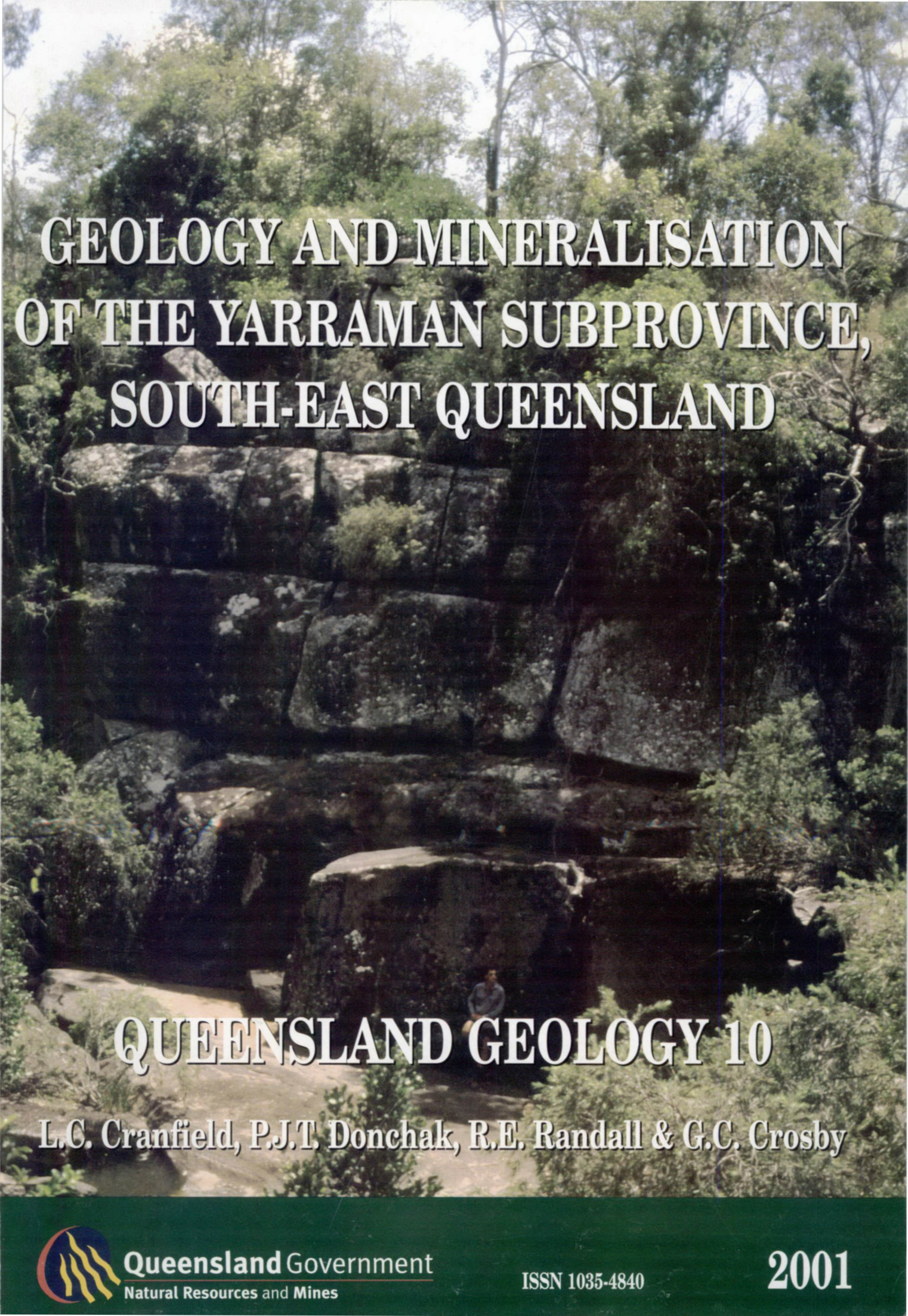


GEOLOGY AND MINERALISATION OF THE YARRAMAN SUBPROVINCE, SOUTH-EAST QUEENSLAND

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L.C. Cranfield, P.J.T. Donchak, R.E. Randall & G.C. Crosby

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COVER PHOTOGRAPHS: RE Randall
Front: Gorge in Taromeo Creek showing good exposure of fine-to medium-grained light grey tonalite $PRgm_d$ (GR 416000, 7033850)

Back: Cliff exposure of kaolinised ?Tertiary sediments (Tm_s?) above columnar jointed basalt (GR 325050, 7074150)

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SUMMARY

The oldest and most extensive sequences in the Yarraman Subprovince, south-east Queensland, are the Late Devonian to early Carboniferous rocks of the Yarrol and Wandilla Provinces. Yarraman Subprovince sediments and volcanics form part of a complex Andean-style orogenic belt of accretionary wedge rocks structurally emplaced by westward-directed subduction along the eastern margin of the Australian craton. A forearc basin (Yarrol Province) developed to the west of the accretionary wedge. Near the end of the Late Carboniferous there was a major tectonic change from subduction-driven compression to crustal extension. Synkinematic, extension-related S-type Late Carboniferous granitoids (now exposed as the Chahpingah Meta-Igneous Complex) intruded the western margin of Yarraman Subprovince. These rocks, together with some areas of deep level metamorphosed accretionary wedge rocks, were either exhumed as extension progressed or during later Permian tectonism.

Oblique plate convergence during the Early Permian resulted in the formation of an array of transtensional back-arc basins within the Yarraman and adjoining subprovinces and shear-induced megafolding to the south in the Texas–Coffs Harbour area. Further to the east, Gympie Province arc volcanism was active at the offshore plate margin.

Early to mid-Permian back-arc (transtensional?) magmatism was almost completely confined to the Yarraman Subprovince where voluminous magmas of the Hivesville and Wooroolin Granites and elements of the Boondooma Igneous Complex were emplaced, partly controlled by old crustal weaknesses.

Late stage antithetic sinistral shearing modified the megafold geometry along a northerly trending crustal weakness which subsequently become the locus of extension forming the embryonic Esk Trough. This feature initiated as a half graben with a faulted eastern margin separating the Yarraman Subprovince from the previously contiguous North D'Aguilar Subprovince. Sedimentation continued into the early Late Permian to the east (in the Esk Trough) and south of the Yarraman Subprovince, with the deposition of the Cressbrook Creek Subprovince.

The earliest sedimentation phase in the Esk Trough ceased in the Late Permian when a major compressional event inverted the basin, in part by reversal of movement along the old west-dipping basin-margin fault. Transpressional shearing of some plutons intruding the Yarraman Subprovince also took place at this time. A major thrusting event in the Late Permian (Hunter–Bowen Orogeny) resulted in foreland loading responsible for pronounced deepening of the Bowen Basin to the north. Analogously, isostatic loading in south-east Queensland produced foreland sagging over the area occupied by the Permian phase of the Esk Trough. The foreland mountain belt provided the source for the adjacent coarse clastic rocks in the Esk Trough. Later flooding of the trough by volcanic calc-alkali-derived detritus (the Neara Volcanics) may be linked to an increase in subduction rate.

I-type, calc-alkali-style magmatism sporadic within the Yarraman Subprovince from the mid-Permian continued into the Late Permian and Early to Middle Triassic. Intrusions are dominated by geochemically similar granodiorite, tonalite, and diorite. Some intrusions may be magmatic equivalents of the Neara Volcanics. These intrusions form the heat source for the base and precious metal mineralisation (Cu, Sb, Sn Au) in the area. More fractionated granites have some associated tin deposits. All metalliferous deposits are very small in size.

Esk Trough sedimentation was terminated by renewed compression in the late Middle Triassic. This was followed by crustal extension and associated bimodal Late Triassic felsic-dominated volcanism accompanied by intrusive activity of mainly granodioritic to granitic composition. Concurrently deposition occurred in a pull-apart depression — the Tarong Basin developed by dextral movement along a northerly-trending fault. Erosion of the plutonic rocks produced detritus for the basal conglomerate fans within the basin. This basin was the site for coal formation, presently providing economic deposits used for electricity generation at Tarong.

At this time, continent-scale extensional downwarp south and west of the Yarraman Subprovince formed the Moreton and Surat Basin components of the Great Australian Basin. Variations in facies within the basins are probably the result of periodic uplift of the source areas of the basin, local and regional changes to base levels, and climatic influences. The Walloon Coal Measures of Early to Middle Jurassic age contain economic coal deposits. Mid-Cretaceous extension initiated a separation of Australia from Gondwana culminating in the opening of the Tasman Sea. Three distinct cooling episodes affected the area since the Late Triassic (mid-Cretaceous, Late Cretaceous, and Late Cretaceous–Early Tertiary). These episodes occurred in response to either kilometre-scale denudation, cooling due to thermal relaxation associated with rifting or a combination of both. Towards the end of the extensional phase, in the Early Eocene, shallow terrestrial basins developed in the north of the Yarraman Subprovince into which the quartzose sands of the Oakdale Sandstone were deposited.

From the late Eocene the Australian continent behaved as a passive margin moving northwards over a hot spot. Tertiary intraplate volcanism resulted in the eruption of basalt, and subordinate rhyolite and trachyte of the Main Range Volcanics that now form the elevated north-northwest trending 'spine' of the Yarraman region. Many of the flows were channelled into ancient stream valleys or filled shallow lakes, mixing with or blanketing clay-rich, commonly diatomaceous sediments. The latter are often now exposed as economically significant deposits. Some hydrothermal alteration of the sediments also occurred at this time.

During the late Miocene, climatic conditions were suitable for widespread lateritisation of most rock types. The lateritisation process formed ferricretes and alcretes and silcretes (some of which have been identified as bauxite deposits) and kaolin clay at depth. Silcrete deposits locally overlie the kaolin clay.

Keywords:- Alice Creek beds, Aranbanga Volcanic Group, Biarraville Formation, Bjelke Petersen beds, 'Black Boy Hill Diorite', Blackbutt, Boondooma Igneous Complex, Box Gully Formation, Buaraba Mudstone, 'Buaraba Granodiorite', Burrandowan, Canoe Creek Granite, Chahpingah Meta-Igneous Complex, Cressbrook Creek Subprovince, Crows Nest, Djuan Tonalite, Esk Trough, Eskdale Granodiorite, Evergreen Formation, Fifer Creek Metamorphics, Gatton Sandstone, GEOMAP 2005, Gilla Volcanics, Gondwana, Goodger, Great Australian Basin, Gympie Province, Hampton Road Rhyolite, Helidon Sandstone, Lockyer Sandstone, Murphy's Creek Sandstone, Hivesville Granite, Hunter-Bowen Orogeny, Kenewah Granodiorite, Koukandowie Formation, Main Range Volcanics, Main Range-Lamington Volcanic Province, Marburg Subgroup, Maronghi Creek beds, Melrose Igneous Complex, Memerambi Granite, Mount Cross Igneous Complex, Mount Langan, Mountefontein Metamorphics, Neara Volcanics, Oakdale Sandstone, Pinecliffe Formation, Precipice Sandstone, Rockhampton Group, SEQ bioregion, Serpentinite, South Buaraba Microdiorite, Southeast Queensland Volcanic and Plutonic Province, Stuart River Granite, Sugarloaf Metamorphics, Taromeo Igneous Complex, Toondahra Granite, Walloon Coal Measures, Wandilla Province, Westgrove Ironstone Member, Wilfred Creek Igneous Complex, Woogaroo Subgroup, Woolshed Mountain Granodiorite, Wooroolin Granite, Woroonden Granodiorite, Yarraman Subprovince, Yarrol Province.

INTRODUCTION

Most of the Chinchilla, Gympie and Ipswich 1:250 000 Sheet areas included in this report (YARRAMAN SPECIAL) were mapped from late 1995 to early 1998 and mineral occurrence mapping was carried out concurrently. This project forms part of GEOMAP 2005 — a regional program of geological and mineral occurrence mapping and resource assessment.

The YARRAMAN SPECIAL covers part of the Wandilla and Yarrol Provinces (Late Devonian to early Carboniferous age), Gympie Province (Permian–Triassic age), Esk Trough (Early–Middle Triassic age), Tarong Basin (Late Triassic age) and the Clarence–Moreton and Surat Basins (Latest Triassic–Jurassic age). A major shear zone is present along the western margin of the Wandilla Province close to the projected boundary between the Wandilla and Yarrol Provinces. Rocks of the Esk Trough, Tarong Basin, and Clarence–Moreton and Surat Basins overlie rocks of the Wandilla, Yarrol and Gympie Provinces. Rocks of Devonian to Triassic age are overlain by volcanics or intruded by granitoids of Permian–Triassic age (South-east Queensland Volcanic and Plutonic Province). Rocks of all provinces and basins are intruded or overlain by Tertiary volcanics of the Main Range–Lamington Province.

Location and access

The YARRAMAN project covers an irregularly shaped area over Chinchilla (part SG 56-09), Gympie (SG 56-10) and Ipswich (SG 56-14) Sheet areas. The outer margins of the map are bounded by longitudes 151°05'E and 152°20'E, and latitudes 26°00'S and 27°35'S (Figure 1). It includes part or all of the following 1:100 000 map sheet areas — BOONDOOMA, JANDOWAE, OAKEY, TOOWOOMBA, ESK, HELIDON, NANANGO, GOOMERI, KINGAROY and MURGON. The region supports a moderate and relatively static population. The region includes the town of Toowoomba on its southern margin and includes the north-west margin of the SEQ 2001 planning area and part of the SEQ bioregion. Other major centres are Kingaroy, Murgon, Nanango, Wondai and Crows Nest. Minor centres in the area are the villages of Yarraman, and Blackbutt in the south and Proston in the north.

The D'Aguilar and New England Highways traverse the southern part of the area. The Bunya Highway traverses the area from south-west to north-east. The Chinchilla–Mundubbera and the Chinchilla–Wondai roads are the major access routes for the western part of the area. The Burrandowan Road links these roads to Kingaroy.

Industries

The main rural activities are peanut growing, small crop farming, forestry, and cattle raising, while the main mining activities are coal extraction to supply the Tarong Power station, and kaolin clay mining. Major hard rock quarries occur near Nanango and Kingaroy. A developing industry in the region is grape harvesting mainly for wine production.

Climate

The region has a subtropical climate with two distinct seasons — a cool 'dry' period in late autumn to Early Spring (May–September) and a warm to hot 'wet' period from spring to autumn. The average annual rainfall is ~1000mm; most rainfall occurs from October–April. Rainfall has been variable in the past 10 years and droughts have become more common than previously. September is commonly the driest month.

Temperatures remain relatively high throughout the year. The mean minimum temperature ranges from ~3°C in July to ~19°C in January.

Vegetation

Most of the region consists of eucalypt woodlands with trees up to ~20m in height. Local areas of vine scrub are present on south-facing slopes in the south-western corner of the area close to the Main Range. Other areas of vine scrub are present on intrusive dykes of rhyolite composition to the west of Boondooma Dam. These areas are considered to be fire-climax vegetation (Sandy Pollock, Department of the Environment, personal communication, 1999). Specific eucalypt vegetation is present over areas of duricrust soil formation. Significant areas of hoop pine (*Araucaria cunninghamii*) plantations have been cultivated in the Blackbutt–Yarraman areas. Colluvial deposits developed on the Toondahra Granite in the north-eastern part of BOONDOOMA carry stands of *Melaleuca* sp.

The groundcover over most of the region consists of short to long grasses that are dependent on the annual rainfall distribution. Specific species of grass trees (*Xanthorrea* sp.) are present locally in specific geological units (e.g. quartz-rich

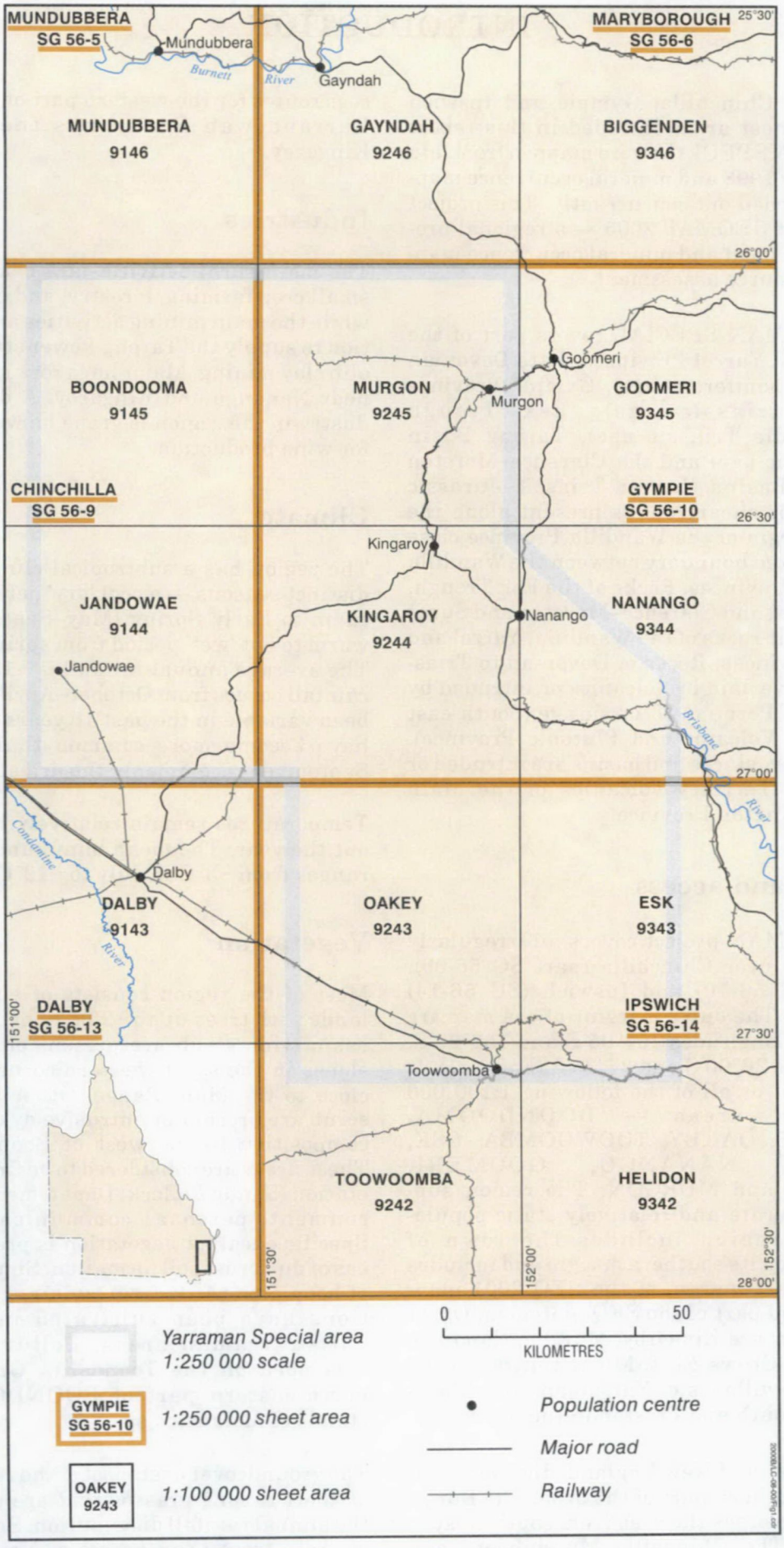


Figure 1. Location of the Yarraman Special Map

sandstone of the Woogaroo Subgroup and the Precipice Sandstone at the base of the Clarence–Moreton and Surat Basins respectively). The north-western margin of the area contains the heavy clay soil of the alluvial plains of the Condamine River which once supported dense brigalow scrub; this has now been cleared and cultivated for cash and feed crops (Reiser, 1971). Areas of the conifer *Callitris* are present on rhyolite of the Aranbanga Volcanic Group and microgranite of the Toondahra Granite to the east and west of Boondooma Dam and along the valley of the Boyne River to the north of the spillway of Boondooma Dam.

Terminology

Classification of clastic rocks follows Crook (1960), that for limestone follows Dunham (1962) and for plutonic rocks the IUGS classification (Strekeisen, 1973) has been used.

Chemical analyses

The Queensland Government Laboratory undertook whole rock chemical analyses.

Age dating

U-Pb (SHRIMP) dating was carried out by Mark Fanning of ANU on zircon samples from the Chahpingah Meta-Igneous Complex. Dr. B. Kohn (formerly of La Trobe University) supervised the analysis of Ar/Ar dating of biotite from granite samples of the South-east Queensland Volcanic and Plutonic Province. Dr. P. Vasconceles of the University of Queensland also carried out Ar/Ar dating of biotite and hornblende from samples from the same province. The results are given in the major section 'AGE DATING'.

PHYSIOGRAPHY

The main physiographic divisions in YARRAMAN are shown in Figure 2. This section describes the landforms and how they formed, and should be read in conjunction with the section 'MORPHOSTRATIGRAPHY' that discusses their evolution and temporal relationships.

The physiography of the area is discussed in terms of the Residual-Erosional-Depositional (R.E.D.) elements in the landscape. In the context of this report Residual elements in the landscape include remnant, indurated paleosols of probable mid-Tertiary age developed on a range of bedrock as well as surfaces of volcanic origin. Erosional elements cover most of the Palaeozoic, Mesozoic and pre-Pliocene rocks (Gympie, Yarrol and Wandilla Provinces, Tarong, Clarence-Moreton and Surat Basins and Main Range–Lamington Province) whereas depositional elements include the alluvial and colluvial deposits of the region.

Residual terrain

A major period of indurated duricrust (laterite and silcrete) development is present in the area. The surface is post-Miocene in age and is developed in areas that probably originally formed valley floors and drainage basins in the landscape. The residual terrain can be recognised in the cuesta-form of much of the duricrusted areas. These areas comprise a gently-sloping indurated surface of ferricrete-rich material (Td^r) overlying silcrete adjacent to a concave-sloping red soil colluvium (TQr^r) that slopes dowward to forming a valley floor containing a drainage-line. This terrain is best developed in the southern part of KINGAROY. The top part of the duricrust profile locally is coincident with the drainage divide between the major river systems.

Erosional terrain

The erosional terrain was developed by the Late Cainozoic dissection of Mesozoic and Early Tertiary landscapes. This terrain is developed over units of the Wandilla, Yarrol and Gympie Provinces, Tarong, Clarence– Moreton and Surat Basins and the Main Range–Lamington Province and is comprised of fresh and weakly weathered saprolith with *in situ* soil development.

Depositional terrain

The depositional terrain is composed of unconsolidated and poorly consolidated material associated with alluvial drainage systems.

Alluvial drainage systems

Three main drainage systems are present in YARRAMAN — the Brisbane River system (with the subsidiary Lockyer–Laidley Sub-basin) over the mid-eastern and south-eastern parts, the

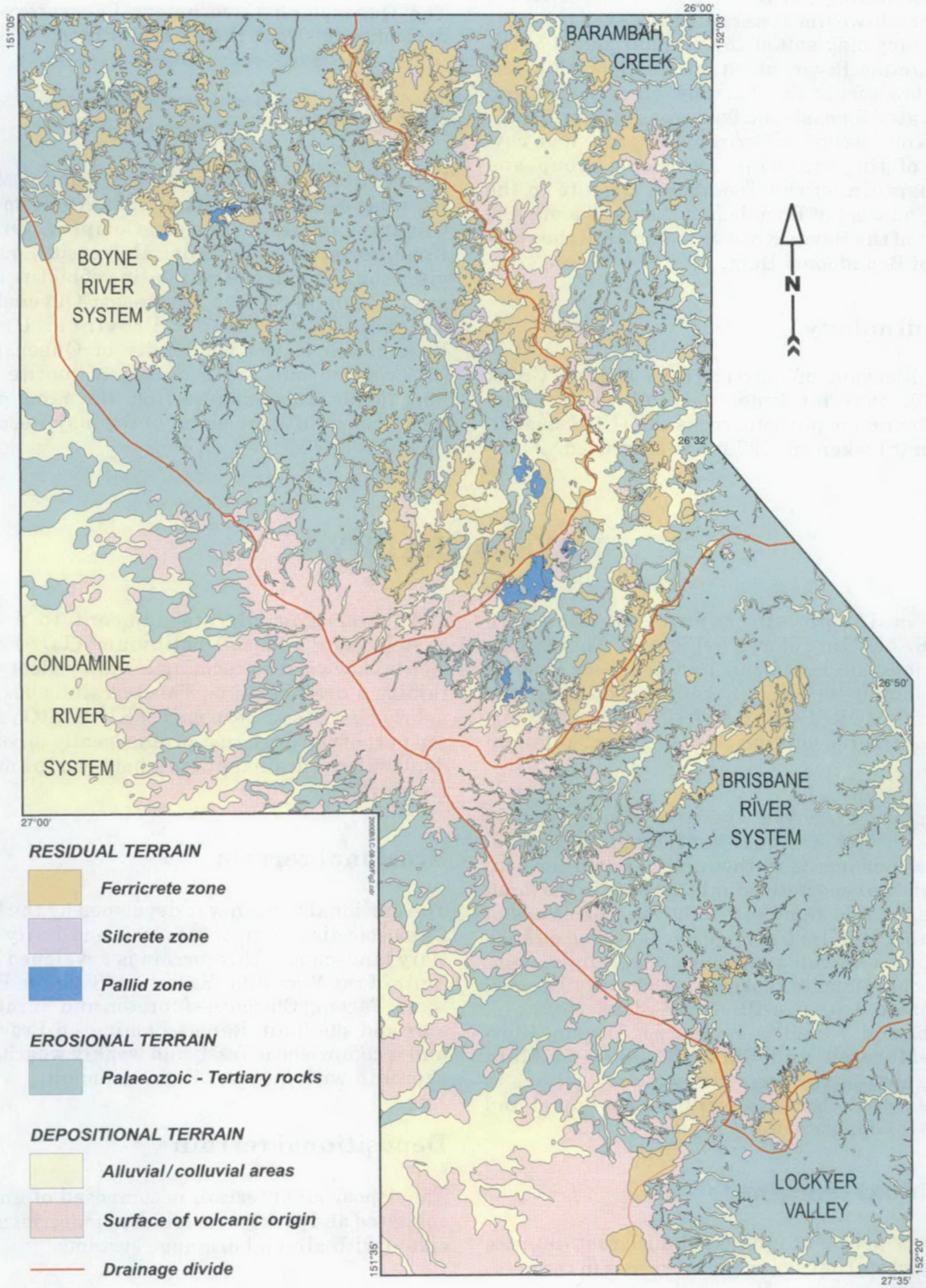


Figure 2. Physiography

Boyne–Burnett River systems in the north, and the westerly flowing Condamine River system in the west. The main divide between westerly and easterly flowing streams occurs along the Bunya Mountains and along the Great Divide in the south-western part of the area.

This part of the Great Divide zone in this region is almost coincident with Ollier's (1982) Great Escarpment — a persistent feature along the eastern seaboard resulting from Cretaceous extension and the consequent opening of the Tasman Sea.

PREVIOUS GEOLOGICAL INVESTIGATIONS

Geological investigations prior to 1975 in this area were compiled as part of the geological mapping of the Chinchilla, Ipswich-Brisbane, and Gympie 1:250 000 Sheet areas. These projects utilised black and white aerial photographs at a scale of approximately 1:85 000 (RC9 series). Preliminary geological maps were produced as a result of these investigations in the Ipswich and Gympie 1:250 000 Sheet areas (Cranfield & others, 1976; Murphy & others, 1976). In the Chinchilla 1:250 000 area a preliminary record (Exon & others, 1968) and a colour map and explanatory notes (Reiser, 1971) were produced.

Since 1976 investigations included studies on construction materials, mineral occurrence investigations, regional geology, tectonics, palaeontology, geochemistry and age dating.

The former Engineering Geology Group and Land Use Planning and Extractive Materials Branch (Department of Mines and Energy) reported on limestone resources, construction materials, industrial rock and mineral resources (Martin, 1977; Warner & Barker, 1979; Geological Survey of Queensland, 1981 and Martin & Neville, 1981).

Scott (1989) described mineral exploration in Gympie, Nanango, Nambour and Goomeri 1:100 000 Sheet areas, and Scott & others (1990) summarised mineralisation trends and exploration in the Gympie Province. This latter paper includes occurrences on the Maryborough and Gympie 1:250 000 Sheet areas.

Contributions to the NEO '93 conference relating to this area included summaries of the Late Palaeozoic and Early Mesozoic tectonic history of south-east Queensland (Holcombe & others (1993), and the tectonostratigraphy of the area (Sliwa & others, 1993). The tectonic evolution of the area was further updated by Holcombe & others (1997a,b), while Korsch & others (1997) have described the deep seismic architecture of the region. Most recent updates to the tectonics and geology of the region are included as part of the NEO '99 Conference (Campbell & others, 1999; Willey,1999; O'Sullivan & others, 1999).

Mineral occurrence (MINOCC) mapping was undertaken in 1994 and 1995 as part of an investigation of the mineralisation of the North D'Aguilar Subprovince (Randall & others, 1996). Regional mapping accompanied by MINOCC mapping was undertaken during the 1997/1998 and the 1998/1999 field seasons. Geologists involved were L.C. Cranfield, P. Donchak, R. Randall and G. Crosby.

As part of the above mapping, rocks were sampled for geochemistry, petrography, radiolaria and radiometric age dating (SHRIMP and Ar/Ar techniques). Radiolaria sampling was undertaken in cooperation with Dr B. Fordham, however results from this study were not rewarding and gave no additional information relevant to this report.

The map was digitally compiled by G. Pascoe and produced by Ross Lane and forms part of the DME's evolving state-wide digital geological map coverage. Geophysical data belonging to DME's Kingaroy Survey (flown by Kevron Geophysics) provided key information for planning traverses, interpretation of magnetic features, and geological boundaries in areas of poor exposure. The geophysics data was also used to assist in assessment of the interpretation of the extent of current and undiscovered mineral resources and has been incorporated as part of this report.

REGIONAL SETTING

Murray (1990) indicated that the Late Devonian to Carboniferous rocks of the Maronghi Creek beds were part of the accretionary wedge of the New England Fold Belt (the **Wandilla Province**). The current tectonic evaluation of rocks in Queensland (Dr Cec Murray, personal com-

munication, 1998) has assigned Wandilla Province rocks on YARRAMAN to the **Yarraman Subprovince**, with younger adjacent rocks to the south-west of Esk assigned to the **Cressbrook Creek Subprovince** — a unit considered to be part of the **Gympie Province**.

Consequently, rocks in this region are subdivided into **seven major pre-Cainozoic tectonic elements**: -

- Late Devonian to Early Carboniferous Yarraman Subprovince (Wandilla Province),
- Late Devonian to Early Carboniferous Yarrol Subprovince,
- Early Permian Cressbrook Creek Subprovince (Gympie Province),
- Early–Middle Triassic Esk Trough,
- Late Triassic Tarong Basin,
- Late Triassic to Jurassic Clarence–Moreton Basin, and
- Late Triassic to Jurassic Surat Basin.

Rocks of the Yarraman and Cressbrook Creek Subprovinces are intruded or overlain by Permian to Triassic rocks of the **South-east Queensland Volcanic and Plutonic Province** (SEQVP). Volcanic rocks of this province include the Permian–Triassic Gilla Volcanics, the Early–Middle Triassic Neara Volcanics, and the Late Triassic Aranbanga Volcanic Group. Major intrusive elements of the SEQVP are the Boondooma Igneous Complex, Taromeo Igneous Complex and the Eskdale Igneous Complex.

The SEQVP and older provinces are overlain and intruded by Tertiary volcanics and minor sediments of the MAIN RANGE– LAMINGTON PROVINCE of Miocene age. A major deep weathering profile of presumed Miocene age mantles all older rocks (including the Main Range–Lamington Province). All units are overlain by morphostratigraphic (alluvial and colluvial) units. For a location of the regional tectonic elements see 'TECTONIC EVOLUTION' section.

STRATIGRAPHY

Table 1 highlights the broad stratigraphic and intrusive units of the Yarraman Subprovince. Details of the relationships between units are summarised under the individual tectonic elements.

PALAEOZOIC ROCKS

WANDILLA PROVINCE

Units of the Wandilla Province are all included in the following metamorphic units in the Yarraman Subprovince — Mountefontein Metamorphics, Maronghi Creek beds; Sugarloaf Metamorphics; Fifer Creek Metamorphics, Bjelke Petersen beds and Chahpingah Meta-igneous Complex.

Maronghi Creek Beds (DCm, DCm_h, DCm_v, DCm_d, $DCmm_c$, DCm_s, DCm_a, DCm^s_w)

Introduction

Early workers referred to the Maronghi Creek beds as Neranleigh–Fernvale beds equivalents because of their lithological similarities to those strata (Cranfield & Schwarzböck, 1974). They were initially defined on the IPSWICH 1:250 000 Sheet area by Cranfield & Schwarzböck (1973). The unit was mapped further by Cranfield & others (1976) and extended north onto the GYMPIE 1:250 000 Sheet by Murphy & others (1976). The unit stretches along the eastern margin of the Yarraman Subprovince, as far north as Murgon, and includes the "Wondai Series" of Reid (1925). Willey (1998) studied the Maronghi Creek beds in the southern part of NANANGO and northern part of ESK and divided it informally into three broad lithological and structural groups — Elements A–C.

Aeromagnetic and radiometric images, and ground observations have been used during the current mapping phase to delineate eight subunits of the Maronghi Creek beds (Table 2).

Distribution

The Maronghi Creek beds occur as a north-north-west trending linear belt forming the eastern margin of the Palaeozoic basement block comprising the Yarraman Subprovince. The linear belt extends for >100km from south-west of Toogoolawah on ESK to Murgon on MURGON, and ranges in width from 5 to 20km. The total area of exposure is >1000km^2. A

Table 1: Stratigraphic and intrusive units of the Yarraman Subprovince

Province	Formation	Symbol	Age	Lithology
CZ_cover	alluvium	Czb	Cainozoic	gravel, sand, mud: mainly basalt detritus
	colluvium	Czc	Cainozoic	residual soil, colluvium : mainly basalt detritus
	alluvium	Qa	Quaternary	clay, silt, sand, gravel; flood plain alluvium
	alluvium	Qha units	Holocene	gravel, clay, silt, sand, active stream channel (Qha), lowest (Qha_1) and higher (Qha_2) river terrace
	alluvium	Qpa units	Pleistocene	stranded river terraces (above general floodplain); clay, silt, sand, gravel (Qpa), lowest (Qpa_1) and higher (Qpa_2) stranded river terrace
	alluvium	Qpf	Quaternary	sandy alluvium of Condamine River, vertebrate fossils
	alluvium	Qal	Quaternary	lakes in alluvial plain: silt, clay
	alluvial fans	Qf units	Quaternary	clay, silt, scree (Qf), Black clay and silt, basalt derived (Qf^b)
	residual soil, colluvium	Qr units	Quaternary	residual soil, colluvium; sand, soil, clay, rock debris (Qr); residual soil, colluvium; sand, silt (Qrs)
	alluvium	TQa	Tertiary Quaternary	locally mottled, poorly consolidated sand, silt, clay, *minor gravel; high level alluvial deposits*, generally dissected, and related to present stream valleys (TQa); partly consolidated and weathered older alluvial deposits: mud, silt, sand (TQa_w — shown by a weathering screen)
	colluvium	TQc units	Tertiary Quaternary	colluvial deposit, clay, silt, scree (TQc); colluvium: basalt soil, clay, cobbles and boulders (TQcb); colluvium sedimentary clay, silt, pebbles and cobbles (TQcs); duricrusted old land surface: ferricrete, silcrete and indurated paleosols at the top of a deep weathering on colluvium (TQc_w — shown by a weathering screen)
	alluvial fans	TQf	Tertiary Quaternary	alluvial fan, silt, mud, clay
	residual soil, colluvium	TQr units	Tertiary Quaternary	pediment slope wash, clay, scree, soil (TQr); red soil, pediment slope wash eroded from Td^r (TQr^r); Residual deposits and pediment slope wash; clay, scree, indurated (TQr^c); residual deposits and pediment slope wash; clay, scree, soil developed from basalt? (TQr^b); residual deposit and pediment slope wash; sand developed from granite? (TQr^s);deeply weathered pediment slope wash, clay, scree, soil (TQr_w)
DURICRUST		Td units	Tertiary	duricrusted old land surface: ferricrete, silcrete and indurated paleosols at the top of a deep weathering profile (Td); laterite, extensive red *soil development, minor ferricrete* (Td^r); silcrete, silicified quartz sandstone (Td^s)
		Ts^s	Tertiary	silicified locally pebbly quartzose sandstone
MAIN RANGE–LAMINGTON VOLCANIC PROVINCE	Main Range Volcanics	Tm units	Tertiary	olivine basalt (Tm); olivine basalt, upper flow (Tm_u); sandstone, shale, siltstone, quartz pebble conglomerate, diatomite and tuffaceous sediments (Tms); Cooby Trachyte Member — dark purplish-grey, very fine-grained trachyte (Tmc); Nutgrove Rhyolite Member — rhyolite breccia with perlite fragments, *minor basalt and* granite fragments (Tm_{nb}); Nutgrove Rhyolite Member — cream to light purple, flow banded rhyolite intrusives and flows, spherulitic in part, rhyolite breccia, minor biotite, minor perlite (Tm_{nr}); (Tm_w, Tm_{uw} shown by weathering screen)

Table 1: Stratigraphy (continued)

Province	Formation	Symbol	Age	Lithology
MAIN RANGE–LAMINGTON VOLCANIC PROVINCE	Oakdale Sandstone	Tk	Tertiary	sandstone, conglomerate, shale
		Tb	Tertiary	olivine basalt
		Tib	Tertiary	olivine basalt plug
		Tid	Tertiary	dolerite, basalt intrusive
		Ts, Ts_w	Tertiary	quartzose to sublabile sandstone, claystone, conglomerate, minor olivine basalt (Ts_w — shown by a weathering screen)
		Tv/b	Tertiary	mainly basalt flows
		Tv_r	Tertiary	rhyolite lava and pyroclastic deposits
		Tv	Tertiary	mainly basalt flows, some plugs
CLARENCE–MORETON BASIN	Walloon Coal Measures	Jw	Jurassic	shale, siltstone, lithic labile sandstone, coal, minor quartz sandstone
	Marburg Subgroup	Jbm	Jurassic	lithofeldspathic labile and sublabile sandstone, siltstone, shale, minor coal, ferruginous oolite marker
	Koukandowie Formation	Jbmk	Jurassic	lithofeldspathic labile and sublabile to quartzose sandstone, siltstone, shale, minor coal, ferruginous oolite marker
	Gatton Sandstone	Jbmg	Jurassic	lithic labile and feldspathic labile sandstone
	Woogaroo Subgroup	RJbw,$RJbw_w$	Triassic jurassic	quartzose sandstone, siltstone, shale, conglomerate, minor coal ($RJbw_w$ — is shown by a weathering screen)
SURAT BASIN	Evergreen Formation	Je_1	Jurassic	siltstone, fine feldspathic to sublabile sandstone
	Evergreen Formation–Westgrove Ironstone Member	Jew	Jurassic	fine lithic sandstone, siltstone, mudstone, concretionary ironstone oolitic in part
	Evergreen Formation	Je_2	Jurassic	arkose and feldspathic sandstone, locally pebbly or calcareous; siltstone, mudstone
	Precipice Sandstone	Jp	Jurassic	quartzose sandstone, siltstone, mudstone, conglomerate
TARONG BASIN	Tarong beds	Rr	Late Triassic	sandstone, shale, coal, conglomerate
		Rrk	Late Triassic	sandstone, shale, coal, conglomerate (deeply weathered kaolinised pallid zone)
SEQVP VOLCANICS		Ri_r	Late Triassic	massive, cream to pale grey, aphyric to sparsely porphyritic rhyolite; locally columnar jointed or brecciated, local rhyolitic tuff
		Ri_s	Late Triassic	massive, cream to pale grey, aphyric to sparsely porphyritic rhyolite; occurs as sheeted sills
	Aranbanga Volcanic Group	Ra	Late Triassic	andesitic to rhyolitic flows and volcaniclastics (including crystal-intermediate lithic lapilli tuff, crystal-rich tuff, pyroxene andesite, vesicular porphyritic andesite), minor polymictic conglomerate, volcanic breccia
		Ra_a	Late Triassic	andesitic volcanics; minor felsic volcanics
		Ra_b	Late Triassic	aphyric or sparsely phyric basalt lava
		Ra_d	Late Triassic	aphyric or sparsely phyric dacite lava; minor rhyolite
		Ra_p	Late Triassic	feldspar-phyric basalt lava
		Ra_r	Late Triassic	aphyric to sparsely phyric rhyolitic pyroclastic deposits and rare lava flows; local intercalated volcanogenic sediments; rare andesitic and basaltic extrusives

Table 1: Stratigraphy (continued)

Province	Formation	Symbol	Age	Lithology
SEQVP VOLCANICS	Aranbanga Volcanic Group	Ra_s	Late Triassic	volcaniclastic siltstone and shale
		Ri_d	Late Triassic	dark grey, fine-grained intrusive dacite
	Undivided volcanics	Rv	Late Triassic	andesite, dacite and rhyolite, volcaniclastic sediments
	Dangore Volcanics	Rvd	Late Triassic	massive, cream, rhyolitic ignimbrite; minor siltstone, shale
SEQVP INTRUSIVES	Farquharson Granite	Rgq	Triassic	pale pinkish-grey, medium grained, equigranular to inequigranular, hornblende-biotite granite (Rgq)
		Rg_1	Triassic	altered, cream to pink aplitic granite
		Rg_2	Triassic	cream to pale grey, fine to medium grained, equigranular biotite-hornblende granite; rare mafic xenoliths
		Rg_3	Triassic	grey, fine-grained, equigranular hornblende-biotite granodiorite
		Rg_4	Triassic	grey to cream, medium-grained, equigranular, biotite granite
		Rg_5	Triassic	dark grey, fine-grained, equigranular, biotite-rich granite with numerous biotite-rich, locally garnet-bearing mafic inclusions
		Rg_6	Triassic	pink, medium grained, equigranular, biotite granite
	Canoe Creek Granite	Rgce	Triassic	pink to grey or cream, fine to locally medium grained, inequigranular, slightly porphyritic biotite-hornblende granite to granodiorite
		Rg_d	Triassic	equigranular to porphyritic, hornblende (-biotite) microdiorite and diorite; local quartz diorite and gabbro
		Rg_{ip}	Triassic	porphyritic microgranite to granite
		Rg_p	Triassic	quartz-feldspar porphyry intrusive
		Rg?	Triassic	acid intrusives, mainly granitoids
	Toondahra Granite	Rgto, $Rgto_f$, $Rgto_w$	Triassic	pink to cream, strongly altered, very fine-grained biotite leucogranite (Rgto); cream, extremely fine-grained, quenched, finely porphyritic leucomicrogranite ($Rgto_f$); ($Rgto_w$ — shown by a weathering screen)
	Wilfred Creek Igneous Complex	Rgi	Triassic	mixed intrusions of dark grey, medium grained, hornblende (biotite) diorite, quartz diorite, tonalite and rare gabbro; local monzogranite
	Djuan Tonalite	Rgj, Rgj_h	Triassic	grey to dark grey tonalite, common xenoliths (Rgj), Hornblendite (Rgj_h)
		Ri_a SEQ	Triassic	unnamed porphyritic andesite intrusions
		Rgg_d	Triassic	medium to coarse-grained gabbro, minor dolerite
	Wooroonden Granodiorite	Rgrd	Triassic	grey, fine to medium grained hornblende-biotite granodiorite, diorite and quartz diorite, local tonalite and gabbro
		Rgugd	Triassic	pink, fine to medium-grained, hornblende granodiorite and diorite
	Memerambi Granite	Rgme	Triassic	cream to grey, equigranular, hornblende-biotite granite
ESK (SEQVP volcanics)	Neara Volcanics	Rtn	Early–Middle Triassic	volcaniclastic conglomerate, andesite, sandstone.
		Rtn_{cg}	Early–Middle Triassic	andesitic to polymictic pebble to cobble conglomerate, andesitic lava and tuff, volcaniclastic arenite; subordinate siltstone and mudstone

Table 1: Stratigraphy (continued)

Province	Formation	Symbol	Age	Lithology
ESK (SEQVP volcanics)	Neara Volcanics	Rtn_a	Early–Middle Triassic	andesite lava, breccia, pyroclastic and epiclastic deposits; minor shale and siltstone
		Rtn_s	Early–Middle Triassic	polymictic to rarely andesitic pebble to cobble conglomerate, volcaniclastic arenite, siltstone and shale
		Rtn_b	Early–Middle Triassic	andesitic pebble to cobble conglomerate
ESK	Gayndah Formation	Rtg	Early–Middle Triassic	polymictic pebble to cobble conglomerate, lithic labile, sublabile and quartzose sandstone, siltstone, shale
	Esk Formation	Rte	Early–Middle Triassic	polymictic pebble to boulder conglomerate, feldspathic sandstone, shale, minor acid tuff
SEQVP INTRUSIVES	Buaraba Granodiorite	R*g*bu	Triassic	granodiorite, leucogranodiorite, tonalite, quartz diorite
	Champion Hills Diorite	R*g*h	Triassic	diorite, gabbro
	South Buaraba Microdiorite	R*g*sb	Triassic	porphyritic very fine-grained microdiorite
	Crows Nest Granite	R*g*r, Rgr_m, Rgr_w	Triassic	biotite granite, adamellite (R*g*r), microgranite (Rgr_m), (Rgr_w — is shown by a weathering screen)
	Eskdale Granodiorite	R*g*es	Early–Middle Triassic	granodiorite, diorite
		$Rges_1$	Early–Middle Triassic	altered coarse grained chloritised hornblende-biotite granodiorite and granite, minor diorite and gabbro
		$Rges_2$	Early–Middle Triassic	coarse grained hornblende-biotite granodiorite
		$Rges_3$	Early–Middle Triassic	fine- to medium grained granodiorite
		$Rges_4$	Middle Triassic	hornblende-biotite granodiorite and diorite *(pyroxene cores to hornblende crystals)*
		$Rges_a$	Early–Middle Triassic	aplitic intrusions some with molybdenite mineralisation
		$Rges_g$	Early–Middle Triassic	diorite, gabbro
		$Rges_{ga}$	Early–Middle Triassic	altered diorite
		$Rges_{gr}$	Early–Middle Triassic	pink granite
		$Rges_l$	Early–Middle Triassic	leucogranodiorite
SEQVP INTRUSIVES	*Boondooma* Igneous Complex (R*g*bo units)	R*g*bo, $Rgbo_a$, $Rgbo_b$, $Rgbo_d$, $Rgbo_k$, $Rgbo_p$, $Rgbo_m$	Triassic	*cream to pale grey, fine to medium grained,* equigranular to coarsely porphyritic biotite-hornblende granite (R*g*bo); cream to pale grey, fine to medium grained, equigranular to coarsely porphyritic biotite-hornblende granite: hydrothermally altered granitoids ($Rgbo_a$); fine to medium grained, even grained biotite granite ($Rgbo_b$); dark grey, medium to coarse granodiorite, dark grey fine to medium diorite ($Rgbo_d$); deeply weathered kaolinised granitoid pallid zone ($Rgbo_k$); coarse grained, quartz-feldspar pegmatite ($Rgbo_p$); cream to pale grey, fresh, medium grained, equigranular to coarsely porphyritic biotite-hornblende granite ($Rgbo_m$);

Table 1: Stratigraphy (continued)

Province	Formation	Symbol	Age	Lithology
SEQVP INTRUSIVES	Boondooma Igneous Complex (PR*g*b units)	PR*g*b, PR*g*b$_g$, PR*g*b$_d$, PR*g*b$_{ga}$, PR*g*b$_k$, PR*g*b$_w$	Permian Triassic	granodiorite, adamellite, granite, tonalite, diorite, gabbro (PR*g*b); even grained grey to pink medium to coarse grained granite (PR*g*b$_g$); fine to coarse equigranular diorite to granodiorite (PR*g*b$_d$); hydrothermally altered medium to coarse granite (PR*g*b$_{ga}$); deeply weathered (kaolinised pallid zone), granite (PR*g*b$_k$); (PR*g*b$_w$ – is shown by a weathering screen)
SEQVP VOLCANICS	Gilla Volcanics	PRgl	Permian Triassic	intermediate to acid volcanics
		PRgl$_a$	Permian Triassic	dark grey aphyric to porphyritic andesite, minor rhyolite
		PRgl$_d$	Permian Triassic	rhyodacite-dacite
		PRgl$_r$	Permian Triassic	flow banded rhyolite, rhyolitic breccia and conglomerate
		PRgl$_s$	Permian Triassic	volcaniclastic sediments
		PRgl$_t$	Permian Triassic	dacitic-rhyolitic tuff
		PRgl$_p$	Permian Triassic	feldspar phyric dacite
SEQVP INTRUSIVES	Wooroolin Granite	PR*g*w	Permian–Triassic	pink, medium grained biotite leucogranite, intruded by scattered aplite dykes
	Melrose Igneous Complex	PR*g*r	Permian Triassic	Grey, fine to medium grained (or locally coarse) grained, equigranular to porphyritic biotite (hornblende) granite and granodiorite; diorite and quartz microdiorite; scattered rafts of quartzite and laminated biotite gneiss
		PR*g*g	Permian Triassic	Cream, fine to coarse grained, banded gneissic leucogranite
	Stuart River Granite	PR*g*t, PR*g*t$_f$	Permian–Triassic	cream to pink, fine to medium (or locally coarse) grained, even grained biotite leucogranite; locally foliated and cut by mylonitic shear zones (PR*g*t); intensely foliated, fine to medium grained, pale grey to pink biotite leucogranite; locally with numerous rafts of mylonitised metasediment and amphibolite (PR*g*t$_f$)
	Taromeo Igneous Complex	R*g*m units	Triassic	light to dark grey, fine to coarse quartz diorite, granodiorite, gabbro, diorite, tonalite? and microdiorite (R*g*m$_d$); pink-grey medium to coarse granite (R*g*m$_g$); light grey medium grained equigranular to sparsely porphyritic biotite-hornblende granodiorite, minor tonalite (R*g*m$_{gd1}$); light grey, grey-pink, medium grained biotite-hornblende granodiorite, granite, quartz monzonite, tonalite and quartz diorite (R*g*m$_{gd2}$)
	Taromeo Igneous Complex	PR*g*m units	Permian–Triassic	granodiorite, tonalite, diorite, gabbro, granite, locally weathered and decomposed (PR*g*m); granodiorite, generally deeply weathered, minor tonalite (PR*g*m$_{gd1}$); light grey medium grained biotite-hornblende granodiorite (PR*g*m$_{gd2}$); grey medium grained tonalite, granodiorite and minor dark grey quartz diorite and diorite, rare quartz gabbro (PR*g*m$_t$).
	Unnamed Intrusions	PR*g*	Permian–Triassic	porphyritic biotite microgranite, granite, diorite, granodiorite, microgranite
	Unnamed Serpentinite	PRs	Permian–Triassic	foliated serpentinite

Table 1: Stratigraphy (continued)

Province	Formation	Symbol	Age	Lithology
SEQVP INTRUSIVES	Hivesville Granite	PR*g*h	Permian	pale grey to pink, medium to coarse grained, equigranular to more commonly porphyritic (often with rapakivi textures), biotite (or more rarely biotite-hornblende) granite; locally intruded by or intermixed with numerous small microdiorite bodies
	Kenewah Granodiorite	PR*g*k	Permian	light grey-pink and grey medium grained biotite granodiorite, porphyritic in part
	unnamed intrusion	P*g*d-SEQ	Permian	leucodiorite, gabbro?, microdiorite intrusions
	unnamed intrusion	P*g*o-SEQ	Permian	dark grey, fine to medium grained, hypersthene diorite/gabbro
	unnamed intrusions	P*g*u-SEQ	Permian	diorite, grey granodiorite; locally pyrite-bearing
	unnamed intrusions	P*i*	Permian	rhyolite
CRESSBROOK CREEK SUBPROVINCE		Ps_d	Permian	mudstone, siltstone, tuff?, tuffaceous sediments, pebble to cobble conglomerate intruded by microdiorite and gabbro dykes
		Ps	Permian	mudstone, siltstone, tuff?, tuffaceous sediments, pebble to cobble conglomerate
CRESSBROOK CREEK SUBPROVINCE (CRESSBROOK CREEK GROUP)	Buaraba Mudstone	Prb, Prb_{aa}, Prb_{sa}	Permian	mudstone, arenite, conglomerate, andesite, basalt, tuffaceous sediments, bioturbation, rare marine fossils and plant fragments (Prb); mudstone, arenite, conglomerate, andesite, basalt, tuffaceous sediments, bioturbation, rare marine fossils and plant fragments — argillic alteration (Prb_{aa}); mudstone, arenite, conglomerate, andesite, basalt, tuffaceous sediments, bioturbation, rare marine fossils and plant fragments — silicic alteration (Prb_{sa})
	Box Gully Formation	Prx, Prx_h	Permian	conglomerate, arenite, shale, andesitic volcanics, rare plant fragments (Prx); conglomerate, arenite, shale, andesitic volcanics, rare plant fragments — hornfelsed (Prx_h)
	Biarraville Formation	Prl, Prl_h	Permian	arenite, siltstone, mudstone, rhyolite, limestone, volcanic conglomerate (Prl); chert, arenite, siltstone, mudstone, rhyolite, limestone, volcanic conglomerate — hornfelsed (Prl_h)
	Hampton Road Rhyolite	Prh, Prh_{sa}, Prh_g	Permian	acid volcanics, chert, conglomerate (Prh); acid volcanics — silicic alteration (Prh_{sa}); acid volcanics chert, conglomerate — numerous gabbro and dolorite dykes and stocks (Prh_g) (Prh_w — deep weathering screen)
	Pinecliffe Formation	Prp	Permian	chert, mudstone, arenite, conglomerate, andesite, basalt, rare marine fossils (Prp_w — deep weathering screen)
SEQVP INTRUSIVES	Woolshed Mountain Granodiorite	P*g*wm	Permian	light grey, medium grained granodiorite
YARRAMAN SUBPROVINCE	Mount Cross Igneous Complex	CPm	Carboniferous	gabbroic intrusions, volcaniclastics (gabbro-derived sediments)
	Maronghi Creek beds	DCm units	Devonian Carboniferous	mudstone, shale, arenite, chert, jasper, acid to basic metavolcanics (DCm); thinly bedded mudstone and red chert (DCm_{mc}); mudstone, shale, arenite, chert, jasper, phyllitic sediments, bedded volcanics, greenstone, minor andesite, in places intruded by numerous microdioritic dykes (DCm_d); hornfelsed mudstone, shale, arenite, chert, jasper, phyllitic sediments (DCm_h); epidote-chlorite schist (DCm_s); altered splitic volcanics, metabasalt, pillow basalt (DCm_v); mudstone, shale, arenite, chert, jasper, phyllitic sediments locally silicified (DCm^s)

Table 1: Stratigraphy (continued)

Province	Formation	Symbol	Age	Lithology
YARRAMAN SUBPROVINCE	Fifer Creek Metamorphics	DCi, DCi_c	Devonian Carboniferous	phyllite and meta-arenite with minor quartzite, gneiss, and migmatite; local shale, siltstone, greywacke, chert (DCi); grey, cream or red, variably recrystallised, thin bedded chert, and metachert interbedded with subordinate pelitic metasediments (DCi_c)
	Sugarloaf Metamorphics	DCo, DCo_v	Devonian Carboniferous	slate, spotted hornfelsed slate, phyllite, quartzite, schist, amphibolite (DCo); basic metavolcanics, amphibolite, meta-arenite, schist, phyllite, slate (DCo_v)
	Chahpingah Meta-Igneous Complex	Cc	Carboniferous–Permian	cream to grey, fine to medium grained, strongly foliated, banded granitic to granodioritic biotite gneiss, locally with garnet and/or cordierite; numerous quartz veins, pegmatite (and locally granite) veins, sills and dykes; small areas of mica schist
	Mountefontein Metamorphics	Ct	Carboniferous	thinly-interlayered biotite gneiss and fine schist, with scattered biotite leucogranite sills and migmatitic veins; thick horizons of hematitic metachert
	Bjelke Petersen beds	Cb, Cb_l	Devonian Carboniferous	mudstone, shale and silicified siltstone(chert?) containing locally sheared basic metavolcanic lenses and scattered limestone bodies (Cb); variably recrystallised, poorly fossiliferous limestone (Cb_l)
YARROL PROVINCE	Rockhampton Group	DCr	Devonian Carboniferous	thin to medium bedded siltstone and mudstone, thick bedded quartz intermediate to lithic and volcanolithic arenite and minor conglomerate; andesitic tuff and rare rhyolitic tuff; rare sandy limestone; local shear(?) zones with mylonite, phyllite and fine schist
	Alice Creek beds	DCc, DCc_l	Devonian Carboniferous	siltstone, arenite, conglomerate, rare plant fossils, locally sheared (DCc); poorly fossiliferous limestone (DCc_l)

Table 2: Units of the Maronghi Creek Beds

Subunit	Generalised Description
DCm	undifferentiated sediments and minor volcanics
DCm_h	hornfelsed
DCm_v	volcanic
DCm_d	intruded by numerous microdiorite dykes
DCm_{mc}	thinly bedded mudstone and chert
DCm_s	schist
DCm_a	amphibolite
DCm^s_w	weathered and silicified meta-arenite, mudstone

brief description of the distribution of the various subunits follows.

A roof pendant (~4.5km^2) of hornfelsed Maronghi Creek beds (**DCm_h**) is present within the Taromeo Igneous Complex ~7km north of Blackbutt. An area (5km^2) hornfelsed by the southern part of the Memerambi Granite is present in the south-east corner of MURGON and north-east corner of KINGAROY. Another area of hornfelsing (8km^2) is located between Barker and Meandu Creeks west of Nanango. Other, smaller areas of hornfelsing (not identified on the map), are present adjacent to intrusive contacts in other parts of NANANGO, ESK and MURGON.

A body (~2.5km^2 in area) of the volcanic subunit (**DCm_v**) occurs ~8km north of Nanango. Two other small areas of ~1km^2 are exposed close to the Esk Trough, 16km and 12km respectively, south-east of Nanango.

Exposure of the Maronghi Creek beds locally contains significant areas of microdiorite intrusions that could not be mapped out at the scale of this project. These zones (**DCm_d**) form two linear belts on the eastern margin of the Yarraman Subprovince. The southern belt (totalling ~45km^2) is separated into two parts by a down-faulted block of Permian sediments (Cranfield & others, 1998; Willey, 1998), and extends from Emu Creek to 0.5km north of the

D'Aguilar Highway, east of Benarkin. The northern belt, of ~20km^2, extends from 8km north of Benarkin to 10km south-east of Nanango.

A mudstone/chert-dominated sequence (**DCm$_{mc}$**) forms an elongate body (~28km^2) up to 4km wide located in the north-east corner of KINGAROY. It extends from Barkers Creek, 7km north-west of Nanango Township to the Nanango–Barkers Creek road ~13km north-east of Kingaroy.

Several small areas of schist (**DCm$_s$**) are present south-east of Nanango as roof pendants in the Taromeo Igneous complex. The largest (~1km^2) is centred approximately one kilometre north-west of Mount Mellera. One small body (~0.4km^2) is exposed in a small gravel pit beside the Seven Mile Diggings Road ~6km south-south-east of Nanango and another (~0.03km^2 in area) is present in a gully draining south into Cooyar Creek. Further south on ESK a wedge (~0.5km^2 in area) of amphibolite (**DCm$_a$**) is located adjacent to the northern contact of the Eskdale Granodiorite. Areas (~3.5km^2) of weathered and silicified Maronghi Creek beds (**DCm^s_w**) are present ~9km north of Nanango.

Topographic expression

The unit forms a range of landscapes, from low, rolling grassy hills to rugged heavily timbered country. As a result the unit exhibits a variety of airphoto patterns, ranging from geologically featureless, evenly drained country in the south to more linear, ridge-dominated patterns in the north.

Geophysical expression

On AIRDATA K–Th–U (RGB) ternary radiometric images, the majority of the unit has a characteristic medium-toned, mottled pink/brown/green combination. Subunit **DCm$_d$** has a distinctive dark tone on the image caused by numerous small dioritic dykes or intrusions. Deeply weathered areas of Maronghi Creek beds have elevated relative thorium and uranium levels and have a deeper green-blue signature on the ternary radiometric image.

All parts of the unit show a uniformly low response on aeromagnetic images.

Lithology

Reid (1925) and Derrington (1954) described the rock types from this unit in the Murgon area and later Fardon (1960) described it in the Cooyar area. The Maronghi Creek beds were first defined by Cranfield & Schwarzböck (1974) as a sequence of interbedded chert, jasper, mudstone, arenite and metavolcanics. Cranfield & others (1976) summarised the unit in the Ipswich 1:250 000 Sheet area as being composed of interbedded chert, jasper, shale, arenite and metavolcanics. Transposition structures showing deformed quartz veins were noted in thin section.

Willey (1998) studied the Maronghi Creek beds in the southern part of NANANGO and northern part of ESK and divided it into three broad groups, Elements A–C, based on structural character. He reported that although chert and jasper were present in the unit, these rock types were not as extensive as indicated by previous authors. Willey also suggested that arenite is the most dominant rock type and considered the silica-rich lithologies did not have chert, jasper, vein quartz or quartzite as their protolith.

The undifferentiated Maronghi Creek beds (**DCm**) include most of 'Element A' as described by Willey (1998). In general, the rocks of unit DCm comprise interbedded massive to poorly sorted quartz lithic to lithic arenites, siltstones and mudstones with rare thin deeply weathered spilitic volcanics. In some areas, most notably south of Emu Creek and in a gully draining into Nukinenda Creek (AMG 419000, 7014200), they may show features characteristic of melange or 'broken formation'. These features are consistent with those described by Raymond (1984) for deformed sediments in melange terrains (Willey, 1998, page 52). Within the arenites numerous irregular subplanar zones show soft sediment grain alignment and/or up to three generations of quartz vein healed brittle fractures (Willey, 1998). Often the density of quartz veining and alteration is so great that in hand specimen, the rocks have the appearance of chert. Bedding, where preserved, is often complexly folded, faulted, boudinaged or sheared.

In the central west and north-western part of NANANGO the undifferentiated Maronghi Creek beds include areas of phyllitic mudstone and siltstone intruded by dykes ranging in composition from basalt to rhyolite. Small areas of hornfelsed sediments, not included in DCm$_h$, occur where numerous intrusions have locally hornfelsed the Maronghi Creek beds around their margins.

Hornfelsed Maronghi Creek beds (**DCm$_h$**) occur in a number of areas adjacent to intrusive bodies. A roof pendant is present within the Taromeo Igneous Complex north of Blackbutt and is composed of hard dark grey to black hornfelsed and semi-hornfelsed quartzose and

lithic arenites. A typical thin section analysis shows fine very angular to sub-rounded plutonic-derived quartz, feldspar and lithic grains within a ?pseudomatrix of biotite and rare muscovite.

The volcanic subunit (**DCm$_v$**) makes up only a small percentage of the overall Maronghi Creek beds and is composed primarily of altered basaltic rocks. A sequence of dark grey metabasalt intruded by numerous dykes is exposed in a road cut on the Burnett Highway north of Nanango (AMG 401463, 7057985). The metabasalt has been completely disruptively deformed, and shear zones are common. Quartz veins up to 20mm wide are common. Silicification is widespread throughout the metabasalts, which also show extensive epidote and chlorite alteration. The metabasalt subunit has also been identified on the eastern margin of the Maronghi Creek beds where it forms pavement outcrop in the bed of Taromeo Creek. At this location the sequence mainly consists of thick flows of dark grey, epidote-altered metabasalt. In thin section, the rock is made up of relict plagioclase laths up to 2mm in length as well as significant epidote and chlorite, and minor actinolite and magnetite. An area of pillow basalt is present further north in the bed of Tom Tom Creek, north of Cooyar Creek. It is composed of altered basaltic pillows up to 60cm across (Plate 3) and has been assigned a tentative Permian age by Campbell & others (1999).

Another small exposure (0.05km^2) of pillow basalt is present in the bed of Calabash Creek in the northern part of ESK (Edwin Willey, personal communication, 1999). In a gully immediately north of Cooyar Creek (AMG 411100, 7043050), grey-green, fine, epidote-chlorite talc schist is present. It shows areas of both massive and strongly sheared rock in outcrop and is considered to be sheared basalt. Calcite veins are present along cleavage planes and the rock contains an anastomosing shear fabric.

Subunit **DCm$_d$** is a composed of fine-grained arenaceous rock types similar to the main body of the unit but has been extensively intruded by microdiorite dykes and irregular intrusions. Willey (1999) identified two suites of the microdiorite intrusives in the southern part of NANANGO — hornblende microdiorites and augite microdiorites. The hornblende microdiorites are composed of 0.4–1.2mm crystals of andesine (50–70%), hornblende (25–40%) and may contain quartz, magnetite/ilmenite and pyrite. They are typically even textured to subophitic and trachytic to pilotaxitic in fine-grained phases. Very rarely they are subporphyritic in andesine to 2.5mm and glomeroporphyritic in hornblende to 3mm. Interstitial and rare coarse granular quartz occurs in ~20% of the sections and may comprise up to 25% of the rock. The augite microdiorites are made up of andesine (50–70%), augite (30–45%) and also may contain minor amounts of quartz, magnetite/ilmenite and pyrite. These rocks are typically even textured to subophitic and subgranular with grains in the 0.3–1mm size range. Rare phases are subporphyritic in andesine or augite. Interstitial quartz is rare and opaques are blocky to skeletal and often dendritic in finer phases.

The subunit **DCm$_{mc}$**, mapped in the north-eastern part of KINGAROY, is composed of thinly bedded (generally 1–2cm) mudstone and red chert. These rock types are well exposed in a major quarry immediately north of Nanango and in small road scrapes ~1km east of Kingaroy airport. Both these areas were sampled for radiolaria, but the samples were barren.

A number of small areas of schist (subunit **DCm$_s$**) are present south and south-east of Nanango. The largest body identified, adjacent to the Seven Miles Diggings Road (AMG 404957, 7042241), is composed of dark grey mica schist with a well-developed foliation defined by the alignment of mica.

Subunit **DCm$_a$** is composed of basic metavolcanics and amphibolite found within the Maronghi Creek beds on ESK. This unit is poorly exposed and forms a thin linear north-west-trending block ~1.5km wide. Subunit **DCm^s_w** comprises a sequence of silicified fine-grained sediments. The more resistant siltstone units form lenticular relict bedding that is commonly contorted and folded. The lithology and structure of this subunit are similar to that of the Amamoor beds of the North D'Aguilar Subprovince.

Environment of deposition and provenance

The unit is thought to represent mainly fine-grained sediments and mafic sea-floor lavas deposited in deep marine conditions before being incorporated into the eastern Australian margin as a subduction complex. The sediments were derived from the eastern Australian continental margin. The dominance of poorly sorted arenite, composed of angular grains and showing no bedding, indicate a density current origin.

Thickness

A reliable estimate of the original thickness of the unit is difficult to make due to structural repetition during subduction. The unit may

have originally been as little as a few hundred metres thick.

Structure

Bedding and the sub-parallel slaty cleavage within the Maronghi Creek beds dip either steeply to the west or east. The unit is assumed to be structurally thickened by imbricate thrusting during the Devonian– Carboniferous subduction process. This process may have also produced the small-scale tight to isoclinal, subhorizontally-plunging folds locally visible in some thin-bedded rocks.

Biostratigraphy and age

No identifiable fossils have been found within the unit. A minimum age of Latest Carboniferous–Early Permian is indicated by Early Permian (291, 296Ma) dates for pyritic microdiorites (Willey, 1998), that intrude the Maronghi Creek beds south of Emu Creek, south-south-west of Blackbutt. A Devonian–Carboniferous age is inferred for the unit because its lithological and structural style is similar to accretionary wedge rocks of that age elsewhere in the northern New England Orogen.

Stratigraphic relationships

The Maronghi Creek beds are unconformably overlain by or faulted against the Triassic Esk Formation along the western margin of the Esk Trough. The unit is faulted against probable Permian unnamed sediments south-east of Blackbutt, and the Middle Carboniferous Bjelke Petersen beds east of Murgon.

The Maronghi Creek beds are thought to be faulted against the Devonian–Carboniferous Sugarloaf Metamorphics and are overlain unconformably by the Permian Gilla Volcanics, Triassic Neara Volcanics and Tarong beds, the Triassic to Jurassic Woogaroo Subgroup, the Jurassic Marburg Formation, the Tertiary Main Range Volcanics and associated sediments.

The Memerambi Granite, the Boondooma and Taromeo Igneous Complexes, the Kenewah Granodiorite, and the Woolshed Mountain Granodiorite intrude the unit. A number of smaller unnamed bodies also intrude the unit in different areas including the Permian microdiorites, porphyries and gabbro/diorites south of Blackbutt described by Willey (1998,1999).

Correlation with other units

The unit is thought to correlate with accretionary wedge rocks of similar age within the northern New England Orogen. Probable correlatives in the nearby North and South D'Aguilar Subprovinces include the Mount Clara beds (around Kilkivan), the Amamoor beds (west of Gympie), the Booloumba beds (south-west of Kenilworth), and the Neranleigh Fernvale beds (north and south of Brisbane). To the north, the unit is thought to correlate with elements of the Curtis Island Group (the Wandilla and Doonside Formations).

Fifer Creek Metamorphics (DCi, DCi_c; new name)

Introduction

Murphy & others (1976) previously mapped the unit on the GYMPIE 1:250 000 sheet as part of unit Pz — an undifferentiated sequence of Palaeozoic metamorphics, sediments and volcanics.

Distribution

The Fifer Creek Metamorphics form a north-north-west trending, 3–4km wide belt extending for >30km in the western half of MURGON.

Derivation of name

The unit is named after Fifer Creek, which traverses through the centre of the outcrop belt, 1km west of Melrose homestead.

Topographic expression

The metamorphics are moderately well exposed as a series of partially cleared strike ridges.

Geophysical expression

The unit registers as pale mottled brown tones on the K–Th–U (RGB) ternary radiometric images, and has a low magnetic response indistinguishable from most of the adjacent units on AIRDATA magnetic images.

Lithology

The unit is variably metamorphosed and deformed, but, in general, the degree of metamorphism and intensity of deformation increases with increasing proximity to the Boondooma Igneous Complex. Higher-grade rocks also occur

in many places close to the eastern margin of the unit bordered by the Hivesville and Stuart River Granites and the Melrose Igneous Complex. Lower grade, less-deformed rocks are more common in the centre of the belt, mainly for ~3–4km north and south of Meyhar Creek.

A lower grade sequence along Meyhar Creek consists mainly of mudstone, siltstone and arenite, with scattered thin-bedded chert horizons. The arenites are variably recrystallised, range from quartzose to lithofeldspathic in composition, and form medium to thick beds sporadically interlayered with the mudstone/siltstone packages. The siltstones are thin-bedded to laminated (or rarely medium-beddded) and very rarely exhibit cross-lamination and grading. They are sporadically siliceous in composition, forming thin beds with a chert-like appearance within the mudstones. Discontinuous intervals and horizons of haematitic chert (locally brecciated) and cream silicified chert occur sporadically throughout the sequence. The cherts are thin and lenticularly bedded, and show well developed chaotic chevron-style slump? folds as well as sporadic tectonic folds (east-verging around AMG 364000, 7089400). Where the cherts and metacherts are extensive, they have been mapped as **subunit DCi_c**. Local intense cleavage development has locally converted the mudstones to slates.

In the east adjacent to the Hivesville Granite, the sequence is annealed and slightly micaceous, and coarse-grained granite sills and rare 'sweat' veins intrude the sediments. Some parts of the eastern margin are even higher grade, with extensive secondary biotite and intense mylonitic cleavage development (e.g. around AMG 363000, 7097000).

The higher grade belts within the unit contain meta-argillite (locally fine schist) and metasiltstone packages as well as intervals of massive, variably recrystallised meta-arenite with scattered strongly to moderately recrystallised, well-bedded chert and metachert horizons and locally-developed mylonites and phyllonites. Laminated mafic amphibolite occurs rarely. Fine to locally coarse secondary biotite (and more rarely cordiorite/andalusite?) is common in the higher-grade rocks, presumably resulting from thermal metamorphism during intrusion of the granitic batholiths. In places the metasiltstone laminae in these sequences have been tectonically transposed with rare remnant isoclinal fold hinges being locally visible.

Thermally metamorphosed rafts of Fifer Creek Metamorphics are well exposed within the Boondooma Igneous Complex north of the Proston water supply pumping station on the Boyne River. These rocks comprise thin to laminated metasiltstone bands within dark grey meta-argillite, forming open to tight folds with a well developed axial plane schistosity dipping steeply to the south-west. Scattered pegmatite and aplite veins (some with tourmaline-rich cores) occur along the axial plane schistosity, and medium grained granite sills occur locally. Fine porphyroblastic biotite is common throughout. Swarms of 'lit-par-lit' style coarse-grained biotite granite sills up to 2m wide occur locally in this area, associated with an increase in the degree of recrystallisation over a distance of only a few metres forming interlayered felsic gneiss and biotite schist. Similar rock types and relationships occur along most of the western margin for at least 1km from the batholith of the Boondooma Igneous Complex.

Structure and deformation

The dominant bedding and cleavage dips are steep to the west. Slates with fine discontinuous siltstone laminae locally display open to isoclinal, gently plunging folds about the major bed-parallel slaty cleavage. Intensive shearing occurs locally within the unit, the most notable exposure being in the spillway of the Gordonbrook Dam. At this locality, the siltstone/mudstone/fine arenite sequence has been cataclastically sheared to form phyllonite and quartzite, with bedding being destroyed by shearing.

Mineralisation

Minor subeconomic silver/lead mineralisation occurs at the Ronald John prospect south of Melrose homestead (AMG 361400, 7088600) within silicified, metasomatised metamorphic rocks adjacent to the contact to the Boondooma Igneous Complex.

Relationships

The unit is intruded by numerous large granitoid bodies, including the Hivesville, Wooroolin and Stuart River Granites, and the Boondooma Igneous Complex, as well as smaller bodies (units PRg_1, Rir, Rg_1, Rg_2, Rg_3, Rgg_d). Basalts of the Tertiary Main Range Volcanics unconformably overlie the unit.

Age and correlation with other units

The unit is considered to represent deeper level more metamorphosed equivalents of the less deformed Maronghi Creek beds, together forming part of the Devonian–Carboniferous accretion-

ary wedge assemblage extending the length of the northern New England Orogen.

Sugarloaf Metamorphics (DCo)

Introduction

Campbell (1952) first used the name Sugarloaf Metamorphics for the rocks of probable Palaeozoic age that crop out east of Crows Nest on the Ipswich 1:250 000 Sheet. Fardon (1960) also described rocks from this area. Cranfield & others (1976) included the rocks near Woolshed Mountain within this unit. They were also included in this unit on the southern part of the Gympie 1:250 000 Sheet area by Murphy & others (1976). The type area was defined by Cranfield & others (1976) as lying along Cressbrook Creek between AMG 422000, 6983530 and AMG 424680, 6983180. The unit is named after The Sugarloaf, a prominent hill adjacent to Cressbrook Creek in the type area.

Distribution

The Sugarloaf Metamorphics form a belt of rocks extending from 3km north of the Esk–Hampton Road in the south to ~1.5km south of Yarraman in the north and has a maximum width of ~15km. A smaller area (~10km^2) of north-west-trending metamorphosed sediments ~11km south of Kumbia have been tentatively assigned to this unit.

Topographic expression

This unit has a variety of topographic expressions from cleared rolling hills to thickly forested rugged country. For the northern part of the unit the air photo patterns show strong north-north-west linear trends which correspond to the dominant foliation.

Geophysical expression

The Sugarloaf Metamorphics have a moderately high mottled white, red green signature on the AIRDATA K–Th–U ternary (RGB) radiometric image. This unit has a similar signature to that of the Maronghi Creek beds and adjacent Boondooma Igneous Complex and Taromeo Igneous Complex.

The unit is also like the Maronghi Creek beds in its magnetic response as it shows a very low response on the reduced to pole magnetic image.

Lithology

Campbell (1952) noted three distinct rock types within the Sugarloaf Metamorphics on ESK, thin-bedded fine-grained sandstone, black slates and contorted phyllites. He reported that sandstone was the most abundant of the three and occurs practically over the whole unit. Forbes (1974) described the Sugarloaf Metamorphics, in the Mount Woolshed–Emu Creek area, as low-grade regional metamorphosed rocks, contact metamorphosed in places to produce some hornfels and schists. Localised very tight isoclinal folding was also observed. In hand specimen it was noted that fine quartz veins follow an axial plane cleavage. Murphy & others (1976) identified only two rock types in the unit on the Gympie 1:250 000 Sheet area, slate and quartz-mica schist. Typically the slate is light to dark grey with a well-developed cleavage and blocky jointing. Spotted slate occurs in some areas.

On KINGAROY and NANANGO, shale, sandstone, phyllitic mudstone, phyllite, and mica schist have been identified within the unit. East of Cooyar Creek (AMG 402381, 7024427) dark grey hornfelsed mudstone occurs close to outcropping Taromeo Igneous Compex intrusives. Strongly cleaved, quartz veined, cream to brown phyllitic shales are exposed in a small quarry beside a forestry track at AMG 404261, 7017317. Elsewhere, light brown cleaved phyllites are prevalant, commonly containing abundant quartz veining. Spotted hornfelsed schist is common close to the contact of the Woolshed Mountain Granodiorite.

Mica schist is the dominant rock type in the isolated body of the unit west of the main body on KINGAROY. On the road above Barkers Creek (AMG 368150, 7035060) the rock is composed of cream-grey mica schist displaying a strong foliation defined by alternating quartz and mica. Abundant fold closures, and common quartz veining along the major cleavage are also present.

A thin zone of amphibolite and metavolcanics (**DCo$_v$**) forms a distinct unit within the Sugarloaf Metamorphics north of Anduramba along the eastern margin of Salty Waterhole Creek. Jones (1955) referred to rocks in this unit as amphibolite whereas McLeod (1972) referred to the rock type as a hornblende schist. The rocks are pale to dark green and display a well-developed schistosity. The rocks exhibit contact metamorphism at the margin of the unit and the schistose nature of the unit is replaced by an indurated massive hornfelsed texture. In thin section McLeod (1972) described differences between the hornfelsed and non-

hornfelsed parts of the unit. Mineralogically the non-hornfelsed part of the unit comprises pale to dark green pleochroic amphibole (hornblende) porphyroblasts (to 2mm) in a groundmass of fibrous amphibole (hornblende), quartz and feldspar minor magnetite and haematite opaques and accessory sphene. The hornfelsed part of the unit contains brown-green pleochroic hornblende porphyroblasts in a groundmass of subhedral plagioclase (altered to kaolin and sericite), deep brown biotite (with alteration to epidote), accessory sphene and zircon. Lenses of recrystallised quartz are commonly present in the hornfelsed zone. South of Cressbrook Creek McLeod (1972) noted the presence of hornblende-diopside-garnet schist. Subhedral plagioclase laths occurs with diopside, and coarse pale yellow epidote and sphene are locally present.

