BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD

Record 1980/33

GEOLOGY OF THE MUNDOGIE 1:100 000 SHEET AREA, NORTHERN TERRITORY

P.G. Stuart-Smith, R.S. Needham, M.J. Roarty ., & I.H. Crick

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(Note: The Mundogie 1:100 000 Sheet is available for sale from BMR, PO Box 378, Canberra City, 2601. Compilation sheets are available from Copy Service, Government Printer (Production), PO Box 84, Canberra, 2600).

ABSTRACT

This Record contains a detailed reappraisal of the geology of the Mundogie 1:100 000 Sheet area, mapped during 1976 and 1977 using 1:25 000 scale colour air photographs. The area was previously mapped by BMR in 1954 and 1955 using 1:50 000 scale black and white photographs and the northeast quarter was examined using 1:16 000 scale black and white photographs in 1972. The Sheet area is about 175 km east-southeast of Darwin and lies mostly within the catchment of the South Alligator River. The main physiographic units are the Arnhem Land Plateau, Uplands and Northern Plains.

The Sheet area is occupied by a sequence of Lower Proterozoic metasediments (the Namoona, Mount Partridge, South Alligator and Finniss River Groups) which have been intruded by dolerites and granite and are unconformably overlain by Carpentarian volcanics and plateau sandstone.

Deposits of gold, silver-lead-zinc, copper and uranium have been worked in the area, with uranium accouting for the majority of the value of minerals produced.

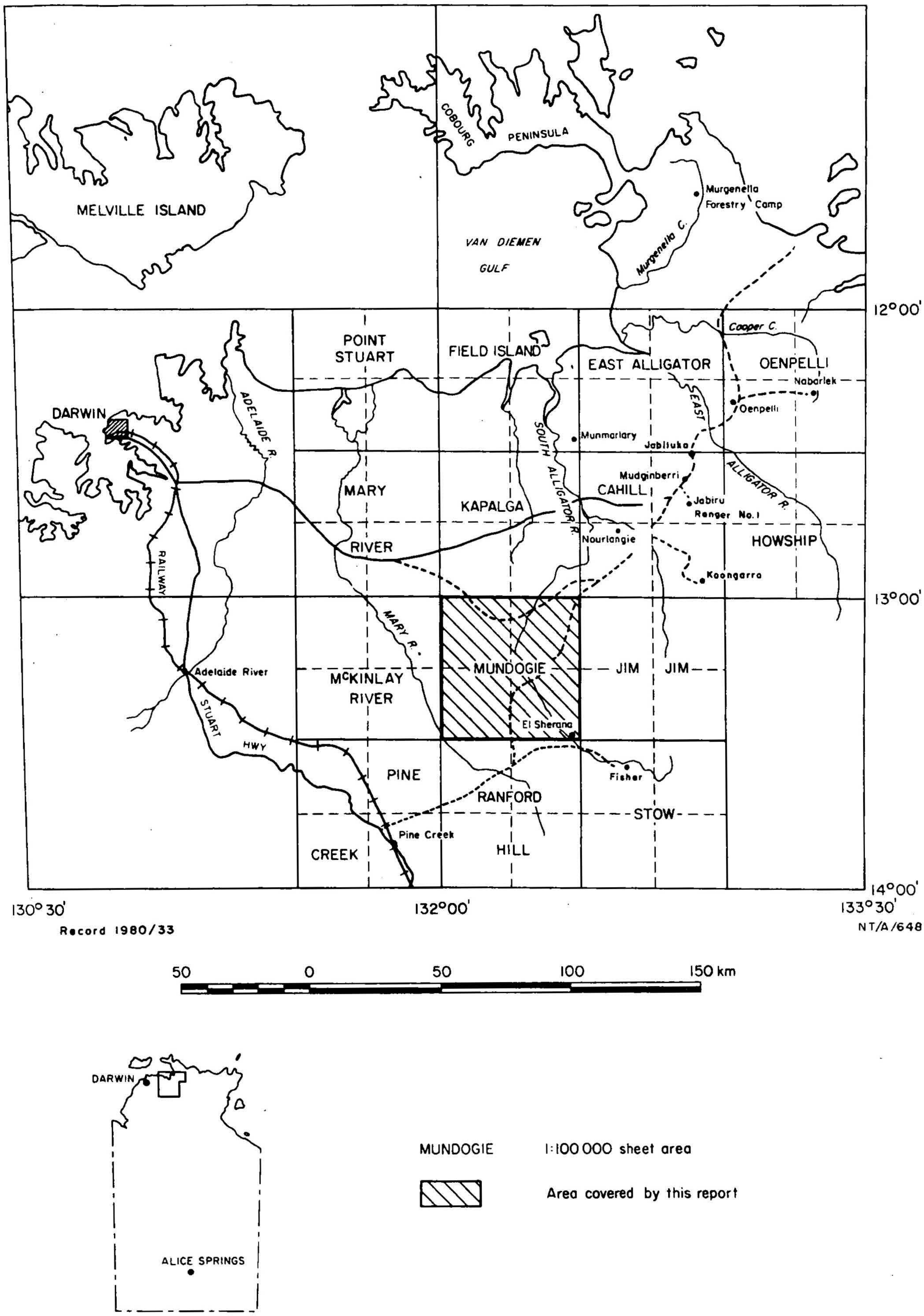

Fig.1 LOCALITY MAP

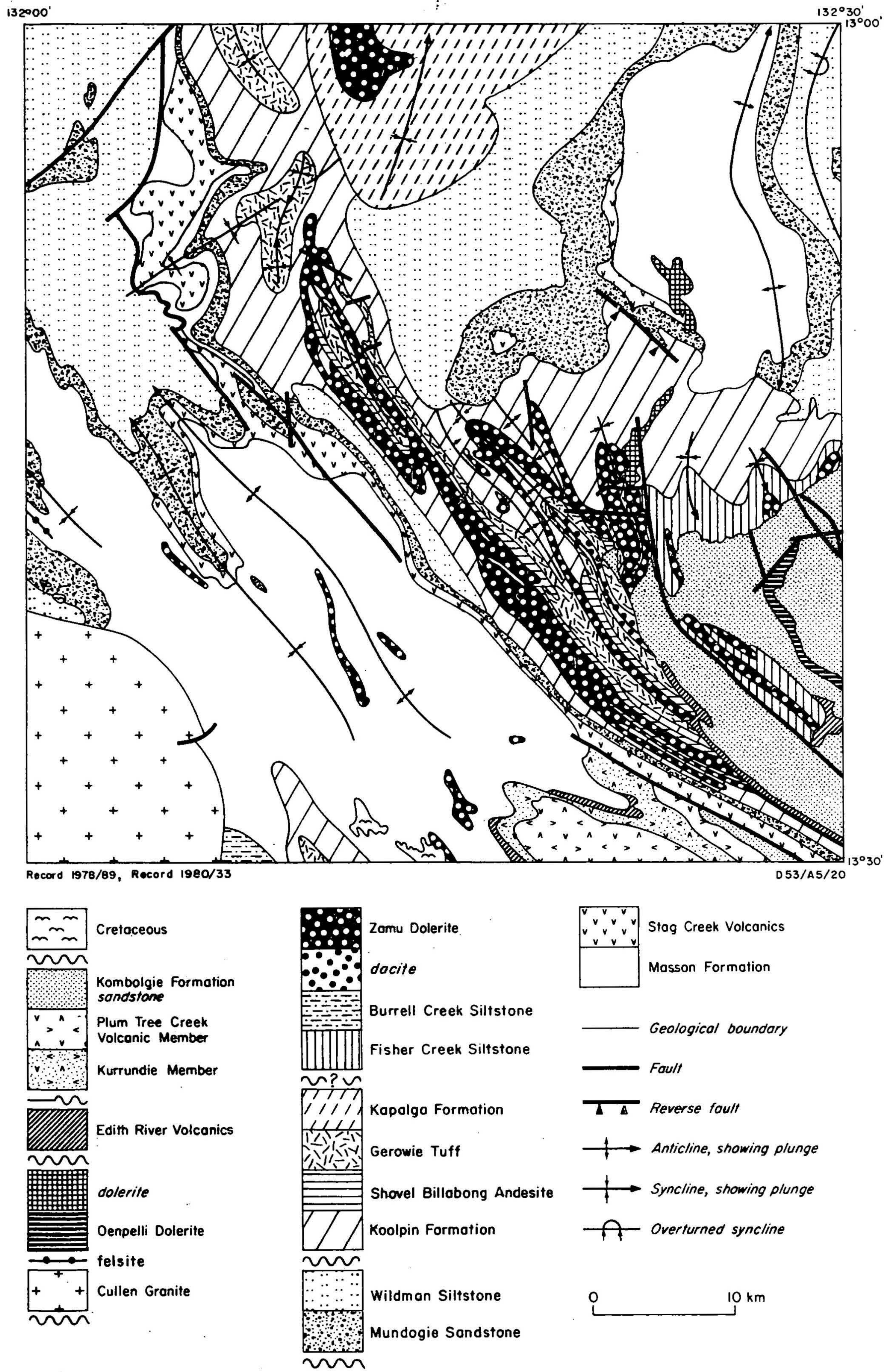

Figure 2 Mundogie 1:100 000 Sheet area, interpreted solid geology

INTRODUCTION

This Record contains a detailed account of the geology of the Mundogie 1:100 000 Sheet area (Fig. 1). The generalised geology of the area is shown in Fig. 2 and a summary of stratigraphy is tabulated in Table 1. A preliminary account was given by Needham, Crick & Stuart-Smith (1978); and a brief description of the geology, with emphasis on differences between the recent work and that of earlier workers, was given by Needham, Crick, Stuart-Smith & Roarty (1978). The latter report contains compilation sheets at 1:25 000 scale (reduced to 1:100 000 scale) of the geology of the Sheet area, thin-section descriptions, and data relating to a scout drilling program. Proposed and approved changes in stratigraphic nomenclature are appended to the present Record.

The northeastern sector of the Sheet area was mapped in 1972 using 1:16 000 scale black and white photography by Needham & others (1975), but the entire area was re-examined by us in 1976 using 1:25 000 scale colour photography, as a joint project with the Northern Territory Geological Survey. The work comprises part of the program of the Pine Creek Project, which is to study the geology, geophysics and mineralisation of the Pine Creek Geosyncline and to produce geological maps at 1:100 000 scale. The 1977 program entailed numerous ground traverses by landrover and foot, and the drilling of 58 scout rotary holes using a BMR Mayhew 1000 rig. Research in the field was in close liaison with a BMR geophysical party whose aim was to supplement geological data mainly in the northern half of the area where exposure is sparse. The geophysical results are being reported separately.

Location and access

The location of the survey area is shown in Figure 1. The area is about 175 km east-southeast of Darwin and is reached by the Jim Jim and Pine Creek roads passing through the Sheet area. Access within the Sheet area is good and is provided mainly by boundary and access tracks within the Goodparla Pastoral lease.

Previous investigations

Early investigations of the Sheet area were mostly reconnaissance visits or cursory examinations of mineral occurrences. Reports of these investigations and later reports on mineral occurrences prepared by the

Aerial, Geological, & Geophysical Survey of Northern Australia are listed by Walpole (1962). In 1954 and 1955 the two 1-mile Sheet areas covering the Mundogie 1:100 000 Sheet area (the Mundogie Hill and Goodparla North 1-mile Sheet areas) were mapped at 1:50 000 photo-scale by geological parties of the BMR. Part of the southern central part of the Sheet area was also mapped at a scale of 1 inch:1000 feet as part of the geological map of the South Alligator River area, Northern Territory (Plate 31 in Walpole, Chrohn, Dunn & Randall, 1968). Since 1969 exploration companies have been active in the area, and have been prospecting principally for uranium and base metals. Reports of their activities are lodged with the Northern Territory Department of Mines & Energy, Darwin and are summarised in the Economic Geology section. All open-file company reports are listed in Appendix 2.

Changes in stratigraphic relationships and nomenclature

The facies-dominated stratigraphic concept of the Pine Creek Geosyncline advanced by Walpole & others (1968) has been replaced by a chronostratigraphic concept in which units are superposed with relatively little interfingering, and continuous through most of the geosyncline with little facies variation (Needham & others, 1980). Accordingly, the definitions of many of the units described by Walpole (1962) in the Mundogie Sheet area have radically changed, and the new definitions are given in Appendix 1. Figure 3 demonstrates diagrammatically the changes to the stratigraphy.

Walpole (1962) grouped the rocks into the Goodparla, Finniss River and South Alligator Groups. The Finniss River and South Alligator Groups are retained, but the Goodparla Group, which contains a mixture of formations known now to belong partly to the South Alligator Group and partly to a position stratigraphically below this group, has been discontinued. The names Namoona Group and Mount Partridge Group now describe those rocks below the South Alligator Group. The South Alligator Group lies below the Finniss River Group and is not confined to a separate basin of deposition nor deposited over an overlapping time interval as inferred by Walpole & others (1968).

The Stag Creek Volcanics are not the remains of an Archaean ridge separating major basins of deposition in the geosyncline, but conformably overly the Masson Formation. The Masson Formation contains carbonaceous shale, calcarenite, sandstone and limestone; greywacke is

Stratigraphy of the Mundogie Sheet area, after Walpole (1962) and Walpole and others (1968).

Stratigraphy of the Mundogie Sheet area as presented in this report.

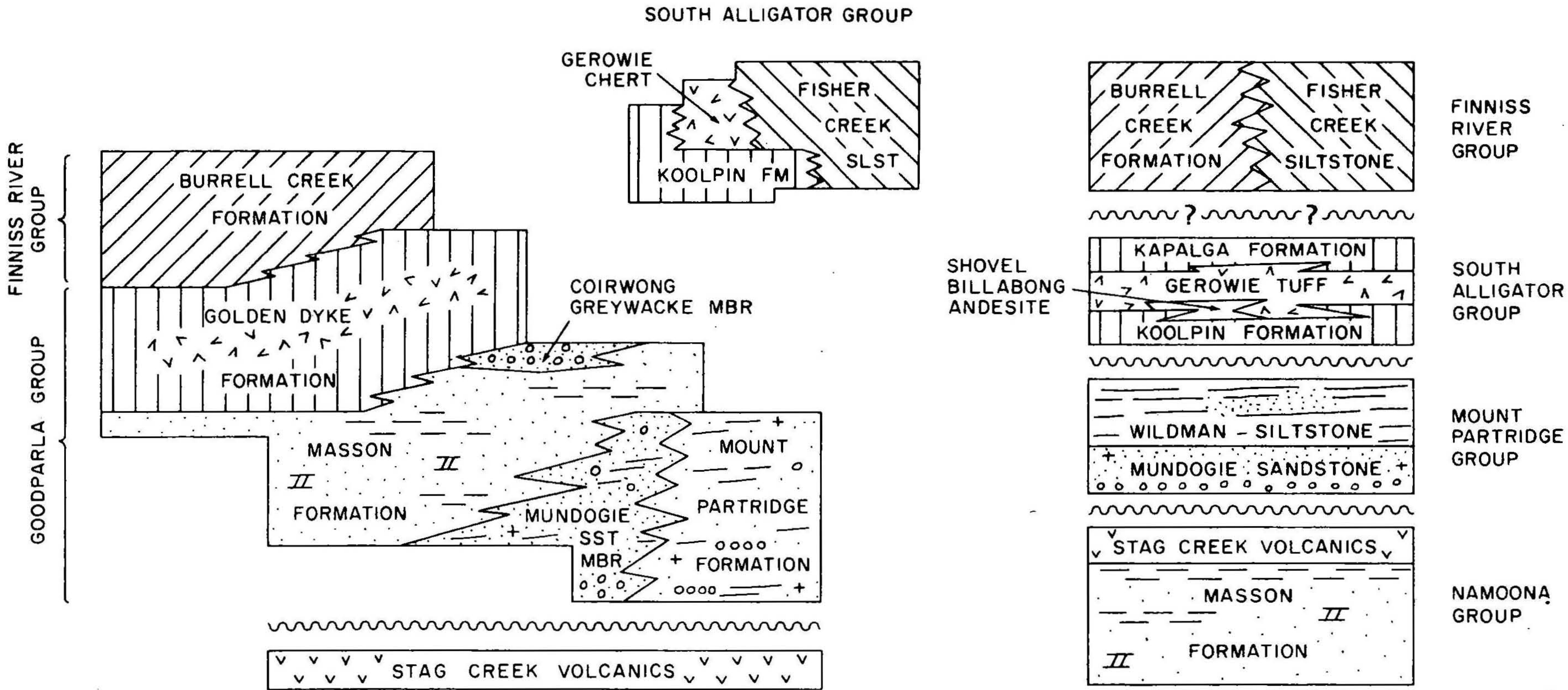

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Fig. 3 Diagrammatic comparison between the Lower Proterozoic stratigraphy of the Mundogie Sheet area and as presented by Walpole (1962), and Walpole & others (1968), and in this Record.

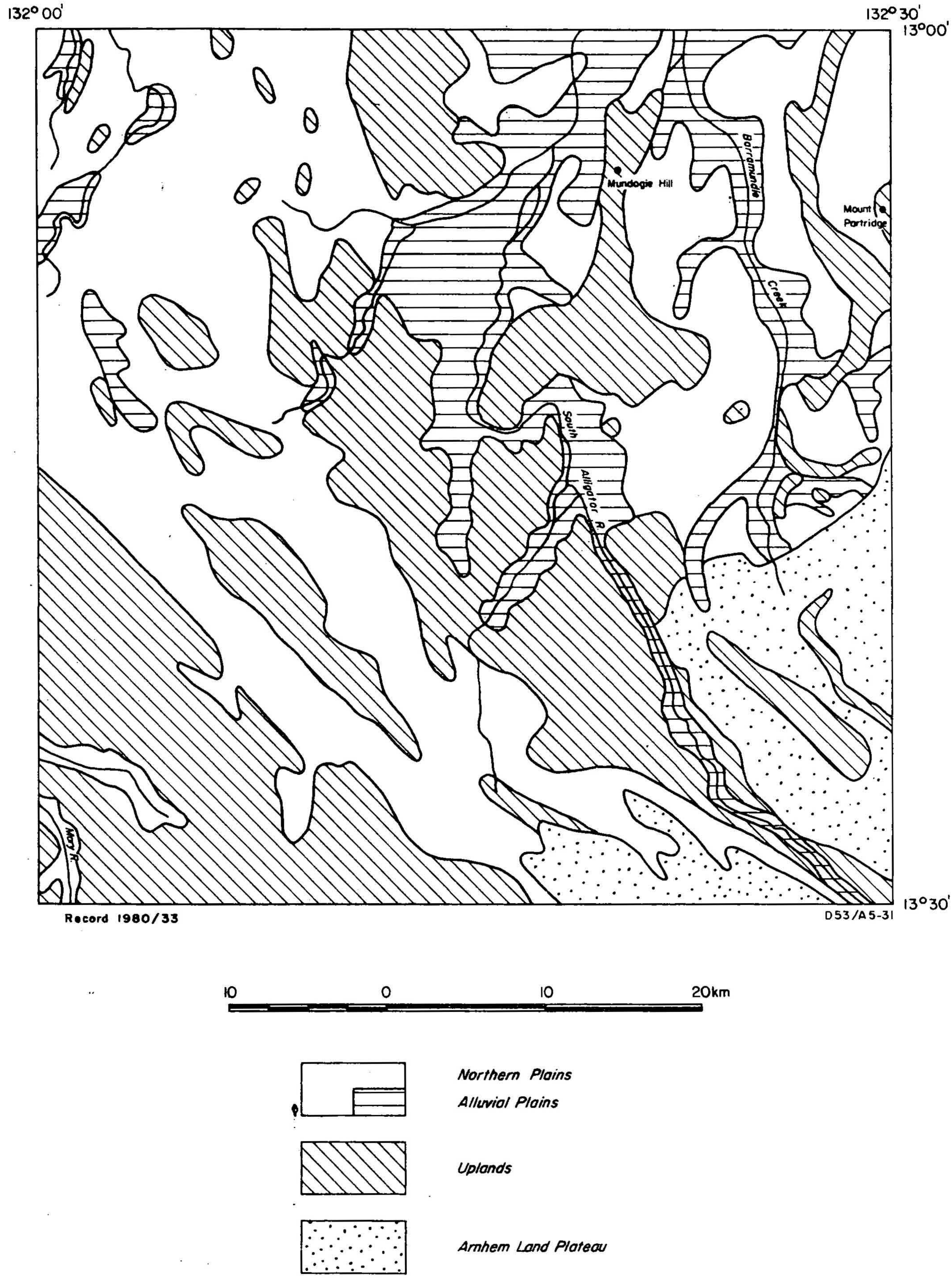


Figure 4 Physiographic sketch map, Mundogie 1:100 000 Sheet area.

only a minor constituent. The two formations make up the Namoona Group. Interbedded sandstone, conglomerate and siltstone of Coirwong Greywacke, Mundogie Sandstone Member and Mount Partridge Formation described by Walpole & others, have been grouped into a single unit, the Mundogie Sandstone, which unconformably overlies the Stag Creek Volcanics and Masson Formation. Siltstone of Walpole's Mount Partridge and Masson Formations which overlie the Mundogie Sandstone are named the Wildman Siltstone. The Mundogie Sandstone and Wildman Siltstone make up the Mount Partridge Group.

In the light of more detailed field research the stratigraphy of the South Alligator Group as defined by Walpole (1962) has been modified: cherty rocks of the Gerowie Chert interpreted by Walpole (1962) as possibly diagenetically altered dolomite interfingering with the Koolpin Formation were identified as tuff and argillite (Crick & others, 1978) which conformably overlie and are interbedded with the Kooplin Formation. These rocks have accordingly been renamed Gerowie Tuff; conformity with the enclosing sediments of this largely ash-fall unit confirms the chronostratigraphic character of the sedimentary pile. Use of the name Koolpin Formation is confined to the iron-rich and chert-banded carbonaceous pelites and carbonates below the Gerowie Tuff. Lithologically similar strata above the tuff are included in the Kapalga Formation. The Fisher Creek Siltstone has been moved from the South Alligator Group into the overlying Finniss River Group, because of its similarity in parts to the Burrell Creek Formation and to a possible unconformity at the base. Rock types in the Fisher Creek Silstone are more diverse than reported by Walpole (1962).

PHYSIOGRAPHY

Most of the Mundogie 1:100 000 Sheet area lies within the catchment of the South Alligator River which flows north to Van Diemen Gulf. The Arnhem Land Plateau, Uplands and Northern Plains (Fig. 4) are the main physiographic units in the Sheet area and have been described by Walpole (1962) and Story & others (1969, 1976).

The dominant physiographic unit of the Sheet area is the Arnhem Land Plateau, whose edge forms sheer scarps up to 150 m high. The plateau is markedly dissected: the main water courses form gorges up to 100 m deep, and tributaries are commonly incised along faults or joints.

Vegetation cover is sparse and confined to patches of tall open forest or annual grasses in pockets of deep sandy soil or in gorges and along the escarpment.

Steep rocky ridges of resistant Lower Proterozoic sediments and igneous rocks form the Uplands (Fig. 5) which rise sharply up to 100 m above the level of the Northern Plains. The ridges have skeletal soils which support a woodland of bloodwood and box with perennial grasses.

The Northern Plains are gently undulating lowlands of rubbly rises formed during the Late Tertiary Period and Recent alluvial flats. The Lower Proterozoic rocks, which form the rises, are deeply weathered and covered by shallow gravelly loams or skeletal soils which support a variable woodland of broadleaved bloodwood and box, and annual or perennial grasses. Sand and silt deposits in channels and floodplains of the South Alligator River system bisect the Sheet area and are more extensive in the northern part.

STRATIGRAPHY

NAMOONA GROUP

The Namoona Group, defined by Needham & others (1980) contains the Masson Formation and the Stag Creek Volcanics and is thought to correlate with the lower member of the Cahill Formation. The group is the oldest unit in the Sheet area and elsewhere in the Pine Creek Geosyncline the Masson Formation or its correlatives overlie the basal Lower Proterozoic Batchelor and Kakadu Groups. Within the Sheet area the group is unconformably overlain by younger Lower Proterozoic, Carpentarian, Cretaceous and Cainozoic sediments.

