BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD

Record 1981/41

GEOLOGY OF THE MARY RIVER AND POINT STUART 1:100 000 SHEET AREAS, NORTHERN TERRITORY

P.G. Stuart-Smith, D.A. Wallace, & M.J. Roarty

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ABSTRACT

This record contains a detailed reappraisal of the geology of the Mary River and Point Stuart 1:100 000 Sheet areas, mapped during 1978 by the Pine Creek Geological Party (BMR and NTGS) using either 1:25 000 or 1:16 000 scale colour aerial photographs in conjunction with 1:89 000 scale panchromatic aerial photographs. The Sheet areas are about 100 km east of Darwin and lie within the catchment of the Mary River. The main physiographic units are the Coastal, Alluvial, and Northern Plains, and the Dissected Foothills.

The Sheet areas are occupied by a sequence of Early Proterozoic metasediments and volcanics of the Mount Partridge, South Alligator, and Finniss River Groups, which have been intruded by the Mount Bundey Granite and Mount Goyder Syenite, and felsite, minette, and other minor dyke rocks. The metasediments, which have been tightly to isoclinally folded and regionally metamorphosed to lower greenschist facies, are unconformably overlain by extensive Cretaceous and Cainozoic sediments.

Crushed rock and sand are presently being extracted from the area, and, apart from the abandoned Mount Bundey iron mine, no economic mineralisation has been located. There are several small base metal and gold and uranium prospects in the area.

INTRODUCTION

This Record contains a detailed account of the geology of the Mary River and Point Stuart 1:100 000 Sheet areas (Fig. 1). A preliminary account was given by Needham & others (1980a). A brief description of 1978 field work in this area was given by Stuart-Smith & others (1980b), who also included 1:100 000 scale reductions of photoscale compilation sheets (with original scales of 1:16 000, 1:25 000 and 1:89 000), thin section descriptions, and data relating to a stratigraphic drill hole in the Mount Bundey area. The generalised geology is shown here in Figure 2 and the stratigraphy is summarised in Table 1. Changes in stratigraphic nomenclature follow the scheme outlined by Needham & others (1980a) and are shown in Table 2. Proposed changes in stratigraphic nomenclature are appended to this Record.

The area was mapped during 1978 using either 1:25 000 or 1:16 000 scale colour airphotos where available, and 1:89 000 scale panchromatic airphotos elsewhere.

The work fulfils part of the objectives of the Pine Creek Project (Needham & others, 1979), which are to study the geology, geophysics, and mineralisation of the Pine Creek Geosyncline and to produce 1:100 000 scale geological maps of the region. The 1978 work entailed numerous ground traverses by Landrover and on foot, and drilling of 12 scout holes.

Copies of the Preliminary Edition of the Mary River/Point Stuart geological map, scale 1:100 000, are available from BMR; price is $4.00 plus packaging and postage.

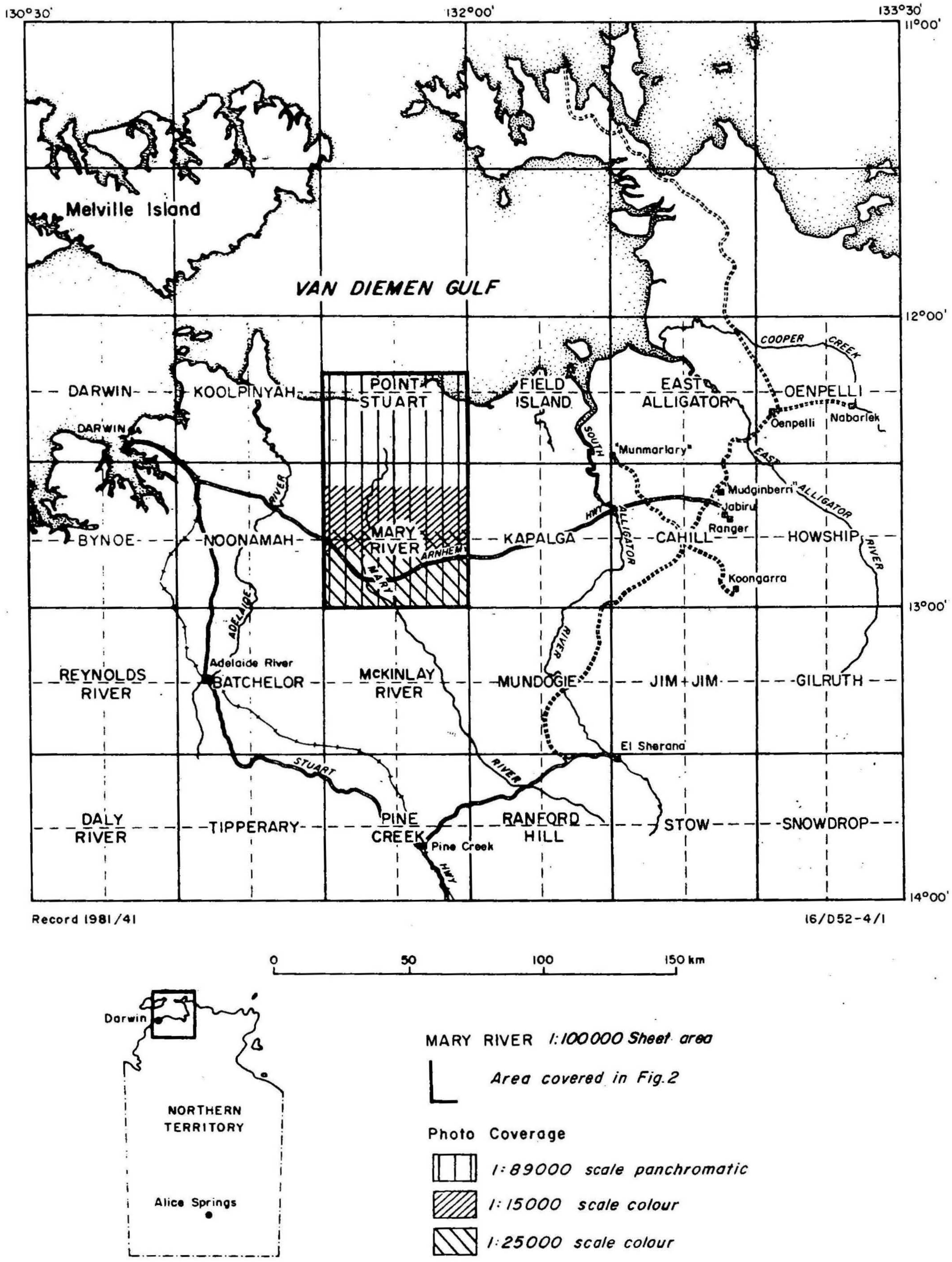
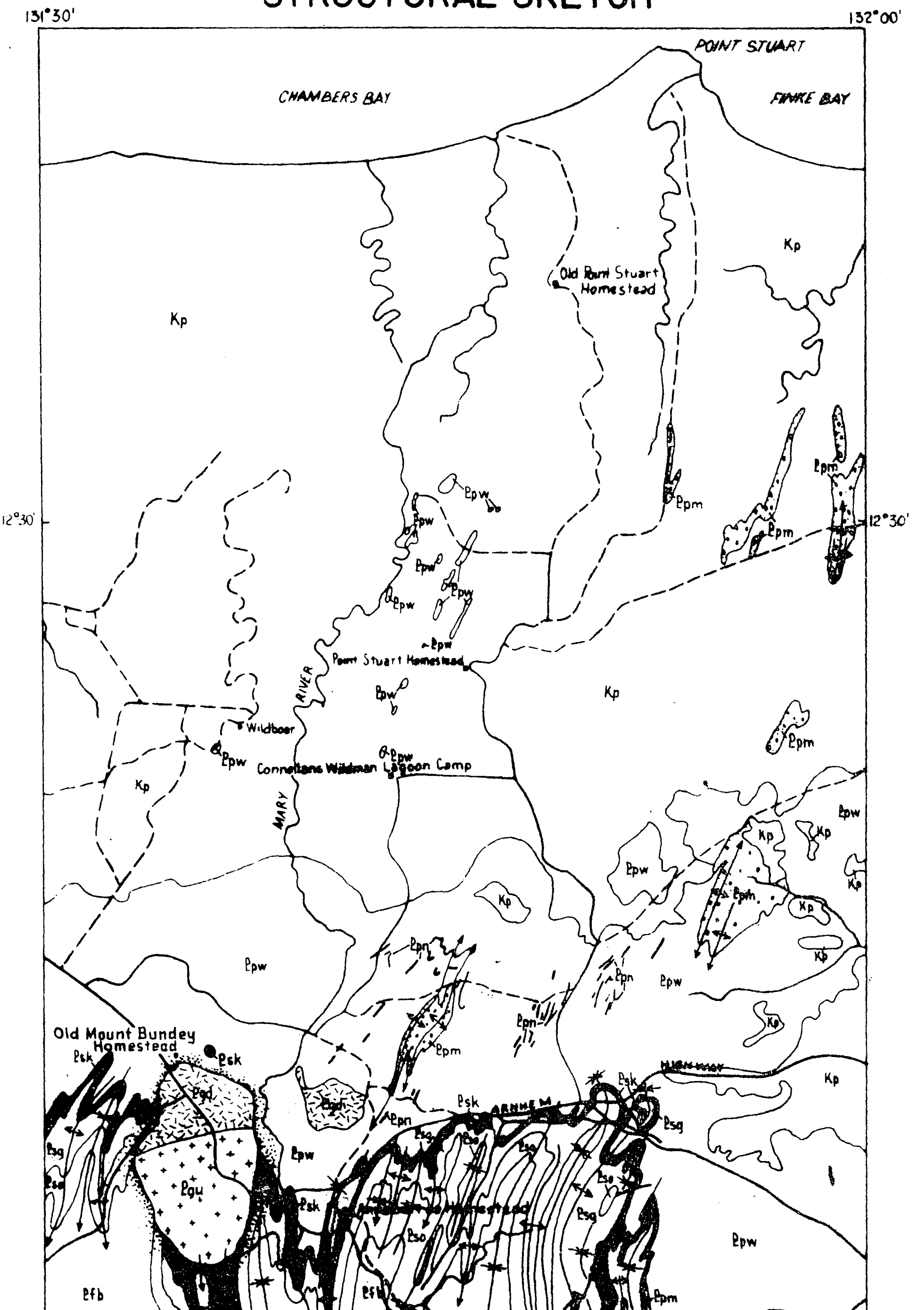


Figure 1 Locality map 16/D52-4/1

STRUCTURAL SKETCH



Kp	Petrel Formation
Pgv	Mount Bundey Granite
Pgd	Mount Goyder Syenite
Pfb	Burrell Cr. Formation
Pso	Mount Bonnie Formation
Psg	Gerowe Tuff
Psk	Koolpin Formation
Ppn	Annaburroo Volc. Member
Ppw	Wildman Siltstone
Ppm	Mundogie Sandstone

Geological boundary
Syncline
Anticline
Fault
Showing trend of plunge of axis
Metamorphic aureole

0 20 km

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Fig. 2 Interpreted solid geology, Mary River and Point Stuart 1:100 000 Sheet areas

TABLE 1. Summary of stratigraphy of the Mary River and Point Stuart 1:100 000 Sheet areas

(Cainozoic units omitted)

		UNIT	DESCRIPTION	FIELD RELATIONS	THICKNESS (m)
CRETA-CEOUS		PETREL FORMATION	Limonitic quartz sandstone; minor conglomerate and breccia	Forms flat-lying caps; unconformably overlies older formations	up to 60
EARLY PROTEROZOIC	FINNISS RIVER GROUP	BURRELL CREEK FORMATION	Shale, phyllite, siltstone, and greywacke	Conformably overlies the Mount Bonnie Formation	1000+
EARLY PROTEROZOIC	SOUTH ALLIGATOR GROUP	MOUNT BONNIE FORMATION	Shale and siltstone, minor banded iron formation, argillite, crystal tuff, tuffaceous chert and greywacke; rare silicified dolomite	Conformably overlies the Gerowie Tuff and underlies the Burrell Creek Formation	650
EARLY PROTEROZOIC	SOUTH ALLIGATOR GROUP	GEROWIE TUFF	Silicified siltstone, argillite, shale, crystal tuff, tuffaceous chert, and minor tuffaceous greywacke	Conformably overlies the Koolpin Formation and underlies the Mount Bonnie Formation	600
EARLY PROTEROZOIC	SOUTH ALLIGATOR GROUP	KOOLPIN FORMATION	Ferruginous siltstone and shale containing bands, lenses and nodules of chert, discontinuous silicified dolomite lenses and ferruginous breccia	Unconformably overlies the Mount Partridge Group and conformably overlain by the Gerowie Tuff	100-200
EARLY PROTEROZOIC	MOUNT PARTRIDGE GROUP	WILDMAN SILTSTONE	Colour banded, laminated shale (pyritic and carbonaceous at depth), siltstone and minor interbeds of medium to coarse sandstone; rare intra-formational breccia and silicified dolomite	Conformably overlies the Mundogie Sandstone; unconformably overlain by the Koolpin Formation	1000+
EARLY PROTEROZOIC	MOUNT PARTRIDGE GROUP	ANNABURROO VOLCANIC	Chloritised pyritic amygda-loidal andesite and porphy-ritic andesite; deeply weathered and ferruginous at the surface	Forms two conformable beds in the Wildman Siltstone about 250 m and 500 m above the base	50-100
EARLY PROTEROZOIC	MOUNT PARTRIDGE GROUP	MUNDOGIE SANDSTONE	Fine to coarse quartz sandstone, quartzite and arkose; minor conglomerate, shale, and siltstone	Oldest exposed unit in the area overlain conformably by the Wildman Siltstone	500+
ARCHAEAN?			Gneissic granite	Concealed by Cretaceous and Cainozoic sediments	

Table 2. Changes in Early Proterozoic stratigraphic nomenclature for the Mary River and Point Stuart 1:100 000 Sheet areas

<table>
<tr><th></th><th colspan="2">Malone (1962); Walpole & others (1968)</th><th colspan="2">This report</th><th></th></tr>
<tr><td>FINNISS RIVER GROUP</td><td colspan="2">Burrell Creek Formation</td><td colspan="2">Burrell Creek Formation</td><td>FINNISS RIVER GROUP</td></tr>
<tr><td rowspan="7">GOODPARLA GROUP</td><td rowspan="3">Golden Dyke Formation</td><td rowspan="2"></td><td colspan="2">*Mount Bonnie Formation</td><td rowspan="3">SOUTH ALLIGATOR GROUP</td></tr>
<tr><td colspan="2">Gerowie Tuff</td></tr>
<tr><td>Craig Creek Member</td><td colspan="2">Koolpin Formation</td></tr>
<tr><td colspan="2"></td><td>u</td><td>u</td><td></td></tr>
<tr><td colspan="2" rowspan="2">Masson Formation</td><td></td><td rowspan="2">Wildman Siltstone</td><td rowspan="3">MOUNT PARTRIDGE GROUP</td></tr>
<tr><td>Annaburroo* volcanic member</td></tr>
<tr><td colspan="2">Mount Partridge Formation</td><td colspan="2">Mundogie Sandstone</td></tr>
</table>

u - unconformity

* - informal name

Location and access

The location of the survey area is shown in Figure 1. The area is about 100 km east of Darwin and is reached by the Arnhem Highway, which crosses the southern part of the area. Access north of the highway is provided by unsealed roads to Point Stuart and Woolner Homesteads, and numerous tracks on the Annaburroo, Wildman River, Point Stuart, Marrakai, and Koolpinyah pastoral leases. The Mary River floodplain bisects the area and is inaccessible throughout most of the year.

Previous investigations

Investigations in the area before 1968 were confined to a BMR survey which was part of a regional evaluation of the Katherine-Darwin region. The results of this survey were published as a 1:250 000 scale geological map and Explanatory Notes (Darwin 1:250 000 Sheet area; Malone, 1962) and a 1-mile Sheet covering the southern third of the current survey area (Mount Bundey 1:63 360 Sheet area) which was produced in 1959.

Since 1968 exploration companies have been active in the area prospecting for uranium, gold, and base metals. Reports of their activities are lodged with the Northern Territory Department of Mines and Energy, Darwin, and are summarised in the economic geology section.

All relevant open-file company reports and BMR publications are listed in Appendices 4 & 5.

