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PRECAMBRIAN GEOLOGY OF THE DUCHESS 1:100 000
SHEET AREA, NORTHWESTERN QUEENSLAND -
PRELIMINARY DATA

by

R.J. Bultitude, D.H. Blake and P.J.T. Donchak (GSQ)

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SUMMARY

Precambrian rocks in the Duchess 1:100 000 Sheet area form part of the Cloncurry Complex. The oldest rocks exposed are mainly upper greenschist to amphibolite-grade acid to intermediate gneiss and schist, recrystallised acid volcanics, and amphibolitic metabasalt mapped as Tewinga Group and Bushy Park Gneiss. The Malbon Group, consisting predominantly of metabasalt and meta-arenite, and the Mary Kathleen Group, a sequence of mainly banded calc-silicate rocks with minor interlayered metabasalt and acid metavolcanics, are considered in this work to be partly equivalent to the Tewinga Group, in contrast to the generally accepted concept that they are significantly younger than the Tewinga Group: in the south of the Sheet area calc-silicate rocks of the Corella Formation (Mary Kathleen Group) are interlayered with quartzofeldspathic geniss similar to adjacent gneisses mapped as undivided Tewinga Group. In the west the Tewinga Group is intruded by the Kalkadoon Granite, and migmatitic (mixed) rocks are common.

A major unconformity in the west separates the Tewinga Group and Kalkadoon Granite from the overlying Bottletree Formation (new name) and Haslingden Group. The Bottletree Formation consists of acid and basic metavolcanics and interlayered volcaniclastic and conglomeratic metasediments; it is overlain by and is partly diachronous with the conglomeratic Yappo Formation at the base of the Haslingden Group. The Yappo Formation is conformably overlain by the Mount Guide Quartzite, formed mainly of crossbedded quartzose, sericitic, and feldspathic meta-arenite. The Eastern Creek Volcanics, consisting of basaltic lava flows and interlayered arenite and conglomerate lenses, conformably overlie the Mount Guide Quartzite, and are the youngest rocks of the Haslingden Group exposed in the Sheet area. The Haslingden Group rocks have been folded into major north-trending upright anticlines and synclines.

The Standish Volcanics, consisting mainly of low-grade (?lower greenschist) regionally metamorphosed felsitic ('cherty') to locally schistose acid volcanics and interlayered basic volcanics, are exposed in the southwest. They overlie the Kalkadoon Granite unconformably in the adjacent Dajarra Sheet area to the south, and are separated from adjacent gneissic rocks of the Tewinga Group by what appears to be a major metamorphic uncon-

formity. The Standish Volcanics are overlain, probably unconformably, by mainly arenaceous sediments tentatively assigned to the Stanbroke Sandstone, which is probably equivalent to arenite and siltstone mapped as Surprise Creek Beds in the northern part of the Sheet area.

Acid and basic plutonic rocks crop out extensively in the Sheet area. They cut mainly the Tewinga Group and Corella Formation. Numerous basic dykes intrude many of the Precambrian units, and relatively scarce acid porphyry dykes cut the Tewinga Group, Malbon Group, and Kalkadoon Granite. A thick dyke consisting mainly of porphyritic microgranite, the Garden Creek Porphyry, intrudes Mount Guide Quartzite.

Base-metal, mostly copper, mineralisation is concentrated mainly in the Tewinga Group and Corella Formation. Most of the mineralisation appears to be localised near amphibolitic dolerite bodies; it is commonly fault-controlled.

INTRODUCTION

This report presents the preliminary results of semi-detailed mapping, by joint Bureau of Mineral Resources (BMR) and Geological Survey of Queensland (GSQ) field parties, of the Precambrian rocks south of Mount Isa, in the Duchess 1:100 000 Sheet area, Queensland. Fieldwork commenced in August 1975 and, except for follow-up checks, was completed in October 1977. The following personnel took part:

August and September 1975	- R.J. Bultitude and R.N. England - full time; C.M. Mock*, D.H. Blake, G.M. Derrick, I.H. Wilson (GSQ) and T.A. Noon (GSQ) for 2 weeks; D.M. Pillinger (draftswoman)
July-late October 1976	- R.J. Bultitude (full time); C.M. Mock (3 weeks). T.A. Noon (GSQ; 2 weeks) and R.M. Hill (1 week); P. Blythe (draftsman)
July-late October 1977	- R.J. Bultitude, D.H. Blake, P.J.T. Donchak (GSQ) - in conjunction with mapping of the Dajarra 1:100 000 Sheet area to the south; G. Young (draftswoman)

The mapping updates the results of the BMR-GSQ regional reconnaissance survey of 1950-58 (Carter, Brooks & Walker, 1961; Carter & Öpik, 1963). Other BMR-GSQ field parties have been working in Sheet areas to the north since 1969 (Derrick, Wilson, Hill, & Mitchell, 1971; Derrick, Wilson, Hill, Glikson & Mitchell, 1974, 1977; Hill, Wilson & Derrick, 1975).

Objectives

The mapping of the Precambrian rocks in the Duchess 1:100 000 Sheet area was undertaken as part of the Duchess project. The aims of the project are:

(1) to systematically map the Precambrian rocks in the Duchess and Urandangi 1:250 000 Sheet areas;

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(2) to produce geological maps at 1:100 000 scale of the areas mapped, and accompanying reports;

(3) to assess the ore-mineral potential of the Sheet areas and;

(4) to undertake detailed studies of certain aspects of the geology, such as a geochemical investigation of the different granite suites and their possible role in the formation and concentration of ore deposits.

Scope of report

This report is essentially a compilation of data from field notebooks - it incorporates the results of brief examination of only a very few thin sections. Consequently rock names are based mainly on hand specimen identification in the field; some may be changed after a more detailed study of thin sections.

Terminology

In this work sandstones are classified according to Pettijohn, Potter & Siever (1972). Terms describing metamorphic facies are as defined by Turner & Verhoogen (1960). The name 'granofels', as suggested by Goldsmith (1959), is used for medium to coarse granoblastic metamorphic rocks which do not have a marked foliation or lineation. The term 'concordant' is used to describe contacts between strata displaying parallelism of bedding or structure, where a hiatus cannot be recognised but may exist (Gary & others, 1972). The term 'migmatite' is used to describe a composite (mixed) rock consisting of igneous or igneous-looking and metamorphic materials which are generally distinguishable megascopically (Gary & others, 1972). Injection of magma, or in situ melting, or both, may have taken place.

Map compilation

The accompanying preliminary edition of the Duchess 1:100 000 map was compiled using colour aerial photographs, at about 1:25 000 scale, taken in June 1971, and black and white aerial photographs, at about 1:85 000 scale, taken in May 1970. The field data were plotted by the geologists on to transparent overlays on the colour aerial photographs and were then transferred by the field draftsman on to large compilation sheets at the same scale. The map was drawn from photographic reductions of the compilation sheets.

Location and access

The Duchess 1:100 000 Sheet area lies between latitudes 21°00'S and 21°30'S, and between longitudes 139°30'E and 140°00'E, in the Duchess 1:250 000 Sheet area.

The Duchess 1:100 000 Sheet area is reasonably well served by roads and tracks; the rugged northern and western parts are the most difficult of access. Formed gravel roads link Duchess with Dajarra (to the southwest), with Mount Isa (to the northwest), with The Monument (to the southeast) and with Cloncurry (to the northeast). A long history of prospecting and small-scale mining in the Sheet area has resulted in a large network of tracks, most of which are not now maintained and can be negotiated only by four-wheel-drive vehicles. Most roads and tracks become impassable for short periods after heavy rain.