Environment of deposition

The unit is thought to represent mainly fine-grained sediments deposited in deep marine conditions before being incorporated into the eastern Australian margin as a subduction complex. The sediments were derived from the eastern Australian continental margin. The dominance of poorly sorted arenite composed of angular grains and showing no bedding indicates a density current origin for this unit.

Thickness

A reliable estimate of the original thickness of the unit is difficult to make due to structural repetition and folding during subduction and thrusting. The unit may have originally been as little as a few hundred metres thick.

Structure

Bedding and the subparallel slaty cleavage within the Sugarloaf Metamorphics dip either steeply to the west or east. Locally, thicker beds of arenite show well developed grading and are only weakly deformed. In general the unit has a well-defined primary cleavage with broad scale outcrop folds. Along the western margin of the unit bedding is parallel to an enhanced cleavage, and this composite surface is strongly deformed by small-scale tight to isoclinal, subhorizontally-plunging folds that are locally visible in some thin-bedded rocks.

Biostratigraphy and age

No fossils have been found within the unit. The unit is pre-Permian in age as the Woolshed Mountain Granodiorite intrudes it. Minimum radiometric ages of Early Triassic (248±0.8Ma) and Cretaceous (137.4±1.1Ma) were generated through Ar/Ar dating of muscovite from samples of mica schist for this report (see 'AGE DATING'). This former age is similar to that of the western part of the adjacent Eskdale Granodiorite, and has probably been reset by intrusion of this unit. Alternatively, the Earliest Triassic age may represents an exhumation age of the unit during the Hunter–Bowen Orogeny (see Geological and Tectonic History). The younger Cretaceous age may represent resetting of muscovite due to a Cretaceous extension event. This age is identical to Jurassic–Cretaceous intrusive rocks in the Maryborough 1:250 000 Sheet area and at Mount Williams on ESK immediately to the east of this area.

Stratigraphic relationships

The Sugarloaf Metamorphics are interpreted to be faulted against the Maronghi Creek beds to the east. The Sugarloaf Metamorphics are unconformably overlain by the Tarong beds and the Woogaroo Subgroup and outliers of the Main Range Volcanics — basalt and sediments on ESK and NANANGO. The unit is faulted against the Permian Pinecliffe Formation on its south-eastern margin.

The unit is intruded by the units of the Eskdale Granodiorite, Crows Nest Granite, Djuan Tonalite and the Woolshed Mountain Granodiorite and unit Pgo, and by the Boondooma Igneous Complex on KINGAROY.

Correlation with other units

The unit is thought to be a deep crustal correlative of the Maronghi Creek beds. The unit may be structurally correlative to lower plate accretionary wedge rocks of similar metamorphic grade in the nearby North and South D'Aguilar Subprovinces (e.g. the Murdering Creek Metamorphics, the Andersen Creek Phyllite, the Bunya Phyllite and the Kurwongbah beds).

Chahpingah Meta-Igneous Complex (Cc; new name)

Introduction

The unit was first recognised as an area of undifferentiated Palaeozoic metamorphics by Exon & others (1968), Reiser (1971) and Murphy & others (1976) during reconnaissance mapping of the Chinchilla and Gympie 1:250 000 sheets. The unit was studied in more detail by Hubbard (1985), and this mapping was followed up by Holcombe & others (1997) who first applied the term "Chahpingah Complex", naming the unit

after the locality of Chahpingah, 16km south-east of the village of Durong. The latter workers studied the structure of the unit, and undertook limited Ar/Ar age dating of the rocks.

Distribution

The unit forms two large adjoining lobate outcrop areas (each ~100km^2), straddling the JANDOWAE/BOONDOOMA sheet boundary and extending to the south-east into KINGAROY and MURGON.

Derivation of name

The unit is named after the locality of Chahpingah situated between Kingaroy and Durong and is herein renamed the Chahpingah Meta-Igneous Complex.

Topographic expression

The unit forms low undulating scrubby country. Exposure is generally poor, although moderate to good outcrops occur on some hillsides and in stream pavements.

Geophysical expression

The unit has a uniformly low magnetic response on geophysical images, but has a characteristic pale green (Th-rich) tinge on the K-Th-U (RGB) ternary radiometric images.

Lithology

The dominant rock type is a cream to grey, fine–medium grained, strongly foliated, banded granitic to granodioritic biotite gneiss. The gneiss commonly contains scattered layer-parallel quartz and locally ptygmatically folded pegmatite veins that in many places appear to be migmatitic in origin. Massive cross-cutting, steeply-dipping pegmatite and fine to locally medium grained, equigranular granite dykes also occur, as well as layer-parallel sills and small intrusions. Small areas of mica schist also present in places.

The gneiss locally grades into massive relatively homogeneous biotite-rich microgranite. Biotite-rich xenoliths are common in these metagranites, where they locally form discontinuous trains representing remnants of earlier metasedimentary layering. The internally-laminated xenoliths are locally tightly to isoclinally folded with the dominant foliation (here designated S_m) as axial plane. Remnant 'ghost layering' is visible in the granitic matrix between the xenoliths, suggesting derivation of the rock fom *in situ* melting of a metasedimentary protolith.

In many places the xenolith trains define well-developed intersection lineations on foliation surfaces as well as a parallel lineation defined by biotite clots. These features are well exposed adjacent to the Burrandowan Road around AMG 357200, 7063500. Similar lineations defined by biotite alignment occur elsewhere throughout the unit, but some of these may represent stretching lineations defining directions of tectonic transport.

The major S_m foliation in the gneiss is defined by alternating mafic biotite-rich layers and quartzofeldspathic layers. The component minerals are mainly quartz and biotite, locally combined with K-feldspar, plagioclase, muscovite and/or garnet. In rare cases, small rootless isoclinal fold hinges of the gneissic lamination are present parallel to the main layering, indicating a transposition origin for the S_m foliation. Isoclinally folded quartz veinlets also occur locally.

At one locality (road cut at GR355117/ 7063690), the usually massive granitic gneiss contains occasional layers up to 20cm thick of aplitic material, which may either represent remnant lithological layering or a series of parallel igneous veins. The layers have been folded into trains of open to isoclinal parasitic folds with the dominant Sm foliation as axial plane, indicating that the layers predate the dominant gneiss-forming deformation event.

In the eastern part of the complex on KINGAROY, small-unmapped bodies of strongly foliated K-feldspar-phyric biotite granite containing thin (to 5cm) pegmatite veins intrude the gneiss. In this region, the complex is also locally intruded by medium grained biotite granite to microgranite (e.g. at AMG 381192, 7039776; 381070, 7040312; and 381995, 7041270). The foliated gneiss locally comprises up to almost 50% migmatitic leucogranite sweats (e.g. the road verge at AMG 353989, 7052319).

Structure and metamorphism

The unit is interpreted to represent a series of synkinematic granitic intrusions, intruded during a period of deep level crustal scale extension that produced the strong S_m foliation. The unit is sporadically cut by regular to chaotic broad crenulations, warps and folds (the axial planes of which are here designated S_2) which may reflect the presence of large scale regional folding of the gneissic layering.

Age

The unit has been radiometrically dated by the Ar/Ar method, as well as by U–Pb zircon SHRIMP dating. The former method gives ages in the 250Ma range (Rod Holcombe, personal communication, 1997) whereas the latter gives a magmatic age of Late Carboniferous (301Ma) age (Cranfield & others, 1998) which is considered to be the age of metamorphism, melting and emplacement of the essentially synkinematic granitic complex. The younger ages are considered to be reset by the effect of the Hunter–Bowen orogeny in this area.

Relationships

The unit is intruded by various phases of the Boondooma Igneous Complex, and has a concordant relationship with the adjacent the Mountefontein Metamorphics, which it probably syntectonically intruded and metamorphosed. Basalts of the Tertiary Main Range Volcanics and Late Triassic sediments of the Surat basin unconformably overlie the unit. The unconformity between the basal sediments of the Surat Basin and the older gneisses is well exposed at AMG 352307, 7050672. The basal conglomerate of the Surat Basin is a quartz-rich conglomerate (derived from pegmatite bodies in the gneiss) and contains rutile concentrations along the bedding planes.

Correlatives

The unit probably represents a series of syntectonic intrusions associated with the metamorphism of the adjacent Mountefontein Metamorphics. This intrusive/metamorphic sequence is similar in age and origin to comparable granites and metamorphics mapped in the North D'Aguilar Subprovince on the eastern margin of the Esk Trough — the Claddagh, Karandah and Gallangowan Granodiorites, and associated metamorphics of the Claddagh–Manumbar assemblage of Little (1993).

Mountefontein Metamorphics (new name; Ct)

Introduction

Murphy & others (1976) included this unit in a sequence of undifferentiated Palaeozoic metamorphics (unit Pz). The unit is metasedimentary in character, and clearly of a different lithology to the surrounding Chahpingah Meta-Igneous Complex from which it is herein separated.

Distribution

The unit occurs ~30km due west of Kingaroy, occupying a roughly rectangular area of ~12km^2.

Derivation of name

The unit is named after Mountefontein homestead that is situated almost on the centre of the outcrop.

Topographic expression

The unit is exposed as elevated ridges and hills covering an area of ~12km^2. The outcrop area has been mostly cleared for grazing, although small patches of dense woodland still remain. Exposure is generally poor and limited mainly to creeks and gullies.

Geophysical expression

The unit has a uniformly low magnetic response on geophysical images, but has a characteristic mauve to purple colour on the Ternary K–Th–U (RGB) radiometric image.

Lithology

The unit consists mainly of thinly interlayered biotite gneiss and fine schist, intruded by scattered biotite-leucogranite sills and migmatitic veins. Thick horizons of thinly banded haematitic metachert occur sporadically throughout the unit. Layering within the unit trends west-south-west parallel to the layering in the enclosing Chahpingah Meta-Igneous Complex.

Structure

The major metamorphic layering in the unit dips at moderate to steep angles to the north-north-west. No significant internal folding was noted.

Relationships

The unit has a concordant relationship with the Chahpingah Meta-Igneous Complex.

Both units are intruded by various phases of the Boondooma Igneous Complex.

Age and correlatives

The grossly concordant relationship, similar metamorphic grade, and presence of granitic sills suggest that the Mountefontein Metamorphics and Chahpingah Meta-Igneous

Complex share a similar tectonic history and age (i.e. late Carboniferous).

Bjelke Petersen beds (new name; Cb,Cb_l)

Introduction

The unit has a characteristic limestone/basalt/turbidite association that is unique within the Yarraman Subprovince. Reid (1925) assigned these rocks to his "Wondai Series" and first noted the limestone (informally known as the "Barambah limestones"). Derrington (1954) described the northernmost limestones and included them in his "Wondai Metamorphics", a named he introduced in place of "Wondai Series". Palmieri (1969) described a conodont fauna from the limestone based on earlier mapping by Sawers (1968). The limestone-bearing sequence was subsequently included in an undivided Carboniferous–Permian (C–P) unit by Murphy & others (1976), a unit that encompassed the "Wondai Metamophics", a term they discontinued. The geology of the limestone bodies was subsequently described in the context of their economic value as quarry rock by Martin (1977).

It is considered that the unique lithological association and consistent ages obtained from the limestones make it desirable to separate the unit from the adjacent undated Maronghi Creek beds.

Distribution

The unit occurs ~3km east of Murgon as a narrow (~1km wide), north-north-west trending sliver over 15km in strike length.

Derivation of name

The unit is named after the Bjelke Petersen Dam, where it is well exposed in cuttings and quarries immediately north of the Dam wall.

Type area

The unit is not well enough exposed to specify a type section. The best exposures of the unit are immediately north of the Dam wall in cuttings and quarries.

Topographic expression

The unit forms the eastern sloping flanks of the major ridge system formed by the adjacent Maronghi Creek beds. The latter sheds chert-rich scree blankets over sections of the Bjelke Petersen beds. The unit is heavily timbered, with no distinctive photo pattern.

Geophysical expression

The unit forms dark tones on AIRDATA K–Th–U ternary radiometric images and also has a low response on aeromagnetic images.

Lithology

The unit consists mainly of interbedded andesitic to basaltic lava, limestone, mudstone, chert, and phyllite. The mafic volcanics are mostly dark grey-green to purple-brown in colour, amygdaloidal and locally strongly sheared. The fine-grained clastics are generally strongly cleaved, and contain thin lenticular beds or laminae of chert or siliceous siltstone.

The limestone occurrences (mapped as Cb_l) range from small pods less than a metre in size to larger bodies up to 300m in length and 150m in width. The limestone and mafic volcanics commonly have thinly-interlayered or interdigitating contacts. A similar relationship between the limestone and enclosing fine-grained clastics was observed at the southernmost limestone locality.

The limestone is moderately to strongly recrystallised, light to dark grey or pale green to pink or brown in colour. The limestone shows significant contamination by volcanic detritus near the contacts. The limestone are commonly internally brecciated and weather to clay and 'terra rossa' soils.

Environment of deposition

The conodont fauna from the limestone suggests a warm water environment for the unit, contrasting with the cold water faunas recorded from most of the accretionary wedge rocks accreted to the eastern Australian continental margin during the Late Palaeozoic. Warm waters may be consistent with a shallow rather than a deep marine environment, and/or with low latitude areas exposed to anomalously warm marine currents. The most likely interpretation is that the mafic lavas represent a series of ocean floor volcanic edifices (guyots) built up in places to a height sufficient for limestone deposition.

The deep marine clastic component of the unit was probably derived from the Australian craton and was deposited during periods of volcanic quiescence.

Thickness

The unit suffers from internal faulting, making an estimate of its thickness difficult. A likely thickness is probably ~500m.

Structure

The unit has well developed, bedding-parallel, slaty cleavage in clastic rocks, extensive fracturing in limestone, and widespread development of an anastomosing schistosity in the basalt. Strong melange-style shear fabrics occur locally. On the eastern side of the Bjelke Petersen Dam wall, elongate limestone phacoids occur within a schistose greenstone matrix. One of the limestone bodies 4km to the south of the dam grades outwards into brecciated limestone that is cut by a 50cm wide mylonitic shear zone. Most of the internal cleavage development, shearing and brecciation is thought to have occurred during Late Palaeozoic subduction of the sequence at the eastern margin of the Australian craton.

The present structural geometry of the unit is characterised by bedding/cleavage dips that are moderate to steep to the west. Company drilling suggests that the limestone sequence is truncated to the west along its contact with the Maronghi Creek beds by a northerly-trending fault.

Biostratigraphy and age

Conodonts, foraminiferids, fish teeth, fish scales, annelid jaws, and crinoid fragments have been recorded from the limestone bodies (Palmieri, 1969; Martin, 1977). The conodont fauna indicates a Namurian/Westphalian (Late Carboniferous, equivalent to an age of about 311–314Ma) age for the Bjelke Petersen beds (Palmieri, 1969). The contact relationships suggest an autochthonous origin for the limestones, suggesting the condont dating is a reliable indicator of the true age of the unit.

Stratigraphic relationships

The unit is faulted against the older Devonian–Carboniferous Maronghi Creek beds and the younger Triassic Esk Formation. The unit is unconformably overlain by Tertiary sediments, and locally capped by Tertiary duricrust surfaces.

Correlation with other units

Similar, probably correlative, warm water conodont faunas have been recorded within the Goodnight beds in the Maryborough 1:250 000 Sheet area (Cranfield, 1994). Other correlatives further to the north may include the accretionary wedge rocks of the youngest part of the Curtis Island Group (the Shoalwater Formation).

YARROL PROVINCE

The Yarrol Province is essentially composed of forearc basin rocks that occur to the west of the Yarrol Fault to the north of mapped area. In YARRAMAN, the boundary to the subduction rocks of the Wandilla Province to the east is poorly defined. The boundary is intruded by the Permian–Triassic Boondooma Igneous Complex in the north and mainly buried beneath rocks of the Surat and Clarence-Moreton Basin in the south.

Rocks assigned to this province are undivided Rockhampton Group in BOONDOOMA in the north and the Alice Creek beds on ESK in the south.

Alice Creek beds (DCc, DCc_l)

Introduction

Geological mapping in the area of outcrop of this unit was undertaken as part of the production of the Ipswich and Brisbane 1:250 000 map sheets (Cranfield & others, 1976). The rocks in this area were considered to form part of the Permian Cressbrook Creek Group however the discovery of *Leptophloem* in mapping by students of the University of South Queensland (USQ) in the early 1970s confirmed a Late Devonian to Early Carboniferous age for the upper part of this unit. Conodonts of Mid–Lower Devonian age (Barry Fordham, personal communication, 1998) have been recovered from bodies of reworked limestone (of unit DCc_l) in the lower part of the unit.

Distribution

The unit is exposed along Alice Creek north of Helidon. The area of outcrop is ~2km^2 and is limited to the bed of the Alice Creek and hill slopes to the east of the creek.

Derivation of name

The name is derived from Alice Creek, a tributary of Lockyer Creek.

Type section

The type section is designated along Alice Creek from AMG 417400, 6962900 to 416500, 6962000. Rock types in the type section comprise predominantly volcanolithic pebble conglomerate and arenite, and minor siltstone. Small limestone outcrops occur in the vicinity of AMG 417400, 6963300 and AMG 417100, 6963600.

Topographic expression

The unit is characterised by a subdued topography below resistant outcrop of Woogaroo Subgroup. The unit forms the bed of Alice Creek and hill slopes to the east of Alice Creek.

Geophysical expression

The unit has a low magnetic response. On the K–Th–U (RGB) ternary radiometric image the unit has an indistinct response due to the limited outcrop area.

Lithology

Rock types from Alice Creek comprise volcanolithic conglomerate, lithic arenite and minor interbedded chert, silicified siltstone and mudstone. Small limestone outcrops occur in the lower part of the unit.

The conglomerate contains pebbles of andesitic to rhyolitic volcanic fragments with minor chert in a feldspathic sandy matrix (Ross, 1986). Chert is generally dark grey to dark green in colour and forms massive blocky jointed outcrops. Indurated mudstone forms thin interbeds in the otherwise massive chert. The andesitic volcanics are dark grey to black in colour and comprise minute plagioclase laths in a fine-grained aphanitic groundmass. The arenite is fine-grained and volcaniclastic. Thin section studies indicate radiolarians are present in siltstones (Ross, 1986). Smith (1974) collected an example of *Leptophloem australe* (McCoy) from a slate at AMG 416500, 6961900 (U.S.Q. collection No. F462).

The limestone bodies are possibly allochthonous. The larger body, at AMG 417400, 6963300, occurs as discontinuous outcrop over ~100m and contains crinoid ossicles and *Thamnopora* sp. in rounded clasts up to 30mm (Ross, 1986). The limestone body at AMG 417100, 6963600 is smaller and has a prominent schistosity trending east west, dipping to the south (Ross, 1986).

Environment of deposition

The Alice Creek beds are interpreted as being deposited in a marine environment, close to a continental margin with an active volcanic arc, i.e. a forearc environment.

Provenance

At least some of the sediment in the Alice Creek beds was supplied from Early to Mid-Devonian limestone reefs and was considered by Ross (1986) to be locally derived due to the sparry nature of the matrix adjacent to the limestone pebbles. The conglomerate and sandstone consist of volcanic fragments and minor chert in a feldspathic sandy matrix (Ross, 1986), indicating a general volcanic provenance. Studies of thin sections indicate radiolarians in the siltstones (Ross, 1986) suggesting a marine depositional environment.

Thickness

The Alice Creek beds have an exposed thickness of ~1000m. It is not known what effect structural thickening has had on the unit.

Structure

Dips in the Alice Creek Beds are generally to the south and south-west at ~70–80°. Shearing within the unit increases in intensity towards a major east west fault which occurs at the northern extent of the unit (Ross, 1986).

Biostratigraphy and age

Smith (1974) identified *Leptophloeum australe* (McCoy) in outcrop in Alice Creek, 2.5km south-south-west of Mount Cross. This indicates that the rocks in this part of Alice Creek area are of Late Devonian–Early Carboniferous age. Conodont faunas indicate an Early to Mid-Devonian (Late Emsian to Early Eifelian) age for the limestones at the base of the sequence. Crinoid ossicles and *Thamnopora* were identified in rounded clasts from one of the limestone bodies (Ross, 1986). These limestones are possibly allochtonous. Thin section studies indicate radiolarians are present in siltstones (Ross, 1986). A Late Devonian to Early Carboniferous age has been assigned to the unit, but the lower part of the unit may be Early–Mid-Devonian in age.

Stratigraphic relationships

The Woogaroo Subgroup unconformably overlies the unit. The Mount Cross Igneous Complex

and unnamed Permian–Triassic granitoids intrude and are faulted against the unit.

Correlation with other units

The unit may be a correlative of the Rockhampton Group, but on fossil evidence appears slightly older.

Rockhampton Group (DCr)

Introduction

Reiser (1971) previously mapped this unit as part of a sequence of undifferentiated Carboniferous sediments and volcanics on the Chinchilla 1:250 000 sheet. The extension of this unit into the Mundubbera 1:250 000 Sheet area was named the Derrangabungy beds by Whitaker & others (1974). Yarrol Project Team (1997) redefined rocks to the west of the Yarrol Fault and its extension to the south as the Rockhampton Group. These rocks were formerly mapped as Caswell Creek Group in the Monto 1:250 000 Sheet area (Murphy, 1976a), and as the Caswell Creek Group and the Derrangbungy beds in the Mundubbera 1:250 000 Sheet area (Murphy, 1976b). Due to the similarity in the sections of these units with the main part of the Rockhampton Group it was proposed by Yarrol Project Team (1997) that all these rocks on the Monto 1:250 000 be included in the Rockhampton Group. Consequently as these similar sequences extend through the Mundubbera 1:250 000 map sheet to the top of BOONDOOMA the sequence in BOONDOOMA is also mapped as Rockhampton Group.

Distribution

The unit occurs in the north-west corner of the BOONDOOMA in two main areas — a western poorly exposed area around Allies Creek and a better exposed eastern area around Brovinia Creek, where the unit is commonly hornfelsed by intrusions of microgranite, rhyolite and pegmatite of the Toondahra Granite. In BOONDOOMA the unit is an extremely diverse and relatively poorly exposed sequence. The unit is best exposed along Brovinia Creek south from Weir Weir homestead to Slaughter Creek. Elsewhere, the unit is only visible in small creeks and gullies that erode colluvial and alluvial deposits.

Topographic expression

The unit is exposed as low wooded hills and ridges in the western part of the area. Along Brovinia Creek they form resistant rock bars adjacent to low sandy terraces of Brovinia Creek.

Geophysical expression

The unit generally has a uniformly low magnetic response and occurs as dark tones on the K–Th–U (RGB) ternary radiometric image.

Lithology

The unit consists of a wide variety of rock types, including volcanics, tuffs, fine sediments, and limestone, as well as local phyllite, fine schist and mylonite. In the eastern outcrop area (around Weir Weir Homestead), the typical rock types are regularly-bedded, laminated indurated flinty mudstone with scattered interbeds of cream, laminated, thin and medium-bedded, fine-grained sandstone and silstone. Sporadic medium to thick volcaniclastic arenite interbeds are also present. The latter contain coarse feldspar and lithic (felsic volcanic) grains together with rare amphibole fragments in an altered fine-grained sublabile matrix. The thinner siltstone/sandstone beds also contain a variable amount of felsic lithic detritus, together with granitic to gneissic basement-derived fragments. Sparse siliceous ooids are also a common component of the sandstones. The sediments are commonly planar bedded, and only rarely exhibit cross-lamination. The rocks are locally strongly jointed with steep south-east and north-east dipping joints. Fine-grained rhyolite dykes, that are quartz-feldspar-phyric or feldspar-phyric in composition, cut the sequence. Massive rhyolites have also been recorded from the area (Exon & others, 1968).

A greater variety of rocks occur in the western outcrop area. Highly deformed and altered rocks occur over a relatively narrow (~600m) mineralised zone adjacent to the western margin of the Toondahra Granite. In the Golden Whiptail mine area, the line of workings expose metamorphic rocks — mainly phyllite, fine schist, quartzite and quartz mylonite. The well developed schistosity in these rocks dips moderately to the west-north-west and is strongly crenulated, kinked and locally brecciated. The anastomosing mica seams in the quartzites locally exhibit asymmetric shear fabrics. Similar rocks occur to the north around the Welcome workings.

A large proportion of the high grade rocks appear to represent deformed fine-grained felsic to andesitic tuffs and epiclastics, containing recognisable relict feldspar crystals, pumice (strongly attenuated fiamme), quartz

phenoclasts, and lithic grains in a fine-grained recrystallised matrix. Rocks with andesitic protoliths are rich in secondary amphibole (tremolite to actinolite) and epidote. Epidote and chlorite alteration is widespread throughout the mineralised belt adjacent to the western margin of the Toondahra Granite. Small aplite, rhyolite and microdiorite intrusions are also common adjacent to the granite contact.

The effects of deformation decrease only a few tens of metres west of the Golden Whiptail workings, where primary rock types become more recognisable. The sequence here includes massive blocky andesitic tuff rich in feldspar crystals cut by scattered quartz-filled tension gashes and sills, as well as occasional rhyolite and aplite sills. The tuffs are interlayered with fine-grained volcaniclastic arenites and some laminated khaki shale. Rare internally laminated rhyolitic tuff layers ~10cm thick have also been noted. Bedding dips are moderate to the north-west.

Lower grade rocks are also exposed along strike to the north, on the northern side of the Allies Creek road. This sequence includes brown, fine-grained, massive sublabile to volcaniclastic arenite; and matrix-supported pebble to granule conglomerate interbedded with rare lenses of sandy fossiliferous limestone. The conglomerate contains clasts of quartz, arenite, and quartzite in a fine to medium grained quartzose matrix containing scattered felsic volcanic detritus. These rocks are locally brecciated. In the bed of Allies Creek further north, thick massive packets of khaki mudstone with an incipient local shallow parting occur interbedded with thin to laminated siltstone layers or medium to thick beds of very fine-grained sandstone. These rocks appear to be less indurated equivalents of the Brovinia Creek sequence.

Two small exposures of schistose rocks occurring south of the main outcrop area (~14km south-west of Boondooma Homestead) have also been assigned to the Brovinia beds. Scattered volcanic?-derived porphyroclasts within the phyllites and greenschists suggest the protolith may be felsic epiclastic deposits and tuffs. A thick milky white quartz 'dyke' which has been extensively mined for industrial quartz intrudes the southernmost inlier in the headwaters of Dangarabungy Creek. The foliation in this area dips steeply, while the foliation in the small inlier to the north dips gently to the east.

Environment of deposition

The unit was probably deposited in a marine shelfal environment, close to a continental margin with an active volcanic arc, i.e a forearc environment.

Thickness

Poor exposure and unknown structure complications make thickness estimations difficult, but the unit may be up to 1000m in thickness.

Structure

Bedding dips within the unit range from gentle to moderate, with westerly dips apparently predominating. In the Brovinia Creek area, gentle warps and undulations are common. The foliation in the schistose mineralised belt adjacent to the Toondahra Granite dips mainly moderately to the north-west, and may result from thrusting or strike-slip movement related to episodic orogen-wide Permo-Triassic shortening.

Biostratigraphy and age

Exon & others (1968) collected brachiopods, bryozoans and crinoid stems from the sandy limestones north of the Allies Creek road (~AMG 314600, 7116200), indicating a Middle Carboniferous age for this part of the sequence.

Stratigraphic relationships

The unit is intruded by the Toondahra Granite and unconformably overlain by sediments and volcanics of the Surat Basin and Main Range Volcanics respectively.

Correlatives

No correlative sequences are known from the Yarraman Subprovince. The unit appears to be slightly younger than the Alice Creek beds.

Mineralisation

A zone of extensive chlorite-epidote alteration adjacent to the Toondahra Granite in the Allies Creek area is noted for small-scale gold production. Mining activity in the area occurred between 1939 and 1942 (Brooks, 1970c), but no detailed record of production is known. A small crushing plant (Stumer's Battery) was set up in 1941 just south of the Allies Creek road midway between the Golden Whiptail workings in the south and "the Northern Workings" to the north.

The Golden Whiptail workings consist of an extensive line of pits and shafts trending north-north-east for several hundred metres. Some of the shafts are well timbered and over 30m deep, varying from vertical to inclined (par-

allel to the westward-dipping foliation in the rocks). A small porphyry sill is exposed locally in the one shaft, and a small intrusion of similar material occurs nearby. Small mullock piles of gossanous quartz occur locally, but these may not be representative of the ore. Exon & others (1968) recorded mullock heaps of distinctive red mudstone with malachite and azurite veining at Stumers Battery.

The workings north of the Allies Creek road occur as a series of scattered shafts in schistose rocks similar to those in the south. The best known deposit is the Welcome, where two timbered water-filled shafts occur in quartzite just north of the Allies Creek road. The other shafts occur in a variety of sites, e.g. close to or within small microdiorite or porphyry intrusions or developed on ferruginised gossans. Most are also fault controlled with some quartz fill. The trend of the lodes appears to be north-east to north-north-east, similar to the Golden Whiptail trend.

The Golden Whiptail /Welcome deformed zone represents an area of long term fault movement, resulting in episodic pumping of mineralising fluids through the rocks as well as providing effective open space sites for deposition. A significant component of the ore-bearing fluids may have been introduced during the late stages of Toondahra Granite intrusion, possibly associated with small late-stage sills and dykes.

GYMPIE PROVINCE

Cressbrook Creek Subprovince Undivided Sediments (Ps)

Introduction

The unit (Ps) was first identified by Cranfield & others (1998) who noted it was similar in appearance to the Rammut Formation of the Gympie Subprovince. It is easily identifiable both on the aerial radiometric image, because of its contrasting signature to adjacent rock units. In outcrop it is lithologically and structurally different from the surrounding Maronghi Creek beds. Willey (1998) described the unit in more detail and referred to it as "Element D". Areas of the unit intruded by micro-diorite dykes of probable Permo-Triassic age have been subdivided into unit Ps_d.

Distribution

The unit is distributed as a roughly north-south trending linear belt ~12km long and 1–2km wide. It extends from just south of Emu Creek to ~5km south-east of Benarkin township. Subunit Ps_d flanks the main body on both its eastern and western sides.

Topographic expression

The unit forms moderate to steep country with elevations ranging from ~260–360m and is covered by thick plantation of mainly hoop pine and native eucalypt forests.

Geophysical expression

The unit has a distinctive radiometric signature of a mottled light yellow-pink-green character that contrasts sharply with adjacent significantly darker areas in which there have been numerous small microdiorite intrusions into the Maronghi Creek beds. Similar to adjacent units, Ps has a ubiquitously low magnetic response on the magnetic image.

Lithology

The unit is composed of fine-grained, thin to medium-bedded mudstone, siltstone, minor sandstone and conglomerate, and lesser andesitic to dacitic volcanics and volcaniclastics. The mudstone and siltstone are generally light to dark grey and may show convolute bedding, load casts, dewatering, and ball and pillow structures. An exposure in a quarry scrape within the forestry at AMG 418876, 7019427 comprises dark grey, thin-bedded mudstone with sparse lenticular rip-up clasts and numerous relict burrow casts. No other recognisable fossils were observed at this locality. A exposure along the ridge above a waterhole on Emu Creek at AMG 418750, 7015600 consists of a sequence of indurated, dark and light grey, laminated to thin-bedded mudstone and siltstone. The rock has a blocky appearance in outcrop due to the intersection of steeply dipping joint fractures and near horizontal bedding planes. Alternating laminar bands of light and dark coloured mudstone commonly exhibit soft sediment deformation structures, most clearly seen on the etched weathering surfaces.

Nearby at AMG 419000, 7015550 medium to thickly bedded volcaniclastic sediments are exposed in a road cut. The exposure consists of grey-green crystal-rich epiclasitc sedimentary rock that in thin section contains euhedral to anhedral quartz and plagioclase crystals, devitrified pumice and minor veins infilled by carbonate. The rock is also silicified and contains fine crosscutting quartz veins.

Conglomerates occur throughout the unit and contain pebble to boulder-size clasts, but are

most commonly pebble to cobble-size. Willey (1998) noted that clasts in the conglomerates are virtually all of sedimentary origin and that no clasts of Maronghi Creek rock types were present. He undertook a random study of the clasts and found all were composed of bioturbated quartz-lithic/lithic arenite to mudstone. However, clasts of sedimentary conglomerate are present east of Emu Creek and show earlier conglomerates must have been reworked. Willey (1998) reported that contacts between the clasts and matrix are generally poorly defined in thin section. Most of the conglomerates are matrix-supported although areas of clast-supported conglomerates are locally present.

Environment of deposition

The majority of rocks in this unit were probably derived from unconsolidated volcanic detritus redeposited from the slopes of nearby stratovolcanoes and vents. Bioturbated muds and silts indicate low energy depositional environments consistent with shallow water lake deposits. These rocks are the most common while the less abundant sandstones and conglomerates are fluvial in character. The poorly sorted conglomerates, containing reworked sediments, are probably the result of debris flows. The abundance of immature volcanic detritus including low energy muds and silts, ashy crystal rich sediments and fluvial sandstones and conglomerates indicate a distal ring plain environment (Cas & Wright, 1987). This contrasts with the intercalated dacitic and andesitic flow tuffs noted by Willey (1998) which suggest a more proximal setting. On the basis of the rock types noted, it would appear the deposits were formed somewhere between the distal and proximal extremes but most likely in a distal volcanic setting.

Thickness

The unit is probably of the order of several hundred metres in thickness.

Structure

The unit is composed of gently dipping volcano-sedimentary beds in contrast to the underlying steeply dipping, intensely deformed, accrectionary wedge rocks of the Maronghi Creek beds. Willey (1998) noted broad horizontally-plunging folds in the unit that occur with a weakly developed axial-plane cleavage. The cleavage penetrates the clasts within the conglomerates and generally dips steeply to the south-west. The less intense and more open style of deformation than the Maronghi Creek beds suggests the unit is somewhat younger and was deformed as a result of later Permo-Triassic events.

Biostratigraphy and age

The age of the unit can not be constrained with any accuracy. No macrofossils were found within the unit and sampling for radiolarian microfossils proved unsuccessful. The less deformed and simpler structure of the unit suggests it is younger than the adjacent Devonian–Carboniferous Maronghi Creek beds. The unit has comparable rock types to the Permian Rammut Formation of the Gympie Province and the Permian volcano-sedimentary Cressbrook Creek beds, and has therefore been assigned a Permian age.

Stratigraphic relationships

This unit is faulted against the Devonian–Carboniferous Maronghi Creek beds, is intruded in places by Permo-Triassic diorite dykes and is overlain by minor Tertiary sediments and volcanics.

Correlation with other units

Based on its composition the unit may be correlate with volcanic to volcaniclastic units within the Cressbrook Creek Group, such as the Hampton Road Rhyolite and Box Gully Formation.

Cressbrook Creek Group

Bryan (1928) first referred to Permo-Carboniferous fossiliferous sediments and rhyolite to the west of Esk as the "Cressbrook Creek Series". Campbell (1952) defined five formations in the vicinity of Cressbrook Creek, which Swindon (1971) referred to 'in passing' as the Cressbrook Creek Group. The group is considered equivalent to the original Cressbrook Creek "Series" and was defined by Cranfield & others (1976) as comprising the Pinecliff Formation, Hampton Road Rhyolite, Biarraville Formation, Box Gully Formation, and Buaraba Mudstone.

Pinecliff Formation

Introduction

Campbell (1952) derived the name from Pinecliff Ridge, a prominent geomorphic feature ~3km south of Mount Deongwar, and recognised a three-fold subdivision of the formation. He named the volcanic middle part the Kipper

Creek Andesites. These have not been identified during the current mapping as separate units.

Distribution

The unit crops out along Cressbrook and Oakey Creeks, and its type section was designated along the creek (Cranfield & others, 1976).

Topographic expression

The unit occupies a rugged, thickly forested area of 78km^2 south of Oakey Creek, at an average elevation of ~450m above sea level.

Geophysical expression

The unit has a non-distinctive mauve and light grey response on the K–Th–U ternary radiometric image. The signature can not be distinguished from rocks of the Sugarloaf Metamorphics to the north and west. The unit has an underlying high magnetic signature.

Lithology

The formation consists of chert and silicified mudstone, with less common volcanics, arenite, and conglomerate. The lower part consists of green and grey chert, quartzite, and minor altered bluish conglomerate and shale. These sediments are overlain by about 150m of basaltic flows and agglomerate. The volcanic flows are spilitic in composition and exhibit well-formed pillow structures. Agglomerate occurs at the base and the top of these volcanics. The basal agglomerate consists of clasts of porphyritic andesite in an andesitic groundmass whereas the top agglomerate consists of fragments of pink fluidal rhyolite in a tuffaceous andesitic groundmass. Chert, conglomerate, and minor coarse feldspathic arenite overlie the volcanics. The chert immediately above the volcanics is greenish and well banded, but becomes more massive higher in the sequence. Conglomerates are present as small, discrete lenticular bodies.

Environment of deposition

Pillow structures in the volcanic interbeds, together with the association of coarse-grained feldspathic arenite and chert, suggest marine deposition on an unstable shelf environment. O'Shea (1975) located a 4cm band of crinoid fossils in a mudstone bed at AMG 424700, 6981500. Rose (1986) located a dark banded lithic arenite containing fossiliferous carbonaceous material at AMG 424530, 6981780. This material consists of a thin stem-like material lying parallel to the bedding plane and, in thin section, is estimated to make up to 15% of the rock.

Provenance

The unit appears to have been derived from a marine source due to the presence of spilitic volcanics. No geochemistry has been undertaken on the unit; its tectonic affinity is indeterminant.

Thickness

To the south of Mount Sugarloaf the unit is ~1500m thick. Cranfield & others (1976) did not consider this as the maximum thickness of the unit as the base is truncated by the Sugarloaf Fault.

Structure

The Pinecliff Formation is folded in a broad east-south-east plunging anticline, which is defined by outcrops of the Kipper Creek Andesite Member (Campbell, 1952). Dips range from about 40°–80°. South of the Sugarloaf Fault and north of the Esk–Hampton Road, the unit is affected by faulting and dips between 70° to the south-south-east and vertical. To the west the Eskdale Granodiorite intrudes the lower part of the Formation. Rose (1986) identified mylonites developed at the contact with Sugarloaf Metamorphics along the Sugarloaf Fault, south-west of Cressbrook Creek.

Biostratigraphy and age

In the absence of definitive fossils in the unit, the age of the unit is tentatively equated with that of the overlying Hampton Road Rhyolite, which has Early Permian fossils.

Stratigraphic relationships

The unit is conformably overlain by the Hampton Road Rhyolite and faulted against younger formations within the group in the north. The unit is faulted against the Sugarloaf Metamorphics along the Sugarloaf Fault, and intruded by units of the Eskdale Granodiorite to the west. The Woogaroo Subgroup unconformably overlies the formation to the south-west.

Correlation with other units

The unit may be a correlative of Early Permian altered basic volcanics mapped to the east in the Cambroon and Northbrook Subprovinces. It may also be a correlative of some parts of the Highbury Volcanics of the Gympie Province in the Gympie area.

Hampton Road Rhyolite

Introduction

Campbell (1952) applied this name to a sequence of interbedded rhyolitic flows, pyroclastics, arenite, conglomerate, and silicified mudstone. It is well exposed along the Esk–Hampton Road along the type section designated by Cranfield & others (1976).

Distribution

The unit occupies an area of ~35km^2 of thickly forested, dominantly rugged country, between 480–580m above sea level along the Esk–Hampton Road and environs.

Topographic expression

The airphoto pattern is dominated by deeply incised valleys adjacent to indurated steep hills that are locally demonstrably dip slopes.

Geophysical expression

The unit has a strong potassic (pink) signature on the ternary K–Th–U radiometric image and a moderate to high magnetic response.

Lithology

The unit contains thick rhyolite flows and pyroclastics and minor interbedded arenite, conglomerate, and chert. The rhyolite flows are glassy, spherulitic or fluidal, and form blocky outcrops that are grey, white, or black. Three marker bands of agglomerate, consisting of purple rhyolitic fragments set in a fine-grained green tuffaceous matrix, occur near the base of the rhyolite. South of the Esk–Hampton Road pyroclastics predominate; these become coarse-grained to the south, indicating an eruptive centre in this direction.

Environment of deposition

The Hampton Road Rhyolite occurs in a conformable sequence between the Pinecliff Formation and the Biarraville Formation, both of which are marine shelf deposits, with the former possibly representing a more unstable deeper water facies. The angular blocky nature of pyroclastics within the unit suggests that at least part of the unit was deposited subaerially.

Thickness

In the south the unit is 1500m thick; in the north it thins to <30m.

Structure

Rocks of the unit dip at 45°–80° on the southern flank of an east-south-east trending anticline, and at 45°–60° on the northern flank. North-east of Mount Deongwar, it is exposed on the flanks of a northerly plunging syncline, but has been differentiated only on the western limb at the present scale of mapping.

Biostratigraphy and age

No fossils are known from the type area of this unit; it was tentatively assigned an Early Permian age based on its similarity with the lower half of the Gympie Group (Rammutt Formation). Beutel (1973) listed a fauna including *Eurydesma* in a dark green cherty rock from 4.5km west of Mount Perseverance, thus indicating an Early Permian age at this locality.

Stratigraphic relationships

The unit conformably overlies the Pinecliff Formation, and is conformably overlain by the Biarraville Formation. In the east, the Hampton Road Rhyolite is faulted against the Toogoolawah Group and the Woogaroo Subgroup by the Western Border Fault. West of this fault, outliers of Woogaroo Subgroup overlie the unit. South of the Esk–Hampton Road small bodies of the 'Champion Hills Diorite' intrude the unit.

Correlation with other units

This unit appears lithologically similar to the Rammutt Formation in the Kin Kin Subprovince of the Gympie Province near Gympie.

Biarraville Formation

Introduction

Campbell (1952) named the Biarraville Formation. The name is derived from Biarraville homestead, 8km south-south-west of Toogoolawah, and the type section is located on Dry Creek (Cranfield & others, 1976).

Distribution

The unit crops out near Buaraba Creek and South Buaraba Creek, Cressbrook Creek, and north of Oakey Creek (Cranfield & others, 1976).

Topographic expression

The area is thickly forested, rugged in places, and forms steep country ~300m above sea level.

Lithology

Rock types include chert, arenite, siltstone, mudstone, sedimentary breccia, rhyolite, crinoidal limestone, and coarse-grained andesitic conglomerate. The type section comprises conglomerate, arenite, and sedimentary breccia with a fossiliferous horizon 4.5m thick, overlain by thin conglomerate beds with abundant fossils in a bed 45cm thick and black chert with rarer fossils. In the headwaters of South Buaraba Creek, a molluscan fauna occurs in a black calcilutite lens in a sequence of black mudstone.

Geophysical expression

On the magnetic and ternary radiometric image the unit has no features to distinguish it from surrounding Permian units due to its limited thickness and similar adjacent rock types.

Environment of deposition

The presence of thin crinoidal limestones, together with arenites and conglomerates containing corals, brachiopods, bryozoans, and molluscs, indicates deposition in a marine, probably shallow water shelf environment.

Thickness

The unit is ~45m thick in the type section, and probably does not exceed 50m elsewhere.

Structure

South of the Esk–Hampton Road, the unit is exposed on the southern flank of an east-south-east plunging anticline. Here it dips between 30°–60° and is disturbed by faulting and the intrusion of diorite. North-east of Mount Deongwar, the formation is folded into a northerly plunging, tight syncline with limbs dipping from 60° to vertical. The structure is complicated by faults both parallel and normal to the axis of the syncline.

Biostratigraphy and age

The following fossils are known from the formation (after Campbell, 1952):

Brachiopods — *Terrakea solida* (Etheridge & Dunn), *Terrakea fragilis* (Dana), *Strophalosia* sp., *Cancrinella* sp., *Streptorhynchus* sp., *Martiniopsis* sp.

Bryozoans — *Polypora* sp., *Fenestella* sp., *Stenopora* sp.

Rugose corals — *Euryphyllum mantuani* Campbell, *Euryphyllum parallelum* Campbell, *Euryphyllum* sp.

Tabulate corals — *Thamnopora wilkinsoni* Etheridge, *Cladochonus* sp.

Bivalve molluscs — *Glyptoleda buarabae* Campbell, *Aviculopecten subquinquelineatus* (McCoy).

As Australian marine Permian faunas were last intensively investigated in the 1970s, this fauna needs to be restudied. Runnegar (1969) suggested equation of the assemblage with Fauna IV (Dickins, 1964) of possible early Late Permian age, but only on the grounds of the presence of *Terrakea solida*. In summary the mid-Permian age proposed by Campbell (1952) is retained.

Stratigraphic relationships

The formation conformably overlies the Hampton Road Rhyolite, and is conformably overlain by the Box Gully Formation. It is intruded by 'Champion Hills Diorite' and unconformably overlain by an outlier of the Neara Volcanics on its northern margin and by the Woogaroo Subgroup to the west.

Correlation with other units

The unit is probably a correlative of the South Curra Limestone in the Gympie area and is approximately the same age. The presence of white to light grey-green, partly silicified limestone, dark grey to olive shale, light grey to brown lithic labile calcareous sandstones, and green to dark green ashy and vitric tuff in PS Baylam 1 and PS Lockrose 1 wells suggests that these wells may contain the Biarraville Formation or a correlative. PS Lockrose penetrated white dense silicified limestone, dark grey blocky pyritic shale and siltstone, light grey to grey-green medium-grained lithic labile sandstone which may be part of this unit.

Box Gully Formation

Introduction

The Box Gully Formation is a name originally established by Campbell (1952) for a sequence of predominantly conglomerate and arenite in the vicinity of Box Gully, a tributary of Buaraba Creek. The name was formalised in Cranfield & others (1976).

Distribution

The Box Gully Formation is mostly exposed around Buaraba Creek on ESK. A small outcrop occurs on Buaraba Creek (South Branch) in the Mount Cross Inlier. Three areas have been tentatively assigned to Box Gully Formation between Kipper and Well Station, north-west of Esk.

Topographic expression

The formation occupies an area of 20km^2, varying from steep rugged boulder strewn slopes to undulating hills between 200–400m above sea level.

Geophysical expression

Magnetic response over the unit is variable. In the vicinity of Buaraba Creek the magnetic response is probably influenced by underlying volcanics and intrusive rocks with a higher magnetic susceptibility. On the K–Th–U (rgb) ternary radiometric image the response is mottled purple-pink tones.

Lithology

The formation consists predominantly of granule and pebble conglomerate and arenite with minor siltstone, shale and andesitic volcanics. The conglomerate, which grades into arenite, consists of angular to subrounded pebbles of black and grey quartz, pink rhyolite, metamorphics, and arenite set in a sandy matrix. The arenite is black to grey, even-grained and non-calcareous; fine-grained beds are carbonaceous in places. Vesicular grey-green andesite and agglomerate is locally interbedded with the arenite and shale.

Environment of deposition

The interbedded conglomerates and arenites point to a shallow shelf or perhaps a continental environment of deposition.

Thickness

The Box Gully Formation is ~1200m thick in the vicinity of Buaraba Creek.

Structure

In the vicinity of Buaraba creek the Box Gully Formation outcrops with a general north-east to south-west strike. Within the zone of outcrop dips vary from 10–90° and folding occurs about north-east trending axes. Locally, fault blocks rotate the strike to a north-westerly trend (Hegarty, 1981). In the Mount Cross area the unit dips at ~30–50° to the north and north-east (Stegman, 1982). Between Kipper and Well Station dips are variable due to more complex faulting and folding of the Permian units in the area.

Biostratigraphy and age

In the absence of fossil evidence the formation is tentatively assigned the same age as the underlying Biarraville Formation, i.e. mid-Permian.

Stratigraphic relationships

The unit conformably overlies the Biarraville Formation, and is conformably overlain by the Buaraba Mudstone. In the vicinity of Buaraba Creek, the unit is intruded by Triassic feldspar porphyrite, quartz diorite, and diorite. The 'Champion Hills Diorite' and 'Buaraba Granodiorite' and 'South Buaraba Microdiorite' and unit PRg intrude the unit to the south of and within the main outcrop area. In the north it is unconformably overlain by an outlier of Neara Volcanics near Well Station and the Woogaroo Subgroup unconformably overlies the unit to the west of Buaraba Creek and in the Mount Cross area.

Correlation with other units

There are no known correlatives in south-east Queensland. The unit may be stratigraphically at about the same level as the Tamaree Formation in the Gympie area.

Buaraba Mudstone

Introduction

Campbell (1952) erected this name for a mudstone sequence with minor interbedded arenite and conglomerate cropping out to the south of Buaraba Creek. The sequence in GSQ Ipswich 19-22R consists of a uniform dark grey mudstone with conspicuous jointing and calcareous veining. Allen (1972) referred to this sequence as Buaraba Mudstone based on its lithology and spore age.

Distribution

The unit crops out over an area of 8km^2 in the vicinity of Buaraba Creek, 2km^2 in the north of the Mount Cross area, 3km^2 in the Alice Creek area, and 2km^2 in the Paradise Creek area.

Topographic expression

The unit forms low undulating hills from 120–240m above sea level in the vicinity of Buaraba Creek, and occupies the creek bed and lower slopes in the Alice Creek and Paradise Creek areas up to 280m. In the Mount Cross area the Buaraba Mudstone forms hilly country 400–500m above sea level.

Geophysical expression

The unit generally has a low magnetic response in the vicinity of Mount Cross, Paradise Creek and Alice Creek and occurs as light tones on the K–Th–U (rgb) ternary radiometric image where outcrop is extensive enough to not be masked by the surrounding Woogaroo Subgroup response. South of Buaraba Creek the magnetic response is influenced by a broad intermediate response probably from underlying more highly magnetic intrusive rocks.

Lithology

South of Buaraba Creek the predominant rock type is mudstone which is black or brown, in part carbonaceous, and usually massive. In places it is rhythmically interbedded with arenite. Minor conglomerate bands similar to those of the underlying Box Gully Formation, and vesicular andesite also occur in some parts of the unit. Allison (1992) found burrows in mudstone and plant fragments at several localities.

In the Mount Cross, Paradise Creek and Alice Creek areas fine-grained sediments are probably either correlative with the Buaraba Mudstone south of Buaraba Creek, or form part of that unit. In the Paradise Creek area, Skerman (1973) described green-grey to dark grey mudstone, siltstone, interbedded tuff, a porphyritic andesite, andesitic breccia, and minor chert. Pan continental (ATP 3820M) mapping of the area suggests that there are more volcaniclastic sediments (including some rhyolitic and andesitic tuffs) in the sequence than suggested by Skerman. In the Alice Creek area mapping by Pan Continental (ATP 3820M, CR16596) shows similar rock types to those in Paradise Creek. The majority of the Alice Creek area consists of light grey to dark grey tuffaceous siltstones, arenaceous volcaniclastics and tuff and fine-grained volcanic-derived sediments. Grey to dark grey siltstone is also present, but is much less than in the Paradise Creek section.

Andesitic volcanics occur in Paradise Creek at AMG 413500, 6963600 and in a tributary at AMG 412200, 6964600. In Alice Creek, a porphyritic andesite flow occurs at AMG 415000, 6961150. This andesitic flow may be a correlative of the andesitic volcanic marker identified by Campbell (1952) in the Buaraba Mudstone south of Buaraba Creek. To the south of the andesitic volcanics in the Paradise Creek inlier, marine fossils occur at four localities and either form two separate marker beds or a single marker beds repeated by folding. In the Alice Creek area marine fossils have been located in a similar stratigraphic position relative to an andesite. In the Buaraba Mudstone south of Buaraba Creek worm burrows were identified in a similar stratigraphic position relative to an andesite horizon described by Campbell (1952).

Environment of deposition

The presence of crinoids, fenestellids and worm burrows in at least one marker bed in the Buaraba Mudstone indicates marine shallow water ?shelfal deposition. Carbonaceous matter in the mudstone is indicative of nearby terrestrial depositional environment.

Thickness

The maximum thickness of the unit is unknown due to onlap by the Woogaroo Subgroup; ~1200m was suggested as the thickness of exposure in the type section by Cranfield & others (1976).

Structure

South of Buaraba Creek rocks from the unit dip generally between 30°–60° on the southern flank of a broad south-east plunging anticline. In the east, to the south of Verandah Creek, dips of between 40–90° indicate localised folding and possible faulting with a north-east trend (Hegarty, 1982; Irvine, 1987). In the Mount Cross area steep southerly dips occur in siltstones with minor conglomerate interbeds. East-west faulting disrupts bedding. Rhyolites diorites and serpentinites have been intruded along these faults. Magnetometer surveys across the serpentinite indicate steep southerly to vertical dips (Smith, 1974; Stegman, 1982).

In the Alice Creek area dips generally vary between 20–50° towards the south and south-east. In the Paradise Creek area in the north, dips are between 60–90° towards the south-south-west, decreasing towards the south. Skerman (1973) identified open folding, with fold axes trending ~320°, south of the andesitic volcanics. In GSQ Ipswich 19-22R Gray (1975) tentatively identified bedding dips of 30–40°.

Biostratigraphy and age

The Buaraba Mudstone was assigned a mid-Permian age by Cranfield & others (1976). De Jersey (1973b) identified Permian miospores in shale samples from 766 and 854m in GSQ Ipswich 19-22R. This unit is probably either correlative with the Buaraba Mudstone, or forms part of that unit.

In the Paradise Creek area Skerman (1973) found worm burrows and crinoids at AMG 412100, 6964150, crinoids at AMG 412550, 6963400 in siltstones and fenestellids and crinoids at AMG 413150, 6963450 in fissile mudstone (location accuracy 150m). Lindsay (1986) collected a crinoidal mudstone sample from AMG 412200, 6965100. Allison (1992) found burrows and plant fragments in mudstone at several localities, and located *Conularia* at AMG 428650, 6970170 south of Buaraba Creek. Ross (1986) identified bioturbation and worm burrows in a siltstone at AMG 419300, 6964400, on Alice Creek north of Mount Cross. In the Alice Creek area Missen (1975) located marine fossils and wood fragments at AMG 414300, 6960200. These were later described by McClung (1977) as Brachiopoda – *Terrakea elongata?*, Bryozoa – *Denmeadopora?* sp., and Gastropoda – *Mourlonopsis strzeleckianan*. Gibson (1975) located marine fossils in the Buaraba Mudstone in the Mount Cross area at AMG 421200, 6964300. These were described by McClung (1977) as Bivalvia – *Aviculopecten* sp. indet., Bryozoa – *Denmeadopora?* sp., Coelenterata – *Thamnopora* sp. and several types of crinoid columnals, including large eliptical forms whose maximum diameter is >10mm. McClung assigned a probable Late Permian age to the fossils. The Buaraba Mudstone has been assigned a Late Permian age on fossil evidence.

Stratigraphic relationships

The unit conformably overlies the Box Gully Formation in the vicinity of Buaraba Creek and is unconformably overlain by the Woogaroo Subgroup. The formation is intruded by Triassic 'Champion Hills Diorite' and 'Buaraba Granodiorite', and is overlain by Triassic rhyolite in the vicinity of Buaraba Creek. Buaraba Mudstone in the northern part of the Mount Cross inlier is faulted with serpentinite, dioritic and rhyolitic intrusions infilling faults (Ross, 1986). The unit has a faulted contact with gabbro of the Mount Cross Igneous Complex to the south. Porphyritic andesite dykes intrude the Alice Creek area. Skerman (1973) considered that the Buaraba Formation conformably overlies Hampton Road Rhyolite in the Paradise Creek area, with the contact being gradational. Interpretation of the regional geology suggests that an extension of faulting from the east, near Mount Cross, should be found at or near the contact. The contact with Hampton Road Rhyolite in Paradise Creek has therefore been interpreted as faulted.

Correlation with other units

The Buaraba Mudstone has no known correlatives. It may be the unit outlined by Allen (1972) at the base of GSQ Ipswich 19-22R near Toowoomba. It appears to be younger than units near Gympie as the unit contains mid–late Permian miospores.

MESOZOIC BASINS

ESK TROUGH

The sequence of the Esk Trough in this area includes the Esk Formation, Gayndah Formation and the Neara Volcanics. Table 3 summarises units of the Esk Trough in the mapped area.

Units comprise the Esk Formation, Gayndah Formation and variants of the Neara Volcanics.

The Bryden Formation mentioned in the following discussion occurs to the east of the mapped area on NANANGO.

Gayndah Formation (Rtg)

Introduction

Ellis (1968) first described this unit as the "Gayndah beds", a sequence of conglomerate, sandstone, siltstone, shale and coal in the vicinity of the township of Gayndah. The unit was upgraded to formation status and defined by Cranfield (1989). A complete section of the unit was cored in GSQ Maryborough 1 (Cranfield, 1979).

Distribution

The bulk of the unit occurs on the MARYBOROUGH 1:250 000 Sheet. However, small extensions of the unit occur further south on the GYMPIE 1:250 000 Sheet. These include a 2km wide north trending belt mapped east of Windera, as well as irregular areas in the north-eastern corner of MURGON and adjacent parts of GOOMERI, and immediately south-west of Boonara in the north-western part of GOOMERI.

Table 3: Units of the Esk Trough

Unit	Symbol	Lithology	Age	Relationships	References
Neara Volcanics	Rtn	volcaniclastic conglomerate, andesite, sandstone	Early–Middle Triassic	the Esk Formation appears to be overlain by the Neara Volcanics (although the contact is now faulted), suggesting a diachronous facies-style relationship between the two units over the length of the basin	Cranfield & others, 1976; Hill & Tweedale, 1955; Hill,1960; Murphy & others,1976; de Jersey, 1972
	Rtn_a	andesite lava, breccia, pyroclastic and epiclastic deposits; minor shale and siltstone	Early–Middle Triassic		this report
	Rtn_b	andesitic pebble to boulder conglomerate	Early–Middle Triassic		this report
	Rtn_{cg}	medium to mainly thick bedded volcaniclastic arenite, interlayed with dominantly andesitic pebble to cobble conglomerate; subordinate siltstone and mudstone interbeds	Early–Middle Triassic	conformably underlies Rtns, Rtnb; most rock types are common to all three units	this report
	Rtn_s	mudstone, siltstone laminae; conglomerate	Early–Middle Triassic	overlies Gayndah Formation conformably	this report
Esk Formation	Rte	polymictic pebble to boulder conglomerate, feldspathic sandstone, shale, minor acid tuff	Early–Middle Triassic; miospores from GSQ stratigraphic wells in the Ipswich 1:250 000 map sheet area	on GOOMERI and NANANGO faulted and overlain by Neara Volcanics; faulted or unconformably overlain by Tarong beds; unconformably overlies or faulted against Maronghi Creek beds; faulted against Bjelke Petersen beds; unconformably overlain by Main Range Volcanics, Oakdale Sandstone and unnamed Tertiary sediments; intruded by phases of the Tarameo Igneous Complex and Brisbane Valley porphyrites; on ESK faulted against the Cressbrook Creek Group, and the Eskdale Granodiorite; unconformably overlain by the Triassic to Jurassic Woogaroo Subgroup south of Esk	Cranfield & others, 1976; Hill & Tweedale, 1955; Hill,1960; Murphy & others, 1976; de Jersey, 1972
Gayndah Formation	Rtg	lithic labile, sublabile and quartzose sandstone, polymictic conglomerate, siltstone, shale	Early–Middle Triassic based on miospores	underlies units of the Neara Volcanics with apparent conformity; intruded by Triassic rhyolite sills and plugs, and is unconformably overlain by elements of the Aranbanga Volcanic Group	Ellis,1968; Cranfield, 1979,1994; de Jersey, 1979

Topographic expression

The unit occurs as rubbly, moderately-timbered strike ridges.

Geophysical expression

The unit forms mottled dark brown tones on AIRDATA radiometric images, and has a low to very low magnetic response on AIRDATA magnetic images.

An exception is the small area on the northern junction of GOOMERI and MURGON, which has a moderate magnetic response, perhaps due to the presence of igneous dykes or sills intruding the sequence.

Lithology

The sequence is dominated by coarse clastic deposits, mainly thick bedded, polymictic, granule to pebble (or occasionally cobble) conglomerates with scattered medium to thick arenaceous interbeds and rare mudstone bands. Sedimentary clasts (mainly chert, jasper, vein quartz, quartzite, quartz arenite, silstone, rare coarse quartz grit/breccia) predominate with other rock types (rhyolite, andesite and basalt) being subordinate. Clasts of aplite and biotite microgranite occur rarely. Clast imbrication and grading occur only rarely within the conglomerates.

The arenites are mainly lithic in composition, containing grains of meta-argillite, siltstone, chert, quartz, and quartzite commonly enclosed in a secondary calcite cement. Volcanolithic arenite occur locally where the arenites contain significant amounts of andesitic and basaltic detritus. Rare quartzose arenites have also been recorded from the formation. The unit is brecciated in the north-eastern corner of MURGON and the passage of hydrothermal fluids has produced a zone of limonite-haematite-carbonate breccias near AMG 39980, 7022500.

Environment of deposition and provenance

The unit is dominated by coarse clastics dumped in alluvial fans sourced from adjacent uplifted ranges consisting of Devonian–Carboniferous accretionary wedge basement rocks and later Permian intrusions.

Thickness

The unit is <200m thick.

Structure

On MURGON, the sequence dips at moderate to shallow angles (mainly to the west).

Biostratigraphy and age

Miospores from GSQ Maryborough 1 are from the *Duplexisporites problematicus* zone (de Jersey, 1979), indicating an early Middle Triassic age.

Stratigraphic relationships

On MURGON and GOOMERI, the Gayndah Formation underlies units of the Neara Volcanics with apparent conformity. The unit is intruded by Triassic rhyolite sills and plugs, and is unconformably overlain by elements of the Aranbanga Volcanic Group.

Correlation with other units

The unit is probably a correlative of the lithologically similar Esk Formation.

Esk Formation (Rte)

Introduction

Cranfield & others (1976) undertook the most extensive mapping of the unit. These authors upgraded the "Esk Shales" of Hill & Tweedale (1955) and "Esk Beds"of Hill (1960) to formation status, proposing the term "Esk Formation". The early nomenclatural history of the unit is summarised in more detail by Cranfield & others (1976). The current mapping extensively revises the boundaries of the unit on MURGON, whereas further south more limited reconnaissance and airphoto interpretation has enabled only broad changes to be made to the mapping of Cranfield & others (1976).

Distribution

On MURGON, the Esk Formation is exposed in the Cherbourg area and for ~8km northwards as a narrow belt flanking both sides of a north-trending, uplifted basement wedge mapped as the Bjelke Petersen beds. The Esk Formation also occurs further east along the western margin of GOOMERI, where it forms a 7km wide north-north-west trending belt forming the western margin of the Esk Trough. The Esk Formation also occupies this position further south on NANANGO.

Topographic expression

On MURGON, the unit is moderately well exposed in creeks and road cuts, and forms low rolling hills and ridges. Further east on GOOMERI and NANANGO, the unit forms a well-defined series of low parallel ridges.

Geophysical expression

The unit forms mottled mid-brown tones on AIRDATA radiometric images. On AIRDATA magnetic images, the unit has a low magnetic response.

Lithology

On MURGON, the unit consists of brown to khaki, medium to thick-bedded conglomerate

and intercalated arenite. The conglomerates contain granules to pebbles or cobbles of quartzite, vein quartz, chert, indurated siltstone and minor andesite set in a lithic labile matrix. The arenites are lithic in composition, containing grains of chert, meta-argillite, quartz, and plagioclase with rare quartzite grains and biotite flakes. In rare cases the conglomerates exhibit clast imbrication or show evidence of large-scale current bedding, scouring into the underlying arenites. On ESK this unit is similar and contains quartz-lithic arenites. The latter are typically clast-supported and comprise subrounded to subangular clasts of metamorphic quartz (60%, 1–2mm), altered chloritised volcanic rock fragments (30%, 2–3mm) and fresh angular to subangular plagioclase (5–7%). The matrix is composed of fine-grained chloritic clays and detrital zircon forms a common heavy mineral.

Environment of deposition and provenance

The coarse clastics of this unit were deposited in a rapidly subsiding intermontane basin. Contemporaneous vulcanism is indicated by the presence of tuffs and tuffaceous arenites in the southern part of the Esk Trough. The clastics were derived mainly from Devonian–Carboniferous accretionary wedge basement rocks and later Permian intrusions.

Thickness

On NANANGO and GOOMERI, the Esk Formation averages ~3000m thick. Further south on ESK, the unit thins to ~300m near Esk.

Structure

The sequence in the Cherbourg area dips gently to the north-west, while further east on GOOMERI the unit dips moderately to the east and is faulted against the overlying Neara Volcanics occupying the central part of the Esk Trough. Further south, in the central and southern part of the Esk Trough, the unit has been folded into a number of subhorizontally-plunging anticlines and synclines.

Biostratigraphy and age

The Esk Formation contains a rich macrofloral assemblage, including *Dicroidium* sp., *Cladophlebis* sp., *Pterophyllum* sp., *Shizoneura* sp., *Taeniopteris* sp. and *Ginkoites* sp. (Murphy & others, 1976), all indicative of a Triassic age. De Jersey (1972) established that microfloral samples from the top of the sequence on Ipswich 1:250 000 Sheet were early Middle Triassic in age. In view of this evidence, Murphy & others (1976) considered the unit to be most likely of Early to Middle Triassic age.

Stratigraphic relationships

The Esk Formation on GOOMERI and NANANGO is in fault contact with the structurally overlying Neara Volcanics. However, on the Ipswich 1:250 000 Sheet area, the Esk Formation overlies the Neara Volcanics with apparent conformity. The Esk Formation is faulted against or is unconformably overlain by the Late Triassic Tarong beds. The unit unconformably overlies or is faulted against the Devonian–Carboniferous Maronghi Creek beds. East of Murgon, the unit is faulted against the older Carboniferous Bjelke Petersen beds and is unconformably overlain by the Tertiary Main Range Volcanics, Oakdale Sandstone and unnamed Tertiary sediments.

The Esk Formation is intruded by phases of the Tarameo Tonalite and by porphyritic intrusive rocks of dacitic to microdiorite composition (the 'Brisbane Valley porphyrites') of Triassic age and Jurassic–Cretaceous hornblende microdiorites to the east of the mapped area.

On ESK and NANANGO, the Esk Formation is faulted against the Permian Cressbrook Creek Group, and the Permian–Triassic Eskdale Granodiorite, and is unconformably overlain by the Triassic to Jurassic Bundamba Group to the south of Esk village.

Correlation with other units

The Esk Formation as mapped in this area may be a lithological correlative of the Gayndah Formation. Stratigraphically it underlies the Neara Volcanics, and Campbell & others (1999) considered that in general the Esk Formation (mainly mapped in the Gympie 1:250 000 Sheet area) conformably overlies the Neara Volcanics and equates with the Bryden Formation on the eastern side of the Esk Trough. This model does not explain why the Esk Formation in the type area *overlies* the Neara volcanics. Possibilities are that rocks equated with the Esk Formation in the Gympie sheet area are laterally equivalent with the Gayndah Formation. This would indicate that similar sequences near Esk and further north are not age equivalents and that the suggestion by Cranfield (1973) that all units of the Esk Trough are lateral facies equivalents is correct.

Neara Volcanics (Rtn, Rtn_s, Rtn_b, Rtn_{cg}, Rtn_a)

Introduction

The first formal study of the unit was undertaken by Hill (1930) who applied the term "Lower Esk Series" to the sequence. Bryan & Jones (1946) subsequently replaced this term with the name "Neara Series". Hill & Tweedale (1955) proposed the term Neara Volcanics, which was adopted by Murphy & others (1976) who mapped the volcanics exposed within the Esk Trough on the Gympie 1:250 000 Sheet area. Cranfield & others (1976) subsequently defined the type area within the southern extension of the Esk Trough on the Ipswich 1:250 000 Sheet area.

Distribution

The Neara Volcanics are exposed mainly within a north-north-west trending deformed basin (the Esk Trough) up to 25km wide and over 120km along, separating basement rocks of the North D'Aguilar Subprovince from probable equivalents in the Yarraman Subprovince. On MURGON, the Neara Volcanics extends beyond the Esk Trough, being exposed to the west as far as Windera as linear or circular erosional remnants beneath the overlying Aranbanga Volcanic Group.

Topographic expression

Immediately north of Murgon, the unit forms recessive low terrain, where exposure is mainly limited to road cuttings and lateritic weathering is widespread. Further north, east of Double Knob, the unit is better exposed, forming low hills and valleys that are generally more recessive than the overlying Aranbanga Volcanic Group. The unit has no distinctive airphoto pattern on MURGON, but does tend to be less densely wooded than adjacent units. To the east on GOOMERI, the unit forms elevated sparsely wooded terrain commonly dominated by linear north-trending ridges.

Geophysical expression

The boundaries of the Neara Volcanics on MURGON have largely been mapped from AIRDATA radiometrics images, where the unit forms a cohesive dark brown tone on standard RGB images. The unit has a patchy, low to sometimes-moderate magnetic response on AIRDATA magnetic images.

Lithology

Undivided Neara Volcanics (Rtn): On MURGON, this unit only exists as a very small area 10km east-south-east of Windera. However, most of the exposed Neara Volcanics in the Esk Trough remains undivided on the GOOMERI, NANANGO and ESK. On MURGON, the unit consists of interbedded andesitic volcaniclastic sediments (conglomerate, arenite and shale) and andesitic volcanics similar to those described in the subunits below. On ESK the unit comprises flow-banded volcanics and volcaniclastic sediments. An outlier of the unit on the western margin of the Eskdale Granodiorite is characterised by abundantly porphyritic andesite. At this locality the andesite contains strongly altered and saussuritised plagioclase phenocrysts with clinozoisite cores (~50%, to 3mm), altered green–brown hornblende (5–7%), and rare chlorite and epidote within a strongly altered groundmass of plagioclase, quartz, epidote and opaques.

Subunit Rtn_s

This subunit has been mapped in three main areas:

(i) as a 2km wide north-trending belt east of Windera,
(ii) as a small but well exposed sliver south of the Crownthorpe road on north-east MURGON, and
(iii) as a narrow north-north-west trending belt in the south-western part of GOOMERI (outside YARRAMAN).

This subunit represents a period of dominantly epiclastic deposition marked by periodic influxes of terrigenous material. The main rock type is medium to locally coarse-grained volcaniclastic arenite consisting of andesitic lithic detritus and feldspar crystals. The deposits are mainly medium to thick-bedded with bedding only locally visible as trains of andesite fragments and quartzite granules or pebbles. In places, these layers occur as much thicker conglomerate beds up to 2m thick, containing pebbles to cobbles of andesite, basalt and rare fine quartzite. The sequence also contains minor andesitic tuff as well as scattered thin to medium beds of carbonaceous mudstone grading into fine siltstone.

A gently dipping well-exposed section of sediments (assigned to Rtn_s) occurs 6km north-north-west of Boat Mountain. At this locality a 15m thick basal sequence of interbedded arenites and polymictic conglomerates dominated by terrigenous material is overlain by

60m of volcaniclastic arenite. Traction current effects are rare, although the conglomerates show crude local imbrication and the thick upper arenite sequence exhibits low angle planar cross-stratification in places. The conglomerates are clast to matrix supported, and poorly to moderately well sorted and contain mainly rounded pebble sized clasts.

Sedimentary clast types predominate (mainly quartzite, chert, jasper, siliceous fine-grained dark grey arenite and occasionally coarse-grained quartz grit), with only minor volcanic/igneous clast types (mainly pink or grey rhyolite, andesite, basalt and rare pink granite). The arenites intercalated with the conglomerates contain ~70% non-volcanic material (mainly grains of chert, fine meta-argillite, quartzite, igneous and metamorphic quartz grains, and rare limestone grains) with the remainder mainly volcanic-derived material (andesite and basalt grains). The volcanic proportion of the thick overlying arenaceous sequence increases to ~75%, before passing upwards into the andesitic boulder beds of subunit Rtn_b.

Subunit Rtn_{cg}

This subunit has been mapped in two areas:

(i) from Murgon north into the Oaky Creek area, occupying over 40km^2, and
(ii) within a 2–5km wide belt extending from just east of Boat Mountain for ~12km north-north-westward into the Redbank Creek area.

The unit consists mainly of thick conglomerate beds intercalated with volcanolithic to lithic arenite, andesitic lava and tuff and minor siltstone and shale. The conglomerates range from oligomictic (dominated by andesite pebbles or more rarely boulders) to polymictic in composition, even within the one outcrop. Clasts of quartzite, chert, siliceous arenite, and indurated mudstone with rare rhyolite and pink fine-grained granite clasts dominate the polymictic conglomerates. The lithic arenites are dominated by grains of chert, silstone, mudstone and fine greywacke, with some igneous and metamorphic (mono and polycrystalline) quartz grains and occasional grains of basalt/andesite.

These rocks grade into oligomictic conglomerates and volcaniclastic arenites with increasing content of andesite-sourced detritus. This is reflected in the volcanic-derived chloritic clay matrix. Significant amounts of secondary calcite cement (up to 15%) occur throughout the sequence. Calcite cement has locally replaced original volcanic clasts. Sedimentary structures, such as grading and crude clast imbrication, occur only rarely throughout the sequence.

The unit stratigraphically underlies units Rtn_s and unit Rtn_b, although many of the constituent rock types are common to all three units. Unit Rtn_{cg} differs from unit Rtn_s in being more poorly bedded, containing a significant amount of andesitic tuff and lava (rare in Rtn_s), as well as a higher overall abundance of lithic clastic detritus than Rtn_s (dominated by volcaniclastic detritus). The transition into unit Rtn_b is marked by an abrupt influx of very thick, massive coarse andesitic-clast conglomerate.

Subunit Rtn_a

This subunit has been mapped in two main areas immediately east and west of Murgon. Small areas have also been mapped east of Windera and in the Rosemary Creek area in the north-east corner of MURGON. The unit registers as very dark brown tones on AIRDATA radiometric images.

The unit consists of andesitic lava, breccia, with pyroclastic and epiclastic desposits. Minor shale and siltstone has also been recorded within the unit. The lavas are massive and finely to coarsely porphyritic in feldspar and locally also in hornblende. Current bedding has been observed within epiclastic arenaceous deposits on Barambah Creek immediately south of Murgon.

Subunit Rtn_b

The unit forms massively-bedded sequences up to 100m thick, exposed north and south of the Crownthorpe road, south-west of Rosemary Island in the north-eastern corner of MURGON, and as a small sliver exposed within the dome east of Windera.

The unit forms dark brown tones on AIRDATA radiometric images, generally indistinguishable from adjacent units Rtn_a, Rtn_s, and Rtn_{cg}. The conglomerates ('andesitic boulder beds') that dominate the unit are the most common rock type within the undivided Neara Volcanics mapped to the east on GOOMERI and NANANGO, but have not been separated out as a unique unit in these areas.

On MURGON, subunit Rtn_b consists mainly of massive, brown, weathered, broadly oligomictic, pebble to cobble (and sometimes boulder) conglomerate, containing between 75–100% of porphyritic andesite clasts. Other clast types include quartzite, chert, indurated siltstone and fine arenite, together with rare quartz grit/brec-

cia, jasper, grey to pink rhyolite, basalt, and pink fine- to coarse-grained biotite granite. The clasts are generally well rounded and locally imbricated. The conglomerates are mainly very thick-bedded with little internal structure, although scattered arenaceous beds (up to 30cm thick) and, more rarely, mudstone bands occur locally. The finer conglomerates tend to be more matrix supported than the coarser varieties, and are more likely to contain arenaceous bands. The latter commonly contain quartz pebbles or grit fragments either scattered throughout or confined to bedding planes. The arenites are mainly lithic in composition containing grains of siltstone, fine greywacke, and chert with occasional andesite and basalt grains.

Environment of deposition and provenance

The sequence probably represents a series of overlapping alluvial fans deposited in a linear basin. Most of the material was derived from erosion of a nearby contemporaneous continental calc-alkali volcanic arc, with a small input from Palaeozoic basement rocks of the North D'Aguilar and Yarraman Subprovinces. Part of the material was probably derived from volcanic mudflows (lahars) down steep-sided volcanic edifices. Further alluvial transport produced significant rounding of the pebble to boulder-sized clasts in the conglomerates.

Thickness

Faulting and folding make estimation of thickness difficult, but the unit is likely to be of the order of 2000m thick.

Structure

The bulk of the unit is exposed on GOOMERI and NANANGO within the Esk Trough, where the sequence is moderately folded about subhorizontal, north or north-north-west trending axes (Murphy & others, 1976).

On MURGON, the unit is exposed north of Boat Mountain in the core of a broad north-north-west trending anticlinal flexure, and dips at moderate to shallow angles to the east or west. Immediately east of Windera, the unit is exposed in the core of a dome created by intrusion of a circular rhyolite body.

Biostratigraphy and age

Extensive macrofloral collections that indicate a Triassic age have been obtained from shales of the Neara Volcanics within the Esk Trough, and the details of these are contained in Murphy & others (1976). Irwin (1973) obtained K–Ar radiometric ages of 236 and 237Ma from volcanics in the Kinbombi area on GOOMERI.

In the IPSWICH 1:250 000 Sheet area, the underlying Bryden Formation and the overlying Esk Formation contain early Middle Triassic microfloras (de Jersey, 1972;1973b). From this evidence, Murphy & others (1976) assigned a probable Early to Middle Triassic age to the unit.

Stratigraphic relationships

In the southern part of the Esk Trough, the Neara Volcanics are conformably underlain by the Bryden Formation on the east side of the basin, and overlain by the Esk Formation on the western side. However, further north on GOOMERI, the Esk Formation appears to underlie the Neara Volcanics (although the contact is now considered to be faulted), suggesting a diachronous facies-style relationship between the two units over the length of the basin.

The Kingaham Creek Granodiorite and scattered small-unnamed Triassic granitoids intrude the Neara Volcanics at various localities throughout the Esk Trough, along with andesite and rhyolite sills and dykes. Along the eastern margin of the Esk Trough, the Neara Volcanics unconformably overlie a number of Palaeozoic basement units belonging to the North D'Aguilar Subprovince (Marumba beds, Claddagh Granodiorite and Mount Clara beds).

On GOOMERI and MURGON, the Neara Volcanics are interpreted to overlie the Gayndah Formation (a probable Bryden Formation equivalent), and are concordantly overlain by the Aranbanga Volcanic Group. Almost all areas of unit Rtn_b are confined to the topmost stratigraphic level of the Neara Volcanics, immediately underlying the Aranbanga Volcanic Group. In places, the conglomerates appear to be interlayered with rhyolites of the Aranbanga Volcanic Group, but as Cranfield (1994) established an unconformity between these two units, the rhyolites have been interpreted as post-depositional sills.

Sediments of the Tertiary Oakdale Sandstone and basalts of the Main Range Volcanics unconformably overlie the Neara Volcanics.

Correlation with other units

The Neara Volcanics are equivalent to the Mount Marcella Volcanics mapped to the north on the Maryborough 1:250 000 Sheet area

(Cranfield, 1994). The unit in this area is more volcaniclastic than volcanic in composition.

TARONG BASIN

Unnamed Triassic sediments were recognised within the Yarraman Subprovince but the name Tarong Basin was first used by Day & others (1974) in describing this Late Triassic coal basin of south-east Queensland. The basin contains only one stratigraphic unit — the Tarong beds.