PHYSIOGRAPHY

Most of the Mary River/Point Stuart area lies within the catchment of the Mary River, which flows north through the centre of the area to the Van Diemen Gulf. The main physiographic units are the Coastal, Alluvial, and Northern Plains, and the Dissected Foothills (Fig. 3). The physiography of the area is described by Malone (1962) and Williams (1969).

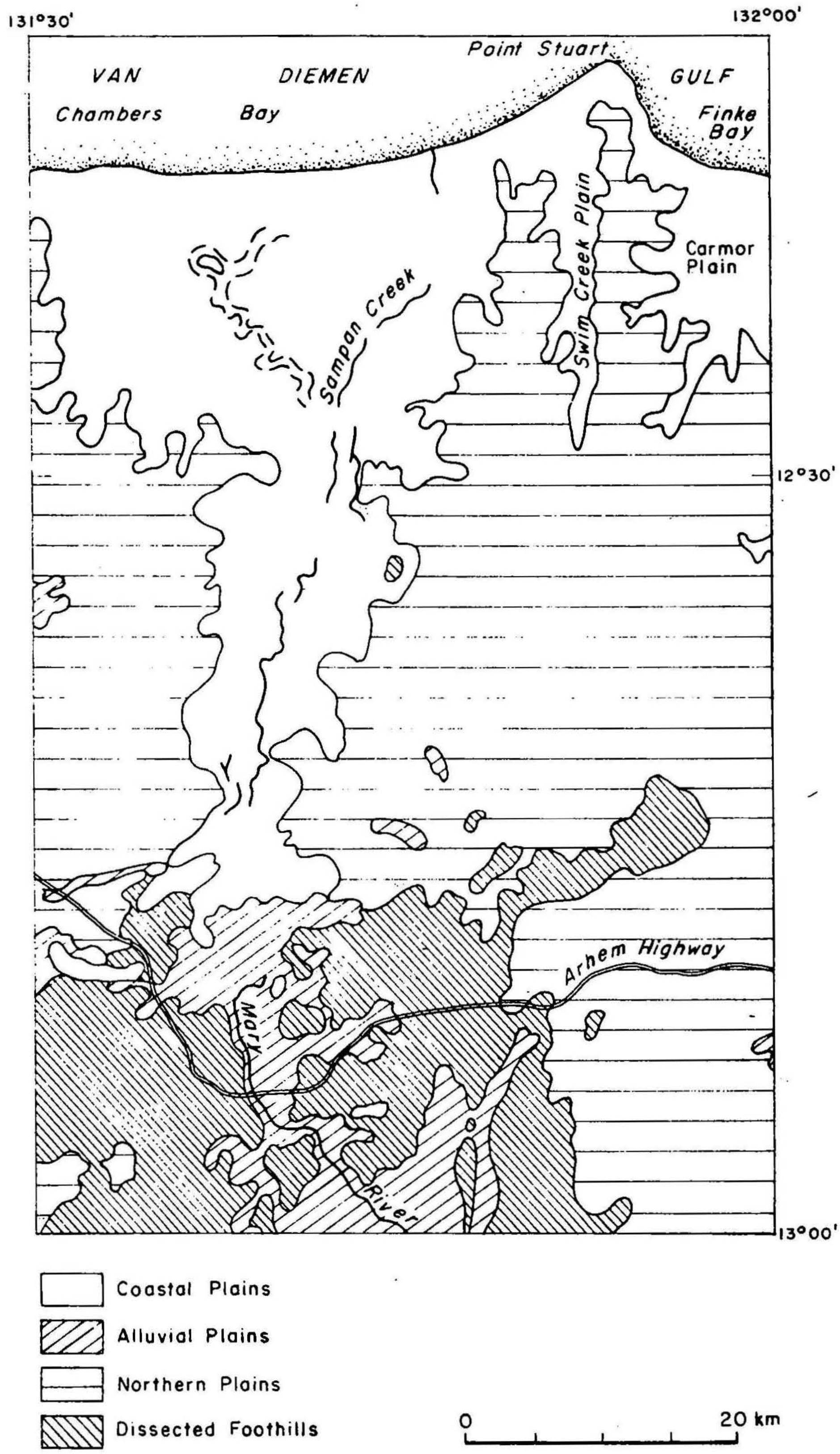

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Fig. 3 Physiographic sketch map, Mary River and Point Stuart 1:100 000 Sheet areas

The Coastal Plains form an extensive flat coastal strip less than 7 m above sea level, which penetrates up to 50 km into the Northern Plains along the Mary River flood plain. The plains consist of poorly-drained estuarine mud and clay flats covered by patches of paperbark forest, herbaceous swamp vegetation, and sedgeland. Four subparallel lines of active and fixed sand dunes lie within 4 km of the coast and converge towards Point Stuart, and another discontinuous line up to 20 km inland approximately parallels the seaward margin of the Northern Plains. Calcic and saline muds occur on tidal flats adjacent to the coastline and river inlets, such as Sampan Creek, and are commonly fringed by mangroves. Freshwater black clays, laid down during seasonal flooding, overlie the estuarine muds and cover most of the plain. Perennial sedge and paperbark swamps are common in low-lying parts of the plains, particularly in embayments and depressions adjacent to the Northern Plains.

The Coastal Plains grade southwards into floodplains, incised channels, and levees of the Mary River which form the Alluvial Plains. These plains have a gentle gradient; they fall from 20 m to 10 m above sea level over 20 km, a fall of roughly 1 in 2000. The plains comprise Quaternary alluvium with deep sandy or silty soils which support open savannah or grassland with scattered trees.

Apart from the Coastal Plains, the northern part of the area is dominated by level, rolling, or dissected lowlands of the Northern Plains which are developed over flat-lying Cretaceous, late Tertiary, and peneplaned Early Proterozoic sediments. Uniform or gradational gravelly and sandy soils are common, and are covered by tall open forest, eucalypt, woodland or scrub.

Rugged boulder-strewn granite hills, and resistant strike ridges of Early Proterozoic metasediments form the Dissected Foothills which rise up to 200 m above the Alluvial Plains in the southeast of the area. Stripping of the Cretaceous and Cainozoic cover in the area adjacent to river courses has also exposed undulating rubbly rises between the strike ridges. The Early Proterozoic rocks are deeply weathered and covered in places by shallow skeletal soils which support eucalypt woodland and tall to mid-height grasses.

STRATIGRAPHY

ARCHAEAN

A negative gravity anomaly, centred on Woolner Homestead and extending into the northwestern part of the Point Stuart Sheet area, was interpreted by Tucker & others (1980) to be caused by a concealed low-density body with outward sloping contacts similar to the Rum Jungle Complex and Jim Jim Granite.

Detailed gravity surveys have since delineated three separate low-density bodies and drilling has confirmed the presence of gneissic granite beneath 60 to 80 m of Cretaceous cover (W. Johnson, CRAE, personal communication). Although no dates are available, an Archaean age is suggested by its gneissic fabric and its inferred stratigraphic position beneath the Mount Partridge Group.

EARLY PROTEROZOIC

MOUNT PARTRIDGE GROUP

A poorly exposed sequence of psammitic and pelitic rocks of the Mount Partridge Group crops out north of the Arnhem Highway and in the southeast of the area. The group contains the oldest exposed units in the area and is unconformably overlain by younger Early Proterozoic, Cretaceous, and Cainozoic sediments.

Units within the group are the Mundogie Sandstone, and the Wildman Siltstone, which contains an informal volcanic unit referred to as the 'Annaburroo volcanic member' (Stuart-Smith & others, 1980b). The volcanics are exposed as extremely weathered brown massive rocks which were previously mapped as dolerite (Dow & Pritchard, 1958).

Mundogie Sandstone

The Mundogie Sandstone crops out as discontinuous rubbly rises and strike ridges along the eastern margin of the area. The most extensive outcrops are north of the Arnhem Highway where prominent strike ridges protrude through a thin veneer of Cretaceous and unconsolidated Cainozoic sediments. Eight kilometres northeast of Mount Goyder, continuous strike ridges rising up to 50 m above the level of the plain, are folded into an elongate dome surrounded by rubbly rises of Wildman Siltstone.

The Mundogie Sandstone is the oldest exposed unit in the area. Elsewhere in the Pine Creek Geosyncline it unconformably overlies the Namoona Group (Needham & others, 1980a). The formation is conformably overlain by the Wildman Siltstone; the contact is well-exposed around the dome northeast of Mount Goyder, and defined by an increase in the proportion of pelitic to psammitic units from less than 50 percent to about 90 percent, and the absence of arkose and conglomerate above the contact. Psammitic units in the Mundogie Sandstone are coarser, less well sorted, and less quartzose than those in the Wildman Siltstone. In places, the Mundogie Sandstone is unconformably overlain by the Koolpin Formation or by remnant Tertiary lateritic cappings.

Description

The Mundogie Sandstone consists of an interbedded sequence of quartz sandstone and minor quartzite, arkose, conglomerate, shale, and siltstone. At least 500 m of the formation is exposed in the dome northeast of Mount Goyder.

<u>Quartz sandstone, quartzite, and arkose</u> comprise over 50 percent of the formation and crop out as quartz-veined, well-jointed, and blocky strike ridges. They form beds ranging from 0.2 to 1 m thick, and are commonly graded with cross-bedding and scour structures present in places. The rocks, which are light grey to bluish, consist of coarse, moderately to poorly sorted quartz, chert, and kaolinised feldspar grains set in a recrystallised, optically continuous granoblastic quartz matrix. Relict well-rounded grain boundaries are preserved, marked by rings of fine reddish-brown iron oxide granules. Trace amounts of secondary muscovite and well-rounded detrital monazite and tourmaline are common.

Pebble conglomerate forms graded beds ranging from 0.5 to 1 m thick, within the arenaceous units. The beds, which form less than 10 percent of the formation, are continuous and occur in at least four different horizons in one locality. The pebbles are less than 1 cm across and consist of sub to well-rounded quartz, quartzite, white chert (silicified domomite?), and minor fine limonitic quartz sandstone and carbonaceous shale clasts. The matrix comprises a poorly sorted recrystallised sand, composed of coarse quartz and chert cemented by reddish-brown iron oxides and minor sericite. Relict well-rounded grain boundaries are rarely preserved.

Shale and siltstone are poorly exposed as ferruginous rubble between the more resistant ridges of psammitic rocks, but probably comprise 40 to 50 percent of the formation. They are reddish brown, finely cleaved to massive friable rocks, and are micaceous in places.

Discussion

The rock types and sedimentary structures present in the Mundogie Sandstone are similar to those present in the formation in other areas of the Pine Creek Geosyncline and are consistent with the depositional model proposed by Stuart-Smith & others (1980c). The sandstone probably formed as a coalesced alluvial fan deposit flanking an Archaean granitic complex, interpreted by Tucker & others (1980) to underlie the present Van Diemen Gulf north of the area. The deposits graded southwards into the subtidal deposits of the Wildman Siltstone which later transgressed over them.

The thickness of conglomerate beds and the size of pebbles decreases from the adjoining Kapalga 1:100 000 Sheet area to the east (Needham & Stuart-Smith, 1978) possibly reflecting a greater distance from the source area. Chert (silicified dolomite) pebbles are also less abundant in conglomerates from the Mary River/Point Stuart area, possibly reflecting a lesser component of the Cahill Formation in the source area (the Cahill Formation is the only older formation known to contain carbonate rocks).

Wildman Siltstone

The Wildman Siltstone is poorly exposed throughout the area, occurring mostly as low undulating rubbly rises north of the Arnhem Highway. Low strike ridges of quartzite and quartz sandstone are exposed along the eastern margin of the Mary River floodplain where thin skeletal soils or veneers of flat-lying Cretaceous and Cainozoic deposits which commonly cover the formation have been stripped back. Road cuttings and borrow pits along the Arnhem Highway provide the best exposures.

The Wildman Siltstone conformably overlies the Mundogie Sandstone and is unconformably overlain by the Koolpin and Petrel Formations. In the southwest the formation is intruded and hornfelsed by the Mount Bundey Granite, Mount Goyder Syenite, and minor minette, aplite, and felsite dykes.

Description

The formation consists mainly of laminated pelitic rocks with minor quartz sandstone, quartzite, and silicified dolomite. The total thickness of the unit in the area is difficult to estimate because of poor exposure and tight to isoclinal folding, but a section at least 1000 m thick is present east of Mount Goyder. In the same region, particularly around the dome of Mundogie Sandstone, deeply weathered intermediate volcanics previously mapped as dolerite (Malone, 1962) are interbedded with the Wildman Siltstone and are informally referred to as the Annaburroo volcanic member.

Pelitic rocks comprise over 90 percent of the formation and include sandy siltstone, siltstone, silty shale, and shale. They are poorly exposed as ferruginous rubble and are commonly colour-banded (mauve, buff, brown, red, white, and grey). Slaty cleavage is well developed and in outcrop predominates over bedding, which is typically laminated to thin. Small-scale lenticular cross-bedding and ripple marks are rarely present. The rocks consist essentially of scattered angular silty quartz grains in a foliated limonite-sericite-quartz matrix. In places they are silicified to a granoblastic mosaic of quartz, sericite, chlorite, iron oxides, and minor feldspar. Iron oxides commonly infill fractures and may constitute up to 40 percent of some laminae. At depth, iron-rich laminae or beds are pyritic, carbonaceous, and dolomitic in places. Within the contact aureole of the Mount Goyder Syenite, pelitic rocks have been metamorphosed to chiastolite hornfels, consisting of very fine-grained foliated granoblastic quartz, graphite, and muscovite and chiastolite porphyroblasts.

Grey quartz sandstone commonly forms thin to massive interbeds, ranging from less than 1 m up to about 5 m thick, in pelitic rocks. They consist of medium to coarse-grained, moderately sorted, sub to well-rounded quartz and minor chert grains cemented by a limonitic, sericitic, and siliceous cement. In places optically continuous quartz surrounds grains, and forms a granoblastic aggregate. Minor amounts of well-rounded detrital monazite, shale fragments, and euhedral pyrite (commonly pseudomorphed by limonite) may be present. Sedimentary structures are common and include fine low-angle cross-bedding, lenticular cross-bedding, ripple marks, current lineations, flute markings, load casts, and rare intraformational breccia.

Fine to very fine brown, yellow, pink, or white quartzite forms laminae or thin interbeds (less than 10 cm thick) in siltstone. It consists of granoblastic quartz, minor sericite, and scattered iron oxides (commonly after pyrite) and trace amounts of well-rounded detrital monazite, sphene, and tourmaline. Rarely, relict well-rounded grain boundaries are preserved.

Isolated outcrops of massive silicified dolomite occur about 4 km southeast of Moon Billabong, 3 km southwest of 'Wildboar', and about 18 km northwest of Mount Bundey. The stratigraphic position of the dolomite is unclear owing to poor exposure, but it appears to be conformable and at least 1000 m above the Mundogie Sandstone contact.

The Annaburroo volcanic member forms at least two conformable beds, ranging from 50 to 100 m thick, about 250 m and 500 m above the base of the Wildman Siltstone. The member crops out as boulder-strewn ridges or hills over about 200 km^2 around the dome of Mundogie Sandstone in the centre of the Mary River Sheet area. Between outcrops the subsurface presence of the member is indicated by a deep reddish-brown soil, and dense tall vegetation which imparts a dark phototone on airphotos similar to that of the Koolpin Formation.