The Townsville to Mount Isa railway line crosses the Duchess 1:100 000 Sheet area. A branch line from Duchess terminates at Dajarra, an important stock-trucking centre about 50 km to the southwest. Northeast of Duchess a recently built spur line extends about 68 km south to high-grade rock phosphate deposits near The Monument. A branch line which formerly ran from the Duchess-Dajarra line south to Trekelano mine is now abandoned.

Cloncurry and Mount Isa are linked by regular air services through central Queensland to Brisbane and Townsville, and Mount Isa is a port of call for commercial jet aircraft flying either a six or seven days-a-week service between Brisbane and Darwin. Charter air services are available from Mount Isa. The more isolated areas are served by the Royal Flying Doctor base at Mount Isa. There are airstrips suitable for landing light planes at Duchess and Bushy Park homestead; some property lessees have also built airstrips near some yards and watering facilities on their grazing leases.

Population and industry

The Sheet area is sparsely populated. Duchess, with a permanent population of about 30, is the largest settlement and has a school, police station, railway station, post office, store and hotel. Most of the men are employed by the Queensland Government and work on the railway. Most of the remaining population lives on pastoral properties.

Cattle-grazing on unimproved natural pastures is the main industry in the Sheet area, which is free of many of the diseases (such as pleuro-pneumonia and redwater fever) and pests (such as cattle tick) found in the wetter parts of tropical Australia. However, the low average annual rainfall places a severe limitation on the period during which soil moisture is available for plant growth in most of the area. The average length of the useful growing period for natural pastures is about 9 weeks (Slatyer, 1964).

Most of the numerous small mines in the Sheet area have long been abandoned. A few - such as the Crown, Dee Jay, and Victoria - are still worked intermittently, mainly in times of high copper prices, by individuals or small groups of miners, the ores being sold to Mount Isa Mines Pty Ltd. Very few of the mines extended far below the zone of secondary enrichment; two notable exceptions are the Duchess and Trekelano mines, both of which were worked economically in the primary sulphide zone down to depths of about 260 m.

Climate (after Slatyer, 1964)

The Sheet area has a semi-arid tropical climate with a short, wet 'summer' season characterised by very hot days, and a long dry 'winter' characterised by pleasant sunny days and cool to cold nights. Average annual rainfall over the Sheet area is low - about 38 cm or less - and tends to decrease from the northeast to the southwest. Some years more than 50 cm have been recorded, but there have also been periods when two or more consecutive years have had annual rainfalls of 20 cm or less. Since 1970 there has been a succession of years with above average annual rainfalls. Most of the rain falls between November and March, although there have been years when cyclonic influences have brought heavy rain in May, June, and even later. The rain comes mainly in storms and is commonly very localised in heavy showers, with rapid runoff. Light rain fell on a few days in most of the 'winter' months during the survey periods.

At Cloncurry to the northeast, average daily temperatures range from about 10°C (minimum) to 24°C (maximum) during July (the coolest month), up to about 24°C (minimum) and 38°C (maximum) during November, December, and January (the hottest months); the estimated annual tank evaporation is about 285 cm. Diurnal variations in temperature are marked in the Duchess Sheet area, particularly in the 'winter' months when night-time temperatures commonly fall below freezing point; rare frosts have been recorded in the higher country, but generally the atmosphere is too dry for ice to form. Daily maxima in excess of 38°C are of frequent occurrence throughout the summer months.

Southeasterly trade winds prevail during the dry season, particularly from June to August, and in times of drought they are commonly heavily charged with dust. Inflow of moisture from the northwest commences in October and results in thunderstorm activity. Showers and thunderstorms become increasingly frequent during November and December. In late December and early January the northwest monsoon brings cloudy conditions and widespread rain. Monsoonal conditions prevail through January and February, after which the winds tend to blow from the southeast again.

Vegetation (after Perry & Lazarides, 1964; Horton, 1976)

Vegetation in the Sheet area consists of mainly shrublands and sparse low woodlands, with short grassy understoreys. Some of the dominant trees are snappy gum (*Eucalyptus brevifolia*), western box (*Eucalyptus argillacea*), bloodwood (*Eucalyptus terminalis*), ghost gum (*Eucalyptus papuana*), and silver-leaf box (*Eucalyptus pruinosa*). Small dense stands of gidgee (also spelt gidyee or gidyea, *Acacia georginae* and *Acacia cambagei*) are common in places. The distinctive and statuesque kurrajong tree (*Brachychiton australe*) and rare native fig (*Ficus platypoda*) grow sparsely on rocky hillsides, mainly in the north.

In many parts of the area, trees are either absent or scarce and the plant community is dominated by a diverse array of shrubs, the most widespread and eye-catching being konkerberry (*Capparis* spp.), cassias (*Cassia* spp.), poverty bushes (*Eremophila* spp.), rattle pods (*Crotalaria* spp.), hibiscus (*Hibiscus* spp.), wattles (*Acacia* spp.), and mulla mullas (*Ptilotus* spp.). Small stands of holly-leaf grevillea (*Grevillea wickhamii*), and rare plants of *Grevillea dryandrii* with their striking inflorescence grow in places on the sides and tops of hills formed on arenaceous metasediments and granite. Sparse, low trees (about 3-4 m high) of various species, such as whitewood (Atalaya hemiglauca), vine tree or supplejack (Ventilago viminalis), beefwood (Grevillea striata), wild orange (Capparis umbonata), corkwood (Hakea suberea or H. lorea), ironwood (Acacia estrophiolata), gidgee (Acacia cambagei), emu apple (Owenia acidula), mulga (Acacia aneura) and native apricot (Pittosporum phillyraeoides), grow in parts of the community. The recent succession of years with above average rainfall has resulted in prolific shrub growth. Dense, in places almost inpenetrable, stands of turpentine bush - mainly Acacia lysiphloia and A. chisholmii - are now very extensive. These wattles have a very sticky resinous coating on their leaves and seedpods for part of the year and thrive on soils derived from the calcareous metasediments of the Corella Formation. Kerosene grasses (Aristida spp.) and spinifex (Triodia spp.) are common understoreys and also grow in areas which have no tree or shrub cover.

Grasslands occupy most of the cracking clay soil plains underlain by lower Palaeozoic sediments in the southeastern part of the Sheet area. Mitchell grass (Astrebla spp.) and Flinders grass (Iseilema spp.) are by far the most important species present. Buffel grass (Cenchrus ciliaris), reputed to have been introduced into the Cloncurry district by the early Afghans who served the region with their camel teams (the grass was used as a saddle packing), is well established in places on the Burke River frontage near Burke Well (also known as Engine Well).

Along most of the main watercourses large river red gums (Eucalyptus camaldulensis) and ghost gums thrive. In the few places where permanent or near-permanent surface water exists tall paperbarks (Melaleuca spp.) overhang the watercourses.

Early history and previous geological investigations

An account of the early history of the region and a summary of geological investigations up to 1960 have been presented by Carter & others (1961) and Carter & Öpik (1963). Mining company activity in the Duchess 1:250 000 Sheet area has been summarised by Noon (1976). Since 1960 much of the Sheet area has been examined by many geologists from numerous mining companies, but, to date, no large base-metal deposits have been found here.

The upper Proterozoic and lower Middle Cambrian sediments of the Burke River Outlier in the southeastern part of the Sheet area were mapped by a BMR-GSQ field party in 1967 (de Keyser, 1968, 1972). An idea of the trials, tribulations and hardships experienced by the early miners and settlers in the area can be gained from the book 'Mines in the Spinifex' by Geoffrey Blainey (1970). A brief historical account is presented below.