MASSON FORMATION

Introduction

The term Masson Formation is restricted in the Mundogie Sheet area to all the sedimentary rocks (excluding volcanogenic sediments) in the Sheet area which underlie the Mundogie Sandstone. Other rocks in the Sheet area included by Walpole & others (1968) in the Masson Formation are now included in the Stag Creek Volcanics or the Mount Partridge Group. The formation crops out in the southwest of the Sheet area as low strike ridges (psammitic units) or as rubbly rises (pelitic units) and is mostly

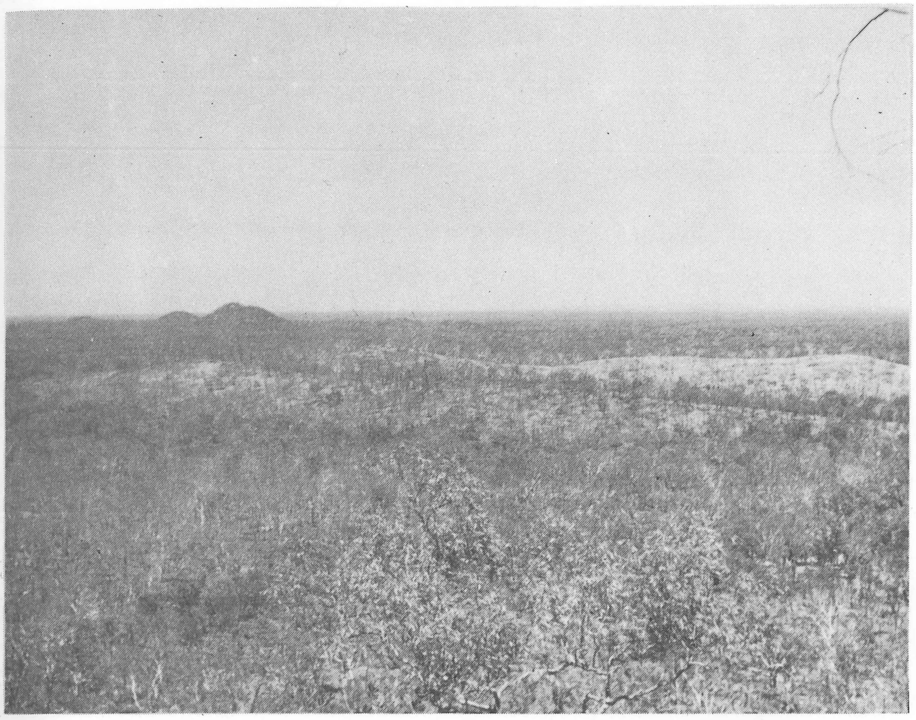


Figure 5. Typical view of uplands looking south from Minglo prospect; white ridge in foreground is Masson Formation and rounded peaks in background are Inbarin Hills. M2249-21

covered by a thin veneer of Cainozoic skeletal soils and in places by mesa-like cappings of Cretaceous sediments (Petrel Formation). In the Barramundie Creek area quartzite, phyllite, schist and dolomite previously mapped as subunit Elp[1] of the Mount Partridge Formation (Needham & others, 1975) underlie the Mundogie Sandstone and in places the Stag Creek Volcanics, and are probably Masson Formation.

Stratigraphic relations

The Masson Formation is the oldest Lower Proterozoic unit exposed in the Sheet area and is overlain conformably by the Stag Creek Volcanics and unconformably by the Mundogie Sandstone, Koolpin Formation, Edith River Volcanics, Kombolgie Formation and Petrel Formation. The Formation is possibly in contact with the Burrell Creek Formation in the southwest of the Sheet area under Cainozoic cover. The contact could be unconformable or faulted.

In the southwest of the Sheet area the Masson Formation has been intruded by the Cullen Granite. A contact metamorphic aureole about 1 km wide, containing chiastolite and cordierite hornfels surrounds the granite. In the same area the formation has been folded into a series of northwest-plunging anticlines and synclines which are commonly displaced several kilometres by strike slip faults.

In the Barramundie Creek area the base of the formation is not exposed but a low gravity anomaly in the area and the presence of hydrothermal gold-bearing and tin-bearing quartz veins possibly indicate the presence of a concealed acid intrusive body close to the surface beneath the Formation.

Description

Formal subdivision of the Masson Formation has not been attempted but a broad two-fold stratigraphic sequence is recognised. The lower unit, about 2500 m thick, is lithologically diverse and is composed of calcarenite, porous quartz sandstone, sandstone, quartzite, siltstone and shale with minor calcareous siltstone and limestone. The upper unit is about 300 m thick and consists of siltstone and shale and is host to Ag-Pb-Zn deposits at Namoona and Minglo.

Shale and siltstone

Shale and siltstone probably comprise over 50 percent of the Masson Formation and typically crop out as flaggy scree over low rises between sandstone and quartzite ridges. They are highly cleaved and very iron-rich. Adjacent to the Cullen Granite in the contact metamorphic aureole the shales are spotted and carbonaceous, and commonly contain chiastolite and cordierite.

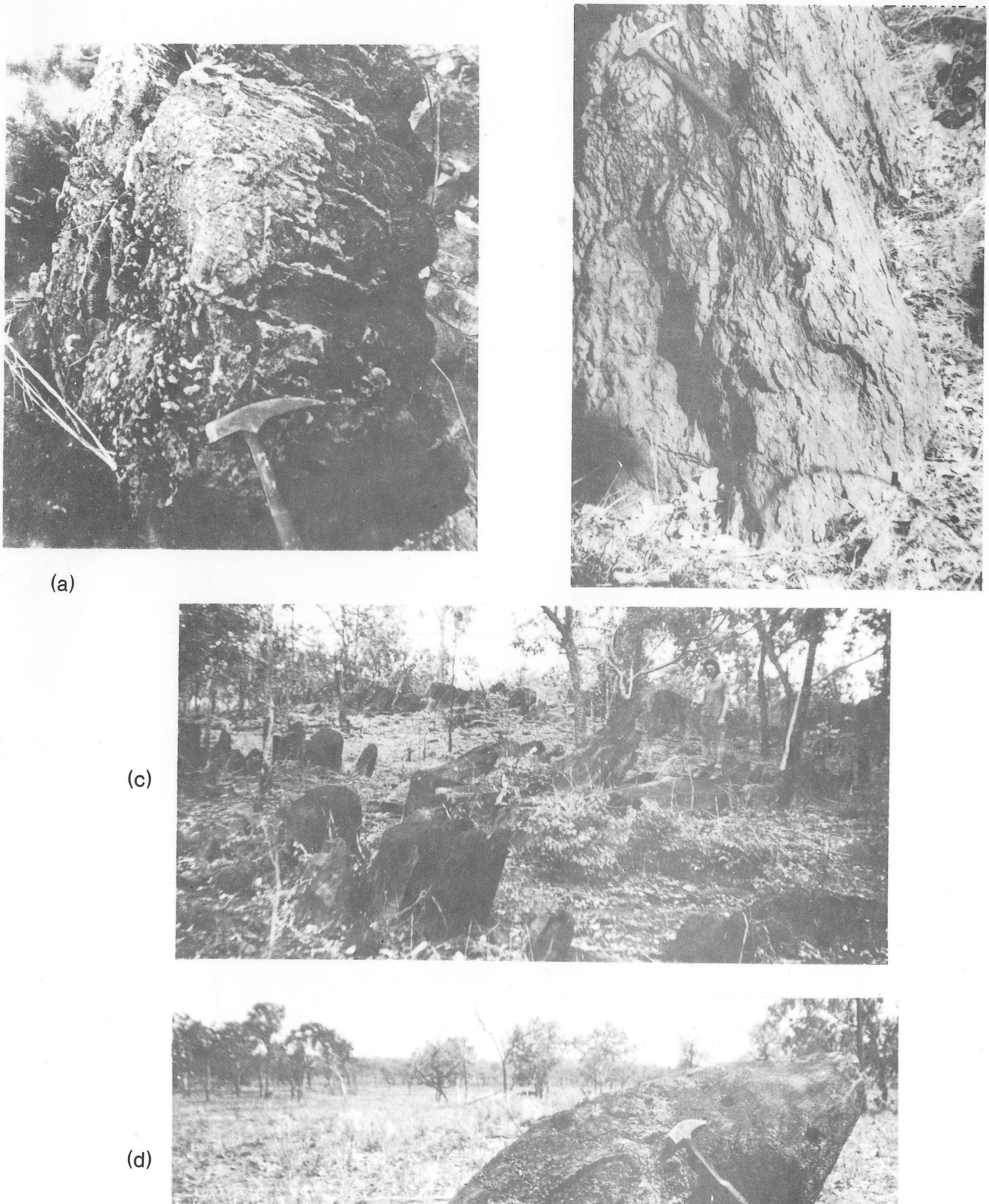
Quartz sandstone

Quartz sandstone crops out as low to massive ridges, is well bedded (30 cm to 1 m thick) and commonly exhibits cross bedding, graded bedding and ripple marks. Interbeds of brick-red shale and siltstone are common. Locally sandstone has been silicified at the surface to form a quartzite. Sandstone and quartzite typically form blocky outcrops due to intense jointing. Both consist of closely packed well sorted medium- to coarse-grained, subangular to rounded quartz grains in a matrix of finer grained granoblastic quartz, minor sericite clots and trace amounts of muscovite. Sutured boundaries on some grains indicate a degree of recrystallisation. Carbonate may be present in the cement.

About 25 percent of quartz sandstones are friable limonitic rocks which have a characteristic dull sound when struck. They are well bedded, quartz veined and consist predominantly of sandy quartz and minor feldspar grains in a ferruginous limonitic cement.

Calcarenite

Calcarenite forms less than 10 percent of a relatively poorly exposed sequence at the base of the formation and usually occurs as bouldery or strike ridge outcrop (Fig. 6a). The rocks have a distinctive porous brown limonitic crust and are dark grey with subrounded to angular grains of limestone, quartz, feldspar and minor rock fragments set in a very fine grained dark grey aphanitic matrix. Poorly to moderately sorted grains ranging in size from 0.25-2.0 mm of fine-grained limestone, quartz, minor feldspar and rock fragments are set in a matrix of coarse recrystallised carbonate, quartz, clots of sericite and trace amounts of muscovite. The matrix mostly constitutes 40-60 percent of the rock. Some of these rocks contain pebbles of quartz and feldspar. Similar rocks overlying the upper silstone/shale unit were termed feldspathic quartz greywacke, as they do not contain limestone grains but have a carbonate



(a)

(b)

(c)

(d)

Figure 6. (a) Calcarenite, Masson Formation, bedding dips steeply to left. M2249-34.

(b) Boulder of basaltic breccia, Stag Creek Volcanics in Mundogie Hill inlier. M2249-36.

(c) Typical outcrop of basaltic breccia, Stag Creek Volcanics. M2249-25.

(d) Tuffaceous, feldspathic quartz greywacke, Stag Creek Volcanics, note bedding at right angles to prominent outcrop attitude. M2249-35.

cement. These rocks also contain volcanic rock fragments and are spatially related to the Stag Creek Volcanics and are therefore considered part of that formation.

Limestone

Rare limestone is interbedded with calcarenite and calcareous siltstone, and crops out in creek beds or low rises. They are predominantly dark grey and finely laminated to massively bedded and consist of fine to coarse-grained granobalstic carbonate (0.05 to 0.5 mm) with minor quartz, opaques and trace amounts of unstrained secondary muscovite usually discordant to the main foliation.

Calcareous silstone

Rare laminated calcareous siltstone, interbedded with limestone and calcarenite, is very similar in appearance to limestone but contains more silt and sandy material and commonly has a siliceous capping. It consists of very fine grained carbonate, quartz, minor sericite and opaques.

STAG CREEK VOLCANICS

Introduction

The term Stag Creek Volcanics was first applied by Raggatt (1958) and subsequently by Walpole (1962) to a narrow belt of 'greenstones', described as altered basalt and basalt agglomerate, in the South Alligator Valley area.

Fieldwork during 1979 proved that the volcanics are more extensive than mapped by earlier workers and include tuffaceous shale, phyllite, siltstone and greywacke previously mapped as sediments of the Masson Formation. They form two major belts: one trending north-westerly from south of El Sherana to 8 km west of Black Jungle Springs and the other, a tightly folded and faulted belt, running parallel to ridges of Mundogie Sandstone from Coirwong Gorge to near the Namoona prospect. The volcanics also crop out in a small inlier 14 km southwest of Mundogie Hill and have been intersected in drill holes 3 km southeast of the Hill.

Except for tuffaceous shale, which crops out as rubbly strike ridges, exposure of the volcanics is poor owing to deep weathering and extensive Cainozoic soil, sand and scree. Basic volcanic flow and breccia rocks typically crop out as isolated boulders or small bouldery mounds (Fig. 6 b, c) and rarely as pavements or in creek beds. A foliation, prominent in outcrop (Fig. 6 b) parallels slaty cleavage in the adjacent pelites and is probably an axial plane cleavage to the regional tight to isoclinal folds rather than a primary flow structure. Where the volcanics are not exposed their subsurface presence is indicated by a deep red soil or a greenish brown clay commonly pitted with shallow depressions a few metres across.

Stratigraphic relations

The Stag Creek Volcanics were orginally thought to be Archaean basment of unknown thickness (Walpole, 1962). Needham & others (1975) suggested that the volcanics were Lower Proterozoic and interbedded with the Masson Formation. This was later confirmed by drilling at Anomaly 2J (GR 151131) and reported by Foy & Miezitis (1977) who also described the unit in some detail.

The volcanics conformably overlie the Masson Formation and are overlain unconformably by the Mundogie Sandstone. Foy & Mietzitiz (1977) found no evidence for an unconformity between the unit and the Coirwong Greywacke (Mundogie Sandstone) in drill core, but where the regional trend is westerly (such as 1 km southeast of Coirwong Gorge or 13 km northwest of Goodparla Homestead) the unconformable relationship is indicated by different structural trends and the variety of rock type beneath the Mundogie Sandstone. The upper and lower contacts of the volcanics are covered by scree or Cainozoic soil cover.

Description

The volcanics form a conformable sequence up to 1000 m thick of interbedded basic volcanic flows, flow breccia, tuff and tuffaceous shale, siltstone and greywacke.

Because of poor exposure, the volcanics cannot be subdivided. In places a 200-m-thick tuffaceous shale unit appears to form the top of the formation.

Basic volcanic flow rocks

The basic volcanic flow rocks are highly altered pyroxene andesite but have been described previously as altered basalts or basaltic andesites

(Foy & Miezitis, 1977). They are typically massive dark greenish aphanitic rocks containing altered feldspar phenocrysts and less commonly small rounded amygdules.

The flow rocks are slightly porphyritic; phenocrysts are mainly composed of discrete or aggregated idiomorphic plagioclase (andesine) up to 1 cm long which is commonly partly or completely replaced by chlorite, colourless to dark yellow epidote, sphene, albite, quartz and hematite. Phenocrysts of highly altered idiomorphic clinopyroxene ($<$1 mm) are rarely present.

The groundmass is composed of fine idiomorphic sodic plagioclase (andesine) crystals or microlites, and intergranular colourless to pale brown augite which is rarely preserved and mostly altered to dark green chlorite. The plagioclase crystals show subparallel alignment or fluidal tecture in places. Quartz and potassic feldspar are rarely present as interstitial minerals. Commonly the groundmass is completely altered to chlorite, granular epidote, sphene, Fe oxides, leucoxene and sericite. Small amygdules or drusy cavities where present are filled with dark green chlorite, radiating clinozoisite or epidote crystals, quartz and carbonate.

Foy & Miezitis (1977) described unusual massive altered volcanic flow rocks from Anomaly 2J as 'consisting of fine intergrowths of biotite and zoisite, with minor chlorite, sericite, and secondary quartz and typically containing up to 5 percent leucoxene, probably after magnetite.'

East of the South Alligator River the volcanic flow rocks have been completely recrystallised to an amphibolite consisting of fine-grained xenoblastic sodic plagioclase, pale green fibrous to subprismatic tremolite-actinolite and minor quartz, dark green chlorite, sphene, Fe oxides and idioblastic epidote. Amygdules infilled with epidote and quartz are present in places.

Basic volcanic breccia

Basic volcanic breccias or 'agglomerate' (Walpole, 1962) crop out more extensively than the flow rocks. They are distinctive greyish green massive rocks composed of angular volcanic rock fragments up to 20 cm across, in a mottled dark green chloritic matrix.

The fragments are similar in composition to the flow rocks but are typically more altered. They have a subtrachytic fabric and consist mainly of even-grained plagioclase (oligoclase-andesine) microlites, granular clinopyroxene, and dark green chlorite. Rarely phenocrysts of colourless idiomorphic clinopyroxene or chloritised, rounded, fractured olivine are present. Alteration products are pale green chlorite, clinozoisite, Fe oxides, sphene, carbonate, sericite, prehnite, leucoxene and quartz.

The matrix is composed of smaller volcanic rock and mineral fragments which are almost completely replaced by dark green chlorite, prehnite, quartz, albite, chalcedony, carbonate, muscovite, potassic feldspar, sphene, and prismatic clinozoisite.

Tuffaceous shale, siltstone and phyllite

Tuffaceous shale, siltstone and phyllite overlie and are interbedded with the basic volcanic flow and breccia rocks. They are composed of fine-grained volcanic material of intermediate to basic composition, probably derived from the same source as the flows and breccias. They are commonly laminated and consist mainly of fine-grained pale to dark green chlorite and minor scattered granular quartz, plagioclase, opaques and sphene. Sericite and carbonate are alteration products. Their tuffaceous nature is confirmed by the curved and elongate shapes of quartz and plagioclase grains and the rare presence of altered glassy shards. Some brecciation in shales has been described by Foy & Miezitis (1977) and attributed to soft sediment gravity slumping.

Tuffaceous greywacke

Tuffaceous greywacke occurs as thin interbeds in tuffaceous shale or as massive beds (Fig. 6d). It consists of well-rounded grains of quartz, chert and highly altered intermediate to basic volcanic material in a matrix of chlorite, hematite and angular fragments of quartz and altered volcanic. Many of the volcanic fragments have a relict subtrachytic texture and are probably similar in composition to the basic volcanic flow and breccia rocks. Foy & Miezitis (1977) describe similar 'tuffites' which also exhibit soft sediment gravity slumping features similar to those in the shales.

Discussion

The Stag Creek Volcanics represent the earliest known Lower Proterozoic volcanic episode in the Pine Creek Geosyncline. The inter-bedded nature of the volcanics with sediments, and rare pillow structures, (K. Wills, pers. comm.) indicates a subaqueous environment, although some subaerial explosive activity many have occurred. Most of the unit is composed of subaqueous flows and breccias. The breccias are probably flow breccias formed by autobrecciation (MacDonald, 1972), where blocks of solidified lava become enbedded in finer debris owing to attrition and shattering of viscous lava during movement. This is thought to be caused by stresses set up during movement of the flow. As the flows were probably subaqueous, steam shattering may have also been an important process of their formation.

MOUNT PARTRIDGE GROUP

A well exposed sequence of psammitic and pelitic rocks of the Mount Partridge Group unconformably overlies the Masson Formation and Stag Creek Volcanics in the Sheet area. The group has been subdivided into the Mundogie Sandstone and the Wildman Siltstone.

The Mundogie Sandstone, which forms the base of the group, is a sequence of sandstone, lesser pelitic and minor conglomerate interbeds. The formation is transitionally overlain by the dominantly pelitic sequence of the Wildman Siltstone.

MUNDOGIE SANDSTONE

Introduction

In the northeast of the Mundogie and the adjoining Kapalga and Jim Jim 1:100 000 Sheet areas the Mundogie Sandstone (previously mapped as the Mundogie Sandstone Member, Walpole, 1962; and subunits Ꞓlp$_2$ and Ꞓlp$_4$ of the Mount Partridge Formation, Needham & others, 1975) crops out as low strike ridges and the prominent Mount Partridge Range which rises 200 m above the plain. The outcrops form a dome (the Barramundie Creek Dome) centred on Barramundie Creek. East of Yemelba, on the eastern side of the dome, rocks of the Mount Partridge Range form the eastern limb of a steep, easterly-dipping, overturned rim syncline. In this area the rocks are strongly foliated, and metamorphosed to upper greenschist facies.

In the extreme northwest of the Sheet area the formation crops out as prominent hills up to 40 m above the level of the plain and consists almost entirely of isoclinally folded quartz sandstone and conglomerate ridges, which form small domes surrounded by Wildman Siltstone. Siltstone, which probably constitutes about 50 percent of the formation here, is poorly exposed as a ferrunginous rubble between sandstone ridges.

West of the South Alligator River the Sandstone crops out as a prominent northwest-trending ridge (previously mapped as Coirwong Greywacke) and as a series of ridges north of Goodparla Homestead (previously mapped as Masson Formation) which are open to tightly folded about shallow northwest-plunging axes. Psammitic units are well exposed and are commonly fractured and veined by quartz.

Stratigraphic relations

The Mundogie Sandstone is overlain conformably by the Wildman Siltstone, and in places unconformably by the Koolpin and Kombolgie Formations. The contact with the Wildman Siltstone is transitional and defined by a decrease in the proportion of psammitic to pelitic units from more than 50 percent to less than 10 percent in the Wildman Siltstone. Psammitic units in the Wildman Siltstone are better sorted, finer-grained and are more quartzose than those in the Mundogie Sandstone.

The base of the Mundogie Sandstone is marked by a poorly sorted conglomerate which disconformably and locally unconformably overlies the Stag Creek Volcanics and the Masson Formation. Because folding before and after deposition of the formation was about similar northwest-trending axes, the unconformable relationship is only evident in the hinge areas where the unit strikes east-west, such as 12 km northwest of Goodparla Homestead.

Description

The Mundogie Sandstone consists of an interbedded sequence of quartz sandstone, feldspathic meta-sandstone, conglomerate, siltstone, slate and schist which reaches a maximum thickness of 2600 m at Spring Peak and thins westwards to 300 m west of the South Alligator River (Fig. 7). Red sandy siltstone, slate and schist are poorly exposed and crop out as rubble between or on the flanks of sandstone or conglomerate strike ridges. Their thickness is inversely related to the thickness of the formation. At Spring Peak, where the formation is thickest,

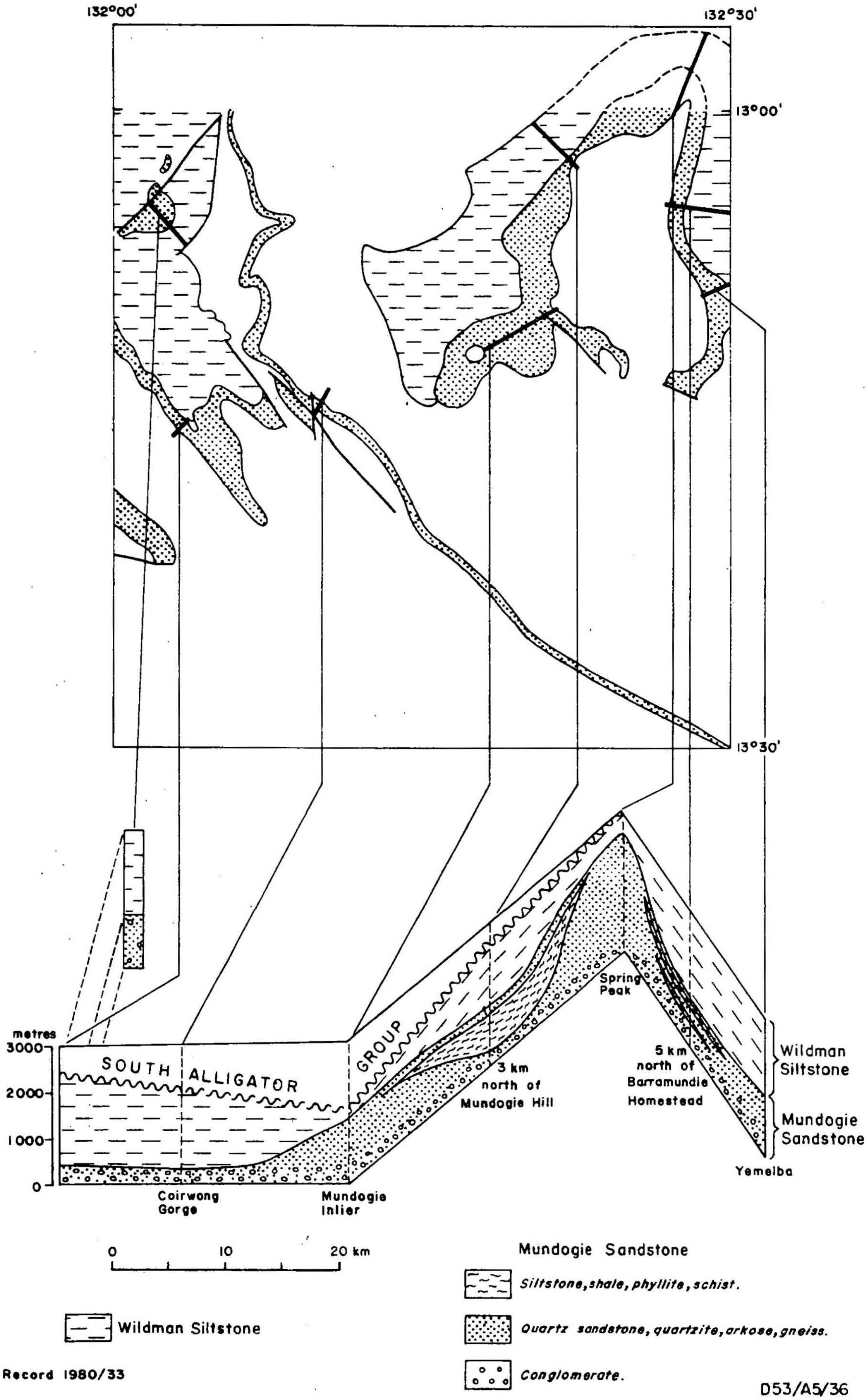


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Fig. 7 Interpreted predeformational facies relationships of the Mount Partridge Group, Mundogie 1:100 000 Sheet area.