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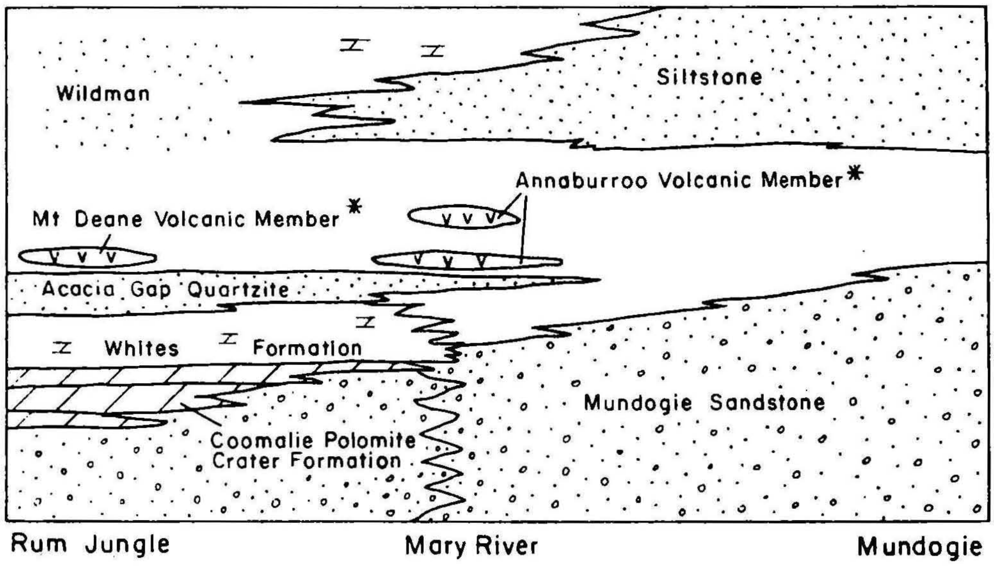

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Fig. 4 Schematic facies relationships of the Mount Partridge Group across the northern part of the Pine Creek Geosyncline

* Informal name

At the surface the volcanics are extremely weathered ferruginous brown to mauve massive rocks. They consist of iron oxides and clay and contain, in places, rounded or flattened limonite patches up to 1 cm across (altered chlorite infilled amygdales) and rare altered white kaolinised feldspar laths (less than 5 mm long). At depth they are either altered fine even-grained amygdaloidal andesite or slightly porphyritic andesite. Even-grained andesite consists of interlocking andesine laths, minor subhedral potassic feldspar crystals, scattered fine opaques and interstitial pale-green chlorite, and patchy carbonate. Carbonate also occurs as veins or with muscovite and chlorite as fillings in ovoid amygdales. The margins of the amygdales are commonly lined by a concentration of opaques and aligned feldspar laths.

The porphyritic variety is finer and consists of slender euhedral andesine laths and rare stout orthoclase crystals (less than 1 mm long) in a groundmass of altered hypocrystalline radiating groups of feldspar laths and longulites, pale-green chlorite, carbonate, and acicular opaques. Coarser patches of anhedral quartz and euhedral pyrite are concentrated in planes which possibly represent flow banding as they parallel bedding in interbedded pyritic carbonaceous shale.

Pyritic carbonaceous shale consists of foliated very fine chlorite, sericite, granular pyrite, and streaked carbonaceous matter. Chlorite also occurs with carbonate and quartz as coarser undeformed scattered grains and are probably replacement products of unstable mineral fragments or glass, reflecting a tuffaceous component.

Discussion

Owing to poor exposure of the Wildman Siltstone, subdivision of the formation is not possible. The twofold subdivision recognised in the Mundogie and McKinlay River 1:100 000 Sheet areas (Stuart-Smith & others, 1980a; Needham & others, 1980b) is not apparent. The presence of silicified dolomite and minor dolomitic carbonaceous shales, absent from the other areas, may indicate a partial sedimentary facies transition towards that of the Coomalie Dolomite and Whites Formation in the Rum Jungle area (see Fig. 4).

The Annaburroo volcanic member, present only in the Mary River 1:100 000 Sheet area, is similar to, and a probable correlative of, the Mount Deane volcanic member in the Rum Jungle area. Its andesitic composition, the lack of a volcanic pile, and the lack of disruption to the sedimentary sequences suggests that both members were probably products of local subaqueous calc-alkaline volcanism in an otherwise stable shallow marine environment.

SOUTH ALLIGATOR GROUP

A distinctive conformable sequence of iron-rich and tuffaceous sediments of the South Alligator Group crops out south of the Arnhem Highway as a sinusoidal belt, open to tightly folded about gently south-dipping axes. The group, which was previously mapped as the Golden Dyke Formation in this area, includes the Koolpin Formation, Gerowie Tuff, and Mount Bonnie Formation. Overall the group shows a broad gradation from iron-rich sediments at the base (Koolpin Formation) through tuffaceous sediments (Gerowie Tuff) into minor greywacke in the Mount Bonnie Formation. This gradation continues upwards into predominantly shale and greywacke of the overlying Finniss River Group.

The South Alligator Group rests unconformably on the Mount Partridge Group and is conformably overlain by the Finniss River Group. The unconformable lower contact is exposed 25 km southeast of Mount Goyder (GR 110620) where ferruginous and cherty siltstones of the Koolpin Formation rest unconformably on fine-grained quartzites of the Wildman Siltstone. Elsewhere a regional unconformity is indicated by converging trends and by differing fold styles between the two groups. Folding in the Mount Partridge Group is tight to isoclinal, compared to rounded open to tight folding in the South Alligator Group (see 'Structure' section below).

Koolpin Formation

The Koolpin Formation unconformably overlies the Mount Partridge Group and is well exposed as a sequence of iron-rich sediments at the base of the South Alligator Group. Outcrops are typically oxidised and gossaneous, and form small hills or strike ridges in a narrow belt of deep reddish-brown clayey skeletal soil, covered by dense and tall vegetation.

These characteristics indicate the subsurface presence of the formation and are represented on aerial photographs as a dark tone. The contrast between this tone and the white phototone of the conformably overlying Gerowie Tuff enable the unit to be traced semi-continuously throughout the southern part of the area.

The formation is intruded and hornfelsed by the Mount Bundey Granite and Mount Goyder Syenite; small quartz dolerite sills of Zamu Dolerite transect the formation 10 km south of Mount Bundey.

Description

The Koolpin Formation consists of ferruginous siltstone and shale, ferruginous silicified breccia, and minor silicified dolomite. The formation is about 100 m thick, but ranges up to 200 m in fold hinges due to tectonic thickening. West of the Mary River a breccia consisting of angular blocks of silicified dolomite and quartz in a red ferruginous matrix commonly forms the base of the unit, and is overlain by a sequence of ferruginous siltstone commonly containing chert bands, lenses, and nodules.

Ferruginous siltstone and shale are the predominant rock types of the formation. They are laminated to thinly bedded and, in places, contain bands, lenses, and nodules (less than 10 cm across) of white, grey, or black chert. Interbedded carbonaceous material is probably also present but is not readily recognisable in weathered surface outcrop. At depth, or where hornfelsed by the Mount Bundey Granite, the rocks are pyritic and more recognisably carbonaceous. In road cuttings along the Arnhem Highway the rocks are well-exposed and are either mauve, purplish grey, or white. At the surface they are commonly weathered to reddish brown ferruginous rubble or a massive ironstone consisting of massive to granular limonite and hematite, minor finely crystalline quartz, and sericite. Very fine sandy to silty angular quartz grains are commonly present. Iron oxides are concentrated in laminae or as crosscutting veins of specular hematite.

The chert bands, lenses, and nodules consist of a granoblastic quartz mosaic which contains concentric bands of iron oxides in places. The chert was probably formed by replacement of carbonate-rich bands within carbonaceous rocks during diagenesis (Stevens & Roberts, in Walpole & others, 1968; Stuart-Smith & others, 1980a).

In surface outcrop, carbonaceous shale is only recognised within the contact aureoles of the Mount Bundey Granite and Mount Goyder Syenite where it has been altered to graphitic andalusite hornfels. Andalusite occurs as randomly oriented porphyroblasts set in a laminated microcrystalline matrix of chlorite, sericite, carbonaceous matter, and minor quartz. White cloudy spots up to 1 mm across, which crosscut the laminae, are present in places and are probably altered cordierite porphyroblasts.

Two types of ferruginous and silicified breccias occur in the formation:

1. A massive hematite breccia consisting of angular and rarely rounded clasts (less than 10 cm across) of quartz and brown or white silicified dolomite set in a red or greyish-brown ferruginous matrix. Limonite and hematite are the main oxides present in the matrix but coatings of manganese oxides on clasts are common. In road-cutting exposures, the breccia can be seen to grade into undisturbed quartz-veined ferruginous siltstone and shale, indicating the breccia is probably a product of surficial lateritisation processes.

2. West and south of Mount Bundey, silty chert breccia commonly forms the base of the formation. It consists of chaotic, coalesced, and broken chert 'ooliths' (less than 1 cm across) in a laminated ferruginous silty matrix. Rare angular clasts (less than 30 cm) of siltstone, quartz sandstone, and quartzite, similar to rock types in the underlying Mount Partridge Group, are present. The breccia possibly formed by slumping of a calcareous oolitic siltstone which was silicified during diagenesis (Dow & Pritchard, 1958), or as a regolith.

Minor discontinuous lenses of grey, yellow, or pink silicified dolomite, up to 4 m thick, occur in the basal breccias. It crops out as isolated large rounded boulders or pavements throughout the area. The

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rock consists of a microcrystalline granoblastic quartz mosaic with granular iron oxides present in fractures or breccia zones. Crosscutting veinlets of coarser recrystallised granuloblastic quartz are commonly present. Similar rocks from the Kapalga area further east described by Needham & Stuart-Smith (1978) were found to grade at depth into fine granoblastic dolomite.

Gerowie Tuff

Tuffaceous and cherty rocks of the Gerowie Tuff crop out south of the Arnhem Highway as a low range of dissected rubbly rounded hills covered by sparse and stunted vegetation and poor skeletal soils. Because of the thinly bedded and well-jointed nature of the rocks, outcrops are low and relatively sparse; the best exposures are in creek beds and road cuttings along the Arnhem Highway and the low range of hills in the southeast of the area.

The Gerowie Tuff conformably overlies the Koolpin Formation, with the contact defined as the base of the lowermost tuffaceous unit. An excellent exposure of the formation and the lower contact is contained in a road cutting on the Arnhem Highway 750 m west of the Mary River. The contact can be readily distinguished on aerial photographs throughout the area by the marked contrast between the dark phototone of the Koolpin Formation and the white tone of the Gerowie Tuff.

In most areas the Gerowie Tuff is readily distinguished from the conformably overlying Mount Bonnie Formation by its different lithology and outcrop pattern. However in the east, where the unit crops out in an 8-km wide north-trending belt, it is difficult to differentiate the Gerowie Tuff from the Mount Bonnie Formation owing to complex folding and the lack of continuous marker beds.

Description

The formation consists predominantly of thinly interbedded green and grey argillite, black glassy crystal tuff and tuffaceous shale, and minor siliceous siltstone, shale, and tuffaceous greywacke. The unit averages 600 m thick but ranges between 500 and 800 m thick, owing to tectonic attenuation on fold limbs and thickening in hinge areas.

Argillite is by far the most predominant rock type and includes grey, brown, and red silicified sediments, and blue, grey, green, and brown cherty rocks. They are laminated to thinly bedded, mostly between 10 and 20 cm thick and rarely up to 80 cm thick, and are intensely jointed. They consist of microcrystalline quartz with sericite or chlorite and minor granular iron oxides. Coarser granoblastic quartz forms interlaced veinlets in places. The presence of chlorite, which is common in interbedded tuffs, may reflect a tuffaceous (probably altered glass) component in the argillites.

Crystal tuff and tuffaceous chert are black glassy flinty rocks, which break with a conchoidal fracture, and commonly have a spotted weathered white to pale brown shell. The rocks were used extensively by the Aboriginals for spearpoints and other implements and there are numerous 'quarries' or 'factories' in the area. Bedded outcrops are rare as the tuff commonly crops out as rounded bouldery rubble. Bedding is mostly massive but may be laminated; microlenticular crossbedding is rarely present.

Crystal tuff is fine-grained (less than 0.5 mm) and consists of angular and splintery crystal fragments of quartz and alkali feldspar in a finer base of angular and curved crystals and crystal fragments of quartz and feldspar (K > Na feldspar) and minor biotite, chlorite, and iron oxides. Feldspars are commonly sericitised and a weak eutaxitic structure is present in places. Tuffaceous chert is similar in composition to crystal tuff but finer (microcrystalline), contains fewer coarser crystal fragments, and is more chloritic, possibly indicating a higher devitrified glass component.

Thin interbeds of siliceous siltstone and shale within tuffs and argillite are poorly exposed, as they weather more readily than the highly siliceous tuffs and argillite. They are similar to sediments in the Koolpin and Mount Bonnie Formations in that they contain rare chert nodules, but they are not as iron-rich.

Rare graded beds of tuffaceous greywacke up to 15 cm thick may be present. They consist of coarse, poorly sorted angular fragments (< 1 cm) of quartz and sericitised feldspar crystals, chert (silicified dolomite), tuffaceous chert, and minor biotite in a finer matrix of the same composition. Trace amounts of monazite(?) and opaques may be present.

Mount Bonnie Formation

A poorly exposed sequence of pelites, greywacke, and tuffaceous sediments of the Mount Bonnie Formation conformably overlies the Gerowie Tuff. The lower contact is exposed in an erosional bank of the Mary River 8 km southeast of Annaburroo Homestead (GR 947640) and is defined as the base of the lowermost greywacke unit.

Outcrops of the formation are readily distinguished on aerial photographs from the Gerowie Tuff and the conformably overlying Burrell Creek Formation by a darker photo-tone, and low rounded hills intermediate in relief between the higher dissected hills of the Gerowie Tuff and the low rises of the Burrell Creek Formation. Bedding trends are well-defined owing to contrasting pale phototones of minor siliceous tuffaceous interbeds.

Description

The Mount Bonnie Formation consists of interbedded shale, siltstone, and greywacke with minor tuffaceous sediments, silicified dolomite, and banded iron formation. The sequence averages 650 m thick throughout the area with no significant variations.

Laminated reddish brown, purple, pink, and yellow shale and siltstone crop out in incised creek beds on the Mary River floodplain or as splintery rubble on low rises. The rocks are mostly ferruginous and are gossaneous or siliceous in places. Like similar rocks in the Koolpin Formation, they contain bands of laminated white, grey, and black chert, minor chert nodules, and rare bands of banded iron formation. They are composed essentially of laminated microcrystalline to silty quartz, fine sericite and iron oxides; sericite being absent from the chert bands, nodules, and iron formation. Pyrite and hematite are present in the iron formation and are commonly altered to limonite. Carbonate rhombs and granules are also rarely present in the iron formation, commonly being replaced by coarser iron oxides which also infill crosscutting fractures.

Massive, dark-green medium to coarse greywacke forms beds up to 1 m thick within shale and comprise about 20 percent of the formation. The rock is readily weathered and only crops out in creek beds. It consists of poorly sorted angular fragments of quartz, alkali feldspar,

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microperthite, chert, and felsic volcanic rocks in a chloritic and sericitic matrix. The rock fragments include tuffaceous chert and crystal tuff identical to interbeds within the sequence and the underlying Gerowie Tuff.

Laminated to thinly bedded argillite, tuffaceous chert, and crystal tuff similar to those in the Gerowie Tuff probably form less than 10 percent of the formation but are prominent with ferruginous siltstone and shale in outcrop.

Rare lenses up to a few metres thick of pale-brown to grey silicified dolomite crop out as strike ridges with ferruginous shale and siltstone. The lenses probably had a similar origin to those in the Koolpin Formation and probably represent chert replacement of carbonate-rich beds within the shale and siltstone during diagenesis.

Discussion

The shallow restricted environment which characterised deposition of the Koolpin Formation probably continued throughout deposition of the South Alligator Group. The great influx of ashfall material starting in Gerowie Tuff times would have temporarily swamped chemical and organic sediment deposition, but this was gradually re-established as volcanic activity waned in Mount Bonnie Formation times.

The Mount Bonnie Formation also represents a transitional facies between the South Alligator and Finniss River Groups, as interbedded greywacke and shale which dominate in the Finniss River Group are also present. Stuart-Smith & others (1980c) suggest that this change in sedimentary facies reflects a fundamental change in the tectonics of the Pine Creek Geosyncline. Basement uplift and volcanism which occurred in the western part of the geosyncline at this time resulted in the influx of flysch-type sediment into the geosyncline.

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FINNISS RIVER GROUP

Burrell Creek Formation

The Burrell Creek Formation is the youngest Early Proterozoic sedimentary unit and the only unit of the Finniss River Group to crop out in the area.

The formation crops out southwest of Mount Bundey as low rubbly rises, or deeply weathered exposures in incised creeks on the McKinlay and Mary River floodplains. Although, in situ, outcrop is poor, bedding trends produced by low strike ridges of resistant greywacke beds in a dominantly pelitic sequence are evident on aerial photographs.