Tarong beds

Introduction

Hill & Tweedale (1955) first used the name Tarong beds for the Triassic sediments identified west of Yarraman and Nanango. Day & others (1974) discussed the regional geology of the Tarong Basin and it was summarised by Murphy & others (1976). Flood (1983), Garces & Flood (1984), and Garces (1985) used standard basin analysis techniques, as described by Miall (1983,1984), to undertake detailed sedimentological studies of the basin. Flood & Garces (1986) and Pegram (1986, 1995) summarised the geology and structure of the Tarong Basin.

Distribution

The Tarong basin is a NNW–SSE trending basin of ~75km in length and ~10km in width, located ~10km west of Nanango and a few kilometres west of Yarraman on KINGAROY. Smaller areas of probable Tarong Basin sediments, forming a roughly linear belt, have been identified ~15km north of Nanango on NANANGO, further north on GOOMERI and extending north to ~3km west of Lake Barambah on MURGON. Some of these sediments were considered to be Tertiary in age by Murphy & others (1976).

Topographic expression

The Tarong Basin sediments form gently rolling to moderately steep country. Aerial photographs show a characteristic steep sided drainage pattern for the unit especially in the Cooyar Creek area.

Geophysical expression

The airborne radiometric signature of the Tarong Basin sediments on the ternary image is characterised by a light mottled white colour though subtle variations occur depending on the location within the basin. West of Nanango the white-yellow-orange radiometric signature is similar to the adjoining Boondooma Igneous Complex, from which much of the clastic material was derived. Further south the signature changes to a mottled white-green-purple and is similar to the adjacent Sugarloaf Metamorphics and Maronghi Creek beds. In areas where the rocks have been weathered the signature has elevated green and blue colours.

The unit has a low magnetic response indistinguishable from the similarly low magnetic responses of the Boondooma Igneous Complex, Sugarloaf Metamorphics and Maronghi Creek beds. The Tarong Basin is also characterised by a low gravity response.

Lithology

The Tarong Basin is made up of clastic sedimentary rocks ranging in grainsize and bedding characteristics from laminated mudstone to massive cobble-boulder polymictic conglomerate. The basin contains significant economically important coal reserves that are currently being exploited at Meandu Mine for power generation. Other coal resources are known from the Kunioon area south of Kingaroy. Flood & Garces (1986), summarised the sediments of the basin as being composed of massive, matrix supported, debris-flow breccias, massive to thinly bedded clast supported, sheet-flow gravel fan conglomerates, sandy matrix-supported distal-flow conglomerates and horizontally stratified, cross-bedded, trough cross-bedded, planar cross-bedded and massive, distal fan or sandy braid-plain sandstones. Thick deposits of laminated mudstone are also present within the basin, most notably close to the coal deposits, and are interpreted as representing waning flood sedimentation in a lacustrine environment. They most likely correspond to the stone bands present in the coal.

Flood (1983), Garces & Flood (1984), and Garces (1985) using standard basin analysis techniques, as described by Miall (1983,1984), identified three east-flowing transverse alluvial deposits on the western margin of the basin. These were referred to as the Stuart, Tanduringie, and Cooyar 'fans' because of their spatial relationship to the palaeodrainage of the Stuart River, Tanduringie Creek and Cooyar Creek. Sediments of the central Tanduringie 'fan' interdigitate with the Kunioon and Meandu coal deposits that occur on either side of this 'fan'. Flood & Garces (1986) reported that vertical profile analyses of surface expressions and subsurface bore cores suggested the gravelly deposits are of the Scott-type while the sandy deposits are more closely related to the Donjek-type (*sensu* Miall, 1978). The Scott-type

model for braided river deposits consists of roughly horizontally bedded gravels with minor sand wedges whereas the Donjek-type model consists of fining upward cycles of mixed bedload of sand and gravel.

Coarse-grained Facies: Conglomerates within the Tarong Basin represent high-energy fan and braided stream deposits. They increase and dominate near the basin margins and with depth, and appear to increase towards the south (Pegram, 1986). On the western margin of the basin the conglomerates contain significant granitic material sourced from the Permo-Triassic Boondooma Igneous Complex.

A road cut on Cooyar Road (AMG 386255, 7038286) shows a sequence of coarse to very coarse sandstone and pebble to cobble, with occasional boulder, conglomerate. The conglomerate contains a variety of clast types including sandstone, acid volcanics, granite (ranging from microgranite to very coarse mica granite), quartz and chert. Clasts of rhyolite are present in conglomerate exposure at AMG 384739, 7041811 and gneissic clasts occur at AMG 386459, 7040262. Clasts in the conglomerate range from very angular to rounded but are generally sub-angular to sub-rounded.

Closer to the contact with the Boondooma Igneous Complex at AMG 382266, 7035902 abundant well-rounded cobble to boulder granitic clasts are present. The unit is characterised by small-scale trough cross-bedding in road sections from Nanango to Tarong Power Station.

Along the western margin of MURGON ~20km to the north-east of the main Tarong Basin is a sequence of interbedded feldspatholithic sandstone and conglomerate with minor fine-grained sediments assigned to the Tarong beds. This sequence forms a north-north-west-trending outcrop area in the Wondai State Forest to ~3km due south of Cherbourg village in the Cherbourg Aboriginal Reserve. In this area the conglomerate and sandstone beds appear identical to those between Nanango and Tarong. This sequence is well exposed as gently folded sequence in a road cut beside the Burnett Highway (AMG 401389, 7063232), north of Nanango. The polymictic conglomerate at this locality is medium to thick-bedded and contains clasts of quartz, jasper, metasediments, acid volcanics and granite. Clast sizes range from pebble to boulder but are commonly pebble to cobble in size. The conglomerate is slightly subordinate in volume to the sandstone present at this locality. The conglomerate exhibits small scale trough cross-bedding and contain clasts of granite, felsic volcanics, carbonaceous shale and metasediments (including chert) at AMG 395720, 7086863 and 397102, 7084734.

Fine-grained Facies: Sandstones and finer-grained facies are common in the Tarong Basin and were deposited as distal fans or as sandy braid-plains. They also predominate in the main coal bearing areas of the basin and consist of labile poorly sorted sandstones associated with polymictic conglomerates, minor siltstones, mudstones and claystones (Pegram, 1986).

Good exposures of the sedimentary sequences can be seen in a number of road cuts. At a large road cut, south-east of Tarong Power Station (AMG 394635, 7034704), the fine-grained rocks are composed of dark grey fossiliferous mudstone, dark grey siltstone and light grey, fine to medium-grained, moderate to poorly sorted sandstone. They constitute only ~20% of the exposure at this site with the remainder being polymictic conglomerate. The laminated to thin-bedded mudstone shows common plant stem fossils and is often intercalated with siltstone and sandstone. Minor coal bands can also be seen within the mudstone. Laminated to thin-bedded siltstones are common and they also contain carbonised plant fragments. The sandstone is laminated to medium-bedded (fining upwards), pebbly in places, and shows small-scale channel fill structures.

At an outlier of Tarong Basin sediments, north of Nanango (AMG 401389, 7063232), sandstone is the dominant rock type, although significant polymictic conglomerate is also present (see 'Coarse-grained Facies'). Here the sandstone is generally medium-grained, poorly sorted and pebbly in places. Bedding is thin to medium-scale and dips shallowly to the east. Beds commonly show poorly sorted pebbly sandstone at the base fining up to well-sorted fine sandstone at the top.

Environment of deposition

Sediments of the Tarong Basin were deposited in a fresh water fluviatile environment with a significant paludal component (Murphy & others, 1976). Coarse-grained facies were deposited in high-energy alluvial fans and talus-slope debris-flows. Finer-grained sandstones and pebbly conglomerates were deposited in distal fans and braided stream environments.

In the Meandu Mine area finer-grained facies, represented by laminated mudstones, siltstones and very fine-medium sandstones that often exhibit ripple markings (Pegram, 1986), were deposited as interfingering beds within the coal deposits in low energy marshy areas.

Provenance

The unit was derived from erosion of granite from the Boondooma Igneous Complex and metasediments of the Maronghi Creek Beds.

Thickness

Hempton & Dunne (1983) used comparitive sedimentological studies of modern and ancient basins to suggest that pull-apart basins exhibit the relationship:

$$y = 0.08x + 0.26$$

where y is the thickness and x is the 'overlap'.

Using this relationship, Flood & Garces, (1986) calculated a total thickness of 1.86km for the Tarong basin. This estimate of sediment cover was considered reasonable as vitrinite reflectance values of the coal at the surface averaged 0.64%. A similar vitrinite reflectance value can be obtained under ~1km of cover and an average geothermal gradient.

Basin development

Flood & Garces (1986) proposed that during the Late Triassic, three rivers flowed eastwards across a prominent north-south dextral strike-slip fault. Sediment from these rivers was deposited in the newly formed pull-apart basin and generated prograding alluvial fans along the western margin.

On the eastern side of the basin, talus-slope debris-flow deposits were identified by Flood & Garces (1986) and Pegram (1986), and infer the eastern side was fault controlled. Much smaller fans and talus-slope deposits formed along this eastern faulted margin. No fault has been positively identified along the eastern margin and has been inferred from the depositional architecture. Pegram (1986) suggested the proposed fault might be an extension of the fault noted by Murphy & others (1976). During the intermediate stage in basin development it was ~5km wide but continuing dextral movement increased the width to about the current width of 10km. By the time the basin had reached 10km in width the 'overlap', or distance the eastern block had moved south, was ~20km.

Once the basin had reached its maximum separation two distinct depocentres formed with a basement high separating them. These depocentres are well shown in the gravity data. This led to the development of the Kunioon and Meandu coal deposits. The Tanduringie Fan underlies the basement high and at the time of its formation shed sediment both north and south into the depocentres and interfingered with the coal deposits.

Biostratigraphy and age

Murphy & others (1976) summarised the palynological studies undertaken on samples from the Tarong basin and these are presented below. Jones (1947) described flora collected from the Tarong Basin, ~6km south-west of Yarraman as *Phlebopteris* sp., *Dicroidium odontopteroides* (Morris) Gothan, and *Czekanowskia tenuifolia* (Johnston) Jones and de Jersey, and assigned a Late Triassic age to the unit. Later Woods & Dear (1962) described a macroflora including *Equisetites* sp., *Cladophlebis australis* (Morris) Seward, *Dicroidium odontopteroides* (Morris) Gothan, *Taeniopteris spatulata* McClelland, and *Sagenopteris* sp., from ~11km west of Nanango and suggested a Late Triassic to Early Jurassic age. De Jersey & Hamilton (1965) described what they considered as a Late Triassic microflora from sediments beneath Tertiary Main Range Volcanics near Taabinga, ~4km south of Kingaroy. These sediments are considered part of the Tarong Basin and were mapped as such by Murphy & others (1976). De Jersey (1970), following further microflora studies, assigned the Tarong Basin sediments to a Late Triassic (Carnian) age.

Stratigraphic relationships

The Tarong beds unconformably overlie the Maronghi Creek beds and Sugarloaf Metamorphics and part of the Permo-Triassic Boondooma Igneous Complex. The Tarong Beds have been intruded by younger phases of this unit south of the Nyora Clay pit at about AMG 38290, 704440. The Triassic–Jurassic Bundamba Group and the Tertiary Main Range Volcanics unconformably overlie the unit.

Correlation with other units

The Tarong Basin is an age correlative (Carnian) of the Ipswich Basin to the south-east of the mapped area around Ipswich.

CLARENCE–MORETON BASIN

The Surat and Clarence–Moreton Basins contain fluviatile and paludal sediments that in this area range from latest Triassic to Jurassic age. The age of the constitiuent formations and their stratigraphic relationships to units in the Surat Basin were redefined in McKellar (1999).

The term Clarence Basin was widely used in New South Wales for the Mesozoic rocks in the north-eastern corner of New South Wales (McElroy, 1962; 1969). McElroy's definition included Late Triassic rocks of the Nymboida Coal Measures. The term 'Moreton Basin' was first defined by Allen & Hogetoorn (1970) to include only the post-Late Triassic rocks of this basin in Queensland, and knowledge of the stratigraphy of the basin was upgraded during mapping of the Warwick and Ipswich–Brisbane 1:250 000 Sheets (Olgers, 1974; Cranfield & others, 1976). Wells & O'Brien (1994), redefining the whole entity as the Clarence–Moreton Basin defined changes to the stratigraphy of the entity. The Clarence–Moreton and Surat Basins are characterised by gravity lows.

Bundamba Group

Cameron (1905,1907) recognised two coal measure sequences separated by an unproductive sandstone sequence in the vicinity of Ipswich, and named them Ipswich Beds (lower coal measures — now Ipswich Coal Measures of the Ipswich Basin), Bundamba Beds or Grits (unproductive sandstone), and Walloon Beds (upper coal measures). Later Dunstan (1915; 1916) equated the Bundamba "Series" in the Ipswich area with his Helidon "Series"and summarised the local stratigraphy. The Bundamba Group became the basal unit of the Clarence–Moreton Basin.

The Bundamba Group, as redefined by Cranfield & Schwarzböck (1972) in the Clarence–Moreton Basin, consists of the Woogaroo Subgroup and the Marburg Formation. Wells & O'Brien (1994) based on mapping in Queensland and New South Wales upgraded the Marburg Formation to subgroup status. As a result, the Bundamba Group is now recognised as containing two subgroups — the Woogaroo Subgroup and Marburg Subgroup. Descriptions of the constituent units of these subgroups are given below.

Woogaroo Subgroup

Introduction

The Woogaroo Subgroup was defined by Cranfield & Schwarzböck (1972) for rocks which are exposed in the Ipswich 1:250 000 Sheet area, and consists of three formations: Aberdare Conglomerate (base), Raceview Formation and Ripley Road Sandstone (top). The unit occurs in ESK where it was defined originally as the Helidon "Series" or Helidon Sandstone (Dunstan, 1915). Building sandstone resources have been used since the early days of European settlement particularly in the construction of major buildings in Brisbane city (Richards, 1916). Murphy & others (1976) extended the unit north on to the Gympie 1:250 000 map Sheet area. The boundary between rocks of the Woogaroo Subgroup of the Clarence–Moreton Basin and the Precipice Sandstone of the Surat Basin is poorly defined and on KINGAROY the change in nomenclature between the basins is placed either side of exposures of Main Range Volcanic basalts.

Distribution

The Woogaroo Subgroup forms an easterly-trending belt along the southern boundary of the mapped area and a north-west-trending belt along the eastern margin of the Great Divide north of Toowoomba.

Topographic expression

The unit comprises well-formed resistant thickly vegetated dip slopes that dip shallowly in a southerly direction in the southern part of the mapped area (including the eastern margin of the area formerly mapped as Helidon Sandstone). Elevations in this area range from about 150–380m. The unit dips due west in the area between Helidon and Cooyar. Near Cooyar the subgroup crops out over 10km^2, and forms low, grassy hills bounded locally by resistant scarps. Here the unit averages 400m above sea level.

Geophysical expression

The Woogaroo Subgroup generally has a very low (dark bluish-green signature) on the ternary K–Th–U radiometric image, and has a generally low to moderate magnetic signature.

Lithology

Sandstone is the dominant rock type, with lesser siltstone and shale, and minor development of conglomerate. The sandstone is massive, coarse grained, sublabile to quartzose and strongly cross-bedded. Near Cooyar, the subgroup comprises coarse grained, well-sorted, quartzose sandstone with siliceous cement, minor siltstone, shale, and some pebble conglomerate consisting of phenoclasts of quartz and quartzite in a white clay matrix. The top of the unit comprises medium to coarse grained massive quartzose sandstone which contrasts with the more rounded easily weathered sandstone of the overlying Marburg Subgroup.

Environment of deposition

The Woogaroo Subgroup was laid down in a fluvial environment, probably by coalescing braided streams. The basal pebbly to conglomeratic sandstone is suggestive of a point-bar deposit, whereas interbedded sandstone, siltstone and shale probably developed as interfluvial deposits. With continued base-levelling, deposition of mature quartzose sand became dominant.

Provenance

Based on the indications of a southerly source for sandstones in this unit detected by Wells & O'Brien (1994) the source material was probably the granitic rocks and Late Devonian to Carboniferous sediments of the Texas Subprovince to the south.

Biostratigraphy and age

Palynology of the unit in the Ipswich 1:250 000 Sheet area by de Jersey (1971) gave spore ages of latest Triassic to early Jurassic (Rhaetian to Liassic) age south of Helidon. De Jersey (1975) subsequently assigned this sequence to the *Polycingulatisporites crenulatus* zone (*Ceratosporites heidonensis* subzone). As no age determinations have been carried out in the mapped area during the current project, de Jersey's age for the whole unit is accepted herein.

Thickness

In the Clarence–Moreton Basin near Cooyar the unit is 50–60m thick, whereas in the Helidon area Cranfield & others (1976) indicate the unit is ~250m thick.

Structure

In the Cooyar area, the unit is subhorizontal or strikes northerly and dips at a low angle to the west. In the Helidon area the unit dips generally to the south, but has steeper dips where it is locally affected by faulting.

Stratigraphic relationships

The Woogaroo Subgroup in the Clarence–Moreton Basin near Cooyar unconformably overlies the Maronghi Creek Beds, Woolshed Mountain Granodiorite and the Tarong beds. It is conformably overlain by units of the Marburg Subgroup, and unconformably overlain by the Main Range Volcanics.

Correlation with other units

The Woogaroo Subgroup is a stratigraphic correlative of the Precipice Sandstone of the Surat Basin. However, the progressive younging of this facies from east to west makes the Precipice Sandstone a time-transgressive unit with a younger age range than the Woogaroo Subgroup.

Marburg Subgroup

Introduction

Reid (1921) first used the stratigraphic name "Marburg". Cranfield & others (1976) give a full discussion of its usage prior to 1976. The Marburg Subgroup as currently defined forms the upper part of the Bundamba Group (Marburg Formation) of Cranfield & Schwarzböck (1972), and includes the Gatton Sandstone (base) and Koukandowie Formation (top) of Wells & O'Brien (1994).

Distribution

In the western corner of the mapped area, the Marburg Formation crops out near Cooyar, and west of Crows Nest. It also occurs as small inliers in the Main Range Volcanics.

Topographic expression

In the area between Crows Nest and Cooyar, the unit forms undulating, hilly country ~300m above sea level. In the western part of the sheet area the unit forms a range of resistant and less resistant benches that vary in elevation from 350–460m in elevation. Most of this area is cleared country utilised for grazing.

Lithology

In the area south of Crows Nest the Marburg Subgroup has recognisable formations — the basal Gatton Sandstone and the overlying Koukandowie Formation. In this area and the region immediately to the south, McTaggart (1963) subdivided the unit (then referred to as the Marburg Formation into several subunits — the Gatton Sandstone (including with the Winwill Conglomerate Member), Ma Ma Creek Sandstone Member (containing a ferruginous oolite marker unit) and the Heifer Creek Sandstone Member. The correlation between these units and current subdivisions of Wells & O'Brien (1994) is given in Figure 3.

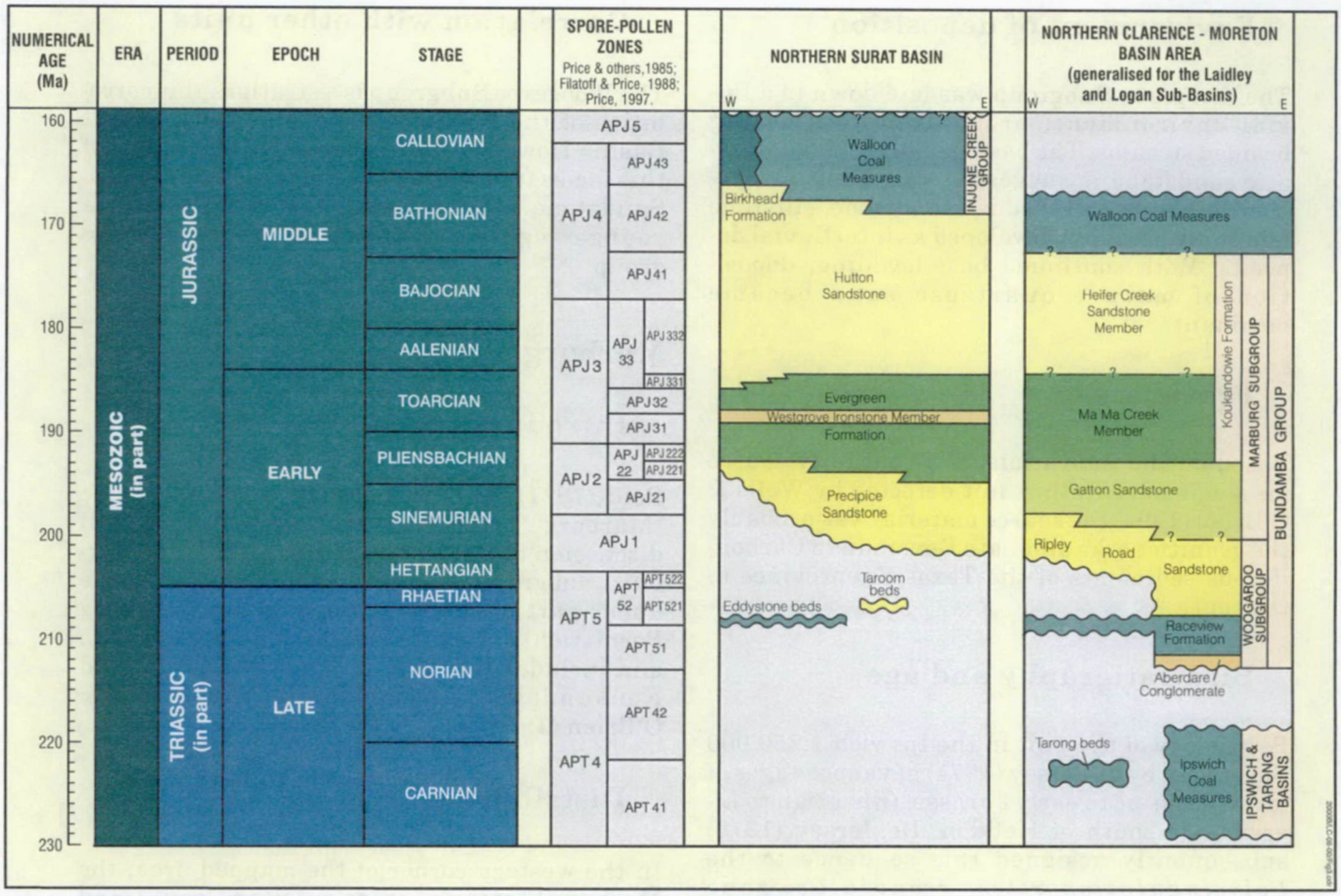


Figure 3. Correlation of units of the Clarence–Moreton and Surat Basins

Gatton Sandstone (Jbmg)

This unit comprises a facies dominated by quartz-lithic green to grey green sandstone with thin conglomerate beds. The type area corresponds to that defined for the unit by McTaggart (1963). The unit has only been recognised as a separate unit from the rest of the Marburg Subgroup in the southern part of the mapped area.

Koukandowie Formation (Jbmk)

The Koukandowie Formation contains the Calamia Member, the Ma Ma Creek Sandstone Member (containing a ferruginous oolite marker unit) and the Heifer Creek Sandstone Member of McTaggart (1963). The basic difference between the Gatton Sandstone and the Koukandowie Formation is that the former is a quartz-lithic sandstone and conglomerate whereas the latter is a feldspathic labile to sublabile sandstone with thick muddy units and locally contains a ferruginous oolite marker bed or beds. Ferruginous oolite marker beds have been recognised by McTaggart (1963) from the Ma Ma Creek Sandstone south-west of Toowoomba. No additional ferruginous oolite marker beds were recognised during the current mapping program.

Undivided Marburg Subgroup (Jbm)

The Marburg Subgroup found in the western part of the mapped area consists almost exclusively of fine to medium and locally coarse grained, buff to white, well sorted, cross-bedded, partly ferruginous, feldspathic labile sandstone, with some siltstone generally more consistent with the Koukandowie Formation. Concretionary ironstone, pebble bands and fossil wood are common in this area. The sandstone west of Kumbia is locally more quartzose than that to the south.

Thickness

In the mapped area, Marburg Subgroup is estimated to have a thickness of 100m.

Structure

In the Clarence–Moreton Basin in the western part of the area, the strata are subhorizontal in-

creasing to 5°–10° locally on the flanks of broad north-north-west trending, very open folds.

Stratigraphic relationships

In the western area, the Marburg Subgroup conformably overlies the Woogaroo Subgroup, and in places overlaps that unit to rest unconformably on the Maronghi Creek Beds, Chahpingah Meta-Igneous Complex, and the Permo-Triassic Boondooma Igneous Complex. The Tertiary Main Range Volcanics overlie the unit unconformably.

Provenance and environment of deposition

The presence of feldspathic and lithic sublabile to labile sandstone as the dominant rock types suggests rapid erosion and deposition in a fluviatile environment. The occurrence of acritarchs associated with the oolitic ironstone was thought to be indicative of marine conditions locally within the Koukandowie Formation however more recent work by Cranfield & others (1994) indicates an arid climate with deposition at a fluvial-lacustine interface.

Biostratigraphy and age

There have been no palynological studies of the Marburg Subgroup in the Clarence–Moreton Basin in the Gympie 1:250 000 Sheet area. Herein an Early–Middle Jurassic age is assigned to the unit in this report.

Walloon Coal Measures

Introduction

Cameron (1907) used the name Walloon beds for the strata outcropping in the Walloon, Rosewood and Dugandan districts of the Clarence–Moreton Basin. Reid (1921) changed the name Walloon beds to Walloon Coal Measures when he mapped the Walloon–Rosewood Coalfield. Whitehouse (1955) nominated the type area as the mining region about the township of Walloon. The type section was designated by Cameron (1970) from 7m to 235m in drillhole N.S. 84 in the Ebenezer district.

Distribution

The unit occurs in the far south of the region, occupying an area of ~250km^2, 30km north-west of Toowoomba. These exposures lie within the Clarence–Moreton Basin east of the structural high (the Kumbarilla Ridge) broadly separating these rocks from equivalents in the Surat Basin to the west.

Topographic expression

The unit forms flat to low undulating terrain flanking the south-western slopes of the Great Dividing Range.

Lithology

The unit consists of lithic and feldspathic labile sandstone interbedded with siltstone, mudstone, carbonaceous shale and coal. Quartzose sandstone occurs rarely. The sandstones are generally fine-grained, thick-bedded and friable, consisting of feldspar and black lithic grains of andesitic material in a montmorillinite matrix. Mudstone occurs either as thin interbeds alternating with sandstone and siltstone beds or as thicker massive beds. The unit is characterised by weathering-resistant clay ironstones and fossil wood fragments, which are commonly found dispersed within the blanketing soils. The coal seams reach commercially viable thicknesses and have been mined to the south-east in the Rosewood–Walloon area.

Environment of deposition

The unit was deposited under low energy fluvial conditions typified by wide flood plains traversed by mature, highly sinuous river systems, combined with extensive shallow water backswamps.

Provenance

The high proportion of andesitic detritus and montmorillonitic matrix of the sandstones indicate nearby contemporaneous volcanism, possibly in the Gympie area to the north-east or the Texas area to the south-west.

Thickness

The Walloon Coal Measures attain a maximum thickness of 600m in the axial region of the Logan River Syncline in northern New South Wales. However, the formation within the Clarence–Moreton Basin has been wholly or partly eroded, with only probably ~200m of section being preserved within the map area.

Biostratigraphy and age

Plant macrofossils are abundant within the unit, and numerous studies have been made. These have been reviewed by Cameron (1970) and Gould (1974; 1980). Macrofloral species

which typify the unit are *Equisetem laterale, Cladophlebis australis, Taeniopteris spatulata* and *Otozamites* sp. (Gould, 1975). The microflora of the unit were studied by de Jersey (1955;1959; 1960a b,c), and dinosaur footprints were described by Cameron (1970). The floral, faunal and stratigraphic evidence are indicative of a Middle Jurassic age.

Stratigraphic relationships

The unit rests conformably on rocks of the Marburg Subgroup, and is unconformably overlain by lavas of the Main Range Volcanics and unconsolidated Cainozoic deposits.

Correlation with other units

The Walloon Coal Measures extend across the Kumbarilla Ridge into the Surat Basin to the west. The Walloon Coal Measures within this basin are considered to be equivalents of the Birkhead Formation to the west within the Eromanga Basin and the Mulgildie Coal Measures to the north in the Mulgildie Basin.

SURAT BASIN

Precipice Sandstone

Introduction

The Precipice Sandstone has been delineated in one area only during the current mapping. Part of this area was originally mapped as Marburg Subgroup by Murphy & others (1976), however this area also contains a basal sequence comprising quartz-rich conglomerate and quartzose sandstone herein equated with the Precipice Sandstone.

Distribution and topographic expression

The unit forms scattered flat lying mesa exposures to the west of Kingaroy on the Iron Pot Road, covering only ~5km^2.

Geophysical expression

The unit has a distinctive dark tone on the K–Th–U ternary radiometric image and a very low magnetic signature.

Lithology

The unit is poorly exposed in the area. Two rock types have been recognised — a basal pebble to coarse cobble conglomerate dominated by light grey to white buck quartz phenoclasts in a clayey matrix, and a well-cemented quartzose sandstone, that form the top of the unit.

Environment of deposition

The Precipice Sandstone was deposited in a fluviatile environment, probably by coalescing braided streams.

Provenance

The unit contains large locally-derived quartz clasts that were most likely eroded from granitic rocks in the Yarraman Subprovince. It differs from the Woogaroo Subgroup of the southern part of the mapped area that Wells & O'Brien (1994) showed had a southerly provenance (?Texas Subprovince).

Thickness

The unit is probably not more than 50m thick in the mapped area.

Structure

In the Yarraman area, the unit is close to flat lying and forms a series of mesas.

Biostratigraphy and age

No fossils have been found in the unit in the study area; the age is inferred as Early Jurassic based on palynology undertaken elsewhere in the Surat Basin.

Stratigraphic relationships

The unit unconformably overlies basement gneiss and granite of the Chahpingah Meta-Igneous Complex and Boondooma Igneous Complex. The unit is conformably overlain by units of the Evergreen Formation, and locally unconformably overlain by Tertiary basalt of the Main Range Volcanics.

Correlation with other units

The Precipice Sandstone is a stratigraphic correlative of the Woogaroo Subgroup of the Clarence–Moreton Basin. However, the progressive younging of the Precipice Sandstone from east to west makes it a time-transgressive unit, which has a younger age range than the Woogaroo Subgroup.

Evergreen Formation

Introduction

Whitehouse (1952,1955) applied the name "Evergreen Shales" to the shaly interval between the Precipice Sandstone and Boxvale Sandstone of Reeves (1947) in the valley of the Dawson River, north of Injune. Jensen & others (1964) defined the Evergreen Formation to include the "Evergreen Shales" as the lower unit, the overlying Boxvale Sandstone as a member, and an upper unit of mudstone, siltstone, and sandstone containing an oolitic member at its base. Mollan & others (1965) named and described the latter as the Westgrove Ironstone Member. They confined this unit to the western side of the Mimosa Syncline. However, in this report the member is considered to occur to the east of the syncline, in north-western YARRAMAN.

Distribution

The lower part of the formation (Je_1) occupies an area of ~80km^2 in the north-west corner of YARRAMAN, west of Boondooma homestead. Smaller isolated patches of the Westgrove Ironstone Member (Jew) occur within this outcrop area. To the south-west, a small area of undifferentiated Evergreen Formation (Je) has been mapped 18km south-west of Kingaroy in central YARRAMAN.

Topographic expression

The Formation forms a dissected mesa terrain. The Westgrove Ironstone Member forms the most prominent mesas and scarps.

Geophysical expression

On YARRAMAN, the Evergreen Formation displays mottled green and brown tones on standard RGB radiometric images. On magnetic images the unit displays sporadic sinous zones of moderate magnetic response, but these features may reflect patterns in the underlying basement. This is supported by the generally low magnetic response of the unit in the deeper parts of the Surat Basin to the west of YARRAMAN. One local exception occurs around AMG 315200, 7104200 where a mesa of concretionary, partly oolitic sandstone of the Westgrove Ironstone Member shows as a prominent highly magnetic anomaly on air-magnetic images, possibly due to the presence of maghemite.

Lithology

The distinctive lower part of the formation (Je_1) comprises a sequence of well-bedded, generally laminated to medium-bedded mudstone, siltstone and fine-grained sublabile to labile sandstone, capped by a distinctive thick interval of fine- to very coarse-grained to pebbly sandstone. The sandstones vary from arkosic to feldspathic (or more rarely calcareous) in composition, and commonly display low angle cross-bedding or ripple marks. Plant debris is locally abundant. The upper sandstone typically contains both alkali and plagioclase feldspar derived from nearby granitoids, and sedimentary and volcanic clasts derived from the underlying Rockhampton Group. Muscovite is common as is some zircon, set in an abundant clay matrix. Where visible, the basal part of the unit consists of coarse sandstone and breccia except where the unit overlies granitic rocks. In the latter case, a basal unbedded granite wash is commonly developed, overlain by arkosic cross-bedded sandstone.

The Westgrove Ironstone Member (Jew) conformably overlies subunit Je_1. The member is characterised by the presence of numerous oolitic and pelletal ironstone beds of varying thickness (up to a maximum of ~1m) within a sequence of fine to locally coarse, lithic to locally oolitic sandstone, interbedded with siltstone and mudstone. Concretionary ironstone (oolitic in part) is also a common rock type. Colours vary from greenish-yellow through yellow to brown reflecting varying degrees of weathering and iron migration. The member is very well bedded, with the coarser rock types medium to thickly bedded and finer rock types more thinly bedded. Cross-laminae, ripple marks and mudcracks occur rarely. The oolitic ironstones are generally limonitic in composition.

Undifferentiated Evergreen Formation (Je) mapped in central YARRAMAN consists of well-bedded carbonaceous mudstone, and siltstone with scattered lithic to quartzose sandstone interbeds.

Environment of deposition

The presence of feldspathic and lithic sublabile to labile sandstone as the dominant rock types suggests rapid erosion and deposition in a fluviatile environment. Lacustrine conditions prevailed only locally. The generally finer nature of the basal Surat Basin sediments further to the west suggests that the coarser basal rocks (Je_1) predominating on YARRAMAN represent a basin margin facies. The occurrence of acritarchs associated with the oolitic ironstone has been thought to be indicative of local marine

conditions within the Westgrove Ironstone Member, but more recent work on equivalent units by Cranfield & others (1994) indicates an arid climate with deposition at a fluvial-lacustine interface.

Provenance

Sediments of the Evergreen Formation are derived from adjacent granitoid massifs to the north and east (including the Boondooma Igneous Complex and the Toondahra and Farquharson Granites on YARRAMAN). The exposed Carboniferous highs also locally contributed detritus to the Evergreen Formation.

Thickness

Units of the Evergreen formation vary in thickness on north-western YARRAMAN — Je_1 is ~80–100m thick in the area, while the overlying Westgrove Ironstone Member (Jew) is ~50m thick.

Structure

The unit is close to flat lying in this area; dips to the west or south are generally <5°.

Biostratigraphy and age

The Evergreen Formation contains abundant plant debris. White (1967) identified *Cladophlebis* sp. and *Brachyphyllum Angustum* Walkom from the formation on the Mundubbera 1:250 000 Sheet area to the north. These fossils are only indicative of a general Mesozoic age. The most useful diagnostic fossils within the Evergreen Formation are spores, pollen, and microplankton, although identification of these was not attempted during the current survey. However, studies elsewhere have shown a Pliensbachian–Toarcian age range for palynofloras from the Evergreen Formation (Green & others, 1997).

The Westgrove Ironstone Member contains an acritarch fauna dominated by *Micrhystridium* sp. A significant change in character of the palynological assemblage occurs within the lower part of the Westgrove Ironstone Member, indicating a major environmental change (Green & others, 1997).

De Jersey & Paten (1963, 1964) conducted palynological studies on cuttings from oil drilling within the formation, which they found to contain assemblages dominated by *Classopollis*. Within the interval from the base of the Precipice Sandstone to the base of the Westgrove Ironstone Member, they recognised assemblages belonging to the J_1 spore subdivision of Evans (1966), whereas for the overlying interval (basal Westgrove Ironstone Member to top of the Evergreen Formation) spore assemblages were considered part of the J_2 spore subdivision. Both subdivisions are indicative of an Early Jurassic age. These subdivisions have been revised subsequently by numerous authors (see Price, 1997), but still indicate an Early Jurassic age range.

Stratigraphic relationships

On YARRAMAN, subunit Je_1 overlies the Tondahra Granite and undivided Rockhampton Group. Undivided Evergreen Formation (Je) conformably overlies the Precipice Sandstone and unconformably overlies the Chahpingah Meta-Igneous Complex. The unit is locally unconformably overlain by small areas of Tertiary basalt lava belonging to the Main Range Volcanics.

Correlation with other units

The Evergreen Formation is a correlative of the Marburg Subgroup. In particular, in this area of the eastern Surat Basin, the unit correlates with the lower part of the Koukandowie Formation (below equivalents of the Heifer Creek Sandstone and its Surat Basin correlative — the Hutton Sandstone).

TERTIARY SEDIMENTS AND VOLCANICS

Undivided Tertiary Sediments

Introduction

Undivided non-fossiliferous sediments of presumed Tertiary age are quartz-rich in composition and occur from ESK in the south to MURGON in the north. Exposure occurs on the Crows Nest Granite on ESK.

Distribution

The largest areas of rocks included in this category crop out ~3km north of Wondai (12km^2), 4km east of Cherbourg (15km^2), 18km north of Nanango (8km^2), and 10km north of of Kingaroy (10km^2).

Topographic expression

The topography is typically low and undulating commonly forming small, vegetated mesas next to major watercourses with prominent breaks at

the margins of these mesas. These rocks display a mainly dendritic drainage pattern on aerial photography.

Geophysical expression

The unit has a characteristic mauve colour on the ternary K–Th–U image and a very subdued magnetic response.

Lithology

Tertiary sediments are invariably deeply weathered and locally exhibit lateritic profiles. In the Wondai area, the unit comprises poorly consolidated polymictic conglomerate and poorly sorted sandstone. Phenoclasts in the conglomerate are well-rounded granules to cobbles of porphyritic, buff coloured acid volcanics, black to brown chert, white quartz, and banded agate. The sandstone and the arenaceous matrix of the conglomerate are coarse-grained, poorly sorted and ferruginous. Lignites and shales reported from this area by Ball (1918) were not observed. The outcrop near Cherbourg consists dominantly of conglomerate, with cream to buff, moderately well-sorted, argillaceous quartzose sandstone of fluviatile origin. This type of sandstone is also exposed north of Nanango. South of Kingaroy, the Tertiary sediments are characterised by grey, weathered siltstone and mudstone and fine to medium-grained well-sorted quartzose sandstone. The sediments form a thin veneer between the Tarong beds and the overlying basalt flows of the Main Range basalt. Fluids from alteration of basalt flows has released silica and this has locally cemented the quartzose sandstones on MURGON and northern KINGAROY producing silicified quartzose sandstones (unit Ts^s).

Environment of deposition

The deposition environment is considered to be fluviatile.

Provenance

The sediments were probably deposited in fluviatile conditions, as stream channel deposits probably from a mainly granite substrate of the Boondooma Igneous Complex, Taromeo Igneous Complex and the Crows Nest Granite. They are usually associated with the Main Range Volcanics commonly beneath the lower flows.

Thickness

The thickness of the undifferentiated Tertiary sediments is unknown. It is probably not greater than 50m.

Structure

The unit is ubiquitously flat-lying over its area of exposure.

Biostratigraphy and age

Ball (1918) reported dicotyledonous plant leaves from Wondai, and Woods (1962) recorded indeterminate dicotyledons and cycadaleans from south-west of Wooroolin. These occurrences and field relationships suggest a likely Early to mid-Tertiary (?Oligocene or Miocene) age for the sediments.

Stratigraphic relationships

The relationship with the volcanics is commonly obscured by lateritisation. West of the Esk Trough, the sediments unconformably overlie units of the Maronghi Creek beds, the Permo-Triassic Boondooma Igneous Complex, and the Neara Volcanics and Esk Formation.

Correlation with other units

Unit Ts^s merges into silcrete unit Td^s.

Oakdale Sandstone

Introduction

The Oakdale Sandstone was first described and named by Derrington (1954) in his honours thesis, and the name was subsequently adopted formally by Hill & Tweedale (1955) and Cribb & others (1960).

Distribution

The unit is exposed as irregular scattered outcrops north of Murgon and extends north-westwards within the broad alluvial valley of Barambah Creek, covering a total of ~30km^2.

Topographic expression

The Oakdale Sandstone is best exposed north-east of Murgon as low hills and on the flanks of ridges capped with Tertiary lava. Elsewhere the unit is very poorly exposed, mainly as low remnant terraces adjacent to Barambah

Creek or exposed in gullies cutting through overlying duricrust surfaces.

Geophysical expression

On the standard ternary radiometric images, the Oakdale Sandstone is characterised by dark tones making it generally indistinguishable from surrounding units. The radiometric response largely reflects the extensive lateritic weathering and soil mantling over the unit. The Oakdale Sandstone also has a low magnetic response, which again makes it indistinguishable from nearby units.

Lithology

The unit consists of cream, massive, poorly-bedded, medium to coarse-grained sandstone with minor pebbly beds, as well as occasional buff-coloured mudstone and siltstone bands. The sandstone ranges from quartzose to feldspatholithic or lithic sublabile in composition (Murphy & others, 1976), with a kaolinitic matrix, and is not strongly lithified. Clasts within the sandstone range from granules to small pebbles of angular to subrounded quartz. Most of the unit is deeply lateritised.

Thickness

The unit is estimated to be <100m thick.

Structure

The unit is undeformed with essentially horizontal dips.

Biostratigraphy and age

Derrington (1954) recorded the presence of rare plant material, specifically a pinnule of a fern-like plant probably related to the present day species of *Blechnum*.

More recent work by Godthelp & others (1992) at a site north of Murgon has unearthed a range of macrofossil vertebrate fossils (the "Tingamurra fauna") from the sediments. Based on an illite date, an overlying basalt date and biocorrelation, the "Tingamarra" sediments appear to be no younger than early Eocene. From the nature of the microchiropteran bat remains in the deposit, it also appears to be no older than early Eocene (Henk Godthelp, personal communication, January 1999). However, radiometric dating (Godthelp & others, 1992) indicated an age of >55Ma (i.e. at least as old as Paleocene). An early to mid-Tertiary age is therefore considered likely.

Stratigraphic relationships

The Oakdale Sandstone unconformably overlies the Triassic Wooroonden Granodiorite and undifferentiated volcanics of the Aranbanga Volcanic Group. The Oakdale Sandstone is of broadly similar age to the overlying Main Range Volcanics, but contacts between the two units are not exposed. The Oakdale Sandstone is capped by ferruginous lateritic weathering surfaces (Td^r, Td) and is unconformably overlain by Quaternary alluvial deposits of the broad Barambah Creek valley.

MAIN RANGE-LAMINGTON VOLCANIC PROVINCE

Main Range Volcanics

Nomenclature and distribution

This unit, named by Stevens (1965), consists of volcanic and pyroclastic rocks of Oligocene to Miocene age and forms the Main Range (or Great Dividing Range) from the New South Wales border at Wilson's Peak, north through Toowoomba, to the Bunya Mountains. Stevens (1965,text-figure 1) showed sections through the Main Range Volcanics and the best and most accessible of these is the highway section near Cunningham's Gap, from Claytons Gully to Mount Mitchell. This section was designated by Cranfield & others (1976) as the type section.

The Toowoomba Volcanics (Dimmick, 1951; Stevens, 1969), Gomaren Basalt (Stevens, 1969), and the Cooby Trachyte (Stevens, 1969) are considered to be members of the Main Range Volcanics. An additional member, the Nutgrove Agglomerate Member, was defined by Cranfield & Schwarzböck (1974). Details of the type sections and distribution of these units are given by Stevens (1969) and Cranfield & Schwarzböck (1974).

Because of continuous outcrop, Cranfield & others (1976) and Murphy & others (1976) have extended usage of the name to cover volcanics that occur from Toowoomba to north of Proston. This interpretation is accepted herein. The Gomaren Basalt has not been delineated outside the area mapped by Stevens (1969) and is therefore not shown on the accompanying map.

Topographic expression

The eastern escarpment of the Great Dividing Range is interpreted as an erosional feature (Reid, 1922; Marks, 1932; Stevens, 1965). It in-

cludes peaks up to 1300m above sea level in the Warwick 1:250 000 Sheet area and in most places the upper 500m of the scarp is characterised by vertical cliff sections. The outcrop belt of the Main Range Volcanics extends southwards into the Warwick 1:250 000 Sheet area, northwards into the Gympie 1:250 000 Sheet area, and westwards into the gently undulating Darling Downs. Outcrops to the east of the escarpment commonly form rugged terrain above soft Mesozoic sediments. Between Kumbia and Proston, the unit is deeply lateritised and crops out poorly. Small isolated mesas of weathered basalt and laterite are characteristic of the western edge of the outcrops in this area. In southern KINGAROY, the Bunya Mountains form the highest topography of the Main Range Volcanics. Terraced basaltic flows are well exposed here. North-east trending spurs of lateritised basalt form the Stuart, Cooyar, and Blackbutt Ranges. The unit comprises the generally non-laterised flows of the Bunya Mountains and deeply weathered and laterised rocks of the Kingaroy area. The topographically highest flow in the Kingaroy area and immediately to the north forms a prominent bench at ~600m above sea level designated as Tm_u. The unit forms steep-sided mesas with steps that indicate several different flows from ESK in the south to MURGON in the north.

On ESK a small outcrop of low level basalt flows overlying granule to boulder gravel, elevation of 400m, occurs at AMG 418700, 6989000, 4km south-east of Bluff Mountain (Tid, elevation 524m). This probably represents a fossil drainage of Anduramba Creek. Elevation to the base of basalt flows generally ranges from 500–600m, with highest pre-flow topography in areas currently overlain by volcanics being 620–640m in the vicinity of Hirsts Hill and Barnes Hill 9km north-east of Crows Nest and the Hampton, Pechey, and Whichella area south of Crows Nest. A maximum elevation of 781m south of Ravensbourne suggests a maximum thickness of 240m of basalt with possible intercalated laterites, on ESK.

Geophysical expression

The geophysical expression of the Main Range Volcanics varies from south-west to north-east across the area. The flows of the Bunya Mountains are generally fresh and have a characteristic reddish tinge on the K–Th–U ternary radiometric image. The Cooby Trachyte Member has been recognised to be more extensive than previously mapped due to a light pink to off white response on the K–Th–U ternary radiometric image. Volcanics of the Nutgrove Rhyolite Member also have a similarly high to very high radiometric signature and a low magnetic response.

In addition, flows and intrusions are either normally or reversely polarised.

Lithology

The Main Range Volcanics are divisible into lower and upper parts of approximately equal thickness. The lower part comprises basalt with intercalations of leucocratic trachyte and trachytic to rhyolitic breccia, while the upper part consists dominantly of olivine basalt. Within the lower part of the unit, thin beds of lacustrine sediments, consisting mainly of diatomite, occur at a few localities.

Stevens (1969) recognised between 17 and 20 individual flows of fine-grained olivine basalt in the type section of the **Toowoomba Volcanics** along the Warrego Highway (Toll Bar), on the eastern outskirts of the City of Toowoomba. Pyroclastic rocks are absent from this section, but occur at the entrance to the Toowoomba Council Quarry and near Harlaxton. These pyroclastic rocks are currently thought to have been formed on the margins of lava pools (Edwin Willey, personal communication, 1999). Ewart & Grenfell (1985) identified volcanic centres in the Main Range Volcanics.

In the Ipswich 1:250 000 Sheet part of the mapped area, olivine basalt forms the dominant rock type (Cranfield & others, 1976). The lower basalt flows contain phenocrysts of plagioclase, clinopyroxene, and olivine, while the basalt flows of the upper part are generally aphyric and contain only microphenocrysts (i.e. 0.5mm) of olivine, clinopyroxene, and plagioclase. In both the upper (unit $\mathbf{Tm_u}$) and lower flows, the groundmass of the olivine basalt comprises labradorite (An_{50} 60%), augite, magnetite, illmenite, and in places olivine (Stevens, 1969). Relatively high percentages of potassium and sodium are characteristic of the Main Range Volcanics. The rocks are not silica-undersaturated, and there are no feldspathoid minerals. Quartz appears in the norms of all the analysed rocks (Stevens, 1965) except for the olivine basalts. The low anorthite and high albite and orthoclase content attest to the alkaline nature of these volcanics.

In many places the top of the volcanic pile is deeply lateritised. The profile, which is 10–30m thick, is well developed in the vicinity of Toowoomba and near Kleinton and Ravensbourne, as well as further north in central, eastern and northern KINGAROY and the central part of MURGON. The south-western part of KINGAROY is characterised by generally fresh

Table 4: Units of the Main Range Volcanics

Formation	Symbol	Lithology
Main Range Volcanics	Tm_u	olivine basalt, upper flow
undivided	Tm	olivine basalt
Cooby Trachyte Member	Tmc	trachyte
Main Range Volcanics sediments	Tms	sandstone, shale, siltstone, conglomerate, diatomite
Nutgrove Rhyolite Member rhyolite	Tmnr	cream, flow banded rhyolite intrusives and flows, spherulitic in part, rhyolite breccia, minor biotite
Nutgrove Rhyolite Member rhyolite breccia	Tmnb	rhyolite breccia
unnamed basalt flows and plugs	Tb	olivine basalt
unnamed basalt plugs	Tib	olivine basalt plug
unnamed dolerite intrusions	Tid	dolerite, basalt (dyke or plug)
unnamed basalt flows	Tv_b	many basalt flows
unnamed rhyolite	Tv_r	rhyolite lava and pyroclastic deposits
undivided	Tv	mainly basalt flows

(non-lateritised) basalts of the Bunya Mountains.

The Nutgrove Agglomerate Member of Cranfield & Schwarzböck (1974) is here renamed the **Nutgrove Rhyolite Member** to more accurately reflect the lithological character of the unit.

The member is exposed in the Nutgrove–Cooyar area, where it consists of cobble to boulder agglomerate with phenoclasts of granite and basalt in a white fine-grained matrix, and minor rhyolite flows and tuff. Tuffaceous sandstone forms the top of the member. Due to similar appearance and setting, a number of other rhyolite plugs with associated breccias have been included in this unit. Dumlao (1990) in a student thesis in the Cooyar area included a series of rhyolitic plugs and pyroclastic rocks in this unit in the St Auburn, Logyard and Mount Warren areas.

On YARRAMAN the Nutgrove Rhyolite Member has been subdivided into two units (Tmn_r and Tmn_b). Unit **Tmn_r** comprises cream, flow-banded rhyolite intrusives and flows. The flows are spherulitic in part, and contain zones of rhyolite breccia, and minor biotite–bearing rhyolite. Dumlao (1990) recognised both rhyolitic plugs and pyroclastic rocks in this part of the unit. The interpreted plug at St Aubyn comprises a white to pinkish flow-banded spherulitic rock. Quartz, biotite, K-feldspar and plagioclase phenocrysts occur in a groundmass of semi-opaque brown glass. The flow-banding dips range from 42°–55°. Perlite at the margin of the flow-banded rhyolite is black to dark green and grades inward towards lighter coloured rhyolite. Perlitic rhyolite commonly occurs at the contact between rhyolite and rhyolite breccia. Unit **Tmn_b** comprises large zones of rhyolite breccia.

The **Cooby Trachyte Member (Tmc)**, which overlies the Gomaren Basalt, consists of fine-grained, purplish-grey trachyte composed of rare phenocrysts of plagioclase (oligoclase) in a groundmass of soda-sanidine, greenish pyroxene, opaques, and deuteric chlorite. This unit was extended from Stevens (1965) type area as part of the current mapping project to the west of Crows Nest.

Intercalated sediments (Tm_s) interfinger with the lavas immediately south of Barambah Creek in central MURGON. The dominant rock types are sandstone, shale, siltstone, conglomerate, diatomite and earthy dolomite. These exposures cover >20km^2 and contain a number of dolomite and clay prospects (Blue Gums, Blue Moon, Blue Rocks, Whitebank, White Hill and Robinsons — see 'ECONOMIC GEOLOGY'). These sediments are considered as time correlatives of sandstone, shale, siltstone, conglomerate and diatomite south of Barker Creek on KINGAROY. Tm_s sediments in this area cover ~5km^2 and contain known diatomite deposits at Maidenwell and an unnamed deposit further to the south. The other area designated as Tm_s occurs as flat lying intercalated sediments covering ~1km^2 at the junction of the Kingaroy–Cooyar Road and the New England highway at AMG 3821, 70203. At this locality a thin section of the white fine to medium grained arenaceous thin to medium-bedded rock has been identified

as a devitrified perlite (Edwin Willey, personal communication,1999).

Subunit Tm_u has been delineated mainly on MURGON as upper bench-forming flows. These basalts are typical of the unit as a whole, containing pyroxene, olivine or, locally, plagioclase phenocrysts in a fine groundmass of iddingsite, plagioclase, pyroxene and opaques. The basalts locally contain glassy xenocrysts or inclusions of coarser grained basalt. Some of the flows are amygdaloidal and vughy. The basalts range from platy to massive, or less commonly columnar-jointed in appearance.

Provenance

Basalts of the Main Range Volcanics are thought to have originated mainly from a series of fissure eruptions close to the present edge of the Great Divide west of Toowoomba. Local vents are known in the Toowoomba area (e.g. Harlaxton Quarry).

Thickness

Stevens(1965) suggested a maximum thickness of ~1000m for the unit along the eastern escarpment of the Great Dividing Range in the Warwick 1:250 000 Sheet area. The thickness in the Ipswich 1:250 000 Sheet area is generally less than this and varies from ~750m thick near Mount Mistake to 165m near Toowoomba (Cranfield & others, 1976).

Geomorphic controls

The Main Range Volcanics were extruded onto an early Tertiary land surface of moderate to rugged relief. The Cooby Trachyte Member filled old valleys cut into the Jurassic Marburg Formation. A contact between Marburg Subgroup and Cooby Trachyte, dipping north at 30°, is exposed on the road to Cooby Creek Dam, and at several other places along the margins of the valley-fillng flows steep walls of the pre-volcanic valleys are exposed. Some sandstone ridges of the pre-volcanic surface are ferruginous and possibly lateritised. In some places thermal metamorphism has produced recrystallisation of the underlying sandstone, forming resistant benches. The later extrusions were largely from fissures and vents along and just east of the present escarpment and formed a sub-horizontal lava plain. Some of the streams that rise in the volcanic rocks west of the escarpment have very short juvenile headwater tracts, indicating that the divide, after cessation of the volcanic extrusions, was not far east of the present one.

Age

Hill & others (1970) illustrated diatoms from the diatomite at Black Duck Creek south of the mapped area. However, they have been studied insufficiently to be useful for age determinations. Green & lrving (1958) and Robertson (1966) suggested a late Tertiary age for these rocks, based on palaeomagnetic studies. They showed that the basalts were both normally and reversely polarised. However, the K/Ar ages of the volcanics, which are considered to be more reliable, range overall from 25–19.4Ma (Webb & others, 1967), indicating that the bulk of the unit was extruded in the Late Oligocene and Early Miocene. Rocks from the upper part of the sequence yielded the youngest ages. Within the mapped area the age of basalts range from 20–25Ma for units of Tm from the Bunya Mountains on KINGAROY. Younger ages 17Ma and 5Ma are from reversely polarised basalt plugs at Brigooda on BOONDOOMA.

Stratigraphic relationships

The Main Range Volcanics unconformably overlie the Sugarloaf Metamorphics, Cressbrook Creek Group, Permian–Triassic granitic intrusions, the Triassic Tarong beds, and the Triassic to Jurassic Woogaroo Subgroup. The Nutgrove Rhyolite Member unconformably overlies the Jurassic Marburg Formation.

MORPHOSTRATIGRAPHIC UNITS

Residual soil and colluvium

The oldest units are residual soil and colluvium (TQr and TQc) units. These units were delineated on the accompanying map mainly through photointerpretation (particularly where undivided i.e. TQr, TQc). Subdivision of these units as mapped is dependent on the underlying bedrock.

TQr^r refers to red soil colluvium and residual soil eroded from unit Td^r — a ferruginised (ferricrete) unit developed through deep weathering processes on Main Range Volcanics near Kingaroy and to the north in the central part of MURGON.

Locally, zones of ferricrete are exposed in unit TQr^r where this unit has been eroded to reveal

Table 5: Morphostratigraphic Units

Age	Unit	Lithology
CAINOZOIC	Czb	gravel,sand,mud: mainly basalt detritus
QUATERNARY	Qa	clay, silt, sand, gravel; flood plain alluvium
HOLOCENE	Qha	clay, silt, sand; active stream channel and low terraces
HOLOCENE	Qha_1	lowest river terrace; gravel, sand, silt, clay
HOLOCENE	Qha_2	second river terrace; sand, silt, clay, gravel
QUATERNARY	Qal	lakes in alluvial plain: silt, clay
QUATERNARY	Qaw	swampy areas of alluvial plain (wallum): sand, peat
QUATERNARY	Qf^b	black clay and silt (basalt derived)
QUATERNARY	Qf	clay, silt, scree
QUATERNARY	Qr	residual soil, colluvium; sand, soil, clay, rock debris
QUATERNARY	Qrs	residual soil, colluvium; sand, silt
QUATERNARY	Qpf	sandy alluvium of Condamine River, vertebrate fossils
PLEISTOCENE	Qpa	high level alluvium; silt, clay, sand, gravel
PLEISTOCENE	Qpa_1	lowest stranded river terrace (above floodplain); clay, silt, sand, gravel
PLEISTOCENE	Qpa_2	highest stranded river terrace (above floodplain); clay, silt, sand, gravel
TERTIARY–QUATERNARY	TQa	locally mottled, poorly consolidated sand, silt, clay, minor gravel; high-level alluvial deposits, generally dissected, and related to present stream valleys
TERTIARY–QUATERNARY	TQc	undivided colluvium: clay, soil, cobbles
TERTIARY–QUATERNARY	TQcb	colluvium (basalt-derived) — soil, clay, cobbles and boulders
TERTIARY–QUATERNARY	TQcs	colluvium (sedimentary) — clay, silt, pebbles and cobbles
TERTIARY–QUATERNARY	TQf	alluvial fan , silt, mud, clay
TERTIARY–QUATERNARY	TQr	pediment slope wash, clay, scree, soil
TERTIARY–QUATERNARY	TQr^b	black soil colluvium and residual soil developed from basalt
TERTIARY–QUATERNARY	TQr^c	residual deposits and pediment slope wash, clay, scree (indurated)
TERTIARY–QUATERNARY	TQr^r	red soil, pediment slope wash eroded from Td^r; locally contains ferricrete exposures
TERTIARY–QUATERNARY	TQr^w	residual brown soil developed on basalt

outcrop of underlying laterised basalt on steep concave slopes near Kingaroy Township.

TQr^c refers to indurated colluvial deposits where pediment deposits have been consolidated to form a well-cemented scree.

TQr^b refers to black soil, colluvium and basalt-derived residual soil; these are present in the Reedy Creek area south of the Kingaroy-Burrandowan Road.

TQr^w refers to brown residual soil developed on top of basalt flows of the Main Range Volcanics along the Bunya Highway south-west of Kumbia and in the adjacent Alice Creek area on KINGAROY.

TQc refers to colluvial units derived from a variety of bedrock components. Residual soil and colluvium are areally significant where they are associated with topographically high, weathered rocks. The variants TQcs and TQcb refer to

colluvial materials derived from basalt. TQcs consists of basalt detritus (cobbles and gravel with minor clay) that has accumulated along old drainage lines. TQcb is mainly formed through solifluxion on basalt exposures and forms a sheet-like deposit dominated by dark brown soil with minor basalt detritus.

Alluvial fans

TQf and Qf refer to alluvial fan deposits. These deposits have been developed on generally shallower slopes than unit TQr and merge at their base into alluvial deposits. In the mapped area TQf refers to probable Pleistocene to Holocene deposits derived from basalt to the west of Kingaroy, whereas Qf units are probably of Holocene age and have well-preserved lobate shapes characteristic of Holocene alluvial fan deposits.

Alluvium

Aluvium is present as current valley fill deposits (units Qa, Qha, Qha_1, Qha_2) on the major streams. Due to scale problems Qha units have been combined on the accompanying Yarraman Special map. On the Darling Downs basalt-derived alluvium dominated by dark grey to black soil is designated as unit Czb. For all the other alluvial units, the proportion of sand, gravel and clay varies within each, both in a downstream sense and laterally across the flood plain of the river systems. Three major systems are present in the area — the Boyne River System, Condamine River System and Brisbane River system. These systems contain Holocene alluvium immediately adjacent to the stream courses (Qha units) and Pleistocene alluvium (Qpa units) at topographically higher levels immediately adjacent to the Holocene alluvium. Disconnected from the Pleistocene alluvium is mottled and locally consolidated alluvium at higher levels along the Boyne and Stuart Rivers and the Brisbane River is a unit mapped as TQa to indicate a possible pre-Pleistocene valley fill alluvial deposit.

Mapping by Harms (in preparation) along the Brisbane River and tributaries in the vicinity of Toogoolawah and environs recognises extensive areas of consolidated alluvium. This alluvium is termed TQa or TQa_w. The w subscript indicates that the alluvium in this area is deeply mottled and has been subjected to a younger period of weathering (?Pliocene to Pleistocene). TQa was also shown to occur topographically higher than the younger (Holocene and Pleistocene) alluvium in the vicinity of the Boyne River and its major tributaries e.g. the Stuart River. This alluvium has a pronounced red and yellow iron-rich mottling and forms poorly sorted and well-consolidated flat-topped hills in these areas. Unit TQa includes a series of very high level gravel deposits that occur close to, and may represent the courses of the ancestral Brisbane, Boyne and Stuart Rivers. These deposits have a mottled sandy or clayey matrix, are very poorly sorted, and contain cobbles to boulders of red chert, minor volcanics and argillite. These deposits are locally strongly indurated and mottled.

High level alluvium (Qpa) of probable Pleistocene age occurs as a prominent, terrace containing mainly silt, with minor sand and gravel. This terrace is preserved as an erosional remnant at various locations along the Brisbane River and other major river systems in south-east Queensland.

Along tributaries of the Condamine River is unit Qpf. This unit was originally mapped on the Chinchilla 1:250 000 map sheet as the Chinchilla sand (Reiser, 1971).

Deep weathering profiles

Areas of duricrust (Td units) mainly cover units of the Main Range Volcanics in the central part of the map. Deep weathering on other geological units is shown on the map by a deep weathering screen or is designated by the symbol Td. The weathering screen generally indicates that the underlying unit is strongly mottled and indurated by the weathering process. In many areas within duricrust units the composition of

Table 6: Deep weathering units

Unit	Symbol	Age	Lithology
Td	Td	TERTIARY	duricrusted old land surface: ferricrete, silcrete and indurated paleosoils at the top of a deep weathering profile
Td^r	Td^r	MIOCENE	laterite, extensive red soil development, minor ferricrete, rare alcrete
Td^s	Td^s	TERTIARY	silcrete, silicified quartz sandstone

the underlying bedrock is difficult to discern. In addition a pallid zone is locally present at the base of the weathering profile. This zone is mainly developed on rocks of the Tarong beds and Permian to Triassic granitic rocks of the Boondooma Igneous Complex. This zone has been designated by a 'k' (for kaolinised) subscript in these units. These zones locally contain good quality kaolinite and form part of the kaolinite resource of the Kingaroy region.

Unit Td^r generally comprises red pisolitic ironstone (forming ferricrete or locally alcrete zones) or mottling on a range of units. It is most extensively developed on the Main Range Volcanics and Boondooma Igneous Complex as a deep red iron or alluminium-rich lateritic soil profile.

Movement of hot carbonated water from the Main Range Volcanics has resulted in hydrothermal alteration over a range of geological units. This has locally desilicated basalt of the Main Range Volcanics and silica has been redeposited to form silcrete zones (Td^s). This unit also comprises silcrete or silica cemented sandstones developed on the Tarong beds, at the top of medium grained granitic units, and on underlying Tertiary sediments (forming unit Tss). The silcrete zone has been recognised from extensive drilling for kaolin deposits in KINGAROY.

Field investigations suggest that there is more than one period of deep weathering and duricrust development. The best evidence of this occurs in extensive areas of regolith north of Kingaroy.

At AMG 367231, 70815881 (MURGON) a weathering profile is developed on colluvial deposits of probable Tertiary age. Boulders in the profile are of quartzose sandstone and granite. These deeply mottled deposits are overlain by silcrete above this cutting. Indurated red soils are extensively developed on Tertiary basalt of the Main Range Volcanics.

IGNEOUS ROCKS

CARBONIFEROUS–PERMIAN INTRUSIVES

Mount Cross Igneous Complex (Cpm)

Introduction

Gibson (1975), Hamerli (1982), Smith (1974), Stegman (1982), Lindsay (1986), Ross (1986), and Katjivikua (1989) described this complex in University of Southern Queensland student theses. The name was published on the Moreton Geology map (Whitaker & Green, 1980). The Mount Cross Igneous Complex contains both intrusive gabbro and sedimentary rocks derived directly from the gabbro. The complex is aligned east west and is bounded to the north and south by faulting that forms part of a regionally significant fault system. Due to the small size of the unit some exaggeration of size has been necessary to show this area at the present map scale. For a better depiction of the relationship between units in this area see Figure 4.

Distribution

The Mount Cross Igneous Complex is an east west elongate body 6km long and up to 1km wide with Mount Cross (AMG 41775, 696295) close to its western extremity.

Derivation of name

The extent of this complex on the accompanying map forms part of an entity described informally by Smith (1974) as "Mount Cross Gabbro Complex". This latter entity included gabbros, dolerites, basalts and serpentinites. In the current mapping this unit (CPm) includes only the gabbro and derived gabbroic sediments.

Topographic expression

The Mount Cross Igneous Complex forms mainly a gently sloping tableland with elevations ranging from 380–500m above sea level. Steep slopes associated with deeply incised gullies and creeks characterise the southern and western margins. The tableland area has been cleared and forms well-grassed grazing land.

Geophysical expression

The ternary K–Th–U radiometric image shows dark tones over this area indicating low responses in all channels. A generally high magnetic response is associated with this unit. This response also extends to the east beneath the cover of Woogaroo Subgroup. At the western margin the magnetic response is low possibly due to a probable reversely polarised Tertiary basalt intrusion at Mount Cross.

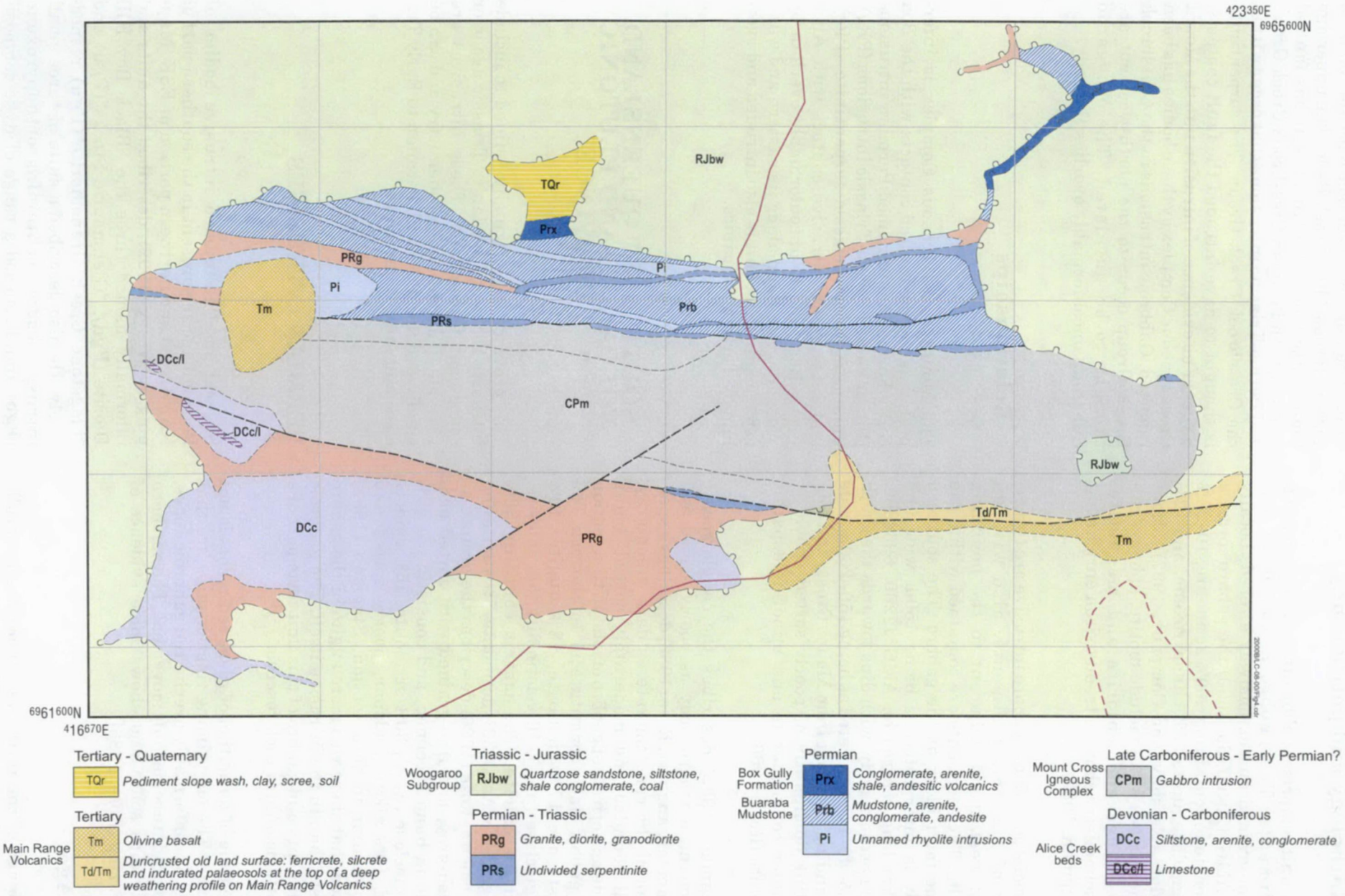


Figure 4. Detailed geology of the Mount Cross area

Lithology and petrography

The unit comprises gabbro and gabbroic-derived sediments. The gabbro is coarse to medium-grained and extensively altered. Locally (at AMG 420400, 6963600) the gabbro forms a greenstone containing ~60% actinolite, 10–20% plagioclase, up to 25% clinopyroxene, and 12% epidote (Kershaw and Company, 1992). Minor minerals (all <5%) include biotite, sphene, calcite, leucoxene, chlorite and magnetite. Geochemistry shows a trend to iron enrichment (Stegman, 1982).

Associated with the gabbro intrusive are two areas of gabbroic sediments, also with an east-west trend, adjacent to the bounding faults. The sediments are contained within the same fault block as the gabbro. The southern body is interpreted as being 150m wide and 1.2km long centred on AMG 42200, 6962900. The northern body, with dips towards the south at 25–40° is interpreted as being 150–200m wide extending 2km east from Mount Cross, and consisting dominantly of poorly sorted pebble to boulder conglomerate and minor feldspathic arenite (Ross, 1986).

Stegman (1982) describes the conglomerate from the northern body as poorly sorted and commonly angular. Ross (1986) describes a specimen of the conglomerate as dark green-grey, well rounded and moderately sorted, being made up entirely of gabbro clasts. In thin section the gabbro clasts constitute 95% of the rock. The clasts are 17% enstatite, 18% augite, 40% plagioclase (An_{54}), 10% actinolite, 5% chlorite, and 5% calcite. The matrix contains 60% plagioclase (An_{50}), 30% actinolite, 5% augite and 5% calcite. Ross (1986) describes the arenite as green-grey, and fine-grained with sorted bedding in hand specimen, and consisting of 45% plagioclase (An_{72}), 30% actinolite, 15% epidote and 10% alkali feldspar, poorly sorted and subangular in thin section. Stegman (1982) noted that there was more augite in the gabbro clasts than in the intrusive itself. The gabbroic sediments and gabbro of this unit form part of a strategic quarry rock reserve.

The time of formation of these sediments is not known. The only timing relationships are that they unconformably overlie the gabbroic rocks, and predate some fault movement. The northern body dips south and shows some evidence of shearing (Ross, 1986).

Age

The age of the intrusive gabbro has generally considered to be Carboniferous–Permian. It has interpreted intrusive contact with Devonian to Carboniferous Alice Creek Beds. The upper age limit is also not well defined — it has faulted contacts with Permian Cressbrook Creek Group and Permo-Triassic intrusions that occur within the Cressbrook Creek Group. The serpentinite is thought to have intruded the fault contacts, however no evidence of intrusion into the Mount Cross Igneous Complex by these bodies has been reported. Gabbroic intrusions in the Cressbrook Creek Group occur to the north-west but are thought to be unrelated. The Woogaroo Subgroup unconformably overlies the body.

Relationships

The Mount Cross Igneous Complex is interpreted as having faulted contacts with the Box Gully Formation, unnamed Permian intrusions (Pi), unnamed Permo-Triassic intrusions (PR*g*), unnamed Permo-Triassic serpentinite (PRs), and interpreted intrusive contact with Alice Creek Beds and is unconformably overlain by Woogaroo Subgroup along its eastern and western margins. The unit is also intruded and overlain by Tertiary volcanics.

SOUTH-EAST QUEENSLAND VOLCANICS AND PLUTONIC PROVINCE

This province was originally defined to include intrusive rocks of Permian to Triassic age over south-east Queensland. These intrusives are variable in extent and geochemistry and can be subdivided into Permian, Permian to Early Triassic and Late Triassic age.

PERMIAN INTRUSIVES

Several small unnamed intrusive bodies of Permian age are present in the southern part of NANANGO and northern portion of ESK. Mapping by Willey (1999), described the units and informally named three the "Black Boy Hill Diorite"(**Pgd**), "Glenmaurie Stocks"(**Pgu**) and "Flagstone Creek Granodiorite"(**Pgu**) respectively. He also described a suite of three small intrusive bodies containing orthopyroxene (**Pgo**) and discussed a range of dyke compositions.

Pgd

Introduction

This body was first identified as a separate unit by Willey (1999) and informally named the "Black Boy Hill Diorite". It is one of a number of small previously unmapped and generally basic intrusions in the region.

Distribution

Willey's (1999) "Black Boy Hill Diorite" is located adjacent to the eastern margin of the southern-most body of the Taromeo Igneous Complex. It crops out over an area of <0.5km^2 and probably represents the top of an intrusion which has just been unroofed (Willey, 1999).

Topographic expression

The 'Black Boy Hill Diorite' is represented by heavily timbered steep country dissected by tributaries of Emu Creek. Exposure is good in some of the deeply incised gullies.

Geophysical expression

Most of the unnamed Permian intrusions show relatively high magnetic responses on the reduced to the pole (RTP) magnetic image. The unit has a very high response, reflected in the abundant magnetite content observed in thin section.

The unit as typical of diorites, shows up as a dark signature on the K–Th–U (RGB) radiometric image. It has low responses on all radiometric channels.

Lithology and petrography

The 'Black Boy Hill Diorite' is a medium to coarse-grained leucodiorite containing andesine (~65%), hornblende (~20%), magnetite of up to 10%, minor biotite (~5%) and rare interstitial quartz. Homogeneity of the unit seems to preclude a volatile-rich phase and indicates a large intrusion at depth (Willey, 1999).

Age

Willey (1998) published a K/Ar age of 270Ma (at the boundary between the Early and Late Permian) for the Black Boy Hill Diorite. This contrasts with the adjacent unit of the Taromeo Igneous Complex that is dated at Middle to Late Triassic (240, 233Ma).

Relationships

The "Black Boy Hill Diorite" intrudes and hornfelses the Devonian–Carboniferous Maronghi Creek beds. No contact with the Taromeo Igneous Complex or the adjacent orthopyroxene unit (Pgo) has been observed.

Pgu

Introduction

Willey (1999) identified two separate stocks (one of which he dated) north of the Eskdale Granodiorite and informally named them Glenmaurie East and West. He also identified another intrusion north-east of the Djuan Tonalite and informally named it the "Flagstone Creek Granodiorite". An intrusion of similar composition but located further north, to the east of Woolshed Mountain Granodiorite, has also been included in this group.

Distribution

'Glenmaurie East' is made up of two discrete lobes with a combined area of 3km^2 and 'Glenmaurie West' covers 2km^2. The 'Flagstone Creek Granodiorite' is a complex intrusion exposed in a body 150–300m in width, and 5km in length. Further north, to the east of the Woolshed Mountain Granodiorite, an elongate body of similar composition is exposed over an area of 0.5km^2, with two small bodies in close proximity cropping out over areas of only a few hundred square metres. Intrusive bodies with similarly small outcrops occur on ESK along Maronghi Creek and around the Glenmaurie stocks. Several north- west-trending dykes, some of which are mineralised, occur to the north of the Eskdale Granodiorite.

Topographic expression

These small bodies, east of Woolshed Mountain Granodiorite and Djuan Tonalite are poorly exposed and deeply weathered. This is also typical for flatter areas of the Glenmaurie bodies on ESK. Generally the bodies form rugged hilly areas (elevation between 180 and 500m) with scattered boulders in the headwaters of Calabashi Creek and south of the junction of Spring and Maronghi Creeks.

Geophysical expression

The 'Flagstone Greek Granodiorite' and an associated intrusive to the north have a relatively lower magnetic response than the 'Glenmaurie Stocks'. Magnetic response for the two

Glenmaurie Stocks is variable with both prominent highs and lows and this shows the heterogeneity of the intrusions. The intrusive body along Calabashi Creek also has both very low and high magnetic signatures whereas the body at the junction of Maronghi and Spring Creeks has small areas of high magnetic response. The magnetic response in the area surrounding the Glenmaurie Stocks suggests that these bodies more extensively intrude the Maronghi Creek Beds at depth over an area possibly as large as 21km^2. On ESK both of the 'Glenmaurie Stocks' have a generally low central response with a higher surrounding response on the K–Th–U ternary radiometric image, probably reflecting the change from dioritic to granitic phases. The more granitic-rich areas have a similar radiometric response to that of the adjacent Maronghi Creek Beds. The units form part of an overall area of moderate–high gravity response.

Lithology and petrography

Willey (1999) described the lithology and petrography of both the Glenmaurie Stocks and the 'Flagstone Creek Granodiorite'. He described the Glenmaurie Stocks as comprising two discrete and heterogeneous bodies. The eastern body is comprised of two lobes, an eastern and western lobe. Petrographic analysis of the eastern lobe shows it to be a homogeneous diorite containing subhedral andesine (60%), hornblende (30–35%), interstitial quartz (3%) and blocky opaques. By contrast, the western lobe is heterogeneous with compositions ranging from augite-hornblende-biotite diorites to granodiorites and granites. The body informally named 'Glenmaurie West' is composed primarily of hornblende-biotite granodiorite with diorite and minor granite.

Of the other intrusions in this unit, the 'Flagstone Creek Granodiorite' and the northern bodies are similar. They have a generalised mineralogy of oligoclase (~40%), quartz (~40%), orthoclase (~20%), biotite (8%) and minor hornblende (~2%). Texture is granular to seriate, medium grained (2–5mm) with glomeroporphyritic mafics. The intrusions can be porphyritic in part with phenocrysts of oligoclase (3–8mm) in a groundmass of quartz and mafic. The 'Flagstone Creek Granodiorite' is locally strongly sheared and fractured though not cataclastically deformed.