The first group of European explorers to venture into the Duchess 1:100 000 Sheet area was led by Burke and Wills on their ill-fated expedition of 1860-61 to the Gulf of Carpentaria. The party crossed the Sheet area close to longitude 140^{o}E, east of the present site of Duchess. They named Green Creek (Green's Creek) and an extract from Will's journal records that 'after crossing the creek we took a due north course over very rugged quartz ranges of an auriferous character. Pieces of iron ore, very rich, were scattered in great numbers over some of the hills' (Anon 1961, pp. 20-21). Following the tragic Burke and Wills expedition came the settlement of the country south of the Gulf of Carpentaria. McKinlay (ca 1863) led an expedition in search of Burke and Wills in 1861 and reported very favourably on the pastoral potential of the Cloncurry district, and in 1867 Ernest Henry found the Great Australia copper deposit near the present site of Cloncurry. In 1884 the northwestern part of the Duchess 1:100 000 Sheet area was explored briefly for gold by the celebrated prospector, James Mulligan, who had discovered the Palmer River goldfield on Cape York Peninsula in 1873. He climbed Mount Guide, and saw a herd of cattle belonging to the pioneer cattleman Alexander Kennedy (who had stocked the area two years before), but found no ore deposits in the area.

In 1897 the rich Duchess lode was discovered by Jack Kennedy, son of Alexander Kennedy, who by this time had made his home at Devoncourt. No ore was mined until 1904, and only a few tons had been extracted by February 1906, when the mine was sold to Hampden-Cloncurry Copper Mines Ltd, who steadily developed the mine. In December 1908 the railway line from Townsville was completed to Cloncurry; this event initiated a period of marked expansion and development in the region. The railway line reached Duchess in October 1912 and Dajarra in 1917. Duchess was a flourishing township in the 1910-1920 period but with the closure of the Duchess mine in 1920 its population quickly dwindled. The mine produced nearly 28 000 tonnes of copper and was the second largest copper producer in the region during the 1900-30 period. Mining of the Trekelano deposit commenced in 1907, but the main period of production was 1928-43, after most of the other copper mines in the region had closed. The railway line from Duchess to Mount Isa was completed in 1929.

When the copper smelter at the Mount Isa mine was completed in early 1953 some of the small copper mines in the Duchess 1:100 000 Sheet area were reopened. As well, deposits of silica-rich ores - e.g., Mount Hope - and high-grade calcite - e.g., Semigem and mumerous other mines in the Juenburra area southwest of Duchess - were exploited and the ores sold to Mount Isa Mines Ltd for use as fluxes in smelting operations. Almost all these mines had closed by the early 1970s and there is now little mining activity in the Sheet area.

The pastoral industry, the other mainstay of the Duchess 1:100 000 Sheet area, has also had severe fluctuations in fortunes, owing to varying climatic and economic conditions.

Topography and drainage

The Precambrian rocks in the Duchess 1:100 000 Sheet area are exposed as a rugged, highly dissected, raised peneplain of moderate relief (Carter & others, 1961). Rock type and structure largely control the landforms. Elevation decreases from about 490 m in the northwest - Mount Guide is the highest point in the region - to about 310 m in the southeast. Relief and elevation decrease towards the margins of the Precambrian outcrop area.

Arenaceous metasediments, being very resistant to erosion generally form the areas of greatest relief. In places, faults are filled with quartz and form razorbacked ridges which strike across the country, some for several kilometres. Erosion of strongly folded (about northerly trending axes) and deformed metasediments and metavolcanics has produced a series of northerly trending ridges and valleys. Most of the granitic rocks have a dense dendritic pattern of small drainage channels, and have weathered to produce fine sandy to coarse gravelly soils. Where erosion is active prominent outcrops and piled masses of large rounded granite boulders are commonly exposed.

Broad, gently undulating plains with little relief have formed on the mainly flat-lying or gently dipping Cambrian sediments in the southeast. In places adjacent to the Pilgrim Fault Zone the Cambrian sequence has been uplifted and tilted and resistant beds form cuestas and hogbacks. A few small mesas and buttes capped by ?Mesozoic sediments, presumably the remnants of a formerly more extensive cover, also occur in the Sheet area. The presence of a Tertiary (Twidale, 1964) erosion surface is indicated by rare remnant cappings of laterite in the west and extensively weathered rock in the south.

The divide between the southerly flowing inland (to Lake Eyre) and northerly flowing Gulf of Carpentaria drainage systems trends northwest across the Sheet area. Watercourses south of the divide (e.g., Burke River, Wills Creek, Yappo Creek, Moonah Creek) belong to the Georgina-Diamantina drainage system. Watercourses north of the divide include the Malbon River, Leichhardt River (East Branch), and Spring Creek. The main watercourses, even within the area of outcropping Precambrian rocks, are heavily alluviated and commonly braided. The height of the divide decreases from about 460 m northwest to about 340 m at Bungalien railway siding in the southeast.

Geomorphology (after Twidale, 1964)

Twidale has recognised two physiographic units in the Duchess 1:100 000 Sheet area: (1) The Isa Highlands, (2) the Carpentaria and Inland Plains.

The Isa Highlands are subdivided into: (1) immaturely dissected plateaus and high plains, and (2) maturely dissected hill country.

The immaturely dissected plateaus and high plains consist mainly of planated arenite and quartzite ridges and plateaus, and are confined to the western part of the Sheet area and to a small area about 6 km southeast of Woonigan railway siding. The maturely dissected hill country, occurring to the east, is formed on more easily eroded greywacke, calcareous and arkosic metasediments, calc-silicate rocks, acid and basic metavolcanics, and some granitic and gneissic rocks. In the Isa Highlands the major drainage elements are subsequent.

The Carpentaria and Inland Plains consist of: (1) plains of erosion that have formed mainly on coarse-grained granitic rocks and quartzo-feldspathic gneisses, and to a much lesser extent on Phanerozoic sediments in the southeast; and (2) immaturely dissected low plateaus and high plains formed on Cambrian sediments in the far southeast.

Twidale (1964) recognised three erosional surfaces in the region:

(1) a pre-mid Mesozoic surface,

(2) an Early to mid-Tertiary surface,

(3) a Late Tertiary-Quaternary surface.

He considered that all of these surfaces were once peneplains, and all contributed to the present configuration of the land surface. Small, low erosional benches in the west apparently are his remnants of the pre-mid Mesozoic surface. The present drainage is probably Tertiary or later in origin. Only one period of mature lateritisation is recognised, probably during the Early to mid Tertiary. However, rocks underlying remnant cappings of Mesozoic sediments are also very deeply weathered and extensively kaolinised.

OUTLINE OF GEOLOGY

The Precambrian rocks in the Mount Isa region form part of the Cloncurry Complex (Carter & others, 1961). They have been separated by previous workers into an eastern succession and a western succession, both consisting of Carpentarian metasedimentary and metavolcanic rocks, and a north-trending central basement belt, consisting of Lower Proterozoic to Carpentarian rocks (Page, 1976, 1978), mainly granitic and acid to basic metavolcanic rocks (Derrick, Wilson & Hill, 1976a, b, c, d, 1977a, 1978). Part of the western succession crops out in the western part of the Duchess 1:100 000 Sheet area. Rocks of the central basement belt are extensively exposed in the western and central parts of the Sheet area, forming part of the Kalkadoon-Leichhardt basement block (Derrick & others, 1974, 1977b). In Sheet areas to the north the Kalkadoon-Leichhardt basement block is mapped as consisting of the Tewinga Group and Kalkadoon Granite (Derrick & others, 1976a); rocks assigned to the Tewinga Group also crop out in the far east of the Duchess 1:100 000 Sheet area.

The Precambrian stratigraphy of the Duchess Sheet area is summarised in Table 1. The oldest rocks exposed are mainly middle to upper greenschist and amphibolite grade rocks of the Tewinga Group. These rocks, and the Kalkadoon Granite which intrudes them, are unconformably overlain in the west by metavolcanics and interlayered mainly conglomeratic metasediments of the Bottletree Formation. The Bottletree Formation is conformably overlain by units mapped as part of the Haslingden Group in Sheet areas to the north, namely (in ascending order): the conglomeratic and partly volcanic Yappo Formation, meta-arenites mapped as Mount Guide Quartzite, and basaltic lava flows and interlayered arenite and conglomerate of the Eastern Creek Volcanics.