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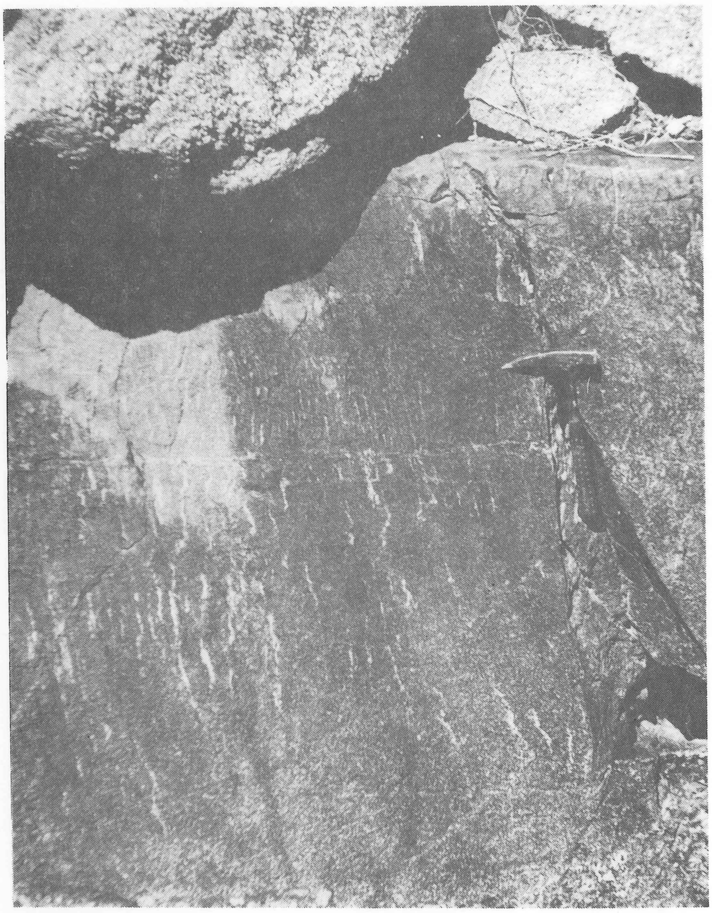
(a)



M2249-22

(b)

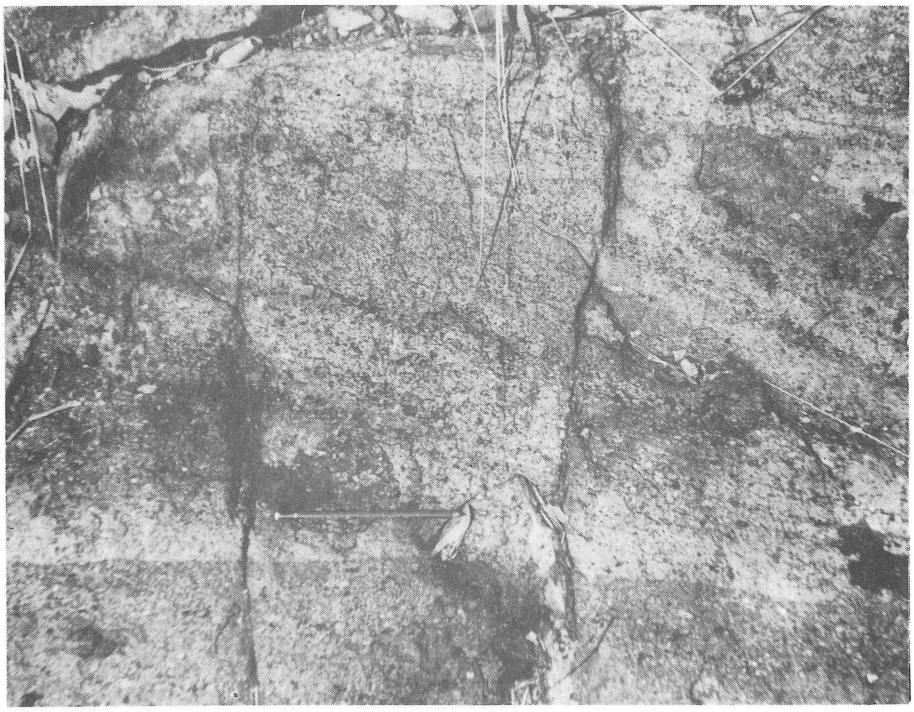


Figure 8. (a) Graded bedding in pebbly coarse quartz sandstone, Mundogie Sandstone, 2.5 km southwest of Goodparla Homestead.

(b) Cross-bedded, coarse quartz sandstone, Mundogie Sandstone.

pelitic units are virtually absent, but in the western part of the Sheet area, where the formation is much thinner, pelitic units constitute up to 50 percent.

Sandstone

Quartz sandstone (Fig. 8 a, b) is the most abundant rock within the formation and forms continuous beds ranging from 0.5 to 2 m thick. It is typically blocky, white, and consists of medium- to coarse-grained, poorly sorted, subangular to well-rounded grains of quartz, sericitised or kaolinised feldspar, and minor chert cemented by optically continuous quartz. Trace amounts of well-rounded tourmaline and monazite grains are present in places. As the metamorphic grade increases eastwards from the South Alligator River the grains become strained and the matrix foliated. Feldspar content in some sandstones also increases eastwards from less than 10 percent west of the South Alligator River to more than 25 percent in the Mount Partridge Range area.

In the Mount Partridge Range area the sandstones have been metamorphosed to feldspar-quartz gneiss, foliated quartzite and muscovite-quartz-feldspar schist (Fig. 9 a, b). They consist of coarse-grained granoblastic quartz, and kaolinised feldspar which is mostly microcline. Relict well-rounded grain boundaries are rarely preserved. In some places, the feldspar grains are several centimetres long, suggesting rapid deposition and lack of sorting.

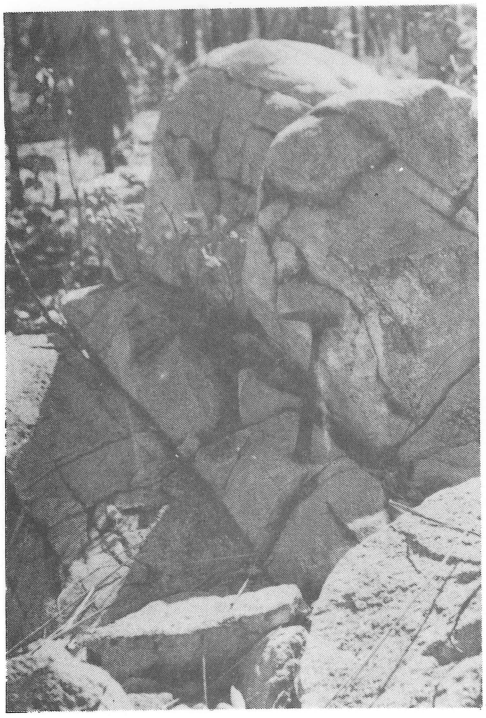
The sandstones are commonly medium bedded and exhibit lenticular cross-bedding, graded bedding and rarely ripple marks. The cross-beds indicate current directions from the north and east.

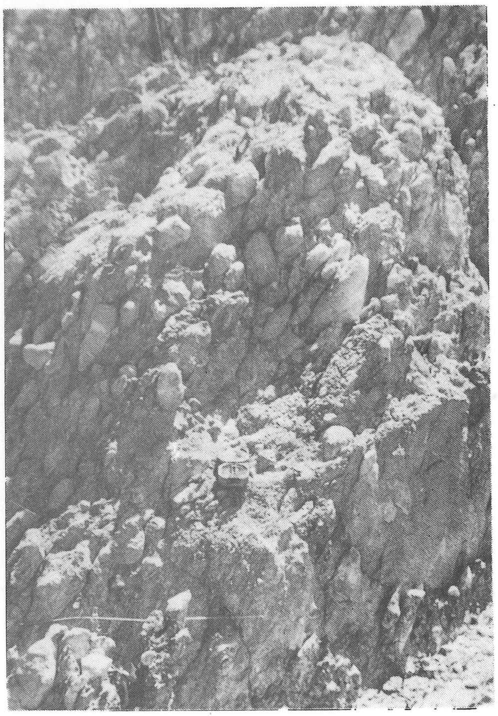
Conglomerate

Conglomerate (Fig. 9c) forms lenses and beds up to 3 m thick at the base of the formation. It typically consists of subrounded to well-rounded pebbles of quartz, minor pink and grey chert, quartz-sericite rock, and quartzite in a poorly sorted coarse to very coarse sandy matrix of recrystallised granoblastic quartz, feldspar and minor sericite and pale brown biotite. Where the matrix has been completely recrystallised, relict well-rounded grain boundaries are marked by a fine ring of limonite granules.

(a)

(b)





(c)

Figure 9. (a) Foliated meta-arkose and mica schist, Mundogie Sandstone, Mount Partridge Range. M2249-28.

(b) Feldspathic quartzite, Mundogie Sandstone, 4 km north of Barramundie Homestead. M2249-29.

(c) Coarse arkosic conglomerate, Mundogie Sandstone, 4 km north of Barramundie Homestead. M2249-31.

Rare pebbles of altered basic volcanic and banded amphibolite are present in conglomerate cropping out at the Mount Partridge Range (Walpole & others, 1968) and were probably derived from the underlying Stag Creek Volcanics and Archaean basement. Strongly chloritic conglomerates and greywackes with a high volcanic component, described by Foy & Mietzitis (1977), are interbedded with the Stag Creek Volcanics and probably belong to that formation rather than the Coirwong Greywacke (Mundogie Sandstone) as they suggest.

Many of the chert pebbles contain limonite pseudomorphs after carbonate rhombohedra and are probably silicified dolomite. The underlying Masson and Cahill Formation contain extensive dolomite beds and could well have been the source of the pebbles.

Pebbles range in size from less than 5 cm west of the South Alligator River to 30 cm in the Mount Partridge Range area. An increase eastwards in metamorphic grade is also evident in conglomerate beds by increased pebble deformation and recrystallisation of the matrix in the Mount Partridge Range area.

Structures present in conglomerate beds include graded bedding and scours.

Siltstone

Siltstone is interbedded with quartz sandstone in the north-western part of the Sheet area and forms beds up to 100 m thick. It is typically laminated, sandy and ferruginous, and consists essentially of sericite, hematite, and subangular very fine grains of quartz, minor chert and trace amounts of monazite.

Discussion

The presence of lenticular cross-bedding, graded bedding, scours, oxidised grain boundaries and the relationship of thickness to composition of the Mundogie Sandstone indicates a continental depositional environment. The decrease in pebble size, feldspar content and thickness of the unit westwards is consistent with cross-bed directions and indicates a near sediment source from the north and east. The Nanambu Complex and Kakadu Group (which crop out over 2500 km^2 northeast of the Mundogie 1:100 000 Sheet area in the East Alligator and Cahill 1:100 000

Sheet areas), and to some extent also the Cahill and Masson Formations, were probably major sources of the Mundogie Sandstone as they are the only older formations in the area that are known to contain appreciable amounts of feldspar or chert (silicified dolomite).

The features observed in the Mundogie Sandstone in the Mundogie 1:100 000 Sheet area indicate that it probably formed as coalesced fan deposits on the southwestern flank of an uplifted area composed mainly of Archaean basement (the Nanambu Complex) and overlying Lower Proterozoic Kakadu Group, and Cahill and Masson Formation.

WILDMAN SILTSTONE

Introduction

The Wildman Siltstone crops out in the northwest of the Mundogie 1:100 000 Sheet area within the catchment area of the Wildman River. Previously mapped as Masson Formation or Mount Partridge Formation (Walpole, 1962), it consists of a sequence, about 2000 m thick, of predominantly colour-banded siltstone, ferruginous siltstone and minor quartz sandstone, quartzite, greywacke, arkose and phyllite.

The formation is poorly exposed as low rubbly rises, in creek beds, or in breakaway slopes beneath extensive Cainozoic sand, laterite, soil and alluvial cover. Pelitic units are best exposed in creek beds as they readily weather to a homogeneous ferruginous rubble. Psammitic rocks are comparatively better exposed and form low bouldery strike ridges. The rocks have been tighlty to isoclinally folded about sub-horizontal axes, and have a well developed slaty cleavage or are intensely jointed.

Stratigraphic relations

About 2000 m of the formation is exposed in the Sheet area. The true thickness is not known, as the formation is unconformably overlain by the Koolpin Formation or is in faulted contact with the Masson Formation or Stag Creek Volcanics. It conformably overlies and is transitional with the Mundogie Sandstone. The lower contact is gradational and defined by an increase in the proportion of pelitic units (from less than 50 percent to more than 90 percent).

Description

Owing to poor exposure, internal stratigraphy of the formation is difficult to determine. Colour-banded siltstone appears to form the lower half of the formation and is overlain by a more homogeneous ferruginous, micaceous siltstone containing interbeds of quartz sandstone, greywacke, arkose, phyllite and slate.

Siltstone, phyllite and slate

Siltstone, phyllite and slate (Fig. 10a) are laminated to thinly bedded and consists essentially of fine-grained Fe oxides, sericite and angular silty quartz grains. The distinctive colour-banded siltstone consists of alternating red and white laminae (<1 cm thick) of silt and shale. The reddish colouring is caused by the concentration of Fe oxides in the shale laminae. At depth the shale laminae are pyritic and carbonaceous.

Quartz sandstone and quartzite

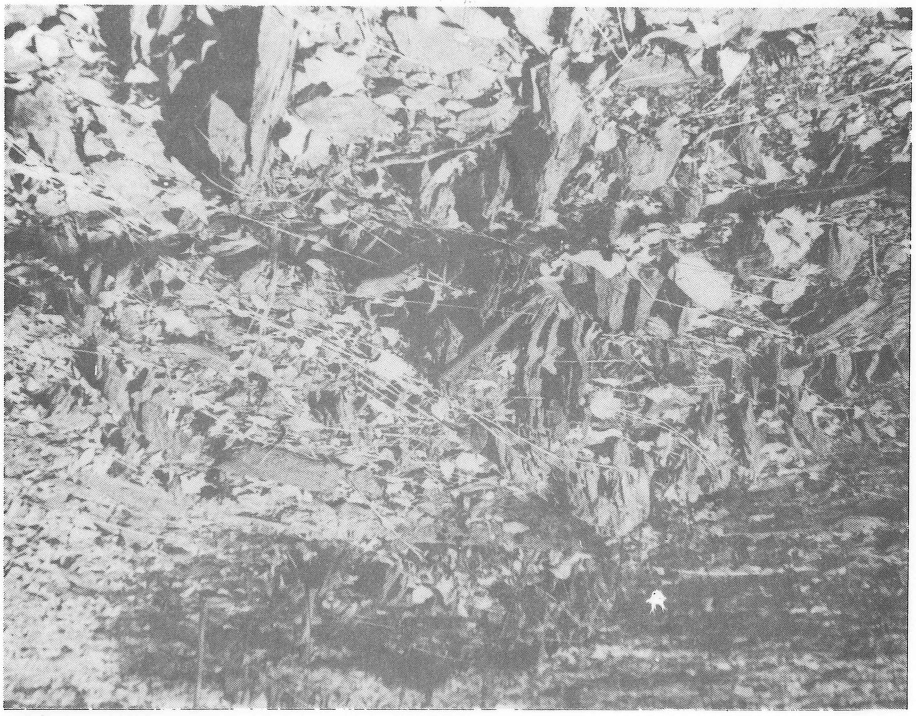
Quartz sandstone and quartzite occur as beds less than 0.5 m thick within siltstone and are commonly laminated (Fig. 10b) or thinly bedded, and flaggy to blocky in outcrop. Lenticular cross-bedding and rare ripple marks are present in places. The rocks consist of poorly sorted, fine to coarse-grained angular strained quartz grains with minor chert, sericitised feldspar and altered lithic fragments and trace amounts of well-rounded tourmaline and monazite. The matrix, where present in the closely packed fabric, consists of recrystallised quartz, sericite and hematite.

Greywacke

Rare coarse, lithic, feldspathic greywacke forms graded beds up to 30 cm thick within ferruginous siltstone. It consists of angular quartz, kaolinised feldspar and fragments of ferruginous siltstone (<10 cm) in a ferruginous silty matrix. Alignment of recrystallised sericite in the matrix imparts a weak foliation.

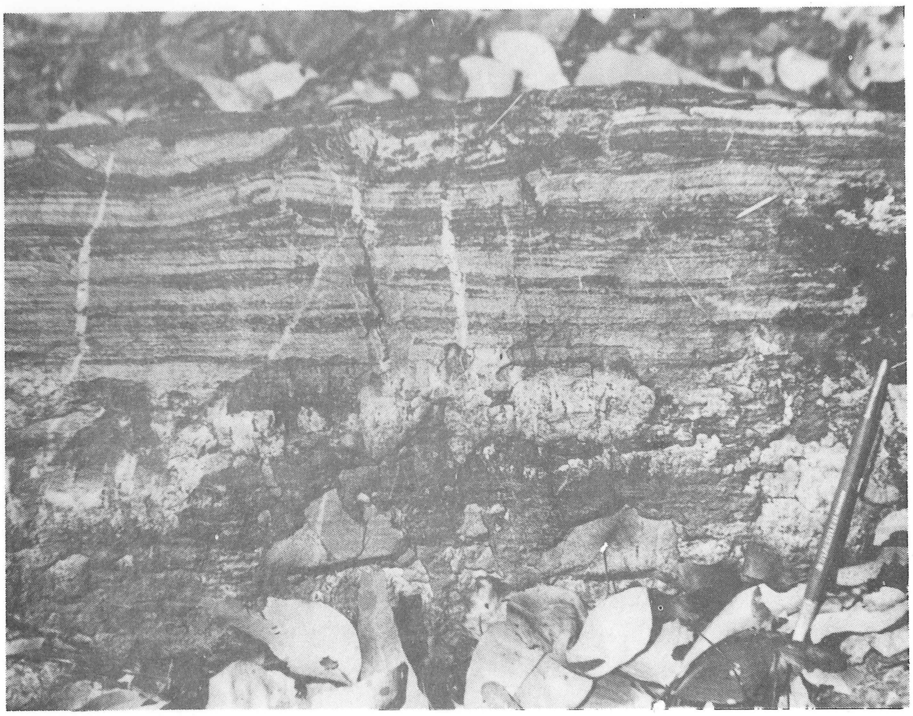
Minor interbeds of weathered dark greenish grey feldspathic greywacke, in slate, phyllite and siltstone, crop out in Buffalo Creek and in a creek bed about 12.5 km west-northwest of Coirwong Gorge. The

M2249-30



(a)

M2249-24



(b)

Figure 10. (a) Hematitic slate, Wildman Siltstone.

(b) Laminated medium quartz sandstone, Wildman Siltstone.

32

greywacke is medium to coarse-grained and consists of poorly sorted, closely packed, angular to subangular grains of quartz, plagioclase, alkali feldspar and microcline in an altered matrix of dark brown biotite, sericite, chlorite and Fe oxides. Similar greywacke, intersected in drill holes on the Buffalo Creek Plain (Needham & others, 1978), commonly forms graded beds up to 30 cm thick, and exhibits scour structures in places.

Discussion

The Wildman Siltstone, in view of its composition, sedimentary structures present, and relationship with underlying units, is interpreted as having been deposited in a shallow-marine environment, possibly as a subtidal facies transitional with the continental deposits of the underlying Mundogie Sandstone.

SOUTH ALLIGATOR GROUP

A distinctive conformable sequence of iron-rich sediments, carbonate and volcanics of the South Alligator Group rests unconformably over the older groups in the Sheet area. The group includes the Koolpin Formation, Gerowie Tuff, Shovel Billabong Andesite, and the Kapalga Formation. Definitions of the Shovel Billabong Andesite and the Kapalga Formation, which are two recently recognised units, are appended along with a revised definition of the Gerowie Tuff, which replaces the name Gerowie Chert (defined by Walpole, 1962). The Fisher Creek Siltstone which was included by Walpole (1962) in the South Alligator Group is now correlated with the Burrell Creek Formation and is therefore included in the overlying Finniss River Group.

The lowermost member of the South Alligator Group, the Koolpin Formation, is mostly pyritic carbonaceous shale which commonly contains chert bands, lenses and nodules, algal carbonate and banded iron formation. The formation is also interbedded with an overlying sequence of tuffs and tuffaceous sediments of the Gerowie Tuff. In places andesitic flows of the Shovel Billabong Andesite separate the two formations or interfinger with the tuffs. The Gerowie Tuff is overlain by the Kapalga Formation, a sequence of Koolpin-type rocks which are unconformably overlain by the flysch-type sediments of the Finniss River Group.

KOOLPIN FORMATION

Introduction

The Koolpin Formation was defined by Walpole (1962) as a 1000-m-thick sequence of algal dolomite, pyritic carbonaceous siltstone with chert lenses, nodules, and bands, and carbonaceous siltstone cropping out in the South Alligator Valley area. The recent fieldwork in the Mundogie 1:100 000 Sheet area substantiates this definition with modification to the distribution and field relations of the unit. The estimate of thickness probably represents an absolute maximum for the formation in the area.

In the extreme south of the Sheet area nodular and chert-banded siltstone, overlain by tuff, forms a south-plunging syncline unconformably overlying the Masson Formation. The sequence, mapped previously as the Golden Dyke Formation, is identical to the Koolpin Formation/Gerowie Tuff sequence of the South Alligator Valley and is therefore correlated with it. Similar siltstone, previously mapped as Koolpin Formation, in the north of the Sheet area overlies the Gerowie Tuff and Wildman Siltstone and therefore considered to be Kapalga Formation.

The formation crops out as prominent strike ridges throughout the area. Dolomite is invariably silicified at the surface and siltstone weathered to a massive limonitic rock, in places capped by gossanous hematite. Carbonaceous shale and siltstone are poorly exposed between strike ridges of siltstone.

Stratigraphic relations

The Koolpin Formation forms the base of the South Alligator Group and unconformably overlies the Masson Formation, Mundogie Sandstone and the Wildman Silstone in the Sheet area. The formation is conformably overlain by the Gerowie Tuff and the Shovel Billabong Andesite and is unconformably overlain by the Coronation Sandstone Member of the Carpentarian Edith River Volcanics on the eastern side of the South Alligator Valley.

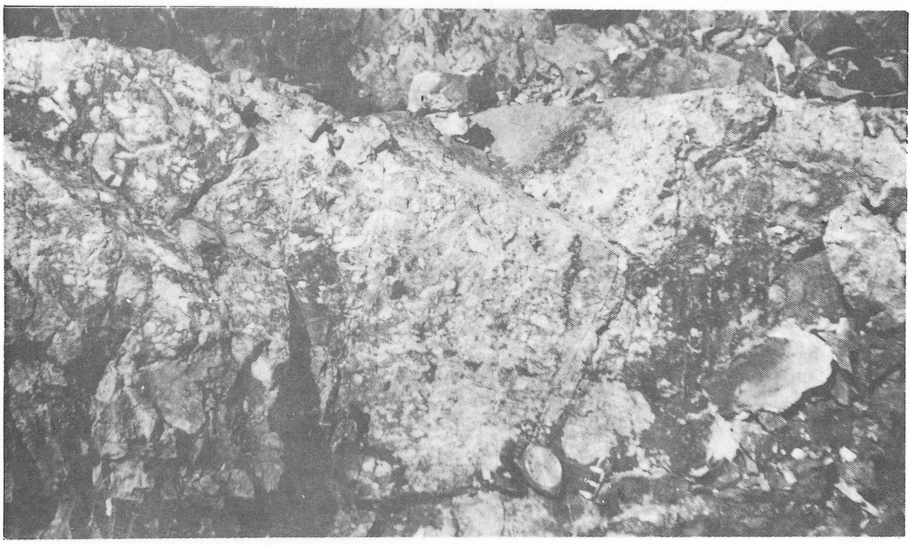
M2249-32

(a)

M2249-14

(b)

M2249-16



(c)

Figure 11. (a) Ferruginous siltstone with chert bands, lenses and nodules, Koolpin Formation.