Relationships between the formation and the older Early Proterozoic units are not clear in the area, but it appears to conformably overlie the Mount Bonnie Formation. The contact is not exposed but is defined as the top of the uppermost unit of either argillite, tuff, shale containing chert bands, lenses, or nodules, or banded iron formation. The 'Burrell Creek facies' component in the underlying Mount Bonnie Formation indicates continuous sedimentation and probably a transitional relationship between the two formations.

Owing to poor exposure and the lack of marker horizons, the thickness of the Burrell Creek Formation is difficult to determine. At least 1000 m is estimated to be present in the area.

Description

The Burrell Creek Formation consists of an interbedded sequence of shale, siltstone, phyllite, and greywacke.

Laminated red, yellow, brown, pink, green, and purple shale, phyllite, and siltstone comprise over 75 percent of the formation and crop out as flaggy rubble or as deeply weathered exposures in creek beds. They are micaceous in places and consist of microcrystalline to fine quartz, sericite, iron oxides (hematite and/or limonite), and rare greenish-brown chlorite. In places, scattered silty quartz grains are present, and a weak foliation marked by aligned sericite crosscuts bedding laminae.

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Either quartz, feldspathic or calcareous greywacke form thin interbeds 10 to 50 cm thick, in shale, phyllite, and siltstone. It crops out as weathered brown, grey, purple, or red massive exposures in creek beds or as rough blocky low strike ridges. The unweathered rock is dark greenish-grey with coarse poorly sorted grains of quartz, chert, feldspar (commonly sericitised), and quartz-sericite rock fragments set in a fine recrystallised matrix of quartz, feldspar, sericite, chlorite, and iron oxide. Randomly orientated biotite and muscovite are present in the matrix within the contact aureole of the Mount Bundey Granite.

'Tombstone greywacke', a dark-grey silicified calcareous greywacke which weathers to form characteristic tombstone-like outcrops and which is common in other sheet areas to the south, was found only in one small creek-bed exposure 5 km southwest of Mount Bundey.

CRETACEOUS

Petrel Formation

Flat-lying Cretaceous sediments cover most of the northern two-thirds of the area. The sediments are covered by a thin veneer of unconsolidated Cainozoic sand and laterite which support a dense woodland of tall eucalypt. The rocks were previously mapped as Mullaman Beds by Skwarko (1966) but were later reclassified as Petrel Formation by Hughes (1978).

The sediments are exposed at the edges of the Mary River floodplain and as remnant mesa-like cappings over Early Proterozoic sediments in the southeast. They range from 3 m in the south to about 60 m thick near Jimmys Creek, and dip gently northwards from 75 m ASL in the south to less than 20 m ASL at Mordy Island, i.e. a gradient of about 1 in 600.

The formation consists of a 3-m basal sequence of porous dark-brown poorly sorted limonitic quartz sandstone, minor conglomerate and breccia overlain in the north by a thicker sequence of unconsolidated quartzose sand. Pebbles and grains in the limonitic sandstone and conglomerate consist of well-rounded quartz, chert, and quartzite.

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Breccia, where present, forms the base of the formation and contains angular blocks of fine quartzite similar to that in the underlying Early Proterozoic Wildman Siltstone.

CAINOZOIC

Cainozoic deposits form a thin veneer over most of the area. They have been divided into the following units: laterite, late Tertiary sand, colluvial silt and sand, and Quaternary continental and marine sediments.

Laterite

Generally the laterite profiles seen in the 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:

Detrital laterite is formed mainly from reworked material cemented by a ferruginous matrix. It generally forms blocks (up to 1 m) and pavements on low hills or breakaways over the Early Proterozoic rocks.

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 blocks or pavements, mostly exposed in the stable regime at the margins of the depositional environment of the coastal plains. Isolated detrital deposits of pisolitic laterite occur in places within depositional 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 in the bottom of amphitheatres at

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the head of creeks, and is typically surrounded by a breakaway of pisolitic or detrital laterite.

Concretionary laterite is pedogenetic in origin, and, unlike the varieties 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

Coarse unconsolidated quartz sand forms the remnants of the Koolpinyah Surface which covers most of the Northern Plains; in places it is dissected. Where the sand has been almost completely removed, structures within the underlying weathered rocks are apparent on aerial photographs.

The late Tertiary sand is probably a fan deposit (Story & others, 1969) derived from Mesozoic sand, silt, and claystone, Kombolgie Formation sandstone, and Early Proterozoic rocks.

At the margins of the Coastal Plains erosion and redeposition of the late Tertiary sand has produced a narrow but distinctive photogeological unit which is characterised by a relatively steep slope of 5^{o}; further erosion has resulted in the development of a winnowed sand veneer on the slope. Because they are a direct product of erosion of unconsolidated sand, and not part of the open drainage system, the clay and silt deposits found in isolated 'swallow holes' developed on the Koolpinyah Surface (Hays, 1965) are also included in the winnowed sand unit; their formation has probably been continuous since the early Tertiary.

Quaternary continental deposits

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

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Alluvial silt, sand, and clay occur in the courses and flood plains of active rivers. Large bodies of unconsolidated quartz sand within the channels of the Mary and McKinlay Rivers, and outwash deposits over the adjacent flood plains, consist mostly of material derived from the Early Proterozoic rocks or late Tertiary sand, and were mostly deposited during floods. Silty levee deposits are developed along the course of the Mary River south of the Arnhem Highway.

Quaternary marine deposits

During the wet season (November to April) marine conditions strongly influence deposition in the Mary River drainage system for a considerable distance inland.

Intertidal mangrove swamps extend along the coastline, and up to 4 km inland in Sampan Creek. Coastal alluvial deposits are comparatively well-drained silt and clay with sparse vegetation cover, such as sedge or samphire; they overlie the poorly drained black soil plains and mud and salt pans, which are also developed adjacent to, and within, estuarine channels. Adjacent to Late Tertiary sand deposits, black soil swamplands which support paperbark and waterweed growth are developed in areas which are perenially waterlogged.

The sediments of abandoned river courses consist mostly of silt and mud. The oxbow lakes were developed before the late Pleistocene to Recent emergence and are shallow depressions in the surface of the flood plain, into which the present drainage system is incised.

The coastal sand ridges are generally parallel to and within 4 km of the present coastline, or are adjacent and parallel to the edge of the Coastal Plains up to 20 km inland.

The dunes are composed of shelly sand and probably originated as sand-bars which extended southwestwards from the now-wooded recurved sand spits at Point Stuart, shifting progressively seawards and northwards. The oldest of these now-discontinuous dunes once extended as a smoothly curved bay-mouth bar from Point Stuart southwest along the margin of the Northern Plains to west of the Mary River near Alligator Head, where it changes direction and runs northwest.

The dunes probably represent the position of former coastlines dating from Late Pleistocene (Browne, 1945). Rapid coastal progradation resulting from emergence between Late Pleistocene and Recent is indicated by the broad coastal plain devoid of dunes. The close grouping of dunes parallel to the present coastline indicates a relatively static sea level with minor Recent fluctuations.

INTRUSIVE ROCKS

MOUNT BUNDEY GRANITE AND MOUNT GOYDER SYENITE

The Mount Bundey Granite and Mount Goyder Syenite form a cogenetic plutonic complex which crops out over an area of about 80 square kilometres between the Old Mount Bundey and Annaburroo Homesteads. The Mount Bundey Granite forms the southern two-thirds of the complex and crops out as rugged bouldery hills rising over 140 m above the adjacent Mary River floodplain. The Mount Goyder Syenite forms the northern third of the Mount Bundey pluton, and a separate small pluton east of the Mary River at Mount Goyder 7 km north of Annaburroo Homestead. The syenite also crops out as rugged bouldery hills but is covered extensively by thin sandy residual soils.

The granite and syenite have been described by Dow & Pritchard (1958), Hasan (1958), Walpole & others (1968), and Hochman (1980).

The granite and syenite intrude a south-plunging folded belt of Early Proterozoic metasediments. The contact is sharp and mostly discordant. On the eastern side of the Mount Bundey pluton, the contact is concordant and follows a shallow easterly-dipping anticlinal limb. A drill hole at Quest 44 showed that the contact was dipping outwards at about 40° to the east (Twist, 1977).

Aplite, syenite, and minette dykes up to several metres wide are common in the granite, syenite, and surrounding metasediments up to 10 km from the Mount Bundey pluton. Xenoliths of country rock are also common near the intrusive contact. Pritchards Lode (the Mount Bundey iron deposit), a large hematite-magnetite body within the Mount Goyder Syenite, is thought to have formed in part by replacement of an iron-rich sedimentary raft or pendant.

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Both the granite and syenite are well-jointed in three predominant directions; 340-350^o, 50-60^o, and 80-90^o (Fig. 9). The northeast and east-trending joints correspond to some post-deformation fault orientations in the Early Proterozoic metasediments. In places the joints are sheared and contain pyrite concentrations.

Description

The Mount Bundey Granite comprises a massive medium to pale-pink granite and minor adamellite. It is composed of potash feldspar, quartz, plagioclase, hornblende, quartz, and trace amounts of sphene, apatite, zircon, allanite, epidote, magnetite, hematite, leucoxene, and pyrite.

The potash feldspar is mocroperthite and typically forms coarse (< 2 cm) subhedral crystals, commonly rimmed by graphic intergrowths with quartz. Zoning is present in places, and rounded inclusions of plagioclase, quartz, biotite, and hornblende are common.

Quartz occurs as anhedral grains and comprises between 20 and 50 percent of the rock. Inclusions of feldspar and the accessory minerals are common.

Plagioclase ranges in composition from An_{28-36} (Hasan, 1958) and forms zoned tabular crystals commonly with cores altered to kaolin, sericite, carbonate and epidote. The outer zones are more sodic, and the borders of some crystals are probably pure albite.

Hornblende and biotite are present in minor amounts and decrease as quartz increases. In rocks containing over 40 percent quartz, hornblende is absent, biotite shows progressive alteration to chlorite, and quartz-feldspar graphic intergrowths are common. Hornblende where present is green to pale-brown and forms euhedral prisms, granular aggregates, and irregular grains moulding feldspar crystals. It is commonly corroded and partially altered to biotite.

Rust-red biotite occurs as irregular grains or decussate aggregates showing partial alteration to chlorite. In places euhedral hornblende, apatite, and anhedral quartz form cores of biotite clots which are surrounded by opaque rims.

Thw Mount Goyder Syenite is a medium to coarse, slightly porphyritic massive rock with a similar composition to the Mount Bundey Granite, but it is distinguished by its lower quartz content (less than 10 percent), higher hornblende content (greater than 10 percent), and, in most cases, the presence of clinopyroxene.

The rock consists of potash feldspar phenocrysts in a hypidiomorphic granular to allotriomorphic groundmass of potash feldspar, hornblende, and minor clinopyroxene, anhedral quartz, golden brown biotite, and sodic plagioclase. Accessory minerals present are subhedral magnetite, sphene, euhedral apatite, zircon, and epidote. Rare allanite and fluorite may be present (Hasan, 1958).

Potash feldspar, as in the Mount Bundey Granite, is microperthitic, and forms subhedral to euhedral, tabular pale-pink phenocrysts up to 2 cm across which are commonly zoned and contain rare inclusions of biotite, clinopyroxene, apatite, hornblende, plagioclase, and quartz. In places the presence of oscillatory zoning suggests that the feldspar was originally plagioclase which has subsequently replaced potash feldspar (Hasan, 1958).

Hornblende mostly forms colourless to pale brown and green anhedral crystals in the groundmass and less common greenish-brown, twinned and zoned euhedral phenocrysts. Magnetite and biotite have replaced hornblende in places. Inclusions of feldspar, biotite, sphene, apatite, and opaque minerals are common.

Colourless clinopyroxene occurs as altered euhedral inclusions in feldspar or as altered cores within hornblende.

Discussion

The petrology and geochemistry of the Mount Bundey Granite and Mount Goyder Syenite indicate that they are genetically related. Apart from the presence of clinopyroxene in syenite, the major and accessory minerals of both rock units are the same. Modal analyses (Hasan, 1958) show a continuous range from granite to syenite. Total mafic minerals decrease with increasing SiO_2 and the proportion of potash feldspar to plagioclase also decreases.

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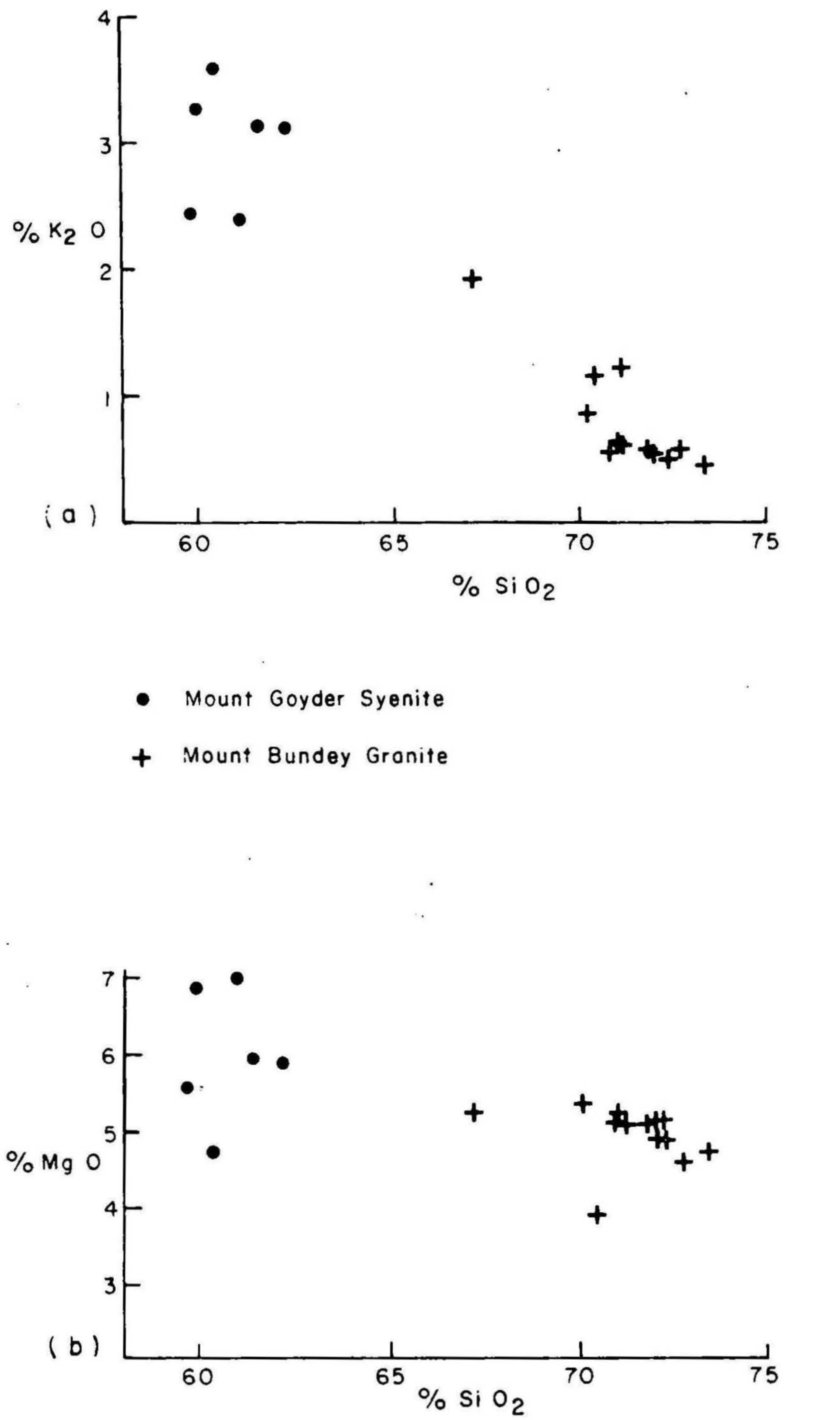

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Fig. 5 (a) Si O_2 versus Mg O plot, Mount Bundey Granite and Mount Goyder Syenite
(b) Si O_2 versus K_2O plot, Mount Bundey Granite and Mount Goyder Syenite

Geochemical differentiation plots show linear trends (Hochman, 1980; Appendixes 2 & 3), which are well-illustrated by the MgO v SiO_2 plot (Fig. 5a). The negative correlation between K_2O and SiO_2 (Fig. 5b) reflects the decreasing potash feldspar to plagioclase ratio with increasing fractionation. This trend is different to trends from other post-orogenic granites in the Pine Creek Geosyncline, which show a positive correlation between alkalis & SiO_2 (Ferguson & others, 1980). Ferguson & others (1980) suggest this is a result of feldspar alteration.