The gold and arsenic mineralised quartz diorite dyke in Nukinenda Creek at AMG 416610, 7010580 is sheared, heavily weathered and altered.

Ages

Potassium/argon age dating by Willey (1998) returned ages of 290 and 285Ma for the 'Glenmaurie East' Stock and 283Ma for the 'Flagstone Creek Granodiorite'. No dating of the other bodies has been undertaken.

Relationships

Similar to the other Permian intrusions the 'Glenmaurie Stocks' (P*gu*) intrude and hornfels the Maronghi Creek beds. The 'Flagstone Creek Granodiorite' (P*gu*) intrudes the Sugarloaf Metamorphics and in part occurs along an interpreted boundary between Sugarloaf Metamorphics and Maronghi Creek Beds.

Associated mineralisation

Diorite dykes with a north-west trend extending from Old Milford Rocks homstead ruins (at 419200 7006200) to the Nukinenda Dyke in Nukinenda Creek contain gold and arsenic mineralisation (see 'ECONOMIC GEOLOGY'). The stratigraphic relationship of the dykes is uncertain, but their degree of alteration suggests that they may be Permian in age. Some alteration and mineralisation may have occurred during emplacement of the Eskdale Granodiorite in the Middle Triassic.

P*go*

Introduction

Three bodies of an orthopyroxene-bearing gabbro to diorite suite have been identified — an eastern body, a central body in the southern part of NANANGO and a southerly body in the northern part of ESK. These bodies have been grouped together as one unit on the basis of their similar heterogeneous basic compositions and presumed Permian ages.

Distribution

The central body, adjacent to the 'Black Boy Hill Diorite', occurs mainly on the southern side of Emu Creek and has an interpreted area of ~1.0km^2. The smaller eastern body has an area of ~1400m^2 while the southern body covers ~2km^2. The eastern body is located at the contact of the Maronghi Creek beds and Esk Formation in the headwaters of Happy Creek, while the southern body occurs between the Djuan Tonalite and Eskdale Granodiorite near the boundary between the Maronghi Creek beds and Sugarloaf Metamorphics.

Topographic expression

The eastern body of the orthopyroxene diorite to gabbro suite forms hilly country and is obscured by the overlying Triassic Esk Formation. The central body also forms steep country incised by Emu Creek and its tributaries. Exposure of the central body is good in the bed of Emu Creek and its minor tributaries. The southern body forms hilly country, is generally poorly exposed, and contains only scattered tors and boulders in soil.

Geophysical expression

All bodies of the orthopyroxene diorite to gabbro suite show high magnetic responses on the RTP magnetic image. In common with the 'Black Boy Hill Diorite', abundant magnetite is present in thin sections from this unit.

Whilst having a dark radiometric signature, indicating low levels of thorium, potassium and uranium, the radiometric signature is not as dark as that of the Black Boy Hill Diorite.

Lithology and petrography

In contrast to the homogeneous 'Black Boy Hill Diorite' the central and north-eastern orthopyroxene bodies are characterised by heterogeneous dioritic and gabbroic rocks, including hypersthene-bearing phases. Thin section analyses by Willey (1999), show the central body contains plagioclase (58–70%), altered olivine (0–4%), orthopyroxene (0–13%), clinopyroxene (1–10%), hornblende (3–10%), biotite (3–8%), opaques (3–6%) and quartz (2–8%). Plagioclase is commonly euhedral to subhedral while mafics are glomeroporphyritic and commonly exhibit hypersthene/augite/hornblende/biotite rims. Quartz and orthoclase occur as interstitial minerals and opaques are commonly rimmed by biotite. Textural variation is also common within the central body with areas containing numerous xenoliths of country rock as well as dioritic (?cognate) xenoliths. At one locality xenoliths of country rock up to 8m in diameter are dominant, forming a volcanic breccia, and may represent a volcanic conduit. No petrographic analyses are recorded for the north-eastern body.

The southern body is more homogeneous than the other two bodies and comprises plagioclase (55–60%), orthopyroxene (8–20%), clinopyroxene (5–7%), hornblende (3–5%), biotite (6–12%), opaques (3–6%) and quartz (3–8%). One thin section included 8% orthoclase.

Age

No age dating has been carried out on the orthopyroxene suite. However, the south-western body of this unit does not show an apparently identical deformation to that present in the 'Flagstone Creek Granodiorite' (283Ma) and therefore must post-date it (Willey, 1999). A portion of the Taromeo Igneous Complex, which is dated at 240Ma, intrudes the central body. On the basis of field relationships an undifferentiated Permian age is assigned to this unit.

Relationships

The two northerly orthopyroxene bodies intrude and hornfels the Maronghi Creek beds. The central body is intruded by the Taromeo Igneous Complex and is faulted against non-hornfelsed, presumed Mesozoic, sediments along its eastern margin. These younger sediments are referred to as Maronghi Creek beds "Element E" by Willey (1998). The southern body intrudes Sugarloaf Metamorphics and probably also intrudes the Pgu unit to its north, however no direct field evidence was found to confirm this.

Unnamed Permian Intrusion (Pi)

Introduction

This body described in a USQ thesis by Ross (1986), and a QUT thesis by Stegman (1982) occurs close to the Mount Cross Igneous Complex. These theses identified small rhyolitic intrusions in the Cressbrook Creek Group north of Mount Cross on ESK.

Distribution

The unit occurs north of Mount Cross as dykes in the Buaraba Mudstone, and has an extent of $<0.5km^2$.

Topographic expression

The area forms hilly moderately vegetated country between 420–500m in elevation.

Geophysical expression

Outcrop of the unit is too small for individual geophysical signatures to be identified.

Lithology and petrography

Initial interpretation indicated the unit consisted of rhyolite dykes and sills causing some soft sediment deformation in the Buaraba Mudstone (Stegman, 1982). Some horizons of

volcanic breccia and agglomerate tuff have also been mapped (Ross, 1986), suggesting the possibility that this unit may be an interbedded volcanic rather than an intrusive one. Ross also noted the formation of cataclastic breccia in the rhyolite due to faulting.

Age

The unit is assigned a Late Permian age because of interpreted soft sediment deformation of Late Permian age Buaraba Mudstone (Stegman, 1982).

Relationships

The unit is within the Buaraba Mudstone. Field evidence from student theses is equivocal. The unit either intrudes Buaraba Mudstone or is a rhyolitic volcanic sequence within the Buaraba Mudstone (depending on which interpretation is accepted). It is intruded by Late Permian to Triassic diorite (PRg) and serpentinite (PRs), and is unconformably overlain by Woogaroo Subgroup (RJbw). It is faulted against the Mount Cross Igneous Complex (CPm).

Woolshed Mountain Granodiorite (Pgwm)

Introduction

This name was proposed by Cranfield & Schwarzböck (1974b) for the granodiorite that occurs at the boundary of the ESK and NANANGO sheets, south-south-west of Blackbutt. Murphy & others (1976) extended the unit by mapping in the Gympie 1: 250 000 Sheet area. The extent of the unit shown on the accompanying map approximates the original defined extents shown by previous regional mapping.

Distribution

The granodiorite is exposed over an area of ~16km^2. The main body occurs north of the Djuan Tonalite on ESK. A small area of granodiorite of this unit (~0.25km^2) occurs within exposure of the Djuan Tonalite at AMG 402000, 7007300.

Topographic expression

The granodiorite forms undulating lightly timbered country ranging in elevation from ~340–500m above sea level, and forms, with a typical dendritic drainage pattern.

Geophysical expression

The RTP magnetic image shows a general low response over the Woolshed Mountain Granodiorite. However the south and south-east parts of the body have a higher response, possibly indicating that the Djuan Tonalite occurs beneath the granodiorite in this area. At AMG 404867, 7013056, in the area of low magnetic response on the image, magnetic susceptibility readings average 31 x 10^{-5}SI units. At AMG 404469, 7011358, in the area of higher magnetic response on the image, magnetic susceptibility readings average 436 x 10^{-5}SI units. The radiometric image shows distinct pink tones for the area of outcrop of the Woolshed Mountain Granodiorite which contrast well with the darker response of the Djuan Tonalite and the lighter response of the Sugarloaf Metamorphics.

Lithology and petrography

Cranfield & others (1976) described the granodiorite as pale pinkish-grey, mottled by dark biotite flakes, medium to coarse-grained, holocrystalline, and hypidiomorphic granular. Thin section constituents are zoned plagioclase (andesine), with sericite alteration, quartz, orthoclase, and biotite, together with minor hornblende, magnetite, epidote, clinozoisite, and chlorite. Accessories include zircon, apatite, and allanite. The plagioclase is of two generations: the earlier generation is coarser-grained, minutely oscillatory zoned, and saussuritised (oligoclase to andesine in composition); the later generation is fresh unzoned andesine.

Orthoclase is perthitic, and has reacted with biotite to form iron oxides, and myrmekitic and wormlike intergrowths. Quartz forms anhedral grains. Biotite is pleochroic brown to green, is altered to epidote and chlorite, and has inclusions of wedge-shaped crystals of allanite and euhedral zircon. Hornblende is blue-green, subhedral, and constitutes ~1% of the rock. Apatite typically occurs as inclusions in plagioclase. In the current mapping thin section from AMG 404469, 7011358, contained biotite and hornblende (locally twinned) that have minor metamict textures and minor alteration to chlorite. There was no apparent difference in rock type from the magnetic and non-magnetic parts of the unit.

Age

The Woolshed Mountain Granodiorite was initially assigned a radiometric (K/Ar) age of 253±8 Ma. This was recalculated to 258.2±8Ma (Late Permian) by Day & others (1983).

Relationships

The unit intrudes the Sugarloaf Metamorphics and is intruded by the Djuan Tonalite. Cranfield & others (1976) reported intrusions of spherulitic rhyolite dykes and a basic dyke within this unit. East west trending rhyolite dykes up to 5m wide appear to be offset by minor faulting at AMG 405980, 7012470. Scott (1963) reported the contact between the Djuan Tonalite and Woolshed Mountain Granodiorite is gradational, and can be distinguished as a mixed phase over <15m. Contact metamorphism of the country rock by the granodiorite is not pronounced. The unit is unconformably overlain by Main Range Volcanics and Tertiary sediments in the north on NANANGO and by a small area of Main Range Volcanics at Woolshed Mountain on ESK. A small area of Woolshed Mountain Granodiorite was recorded within the Djuan Tonalite at AMG 402000, 7007300.

PERMIAN TO MID-TRIASSIC INTRUSIVES

Taromeo Igneous Complex (PR*gm*)

Introduction

The Taromeo Igneous Complex is a new name for the Taromeo Tonalite as defined by Murphy & others (1976). Gradwell (1949) informally named the complex as the "Yarraman Granodiorite" and "Taromeo Tonalite" and more recently Willey (1999) informally named the southern-most portion the "Googa Googa Granodiorite" and "Googa Googa Tonalite" respectively. Other studies undertaken over various parts of the complex include QUT student theses by Barrie (1982), Bowden (1985), Robertson (1987) and Wehrle (1995).

Aerial magnetic and radiometric images along with field mapping have been used to assign seven units within the complex, namely; R*gm*$_d$, R*gm*$_g$, R*gm*$_{gd2}$, R*gm*$_{gd1}$, PR*gm*$_{gd2}$, PR*gm*$_{gd1}$ and PR*gm*$_t$ (Figure 5). Unassigned areas are referred to as PR*gm* (Table 7).

Distribution

The spatially and genetically related intrusions (Wehrle, 1995) making up the complex, form a roughly north-north-west trending mass extending from Emu Creek, south of Blackbutt, to Barkers Creek north-west of Nanango and cover an overall area of ~300km^2 (see Table 7).

Topographic expression

Outcrop within the Taromeo Igneous Complex is generally poor with most of the units forming gently rolling soil covered hills and valleys. Good exposures of rock can be found along the old coach road linking Blackbutt and Nanango (PR*gm*$_t$) and beside Seven Mile Diggings Road south of Nanango (PR*gm*$_{gd2}$). Large tors of PR*gm*$_{gd2}$ are present beside the D'Aguilar Highway north-west of Nanango.

Tors of R*gm*$_{gd2}$ crop out on hillsides east of the D'Aguilar Highway in the Cooyar Creek valley and scattered outcrop can be found on the hills north of Blackbutt near the abandoned Taromeo and Ashington mines. Exposure of PR*gm*$_{gd1}$ is poor although minor weathered outcrop is present in some gullies. Duricrust and weathered Tertiary sediments and volcanics obscure the majority of the unit.

Further north, exposure of R*gm*$_d$ in the headwaters of Taromeo Creek is impressive where it forms prominent steep creek banks (Plate 4). Subunit R*gm*$_{gd1}$ forms the topographically low area of the Googa Googa Creek valley and adjoining Emu Creek. Here, scattered outcrop is present on the valley floor north of Emu Creek. Subunit R*gm*$_g$ is exposed as roadside boulders on the access road to Blackbutt Heights Estate.

Geophysical expression

Magnetics

The Taromeo Complex exhibits well-developed magnetic zoning. The magnetic properties of the Taromeo Igneous Complex are variable. This is reflected in both the variations in the total magnetic intensity images in the aerial magnetic data and the hand-held magnetic susceptibility readings. Low responses on the image are supported by low magnetic susceptibility readings, indicating no reverse polarised areas are present within the unit. Similarly, units that show low a magnetic response are those that contain lower amounts of magnetite. All units except for PR*gm*$_t$ have a moderate to high magnetic response on the images.

Subunit R*gm*$_d$, although generally poorly exposed, except in Taromeo Creek, has the strongest magnetic response of all the units. The RTP image shows that this intrusion is considerably larger than the mapped boundaries indicate and has a significant sub-surface component.

Subunit R*gm*$_{gd2}$ is unique within the Taromeo Igneous Complex, by having a characteristic nested pluton structure with concentric rings of

Table 7: Units of the Taromeo Igneous Complex

Subunit	Distribution	Lithology	Relationship	Age (Ma)	Reference
PR*gm* (undivided)	five major bodies; four are distributed 6–10km south of Blackbutt (~0.4km^2, ~1km^2, ~3km^2, ~0.6km^2) and one 3km east of Benarkin (~6km^2); small bodies between Emu Ck and Blackbutt	granodiorite, tonalite, diorite, gabbro, granite, locally weathered and decomposed	intrudes Maronghi Creek beds and is possibly overlain by Triassic Esk Formation; overlain by laterised Tertiary sediments and Main Range Volcanics	?Permo-Triassic	Murphy & others (1976)
R*gm*$_d$	south of the confluence of the east and west branches of Taromeo Creek (~7km^2) ~7km north of Benarkin; isolated outcrop to the north of main body	light to dark grey, fine to coarse quartz diorite, granodiorite, gabbro, diorite, tonalite? and microdiorite	intrudes Maronghi Creek beds; intrudes Triassic Esk Formation near Red Queen copper mine	?Late Triassic	Hart & Gould (1988)
R*gm*$_g$	~8km north of Blackbutt (~6.5km^2)	pink–grey medium to coarse granite	intrudes Gilla Volcanics; most probably intrudes R*gm*$_{gd2}$	?Late Triassic	this report
R*gm*$_{gd2}$	roughly reniform shaped body located in about the middle of the complex ~8km NNE of Blackbutt (~25km^2; mostly obscured by Gilla Volcanics	light grey, grey–pink, medium grained biotite hornblende granodiorite, granite, quartz monzonite, tonalite and quartz diorite	intrudes Gilla Volcanics; crosscut PR*gm*$_t$	K/Ar 229±11	Gradwell (1949); Green (1976), unpublished UQ lab notes
R*gm*$_{gd1}$	6km south of Blackbutt (~20km^2)	light grey medium grained equigranular to sparsely porphyritic biotite hornblende granodiorite, minor tonalite	intrudes Maronghi Creek beds and ?Gilla Volcanics; intrudes unnamed Permian intrusives on eastern margin; intrudes unassigned Taromeo Igneous Complex on western side; overlain by laterised Tertiary sediments and Main Range Volcanics	K/Ar 233, 240	Murphy & others (1976); Willey (1998); Willey (1999)
PR*gm*$_{gd2}$	trends north-west from ~1km north of Seven Mile diggings to Barkers Creek north-west of Nanango (60km^2)	light grey medium grained biotite hornblende granodiorite	intrudes Maronghi Creek beds and PR*gm*$_t$	Ar/Ar 248, 263.3 K/Ar 225.7	Gradwell (1949); UQ recalculation of Webb & McDougall (1968) and Harding (1969); Murphy & others (1976); Wehrle (1995)
PR*gm*$_{gd1}$	~3km NE of Blackbutt (3km^2)	granodiorite, generally deeply weathered, minor tonalite	intruded Maronghi Creek beds; overlain by Tertiary sediments and laterised Main Range Volcanics	?Permo-Triassic	this report
PR*gm*$_t$	three major bodies; southern portion extends from 7km north of Benarkin to 6km west of Blackbutt and north to Taromeo Copper Mine (~30km^2); the other two bodies are 11km SE (5km^2) and 7km SSE of Nanango, (30km^2)	grey medium grained tonalite, granodiorite and minor dark grey quartz diorite and diorite, rare quartz gabbro	intruded Maronghi Creek beds and Gilla Volcanics; may have intruded PR*gm*$_{gd2}$ or was possibly comagmatic	K/Ar 242.9	UQ recalculation of Webb & McDougall (1968); Murphy & others (1976); Wehrle (1995)

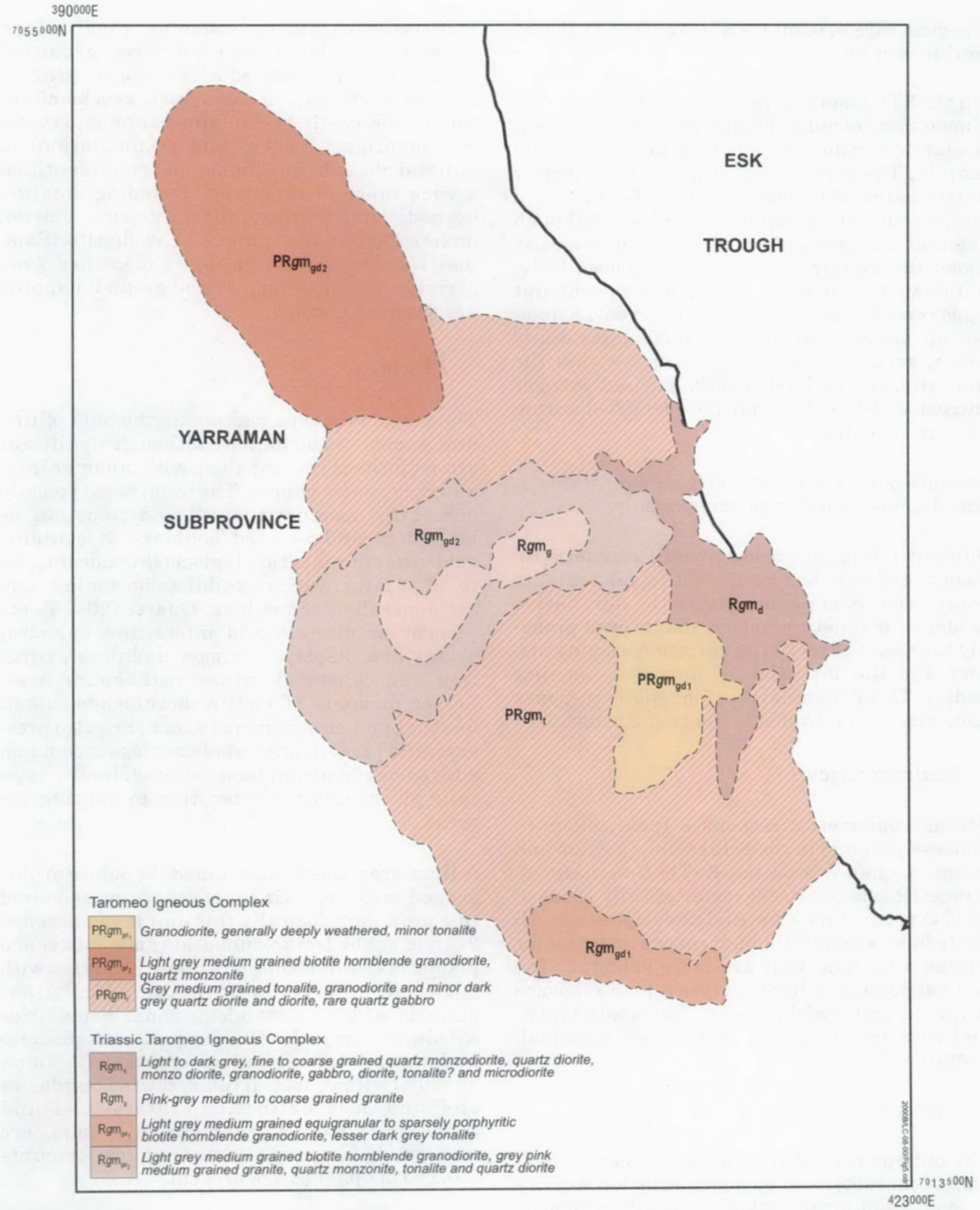


Figure 5. Interpreted extent of Taromeo Igneous Complex with Gilla Volcanics, Maronghi Creek beds and more recent surficial deposits removed

relatively higher magnetic intensity. The eastern side of the unit is more magnetically intense and corresponds with more typically mafic rock types.

The moderate magnetic response of subunit Rgm$_{gd1}$ on the reduced to the pole (RTP) image makes it easily distinguishable from the surrounding nonmagnetic Maronghi Creek beds and units of the Gilla Volcanics. This feature was used as a major aid in the delineation of the unit boundary. Hand held magnetic susceptibility meter readings average 1366x10^{-5} at an outcrop adjacent to the road at AMG 4102, 70203 on NANANGO. These readings are consistent with

the moderate percentage of magnetite observed in thin section.

On the RTP magnetic image, subunit PR*g*m_{gd2} is shown to be ovoid in shape with an overall low magnetic response that is heightened along its margin. The zone of higher magnetic intensity surrounding the intrusion may be due to a chilled margin or hornfelsing effect. Although the unit displays increased magnetic intensity along the margin and at several places in its north-western portion, the bulk of the subunit appears to be the result of a single event. A number of relatively higher, and one substantially lower, areas of magnetic response within the unit are most probably poorly exposed younger intrusive bodies that were not identified during current mapping.

Because of very poor exposure subunit PR*g*m_{gd1} was delineated using geophysics only.

Subunit PR*g*m_t has a low overall magnetic response and this has been used to delineate its boundaries. Some areas within the unit have a moderate magnetic response that is most probably the result of rock type variation, cooling history and the intrusion of numerous smaller bodies. This dissimilarity of magnetic response shows the unit is probably composite in nature.

Radiometrics

Strong radiometric responses (pale colour — 'hottest' plutons) in the potassium, thorium and uranium channels on the K–Th–U ternary radiometric image are characteristically areas of good exposure and a more felsic composition. All units have a generally high response except for PR*g*m_t and R*g*m_d that are more subdued. The central portion of R*g*m_{gd2} gives a high response in all channels and has been delineated as R*g*m_g and corresponds with a more felsic grey-pink granite.

Gravity

The outcrop area of the Taromeo Igneous Complex is characterised by a generally low gravity response similar to that of the Eskdale Igneous Complex to the south.

Lithology and petrography

Gradwell (1949) described rocks of the area as being tonalite and granodiorite in composition. Murphy & others (1976) acknowledged the variability of the Taromeo Igneous Complex and described rock types ranging from granite to gabbro. Tonalite was found to be the dominant rock type. Wehrle (1995) also recognised two rock types within the complex, tonalite and granodiorite, but identified three granitoid groups using normalised REE patterns. He considered that variations in rock geochemistry could most easily be explained through crystal fractionation (removal and accumulation) of mineral phases. Current mapping has identified a wide range of rock types including tonalite, granodiorite, granite, quartz diorite, diorite, quartz gabbro and quartz monzodiorite. Samples were obtained from units identified from aerial geophysical images and ground mapping are described below.

PR*g*m_t

The major rock type making up the bulk of this unit appears to be tonalite although significant granodiorite is present along with minor granite and rare quartz gabbro. The tonalite is typically dark grey, medium grained and crops out as large tors and isolated boulders. It contains subhedral to euhedral plagioclase (Andesine, up to 40%) laths, which exhibit some zoning, and are generally 2–3mm long. Quartz (20–30%) is present as discrete and interstitial anhedral grains and displays common undulose extinction and consertal intergrowth boundaries. Lesser amounts of biotite, hornblende, alkali feldspar and minor zircon (<1mm) are also present. Mild sericitisation of plagioclase is common with some cores completely altered. Biotite typically shows chlorite alteration to varying degrees.

A light grey, medium, grained, hypidiomorphic granodiorite occurs in the southern-most body of this unit. Petrologically this unit is composed of 2–4mm subhedral to euhedral commonly zoned plagioclase (andesine, 40–50%) crystals, with slight to moderate sericite alteration. Alteration is also present along zonal boundaries within the crystals. Quartz occurs as discrete and interstitial anhedral crystals (2–3mm, 20–30%) with consertal intergrowth boundaries and undulose extinction. Interstitial and subhedral alkali feldspar grains 1–3mm, are moderately common (15%). Only low amounts (<0.1%) of opaques are present.

Numerous dykes intrude the unit and range in composition from basalt to quartz feldspar pegmatite.

R*g*m_g

Grey-pink medium to coarse-grained granite and granodiorite are the main rock types in this unit. Some finer-grained and porphyritic equivalents are also present. A typical example of the granite is composed of plagioclase laths (~25%)

to 5mm and graphically intergrown orthoclase (~35%) and quartz (~25%). Biotite (5%) is the most common mafic mineral and small amounts of hornblende (~1%) are present.

Petrographic analysis of a moderately porphyritic granodiorite revealed a predominance of plagioclase (~35%) in both the phenocrysts (to 5mm) and in the groundmass and orthoclase (~25%) as interstitial grains and as rare perthitic grains. Quartz (~25%) occurs as both phenocrysts to 5mm and within the groundmass. Other minerals include biotite (~7%) to 3mm, minor magnetite (<1%) and sericite as an alteration of feldspar.

Rgm_d

This unit is composed primarily of quartz diorite and quartz monzodiorite, and minor diorite to granodiorite.

Medium to coarse-grained biotite-hypersthene and hypersthene augite diorites occur as creek bank exposures near their confluence of Taromeo and Teelah Creeks. Both types of diorite contain andesine (45–60%) laths to 6mm while minor (<2%) quartz is present in micrographic texture as well as in fine quartz-calcite veinlets. Common symplectite texture is present in the biotite hypersthene diorite with the hypersthene heavily included with magnetite and ilmenite.

Rgm_{gd2}

Light and dark grey granodiorites appear to be the main rock types but smaller proportions of granite, tonalite and quartz diorite are also present. A smaller central portion of the unit is predominantly medium to coarse-grained grey-pink granite, and has been described as a separate unit (Rgm_g).

Murphy & others (1976) described the main rock type near the contact with the Gilla Volcanics east of Yarraman, as a hornblende-biotite adamellite. A thin section from near this locality contained andesine (40%), alkali feldspar (35%), quartz (15%), biotite (5%), hornblende (3%) and rare zircon. Based on these modal percentages it plots in the quartz monzonite field on the IUGS QAPF classification. Another sample from the western side of the D'Aguilar Highway near Pidna was a medium-grained granodiorite. It contained quartz in graphic intergrowths, andesine plagioclase, alkali feldspar, biotite, hornblende and scattered opaques.

Rgm_{gd1}

Willey (1999) divided the unit Rgm_{gd1} into the 'Googa Googa Tonalite' and 'Googa Googa Granodiorite'. Unit Rgm_{gd1} is composed primarily of granodiorite (16km^2) with tonalite (0.8km^2) restricted to the easternmost portion of the unit. Radiometric dating by Willey (1998) indicated the tonalite phase (240Ma) is older than the granodiorite (233Ma). The eastern extremity of the unit abuts a leucodiorite ('Black Boy Hill Diorite') which Willey (1998) reported as being Permian (270Ma) in age.

Petrographic analysis of the granodiorite has revealed a composition of oligoclase-andesine plagioclase (30–50%), quartz (15–40%), orthoclase (5–10%), hornblende (5–10%), biotite (10–15%) and accessory sphene, zircon and opaques. The tonalite phase was described by Willey (1999), as "hornblende (12–22%), biotite (3–8%), oligoclase (55–62%) and quartz (18–22%)".

$PRgm_{gd2}$

Murphy & others (1976) nominated this unit as the type area for the Taromeo Tonalite. Exposure is generally poor although tors can be found adjacent to the D'Aguilar Highway west of Nanango and beside the Seven-Mile Diggings road south of Nanango. The unit is composed primarily of grey medium-grained granodiorite but also contains quartz monzonite, quartz monzodiorite, tonalite and granite.

Petrographic analysis showed that the unit was a medium-grained hornblende biotite granodiorite containing 2–3mm plagioclase laths (40%), anhedral quartz (30%), alkali feldspar (20%), biotite (5%), hornblende (5%) and small subhedral zircons.

Minor gold mineralisation is present within this unit ~1.4km east of Nanango and was exploited during the late 1800s and early 1900s (Randall & others, 1996). Mineralisation occurs in a decomposed felsite dyke 3–6m wide.

Geochemistry

Geochemical samples were collected for all subunits, except $PRgm_{gd1}$, and analysed at the Government Chemical Laboratories. All samples were obtained using a sledgehammer. Analyses have been plotted onto standard geochemical diagrams and are presented in the 'GEOCHEMISTRY' chapter of this report.

Age

Staff of the University of Queensland recalculated six radiometric age dates for different areas of the Taromeo Igneous Complex using 1980 constants (Rod Holcombe, personal communication, 1998). Recalculation of the original GSQ, Webb & McDougall (1968) and Harding (1969) dates gives an age range of hornblende Ar/Ar 263.3Ma to biotite K/Ar 225.7Ma. Significantly, the oldest and youngest ages were calculated from the same quartz monzonite sample located within PR*gm*$_{gd2}$. Together with other ages recorded from PR*gm*$_t$ (242.9Ma Webb & McDougall (1968)) and R*gm*$_{gd1}$ (233, 240Ma (Willey, 1998)) an age of Latest Permian to Late Triassic can be assigned to this complex.

The cross-cutting relationship displayed by R*gm*$_{gd2}$ on the RTP magnetic image shows it to be younger than PR*gm*$_t$ (242.9Ma). This is confirmed by an Ar/Ar date of 229±11Ma (Green, University of Queensland unpublished laboratory notes). No radiometric dates have been undertaken on unit R*gm*$_d$ although its intrusive relationship shown by hornfelsing of Early to Middle Triassic Esk Formation (AMG 416700, 7035400) indicates a probable Middle–Late Triassic age. A relational age for unit PR*gm*$_{gd1}$ is difficult to establish. A paucity of outcrop, deep weathering and Tertiary cover makes sampling for radiometric dating difficult.

Relationships

The Taromeo Igneous Complex intrudes the Devonian to Carboniferous Maronghi Creek beds and Sugarloaf Metamorphics, and the Permian to Triassic Gilla Volcanics. At least part of the complex intrudes the Early to Middle Triassic Esk Formation near the Red Queen Mine. Murphy & others (1976) reported a faulted contact with the Esk Formation east of Benarkin. Tertiary sediments and Tertiary Main Range Volcanics overlie part the complex.

Within the complex, PR*gm*$_t$, PR*gm*$_{gd2}$ and PR*gm*$_{gd1}$ appear to be oldest phases and are crosscut or intruded by the younger phases R*gm*$_{gd2}$, R*gm*$_{gd1}$ and R*gm*$_d$.

Mineralisation

Several abandoned mines and mineral occurrences are present in PR*gm*$_t$ which were worked for gold and copper in the early part of this century, although returns were low (Randall & others, 1996). Seven-Mile Diggings, Yarraman Creek diggings and Resurrection Mine, all exploited low-grade alluvial gold. Sawers (1967) reported the presence of minor bismuthinite at the Bismuth Prospect, close to the Seven-Mile Diggings. Ashington Mine, Taromeo Copper Mine and Golden Bird Mine produced copper, gold and silver from chloritic and silicic altered shear zones within PR*gm*$_t$. Small amounts of cobaltite were noted at Golden Bird (Denmead, 1934).

Stuart River Granite (new name; PR*gt*, PR*gt*$_f$)

Introduction

The unit was previously mapped by Murphy & others (1976) and included as part of their Boondooma Igneous Complex.

Distribution

The unit forms a north-north-west trending teardrop shaped pluton 15km in length and up to 4km wide, located ~18km due west of the township of Wondai.

Derivation of name

The unit is named after the Stuart River, which flows through the centre of the pluton.

Type area

The type area of the unit is designated as in the Stuart River around AMG 366300, 7089500.

Topographic expression

The unit forms an area of low bouldery hills that average 420m in elevation.

Geophysical expression

The unit has a low magnetic response on AIRDATA aeromagnetic images and a distinctive bright pink tone (potassic-rich signature) on the ternary K–Th–U radiometric image.

Lithology and petrography

The granite is fine- to medium- (or rarely coarse-) grained and cream in colour, with local areas of metasomatic? pinkening (of matrix feldspar) being common throughout the pluton. The granite is equigranular and leucocratic with the mafic minerals (fine biotite as scattered clots) making up only ~1% of the rock, associated with relatively coarse accessory sphene grains. Accessory opaques are very low or absent from the rock, which is consistent with its low magnetic response on geophysical images. In thin section,

the granite is commonly extensively recrystallised with scattered anhedral, mainly alkali feldspar grains and aggregates surrounded by anastomosing zones of strained, dynamically recrystallised, finer grained quartz aggregates.

The southernmost part of the granite (subunit PRgt_f), is relatively homogeneously fine-grained, leucocratic, and penetratively foliated.

The western contact with the Fifer Creek Metamorphics is characterised by numerous quartz blows and silica flooding of the metasediments.

Deformation

The granite is commonly cut by networks of anastomosing mylonitic shears and brittle fractures, which account for the widespread partial recrystallisation throughout the pluton. In a few places, (especially in subunit $_{PRgtf}$) biotite alignment defines a penetrative, steeply dipping, north-west to north-north-west trending foliation visible at outcrop scale. At one locality (AMG 366351, 7084851) a north-west plunging down-dip lineation is visible. The most intensely deformed rocks appear to be in the south where the granite contains mylonitic metasedimentary rafts of country rock, and within the more intensely foliated PRgt_f subunit.

Age

The PR*gt* and PRgt_f phases of the Stuart River Granite yielded Ar/Ar biotite ages of 255.5±0.6Ma and 250±0.8Ma respectively (Vasconcelos & Feng, 2000).

Relationships

The unit intrudes the Fifer Creek Metamorphics and is intruded by a small granite body mapped as unit Rg_2. The relationship with surrounding intrusive units (unit Rg_5, the Melrose Igneous Complex and the Hivesville Granite) is unknown although the regular geometry of the pluton suggests that it may have intruded these units. The granite is intruded by aplite and rhyolite dykes of unknown age.

Wooroolin Granite (new name; PRgw)

Introduction

Murphy & others (1976) previously mapped the unit as part of the Boondooma Igneous Complex.

Distribution

The unit forms an arcuate 1–2km wide belt, extending south-east for ~15km from West Wooroolin homestead, north of Kingaroy.

Derivation of name

The granite is named after the small township of Wooroolin, located 6km to the north-east of the unit.

Type area

The type area is on the north shore of Gordonbrook Dam around AMG 375700, 7074400.

Topographic expression

The unit is moderately well exposed as recessive undulating country forming the valley of the Stuart River. Elevations range from ~390m to 438m.

Geophysical expression

The unit has a low magnetic response on aeromagnetic images and displays pink tones on the radiometric images.

Lithology and petrography

The unit is dominated by leucocratic, pink, medium- to locally fine-grained, equigranular biotite granite. The biotite occurs as discrete plates scattered throughout the rock. Blocky aplitic phases occur locally. Potassic and limonitic alteration of the granite is widepread and fresh exposure is rare. The granite is intruded by a network of shallow dipping aplite veins and occasional thick basalt dykes.

Age

The unit has yielded a 274±28Ma Rb/Sr whole rock age and a 258.2Ma K/Ar biotite age from a site 5km south-west of Memerambi (Webb & McDougall, 1968). These dates are nominally of Permian age, but the imprecision of the error bar on the Rb/Sr age makes it possible that the granite ranges up into the Late Triassic.

Relationships

The granite intrudes the Devonian to Carboniferous Maronghi Creek beds and their probable metamorphosed equivalents, the Fifer Creek Metamorphics. The relationship between the lithologically different Stuart River and Hives-

ville Granites to the north is unknown, although the Wooroolin Granite may be cogenetic with the latter. The Wooroolin Granite is locally overlain by silicified Tertiary sandstones and lateritised basalt flows of the Main Range Volcanics (and intruded by related basalt dykes).

Hivesville Granite (new name; PRgh)

Introduction

The northern part of this body was previously mapped by Murphy & others (1976), as part of the Wigton Adamellite, whereas they mapped the southern section as part of the Boondooma Igneous Complex. The current mapping indicates that the comparable textural and lithological characteristics of both areas require their unification as one unit. Gradwell (1956) has also described the unit in the type area.

Distribution

The unit is irregularly distributed over a roughly triangular area, extending south-easterly from the Hivesville–Proston area to the Tingoora–Durong road. The granite is exposed over an area of roughly 200km^2.

Derivation of name

The unit is named after the township of Hivesville where good exposures of the granite are readily accessible.

Type area

The type area is designated as the western outskirts of the township of Hivesville around AMG 369100, 7104170.

Topographic expression

The unit forms recessive bouldery terrain or low undulating heavily wooded terrain that ranges in elevation from ~320m–400m.

Geophysical expression

The unit has a uniformly low magnetic response on magnetic images, and has pale to medium pink tones on the standard radiometric images.

Lithology and petrography

The typical rock type of the unit is a cream to pale grey or pink, inequigranular, coarsely megacrystic biotite granite, displaying a characteristic rapakivi texture in the type area. The matrix is commonly a quenched aggregate of fine or medium-grained quartz, feldspar and biotite. In many outcrops, the quenched matrix also contains coarse rounded quartz aggregates up to 1.5cm across as well as large feldspar phenocrysts (averaging 2–3cm across). Where quenching has not occurred, the granite ranges from coarse to very coarse in grain size, and as the phenocryst/megacryst density increases the rocks range from porphyritic to more even grained varieties (consisting of closely packed coarse feldspar crystals). Biotite within the granites occurs as clots, disseminated flakes or sliver-like aggregates (the latter in association with mafic xenoliths) making up to 8% of the rock. The biotites are locally aligned parallel to a tectonic or flow foliation.

The phenocrysts are generally composed of perthitic alkali feldspar with subordinate plagioclase. Where a rapakivi texture is developed, the alkali feldspars are rimmed by albite containing groundmass grains (generally quartz) which locally display micrographic intergrowth textures. Biotite flakes are associated with accessory sphene and to a lesser extent, zircon. Accessory opaque minerals (such as magnetite) are rare, which accounts for the low magnetic response of the granite on geophysical images. The quartz in the granites ranges from moderately strained to strongly dynamically recrystallised. In the most intense examples, fine subgrain aggregates of dynamically recrystallised quartz anastamose around coarser relatively undeformed feldspar aggregates and phenocrysts (e.g. around AMG 368300, 7106300). A significant amount of matrix recrystallisation is commonly present in rocks that appear macroscopically undeformed.

Scattered mafic xenoliths (mostly porphyritic microdiorites, tonalites) are common within the granites. At AMG 362047, 7068580 tor exposure in the creek of coarse-grained K-feldspar-phyric biotite xenolithic granite cut by rare medium-grained granite dyke; xenoliths of biotite and tonalite (some foliation). Mafic dykes sporadically intrude the unit. They are of similar composition to the xenoliths and commonly contain feldspar phenocrysts similar to those in the granite. The mafic/felsic contacts range from knife-sharp to crenulate in nature, the latter suggesting local liquid-liquid contact of the two magmas. At one locality (AMG 365800, 7109800), the granite displays a flow foliation around a small microdiorite body. The granite is intruded locally by dykes and small bodies of dolerite, gabbro, andesite, aplite, rhyolite and dacite.

Deformation

At a few localities the granite is foliated and extensively recrystallised over zones ranging from tens of metres in width to narrow mylonitic shears up to a few centimetres wide. The foliations are mostly north to north-north-west trending and steeply dipping. More detailed mapping is required to determine if the foliated parts of the granite can be related to distinct map-scale faults or continuous shear zones.

Age

The unit at Hivesville has yielded a 274±28Ma Rb/Sr whole rock age and a 250.1Ma K/Ar biotite age (Webb & McDougall, 1968). The most recent radiometric dates from the unit in this project are Ar/Ar dates on hornblende and biotite from two sites in the unit (AMG 368913, 7104100 and 366500, 7108800). These gave age dates of 254.5±1.1Ma and 260.5±0.8Ma respectively (Vasconceles & Feng, 2000). All these dates indicate a possible age range from Permian to Late Triassic.

Relationships

The Hivesville Granite is intruded by unnamed granodiorite (Rgu_{gd}, Rg_3), diorite (Rg_d), gabbro/diorite (Rgg_d), porphyritic microgranite (Rg_{ip}), and granite bodies (Rg_4) of probable Triassic age. The teardrop shaped, Permo-Triassic Stuart River Granite also probably intrudes the unit. Tertiary sediments and basic lavas of the Main Range Volcanics overlie the granite. The granite is locally strongly weathered and kaolinised with a well-developed Tertiary laterite capping.

Mineralisation

Deeply weathered and kaolinised granite in the Hivesville area has been sporadically mined as a source of high-grade clay (see 'ECONOMIC GEOLOGY' section).

Melrose Igneous Complex (new name; PRgr)

Introduction

The Melrose Igneous Complex comprises intermingled felsic to mafic coarse-grained intrusives and metamorphics that were previously included within the Boondooma Igneous Complex by Murphy & others (1976).

Distribution

The Melrose Igneous Complex forms a narrow belt extending south-east for ~8km from a position ~2km east of Melrose homestead, 14km south-south-east of Proston. The unit flanks the north-eastern margin of the Stuart River Granite, covering an area of ~4km^2.

Derivation of name

The unit is named after Melrose homestead, which is situated ~2km to the west of the complex.

Type area

The type area is designated as between AMG 366000, 7091300 and 367200, 7092000 near the intersection of Galbraith Creek and the Stuart River.

Topographic expression

The unit forms sparsely wooded low ridges and undulating hills ranging from 340m to 380m in elevation.

Geophysical expression

The unit has a low magnetic response on aeromagnetic images and occurs as dark mottled brown tones on the RGB radiometric images.

Lithology and petrography

The unit contains a variety of mostly mafic rock types, along with scattered granite phases and metasedimentary rafts. The most typical mafic rock type is fine- to medium-grained, dark grey hornblende diorite which ranges in texture from equigranular to coarsely porphyritic (or megacrystic) in feldspar. This rock type locally grades into microgranodiorite or more rarely dolerite. The granitic component of the unit is lithologically similar to the Hivesville Granite, ranging from equigranular to coarsely megacrystic, in a quenched, fine-grained matrix. The metasedimentary rafts are mainly laminated siliceous or biotite gneiss, probably representing fragments of the nearby Fifer Creek Metamorphics.

Near the Galbraith Creek-Stuart River confluence the unit is cut by north-west-trending steeply dipping mylonitic shear zones which have a sinistral sense of shear.

Age

No radiometric dating of the unit has been undertaken, but parts of the unit have lithological similarities to the adjacent Hivesville Granite. Consequently the Melrose Igneous Complex is thought to range from Permian to Triassic in age.

Relationships

The complex intrudes the Fifer Creek Metamorphics and is intruded by Triassic diorite (Rg_d), granodiorite (Rg_3), and granite (Rg_2) bodies, and probably also by the Permo-Triassic Stuart River Granite. The unit has an uncertain relationship with the Hivesville Granite and may be close to the same age. The common occurrence of feldspar megacrysts (or porphyroblasts) in both units and the range of mafic to felsic compositions in the Melrose Igneous Complex suggest that the latter results from the admixture of mafic magmas with Hivesville Granite magmas along the western margin of the granite pluton.

PERMIAN-TRIASSIC INTRUSIONS

Two unnamed Permo-Triassic units units PR*gg* and PRg have been mapped in the area.

Unit PR*gg*

This unit is the largest of these intrusions, forming a linear north-north-west trending body covering over 30km^2, 8km west of the township of Memerambi. The unit has low magnetic response and forms dark mottled tones on radiometric images (mainly as a result of the extensive residual and colluvial soil cover over the unit). The unit is comprised of cream, variably recrystallised fine to medium grained, strongly foliated gneissic biotite granite. The granite locally displays compositional banding with numerous layer-parallel pegmatite sweats, veinlets and lenses. The unit is unconformably overlain by sandy Tertiary sediments and intruded by a small mafic Tertiary plug (unit Tb).

PRg

Three areas of unnamed Permian to Triassic intrusions occur, one on MURGON and two on ESK.

On MURGON a small circular body (~1km^2) forms low scrubby country 16km north-north-west of Hivesville. The unit has low magnetic response and forms dark pink tones on the ternary K–Th–U radiometric image. The dominant rock type is sparsely porphyrytic biotite microgranite. The unit is unconformably overlain by elements of the Aranbanga Volcanic Group. A ferruginous Tertiary duricrust soil profile is developed on parts of the unit .

On ESK a body of ~3km^2 occurs near Mount Sevastopol, north of Cressbrook Creek. Hayward (1985) informally called it the Mount Sevastopol Microgranite. It is massive and has a pale pink colour when fresh. From a thin section at AMG 422949, 6986985 minerals present include zoned and twinned plagioclase (laths up to 4mm, rarely to 10mm), quartz, orthoclase, mafic minerals almost completely altered to chlorite, opaques and remnants of orthopyroxene. A notable feature is the extensive myrmekitic texture and minor micrographic texture. Minor zircon is associated with chloritised mafic minerals. The unit intrudes the Sugarloaf Metamorphics.

Shearing in the microgranite was observed at AMG 424535, 6989720, adjacent to the contact with Eskdale Granodiorite. Average magnetic susceptibility readings for points within the microgranite ranged from 55 x 10^{-5}S to 736 x 10^{-5}S. The magnetic image shows a variable but generally moderate response, which contrasts with the low response in the Sugarloaf Metamorphics to the south. On the radiometric image the body is distinguished by light pink tones, in contrast to the darker tones of the adjacent units — Sugarloaf Metamorphics in the south and Eskdale Granodiorite to the north.

A group of dioritic intrusives dykes occur to the north of the Mount Cross Igneous Complex and form massive intrusions to the south of the Mount Cross Igneous Complex on ESK. Total outcrop area is in the order of 1.25km^2 Ross (1986) indicates that the diorite dykes to the north infill fault zones in the area. A diorite intrusion separates outcrop of Buaraba Mudstone from outcrop of Box Gully Formation. To the north of Mount Cross the bodies are too small to register an individual geophysical signature on images. The dioritic intrusions to the south of Mount Cross are massive intrusions into the Alice Creek Beds.

Stegman (1982) identified a contact metamorphic effect of up to 50m, although Ross (1986) found it is difficult to distinguish from regional effects. The size of these intrusions is not known as Mesozoic sediments unconformably overlie them. To the south and east of Mount Cross a high magnetic response and a low radiometric response is probably due to a combination of the diorite intrusions and the adjacent Mount Cross Igneous Complex that has a similar response. This area of high magnetic response extends to

the east for ~4km under the cover of the unconformably overlying Woogaroo Subgroup. Equivalents of the dioritic intrusions may extend under cover up to 6km to the south-east as suggested by the moderate magnetic responses in this area. Ross (1986) reported chalcopyrite and arsenopyrite in an altered monzodiorite. A thin section of the rock contained 35% actinolite, 20% plagioclase (An_{46}), 10% microcline, 15% quartz, 5% hornblende, calcite and chlorite. The location is not known.

Kenewah Granodiorite (new name; PRgk)

Introduction

This is a new name for a granodiorite body originally mapped as part of the Woolshed Mountain Granodiorite by Cranfield & Schwarzböck (1974). The RTP magnetic image shows the Kenewah Granodiorite to be a separate body from the main Woolshed Mountain Granodiorite. On the basis of this substantially different magnetic response a new unit is proposed.

Distribution

The Kenewah Granodiorite is located in the south-eastern bottom corner of KINGAROY in the headwaters of the eastern branch of Oaky Creek and eastern branch of Granite Creek. The two areas of exposure are separated by Tertiary cover and have a combined area of ~8km^2. Elevations in this unit range from ~440m–500m above sea level.

Derivation of name

The Kenewah Granodiorite was named after Kenewah property which is situated on the western side of Cooyar Creek.

Type Area

A type area for the Kenewah Granodiorite is the valley containing the headwaters of the eastern branch of Granite Creek. In this valley scattered tors of light grey medium- to coarse-grained granodiorite occur adjacent to the road. Examples of the granite can also be found beside the road in the headwaters of the eastern branch of Oaky Creek.

Topographic expression

The Kenewah Granodiorite forms hilly country on the drainage divide between Granite and Oaky Creeks along the western margin of the Blackbutt Range. Deeply weathered Tertiary sediments and volcanics, which form the cuesta-like Blackbutt Range, obscure the majority of the unit.

Geophysical expression

Magnetic response was used to distinguish the Kenewah Granodiorite from the Woolshed Mountain Granodiorite on the RTP magnetic image. The moderate magnetic response shown by the Kenewah Granodiorite contrasts sharply with the very low response of the Woolshed Mountain Granodiorite. The subsurface body is ~19km^2 in area and is elongated in a south-westerly direction.

Contrast on the RGBI (total count as intensity layer) radiometric image is also substantial with the Kenewah Granodiorite giving a 'hot' (white) response whereas the Woolshed Mountain Granodiorite has a reddish signature.

Lithology and petrography

The Kenewah Granodiorite is composed of medium grained light to dark grey and pink, even to moderately porphyritic, biotite hornblende granodiorite and lesser grey-pink medium grained sparsely porphyritic biotite granite. The sparsely porphyritic granite contains alkali feldspar phenocrysts to 20mm although the most common size is ~5mm.

Age

No age dating of this unit has been attempted though it is probably of Permo-Triassic age.

Relationships

The Kenewah Granodiorite intrudes and hornfelses the Devonian–Carboniferous Sugarloaf Metamorphics along the contact. Sediments of the Triassic Tarong Basin, and sediments and volcanics of Tertiary age, overlie the Kenewah Granodiorite. Small Tertiary rhyolitic? plugs intrude the Kenewah Granodiorite near its south-western margin.

PRs (serpentinite)

Introduction

Outcropping serpentinite in the vicinity of Mount Cross has been detailed in student theses from USQ — (Ross (1986), Gibson (1975), Hamerli (1992), Katjivikua (1989) and Smith (1974)), and a QUT thesis by Stegman (1982). Ross (1986) states that the serpentinite forms

distinct linear outcrops within three major east west trending fault zones.

Distribution

The serpentinite generally occurs as narrow outcrops in easterly-trending fault zones to the north-east of Mount Cross. A small outcrop occurs to the east-south-east of Mount Cross at AMG 420200, 6962800. A small outcrop also occurs west of Mount Cross, in Paradise Creek at AMG 415200, 6964450 (Edwin Willey, personal communication, 1999).

Topographic expression

Due to the small size of the serpentinite bodies, they are not distinct topography-forming features.

Geophysical expression

A small positive magnetic anomaly on the total magnetic response image coincides with the serpentinite outcrop in Paradise Creek. Adjacent to the Mount Cross Igneous Complex there is no individual anomaly associated with the serpentinite. On reduced to the pole magnetic images small positive responses form a linear trend corresponding to the position of the serpentinite at the contact between the Mount Cross Igneous Complex and Buaraba Mudstone.

Lithology and petrography

Ross (1986) describes the serpentinite as having a prominent schistosity with well-developed crenulation suggesting multiple fault movement. The schistosity is subparallel to orientation of the faults. The conclusion from magnetometer surveys carried out (Smith, 1974; Stegman, 1982) was that the serpentinite bodies dip steeply to the south.

Geochemistry

No geochemical studies were carried out on the serpentinite during the current project.

Age

The serpentinite is defined by its stratigraphic relationships — it is emplaced along intruded fault planes in Late Permian age Buaraba Mudstone and is unconformably overlain by Woogaroo Subgroup. It has therefore been assigned a Permian to Triassic age.

Relationships

The serpentinite is tectonically emplaced along fault planes (probably part of the Yarrol Fault) in Permian Cressbrook Creek Group and at contact between Cressbrook Creek Group and Mount Cross Igneous Complex (CPm), and at contact between diorites (PRg) and CPm.

Boondooma Igneous Complex

Murphy & others (1976) first used the name Boondooma Igneous Complex to describe the largest mass of feldspar-phyric granitic rock of the Yarraman Block that occurred on KINGAROY, MURGON, and BOONDOOMA 1:100 000 Sheet areas. Earlier, Hill & Denmead, (1960) referred to this granitic mass as part of the Yarraman Complex. It includes the Boyne River Granite as detailed by McTaggart (1963). Exon & others (1968) also described feldspar-phyric granitic rock over the area covered by the Chinchilla 1:250 000 map sheet.

During current mapping, two major subdivisions — Triassic and Permo-Triassic Boondooma Complex (units PR*g*b and derivatives and R*g*bo and derivatives) were based on radiometric age dates or interpreted on the basis of intrusive and stratigraphic relationships. Both the Permo-Triassic and Triassic parts of the Boondooma Igneous Complex have been subject to deep weathering and locally have preserved zones of strongly mottled and or kaolinised granite. These areas have some potential as kaolin clay resources and are designated by a 'k' subscript. Other variations within the unit are related to zones of deep weathering and alteration. Within the main area of Boondooma Igneous Complex designated as R*g*bo are zones of very coarsely and abundantly porphyritic coarse grained granite (mapped locally as R*g*bo^{p}), and undivided zones of even grained medium granite, microgranite and rhyolite and more basic pods of granodiorite, tonalite to diorite unit R*g*bo$_{d}$).

Permo-Triassic Boondooma Igneous Complex (PR*g*b, PR*g*b$_{g}$, PR*g*b$_{d}$, PR*g*b$_{k}$)

Introduction

The Permo-Triassic portion of the Boondooma Igneous Complex is restricted to the southern most part of the complex. It has been subdivided lithologically into the two major units, PR*g*b$_{g}$, (a granitic to tonalite phase) and PR*g*b$_{d}$ (a more basic granodiorite to diorite phase) and three smaller units — PR*g*b, PR*g*b$_{ga,}$ and PR*g*b$_{k}$.

Smaller hydrothermally weathered ($PRgb_{ga}$) and deeply weathered pallid zone ($PRgb_k$) units have also been identified.

Fardon (1960), Lockhart (1988) and Leiseman (1988) undertook detailed mapping around Cooyar in the southern-most part of KINGAROY and covered exposure of these units.

Distribution

Undivided parts of this unit (PR*gb*) occur as small bodies intruding the Chahpingah Meta-Igneous Complex. These masses are composed dominantly of coarse- to very coarse-grained biotite granite in the northern part of KINGAROY. Another area of similar granite is present in central KINGAROY near AMG 38000, 705100.

Large areas of the granitic phase ($PRgb_g$) crop out from south of Goodger to around Maidenwell whereas smaller areas are present as far south as south-west of Cooyar. The granitic phase is exposed over an area of ~150km^2.

Smaller areas characterise the $PRgb_d$ phase. These are present on the eastern side and southern margin of the granitic phase from Cooyar in the south to north of Tanduringie homestead on the Kingaroy–Cooyar road. Total exposure of this phase is ~17km^2.

A very small area (~0.5km^2) of hydrothermally altered granite (unit $PRgb_{ga}$) is present south of the range road west of Cooyar.

Areas of deeply weathered pallid zone ($PRgb_k$) granite occur along ridge tops adjacent to the road south of the Maidenwell diatomite deposit and closer to Maidenwell Township. This unit of deeply weathered, pallid zone granite is mapped over an area of ~5.5km^2 although there are probably additional areas that have not been recognised in this area.

Reference areas

The reference area for the granitic phase ($PRgb_g$) of the Permo-Triassic Boondooma Igneous Complex is designated along and adjacent to the Bunya Mountains Road west of Maidenwell. East of Wengen Creek and adjacent to the road, are tors of grey-pink medium grained granite. Tors are also present on the hillside to the north of the road along Wengen Creek. Areas of coarser grained pink granite occur north of Maidenwell adjacent to the Kingaroy–Cooyar Road.

The more dioritic phase ($PRgb_d$) of the intrusion has a designated reference area north-west of Cooyar as outcrops adjacent to the Kingaroy–Cooyar Road. In this area dark grey medium-grained diorite boulders occur on the eastern side of the road and dark grey granodiorite–diorite is present nearby in a small quarry.

Topographic expression

Unit PR*gb*

This rock unit is characterised by gently undulating country in the northern part of KINGAROY.

Unit $PRgb_g$

This unit is characterised by undulating country with well-developed linear gullies that follow master joints in the unit.

Geophysical expression

Both unit PR*gb* and $PRgb_g$ units have a high radiometric signature (white to pale red and yellow on a ternary K–Th–U image. Unit PR*gbd* commonly has a slightly darker signature on the ternary K–Th–U image. In the southern part of the Boondooma Igneous Complex the reddish radiometric signature of unit $PRgb_g$ is indistinguishable from that of the adjacent Tarong beds.

Lithology and petrography

$PRgb_k$

Zones of kaolinised granite ($PRgb_k$) are present at AMG 379734, 7044473; 376590, 7044629, and 382072, 7047929. These zones are characterised by rocks composed of kaolinised feldspar and quartz. The weathering and alteration processes have destroyed all mafic minerals in these zones.

$PRgb_g$

This unit is characterised by a low mafic content (generally <10% comprising dominantly biotite with lesser amounts of hornblende), and is commonly equigranular and medium to coarse-grained. Texturally the unit contains areas that are porphyritic in quartz and plagioclase (AMG 382914, 7014070) or quartz and K-feldspar that have a granophyric texture (AMG 383086, 7034437, 37402, 7031362) or are hypidiomorphic. Compositionally the unit is dominated by granites to granodiorite, with areas of intermingled leucoquartz diorite and

granodiorite (AMG 380350, 7036350). The plagioclase is commonly zoned oligoclase and euhedral in shape and dusty and altered in thin section. K-feldspar forms large interstitial simply twinned, poikilitic crystals (up to 10mm at AMG 381476, 7031751) with inclusions of plagioclase with albitic rims. Biotite is most commonly the dominant mafic mineral. It is dark red-brown to foxy-brown in colour, and is commonly altered to chlorite along cleavage traces. It is locally altered to opaques (?magnetite at AMG 381196, 7013770, and 379372, 7037734).

Hornblende is <50 % of the mafic minerals, and was not observed in all thin sections. It occurs at AMG 384326, 7034437, RR 380350, 7036350 (where it has pyroxene cores) and at 378421, 7038160; 376280, 7030740 and 397371, 7037734. In these areas it is green-brown pleochroic and twinned and forms subhedral to euhedral crystals up to 2mm in size. Accessory minerals from PRgbg are not common and include zircon associated with metamict alteration of biotite with possible sphene (AMG 378421, 7038160). The most southerly part of this unit is locally hydrothermally altered.

PR*g*bd

Rocks form this unit contain significant amounts of mafics (>20% and >35% in some locations). Compositionally it comprises mafic granodiorites and tonalite to quartz diorite. Rocks from this unit are dark brown to dark grey-brown in colour and are commonly medium- to coarse-grained. Texturally they are different from PR*g*b$_g$ as quartz forms clear interstitial pools up to 5mm and hornblende-plagioclase has a subophitic relationship. K-feldspar is generally low in abundance, but is present in thin sections of granodiorite from AMG 386425, 7019608; 383559, 7014210 and 386420, 7014890. Granodiorite at AMG 386420, 7014890 contains hornblende that is subhedral, green-brown in colour, twinned, and forms crystals up to 3mm in size. Pyroxene cores to the hornblende were observed in thin sections from tonalite from AMG 383734, 7015106 and 382222, 7035690; and granodiorite at AMG 386425, 7019608 and 386420, 7014890.

Biotite is dark brown to reddish-brown and occurs as cleavage flakes from 0.5–2mm with alteration to chlorite along cleavage planes. PR*g*b$_d$ contains more opaque minerals than PR*g*b$_g$. These are commonly associated with alteration of hornblende. The mafic minerals in units PR*g*b$_g$ and PR*g*b$_d$ are essentially the same in colour and character. Accessory minerals from PR*g*b$_d$ include apatite and zircon.

Age

Ages of units of PR*g*b are given in Table 8.

Relationships

Unit PR*g*b intrudes the Chahpingah Meta-Igneous Complex in northern KINGAROY. The Tarong beds and basalt of the Main Range Volcanics unconformably overlie unit PR*g*b. PR*g*b$_g$ intrudes PR*g*b$_d$ in the southern part of KINGAROY.

Triassic Boondooma Igneous Complex (units R*g*bo, R*g*bo$_p$, R*g*bo$_k$, R*g*bo$_m$, R*g*bo$_d$, R*g*bo$_a$, R*g*bo$_b$)

Introduction

The majority of the Boondooma Igneous Complex is made up of a mass of generally weathered, grey pink, medium grained granite but it also contains rocks with a range of grain sizes and textures with significant areas of rhyolite dykes particularly in BOONDOOMA and MURGON. In the northern part of the unit there is a predominanace of K-feldspar phyric megacrystic granite.

Distribution

The Triassic part of the Boondooma Igneous Complex forms the greater part of the unit and extends from near Goodger in the south to north of Boondooma Dam.

Reference area

The type area of R*g*bo of the Boondooma Igneous Complex is designated as the creek section along Kingar Creek and its tributaries from AMG3305, 711250 to AMG 3345, 71089. This area is dominated by K-feldspar-phyric megacrystic granite with low mafic content. No specific reference areas given for other R*g*bo units.

Topographic expression

Unit Rgbo and other Triassic Boondooma units generally form low lying undulating country (250–400m elevation) in western MURGON, north-eastern BOONDOOMA and north-eastern JANDOWAE. This area is characterised in BOONDOOMA and MURGON by sparse north-east-trending dykes that locally form vine scrub thickets as vegetation anomalies.

Table 8: Units of the Boondooma Igneous Complex

Unit	Lithology	Relationships	Radiometric age dating
R*g*bo	coarsely K-feldspar-phyric to megacrystic biotite granite, K-feldspar-phyric medium grained granite, even grained medium grained biotite granite, microgranite, rhyolite and microgranite dykes	intrudes PR*g*b, Chahpingah Meta-Igneous Complex	age dates in the unit are sparse, indicating a generally Early Triassic age — 248±2.1, 238.9Ma
R*g*bo^{p}	coarsely K-feldspar-phyric to megacrystic biotite granite	part of unit R*g*bo with large K-feldspar phenocrysts in the northern part of KINGAROY	no radiometric age dating
R*g*bo$_{k}$	kaolinised granite	strongly kaolinised granite immediately south-west of Kingaroy township	no radiometric age dating
R*g*bo$_{d}$	pyroxene–hornblende diorite	intrudes PR*g*b, Chahpingah Meta-Igneous Complex	no radiometric age dating
PR*g*b	even grained medium- to coarse-grained biotite granite commonly strongly jointed and weathered	intrudes Maronghi Creek beds, overlain by Tarong beds	age dates vary from >250Ma (253, 257, 254) to 215Ma
PR*g*b$_{g}$	grey–pink medium-grained granite, coarse-grained pink granite; locally hydrothermally altered (shown by screen on map)	intrudes Maronghi Creek beds, Sugarloaf Metamorphics and is overlain unconformably by undivided Tertiary sediments (Ts)	age dates are variable — 260.2Ma, 249Ma
PR*g*b$_{d}$	dark grey even-grained diorites to granodioites	intruded by granitic phase (PR*g*b$_{g}$)	267.9±8Ma
PR*g*b$_{k}$	light grey to white deeply weathered and kaolinised granite	unconformably overlain by duricrust units Td and Td^{r}	age date of 252±2.6Ma, 272.7±9Ma

Geophysical expression

The unit form a distinctive radiometric unit characterised by high to very high counts (pale reds, orange and white) on the ternary K-Th-U image. These signatures are present for the Triassic granitic (R*g*bo — pale) and dioritic (R*g*b$_{d}$ — darker) units. These signatures are characteristic of all the Triassic part of the Boondooma Igneous Complex. The magnetic signature of most of the Boondooma Igneous Complex is weak and has some 'bullet hole' anomalies suggesting some basalt intrusions at depth and at surface. Follow up fieldwork on these anomalies showed that some areas had poorly exposed basalt, whereas others (eg AMG 3377, 71025) were poorly exposed red and brown residual soil.

Lithology and petrography

Unit R*g*bo

This part of the complex is characterised by a coarsely K-feldspar porphyritic biotite granite commonly exhibiting cumulate texture. Variations in both the size and abundance of K-feldspar crystals content are present in the unit.

The unit also contains significant areas of K-feldspar-phyric medium grained granite at AMG 332350, 7110500 associated with ferruginous mottling. Other rock types in this unit are medium-grained biotite granite, and microgranite.

Abundant areas of rhyolite dykes and microgranite dykes are present in this unit mainly in the northern part of BOONDOOMA and in MURGON. These dykes trend dominantly north-easterly (locally EW) and are poorly exposed in MURGON. In the north-eastern part of BOONDOOMA they form ring dykes at the margin of an outlier of Aranbanga Volcanic Group adjacent to Boondooma Dam spillway at the northern end of the dam.

The unit is locally deeply weathered over much of its outcrop area and develops either a ferruginised zone, a mottled zone or alternatively is kaolinised. Well-developed ferruginised zones occur in MURGON at AMG 355950, 7077590 (associated with minor ironstone lag gravels), in BOONDOOMA at AMG 341935, 7110729 as a breakaway zone in an eroded ferruginous duricrust capping with mottled and pallid material. Pallid zones in the granite were noted at AMG 381617, 7047591 associated with deeply weathered decomposed

granite, at AMG 381315, 7045796 adjacent to tor exposure of fresh biotite granite. At AMG 380871, 7045788 boulders of diorite are cut by kaolinised quartzo-feldspathic microgranite, equigranular granite.

K-feldspar-phyric granite phase

The K-feldspar-phyric phase is very characteristic in outcrop forming zones with very coarse and abundant K-feldspar megacrysts. The K-feldspar are locally up to 7cm along the eastern margin of the complex (AMG 366242, 6060542 and 3652198, 7069373), and along Kingar Creek and environs (AMG 334150, 7109150; 334150, 7109150;333750, 7109700; 332650, 7110000; 336521, 7106833; 338200, 7109029; 341268, 7110825 and 343060, 7111990).

At AMG 343550, 7101875 along Kingar Creek weathered tor outcrop of very coarsely K-feldspar-phyric biotite granite contains zones of cumulate feldspar comprising ~40% of the rock. Large K-feldspar crystals are also present in a typical K-feldspar megacrystic granite between Manar and Boondooma homesteads in BOONDOOMA. Crystals here are coarsest at AMG 340291, 7103425 (up to 8cm), but vary from 2cm (AMG 333526, 7106508) to 6 cm (AMG 346722, 7101101). Immediately south of AMG 334050, 7109400 exposures have alternating porphritic K-feldspar and equigranular bands. Shearing is present at AMG 333750, 7109700 in a coarsely porphyritic K-feldspar granite containing biotite clots and xenoliths and cut by a pegmatite vein.

Good exposures of abundantly porphyritic K-feldspar biotite granite occur at AMG 351973, 7097924, AMG 353536, 7100876; 341420, 7101564; 353046, 7102225; 344450, 7111157; 336922, 7094187 and 348614, 7108776. Micrographic intergrowths are locally present (AMG 348614, 7108776). Dykes of rhyolite and microgranite locally cut the phase. Locally this phase is strongly decomposed (AMG 336521, 7106833).

The K-feldspar megacrysts are locally aligned to give a platy flow layering at AMG 333750, 7102875. At AMG 349510, 7113069 K-feldspar sparsely phyric granite is strongly fractured and brecciated. This exposure contains volcanic boulders and granite clasts in a fine-grained groundmass. At AMG 350250, 7101488 water washed tor pavements of K-feldspar phyric granite contain xenoliths (to ~1.5m) of dark microgranite containing rare K-feldspar phenocrysts. At AMG 345578, 7101787 south of Boondooma Dam tor exposure of typical feldspar-phyric granite contains xenoliths of microgranite up to 1m x 0.5m. At AMG 337753, 7100698 boulder outcrop of coarsely K-feldspar-phyric biotite granite to granodiorite contains 8–10% biotite and is weakly jointed. At AMG 334401, 7082818 outcrop of K-feldspar megacrystic biotite granite is intruded by medium-grained biotite microgranite (possibly related to Toondahra Granite.

Even-grained coarse granite

In KINGAROY at AMG 350720, 7111215 the unit contains indurated very coarse even-grained biotite granite cut by minor rhyolite dykes. At AMG 357442, 7067921 deeply weathered fine to very coarse granite weathered to clays is intruded by an aplite dyke. At AMG 373514, 7052026 the granite is coarse, even grained and has well developed jointing. At AMG 375520, 7051061 a medium, even-grained locally coarse biotite granite contains ~3% biotite. In MURGON at AMG363097, 7085074 is tor outcrop of cream, fine to slightly medium grained, equigranular granite with small biotite clots. Similarly at AMG360031, 7092388 cream, fine- to medium-grained, equigranular, hypidiomorphic biotite (minor hornblende) granite to tonalite is moderately magnetic and forms tors and pavement exposures. In thin section it is even grained hypidiomorphic and contains subhedral plagioclase 37%, K-feldspar 3%, quartz 60% hornblende 2%, biotite 2% and small amounts of accessory opaques included in aggregates of hornblende and biotite. At AMG 354008, 7106917 a pinkish cream granite, ranges in grain size from equigranular to porphyritic and contains sparse euhedral feldspar, biotite and rare mafic metasedimentary xenoliths.

Medium grained granite

At AMG 361702, 7086991 is a pale grey, fine to medium grained, equigranular, biotite (~4%) tonalite phase (not differentiated from other areas of Rgbo). The rock contains sparse scattered xenoliths of rounded, more mafic material. In thin section it shows as fine to medium grained, and inequigranular with euhedral plagioclase crystals to 50%, finer interstitial quartz to ~ 41% and aggregates of biotite (4%), hornblende (4%) and with significant amounts of coarse opaques (to 1%).

At AMG359467, 7092582 a moderately porphyritic medium grained biotite granite/syenogranite contains abundant coarse pink K-feldspar phenocrysts. In thin section the large K-feldspar phenocrysts comprise 50% of the rock with plagioclase 10%, quartz 40%, biotite 3%, hornblende1%, and low to no opaques.

Table 9: Dyke compositions cutting Rgbo

GRID REFERENCE	COMPOSITION
AMG 332650, 7110000	strongly jointed K-feldspar-phyric rhyolite
AMG 341268, 7110825	aphyric aplite
AMG 343060, 7111990	feldspar-quartz-phyric microgranite
AMG 352494,7101876	banded medium grained aplitic granite
AMG 349186, 7114689	K-feldspar-phyric weathered rhyolite
AMG 338608, 7115000,	quartz-feldspar-phyric rhyolite
AMG 7109256, 344375	mauve rhyolite, brown K-feldspar-phyric microgranite intruding coarse even-grained granite
AMG 345295, 7111183; 348355, 7109677; 349662, 7113823	feldspar-phyric microgranite
AMG 349722, 7112333	weathered flow-banded brecciated rhyolite
AMG 35601, 7112743	dark sparsely phyric strongly jointed dacite
AMG 346067, 7112530	massive regularly jointed rhyolite
AMG 339525, 7113600	aphyric rhyolite
AMG 338657, 7113629	aphyric weathered rhyolite
AMG 341029, 7113537	feldspar-phyric flow-banded rhyolite
AMG 344182, 7112493	jointed rhyolite, dacite, microgranite
AMG 336418, 7107624; 336400, 7106800	sugary biotite aplite

Rhyolite/Aplite/Microgranite

Part of the area mapped as Rgbo contains zones of microgranite and aplite and rhyolite as thin to thick dykes and as small intrusions. Areas of biotite-bearing microgranite are generally even grained and non-porphyritc and locally contain mariolitic cavities.

Rhyolite and aplite dykes are most common in the northern part of BOONDOOMA and were noted at the following AMG localities. They are either porphritic or non-porphyritic. Examples of these dykes are summarised in Table 9.

Decogranite

Rgbo forms decomposed granite at the following localities mainly in BOONDOOMA and MURGON. These are locally coincident with sandpits on coarse and sparsely K-feldspar-phyric granite cut by a spherulitic rhyolite dykes at AMG 345555, 7112060 and as surficial sand at AMG 379287, 7051001. Mottled and white decomposed granite occurs at AMG 379973, 7052491 on MURGON. At AMG 360291, 7056633 a road scrape comprises tor outcrop of very coarse granite with variable amounts of biotite; biotite-rich layers is strongly decomposed. At AMG 379678, 7054093 a road exposure in sandy soil is a strongly jointed even grained medium to coarse biotite granite. A strongly decomposed faulted zone of the granite occurs at the main Kingaroy rubbish tip (AMG 379500, 7061800; Plate 2.

Outcrop of Rgbo in JANDOWAE comprises dominantly K-feldspar megacrystic granite with generally <10% mafics. K-feldspar forms subhedral or anhedral poikilitic crystals that range in size to >5cm. These crystals are dominantly orthoclase microperthite locally with microcline microperthite (AMG 344268, 7090784; 334425, 7082895; 340577, 7081802). They enclose biotite, chlorite and plagioclase crystals. Plagioclase generally forms subhedral laths of oligoclase (locally with albite rims in microperthite). The plagioclase is commonly zoned and strongly sausseritised. Biotite is the most common mafic mineral, but most rocks also contain hornblende. The biotite is commonly altered to chlorite along cleavage traces and is locally metamict with inclusions of zircon. Opaques are generally not common, but occur in some thin sections associated with biotite (AMG 344582, 707661). Sphene forms a very common coarse-grained accessory (to 3mm) in many exposures (AMG 348407, 707661; 344582, 707661; 340577, 7081802, and 350271, 7069157).

Rocks with very low mafics form a distinct unit with muscovite as the common alteration mica (AMG 344582, 707661; 348407, 707661; 344514, 7090080; 343637, 7091590).

$Rgbo_p$

A zone of very coarsely porphyritic granite occurs in the northern part of KINGAROY from AMG 367498, 7062396. This zone is characterised by sparse large boulder outcrop of altered very coarsely phyric biotite granite.

Pallid zone rocks – $Rgbo_k$

This part of the unit is characterised by deeply weathered white altered rocks that include a variety of rock types. The rocks in this zone are strongly kaolinised (e.g. at AMG 377400, 7042098) or kaolinised and mottled (e.g. AMG 359716, 7078870) and locally silicified (AMG 377148, 7041876, AMG 373989, 7066760) or has zones of silcrete boulders (e.g. AMG 365487, 7083179). Mottled and kaolinised rocks locally form small caves due to tunnel weathering (AMG 359716, 7078870). Zones within the granite contain seggregations of quartz, haematite, mica kaolinite (e.g. at AMG 358525, 7078205 and 358044, 7077942).

Ferricrete and white clay occurs with quartz pebbles in a deeply mottled, kaolinised, coarse granite at AMG 363242, 7080266. The unit comprises cemented scree with cobbles and with weathered granite and a 2m wide pegmatite zone at AMG 332153, 7110202. Outcrop at AMG 351010, 7103864 comprises creek exposure in a typical K-feldspar-phyric decomposed granite and ferruginised transported granite wash on the bank and in the creek.

The unit locally contains zones of megamottling in rhyolite (AMG 354850, 7076950) or granite (AMG 356693, 7071126). At AMG 379578, 7062424 a road cutting in mottled granitic saprolith contains red and yellow iron stained material and surface gravel of yellow and red pisolitic nodules in a podzolised soil that appears locally cemented. At AMG 379583, 7062118 exposure of laterite over mottled granite suggests 2 or perhaps 3 periods of laterite formation. At AMG 381017, 7057022 can be seen an outcrop of ferruginous zone with bleached pallid and mottled zone.

$Rgbo_d$

The dioritic phase of the Boondooma Igneous Complex (unit $Rgbo_d$) is generally poorly exposed and comprises only a small amount of the total outcrop area. At AMG 380931, 7044715 exposure of green altered dioritic rock is cut by numerous dykes. Tor outcrop of tonalite characterises the area close to AMG 378264, 7063040. At AMG 380979, 7044820 and 381154, 7042426, well-jointed onionskin weathered microdiorite to dolerite is intruded by granite apophyses, dykes and minor aplite.

$Rgbo_b$

The $Rgbo_b$ unit was identified primarily from the radiometric image. It has a relatively high response on the potassium and thorium channels compared to the surrounding rock-feldspar. Rock types within this unit have a range of grain size and texture, but are generally dominated by fine to medium grained biotite granite. $Rgbo_b$ comprises two bodies, a larger southern body north and south of the Chinchilla–Wondai Road (40km^2) and a much smaller northern body north of the Boyne River (0.3km^2).

Relationships

Rgbo units intrude the Feifer Creek Metamorphics along their eastern margin, and are unconformably overlain by the Dangore volcanics in the south-west of MURGON and by the Aranbanga Volcanic Group units in the north-west of MURGON and north-east BOONDOOMA.

Ages

Unit Rgbo has age dates from 238 and 245 Ma from MURGON (Early Triassic). Dykes cutting the unit are probably of Late Triassic age similar to that proposed for the Toondahra Granite that is assumed to be comagmatic with the Aranbanga Volcanic Group. Units $Rgbo_d$, $Rgbo_b$, $Rgbo_p$ and $Rgbo_k$ were not dated during the current mapping program.

Wilfred Creek Igneous Complex (new name; Rgi)

Introduction

Reiser (1971) previously included rocks of this unit in a large area of unnamed granite of probable Permian age in the Chinchilla 1:250 000 sheet.

Distribution

The Wilfred Creek Igneous Complex forms a lozenge-shaped body outcropping over an area of ~20km^2 about 8km north-west of Boondooma Homestead and 30km west of Proston.

Derivation of name

The unit is named after Wilfred Creek that drains the southern apex of the outcrop area.

Type area

The type area stretches for ~2km west-south-west of Di Di homestead.

Topographic expression

The complex forms low wooded hills that range in elevation from about 360–420m and are locally capped by dissected surfaces of duricrust.

Geophysical expression

The rocks of the complex exhibit moderately high magnetic susceptibilities, contrasting well on aerial magnetic surveys to the surrounding poorly magnetised granite units. The unit also has a distinctive dark response on airborne radiometric images of the area.