(b) Thinly bedded black cherty tuff, Gerowie Tuff.

Description

Walpole & others (1968) described the formation as consisting of two main members - discontinuous algal reefs, and a pyritic carbonaceous siltstone with bands, lenses, and nodules of silicified dolomite. In the northwest of the Sheet area, the algal reef member forms the base of the formation, and is marked by a sandy dolomite breccia which grades southwards into more massive silicified dolomite with possible columnar algal structures in places. In the centre and southeast of the Sheet area these rock types are absent and the base of the formation is marked by massive chert-banded ferruginous siltstone of the siltstone member.

Dolomite

Massive brecciated silicified dolomite containing minor interbeds of siliceous dolomitic siltstone, ferruginous siltstone and phyllite, and chert-banded and nodular ferruginous siltstone, crops out in the northwest part of the Sheet area. The massive silicified dolomite commonly consists of a fine-grained mosaic of granoblastic quartz with rare carbonate rhomb moulds. Pseudo-algal structures such as columnar solution structures made up of radial and concentric growths of quartz occur in places. The growths are infilled by coarse-grained polygonal quartz, and fine grey silicified dolomite containing wavy bands or laminae of fine-grained opaques in places.

Breccia consisting of silicified dolomitic angular blocks in a fine-grained to sandy quartz matrix are common in places. Walpole & others (1968) reported the presence of *Collenia*-type algal bioherms in the South Alligator River Valley and considered the siliceous dolomite to be either silicified reef structure or associated reef breccias. In places silicification structures in the blocks of the breccia are broken, indicating that silicification had taken place prior to brecciation. Needham & Stuart-Smith (1978) described one such breccia 8 km northwest of Black Jungle Spring as probably being derived from a nearby outcrop of silicified dolomite in the Masson Formation.

Silicified carbonate breccia underlies chert nodular siltstone on the western side of a synclinal structure 14 km south-southwest of the Goodparla Homestead, and continues to the northwest for 5 km where in places it forms isolated knolls of massive silicified carbonate overlying pyritic carbonaceous siltstone of the Masson Formation. The breccia

(a)

(b)

(c)

Figure 12. (a) Angular unconformity between the Coronation Sandstone Member of the Edith River Volcanics and the Koolpin Formation.

(b) Cross-bedded coarse quartz sandstone, Kombolgie Formation.

(c) Quartz pebble conglomerate, Kombolgie Formation, Kurrundie Member.

commonly contains psuedo-algal structures made up of broken pieces of laminated nodules of black chert in a fine-grained granoblastic quartz matrix. The matrix contains rare pseudomorphs of carbonate rhombohedra with coarse-grained granuloblastic quartz infilling cavities, and minor interstitial limonite. The close association of the breccia with the more massive silicified dolomite strongly suggests that in places it is a reef breccia.

Ferruginous siltstone with chert bands, lenses and nodules

Ferruginous siltstone commonly containing bands, lenses and nodules of white, grey or black chert is a distinctive rock-type common to all the formations in the South Alligator Group, and is best developed in the Koolpin Formation (Fig. 11a). The siltstone is typically composed of fine-grained sericite, minor crytocrystalline quartz with iron oxides concentrated in fractures and laminations. At depth the 'siltstone' is a pyritic carbonaceous silty shale.

In places, such as near the Rockhole mine and at the cattle yards 3 km west of Shovel Billabong, the siltstone grades into banded iron formation (BIF). Here the BIF, which forms a 2-m-thick bed at the top of the Koolpin Formation, extends 6 km to the northwest and interfingers with the Gerowie Tuff and Shovel Billabong Andesite. The bed is composed of alternating chert and magnetite-rich laminae up to 2 cm thick. Bands of jasper, which grade into grey to black chert to the north, are also present in underlying siltstone 1.5 km west of Shovel Billabong.

Chert bands, lenses and nodules within the siltstone consist of fine-grained granoblastic to crytocrystalline quartz, which contains rare ghost carbonate rhombs, hematite, limonite and carbonaceous matter. The shape of the nodules ranges from circular to oval across the bedding, and circular to rod-like, or irregular lobate in the plane of bedding.

Discussion

The presence of abundant pyritic carbonaceous sediment, including shungite (Muir and Jackson, 1978), in the 'siltstone member', indicates that the sediments accumulated under reducing conditions in fresh to slightly brackish water (Crick & others, 1980). The banded iron formation could also have been deposited in such an environment in a similar manner to modern bog iron ores.

The origin of the chert bands, lenses and nodules is uncertain. They probably formed by the replacement of carbonate-rich bands within carbonaceous siltstone during diagenesis. Stevens and Roberts (in Walpole & others, 1968) reported that nodules in a drill core specimen from Rockhole mine, are within bands containing silt-size lenticular to subspherical cloudy dolomite, and that banding of the matrix is arched around the nodules. The presence of ghost carbonate rhombs in the chert supports this theory. However, in some places the nodules appear to be randomly orientated or brecciated in a siltstone matrix and give the appeareance of having formed during sedimentation, possibly as primary silica gels. In other places a tectonic origin for the nodules is plausible. Fifteen kilometres south of the abandoned Barramundie Homestead, nodules present in ferruginous siltstone form rods which are oriented parallel to minor fold axes. The nodules are clearly deformed and may have formed by deformation of an original chert layer or nodule.

Walpole & others (1968) suggested that the 'algal reef member' represented discontinuous bioherms which intertongued with the 'siltstone member'. Crick & others (1980) describe one such bioherm, from the central part of the South Alligator Valley, as containing several intertidal forms of stromatolite and interbedded clastic carbonate, and suggest a high-energy, shallow-water environment. The presence of small prismatic gypsum pseudomorphs, which are common in some beds, indicates a degree of hypersalinity. However a different environment for the 'algal reef member' in the Mundogie Sheet area is indicated by the absence of fresh carbonate and indisputable stromatolitic structures, and different field relationships. North of Coirwong Gorge the 'algal reefs' consists of thin to massive beds and lenses of silicified dolomite which grade southwards into the 'siltstone member'. It seems probably that the massive silicified dolomite in the north of the Sheet area represents a greater development of the lenses and nodules present in the 'siltstone member' rather than 'algal reefs' and that a similar depositional environment existed throughout the Koolpin Formation in the Sheet area. A diagenetic carbonate origin for the nodules and the massive silicified dolomite is therefore supported. The gradation from the 'siltstone member' in the south to the 'algal reef member' in the north may reflect differences in supply of carbonate or porosity of the sediments during diagenesis.

SHOVEL BILLABONG ANDESITE

Introduction

Distinctive dull, grey, massive and glassy rocks from the Gerowie Creek-Coirwong Creek area were first described as variolitic dolerite by Bryan (1962), who considered them to be intrusive rocks related to the Zamu Complex (Zamu Dolerite). These rocks, now identified as variolitic andesite and microdiorite, are considered to be extrusives and are referred to as the Shovel Billabong Andesite (Ɇvb).

The formation crops out as a discontinuous northwest-trending belt extending from 5 km north of Rockhole mine to 8 km north of Coirwong Gorge. Its easterly extent is terminated by a north trending high-angle reverse fault (the Waterfall Creek Fault) about 6.5 km east of Shovel Billabong. Exposure of the unit is repeated several times by isoclinal folding.

The unit is poorly exposed as slightly weathered and extensively jointed and fractured pavements, or as low sandy rises with scattered rubble. Like other basic igneous rocks inthe area, a deep reddish brown soil is developed adjacent to outcrops.

Stratigraphic relations

The Shovel Billabong Andesite forms a conformable unit about 40 km long and 100 to 300 m thick, separating the sedimentary sequences of the Koolpin Formation and the Gerowie Tuff. Minor interfingering with the overlying Gerowie Tuff occurs in places. Near Shovel Billabong the unit consists of at least two flows, separated by a 100 m bed of Gerowie Tuff. Considering the extent and thickness of the unit, and the presence of variolitic quench textures throughout most of the unit it probably consists of a number of small flows. Owing to poor exposure the relationship between variolitic andesite and microdiorite is not clear but appears to be gradational: the microdiorite probably forms the centres of thicker flows.

Description

Variolitic andesite

The variolitic andesite is an aphantic dull grey rock very similar to rocks of the Stag Creek Volcanics, and veins in, and chilled margins to, the Zamu Dolerite, Bryan (1962).

The rock is porphyritic with microphenocrysts of plagioclase and clinopyroxene in a pale-brown altered glassy groundmass containing crystallites. The plagioclase microphenocrysts occur as discrete or aggregated idiomorphic crystals (<2 mm) and are completey sericitised or albitised. Less commonly, pale green chlorite pseudomorphs after idiomorhpic clinopyroxene microphenocrysts are present.

The crystallites occur as swallow-tail, sheaf-like, radiating or feather-like groupings. Bryan (1962) described the crystallites as monoclinic pyroxene but most are too altered for identification. They probably consist also of feldspar and hornblende which are common minerals in the groundmass of microdiorite.

Microdiorite

Microdiorite is a medium-grained porphyritic phase of the variolitic andesite. It consists of idiomorphic sericitised plagioclase and prismatic pale brown augite phenocrysts in a groundmass of altered plagioclase (andesine) microlites, acicular pale brown to dark green hornblende, granular and skeletal opaques, and minor interstitial quartz, alkali feldspar and clinopyroxene. Clinopyroxene is commonly altered to a dark green amphibole.

Discussion

The origin of the Shovel Billabong Andesite has been considered by previous workers to be engmatic and probably intrusive. Bryan (1962) recognised that the unit, although similar to chilled margins of the Zamu Dolerite, was too thick, and proposed an alternative explanation. He suggested the unit represents 'a segregation of the magma that was intruded separately as a series of very small masses that chilled quickly'. Walpole & others (1968) suggested that it intruded before the main mass of dolerite (Zamu Dolerite), presumably into a cooler and possibly wet environment. As there is no field evidence to support a multiple intrusive origin we consider that the great thickness of quenched magma could only have formed by a multiple subaqueous extrusion. The association of the unit with the Gerowie Tuff (previously not recognised as a volcanic unit) supports a volcanic origin for the Shovel Billabong Andesite.

GEROWIE TUFF

Introduction

The Gerowie Tuff is a new name replacing Gerowie Chert (Walpole & others, 1968) which was considered to be a dolomitic facies variant of the Koolpin Formation and the Fisher Creek Siltstone. The identification of the tuff has been a key in unravelling the chronostratigraphy of the Pine Creek Geosyncline as outlined by Needham & others (1980). The unit consists of a 750-m-thick sequence of interbedded tuff, tuffaceous sediments and ferruginous siltstone with chert nodules. The formation crops out in the Mundogie 1:100 000 Sheet area as low rubble-strewn rises in a belt running the length of the South Alligator River Valley (previously mapped as Gerowie Chert) and in a small south-plunging syncline in the southwest of the area (previously mapped as Golden Dyke Formation). It typically has a light photo-tone and characteristically has two to three times higher radioactivity (indicating high potassium content) than background for the region.

Stratigaphic relations

The tuff conformably overlies the Koolpin Formation and is interbedded with Koolpin-type sediments and the Shovel Billabong Andesite in the centre and southeast of the Sheet area. The base of the Tuff in this area is taken as the base of the lowermost tuff or tuffaceous sediment. In the northwest of the Sheet area it overlies massive and brecciated silicified dolomite, the contact here being more sharply defined.

The tuff is overlain in the north by the Kapalga Formation and is unconformably overlain by the Carpentarian Edith River Volcanics in the South Alligator Valley area. In the east the unit is faulted against the Fisher Creek Siltstone by the Waterfall Creek Fault about 6.5 km east of Shovel Billabong. The nature of the contact with the Kapalga Formation is not clear and appears unconformable. However, outside the Sheet area a conformable relationship is indicated.

Description

Tuff

Three types of tuff have been described in detail from the unit by Crick & others (1978), who consider it to be equivalent to a similar sequence of tuff in the Golden Dyke Formation in the Burnside area.

The three types of tuff described by Crick & others (1978) are:

1) a fine-grained, thin-bedded, blocky black, chert-like variety commonly having a weathered white shell (Fig. 11b);

2) a coarser-grained more feldspathic tuff which has a dull green, white-spotted appearance;

3) a coarse-grained greyish-green lithic tuff.

Minor amounts of ignimbrite also occur - composed of angular, curved, rounded and partly resorbed crystal fragments of quartz, sericitised feldspar and volcanic clasts in a finer-grained matrix of crystalline and devitrified glass.

Tuffaceous and cherty sediments

Interbedded with the tuffs are light-coloured tuffaceous and fine cherty sediments. The tuffaceous sediments are fine to coarse-grained poorly sorted arenites and lutites consisting of angular to rounded, in places curved and elongate, grains of quartz and K and Na feldspar. Grains of biotite and chert are commonly present as well as clasts of fine-grained volcanic material and siltstone, and rare nodules of chert. The fine-grained cherty sediments, which are probably altered tuffs, typically contain minor angular fragments of quartz, and rare chert, sericitised feldspar, and altered glass shards in a fine-grained sericitic, chloritic quartz matrix.

Siltstone

In the southern half of the Sheet area, narrow discontinuous beds of ferruginous siltstone, commonly containing chert nodules and bands similar to Koolpin Formation-type rocks, are interbedded with tuff and tuffaceous seidment (Fig. 11c).

Discussion

The Gerowie Tuff probably formed as subaqueous accumulations of fine wind-borne and water-borne siliceous ash. Conformity with the underlying Koolpin Formation and the presence of interbedded pelitic sediments containing chert nodules indicate continuation of the restricted fresh to slightly brackish water environment, which characterised the Koolpin Formation, throughout the volcanic episode.

The subaerial acid volcanoes from which the tuff was derived were probably in or close to the Sheet area, as the thickest and coarsest accumulations of tuff in the Pine Creek Geosyncline occur in the South Alligator Valley (Stuart-Smith & others, 1980). This is also indicated by the presence, in the Sheet area, of the Shovel Billabong Andesite and a dacite body, which are probably related to the same volcanic episode which produced the tuff.

KAPALGA FORMATION

About 2700 m of the Kapalga Formation crops out as prominent strike ridges in the northern part of the Mundogie 1:100 000 Sheet area, where it forms the limbs of a broad north-plunging syncline (the West Alligator Syncline) which is part of a larger basin-like structure extending northwards into the Kapalga 1:100 000 Sheet area. The formation was previously mapped as Koolpin Formation (Needham & Stuart-Smith, 1978) and is now differentiated from it, as the Kapalga Formation is less deformed and appears to unconformably overlie the Koolpin Formation and Gerowie Tuff, which crop out 3 km west of Kapalga Formation rocks in the Black Jungle Springs area. Minor fold axes within the West Alligator Syncline plunge north-northwest in contrast to the sub-horizontal axes of the underlying formations. The formation also appears to unconformably overlie the Wildman Siltstone on the eastern limb of the West Alligator Syncline. Three conformable bodies, one over 2000 m thick, of Zamu dolerite intrude the formation and probably extend beneath the widespread Cainozoic cover that separates ridges of Kapalga Formation. The top of the unit is not exposed in the Sheet area but in adjacent Sheet areas is overlain by the Burrell Creek Formation.

The formation contains similar rocks to the Koolpin Formation, mainly hematitic siltstone containing in places bands, lenses and nodules of chert, and minor phyllite and carbonaceous shale. The lenses and nodules of chert are commonly less than 10 cm thick but range up to 20 cm thick and are flattened or elongated parallel to minor fold axes. Lenses of massive and nodular silicified dolomite are present near the base of the formation (Needham & Stuart-Smith, 1978).

FINNISS RIVER GROUP

The Finniss River Group includes two lateral equivalents, the Fisher Creek Siltstone and the Burrell Creek Formation, within the Sheet area. The group, the youngest Lower Proterozoic sedimentary unit in the Pine Creek Geosyncline, is unconformably overlain by the Carpentarian Edith River Volcanics and Kombolgie Formation. Relationships between the group and older Lower Proterozoic units are problematical owing to poor exposure, but it appears to overlie the South Alligator Group unconformably. Elsewhere in the Pine Creek Geosyncline the group conformably overlies, and is transitional with, the Kapalga Formation.

FISHER CREEK SILTSTONE

Introduction

A folded sequence of interbedded shale, sandstone, slate, arkose and greywacke is exposed mainly in the footslope of the Arnhem Land Escarpment and in adjacent hills to the north between the Waterfall Creek Fault and the southern end of the Mount Partridge Range. The Waterfall Creek Fault donwthrows these rocks against argillite of the Gerowie Tuff. Where bedding is preserved, the sequence strikes north to northwest with dips ranging from 60° to 90°. On the plains north of the escarpment and west of Barramundie Creek, sets of curved photo-trends are consistent with measured bedding directions in scattered exposures in roadside gravel pits and indicate a synclinal closure plunging south. Foliations west of Barramundie Creek are largely parallel to the axial plane of this closure. On the plains east of the creek, foliations are mainly northwesterly. In this area a large syncline of chert-banded and rodded hematitic siltstone of the Koolpin Formation plunges south, but Fisher Creek Siltstone lithologies crop out continuously along the base of the escarpment in this area where Koolpin Formation rocks might be expected.

The only other area of exposure of Fisher Creek Siltstone in the Mundgoie Sheet area is in the Waterfall Creek Inlier in the southeast. Here the rocks are poorly exposed, but comprise the same interbedded sequence as described above. Rocks of the formation are generally deeply weathered. The pelitic rocks are commonly weathered to red and brown, and the coarser rock types to bluff, grey and purple. Exposures on the plains and in the inlier are covered with sand and laterite, and are commonly within the leached section of the weathering profile. Those near the escarpment are commonly partly covered by blocky sandstone scree shed from the Kombolgie Formation.

Stratigraphic relations

Although folded about similar trending axes to the Koolpin Formation between the Waterfall Creek Fault and the southern end of Mount Partridge Range, folds in the Fisher Creek Siltstone appear to have less amplitude. This and the apparent truncations of a prominent south-plunging syncline of Koolpin Formation rocks east of Barramundie Creek, suggest an unconformable relationship between the two formations. The Fisher Creek Siltstone is faulted against Gerowie Tuff by the Waterfall Creek Fault, and is overlain with marked angular unconformity by Kombolgie Formation sandstone, which forms massive beds dipping generally less than 20° south along the escarpment. The Siltstone is faulted up against sandstone of the Kombolgie Formation on the southwest side of the Waterfall Creek Inlier, and sandstone unconformably overlies and dips radially away from the Fisher Creek Siltstone rocks around the rest of the inlier, suggesting this area was a basement high during Kombolgie Formation deposition. In places in the southeastern end of the inlier, pockets of Edith River Volcanics at the base of the Kombolgie Formation rest unconformably over the Fisher Creek Siltstone. The Siltstone is intruded and hornfelsed by conformable quartz dolerite sills of the Zamu Dolerite, up to 100 m but generally less than 20 m thick.

Description

The formation contains an interbedded sequence with beds ranging from 10 cm to over 20 m, of about 50 percent shale and slate, 35 percent sandstone and siltstone, 10 percent greywacke and 5 percent arkose, with minor hematitic siltstone containing rounded nodules of chert.

The shale and slate are commonly red-brown when weathered, with more prominent shades of grey where fresher. At one locality (GR234286) dark grey slatey shale contains pyrite and is carbonaceous. In places these pelites are phyllitic and chloritic, most commonly weathering to greeen tones. Folding is commonly evident, closures are sharp and limbs are tight. Axes, and, where apparent, crenulations and mineral elongations, plunge about 30° to the southeast. The phyllitic rocks are commonly knotted.

Siltstone in the formation grades into fine silty sandstone, and through to medium and coarse sandstone which are commonly feldspathic. Hematitic shale at GR264311 contains rods of fine quartzite plunging parallel to the crenulation, and rare chert nodules are present at GR241294. These rocks are commonly weathered to red-brown shales, and the sandstone may also be purple, grey, or buff. The purple sandstone commonly contains buff specks up to 2 cm across in which subordinate minerals such as feldspar and muscovite are more apparent. The sandstone is fissile to massive, mostly has a clayey matrix, and in places contains muscovite. It is commonly bimodally sorted; elsewhere sorting ranges from moderate to poor. Quartz is generally angular and in some specimens grains of quartzite and chert may make up nearly half of the rock. Grains of minor feldspathic and/or sericitic rock fragments in a finer grained, generally foliated matrix of the same composition with minor aligned sericite and derformed muscovite make up the remainder. Traces of well-rounded monazite and tourmaline may be present. The feldspathic sandstone commonly grades into arkose and greywacke, although these rock types may be distinctly interbedded. The arkose ranges from fine to coarse-grained, is very poorly sorted, with highly angular fragments and elongate splinters of quartz, chert, and plagioclase and alkali feldspar, in a fine chloritic matrix of the same composition, plus biotite, muscovite and opaques. The greywacke is medium-grained and also very poorly sorted, containing angular grains of plagioclase, alkali feldspar, similar to spotted tuff in the Gerowie Tuff. Pale green chlorite and granular opaques form an incipent foliation in the closely packed fabric of the greywacke.

Discussion

The Fisher Creek Siltstone succession in the Mundogie Sheet area differs substantially from the description given by Walpole (1962) and Walpole & others (1968), who described it as a thick monotonous sequence of siltstone with minor greywacke-siltstone and micaceous greywacke. Siltstone is not the dominant unit in the formation in this area. The variety of rock types and presence of lithic volcanic material indicates a nearby juvenile provenance, probably composed partly of Gerowie Tuff. Outcrops are generally well weathered, but the occurrence of dark grey carbonaceous pelites in places indicates that the formation is, at least in part, carbonaceous at depth. Walpole (1962) and Walpole & others (1968) suggested that the Fisher Creek Siltstone grades laterally into the 'Gerowie Chert' (now Gerowie Tuff) in the Mundogie Sheet area. The interfingering of the units they cited ('thinly interbedded green and white banded siliceous siltstone and mauve siltstone, and some beds up to 2 m thick of mauve fine-grained greywacke and grey-green medium-grained greywacke' - Walpole & others, 1968, p. 50) are all Gerowie Tuff rock types - tuff and argillite - and the only exposed contact between the two formations is the faulted contact of the Waterfall Creek Fault. Probable Gerowie Tuff detritus in the greywacke of the Fisher Creek Siltstone suggests instability in South Alligator Group times in the eastern part of the Mundogie Sheet area.

BURRELL CREEK FORMATION

The Burrell Creek Formation crops out as rubbly rises over a small area in the southwest of the Sheet area, where it overlies the Masson Formation and is intruded by the Cullen Granite. Stratigraphic relations with the underlying Masson Formation are unclear, owing to poor rubble exposure, but appear unconformably or faulted.

The formation consists of blocky fine-grained grey micaceous siltstone with minor sandy interbeds up to 10 cm thick. In the contact auerole of the Cullen Granite the siltstone has been metamorphosed to a blocky quartzitic rock which crops out as a prominent ridge.

EDITH RIVER VOLCANICS

The Edith River Volcanics are an interbedded sequence of lavas, ignimbrites, pyroclastic rocks, sediments and tuffaceous sediments. Descriptions by earlier workers (Woolnough, 1912; Jensen, 1915; Noakes, 1949; Hossfeld, 1954; Rattigan & Clarke, 1955) of the volcanics in the southeast of the Pine Creek Geosyncline have been aggregated by Walpole & others (1968) who considered them to form the base of the Carpentarian Katherine River Group. However, the volcanics, at 1760 m.y. (Leggo *in* Walpole & others, 1968) are older than the Oenpelli Dolerite (1688 m.y., Page & others, 1980) on which the Kombolgie Formation rests with unconformity; the Edith River Volcanics and Kombolgie Formation are thus separated by a period during which the Oenpelli Dolerite was emplaced and subsequently exposed by erosion, and cannot be considered as members of the same group. The volcanics have been studied in type areas at Edith Falls 23 km north-northwest of Katherine by Rattigan &

Clarke (1955) and on the western and southern flanks of the Malone Creek Stock 25 km southeast of El Sherana (Walpole & others, 1968). Stewart (1965) studied the petrology of the volcanics at both localities. In the South Alligator Valley they comprise 1050 m of ignimbrite, rhyolite, dacite, ashstone, tuff and minor basalt.

The volcanics are confined to the southeast of the Mundogie Sheet area and extend 20 km northwest of the Rockhole mine below sandstone of the Kombolgie Formation in the Arnhem Land escarpment. Between Coronation Hill and Rockhole (i.e. southeast of the Mundogie Sheet area) the volanics have been subdivided into three members: the Coronation, Scinto Breccia and Pul Pul Rhyolite Members, but only the Coronation and Pul Pul Rhyolite Members are present in the Mundogie Sheet area. The volcanics are undifferentiated in places due to poor exposure and talus cover.