The lack of rocks with a SiO_2 content between 62 and 67 percent in the Mount Bundey Granite/Mount Goyder Syenite Plutonic Complex is reflected by the absence of granites with a quartz content less than 20 percent, and the sharp contact between granite and syenite. Field relations and geochemical trends indicate that the Mount Bundey Granite is younger and more fractionated than the Mount Goyder Syenite.

Using chemical, mineralogical, and field criteria established by Chappell & White (1974) to distinguish two types of granitoids in the Palaeozoic Lachlan Fold Belt of southeastern Australia, Ferguson & others (1980) and Hochman (1980) concluded that the Mount Bundey Granite and Mount Goyder Syenite, like other post-orogenic granitoids of the Pine Creek Geosyncline, were derived from an igneous source. Ferguson & others (1980) suggested that the granitoids possibly represent products of a small degree of partial melting or are the end products of fractionation derived from a uranium-enriched igneous component of the basement as represented by some of the Archaean granitoids in the geosyncline. Hochman (1980) prefers a model involving derivation by partial melting of siliceous granulite, as a result of mantle plume activity in the lower crust.

ZAMU DOLERITE

Small bodies of quartz dolerite and gabbro crop out south of the Mount Bundey Granite and were intersected in a drillhole (SR3) at Quest 29 (Twist, 1977). The bodies range up to 60 m thick and intrude hornfelsed sediments of the Koolpin Formation. They appear broadly conformable to the enclosing sediments and are commonly altered and veined by quartz-feldspar pegmatites. Their pre-granite age, as indicated by their alteration and conformable nature, suggest that they may be Zamu Dolerite, which forms extensive pre-orogenic sills in Early Proterozoic metasediments in other parts of the Pine Creek Geosyncline.

OTHER INTRUSIVE ROCKS

Minette

Numerous deeply weathered and poorly exposed medium-grained and porphyritic minette dykes intrude the Early Proterozoic metasediments and the Carpentarian Mount Bundey Granite and Mount Goyder Syenite. The dykes are up to several metres wide and are confined to within 10 km of Mount Bundey.

The minette is dark greenish grey when fresh, but is commonly weathered to a soft ferruginous clayey rock. The rock consists of euhedral pale-brown biotite phenocrysts up to 1 cm across, in a groundmass of euhedral biotite, cloudy potash feldspar, sodic plagioclase, and minor anhedral quartz. Accessory minerals present are granular sphene, patchy carbonate, magnetite, acicular apatite, and rare prismatic zircon.

Feldspars are commonly sericitised and biotite is altered to chlorite, muscovite, quartz, and iron oxides. In places biotite is replaced by fibrous tremolite/actinolite, and minor colourless clinopyroxene (partly altered to biotite) may be present.

The mineralogy and the spatial distribution of the minette suggests an affinity and probable genetic relationship with the Mount Bundey Granite and Mount Goyder Syenite.

Felsite

Felsite dykes 1 to 3 m wide and up to 200 m long intrude the Early Proterozoic metasediments of the Mount Partridge and South Alligator Groups in the southern part of the Mary River 1:100 000 Sheet area. The contact relations are obscure owing to poor exposure. However, they appear to parallel the northerly trend of the metasediments which suggests that they are probably post orogenic; similar felsite dykes in the adjoining McKinlay River 1:100 000 Sheet area are seen to have crosscutting contacts.

The felsite is a massive pale-green aphanitic rock with a characteristic high radioactivity of over 100 cps TC (2 to 4 times background). It consists of fine potash feldspar prisms, micrographic intergrowths, and quartz, which are commonly altered to a mosaic of quartz, sericite, and iron oxides. Iron oxides also occur as pseudomorphs after pyrite. In places the felsite is porphyritic, with phenocrysts (< 2 mm) of embayed subhedral to euhedral quartz, and minor sericitised stout euhedral alkali feldspar crystals or aggregates. Feldspar also commonly forms rims around quartz phenocrysts.

METAMORPHISM

All the Early Proterozoic rocks in the area have been regionally metamorphosed to lower greenschist facies and locally contact-metamorphosed by the Mount Bundey Granite and Mount Goyder Syenite.

The Early Proterozoic metasediments show little alteration of their original texture and mineralogy. Typical metamorphic changes in the pelitic rocks are the development of fine-grained, weakly foliated sericite, microcrystalline quartz, sericite, chlorite, and minor muscovite. Feldspar, where present, particularly in tuffaceous sediments of the South Alligator Group, is invariably sericitised. Psammitic rocks commonly exhibit fractured and strained grains with recrystallised optically continuous quartz overgrowths; relict grain boundaries are preserved in places; minor recrystallised sericite or muscovite may be present. Both pelitic and psammitic metasediments are commonly veined by coarse granoblastic quartz. Mafic volcanics of the Annaburroo volcanic member are extensively chloritised and carbonated, with no original mafic minerals or glass preserved. Carbonate occurs as veins or with muscovite and chlorite as amygdaloidal fillings.

Metasediments of the Wildman Siltstone, Koolpin Formation, Gerowie Tuff, Mount Bonnie Formation, and Burrell Creek Formation are in contact with the Mount Bundey Granite and/or Mount Goyder Syenite and are hornfelsed in an aureole up to 500 m wide. Within the aureole, carbonaceous rocks of the Wildman Siltstone and Koolpin Formation are altered to chiastolite carbonaceous hornfels. The chiastolite occurs as randomly orientated porphyroblasts set in a laminated microcrystalline matrix of chlorite, sericite, carbonaceous matter, and minor quartz. Sandstone of the Wildman Siltstone is altered to quartzite and greywackes of the Burrell Creek and Mount Bonnie Formations are silicified. Biotite and muscovite are commonly present in the matrix of greywackes. White cloudy spots up to 1 mm across, which crosscut laminae, are present in pelitic rocks in all of the formations and are probably altered cordierite porphyroblasts. A skarn within the Koolpin Formation, containing Mo, Cu, Zn, and Fe sulphides, was also intersected in a drillhole at Quest 44 (Twist, 1977).

STRUCTURE

The Early Proterozoic metasediments of the Mary River/Point Stuart area underwent a major metamorphic and deformation event about 1800 m.y. ago (Page & others, 1980). The metasediments were subsequently intruded by the Mount Bundey/Mount Goyder plutonic complex about 1790 m.y. ago (Riley, 1980) and were eventually peneplained and overlain by a thin cover of Cretaceous and Cainozoic sediments. The metasediments now form the northern margin of a broad synclinorium which extends southwards to Pine Creek and westwards to Batchelor. The synclinorium is separated from the West Alligator Syncline to the east by an anticlinorium running southwards from the headwaters of the Wildman River to the eastern lobe of the Cullen Granite.

The structural elements of the area (Fig. 6) form four domains: domain 1, areas of extensive Cretaceous and Cainozoic cover; domain 2, outcrops of Mount Partridge Group; domain 3, outcrops of South Alligator and Finniss River Groups; and domain 4, outcrops of the Mount Bundey/Mount Goyder plutonic complex.

The Early Proterozoic sediments have undergone one major phase of folding. Beds in domain 3 are tightly folded whereas those in domain 2 are tight to isoclinally folded. Fold axes in both domains are subhorizontal to shallow south-plunging, and trend 180° to 200°. Minor northward plunges are common, particularly in domain 2. The change in fold axis orientation is gradational from 180° in the south to 200° in the north and reflects a regional rotation about a northwest-trending flexure which extends from Marrakai (Noonamah 1:100 000 Sheet area) to Coirwong Gorge (Mundogie 1:100 000 Sheet area). A weak near-vertical axial plane slaty to phyllitic cleavage is well-developed in pelitic rocks of the Wildman Siltstone, Mount Bonnie, and Burrell Creek Formations.

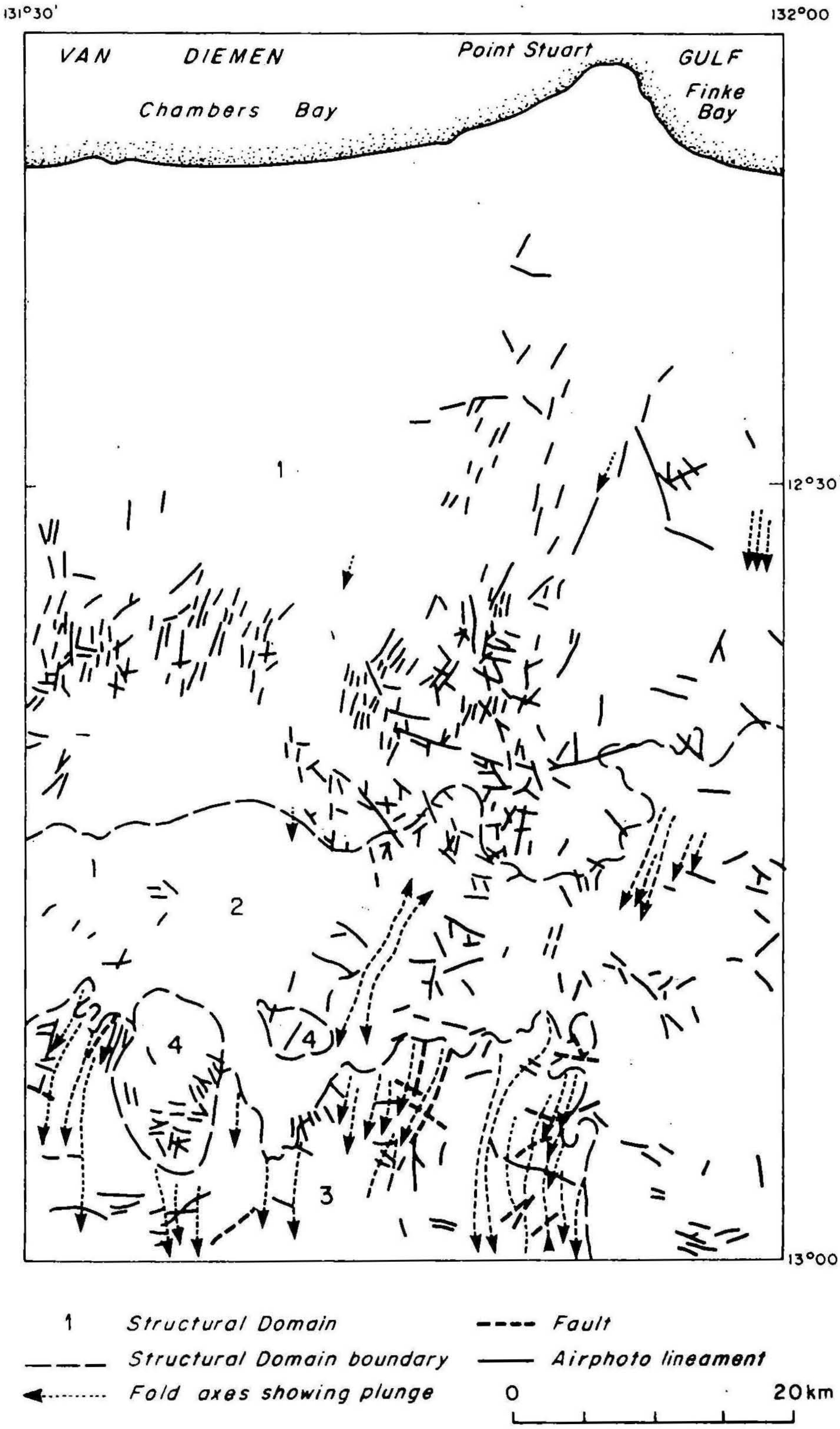

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Fig. 6 Major structural elements, Mary River and Point Stuart 1:100 000 Sheet areas

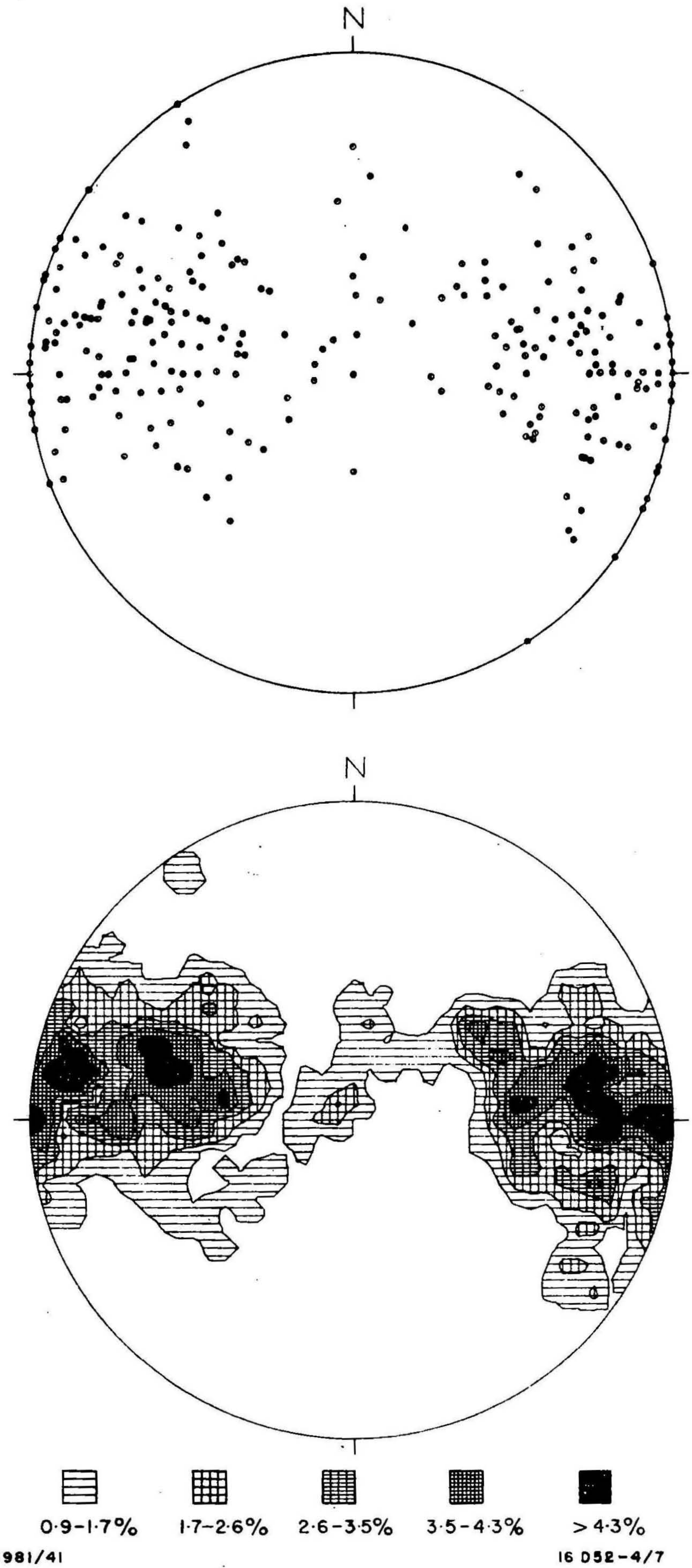

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Fig. 7 Orientation data and contour plot of poles to bedding, Domain 3