Lithology and petrology

The unit dominantly consists of mafic igneous rock types, including diorite, quartz diorite, tonalite and more rarely gabbro. The unit also contains zones of monzogranite which commonly contains numerous large (up to 50cm across) xenoliths of the more mafic varieties which comprise up to 50% of the total rock. All the rock types are mid- to dark grey, equigranular, and generally fine- to medium-grained, although coarser grained gabbros and megacrystic monzogranites occur locally. Poikiolitic hornblende dominates over biotite in the mafic rocks and both crystals show some evidence of alteration to chlorite.

Relationships

The northern culmination of the body is in contact with the Toondahra Granite, with which its relationship is uncertain. To the south unit Rgbo (Boondooma Igneous Complex) surrounds the rest of the body. Rgbo is interpreted as a younger intrusive unit than the Wilfred Creek Igneous Complex due to the presence of numerous gently-dipping pegmatite and aplite dykes and veins of Rgbo that cut the marginal phases of the Wilfred Creek Igneous Complex.

Age

No age dating of the unit has been undertaken, but a Middle to Late Triassic age is considered most likely.

Eskdale Igneous Complex (Rges units)

Introduction

Cranfield & Schwarzböck (1974) formally defined the Eskdale Granodiorite. More recent work has been carried out in this unit during student projects at the University of Southern Queensland and Queensland University of Technology (Hayward, 1985; Snape, 1991 and Sparks, 1985). The Eskdale Igneous Complex is an update of the name Eskdale Granodiorite as used by Campbell (1952) and defined by Cranfield & others (1976).

Distribution

The main body of Eskdale Igneous Complex ($Rges_{1-4}$) occurs within the limits of AMG 407000, 7009000 and AMG 428000, 6979000, from just south of Cressbrook Dam to just north of Nukinenda Homestead. Another body adjacent to and faulted against the Esk Trough occurs as a north south elongate body, extending from Cressbrook Creek to Ivory Creek. Scattered small intrusions (<3km^2) assigned to the Eskdale Granodiorite occur north and north east of Ravensbourne, around Mount Deongwar, near Glen Oak and also near Greenvale on ESK.

Topographic expression

The Eskdale Igneous Complex generally forms a depressed basin-shape topography of rolling hills ranging from 200–400m in elevation, is well cleared and mostly used for grazing of cattle. Locally a more rugged topography is formed that is often forested. Hornfelsed sediments at the margins of the complex are almost always topographically higher except where the generally north-east trending drainages cut the eastern margin of the basin.

Geophysical expression

The main body of the Eskdale Igneous Complex ($Rges_{1-4}$) is zoned on both the radiometric and magnetic images. Clowes (1997) subdivided the Eskdale Igneous Complex on the basis of geochemistry into 6 groups. Based on the total alkalis and silica plots (TAS) of 32 samples there were 13 granodiorites, 13 diorite, 4 granites and one gabbro. These groups could be shown to correspond roughly to a magnetic zoning of the pluton into 3 main concentric zones P1–P3. Current work adds a later zone that overprints the boundary between the outermost zone and the second zone. This allows the unit to be discussed in terms of 4 main magnetic zones ($Rges_1$–$Rges_4$). The radiometric distinction be-

tween these zones is less distinct; there appears to be a general orange tone on the ternary radiometric image coincident with exposure of granodiorite and more potassic zones related to granite outcrop in the central core and as a part of $Rges_3$.

Lithology and petrography

The Eskdale Igneous Complex comprises the following subunits – Rges (undivided), $Rges_L$, $Rges_a$, $Rges_g$, $Rges_{gr}$, $Rges_a$, $Rges_1$, $Rges_2$, $Rges_3$, and $Rges_4$ (Table 10). Areally the largest units of the complex ($Rges_1$, $Rges_2$, $Rges_3$, and $Rges_4$) are concentrically zoned around an inner core of granodiorite ($Rges_1$). Unit $Rges_L$ occurs along the eastern margin immediately north of the Anduramba Molybdenum Prospect. Undivided Eskdale Igneous Complex is now mainly confined to small bodies to the south of Cressbrook Creek Dam that intrude units of the Cressbrook Creek Group and the Sugarloaf Metamorphics. Units $Rges_g$, $Rges_{ga}$ and $Rges_{gr}$ occur mainly as satellitic bodies to the main intrusion.

Rges (Undivided)

Undivided Eskdale Igneous Complex is mapped in this report as small satellite intrusive bodies that are present immediately west and south of the main basinal intrusive area that characterises the unit. These bodies are <5km^2 and comprise biotite hornblende granodiorite and diorite.

$Rges_1$

A total of 11 thin sections were collected during recent remapping of this unit. In general the central and western margins of this unit are characterised by pale orange tones on the ternary radiometric image and moderate magnetics. The main part of $Rges_1$ is a medium grained granodiorite with quartz, K-feldspar, plagioclase, hornblende and biotite and accessory apatite, sphene, zircon and magnetite. The unit, comprising on average 45–49% plagioclase (subhedral twinned and locally zoned and sericitised) and quartz, forms interstitial pools. K-feldspar is anhedral and interstitial between plagioclase hornblende and biotite. A myrmekite-antiperthite intergrowth occurs between plagioclase rims and K-feldspar. Biotite is brown to dark brown and rims hornblende.

$Rges_2$

$Rges_2$ comprises a zone of light grey hornblende-biotite granodiorite essentially similar to that of granodiorite of $Rges_1$, but having approximately 30% subhedral twinned fresh plagioclase, 30–35 % quartz, ~15% K-feldspar as subhedral orthoclase and ~20% mafics. Mafics comprise about equal amounts of biotite and hornblende. The biotite comprises dark brown to light brown pleochroic ragged grains and the hornblende is subhedral to euhedral pleochroic green to brown and twinned, and has augite cores.

Opaques comprise ~2–3% of the rock and minor constituents are muscovite and chlorite and accessory zircon and sphene (associated with opaques).

$Rges_3$

$Rges_3$ is a unit of light grey biotite-hornblende granite, hornblende-biotite granodiorite and rare marginal gabbro. In thin section the granite comprises plagioclase (25%) subhedral fresh and polysynthetically twinned, quartz (40%) as anhedral interstitial pools, K-feldspar 30% subhedral, orthoclase and ~5% mafics. The mafics comprise approximately equal amounts of biotite and hornblende and are similar to other phases of the Eskdale Igneous Complex.

The thin section contains <1% opaques and accessory zircon, apatite and sphene and minor chlorite alteration. The gabbro phase is in the most magnetically high part of this unit.

$Rges_4$

$Rges_4$ is a unit of grey even-grained more plagioclase-rich granodiorite. In thin section the unit contains 35–45% fresh subhedral twinned plagioclase, 30–40% quartz, 10% anhedral to subhedral K-feldspar (orthoclase with pericline twins), 15–20% mafics (biotite, hornblende similar to other units of the Eskdale igneous Complex). Hornblende is twinned subhedral to euhedral and commonly has augite cores and biotite rims. Sphene, zircon and apatite are common accessories. This phase of the Eskdale Igneous Complex contains a few xenoliths of biotite clots.

$Rges_{gr}$

A zone of granite characterised by lower magnetic response associated with alteration occurs along the southern central and south central part within unit $Rges_1$ of the unit. It is characterised by low opaques (<1% in thin sections from AMG 421172, 6991537; 418650, 6995300) and strong alteration of the mafic minerals to calcite, chlorite and epidote. The unit in the core of the unit within $Rges_1$ includes the Robyndale Adamellite of Creaser (1984).

Table 10: Units of the Eskdale Igneous Complex

Subunit	Distribution	Lithology	Relationship	Age (Ma)	Reference
Rges (undivided)	scattered small bodies to the east, south and west of the main body	granodiorite, tonalite, diorite, gabbro, aplite, granite, minor pegmatite, locally weathered and decomposed	these bodies intrude Maronghi Creek Beds, Sugarloaf Metamorphics, Cressbrook Creek Group	Triassic	Murphy & others (1976)
$Rges_1$	subdivision of main body on basis of radiometrics, occurring in the central, western and southern portions of the main body	grey medium-grained hornblende-biotite granodiorite, central zone of strongly altered biotite granite and haematitically altered chloritic granite	intrudes Sugarloaf Metamorphics	K/Ar 242.9±8Ma 248.0±7Ma	UQ recalculation of Webb & McDougall (1968)
$Rges_2$	subdivision of main body on basis of radiometrics, occurring as a circular body 8km^2 centred on AMG 421000, 6997000	hornblende-biotite granodiorite		Triassic	this report
$Rges_3$	arcuate body separating the central portion from the north and eastern portions of the Eskdale Granodiorite	biotite granite, granodiorite, minor gabbro		Triassic	this report
$Rges_4$	subdivision of main body on basis of radiometrics, occurring in the northern and eastern portions of the main body	hornblende-biotite granodiorite		K/Ar 237.9±7Ma	UQ recalculation of Webb & McDougall (1968); Murphy & others (1976)
$Rges_{gr}$	2km^2 centred on AMG 433250, 7000000 west of Sandy Gully within central core of Rges	pink–grey medium to coarse granite; locally strongly altered	faulted against Esk Formation	Triassic	this report
$Rges_a$ includes the 'Anduramba porphyry'	small late stage mapped and interpreted intrusions within the main body	quartz feldspar porphyritic rhyolite, aplite	intrudes Eskdale Granodiorite and Sugarloaf Metamorphics	203+16Ma minimum (fission track)	BHP CR13666
Rge_g	scattered intrusions marginal to, and isolated from the main body; some informally named as Sandy Gully intrusion, Glen Oak Diorite, Buckamara Igneous Complex	diorite, gabbro, hornblende gabbro, hornblende microgabbro	intrudes Sugarloaf Metamorphics, Cressbrook Creek Group, intruded by Crows Nest Granite, unconformably overlain by Woogaroo Subgroup, Main Range Volcanics	Triassic	Sparks, 1985
$Rges_{ga}$	0.5km^2 centred on AMG 433250, 7003750 on Grass Tree Creek	altered granodiorite	faulted against Esk Formation	Triassic	this report
$Rges_L$	small elongate body north and west of Anduramba pipe	leucogranodiorite	marginal phase in contact with $Rges_1$, $Rges_3$, $Rges_4$	Triassic	BHP CR13666

$Rges_a$

The Anduramba porphyritic rhyolite plug is present at AMG 411498, 6997129. The plug is approximately circular and forms a hill covering an area of ~0.1km^2. It has a low magnetic and high radiometric signature. Creaser (1984) made the following observations about the plug:-

- texture varies from mainly porphyritic to a central area that is medium grained granitic, porphyritic texture only occurs to 200m below the surface,

- plagioclase is subhedral and unzoned, quartz is subhedral, K-feldspar is subhedral and forms large perthitic plates, minor relict biotite is extensively altered, and relict magnetite has been altered to leucoxene in haematite?, accessory zircon and xenotime, and
- extensive alteration including quartz-sericite-pyrite alteration, cutting quartz veins related to an early stockworking event, and kaolinite alteration that post-dates the quartz-sericite-pyrite alteration. Alteration extends into the surrounding granodiorite. The alteration assemblage at the Eskdale Antimony prospect is similar to the latest stage of alteration at Anduramba.

Two small aplitic intrusions are centred on AMG 421600, 6999000. These intrusions have a distinctive high radiometric and low magnetic signature. Similar felsic units possibly occur at AMG 418500, 7001000; AMG 419800, 6990900 and AMG 418200, 6990000 on the basis of radiometric and magnetic signatures.

$Rges_g$

This unit is essentially the informally named 'Glen Oak Diorite' of Creaser (1984) and is composed of medium even-grained dark grey mafic rich quartz hornblende diorite to gabbro. Thin sections from this unit show that it varies from hornblende quartz diorite to gabbro.

$Rges_{ga}$

This unit is present along the eastern margin of the mapped area in the headwaters of Grass Tree Creek. In outcrop the unit is a fine- to medium-grained dark grey, mafic-rich hornblende microdiorite. A thin section from AMG 433450 7003450 contained subhedral polysynthetically twinned dusty altered plagioclase laths (30%, 0.5–1mm), light to dark brown pleochroic subhedral to anhedral locally altered along cleavages to chlorite (40% 0.5–1mm), interstitial quartz (10%, 0.5–1mm) with associated apatite crystals and opaques along fractures. Opaques and apatite each comprises ~5% of the rock. This area has a slightly paler tone on the ternary radiometric image than the adjacent $Rges_g$ unit.

$Rges_L$

Creagh (1982) described this unit, which was included as part of the tenement mapping in Authority to Prospect 2244M, focused on the Anduramba molybdenum deposit. It covers ~1km^2 on the western margin of the main body of the Eskdale Granodiorite and is reported to be locally intrusive into the main body of the Eskdale Granodiorite. In CR13666 it is described as leucocratic, fine- to medium-grained with no mafic minerals in outcrop and as containing dominantly subhedral albite, anhedral quartz potash feldspar, with minor garnets, sphene, apatite, fluorite, pyrite and zircon in thin section. Coarse pegmatitic zones often contain tourmaline (CR13666).

Geochemistry

The complex was sampled as whole rock samples for geochemical analysis. (See the section 'GEOCHEMISTRY').

Age

Fission track dating from the Anduramba intrusions ($Rges_a$) produced three dates, 203±16Ma minimum age, 109 and 7Ma. Other units of the Eskdale Igneous Complex that have been dated include $Rges_1$ (K/Ar ages of 242.9±8 and 248.0±7Ma through a University of Queensland recalculation of Webb & McDougall (1968)), and $Rges_4$ (K/Ar 237.9±7Ma, University of Queensland recalculation of Webb & McDougall (1968) and cited in Murphy & others (1976)).

Relationships

The main body of the Eskdale Igneous Complex (309km^2) intrudes Maronghi Creek Beds, Sugarloaf Metamorphics and Cressbrook Creek Group and is intruded by the Crows Nest Granite, Tertiary dolerite and basalt. Tertiary basalt and the Woogaroo Subgroup unconformably overlie units of the complex. A number of small bodies up to 1.5km^2 intrude the Maronghi Creek Beds, Sugarloaf Metamorphics and Cressbrook Creek Group. Unit $Rges_{ga}$ appears to be part of a block that has faulted contacts to Maronghi Creek Beds, Neara Volcanics, and Esk Formation and occupies ~8km^2. At AMG 412300, 6990300 the Crows Nest Granite intrudes the Eskdale Granodiorite (Creaser, 1984).

Associated mineralisation

A late stage porphyry intrusion at Anduramba, AMG 411500, 6997000 contains molybdenite and tungsten mineralisation which has been mined. Exploration around the porphyry also located sericitic gossans that are strongly anomalous in silver, lead and copper, and weakly anomalous in zinc, molybdenum and tin (CR13666). Creaser (1984) identified three alteration events, associated with the porphyry intrusion, including a quartz-sericite-pyrite event, which had associated molybdenite, wolframite and rare arsenopyrite. Alteration simi-

lar to the quartz-sericite-pyrite type of Creaser (1984) occurs as zones generally 1–2m wide, but up to 10m wide, and up to 500m long. This alteration is located 9km to the east of the Anduramba intrusion at AMG 419381, 6993619; AMG 420818, 6994897; AMG 420375, 6995100; AMG 420095, 6995457; AMG 422068, 6995317; AMG 421514, 6998244, and AMG 422397, 6998250. The alteration destroys the texture of the granodiorite. Minor molybdenite and copper mineralisation occurs on a joint located at AMG 418000, 6989300 (Snape, 1991). Minor molybdenite, pyrite and possible chalcopyrite are associated with small aplitic intrusions around AMG 421600, 6999000.

Minor disseminated copper mineralisation was located adjacent to the Esk Anduramba road at AMG 417800, 6995200 and as small isolated outcrops near AMG 417950, 6995400 east of Robyndale Homestead (Eskdale West). Creaser (1984) also located chalcopyrite in outcrop at AMG 417900, 6995100.

Antimony mineralisation has been mined from shafts and a small opencut, from joints/shears west of Eskdale West around AMG 415822, 6996760.

Pits and shafts have been excavated in the granodiorite near its contact with the Maronghi Creek Beds, on what is assumed to be gold mineralisation, near the old Milford Rocks homestead ruins (now only stumps remain).

A small pit exposing quartz fragments in soil is located at AMG 416659, 7008266. A speck of gold was tentatively identified from quartz at this location.

Limonite stringers in altered granodiorite occur at AMG 421535, 6991557 and limonite stringers in altered diorite occur at AMG 433001, 7003787.

Crows Nest Granite (Rgr)

This name, first used by Jones (1955), was formally defined as Crow's Nest Granite by Cranfield & Schwarzböck (1974b). The outcrop area forms a north-north-westerly trending belt occupying ~100km^2 and is bounded by Pierce's Creek to the north, and the Esk–Hampton Road to the south. The average elevation is 470m; however, in places (e.g. near Perseverance Creek Dam), coarser-grained variants form steep cliffs up to 630m above sea level. The type locality extends along the Crows Nest–Perseverance Creek Dam road from about AMG 40980, 69803 to 41180, 69813. The unit was named Crows Nest Granite by Whitaker & Green (1980) and this name is used herein.

Lithology and petrology

Informal names 'Rocky Creek Granite', Central Granite, 'Vonhoff Granite', 'Woodville Granite' Paradise granite and the 'Rangeview Aplite' have been used by Holden (1991) for parts of the Crows Nest Granite. The approximate location

Table 11: Informal subdivisions of the Crows Nest Granite

Holden (1991) Subdivision	Characteristics
'Rocky Creek Granite'— southern part of Holden's area	brick red medium grained, strongly altered comprising quartz (anhedral and strained with fluid inclusions 20%), plagioclase (albite 15%, oligoclase, 10%) K-feldspar (strained altered and fractured 30%), biotite (5%), sericite (5%), chlorite (5%) and epidote (5%) after both feldspar and opaques (5%)
'Central Granite' — centre of Crows Nest Granite pluton	white, medium grained, comprising quartz (20%, euhedral with fluid inclusions), K-feldspar (orthoclase, 5%; microcline, 10%), plagioclase (albite 10%, oligoclase, 5%) with myrmekite intergrowths), biotite (2%), chlorite (after biotite 3%), epidote and sericite (after feldspar, 3%) and opaques (anhedral, 5%) and a trace of carbonate alteration
'Vonhoff Granite'	dark pink, comprising quartz (coarse strained and locally recrystallised anhedral crystals with abundant fluid inclusions, 20%), plagioclase (oligoclase, 5%, andesine 5%, albite 10%), K-feldspar (40% orthoclase (locally perthitic), microcline 5%), biotite (5%), sericite-chlorite alteration (3%, after feldspar) and opaques
'Woodville Granite'	grey, comprising mainly quartz (highly strained), K-feldspar, plagioclase and biotite
'Paradise Granite'	pale pink, comprising quartz (strained with abundant fluid inclusions, 25%), K-feldspar (orthoclase, 10%, microcline, 5%), plagioclase (albite, 20%, oligoclase 20%), biotite (5%), sericite (5%), chlorite (5%), apatite and zircon; feldspars are strongly altered, and there are locally K-feldspar-quartz intergrowths
'Rangeview Aplite'	light brown, fine-grained comprising quartz (strained with fluid inclusions and as porphyroblasts in a fine matrix), graphic and granophyric K-feldspar intergrowths, plagioclase (andesine and oligoclase and locally myrmekitic) minor chlorite, sericite, carbonate (after feldspar) and opaques

and outcrop and thin section characteristics of his subdivisions are given in Table 11.

Holden (1991) also recognised three phases of dykes in the granite — aplite within the Crows Nest Granite, dolerite in the Sugarloaf metamorphics and rhyolite in the Eskdale Granodiorite.

Relationships

Holden (1991) could not identify the relative ages between his different subunits of the Crows Nest Granite. The granite intrudes the Sugarloaf Metamorphics and the Permian Cressbrook Creek Group and is unconformably overlain by the Triassic–Jurassic Bundamba Group and the Tertiary Main Range Volcanics. The zone of hornfels of the Crows Nest Granite is very narrow, usually <30m, and is best represented in the vicinity of Pierce's Creek where a zone of dark brown flinty hornfels is developed in the Sugarloaf Metamorphics. The relationship of the Crows Nest Granite to the Eskdale Igneous Complex is unknown. Clowes (1997) considered there were two possibilities:-

- the Crows Nest Granite was intruded prior to the Eskdale Igneous Complex and the Eskdale Igneous Complex intruded through it leaving roof pendants of Crows Nest Granite at the core of unit $Rges_1$, or
- the Crows Nest Granite represents a fractionated product of the Eskdale Igneous Complex. Clowes (1997) indicated that there were no definite geochemical trends to support this proposal.

Geochemistry

Holden (1991) carried out geochemistry on the Crows Nest Granite and showed that each of the phases had very similar spidergram patterns. The CIPW mineralogy of the samples indicated normative corundum and hypersthene which was interpreted by Holden (1991) to indicate that the Crows Nest Granite had an s-type affinity.

Age

Radiometric dating of biotite from this granite has given ages of 234 and 237±8 Ma, (K/Ar) and 242Ma (Rb/Sr), indicating a Late Permian or Early Triassic age.

Djuan Tonalite (PRgj, $PRgj_h$)

Introduction

Cranfield & Schwarzböck (1974) applied this name to a tonalite that occurs adjacent to the Crows Nest–Blackbutt Road, and designated a type locality along this road from about AMG 40100, 700400.

Distribution

The unit occurs in the north-west corner of ESK and the north-east corner of OAKEY.

Topographic expression

The unit occupies ~95km^2 in the north-western margin of ESK and forms a basinal area of undulating sparsely timbered, grazing country, between 390m and 420m in elevation.

Geophysical expression

The main part of the unit (PR*gj*) has a varied magnetic response. It is high over most of the western and central part of the outcrop area and very low along the western third of the mapped area. A northerly trending fault apparently defines the boundary between these two magnetic zones. In general the unit has dark tones on the ternary radiometric image denoting a low radiometric response in all channels. Unit $PRgj_h$ is characterised by the highest magnetic signature of this body.

Lithology and petrography

The main part of the tonalite (**PRgj**) is grey to dark grey, distinctly xenolithic, and generally variable in grain size and modal composition. Clots of ferromagnesian minerals commonly form dark patches. The rock contains plagioclase, quartz, hornblende, biotite, and rarely potash feldspar and clinopyroxene. Accessory magnetite, sphene, apatite, and zircon are present; the major alteration products include sericite, laumontite, chlorite, epidote, iron oxide, and leucoxene. The rock types of the xenoliths in the tonalite vary considerably; some are blocks of Sugarloaf Metamorphics (from fragments of wall rock broken off during intrusion of the tonalite); others are of igneous derivation. The xenoliths are either round or elongate, and range from a few centimetres to large blocks up to 1m in diameter. Most of the xenoliths appear as dark patches of hornblende-rich material containing plagioclase phenocrysts. The latter are sometimes rounded, or near the boundary of the xenolith aligned subparallel to the general lineation of hornblende prisms. Student work by

Scott (1963) defined a well-developed platy flow foliation in the unit. An overall trend of this foliation parallels the trend in the Sugarloaf Metamorphics. Hornblende laths are strongly aligned resembling metamorphic amphibolites. Quartz is only a very minor constituent of the rock.

Unit **Rgj$_h$** is characterised by a conspicuous zone of hornblende rich rocks, in the vicinity of the junction of Sandy Waterhole Creek and Emu Creek. This was considered as either a concentration of xenoliths or a separate phase of the unit by Cranfield & others (1976). Present concepts of this area is that it is a separate phase of the unit. Rosette-textured rocks, consisting of sericitised plagioclase enclosing hornblende, minor interstitial quartz, sphene, chlorite, iron oxide, apatite, and zircon, are present in this area. Dykes intruding the tonalite are mainly concentrated in the vicinity of Djuan, where approximately 30 dykes of varying composition intrude the unit. Other dykes swarms described by Cranfield & others (1976) include rhyolite dyke swarms with a well-developed quasi-vertical foliation, dolerites, amphibolite dykes, 'porphyritic hornblende' dykes (basaltic hornblende in a groundmass of hornblende and plagioclase), teschenite (with conspicuous serpentine alteration) and feldspar porphyry and altered granophyre.

Horneblende-rich (appinite) bodies up to 1km long and 100m wide, and comprising 50–80% hornblende (1–10 mm long), occur along the margins of the tonalite. In the largest of these, segregations associated with hornblende-rich rocks occur, comprising a pegmatitic and a hydrothermal phase. The pegmatitic phase is either hornblende-rich and contains plagioclase, iron oxide, apatite, sphene, and zircon, or tourmaline-rich and contains potash feldspar, quartz, plagioclase, and radiating tourmaline crystal aggregates; the hydrothermal phase comprises intergrowths of quartz and plagioclase.

Foliation of the Djuan Tonalite is very prominent and parallels the schistosity in the Sugarloaf Metamorphics, except at the contact where a general east-west trend predominates. Evidently the intrusion was controlled by the previously developed metamorphic foliation. Lineations in the northern part plunge south, those in the central part are quasi-horizontal, whereas those to the south plunge northwards. This suggests a lopolithic shape for the intrusion.

Zones of appinite-rich rocks up to 1km by 100m wide along the eastern margin of the unit were described by Cranfield & others (1976).

Geochemistry

Samples for geochemistry were collected from this unit and are discussed in the section on Geochemistry at the end of the report.

Age

The K/Ar age of the Djuan Tonalite was quoted as 230±8Ma by Cranfield & others (1976) and recalculated to 234.8±8 i.e. late Middle Triassic. This age was collected from the eastern margin of the unit at AMG 401256, 7007103. Ar/Ar age dates from the unit indicate an older (Permian) age 258.5±0.9 (biotite) and 263.7±0.9 (hornblende) (Vasconceles & Feng, 2000) from AMG 398768, 6999826 on the western margin of the intrusion. Based on the age variations in the unit it is grouped with the Permian–Triassic suite of intrusions in the Yarraman Subprovince.

Relationships

The Djuan Tonalite intrudes the Palaeozoic Sugarloaf Metamorphics and Maronghi Creek Beds. The relationship to the Woolshed Mountain Granodiorite is poorly exposed; the units may be of similar age.

The Triassic Tarong beds and Tertiary Main Range Volcanics unconformably overlie the unit.

'Champion Hills Diorite (Rgh)'

Introduction

This unit was first mapped and informally described by Campbell (1952). Other workers who have studied the unit are McPhee (1974), Costello (1975), Reimers (1977), Ross (1988) and Murphy (1989) from the University of Southern Queensland and Hegarty (1981), McCabe (1982) and Slijderink (1988) from the Queensland University of Technology.

Distribution

The unit covers an area of ~9.5km^2 south of the Esk–Hampton road. The larger bodies occur in the vicinity of Oaky Creek and Verandah Creek. Bodies with a north south elongation occur near the intersection of Verandah Creek and Buaraba Creek. Scattered small diorite and gabbroic intrusions between Buaraba Creek and the Esk–Hampton road have also been included in this unit.

Derivation of name

Campbell (1952) informally called the unit the 'Champion Hills Basic Diorite', but the name has been modified to Champion Hills Diorite for this report.

Type area

The type area designated by Campbell (1952) for this unit is accepted for this report.

Topographic expression

The larger bodies of Champion Hills Diorite form hilly to sloping country, 140–310m above sea level, that is generally well cleared and used for grazing. Many of the smaller bodies occur as intrusions in the Hampton Road Rhyolite, which is rugged and well forested.

Geophysical expression

Magnetic response of this unit is variable and is significantly high in the vicinity of AMG 430000, 6977000. Similar high responses to the east of Verandah Creek may indicate that small areas of Champion Hills Diorite also occur beneath the cover of Woogaroo Subgroup. The ternary radiometric image has shows generally dark tones over the outcrop area of the unit.

Lithology and petrography

Rock types described from the unit include gabbro, dolerite, pyroxenite, basic diorite, and quartz diorite. Rocks are grey-green, occasionally dark grey when fresh, and range from fine- to coarse-grained, porphyritic (up to 7mm) in parts. Chlorite alteration is common.

McPhee (1974) describes thin sections from the unit. An ophitic and subophitic texture is common with replacement of augite by actinolitic hornblende and overgrowths of hornblende over augite. At AMG 432400, 6975000 the rock type is a plagioclase dolerite containing 65% plagioclase, 19% augite, 10% hornblende and minor chlorite and leucoxene. The augite was partially altered to chlorite, secondary hornblende and minor epidote.

At AMG 430600, 6976200 is an altered dolerite containing 51% plagioclase, 45% hornblende/augite, and minor magnetite and chlorite. Augite was almost completely replaced by actinolitic hornblende and remnant ophitic texture remains. At AMG 429200, 6975300 is exposure of dark grey gabbro containing 54% plagioclase, 27% augite and 15% hornblende with minor magnetite. Fibrous green amphiboles occur as alteration products of hornblende.

At AMG 428400, 6974500 is an exposure of pyroxenite containing >70% pyroxene and plagioclase, hornblende, magnetite and quartz. McPee (1974) comments that "pyroxene content is variable" in the area so this rock may represent an extreme example of pyroxene enrichment.

Campbell (1952) identified plagioclase (mostly andesine), titaniferous and common augite, chlorite and golden yellow chlorite, clinozoisite, zircon, magnetite, ilmenite and quartz in the dioritic rocks. A gabbro at AMG 431000, 6975100 contained calcic plagioclase, diallage, augite, hornblende, sphene, uralite, quartz and chlorite, with ophitic structures common. Ilmenite is present as skeletal crystals and inclusions in augite. Murphy (1989) suggested that several small gabbroic/doleritic outcrops in the North Buaraba Creek area are part of one intrusive event that includes all of the gabbroic rocks of the region.

Geochemistry

No samples for geochemistry were processed as part of the Yarraman Project.

Age

Porphyry dykes of the South Buaraba Microdiorite, which is assigned an early to mid Triassic age, intrude the Champion Hills Diorite. The Champion Hills Diorite intrudes the late Permian age Buaraba Mudstone of the Cressbrook Creek Group. The Champion Hills Diorite has been assigned an Early–Middle Triassic age.

Relationships

The 'Champion Hills Diorite' intrudes the Cressbrook Creek Group. Roof pendants of Cressbrook Creek Group suggest that it is the upper parts of the batholith that are exposed in the main outcrop area of the unit. Porphyry dykes of the South Buaraba Microdiorite and the Buaraba Granodiorite intrude the Champion Hills Diorite. The Woogaroo Subgroup unconformably overlies the unit. Ross (1988) also described a slickensided contact between lithic sandstones of the Woogaroo Subgroup and Champion Hills Diorite at AMG 432800, 6975200.

Associated mineralisation

Reimers (1977) states that "in some areas chalcopyrite and pyrite are found in a disseminated form in the dolerites". No further details of this mineralisation are available.

'South Buaraba Microdiorite (Rgsb)'

Introduction

This unit was first mapped and described by Campbell (1952). Other workers who studied the unit were Houtgraaf (1974), Vonhoff (1975), Reimers (1977) and Tudor (1985) from the University of Southern Queensland and Hegarty (1981), McCabe (1982) and Slijderink (1988) from the Queensland University of Technology.

Campbell informally called the unit the 'South Buaraba Feldspar Porphyrite' and considered it as an intrusive. Campbell's mapping was accepted in the production of the Ipswich 1:250 000 map (Cranfield & Schwarzböck, 1973). The microdiorite was generally considered younger than the Champion Hills Diorite because Campbell (1952) mapped porphyrite dykes in the diorite "behind Buaraba Post Office" (approximately AMG 432100, 6973600), and older than the Buaraba Granodiorite, as the microdiorite was intruded by a granodiorite dyke at AMG 424500, 6968000 (Campbell, 1952).

Distribution

The outcrop occupies ~14 km^2 west of Box Gully, centred on the south branch of Buaraba Creek. The Buaraba Granodiorite separates two small outcrops <0.25 km^2 from the main body on the south-east edge. Campbell (1952) attributed dykes adjacent to the Buaraba Post Office to the South Buaraba Microdiorite. During current mapping other small outcrops that may be related to the unit were located north of Buaraba Creek AMG 424100, 6974800; 423900, 6975100 and 423600, 6975800.

Revision of name

The name has been modified to 'South Buaraba Microdiorite' to better reflect the interpretation of it as an intrusive body.

Type area

The type area of the unit defined in this report is the area of outcrop of the unit centred on South Buaraba Creek around AMG.424000, 6970000.

Topographic expression

Topography ranges from 200m in Buaraba Creek to a maximum of 500m elevation to the west of the creek. Selective clearing has been carried out on the less steep slopes.

Geophysical expression

A combined K–Th–U ternary false colour radiometric image has a variable response but defines the South Buaraba Microdiorite reasonably well. The unit has a low to moderate potassium response in contrast to the higher response of the nearby Cressbrook Creek Group and lower response of the Woogaroo Subgroup to the west. However there is little contrast on the radiometric image with the Woogaroo Subgroup to the south. A low thorium response over most of the unit gives good contrast with surrounding units, except on the northern contact where a higher Th response in the body is similar to that of the Cressbrook Creek Group.

The magnetic response of the unit is variable. High magnetic responses correlate reasonably well with the low thorium responses at both the east and west sides of the body. Over the remainder of the body there is a lower magnetic response, generally slightly lower than surrounding rocks, similar to that of the 'Buaraba Granodiorite'. The body has an oval shape elongate north-east-south-west. The body may occur near the surface up to 400m west of the interpreted geological boundary, beneath the overlying Woogaroo Subgroup.

Lithology and petrography

In hand specimen the rock is dark grey and aphanitic to porphyritic with phenocrysts of feldspar and locally hornblende. Thin section descriptions by Campbell (1952) and Cranfield & others (1976) indicate major constituents are plagioclase (andesine), hornblende and secondary chlorite. Minor constituents are quartz, biotite, K-feldspar with accessory minerals magnetite, apatite, zircon and epidote, and a high percentage of groundmass that is often cryptocrystalline and microcrystalline.

Structure

Edwin Willey (personal communication, April 1999) speculates that the microdiorite represents a caldera infill structure that has been intruded by a later ring dyke structure after caldera collapse. The surrounding portion of the Buaraba Granodiorite represents the ring dyke system. It seems likely that the structure also has associated small intrusions, represented by

dykes described by Cambell (1952) and possibly also the small outcrops to the north of Buaraba Creek.

Age

The Buaraba Granodiorite indicates a minimum age of Middle Triassic as it intrudes the South Buaraba Microdiorite. Porphyry dykes intruding the Champion Hills Diorite, adjacent to the Buaraba Post Office indicate a maximum age for the unit. All of these units intrude the Permian age Cressbrook Creek Group. The South Buaraba Microdiorite has been assigned early to mid-Triassic age.

Relationships

The South Buaraba Microdiorite is intruded by the Buaraba Granodiorite and intrudes the Champion Hills Diorite and Cressbrook Creek Group as described by Campbell (1952). The Woogaroo Subgroup unconformably overlies the unit.

'Buaraba Granodiorite (Rgbu)'

Introduction

This unit was first mapped and informally called the "Buaraba Quartz Diorite" by Campbell (1952). Other workers who studied the unit were Houtgraaf (1974), Vonhoff (1975), Costello (1975), and Tudor (1985) from the University of Southern Queensland and Hegarty (1981), McCabe (1982), Early (1984), Irvine (1987) and Slijderink (1988) from the Queensland University of Technology.

Campbell informally called the unit the 'Buaraba Quartz Diorite'. Campbell's mapping was accepted in the production of the Ipswich 1:250 000 map (Cranfield & Schwarzböck, 1973). Because of contact and intrusive relationships the Buaraba Granodiorite was considered to be younger than the South Buaraba Microdiorite and the Champion Hills Diorite. Work by later authors has agreed with this, but the rock type was generally considered to be more in the granodiorite to tonalite range, with diorite occurring as a more minor phase.

Distribution

The outcrop occupies ~8km^2 mostly on the north bank of Buaraba Creek and also forms a possible ring dyke structure around the South Buaraba Microdiorite which occurs to the west of the main body of Buaraba Granodiorite.

Derivation of name

Campbell (1952) informally called the unit the 'Buaraba Quartz Diorite'. Later investigations suggest that there is a higher proportion of granodiorite and tonalite than diorite, and the name has been changed to 'Buaraba Granodiorite'.

Type area

The type area is designated as north of Buaraba Creek around AMG 429600, 6974200.

Topographic expression

The 'Buaraba Granodiorite' generally has a relatively low topographic expression with creek flats and rolling hills from 140–200m in the main body, with an associated sandy soil. It is generally well cleared with sparse outcrop and is covered by regolith and alluvium near the creeks and larger gullies. Topography in the western area around the South Buaraba Microdiorite is up to 520m, is steep and is influenced by the surrounding country rocks. In this area Tudor (1985) notes the 'Buaraba Granodiorite' occurs as boulders up to 3m in diameter and as rubbly outcrop, with poor exposure and hidden contacts.

Geophysical expression

The 'Buaraba Granodiorite' has a variable intermediate magnetic response and a mottled pinkisk and blueish radiometric response on the K–Th–U radiometric image. Neither response is distinctive.

Lithology and petrography

Costello (1975) described the main body along Buaraba Creek as being mostly a grey, even-textured, medium- to coarse-grained granodiorite containing zoned and twinned plagioclase, quartz, orthoclase, hornblende (green), biotite, and minor magnetite and with minor occurrences of leucogranodiorite.

The leucogranodiorite was described as even-textured, medium to coarse-grained, pink-grey in colour, in hand specimen, and containing mainly plagioclase, with a strong core rim difference in composition and with oscillatory and patchy zoning, and albite twinning. Quartz has undulose extinction, orthoclase with carlsbad twinning, and other constituents in thin section include hornblende (green), biotite (brown) and minor magnetite. Campbell (1952) described the leucogranodiorite as a greyish rock sometimes with a pinkish tint

holocrystalline, medium grained and even textured. Quartz is always abundant and hornblende is predominantly green but varies to the dark brown (basaltic) variety. Biotite is less abundant than hornblende and chlorite is a common secondary mineral. Orthoclase is present in small amounts. Apatite, zircon and magnetite occur as accessories. Campbell (1952) considered the main rock type to be quartz diorite.

McPhee (1974) noted that the less mafic leucogranodiorite parts tended to be pinker and that there are a numerous minor intrusions including diorite, microdiorite, and porphyrite dykes. Houtgraaf (1974) commented that microdiorite occurs as small isolated bodies generally along the chilled margins of the granodiorite. Tudor (1985) described the ring-shaped portion of the body, around the 'South Buaraba Microdiorite' as a tonalite. He described it as medium- to coarse-grained, massive, and even-textured, containing plagioclase, quartz, biotite and hornblende, in hand specimen and as containing 30–55% plagioclase, 22–54% quartz, 5–10% hornblende, 5–8% biotite, 0–10% chlorite, with accessory magnetite, zircon, apatite, and epidote in thin section.

Geochemistry

No geochemistry was undertaken in this unit during the current mapping program.

Age

A K/Ar radiometric age was initally reported as 187±7Ma and interpreted as minimum age due to possible argon loss (Cranfield & others, 1976). This date was updated to 191Ma in Day & others (1983).

The currently used age is 237.9±7my (Rod Holcombe, personal communication, 1999). An early to mid-Triassic age has been assigned to the unit.

Relationships

The 'Buaraba Granodiorite' intrudes 'South Buaraba Microdiorite', 'Champion Hills Diorite' and units of the Cressbrook Creek Group, and is overlain by Woogaroo Subgroup.

Associated mineralisation

Vonhoff (1975) reported molybdenite occurring as thin veins in a piece of float of fractured granodiorite. A location was not given but it appears to be related to 'Buaraba Granodiorite' on the north-west side of the 'South Buaraba Microdiorite'.

Houtgraaf (1974) noted minor cubic pyrite along the granodiorite sediment contact to the Cressbrook Creek Group.

Farquharson Granite (new name; Rgq)

Introduction

Reiser (1971) previously mapped the unit as part of a large area of undivided granite of possible Permian age on the Chinchilla 1:250 000 sheet.

Distribution

The unit forms a roughly rectangular-shaped body outcropping over an area of ~25km^2, 7km west of Boondooma Homestead, 30km west of Proston. Subunit Rgq_d occurs on the north-western margin of the main body as a north-north-west trending elongate body ~1km wide.

Derivation of name

The granite is named after Farquharson Creek that drains the northern end of the outcrop area.

Type area

The type area of the Farquharson Granite is in the headwaters of Farquharson Creek on BOONDOOMA.

Topographic expression

The unit forms low flat country rising to low wooded hills with elevation between 320–340m in elevation. Tertiary duricrust mesas are developed in places on the unit.

Geophysical expression

The radiometric response of the unit is almost indistinguishable from that of the surrounding rocks. However, the unit has a moderate to high magnetic susceptibility, which contrasts with the surrounding poorly magnetised units. The magnetic image shows the unit to apparently consist of a number of amalgamated north-trending dyke-like bodies, between which slivers of Toondahra Granite have been mapped.

Lithology

The granite is pale pinkish-grey in colour, medium-grained, equigranular to locally porphyritic hornblende-biotite granite. It has a hypidiomorphic granular texture in thin section

and contains prominent mainly euhedral accessory sphene crystals. Hornblende and biotite occur in roughly equal proportions. The rock is also relatively rich in opaque iron oxide grains, accounting for the unit's moderate to high magnetic susceptibility values. Thin sections from along the eastern margin of the unit show some evidence of quenching, with coarser crystals and crystal aggregates enveloped in a matrix of very fine-grained feldspar and quartz.

Age

No age dating of the unit has been undertaken, but a Middle–Late Triassic age is considered most likely.

Relationships

Along its northern margin the Farquharson Granite is partly faulted against the Toondahra Granite along a west-north-west trending fault. The unit probably has an intrusive relationship with the Toondahra Granite, and the microscopic quench textures near its contact with the Boondooma Igneous Complex to the east also suggests a similar relationship.

Wooroonden Granodiorite (new name; Rgrd)

Introduction

Murphy & others (1976) previously mapped the unit as part of the Wigton Adamellite. The northern part of the unit was mapped in some detail as part of Queensland University of Technology honours study (Lowien, 1997).

Distribution

The unit occurs as a north-north-west trending body exposed in the valley of Barambah Creek north of Hivesville, covering an area of ~16km^2.

Derivation of name

The unit is named after the Parish of Wooroonden within which most of the unit is exposed.

Type area

The type area for the unit is centred on AMG 372200, 7118200.

Topographic expression

The unit is poorly exposed in the alluvial flats to the east of Barambah Creek. To the west of the creek, the unit is slightly better exposed and forms undulating low hills with elevations ranging from 250–370m.

Geophysical expression

On the ternary radiometric images, the unit has a mottled dark brown/pink tone, partly reflecting colluvial, alluvial and weathered soil mantling as well as the primary lithological response. The main body of the unit has a characteristic medium to high magnetic response on the RTP magnetic images. However, some marginal areas have a relatively low magnetic response.

Lithology and petrography

The characteristic rock type is cream to pale or dark grey, fine- or medium-grained, equigranular, biotite-hornblende granodiorite, containing sparse to locally abundant (up to 60%) mafic clots and xenoliths. Compositional variations include quartz monzodiorite, monzodiorite, and tonalite. Dark grey, medium to coarse-grained gabbro to dolerite occurs in places north of Crystal Springs homestead, but has not been mapped as a separate entity.

The granodiorite has a hypidiomorphic granular texture in thin section and commonly contains abundant accessory magnetite accounting for its moderate to strong magnetic signature. The relative proportions of plagioclase and alkali feldspar vary, with either locally predominating over the other. A similar relationship occurs between hornblende and biotite, which combined generally make up to 7% of the total rock. Both the latter minerals commonly form coarse locally poikilitic grains. Mafic clots and even grained to porphyritic mafic xenoliths are common throughout much of the pluton, locally making up to 60% of the rock. Zones of chloritic alteration occur in areas of known mineralisation. The granodiorite locally shows evidence of moderate tectonic recrystallisation.

In the Golden Spur mine area, east-north-east trending shears, along which aplite dykes have been intruded, cut the granite.

Geochemistry

Whole rock analyses by Lowien (1997) suggested that the unit was part of a metaluminous, medium-K, calc-alkaline complex. He proposed that the parent magma was derived from a high

degree of melting of a slightly depleted mantle wedge source, modified by LIL-enriched fluids originating from subducting oceanic lithosphere.

Age

No age dating of the unit has been undertaken, but the unit is probably slightly younger than the Late Triassic Aranbanga Volcanic Group which it is interpreted to intrude.

Relationships

The unit probably intrudes the Late Triassic Aranbanga Group, and is intruded by or comagmatic with granite bodies mapped as unit Rg_4 or Rg_6. The pluton is locally intruded by aplite, diorite, andesite, rhyolite and dacite dykes, which are probably only slightly younger than the granodiorite.

The Wooroonden Granodiorite is unconformably overlain by Oakdale Sandstone, and is capped by Tertiary duricrust surfaces in places. Alluvial deposits of Barambah Creek and Tertiary basalts and sediments of the Main Range Volcanics mantle geophysical (magnetic)-interpreted extensions of the unit to the south.

Associated mineralisation

Significant gold mineralisation occurs at a number of small, fracture-controlled deposits on the east bank of Barambah Creek, east of Crystal Springs. These deposits include the Bar 23 (worked for a short period in the 1920s), and the Red Rock, Misst, and Golden Spur deposits worked by small single-miner operations since the 1930s.

Canoe Creek Granite (new name; Rgce)

Introduction

Murphy & others (1976) previously mapped the unit as part of the Wigton Adamellite. The northern part of the unit on the Maryborough 1:250 000 Sheet was mapped as an undivided Permo-Triassic granite by Cranfield (1994), and was also studied as part of a Queensland University of Technology honours study (Stensen, 1997).

Distribution

Only the southern part of the unit (covering ~30km^2) is exposed on the Gympie 1:250 000 Sheet, 18km north of Proston. The unit forms part of a larger, roughly circular pluton covering >150km^2, mainly on the Maryborough 1:250 000 Sheet.

Derivation of name

The unit is named after Canoe Creek, which flows through the south-western corner of the intrusion.

Type area

The type area is designated as the headwaters of Twelve Mile Creek around AMG 365200, 7122300.

Topographic expression

The unit forms low, bouldery hills interspersed with sandy plains. Elevation range is from 330–460m.

Geophysical expression

The unit occurs as mid to dark pink on the ternary radiometric images, distinct from the paler pink tones of the adjoining Aranbanga Volcanic Group to the south. The unit has a moderate response on aeromagnetic images.

Lithology and petrography

The granite is pale grey to pink in colour, and is mostly fine- to locally medium-grained. It is characteristically sparsely porphyritic, with small (up to 3mm in length) euhedral feldspar phenocrysts, scattered through a finer matrix commonly altered pink matrix. The granite has a low mafic content with biotite and locally minor hornblende making up to ~1–3% of the rock. In thin section, the quartz-feldspar matrix sporadically displays very fine graphic intergrowth textures, and contains coarse accessory sphene and common fine opaque grains (probably mostly magnetite, accounting for the moderate magnetic response on geophysical images). The phenocrysts are mainly plagioclase and alkali feldspar, both generally showing strong sericitic alteration. Epidote/chlorite/calcite alteration is common throughout the pluton. Mafic clots and small xenoliths are only common locally within the granite.

Geochemistry

Based on whole rock geochemistry Stensen (1997) interpreted the unit as an S-type granite, forming a mostly peraluminous, high K, calc-alkaline intrusion derived from *in situ* frac-

tional crystallisation and differentiation of a sedimentary source.

Age

No radiometric age dating of the unit has been undertaken, but the granite is considered to most likely intrude the Late Triassic Aranbanga Volcanic Group, and to be of Late Triassic age.

Relationships

The unit is considered to intrude the Late Triassic Aranbanga Volcanic Group. Small areas of Tertiary duricrust are developed in places on the granite. The unit is locally intruded by rhyolite dykes and small aplite bodies.

Memerambi Granite (new name; Rgme)

Introduction

Murphy & others (1976) mapped the unit as part of the Boondooma Igneous Complex.

Distribution

The unit occurs 15km NE of Kingaroy where it forms a roughly circular pluton covering ~130km^2.

Derivation of name

The unit is named after the township of Memerambi that is situated 5km to the west of the intrusion.

Type area

The type area is designated to be around AMG 395500, 7073100, 13km east of Memerambi.

Topographic expression

The unit forms sandy plains with occasional outcropping tors or low hills with elevation ranging from 320–400m.

Geophysical expression

The unit has a moderately high magnetic response on RTP aeromagnetic images and displays strong pink tones on the ternary radiometric image.

Lithology and petrography

The unit consists of cream to pale grey, medium to locally fine-grained, inequigranular biotite-hornblende granite. In thin section, micrographic intergrowth textures are locally developed. The mafic minerals occur as scattered fine clots making up to 4% of the rock except in the southern margin of the body where the mafic content ranges up to 7%. The granite contains sparse rounded fine-grained mafic xenoliths averaging 10cm across. In the southern part of the unit it is deeply weathered medium-grained biotite microgranite with local mariolitic cavities. Pits for extraction of sand and decomposed granite are developed in the unit at AMG 394021, 7070027; 394492, 7069424 and 395737, 7066488 respectively. The unit is locally deeply weathered and at AMG 388663, 7054760 the outcrop comprises strongly mottled microgranite and minor ferricrete.

Age

No age dating of the pluton has been carried out. The unit is thought to be Triassic in age, older than the overlying Late Triassic Tarong beds.

Relationships

The Late Triassic Tarong beds, and Tertiary basalts of the Main Range Volcanics unconformably overlie the unit. Extensive areas of Tertiary duricrust up to 10m thick are also developed on the granite.

Mineralisation

According to local anecdotal communications, a small gold occurrence (the Wondi mine) is thought to occur within the granite on the west side of the Charlestown road at AMG 390860, 7078650. No record of production is known from the mine.

Toondahra Granite (Rgto, Rgto$_t$, Rgto$_f$)

Introduction

The unit was mapped initially by Withnall (1971) as part of an honours thesis in the southern part of the Mundubbera 1: 250 000 Sheet area. The unit was included on the Mundubbera 1:250 000 map Sheet (Whitaker & others, 1974).

Distribution

The unit occurs adjacent to outcrop of Aranbanga Volcanic Group rocks on the Mun-

dubbera 1:250 000 Sheet and extends south into the north-eastern part of BOONDOOMA. Outcrop of the unit extends west into the Allies Creek area.

Topographic expression

The unit is characterised by a very strongly developed pattern of north-east and north-west joints. The northern part of the unit (north-west of Manar homestead) forms high resistant hills. This photopattern is typical of tin granites in Queensland (similar to the Elizabeth Creek Granite in North Queensland, and the Crows Nest Granite to the south). The unit contains topographically flat areas (due to weathering) at the top of the range ~5km north-west of Manar. In this area the vegetation is dominated by grass trees (*Xanthorrea* sp.) and paperbarks (*Melaleuca* sp.). *Callitrus* sp. with local ironbark dominates vegetation adjacent to the Boyne River in this unit north of Boondooma Dam. This vegetation is associated with either rhyolite or microgranite exposures.

Geophysical expression

The unit has a strong radiometric signature in the ternary K–Th–U image (close to white being high in all channels). It has a generally low magnetic response in the aeromagnetic data and a generally low magnetic susceptibility. High magnetic susceptibility associated with the unit is caused by later intrusions of dacite (see unit Rid).

Lithology and petrography

The main part of the unit granite (**Rgto**) is most commonly fine or fine to medium grained, pink in colour (varying locally to grey or cream), equigranular and leucocratic, containing small amounts (~3% or less) of very fine biotite and rarely blue-green hornblende. Chlorite-epidote alteration is common in places. Textures show local variation, ranging from medium- to coarse-grained equigranular varieties, to inequigranular varieties with either coarse quartz aggregates or phenocrysts in a finer grained matrix, or feldspar phenocrysts in a microgranitic matrix. In thin section, the granites commonly display well-developed graphic intergrowth textures between quartz and alkali feldspar. A very fine-grained, locally flow banded porphyritic microgranite phase has been mapped east of Allies Creek (**subunit $\mathbf{Rgto_f}$**). Some of the microgranites east of Allies Creek village display columnar jointing.

The granite body east of Allies Creek displays prominent north-south jointing and shearing in places, and is intruded by sporadic massive to flow banded porphyritic rhyolite dykes near its margin. The dykes are also common in the adjacent country rock.

In the north-eastern part of BOONDOOMA the unit comprises tor exposure of altered pink granite. Considerable areas of altered microgranite and rhyolite are present immediately north of Boondooma Dam where they are associated with rhyolitic ignimbrite and dyke swarms of mainly rhyolitic in composition. These units are probably part of the outlier of the Aranbanga Volcanic Group.

The area east of Manar homestead is composed mainly of intercalated microgranite cut by rhyolite dykes that are locally sparsely porphyritic and strongly flow-banded. The dykes vary from grey fine-grained and aphyric to flow-banded, spherulitic and locally porphyritic. Probable ring dykes are present at AMG 339435, 7120306. Coarsely porphyritic rhyolite at AMG 33467, 7120740 is composed of euhedral embayed quartz (20% to 5mm), and feldspar phenocrysts (subhedral K-feldspar, 5% to 3mm, oligoclase, 20% subhedral to euhedral, 0.5–3mm). The rhyolite also contains minor dark brown biotite crystals (2% altering to opaques along cleavage planes) set in a groundmass of microcystalline quartz and chlorite. The microgranite is locally quartz-feldspar-phyric and contains both hornblende and biotite at AMG 344734, 7121575.

An alteration zone in coarse-grained granite with fine altered rhyolite occurs at AMG 345859, 7118820. Strongly jointed aplitic microgranite with mariolitic cavities occurs at AMG 345724, 7119149. Exposures of deeply weathered aplite are present on the road and adjacent hill at AMG 338219, 7121822. At AMG 344672, 7120740 at the junction of property tracks marked 7 and 8 at the Manar Four Wheel Drive Tourist Park are exposures of flow-banded rhyolite. Flow-banded rhyolite also occurs at AMG 337015, 7122224 and aplite dykes are associated with pavement exposure of pale pink altered granite at AMG 337366, 7121578.

The dykes also show a local vegetation anomaly; for example at AMG 346839, 7112002 a change from mainly *Eucalyptus crebra* to *Callitris* is coincident with rubbly outcrop of sparsely K-feldspar-phyric microgranite containing mariolitic cavities.

Rhyolite dykes intrude brecciated granite containing granite clasts in a dark green groundmass. These are associated with higher magnetic response at AMG 336366, 7119250.

Coarse-grained biotite granodiorite forms pavements associated with flow-banded rhyolite at AMG 337927, 7116808. Very fine to medium to coarse granite and biotite microgranite with minor xenoliths occurs at AMG 348431, 7116964. Strongly jointed flow-banded microgranite and equigranular microgranite occur at AMG 337357, 7122156 and AMG 346271, 7120925 respectively. Pavement of coarse biotite granite with biotite clots occurs at AMG, 336997, 7120229. A dyke of feldspar-phyric microgranite with a hard silicified indurated groundmass is present at AMG 335238, 7118175. Large rounded tors of microgranite with abundant mariolitic cavities forms a prominent hill at AMG 329771, 7112683.

Outcrop of a discrete body of relatively fresh tonalite at AMG 338083, 7120980 near Manar homestead comprises mainly quartz and plagioclase (30 and 40% respectively) with minor K-feldspar (5% untwinned), biotite and hornblende (trace). The biotite and hornblende are altered to chlorite. Apatite is a minor accessory.

Kaolinised and decomposed granite are present at AMG 327509, 7110838 and 329703, 7114892. Exposures of light grey to white even grained biotite with minor rhyolite were noted at 329852, 7113906 and 338118, 7119923.

Relationships

The unit is intruded by unit R*id*, and is probably comagmatic with rhyolite ignimbrite of the Aranbanga Volcanic Group.

Mineralisation

The crossing of Rocky Creek at AMG 322523, 7118930 adjacent to tin workings described by Ball (1903) is on strongly jointed rhyolite. Along Rocky Creek there are large pits at AMG 316500, 7119005 and mullock heaps along the creek westwards for ~200m.

MINOR UNNAMED TRIASSIC INTRUSIONS

Rg_{ip}

This unit forms a small circular body (~1km^2 in area), exposed on the cleared slopes of a low plateau 7km south-east of the township of Proston. The unit consists of grey sparsely to strongly feldspar-phyric, biotite (~2%) microgranite. The feldspar phenocrysts average only ~3–5mm in length. The unit has a high magnetic response forming a circular 'bullseye' feature on aeromagnetic images suggestive of a cylindrical body. A few scattered dolerite boulders found on the northern flanks of the body may have also contributed to the intensity of the magnetic anomaly, but exposure is too poor to ascertain their extent. The unit exhibits dark mottled pink to brown tones on radiometric images. The unit intrudes the Hivesville Granite.

Rgu_{gd}

Intrusives assigned to this unit have been mapped in two localities. The westernmost covers ~4km^2 flanking the Hivesville– Gayndah road, 7km north-west of Hivesville. This body consists of grey, fine to medium grained, inequigranular hornblende tonalite to granodiorite. Slightly coarser plagioclase crystals set in a variable-grainsize groundmass are common. Hornblende makes up ~6–7% of the rock and opaque content is very low, accounting for the poor magnetic response of this body. This body is interpreted to intrude the Hivesville Granite, and is capped by a well-developed ferruginous duricrust profile.

The easternmost body occurs as a small, very poorly exposed circular pluton covering an area of ~1km^2, 13km north of Murgon. This intrusive consists of pink, fine- to medium-grained, equigranular tonalite to diorite with a relatively high magnetic response (showing as a small circular anomaly on aeromagnetic images). The body intrudes elements of the Neara Volcanics and Aranbanga Volcanic Group.

Rg_1

The unit is exposed as a hill occupying an area of <1km^2, 2.5km north of Melrose homestead, south of Proston. The unit consists of altered cream to pink aplitic granite criss-crossed by a network of sugary quartz veins. The unit shows up as pale pink tones on radiometric images and has a low magnetic response on aeromagnetic images. It intrudes the Fifer Creek Metamorphics and has an unknown relationship with the adjacent Rg_2 unit.

Rg_2

This unit occurs immediately north of Melrose homestead, 12km south of Proston. It outcrops over an area of ~5km^2 as low groups of tors within the Stuart River valley. It consists of medium to locally fine-grained, equigranular biotite (-hornblende) granite with rare mafic xenoliths. The unit has a low magnetic response and shows up as a mottled brown tone on radiometric images, indistinguishable from sur-

rounding units. The unit intrudes the Fifer Creek Metamorphics, the Stuart River Granite, and the Melrose Igneous Complex. Its relationship with the adjacent Rg_3 unit is unknown.

Rg_3

This unit is exposed as a narrow, north-trending body 3km north-east of Melrose homestead, 12km south-south-east of Proston. It is generally poorly exposed over an area of ~3km^2, most exposures being found in creeks and gullies. The unit consists mainly of grey, fine-grained, equigranular biotite-hornblende-pyroxene (hypersthene) tonalite, which weathers to a rich red soil. The unit has a low magnetic response and shows up as a mottled brown tone on radiometric images, indistinguishable from surrounding units. The unit intrudes the Fifer Creek Metamorphics, the Hivesville Granite and the Melrose Igneous Complex. Its relationship with the adjacent Rg_2 unit is unknown.

Rg_4

The unit forms a north-north-west trending wedge occupying over 20km^2, 9km north of Hivesville. The unit is very poorly exposed and commonly weathered to a decomposed state. The main rock type is grey to cream, medium to locally coarse grained, equigranular biotite–hornblende monzogranite. The mafic content of the rock is ~4%, with biotite (as coarse books) predominating over small amounts of fine-grained hornblende. The unit has a moderate magnetic response on aeromagnetic images. On the ternary radiometric images, the unit occurs as a mottled dark brown/pink tone, partly reflecting colluvial, alluvial and weathered soil mantling as well as the primary lithological response. The unit is interpreted to intrude the Hivesville Granite and has an unknown relationship with the adjacent Woorooden Granodiorite. A Tertiary ferruginous duricrust profile, silicified quartz sandstone and silcrete locally overlie the unit.

Rg_5

This unit forms a small (~5km^2) roughly rectangular body outcropping as tors and undulating country 18km south of Hivesville. Two other small areas have been noted further north around AMG 358711, 709501, and further south around AMG 364417, 7079849. The unit has a low magnetic response and grey to dark tones on the ternary radiometric image. The dominant rock type is a dark grey, fine-grained, equigranular biotite-rich granite to locally granodiorite, containing numerous locally garnetiferous mafic clots and larger, often laminated, schleiren-syle metasedimentary inclusions. The unit contains up to 15% biotite, and locally has mariolitic cavities. The unit yielded an Ar/Ar biotite age of 230.6±0.7Ma and intrudes the Stuart River Granite, Boondooma Igneous Complex and the Fifer Creek Metamorphics.

Rg_6

The unit forms a small irregularly shaped, poorly exposed body covering ~5km^2 of undulating scrubby country 17km north-north-east of Hivesville. The body consists of pink, medium grained, equigranular biotite (-hornblende) monzogranite. The unit shows as bright pink tones on the ternary radiometric images (contrasting with the surrounding darker-toned more mafic units), and has a moderate magnetic response on RTP aeromagnetic images.

The unit has an unknown relationship with the surrounding Wooroonden Granodiorite, as no contacts have been observed. Small areas of Tertiary ferruginous duricrust are developed on the granite.

Rgg_d

Two small bodies assigned to this unit have been mapped — one flanking the highway immediately west of Proston and another much smaller area 6km east-north-east of Proston. The body west of Proston occupies a valley with low bouldery outcrop, and has been previously been studied by Kirkegaard (1960) and Gradwell (1958). The dominant rock type in both bodies is medium to coarse-grained gabbro locally grading to dolerite and diorite.

At Proston, the rock contains scattered seams, lenses and cavities filled with coarse plagioclase and pyroxene (commonly altered to amphibole). Calcite occurs in the centre of these segregations, but is commonly weathered out to form cavities. In thin section the gabbro consists mainly of plagioclase, augite, secondary uralite, and rare brown hornblende together with accessory large platy crystals of ilmenite and occasional pyrite (Kirkegaard, 1960).

The body west of Proston intrudes the Fifer Creek Metamorphics, and contains scattered screens of quartzitic metasediments derived from the latter. Both bodies are interpreted to also intrude the Hivesville Granite. They have a low magnetic response on aeromagnetic images and show up as dark brown tones on standard radiometric images. The unit is locally overlain by duricrust e.g. at AMG 379516, 7069690

strongly cleaved sheared medium-grained granite is overlain by red soil with large boulders of silicrete. Additionally at AMG 377139, 7070907 the unit contains very coarse even-grained granite to pegmatite in a pit excavation.

Ri_r

The unit occurs as a number of small (up to 2km across) irregular to dome-like intrusions and plugs consisting of massive cream to pale grey, aphyric to sparsely porphyritic rhyolite. The rhyolite is locally columnar jointed or brecciated. Most of the intrusions are associated with the Aranbanga Volcanic Group in the northern part of the Yarraman Subprovince and probably represent late-stage resurgent melts associated with the last phase of this magmatic event. The largest of the intrusions occurs as a roughly circular body east of Windera, doming the enclosing strata of the Toogoolawah and Aranbanga Volcanic Groups. Rhyolitic intrusions of <0.5km^2 also occur on ESK at AMG 408500, 7008800, (Smith, 1987), near the contact of Sugarloaf Metamorphics and Djuan Tonalite. At AMG 410000, 7003300, Mujdrica, (1987) described rhyolite intruding the Sugarloaf Metamorphics. At AMG 404600, 7002800, Horne (1988) identified porphyritic rhyolite intruding the Djuan Tonalite. Scott (1963) identified this body as a tuff. At AMG 433000, 6997500, Richards (1976) described rhyolite with a dark matrix with large amounts of clear quartz apparently filling voids in the finer matrix, intruding Cressbrook Creek Group. At AMG 419700, 6979200 Baxter (1988) located a rhyolite intrusion at the contact between Eskdale Granodiorite and Sugarloaf Metamorphics.

Ri_s

The unit occurs as thin sill-like stratabound sheets intruding rocks of the Toogoolawah and Aranbanga Volcanic Groups in the northern part of the Yarraman Subprovince. These intrusions consist of cream to pale grey, aphyric to sparsely porphyritic rhyolite, ranging from massive to locally flow-banded. The unit is interpreted as representing sill-forming bodies derived from the same intrusive melt phase as unit Ri_r (described above). However, the intrusive nature of all these bodies has not been proven.

Ri_a

The unit occurs as porphyritic andesite dykes up to 200m wide intruding rocks of the Buaraba Mudstone in Alice Creek on ESK. Pan Continental (CR16596) considered that intense silicification and slickensides near the margins of the dykes indicated that they were intruded along existing structures. The Alice Creek gold mine occurs as narrow structurally controlled quartz veins in the dykes. Due to the relatively small size of the intrusions there is no distinct radiometric signature. There is a low magnetic response over the dykes and surrounding rocks. On the magnetic image a high magnetic response occurs ~1km to the south of the dykes and possibly represents a larger intrusive body under the cover of Woogaroo Subgroup.

Rg_d

Numerous small bodies of dark grey fine- to medium-grained diorite occur throughout the mapped area. They are distinguished by dark brown to black tones on the ternary radiometric image and have a low magnetic response on the RTP magnetic image. Some of the bodies are reversely polarised (e.g. the body flanking the main road 3km north-west of Byee, north-west of Murgon).

West of Boondooma Homestead the unit consists of dark-grey, medium to coarse grained, equigranular quartz diorite and diorite containing roughly equal proportions of hornblende and biotite. The rock displays an idiomorphic to hypidiomorphic granular texture in thin section.

PERMIAN–TRIASSIC VOLCANICS

Gilla Volcanics (PRgl, $PRgl_a$, $PRgl_d$, $PRgl_r$, $PRgl_s$, $PRgl_t$, $PRgl_p$)

Introduction

The Gilla Volcanics is a new name for the Gilla Andesite and has been assigned to the unit to better reflect the wide range of volcanic and volcaniclastic rock types present. Gradwell (1949) first named it the Gilla Andesite after noting its dominantly andesitic composition. Further studies by Murphy & others (1976), Barrie (1982), Brown (1982), Topping (1985) and Wehrle (1995) indicated the unit is composed of volcanic and volcaniclastic rock types ranging from intermediate to acid in composition. Six subunits have been identified within the unit and are tabulated in Table 12.

Distribution

Exposure of the Gilla Volcanics occurs on the south-western margin of NANANGO and

Table 12: Units of the Gilla Volcanics

PRgl	undifferentiated intermediate to acid volcanics
$PRgl_a$	dark grey aphyric to porphyritic andesite, minor rhyolite and dacite, some intercalated volcaniclastics
$PRgl_d$	rhyodacite-dacite
$PRgl_p$	feldspar porphyritic dacite
$PRgl_r$	flow banded rhyolite, rhyolitic breccia and conglomerate
$PRgl_s$	volcaniclastic sediments
$PRgl_t$	dacitic-rhyolitic tuff

south-eastern KINGAROY. It consists of a single large (~55km^2) subdivided body (**$PRgl_a$ $PRgl_d$ $PRgl_r$ $PRgl_s$ $PRgl_t$ $PRgl_p$**) centred ~10km north-west of Blackbutt township and three smaller undivided bodies **(PRgl)** 8–11km south and south-west of the township.

Subunit **$PRgl_a$** is the largest subunit and makes up the bulk of the subdivided body. The rhyodacite-dacite subunit (**$PRgl_d$**) is exposed over ~1km^2 and is located on the eastern margin of the subdivided body east of Cooyar Creek. Subunit $PRgl_r$ has the second largest exposure and covers a total area of ~8km^2. Three discrete bodies have been identified with the largest exposed over 5km^2 and located ~12km south of Nanango. Of the other two exposures, one forms an arcuate body of ~2.5km^2 south of the previously mentioned exposure. The smallest body of this subunit (0.5km^2) is west of Cooyar Creek, ~9km north-north-west of Blackbutt. Feldspar porphyritic dacite (**$PRgl_p$**) is present adjacent to the rhyodacite-dacite unit and covers an area of ~1km^2.

Volcanogenic sedimentary deposits (**$PRgl_s$**) of sandstones, conglomerates and breccias make up only a small percentage of the Gilla Volcanics (Wehrle, 1995). Although they are often intercalated with volcanic flows or pyroclastic deposits, an area (0.6km^2) of volcanogenic sediments has been identified on the northern margin of the Gilla Volcanics.

Pyroclastic rocks, similar to the volcanogenic sedimentary deposits, are often intercalated with the primary volcanic flows. Some areas of pyroclastic deposits ($PRgl_t$) are large enough to be mapped as separate subunits and have been identified in the northern (~1km^2), central (0.2km^2) and southern (0.8km^2) parts of the main body of the Gilla Volcanics. Wehrle (1995) estimated as much as 15% of the total volume, of the southern area of the main body, is pyroclastic deposits.

Five areas of undivided Gilla Volcanics **(PRgl)** have been identified. The major area is located on the southern margin of the Taromeo Igneous Complex ($PRgm_{gd3}$) and covers an area of ~4.5km^2. Two other bodies are present close by, one 4km to the east (0.5km^2) and one 2km to the north-west (0.2km^2). The other two small bodies are located ~2km south of Mount Mellera, and ~9km north of Blackbutt.

Structure

The Gilla Volcanics probably represents remnants of a collapsed caldera. Bedding of the volcanic flows and volcaniclastic beds dip generally towards the centre of the main body consistent with a collapsed caldera model.

Topographic expression

The Gilla Volcanics generally form rolling grassy hills but also include small areas of thick native and plantation forest. Elevations range from ~320m–550m.

Geophysical expression

Airborne ternary radiometric images of the Gilla Volcanics give an overall mottled white-green-purple signature, though it has a range of responses. It is similar to parts of the Taromeo Igneous Complex though it lacks the yellow-orange tones of that unit. The body of the unit adjacent to the southernmost exposure of the Taromeo Igneous Complex has a signature showing higher levels of red, indicating relatively higher levels of potassium.

No unique pattern attributable to the Gilla Volcanics was distinguished on the airborne magnetic image. The volcanics have an overall low magnetic response with no significant contrast to surrounding units. Hand-held magnetic susceptibility readings gave values ranging from 10-4000 x 10^{-5} SI units for andesite and 0-500 x 10^{-5} SI units for rhyolite-dacite. Al-

though individual andesites gave relatively high magnetic susceptibility readings, the overall low volumes of rock, strong response from the underlying Taromeo Igneous Complex, and patchy exposure of outcrop, failed to give the unit a characteristic signature. The Gilla Volcanics and the Taromeo Igneous Complex cover an area associated with a deep gravity low.

Lithology and petrography

Gradwell (1949) described andesite, andesitic and rhyolitic agglomerate, feldspar porphyry and rhyolite from the Gilla Volcanics. Rock types noted by Wehrle (1995) include andesite, rhyolite, flow-banded rhyolite, dacite and feldspar porphyry. He also observed rapid and complex changes in the rock types along with abrupt facies changes, most typically from andesite flows to volcaniclastic deposits. Although the contacts are often obscured, relationships can be observed along the roughly flat-lying creek exposures.

Dennis (1974) described the rocks south of the Taromeo Igneous Complex (Rgm_{gd1}) and north of Emu Creek, as a series of acid volcanics **(PRgl?)** in contact with the southern boundary of the granodiorite. He summarised the unit as being made up of rhyolites, dacites, andesite, andesitic tuffs and other tuffaceous rocks. Rocks close to the contact with the granodiorite have been recrystallised and may show disseminated pyrite.

The rhyolites range in colour from light green to grey-brown and contain feldspar phenocrysts to 3mm. In some of the flow-banded rhyolites, the feldspar phenocrysts are roughly aligned to the flow bands. The metarhyolite is light coloured and contains red weathered phenocrysts of feldspar to 2mm. Thin section analysis indicates the groundmass is highly siliceous and has been recrystallised. Relict feldspars contain significant hematite, and there is minor muscovite and chlorite present within the rock.

The dacites are generally light-coloured, porphyritic, and contain feldspar and mafic phenocrysts to 4mm. Thin section analysis of metadacite shows the rock consists of plagioclase laths and aggregates of biotite and magnetite in a finely crystalline siliceous groundmass with disseminated fine biotite.

Andesites range from sparsely to abundantly porphyritic with a weakly to moderately well-developed trachytic texture. Andesitic tuffs occur with feldspar crystals to 3mm in a fine dark grey groundmass. In thin section the plagioclase crystals show varying stages of alteration to epidote. Fine biotite flakes with some quartz that are disseminated throughout the rock are probably products of metamorphism.

Subunit $\mathbf{PRgl_a}$ is composed primarily of andesitic flows with lesser intercalated andesitic to rhylolitic volcaniclastics. Minor flow-banded rhyolite is also present. Lava flows from different areas in the unit indicate hornfelsing to varying degrees by the Taromeo Igneous Complex. Silicification and carbonate alteration is common in some outcrops. The andesite flows are generally made up of holocrystalline, fine-grained porphyritic rocks with hypidiomorphic texture and weakly developed trachytic texture (Wehrle, 1995). Phenocrysts are dominantly plagioclase feldspar and clinopyroxene with lesser hornblende. Clinopyroxene and hornblende crystals are often closely associated in a glomeroporphyritic texture. The rocks generally contain 1–2% magnetite opaques scattered throughout and/or forming glomerophyric clumps.

Plagioclase is the dominant phenocryst mineral and ranges in abundance from 20–30%. Crystals are typically subhedral to euhedral averaging 1–2mm but may be up to 5mm in length. Normal zoning is common and ion probe analyses, undertaken by Wehrle (1995), showed the composition ranging from An_{57} cores through to An_{48} rims. Plagioclase crystals are often broken and may show slight to nearly complete sericite and clay alteration.

Clinopyroxene crystals are the next most dominant phenocrysts with abundances from 4–15%. They generally average <1mm in size but may range up to 3mm. All clinopyroxenes have an augite composition. An average composition of the augites is 43mol% $CaSiO_3$, 44mol% $MgSiO_3$, 13mol% (Fe, Mn) SiO_3 with slightly Mg enriched cores (Wehrle, 1995). Alteration of augite to epidote and chlorite is common.

Hornblende crystals make up to 5% of the phenocrysts within the andesite flows. The subhedral to euhedral, elongate prismatic hornblende crystals have an average size of <1mm but may be as large as 3mm. The hornblendes are compositionally unzoned, and of an Al-poor variety (Wehrle, 1995). Hornblendes are often moderately to completely altered to chlorite.

An example of a flow-banded rhyolite lava within $\mathbf{PRgl_a}$ is present beside a track on the side of a hill at AMG 406090, 7029636 (Plate 8). In outcrop the rock shows well-defined contorted flow bands with raised finer grained resistant bands. Thin section analysis shows the rock contains generally complete quartz and feldspar crystals in a layered fine-grained

groundmass. Sericite, clay and calcite alteration is common along flow foliations.

Intercalated with some of the flows are andesitic to rhyolitic pyroclastics. At AMG 404581, 7035149 a layer of andesitic welded rheomorphic ignimbrite occurs above a sparsely porphyritic andesite lava flow. The ignimbrite is composed of abundant complete, broken or shattered plagioclase phenocrysts within a flow-foliated glassy groundmass. Also present are completely chloritised pyroxene and probable hornblende phenocrysts along with rare quartz phenocrysts to 1mm. The flow foliation is defined by light and dark coloured devitrified glass and stretched tube pumice.

Wehrle (1995) described subunit **PRgl$_d$** as being composed of fine-grained porphyritic dacite. He reported on an exposure of the subunit in Yarraman Creek (AMG 403500, 7037700) as being composed of alternating blue-grey and cream bands, containing fine laminations, dipping west at 35°. The undulating bands have a wavelength of 1.5m and appear to be the result of flow or surge processes. The dark bands contain subangular mineral fragments and appear to be finely laminated andesite.

Subunit **PRgl$_p$** is exposed north of subunit **PRgl$_d$** and is composed of coarse feldspar porphyritic andesite-dacite. This rock type differs from the majority of andesite and dacite flows by the abundance of plagioclase phenocrysts. Locally the phenocrysts can reach lengths of >20mm and make up >40% of the rock. Wehrle (1995) noted that the rock was conspicuously mafic (~50% SiO_2). Gradwell (1949) identified small areas of the rock type in the north-western part of the Gilla Vocanics while Robertson (1987) noted it on the western side, and Barrie (1982) on the eastern side in Cooyar Creek.

Subunit **PRgl$_r$** is composed of flow-banded rhyolite, rhyolitic breccia and conglomerate. Wehrle (1995) described an up to 150m thick rhyolite exposure dipping ~21° to the north-west, in Nora Gully (AMG 404500, 7030800). The rock is flow-banded and shows disruption to the flow bands caused by autobrecciation. Andesite lenses are irregularly intercalated with the rhyolite towards the top of the unit. Secondary sulphide minerals are common within the unit most notably within the brecciated zones. Robertson (1987) noted a similar flow-banded rhyolite on the western margin of the Gilla Volcanics. He recorded steep dips within the unit to the east.

White-cream rhyolite is exposed in a road cut on the side of a hill at AMG 406686, 7033443. The rock contains pyrite crystals to 1mm, is stained by Jarosite in places and has quartz veins to 10mm containing small amounts of magnetite. In thin section the rock shows spherulitic devitrification textures and is strongly altered to sericite and muscovite.

An outcrop of light grey-cream, silicified pebbly conglomerate can be found beside the track ~1.5km south of Yarraman Creek at AMG 402577, 7036210. The conglomerate is polymictic and contains angular to subrounded clasts of andesite, dacite, quartz and rhyolite. The rock coincides with a marked change in soil colour from dark grey to light brown. Scattered float of silicified andesite and dacite is also present.

Subunit **PRgl$_s$** comprises bedded volcanogenic sandstones, conglomerates and breccias. Composition of the sediments reflects the volcanic source material available and therefore andesitic material is the most abundant. The more coarse-grained deposits typically lack stratification.

Rocks of subunit **PRgl$_t$** show a range of compositions and textures (Wehrle, 1995). They are often difficult to distinguish from epiclastic deposits in the field and thin section analysis is generally needed to confirm their classification. The deposits can be monolithologic or polylithologic and may contain clasts of andesite, feldspar porphyry, rhyolite, and dacite in differing proportions, though andesite is the volumetrically dominant clast type. Rocks range in grain-size from fine-grained tuffs, to breccias with subrounded to subangular andesite blocks of up to 3m in diameter. Pyroclastic surge, fall, and flow processes (Fisher 1979; Cas & Wright, 1987;and McPhie & others, 1993) formed the deposits that include block and ash flow, air fall and ignimbrite deposits.

An exposure in the southern part of the Gilla Volcanics, at AMG 404400, 7028500, shows large unsorted andesitic blocks in an ash matrix. The matrix exhibits ash flow textures and contains numerous small andesitic clasts. The larger clasts are lithic and are made up of irregular shaped blocks, typically ~200mm in diameter, of andesite in a crystal-rich to crystal-poor matrix.

Pyroclastic flows have been identified further north in Yarraman Creek, stratigraphically below andesite lava flows (Wehrle, 1995). An example from this locality exhibits some of the elements of an idealised pyroclastic flow as described by Fisher (1979). The base of the exposure is composed of an angular fragmental flow deposit that grades into a 0.5m thick fine-grained layered tuffaceous bed. The

tuffaceous bed is probably the result of an ash-cloud surge deposit.