The Haslingden Group rocks have been folded about northerly trending, roughly vertical axes into major anticlines and synclines. They commonly show a well-developed axial-plane cleavage and are regionally metamorphosed to the lower and middle greenschist grade.

In the eastern part of the Sheet area there are extensive exposures of the Corella Formation, which consists predominantly of banded calc-silicate rocks. This formation, together with the underlying Ballara Quartzite, Overhang Jaspilite, Mitakoodi Quartzite, and Marraba Volcanics, has been mapped as part of the eastern succession in Sheet areas to the north. In the northern part of the Duchess Sheet area this succession appears to concordantly overlie the Argylla Formation, the uppermost unit of the Tewinga Group. However, in the southern part of the Duchess Sheet area, the basal Corella Formation contains lenses or pods of coarse quartzofeldspathic gneiss and augen gneiss (shown as Ekc_t on the map) similar to gneisses in the adjacent basement rocks, mapped as undivided Tewinga Group, indicating an apparent interfingering relation. Consequently, the Corella Formation and underlying formations are tentatively regarded as forming part of the basement sequence, and to be older than the Kalkadoon Granite.

This interpretation contrasts with that of Derrick & others (1974. 1977 a, b) who mapped the adjacent Mary Kathleen Sheet area, to the north. There, the Ballara Quartzite and, by inference, the Corella Formation are interpreted to be unconformable on acid volcanics mapped as Argylla Formation (upper Tewinga Group; dated at 1777 ± 7 m.y., Page, 1978), and to be significantly younger than Kalkadoon Granite, dated at $1862 {}^{+27}_{-21}$ m.y. (Page, 1978). This conflict in interpretations highlights one of the main problems in reconstructing the stratigraphy of the area - that of reliably correlating units in an intensely deformed region consisting largely of undated granite complexes and sequences of apparently mainly subaerial acid and basic metavolcanics.

In the south a unit consisting mainly of low-grade regionally metamorphosed (up to ?lower greenschist grade) felsitic ('cherty') to locally schistose acid volcanics and interlayered basic volcanics is mapped as the Standish Volcanics. This unit overlies the Kalkadoon Granite apparently unconformably, and is separated from adjacent gneissic rocks of the Tewinga Group by what appears to be a major metamorphic unconformity. The Standish Volcanics are overlain, probably unconformably, by mainly arenaceous sediments tentatively assigned to the Stanbroke Sandstone, which is probably equivalent to units assigned to the Surprise Creek Beds in the northern part of the Duchess Sheet area.

The general lack of distinctive marker units and inadequate stratigraphic control in much of the Sheet area commonly makes the various volcanic units difficult to distinguish. It seems likely that the Tewinga Group mapped in the northern part of the Sheet area - in particular, belts of acid and basic volcanics associated with the Surprise Creek Beds - contains units equivalent to units in the Standish Volcanics mapped in the southern part of the sheet area.

Intrusive igneous rocks outcrop out extensively in the sheet area and are mapped as Kalkadoon Granite, Wimberu Granite, Mairindi Creek Granite, Bowlers Hole Granite, Burstall-type granite, Mount Erle Igneous Complex, Garden Creek Porphyry, Myubee Gabbro, and numerous basic dykes and sills?

In the east the Pilgrim Fault Zone, with vertical displacements of up to about 300 m (Carter & Öpik, 1963), marks the western boundary of the mainly Cambro-Ordovician Burke River Outlier.

Scattered outcrops of flat-lying, poorly consolidated conglomeratic and finer grained sedimentary rocks are mapped as possible Mesozoic. They generally occur as low mesas. Other small mesas are capped by laterite and extensively weathered bedrock; these are remnants of probably Tertiary weathering profiles.

Table 1. SUMMARY OF PRECAMBRIAN STRATIGRAPHY, DUCHESS 1:100 000 SHEET AREA

Rock unit (max. thickness in metres)	Main rock types (and map symbols)	Relations
Mount Birnie Beds (210)	Sandstone, conglomerate, shale, mudstone, dolomite (Єlb); tillite (Єlt)	Unconformable on older units
	MAJOR UNCONFORMITY	
Unnamed	Porphyritic biotite microgranodiorite (Ꝑg$_d$)	Probably intrudes Leichhardt Metamorphics and Standish Volcanics
Stanbroke Sandstone (300)	Quartz arenite, feldspathic arenite, arkose, siltstone, conglomerate (Ꝑb?)	Probably unconformable on Standish Volcanics
Surprise Creek Beds (700)	Feldspathic arenite, quartz arenite, siltstone, limestone, marl, conglomerate (Ꝑr, Ꝑr?); feldspathic siltstone (Ꝑr$_t$)	Unconformable on Kalkadoon Granite and probably also on Haslingden and Tewinga Groups

Table 1 (continued)

Rock unit (max. thickness in metres)	Main rock types (and map symbols)	Relations
Standish Volcanics (2500?)	Massive grey, red-brown, maroon, felsitic quartz-feldspar porphyry (Ꝑsa); massive dark grey felsitic acid volcanics (Ꝑsa$_1$); red-brown partly schistose, porphyritic acid volcanics (Ꝑsa$_2$); schistose acid volcanics (Ꝑsa$_s$); non-foliated to schistose metabasalt (Ꝑsb); quartz arenite, feldspathic arenite, meta-siltstone, arkose, conglomerate (Ꝑss)	Overlies Kalkadoon Granite probably unconformably; inferred to be unconformable on Tewinga Group; intruded by dolerite dykes and probably by biotite microgranodiorite
Mount Philp Breccia	Breccia (Ꝑdb): fragments of Corella formation rocks in pink igneous groundmass	Cuts Corella Formation; intimately associated with metadolerite
Myubee Gabbro	Medium to coarse olivine-biotite gabbro (Ꝑbm)	Intrudes Corella Formation; intimately associated with Burstall-type granite

Table 1 (continued)

Rock unit (max. thickness in metres)	Main rock types (and map symbols)	Relations
Burstall Granite?	Medium to coarse biotite leuco-granite (Ᵽgb); graphic tourmaline-quartz-feldspar pegmatite (Ᵽgb$_p$)	Intrudes Corella Formation and amphibolitic dolerite bodies in the Corella Formation; cut by unmetamorphosed dolerite dyke
Mount Erle Igneous Complex	Fine to medium hornblende biotite granite (Ᵽgd); graphic pegmatite (Ᵽgd$_p$); fine to coarse dolerite (Ᵽgd$_o$); intimate mixture of granite, dolerite, and heterogeneous dioritic hybrid rocks (Ᵽgd$_m$)	Intrudes Corella Formation
Garden Creek Porphyry	Porphyritic microgranite (Ᵽgp)	Intrudes Mount Guide Quartzite

Table 1 (continued)

Rock unit (max. thickness in metres)	Main rock types (and map symbols)	Relations
HASLINGDEN GROUP		
Eastern Creek Volcanics (2250)	Non-foliated to schistose metabasalt (Ᵽhe); quartz arenite, feldspathic arenite, conglomerate ($Ᵽhe_q$)	Conformable on Mount Guide Quartzite; intruded by amphibolitic dolerite dykes
Mount Guide Quartzite (1560)	Sericitic, quartzose and feldspathic meta-arenite (Ᵽhg)	Conformable on Yappo Formation and locally on Bottletree Formation; intruded by Garden Creek Porphyry, amphibolitic dolerite dykes
Yappo Formation (3750)	Greywacke (Ᵽhy); conglomerate (Phy_{cg})	Conformably overlies and locally interfingers with Bottletree Formation; unconformable on Kalkadoon Granite; intruded by amphibolitic dolerite dykes