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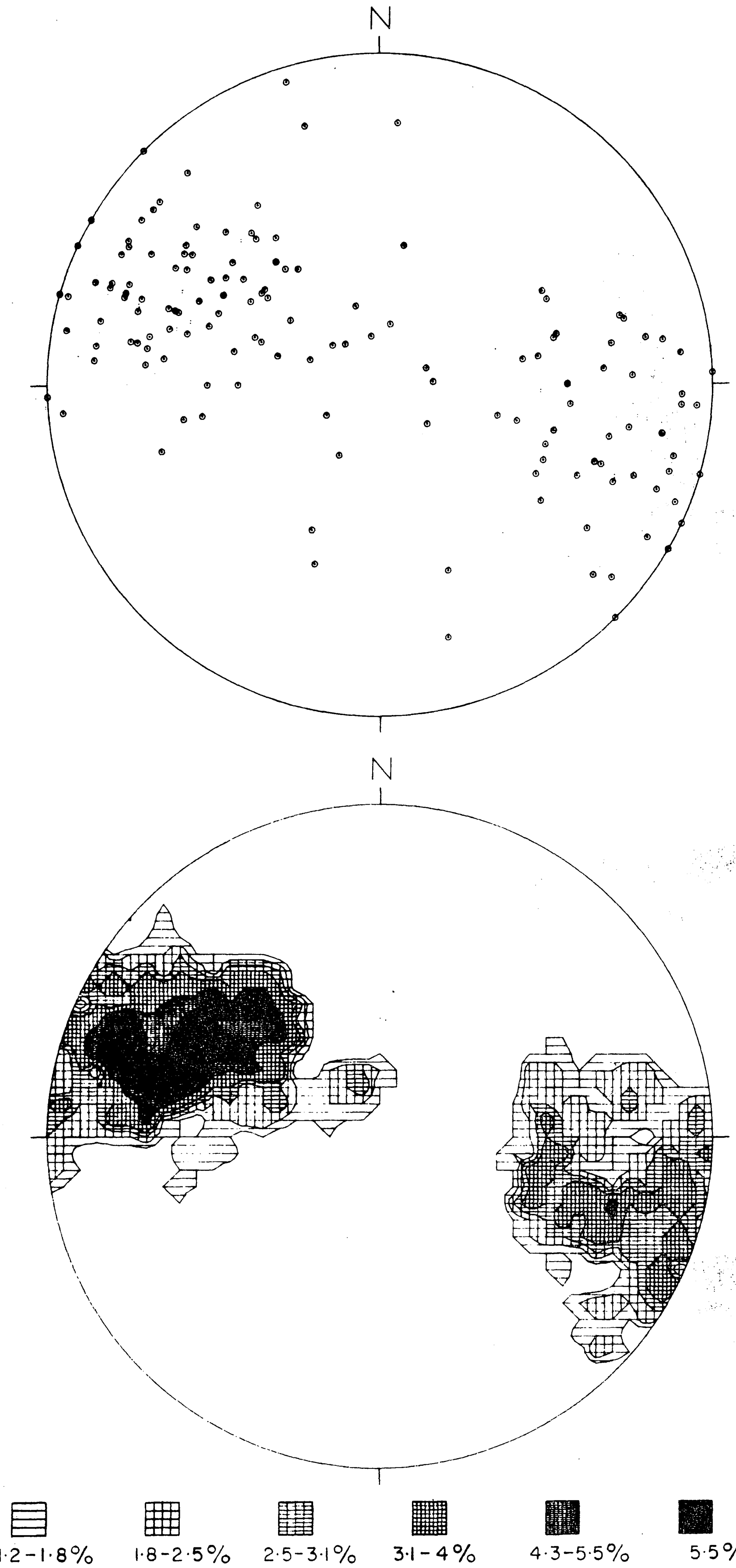

Fig.8 Orientation data and contour plot of poles to bedding, Domain 2

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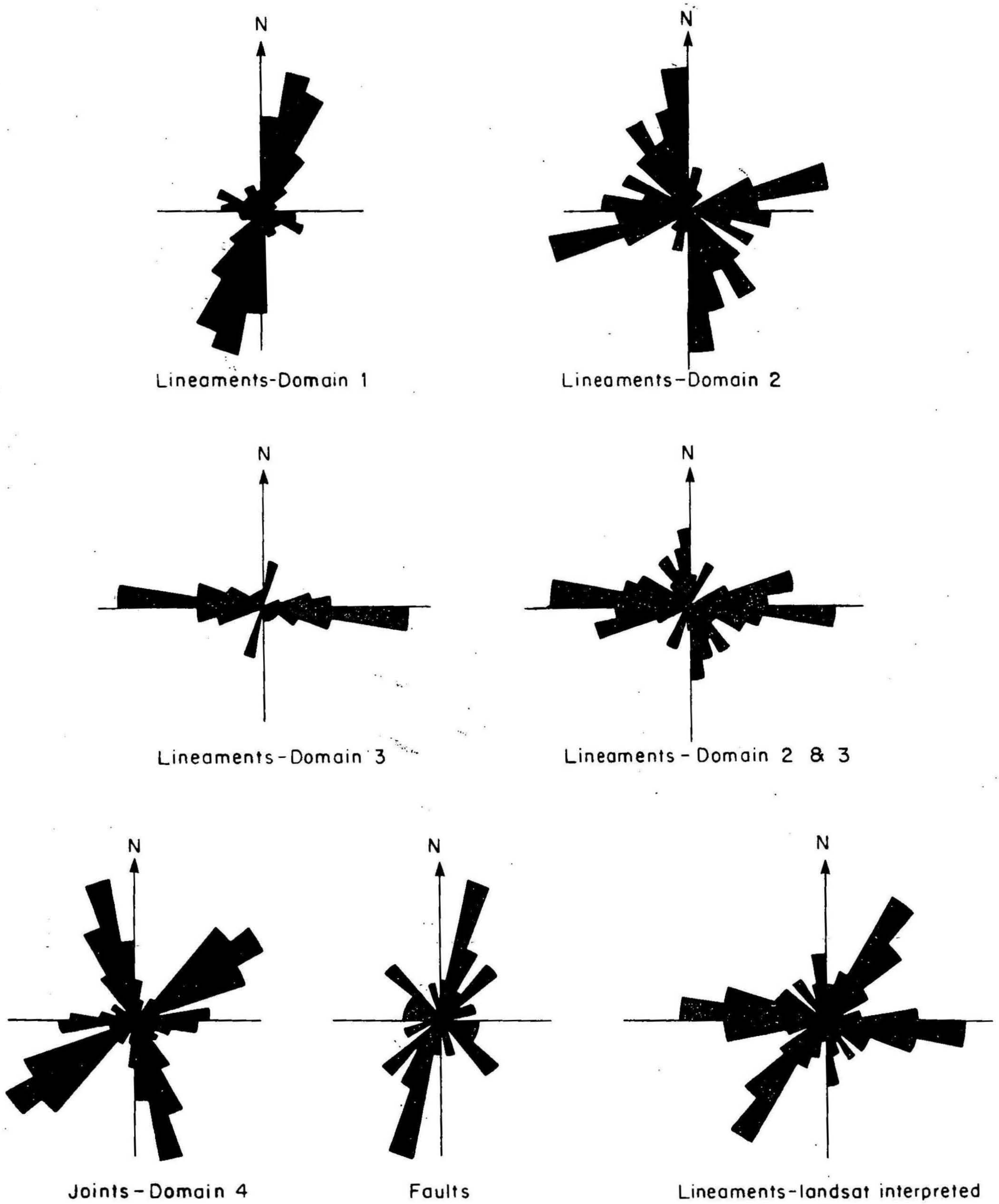

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Fig. 9 Azimuth distribution of Structural features in the Mary River and Point Stuart 1:100 000 Sheet areas

Stereographic contour plots (Figs. 7 & 8) indicate that folds in domain 2 are asymmetrical, with the predominance of easterly-dipping limbs at about 70° and minor westerly dipping limbs between 80° and 90°. Folds in domain 3 are symmetrical with limbs dipping between 60° and 90°. The asymmetry of the contour plot in domain 2 is probably a result of overturning, as overturned dips were observed and fold hinges, where exposed, are symmetrical.

An unconformity beneath the Koolpin Formation is exposed 25 km southeast of Mount Goyder (GR 110620), and is indicated by the termination of quartzite beds in the Wildman Siltstone against the Koolpin Formation 3 km south of Annaburroo Homestead in the hinge of the south-plunging anticline (GR 900680). Elsewhere, an unconformity is indicated by converging trends in hinge areas, and by the different fold styles of domains 2 and 3. As the stereographic plots indicate, one episode of folding in domains 2 and 3, the overturning of folds in domain 2, and the angular discordance of beds in hinge areas can be explained by a shallow angular unconformity beneath the Koolpin Formation. Beds in the Mount Partridge Group (domain 2) dip westwards less than 20° relative to the unconformity plane, which is consistent with Koolpin Formation overlying Mundogie Sandstone in the eastern part of the area and Wildman Siltstone in the west. This relationship is not uniform throughout the Pine Creek Geosyncline, but is consistent with the low degree of deformation, indicated by warping and minor folding of the Mount Partridge Group prior to deposition of the South Alligator Group, in the Mundogie 1:100 000 Sheet area (Stuart-Smith & others, 1980a).

The regional structure is locally modified by faults up to 10 km long, which typically have small displacements ranging from a few metres to 1 km. The faults show one major concentration at 010°-020°, and two minor concentrations at 050°-060° and 130°-140° (Fig. 9). Faults with a 010°-020° orientation show strike-slip displacements and were most probably contemporaneous with the major period of folding as they parallel the axial plane of folds and have been rotated about the regional northwest-trending flexure. Faults in the other two orientations are short and postdate folding, as they displace fold limbs and the north-trending strike-slip faults.

Airphoto and Landsat lineaments are common throughout the area, particularly in domain 1 (Figs. 6 & 10). The airphoto lineaments are commonly between 1 to 2 km long but can be up to 8 km long. Landsat lineaments are markedly longer, ranging from 5 to over 50 km in length.

Lineaments in all structural domains (Fig. 9) show a concentration between 90° and 100° that parallels faults and joints associated with the regional northwest-trending flexure. A strong 010°-020° concentration, particularly in domain 1, corresponds to the predominant bedding and fault orientations in the Early Proterozoic metasediments.

A prominent northeast trend (030°-040°) in Landsat lineaments corresponds to major positive magnetic lineaments interpreted by Tucker & others (1980) to be caused by dykes. This orientation is not reflected in airphoto lineament concentrations.

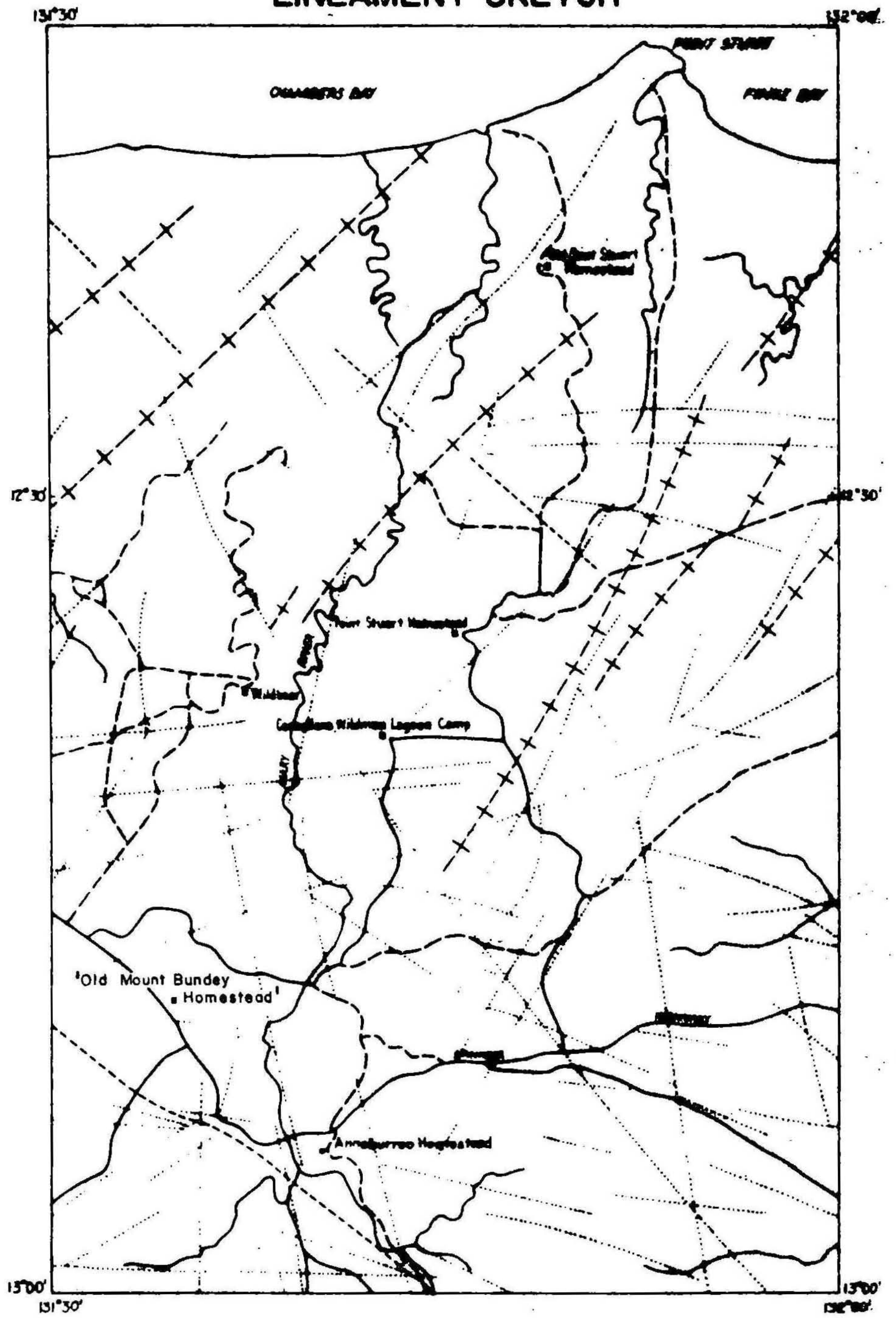
Northwest-trending negative magnetic lineaments, which parallel a minor fault orientation in Early Proterozoic rocks, are also interpreted to be caused by dykes. Drilling by NTGS in the Noonamah 1:100 000 Sheet area, on a continuation of one such lineament passing through Mount Bundey, intersected altered dolerite and picrite at depth (W. Newton, personal communication). The dykes have a preliminary minimum Palaeozoic K/Ar mineral age of about 400 m.y. (Amdel determination for NTGS).

ECONOMIC GEOLOGY

Apart from the Mount Bundey iron mine, no economic mineralisation has been located in the Mary River and Point Stuart 1:100 000 Sheet areas. Several small base metal and gold prospects occur in the Koolpin Formation within the contact aureole of the Mount Bundey Granite (Fig. 11). Crushed rock and sand are being extracted from the area.