Age

Gradwell (1949) suggested a Permian age for the Gilla Volcanics on the basis of lithological and stratigraphic correlation with similar volcanic units. Murphy & others (1976) believed the distribution and composition of the volcanics were consistent with being comagmatic with the Taromeo Igneous Complex. Wehrle (1995) agreed and showed the Gilla Volcanics had similar normalised REE patterns to the Taromeo Igneous Complex. He suggested they are genetically related but have formed from different parental magma. Geochemical samples of the Gilla Volcanics plot with the younger phases of the Taromeo Igneous Complex on TAS diagrams indicating a similar source.

Relationships

The Gilla Volcanics unconformably overlie the Devonian-Carboniferous Maronghi Creek beds and Sugarloaf Metamorphics. Hornfelsing of the volcanics indicate they have been intruded by at least part of the Permo-Triassic Taromeo Igneous Complex. Finally, Tertiary Main Range Volcanics have overlain the unit.

LATE TRIASSIC FELSIC VOLCANICS

Aranbanga Volcanic Group

Introduction

The unit is exposed most extensively to the north on the Maryborough 1:250 000 Sheet, where Ellis (1968) first recognised the sequence and applied the name "Aranbanga Beds" to the rocks. Later mapping in the area revised the stratigraphy of the sequence, proposing the unit be elevated to group status as the Aranbanga Volcanic Group, comprising a number of mappable formations (Cranfield, 1989). None of these formations are recognised on the Gympie 1:250 000 Sheet, because of a lack of outcrop continuity and the much more restricted extent of the unit. However, a number of lithological subunits have been mapped, some of which may be correlatives of formations mapped to the north on the Maryborough 1:250 000 map sheet area.

Distribution

The unit forms an extensive area (~200km^2) of volcanics covering the north-eastern corner of MURGON, as well as more restricted areas further west along the northern edge of the sheet.

Topographic expression

The unit forms rugged steep ridges, hills and small plateaux in the north-east of MURGON ranging to low undulating scrubby hills further west. Tertiary laterite mesas sporadically cap the unit, and locally display moderately well developed jointing on airphotos.

Geophysical expression

Because the unit consists of a number of different rock types, its geophysical character is variable. Rhyolite-dominated sequences generally show up as light creamy tones on ternary K–Th–U (RGB) radiometric images, whereas andesitic and basaltic units show as dark brown tones. The magnetic response of most of the units is relatively low, except for some andesite flows. In particular, magnetic highs in the north-eastern corner of MURGON (in an area mapped as rhyolite-dominated) are thought to result from thick andesite flows underlying ryholite sheets at very shallow depths.

Lithology and petrography

Undivided Aranbanga Volcanic Group (Ra)

A variety of diverse volcanic and volcaniclastic rocks are contained within this unit, including most of rock types contained described within the other subunits descibed below. North of Windera, very fine-grained dark grey basalt and very fine-grained, pale grey to cream rhyolite are the most common rock types. Both rock types are typically massive and featureless, although the basalts commonly have a flaggy fissility. These rock types are less common further west in the valley of Barambah Creek, where lithic, pumiceous, rhyolitic to dacitic ignimbrite, vesicular to amygdaloidal basalt lava, and lithic chloritic volcaniclastic sediments predominate. The latter are thin to medium or thick bedded, with well-defined planar beds defined by trains of angular rhyolitic fragments up to 2cm across.

Flaggy flow-layered rhyolite sills and dykes also intrude this sequence. North of Abbeywood, the undivided Aranbanga Volcanic Group contains mainly ryholitic tuff, lithic ignimbrite and lava, with minor basalt and dacite. The rhyolite lavas form massive flow layered or locally autobrecciated pavements. The rhyolite lavas in this area are sparsely porphyritic, and contain phenocrysts of plagioclase and locally biotite in a microcrystalline groundmass of quartz,

plagioclase, and biotite (or chlorite after biotite) and rare opaques.

In the north-western part of this outcrop area east of Geer Creek the unit is also characterised by crystal and clast rich ignimbrite. These rocks contain crystals of plagioclase, quartz and K-feldspar (orthoclase) (up to 35%), moderately flattened and devitrified pumice, and clasts of quartzite, quartz-haematite rock, and plagioclase-phyric rhyolite to dacite set in a groundmass of brown glass and fused glass shards. Ignimbrites in this area also locally brecciated and comprise a groundmass of densely welded glass shard up to 70% of the rock at AMG 357064, 7120639.

In the south-west of this area south of the Junction of Geer and Canoe Creeks the unit comprises similar crystal-rich, clast-rich ignimbrite to that to the north of Geer Creek, but also contains dacite flows overlain by intercalated conglomerate and fine arenite and dacitic tuff at AMG 355879, 7121520. The groundmass is also composed of light brown glass and fused glass shards. The rhyolite flows in this area are K-feldspar-phyric.

Subunit Ra_r: This unit is widespread throughout the north-eastern and north-western corners of MURGON and in the north-east corner of adjacent BOONDOOMA.

In MURGON rhyolitic volcanics and associated volcaniclastic sediments dominate the unit, although trachyte, andesite and basalt flows and pyroclastics also occur rarely within the sequence. The rhyolite is cream to red-brown or locally green in colour, contain sparse feldspar (mainly plagioclase with alteration to carbonate), and/or quartz phenocrysts and minor biotite (altering to chlorite and opaques). The rhyolites have a cryptocrystalline to microcrystalline groundmass and locally contain variably-welded glass shards. The rhyolite flows are locally brecciated and contain tension gash veins with multiple infills of carbonate fibres, carbonate drusy infill and chalcedony. Many of the rhyolites probably represent ignimbrite flows, but their weathered sinter-like appearance suggests only a moderate degree of welding.

Crystal content in the ignimbrite layers comprises approximately equal amounts of plagioclase, K-feldspar and quartz. Rock fragment clasts are dominantly of coarsely and sparsely plagioclase-phyric dacite. The groundmass is dominantly a light brown glass with fused glass shards. Individual cooling units range 3–15m in thickness, and commonly contain up to 20% flattened pumice fragments up to 4cm in length. The latter generally weather readily to form cavities. Trough cross-bedding and scouring occur locally and may represent base surge deposits. Eutaxitic textures are visible locally. Rhyolite lava flows are rare. Lava textures range from flow banded to brecciated, massive or spherulitic. Numerous flow-banded to massive rhyolite sills intrude the sequence and locally may be difficult to distinguish from extrusive flows. Dykes of similar composition intrude the unit and the adjacent Toondahra Granite. At AMG 396307, 7121042 an abundantly plagioclase-phyric (phenocrysts to 50%) trachyte flow has a groundmass of plagioclase needles, chlorite and minor opaques, and is cut by thin (to 2mm) haematite-chlorite veins with some brecciation.

In north-east BOONDOOMA and north-west MURGON the unit contains flow-banded rhyolite, crystal and clast-rich ignimbrite, K-feldspar-phyric to aphyric biotite rhyolites. Flow-banded to massive rhyolite sills intrude the sequence and locally may be difficult to distinguish from extrusive flows. Rhyolite dykes of similar composition intrude the unit and the adjacent Toondahra Granite. North of Boondooma Dam a rhyolitic dyke swarm that intrudes the Toondahra Granite may mark a ring fracture system at the southern end of unit Ra_r. At the Boondooma Dam spillway flow-banded rhyolite and dark fine-grained aphyric dacite successively intrude pink eutaxitically layered clast-rich and spherulitic (pumice-rich) ignimbrite. The whole section has been extensively propylitically altered to a green chloritic breccia. This breccia forms the unstable western side of the spillway. At the northern end of the main spillway this section is faulted against weathered Toondahra Granite outcrop.

Non-welded, banded to massive lithic rhyolitic tuffs also occur sporadically throughout the sequence. These typically contain angular pink to grey rhyolite, andesite and/or basalt clasts (averaging ~1cm across), feldspar and quartz crystals, pumice clasts and rare basement metasedimentary clasts in a fine-grained felsic, locally flow-layered matrix (locally with glass shards). Prominent red garnet crystals are characteristic of many of these tuffs. Lithic content varies from 30% (matrix-supported) to 90% (mostly clast-supported). Parts of these lithic-rich sequences are thinly-bedded, well-sorted and locally graded, and may represent coarse-grained epiclastic sediments deposited by erosion of nearby primary deposits. Tuffacous mudstone/ash fall tuffs layers also occur locally.

Medium to thick-bedded volcaniclastic arenites with occasional mudstone intervals occur spo-

radically throughout the sequence. Volcaniclastic sediments of rhyolitic composition are well exposed in Rose Creek 3km east-south-east of Windera. At this locality, medium to thick-bedded (locally internally thin-bedded), fine-grained rhyolitic tuffs are interlayered with epiclastic sediments. The latter are cross-bedded in part and locally scour underlying beds. Volcaniclastic arenites locally contain beds (up to 1m thick) of conglomerate in which the bulk of the clasts are rhyolite. This sequence also contains eutaxitically-layered ignimbrites up to 3m thick, typically capped by beds of laminated waterlain or airfall tuff.

Coarse sediments with a significant nonvolcaniclastic component occur locally within the rhyolite-dominated sequence. A good example occurs at AMG 399270, 7113150 where pebble to cobble conglomerate beds up to 10m thick occur interbedded with pebbly lithic arenites. The clasts are mainly rhyolite, andesite and indurated siltstone in a matrix of mainly sedimentary rock grains.

Thick sequences of planar-bedded laminated fine siltstone and interlayered carbonaceous mudstone also occur in places within subunit Ra_r. The mudstones are locally rich in glass shards or detrital mica.

Subunit Ra_a: This unit occurs mainly as a narrow north-north-west trending belt north of Boat Mountain, as well as a small area north-east of Windera. Dark grey-green andesitic tuff and lava dominate the unit. These rocks are moderately to abundantly feldspar crystal-rich and locally also contain scattered hornblende phenocrysts.

Subunit Ra_b: This unit consists almost entirely of fine-grained basalt, mainly exposed over an area of ~10km^2 east of Cloyna and as a few small areas occur further to the north and north-east. The basalts in the Cloyna-Windera area are very fine-grained, and pale grey, generally with a strong subhorizontal flaggy fissility (reflecting feldpar crystal alignment at the microscopic scale). These basalts are commonly aphanitic, although fine feldspar crystals are visible locally and are rich in minute rutile (and ilmenite?) crystals. The basalt further east near Redbank Creek is massive, coarser-grained and contains augite and olivine phenocrysts.

Subunit Ra_p: This unit occurs on the north-eastern flanks of the Windera domal structure, and over a small area south of Cloyna. The unit is characterised by dark grey basalt rich in coarse feldspar crystals (up to 1cm in length). The basalt is commonly amygdaloidal with scattered larger partly crystalline vugs up to 4cm across.

Subunit Ra_d: The unit occurs as small areas on the northern flanks of the Windera domal structure and as a small area north of Proston, but is more extensive on the Maryborough 1:250 000 Sheet area to the north. The unit consists of pale grey to pink or brown dacite lava that is sparsely to moderately feldspar crystal-rich. The dacites are locally brecciated and chloritically altered.

Subunit Ra_s: This unit occurs as small slivers exposed 1–2km east of Double Knob. The sequence consists mainly of medium to thick-bedded volcaniclastic arenite with occasional mudstone interbeds. The arenites are locally thin-bedded to laminated, especially in the mudstone-rich intervals. Bedding styles range from planar to trough cross-bedded. The arenites are mainly medium to coarse-grained with coarse quartz and rhyolite pebbles locally scattered along bedding planes. The arenites consist mainly of andesite grains, plagioclase crystals, and minor grains of rhyolite. The andesitic component of the clastics was probably derived from erosion of an underlying sequence of andesites (subunit Ra_a).

Thickness

The maximium thickness of the group on MURGON is ~250m.

Structure

Bedding within the unit is mainly shallow, with the exception of the Windera area where a circular intrusive domes the surrounding sequence to a moderate concentric dip.

Biostratigraphy and age

Mudstone intervals within the volcanics commonly contain small flattened freshwater bivalves belonging to the order *Conchastrata* (e.g. at AMG 391278, 7111106). Radiometric age date on unit Ra_b at Cloyna indicated a Late Triassic age (Geological Survey of Queensland, 1981).

Stratigraphic relationships

Cranfield (1994) demonstrated an unconformity between the Aranbanga Volcanic Group and the underlying Neara Volcanics. This relationship could not be confirmed on MURGON, where the two units appear concordant. North-west of Proston, the Aranbanga Volcanic Group unconformably overlies the Fifer Creek Metamophics and is probably intruded by the Toondahra Granite. North and north-east of Proston, the

unit is intruded by undifferentiated Permo-Triassic granite, the Canoe Creek Granite and the Wooroonden Granodiorite. The Aranbanga Volcanic Group is intruded by Late Triassic rhyolite plugs and domes (unit Ri_r) as well as rhyolite sills (unit Ri_s). The Tertiary Oakdale Sandstone and the Main Range Volcanics unconformably overlie the unit. Extensive areas of weathered Tertiary duricrust are also developed on top of the unit.

Correlatives

The garnet-bearing tuffs within subunit Ra_r may be equivalent to the garnetiferous Dadamarine Rhyolite and Ooramera Volcanics mapped to the north on the Maryborough 1:250 000 sheet by Cranfield (1994).

Rv Undivided Triassic Volcanics — (Near Buaraba Creek)

Introduction

The unit was included on the Ipswich 1:250 000 geology map as undifferentiated Triassic volcanics consisting of rhyolite flows and breccia, andesitic flows and basalt (Cranfield & Schwarzböck, 1973).

Distribution

Outcrop of ~2km^2 occurs in the Buaraba area, south west of Buaraba Creek and around Galloping Creek.

Topographic expression

The unit occurs as scattered outcrop, barely visible above grass in generally flat cleared country. Elevations in the unit range from 120–220m.

Geophysical expression

The area covered by the unit shows weak variable magnetic responses. The radiometric image shows similar responses to the Woogaroo Subgroup, probably due to poor outcrop of the volcanics and to transported soils from the adjacent, topographically higher, Woogaroo Subgroup.

Lithology

In the Buaraba area Irvine (1987) mapped rhyolite tuffs and flows with minor siltstone and arkose and dips of 15° to the south-west. Gibson (1975) mapped lithic sandstones, tuffaceous sediments, dacites and minor andesite in Galloping Creek area. The sandstones contain some well-rounded chert pebbles (2–3mm). The dacites contain rare feldspar phenocrysts. Tuffaceous sediments contain abundant pyrite in parts. These volcanics in the Galloping Creek area are interpreted in this report to be an extension of the volcanics described by Irvine (1987) about 2km to the north-west.

Stratigraphic relationships

The unit is assumed to unconformably overlie the Cressbrook Creek Group and is unconformably overlain by Woogaroo Subgroup.

Structure

Gibson (1975) interpreted folding with north-east trending axes in the Galloping Creek area.

Correlation with other units

There are no known direct correlatives of this unit.

Dangore Volcanics (new name; Rvd)

Introduction

Murphy & others (1976) previously mapped the unit as part of the mainly mafic Tertiary Main Range Volcanics. Unpublished Geological Survey mapping indicated the presence of felsic volcanic in the vicinity of Dangore Mountain. Field checking of an area of high radiometric signature on the ternary K–Th–U radiometric image resulted in the determination of a mainly acid volcanic sequence dominated by rhyolitic volcanics.

Distribution

The unit is situated 25km north-west of Kingaroy south of the Chinchilla–Wondai road, where it is exposed as a roughly rectangular area covering ~25km^2.

Topographic expression

The unit forms elevated heavily wooded country including a 140m elevation change from the adjacent country at Mount Dangore. The unit ranges from ~460m–600m at Mount Dangore.

Geophysical expression

The unit is characterised by a roughly square-shaped brown-coloured radiometric anomaly on the K–Th–U ternary image that cov-

ers the outcrop of the Dangore Volcanics, and a complex moderate to high composite north-east-trending magnetic anomaly that covers a larger area than the outcrop of the unit.

Lithology and petrography

The unit is composed of rhyolite breccia and rhyolitic ignimbrite in a section along the Dangore Mountain Road. The rhyolite breccia is mottled and weathered and comprises angular, granule to cobble-size clasts of flow-banded rhyolite in an ashy groundmass at AMG 359315, 7073198 and 360893, 7073778. The rhyolitic ignimbrite is strongly jointed and typically forms low pavement exposure along the Dangore Mountain Road and an adjacent forestry track to the north of the road. The ignimbrite has steep jointing and is crystal-rich in exposures at AMG 360054, 7073578; 359602, 70749910 and 360248, 7073530, and both crystal-rich and clast-rich at 360054, 7073578 and 359602, 70749910. A thin section of ignimbrite from AMG 360054, 7073578 is a clast-bearing crystal-rich pyroclastic rock. Crystals which comprise close to 45% of the rock consist dominantly of broken, altered subhedral plagioclase (90%, to 2mm), quartz as resorbed broken crystals (5%, to 1.5 mm), and chlorite (?after biotite) and associated with opaques (2%, to 2mm). Clasts (~15% of the rock) consist dominantly of pumice (70%, 0.5–3mm). The pumice is strongly flattened and recrystallised and has locally been altered to quartz-carbonate masses. The groundmass is light brown in thin section and comprises a strongly welded mass of pumice and welded glass shards.

Thickness

The unit appears to be shallow dipping (to 15°); thickness of ~200m is suggested herein.

Structure

The unit appears to be shallowly dipping throughout and unconformable on unit Rgbo of the Boondooma Igneous Complex.

Biostratigraphy and age

The unit is lithologically similar to the Aranbanga Volcanic Group, and in a similar structural position; it is assumed to be of Late Triassic age.

Correlatives

The unit is assumed to be an age correlative of the Aranbanga Volcanic Group.

TERTIARY INTRUSIVES

Tid: Two small alkali dolerite plugs have been mapped north of Kingaroy, one at AMG 3856400, 7075600 3km north-east of Memerambi and the other forming Mount McEuen at AMG 374200, 7095100.

The Memerambi body is exposed in a large quarry, where the unit has a very distinctive subhorizontal parting, in some areas parallel to a microscopic flow alignment. Cowie (1969) descibed the body as consisting mainly of teschenite with subordinate picrite-dolerite, showing a progressive decrease in olivine and increase in plagioclase and clinopyroxene content with increasing height in the intrusion. The margin of the body is chilled. The Mount McEuen body is similar in composition and has a similar subhorizontal flaggy cleavage. Both bodies intrude flows of the Main Range Volcanics.

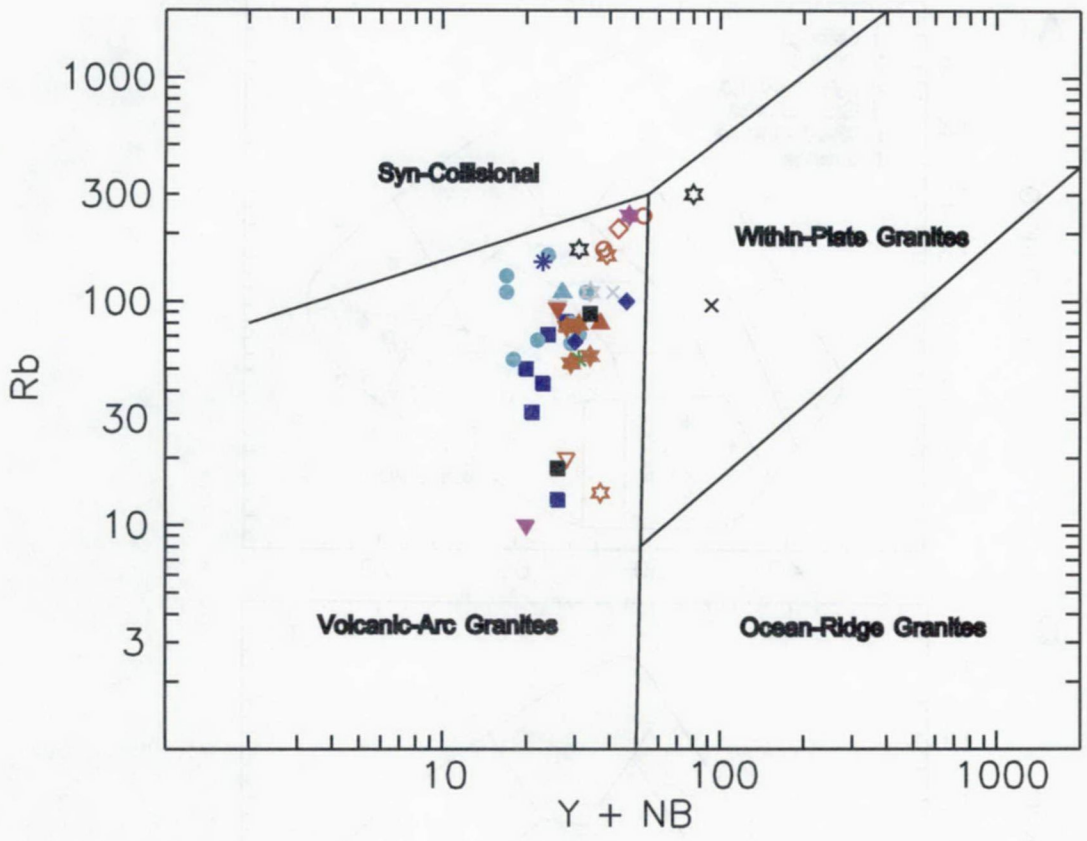
YARRAMAN SUBPROVINCE GEOCHEMISTRY

Introduction

Yarraman Subprovince granitoids show a range of compositions from diorite/gabbro to granite on geochemical discrimination diagrams (Figures 6–10). All bodies analysed are I-type in character, Permo-Triassic to Triassic in age, and plot in the volcanic arc granite fields on trace element discrimination diagrams (Figures 7A–C).

Two broad geochemical suites based largely on relative alkali contents, but also defined by other major and trace elements, are present in the Yarraman Subprovince (Figure 8, Table 13).

Group 1 is relatively depleted in total alkalis (Na_2O+K_2O), cerium (Ce), zirconium (Zr) and niobium (Nb), and relatively elevated in calcium (CaO), and is generally, but not exclusively, made up of the older units. This group includes Permo-Triassic subunits of the Boondooma Igneous Complex ($PRgb_d$, $PRgb_g$) and Taromeo Igneous Complex ($PRgm_t$, $PRgm_{gd2}$), the Hivesville Granite (PRgh) and Stuart River Granite (PRgt). Other units are the Woolshed Mountain Granodiorite (PRgwm), Djuan



- Boondooma Igneous Complex/d
- Boondooma Igneous Complex/g
- Boondooma Igneous Complex/o
- Boondooma Igneous Complex/t
- Crows Nest Granite
- Djuan Tonalite
- Eskdale Granodiorite/1
- Eskdale Granodiorite/2
- Eskdale Granodiorite/3
- Eskdale Granodiorite/4
- Eskdale Granodiorite/A
- Eskdale Granodiorite/M
- Farquharson Granite
- Hivesville Granite
- Unnamed Permian diorite (Pgd)
- Unnamed Permian Opx Diorite (Pgo)
- Unnamed Permian diorite, granodiorite (Pgu)
- Unnamed Permo-Triassic granodiorite (PRg)
- Unnamed Permo-Triassic granite (PR1)
- Unnamed Triassic granite (Rg6)
- Unnamed Triassic Intrusions (Rgd)
- Unnamed Triassic granite (Rgip)
- Stuart River Granite
- Taromeo Igneous Complex/d
- Taromeo Igneous Complex/g
- Taromeo Igneous Complex/PRgd2
- Taromeo Igneous Complex/Rgd1
- Taromeo Igneous Complex/Rgd2
- Taromeo Igneous Complex/t
- Toondara Granite
- Wilfred Creek Igneous Complex
- Woolshed Mountain Granodiorite
- Wooroonden Granodiorite

Figure 6. Discrimination diagrams for granites of the Yarraman Subprovince based on Rb-(Y+Nb) variations of Pearce & others (1984)

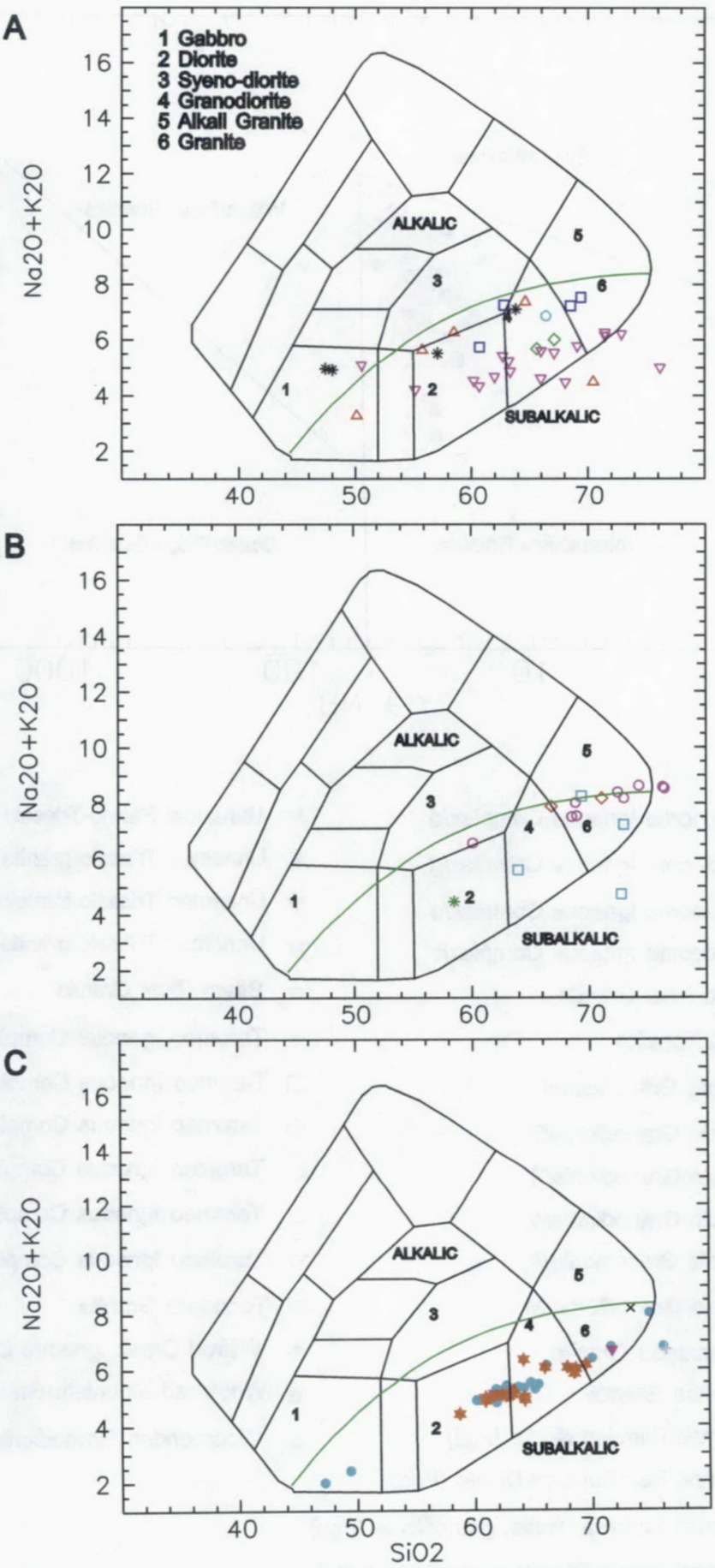


Figure 7. Total alkalis versus silica (TAS) diagram of Cox & others (1979) adapted by Wilson (1989) for plutonic rocks. The green curved line divides alkalic and subalkalic rocks. A - Taromeo Igneous Complex; B - Boondooma Igneous Complex C - Eskdale Granodiorite

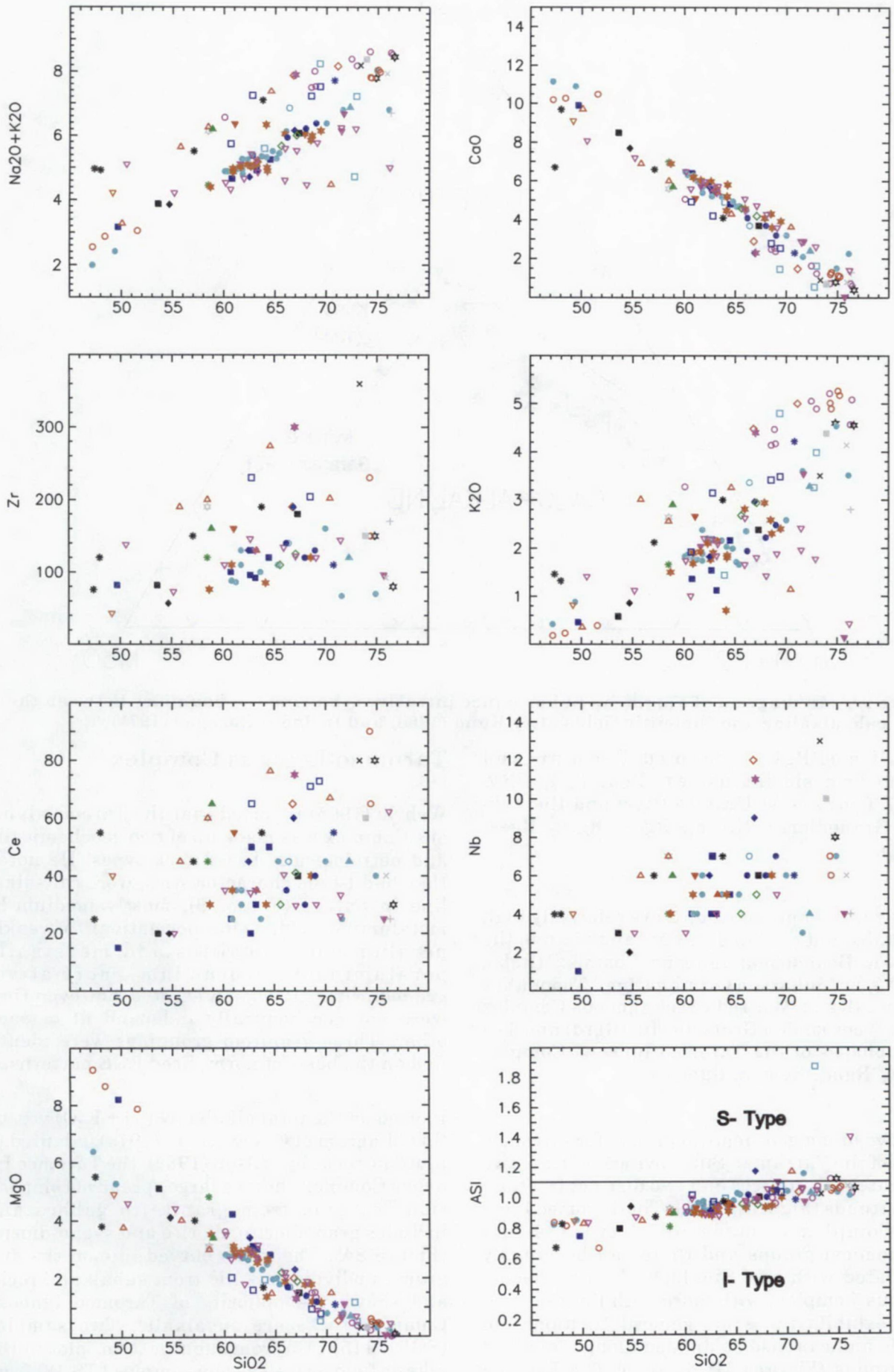


Figure 8. Harker diagrams of Yarraman Subprovince intrusive units; Aluminium Saturation Index (ASI) versus SiO_2 diagram from Chappell & White (1974)

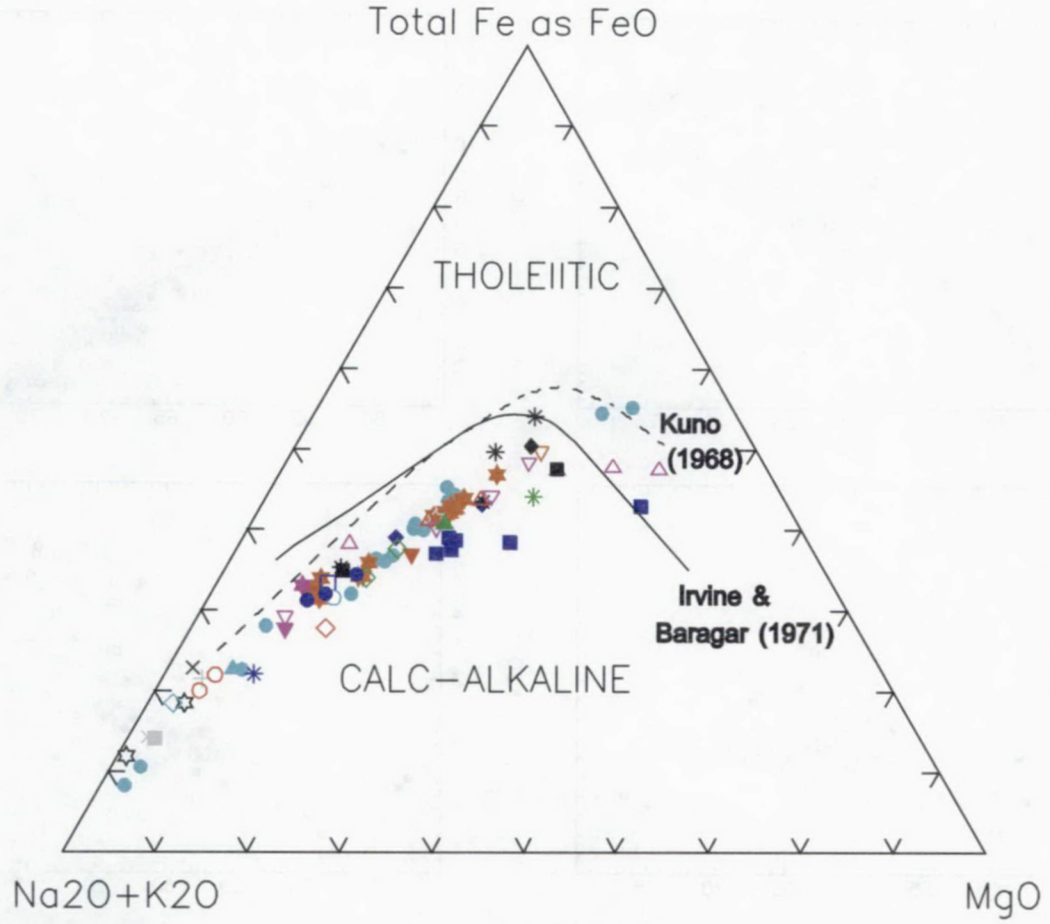


Figure 9. AMF diagram of Yarraman Subprovince intrusives showing the boundary between the calc-alkaline and tholeiitic fields after Kuno (1968) and Irvine & Baragar (1971)

Tonalite (PR*gj*), unnamed Permian and Permo-Triassic intrusives (P*gu*, P*gd*, PR*g*, PRg_1), Crows Nest Granite (R*gr*) and the Eskdale Granodiorite (Rges_4, Rges_3 Rges_2 Rges_1 Rges_a).

Units that comprise Group 2 are relatively high in alkalis and depleted in CaO and include the Triassic Boondooma Igneous Complex (R*gbo*, R*gbo*^{p}), Farquharson Granite (R*gq*), Toondahra Granite (R*gto*), Wilfred Creek Igneous Complex (R*gi*), Wooroonden Granodiorite (R*grd*) and Triassic phases of the Taromeo Igneous Complex (Rgm_d, Rgm_g, Rgm_{gd2}, Rgm_{gd1}).

The two broad geochemical groups for intrusive units of the Yarraman Subprovince indicate two separate melt sources and two distinct fractionation trends (Figure 8, 10A). The Taromeo Igneous Complex is made up of two distinct geochemical groups and these can be broadly correlated with age. Similarly the Boondooma Igneous Complex, with more with limited samples, exhibits the same general fractionation trends and can also be divided along identified age groups (Figures 7B, 8, 10A). The Eskdale Granodiorite appears to belong to a single geochemical suite and therefore a single source.

Taromeo Igneous Complex

Wehrle (1995) reported that the Taromeo Igneous Complex was made up of two geochemically and petrologically based rock types. He noted they had I-type characteristics, were calc-alkaline in nature (Figure 9), mostly medium-K, metaluminous (diopside normative) to weakly peraluminous tonalites and marginally peraluminous (corundum normative) granodiorites. It was suggested however they were not geochemically independent of each other. Three granitoid groupings were identified on the basis of normalised REE patterns.

Plotted on the total alkalis ($Na_2O + K_2O$) versus SiO_2 diagram of Cox & others (1979), adapted to plutonic rocks by Wilson (1989), the Taromeo Igneous Complex shows a large spread of compositions ranging from granite to gabbro and includes granodiorite, diorite and syeno-diorite (Figure 8A). The green curved line on the diagram subdivides alkalic from subalkalic rocks and shows the majority of Taromeo Igneous Complex rocks are subalkalic. Two samples (SQRR 115, 116) from subunit Rgm_d plot in the alkalic field as well as one sample (TTS 18) from PRgm_t. Petrographic analysis (see 'PERMO-TRIASSIC INTRUSIVES') confirms a wide

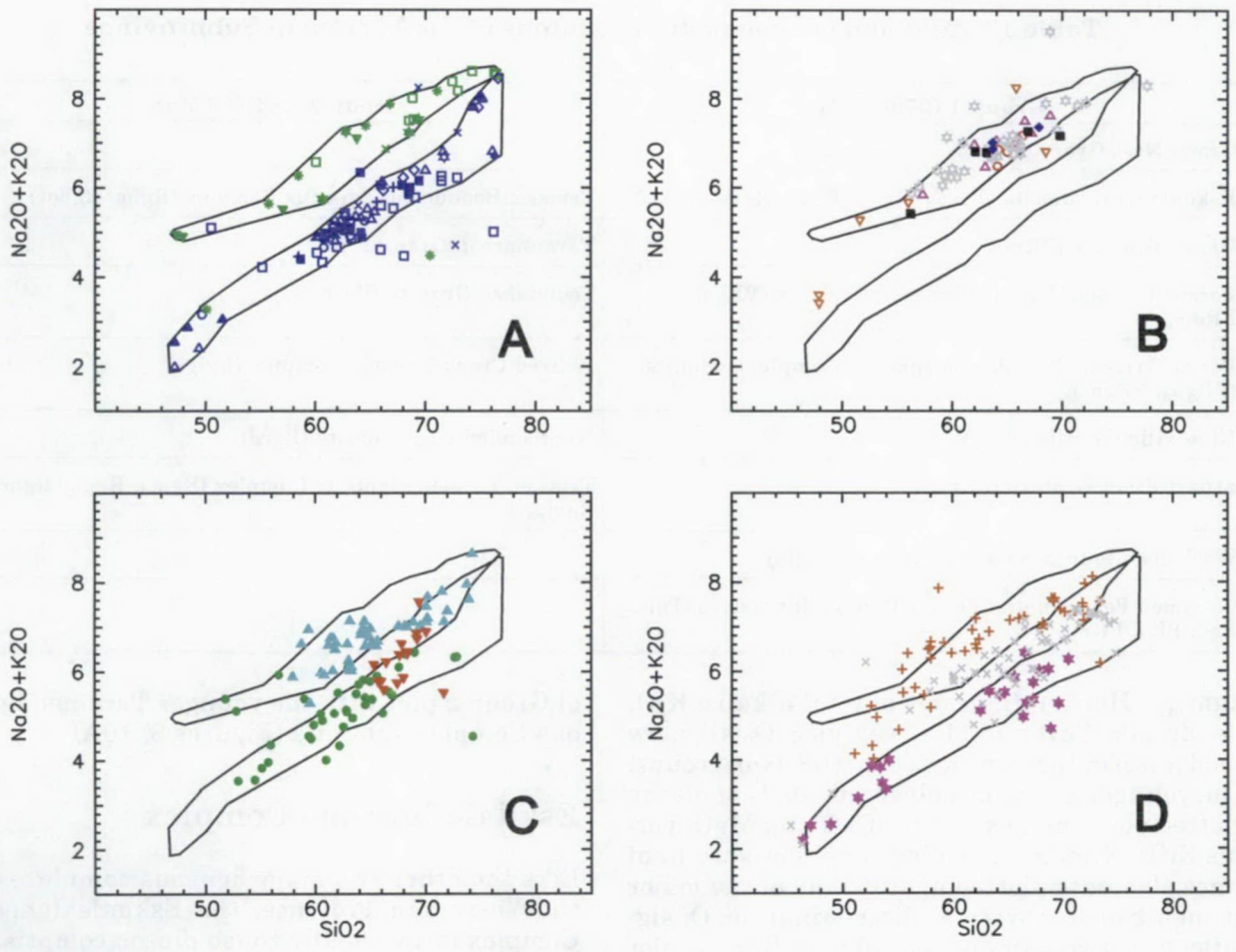




Figure 10. Yarraman Subprovince groups compared with Permo-Triassic D'Aguilar Subprovince and geochemical suites from the Yarrol Subprovince and Clarence River Supersuite. A - Yarraman Subprovince; B - D'Aguilar Subprovince; C - Clarence River Supersuite; D - Yarrol Subprovince.

range of rock types present in the Taromeo Igneous Complex.

All phases of the Taromeo Igneous Complex (Rgm_d, Rgm_g, Rgm_{gd2}, Rgm_{gd1}, $PRgm_{gd2}$, $PRgm_t$) are represented by geochemical analyses except for $PRgm_{gd1}$. Two major geochemical groups within the Taromeo Igneous Complex have been identified based on Harker diagrams (Figures 8, 10A). The two groups are the 260–240Ma subunits ($PRgm_t$ and $PRgm_{gd2}$), and the younger 240–220Ma subunits (Rgm_d, Rgm_g, Rgm_{gd2},

Table 13: Ages and geochemistry of plutons of the Yarraman Subprovince

Group 1 (270–233Ma)	Group 2 (249–229Ma)
Crows Nest Granite (R*gr*)	
Eskdale Granodiorite (R*ges*$_4$, R*ges*$_3$ R*ges*$_2$ R*ges*$_1$ R*ges*$_a$)	Triassic Boondooma Igneous Complex (R*gbo*, R*gbo*^{p})
Djuan Tonalite (PR*gj*)	Farquharson Granite (R*gq*)
Permo-Triassic Taromeo Igneous Complex (PR*gm*$_t$, PR*gm*$_{gd2}$)	Toondahra Granite (R*gto*)
Permo-Triassic Boondooma Igneous Complex subunits (PR*gb*$_d$, PR*gb*$_g$)	Wilfred Creek Igneous Complex (R*gi*)
Hivesville Granite (PR*gh*)	Wooroonden Granodiorite (R*grd*)
Stuart River Granite (PR*gt*)	Triassic Taromeo Igneous Complex (Rgm$_d$, Rgm$_g$, Rgm$_{gd2}$, Rgm$_{gd1}$)
Woolshed Mountain Granodiorite (PR*gwm*)	
unnamed Permian and Permo-Triassic intrusives (P*gu*, P*gd*, PR*g*, PR*g*$_1$)	

Rgm$_{gd1}$). Harker diagrams of total alkalis, K_2O, Ce, Zr, Nb, CaO and MgO versus SiO_2 all show good discrimination between the two groups. The younger group has elevated levels of all the plotted elements, except for CaO and MgO, versus SiO_2. Similar X–Y diagrams (not shown) of trace elements plotted against any of the major elements also show clear discrimination. Of significance, two samples of subunit Rgm$_{gd2}$ plot with the older phase rocks. A possible explanation is that samples may have been from blocks of older material within the younger intrusive.

Boondooma Igneous Complex

The Boondooma Igneous Complex rocks show a range of compositions from granite through to diorite on the total alkali versus SiO_2 diagram of Cox & others (1979), adapted to plutonic rocks by Wilson (1989). Most samples however, plot in the granite fields and are consistent with petrographic studies (see 'PERMO-TRIASSIC INTRUSIVES').

Current mapping shows the Boondooma Igneous Complex is made up of a number of intrusive episodes. The Complex is made up of two major age divisions, Permo-Triassic and Triassic, both showing a range of rock compositions and textures. Although geochemical sampling is limited the Boondooma Igneous Complex, and subunits like those in the Taromeo Igneous Complex, plot as two distinct geochemical groups and mirror the mapped age divisions. The older 267.9–249Ma subunits (PR*gb*$_g$ and PR*gb*$_d$) of Group 1 show similar trends to the older Taromeo Igneous Complex subunits while the younger 250–215Ma subunits (R*gbo*, R*gbo*^{p}) of Group 2 plot with the younger Taromeo Igneous Complex subunits (Figures 8, 10A).

Eskdale Igneous Complex

Like the other two major igneous complexes in the Yarraman Province, the Eskdale Igneous Complex is a normally zoned pluton comprising a range of rock compositions from granite through to diorite/gabbro.

The total alkali versus SiO_2 diagram shows the majority of samples plot in the granodiorite /diorite fields (Figure 7C) as confirmed by petrographic analysis. Unlike the other major igneous complexes the Eskdale Igneous Complex is made up of only one geochemical suite. It plots with and has many geochemical similarities to the older phases of the Taromeo and Boondooma Igneous Complexes while being as young as 233Ma (Figure 8, Table 13).

Province Comparisons

The two geochemical groups identified in the Yarraman Subprovince can be readily correlated with geochemical suites from the D'Aguilar Block of southern Queensland, the Yarrol Province of central Queensland, and the Clarence River Supersuite of northern New South Wales.

The representative units of the Yarraman Subprovince used for comparison purposes are the Taromeo Igneous Complex, subdivided into six subunits, the Boondooma Igneous Complex, subdivided into three subunits and the Eskdale Igneous Complex, subdivided into six subunits. Other smaller units from the Yarraman Block

Table 14: Correlation of geochemistry in south-east Queensland

Yarraman Subprovince	D'Aguilar Subprovince	Yarrol Subprovince	Clarence River Supersuite
Group 2	D'Aguilar P–T Intrusives	Littlemore Suite	Bruxner Suite
Group 1		Monal Suite	Towgon Suite
		Dumgree Suite	Duncans Creek Suite

included in the comparison plots are the Crows Nest Granite, Djuan Granodiorite, Hivesville Granodiorite and Woolshed Mountain Granodiorite.

Five Permo-Triassic intrusive units of the D'Aguilar Subprovince are used for comparison purposes. They are the Kimbala Granodiorite, Kingaham Creek Granodiorite, Neurum Complex, Tungi Granodiorite and Woolooga Quartz Monzonite.

Murray & others (2000, in preparation) defined three geochemical suites of the Yarrol Province as the Dumgree Suite (Dumgree Tonalite, Bundaleer Tonalite, Bajool Quartz Diorite), Littlemore Suite (Littlemore Granodiorite, Flaggy Quartz Monzodiorite, Lawyer Granodiorite, Redshirt Granite, Mount Seaview Igneous Complex, Craiglands Quartz Monzodiorite, Kabra Quartz Monzodiorite) and the Monal Suite (Monal Granodiorite, Moonkan Granite, Umbrella Granodiorite, Rock Point Granodiorite Pack Granite, Diglum Granodiorite, Munholme Quartz Diorite, Mannersly Quartz Microdiorite, Zig Zag Tonalite, Ridgelands Granodiorite, Lookerbie Igneous Complex).

Three geochemical suites of the Clarence River Supersuite as defined by Shaw & Flood (1981) and Bryant & others (1997) are also shown. These suites are the Duncans Creek Suite (Duncan's Creek Trondhjemite, Mount Ephraim intrusion, and high-Si group within the Kaloe Granodiorite), Bruxner Suite (Bruxner Monzogranite, Koreelan Creek Granodiorite, Boswell and Gummi Plains intrusions, the high-K group within the Dumbudgery Creek Granodiorite and the low-Si group within the Kaloe Granodiorite) and the Towgon Suite (Towgon Grange and Jenny Lind Granodiorite, Omdale Brook intrusion, and the low-K Dumbudgery Creek Granodiorite).

Yarraman Subprovince Group 2 (generally younger) units can be correlated with units of similar age in the D'Aguilar Subprovince to the east. This is consistent with the Gust & others (1993) hypothesis of granitoids of similar age and composition forming north-westerly trending belts that generally shift eastwards with time. The Triassic phases of the Boondooma Igneous Complex also plot with the younger Taromeo Igneous Complex and D'Aguilar Subprovince subunits although they are located west of the older and more mafic Permo-Triassic Taromeo Igneous Complex.

Dr Cec Murray (personal communication, 2000) showed the Dumgree Suite (YAR) is geochemically similar to the Duncans Creek Suite (CRS), the Littlemore Suite (YAR) is similar to the Bruxner Suite (CRS) and the Monal Suite (YAR) is similar to the Towgon Suite (CRS).

Group 2 (generally younger) intrusives of the Yarraman Subprovince and Permo-Triassic intrusives of the D'Aguilar Subprovince are geochemically similar to the Littlemore (YAR) and Bruxner (CRS) suites(Figures 10 A–C).

Group 1 (generally older) Yarraman Subprovince units correlate well with the Monal (YAR) and Towgon (CRS) suites (Figures 10 A–C). The Dumgree (YAR) and Duncan's Creek (CRS) form a separate group and plot midway between Yarraman Subprovince Groups 1 and 2. Geochemical suites are summarised in Table 14.

AGE DATING

Radiometric age dating was carried out on samples from the Permian–Triassic granites, the Chahpingah meta-igneous complex and the Sugarloaf Metamorphics. Dating techniques employed were Ar/Ar dating on most samples and SHRIMP dating of zircons from the Chahpingah Meta-igneous Complex.

Age dates undertaken for this report are highlighted in bold. This section also includes spectra for Ar/Ar age dating.

Figures 11 to 20 show the results of Ar/Ar dating.

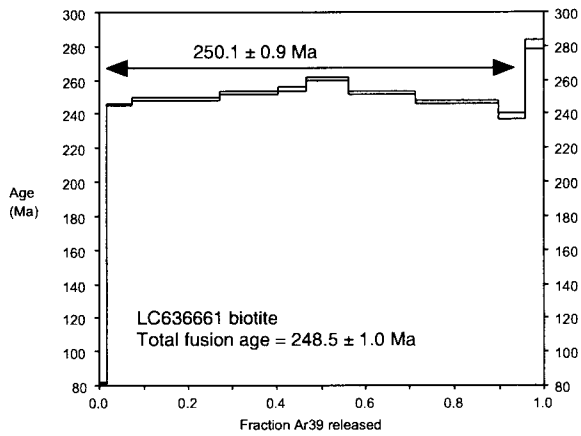


Figure 11. The age spectrum from biotite LC63661 biotite is slightly discordant and does not form a true plateau. However, the average age of most of the gas is 250.1±0.9Ma, which appears to be the time the sample cooled below 350–300°C.

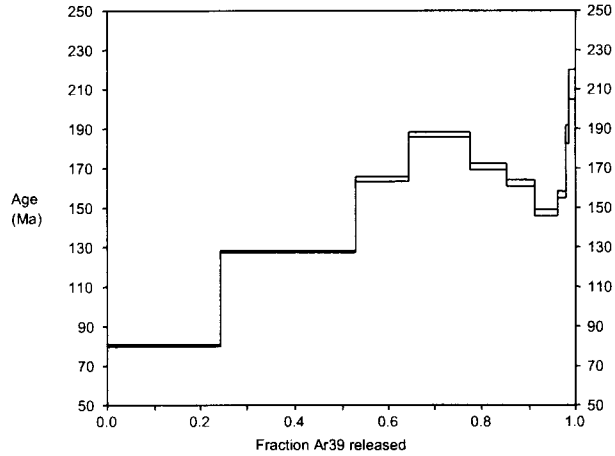


Figure 12. SQGC387 biotite.Total fusion age = 137.4±1.1Ma. Biotite from sample SQGC387 yields a very discordant age spectrum, which could be due to argon loss at about 80Ma. It is however, likely that this separate contains chlorite intergrown with the biotite, based on the form of the spectrum and K/Ca ratio, and therefore the any age calculated is unlikely to have any geological meaning.

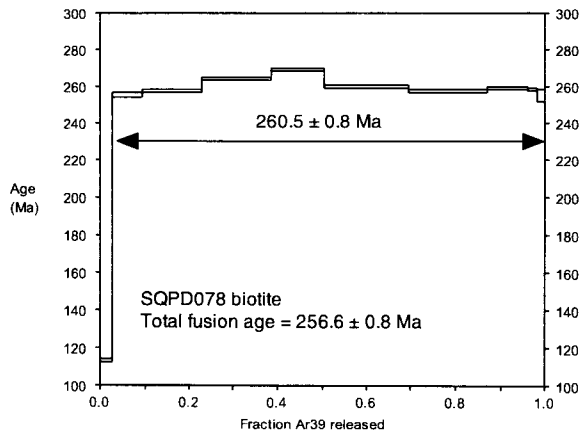


Figure 13. The age spectrum from SQPD078 biotite does not yield a true plateau, but the flat portion of the gives a relatively well defined age of 256.6±0.8Ma.

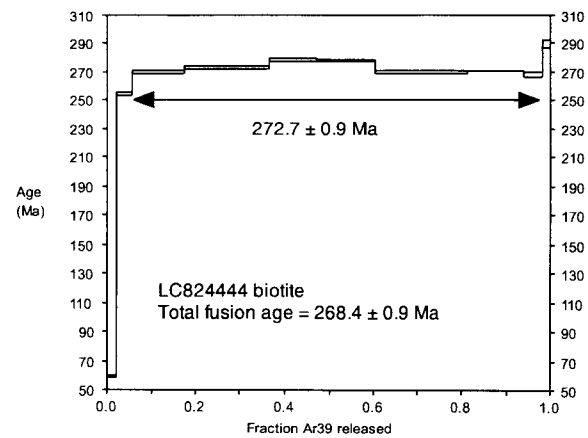


Figure 14. The average age of 272.7±0.9Ma for the relatively flat portion of the age spectrum records the time of cooling of sample LC824444 below biotite closure (~350–300°C).

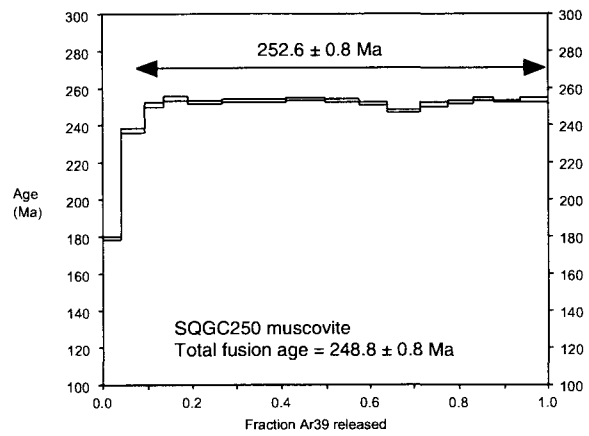


Figure 15. SQGC250 muscovite yields a well defined plateau age of 252.6±0.8Ma for >90% of the gas released. This age records cooling below ~400–350°C for this sample.

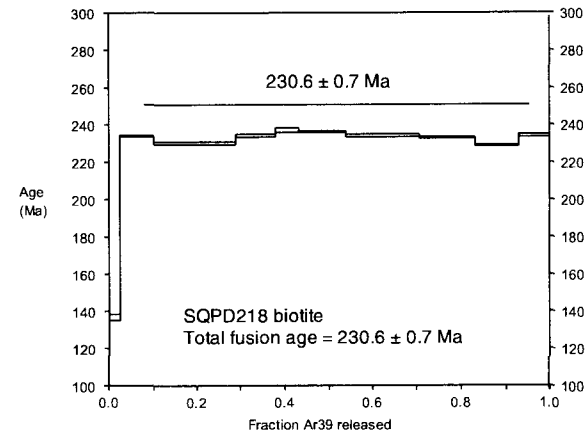


Figure 16. The plateau-like portion of the gas from sample SQPD218 biotite gives a well defined age of 230.6±0.7Ma.

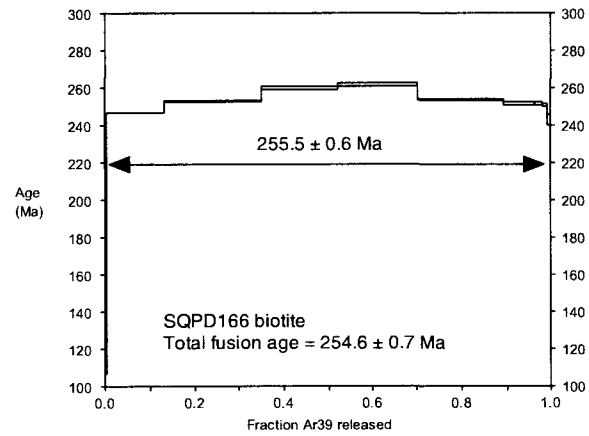


Figure 17. As in the previous sample, the age spectrum from SQPD166 biotite is slightly discordant, but the average age of 255.5±0.6Ma for most of the gas is a good estimate of when it cooled below about 350–300°C.

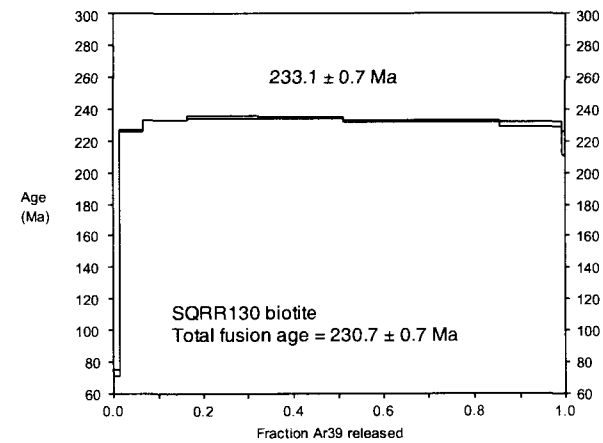


Figure 18. Biotite from sample SQRR130 yields a plateau age of 233.1±0.7Ma, that records the time of cooling below 350–300°C.

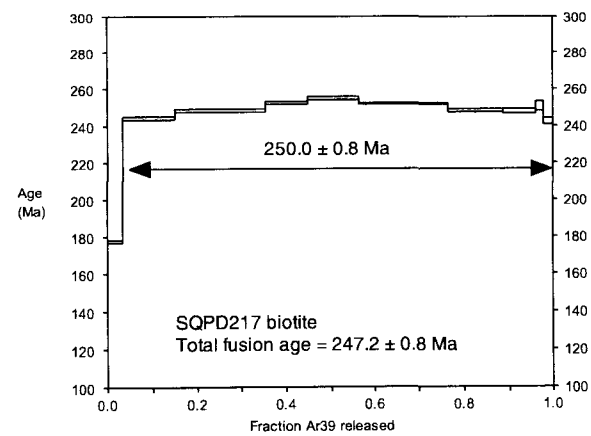


Figure 19. This is another sample that does not quite give a plateau age because of minor discordance. The age of 250.0±0.8Ma given by >95% of the gas is the best age for the biotite.

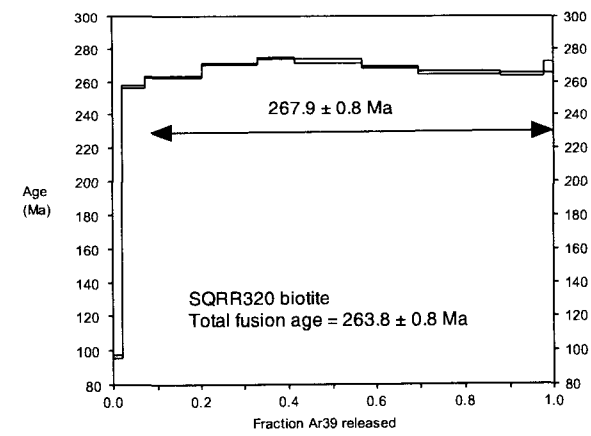


Figure 20. The flat portion of SQRR320 biotite gives an average age of 267.9±0.8Ma.

Table 15: Age dating

Unit	Age Date (Ma)	Easting	Northing	Field; Lab Number	Reference
Boondooma Igneous Complex (R*g*bo)	221.6±7	362424	7059873	GY2; QA131	GSQ. UQ Lab notes pre-1975, Murphy & others (1976)
Boondooma Igneous Complex (R*g*bo)	245.0	355549	7100909	G56/10/8; GA5313	Webb & McDougall (1968)
Boondooma Igneous Complex (R*g*bo)	238.9±7	351152	7083499	GY1; QA130	Murphy & others (1976)
Boondooma Igneous Complex (R*g*bo)	236.8±10	351152	7083499	GY1; AA108	Murphy & others (1976)
Boondooma (R*g*bo)	229.8±0.5	319173	7101447	SQPD407	Vasconcelos & Feng (2000)
Boondooma (R*g*bo)	228.7±0.8	319173	7101447	SQPD407	Vasconcelos & Feng (2000)
Boondooma Igneous Complex (PRbg_g)	260.2±11	380147	7028069	GY5; AA83	GSQ. UQ Lab notes pre-1975, Murphy & others (1976)
Boondooma Igneous Complex (PRbg_g)	249.0±7	376464	7030770	GY4; QA133	GSQ. UQ Lab notes pre-1975, Murphy & others (1976)
Boondooma Igneous Complex (R*g*bo)	250.1±0.9	363600	7066100	LC 636661	Vasconcelos & Feng (2000)
Boondooma Igneous Complex (PR*g*b$_k$)	272.7±0.9	382400	7044400	LC 824444	Vasconcelos & Feng (2000)
Boondooma Igneous Complex (PR*g*b$_d$)	267.9±0.8	383734	7015106	SQRR320	Vasconcelos & Feng (2000)
Chahpingah Meta-Igneous Complex (Cc)	260±8	35364	7064878	SQLC44	Cranfield & others (1998)
Chahpingah Meta-Igneous Complex (Cc)	301±5	356002	7063490	SQPD110	Cranfield & others (1998)
Crows Nest Granite (R*g*r)	236.9	405500	6993500	G56/14/19; GA5326	Webb & McDougall (1968)
Crows Nest Granite (R*g*r)	241.9±8	412700	6980600	223; QA94	Smith (1972)
Crows Nest Granite (R*g*r)	238.9	405500	6993500	G56/14/19; GA5326	Webb & McDougall (1968)
Djuan Tonalite (PR*g*j)	258.5±0.9	398768	6999826	SQLC DT1	Vasconcelos & Feng (2000)
Djuan Tonalite (PR*g*j)	263.7±0.9	398768	6999826	SQL CDT1	Vasconcelos & Feng (2000)
Djuan Tonalite (PR*g*j)	234.8±8	401256	7007103	ID2; QA90	Ipswich map notes, Cranfield & others (1976)
Dyke in DCm$_d$	258±2	416650	7016790	R6890	Willey (1998)
Dyke in DCm$_d$	291±4	417700	7015100	R7591	Willey (1998)
Dyke in DCm$_d$	296±6	417450	7014930	R7593	Willey (1998)
Eskdale Granodiorite (R*g*es$_4$)	233.0	425700	6992700	G56/14/8; GA5298	Webb (1967), Webb & McDougall (1968)
Eskdale Granodiorite (R*g*es$_1$)	242.9±8	410400	6995900	ID4; QA91	Ipswich map notes, Cranfield & others (1976)
Eskdale Granodiorite (R*g*es$_1$)	248.0±7	410400	6995900	ID4; QA86	Ipswich map notes, Cranfield & others (1976)
Glenmaurie Stocks (Pgu)	290±2	426840	7008210	R7833	Willey (1998)
Glenmaurie Stocks (Pgu)	285±2	425650	7008250	R7844	Willey (1998)
Hivesville Granite (PR*g*h)	254.5±1.1	366500	7108800	PDSite5-665088	Vasconcelos & Feng (2000)

Table 15: Age dating (continued)

Unit	Age Date (Ma)	Easting	Northing	Field; Lab Number	Reference
Hivesville Granite (PRgh)	260.5±0.8	368913	7104100	SQPD078	Vasconcelos & Feng (2000)
Main Range Volcanics (Tm)	17.8±0.2	345200	7095300	DA37	Robertson (1994)
Main Range Volcanics (Tm)	0.451±0.04	345400	7095300	DA35	Robertson (1994)
Main Range Volcanics (Tm)	0.381±0.025	345100	7095100	DA34	Robertson (1994)
Main Range Volcanics (Tm)	29.4±0.3	397600	7041266	DA9	Murray & others (1981)
Main Range Volcanics (Tm)	23.2±0.5	355950	7031450	UQ38775; Q164; QA314	Ewart & Grenfell (1985), University of Queensland (UQ) Lab report 1975–1988
Main Range Volcanics (Tm)	23.6±0.5	422980	7095596	UQ38774; Q166; QA313	Ewart & Grenfell (1985), UQ Lab report 1975–1987
Main Range Volcanics (Tm)	23.5±0.6	420184	7099213	UQ38782; Q174; QA311	Ewart & Grenfell (1985), UQ Lab report 1975–1987
Main Range Volcanics (Tm)	23.7±0.5	420198	7098299	UQ38779; Q171; QA310	Ewart & Grenfell (1985), UQ Lab report 1975–1987
Main Range Volcanics (Tm)	22.0±0.3	356850	7028000	DA10	Murray & others (1981)
Memerambi Granite (Prgme)	254.0±8	397793	7066880	V3; QA186	AV, unpublished lab notes
Stuart River Granite (PRgt)	250.0±0.8	365633	7084460	SQPD217	Vasconcelos & Feng (2000)
Stuart River Granite (PRgt)	255.5±0.6	364024	7093321	SQPD166	Vasconcelos & Feng (2000)
Sugarloaf Metamorphics (DCo)	137.4 ± 1.1	401810	6997231	SQGC387	Vasconcelos & Feng (2000)
Sugarloaf Metamorphics (Dco)	252.6±0.8	402497	6996737	SQGC250	Vasconcelos & Feng (2000)
Taromeo Igneous Complex (Rgm_{gd1})	233.1±0.7	410100	7020300	SQRR 130	Vasconcelos & Feng (2000)
Taromeo Igneous Complex (Rgm_{gd1})	240±2	415609	7017433	R7624	Willey (1998)
Taromeo Igneous Complex (Rgm_{gd1})	233±2	413029	7017223	R7626	Willey (1998)
Taromeo Igneous Complex (PRgmt)	242.9	403341	7038287	G56/10/7; GA5312	Webb & McDougall (1968)
Taromeo Igneous Complex ($PRgm_{gd2}$)	250.1	401651	7043483	G56/10/6; GA5296	Webb & McDougall (1968), Harding (1969)
Taromeo Igneous Complex ($PRgm_{gd2}$)	240.9	401651	7043483	G56/10/6; GA5296	Webb & McDougall (1968), Harding (1969)
Taromeo Igneous Complex ($PRgm_{gd2}$)	225.7±7	395527	7047393	GY3; QA132	GSQ. UQ Lab notes pre-1975, Murphy & others (1976)
Taromeo Igneous Complex ($PRgm_{gd2}$)	263.3±21	395527	7047393	GY3; AA84	GSQ. UQ Lab notes pre-1975, Murphy & others (1976)
Taromeo Igneous Complex ($PRgm_{gd2}$)	248.0±8	395527	7047393	GY3; AA109	Murphy & others (1976)

Table 15: Age dating (continued)

Unit	Age Date (Ma)	Easting	Northing	Field; Lab Number	Reference
Taromeo Igneous Complex (Rgm_{gd2})	229.0±11	401746	7028876	GY1-9; AA85	Green (1976), unpublished lab notes
Undiff. Jur.-Cret. Intrusion	138.1	420132	7043017	GA5538	Green & Webb (1974)
Undiff. Jur.-Cret. Intrusion	137.0	418601	7043132	GA5537	Green & Webb (1974)
Blackboy Hill diorite (Pgd)	270±2	416458	7017433	R7899	Willey (1998)
unnamed granodiorite (Pgu)	283±2	409120	7008930	R7769	Willey (1998)
unnamed granodiorite (Rg_5)	230.6±0.7	364450	7084900	SQPD218	Vasconcelos & Feng (2000)
Woolshed Mountain Granodiorite (Pgwm)	258.2±8	403800	7011600	ID1; QA85	Ipswich map notes, Cranfield & others (1976)
Wooroolin Granite (PRgw)	274.0±28	378833	7070087	G56/10/10; GA5382	Webb & McDougall (1968)
Wooroolin Granite (PRgw)	258.2	378833	7070087	G56/10/9; GA5382	Webb & others (1965)

TECTONIC EVOLUTION

LATE DEVONIAN TO EARLY CARBONIFEROUS

The Yarraman Subprovince of the Wandilla Province forms part of the New England Orogen (NEO), a complex orogenic belt of rocks structurally emplaced along the eastern margin of the Australian craton from the Devonian to the Carboniferous. Andean-style, westward-dipping subduction was active along the eastern margin of the continent during this period, forming an accretionary package of rocks assigned to the Wandilla Province. The latter occurs along the eastern margin of the NEO, extending southward from central Queensland to the southern Queensland border.

In the Yarraman Subprovince, most of the accretionary sequence is represented by the the Maronghi Creek beds, which comprise the north-north-west trending structural 'backbone' of the subprovince. These rocks formed by progressive accretion of deep to marginal marine deposits and associated ocean floor volcanics within the westward-dipping subduction zone. To the east and south-east, correlative rocks formed in the same tectonic environment include the Amamoor beds of the North D'Aguilar Subprovince and the Neranleigh–Fernvale beds of the South D'Aguilar and Beenleigh Subprovinces. These eastern subprovinces are thought to have been formerly contiguous with the Yarraman Subprovince but are now separated by a linear north-north-west trending Triassic basin — the Esk Trough.

The Late Carboniferous marked the last stages of accretion preserved within the Wandilla Province. At this time limestone bodies, fine sediment and mafic lava of the Bjelke Petersen beds were accreted against the Maronghi Creek beds. The former are thought to have been deposited in shallow warm ocean waters atop a mafic volcanic edifice (a guyot) before being transported towards the cool waters of the Australian continental margin by the colliding oceanic plate.

A forearc basin (the Yarrol Forearc Basin) was developed to the west of the accretionary wedge package, and was characterised by the development of Early Carboniferous oolitic shelfal limestone deposits unique in the geological history of eastern Queensland. These rocks have been assigned to the Yarrol Province, elements of which (the Rockhampton Group and the Alice Creek beds) are thought to have been emplaced against the western and southern margins of the Yarraman Subprovince by a major fault structure. This fault is presumed to be largely concealed by later intrusions and younger cover sequences. This fault is equivalent to the Yarrol Fault and its extensions mapped to the north in central Queensland, where thin serpentinite bodies typically mark the fault trace.

LATE CARBONIFEROUS–EARLY PERMIAN

Near the end of the Late Carboniferous (at ~303Ma) a major tectonic change from subduction-driven compression to crustal extension took place within the North D'Aguilar Subprovince (Donchak & others, 1995; Holcombe & others, 1993) and probably also in the adjacent Yarraman Subprovince. The tectonic mechanisms responsible for this transition are poorly understood, but may involve factors such as the generation of backarc mantle plumes, decreased plate convergence rates, or elevated geothermal gradients beneath overthickened accreted crust combined with gravitational collapse of the pile.

In the North D'Aguilar Subprovince extension of the old accretionary complex rocks occurred along a low angle detachment-style fault (the Mount Mia Fault), that juxtaposed deeper higher grade levels of the complex (forming the **lower plate**) against lower grade higher levels of the complex (forming the **upper plate**). During the extensional event, synkinematic S-type granitoids (the Claddagh, Gallangowan and Karandah Granodiorites; see Crouch & others, 1995) were intruded at various levels along the detachment zone, mostly intruding lower plate rocks, but locally intruding the upper plate sequence (Sliwa, 1994). At deep levels within the extending subduction complex, high crustal heat flows associated with granitoid emplacement metamorphosed adjacent lower plate rocks to amphibolite grade. These high grade aureole rocks were referred to as the "Claddagh–Manumbar Assemblage" by Little (1993) and include the Manumbar Metamorphics and Wide Bay Creek Gneiss of Donchak & others (1995).

U–Pb SHRIMP and $^{40}Ar/^{39}Ar$ dating (this report and Little & others, 1993) has demonstrated that synkinematic granitoids (the Chahpingah Meta-Igneous Complex) similar to the North D'Aguilar S-type intrusions intruded the western margin of Yarraman Subprovince at roughly the same time as the latter (i.e. ~301Ma). This suggests that the magma for the Chahpingah Meta-Igneous Complex was generated in the extensional environment in the late Carboniferous. The Chahpingah Meta-Igneous Complex is also associated with adjacent metamorphic package (the Mountefontein Metamorphics) which are essentially equivalent to Little's "Claddagh–Manumbar Assemblage". Possible equivalents of the deeper level lower plate accretionary rocks of the North D'Aguilar Subprovince are the Fifer Creek and Sugarloaf Metamorphics.

The detailed geometry of the extensional fault complex beneath the North D'Aguilar Subprovince and its links with possible synchronous extensional faults beneath the Yarraman Subprovince are unknown. Extension may be restricted to one major detachment surface that is continuous beneath both subprovinces, or may have occurred along multiple faults either with the same dip or opposing dips (see Figure 21). In the context of the simplest single detachment scenario, the east-dipping discontinuity between the Beenleigh and South D'Aguilar Subprovinces imaged in the Brisbane–Eromanga deep seismic transect (Finlayson,1990, figure 16) can be interpreted as resulting from east-block-down extension with a geometry similar to that presented by Lister & others (1991; figure 2), modified by later thrusting and crustal loading events (see Figure 22). This geometry is consistent with the increasingly deeper crustal character (i.e. increasing metamorphic grade and degree of deformation) of the Yarraman Subprovince rocks from east to west. Alternatively, the deeper level rocks of the Chahpingah Meta-Igneous Complex may have been exhumed during later tectonism associated with the Permo-Triassic Hunter Bowen Orogeny.

The southern half of the Yarraman Subprovince containing the Sugarloaf Metamorphics is more difficult to interpret as a simple eroded detachment system. The Sugarloaf Metamorphics are dominated by a moderate to steeply-inclined foliation dipping westward before swinging towards southerly dips near the southern end of the subprovince. The relatively steep orientation of these structures is not consistent with the more gently dipping features expected in a low angle detachment system. These steep structures may therefore represent deep level subduction-related features within a higher grade slice of the subduction complex exhumed either during Late Carboniferous extension or a younger Early Permian event predating deposition of the overlying Cressbrook Creek Group.

In the latter case, the event considered most likely to have been associated with the exhumation of the Sugarloaf Metamorphics at this time is the Texas–Coffs Harbour megafolding event (Lennox & Flood, 1997; Harrington & Korsch, 1987). This event involved north-south, apparently dextral translation and crustal-scale folding of accreted terrains inboard of the continental plate margin, presumably resulting from oblique convergence at that time. Large amounts of horizontal shortening during this event was achieved by the formation of regional scale megafolds forming a double orocline stretching from Texas in the north-west to Coffs Harbour in the south-east.

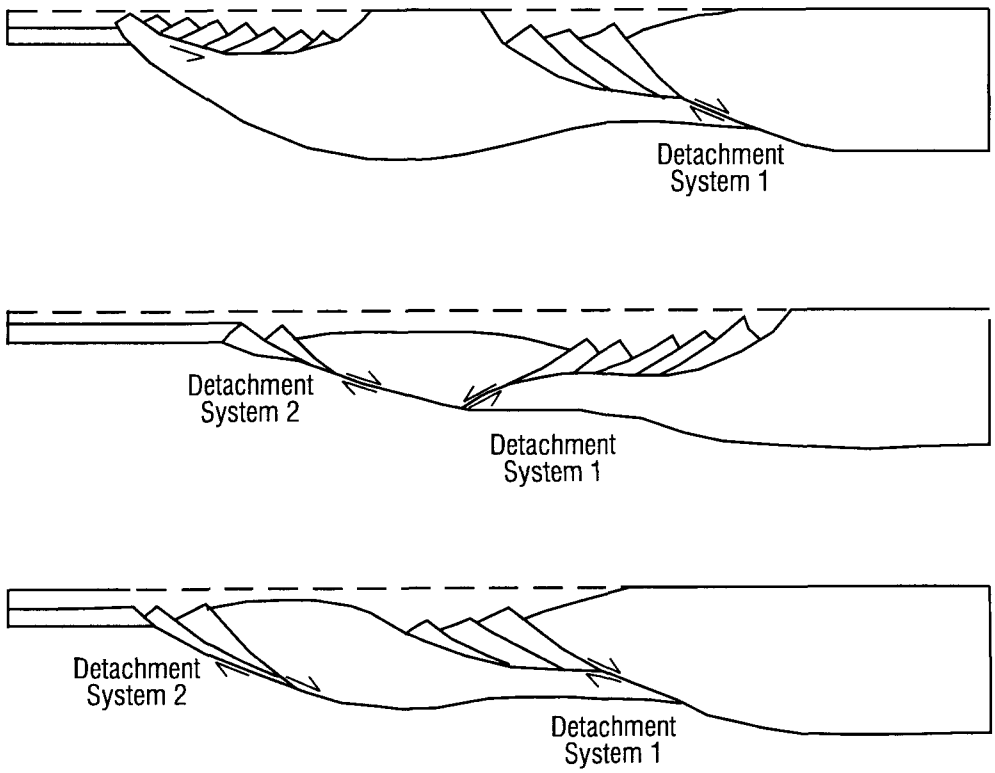


Figure 21. Possible extensional geometrics produced by paired detachment systems (after Lister & others, 1986).

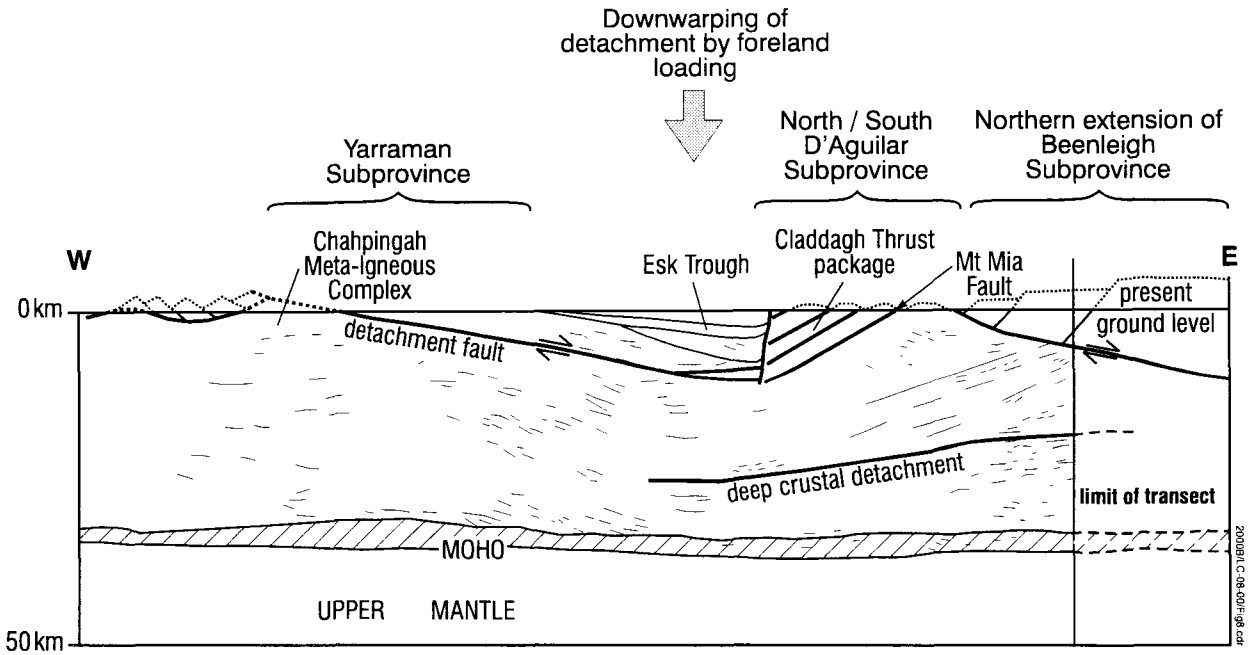


Figure 22. Schematic east-west crustal section across Yarraman and adjacent North/South D'Aguilar Subprovinces — profile is interpretive only and includes selected seismic features recognised in Brisbane–Eromanga Geoscience Transect (after Finlayson, 1990; figure 16) conducted over the Clarence–Moreton Basin immediately south of the Yarraman Subprovince.