The volcanics crop out as a lenticular unit up to 100 m thick below the Kombolgie Formation northeast of the South Alligator River, and below the basal Kurrundie Member of the Kombolgie Formation west of the river.

The volcanics overlie deformed Lower Proterozoic rocks with a marked regional unconformity (Fig. 12a) and are overlain by the Kombolgie Formation. According to previous workers the relationship between the volcanics and the Kombolgie Formation differs from place to place. In the South Alligator River Valley there is in places a strong angular unconformity between them, but elsewhere they appear to be conformable (Walpole & others, 1968). In the Sheet area the contact is largely obscured by talus, but where exposed in unconformable.

Coronation Member

The Coronation Member forms the base of the Edith River Volcanics and consists of an interbedded sequence of rhyolite, ignimbrite, agglomerate, greywacke-conglomerate, greywacke-pebble conglomerate, coarse sandstone and polymictic conglomerate, ranging in thickness from 50 cm to 70 m (Walpole & others, 1968). Quartz sandstone and conglomerate are the only rock types present in the Sheet area.

Quartz sandstone

Quartz sandstone is typically pebbly and tuffaceous and commonly exhibits graded bedding. It consists of well-rounded coarse-grained quartz and minor quartzite and felsic volcanic grains, commonly with secondary quartz rims, in a matrix of fine-grained felsic volcanic material (quartz, sericite, hematite) and trace amounts of well-rounded tourmaline and monazite.

Conglomerate

Above the Sterrets (Rockhole No. 3) mine polymictic conglomerate beds are draped unconformably over steeply dipping, chert banded and nodular ferruginous siltstone of the Koolpin Formation (Fig. 12a). The beds contain well-rounded pebbles of quartz and acid volcanics up to 10 cm across.

Pul Pul Rhyolite Member

All the exposures of volcanic rocks, in the Edith River Volcanics, north of the Rockhole mine were described by Stewart (1965) who considered they belonged to the Pul Pul Rhyolite Member. Rock types in the member include altered purple and mauve amygdaloidal porphyritic pyroclastics, mauve quartz porphyritic volcanics (flow-banded in part), fractured white siliceous medium-grained banded volcanics, pinkish and reddish brown siliecous slightly porphyritic tuff, rhyolite, dark greenish grey trachyte and trachyandesites and reddish brown banded ignimbrites. With the exception of the dark greenish grey trachytes and trachyandesites, the rocks are markedly similar in texture and composition and have been classified as either rhyolite flow rocks, or devitrified welded tuff where there are indications of eutaxitic textures.

Rhyolite and welded tuff

Rhyolite and welded tuff typically consist of rounded and rarely euhedral phenocrysts and fragments, 1-2mm across, of quartz and feldspar (sericitised) set in a base of microcrystalline alkali feldspar, quartz and minor clots of chlorite and trace amounts of euhedral ?monazite. The quartz crystals are commonly embayed and rimmed by alkali feldspar. In the siliceous matrix devitrified shards of glass commonly have a eutaxitic texture.

Mottled purple and white, fine-grained siliceous rocks are probably rhyolite. They contain quartz crystals and irregular patches of whitish material up to 2 cm long set in a fine-grained purple matrix. Quartz phenocrysts are rounded and invariably have secondary rims of dusty quartz. The groundmass is silicified and consists almost entirely of very small quartz grains with a little sericite and hematite.

Trachyte and trachyandesite

Trachyte consists of phenocrysts of subhedral plagioclase partly pseudomorphed by carbonate and quartz, and subhedral clinopyroxene now replaced by chlorite. The phenocrysts are set in a groundmass of plagioclase (0.1 mm across), chlorite and carbonate. Trachyandesite has a similar porphyritic fabric, and consist of phenocrysts (2 mm across) of subhedral twinned colourless clinopyroxene (augite), commonly replaced by pale green chlorite, and euhedral plagioclase completely sericitised or carbonated. The groundmass has a subtrachytic fabric (0.1 mm in size) of plagioclase laths (andesine), subhedral clinopyroxene prisms, magnetite octahedra and interstitial potassium feldspar, quartz and minor chlorite.

KATHERINE RIVER GROUP

KOMBOLGIE FORMATION

Introduction

The Kombolgie Formation, a sequence of mostly near-horizontal coarse arenite, rudite, pyroclastics and acid to basic volcanics, is part of the Carpentarian Katherine River Group (Walpole & others, 1968). It crops out over 420 km^2 in the southeast of the Mundogie 1:100 000 Sheet area and forms the gently sloping, deeply dissected Arnhem Land Plateau bounded by almost sheer escarpments up to 120 m in height. The South Alligator River Valley divides the Mount Callanan Basin outlier west of the river from the main plateau.

Stratigraphic relations

The Kombolgie Formation unconformably overlies the Edith River Volcanics, Fisher Creek Siltstone, Koolpin Formation, Gerowie Tuff, Zamu Dolerite, and Oenpelli Dolerite, east of the South Alligator River and the Edith River Volcanics, Zamu Dolerite, and Masson Formation west of the river. It is faulted against older rocks on the west side of both the South Alligator Valley and the Waterfall Creek Inlier. The underlying rocks are in most cases concealed by talus from the escarpment face.

Description

In the Sheet area the formation consists of undifferentiated quartz sandstone and the Kurrundie and Plum Tree Creek Volcanic Members. The thickness of the formation is about 700 m in the Mount Callanan Basin and 600 m northeast of the South Alligator River. The basal Kurrundie Member and the conformably overlying Plum Tree Creek Volcanic Member, which only occur in the Callanan Basin, are 220 m and 370 m thick respectively. The Plum Tree Creek Volcanic Member has been further subdivided into lower volcanics and minor shales (170 m thick) and upper interbedded volcanics and sandstone (200 m thick).

The undifferentiated quartz sandstone of the Kombolgie Formation consists of clean to medium coarse quartz sandstone with minor shale and pebble conglomerate beds up to 10 m thick. The sandstone is fair to poorly sorted, well-bedded, and indurated at the surface to give the rock a quartzitic appearance. Crossbedding and ripple marks are commonly present (Fig. 12b). The sandstone has been subjected to major faulting and jointing. The sandstone consists of subangular grains of quartz (0.5 to 2 mm across) and minor quartzite and chert in a matrix of recrystallised granoblastic quartz, sericite and opaque limonite. The grain boundaries are sutured and partly recrystallised.

The basal Kurrundie Member consists of a distinctive purple pebble conglomerate (Fig. 12c) and minor medium to coarse, compact, quartz sandstone and white pebble conglomerate. The distinctive purple pebble conglomerate is composed of very poorly sorted subrounded quartz pebbles, fragments of broken and angular quartz, chert and jasper set in a fine-grained crumbly sandy ferruginous cement. Thinly-bedded quartz sandstone, which is pebbly in places, is present towards the base of the member in the northwest of the Mount Callanan Basin. The sandstone consists of angular and rarely rounded grains of quartz (2 mm across) cemented by minor secondary quartz rims with a recrystallised matrix of quartz and greenish brown mica (biotite?). The grain boundaries are partly recrystallised and interlocking.

The conformably overlying Plum Tree Creek Volcanic Member (also referred to as Plum Tree Volcanic Member by Stewart, 1965, and Walpole & others, 1968) consists of a basal unit of mixed volcanics and minor banded shales overlain by a sequence of interbedded volcanics and compact well-bedded medium to coarse-grained sandstones. The mixed volcanics of the basal subunit are massive, light yellowish brown, reddish brown and purple siliceous porphyritic volcanic rocks containing phenocrysts of quartz and feldspar. The rocks commonly have a pitted surface caused by preferential weathering of feldspar phenocrysts and contain patches of yellowish brown limonite. Thinly laminated grey shale is interbedded with the volcanics towards the base of the sequence.

The upper subunit consists of interbedded, compact, well-bedded, medium to coarse-grained sandstone which is feldspathic in part, and volcanics which rarely crop out.

Stewart (1965) described the volcanic rocks as ignimbrite, lava flows or tuffs. Ignimbrite is devitrified and contains phenocrysts of feldspar and a dark mafic mineral. The phenocrysts are altered plagioclase, alkali feldspar and chlorite (after hornblende or biotite). The groundmass consists of quartz and alkali feldspar. Accessory minerals include zircon, apatite and sphene and minor amounts of chlorite, sericite, calcite and hematite. Extensive alteration in the ignimbrites has obliterated any original glass present.

Detailed geological appraisal of radiometric anomalies (300 ppm U_3O_8 and 4850 ppm Th maximum) within the sandstone lenses of the Plum Tree Creek Volcanic Member by Noranda (Foy & others, 1973) revealed that the sandstone lenses, which are from 50 cm to 15 m thick, consist of well sorted, medium quartz grains in a clay matrix and are interbedded with greenish grey andesites and fine-grained pinkish siliceous rhyolites. The andesites contain dominantly chlorite with agate-filled vesicles. Fine-grained crystalline pyrite may be present along joint places.

CRETACEOUS

PETREL FORMATION

A thin veneer of flat-lying Cretaceous rocks crops out in the extreme south of the Sheet area and near the Minglo mine in the west. They are the northern extremities of an extensive tableland of Cretaceous sediments that extends into the Ranford Hill and Stow 1:100 000 Sheet areas. These rocks were previously mapped as Mullaman Beds by Skwarko (1966), who placed them into the Neocomian marine quartz sandstone and siltstone of his near-shore 'Coastal Belt' facies, equivalent to the Neocomian to Aptian 'Inland Belt' rocks which crop out further to the west near Pine Creek. Hughes (1978) discontinued the term Mullaman Beds; he correlated the basal part of the 'Inland Belt' (Skwarko's Unit C'), with the Upper Jurassic/Neocomian Petrel Formation, and the upper parts ('Units A and B' of hte 'Inland Belt') with the Darwin Member, the basal part of the Aptian to Cenonomian Bathurst Island Formation (the Bathurst Island Formation disconformably overlies the Petrel Formation). Hughes (1978) classifies all of the Mesozoic rocks of the Katherine-Darwin area as Petrel Formation, considering they were all part of Skwarko's 'Inland Belt'. However those of the Mundogie and surrounding Sheet areas to the north, southeast and east were all placed in the 'Coastal Belt' by Skwarko, which brings into question the validity of Hughes' classification of these rocks as Petrel Formation.

The Cretaceous sediments in the Sheet area are one to two metres thick and overlie Lower Proterozoic rocks, mainly Masson Formation. They form mesas and tablelands bounded by scarps 1 to 2 m high and are the remnants of a thin succession of sandstone, conglomerate and siltstone. In places talus from the Cretaceous rocks obscures the underlying Lower Proterozoic rocks.

Skwarko (1966) describes the main rock types in the 'Coastal Belt' as sandstones, siltstone and conglomerate in decreasing order of abundance. The Cretaceous sediments in the Sheet area consists of very ferruginous poorly sorted sandstone, grit, and pebble conglomerate cemented together by a ferruginous sandy matrix which in places contains angular siltstone fragments. The sediments have in places been silicified, ferruginised and lateritised. The conglomerates contain rounded whitish quartz pebbles from 0.5 to 8 cm across. The ferruginous sandstones are porous, poorly sorted, and contain angular and rounded quartz grains up to 0.5 cm across.

CAINOZOIC

Cainozoic sediments form a veneer over the Northern Plains and also form talus slopes and colluvial sand around and upon the Arnhem Land Plateau.

The deposits have been divided into the following units: laterite, Late Tertiary sand and gravel, high-level alluvium, talus and other rubble, and Quaternary continental sediments. Where these deposits are undifferentiated or consist mainly of skeletal soils they are designated Cz.

Laterite (Czl)

Generally the profiles seen in the Sheet area are either detrital or are truncated remnants of the standard laterite profile described by Whitehouse (1940).

Of the laterite types described by Williams (1969) in the Adelaide River/Alligator River area, the following types have been recognised:

Detritial laterite is formed mainly from reworked material cemented in a ferruginous matrix. It generally forms blocks (up to 1 m) and pavements on low hills or breakaways.

Pisolitic laterite is the upper part of the standard laterite profile, and consists predominantly of cemented ovoid ironstone pisoliths, between 0.25 and 1 cm in diameter, which are commonly case-hardened or varnished. It occurs as isolated deposits within drainage systems. It can also be detrital.

Mottled-zone laterite is the middle part of the standard laterite profile, and consists of deeply weathered bedrock grading up into a ferruginous zone of generally pisolitic laterite, and down into a pallid zone. It commonly occurs over Lower Proterozoic rocks in the bottom of amphitheatres at the head of creeks, and is typically surrounded by a breakaway of pisolitic or detrital laterite.

Concretionary laterite is pedogenic in origin and, unlike the laterites already described, is actively forming, rather than being in an erosional or stable environment. It is expressed as ferruginous mottling in poorly drained alluvial soils, or as ironstone nodules in situ in the soil profile.

Late Tertiary sand (Czs) and gravel (Czg)

Coarse unconsolidated quartz sand and gravel form the remnants of the Koolpinyah Surface (Story & others, 1969), which covers much of the survey area; in places it is dissected. Where the sand and gravels have been almost completely removed, structures within the underlying weathered rocks become apparent on aerial photographs.

The Late Tertiary sand and gravel are probably fan deposits (Story & others, 1969) derived from Mesozoic sand, silt, and claystone, Kombolgie Formation sandstone, and Lower Proterozoic rocks. Clean, unconsolidated quartz sand, developed in situ on the Arnhem Land Plateau from Kombolgie Formation sandstone, has formed continuously in an erosional environment since the Early Tertiary.

At the margins of the South Alligator River floodplain, erosion and redeposition of Czs have produced a narrow but distinct photogeological unit (Cza) which is characterised by a relatively steep slope of 5°; winnowing of the sands by erosion has resulted in the development of a sandy veneer on the slope.

High-level alluvium (Czc)

Gravelly skeletal soils form high-level (60 m asl) alluvial plains in the northwestern part of the Sheet area in the upper catchment of Craig Creek, which flows westwards into the Mary River. The plains are incised by Quaternary alluvial courses which have exposed deeply weathered Lower Proterozoic rocks beneath the older alluvial capping.

Talus and other rubble (Czt)

Talus slopes are commonly developed adjacent to the Arnhem Land Plateau where the base of the Kombolgie Formation is above ground level. In places the scree conceals the contact between the Kombolgie Formation and the underlying strata, but locally a bench is developed at the top of the talus slope, and the unconformity is exposed below an overhang of sandstone formed by preferential erosion of the Lower Proterozoic rocks. The talus is composed mostly of large blocks (up to 20 m) of Kombolgie Formation sandstone, but pebbles or clasts of the underlying rocks are commonly present.

Quaternary continental deposits

Deposition in a continental environment during the Quaternary is represented by a variety of alluvial types.

Alluvial silt, sand, and clay (Qa) occur in the courses and flood plains of active rivers. Large bodies of unconsolidated quartz sand (Qs) within the channels of major creeks and rivers, and outwash deposits (Qs) over the adjacent flood plains, consist mostly of material derived from the Kombolgie Formation or Late Tertiary sand, and were mostly deposited during floods. Silty levee deposits (Qal) are developed in places along the course of the South Alligator River north of Buffalo Creek Plain. Black humic soils and clays (Qf) are commonly developed in poorly drained depressions within drainage systems.

INTRUSIVE ROCKS

ZAMU DOLERITE

Introduction

Basic intrusive rocks in the South Alligator River area were first mapped by Walpole (1962) as 'Zamu Complex', the name originally applied by Stewart (1959) to the predominantly basic intrusions in the Zamu Creek area, east-southeast of El Sherana. Ferguson & Needham (1978) discussed the chemistry, petrology and genesis of these and other basic igneous rocks in the Pine Creek Geosyncline and proposed the name 'Zamu Dolerite' (Ėdz) to include all the intrusive basic igneous rocks of the Pine Creek Geosyncline which were emplaced before th 1800 m.y. regional deformation and metamorphism.

In the Mundogie 1:100 000 Sheet area the intrusions are folded to form a belt, less than 12 km wide, aligned roughly along the South Alligator River Valley. The intrusions closely follow the regional northwest trend of the Lower Proterozoic rocks and are mostly concordant with bedding. In some places the intrusions bifurcate, forming an interlaced pattern.

The intrusions comprise a tholeiitic differentiation suite of olivine dolerite, quartz dolerite, and granophyre. Exposures of 'variolitic dolerite' described by Bryan (1962) are considered to be extrusives and part of the Shovel Billabong Andesite.

The unit is fairly well exposed as low rubble and boulder strewn ridges or as prominent bouldery hills and pavements. The presence of the unit at shallow depths is indicated by deep reddish brown soil and scattered rubble.

Stratigraphic relations

The Dolerite forms extensive sills up to 1 km thick and minor dykes in the Lower Proterozoic units, and is folded with them about subhorizontal fold axes. There are probably only five or six major sills in the Sheet area which are repeated several times by folding.

Contact effects are generally obscure, but further south in the Zamu Creek area, where metamorphism and alteration of the dolerite and country rock are less apparent, low-grade hornfels of the Fisher Creek Siltstone in places forms elongate ridges parallel to the margins of intrusions.

Chilled margins are not exposed but have been intersected in drillholes. Bryan (1962) described a 1 foot thick (0.3 m) variolitic dolerite selvage at the contact of a medium-grained augite dolerite sill, intersected in a drillhole 6.5 km east-northeast of Coirwong Gorge.

There appears to be a broad gradation from mafic to felsic differentiates corresponding to younging in the host sediments (Fig. 13). Olivine dolerite is only present in the Masson Formation and granophyre forms the tops of quartz dolerite sills in the Gerowie Tuff and the Fisher Creek Siltstone.

Description

Olivine dolerite

Olivine dolerite crops out west of the South Alligator River, where it intrudes the Masson Formation and Stag Creek Volcanics. It is olive green and has a distinctive knotted appearance on weathered surfaces caused by differential weathering of coarse-grained clinopyroxene and less resistant feldspar.

Characteristically, olivine dolerite has an ophitic texture and consists of augite, plagioclase, olivine and minor alkali feldspar. Large ($\lessdot$1 cm) subidiomorphic crystals of pale brown augite mould idiomorphic plagioclase crystals and rounded olivine crystals. Augite

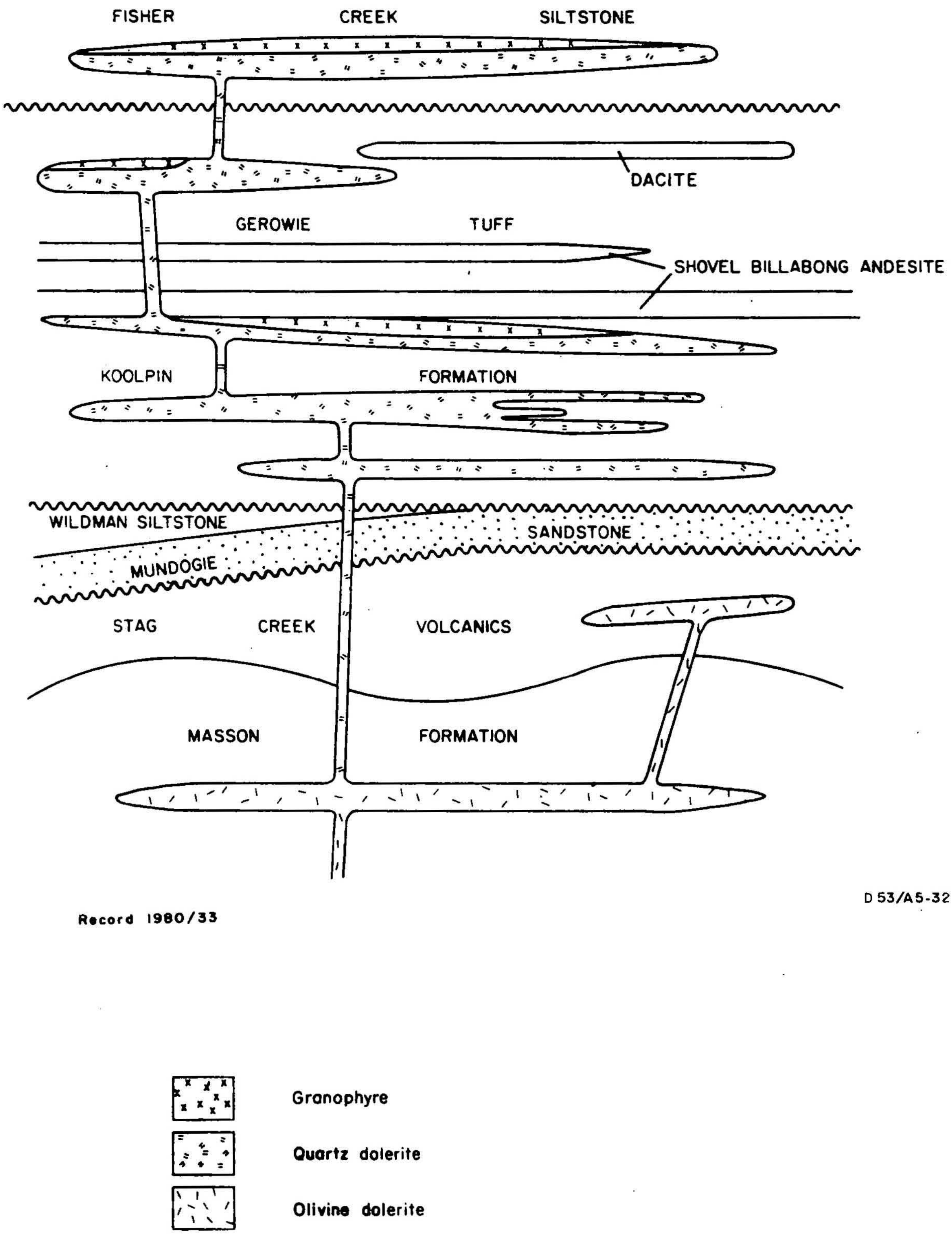


Figure 13 Schematic diagram showing relations of Zamu Dolerite to Lower Proterozoic formations.

is commonly altered to chlorite along fractures, cleavage traces and crystal margins. Plagioclase is medium-grained (<2 mm), zoned, rarely porphyritic (<1 cm), and commonly altered to sericite or chlorite. Olivine is present as medium-grained, colourless, fractured, rounded crystals or as polygonal aggregates and is rarely preserved, typically being completely replaced by chlorite pseudomorphs. Alkali feldspar, where present (<2 per cent), forms rims on plagioclase or is graphically intergrown with quartz as an interstitial mesostasis. Accessory minerals are greenish brown biotite, carbonate, acicular apatite, anhedral quartz, epidote, sphene, and irregular and skeletal opaques.

Quartz dolerite

Most of the Zamu Dolerite intrusions are varieties of quartz dolerite. Quartz dolerite is a medium to coarse-grained massive holocrystalline rock with a typical ophitic or intersertal texture, and consists essentially of plagioclase, clinopyroxene and an interstitial mesostasis of quartz, feldspar and secondary minerals.

Clinopyroxene is the principal mafic mineral, and is typically a pale brown augite which occurs as ragged subprismatic, twinned crystals up to 1 cm long. Rarely clinopyroxene exhibiting schiller structure is present and may be inverted pigeonite. Clinopyroxenes are commonly altered to dark green chlorite and/or greenish brown hornblende.

Plagioclase is present as strongly sericitised idiomorphic crystals (<2 mm) partly enclosed by clinopyroxene and commonly rimmed by alkali feldspar. Less altered crystals exhibit relict twinning and zoning.

The interstitial mesostasis constitutes up to 20 percent of the rock and consists of graphic intergrowths of quartz and alkali feldspar, anhedral quartz, minor euhedral potassic feldspar, opaques and acicular apatite. Epidote, biotite, carbonate, prehnite and chlorite are common secondary minerals in the mesostasis.

Granophyre

Granophyre occurs in small isolated outcrops near the top of some quartz dolerite sills. It is typically pinkish brown, fine to medium-grained, massive and leucocratic, consisting almost entirely of graphically intergrown sericitised feldspar and quartz.

The rock contains scattered stout euhedral prisms of alkali feldspar (<2 mm) and irregular quartz anhedra set in a graphically intergrown matrix of quartz and feldspar. The feldspar euhedra are invariably sericitised, untwinned and rarely zoned. The only mafic mineral present is pale green chlorite which forms clots possibly as an alteration product of amphibole. Bryan (1962) described slender prisms of hornblende in a granophyre from the Coirwong Creek-Gerowie Creek area. Accessory carbonate, sphene, biotite, apatite and prehnite are present.

Discussion

Walpole & others (1968) and Bryan (1962) state that owing to low relief, absence of layering in intrusions and poor outcrops of adjacent sediments, the apparent concordance of the Zamu Dolerite is difficult to establish in the Mundogie 1:100 000 Sheet area. However the similar grade of metamorphism of the intrusions and their host sediments, and the relationship of the differentiation series to stratigraphy, indicates that the intrustions are older than the 1800 m.y. regional orogenic event. They were probably intruded into undeformed strata as conformable bodies in a single igneous event, derived from a common parent magma.