Before 1968, field investigations of the area were confined to activities carried out by BMR as part of a regional evaluation of the Darwin-Katherine area (Walpole & others, 1968), and assessment of the Mount Bundey iron deposits. Exploration for uranium, base metals, and gold within the Early Proterozoic rocks, and heavy minerals and lime in

LINEAMENT SKETCH



Aeromagnetic interpretation by D. Tucker BMR
Landsat interpretation by C. Simpson BMR;
J. Huntington, J. Leishman CSIRO

—+—	*Positive*	*Aeromagnetic lineaments*
--------	*Negative*	
....	*Landsat interpreted lineaments*	

0 — 20 km

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Fig. 10 Interpreted Landsat and aeromagnetic lineaments, Mary River and Point Stuart 1:100 000 Sheet areas

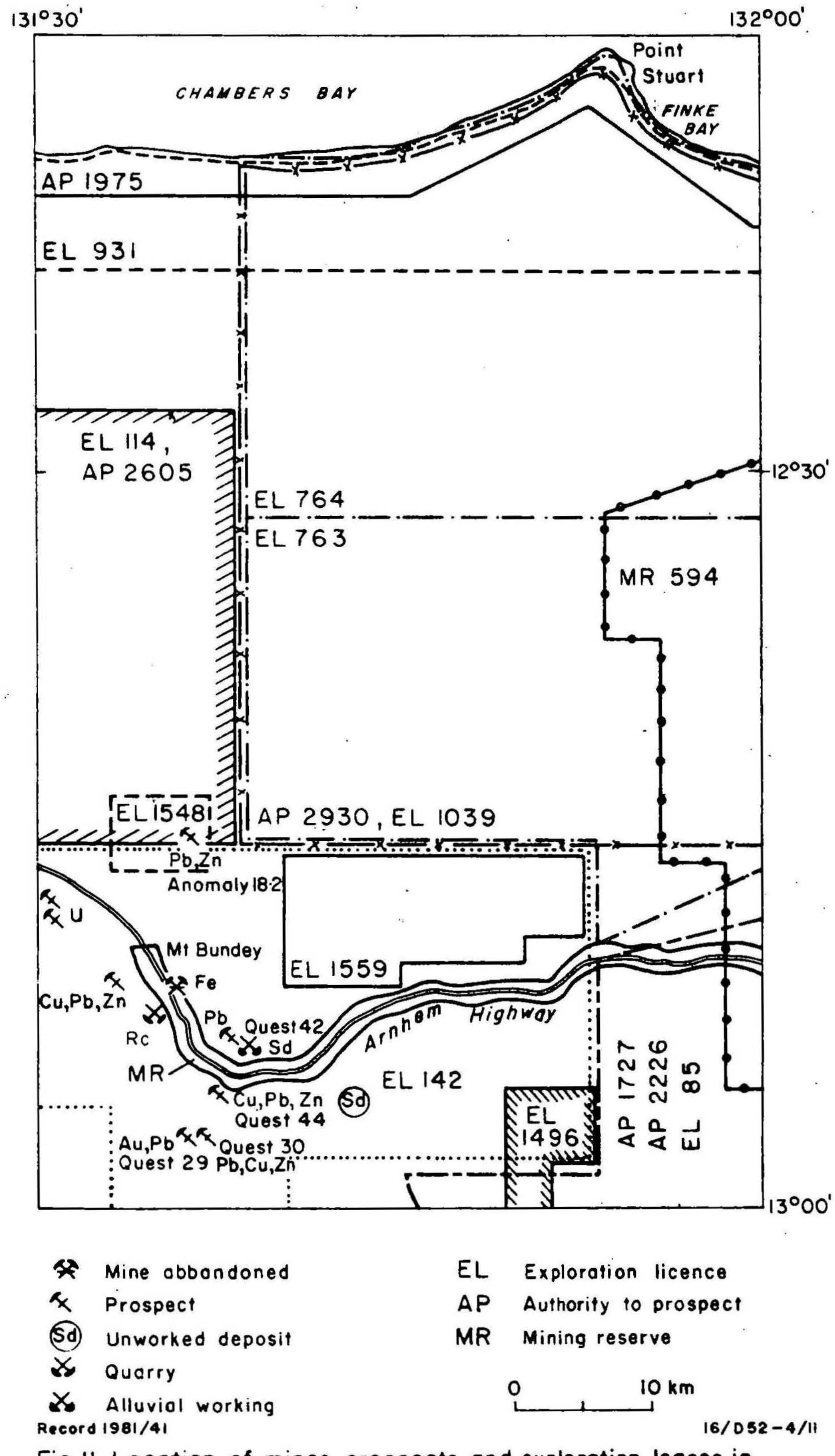

Fig. 11 Location of mines, prospects, and exploration leases in the Mary River and Point Stuart 1:100 000 Sheet areas Compiled from mining tenure maps of the Northern Territory Department of Mines and Energy to December 1979

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coastal sand ridges, began in 1968 when the first authorities to prospect in the area were issued. (Note: The term 'Authority to Prospect' has since been superseded by the term 'Exploration Licence').

Between 1968 and 1972 most of the area was covered by exploration licences. Investigations were regionally orientated and included geological mapping, airborne and ground radiometric and magnetic surveys, stream sediment surveys, rock chip sampling, and auger drilling. Elements assayed in stream sediments samples included Cu, Pb, Zn, Au, As, Ni, Co, and U. Rock chip and soil samples were analysed for all or some of the following U, Cu, Pb, Zn, Ag, Au, As, Mn, Fe, Ti, Cr, V, Ni, Co; uranium was also analysed in stream waters.

These investigations revealed that low-order radiometric anomalies in the region were related to a thin surficial Cainozoic laterite capping on Early Proterozoic sediments, a common occurrence in laterites of the region. Most geochemical anomalies were also low-order and were considered to reflect changes in rock type. Auger drilling by CRAE in the northern part of the Mary River Sheet area showed that magnetite was present with higher metal values and that basic to intermediate dykes were probably the source of the anomalies. Later work in EL 1559 (Wills, 1979a) showed that anomalies were coincident with strike ridges of the Annaburroo volcanic member (previously mapped as dolerite). Significant base metal and gold prospects located during these regional investigations (Quest Nos. 29, 30, 42, and 44, and Anomaly 18.2) are discussed separately.

IRON

Mount Bundey

(Dow & Pritchard, 1958; Dunn, 1964; Milsom & Finney, 1965; Ryan, 1969; Ryan, 1976; Taube, 1966; Walpole & others, 1968).

The Mount Bundey iron ore deposit (known originally as Pritchard's Lode) located 2 km north of Mount Bundey, was first noted by Dow & Pritchard (1958) during regional mapping by BMR. The deposit was mined between 1968 and 1971, yielding 843 063 tonnes of ore at an average grade of 63.43 percent Fe, 0.108 percent S, and 0.057 percent P_2O_5; about 60 percent was produced from the lode and the balance from scree and rubble. The mine closed when the sulphur content in the ore at depth became too high to warrant further production (Ryan, 1976).

The geology of the deposit is shown in Figure 12 and is reviewed in detail by Ryan (1976), who described two groups of tabular ironstone bodies. These bodies were thought to represent the limbs of a major syncline, each interbedded with near-vertical banded sedimentary rocks and surrounded by the Mount Goyder Syenite. The lodes are well-jointed, faulted, and brecciated in part. The easternmost of the two is about 700 m long and up to 50 m wide, and provided most of the ore. The ironstone bodies consisted of massive martite with varying amounts of hematite and goethite. At the surface a little pyrite was present but below the zone of oxidation it was more abundant, forming a pyrite-magnetite rock. Finely bedded ferruginous sedimentary rock, mica-schist, chlorite-mica schist, and hornfels envelop the ironstone bodies and are interbedded with them. Aplite and granitic dykes and diffuse zones of chlorite cut the ironstone and the sediments. The enclosing syenite is strongly porphyritic and commonly shows a crude gneissic texture close to the contact with the sediments, which ranges from sharp and obviously intrusive to gradational and indefinable.

Ryan (1976) discussed the genesis of the deposit and suggested that the lodes formed by pre-Cretaceous supergene enrichment (which has continued to the present day) of iron-rich sediments included in the Mount Goyder Syenite during intrusion. Hornfelsed dolomitic, pyritic, and carbonate sediments of the Koolpin Formation, which crop out near the Mount Bundey Granite and Mount Goyder Syenite, were probably the source of the inclusion. The presence of abundant carbon and pyrite may have helped produce a reducing environment, and the formation of magnetite during metamorphism of the sediment accompanying igneous intrusion.

BASE METALS AND GOLD

Quest 29 prospect

Reconnaissance rock chip sampling by Geopeko (Twist, 1977) revealed anomalous lead and gold values in an outcrop of ferruginous siltstone of the Koolpin Formation 9 km southwest of the Annaburroo Homestead. The outcrop was costeaned and further samples collected and assayed for Cu, Pb, Zn, Ni, Ag, and Au.

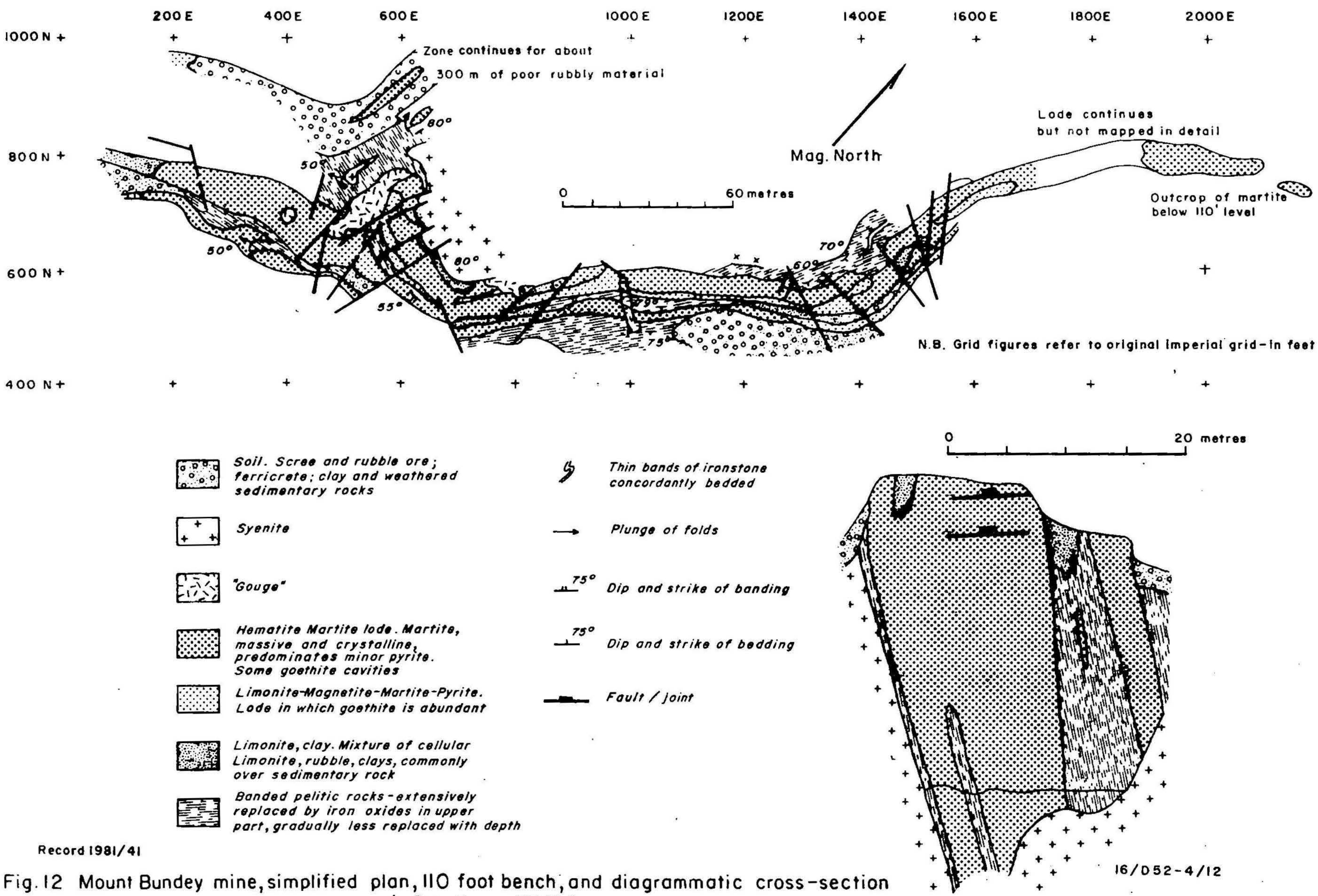

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Fig. 12 Mount Bundey mine, simplified plan, 110 foot bench, and diagrammatic cross-section (after Ryan, 1976)

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The lead mineralisation occurs as secondary minerals within a narrow quartz-veined gossan up to 10 m wide. A diamond drillhole designed to test continuation of the mineralisation at depth found the mineralised zone at 45 m depth had decreased to a third its surface width with an average grade of 0.4% Pb and 1.3% Zn. The mineralisation is associated with siderite-quartz bands within brecciated sericitised trachyte (probably altered minette) which is conformable with sericitised cordierite-biotite hornfels of the Koolpin Formation. Sulphides present in the siderite bands include arsenopyrite, galena, sphalerite, chalcopyrite, and minor pyrite.

About 1 km south of the lead lode, gold mineralisation, up to 57.3 grams/tonne, occurs at the surface as a separate lode 60 m long and 1 m wide, composed of a series of small gossanous granitic pegmatites. A diamond drillhole (total depth 128.59 m) located low-grade (less than 2.19 g/t Au) mineralisation at 23 m depth. The drillhole intersected mainly pyritic carbonaceous shale of the Koolpin Formation which is extensively intruded by altered gabbro and dolerite of the Zamu Dolerite and narrow minette dykes. The gold mineralisation is associated with small pyrite, pyrrhotite, and arsenopyrite-bearing quartz-feldspar pegmatites which intrude the sequence. Gold occurs as inclusions in arsenopyrite. The shale contains anomalous base metal values of up to 1200 ppm Zn, 740 ppm Cu, 360 ppm Pb, and 400 ppm Ni.

Quest 30 prospect

Anomalous values of Pb (up to 12%), Cu (1000 ppm), and Zn (500 ppm) over a strike length of 400 m are coincident with a magnetic anomaly over an outcrop of siliceous ironstone of the Koolpin Formation about 8 km southwest of Annaburroo Homestead (Twist, 1968). Spongy quartzose gossans are present in the outcrops within shear zones. Goethite boxworks are well-developed and derived from coarsely crystalline and finer granular galena, and possibly arsenopyrite. Patches and coatings of beudantite are common and are intergrown with other secondary minerals. Minor pyrite and possibly chalcopyrite and bismuth are present in places.

Investigations of the anomaly by Geopeko included surface grab sampling, costeaning, auger drilling (243 holes to 1 m depth), and ground magnetic and self-potential surveys. Samples collected during the program were analysed for Co, Cu, Pb, An, Mn, Ni, P, and Ti. A diamond drillhole showed that the high surface values did not continue at depth and no further work has been done on the prospect.

Quest 42 prospect

Minor lead mineralisation occurs in rocks of the South Alligator Group 2 km north of the Arnhem Highway on the western bank of the Mary River (Howard & Browne, 1975). The sequence overlies the Wildman Siltstone and forms a tight south-plunging syncline on the eastern margin of the Mount Bundey Granite. The rocks are cut by fault zones and numerous dykes ranging in composition from microsyenite to minette.

Anomalous base metal values were obtained from rock chip samples of the dykes, fault zones, and a quartz-goethite horizon in the Koolpin Formation (Table 3). The most significant of these are 0.4% Pb from a massive quartz-hematite fracture filling and 0.3% Zn from the quartz-goethite horizon.

The area is presently covered by mineral leases and is currently being investigated by Geopeko (Quest 42; Twist, 1977).

Quest 44 prospect

Geochemical, radiometric, and magnetic anomalies 5 km west of Annaburroo Homestead, located during a regional survey by Geopeko (Twist, 1977), occur within the Koolpin Formation where it is intruded and hornfelsed by the Mount Bundey Granite. Rock chip, channel (in costeans), and C-horizon soil samples were collected, and detailed geological mapping, and ground magnetic, self potential, and electro-magnetic surveys were conducted over the anomalous horizon.

Three auger/core holes and one diamond drillhole intersected hornfelsed sediments of the Gerowie Tuff and the Koolpin Formation and bottomed in the Mount Bundey Granite, but failed to intersect economic mineralisation. The sediments form a conformable sequence that parallels the granite contact which dips 35^{o} to the east.

Table 3. Summary of maximum values of outcrop chip sample geochemistry, Quest 42 (from Howard & Browne, 1975)

Rock unit		Maximum Value												
		U ppm	Cu ppm	Pb ppm	Zn ppm	Au ppm	Ag ppm	Mn ppm	Fe %	Ti %	As ppm	Ni ppm	Be ppm	Li ppm
Koolpin Formation		47	395	830	3106	-	-	-	-	-	-	-	-	-
Gerowie	(Flows	40	500	168	1150	-	2.4	9	31	-	-	-	-	-
Tuff	(Tuffs	4	44	72	36	-	0.4	41	11.1	0.15	-	-	-	-
Dykes	(Mica lamprophyre	19	300	330	240	x	1.8	3900	13	0.96	-	370	-	-
	(Microsyenite	18	170	150	2680	-	-	1950	6.6	-	-	650	50	45
Fault	(Quartz-hematite rock	36	250	4050	1400	0.5	3.4	-	-	-	1800	-	-	-
zones	(Quartz veins	-	-	650	-	-	-	-	-	-	-	-	-	-

x = Below limits of detection

\- = not determined

Anomalous values of Cu, Pb, and Zn were obtained throughout the intersections of the Koolpin Formation in the diamond drillhole, the most significant being 1.2% Pb, 1.9% Zn, and 231 ppm Cu over 1 m. Mineralisation occurs mainly in chloritic zones within hornfelsed carbonaceous slate, as fine deuteric patches of pale sphalerite and veins of massive sphalerite. Minor amounts of galena and chalcopyrite occur mostly as inclusions in sphalerite but may form coarser patches or veins intergrown with it. Pyrite is present as discrete masses and veins. Minor amounts of molybdenite occur with pyrrhotite and pyrite and traces of chalcopyrite and sphalerite as veins and disseminations in a skarn adjacent to the granite contact.