Using a model analogous to that of Harrington & Korsch (1987) the formation of the Texas Megafold involved telescoping of the Yarraman Subprovince/Yarrol Province sequence along a major dextral transcurrent north-trending fault bounding them to the west (the Mooki Fault system; see Figure 23). A mid-crustal detachment imaged in deep seismic sections was postulated to facilitate this movement at depth (Korsch & others, 1990).

The complex series of deformation events affecting the region in the Early Permian also included north-trending sinistral fault movement

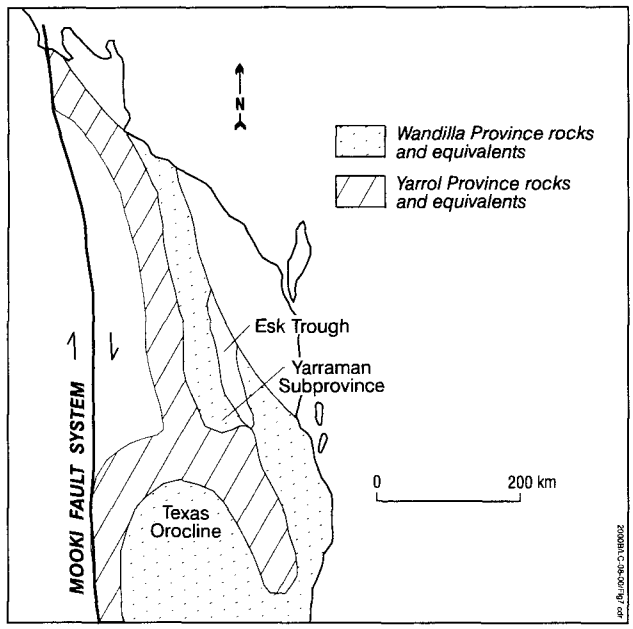


Figure 23. Regional distribution of Wandilla and Yarrol Province rocks in southern coastal Queensland, showing position of proposed western boundary Mooki Fault System (modified after Harrington & Korsch, 1987).

along the eastern margin of the Yarraman Subprovince at its junction with the South D'Aguilar Subprovince (see Figure 24). This faulting is indicated by the complementary asymmetry of map-scale fold trends in the Neranleigh Fernvale beds (South D'Aguilar Subprovince) and Sugarloaf Metamorphics (Yarraman Subprovince). This asymmetry is mirrored by the easterly trends in serpentinites and basic intrusives (the Mount Cross Igneous Complex) which define the southern culmination of the Yarraman Subprovince at its junction with rocks of the Yarrol Province (i.e. the Alice Creek beds). The serpentinites in the Pine Mountain area marking the western margin of the South D'Aguilar Subprovince are probably equivalents of the Mount Cross rocks dispersed along the southward continuation of the Yarrol–Wandilla Province boundary.

The apparent sinistral offset along this zone may result from pinning or 'lock-up' of the eastern half of the double orocline (i.e. the Beenleigh and North and South D'Aguilar portions of the Coffs Harbour Megafold) during the later stages of its evolution. During this final phase, continued southward translation of the Yarraman Subprovince may have occurred along old crustal weaknesses separating it from the adjacent pinned crustal block, explaining the antithetic sinistral shear sense interpreted at this location.

In this context the Sugarloaf Metamorphics may result from upthrusting of deeper level subduction complex and/or lower plate rocks over the Maronghi creek beds as a result of north-south compressional to transpressional shortening during this event. The decrease in grade of the Sugarloaf Metamorphics in the north of its outcrop area may reflect a northward decrease in throw along these fault systems (see Figure 24). The older ages of the Yarrol Subprovince rocks to the south of the Yarraman Subprovince (the Late Devonian Alice Creek beds) relative to those exposed on the north-western flanks of the subprovince (mid-Carboniferous Rockhampton Group) are also consistent with upthrusting of deeper level rocks at the southern culmination of the Yarraman Subprovince during the Texas Megafold event.

As well as uplift and megafolding, the Early Permian crustal shear couple resulted in the formation of an array of transtensional basins with complex geometries. These include the embryonic Esk Trough, which inititiated as a half graben with a faulted eastern margin, and the numerous small Permian basins documented from the Texas Subprovince to the south-west. The Marumba beds were deposited into the Esk Trough at this time, while volcaniclastics and sediments of unit Ps were deposited in a smaller localised fault-bound basin to the west in the Yarraman Subprovince.

To the east, mafic and lesser felsic volcanics and coarse clastics of the Cedarton Volcanics and Cambroon beds were deposited in fault-controlled basins within the North D'Aguilar Subprovince. Sedimentation continued into the early Late Permian to the east (in the Esk Trough) and south of the Yarraman Subprovince, with the deposition of the Cressbrook Creek Group and its probable equivalent, the Northbrook beds, now faulted against rocks of the South D'Aguilar Subprovince.

Early to mid-Permian back-arc (transtensional?) magmatism was almost completely confined to the Yarraman Subprovince where voluminous magmas of the Hivesville and Wooroolin Granites and elements of the Boondooma Igneous Complex were emplaced, partly controlled by old crustal weaknesses. Far to the east, volcanics of the Gympie Group were erupted as part of an Early Permian magmatic chain along the convergent plate margin.

LATE PERMIAN–MIDDLE TRIASSIC

The early phase of sedimentation in the Esk Trough ceased in the Late Permian when a ma-

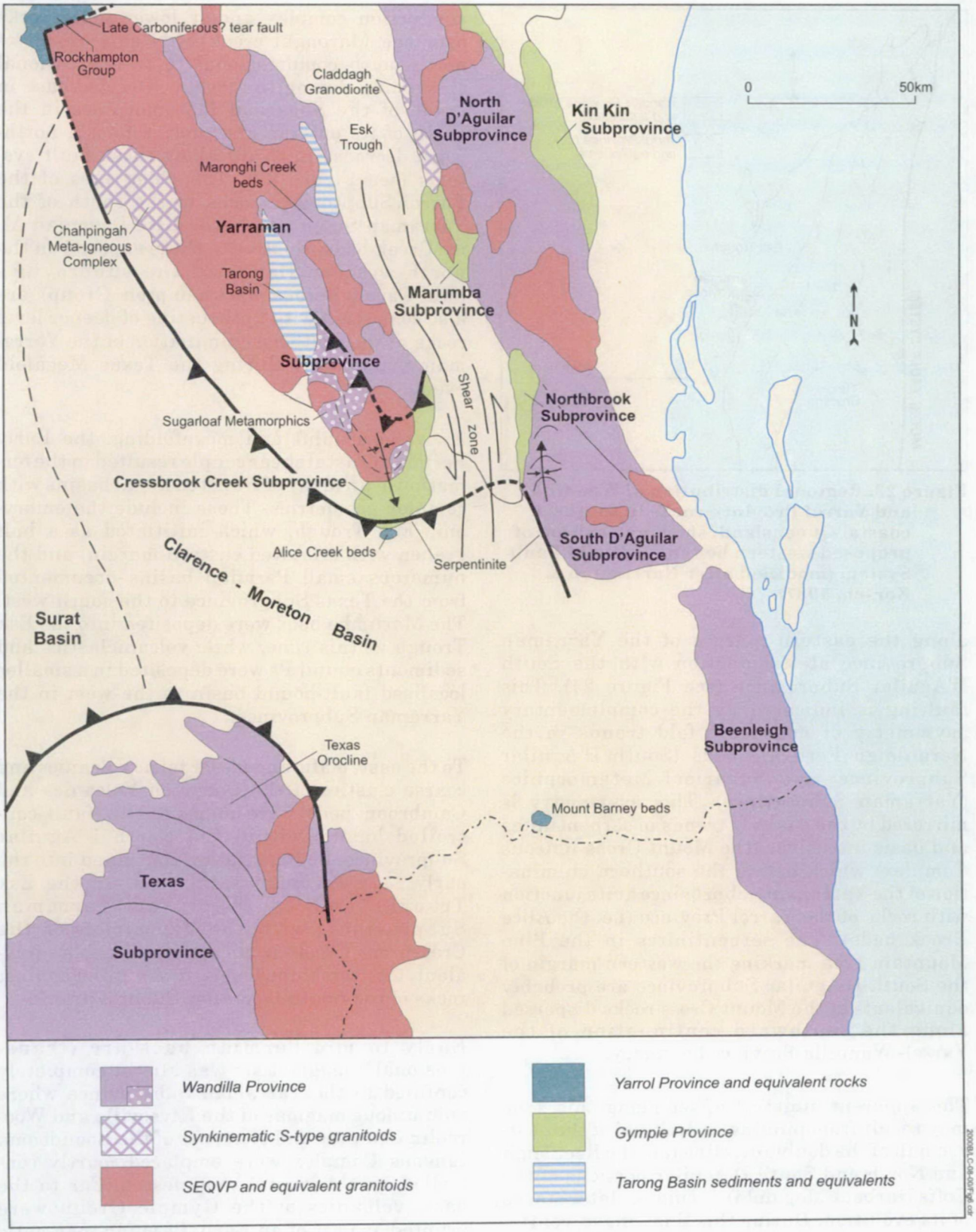


Figure 24. Selected structural elements of the Yarraman Subprovince and environs, showing thrust faults, north-south shearing and related folding proposed for the Permian.

jor compressional event inverted the basin, in part by reversal of movement along the old west-dipping basin-margin fault. In the north, detachment-related basement granitoids (the Claddagh and Gallangowan Granodiorites) and their aureoles were exposed along the Claddagh Thrust (Holcombe & others, 1993), while further south basal trough sediments (the Marumba beds) overlying polydeformed basement rocks (the Jimna Phyllite) were exposed in east-verg-

ing thrust sheets. Transpressional shearing of some of the plutons within the Yarraman Subprovince (the Hivesville and Stuart River Granites) probably also occurred at this time.

Campbell & others (1999) assign this thrusting event to the Late Permian phase of the Hunter–Bowen Orogeny, and equate this event with the foreland loading responsible for pronounced deepening of the Bowen Basin to the north. In an analogous manner, these authors propose that isostatic loading in south-east Queensland during this event produced foreland sagging over the area occupied by the Permian phase of the Esk Trough.

Field evidence from the Maryborough 1:250 000 sheet area to the north (Len Cranfield, personal communication, December 1999) suggests that the Late Permian Hunter–Bowen compressional event also involved collision of the Gympie Province rocks from the east. This is because these rocks are unconformably overlain by Early–Middle Triassic rocks of the second phase of Esk Trough sedimentation (i.e. the Neara Volcanics). The Gympie Province must have therefore been emplaced into its current position before deposition of the Neara Volcanics, either in the Late Permian or earliest Triassic, more than likely synchronous with the Claddagh Thrust event.

The foreland mountain belt produced by the Late Permian Hunter–Bowen event provided the source for the adjacent coarse clastic rocks of the Early–Middle Triassic Bryden, Esk and Gayndah Formations deposited in the renewed Esk Trough to the west. The overlying Early to Middle Triassic Neara Formation is dominated by andesitic volcaniclastics probably reflecting a surge of calcalkali style magmatism associated with an increase in subduction rate.

To the west of the Esk Trough, I-type, calcalkali-style magmatism had sporadically affected the Yarraman Subprovince since the mid-Permian with the intrusion of the Hivesville and Wooroolin Granites and elements of the Boondooma Igneous Complex (as already mentioned). This style of intrusion continued into the Late Permian and Early to Middle Triassic with the intrusion of the various plutons including the Eskdale Igneous Complex, Taromeo Igneous Complex, Woolshed Mountain Granodiorite, part of the Boondooma Igneous Complex, and the Stuart River Granite. Volumetrically, this period of intrusion is dominated by granodiorite, tonalite, and diorite with strikingly similar geochemical affinities (see earlier section 'GEOCHEMISTRY').

These styles of intrusion may locally represent magmatic equivalents of the Neara Volcanics, but current directions within the Esk Trough (Campbell & others, 1999) are not consistent with these plutons being magmatic roots to Yarraman Subprovince feeder vents. However, the andesites, rhyolites, dacites and volcaniclastics of the Gilla Volcanics are almost certainly locally sourced from comagmatic Late Permian or Early Triassic phases of the Taromeo Igneous Complex.

MIDDLE–LATE TRIASSIC

Sedimentation within the Esk Trough was brought to a halt by renewed Hunter–Bowen compression in the late Middle Triassic, producing widespread large-scale north-north-west trending open folding and faulting of the Trough sediments. This event was immediately followed by a period of crustal extension and associated bimodal felsic-dominated volcanism represented by the Late Triassic Aranbanga Volcanic Group (extending over the northern part of the Esk Trough sequence) and the Dangore Volcanics (within the Yarraman Subprovince to the south-west). The Dangore Volcanics appear to have been locally sourced whereas the Aranbanga Volcanics were probably both locally sourced (from a vent near Boondooma Dam) and from the Gayndah center to the north. Mantle upwelling due to slab rollback was the likely thermal driving force behind this period of extension-related volcanism.

Volcanism at this time was accompanied by plutonic activity with geochemical intrusive signatures contrasting with older Permo-Triassic intrusives (i.e. the former displays relatively higher alkali content and depletion in CaO than the latter). These younger intrusives include the later phases of the Taromeo and Boondooma Igneous Complexes, the Wilfred Creek Igneous Complex, and the Farquharson and Toondahra Granites. A major east-north-east trending crustal dislocation separating the Yarraman Subprovince from the Yarrol Province to the north controlled the intrusion of the Toondahra Granite. This feature may represent a reactivated Late Carboniferous transfer or tear fault.

Later Triassic plutonism in the Yarraman Subprovince is dominated by granodioritic to granitic intrusions, although more mafic compositions also occur. Regionally, the intrusives of the South-east Queensland Volcanic and Plutonic Province (SEQVP) show a general trend towards more felsic compositions with time (see 'GEOCHEMISTRY' section). Moreover, there is regional trend towards eastward

younging of granitoid plutons, with more of the younger bodies occurring within the North D'Aguilar Subprovince than in the Yarraman Subprovince to the west. This trend is consistent with eastward stepping of subduction and/or slab rollback during the Late Permian and Triassic.

Volcanism and plutonism in the Late Triassic were also accompanied by terrestrial sedimentation within linear fault-controlled basins — the Tarong Basin and its equivalents. Erosion of the Boondooma Igneous Complex produced detritus for the basal conglomerate of the Tarong Basin. Flood & Garces (1986) describe the basin as a pull-apart depression developed in the Carnian (early Late Triassic) by dextral movement along a northerly-trending fault. However, their description of a faulted eastern margin is also consistent with an extensional half-graben. Preserved remnants of the Tarong beds have now been recognised north-east of the Tarong Basin, indicating that more than one basin existed at the time.

LATEST TRIASSIC–CAINOZOIC

In the Latest Triassic, the final phases of igneous activity within the Taromeo and Boondooma Igneous Complexes took place, with the former intruding Esk Trough sediments and the latter intruding Tarong Basin sediments.

This period also saw the initiation of continent-scale extensional downwarping producing a broad terrestrial basin now exposed to the west and south of the Yarraman Subprovince. The initial sediments included a package of sandstone, siltstone, and carbonaceous shale (point bar, levee and alluvial floodplain deposits) which formed the lower part of the Woogaroo Subgroup of the Clarence–Moreton Basin and Precipice Sandstone of the Surat Basin. This was followed by a sequence of quartz-rich braid plain deposits — the top quartz-sandstone of the Woogaroo Subgroup and Precipice Sandstone. The continuing development of the Clarence–Moreton and Surat Basins includes changes in source area reflected by different sandstone composition. Periods of sandstone deposition alternated with finer grained fluviolacustrine sedimentation. Extensive areas of ferruginous oolite were developed as a lake shoreline facies. Provenance areas of the sandstones were generally from the south and west. Variations in facies within the basin are probably the result of periodic uplift of the source areas of the basin, local and regional changes to base levels, and climatic influences.

In the mid-Cretaceous, an extensional environment became dominant in eastern Australia, initiating continental breakup which eventually culminated in the opening of the Tasman Sea in the Late Cretaceous and Early Tertiary.

O'Sullivan & others (1999) demonstrated three distinct cooling episodes affecting the area since the end of the Hunter Bowen Orogeny in the Late Triassic. These episodes occurred in response to either kilometre-scale denudation, cooling due to thermal relaxation associated with rifting or a combination of both. Based on earlier work from southern Australia, O'Sullivan & others (1999) suggested the mid-Cretaceous (105–90Ma) cooling event followed the onset of continental extension in the Tasman Sea at ~96Ma. Cooling at this time may have been accompanied by kilometre-scale denudation over parts of the eastern highlands of south-eastern Queensland and may have post-dated underplating inboard of the rift. The effects of the third period of cooling (75–60Ma) was most significant along the eastern margin and may be due to break up of the continent following major rifting that commenced during the Late Cretaceous and continued into the Early Tertiary.

Towards the end of the extensional phase, in the Early Eocene, shallow terrestrial basins developed in the north of the Yarraman Subprovince into which the quartzose sands of the Oakdale Sandstone were deposited.

From the late Eocene the Australian continent behaved as a passive margin moving northwards over a hot spot (Johnson & others, 1989). Tertiary intraplate volcanism resulted in the eruption of basalt, and subordinate rhyolite and trachyte of the Main Range Volcanics that now form the elevated north-north-west trending 'spine' of the Yarraman region. Many of the flows were channelled into ancient stream valleys or filled shallow lakes, mixing with or blanketing clay-rich, commonly diatomaceous sediments. The latter are often now exposed as economically significant deposits.

During the late Miocene, climatic conditions were suitable for widespread lateritisation of most rock types. The iron-rich duricrust profiles were particularly well developed in the Kingaroy–Proston area, contrasting with the minor amounts of lateritic weathering known from the Esk Trough or North D'Aguilar Subprovince to the east.

MINING HISTORY AND EXPLORATION

This report updates the pre-1996 exploration history of the region contained in Murphy & others (1976), Olgers & others (1969) and Randall & others (1996) and an exploration summary by Scott (1989), which documented company activity on the Gympie, Goomeri, Nambour and Nanango 1:100 000 sheet areas from January 1976 to April 1988.

For convenience, the mining history and exploration in this report is grouped alphabetically under commodities and then structural elements. Areas within structural elements are listed alphabetically. Exploration targets and models, exploration title holders, the exploration techniques used and the mineralisation, prospects and mines are discussed. Brief outlines of early and recent exploration and mining are also included.

EARLY HISTORY OVERVIEW (PRE-1965)

It is possible gold was discovered at Nanango as early as 1860 although James Nash is generally credited with its discovery there in 1867 (de Havelland, 1987). De Havelland (1987) has compiled a detailed early history of gold mining of this area.

Historically the western parts of GOOMERI and NANANGO have recorded significant production in a number of commodities, chiefly gold, copper, silver, lead, bismuth, cobalt and manganese. Antimony, molybdenum, and nickel mineralisation is also known to occur in the area but no mineral production has been reported. Further west on KINGAROY, metalliferous deposits are rare but significant deposits of clay, diatomite and coal are present. Minor amounts of tin, gold, copper and molybenum are known to occur on ESK, MURGON, BOONDOOMA, and JANDOWAE. This report covers the mineral occurrence and mineral commodities over the mapped area.

MINES, MINERAL OCCURRENCES AND RESOURCES

GROUNDWATER

Warner (1964) investigated the groundwater of part of the South Burnett district. The potential of the major units in the area is discussed below.

Stock supplies are generally available in decomposed granitic rock at shallow depth. In fissures at moderate depth water can be expected but yields are unpredictable.

The Palaeozoic rocks consist of volcanics and highly indurated sediments and water supplies in them are small and unpredictable because of low permeability. Any subsurface water would be expected to occur at depths exceeding 30m where fissures are less likely to be clogged with clay. A high proportion of dry holes is to be expected.

In the Neara Volcanics, low yields can be obtained at moderate depth. The quality is variable, the bicarbonate content often being too high for human consumption. The Gayndah and Esk Formations are well cemented and generally of low permeability. Only low supplies are likely. Higher yields at moderate depth can be expected within the Esk Formation which is generally more porous and permeable. Apart from alluvium, the most favourable unit is the Tarong Beds that almost invariably provides excellent stock supplies.

The quartzose sandstones of the Woogaroo Subgroup are porous and give low to moderate yields. The Marburg Subgroup and the Evergreen Formation yield low to moderate supplies. Low to moderate yields of water of variable quality can be expected from Tertiary basalt at shallow depths although only 50–60% of holes produce water. The water occupies fissures and vesicles and yields depend on the degree of interconnection between these openings. In general the underlying strata offer better water prospects than the basalt itself. Water at the base of duricrust profiles (ferricrete and silcrete) profile is generally saline.

In most parts the best supplies of underground water come from alluvium. Moderate to high yields of good quality water are available along the Brisbane River and its tributaries. Supplies suitable for irrigation may be obtained from the alluvium of Barkers, Barambah and Meandu Creeks. Stock supplies are generally available from other alluvial sources.

ALUMINIUM

Main Range Volcanic Province

Kingaroy Area

Numerous bauxite deposits occur in the South Burnett district though most are small (Table 16). Murphy & others (1976) noted that with the development of very large bauxite deposits elsewhere in Australia the south Burnett occurrences are of no current economic significance.

Shepherd & Connah (1947) reported on the known bauxite occurrences in the Kingaroy, Yarraman and Kumbia areas. Bauxite is present on the high ridges west of the main Yarraman–Nanango road though outcrop is scarce and pine plantation forest litter masks the underlying soil and rock. Within the large continuous area of laterite between Kingaroy and Goodger, bauxitisation is widespread. Bauxite from this area is generally of high quality. Approximately 5km east of Kingaroy bauxite crops out as boulders on portions 120v and 158v, parish of Booie and portion 46v, parish of Coolabunia. In the Kingaroy–Coolabunia area there are numerous surface indications of bauxite. Near Mount Wooroolin, ~3km west of Kingaroy, bauxite is present beneath a 2m capping of ferruginous capping and crops out on the slopes of the mountain. Shepherd & Connah (1947) believed four main areas around Kingaroy were favourable prospects for large tonnages of bauxite. Of the localities, one is 5km north of Kingaroy, the second is 5km south-east of Kingaroy, the third is 2.4km east of Coolabunia railway station and the fourth is 1.6km south-south-east of Goodger railway station.

Toowoomba–Crows Nest Area

A number of small bauxite occurrences are also present in the Toowoomba–Crows Nest area (Table 16). Shepherd & Connah (1948) reported on and sampled the known bauxite deposits between Toowoomba and Crows Nest. It was concluded that within the large development of laterite numerous low to medium-grade deposits were present. As with bauxite in the Kingaroy area, discoveries of very large deposits elsewhere in Australia have made these smaller deposits uneconomic at present.The deposits of the Toowoomba area, described by Shepherd & Connah (1948), range in grade from 9–42% alkali soluble Al_2O_3 and have reserves in excess of 250 000t in the Hampton area (Owen, 1954).

Murgon Area

Bauxite is present at Boat Mountain ~10km north-north-east of Murgon (Table 16). Shepherd & Connah (1947) described Boat Mountain as a steep, isolated, flat topped peak ~1.2km long and ~60m wide. The upper part of the mountain is laterite overlying Tertiary Main Range basalt. On the central part of the eastern side bauxite nodules occur in the laterite for ~3m. Low-grade bauxite is present on the lower slopes of the mountain.

ANTIMONY

Yarraman Subprovince

Crows Nest Area

Denmead (1940) was the first to report on the Eskdale Antimony Lode though no date is known for its discovery (Table 17). The deposit is located ~16km north-north-east of Crows Nest within the Eskdale Igneous Complex (?$Rges_{r1}$) in Portions 3V and 22, Parish of Eskdale. The lode was investigated by Cribb (1941) and Sawers (1971b). The lode, which is 1–1.2m wide and occupies a persistent fissure at least 520m long, consists of weathered sheared granitic material, strikes east-north-east, and dips steeply to the north or vertically (Sawers, 1971b). Staining by iron and manganese oxides and slight kaolinitised Eskdale Granodiorite are prominent features. Mineralisation is restricted to veins, and blebs of stibnite which are erratically distributed throughout. The lode strikes east-west with an almost vertical dip and has a width of between 1–1.5m. Lode material is composed of sheared granitic rock with stibnite and quartz, some calcite and quartz with splashes of stibnite. Total production is estimated at 70t of unknown grade.

Krosch (1973) reported on a Mines Department drilling program that was carried out at the deposit during 1971 and early 1972. Eleven holes in ML 142, Toowoomba, were drilled and intersected the lode over a distance of 600m and proved the persistence of the lode at depth although significant mineralisation was only encountered at the eastern end. Indicated reserves to a depth of ~36m were 3000t averaging ~3% antimony.

EPM 5223 Anduramba consisting of 50 sub-blocks was granted to Panview Pty Ltd on the 9 February 1988. The EPM area encompassed the known area of antimony mineralisation. Both the Eskdale antimony and Anduramba (Felix) molybdenum deposits were

Table 16: Aluminum

Deposit Name	Location	Status	Size	Location (AMG)	
Kingaroy area					
Yarraman	~2km W of Yarraman	mineral occurrence	very small	395900	7031200
Kingaroy	~7km WNW of Brooklands	mineral occurrence	very small	375300	7044200
Kingaroy	~6km NW of Brooklands	mineral occurrence	very small	377900	7045700
Mt Wooroolin	3km NW of Kingaroy	mineral occurrence	very small	381100	7065500
Kingaroy	~7km N of Brooklands	mineral occurrence	very small	368290	7048200
Kingaroy	~5km NE of Kingaroy	mineral occurrence	very small	387600	7067400
Kingaroy	~5km NE of Kingaroy	mineral occurrence	very small	388000	7067400
Kingaroy	~7km SE of Kingaroy	mineral occurrence	very small	388100	7057600
Kingaroy	~10km SE of Kingaroy	mineral occurrence	very small	388600	7055000
Kingaroy	~5km ESE of Kingaroy	mineral occurrence	very small	389200	7062200
Kingaroy	~11km SE of Kingaroy	mineral occurrence	very small	390200	7054500
Kingaroy	~6km E of Kingaroy	mineral occurrence	very small	390900	7063900
Kingaroy	~12km SE of Kingaroy	mineral occurrence	very small	393900	7057200
Kingaroy	~6km SE of Kingaroy	mineral occurrence	very small	387000	7058000
Kumbia Bauxite	~10.5km N of Kumbia	mineral occurrence	very small	369800	7057000
Kumbia Bauxite	~ 9.5km NE of Kumbia	mineral occurrence	very small	373600	7053300
Kumbia Bauxite	~5km WSW of Kumbia	mineral occurrence	very small	361500	7046400
Kumbia Bauxite	~10km NE of Kumbia	mineral occurrence	very small	374100	7053200
Kumbia Bauxite	~9.5km ESE of Kumbia	mineral occurrence	very small	375600	7044100
Toowoomba-Crows Nest area					
unnamed 1	~9km NE of Meringandan	mineral occurrence	very small	400900	6970200
unnamed 2	~8.5km E of Meringandan	mineral occurrence	very small	401100	6966000
unnamed 3	~7km E of Meringandan	mineral occurrence	very small	399800	6966000
unnamed 4	~8km E of Meringandan	mineral occurrence	very small	400400	6964800
unnamed 5	~7km E of Meringandan	mineral occurrence	very small	399700	6964900
unnamed 5	~7.5km E of Meringandan	mineral occurrence	very small	400000	6964100
unnamed 7	~8.5km E of Meringandan	mineral occurrence	very small	401000	6963700
unnamed 8	~ 5km E of Meringandan	mineral occurrence	very small	397600	6964800
unnamed 9	~3.5km E of Meringandan	mineral occurrence	very small	396200	6964900
unnamed 10	~4.5km ESE of Meringandan	mineral occurrence	very small	396700	6963300
unnamed 11	~6km ESE of Meringandan	mineral occurrence	very small	397700	6962000
Murgon area					
Boat Mountain	10km NNE of Murgon	mineral occurrence	very small	397600	7106300

Table 17: Antimony

Deposit Name	Location	Status	Size	Location (AMG)	
Eskdale	16km NNE of Crows Nest	abandoned	small	416200	6996600
Eskdale Antimony	1.5km WNW of Eskdale Homestead	abandoned	very small	415822	6996760
unnamed	13.5km NNE of Crows Nest	abandoned	very small	411600	6996900

within the EPM boundary. A lineament study and literature search was carried out.

BISMUTH

Yarraman Subprovince

Nanango area

Bismuth has been worked on a small scale in the Nanango area. At Mount Langan (AMG 415100, 7017250), 16km south of Blackbutt, low-grade bismuth-silver-gold mineralisation was worked intermittently from 1903–1920 (Ball, 1906a, 1920; Dunstan, 1913b; Cameron, 1917). Of 2032t mined from a small 'glory hole', only half was treated. The mineralisation is in greisenised granitic rocks and is associated with closely spaced joints dipping 15–45° to the west-south-west (Brooks, 1970a). Other vertically dipping sets of joints striking north-east and north-west may also have had some localising influence. Bismite and bismuthinite were recorded from the Mystery lode (Cribb, 1947c). Brooks (1970a) doubted whether the grade of the primary mineralisation would enable profitable mining.

Bismuth is also known 11km south-east of Nanango within the Seven Mile Diggings Mining Reserve (centred on AMG 405650, 7040100). Workings here exposed a quartz lode up to 1.5m wide within 'granitic rock' over a length of 30m. Mineralisation consists of minor amounts of bismuthinite partially altered to bismite and localised in one or two veins near the footwall of the lode (Sawers, 1967). A representative sample of the lode assayed 0.3% bismuth.

BUILDING STONE

Yarraman Subprovince

Blackbutt Area

Wolff (1957) reported that the 'Blackbutt Granite' (now mapped as part of the Taromeo Igneous Complex, $PRgm_t$) had become an important source of grey granite to the building and monumental trades (Table 18). Murphy & others (1976) reported granite quarries were ~3km north of Blackbutt. The dark-grey, medium-grained, even-textured tonalite is resistant to weathering and takes a high polish. 'Blackbutt Granite' was used in the base course of the old State Government Insurance Building (now Rendezvous Apartments Hotel). In 1988, Granite Resources Ltd investigated potential dimension stone resources of Taromeo Igneous Complex rocks in the Emu creek area. Core from two diamond drill holes indicated high sulphide content in the groundmass and no further development was undertaken (Trezise, 1990).

A small quarry was developed in a phase of the Taromeo Igneous Complex (Rgm_d) approximately 10.5km north-east of Blackbutt. P.J. Lowther and Son Pty Ltd held a building stone Mining Lease 203285 (old ML 129NANA), "Black Beauty" over this quarry between 1974 and 1975.

Boondooma Area

The Boondooma Igneous Complex is made up of a variety of rock types and several of these have potential as building stone sources. In the Nanango–Maidenwell area, Granite Resources Ltd investigated two granite deposits. A trial quarry was opened to test "Nanango Peach", an

Table 18: Building stone – Blackbutt

Deposit Name	Location	Status	Size	Location (AMG)	
Blackbutt Granite	~3km north of Blackbutt	abandoned	small	409500	7029300
Black Beauty	~10.5km NE of Blackbutt	abandoned	very small	416900	7033850

attractive pink-grey, medium-grained granite ($PRgb_g$). The granite crops out well, has widely spaced joints and is part of a large resource (Trezise, 1990).

Crows Nest Area

Trezise (1990) reported building stone production from both the Eskdale Igneous Complex (Anduramba quarry) and Crows Nest Granite (Ravensbourne or Ulam Carrara quarry) in the Crows Nest area. Dimmick (1949) noted that Mr Zeigler of Toowoomba used Crows Nest Granite (this area is now mapped as Eskdale Igneous Complex, $Rges_{r1}$), obtained from a small quarry approximately 11km by road north-north-east of Crows Nest, intermittently as a source of monumental stone. Dimmick (1949) also described other potential granite deposits 2–3km east of Crows Nest (Portion 22V, Crows Nest) area. He believed the granite was suitable for use as building stone because of the lack of pyrite contamination, wide spaced joints and uniform composition. Wolff (1957) noted the Crows Nest Granite was pink, medium grained and that large blocks of high quality stone could be obtained. Trezise (1990) described the Crows Nest Granite as containing closely spaced joints and being of little or no use as building stone. Currently, Lachlan Valley Granite Supplies hold ML 50009 (Austin Pink), approximately 9km north of Crows Nest within the Crows Nest Granite.

During 1989, Marlborough Gold Mines Ltd and Pavstar Pty Ltd entered into an agreement with Nknda Pty Ltd to quarry black granite from the Nukinenda deposit, ~25km north of Crows Nest. The medium-grained, black, porphyritic quartz gabbro occurs as a small body ($Rges_g$) in the contact zone with the Eskdale Igneous Complex and Maronghi Creek beds.

Clarence–Moreton Basin

Helidon Area

Willmott (1987) and Trezise (1990) reported on and summarised the building stone resources of the Helidon area (Table 19). Sandstone for building purposes has been quarried from the Helidon area for over 100 years and continues to be extracted. Although historically significant amounts of building stone were quarried, production declined drastically after the 1950s with the advent of new building techniques and higher labour costs. A minor resurgence occurred during the late 1980s with renewed interest in Helidon Sandstone, Lockyer Sandstone and Murphy's Creek Sandstone (commercial names for sandstone of the Woogaroo Subgroup)

Table 19: Building stone — Helidon

Deposit Name	Location	Status	Size	Location	(AMG)
Wagner's (Wright's, Freestone) Quarry	~4.5km NNE of Helidon	operating	medium	416800	6955600
Commerford's (Jude's, Miller's, Old State Quarries)	~4.5km NW of Helidon	operating	small	411900	6956500
Helidon Sandstone Company (Spratt's,Jude's University, Old State Quarries)	~4.5km NW of Helidon	operating	small	412000	6956500
Ziegler's (Cleary's) Quarry	~11.5km NW of Helidon	operating	small	409300	6963200
Ziegler's Quarry	~5km NW of Helidon	operating	small	410800	6957700
Lockyer Sandstone or Corrigan's Quarry	~3.5km NNE of Helidon	operating	small	415400	6955000
Pearson's Quarry	~6km NNE of Helidon	abandoned	small	416600	6957400
Waterfall, Plantation or Whitestone Quarry	~5km NNE of Helidon	abandoned	small	415800	6957100
Jude's and Phippard's Quarries	not located but believed NE of Wright's Quarry	abandoned	small		
Montgomery's Quarry	several small quarries near Ziegler's (Trezise, 1990), 5km NW of Helidon	abandoned	small		
Stronach's Quarry	not located, possibly near Ziegler's New Quarry (Willmott, 1987)	abandoned	small		

for rough landscaping applications and for cutting into tiles. Trezise (1990) reported that most companies involved in Helidon Sandstone quarrying had undertaken expansion of production and processing operations due to increased demand.

Helidon Sandstone

Helidon Sandstone is quarried from thick beds of fine- to medium-grained sandstone north of Helidon Township (Willmott, 1987). Carmichael (1987) noted that all "Helidon Sandstone" quarries appear to be located in the same part of the stratigraphic unit. Trezise (1990) summarised operating quarries exploiting "Helidon Sandstone" and commented on quarrying activities and products.

Helidon Sandstone ranges in colour from light brown through pink and mauve to white-grey (Willmott, 1987). Concentric banding is common in some areas, as is speckled 'salt and pepper' texture. Light brown stone either with or without banding has been the most popular. Because of the subdued topography quarries have generally been developed as deep pits. Problems of colour variability, hardness, closely spaced joints, indistinct and irregular bedding planes and drainage of pits have been encountered during quarrying (Morton, 1927; Denmead, 1945). Richards (1918) and Wolff (1957) reported on the physical properties and chemical analyses of the stone.

Helidon Sandstone was used in the construction of numerous major buildings within Brisbane. A selection of these buildings as listed by Richards (1918) include, the base course of Parliament House (1865–67), Elizabeth Street front of the old Treasury building (1890–93), old Executive Building (1901–05), old State Savings Bank (1915–), part of old Parliament House (1860–62) and the old South Brisbane Town Hall (1890). Helidon Sandstone was used in the construction of the University of Queensland at St Lucia.

In May 1991 Tarack Pty Ltd took out 48 sub-blocks under EPM 7572 and targeted sandstone for building stone and monumental stone. During the 3 years of tenure, geological mapping, chip drilling and core drilling were carried out. Helidon Sandstone in the southern part of the EPM area was found to be suitable for quarrying and processing. Two mining lease applications (MLA 50086 and MLA 50087) and one mineral development licence (MDLA 151) were lodged towards the completion of the third year.

Lockyer Sandstone

Similar to the Helidon Sandstone, Lockyer Sandstone was quarried from the Woogaroo Subgroup. Stone bearing the Lockyer Sandstone name was worked briefly from two adjacent quarries reportedly 1.6km north-west of Lockyer siding (Denmead, 1945). Willmott (1987) believed the location was most likely north-east of Lockyer siding where several old sandstone pits are located. It was also believed the "Lockyer Sandstone" was little different to Helidon Sandstone.

Murphy's Creek Sandstone

Murphy's Creek Sandstone was worked from at least three quarries in the Murphy's Creek area, ~22km south of Crows Nest, between 1870 and 1900 (Anonymous, 1888; Richards, 1918) (Table 20). The rock is a generally medium-grained, white to light grey, lighter in colour and coarser than the Helidon Sandstone and it lacks the concentric colour bands. Murphy's Creek Sandstone was used in the construction of major Brisbane buildings including the old Museum/Public Library (erected 1877–79) on William Street, old Custom House (1887), Eagle Street, columns on the George Street side of the old Treasury building (1890–93) and the front portico of the old Government House (1860–62). The Toowoomba Court House and Post Office were also constructed of Murphy's Creek Sandstone.

Willmott (1987) noted the locations of Murphy's Creek Sandstone quarries were not clear from the old literature and knowledge of them has largely been lost. Enquiries made during his

Table 20: Building stone — Murphy's Creek

Deposit Name	Location	Status	Size	Location (AMG)	
?Cameron's Quarry	~13.5km NNW of Helidon	abandoned	small	408700	6965200
Tweed's Quarry	~ 8.5km NNW of Helidon	abandoned	small	409400	6960400
unnamed	~10.5km NNW of Helidon	abandoned	very small	409000	6961600
unnamed	~10.5km NNW of Helidon	abandoned	very small	409100	6961500
unnamed	~11.5km NW of Helidon	abandoned	very small	408600	6962600

Table 21: Building stone — Highfields

Deposit Name	Location	Status	Size	Location	(AMG)
Highfields	~14km north of Toowoomba	abandoned	small	396500	6966000

survey revealed four very old quarries containing rock resembling that in the old Brisbane buildings. Quarrying was undertaken from the upper beds of the Woogaroo Subgroup just below the Marburg Subgroup.

Surat Basin

Highfields Area

Sandstone was quarried from deposits of the Marburg Subgroup, adjacent to the now dismantled railway line near Highfields, ~14km north of Toowoomba (Table 21). Richards (1918) noted that the stone was used in the construction of the first wing of the Treasury Building (1887–89) (now Treasury Casino) in Brisbane. The stone was not considered very successful owing to its poor weathering qualities. Although originally white in colour it has a tendency to discolour, contains prominent cross-bedding and is very soft. Almost all witnesses gave adverse opinions of the stone to the Select Committee on sandstone quarries in 1888.

Main Range Volcanic Province

Crows Nest Area

In late 1988, Jalsign Pty Ltd obtained extractive industry permits to develop a quarry at Bluff Mountain, a Tertiary dolerite plug (T*id*), ~11km north-east of Crows Nest (Trezise, 1990). Thomas Stanislaus Jilek took out **EPM 9282 (CR: 25849)** over Bluff Mountain in 1993 to assess the dimension stone prospects of the dolerite. The dolerite occurs as a plug rising from the floor of a valley consisting of grey granodiorite, part of the Eskdale Igneous Complex. Texture of the dolerite is uniform and fairly coarse-grained in the centre of the exposure, at the top of the mountain. It is finer-grained on the north-east side. Numerous tightly spaced cracks are evident in exposed material. Two consultants examined a Bluff Mountain dolerite pillar with specific attention to visible cracking in exposures. Three small blocks were removed from the top of the pillar using a Cobra drill and explosive and examined for cracking. Cracking was ubiquitous, making the dolerite unsuitable for dimension stone.

CLAY-KAOLIN

Yarraman Subprovince

Kingaroy Area

The Kingaroy area contains significant high quality kaolin reserves with many recognised since the early part of the twentieth century (Table 22). Sawers (1963) noted that John Swain sent two samples, obtained from the Goodger area in 1919, to the Chief Government Geologist for analysis. One was of mica quartzite and the other of kaolin clay that was considered suitable for pottery use. Denmead (1929) commented on the clay deposits of the greater Kingaroy area in relation to pottery manufacture. He noted the Goodger deposits were said to be of sedimentary origin interbedded with Mesozoic coal and that the Tarong (Brooklands) deposits were of kaolinised granite.

Connah (1950a) reported the clays at Goodger and Brooklands were extensive and that successful working of the deposits was dependent on marketing. He also noted that the clay at Goodger was derived from flat-bedded sedimentary strata while the clay at Brooklands was derived from the weathering of granitic feldspars. Laycock (1961) and Sawers (1963) described kaolin clay deposits at Goodger as being associated with the flat lying Tarong beds underlying Main Range Volcanics. Sawers & Cooper (1986) reported that white kaolin occured in the Kingaroy area as limited, but economic, deposits. Field investigations in 1997 showed that the Goodger kaolin deposits occur beneath a bed of quartz-rich (locally silica-cemented) sandstone that occur immediately beneath relatively fresh basalt of the Main Range Volcanics.

Kingaroy Kaolin Pty Ltd at Goodger (Goodger 1, Nyora), and Brooklands (Huber South), have a substantial resource base and could support a level of production higher than their current rate of ~5000tpa (Smart, 1999).

Location of deposits and known occurrences of kaolin clay in the greater Kingaroy area are presented in Table 23.

Table 22: Kaolin Clay — Kingaroy Area

Deposit Name	Location	Status	Size	Location	(AMG)
Cooyar Kaolin	~4km N of Cooyar	abandoned	very small	384214	7019265
Yarraman	~3.2km NNW of Yarraman	mineral occurrence	very small	397700	7033000
Winter No 1	~13km SW of Kingaroy	mineral occurrence	small	375409	7053586
Boonenne	~6km S of Kingaroy	operating Mine	small	383006	7057412
Nanango Bricks	~1.5km N of Nanango	mineral occurrence	small	400250	7050800
Hilary Clay	~2km N of Nanango	abandoned	small	399900	7051100
unnamed	~8km SSW of Nanango	mineral occurrence	small	396132	7042202
Ml 203349	~2km N of Cooyar	mineral occurrence	small	383766	7017015
Goodger 1	~16km S of Kingaroy	operating Mine	small	385386	7048141
Huber South (Brookland)	~20km SSW of Kingaroy	abandoned	small	376575	7044519
Brookland	~23km SSW of Kingaroy	mineral occurrence	small	378157	7040900
Nyora	~15km S of Kingaroy	operating Mine	medium	385250	7048940
Wattle Grove	~16km WSW of Kingaroy	abandoned	small	368759	7060104
Wattle Grove 139	~10km WSW of Kingaroy	abandoned	small	374202	7060990
Taabinga South	~8km S of Kingaroy	mineral occurrence	small	382300	7055800
Taabinga Kaolin	~5km SSE of Kingaroy	abandoned	small	385600	7058900
Taabinga No 1	~14km SSW of Kingaroy	abandoned	small	377085	7051787
Ushers Hill	~7km SSE of Kingaroy	mineral occurrence	small	386300	7057300
Wattle Grove 184	~12km WSW of Kingaroy	abandoned	small	372045	7060784
Morrissey	~13km SW of Kingaroy	operating Mine	small	375100	7054014
Huber North	~10km S of Kingaroy	abandoned	small	381764	7054200
Huber West	~15km SSW of Kingaroy	abandoned	small	378632	7049124
Huber East	~15km S of Kingaroy	abandoned	small	382317	7048236
Maryvale	~16km S of Kingaroy	mineral occurrence	small	385556	7047650
Nanango Clay Pit	~13km S of Kingaroy	abandoned	small	385143	7050600
Sunshine	~1.5km N of Nanango	mineral occurrence	small	400100	7050750
Links No2	~6km S of Kingaroy	mineral occurrence	small	382577	7059008
Links No1	~7km S of Kingaroy	mineral occurrence	small	382247	7058698
Rebecca	~18km SSW of Kingaroy	abandoned	small	375214	7048045
unnamed (Ml5675)	~12km S of Kingaroy	abandoned	very small	385750	7050975
Cedars Mine	~10km SW of Yarraman	operating	medium	389311	7026082
unnamed (Ml 203276)	~7km N of Cooyar	mineral occurrence	very small	384104	7022188
unnamed (Ml 203275)	~6.5km N of Cooyar	mineral occurrence	very small	384182	7022712
unnamed (Ml 202170)	~9km SW of Yarraman	mineral occurrence	very small	389688	7027162
unnamed (Ml 203250)	~5km SW of Yarraman	mineral occurrence	small	394120	7028461

Table 23: Kaolin Clay — Esk

Deposit Name	Location	Status	Size	Location	(AMG)
Pyramid Group	~15km W of Esk	abandoned	very small	427195	6989193

Table 24: Kaolin Clay — Murgon

Deposit Name	Location	Status	Size	Location	(AMG)
Wondai Clay	on SE outskirts of Wondai	abandoned	small	388250	7087980
unnamed	14km WNW of Wondai	mineral occurrence	very small	373850	7092200
unnamed	7km WNW of Wondai	mineral occurrence	very small	377740	7091280
unnamed	1km N of Wondai	mineral occurrence	very small	388300	7089620
unnamed	2km E of Wondai	mineral occurrence	very small	389999	7088550
unnamed	5km SE of Wondai	mineral occurrence	very small	392000	7085500
unnamed	Abbeywood area 31km NW of Wondai	inactive	very small	364759	7109182
Hivesville	300m E of Hivesville	mineral occurrence	small	369300	7103800
Hivesville	1km SW of Hivesville	inactive	very small	368370	7103100
Proston N	13km NW of Hivesville	mineral occurrence	very small	359945	7112650
Proston N	15km NW of Hivesville	inactive	very small	359170	7113852
unnamed	8km WNW of Wondai	mineral occurrence	very small	380300	7091300
unnamed	19km NW of Wondai	mineral occurrence	very small	372280	7099900
Robinsons	17km NW of Wondai	mineral occurrence	very small	373700	7097315
Whitehill	19km NW of Wondai	abandoned	very small	373180	7102170
Whitebank	19km NW of Wondai	abandoned	very small	373180	7102172
Blue Moon	19km NW of Wondai	abandoned	very small	372750	7101850
Blue Gums	19km NW of Wondai	abandoned	very small	372100	7101300
Blue Rock	19km NW of Wondai	abandoned	very small	372700	7100300

Esk Area

In the Esk area (Table 23), Kaolin was the target within **EPM 4019**. Samples of kaolin and silica were collected and tested. Initially the kaolin was considered to be of unsuitable quality for pharmaceutical, industrial, printing and in bread baking applications because of the contamination by silica from a nearby sand mining operation. However, a range of recommended uses was proposed and it was decided to leave the deposits intact while further laboratory tests and trials were completed and overseas sales negotiations entered into fully. The uses for the kaolin included sealing dams, containing the effects of oil spillage, fruit preservation, pilling and treating ulcerous wounds.

EPM 9932 consisted of an area (1 sub-block) of land surrounding that held under Mining Lease 5977, ~15 km south-east of Crows Nest. Mr. and Mrs. Philp held both EPM 9932 and Mining Lease 5977. A literature search was made for the area and reconnaissance fieldwork involving hand sampling was carried out in the EPM area. The silica content and clay characteristics of the EPM were ascertained but not reported in CR 26574. Samples taken during this work were forwarded for testing. Extensive research into the economic viability of the clay was initiated. Further exploration was planned (further testing, determining the extent of the resource).

Table 25: Kaolin clay — Boondooma

Deposit Name	Location	Status	Size	Location	(AMG)
Binelong	5km south of South Durong	mineral occurrence	small	325447	7074512
Sunray	5km south of South Durong	mineral occurrence	very small	324480	7074377
Glory	5km south of South Durong	mineral occurrence	very small	325055	7074129

Resources of sand, clay and basalt are present at Ravensbourne. The sand will be used in concrete production, the clay in clay building products and the basalt on site for road base and stabilisation of land forms.

Murgon Area

Reid (1925) noted a significant deposit of kaolin at Hivesville that was derived from the underlying granite (Table 24). Tests proved the kaolin to be of low quality. No high-grade material was found, although exploration was not exhaustive.

Boondooma Area

Approximately 5km south of South Durong small deposits of kaolinite are exposed in a steep creek bank (Table 25). Leases have been held over the clay deposits in the area and include "Glory" (ML 203252) from 1951–1953, "Binelong" (ML 203273) from 1961 to 1965 and "Sunray" (ML 209195) from 1970 to 1974. No apparent production has taken place on any of the leases.

Jandowae Area

In JANDOWAE clay drilling for white clay was carried out 10km south-east of Warra area under **EPM 10816** (CR 27677). A brief drilling program was completed within EPM 10816 to test for white clay intersections reported in an earlier drilling campaign for coal. Clay was encountered although most of it appears to be red or pale grey, often contaminated with iron oxides.

The EPM covers an area of surface exposure of Pleistocene Condamine River alluvials. Drilling revealed a persistent layer of coarse sand at depths of 5–12m underlying the alluvials. Previous drilling intersected thin discontinuous Jurassic Injune Creek Group coal beds at depths of 36–40m. Coloured clays occupy the interval between the sand and the coal beds.

Global Minerals Pty Ltd tested the area in the 1970s for coal deposits suitable for open cut mining.

Regional mapping indicates that a period of deep weathering occurred in the Cretaceous, and the Jurassic to Lower Cretaceous Kumbarilla beds immediately south of the Condamine River are lateritised. This weathering period may have contributed to the red colouration of many of the clays, gravels and sands encountered during drilling.

Three holes (D7, D14, and D14A) previously drilled for coal were selected for redrilling. Drill sites were selected as close to the original holes as possible however no evidence of the original drill sites were found. A 1m logging interval was maintained until target depth, then samples were taken over 3m, being split through a rifle to roughly 1kg in weight. Of interest are the green montmorillonitic clay fragments recorded between 27–28 m depth in D16A/R2. All holes from this drilling programme failed to intersect significant white clay. Drill logs are included in CR 27677.

CLAY-BENTONITE

Main Range Volcanic Province

Yarraman Area

Bentonite were first recognised in the Yarraman area around 1913 (Cribb, 1943a). The moist nature of the ground led to speculation of underground water supplies and the sinking of shal-

Table 26: Bentonite

Deposit Name	Location	Status	Size	Location	(AMG)
Cedars Mine	~10km SW of Yarraman	operating	medium	389311	7026082

low auger holes. Drilling revealed fragments of soapy clay and by 1936 two classes of clay, based on physical properties, were being exploited by underground workings. One clay was white to light grey in colour and of earthy to granular texture while the other was light cream to buff in colour with occasional patches of yellow, light green, pink or red.

Fisher (1946) reported on the results of a government drilling program undertaken at the Yarraman bentonite deposit. Croft & Zeissink (1967) determined the Yarraman bentonite deposit was derived from the devitrification and alteration of pyroclastic material. Remnant ash particles, vitric lapilli and pumice were identified. It was noted that three clay horizons were present in the deposit and that these developed because of variations in composition, pre-depositional and diagenetic history. Subaerial weathering of the ash prior to deposition in an aqueous environment formed the hydrated halloysite, allophane and gibbsite found in the basal layer. Montmorillinite and α-cristobalite found in the central horizon were produced by alteration of the ash *in situ* under conditions of impeded drainage. Weathering of montmorillinite in a freely leached environment formed the kaolinite of the upper horizon.

The Yarraman bentonite is currently being exploited at Cedars Mine (GR 389311 7026082). Mining is by open cut and the material is washed, dried and bagged on site.

COAL

Coal seams are known in the Tarong Beds, Woogaroo Subgroup, Marburg Subgroup, Evergreen Formation, and Walloon Coal Measures. Very thin seams of poor quality coal occur in the Marburg Subgroup and Evergreen Formation. These coal occurrences were summarised in Murphy & others (1976). None of these deposits have economic value.

Tarong Coalfield

Murphy & others (1976) summarised the history of the existence and development of coal in the Tarong beds. The Tarong beds contain the only deposits currently being mined, at the Meandu Mine near Tarong Power station. Resources have also been identified in the Kunioon area and the Taabinga area near Kingaroy.

The Kunioon deposit (MDL 201) owned by Rio Tinto Ltd has two coal seams of economic interest — the Kunioon Seam and the Swain-Goodger Seam (both averaging 13m thick). Kunioon contains 358Mt measured and 89Mt indicated opencut resources.

The Taabinga deposit (EPC 686C) owned by Tarong Energy Corporation Ltd has two seams with economic potential, the 'A' seam (15.7m thick) and the 'B' seam up to 8m in thickness (Coxhead, 1999). Taabinga (near Kingaroy) contains 80Mt measured and 47Mt indicated opencut resources (Coxhead, 1999).

The coal in the Meandu and Kunioon areas can be classified as high ash, high volatile, bituminous, low sulphur steaming coal with weak coking properties (Pegram, 1995). All seams have a high raw coal ash content that ranges from 25–45% (28% average) and require washing to keep to product specification (Coxhead, 1999). Seam quality has been shown to deteriorate down sequence and the seams low in the sequence are dull with a few light bands. Seams higher in the sequence are generally brighter with between 10–40% bright bands.

Up to fifteen seams are present in the Meandu Mine (ML 6674, MDL 2200) operated by Pacific Coal Pty Ltd. The King Seam and Seams A to J inclusive are the principal seams mined at Meandu. The bulk of the mine area has no tertiary cover except for a small area on the eastern side where there has been deep pre-Tertiary erosion and infill. Some lateritic profiles are developed to the north of the mined area. The coal resources are contained mainly in two seams — the King Seam and the Queen Seam (16 and 34m respectively) (Coxhead, 1999). Current production from the mine is 5.4Mtpa (Coxhead, 1999). Resources remaining in the Meandu Mine are estimated at 165Mt measured and 39Mt indicated (Coxhead, 1999).

Oakey-Acland Coalfield

Coal was first mined in the area in 1885 in the Gowrie Colliery to the south of the area. Other small mines were opened in the ensuing years near Gowrie Colliery and near Acland ~20km north of Oakey (Mengel, 1963a). Ball (1946) reported the occurrences of coal associated with oil shale from the Willeroo No 2 Colliery, and similarly Reid (1920) reported on coal and a 1.5m thick sequence of oil shale (with yields ranging from about 100–150l/t) from the 32m level in a well near Sabine railway siding.

The historical Oakey–Acland Coalfield is considered to comprise four mine areas — Balgowan, Acland, Sugarloaf and Willeroo. Mengel (1963a, b) provided a comprehensive report on the Oakey-Acland coalfield which produced coal from underground mining. The main

seam is very banded, up to 20m thick of which only the bottom 2m is worked and is known differently in the different mine areas (Cranfield & others, 1975). Production figures for the field are not precisely known, as they are included under Darling Downs Coalfield in the Annual Reports of the Department of Mines. However, product from other areas in the Darling Downs Coalfield has always been minor in comparison with that from the Oakey-Acland field, so that the trends of production closely paralleled the Oakey-Acland field.

Reserves from the Acland, Willeroo, and Sugarloaf Mine areas (after Mengel, 1963a,b) were then considered to amount to some 15Mt. The field ceased production in 1984 (Goscombe & Coxhead, 1995). The proximate analysis of the coal was summarised in Cranfield & others (1975). The washed coal as then sold had an ash content of 225 and a calorific value of 24Mj/kg on an air-dried basis.

Renewal of interest in the Acland area has occurred in the past year through New Hope Colleries. The coals from the Oakey-Acland Coalfields are very high-volatile A and high-volatile B bituminous (A.S.T.M. classification). They are strongly perhydrous and yield high tar and gas on carbonisation. Ash contents of the coals range from 15–34% (Mengel, 1963a). They are good gas making coals, but require blending to produce a satisfactory coke (Queensland Coal Board, 1976).

Further resources suitable for open cut extraction from the Walloon Coal Measures are present in the Acland-Bowenville area are currently under application for development. Reserves for the area have been quoted as 510Mt of measured and indicated resources (Goscombe & Coxhead, 1995), 462.67Mt (Philp, 1998) and 539Mt (Coxhead, 1999). Shell Coal Pty Ltd has identified resources in EPC 513 and MDL 244 at Glen Rosyln, Sabine and Manningvale as well as the abandoned Acland Colliery. The area has potential for large tonnages of low ratio open cut coal as a low cost fuel for power generation. Shell has designed plans for an opencut coal mine and a large on-site base load power station. Glen Roslyn and Sabine in MDLa244 have 122 and 76Mt measured and 125 and 76Mt indicated resources respectively. Manningvale in MDLa244 has 140Mt of indicated resources (Coxhead, 1999).

COBALT

Yarraman Subprovince

Blackbutt Area

Minor cobalt mineralisation is present at the Golden Bird gold prospect ~5km north of Blackbutt. Denmead (1934) reported that cobaltite is present at 15m depth as disseminated grains within a chlorite matrix. Minor amounts of erythrite are also present along cracks or cavities previously filled with cobaltite.

COPPER

Yarraman Subprovince

Blackbutt Area

Cameron (1913) reported on the Taromeo Copper Mine (New Years Shaft, AMG 408900, 7032450), 7km north of Blackbutt (Table 27). Workings consisted of a shaft with four drives and some stoping. He stated that the lode strikes east-west and consisted of ironstained chloritic and siliceous material along well-defined fissures in the granite. The lode was driven on for ~4m in either direction from the shaft and in the west face it decreased to ~150mm of good ore and on the east face to ~200mm of poor ore. Cameron (1916) described an almost vertical lode striking slightly north of east in granitic rock. Workings consisted of a shaft with four drives and some stoping. Between 1913–1916, 50t of ore sent away for treatment yielded 6.1t copper, 3kg silver and 0.3kg gold. The operators debated whether they should sink further but Cameron (1916) advised proving further stoping ground before further sinking. The fissure is persistent and can be traced for ~1.2km. Two other fissures are present in the area, one 400m to the north and the other 200m south. These can be traced for almost the same distance. The mine occurs in unit $PRgm_t$ of the Taromeo Igneous Complex as do other nearby small deposits including Ashington (AMG 407150, 7030750) copper–gold mine and the Golden Bird gold group (AMG 408850, 7030700).

Ball (1912c) reported on the Ashington copper–gold mine and noted that over a period of seven years four shafts had been sunk at the site. Samples were taken for analysis from gossany chloritic leaders but the results were disappointing. Ball (1912c) believed that because of the small size of the leaders they did not

Table 27: Copper — Blackbutt

Deposit Name	Location	Status	Size	Location	(AMG)
Red Queen	21.1km SE of Nanango	abandoned	very small	416700	7035400
Black Diamond	21.7km SE of Nanango	abandoned	very small	416950	7034750
Taromeo Copper	18.8km SSE of Nanango	abandoned	very small	408900	7032450
Ashington	19.7km SSE of Nanango	abandoned	very small	407150	7030750

Table 28: Copper — Crows Nest

Deposit Name	Location	Status	Size	Location	(AMG)
unnamed	16km NE of Crows Nest	mineral occurrence	very small	417800	6995200

Table 29: Copper — Jandowae

Deposit Name	Location	Status	Size	Location	(AMG)
Fernbank	46km NE of Jandowae	abandoned	very small	347907	7065637

Table 30: Copper — Yarraman

Deposit Name	Location	Status	Size	Location	(AMG)
Kooralgin	~10km SSW of Yarraman	mineral occurrence	very small	395100	7021500
Cooyar East Cu Prospect	~8km ESE of Cooyar	mineral occurrence	very small	391900	7013200

warrant further work although there was a possibility of them increasing in size with depth.

Ball (1900) reported on small quantities of copper present at mines of the Taromeo Creek area ~10km north-north-east of Blackbutt. At the Black Diamond and Red Queen prospects copper and silver occur with gold in reefs in granite.

Crows Nest Area

Approximately 1km south-east of Eskdale West (Robyn Dale) beside the Esk–Anduramba Road, copper mineralisation is disseminated throughout a microgranite (Table 28). No workings are present at the site.

Jandowae Area

On JANDOWAE minor copper was exploited at Fernbank Mine (AMG 347907, 7065637) (Table 29). The abandoned mine is located in an area of mica schist within the Chahpingah Meta-Igneous Complex (Cc). Workings now consist of two collapsed shafts and the remains of a wooden headframe. The property owner believes the shaft lower down the slope reached a depth of 20m. Small amounts of malachite and azurite are disseminated throughout the host rock.

Yarraman Area

Approximately 10km south-south-west of Yarraman minor copper mineralisation is present at Kooralgin prospect within sediments of the Tarong Basin (Berkman, 1997). A minor copper occurrence is also recorded ~8km east-south-east of Cooyar within the Triassic–Jurassic sediments of the Woogaroo Subgroup (Berkman, 1997).

Cressbrook Creek Subprovince

Esk Area

Jackson (1901b) reported on the Great Pyramid Prospecting area located ~15km west of Esk (Table 31). Mineralisation occurs chiefly in the sedimentary Pinecliffe Formation (PRp) of the

Table 31: Copper – Esk

Deposit Name	Location	Status	Size	Location	(AMG)
Rising Star	14.4km NW of Esk	abandoned	very small	429210	6992620
North Star	14.4km NW of Esk	abandoned	very small	429245	6992724
Pyramid Group	15km W of Esk	mineral occurrence	very small	426970	6988777
Blue Hill	12km WSW of Esk	abandoned	very small	430700	6983200
Blue Hill	12.5km WSW of Esk	mineral occurrence	very small	430700	6983200
Silver Crown	7.5km NNE of Murphy's Ck Railway Station	abandoned	very small	409800	6968700
Paradise Creek	7km ENE of Murphys Ck Railway Station	abandoned	very small	413600	6963500
unnamed	7.5km NNE of Murphy's Ck Railway Station	abandoned	very small	409800	6968800
unnamed	200m SSE of Main Paradise Creek workings	abandoned	very small	413700	6963200
unnamed	14km W of Esk	abandoned	very small	427946	6989083
unnamed	15km W of Esk	abandoned	very small	427585	6988760
unnamed	16km ESE of Crows Nest	abandoned	very small	421570	6977940

Cressbrook Creek Group close to intrusions of the Eskdale Granodiorite. Some native copper was reputedly found though mineralisation is generally copper carbonate infilling cracks and joint planes within the altered sedimentary rocks. A tunnel driven though hard intrusive rock showed strings of chalcopyrite.

Cameron (1910), Saint-Smith (1920), Reid (1923) and Cribb (1938) reported on copper mineralisation in the Murphy's Creek area, ~15km south of Crows Nest. Cameron (1910) inspected the Moller and Bennett's workings located on Portion 52v, ~7km north of Murphy's Creek Station. He noted chalcopyrite mineralisation in broken slaty rock in the Hampton Road Rhyolite (PRh), but was not convinced the deposit could be worked profitably.

Saint-Smith (1920) reported on the same occurrence as Cameron (1910) and also believed the deposit did not warrant large exploration expenditure. Mineralisation occurs in extremely hard quartzite and slate along the steep sides of Rocky Gorge Creek. Reid (1923) visited the prospect and sampled the ore for assaying. Results were disappointing with the richest patches returning values of 7.7% copper. Average values in the ore dump were ~4% and considered too low to be economically viable.

Dampier Mining Co. Ltd undertook exploration under EPM 1292 to explore for possible copper mineralisation in eastern Queensland. EPM 1292 was taken out over 78 sub-blocks SW of Toogoolawah. The area covered is centred on the district of Eskvale, and covers a block of Permian acid–intermediate volcanic rocks, reported to contain abandoned copper, lead and zinc prospects. Exploration within EPM 1292 consisted of a literature search, one week of field mapping and a detailed petrological study of representative rock units and mineralised zones. At the time EPM 1292 was granted to Dampier Mining Co Ltd a number of Mining Leases (MLs) were held within the EPM. These leases were ML 664 (Cu) granted to Clark, Clark, Hoffman and Owen on 26/8/1969; ML 156, ML 159, ML 160 (Bi, Cu, Pb, Ag, Sn, Zn) ML 170 and ML 171 (Bi, Cu, Pb, Ag, Sn, Zn, Sb, Ni, Co) and ML 177 and ML 178 (Cu, Pb, Zn, Bi, Ag, Ni, Mo) all granted to Eagle Exploration on the 23/12/1970; and ML 191 and ML 193 (Fe and others) granted to Pakleppa, Hanson and Palmer on the 11/6/1970. The Rising Star, The North Star, and Great Pyramid workings are also within the EPM area.

EPM 3117 of 100 sub-blocks was granted to Gulf and Western Exploration Pty Ltd on 31st August 1981. The EPM area is underlain by Lower Permian acid–intermediate volcanics and volcaniclastics of the Cressbrook Creek Group. Results of previous sampling, coupled with the lithology of the area, and the style and geochemistry of minor Cu, Pb Zn mineralisation suggested that the area has potential for disseminated silver deposits. Gulf and Western Exploration Pty Ltd have conducted a literature search, geological mapping and sampling of the area. A number of minor showings of Cu, Pb, Zn

Table 32: Diatomite

Deposit Name	Location	Status	Size	Location	(AMG)
Maidenwell	6km NNW of Maidenwell	operating	small	378213	7035211
Portion 21	6km NNW of Maidenwell	mineral occurrence	small	378604	7034692

and Ag occur in the Cressbrook Creek area, including the North Star, the Rising Star and the Pyramid Mines. Networks of sulphide-filled joints and fissures occur in andesite and tuff.

Sulphide is common in the sequence on the slopes on Mount Tin Tin, occurring as fine disseminated pyrite and gossan-filled veins, or filling interstices between clastic fragments. Values up to 3.65% Cu and 46ppm Ag have been reported from the Rising Star area and similar Cu–Ag values have been recorded north of the Eskdale–Hampton Road. None of these showings is of great economic significance, but their presence provides tangible evidence of the style of mineralisation sought.

It was concluded that the shear zones within the andesite/sediment pile contain low-grade base metals (up to 0.8% Cu) but negligible precious metal values. The quartz veinlet stockwork within the rhyolite unit at Great Pyramid is not anomalous in any metals. A silicified volcanic breccia at Little Kipper Creek assayed 0.17g Au/tonne. However a similar sample 100m away was not anomalous. It was considered that the EPM area has no potential for a bulk low grade gold deposit and it was relinquished in full.

Sovereign Mining Pty Ltd was granted **EPM 3506** (48 sub-blocks) on the 30th May, 1983. The exploration targets were volcanogenic base metals and epithermal alluvial gold associated with Lower Permian acid–intermediate volcanics and sediments. The EPM area covers part of the gazetted Ravensbourne Goldfield. Results of the work indicated that a number of drainages other than those associated with known mineral occurrences are anomalous in base metals and gold. It was concluded from a review of the geological and geochemical data that the probability of locally economic mineralisation of the type sought was too low and the EPM was relinquished in full.

DIATOMITE

Main Range Volcanic Province

Cooyar Area

Diatomite is present on a small plateau near Maidenwell, ~21km north-north-west of Cooyar (Table 32). Dunstan (1913b) first reported on this occurrence in the Queensland Mineral Index and Guide. Bruvel (1999) noted that at Maidenwell the diatomite forms a continuous bed ~4m thick. It is light yellow-brown, finely laminated and a little clayey. The major diatom present is *Melosira*.

The deposit at Maidenwell is associated with a Tertiary sedimentary sequence (Tm_s) within basaltic flows of the Main Range Volcanics (Tm).

DOLOMITE

Main Range Volcanic Province

Wondai Area

Dolomite occurrences are present between 8–19km north-west of Wondai and are hosted by sediments and volcanics of the Main Range Volcanics (Table 33). Rock-Ex Enterprises (EPM 6467M) examined the dolomite occurrences and noted dolomite and kaolin were spatially associated. It was also noted that dolomites were associated with basalt-generated hot water spring deposits. Dolomites and smectite clays were formed by the alteration of basal basaltic flows by the outwashing of carbonated spring waters. This process also accounts for the saltiness of the dolomite. Proximal dolomite is localised in north-trending faults cutting granite, basalt and sediments. Within the deposits zonation is exhibited and shows a trend from siliceous ironstone to dolomite to saline kaolin to silcrete. Dolomites near Wondai have a high moisture content and contamination by 'slippery black' (Si–Al based clay with little or no Mg or Ca).

Table 33: Dolomite

Deposit Name	Location	Status	Size	Location	(AMG)
Robinsons	17km NW of Wondai	mineral occurrence	very small	373700	7097315
Whitehill	19km NW of Wondai	abandoned	very small	373180	7102170
Whitebank	19km NW of Wondai	abandoned	very small	373180	7102172
Blue Moon	19km NW of Wondai	abandoned	very small	372750	7101850
Blue Gums	19km NW of Wondai	abandoned	very small	372100	7101300
Blue Rock	19km NW of Wondai	abandoned	very small	372700	7100300
unnamed	8km WNW of Wondai	mineral occurrence	very small	380300	7091300
unnamed	19km NW of Wondai	mineral occurrence	very small	372280	7099900
unnamed	17km NW of Wondai	mineral occurrence	very small	373670	7098260
unnamed	14km NW of Wondai	mineral occurrence	very small	376600	7096800
unnamed	11km NW of Wondai	mineral occurrence	very small	379000	7095800

FELDSPAR

Yarraman Subprovince

Boondooma and Kilcoy Areas

Mining leases were taken out over pegmatitic feldspar deposits on the southern part of BOONDOOMA and northern part of JANDOWAE within the Chahpingah Metamorphic Complex (Table 34).

On KINGAROY leases were taken out over feldspar deposits within the Permo-Triassic Boondooma Igneous Complex. No production was recorded on any of the leases.

GEMSTONES

Yarraman Subprovince

Murgon Area

Agate is present ~25km north-west of Murgon associated with the Late Triassic Aranbanga Volcanics (Table 35). The agate occurs as vugh fillings in rhyolite. Murphy & others (1976) reported the presence of chalcedony, jasper, amethyst, quartz crystal geodes, banded agate, moss agate and petrified wood at Cloyna and Windera. These deposits were originally thought to be of Tertiary age.

Table 34: Feldspar

Deposit Name	Location	Status	Size	Location	(AMG)
Chahpingah (Boondooma)	16km SE of South Durong	mineral occurrence	very small	335976	7068065
unnamed (Jandowae)	7km SW of Chahpingah	mineral occurrence	very small	332523	7067405
Luck Deep (Kingaroy)	2.5km SW of Brooklands	mineral occurrence	very small	378700	7039800
Brooklands (Kingaroy)	1km SW of Brooklands	mineral occurrence	very xmall	380000	7038700

Table 35: Gemstones — Murgon

Deposit Name	Location	Status	Size	Location	(AMG)
unnamed (Agate)	25km NW of Murgon	mineral occurrence	very small	377720	7115220
Windera (Agate)	24km NNW of Murgon	mineral occurrence	Very Small	385300	7119820

Table 36: Gemstones — Proston, Murgon and Kingaroy

Deposit Name	Location	Status	Size	Location	(AMG)
Brigooda (Diamond, Garnet)	~17km SW of Proston	mineral occurrence	very small	344800	7095400
Garnet Gully (Garnet)	~17km SW of Proston	abandoned	small	345000	7094700
Leurajoy (Garnet)	~17km SW of Proston	operating	small	344700	7094800
Ballogie (Garnet)	35km W of Wondai	mineral occurrence	very small	352800	7090000
Boyne River (Sapphire)	24km W of Kingaroy	mineral occurrence	very small	360400	7060300

Nanango Area

At Seven Mile Diggings (AMG 405650, 7040100) near Nanango, rare zircon, topaz, garnet, spinel, sapphire and ruby were recovered along with alluvial gold (Brooks, 1963).

Main Range Volcanic Province

Proston, Murgon and Kingaroy Areas

The report of a diamond being discovered at Brigooda, ~20km south-west of Proston, led to the taking up of two exploration permits (EPMs 10048 and 10049) by BHP Minerals in 1995 (Table 36). Earlier, Robertson & others (1985) reported on the occurrence of upper mantle xenoliths and megacrysts at Brigooda. They also commented on the origin of the Brigooda basalt and breccia. Robertson (1994) reported on a small diamond recovered from the Brigooda–Lawsons Broad area. It was noted that no classical diamond indicator minerals were present and that this posed a dilemma for diamond exploration. Robertson (1996) noted that the diamond could be directly linked with alkali basalt and pyroclastic derivatives. Hollis & others (1983) reported on the origin of the Tertiary breccia pipe at Ballogie. Two bulk samples were excavated at Brigooda and Ballogie by BHP Minerals and treated at Inverall (NSW) by trommel and jig. No new diamonds were recovered and the tenement was relinquished (CR 27887).

Gem quality garnet is present near Brigooda at Garnet Gully, Ballogie and Leurajoy, and has been known about for more than 30 years (Robertson, 1994). Other gemstones present with the garnet include peridot (gem quality olivine), rare zircon and sapphire.

Sawers (1966) reported on the Boyne River sapphire occurrence after press publicity. His inspection revealed a number of fossickers at the site but he found no sapphires. It was concluded that the deposit was superficial and of limited extent and there was no evidence of a field of any size.

Gem quality olivine was first recorded from the Tertiary Main Range Volcanics at Spring Bluff railway station (AMG 398731, 69617471) in 1909 (Cameron, 1910). Other occurrences are reported near the Harlaxton quarry, Toowoomba municipal quarry, at Mount Tabletop. The best potential source of gem quality olivine are scree slopes of Tertiary basalt south of Toowoomba. Gem quality feldspar occurs rarely in the Main Range Volcanics locally on KINGAROY, and may occur in the volcanics in the area north of Toowoomba on OAKEY.

GOLD

Yarraman Subprovince

Boondooma Area

Only small amounts of gold have been recovered from the Boondooma area (Table 37). At Spring Creek, east of South Durong small amounts of alluvial gold have been noted (CR 23774).

The main period of activity in the Allies Creek area in the northern part of BOONDOOMA was from 1939–1942. Brooks (1970c) reported on the workings and considered the deposits were not of economic significance. A shaft was sunk at Gold Prospecting Area 1574 on a lode said to be 1.2m wide at the surface but which narrowed to 15cm below 6m. Prospecting work was carried out at a number of areas and in 1941 Mr. A. Stumer erected a five-head battery. Approximately 10t of ore from the Welcome mine were awaiting crushing by the end of 1941 but no production was recorded.

Workings at the Golden Whiptail consisted of shafts, costeans and trenches distributed along the lode over a distance of ~300m. Mineralisation is associated with a north-north-east

Table 37: Gold — Boondooma

Deposit Name	Location	Status	Size	Location	(AMG)
Spring Creek	9km E of South Durong	mineral occurrence	very small	333700	7078600
Welcome	6km NE of Allies Creek	abandoned	very small	316230	7116180
Golden Whiptail	5km ENE of Allies Creek	abandoned	very small	315358	7114820
Stumer's Shaft	6km NE of Allies Creek	abandoned	very small	315998	7116479
Dangarabungy	in state forest off	operating	very small	312465	7093985
unnamed	6km NE of Allies Creek	abandoned	very small	316251	7116688
unnamed	6km NE of Allies Creek	abandoned	very small	316370	7116659
unnamed	6km NE of Allies Creek	abandoned	very small	316384	7116582
unnamed	6km NE of Allies Creek	abandoned	very small	316385	7116496
unnamed	7km NNE of Allies Creek	abandoned	very small	315812	7117085

trending shear. In all eleven shafts were sunk and most have since collapsed. The deepest was partly timbered and probably reached a depth of >30m. A sample taken from a trench in the southern part of the workings by Brooks (1970c) assayed 1dwt/ton gold and 7.8dwt/tonne silver.

Small scale prospecting for gold was carried out at Dangarabungy, located in a State Forest ~19km north-west of South Durong. Pits and possibly some shafts were sunk in an up to 15m wide quartz dyke intruding schists of the Rockhampton Group (DCr). Recently the quartz has been used for landscaping purposes and current open cut workings are ~135m long, 15m wide and ~8m deep.

Nanango–Blackbutt Area

Gold at the One Mile line of workings (general grid reference AMG 4023500, 7049700) was said to have been discovered a few years before the opening of the Gympie deposits in 1867 (Table 38). No records are available on the gold won during those early years but Messrs. O'Brien and Hooper were credited with obtaining a few thousand pounds worth of gold. A slight revival took place in 1891 when Perseverance GM Co. began operations. Parsons and party erected a Chilian mill and puddling plant and by picking the best stone from the old workings managed to put through between 500–1000t of ore for an average of ~7.8g/t gold. They ceased work in 1894 and in 1900 the Nanango Dyke Syndicate applied for the abandoned ground and renamed it Golden King (AMG-402300, 7050000). The first crushing of 90t only returned 434g of gold and the mine was closed down. Mr. Gray, who worked on the 10m level near Hoopers Luck (AMG-402300, 7049900), reopened the old workings in 1913. Driving southwards he obtained 12t of ore which was crushed at Gympie for a return of 310g gold. Grays Luck GM Co. was floated and with Government aid the shaft was sunk to 82.6m. No gold-bearing reef was found (Ball, 1915).

The area appears to have remained idle until the 1930s when Messrs. Nielsen and Magnussen applied for Government assistance to continue sinking a shaft 200m north of the old Golden King and Grays Luck Mine. Cribb (1935) reported unfavourably on the mine and concluded the assays of samples taken revealed no payable ore. The One Mile Group now comprises a number of collapsed, filled and still open shafts, pits and scrapes which extend for over 1km. Most workings have been filled and are within small acreage holdings. Workings extend from the British Crown (at about AMG 402000, 7050500) in the north to Mary Jane (AMG 402400, 7049600) in the south and include, from north to south, Phoenix, Golden King Perseverance, Hooper's Luck, Hertzberg and Cohen, O'Brien's, Golden Pile and Parson's. At the northern end of the workings a tunnel was said to have been driven under Brights Road to workings on the other side. Mullock dumps were removed by a sawmill operator, and by the local council, for road aggregate (Arthur Bright, 1994, personal communication).