Table 1 (continued)

Rock unit (max. thickness in metres)	Main rock types (and map symbols)	Relations
Bottletree Formation (3000)	Schistose acid volcanics, greywacke (Ᵽht$_a$); schistose metabasalt (Ᵽht$_b$); greywacke conglomerate (Ᵽht$_{cg}$)	Unconformable on Tewinga Group gneisses and Kalkadoon Granite; interfingers with lower part of Yappo Formation; intruded by amphibolitic dolerite dykes
	MAJOR UNCONFORMITY	
Wimberu Granite	Medium to coarse biotite granite (Ᵽgm)	Intrudes Argylla Formation
Bowlers Hole Granite	Foliated medium to coarse biotite granite (Ᵽgo)	Intrudes Magna Lynn Metabasalt and probably Argylla Formation; cut by amphibolitic dolerite dykes
Mairindi Creek Granite	Foliated, medium to coarse, moderately porphyritic biotite granite (Ᵽgr)	Intrudes Tewinga Group; cut by amphibolitic dolerite dykes

Table 1 (continued)

Rock unit (max. thickness in metres)	Main rock types (and map symbols)	Relations
Kalkadoon Granite	Medium to coarse, commonly porphyritic biotite granite and granodiorite (Ᵽgk); diorite (Ᵽgk$_{d}$); massive to foliated, xenolithic granite and migmatitic gneiss (Ᵽgk$_{m}$)	Intrudes and forms migmatites with Tewinga Group
MARY KATHLEEN GROUP		
Corella Formation (unknown)	Scapolitic recrystallised impure limestone and calc-silicate rocks (Ᵽkc); calc-silicate breccia (Ᵽkc$_{br}$); albitite and associated diopside-rich calc-silicate rocks (Ᵽkc$_{g}$); metasomatic calc-silicate rocks containing abundant feldspar; diopside, scapolite (Ᵽkc$_{r}$); garnetite and garnet-diopside/salite skarn rocks (Ᵽkc$_{s}$); impure marble and associated scapolitic and garnetiferous calc-silicate granofels	Apparently conformable on Ballara Quartzite; apparently concordant with underlying Argylla Formation and Bushy Park Gneiss; apparently interfingers with and overlies undivided Tewinga Group gneiss; intruded by Burstall-type granite, by Mount Erle Igneous Complex, by aplite, feldspar porphyry and pegmatite, by Myubee Gabbro, by many basic dykes

Table 1 (continued)

Rock unit (max. thickness in metres)	Main rock types (and map symbols)	Relations
	(Ᵽkc$_l$); massive to schistose meta-basalt, para-amphibolite (Ᵽkc$_b$); pink to mauve feldspar porphyry, non-porphyritic metarhyolite and meta-dacite, medium to coarse quartzo-feldspathic granofels (Ᵽkc$_a$); quartzose, calcareous, and feldspathic meta-arenites (Ᵽkc$_q$); massive to finely banded ironstone (Ᵽkc$_i$); quartz-feldspar-mica schist (Ᵽkc$_p$); fine to coarse quartzofeldspathic gneiss, augen gneiss, para-amphibolite (Ᵽkc$_t$); granitic gneiss, calc-silicate granofels (Ᵽkc$_m$)	(and sills?) and bodies of amphibolitic dolerite
Overhang Jaspilite (850)	Regionally metamorphosed limestone, siltstone, chert, hematite-rich layers (Ᵽkj); fine-grained ?feld-spathic quartzite (Ᵽkj$_q$)	Conformable on Mitakoodi Quartzite; faulted against Corella Formation and Mount Birnie Beds

Table 1 (continued)

Rock unit (max. thickness in metres)	Main rock types (and map symbols)	Relations
Ballara Quartzite (450)	Sericitic, feldspathic, and quartzose meta-arenite (Ᵽkb)	Overlain conformably by Corella Formation; apparently concordant with underlying Argylla Formation
MALBON GROUP		
Mitakoodi Quartzite (470)	Regionally metamorphosed feldspathic arenite, quartz arenite, calcareous arenite, limestone, impure limestone (Ᵽnm); metabasalt (Ᵽnm$_b$)	Overlain conformably by Overhang Jaspilite; conformable on Marraba Volcanics; intruded by amphibolitic dolerite and rare feldspar porphyry dykes
Marraba Volcanics (700)	Metabasalt, metasiltstone, biotite schist, chlorite schist (Ᵽna); schistose micaceous metasiltstone (Ᵽnt); schistose metabasalt (Ᵽnc)	Concordantly overlies and possibly locally interfingers with Argylla Formation; conformably overlain by Mitakoodi Quartzite; cut by amphibolitic dolerite

Table 1 (continued)

Rock unit (max. thickness in metres)	Main rock types (and map symbols)	Relations
Bushy Park Gneiss	Medium to coarse quartz-feldspar-biotite gneiss, augen gneiss (Ꝑgy)	Interlayered with metabasalt of Argylla Formation; faulted against undivided Tewinga Group. Probably at least partly equivalent to Tewinga Group gneisses
TEWINGA GROUP		
Argylla Formation (3000)	Red-brown to grey, richly porphyritic to even-grained, commonly schistose or gneissic acid metavolcanics (Ꝑea); schistose, coarse quartz-feldspar porphyry (Ꝑea$_h$); metabasalt (Ꝑea$_b$?); interlayered metabasalt and medium to coarse quartzofeldspathic gneiss (Ꝑea$_m$); sericitic, quartzose and feldspathic meta-arenite (Ꝑea$_q$)	Conformably overlies and locally interfingers with Magna Lynn Metabasalt

Table 1 (continued)

Rock unit (max. thickness in metres)	Main rock types (and map symbols)	Relations
Magna Lynn Metabasalt (300)	Massive and amygdaloidal metabasalt (Ꝑem); epidotised quartzite, quartzose, feldspathic and ?tuffaceous meta-arenite (Ꝑem$_{q}$)	Conformably overlies and locally interfingers with Leichhardt Metamorphics
Leichhardt Metamorphics (1000+)	Mainly massive, grey, recrystallised acid volcanics (Ꝑel, Ꝑel?)	Intruded by Kalkadoon Granite and metadolerite dykes; may include some younger acid volcanics
Undivided Tewinga Group (1000+)	Schistose to gneissic quartz-feldspar porphyry (Ꝑe); massive to schistose quartzite (Ꝑe$_{q}$); granitic to granodioritic gneiss, augen gneiss (Ꝑe$_{t}$); migmatitic gneiss, biotite granite, leucogranite (Ꝑe$_{m}$)	Intruded by Kalkadoon Granite, Mount Erle Igneous Complex, and metadolerite dykes; unconformably overlain by Bottletree and Yappo Formations; inferred to be overlain unconformably by Standish Volcanics

DESCRIPTIVE NOTES ON PRECAMBRIAN STRATIGRAPHIC UNITS OF THE CLONCURRY COMPLEX

Tewinga Group

The Tewinga Group is named after Tewinga County, Cloncurry 1:250 000 Sheet area (Derrick & others, 1976a). It includes the oldest rocks exposed in the Duchess Sheet area, where it comprises three formally named stratigraphic units - Leichhardt Metamorphics, Magna Lynn Metabasalt, and Argylla Formation - and a part mapped as 'undivided' Tewinga Group, which consists of three lithologic, rather than stratigraphic, units.

Undivided Tewinga Group

Map symbols: Pe, Pe_q, Pe_t, Pe_m.

Nomenclature: Previously mapped in Sheet area partly as Kalkadoon Granite with 'numerous metamorphic remnants' and partly as Leichhardt Metamorphics (Carter & others, 1961; Carter & Öpik, 1963); mapped as Leichhardt Metamorphics in adjoining Mary Kathleen 1:100 000 Sheet area to north (Derrick & others, 1974, 1977b).

