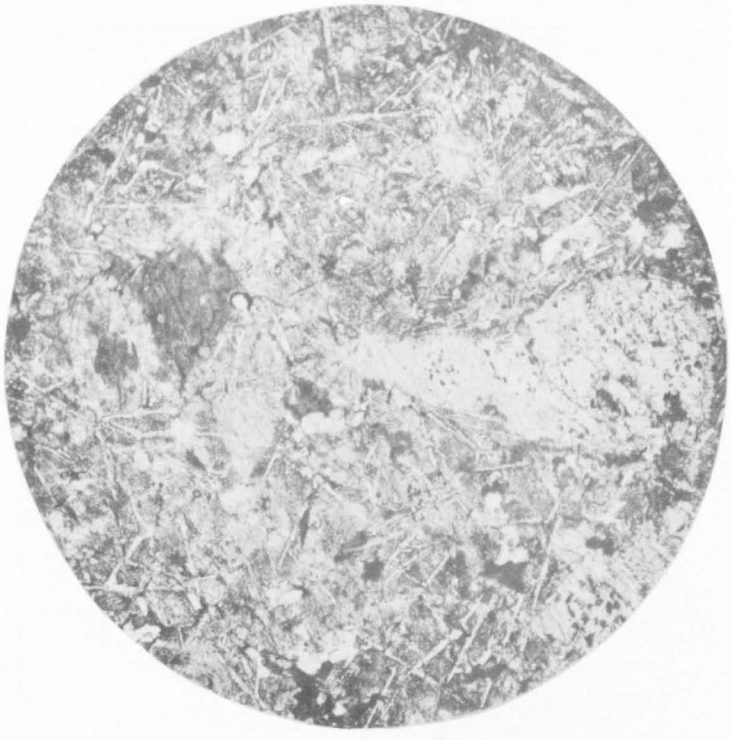


Fig.1. Quartz-feldspar porphyry showing prominent quartz laths in the ground-mass. The two phenocrysts are feldspar and chlorite. Edith River Volcanics, Birdie Creek Basin. Ordinary light, X35. Specimen R7711.

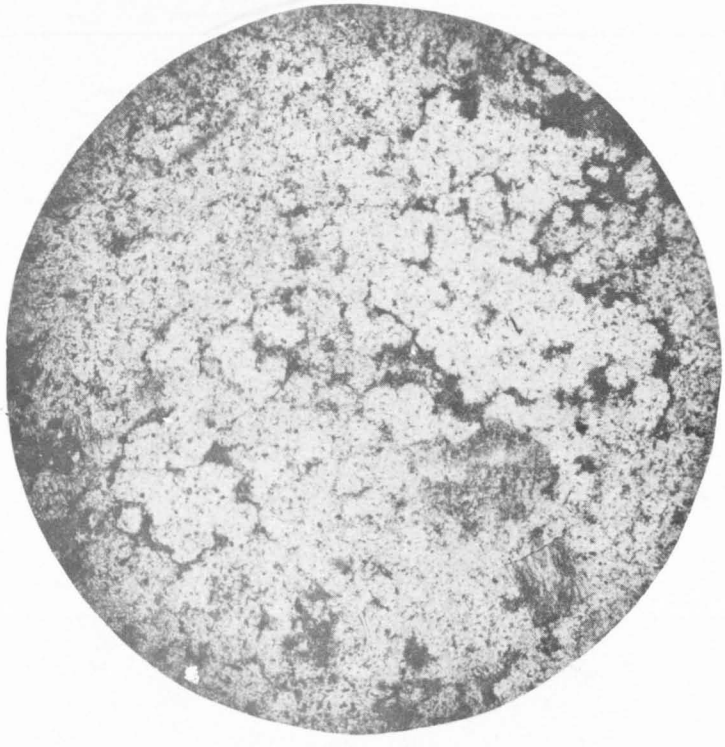


Fig.2. Devitrified ignimbrite showing peculiar corona-like distribution of chlorite (see page 15). Plum Tree Volcanic Member, Mount Callanan Basin. Ordinary light, X35. Specimen R7746.

PLATE 6

MIDDLE PROTEROZOIC GEOLOGY OF THE KATHERINE–SOUTH ALLIGATOR RIVER AREA

NORTHERN TERRITORY

Scale 1 : 250,000

5 0 5 10 15 MILES

5 0 5 10 15 20 25 KILOMETRES

Geology from maps published by the Bureau of Mineral Resources
Compiled, 1963, by: P.R. Dunn and J.R. Stewart

Reference

QUATERNARY
- Qa — Alluvium, soil cover

CRETACEOUS
- Mullaman Beds — Klm — Sandstone, siltstone

CAMBRIAN
- Daly River Group — €md — Limestone, sandstone
- Antrim Plateau Volcanics — €la — Basalt, sandstone

UPPER PROTEROZOIC
- Tolmer Group — Put — Sandstone

MIDDLE PROTEROZOIC
- Katherine River Group
  - Kombolgie Formation — Phk — Sandstone, conglomerate
  - Henwood Creek Volcanic Member — Phhf — Andesite, basalt
  - McAddens Creek Volcanic Member — Phm — Andesite, basalt
  - Birdie Creek Volcanic Member — Phb — Andesite
  - Plum Tree Creek Volcanic Member — Phl — Andesitic ignimbrite
  - Kurrundi Member — Phr — Tuffaceous sandstone, conglomerate
  - Edith River Volcanics — Phe — Rhyolitic and andesitic ignimbrite, basalt, tuff
  - Phillips Creek Member — Php — Sandstone, conglomerate, shale
  - (Volcanics near Fergusson Siding) — Phf — Rhyolite flows and hypabyssals

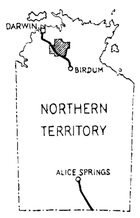
LOWER PROTEROZOIC
- Granite
- Dolerite, gabbro
- South Alligator R Group — Pla — Siltstone, chert, limestone
- Finniss River Group
  - Burrell Creek Formation — Plb — Siltstone, greywacke
  - Dorothy Volcanics — Minor basic lavas
- Goodparla Group — Plg — Quartz greywacke, siltstone, chert

ARCHAEAN
- Stag Creek Volcanics — Altered basalt and basaltic agglomerate

Reference

- Geological boundary
- Anticline (showing plunge)
- Fault
- Strike and dip of strata
- Dip <15°
- Dip 15-45°
- Trend lines (air-photo interpretation)
- Joint pattern
- Shear zone
- Dyke, d-dolerite, q-quartz, qp-quartz porphyry
- Mine
- Prospect
- Au Gold
- Cu Copper
- U Uranium
- W Tungsten
- Road
- Vehicle track
- Railway with siding
- Town
- Settlement, camp
- "Goodparla" Homestead

INDEX TO 1:250,000 AND 1 INCH TO 1 MILE SHEETS



PINE CREEK | MT EVELYN
GOODPARLA NORTH | JIM-JIM CREEK
GOODPARLA SOUTH | MT EVELYN
TABLETOP | RANFORD HILL | MT STOW
LEWIN SPRINGS | MT TODD | MT HARVEY
FLORINA | KATHERINE | KATHERINE RIVER
FERGUSSON RIVER | KATHERINE

Sections

SCALE : V/H = 4