AOG Minerals, under **EPM 2951** in 1981, failed to define a substantial alteration halo at One Mile Diggings and concluded there was no indication of extensive stockwork mineralisation. Work undertaken by Peninsula Tin Pty Ltd (**EPM 3514**) in 1983 consisted of costeaning and sampling. A total of 309 samples were taken for gold analysis and 23 rock samples were taken

Table 38: Gold — Nanango–Blackbutt

Deposit Name	Location	Status	Size	Location	(AMG)
Grehan's A1	36.7km SSE of Nanango	abandoned	very small	413000	7014850
Marcasite	36.6km SSE of Nanango	abandoned	very small	413950	7015300
Nethercotes Mine	20.8km SE of Nanango	abandoned	very small	416650	7035800
One Mile Creek	1.4km E of Nanango	abandoned	very small	402350	7049700
Resurrection Mine	11.1km S of Nanango	abandoned	very small	401200	7038450
Seven Mile	10.5km SSE of Nanango	mineral occurrence	very small	405650	7040100
Yarraman Creek	11.6km SSE of Nanango	abandoned	very small	406700	7039350
Golden Bird	20.4km SSE of Nanango	abandoned	very small	408850	7030700
Mount Franey	6.7km SE of Nanango	abandoned	very small	406300	7045400
Opossum Creek	34.6km SSE of Nanango	abandoned	very small	416350	7018500
Emu Creek	35.6km SSE of Nanango	abandoned	very small	415550	7017050
General Jim	35.7km SSE of Nanango	abandoned	very small	415650	7016900
McNamara	15.3km SE of Nanango	abandoned	very small	413600	7040750
Mount Langan	35.2km SSE of Nanango	abandoned	very small	415100	7017250
Neilsen's	15.2km SE of Nanango	abandoned	very small	413250	7040500
Nellie Grant	13.8km ESE of Nanango	abandoned	very small	412500	7041950
Nukinenda	36.3km SSE of Nanango	abandoned	very small	413500	7015400
unnamed	4km NE of Nukinenda	abandoned	very small	417900	7008300
Nukinenda Creek	Nukinenda Creek	abandoned	very small	416703	7010505
unnamed	3km NE of Nukinenda	mineral occurrence	very small	416659	7008266
Milford Rocks	4.5km E of Nukinenda	abandoned	very small	419401	7006287
unnamed	4.5km E of Nukinenda	abandoned	very small	419117	7006044
unnamed	4km ENE of Nukinenda	abandoned	very small	418350	7007650
unnamed	4km ENE of Nukinenda	abandoned	very small	418210	7007926
Pickles Workings	15.2km SE of Nanango	abandoned	very small	413240	7040500
The Gold Show	14.9km ESE of Nanango	mineral occurrence	very small	413600	7041500
Yellow Ore	35.2km SSE of Nanango	abandoned	very small	415200	7017300
Red Queen Cu/Au	21.1km SE of Nanango	abandoned	very small	416700	7035400
Black Diamond Cu/Au	21.7km SE of Nanango	abandoned	very small	416950	7034750
Taromeo Copper Mine	18.8km SSE of Nanango	abandoned	very small	408900	7032450
Ashington Cu/Au	19.7km SSE of Nanango	abandoned	very small	407150	7030750
unnamed	Nukinenda Creek	mineral occurrence	very small	417850	7014300
unnamed	beside Forestry Track	mineral occurrence	very small	417288	7018012
unnamed	beside Forestry Track	mineral occurrence	very small	419555	7021113
unnamed	road cut S of Emu Ck	mineral occurrence	very small	412970	7016971

for later examination. Assay results indicated some elevated values (up to 2.3ppm gold) within a felsic dyke containing quartz stringers. This zone is not extensive and contains the area previously worked by miners. Altered siltstones about the dyke exhibit only marginally elevated gold values over the unaltered adjacent rocks. These values were considered to be far below the economic working values. A definite alteration halo exists about the felsic dyke but neither the altered rocks nor the dyke contain economically viable gold values.

After gold was discovered in the Nanango district in 1867 a rush to Seven Mile Diggings (centred on AMG 405650, 7040100) followed. The Seven Mile Diggings are situated near the junction of Yarraman and Cooyar Creeks, ~11km south-east of Nanango. By 1889 the field was abandoned and most miners went to Gympie. Mining recommenced in the early 1890s and continued until the early 1900s. Mining at the Seven Mile Provisional Goldfield has since been sporadic. Economically recoverable gold exists only in alluvial deposits that have been mined on a small scale with only a few shafts being sunk into the wash. Some reefs proved to be uneconomic. A number of gullies were worked including Callaghans Gully (in which Rands (1886) reported 21.7kg gold was obtained), Duffer Gully, Diggings Gully, Long Gully and Road Gully. The only flat worked to any extent was on the eastern side of Diggings Gully and almost in the centre of the field. Gold is not concentrated on the bottom of the wash but is evenly distributed throughout.

Gold recovered from the Wallace and Eldridge claim averaged over 31g/t of material troughed. Alluvial gold was worked in the 1890s and up to 700 men worked there at one time. No large-scale mining of reefs or alluvium was undertaken. Morton (1933, 1935) reported on attempts to revive alluvial mining but the ground was apparently neither extensive nor very rich. The greater part of the alluvial deposits was derived from insignificant veins in granite. Zircons, topaz, garnet, spinel, sapphires and ruby were also recovered from this claim (Brooks, 1963). Dash (1985) reported on the Nanango Shire Council's proposal to have the goldfield declared as a Recreation Reserve, though this has not occurred. **MLA 246** was applied for over the area but was not granted.

Gold was discovered in the Mount Langan (Mystery Mine, AMG 415100, 7017250) in 1902 by a stockman. Mr Henderson took up a prospecting area he named the Dattu-Dattu Mine. The prospects obtained near the Mystery Lode induced Messrs Palethorpe, Thorn and Langan to amalgamate with him. After Palethorpe's death in 1904 the property reverted to Mr. Hempstead, who abandoned the area some months later. Langan pegged the ground as a prospecting area and called it Snowdrop. Langan held five Prospecting Areas (PAs) in the area that he registered under the names of Snowdrop, Iceberg, Alexandra Queen, Silver Knob and Silver Star. Palethorpe's shaft was sunk to 8m on a band of altered granite (Taromeo Igneous Complex unit Rgm_{gd1}) 600mm wide and was said to have been carrying free gold. A sample from 5m down the shaft assayed 3g/t gold and 209g/t silver.

The Dattu-Dattu shaft was said to be 12m deep. A sample from the 5m level assayed 53g/t gold, 192g/t silver and trace bismuth. Silver Knob was sampled and returned values of trace gold, 967g/t silver, 13% lead and nil bismuth. Langan submitted a sample which when crushed and panned yielded 0.03% cassiterite (Ball, 1906a).

Further development took place in 1917 when ore was mined from an open cut (Glory Hole) on the Mystery Lode. Approximately 350t of ore were mined for a return of 308kg bismuth, 20.8kg silver and 341g of gold. In 1919 a trial parcel of 65t of ore was concentrated to 350kg and assayed 217–248g/t gold, 22.7–25.3kg/t silver and 19.4–23.4% bismuth. Mineralisation of the Mystery Lode is associated with closely spaced joints dipping 15–45° west-south-west.

In contrast the Snowdrop Lode strikes north-east and dips vertically. Snowdrop Lode consists of greisenised and silicified granodiorite up to 4m wide and is better defined than the Mystery Lode. Significant mineralisation, however, is confined to narrow veins within the lode. Assay results from rock chip sampling indicates only weak bismuth–silver–gold mineralisation extends laterally beyond the Glory Hole. Dimensions of the Glory Hole indicate no more than a few thousand tons of ore would be available for open cut and grades would not justify underground operations. Significant mineralisation in the Snowdrop Lode appeared to be of very limited extent. Diamond drilling of lodes in the Glory Hole could not be justified by the Mines Department (Brooks, 1970a).

CRA Exploration Pty Ltd under **EPM 462** undertook drainage sampling in the Mount Langan area during the late 1960s. AOG Minerals held **EPM 2507** during 1980–81 but relinquished the area after stream sediment sampling failed to locate any significant anomalous areas.

Burmine Pty Ltd acquired **EPM 4054** in 1985 and reported that Mount Langan prospect was held under **ML236 Nanango**, by Menzies Gold

N.L. Menzies purchased the lease after recognising an extensive area of flat-sheeted joints and intense argillic and propyllitic alteration south of an earlier worked open cut. In August 1985, Menzies drilled a 97.3m diamond drill hole under the open cut and intersected 65m of heavily altered, brecciated and pyritic granite. In June 1987 Menzies drilled eight percussion drill holes for a total of 363.2m at Mount Langan to follow up on earlier work. The walls of the open cut contain large (0.5m) breccia fragments, dominantly clast supported, with an overprinting of flat layering or jointing. The surrounding alteration is continuous over an area of five hectares, and a potential tonnage of the order of 100 000t per vertical metre is indicated. Mineralisation (bismuth–gold–silver) at Mount Langan is of two types; quartz veins and disseminated. The quartz veins dip steeply and are contained in greisenised granodiorite, such as the Snowdrop workings. The veins are usually less than 0.3m wide with contact sericitisation (?greisenisation) up to 2m on either side of the vein. Disseminated mineralisation in argillically-altered granodiorite breccia has been overprinted by sheeted joints dipping 15° west-south-west, e.g. Mystery Opencut. It was recommended that the EPM should be relinquished and that **ML 236** retained.

EPM 4752 was granted to Pensacola Pty Ltd on 21/5/1987 for a term of one year. It initially covered 23 sub-blocks surrounding a number of gold-arsenic prospects in the Nukinenda district. The EPM was granted to Pensacola Pty Ltd on 14/5/1987 and in early 1988 Pensacola entered a joint venture agreement with Marlborough Gold Mines Ltd. Early exploration by Pensacola included costeaning and surface sampling of several gold prospects which were worked on a small scale prior to 1940. Marlborough carried out a shallow percussion and diamond core drilling program of hydrothermally altered and mineralised Permo-Triassic hypabyssal intrusives intruding the Maronghi Creek beds. Prospects in the area include the **Nukinenda Dyke (AMG** 416703, 7010505), **Marcasite** (AMG 413950, 7015300) and **Grehan's A1** (AMG 413000, 7014850).

The Nukinenda Gold Project comprised **EPM 4752M** and **MLA 254** Nanango covering a number of gold prospects falling largely within the Maronghi Creek beds where gold mineralisation is associated with felsite-microgranite intrusives (too small to show at current mapping scale). Other indications of potential gold mineralisation have been found associated with chert–jasper sequences within the Maronghi Creek beds.

Early investigations by Pensacola in 1987 included costeaning and surface sampling of several gold prospects that were worked on a small-scale prior to 1940. Petrography was performed on polished thin sections from samples obtained from the rhyolite of the Big Cut at Grehans A1 Prospect. No gold was found in the Grehans A1 rhyolite, but there were weathered holes (after arsenopyrite) and traces of arsenopyrite indicating the possibility of leaching. Pensacola consistently obtained up to 2.0g/t gold from samples taken from the Grehans A1, while the Marcasite Prospect only yielded background results.

In 1988, Marlborough Gold Mines Ltd became the operator and carried out a two-stage exploration program concentrating on shallow percussion and diamond core drilling of hydrothermally altered and mineralised Permo-Triassic hypabyssal intrusives in the Marcasite and Grehan's A1 prospects. A total of 21 RAB, RC, and diamond-cored holes were drilled for an aggregate 809.4m. In addition, three shallow percussion holes were drilled at both Grehans A1 and Marcasite Prospects and one each in two other prospect areas. The holes at Grehans A1 recorded a 14m intersection averaging 0.44g/t gold within an altered felsite-microgranite intrusive. The other hole at the Marcasite Prospect failed to intersect significant mineralisation.

Regional stream sediment sampling with follow-up geochemical soil sampling and rock chip sampling was conducted over 26 continuous basins anomalous in arsenic referred to as the Emu Creek prospect. A group of copper anomalies near the junction of Prices Gully and Emu Creek cover a series of pyritic microgranite dykes. During 1989, further rock chip and samples were collected and a two-hole percussion drilling programme was completed in the Emu Creek prospect area (AMG 415550, 7017050). Grid soil sampling was carried out at the Marcasite and Big Cut prospects. Reconnaissance and rock chip sampling over soil anomalies and abandoned workings failed to establish any significant new zones of alteration and/or mineralisation that warrant detailed follow-up investigation.

MLA 254 Nanango was made on 5/8/87 for an area of 1000 m by 500m less a triangular area of ~350m by 250m in the south-west corner. The MLA was made to cover an extension of the **Milford Rocks Prospect** (AMG 419401, 7006287) outside the south-east corner of EPM 4752.

Gold mineralisation worked previously at the **Nukinenda Dyke Gold prospect** is contained

in gold–arsenopyrite bearing quartz veins hosted in a north-west trending diorite porphyrite dyke. Old workings, most of which are very shallow, extend along the outcrop of the dyke for a distance of 650m on opposite sides of the Nukinenda Creek. A programme of percussion and core drilling was carried out at the Nukinenda dyke gold prospect as a follow up to earlier reverse circulation drilling. Results of the drilling indicate that, although the dyke is weakly mineralised over a considerable strike length of ~650m, grades are too low for an economic deposit. Higher grade patches of gold–arsenopyrite mineralisation within the dyke are too widely spaced and erratic in their distribution for the dyke to have much potential for the proving up of a small to moderate tonnage orebody at shallow depth.

The **Marcasite** and **Grehan's A1** prospects were drilled and none of the holes intersected potentially significant mineralisation. Establishing a sampling grid, geological mapping and geochemical soil sampling were carried out at the prospects but delineated few worthwhile targets for drilling. Grehan's A1 (Big Cut) prospect contains a number of abandoned shallow workings within a microgranite dyke that intrudes black siltstones of the Maronghi Creek beds. Gold mineralisation occurs with arsenopyrite and pyrite in narrow quartz veins within bleached and weakly altered microgranite. The Marcasite prospect is a series of shallow pits trending north-east located along the north-eastern edge of a prominent chert outcrop that trends north-east.

East Ridge prospect covers chert-jasper sequences of the middle unit of the Maronghi Creek beds intruded by scattered dykes of tonalite-diorite porphyry. A sample of altered diorite from the northern part of the prospect area assayed 1.45 g/t Au and 0.43% Pb.

Central Ridge prospect also covers chert-jasper sequences of the middle unit of the Maronghi Creek beds intruded by scattered dykes of tonalite-diorite porphyry. A soil traverse line across a jasper unit to the south recorded no anomalous values although a rock chip of red jasper was found to contain 0.50g/t Au.

The **Cattle Pens** prospect covers silicified ferruginous breccias that contain anomalous gold and arsenic values in places. Geochemical soil traverse lines that traverse across breccias and jaspers of the prospect returned no anomalous metal values. A shallow percussion hole failed to intersect significant gold concentrations.

Andrew's Haematite Ridge prospect is over chert-jasper sequences of the Maronghi Creek beds. Disseminated pyrite and boxwork is visible in the more silicified and massive cherts. Bedding is poorly defined by alternating haematite-rich and haematite-poor layers. Rock chip samples failed to record any significant mineralisation.

Belz's workings are located in a low-order zinc drainage-basin anomaly in the north-western part of **EPM 4752**. The workings include an abandoned shaft and shallow pit situated adjacent to a north-east trending microgranite dyke. Fine-grained quartz and feldspar comprise the bulk of the dyke rock that contains minor disseminated pyrite and arsenopyrite. The workings are located in hornfelsed sediments of the Maronghi Creek beds immediately north-west of the microgranite dyke. Mineralisation appears to be controlled by fine fracturing forming thin veins of quartz and limonite. Two rock chip samples from the shaft mullock heap recorded encouraging gold values of 0.22g/t Au and 0.54g/t Au, but mineralisation is too localised along a short strike length to be of significant economic importance.

A regional geological mapping and a stream sediment sampling survey were also undertaken during 1988. Extension of the stream sediment survey to the north into the adjoining **EPM 5498M** (also being explored by Marlborough) delineated 26 areas anomalous in arsenic spanning the boundary of the two ATPs. This combined group of anomalies was called the Emu Creek Prospect (centred on AMG 412800, 7017700). Sampling programs outlined several areas strongly anomalous in arsenic that were generally spatially associated with quartzite lenses or microgranite dykes in unit Rgm_{gd1} of the Taromeo Igneous Complex. Rock chip sampling of quartz-arsenopyrite veins within these quartzite lenses detected weakly anomalous gold.

A two-hole percussion-drilling program was subsequently undertaken on the Emu Creek Prospect within the adjoining **EPM 5498M**. A black granite resource within the original tenement boundary was also evaluated. Three core samples from the black granite resource were assayed for platinum group elements platinum, palladium and rhodium as well as gold. Within the EPM area a total of twelve rock chip samples were collected and analysed for arsenic, bismuth, mercury, antimony, selenium, tellurium and gold. Rock chip sampling was conducted over soil anomalies and abandoned workings but failed to establish any significant new zones of alteration and/or mineralisation that would warrant detailed follow-up investigations.

Keela-Wee Exploration Ltd **(EPM 5710)** reported that this tenement contains mainly siliceous and micaceous mudstones of the Maronghi Creek beds intruded by small bodies of Taromeo Igneous Complex (Rgm_d). Exploration in the area commenced with a program of stream sediment sampling (including a proportion as bulk leach samples), and rock-chip sampling, mostly along a creek system draining a series of old pits. A follow-up soil sampling grid was employed to establish a drilling target, and one percussion hole was subsequently drilled to 127 metres in the vicinity of the old Opossum Creek (AMG 416350, 7018500) workings. The hole intersected abundant pyrite mineralisation within brecciated cherts between 26–86m. Anomalous gold was intersected between 24–28m with a maximum assay of 2.28ppm between 24–26m. However, the surface geology was considered to indicate that the zone of mineralisation was probably very limited in size, and consequently the ground was surrendered.

In the Taromeo Creek area ~10km north-north-east of Blackbutt, several shafts were sunk on the Black Diamond and Red Queen prospects. Ball (1900) reported that copper and silver occur with gold in reefs in granite.

The Black Diamond Gold Mine (GR 416950, 7034750), now mapped in unit Rgm_d of the Taromeo Igneous Complex, is located ~12km north-north-west of Blackbutt. It is situated beside Coppermine Gully ~1km south-east of the Red Queen and now consists of a series of collapsed shafts and trenches. A small rush took place at the site during the mid 1880s. Approximately 200m north-east of Black Diamond, a shaft called "The Boer Shaft" was sunk in the bed of Coppermine Creek on a vein of ferruginous quartz varying from 560mm to 1.2m in width (Ball, 1900).

Pits and trenches of the former Black Diamond Gold Mine form a line with approximately the same north-east–south-west trend as the Red Queen mine (AMG 416700, 7035400) and extend for almost 1km. One shaft of the Black Diamond was said to have reached 10m in depth. In one place the reef measured 560mm but averaged no more than 300mm in width. Lode material consists of quartz stained with iron oxides, copper oxides, malachite and gold. The mineralised vein occurs between the slickensided granitic footwall and a hanging wall of broken quartz that is up to 150mm thick and slickensided. The vein strikes north-east to south-west and dips steeply to the south-east. The host rocks at Red Queen are sedimentary rocks of the Esk Formation.

EPM 4970M Taromeo was granted to Energy Minerals Pty Ltd on the 28th September 1987. Valdora Minerals Limited (Valdora) was granted the right to earn 100% interest in the area in return for a guarantee to fulfil EPM expenditure and reporting commitments. Valdora subsequently became the registered holder of the EPM. Keela-Wee Exploration Limited (Keela-Wee) entered into a joint venture agreement with title holders Valdora Minerals Limited in May 1989, with Keela-Wee as manager and operator.

Six rock chips from the Black Diamond and Red Queen were assayed for gold only, in an attempt to repeat Valdora's earlier rock chip assays. A best result of 36.5g/t gold was obtained. Soil sampling was conducted over a selected portion of the old Black Diamond gold mine in order to validate Valdora's previous anomalies (up to 27.1g/t gold and 8.5% arsenic for the Red Queen and up to 11.0g/t gold for the Black Diamond). Peak values for anomalous elements were 0.11ppm gold, 46.3ppm arsenic, 66.0ppm copper, 28.3ppm molybdenum, and 111ppm zinc. The arsenic anomalies correlate well with the gold anomalies. Most gold anomalies lie in gullies or flat areas, whereas the major arsenic anomaly (46.3ppm) lies on the second highest hill in the grid area and slightly south-west of the main copper-anomalous trend. The peak gold value could be related to trench backfill material. A ground magnetic survey was conducted at the same time as the soil sampling over the grid, however the results were inconclusive.

A proposed two hole percussion drilling program to test the arsenic anomaly, was delayed due to heavy rain and subsequently cancelled due to discouraging results in **EPMs 5224 and 5225** held by Keela-Wee in the general vicinity of **EPM 4970M** Taromeo. Keela-Wee withdrew from the joint venture on the 19th September, 1989 and the EPM was relinquished.

The Red Queen Mine was opened prior to 1900 and was sunk to ~50m. Ball (1900) reported the gold content of the ore varied from 0–6g/t gold, 8–15g/t silver and a trace of copper. At 10.8m below the collar in the main shaft the values had increased to 20g/t gold, 21g/t silver and 0.64% copper. No figures were recorded but production is believed to have been small. Another shaft was sunk on the mineralisation to test a north-east extension of the lode to 17m depth. Ball (1912a) recorded panning native silver and copper from dump material associated with this shaft. Two more shafts were sunk in the 1970s, one 27m south-west and the other 41m to the west over a gully. Based on data presented by Ball (1900, 1912a) it would appear that the north-east end of the mineralisation shows the

most promise. Robertson (1974) reported that unless the veins increased in both value and width with depth there appeared little chance of payable quantities of ore being discovered.

The Golden Bird group (AMG 408900, 7030700) is located ~5km north-north-west of Blackbutt and close to Ashington and Taromeo copper/gold mines. Golden Bird is made up of eight gold mining leases (GMLs) bordering on one another. Denmead (1934) reported that small crustal deformation had resulted in fractures that allowed gold bearing solutions to percolate through the quartz diorite in three ways, namely:

1. a system of small irregular quartz veins,
2. a well defined formation containing quartz, and
3. a chloritic formation with little quartz.

Small quartz veins that comprise the deposit vary greatly in width and range up to 150mm but average 50mm in width. Gold values for these were often high at the surface but diminished rapidly with depth. A strongly defined formation called "Paddy's Reef" is ~460mm in width and contains quartz in varying proportions as well as being chloritic in character. The chloritic formation with little quartz resembles a dyke but is a band of highly altered quartz diorite and is variable in both composition and texture. Silica is present as small irregular quartz veins, as cryptocrystalline cherty material or as glassy grains. At a depth of 15m there is less silica and more chlorite. Minor cobaltite is also present at this depth as disseminated grains within the chlorite matrix. Gold values decline with depth and are absent below 15m.

Mount Franey (Mount Powers, Golden Gull PA, AMG 406300, 7045400) is located ~9km east of Nanango and is hosted by the Maronghi Creek beds. The Nanango Gold Mining Syndicate, consisting of residents of Nanango, applied for GMLs 22–26 in 1921, over areas of Greenwood Creek and Mount Powers. Ball (1921) reported on the Syndicate's leases that covered the old Mount Powers workings. A sample from the Syndicate's 10m shaft returned assay values of 4g/t gold and 1.6g/t silver. Three tonnes of iron-stained gold-bearing quartz was sampled and assayed 158g/t gold and 17g/t silver. McKeone and party sent a trial crushing, from their Greenwood Creek prospect, to the State battery at Gympie with a disappointing return of 53g gold. A report by Denmead (1944) on the Golden Gull Prospecting Area at Mount Powers, was not encouraging. Workings were concentrated on a 5m wide quartz veined intermediate dyke. On the available evidence the quartz veins were not rich enough to warrant mining of the entire dyke. He advised the Nanango Prospecting Syndicate to continue prospecting but if grades did not improve to abandon the prospect.

Kingaroy–Cooyar Area

EPM 5447M (CR: 20700) Cooyar, was granted to Joseph Patrick Williams on 20th June 1988 and relinquished on 14th July 1989. Exploration in this area was for gold and base metals (Table 39). The area was selected as a gold and base metal prospective area because of regional geophysical trends and radial dykes that suggested doming and a model of epithermal mineralisation with low silica content. Exploration involved detailed mapping, stream sediment and rock geochemistry and geophysics. Three areas were selected for geophysical tests. The stratigraphic units within the EPM area are the Maronghi Creek beds, Boondooma Igneous Complex, Woogaroo Subgroup, Marburg Subgroup and Main Range Volcanics. Structurally the area is part of the Yarraman Subprovince and regional trends are north-north-west that is shown by the regional Bouguer gravity map.

The Maronghi Creek beds consist mainly of metagreywacke and metasiltstone. Intruding the Maronghi Creek beds, the Boondooma Igneous Complex consists of granite and granodiorite in this area. Contacts with the Maronghi Creek beds are generally sharp though in areas they have been altered by hydrothermal processes. A major northerly foliation occurs in some parts of the complex within the area and could be related to a deep seated ductile deformation event. A brittle phase of faulting was also recognised in the area and both ductile and brittle deformations are present in the Maronghi Creek beds and the Boondooma Igneous Complex. The Jurassic Marburg Formation overlies both the Maronghi Creek beds and Boondooma Igneous Complex. Radial dyke patterns indicated by the regional geology have not

Table 39: Gold — Kingaroy–Cooyar

Deposit Name	Location	Status	Size	Location	(AMG)
unnamed	~3km SW of Cooyar	abandoned	very small	381350	7013400
Ml 203156	~4km W of Maidenwell	mineral occurrence	very small	375964	7030789

been substantiated and no such pattern was located east of Cooyar. However an interesting dyke swarm is located south-east of the township.

West of the township very few dykes were located although no radial pattern could be seen. However, in that area the metasediments are part of a mineralised roof pendant that was considered significant. The distribution of dykes in the area suggested a radial pattern that may be due to doming — one west of Cooyar and the other to the north-east. Regional gravity anomalies suggested that the dykes may be genetically related to the Eskdale Igneous Complex, a complex associated with many gold occurrences. Williams (1987) proposed a similar genetic relationship between the Djuan Tonalite and the Eskdale Igneous Complex. It appears likely that the Boondooma Complex at Cooyar was also genetically related to this system which has little excess silica in the form of quartz reefs.

Prior to this investigation, no mineralisation had been recorded at Cooyar. Mapping revealed the existence of shafts near Rangemore Road. The workings have been filled in (property of Mr. Jones) and the quartz mullock used for retaining walls. Mr. Jones stated that the shaft was 20ft deep with a 30ft drive. From mapping this would follow a shear on a bearing of 95°. In addition to this mineralisation, minor sulphides were recognised in:

a. a dyke swarm south east of Cooyar,
b. a roof pendant on Cooper Station,
c. a contact zone south of Rangemore Road, and
d. a rhyolite plug to the south-west of Cooyar.

A stream sediment sampling program was conducted over the EPM area. Samples of 8kg each (3mm sieve) were collected for treatment by cyanide leach. The high velocity nature of streams precluded other forms of sampling. Stream sediment sampling results indicate an increase in values towards area 1 (immediately north of the old shaft). However, due to a lack of samples in high velocity streams and the low values recorded, it was impossible to define a target locality.

Forty-two rock chip samples (4kg samples) were assayed for gold by fire assay and silver and copper by AAS. The highest gold value of 0.06 Au was from a sulphide-bearing hornfels, and the highest copper value was 35ppm from a granite sample. Silver was not detected (<1) in any sample. The original premise of radial dykes indicating doming was proved incorrect. However, the Maronghi Creek beds north of Rangemore Road are a roof pendant and contain disseminated mineralisation along the granodiorite-hornfels area in the south. Sulphide mineralisation also occurs in the rhyolite plug to the south-west. Mineralisation in a dyke swarm to the south-south-east of Cooyar was considered insignificant. Geochemical and magnetic survey results did not indicate any areas worthy of follow-up.

Murgon Area

A small number of minor gold deposits are present in the Murgon area (Table 40). Bar 23, Misst, Red Rock and Golden Spur are all located in the Wooroonden Granodiorite. Saint-Smith (1923) visited the Bar 23 gold mine and noted in his report that gold was discovered there by John Corry in 1922. The workings now consist of a small pit on the western side of Stonelands Road near the Red Rock prospect. Kay (1978) reported on Red Rock prospect and noted the gold occurred in a series of narrow (30mm wide), subparallel veins of glassy quartz. The veins are vertical and strike east-west in decomposed granitic rocks. Kay (1978) did not visit the Misst prospect but noted it was said to be geologically

Table 40: Gold — Murgon

Deposit Name	Location	Status	Size	Location	(AMG)
Bar 23 Gold Mine	27km NW of Murgon	abandoned	very small	373590	7114692
Red Rock	27km NW of Murgon	abandoned	very small	373612	7114303
Golden Spur	27km NW of Murgon	abandoned	very small	373635	7116782
Misst	27km NW of Murgon	abandoned	very small	373380	7114354
Boisens No 1	not Located; ~1km S of Wondai	abandoned	very small	387520	7086620
Boisens No 2	not Located; ~2km S of Wondai	abandoned	very small	386800	7085899
Wondi	10km SE of Wondai	abandoned	very small	390860	7078650

Table 41: Gold — Esk-Crows Nest

Deposit Name	Location	Status	Size	Location	(AMG)
unnamed	17km ESE of Crows Nest	abandoned	very small	423050	6979720
unnamed	16.5km ESE of Crows Nest	abandoned	very small	421310	6976884
unnamed	16.5km ESE of Crows Nest	abandoned	very small	421290	6976470
unnamed	16.5km ESE of Crows Nest	abandoned	very small	421220	6976800
unnamed	16.5km ESE of Crows Nest	abandoned	very small	421240	6976960
unnamed	16km ESE of Crows Nest	abandoned	very small	421610	6978030
unnamed	16km ESE of Crows Nest	mineral occurrence	very small	421547	6977890
Sylvester	17km ESE of Crows Nest	abandoned	very small	422960	6979520
Kipper Creek	~13.5km W of Esk	mineral occurrence	very small	428876	6987366
Saxon	Pyramid Group, ~14km W of Esk	abandoned	very small	428185	6988640

similar to Red Rock. D. Schultz probably worked the Golden Spur in the 1960s and 1970s.

Boisen's No. 1 and No. 2 were not located during the 1997 Departmental mapping program though anecdotal evidence (Mick Boisen, personal communication, 1998) suggested little if any gold was recovered. The workings at Wondi are partially filled with red chimney brick and corregated iron.

Cressbrook Creek Subprovince

Esk-Crows Nest Area

Sovereign Mining Pty Ltd was granted **EPM 3506** (48 sub-blocks) on the 30th May, 1983. The exploration targets were volcanogenic base metals and epithermal and alluvial gold, associated with Lower Permian acid–intermediate volcanics and sediments (Table 41). The EPM area covers part of the gazetted Ravensbourne Goldfield. Sovereign completed detailed photogeological interpretation, reinterpretations of previous stream sediment geochemical data, reconnaissance rock chip geochemical sampling and stream sediment geochemical sampling.

Results of this work indicated a number of drainages other than those associated with known mineral occurrences that are anomalous in base metals and gold. It was concluded from a review of the geological and geochemical data that the probability of locally economic mineralisation of the type sought, was too low and the EPM was relinquished in full.

Helidon Area

Cribb (1936) inspected mining claims on Alice Creek ~7.5km north of Helidon in the Lockyer District (Table 42). It was noted that the Bundamba Group sandstones had been eroded by Alice Creek and exposed older slates and sedimentary rocks (Pinecliffe Formation). In the area large dykes of porphyrite and porphry had intruded the older rocks. An underlie shaft at Discovery Claim was sunk on a reef, averaging 75mm wide, within a porphyry dyke. Gold occurs in a reef of arsenopyrite, pyrite and quartz between walls of altered intrusive. An average value of 37.3g/t Au was obtained by sampling

Table 42: Gold — Helidon

Deposit Name	Location	Status	Size	Location	(AMG)
unnamed	10km N of Helidon	abandoned	very small	413400	6963200
Alice Creek	Alice Creek, 7.5km N of Helidon	operating	very small	414000	6959400
unnamed	Alice Creek, 6km N of Helidon	abandoned	very small	412800	6958900
unnamed	~7.5km N of Helidon	abandoned	very small	414000	6960000

over 90–180 mm. Cribb (1937) again reported on operations at Alice Creek and noted that at the time many claims had been pegged despite the identification of only one reef. It was believed that only those claims situated on the line of reef outcrop had any prospects.

Murphy's Creek (EPM 3920) was granted to Pancontinental Mining Limited on 23/8/86. The target was bulk tonnage, low-grade gold mineralisation in quartz vein-stockworks. There are no major mines in the EPM, but small old workings exist at the Alice Creek gold mine (AMG 414000, 6959400, active at that time), Paradise Creek copper mine (AMG 413600, 6963500), abandoned) and the Silver Crown lead–zinc–silver mine (AMG 409800, 6968800, abandoned). At Alice Creek Mine gold was still being mined on a small scale. The gold is vein hosted, high grade (10g/t Au) but of low tonnage. Production records were unavailable but grades worked were quite high (to 53g/tonne Au). Gold-silver mineralisation in the EPM area is associated with hydrothermally induced quartz veining and brecciation. Potential for epithermal mineralisation was enhanced by the discovery of a gold-bearing silicified breccia at Kynoch Road Prospect, as well as gold quartz vein-stockwork mineralisation in the Alice Creek Prospect in the southern part of the EPM.

Kynoch Road Prospect was geologically mapped at 1:1000 scale and 17.8 line km of gridding and 3 line km of soil sampling was carried out. A ground magnetic survey totalling 6.05 line km was completed. Backhoe trenching consisted of 10 trenches for 637m and the trenches were channel sampled. Reconnaissance geological mapping, rock-chip and bulk stream sediment sampling was also carried out in the area surrounding the prospect. An I.P. geophysical survey totalling 4.0 line kilometres was completed. The results of the channel sampling revealed continuous moderate gold anomalism within the north-east trending hydrothermal breccia, weak anomalism within the marginal advanced argillic alteration zone and strongly anomalous to ore grade values from zones of quartz veining. It also showed quartz-vein stockwork marginal to both the breccia and the argillic alteration zone. The best intercept was 5m at 2.17g/t Au from 30–35m in Trench A.

The Kynoch Road Prospect consists of a hydrothermal breccia of significant width (70m) and strike (150m) has been exposed with marginal advanced argillic alteration and sulphide quartz-vein stockwork development. Anomalous gold has been recorded from more ferruginous, possibly later generations of hydrofracturing within the breccia. Ore-grade values from channel sampling (5m @ 2.17g/t Au) and rock chip sampling (9.44g/t Au) have been recorded from sulphidic quartz-vein stockwork zones which outcrop marginal to the breccia. A significant drill target is indicated which was planned to be drilled in the forthcoming exploration programme.

Alice Creek Prospect. Outcrop and contour bench exposures at the Alice Creek Prospect were geologically mapped at 1:1000 scale and 4.5 line km of grid sampling and 2.4 line km of soil sampling was completed. A ground magnetic survey totalling 5.5 line km was completed. Three new contour benches were bulldozed for 570m and the benches were channel sampled. Reconnaissance geological mapping, rock chip, panned concentrate and bulk stream sediment sampling was also carried out in the area surrounding the prospect.

The outcropping source of strongly gold anomalous (to 30g/t Au), ferruginous, crystalline quartz float occurring at the base of the slope has been identified as a zone of outcropping quartz veining with silicic alteration and disseminated sulphides, ~25m wide. Much of this exposed width is only weakly auriferous with narrow zones (to 2m) carrying high anomalous values (to 1.76g/t Au). A low-grade disseminated gold target may exist on the flanks of the silicic alteration zone with broad intercepts of up to 30m @ 0.68g/t Au (includes 5m @ 1g/t Au) being recorded. Drill testing of this prospect was recommended.

The **Staghorn Prospect** was identified and is located one kilometre north-west of the Kynoch Road Prospect. It was located during regional mapping and indicates a possible repetition of the alteration and mineralisation seen at Kynoch Road. A hydrothermal breccia is exposed in the western part of the prospect. Rock chip sampling revealed background to weakly anomalous levels of gold (maximum assay 0.03g/t Au), arsenic, mercury, antimony, base metals and silver. Anomalous bismuth (up to twice the background), selenium (over 6 times background), tellurium (twice background) and sulphur (over 10 times background) were recorded. These results suggest a gold barren hydrothermal system has been exposed which may genetically related to the gold bearing Kynoch Road system one kilometre to the south-east.

The **Mount Cross Prospect** was downgraded in 1984 after a stream sediment survey. Check panned concentrate sampling provided encouragement for re-evaluation of this prospect as a gold target. The panned concentrate sampling indicates that coarse gold is being shed into the lower reaches of Alice Creek. The most likely

source being the Alice Creek mine or the Alice Creek gold prospect. The potential of this prospect lies in the possibility of discovery of base and/or precious metals mineralisation within the Palaeozoic volcanic units. There is also the possibility of chromite or platinoid concentrations occurring within the mafic-ultramafic intrusives.

The **Silver Crown prospect** was initially thought to be a prospective VMS target. An orientation stream sediment survey conducted around the known mineralisation at Silver Crown showed that the best indicator elements were copper, lead, zinc and arsenic. Lead and zinc were the most strongly anomalous elements and are representative of known mineralisation at Silver Crown. Geophysical surveys (I.P/E.M., and ground magnetics) were conducted over the area. After geologically mapping and rock chip sampling, the Silver Crown prospect was downgraded due to the subaerial nature of the volcanic sequence and the discovery that alteration and sulphide mineralisation, while broadly stratabound, was epigenetic and hydrothermal. Analytical results downgrade the prospectivity of the pyroclastic unit as a massive sulphide target. The low precious metal content (<0.10g/t Au) of the silicic altered sulphide bearing zone also reduces its potential as an epithermal gold target. The best values from rock chip sampling by Pancontinental Mining are 1.17%Pb, 1.67%Zn, 2.24%Cu, 0.46g/t Au and 72g/t Ag. The contained tonnage was too small to constitute a viable target, however this mineralisation may constitute a feeder zone to stratigraphically higher large tonnage massive sulphide mineralisation. The most likely target area for development of massive sulphides would be within a fine distal facies, which could exist downdip beneath Mesozoic cover rocks to the south. The large area of exposed volcaniclastics to the south-east of the volcanics could also have massive sulphide potential.

The **Paradise Creek prospect** was considered prospective for quartz vein-stockwork hosted precious metals on the basis of hydrothermal alteration and encouraging rock chip results (130g/t Ag, 0.31g/t Au and 13.4% Cu). At the Paradise Creek prospect creation of a sampling grid, orientation soil sampling, detailed geological mapping (1:500 scale), location of mine workings, petrological examination and rock chip sampling were conducted. Weakly anomalous gold values from the soil (40ppb Au) correlate with weakly anomalous gold values from channel sampling of quartz lodes (max.0.3g/t Au).

In the **Perseverance Area** there is some scope for the development of epithermal breccia hosted mineralisation indicated by the presence of haematite breccia lodes that intrude both the rhyolitic and tuffaceous units. Strong argillic alteration occurs in wall rocks adjacent to these lodes. Rock chip sampling within the Hampton Road Rhyolite and the thick tuffaceous sequence reveal no significant gold values, all were less than 0.01g/t Au. The haematite breccia lodes near Perseverance village show low gold and arsenic with maximum rock chip assays of 0.07g/t Au and 16ppm As. Immediately north of the Esk–Hampton road strongly silicified, veined and base metal sulphide bearing Hampton Road Rhyolite returned background gold assays (0.03g/t Au) and anomalous arsenic (125ppm), copper (640ppm), tellurium (1.15ppm) and barium (1600ppm).

Exploration by Pancontinental Mining Limited **EPM 5232 M** (CRs 19375, 20678), assessed the Murphy's Creek prospect which has targeted bulk tonnage, low-grade gold mineralisation in quartz vein stockworks. A mineralised breccia zone was identified in a gold-bearing silicified breccia at the Kynoch Road Prospect as well as gold quartz vein-stockwork mineralisation in the Alice Creek Prospect in the southern part of the project area.

EPM 4484 was granted to Hoult Mining and Exploration Pty Ltd on 16/11/1986 and was surrendered in November 1988. The tenement was originally 80 sub-blocks and the target was epithermal gold and volcanogenic silver and base metal mineralisation. Numerous pits, shafts and workings were examined from the Bunker's Hill area through to the north-eastern Sylvester zone. Photogeological studies indicated that volcanogenic silver–base metal occurrences were located in the axial regions of a north-east trending fold belt while the gold is concentrated in a block faulted area in the south of the tenement. Petrology and geochemistry confirmed the existence of extensively altered zones anomalous in epithermal type trace elements. However, bulk leach gold and stream sediment geochemistry failed to indicate any areas of potential mineralisation.

EPM 5224 and **EPM 5225** were held by Keela-Wee Exploration Limited. Exploration was conducted and reported together. A reconnaissance bulk cyanide leach, -40# stream sediment and rock chip sampling programme was conducted in late 1988. Follow-up sampling did not provide evidence to explain some of the anomalies reported in previous reports. EPM 5224 consisted of 12 sub-blocks on NANANGO. Results were disappointing and consequently the EPM was relinquished. **EPM 5225** consisted of 6 sub-blocks. The only mineralisation evident was disseminated pyrite contained predominantly in the siliceous mudstone near granitoid

contacts. A detailed follow-up programme consisting of bulk cyanide leach and rock chip sampling was conducted in early 1989 by Keela-Wee Exploration Limited. Only one BLEG sample returned a gold value >1.0ppb. Follow-up of the 6.2ppb Au assay failed to either locate the source or repeat the value. Results were disappointing and consequently the EPM was relinquished on March 23rd, 1989.

Pancontinental Mining Ltd held **EPM 5231** (100 sub-blocks) from 11/2/1988 and 10/2/1989. Regional geological mapping at 1:25 000 scale was conducted in conjunction with the geochemical sampling program. A total of 26 BLEG samples were collected from within the EPM area. The average sample spacing was ~2km. A total of 15 panned concentrate samples were collected from within the tenement. Sixteen rock chip and ten channel samples were also collected. Weak and localised gold-barren propylitic alteration and quartz veining occur marginal to granodioritic Permo-Triassic intrusives that transect the Permian volcanic sequence. An outcrop of jasper-bearing quartz-vein stockwork in the Mount Cross area was found to be gold-barren. Exploration failed to discover any significant precious metals mineralisation worthy of follow-up; consequently the EPM was relinquished.

Pancontinental Mining Ltd. held **EPM 5232,** made up of 100 sub-blocks, from 11/8/1988 to 10/2/1989. Exploration was designed to evaluate the regional potential of the tenement as well as to test the Kynoch Road prospect with a geophysical survey and a petrological study. Regional geological mapping, BLEG sampling, panned concentrate sampling and rock chip sampling was carried out at a regional scale. A petrological study and CSAMT survey was carried out at the Kynoch Road prospect. Exploration failed to discover any significant precious metals mineralisation worthy of follow-up; consequently the EPM was relinquished.

EPM 5479 Milford Rocks, comprising 56 sub-blocks was held by a joint venture of Pensacola Pty Ltd (48.45%), Pavstar Pty Ltd (46.55%) and Jalsign Pty Ltd (5%). The area was considered prospective for gold mineralisation and it was planned to conduct exploration in conjunction with exploration activities on the adjacent EPM 4752 in which Pensacola and Pavstar also held substantial interests. A literature search of the area was conducted. The main target within EPM 5479 was gold, although all economic mineral deposits, and industrial deposits were of interest. Small gold occurrences have been reported within and immediately adjacent to EPM 5479. Extrapolation of the influence of exploration work from adjoining EPM 4752 into EPM 5479 has been used in the tenement assessment, information review and field prospecting. Only reconnaissance prospecting was undertaken in EPM 5479 due to abnormally wet weather. It was decided not to renew EPM 5479 Milford Rocks because of low apparent prospectivity and commitments of the joint venture resources elsewhere.

EPM 6087 consisted of initially 94 sub-blocks reduced to 23 sub-blocks, located 10km west of Esk. Initially CRA Exploration Pty Ltd carried out exploration in a Joint Venture with titleholder P.J.Byne. Exploration of the area has included geochemical surveys, geological mapping, geophysical surveys (ground EM and aeromagnetics) and drilling. An extensive elongate zone exhibiting elevated base metal geochemical results was identified. Drilling within two small selected areas of this zone has returned encouraging results. The best drill intersection for gold was 14m at 1.12g/t Au. Elevated copper, lead and zinc values were also recorded in some holes. The best copper intersection was 2m at 2.37%. It was considered that the EPM area remained prospective for volcanic hosted base metal (±gold) type deposits and gold mineralisation associated with quartz vein (stockworked) systems within hydrothermal feeder zones. During the final term of the tenement Auralia Resources NL merged with Ross Mining NL. As a result of the merger, Ross Mining acquired management of the tenement. Ross Mining geologists after study of results obtained by CRA during the joint venture with Auralia, recommended that no further work was warranted and the EPM was allowed to expire on 19th October 1995.

EPM 7543 Champion of 49 sub-blocks was granted to CRA Exploration Pty Ltd on 27/8/1990. Exploration consisted of a literature review, re-evaluation of previous stream sediment results, geological mapping at 1:10 000 scale, rock chip sampling (42 samples) and ridge and spur sampling (44 samples). Several base metal and gold occurrences were reported north and west of the area which in association with the volcanic sequence suggested the area is prospective for volcanogenic base metal deposits (VMS) and perhaps epithermal or porphyry system related precious metal deposits. Soil sampling has identified a small area of moderately anomalous lead (210ppm Pb maximum) and zinc (460ppm Zn) in soils in the northern part of the EPM. As no significantly anomalous values of base metals or gold were encountered in rock chips it was considered that the area had little potential for significant base metal or gold mineralisation and the EPM was relinquished.

Table 43: Gold — Goomeri

Deposit Name	Location	Status	Size	Location	(AMG)
South Burnett	22.2km WNW of Kilkivan	abandoned	very small	403350	7123400

Esk Trough

Goomeri Area

South Burnett Mine (AMG 403350, 7123400) in the Tansey area was first prospected in the 1918–19 period and was known as Mount Mac (Table 43). Major development was undertaken from 1934–1942 when the South Burnett Gold Mining Development Syndicate produced 3200t of ore for a yield of 40.772kg gold and 36.947kg silver. From an insignificant outcrop the ore-body increased in size with depth and reached a length of 84m on the 87m level. Ore was crushed and treated at the syndicate's five-head battery and amalgamation plant. The Department of Mines drilled the mine area in 1966–67 as part of a general program of exploration in the Kilkivan area. Two holes intersected gold–silver ore of possible economic significance. Supplementary drilling was then carried out in 1968, but only one hole reached target depth. Gold is associated with quartz and quartz-calcite veins in sheared graphitic mudstone of the Neara Volcanics, adjacent to and within andesitic dykes. Gold mineralisation may be genetically related to trachyte dykes, which are more numerous within a 400m radius of the mine (Brooks, 1970a). In a geochemical prospecting program undertaken by Ridley (1968), nine areas were identified as anomalous. Negative results from costeaning three of the anomalies indicate the anomalies reflect weak local mineralisation about the mine. Tailings have been recently removed from the old onsite plant area.

In 1981, Samantha Exploration **(EPM 3078-CRs 10032, 11232)** searched for low grade gold and copper deposits near Tansey. An epithermal model for exploration was based on occurrences of low grade gold deposits at Mount Rawdon and porphyry-style copper deposits at Goonulum Creek. From 52 samples assayed for gold from an anomalous arsenic area, only 13 samples returned 2045ppm gold. As a result of regional mapping, stream sediment and rock chip geochemistry it was considered that the type of mineralisation sought was unlikely to be found and the EPM was relinquished.

Peko-Wallsend took out an **EPM (3635)** to explore for bulk low-grade gold in the Tansey area. Known mineral occurrences in the EPM included the South Burnett Mine (AMG 403350, 7123400). Sampling at the South Burnett Mine returned some promising results but the limited dimensions of the mineralisation and the restricted alteration zone indicated a large scale ore body was unlikely.

International Geological Services Pty Ltd **(EPM 5110)** undertook investigations in the area in 1989. Detailed air photo interpretation was undertaken and an interpretative geological map produced. Further work was recommended but not undertaken.

Battle Mountain (Australia) Inc **(EPM 7736)** explored in the Tansey area but only three -180μm stream sediment samples and one rock chip sample were taken. The investigation failed to identify an economically viable deposit.

IRON OXIDE

Yarraman Subprovince

Nanango and Murgon Areas

At the now abandoned Lucky Friday mine, 31.8km south-south-east of Nanango, iron oxide was recovered by open cut during 1948–1951 (Table 44). Iron oxide is present within the Devonian–Carboniferous Maronghi Creek beds. Production figures are incomplete, however a total of at least 130t of iron ore as haematite were recovered for possible paint and enamel manufacture.

Table 44: Iron Oxide

Deposit Name	Location	Status	Size	Location	(AMG)
Lucky Friday	~32km SSE of Nanango	abandoned	very small	415450	7021150

Table 45: Limestone

Deposit Name	Location	Status	Size	Location	(AMG)
Barambah	6km SE of Murgon	operating	small	397620	7091800
Barambah	6.5km SE of Murgon	mineral occurrence	small	397810	7091180
Barkers Creek	7.5km SE of Murgon	abandoned	very small	397802	7090300
Cherbourg	11km SSE of Murgon	mineral occurrence	very small	398550	7086200
Grasstree	13km NNW of Hivesville	mineral occurrence	very small	374450	7116220

LIMESTONE

Yarraman Subprovince

Murgon Area

Limestone deposits south-east of Murgon are part of the Carboniferous Bjelke-Petersen beds (Cb_l) (Table 45). The limestone is variably recrystallised and poorly fossiliferous. The geology of the Barambah limestone bodies was subsequently described in some detail by Martin (1977) in the context of their economic value as quarry rock.

At Grasstree minor earthy lime is present within the Wooroonden Granodiorite.

MANGANESE

Yarraman Subprovince

Nanango Area

Minor manganese mineralisation is present within sediments of the Maronghi Creek beds (DCm) west of Nanango (Table 46). Extracts from Warden's reports in the Annual Report, Mines Department show prospecting for manganese west of Nanango started as early as 1917. Trenching proved good ore grades to ~10m depth. Two shafts were sunk on Nancy Mining Lease Nos 16 and 17, ~7km south-west of Nanango, to depths of 23 and 15m respectively. Fair ore was exposed in the first shaft and a small quantity was sent away for treatment. Ball (1919a), had a sample from the Nancy Mine assayed and it returned a value of 30.5% total manganese.

MOLYBDENUM

Yarraman Subprovince

Esk Area

Ball (1919b) was the first to note molybdenite mineralisation at Anduramba, ~14km north-north-east of Crows Nest, in a report on the Felix molybdenite mine (Table 47). Mineralisation is mostly in small quartz veins encased in sericitised and greisenised aplite. The few small leaders worked in the schist carried wolfram to the exclusion of molybdenite. It was thought the prospect did not warrant the con-

Table 46: Manganese

Deposit Name	Location	Status	Size	Location	(AMG)
Nancy Mine	~7km SW of Nanango	abandoned	very small	393977	7045538

Table 47: Molybdenum

Deposit Name	Location	Status	Size	Location	(AMG)
Anduramba	~14km NNE of Crows Nest	abandoned	very small	411498	6997129
unnamed	Anduramba Prospect Area	abandoned	very small	411300	6997150
unnamed	250m NW of Main Anduramba Workings	mineral occurrence	very small	411376	6997356
unnamed	24km NW of Esk	mineral occurrence	very small	421700	6998950

struction of a treatment plant and that a proposed adit could not be justified on the basis of surface values. Denmead (1935) inspected the Anduramba workings and concluded the mineralisation was not rich enough for hand dressing or large enough for mechanical concentration.

Exploration by CRA Pty Ltd on **EPM 462** was carried out as a drainage sampling and a soil survey. Most of the samples were from the Anduramba area. The Eskdale Antimony Lode (Midas) and Anduramba molybdenite and wolfram workings were within the EPM area.

Geological and geochemical investigations by CRA Exploration of the Anduramba molybdenum tungsten prospect indicated a pipe-like porphyry intrusion carrying disseminated molybdenite, wolframite and some recognisable yellow oxide of molybdenum at surface. On the basis of soil sampling a geochemical target area of 122,000 tons per foot of +100ppm Mo was established. Limited diamond core drilling, amounting to 10 holes aggregating 5767ft depth suggests that considering only a higher grade core to the disseminated mineralisation gives a body of plan dimensions 800ft by 350ft with an oxide zone 120ft average thickness and sulphide zone 250ft thick. In the oxide zone reserves of 2Mt @ ~600ppm total molybdenum have been delineated. From the sulphide zone reserves of 5Mt @ 677ppm molybdenum have been estimated. Considering the ore body to have dimensions of ~800 ft by 600ft by 400ft average vertical thickness, gives 16,000,000 tons @ 707ppm Mo. A factor of $12ft^3$ to the ton was employed in these estimates.

No significant extension of the Anduramba anomaly was revealed. The highest molybdenum value in the soil is 24ppm. **EPM 2244**, initially of 100 sub-blocks, was located 60km north of Toowoomba. The target for BHP Minerals was a molybdenum resource to fulfil the commodity need in the steelworks industry. Research and a literature search focussed attention on the Anduramba Prospect, where earlier exploration had been carried out centred on the old Felix Mine (Mo). Mineralisation appeared to be associated with a porphyry plug, situated on the western margin of the Eskdale Granodiorite. A comprehensive exploration programme was conducted over 4 years including several phases of drilling. Near-surface bulk grade and tonnage indications were always subeconomic — a possible resource of 20Mt at 0.07% Mo or 8Mt at 0.11% was outlined.

BHP carried out a conventional surface exploration programme and an airborne magnetic/radiometric survey. Subsurface testing comprised 1100m of percussion drilling and 2166m of diamond drilling. The best intersections were in borehole AN13 with 12m of 0.27% Mo and 22m at 0.18%. A near surface subeconomic resource of ~8Mt at 0.11% Mo is inferred. Mineralisation and alteration is associated with the intrusion of a porphyry plug on the western margin of the Eskdale Granodiorite. This porphyritic rhyolite plug and associated rhyolite dykes are fractionated end-members of the Crows Nest Suite. The porphyry plug appears to be the centre of hydrothermal activity. Early stockworking is restricted to the upper levels of the plug and quartz-sericite-pyrite and later kaolinitic alteration followed this phase. There is a strong east-north-east structural control on alteration and mineralisation, associated with a regional stress field. The possibility of extensive high-grade molybdenum mineralisation in zones not drilled, is considered to be very small.

NICKEL

Yarraman Subprovince

Murgon Area

Syvret (1968) inspected two nickel prospects located in Portions 14 and 63, Parish of Windera, near Cloyna in the Murgon district (Table 48). The prospect in Portion 14 is ~1.6km south of Windera township and ~23km north-west of Murgon. Mineralisation was noted in a 600mm deep pit on the southern bank of Windera Creek ~200m upstream of the crossing. The pit exposed a 60mm wide green, siliceous vein striking 015° and dipping east-south-east at 55°. Two samples from the pit returned only trace values for nickel.

The other prospect is located ~2.4km south-south-east of Portion 14 and immediately west of the Murgon–Gayndah road bridge cross-

Table 48: Nickel

Deposit Name	Location	Status	Size	Location	(AMG)
unnamed	1.6km S of Windera, 23km NW of Murgon	mineral occurrence	very small	382370	7116700
unnamed	20km NW of Murgon	mineral occurrence	very small	383363	7114480

ing of Windera Creek. Exposed in a north-east trending gully is a basic dyke containing weathered chloritic clay with local magnesite as nodules and veins. A sample submitted to the Government Chemical Laboratory also returned a trace value for nickel.

Both prospects contain low grades and limited resources and are currently uneconomic.

SILVER–LEAD

Yarraman Subprovince

Murgon Area

Saint-Smith (1922a) reported on the Ronald John Lead Mine and was not convinced the deposit could be worked economically (Table 49). The mine was developed in slates, shales and quartzites of the Fifer Creek Metamorphics (DCi). Sampling of the lode material was carried out from a drive off a 10m deep shaft but the assay results of only a trace of silver, lead and gold were disappointing. A sample that was taken from a nearby pothole showed assay results of silver 111.969g/t; lead 1.6%; gold 0.907g/t.

Nanango Area

A number of small deposits of silver-lead have been worked in an area south-east of Nanango and include Kingsley Racecourse (AMG 413500, 7041400), Murrell's Shaft (AMG 413900, 7040200), The Sunshine (AMG 414000, 7040400) and two unnamed sites (AMG 413900, 7040900, and 415600, 7017000) (Table 50). Only small amounts of ore were recovered. These vein-type deposits are within the Maronghi Creek beds (DCm_d) and have low prospectivity.

Cressbrook Creek Subprovince

Esk and Crows Nest areas

Only small amounts of silver and lead have been won in the Esk and Crows Nest areas (Table 51). At Galena Lode, located ~330m north of the North Star Tunnel (copper) and 14km north-west of Esk, a shaft was sunk on altered rocks to a depth of ~12m. Jackson (1901a) noted that a small vein of galena was present ~40m north of the shaft and there were several other outcrops of copper carbonate nearby. Mineralisation in the shaft was restricted to small veins and stringers of chalcopyrite.

Cribb (1938) reported on the Silver Crown silver–lead workings at Murphy's Creek ~15km south of Crows Nest and 8km north of Murphy's Creek Railway Station. Workings were developed on a 150mm wide vein that increased to 900mm wide at a depth of 10m. The vein material consisted of chalcedonic quartz carrying galena and chalcopyrite. Near the bottom of the shaft the vein changed to solid sulphides of mainly galena with small amounts of sphalerite and chalcopyrite. Morton (1948) later inspected the workings and found the lead-zinc mineralisation occurred in a vein associated with minor fracturing in an area of highly silicified and slightly pyritised rocks. It was noted that no ore of marketable grade could be seen and that field evidence indicated only small sporadic bunches of ore were present.

Other small unnamed deposits are present close to the Silver Crown workings. At an unnamed

Table 49: Silver–lead — Murgon

Deposit Name	Location	Status	Size	Location	(AMG)
Ronald John Lead Mine	17km South of Proston	abandoned	very small	361363	7088592

Table 50: Silver–lead — Nanango

Deposit Name	Location	Status	Size	Location	(AMG)
Kingsley's Racecourse	14.9km ESE of Nanango	abandoned	very small	413500	7041400
Murrell's Shaft	15.9km SE of Nanango	abandoned	very small	413900	7040200
The Sunshine	15.9km SE of Nanango	abandoned	very small	414000	7040350
unnamed	in bed of Telah Creek	mineral occurrence	very small	413893	7037626
unnamed	15.5km SE of Nanango	abandoned	very small	413900	7040900
unnamed	35.6km SSE of Nanango	abandoned	very small	415550	7017000

Table 51: Silver–lead — Esk and Crows Nest

Deposit Name	Location	Status	Size	Location	(AMG)
Galena Lode	14.4km NW of Esk	abandoned	very small	429200	6993100
Silver Crown	~15km S of Crows Nest and 5.5km S of Hampton	abandoned	very small	409800	6968700
unnamed	6km SSE of Hampton	mineral occurrence	very small	410250	6968300
unnamed	4.5km SSE of Hampton	mineral occurrence	very small	409450	6969300
unnamed	5km SSE of Hampton	abandoned	very small	409806	6968770

occurrence ~6km south of Hampton, pyrite and galena is present along with some chalcopyrite and sphalerite. The occurrence is associated with an epithermal alteration zone within the Permian Hampton Road Rhyolite (PRh).

Other occurrences are located ~4.5 and 5km south of Hampton. The former contains pyrite and galena in a tuffaceous unit of the Hampton Road Rhyolite. Workings at the other occurrence are ~50m north of the old Silver Crown tramway and are made up of shafts, pits and trenches.

EPM 3117 of 100 sub-blocks was granted to Gulf and Western Exploration Pty Ltd on 31st August 1981. The EPM area is underlain by Lower Permian acid–intermediate volcanics and volcaniclastics of the Cressbrook Creek Group. Results of previous sampling, coupled with the lithology of the area, and the style and geochemistry of minor Cu, Pb Zn mineralisation suggested that the area has potential for disseminated silver deposits. Gulf and Western Exploration Pty Ltd conducted a literature search, geological mapping and sampling of the area. A number of minor showings of Cu, Pb, Zn and Ag occur in the Cressbrook Creek area, including the North Star, the Rising Star and the Pyramid Mines. Networks of sulphide-filled joints and fissures occur in andesite and tuff. Sulphide is common in the sequence on the slopes on Mount Tin Tin, occurring as fine disseminated pyrite and gossan-filled veins, or filling interstices between clastic fragments. Values up to 3.65% Cu and 46ppm Ag have been reported from the Rising Star area and similar Cu–Ag values have been recorded north of the Eskdale–Hampton Road. None of these showings is of great economic significance, but their presence provides tangible evidence of the style of mineralisation sought. It was concluded that the shear zones within the andesite/sediment pile contain low-grade base metals (up to 0.8% Cu) but negligible precious metal values.

TIN

Yarraman Subprovince

Boondooma Area

Ball (1904) reported that Hopkins and Truze made the first recorded discovery of tinstone in the Burnett District in October 1903 (Table 52). The find said to be very rich (Ball, 1912b). A small rush set in after the announcement of the discovery. Saint-Smith (1922b) and Morton (1924) later reported on the Rocky Creek alluvial tin occurrences. Cassiterite found in the area is medium- to fine-grained and consists of black, ruby and amber varieties. Ilmenite, rutile and magnetite are present in small quantities.

During 1908, eight prospecting areas were applied for and granted at Rocky Creek, Brovinia, for the purpose of prospecting for tin. Some good specimens were obtained and the prospectors believed there was a large lode in the vicinity of Rocky Creek. Several small prospecting pits up to 1m in depth were sunk ~700m east of the Munboree homestead, (AMG 332500, 7130300). Prospecting was done on Rocky and Brovinia Creeks, but no payable finds were made, and the locality became largely deserted.

Occasional fossickers extended their sphere of operations across a low divide into Kingar Creek also discovered lode tin on the plateau north of Rocky Creek. Ball (1912b) noted that kaolinisation of the felspathic country in Powers's lode workings had probably been brought about by pneumatolytic after-action. However, greisenisation of the granite so common on other fields had not taken place, and topaz (an almost universal associate of tin) was rare, if not absent. The desultory exploitation of the lode tin by Powers and Macnamara again drew the attention of investors to the field, and during 1912 a number of dredging claims were pegged out on Rocky, Micananagy, Brovinia, Barnabywonagy, Kingar, and Baranga Creeks.

Table 52: Tin — Boondooma

Deposit Name	Location	Status	Size	Location	(AMG)
Rocky Creek	~60km S of Mundubbera	abandoned	small	324550	7119350
Burnett Claim	~60km SSE of Mundubbera	abandoned	very small	326750	7119350
Burnett	~60km SSE of Mundubbera	abandoned	very small	326856	7118390
unnamed	~60km SSE of Mundubbera	abandoned	very small	326500	7118950
Boondooma	~60km SSE of Mundubbera	abandoned	very small	327230	7119560
Susanne	~60km SSE of Mundubbera	abandoned	very small	322790	7118850
unnamed	~60km SSE of Mundubbera	abandoned	very small	327300	7119100
Kingar Creek	~ 30km W of Proston	abandoned	small	334500	7108000

No program was undertaken to thoroughly test the ground but a few test pits were sunk on Rocky, Barnabywonagy, and Kingar Creeks. During 1910 an ineffectual attempt was made by the Ruby Tin Sluicing Company to treat the wash at the prospector's claim on Rocky Creek.

The Rocky Creek Syndicate worked the deposits mined by the Ruby Tin Sluicing Company Ltd. in 1924. Three leases, Perseverance, Tutankhamen and English were worked at the time of the Morton (1924) visit. These occurrences are near the contact zone between the Palaeozoic sedimentary rocks and an extensive mass of granite. The contact is well exposed at the Gorge Waterhole, where Gorge Creek joins Rocky Creek.

No cassiterite was found in Brovinia Creek above the junction of Rocky Creek. The only sign of a lode was on the right side of Rocky Creek, above where the prospectors were working. Here a body 1.2m wide of fissile and spherulitic felsite, dipping 60° to the south-west, contained grains and films of cassiterite, amounting to <1%.

The P.C. workings (3.2km long) were on Rocky Creek. Early in January 1904 provisional dredging areas from 1.5–3km in length had been pegged out along Rocky Creek from its junction with Brovinia Creek to 9.5km above the P.C. Area. Areas had also been taken up on Brovinia Creek both above and below the junction, and on Busbnell's Flat between the two creeks. Holders of the P.C. worked the bed of the creek. The clayey sand beneath the bed surface was found to contain no cassiterite. The creek wash was estimated to carry <2ozs of cassiterite to the dish and was also found to contain ilmenite, rutile, topaz, zircon and amethyst.

During 1951 the Ruby Tin Sluicing Co. Ltd. installed machinery valued at £4,500 on its dredging lease at Rocky Creek and was ready to produce as soon as sufficient water was available. By 1952 the Ruby Tin Sluicing Co. Ltd. had still not gone into production due to a shortage of water caused by the prolonged dry summer of 1951–52. The company then sold all its machinery and decided not to proceed any further with the venture.

Lode mining was attempted at ML 1 (Burnett Tin Lode Claim). The lease was located ~400m east-north-east of the prospector's workings on Rocky Creek. In all, four shafts were sunk at intervals of ~20m. Depths of shafts ranged from 6m in the middle shaft, 10m in the western and eastern shafts to 21m in the main shaft.

The main shaft was sunk on leaders, and at the 18m level these leaders were followed by a drive to the south-south-west for 10m. Another drive at the 10m level runs south-south-east in decomposed aplite with several thin, discontinuous, steeply-dipping leaders, on which were seen small bunches of tourmaline and cassiterite. The leaders came together in the face of the drive and were gouged out. A sample from over a width of 0.30m consisted of kaolinised aplite and bluish cherty quartz and contained 1.1% tin (Government Analyst). Samples from the middle and eastern shafts were analysed but contained no tin.

During exploration on **EPM 4762**, a total of 43 rock chip and 49 BLEG stream sediment samples were collected and analysed for Au, Ag, As, Cu, Pb, Zn, Sb and Ba. None of the assay results was considered anomalous. Quartz venation and brecciation occur within the Aranbanga beds and next to its contact with the Toondahra Granite. Geer Prospect, occurring in **EPM 4821**, extends onto the present EPM. South of the Jondarby homestead turnoff (AMG 338000, 7126400), the Toondahra Granite and Aranbanga Beds are pervasively kaolinised with local stringer quartz venation up to 3 mm wide. The altered and veined zone extends for a

Table 53: Tin — Esk

Deposit Name	Location	Status	Size	Location	(AMG)
Hogarth's Holes	4.5km ESE of Crows Nest	abandoned	very small	410900	6982800
Three Mile Ck	4.5km ESE of Crows Nest	abandoned	very small	411400	6982800
Two Mile Ck	3.5km ESE of Crows Nest	mineral occurrence	very small	410100	6983500

distance of 15–20m on either side of the contact and up to 10m along the contact (CR17836F).

Esk Area

Minor tin mineralisation is present ~4km east of Crows Nest at Hogarth's Holes (AMG 410900, 6982800), Two Mile (Tin) Creek (AMG 410100, 6983500) and Three Mile Creek (AMG 411400, 6982800) (Table 53). Ball (1903) was the first to report on tin mineralisation in this area. He believed only the small discontinuous alluvial deposits showed any prospectivity. Lode deposits appeared to be low grade and too small to be of interest. A number of creeks were worked from around 1883–1903 for an estimated return of ~13t of cassiterite (Sawers, 1971a). Mining was carried out mainly on portion 46v but also occurred on portions 45v, 103v, 1287 and 2685 Crows Nest.

Cassiterite occurs chiefly in alluvial ground along Two Mile (Tin) and Three Mile Creeks (Ball, 1903). Creek 'wash' is made up of granite fragments and quartz and in places contains considerable kaolin. Significant ruby and amber cassiterite is present along with the black variety. Limited quantities of small topaz and zircon as well as rare sapphires were also reported. Ball (1903) noted that scarce comparatively large flakes of gold were sometime obtained but never in quantities worth considering. Alluvial cassiterite values were reported as uneven and extensive prospecting would be needed to delineate worked out areas and test remaining ground (Morton, 1950).

Sawers (1971a) observed minor amounts of wolfram in pegmatite outcrop and while loaming in the vicinity noted significant quantities of coarse cassiterite. He noted that alluvial deposits were shallow, only occupy small areas along the creeks and gullies and the richer portions had probably been mined.

TITANIUM

Yarraman Subprovince

Kingaroy Area

Rutile is present at a number of localities west of Kingaroy associated with gneissic granite-granodiorite of the Chahpingah Metamorphic Complex (Cc) (Table 54). Jack (1896) noted lumps of rutile up to pigeon's egg size could be washed from the surface of the granite in a gully draining into the western bank of Jumma Creek. Morton (1929) reported on the rutile deposits of the Kingaroy district and noted the rutile was derived from gneissic granite. Within the gneiss it occurred as scattered nodules surrounded by a thin segregation of biotite. Numerous aplite and tourmaline bearing pegmatite dykes intrude the gneiss. In the current mapping crystals of rutile were fund at the unconformity to overlying rocks of the Surat Basin along the Iron Pot Road.

Cribb (1943b) summarised the Kingaroy rutile deposits as being of irregular distribution and believed the showings did not indicate any large

Table 54: Titanium — Kingaroy

Deposit Name	Location	Status	Size	Location	(AMG)
Jumma Creek	Portion 5v, Parish of Burrandowan, left branch of Jumma Ck	mineral occurrence	very small	355100	7059600
Mannuen Creek	Portion 42v Parish of Dangore, 22km SW of Kingaroy	abandoned	very small	356700	7062000
Kingaroy	gully N of Mannuen Creek	mineral occurrence	very small	357600	7062000
Blackjack	9.6km south-east of South Durong township	mineral occurrence	very small	329300	7072300

Table 55: Vermiculite

Deposit Name`	Location	Status	Size	Location	(AMG)
Emu Creek	33.9km SSE of Nanango	mineral occurrence	very small	412800	7017700

accumulations. It was also noted that the rutile crystals showed a wide range of compositions from rutile with a thin film of ilmenite to ilmenite with no rutile core. No crystals composed wholly of rutile were seen.

Robertson (1974) inspected the Blackjack prospect.

VERMICULITE

Yarraman Subprovince

Blackbutt Area

The Emu Creek vermiculite occurrence was first located by a stockman named R. McLaughlin before 1944 (Table 55). It is located in rough country ~8.5km south of Blackbutt near the head of a steep gully on the southern side of Emu Creek. The vermiculite occurs in coarse flakes up to 50mm across in a well marked vein, commonly associated with quartz. His vein has been exposed in a shallow cut.

On the foot wall of the vein is a 25–50mm band of greisenised granite of the Taromeo Igneous Complex (Rgm_{gd1}). Vermiculite constitutes at least 50% of the vein and readily separates from the quartz. Samples were submitted to Australian buyers for testing with unknown results (Connah, 1950b).

The deposit was not located during a 1994 Department of Mines and Energy mineral occurrence survey.

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Plate 1: Deep weathering profile — Burrandowan–Durong road



Plate 2. Kingaroy Tip faulting in deeply weathered granite of unit Rgbo of the Boondooma Igneous Complex



Plate 3. Pillow basalt within DCm_d in the bed of Tom Tom Creek east of Nanango (GR411350, 7044500). Though mapped as Maronghi Creek beds the basalt is probably Permian in age. Lens cap is 55mm in diameter.

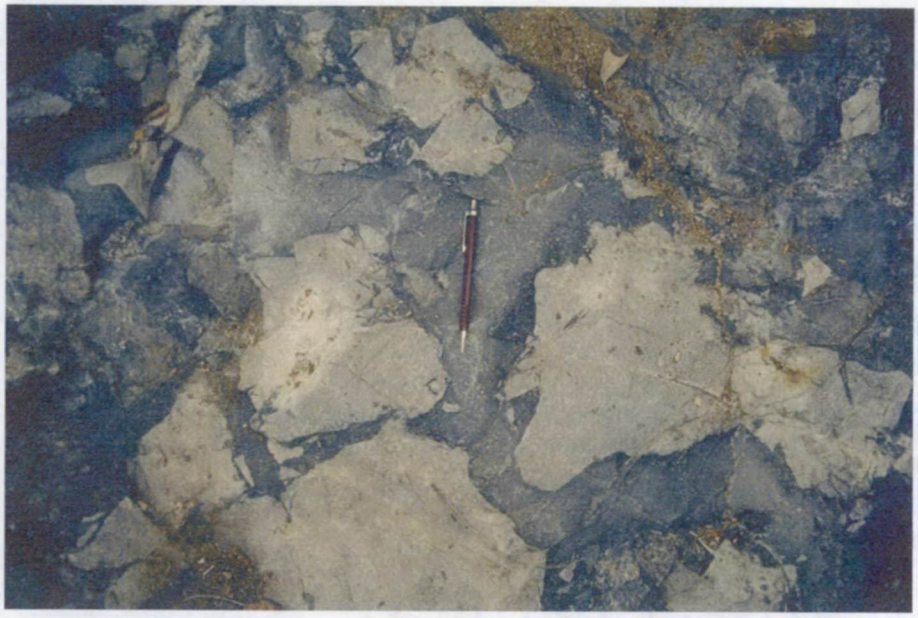


Plate 4. Bed of a gully draining into Teelah Creek showing multiple intrusive phases of Rgm_d (GR 413900, 7037650) pen is approximately 150mm long.



Plate 5. Close-up of oxidised sulphide mineralisation in the bank of Teelah Creek (GR 413900, 7037650) Geopick is approximately 320mm long.

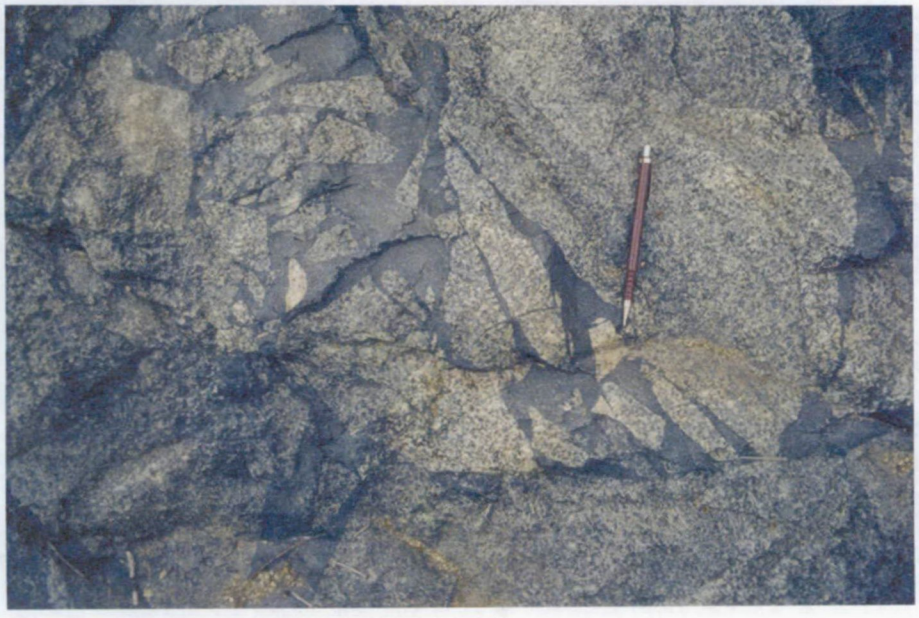


Plate 6. Dark grey andesite intruding Rgm_d in Teelah Creek (GR 413900, 7037650) Pen is approximately 150mm long.



Plate 7. Road cut showing possible sediments of the Tarong Basin (Rr) (GR 401400, 7063250). Note the gently folded beds of polymictic conglomerate. Face is approximately 5m high.



Plate 8. Close-up of flow -banded rhyolite of the Gilla Volcanics (PRglr). (GR 406090, 7029650). Pen is approximately 150mm long.



Plate 9. Pink granite ($PRgb_g$) with mafic fragments plucked from the wall rock (GR 381100, 7014250).

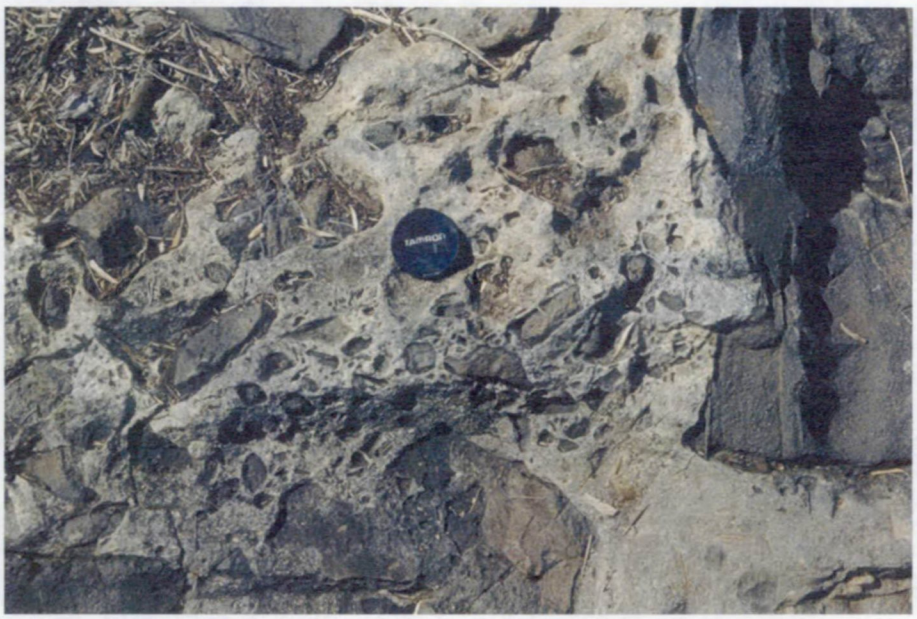


Plate 10. Angular clasts of dark grey microdiorite within light grey-pink intrusive ($PRgb_g$) (GR 381100, 7014250) Lens cap is approximately 55mm in diameter.



Plate 11. Clasts of dark grey microdiorite within fine to medium grained granite ($PRgb_g$). (GR 381100, 7014250) Lens cap is approximately 55mm in diameter.



Plate 12. Sequence of meta-rhyolite? and fine mica schist of the Rockhampton Group exposed at Dangarabungy mine/quarry



Plate 13. Outcrop of coarsely K-spar phyric granite of the Boondooma Igneous Complex ($Rgbo^{p}$) with dark grey mafic xenoliths (GR 332800, 7092250). Pen is approximately 150mm long.



Plate 14. Columnar jointed Tertiary basalt (Tm) in the bed of Waterloo Creek (GR 325650, 7074900)