Distribution. Crops out in a north to northwest-trending belt in the west and south; extends north and south into adjoining Sheet areas.

Reference areas. In southwest, from GR 518238 to GR 558238, where Pe, Pe_q, and Pe_t, and their interrelations, are exposed; in central west, from GR 532470 to GR 553470, where Pe_m and its relations to Kalkadoon Granite and Bottletree Formation are exposed.

Thickness. Unknown. Base not exposed. No stratigraphic sequences measured because of structural complexities, relatively high-grade regional metamorphism, and absence of facing evidence.

Topographic expression and airphoto characteristics. Forms rugged to gently undulating terrain which shows as pale to dark tones, with foliation trends commonly visible, on aerial photographs; the range in colour tones reflect the wide variety of rock types present.

<u>General lithology</u>. Consists of regionally metamorphosed acid, basic, and intermediate volcanics and associated sedimentary rocks. Lithologic units distinguished are: <u>Pe</u>, mainly interlayered schistose to gneissic acid porphyry, mica schist, meta-arkose, and quartzite; $\underline{Pe}_q$, massive to schistose quartzite; $\underline{Pe}_t$, granitic to granodioritic gneiss and augen gneiss; migmatitic gneiss and biotite granite.

<u>Details of lithology</u>. <u>Pe</u>. Red-brown, pink to grey, schistose to locally gneissic acid volcanics commonly containing remnant feldspar and/or quartz phenocrysts, much recrystallised; metamorphic biotite common; flow banding preserved in some units; biotite and muscovite-biotite schist; pink medium to coarse-grained, even-grained, 'aplitic' meta-arkose and grey to maroon quartzite; completely recrystallised acid volcanics; laminated to thin-bedded, fine-grained, tuffaceous? metasediments; minor fine to coarse-grained biotite-quartz-feldspar gneiss, augen gneiss, basic schist, quartzose schist, thin-banded quartz-feldspar-mica schist, epidotic quartzite, metarhyolite, migmatitic (mixed) rocks; rare schistose metabasalt?; veins and pods of aplite, pegmatite, leucogranite, microgranite, muscovite granite, and biotite granite present in places. Rock types thinly to thickly interlayered. Foliation locally crenulated.

$\underline{Pe}_q$. Ridge-forming quartzite (meta-arenite) in south; massive to schistose, white to grey or maroon and locally glassy, fine to medium-grained, partly feldspathic and sericitic, and generally thin-bedded to laminated; schistosity generally parallel to bedding; isoclinal minor folds (?drag folds) present locally.

$\underline{Pe}_t$. Mainly pinkish, fine to coarse-grained granitic to granodioritic gneiss (?metamorphosed acid tuff) which commonly contains white or pink feldspar augen or euhedral to subhedral feldspar megacrysts (relict phenocrysts), or tboth, and dark streaky xenoliths: banded to massive; consists essentially of biotite $\pm$ hornblende + quartz + microcline + sodic plagioclase; apatite, metamict ?allanite, epidote, fluorite, muscovite, opaque minerals, sphene, tourmaline, and zircon are common accessory minerals; some poikiloblastic garnet and ?andalusite present in southwest; commonly exposed as spheroidal boulders and tors. Minor bands of quartzite, meta-arkose, metarhyolite, and biotite schist; some metarhyolite contains porphyroblastic amphibole needles. Cross-cutting and concordant veins of aplite, pegmatite, and granite are common.

$\underline{Pe_m}$. Migmatitic gneiss, generally similar to Pe_t; extensively recrystallised schistose to even-grained 'aplitic', grey to red-brown acid volcanics, quartz-feldspar porphyry, commonly containing scattered remnant feldspar and/or quartz phenocrysts; numerous patches and veins of massive to foliated aplite, pegmatite, medium to coarse-grained biotite leucogranite, biotite-muscovite granite, and coarse-grained patchily porphyritic biotite granite; minor biotite $\pm$ quartz $\pm$ muscovite schist, metabasalt, chlorite schist epidotic quartzite, medium-grained biotite gneiss; rare ?meta-andesite. Some cross-cutting aplite veins may represent mobilised meta-arkose.

Structure and metamorphism. Foliation mainly trends between north and north-west, is steeply dipping to vertical, and appears to be generally more or less parallel to primary layering or bedding. Small crenulations occur locally, but no major folds have been identified. Extensive zones of cata-clastic deformation are associated with faults. Regional metamorphism is probably of upper greenschist and amphibolite grade, markedly higher than that of Haslingden Group and younger rocks.

Relations. Pe, Pe_q, Pe_t, and Pe_m have concordant, interfingering, and gra-dational contacts with one another. They are intruded by Kalkadoon Granite, Mount Erle Igneous Complex, pegmatite veins thought to be related to the granites, and numerous doleritic to amphibolitic basic dykes of various ages; and are overlain unconformably by the Bottletree Formation, and the Yappo Formation of the Haslingden Group. They are also inferred to be overlain unconformably by Standish Volcanics. Their relation to Bushy Park Gneiss is uncertain - they may be facies equivalents.

Age. Probably early Proterozoic. Regionally metamorphosed and intruded by Kalkadoon Granite before Haslingden Group time.

Correlations. Considered by us to be probable lateral equivalents of the Leichhardt Metamorphics, Magna Lynn Metabasalt, and Argylla Formation - the formally named stratigraphic units of the Tewinga Group - and also of the Malbon and Mary Kathleen Groups; however, workers in Sheet areas to north consider that the Tewinga Group is much older than and unconformably underlies the Malbon and Mary Kathleen Groups (Derrick & others, 1977a). Main reasons for our correlations are: (1) augen gneiss similar to that mapped as Pe_t is interlayered with calc-silicate rocks of the Corella Formation (Mary Kathleen Group) in the south of the Duchess 1:100 000 Sheet area (e.g., near GR 763270); (2) throughout much of the Duchess Sheet area rocks of the Tewinga Group and Corella Formation appear to be of similar metamorphic grade (mainly amphibolite grade) and to be more metamorphosed than rocks of the Haslingden Group and Standish Volcanics; and (3) no unconformities are known between Tewinga, Malbon, and Mary Kathleen Groups in the Duchess Sheet area. The simplest interpretation of the available evidence is that the Tewinga and Mary Kathleen Groups are of similar age, both being regionally metamorphosed before the Haslingden Group and Standish Volcanics were laid down.

Mineralisation. Very sparse. O'Brien's Soak silver mine only significant producer of ore - mainly naumannite associated with native silver and cerargyrite in calcite gangue (Carter & others, 1961). Traces of copper mineralisation adjacent to some metadolerite dykes.

Remarks. Regionally metamorphosed and intruded by Kalkadoon Granite before Haslingden Group time.

Leichhardt Metamorphics

Map symbols. Pel, Pel?

Nomenclature. Named and defined by Carter & others (1961); revised by Derrick & others (1976a); type area in northwest of Cloncurry 1:250 000 Sheet area.

Distribution. Crops out in north-trending belts in central-northern part of Sheet area; extends northwards into Mary Kathleen Sheet area.

Reference area. Near GR 740750, where metamorphosed acid volcanics of Leichhardt Metamorphics are overlain conformably to the east by Magna Lynn Metabasalt.

Thickness. Probably more than 1000 m, but uncertain because; (1) base not exposed; and (2) probable structural complexities present.

Topographic expression and airphoto characteristics. Forms steeply to gently rounded hills and undulating terrain; has pale to dark tones, with trend lines rarely evident, on aerial photographs.

General lithology. Mainly massive, grey to greyish maroon, extensively recrystallised and slightly foliated acid volcanics.