Ferguson & Needham (1978) concluded that the intrusions form part of a major Lower Proterozoic tholeiitic suite in the Pine Creek Geosyncline. The intrusions are orthopyroxene-normative and their major and trace-element chemistry closely parallels the trends of other continental tholeiitic suites. The more evolved members were produced by olivine and possibly plagioclase fractionation.

CULLEN GRANITE

Introduction

The Cullen Granite forms a 2800 km^2 discordant, roughly V-shaped batholith in the middle of the Pine Creek Geosyncline, and is the largest of a number of intrusive Carpentarian granites in the region. The granite was named after the Cullen River (Noakes, 1949), a tributary of the Fergusson River. The northeastern corner of the batholith crops out in the southwest of the Mundogie 1:100 000 Sheet area over about 132 km^2.

Rattigan & Clarke (1955) identified three types of granite from the southern-most part of the batholith in the Edith River area. Walpole & others (1968) recognised five phases, consisting of three varieties of granite and two varieties of adamellite. Ewers & Scott (1977) carried out a geochemical study of the Cullen Granite and substantiated the five types of Walpole & others (1968). Two of these types, the pink coarse porphyritic granite and the pink and green coarse porphyritic granite, occur in the Mundogie Sheet area.

The margins of the granite form rugged hills with almost continuous outcrop up to 3 km wide. Away from the margin, outcrop consists of rock pavements and occasional rocky rounded hills separated by extensive drainage channels and converging alluvial flats. Much of this area consists of low rubbly rises of unconsolidated Cainozoic sand and weathered granitic material.

Stratigraphic relationships

In the Sheet area the Cullen Granite intrudes the Burrell Creek Formation, Mundogie Sandstone and Masson Formation. The contact is discordant and faulted in places. A contact metamorphic auerole up to 1 km wide in the sediments surrounds the Granite in the Sheet area.

The granite is post-orogenic, and work by Leggo (Walpole & others, 1968) indicates an age of 1760 m.y. Recently the mineral whole-rock isochrons (Rb-Sr) have been recalculated at 1780 m.y. (Riley, 1979).

Description

The rugged hills near the edge of the batholith consist of pink coarse-grained porphyritic quartz-orthoclase-plagioclase-biotite granite, which is the G1 granite of Ewers & Scott (1977). This type is massive and porphyritic with phenocrysts of pink potassium feldspar up to 5 cm acorss and an average grainsize of 3 mm. It consists of quartz, microcline, microperthite, albite-oligoclase which has largely been sericitised, red iron oxides, biotite which has partly been altered to chlorite, minor hornblende, and secondary muscovite. Accessory minerals include sphene, zircon and fluorite.

Pink and green coarse porphyritic granite forms isolated outcrops in the centre of the batholith, and is the G2 granite of Ewers & Scott. This rock is coarse, with large phenocrysts of pink microcline and microperthite up to 6 cm across and smaller grains of pale green plagioclase. It is very similar to the G1 phase except that plagioclase is slightly more calcium rich (i.e. oligoclase, andesine), hornblende is more abundant, and the iron oxides are black and opaque. The obvious changes in relief and outcrop pattern away from the margin of the batholith suggest a phase boundary roughly parallel to the edge of the granite mass.

Randomly oriented aplitic dykes cut pavements of the two granite phases. The dykes are less than 10 cm wide, and are similar in composition to the porphyritic granites but are finer-grained.

Discussion

On the basis of chemical, mineralogical and field criteria used by Chappell & White (1964) to distinguish two types of granitoids in the Lachlan Fold belt, Ferguson & others (1980) suggest that the Cullen Granite and other late orogenic granites in the Pine Creek Geosyncline were derived from a primarily igneous source (I-type granite). The granite probably represents ~~a~~ products of a small degree of partial melting (minimum temperature) or end product of fractionation from a source moderately enriched in potassium and silica (Ferguson & others, 1980).

OENPELLI DOLERITE

The Oenpelli Dolerite crops out within the Arnhem Land Plateau in the southeast of the Mundogie 1:100 000 Sheet area as an elongate inlier along the headwaters of Barramundie Creek. The outcrops are mostly covered by sandstone talus from the Kombolgie Formation, which unconformably overlies the Dolerite.

The Dolerite has been described in detail by Smart & others (1976) and Stuart-Smith & Ferguson (1978) as symmetrically differentiated layered sheet-like intrusions which intruded Lower Proterozoic rocks after the 1800 M.a. regional metamorphism (Page, 1974). Contacts with Lower Proterozoic metasediments are not exposed in the area. The Dolerite yields a concordant Rb-Sr total-rock and mineral age of 1688 ± 65 M.a. (Page & others, 1980).

The Dolerite exposures in the Sheet area are part of a sheet-like intrusion about 150 m thick which dips shallowly to the east and forms the western edge of a large ellopsoidal basin-like structure at least 100 km long by 50 km across. The intrusion consists of symmetrically differentiated layers of olivine dolerite and minor felsic differentiates. All the rock types described by Stuart-Smith & Ferguson (1978) are present in the intrusion.

Stuart-Smith & Ferguson (1978) suggested the Dolerite forms a major tholeiitic province which has .. 'evolved by polybaric olivine fractionation during slow, or intermittent, uprise from higher-magnesia magma generated by partial melting within the upper mantle; plagioclase is an additional liquidus phase at shallow-crustal levels'. The magma was intruded as sheet-like bodies which crystallised from the upper and lower margins towards the centre, where the more felsic differentiates were concentrated.

OTHER INTRUSIVE ROCKS

Dolerite in the Barramundie Creek area

A non-outcropping dolerite dyke distinguished by a distinctive red soil and thick vegetation cover over a deep clayey weathering profile occurs in the Barramundie Creek area between the abandoned Barramundie Homestead and Shovel Billabong. The dyke transgresses Lower Proterozoic strata and structures, and thus post-dates the 1800 M.a. regional metamorphic and deformation event.

A dolerite dyke which transgresses the Ranger orebody, in the Cahill 1:100 000 Sheet area, was recently dated at 1370 M.a. (Page & others, 1980). However, this dyke has a strong linear magnetic expression which is not observed over the Barramundie Creek area dolerite.

The dolerite at Barramundie Creek has been intersected in one drillhole (BMR Mundogie 42, grid ref. 185438) about 7 km southwest of the abandoned Barramundie Homestead (Needham & others, 1978). The dolerite is a medium-grained olivine dolerite similar to those in the Oenpelli Dolerite or Zamu Dolerite (where unaltered). It has an ophitic fabric and consists mainly of subidiomorphic crystals of pale brown augite (<2 mm) which mould finer-grained (<1 mm) idiomorphic plagioclase crystals. Olivine is present as rounded colourless fractured crystals or in polygonal aggregates, and is commonly altered to dark green chlorite and opaques. Accessory minerals include interstitial pale greenish brown biotite, irregular opaque grains, acicular apatite, interstitial alkali feldspar and rare graphic intergrowths of alkali feldspar and quartz.

The post-orogenic age of the dolerite and its composition are similar to those of the Oenpelli Dolerite. However, its lack of outcrop and form differ markedly from the usually prominent curvilinear ridges of the Oenpelli Dolerite, which may indicate a different style of intrusion, probably at a later date.

Dacite

A conformable body of dacite (Ᵽda) 200 m thick and 14 km long occurs within the Gerowie Tuff near Shovel Billabong. It is readily distinguished from dolerite intrusions of the Zamu Dolerite by its porphyritic texture and high radioactivity of 60 to 90 cps (about 2 to 3 x background for the region).

The dacite consists of plagioclase and minor augite phenocrysts in a holocrystalline groundmass of the same composition. The phenocrysts are composed mainly of sericitised zoned sodic plagioclase and minor chloritised subidiomorphic pale-brown augite, rounded quartz and alkali feldspar and quartz and minor stout prisms of orthoclase and sodic plagioclase. Accessory minerals include rounded opaque grains and apatite. Commonly the groundmass is extensively altered to pale brownish-green chlorite and sericite.

It is not clear whether the dacite is a shallow predeformational sill (in which case it would be a lamprophyre) or a volcanic rock possibly related to the Gerowie Tuff and Shovel Billabong Andesite. Contacts with the enclosing Gerowie Tuff are not exposed but in several places can be located to within a metre. Unlike the Zamu Dolerite there is no evidence of contact metamorphism which might confirm an intrusive origin. However, the body appears to be homogenous, with no evidence of flow tops, brecciation, flow textures or any other volcanic features.

The dacite is unlike any other known intrusive within the Pine Creek Geosyncline and is chemically (P. Stuart-Smith, unpublished data) quite distinct from the Zamu Dolerite and is unlikely to be related to the tholeiitic suite. Its spatial relation with the other

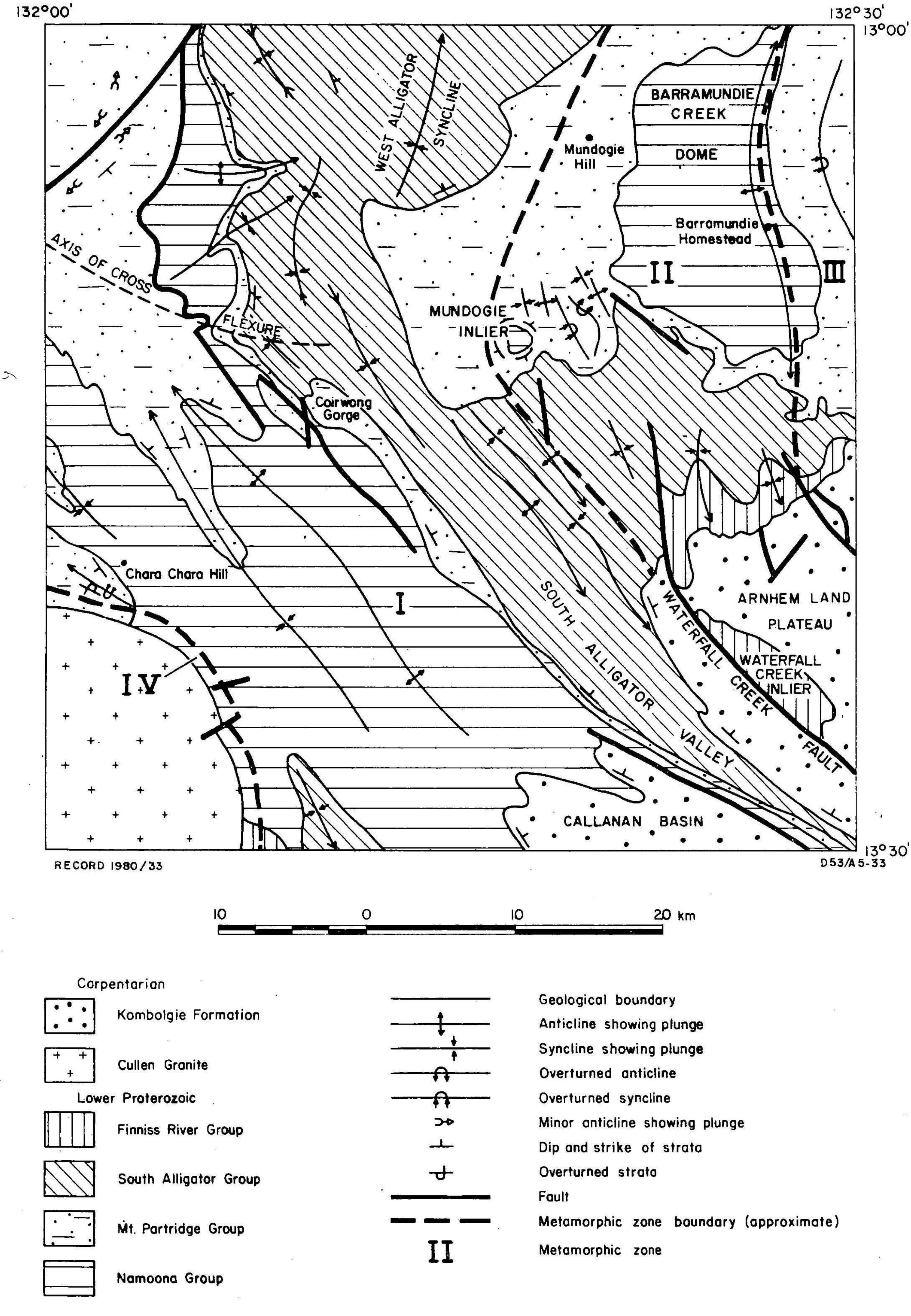


Figure 14 Major structural and metamorphic elements, Mundogie 1:100 000 Sheet area.

volcanics near their postulated source (Stuart-Smith & others, 1980) and its compatible felsic composition indicate that it is probably related to the volcanic pile either as a shallow intrusion or as a series of flows.

Felsite

A felsite dyke (f) 5 km long intrudes the Masson Formation 6 km west-northwest of Namoona prospect. The syke parallels the regional northwest trend and cleavage of the Lower Proterozoic metasediments, and extends into the adjoining McKinlay River 1:100 000 Sheet area where similar felsite dykes have been observed.

The dykes are post-orogenic and are possibly related to the nearby Carpentarian Cullen Granite.

The felsite is a massive, pale-green sericitised rock containing minor sericitised euhedral feldspar phenocrysts (<2 mm). Characteristically it has a high radioactivity of over 100 cps (2 to 4 x background of the region).

METAMORPHISM

All the Lower Proterozoic rocks in the Mundogie 1:100 000 Sheet area have been regionally metamorphosed to greenschist facies (zones I, II, and III in Fig. 14) and locally contact-metamorphosed by the Cullen Granite (zone IV in Fig. 14). The three regional metamorphic zones range from lower greenschist facies (zone I) in the western part of the Sheet area to probably upper greenschist facies (zone III) in the north-eastern part. This trend is consistent with the amphibolite grade of rocks about 25 km to the east in the Jim Jim 1:100 000 Sheet area (Stuart-Smith & Hone, 1975), and the eastwards increase in metamorphic grade in the Kapalga 1:100 000 Sheet area to the north (Stuart-Smith, 1977).

Zone I

West of the South Alligator River most of the Lower Proterozoic rocks retain their original sedimentary textures with little metamorphic recrystallisation. Pelitic rocks have a well-developed slaty cleavage and contain fine-grained sericite, chlorite, and rarely epidote.

Psammitic rocks are commonly fractured and veined by quartz. Basic flows and breccias of the Stag Creek Volcanics typically have one of the following two mineral assemblages:

(1) chlorite + epidote + sphene ± sericite ± Fe oxides.

(2) chlorite + carbonate ± albite ± orthoclase ± sphene ± sericite ± Fe oxides ± quartz ± epidote ± prehnite.

Zone II

This zone covers most of the northeastern part of the Sheet area and is characterised by the appearance of amphibole in basic volcanic rocks and recrystallisation of sandstone to foliated quartzite. Pebbles in conglomerate are commonly deformed to oval shapes parallel to the foliation. Pelitic rocks show a well-developed phyllitic foliation. Basic rocks of the Stag Creek Volcanics have the following mineral assemblage:

actinolite + epidote + sphene ± chlorite ± quartz ± Fe oxides

Zone III

This zone is confined to the Mount Partridge Range in the far northeast of the Sheet area. Pelitic rocks are typically ferruginous mica (muscovite, chlorite, biotite) schists and psammitic rocks are strongly foliated and recrystallised to foliated quartzite, feldspar-quartz gneiss and muscovite-quartz-feldspar schist. Pebbles in conglomerates are strongly deformed to flattened cigar shapes parallel to the plane of foliation.

Zone IV

In the southwestern part of the Sheet area a contact metamorphic auerole up to 1 km wide, in Lower Proterozoic rocks, surrounds the Cullen Granite. Strata in this zone are commonly faulted and overturned away from the granite margin. Besides slight induration and a well-developed slaty cleavage in pelitic rocks, contact effects are limited to patchy occurrences of spotted chiastolite and cordierite hornfels, particularly in carbonaceous pelitic rocks. Cordierite hornfels typically consists of porphyroblasts of cordierite and minor poikilitic muscovite in a matrix of finer-grained biotite, quartz and minor tourmaline.

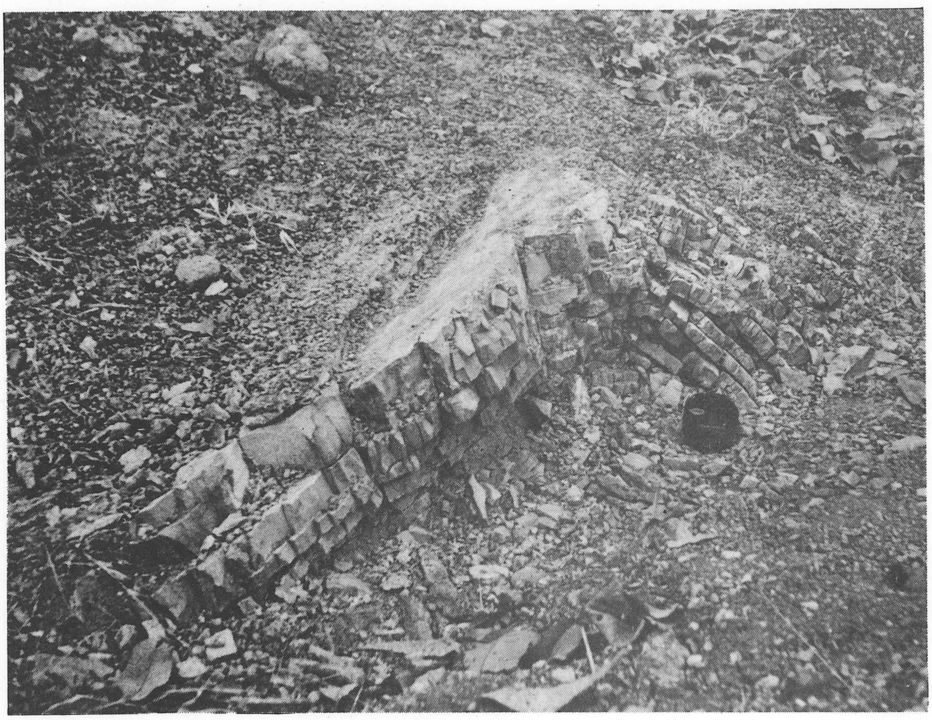


Figure 15. Angular tight fold in claystone, Masson Formation, 4 km east of Goodparla Homestead; note fanning fracture cleavage and sub-horizontal axis.

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STRUCTURE

The Lower Proterozoic rocks of the Mundogie 1:100 000 Sheet area, in the centre of the Pine Creek Geosyncline, probably represent one of the thickest preserved sequences in the geosyncline. An estimated depth to basement of about 5 km in the South Alligator Valley area is consistent with geophysical evidence (Tucker & others, 1978) and is contradictory to previous concepts of a basement high in the area, which were based on an interpreted Archaean age for the Stag Creek Volcanics (Walpole & others, 1968).

The Lower Proterozoic rocks in the Sheet area form three regional structural domains. A central synclinorum, including the West Alligator syncline, parallel to the South Alligator River, separates an anticlinorum around the Cullen Granite in the west and the Barramundie Creek Dome in the east. The rocks have undergone one major deformation (1800 Ma) characterised by rounded tight to isoclinal folding about sub-horizontal axes (Fig. 15) and associated strike slip faulting. Sequences are repeated as much as five or six times throughout the Sheet area and elongate basin and dome structures are common. Steep easterly dips predominate and overturning is prevalent, particularly east of the South Alligator River.

Fold axes in the southern part of the Sheet area trend north-westerly and curve to north-northeasterly in the northern part (Fig. 14). In the northwest this change is more abrupt and minor cross-folding and probably faulting are associated with it. The change in strike corresponds to a regional flexure extending from 4 km northwest of Coirwong Gorge to Marrakai Homestead 100 km to the northeast. The intensity of cross-folding in the northwestern part of the Sheet area may be related to the nearby intersection of this flexure and another one, the 'Grove Hill Cross-flexure' (Walpole & others, 1968) extending northeast for 75 km through Hayes Creek and Mount Douglas.

An east-dipping axial plane cleavage to the tight and isoclinal folds is well-developed in all the sediments throughout the area. West of the South Alligator River it is present as a slaty cleavage in pelitic rocks, as fractures, commonly quartz-filled in psammitic rocks, and as a foliation in the Stag Creek Volcanics. As the metamorphic grade increases eastwards from the South Alligator River the cleavage changes from a foliation in the Mundogie Hill area to a schistosity or gneissic foliation east of Barramundie Homestead. The foliation in this area is commonly mistaken for bedding in psammitic units.

Most of the major faults in the area are strike-slip faults parallel to the axial plane cleavage, and were probably contemporaneous with the major folding episode. In some cases thrusting may have occurred, such as between the Mundogie Sandstone and the Koolpin Formation 8 km south of Mundogie Hill; a similar fault is interpreted between the Stag Creek Volcanics and the Wildman Siltstone in the northwestern part of the Sheet area.

Some modification to the regional structure in the southwestern part of the Sheet area has been caused by intrusion of the Cullen Granite. The Granite contact is discordant and locally displaced by faults. Overturning of the sediments away from the granite is common around its margins and is well illustrated in graded beds of the Mundogie Sandstone at Chara Chara Hill.

Within the Lower Proterozoic succession there are unconformities beneath the Mundogie Sandstone, Koolpin Formation and possibly the Kapalga Formation and Fisher Creek Siltstone. Difference in fold style, and angularity across these unconformities are minor, indicating that deformation during Lower Proterozoic sedimentation consisted only of warping to minor folding.

Peneplanation of the Lower Proterozoic metasediments occurred between 1800 Ma and 1760 Ma as the Edith River Volcanics overlie the Lower Proterozoic rocks with a marked regional unconformity which roughly coincides with the present land surface. Minor warping and erosion followed deposition of the volcanics until after the intrusion of a lopolith-like sheet of Oenpelli Dolerite at 1688 Ma, which was partly exhumed to form a basement high to subsequent deposition of the Kombolgie Formation.

The Kombolgie Formation in the area forms the western extremity of the Arnhem Land Plateau and the eastern-most of two major synclines which comprise the Callanan Basin, The units are typically subhorizontal with locally steep marginal dips up to 70^{o} associated with reactivated

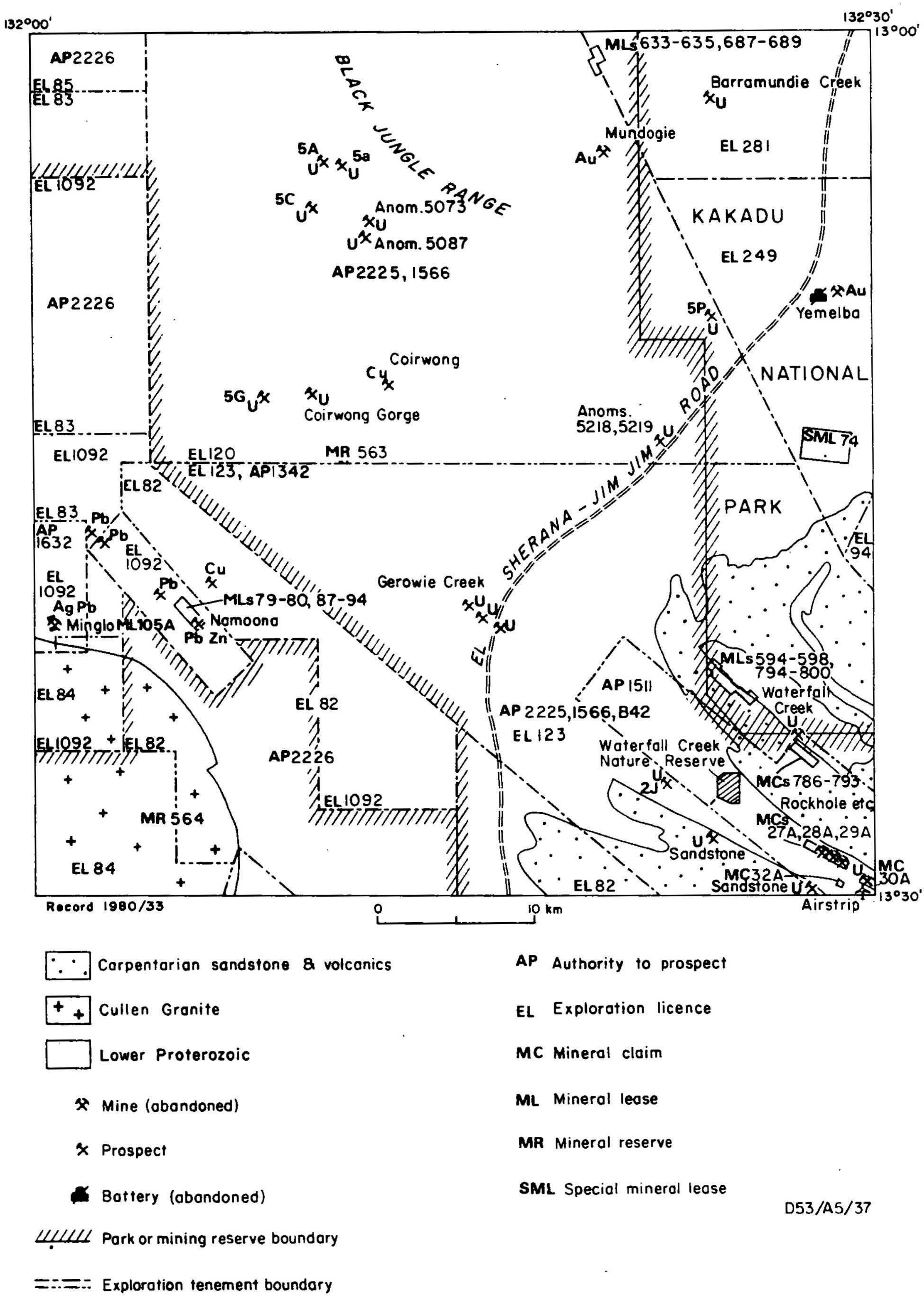

Fig. 16 Location of mines, prospects and exploration and mineral leases in the Mundogie 1:100 000 Sheet area. Compiled from Mining Tenure maps of the Northern Territory Department of Mines and Energy to 1979.