Anomaly 18.2

An ironstone 13 km north of Mount Bundey discovered during regional mapping by CRAE (Wills, 1979b; Sevensson, 1979) yielded maximum assays of 1370 ppm Pb, 3120 ppm Zn, 277 ppm Cu, and 1.58% Mn. Follow-up soil sampling, auger drilling, and a 30-m long costean outlined a bedrock anomaly of 0.5% Pb about 20 m wide and 200 m long. Maximum assays obtained were 2.08% Pb and 0.37% Zn. A 04.2 m diamond drillhole intersected weathered shale, dolomite, graphitic dolomitic shale, and minor tuff of the Wildman Siltstone. Low-grade mineralisation of visible galena and sphalerite was intersected, the most significant intersection being 4 m of 9245 ppm Pb, 1475 ppm Zn, 258 ppm Cu, and 3695 ppm Mn. A follow-up auger drilling program totalling 238 m failed to locate further drill targets.

MINERAL SANDS

Presently active and older stranded coastal sand ridges flanking Chambers and Finke Bays have been prospected for heavy minerals and their lime content.

Shallow scout boring by Placer Prospecting Australia Pty Ltd (Murphy, 1969) failed to locate significant sand bodies or heavy mineral concentrates. The bores ranged from 3 to 8 m in depth and showed that a shallow zone of black loam covered the coastal plains and was underlain by a coarse shelly base. About 95 percent of the area traversed consisted of mud and shell fragments with little sand.

The sand ridges were investigated by Northern Cement Pty Ltd in 1973 and 1974 for their lime content (Appendix 5). Analyses of 19 hand auger samples showed they contained an average of 35.4% CaO, and 0.38% MgO. No further work was carried out.

SAND AND CRUSHED ROCK

Currently, three companies hold mining leases for river sand along an 8 km stretch of the Mary River around the Annaburroo Homestead. Total production for the two years ending June 1979 was 43,123 tonnes.

Crushed rock and weathered sands from the Mount Bundey Granite are presently being extracted about 2 km south of the abandoned Mount Bundey iron mine. No production figures for the operations are available.

ACKNOWLEDGEMENTS

We wish to thank T. Baldwin of 'Annaburroo' for his much appreciated hospitality, and BP Minerals and Union Oil Development Corporation for freely supplying company information and for discussions with their field geologists.

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APPENDIX 1 - Definitions of new stratigraphic units.

A. ANNABURROO VOLCANIC MEMBER

Derivation of name: Annaburroo Homestead, Grid reference 899708. Mary River 1:100 000 Sheet area.

Distribution: Narrow, discontinuous, boulder-strewn ridges or hills cropping out over about 200 km^2, northeast of Annaburroo Homestead, in the centre of the Mary River 1:100 000 Sheet area.

Type locality: Ridge outcrop exposing about a 50 m thick section of deeply weathered ferruginous andesite (131°44'E, 12°51'S; Darwin 1:250 000 Sheet area). Unweathered volcanics intersected in two drillholes at depth (BMR drillholes MR1, MR2; grid reference 964764, 964766 respectively; Mary River 1:100 000 Sheet area).

Lithology: Interbedded chloritised and pyritic fine even-grained amygdaloidal andesite, porphyritic andesite, and tuffaceous pyritic carbonaceous shale. Weathers to a ferruginous brown to mauve massive rock at the surface.

Thickness: 50 to 100 m.

Relationships and boundary criteria: Forms at least two conformable beds within the Wildman Siltstone about 250 m and 500 m above the top of the Mundogie Sandstone. Lithologically distinct from the enclosing pelitic sediments of the Wildman Siltstone.

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

Synonymy: Malone (1962) and Walpole & others (1968) mapped the volcanics as dolerite and included them in the Zamu Complex.

B. MOUNT BONNIE FORMATION

Derivation of name: Mount Bonnie mine (131°33'E, 13°33'S). Pine Creek 1:250 000 Sheet area.

Distribution: The unit forms well-exposed ridges in the Alligator River, Darwin, Pine Creek, and Mount Evelyn 1:250 000 Sheet areas.

Type section: (131°43'E, 12°59'S; Darwin 1:250 000 Sheet area) 450 metres of interbedded argillite, shale, siltstone, greywacke, tuff, and shale with black or white chert bands, lenses, and nodules exposed along the northern bank of the Mary River from grid reference 945639 to 948640 (Mary River 1:100 000 Sheet area).

Reference area: Well-exposed ridges and drill-core intersections in the Margaret Syncline around the Mount Bonnie mine.

Lithology: Interbedded shale, siltstone, shale with black or white chert bands, lenses, and nodules, argillite, tuffaceous chert, black glassy crystal tuff, greywacke, minor silicified dolomite and banded iron formation.

Thickness: 650 to 850 metres, locally thins to 200 to 300 metres.

Relationships and boundary criteria: Conformably overlies the Gerowie Tuff and is conformably overlain by the Burrell Creek Formation. The base of the unit is defined as the base of the lowermost greywacke. The unit also contains a smaller proportion (less than 10 percent) of tuff and argillite compared to the Gerowie Tuff. The top of the unit is defined by the uppermost unit of either argillite, tuff, shale containing chert bands, lenses, and nodules, or banded iron formation.

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

Synonymy: Walpole & others (1968) included these beds in the Koolpin Formation in the Alligator River and Mount Evelyn 1:250 000 Sheet areas and in the Golden Dyke Formation in the Darwin and Pine Creek 1:250 000 Sheet areas. Described by Goulevitch (1980) as Kapalga Formation and included by Needham & others (1980a) in the Kapalga Formation.

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APPENDIX 2. Mount Bundey Granite - Chemical Analyses

Sample No.	PCGR272[1]	PCGR273[2]	PCGR274[2]	PCGR275[2]	G3[3]	G3A[3]	G4[3]	G5[3]	G6[3]	GT1[3]	GT2[3]	GT3[3]	GQ[3]	GQ2[3]
SiO_2	72.71	70.40	73.40	71.16	71.97	72.02	72.03	72.03	67.25	72.36	70.99	71.00	70.15	71.78
TiO_2	0.28	0.34	0.26	0.09	0.27	0.26	0.28	0.30	0.46	0.29	0.31	0.31	0.34	0.24
Al_2O_3	13.15	15.18	13.00	13.82	13.77	13.54	13.66	13.16	13.12	13.50	13.62	13.74	13.95	13.63
Fe_2O_3	1.06	1.57	0.94	1.59	2.35	2.24	2.37	2.62	4.50	2.52	2.82	2.59	2.72	2.33
FeO	1.25	1.36	1.29	1.09										
MnO	0.04	0.05	0.03	0.03	0.02	0.02	0.02	0.04	0.10	0.04	0.04	0.04	0.03	0.01
MgO	0.59	1.16	0.47	1.23	0.57	0.55	0.55	0.55	1.93	0.53	0.65	0.63	0.87	0.56
CaO	1.50	1.53	1.66	1.45	1.47	1.23	1.42	1.52	2.50	1.42	1.29	1.36	1.65	1.31
Na_2O	3.65	3.39	3.50	3.71	3.91	3.80	3.79	3.54	3.47	3.67	3.71	3.75	3.85	3.73
K_2O	4.54	3.84	4.65	5.05	5.01	5.08	5.06	4.87	5.16	4.80	5.09	5.10	5.32	5.05
P_2O_5	0.15	0.16	0.14	0.07	0.11	0.10	0.10	0.11	0.38	0.11	0.12	0.11	0.16	0.10
S	0.01	<0.01	<0.01	<0.01	-	-	-	-	-	-	-	-	-	-
H_2O^+	0.55*	0.63	0.51	0.58	0.47*	0.59*	0.43*	0.48*	0.38*	0.43*	0.68*	0.54*	0.31*	0.51*
H_2O^-	-	0.03	0.06	ND	-	-	-	-	-	-	-	-	-	-
CO_2	<0.05	-	0.10	-	-	-	-	-	-	-	-	-	-	-
Total (percent)		99.64	99.92	99.87	99.91	99.42	99.71	99.20	99.24	99.67	99.33	99.17	99.35	99.25
						Minor elements - ppm								
Bd	696	-	-	-	920	1000	890	820	855	760	845	905	1170	850
Sr	420	-	-	-	430	400	430	375	365	400	400	430	665	405
Rb	280	-	-	-	255	275	265	285	345	275	275	270	250	295
Y	19	-	-	-	10	-	12	17	29	14	17	18	13	-
Zr	206	-	-	-	210	180	200	245	250	225	205	220	260	120
Nb	-	-	-	-	23	25	24	28	30	26	22	25	30	55
Ce	309	-	-	-	115	97	120	155	195	150	145	140	120	110
Nd	-	-	-	-	32	31	35	42	81	41	44	46	33	29
Sc	7	-	-	-	4	-	3	4	9	5	4	3	5	-
U	10	-	-	-	14	-	-	-	11.1	-	-	-	12.3	-

1 - Ferguson & others, 1980.
2 - Walpole & others, 1968.
3 - Hochman, 1980.

\- not determined
* loss on ignition
ND not detected

APPENDIX 3. Mount Goyder Syenite - Chemical analyses.

Sample	[2]PCGR276	[2]PCGR277	[3]G1	[3]G2	[3]GS	[3]GS1
SiO_2	59.76	60.40	61.05	59.95	62.24	61.49
TiO_2	0.15	0.35	0.72	0.76	0.63	0.59
Al_2O_3	16.56	17.21	14.74	14.16	14.21	14.19
Fe_2O_3	5.38	1.99	4.99	5.59	5.09	5.12
FeO	1.52	2.84				
MnO	0.09	0.04	0.10	0.10	0.07	0.07
MgO	2.44	3.60	2.40	3.26	3.12	3.13
CaO	2.14	4.02	2.53	3.26	3.53	3.74
Na_2O	4.98	3.24	4.62	3.91	3.54	3.67
K_2O	5.52	4.70	6.96	6.89	5.85	5.90
P_2O_5	0.10	0.08	0.49	0.74	0.44	0.43
S	<0.01	<0.01	-	-	-	-
H_2O^+	0.94	0.92	0.35*	0.39*	0.43*	0.74*
H_2O^-	ND	0.04	-	-	-	-
CO_2	-	-	-	-	-	-
Total (percent)	99.58	99.43	98.94	99.01	99.15	99.07
			Minor elements - ppm			
Ba	-	-	2300	2850	2840	3130
Sr	-	-	1670	1790	1470	1535
Rb	-	-	225	220	220	195
Y	-	-	18	16	23	-
Zr	-	-	805	740	35	33
Ce	-	-	310	250	285	265
Nd	-	-	110	95	105	85
Sc	-	-	9	12	16	-
U	-	-	12	12.3	15.7	-

- not determined

* loss on ignition

ND not detected

2 Walpole & others (1968)

3 Hochman (1980)

APPENDIX 4

Publications of the Bureau of Mineral Resources, relevant to the Mary River and Point Stuart 1:100 000 Sheet areas.

Publication	Author(s)	Title
Records (unpublished)		
1958/36	Hasan, S.M.	Petrography and petrology of Mount Bundey Granite and Mount Goyder Syenite, N.T.
1958/122	Dow, D.B., & Pritchard, P.W.	The geology of Woolwonga, Mount Bundey, and Marrakai East areas, Northern Territory.
1962/185	Ashley, J.	Mount Bundey test magnetic survey, Northern Territory, 1962.
1964/18	Dunn, P.G.	Geology and drilling results: Pritchards lode - Mount Bundey area, Northern Territory.
1964/22	Barclay, J.	Low-grade iron deposits near Marrakai Crossing, Northern Territory. In Minor metalliferous investigations, Northern Territory Resident Geological Section.
1965/7	Milson, J.S., & Finney, W.A.	Mount Bundey detailed aeromagnetic survey, Northern Territory, 1964, preliminary.
1965/61	Milson, J.S., & Finney, W.A.	Mount Bundey detailed aeromagnetic survey, Northern Territory, 1964.
1966/101	Goodeve, P.E.	Darwin-Pine Creek contract aeromagnetic survey, 1963.
1969/91	Dodson, R.G., Shields, J.W., & Daly, M.R.	Iron ore reconnaissance by helicopter.
1980/15	Stuart-Smith, P.G., Wallace, D.A., & Roarty, M.J.	Pine Creek Party 1978 data record: Point Stuart, Mary River, and Mundogie 1:100 000 Sheet areas.
Bulletins		
16	Noakes, L.C.	A geological reconnaissance of the Katherine-Darwin region, Northern Territory (1941).
82	Walpole, B.P., Crohn, P.W., Dunn, P.R., & Randal, M.A.	Geology of the Katherine-Darwin region, Northern Territory (1968).

APPENDIX 5

Company reports relevant to the Mary River and Point Stuart 1:100 000 Sheet areas filed at the N.T. Department of Mines and Energy, Darwin.

N.T. Dept of Mines & Energy File No. (Company report - year/report No.)	Lease No.	Main prospected minerals	Abbreviated title and company
CR 68/7	AP1730, 1729, 1728, 1751, 1727	Cu, Ni, Co, Pb, Zn	Phase I Investigations of 8 mile Creek, Rosie Creek, Nagi Hill, Jim Jim, Mary River 1968. Australian Geophysical.
CR 69/31	AP1975	Heavy minerals	Report, Chambers and Finke Bays, Heavy mineral beach sands. Placer Prospecting Aust. Pty Ltd.
CR 71/6	AP2226	U, Ag, Pb, Zn	Report on Phase II Investigations 1971. Australian Geophysical.
CR 71/97	AP2226	U	Final report of the 1971 Airborne and ground spectrometer surveys 1971. Australian Geophysical.
CR 72/85A	AP2930	U, Cu, Pb, Zn	Annual report lower Mary River. CRAE.
CR 72/85	EL763, 764	U, Cu, Pb, Zn	Report for year ended 30/9/72 Lower Mary River parts A-B. CRAE 1972.
CR 73/10	E182-85	U	Report on Exploration and expenditure. Quarter ended 28/8/72, 1973. Ada Explorations.
CR 73/48	EL114	U	Quarterly report No. 3, Marrakai 1973. Kewanee.
CR 73/60	EL623	U	Quarterly report No. 1, period ending 21/1/73, Rum Jungle Area D, parts A-B. Kewanee, 1973.
CR 73/65	AP2605	Cu, Pb, Zn, Co, Ni	Final report and maps Marrakai Area, parts A-C. Kewanee 1973.

APPENDIX 5 (cont)

N.T. Dept of Mines & Energy File No. (Company report - year/report No.)	Lease No.	Main prospected minerals	Abbreviated title and company
CR 73/90	EL763, 764		Final report lower Mary River. CRAE 1973.
CR 73/124	EL142	Cu, Pb, Zn	Progress report Quest 30 prospect. Geopeko, 1973.
CR 73/149	EL82-85	U	1972 Exploration report - Mary River uranium joint venture. Macmine, 1973.
CR 74/111	EL142	Cu, Pb, Zn, U, Ag, Au, As, Mn, Fe, Ti, Co	Report on area relinquished at 30.3.74, Geopeko, 1974.
CR 74/150	"	"	Report on areas retained at 30/3/74. Geopeko, 1974.
CR 75/120	"	"	Report on areas retained as at 31/3/75. GD 75/2. Geopeko, 1975.
CR 75/121	"	"	Report on areas relinquished as at 31/3/75. GD 75/3 Geopeko, 1975.
CR 75/132	"	"	Progress report, Quest 42 prospect, NT. Geopeko, 1975.
CR 76/49	"	"	Report on areas relinquished from EL142 at 30/8/76. Geopeko, 1976.
CR 76/68	"	"	D76/2 work on areas retained as at 31/3/76. Geopeko, 1976.
CR 77/94	"	"	Progress report on Quest 29 prospect. Geopeko, 1977.
CR 78/4	EL91	limestone	Final report for the year 1973/1974. Northern Cement Pty Ltd.
CR 78/113	EL1469	Cu, Pb, Zn	Final report Annaburroo East, Pine Creek Basin. CRAE.
CR 78/125	EL1559	Cu, Pb, Zn	Mount Goyder annual report, Pine Creek Basin. CRAE.

APPENDIX 5 (cont)

N.T. Dept of Mines & Energy File No. (Company report - year/report No.)	Lease No.	Main prospected minerals	Abbreviated title and company
CR 79/59	EL1559	Cu, Pb, Zn	Final report Mount Goyder, Pine Creek Basin. CRAE.
CR 79/97	EL1548	"	Report for 2 years ending 24/4/79, Dora Creek. CRAE.
CR 79/194	"	"	Final report, Dora Creek. CRAE, 1979.

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