Details of lithology. Sheared and metamorphosed rhyolite, rhyodacite, and dacite: commonly contain small phenocrysts of quartz or feldspar, or both, in pale to dark grey, fine-grained, and recrystallised siliceous groundmass generally containing numerous small clots and/or thin bands rich in fine biotite flakes; may include both lavas and massive tuffs; well-developed flow banding common in some units and phenocrysts commonly show well-defined preferred orientation. Rhyolite is highly siliceous (quartzitic), non-porphyritic or with sparse quartz ± feldspar phenocrysts; rhyodacite is less siliceous, and has both quartz and feldspar phenocrysts; dacite contains feldspar phenocrysts in dark groundmass. Some units contain abundant, elongate, angular to rounded lithic and commonly flattened ?pumice fragments up to 15 cm long. Minor laminated to thin-bedded tuff. Rare interlayered amygdaloidal metabasalt and possible meta-andesite (now mainly highly sheared mica schist rich in chlorite).

Structure and metamorphism. Foliation where present is subvertical and mainly trends between north and northwest. Partial to extensive recrystallisation indicates moderate (Pel?, ?middle to upper greenschist) to relatively high (Pel, ?amphibolite) grade regional metamorphism; some Pel? may be lower greenschist grade.

Stratigraphic relations. Pel is overlain conformably by, and interfingers with, Magna Lynn Metabasalt, and is intruded by Kalkadoon Granite. Pel? is generally fault-bounded, and its relations to adjacent units - Bushy Park Gneiss, Kalkadoon Granite, ?Magna Lynn Metabasalt, and Surprise Creek Beds - are not clear; in places phases of Kalkadoon Granite adjacent to contact with Pel? units contain large inclusions of extensively recrystallised acid volcanics; Pel? also appear to be intruded by veins and small masses (not shown on map) of extensively weathered, poorly exposed coarse-grained biotite granite and fine-grained biotite leucogranite (e.g., at GR 703568 and GR 687481) but contacts invariably poorly exposed. Both Pel and Pel? are intruded by basic dykes; Pel also cut by numerous feldspar $\pm$ quartz porphyry dykes.

Age. Early Proterozoic. Some samples of Leichhardt Metamorphics to north of Sheet area have given U-Pb zircon ages of about 1870 m.y. (Page, 1976, 1978).

Correlations. Considered to be stratigraphically equivalent to part of undivided Tewinga Group exposed to west and south.

Mineralisation. None known in Sheet area.

Remarks. Pel is inferred to be equivalent to acid gneisses mapped as undivided Tewinga Group. The less metamorphosed Pel? may include some younger acid volcanics, perhaps equivalent to those in the Bottletree Formation or Standish Volcanics. The general lack of distinctive marker units and inadequate stratigraphic control in much of the Sheet area commonly makes the various acid volcanic units very difficult to distinguish from one another.

Magna Lynn Metabasalt

Map symbols. Pem, Pem_q.

Nomenclature. The Magna Lynn copper mine in Cloncurry 1:250 000 Sheet area; defined by Derrick, Wilson & Hill (1976a). Briefly described in Duchess Sheet area by Bultitude, England & Gardner (1976), Bultitude, Gardner & Noon (1977a), Blake, Bultitude & Donchak (1978a). Mapped as 'db' and described as 'metadolerite and metabasalt' by Carter & Öpik (1963).

Distribution . North-trending belts up to about 2 km wide in central-northern part of the Sheet area; extends into Sheet areas to the north.

Reference locality in Sheet area. About 18-20 km east-northeast of Kurbayia railway siding - from GR 742 755 to GR 769745.

Thickness . Uncertain because of extensive folding and faulting; probably at least 1300 m in north.

Topographic expression and airphoto characteristics. Forms rough hilly terrain in north and hilly to low undulating to flat country to south; quartzite and quartz arenite lenses and feldspar porphyry dykes form sharp-crested ridges and knolls. Overall dark tones on aerial photographs.

General lithology. Massive and amygdaloidal metabasalt with some flow-margin breccia; biotite, chlorite, and actinolite schists; minor intercalated meta-sediments.

Details of lithology. Ꝑem. Predominantly partly epidotic, dark green to black, fine-grained basaltic lava flows with massive centres and amygdaloidal upper, and, less commonly, basal parts; flow-margin breccia common; extensively altered to fine-grained biotite, chlorite, and actinolite schists adjacent to faults and granitic intrusions; numerous thin sedimentary intercalations; commonly cut by quartz veins and pods. Schists locally show a well-developed crenulation cleavage. Flow-margin breccias consist of angular to rounded fragments of epidotic amygdaloidal basalt in a generally epidotic quartzite matrix, or, more rarely, in a fine-grained mafic matrix probably formed of comminuted basaltic lava debris. Some basalt lavas have scoriaceous flow tops in which interstices and cavities are filled with fine-grained quartzite (e.g., at GR 732753). Some possible pillow lava is present in the north (e.g., at GR 726707 and GR 765718).

Ꝑem$_q$. Metasedimentary intercalations, only the larger of which are distinguished on the 1:100 000 map; consist mainly of locally cross-bedded, thin to thick-bedded, fine to medium-grained, pale brown, white, green, grey, commonly ironstained and extensively epidotised quartzite, quartz arenite, feldspathic arenite, and labile arenite with abundant biotite; also fine-grained, thin-bedded to laminated, biotite-rich tuffaceous metasediments and pebbly meta-arenite containing scattered clasts of amygdaloidal basalt; mainly present near base of formation and adjacent to the Bowlers Hole Granite. Intercalations range in thickness from less than 5 m (the majority) to about 50 m.

A predominantly sedimentary sequence (not shown on map) about 30 m thick is exposed at what is interpreted to be the base of the formation about 14 km east of Kurbayia railway siding (GR 716725). Here a thin, schistose amygdaloidal metabasalt lava flow overlying acid metavolcanics mapped as Leichhardt Metamorphics is overlain by laminated to thin-bedded dark grey fine-grained labile (tuffaceous?) metasediments, above which is a conglomeratic unit about 10 m thick and a thin to thick-bedded friable pale brown to dark red schistose ?feldspathic arenite; the conglomerate contains scattered pebbles less than 3 cm of quartzite, and flattened angular to subrounded clasts of extensively altered white to pale brown acid volcanics in a fine-grained schistose labile matrix which makes up more than 50 percent of the rock.

About 2.5 km to the south a basal sedimentary sequence 30 to 50 m thick, overlain by metabasalt, consists of (from the base) cross-bedded and brecciated quartz arenite and feldspathic arenite, laminated to thin-bedded micaceous metasiltstone containing small clasts of chlorite schist (metamorphosed ?clay pellets), and thin to medium-bedded friable fine to coarse-grained ferruginous quartzose arenite and cross-bedded quartzose arenite; basal arenites are epidotised and silicified, contain ?chlorite-rich zones and heavy mineral bands, and have fracture-fillings of quartz and minor pyrite. Basal conglomerate - present locally - contains mainly deeply weathered angular fragments of fine-grained mica schist, some of which contains possible remnant quartz phenocrysts, with minor rounded quartzite pebbles in a schistose, ferruginous, micaceous matrix.

Structure and metamorphism. Mainly north-trending, steeply east-dipping and east-facing; intensely faulted, particularly in north. Regional metamorphism probably mainly upper greenschist facies.

Stratigraphic relations. Overlies acid metavolcanics mapped as Leichhardt Metamorphics apparently conformably, and is overlain, apparently conformably, by Argylla Formation; locally interfingers with acid volcanics of these two formations; discontinuous conglomerate lenses at base probably filling local depressions. Intruded by dykes of quartz-feldspar porphyry and metadolerite and by Bowlers Hole and Mairindi Creek Granites.

Age. Proterozoic - possibly Carpentarian (Derrick, Wilson & Hill, 1976a).