Lower Proterozoic faults that parallel the underlying northwest-trending Lower Proterozoic rocks. Walpole & others (1968) observed the lack of overturning or flattening of dips in the Lower Proterozoic rocks underlying the Callanan Basin and suggested that the Carpentarian structures were formed by faulting and not by warping of the basement. Substantial differences in thickness and composition of the Kombolgie Formation between the Callanan Basin and the plateau indicate that faulting was probably active during sedimentation.

ECONOMIC GEOLOGY

The Mundogie Sheet area contains gold, silver-lead-zinc, copper and uranium workings (Fig. 16). Uranium produced mainly from the Rockhole deposit and in small amounts from adjacent prospects accounts for most of the value of minerals produced in the area (Table 2). Rockhole formed the northermost part of the South Alligator Uranium Field, discovered and worked between 1953 and the early 1960s. Despite a systematic search for uranium following the discoveries of large uranium and uranium-gold deposits of the Alligator Rivers Uranium Field, no significant new deposits have been found in this area.

Alluvial and reef gold were mined at Yemelba in the 1930s and a stamp battery was erected there; surface and underground workings evident at Mundogie Hill are 1.5 km south of the position given by Crohn (1968) for small eluvial and alluvial gold workings at 'the Mundogie Hill locality', and are the only trace left of any mining activity in that area.

A number of small base-metal prospects are scattered in the southwest part of the Sheet, but Minglo (Pb, Ag) was the only producer. Exploration interest in base metals has continued sporadically since the early 1950s; most work was concentrated at the Namoona prospect. Minor surface iron-rich cappings noted by Crohn (1968) and investigated by N.T. Mines Branch proved to be of no economic significance. Open-file company reports held by the Northern Territory Department of Mines & Energy that are relevant to the Mundogie Sheet area are listed in Appendix 2; Figure 16 shows mines and prospects in the Sheet area, and indicates those areas investigated by mining companies.

URANIUM

The first uranium discovery in the area was by Mr R. Coxon of Uranium Development & Prospecting NL on 1 November 1954 (Lord, 1954). This discovery (at times also known as 'O'Dwyer's', 'UDP' and 'Rockhole No. 3') and the Teagues, Rockhole No. 1, Rockhole No. 2 and Sterret's workings, occur along a 730-m line of patchy mineralisation along a northwest-trending reverse fault downfaulting Carpentarian units on the northeast side against Koolpin Formation shale and siltstone (Fig. 17). The Carpentarian units are sandstone of the Kombolgie Formation, and rhyolite and pyroclastics of the Pul Pul Rhyolite Member and sandstone of the Coronation Member of the Edith River Volcanics. The Airstrip workings lie 4.5 km southeast of Rockhole and are in a similar geological setting, whilst the Coirwong Gorge prospect lies 45 km northwest along strike from Rockhole, also in Koolpin Formation. The 2J, Barramundie Creek, 'Anomalies 5A, 5a, 5C, 5G and 5P', Gerowie Creek, Sandstone and Waterfall Creek prospects have been discovered since 1971 by ground checking of airborne radiometric and magnetic surveys, and lie in a variety of geological environments. Minor mineralisation has been located in some of these prospects but currently no uranium exploration work is being done in the area.

Taylor (1968), Crohn (1968) and Foy (1975) summarised the geology of the major uranium occurrences in the area, and Taylor (1968) discussed the possible origin and control of the uranium mineralisation.

Rockhole (including No. 1, No. 2 and No. 3 (O'Dwyers) adits)

Bryan (1959) described the Rockhole deposit and included surface plans and underground plans and sections. Progress of developmental work and mining is given mainly by Lord (1956 a,b,c), and Prichard (1957 a,b; 1958 a,b; 1960 a,b,c; 1961 a,b,c). Mining ceased on 30 November 1961, at which time the workings consisted of about 1020 m of drives, and 525 m of rises, winzes and shaft (Figs. 18 a,b). Most ore was won from the No. 2 adit level, the remainder from No. 3 adit (O'Dywer). Secondary uranium minerals at the portal of the No. 1 adit proved to be surficial and development ceased after 30 m. No. 2 adit is 363 m long, and intersected the 'No. 1 Orebody' of about 1200 tons averaging 1.86% equivalent U_3O_8, over a distance of 27 m commencing 7.6 m from the portal, and the 'No. 2 Orebody' of about 4500 tons averaging 1.63% equivalent U_3O_8, as two large ore shoots and much smaller ones over a distance of 180 m

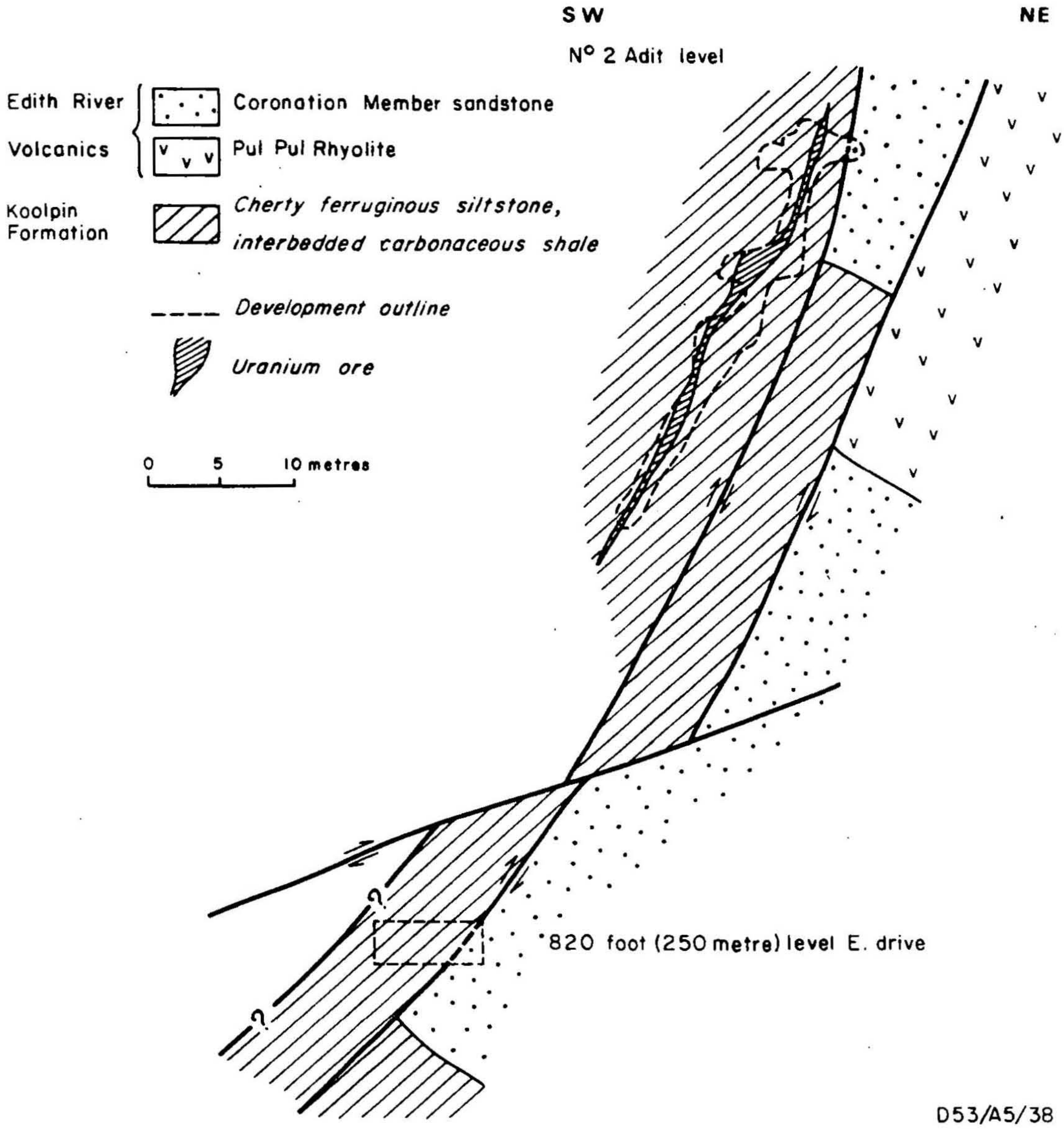

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Fig. 17 Section 200 E through the Rockhole mine along azimuth 30°. After Taylor (1968).

Fig.18(a): LEVEL PLAN OF ROCKHOLE No's 1 and 2, AND O'DWYERS AND STERRETS. Geology projected to plane of Adit level from mine cross sections in Bryan (1959) and Prichard (1961).

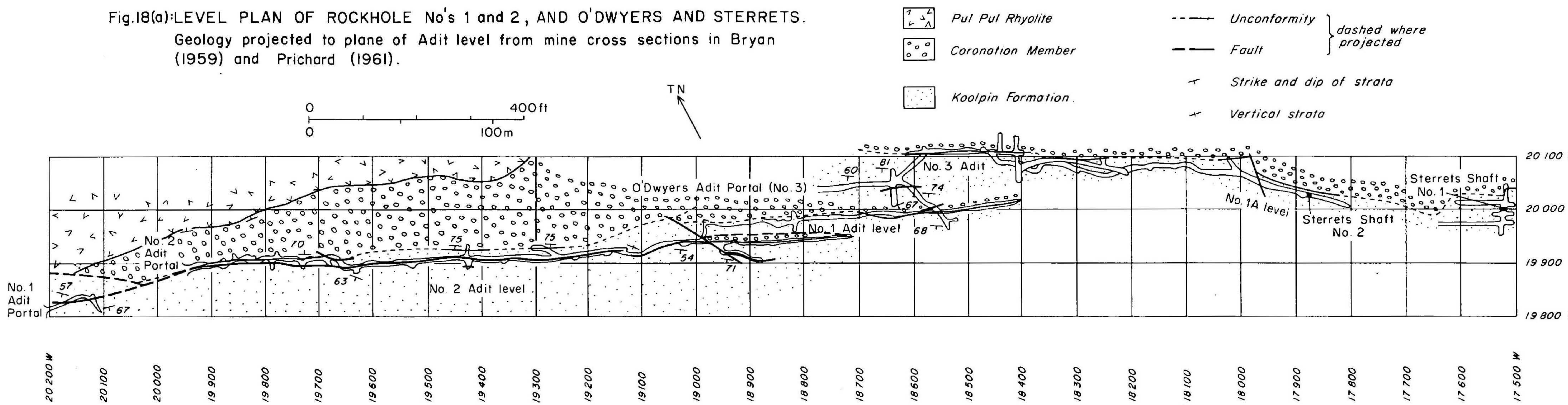
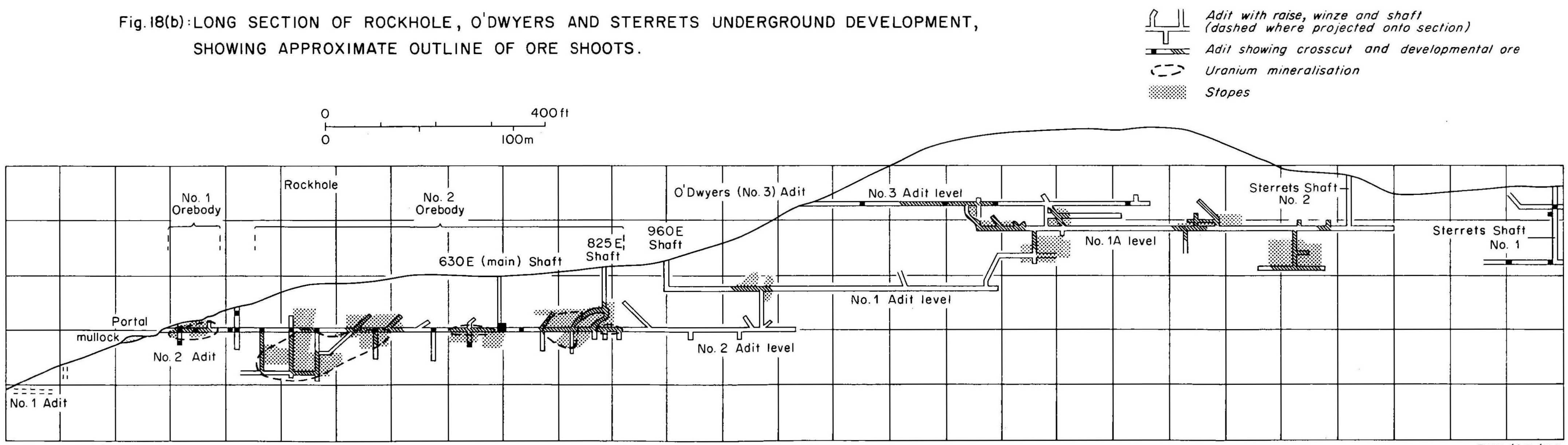


Fig.18(b): LONG SECTION OF ROCKHOLE, O'DWYERS AND STERRETS UNDERGROUND DEVELOPMENT, SHOWING APPROXIMATE OUTLINE OF ORE SHOOTS.



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commencing 77.7 m from the portal (Fig. 18b). Another shaft was sunk to 21 m, east of the No. 2 Orebody in 1960; a drive ('Level No. 1') was made from the bottom of the shaft running eastwards at 18 m above the level of the No. 2 Adit (then known as 'Level No. 2'). The drive intersected Koolpin Formation shale near the Lower Proterozoic/ Carpentarian unconformity. Patchy pitchblende mineralisation was intersected with high-grade ore from 41 to 44 m and 52 to 55 m from the shaft. The drive was extended to 183 m, passing below O'Dwyers, and linked by a rise to a higher drive from Sterrets (Fig. 18b). During early development by Uranium Development & Prospecting Ltd in 1957, 20 tons of rich secondary ore was won from the surface at O'Dwyers, but a 61-m adit in Lower Proterozoic shale failed to intersect ore. Rehabilitation by South Alligator Uranium NL in 1961 involved cross-cutting (at 27.4 m from the portal) to the contact between the shale and Carpentarian rocks (where mineralisation was known to be concentrated in the adjacent workings in Rockhole Nos 1 and 2) and then driving along the contact for 49 m. Rich lenses of ore were encountered either side of the contact, and the drive was later extended to link up with the Sterrets underground workings 250 m from the O'Dwyers portal. Mineralisation was found intermittently over 207 m of the drive, and totalled about 685 tons containing 18200 lbs U_3O_8.

South Alligator Uranium NL fulfilled a $2.5-million contract with the United Kingdom Atomic Energy Authority with the ore from the Rockhole mine; leaving a surplus production of 1250 tons of ore containing 42000 lb U_3O_8, and 829 lbs of mill concentrate containing about 670 lbs U_3O_8.

United Uranium NL noted 'some small ore occurrences' below the Rockhole workings in 1968 'which could be mined with an established operation in the field', but considered that the possibility of larger tonnages of low-grade ore needed further investigations. Noranda (Australia) Ltd were operators for a consortium conducting investigations at Rockhole from 1970 to 1977 and later Utah Mining became the operator. During these investigations another adit was driven about 76 m below the level of No. 2 Adit to test for deeper ore shoots. Results of these investigations are unavailable.

Sterrets

Minor occurrences of secondary uranium near Rockhole mentioned by Lord (1956 a) probably included the Sterrets and Teagues workings, where waggon drilling in mid-1956 intersected minor radioactivity in some holes (Lord, 1956 c). Underground exploration began in 1958 (Prichard, 1958 a, b). Two shafts were put down through less than 2 m of flat-lying sandstone into steeply dipping siltstone. Drives along the sandstone/siltstone contact (interpreted as a reverse fault) intersected patchy ore-grade pitchblende mineralisation in graphitic and ferruginous shale (Prichard, 1960 c). The westward drive was finally connected by a rise to O'Dwyer's No.3 adit in 1961, and 690 tons of developmental ore containing about 18600 lb U_3O_8 was produced. The eastward drives intersected only 5 m of low-grade ore. Mineralisation extended in places into the sandstone hanging wall, which in places also contained tuff of the Edith River Volcanics.

Téagues

This occurrence was also probably one of those reported by Lord (1956a). Lord (1956b) first used the name 'Teagues', and described uranium mineralisation in the faulted sandstone/siltstone contact, and fractures within sandstone near the fault. Anomalous radioactivity with visible patchy secondary mineralisation was disclosed after bulldozing along the contact for 30 m. Two shafts put down on the fault passed into Lower Proterozoic shale as the contact steepened. Drives and crosscuts back to the contact and also away from the contact into the shale failed to intersect mineralisation or graphitic shale. Anomalous radioactivity was confined to 12 m below surface in the shafts (Prichard, 1961b).

Airstrip

Anomalous radioactivity of 4 x background was discovered over 'nodular dolomitic marl beds' in weathered Koolpin Formation rocks. An adit 55 m long was designed to intersect these beds about 30 m from the portal, but no significant radioactivity was encountered (Prichard, 1957b). Some years later a shaft was put down into 19 m of sandstone over 4 m of Lower Proterozoic shale. The shale was 'slightly radioactive', but a 2 m drive east from the bottom of the shaft passed through barren sandstone all the way and work was discontinued (Prichard, 1961c).

Coirwong Gorge

A small area of anomalous radioactivity near Coirwong Gorge was costeaned in the 1950s (C.E. Prichard, pers. comm.) but the current survey failed to locate any trace of earthworks or anomalous radiation at the position shown by Walpole (1962). There is no recorded production from this locality (Crohn, 1968), which is in hematitic siltstone with chert bands and nodules, in places with lenses of silicified dolomite, of the Koolpin Formation.

Barramundie Creek

Rotary percussion holes were put down in 1973 by Noranda (Australia) Ltd on a 2-km-square grid over a radiometric anomaly in the centre of the Barramundie Creek plains (Anomaly 5158; Miezitis & others, 1974; Foy & others, 1975 a, b). Carbonaceous shale and carbonate of the Masson Formation were intersected, but no significant radioactivity was encountered.

2J

An anomaly over the Stag Creek Volcanics/Mundogie Sandstone boundary in the southeast of the Sheet area was delineated by interpretation of data from airborne radiometric and magnetic surveys flown for Noranda (Australia) Ltd in 1970 (Foy & others, 1973; Foy & Miezitis, 1977). The prospect lies on a weak airborne radiometric anomaly, and on a ground anomaly of up to 4 x background over an area of about 10 000 m^2. Nine rotary percussion (690 m) and six diamond-drillholes (337 m) delineated irregular bodies of mineralisation in an area 75 m long by 20 to 50 m wide and extending to 65 m below surface in the weathered zone, over tuffaceous sediments and lesser basic lavas of the Stag Creek Volcanics. The highest assay was 9780 ppm U_3O_8, and the mineralised zones averaged about 200 ppm in contrast to 'local background' values of 16 ppm. Some of the uranium is associated with goethite and manganese oxides; the only discrete uranium mineral found was a 'yellow-green micaceous uranyl phosphate'.

The mineralisation is apparently confined by the contact with the Mundogie Sandstone and by a minor fault at the northern end of the prospect. The mineralisation may be a primary concentration of uranium at the tuffaceous shale/basalt contact which has been oxidised and mobilised by groundwater to form a 'tail' of mineralisation below a minor creek; alternatively it may be a secondary weathering concentration from an unknown source (Foy & Miezitis, 1977).

Gerowie Creek

Three radon-emanometer anomalies were delineated by Noranda (Australia) Ltd in 1973 off the northern flank of the Mundogie Sandstone either side of the Jim Jim-Pine Creek road. Six rotary percussion holes totalling 532 m failed to intersect any economically significant mineralisation (Foy & others, 1975b).

Sandstone

Several small but intense radiometric anomalies were located in sandstone lenses within the Plum Tree Creek Volcanic Member of the Kombolgie Formation by an airborne survey flown for Noranda (Australia) Ltd (Foy & others, 1973). The anomalies are scattered at either end, and on the southwest limb, of a northwest-trending elongate basin of Kombolgie Formation southeast of the 2J anomaly. Surface samples gave uranium values of 300 ppm U_3O_8 and 4850 ppm Th. Assays of cuttings from 15 rotary percussion drill holes (totalling 610 m) drilled into the sandstone lenses in the hinge areas at the ends of the basinal structure gave uranium values of less than 14 ppm U_3O_8.

Investigations of these anomalies included detailed mapping of the basinal structure in which the anomalies are situated.

Barramundie Creek area regional investigation by Noranda (Australia) Ltd (ELs 120, 123)

Noranda (Australia) Ltd conducted a program of regional mapping, detailed structural analysis and drilling in ELs 120 and 123 (Fig. 16) over mainly Masson Formation rocks in the Barramundie Creek Dome, and rocks of the Mundogie Sandstone, Koolpin Formation and Fisher Creek Siltstone intruded by some dolerite bodies in the west and south (Foy & others, 1975a; Wright, 1976). Subsurface geology was investigated in the south by 149 auger holes totalling 1278 m, over about 18 km^2 (Foy & others, 1975a & b) and maximum values obtained from cuttings were 240 ppm Cu, 800 ppm Pb, 1400 pm Zn, 700 ppm Ni, 102 ppm Co and 12 ppm U_3O_8.

The grid, about 15 km northeast of the Gerowie Creek prospects (Fig. 16), was designed to test metal values over a concealed fault which throws Lower Proterozoic rocks against Carpentarian units further south. The anomalous metal values (19 of the 149 auger holes were regarded as having 'anomalous values') were attributed to rock type variation (e.g. several of the anomalous Ni and Co values were from weathered dolerite), the weathering profile, or to the north-trending fault which passed through the centre of the gridded area.

A radon-emanometer survey was also conducted by Noranda (Australia) Ltd, testing for radon leakage along the fault. Several weak anomalies up to about 3 x background were recorded (Foy & others, 1975b), but the grid was too small to accurately assess whether the anomalies were related to the north-trending fault, to cross-faults, or to normal variations in local background radioactivity. The radon anomalies were later tested by rotary percussion drilling, but no significant results were obtained.

Fourteen airborne radiometric anomalies delineated in EL 120 by airborne and ground investigations in 1970-72 were geologically mapped, and rotary percussion drilling was used to test the 5P, 5A, 5a, 5C and 5G anomalies (Fig. 16). Low uranium assays were obtained from anomalies 5073 and 5087 which are located in Cainozoic laterite and alluvium (Miezitis & others, 1974). The anomalies lie roughly along the strike of the underlying Lower Proterozoic rocks, indicating that they may be related to bedrock. Anomalies 5218 and 5219 lie on the western edge of the auger grid. The anomalies lie over alluvium and the auger traverse between the anomalies failed to detect anomalous values at depth (Foy & others, 1975a).

Anomaly 5P

An area of anomalous radioactivity measuring 1200 x 400 m in Masson Formation at the southern end of the Mundogie Dome was delinated by Noranda (Australia) Ltd in 1972 by ground reconnaissance of airborne radiometric anomalies located by an airborne survey in 1970. Eight rotary percussion holes totalling 540 m intersected siltstone, sandstone, arkose, cherty sediments and dolomite; in each hole one or more of these rock types overlies coarse-grained dolerite. Maximum values obtained from cuttings were: 61 ppm U_3O_8, 2800 ppm Cu, 2500 ppm Zn and 1000 ppm Pb. These values are probably the result of slight concentration of uranium during weathering (Miezitis & others, 1974).

Anomalies 5A, 5a, 5C and 5G

Twenty-eight rotary percussion holes, totalling 1229 m were drilled on the anomalies and indicated that their sources were surficial concentrations of uranium oxide (Foy & others, 1975a).

Ten holes toalling 152 m at Anomalies 5A and 5a penetrated bedrock below laterite. Metal values were generally higher in the laterite (U, 7-8 ppm; Ni, 33 ppm; Co, 29 ppm) than in bedrock (U, 5-6 ppm; Ni, 23-26 ppm; Co, 19-20 ppm), but Zn was higher in bedrock (61 ppm) than in the laterite (19 ppm).

Samples from the weathered zone in six holes at Anomaly 5C yielded maximum concentrations of U 32 ppm, Cu 260 ppm; Ni 150 ppm, Co 110 ppm; Pb 210 ppm and Zn 190 ppm.

Six holes totalling 221 m intersected siltstone, sandstone, arkose and dolomite of the Masson Formation at Anomaly 5G. Maximum values were U 51 ppm; Cu 750 ppm; Ni 510 ppm; Co 1000 ppm; Pb 150 ppm and Zn 680 ppm.

A radon-emanometer survey was conducted over the Mundogie Sandstone for 8 km of strike length either side of Goodparla Creek, northwest of Anomaly 5G. No anomalous values were recorded (Foy & others, 1975a).

Waterfall Creek

Radon anomalies were defined near the southwest margin of the Waterfall Creek Inlier by Noranda (Australia) Ltd adjacent to the faulted Kombolgie Formation/Fisher Creek Siltstone contact. Three rotary percussion drill holes intersected minor mineralisation (Foy & others, 1975b).

Regional investigations south of Mount Partridge Range by Pechiney (Australia) Pty Ltd and Project Mining Corporation

In a joint venture between Pechiney (Australia) Exploration Pty and Project Mining Corporation an extensive program of mapping, ground radiometric and radon surveys, and auger, rotary percussion and diamond drilling was conducted from 1972 to 1975. Work in the early part of the venture consisted mainly of detailed mapping and ground radiometrics over ELs 94 and 249, which cover outcrops of the Mount Partridge Group, and Masson Formation. Later emphasis was on detailed mapping, radon surveys and drilling of Koolpin Formation rocks in the south of the leases. Most of the drilling was concentrated in the southwest corner of EL 249 around the contact between the Mundogie Sandstone and the Koolpin Formation. Some radiometric and radon anomalies were detected and were the main targets of the drilling, but no mineralisation was intersected (Dewar, 1975a; 1975b).

BASE METALS

Several small base-metal occurrences were located in the 1950s, mainly by prospectors working for Australian Mining & Smelting Co. Ltd and the Broken Hill Pty Co. Ltd. Namoona is the largest occurrence but the only recorded production is from Minglo. The current survey located several minor occurrences along a northwesterly line from Namoona in the Masson Formation and also a small copper show in Stag Creek Volcanics 3 km north of Namoona. The minor occurrences were probably investigated in the same period during the 1950s when the Namoona prospect was discovered. They each consist of geothite-rich and hematite-rich gossanous ridges, along or close to strike, commonly with visible secondary minerals. The Pb-Zn gossans commonly display encrustations of white secondary zinc minerals. The gossanous capping at the copper prospect contains malachite at surface and in the weathered zone. Each of these prospects has been costeaned and drilled, but there are no records of this work.

Base-metal exploration commenced again in the 1970s after a decade of little activity in the 1960s. CRAE Ltd conducted extensive regional mapping surveys and soil geochemical surveys in a search for base-metals over most of the Masson Formation in the Sheet area; Noranda (Australia) Ltd located a small occurrence of lead in the Kapalga Formation (South Alligator Prospect) during investigations near the northern edge of the Sheet area and several subeconomic anomalous metal concentrations while drilling radiometric anomalies.

<u>Namoona</u>

A gossanous ridge in Masson Formation 4 km west of Goodparla homestead contains visible galena, cerrusite and pyromorphite. Costeans cut through another gossan on the northeast flank reveal several seams of massive galena up to 0.6 m wide only 1 m below the surface (Fig. 19a). A long history of testing, however, has determined a low average grade.

Lead mineralisation was found at Namoona in September 1954 by a prospecting team of Australian Mining & Smelting Co. Ltd led by H. Brennan. BMR carried out a preliminary geochemical survey at the site and detected a lead anomaly extending over at least 1340 m (Debnam, 1955a). At the time two costeans had been cut and lead mineralisation revealed. In the following wet season the company carried out an extensive costeaning and drilling program at the discovery site and at a northwestern extension indicated by outcropping mineralisation and by anomalous Pb soil geochemistry. Over 40 costeans were cut, several shallow waggon drillholes were put down, and one 122-m diamond hole drilled. Only isolated concentrations of lead mineralisation were found (Debnam, 1955b). Further geochemical work by BMR in 1955 detected '4th order' Pb anomalies (greater than 100 x background) over a strike length of 6400 m out of a total of 9250 m of strike length tested. Crohn (1968) reports that the costeaning revealed several seams of massive galena up to 0.6 m wide; some were bedded and others in small shear zones, and some may be suitable for small-scale selective mining.

The area was reinspected in 1964 and an Authority to Prospect of 8 square miles was applied for by CRAE Exploration Pty Ltd and United Uranium NL. A geochemical survey was followed by more costeaning and drilling from 1965 to 1967. The best intersection was in the oxidised zone - 3.77% Pb and 1.5 oz Ag/ton over 3.5 m. Deeper mineralisation was confined to carbonaceous and calcareous (and in places micaceous) siltstone with minor greywacke and shale; minor mineralisation was also associated with quartz and carbonate-filled fissures (Berger & Normand, 1972).

The prospect was acquired by Western Nuclear in 1968. In 1971 Le Nickel Exploration carried out a small exploration program including geological mapping and stream-sediment geochemistry with 'disappointing' results. They concluded that the prospect contained primary stratiform disseminated mineralisation related to a horizon of siltstone and shale, and that the mineralisation in small quartz veins and/or brecciated zones filled by quartz and carbonate was epigenetic (Berger & Normand, 1972).

(a)

(b)

Figure 19. (a) Costean exposing main lode, Namoona prospect. M2249-20

(b) Minglo prospect, view looking south along strike of lode. M2249-12

CRAE Exploration Pty Ltd conducted more work at the prospect in 1976-78. Costeaning yielded 2-3% Pb over widths of up to 9 m across strike below the gossan on the top of the ridge in some places, but drilling once again only intersected subeconomic Pb-Zn grades. The ridge-top gossan, containing stratiform Pb-Zn mineralisation, occurs within calcarenite; which is deeply weathered to a blocky white quartzitic rock, ferruginous and quartz-veined in places, and is interbedded in a sequence of pyritic calcareous carbonaceous shale weathered to a ferruginous red, pale-mauve and cream shale. The sequence dips 60° to the southwest. The lode on the northeast flank of the ridge has less prominent gossan development and contains only lead; the lode appears bedded in places and is in minor shears elsewhere.

There is no recorded production from the Namoona prospect.

Minglo

A quartz breccia zone up to 1-2 m wide, with minor secondary lead ochres and films apparent at the surface, transects hornfelsed pyritic carbonaceous shale of the Wildman Siltstone along 170°, 13 km west of 'Goodparla' homestead. The carbonaceous shale is continuous across strike to the northeast to a prominent ridge of Mundogie Sandstone capped by Mesozoic strata (Chara Chara Hill) clayey and pebbly sandstone of the Wildman Siltstone. The shale is in the outer part of the metamorphic aureole of the Cullen Granite, and the mine lies 1.25 km north of the contact. Dips range considerably within 200 m of the mine and may reflect folding associated with the fault. Locally at the mine they are 30° south-southwest.

The ore consists of galena and minor anglesite within the breccia. Workings are a 15-m vertical shaft with drives along the direction of the lode at the 15-m level, and two deep gouges (Fig. 19b). Production was 6.8 tonnes of lead and 2550g of silver in 1964-5.

South Alligator prospect

A north-trending gossaneous siliceous breccia zone cutting Kapalga Formation rocks near the northern edge of the Sheet area 1 km west of the South Alligator River was found in 1974 by Noranda (Australia) Ltd to contain high base-metal values. Up to 7.2% Pb was obtained over 2 m in the breccia, with values of As up to 5000 ppm and Au up to 0.04 oz/ton (Foy & others, 1975b). The prospect was considered too small to warrant further work.

Coirwong

A diamond-drillhole (D.D.H. Mundogie Hill No. 1) was put down in 1959 by BHP 6.4 km east-northeast of Coirwong Gorge, mainly into Zamu Dolerite. Crohn (1968) records the area as a copper prospect, but no description is given. The hole passed through 33.5 m of dolerite, over 30.5 m of pyritic siltstone and chert of the Koolpin Formation, over 9.1 m of dolerite, at which point drilling stopped (Bryan, 1962).

GOLD

Gold was produced at Yemelba and Mundogie Hill. According to Crohn (1968) production at Mundogie Hill was mainly from eluvial and alluvial deposits. At Yemelba much of the activity appears to have been in auriferous quartz veins; there are also numerous pits into alluvium and the remains of small dams along an adjacent creek, suggesting some alluvial mining. There is no evidence today of mining at the location given for the Mundogie Hill workings by Crohn, but there are underground workings 1.5 km further south.

Yemelba

A derelict stamp battery is surrounded by numerous costeans and shallow gouges (maximum depth 3.5 m), and one deeper larger gouge 10 m deep, into auriferous quartz reefs with minor pyrite and locally copper, in quartzite of the Masson Formation. There is also evidence of eluvial and alluvial mining in the creek draining westwards through the area. The quartz reefs trend about north; the costeans may post-date the recorded period of production of 1933-39, which yielded about 250 oz of gold.

Mundogie Hill

Crohn (1968) described small eluvial and alluvial gold deposits about 2 km southeast of the old Darwin-Jim Jim road crossing over the South Alligator River in the north of the Sheet area. There is no evidence of any such activity remaining, but an underground development into a north-trending quartz breccia reef is located 1.5 km further south on Mundogie Hill. The development is Y-shaped and consists of an adit of 34 m and two drives each of 7 m entering from the north flank of the hill. The adit passes through ferruginised phyllite striking 180^{o} and dipping 34^{o} north, and the drives are developed in flat-lying phyllite that includes a 1-m-thick conformable zone of auriferous quartz bands and boudins. At the peak of the hill above the underground workings, a series of small shallow pits 1 m wide trends 178°, and several trenches cross the line of the lode. The thin auriferous quartz veins strike 350° and dip 87° east in coarse-grained meta-arkose of the Mundogie Sandstone. There is no recorded production.

IRON

Ridges of Koolpin Formation and Kapalga Formation rocks commonly consist of, or are capped by crags of, massive to botryoidal to brecciated or cellular hematite-goethite ore. The best developments are in the Black Jungle Range (Kapalga Formation) and northwest of Coirwong Gorge (Koolpin Formation). Crohn (1968) reports that BHP tested these occurrences for sulphides by a limited diamond-drilling program which intersected pyritic beds. Crohn recommended further investigation of these rocks after referring to the uranium, gold and copper mineralisation occurring in similar strongly pyritic rocks in the Rum Jungle and Brocks Creek areas.

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APPENDIX 1

Changes in stratigraphic nomenclature

GEROWIE TUFF

Derivation of name: as for Gerowie Chert (Walpole, 1962).

Distribution: Well-exposed in discontinuous belt of rubbly rises throughout the Pine Creek and southern portion of the Darwin and Alligator River 1:250 000 Sheet areas, and in the South Alligator Valley (Mount Evelyn 1:250 000 Sheet area).

Type section: (131°38'E, 12°55'S Darwin 1:250 000 Sheet area) 500-m section exposed in roadcutting adjacent ot the Arnhem highway from 750 to 1250 m west from the western end of the Mary River bridge. Only the lower contact is exposed, defined by the base of a coarse-grained pink lithic tuff bed.

Lithology: Laminated to thin-bedded grey, brown and pink argillite, lithic tuff, feldspathic tuff. black glassy spotted tuff (commonly with a weathered white shell), shale, and rare felsic crystalline flow rocks and shale with white, grey or black chert nodules.

Thickness: Ranges from 200 m in the western part of the Pine Creek Geosyncline to 750 m in the South Alligator Valley.

Relationships and boundary criteria: Conformably overlies the Koolpin Formation - contact defined by first appearance of tuff. In the South Alligator Valley area the lower contact is not well defined and some interbedding of the unit with the Koolpin Formation is apparent. The unit is conformably overlain by the Kapalga and Mount Bonnie Formations - contact defined at the base of the first massive feldspathic greywacke or extensive development of shale with chert lenses, bands, and nodules. In the South Alligator Valley the unit also interfingers with the Shovel Billabong Andesite.

Age and evidence: Lower Proterozoic, as it forms part of the Lower Proterozoic metasedimentary sequence of the Pine Creek Geosyncline which overlies dated Archaean rocks (Page & others, 1980) and underlies the Kombolgie Formation which locally is the lowermost unit in the Carpentarian McArthur Basin sequence.

Synonymy: Walpole (1962) named these beds Gerowie Chert in the Mount Evelyn 1:250 000 Sheet area and Malone (1962) included them in the Golden Dyke Formation in the Darwin Pine Creek 1:250 000 Sheet areas.

References: Described by not named: I.H. CRICK, P.G. STUART-SMITH & R.S. NEEDHAM, 1978: Stratigraphic significance of a discovery of Lower Proterozoic tuff in the Pine Creek Geosyncline; BMR Jour. of Aust. Geol. & Geophys. vol. 3, 163-165.

SHOVEL BILLABONG ANDESITE

Derivation of name: Shovel Billabong, 132°19'E, 13°18'S, Mount Evelyn 1:250 000 Sheet area.

Distribution: Poorly exposed pavements and rubbly rises in a discontinuous northwest-trending belt, about 40 km long, extending from 5 km north of Rockhole mine to 8 km north of Coirwong Gorge, Mount Evelyn 1:250 000 Sheet area.

Type locality: 3 km southwest of Shovel Billabong (132°18'E, 13°19'S).

Lithology: Variolitic andesite and microdiorite, microdiorite probably forms centres of thicker flows.

Thickness: Range 100 to 300 m

Relationships and boundary criteria: Contacts not exposed. Unit conformably overlies the Koolpin Formation and interfingers with the overlying Gerowie Tuff. Probably consists of a number of small flows; at least two flows identified in type locality.

Age and evidence: Lower Proterozoic, as it forms part of the Lower Proterozoic metasedimentary sequence of the Pine Creek Geosyncline which overlies dated Archaean rocks (Page & others, 1980) and underlies the Kombolgie Formation which locally is the lowermost unit in the Carpentarian McArthur Basin sequence.

Synonymy: Walpole (1962) included this unit in the 'Zamu Complex' (Mount Evelyn 1:250 000 Sheet area).

APPENDIX 2

Company reports relevant to the Mundogie Sheet area filed at N.T. Department of Mines & Energy (the first two numbers of the Dept. of Mines & Energy file number refer to the year of the report)

N.T. Dept. of Mines & Energy File No.	Lease No.	Main prospected minerals	Abbreviated title and company
CR35/1		Au	Departmental report, Yemelba, Arnhem Land Gold Development N.L.
CR57/16		U	The South Alligator River Uranium Field. United Uranium N.L.
CR59/6	AP448	Pb, Zn	Summary of Conclusions, Namoona area AP448. CRAE.
CR64/22	AP1130	Pb, Zn	Geochemical prospecting, northern lead anomalies, Namoona. AP1130. CRAE
CR66/26		Pb, Zn	Interim report, northern anomalies, Namoona. United Uranium N.L.
CR66/32	AP1342, 1511	U	Interim report, South Alligator area AP1342, 1511 United Uranium N.L.
CR67/34	AP1566	U	Report on reconnaissance stream sampling, northern area South Alligator region. AP1566. United Uranium N.L.
CR67/35	AP1511	Pb, Zn	Final report Namoona lead prospect AP1551. United Uranium N.L.
CR71/6	AP2226	U	Report on investigations AP2226. Australian Geophysical.
CR71/50	AP1632	Pb, Ag	Progress report Minglo prospect AP1632. Murray Brennan.

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CR71/97	AP2226	U	Final report 1971 Air and ground spectrometer surveys AP2226. Australian Geophysical.
CR72/44	EL94, 95 249	U	Geological report Jim Jim region EL94, 95, 249. Project Development Corp.
CR72/88		U	Report of aerial prospecting EL94, 95, 249. Pechiney (Aust.) Expl.
CR73/10	EL82-85		Report on exploration and expenditure EL82-85. Macmine.
CR73/42	EL281	U	Report on prospecting, EL281. Noranda Aust. Ltd.
CR73/45	EL120	U	Report on prospecting, EL120. Noranda Aust. Ltd.
CR73/46	EL123	U	Report on prospecting, EL123. Noranda Aust. Ltd.
CR73/113	EL94, 95, 249	U	Results of 1972 prospection Phase I-II, E194, 95, 249. Project Development.
CR73/149	EL82-85		1972 exploration report EL82-85. Macmine.
CR73/182	EL525	Pb, Zn	Annual Report Namoona EL525. Western Nuclear.
CR73/228	AP2113, EL525	Pb, Zn	Progress report Namoona AP2113, EL525. Le Nickel.
CR74/58	EL94, 95 249	U	1973 Prospection Jim Jim EL94, 95, 249. Pechiney (Aust.) Expl.
CR74/61	EL120	U	Report 1973 Investigations EL120. Noranda Aust. Ltd.

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CR74/62C,D	EL123	U	Report 1973 Investigations EL123. Noranda Aust. Ltd.
CR75/44	EL120	U	Report 1974 Investigations EL120. Noranda Aust. Ltd.
CR75/45	EL123	U	Report 1974 Investigations EL123. Noranda Aust. Ltd.
CR75/47	EL94, 249	U	Report 1974 Fieldwork EL94, 249. Pechiney (Aust) Expl.
CR76/6	EL94, 249	U	1975 Fieldwork, uranium exploration EL94, 249. Pechiney (Aust.) Expl.
CR76/27	EL120	U	Report 1975 Investigations EL120. Noranda Aust. Ltd.
CR76/28	EL123	U	Report 1975 Investigations EL123. Noranda Aust. Ltd.
CR77/31	EL123	U	1976 Investigations EL123. Noranda Aust. Ltd. Report 261.
CR77/33	EL120	U	1976 Investigations EL120. Noranda Aust. Ltd. Report 260.
CR77/56	EL123	U	1975 Investigations EL123. Noranda Aust. Ltd. Report 255.
CR77/57	EL123	U	1974 Investigations EL123. Noranda Aust. Ltd. Report 252.
CR77/59	EL123	U	1972/3 Investigations, relinquished areas, EL123. Noranda Aust. Ltd. Report 264.
CR77/84	EL249	U	Final report E1249. Project Mining Corp.

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CR77/91A,B	AP2225	U	Geophysical maps, magnetic and radiometric, AP2225. Noranda Aust. Ltd. and United Uranium N.L.
CR78/62	EL1092	Cu, Pb, Zn	Annual report Moline 1091, Goodparla 1092, Frances Creek 1093, George Creek 1094 EL's. CRAE.
CR79/55	EL1092	Cu, Pb, Zn	Annual report, Goodparla. Pine Creek Basin EL1092. CRAE.

TABLE 1. SUMMARY OF STRATIGRAPHY OF THE MUNDOGIE 1:100 000 SHEET AREA (CAINOZOIC UNITS OMITTED)

Age	Group / Formation	Unit	Lithology	Field Relations	Thickness (m)
CRETACEOUS		PETREL FORMATION	Sandstone, conglomerate	Forms flat-lying veneer over older formations	2
	KATHERINE RIVER GROUP; KOMBOLGIE FORMATION Bhk		Sandstone, conglomerate, minor shale	Unconformably overlies the Edith River Volcanics and the Masson Formation	600-1500
	KATHERINE RIVER GROUP; KOMBOLGIE FORMATION Bhk	PLUM TREE CREEK VOLCANIC MEMBER Bhp	Porphyritic felsic volcanics, sandstone and shale	Conformably overlies the Kurrundie Member	370
	KATHERINE RIVER GROUP; KOMBOLGIE FORMATION Bhk	KURRUNDIE MEMBER Bhr	Pebble conglomerate, quartz sandstone	Forms base of the Kombolgie Formation west of the South Alligator River	220
CARPENTARIAN	EDITH RIVER VOLCANICS	PUL PUL RHYOLITE MEMBER Bhep	Rhyolite, ignimbrite, trachyte, trachyandesite	Conformably overlies the Coronation Member	<100
CARPENTARIAN	EDITH RIVER VOLCANICS	CORONATION MEMBER Bhec	Pebbly coarse quartz sandstone commonly tuffaceous	Forms base of the Carpentarian sediments - overlies older units with a marked regional unconformity	
CARPENTARIAN		Bd	Olivine dolerite	Dykes intruding Lower Proterozoic metasediments in the Barramundie Creek area.	
CARPENTARIAN		OENPELLI DOLERITE Bdo	Olivine dolerite and minor felsic differentiates	Intrudes Lower Proterozoic rocks as a series of lopoliths	<250
CARPENTARIAN			Felsite	Minor dyke intruding Masson Formation	
CARPENTARIAN		CULLEN GRANITE Bgc	Pink and grey porphyritic granite, minor medium granite and aplite	Intrudes the Masson Formation, Mundogie Sandstone, Wildman Siltstone, and Burrell Creek Formations	
LOWER PROTEROZOIC		ZAMU DOLERITE Bdz	Quartz dolerite, minor olivine dolerite and granophyre	Layered sills and minor dykes	<2500
LOWER PROTEROZOIC		Bda	Dacite	Forms a sill? intruding Gerowie Tuff near Shovel Billabong	200
LOWER PROTEROZOIC	FINNISS RIVER GROUP	BURRELL CREEK FORMATION Bu	Micaceous sandy siltstone	Unconformably? overlies the Masson Formation	unknown
LOWER PROTEROZOIC	FINNISS RIVER GROUP	FISHER CREEK SILTSTONE Bff	Siltstone, greywacke, slate, arkose, sandstone	Unconformably? overlies the Koolpin Formation	unknown
LOWER PROTEROZOIC	SOUTH ALLIGATOR GROUP	KAPALGA FORMATION Bsp	Ferruginous siltstone with chert bands, lenses and nodules, minor silicified dolomite, phyllite and carbonaceous shale	Unconformably? overlies the Koolpin Formation, Gerowie Tuff and Wildman Siltstone.	<5000
LOWER PROTEROZOIC	SOUTH ALLIGATOR GROUP	GEROWIE TUFF Bvg	Argillite, tuff, pale green tuffaceous greywacke	Conformably overlies the Koolpin Formation	750
LOWER PROTEROZOIC	SOUTH ALLIGATOR GROUP	SHOVEL BILLABONG ANDESITE Bvb	Variolitic andesite, microdiorite	Forms flows interbedded with the Gerowie Tuff	100-300
LOWER PROTEROZOIC	SOUTH ALLIGATOR GROUP	KOOLPIN FORMATION Bsk	Ferruginous siltstone with chert bands, lenses and nodules, pyritic carbonaceous shale, silicified dolomite, minor phyllite, jasper and BIF	Unconformably overlies older units	1000

LOWER PROTEROZOIC	MOUNT PARTRIDGE GROUP	WILDMAN SILTSTONE Bpw	Siltstone (carbonaceous at depth in places), red and cream laminated siltstone, quartz sandstone	Conformably overlies the Mundogie Sandstone	2000?
		MUNDOGIE SANDSTONE Bpm	Quartz sandstone feldspathic meta-sandstone, conglomerate, phyllite, siltstone and schist	Unconformably overlies Masson Formation and Stag Creek Volcanics	300-2600
	NAMOONA GROUP	STAG CREEK VOLCANICS Bvs	Basic volcanic flows and flow breccia, tuffaceous shale, siltstone and greywacke	Overlain unconformably by the Mundogie Sandstone	1000
		MASSON FORMATION Bnm	Shale (carbonaceous at depth) calcarenite, sandstone, dolomite	Oldest Lower Proterozoic unit in the area, conformably overlain by the Stag Creek Volcanics	2500

TABLE 2. RECORDED PRODUCTION AND TONNAGE/GRADE FIGURES FOR METALS PRODUCED IN THE MUNDOGIE SHEET AREA.

Mine	Tonnes/grade	Metal			
		Au (grammes)	Ag (grammes)	Pb (tonnes)	U_3O_8 (tonnes)
Minglo	18.4 @ 58% Pb; 138 g/Ag ?		2550	6.8	
Rockhole/Sterretts/ Teagues	13 200 @ 1.1% U_3O_8	some gold			152
Yemelba		7775			
Totals		7775 g	2550 g	6.8	152