Correlation. Contiguous with the Magna Lynn Metabasalt of the Mary Kathleen 1:100 000 Sheet area (Derrick & others, 1977a, b).

Mineralisation. Minor copper mineralisation - mainly malachite, azurite, chrysocolla, and chalcopyrite - common along fractures and cleavage planes, in shear zones, and in amygdales.

Remarks. Rarity of possible pillow structures and hyaloclastite breccia suggests that the basaltic volcanism was mainly subaerial. Numerous lava flows are present. The predominantly arenaceous intercalated metasediments, locally cross-bedded and ripple-marked, are probably shallow-water deposits.

As in the adjacent Mary Kathleen Sheet area to the north (Derrick & others, 1974, 1977b), there appear to be no obvious major breaks between the Magna Lynn Metabasalt and the Leichhardt Metamorphics (Ɓel) below and the Argylla Formation above; these three fromations appear to be essentially conformable, and to locally interfinger with one another. Stratigraphic control is provided by contrasting rock types and scattered lenses of cross-bedded arenite and quartzite, which consistently face east.

About 6 km northwest of St Andrews Tank, a largely arbitrary boundary separates Magna Lynn Metabasalt from metabasalt with metasedimentary lenses mapped as part of the Argylla Formation ($Ɓea_m$): both units are similar lithologically and both are cut by Mairindi Creek Granite, but the metabasalt sequence assigned to the Argylla Formation contains numerous lenses of acid gneissic rocks, the larger of which are mapped as Bushy Park Gneiss.

Argylla Formation

Map symbols. Ɓea, $Ɓea_h$, $Ɓea_m$?, $Ɓea_b$?, $Ɓea_q$.

Nomenclature. Argylla Creek, Cloncurry 1:250 000 Sheet area; formation defined by Carter & others (1961), revised by Derrick & others (1976a). Previously described in Duchess Sheet area by Carter & others (1961), Carter & Öpik (1963), Bultitude & others (1976, 1977 a, b).

Distribution. (1). North to northeast-trending belts 0.5 km to 7 km wide in central-northern part of the Sheet area. (2). North to northeast-trending belt, maximum width more than 6 km, in east. Not as extensive as shown on previous maps (Carter & others, 1961, Carter & Öpik, 1963).

Topographic expression and airphoto characteristics. Forms rough bouldery, hilly country with some low undulating terrain and narrow valleys in the central north, and mainly low undulating country in the east. Lenses of arenaceous metasediments form steep-sided ridges and cuestas. Mainly dark brown and reddish brown tones on colour aerial photographs.

Reference section in Sheet area. Northeast of Bushy Park homestead - from GR 694482 to GR 711531.

Thickness. Probably about 3000 m northeast of Bushy Park homestead.

General lithology. Porphyritic to even-grained, commonly schistose, locally gneissic acid metavolcanics; minor metabasalt, granitic gneiss, quartzite, and sericitic, feldspathic and quartzose meta-arenite; rare conglomerate, cordierite-anthophyllite schist, calc-silicate granofels.

Details of lithology. Ɛea. Mainly extensively recrystallised red-brown to dark grey, richly porphyritic to non-porphyritic, rhyolitic to ?dacitic metavolcanics: commonly contain subhedral to euhedral feldspar phenocrysts up to about 2.5 cm long, and generally subordinate and smaller quartz phenocrysts, which rarely are opalescent blue; rare lithic fragments up to 5 cm long present locally; includes probable tuffs and ignimbrites, possible high-level intrusives, some undoubted lavas which show well-developed flow banding and, rarely, slightly amygdaloidal zones and flow breccia, and minor massive to bedded agglomerate. Individual volcanic units range from massive and virtually structureless to regularly banded with alternating phenocryst-rich and phenocryst-poor zones. A well-developed primary foliation, defined by alignment of feldspar phenocrysts, is present locally. Red-brown porphyry underlying Ballara Quartzite about 5.5 km east-southeast of Woonigan railway siding, at about GR 704547, contains abnormally large pink feldspar phenocrysts, up to about 4 cm x 1.5 cm. This porphyry generally forms large massive blocks, but in places is altered to quartz-muscovite schist and quartz-biotite schist containing 'ghosts' of feldspar phenocrysts.

$\underline{Ęea_h}$. Small elongate bodies (generally less than 20 m thick) of acid porphyry containing euhedral to subhedral feldspar and, generally subordinate, smaller quartz phenocrysts, commonly opalescent blue, in dark red-brown to grey, fine-grained, recrystallised siliceous groundmass containing abundant fine biotite; commonly flow-banded; margins characteristically much finer in grainsize than interiors; most common in north where interlayered with Magna Lynn Metabasalt; sharp contacts with adjacent basic rocks; probably high-level intrusives. The porphyry bodies commonly contain lensoid to subangular lithic fragments, up to about 1 m long, of (1) dark grey fine-grained quartzfeldspar-biotite rock with scattered small feldspar 'phenocrysts', feldspar-biotite rock with scattered small feldspar 'phenocrysts', (2) medium-grained quartz-feldspar porphyry containing abundant biotite, and (3) fine-grained basic rock. Deeper-level equivalents of this unit may be represented by some relatively coarse quartz-feldspar porphyry dykes cutting Leichhardt Metamorphics and Kalkadoon Granite.

$\underline{Ęea_m?}$ Strongly foliated, fine-grained schistose amphibolite, amygdaloidal and massive metabasalt, biotite schist, with some interbedded metasediments (mainly quartzite), and numerous interlayered lenses of medium to coarse-grained, strongly foliated quartzofeldspathic gneiss, augen gneiss, and foliated granite (larger lenses mapped separately as Bushy Park Gneiss); also some schistose, extensively recrystallised porphyritic to non-porphyritic acid volcanics, and cross-cutting veins of foliated aplite and pegmatite. Unit crops out in north-trending belt extending north and south of the Mount Hope mines; biotite-rich metasediments adjacent to Mairindi Creek Granite northwest of St Andrews Tank are commonly schistose and crenulated, and contain rare garnet. In places, as northeast of the Mount Hope mines and in the area around Lady Fanny mine, thin schistose amphibolite units of $Ęea_m$? interfinger with acid volcanics of Ęea.

$\underline{Ęea_b?}$. Mainly fine-grained actinolite schist, with amygdaloidal zones, and lenses less than 5 m thick of fine to medium-grained, well-sorted, quartz arenite, commonly extensively epidotised; minor highly sheared, red-brown quartz-feldspar porphyry (possibly intrusive) and thin-bedded, schistose, biotite-rich meta-arenite; crops out north of the Fountain Range Fault; amygdales in metabasalts filled mainly with quartz and epidote; epidote common along joint planes and partings; metasediments contain minor malachite and rare chalcopyrite.

$\underline{Ęea_q}$. Mainly feldspathic and quartzose meta-arenite which is thin to medium-bedded, fine to medium-grained, white, buff, pale brown to red-brown, pale grey, steel grey, or glassy; commonly schistose and sericitic; locally ferruginised and silicified; minor brown to grey, fine-grained meta-arenite containing biotite, schistose micaceous metasiltstone which is fine-grained and pale brown to buff, and fine-grained mica schist and ?tuffaceous metasediments which are laminated to thin-bedded and pale brown to buff; also lens of cordierite-anthophyllite schist, forming large rounded boulders and cut by thin veins of quartz-feldspar pegmatite, at GR 787666. The meta-sediments are concentrated in the upper part of the Argylla Formation.

The meta-arenites commonly show ripple marks and cross-bedding, contain fine black layers rich in heavy minerals, and have white clay in the matrix; some (e.g., meta-arenites 4.5 km east-southeast and 5 km north-east of Bushy Park homestead, at GR 718469 and GR 703523 respectively) contain scattered subrounded vein quartz clasts (up to about 1 cm across) and rounded pebbles of medium-grained quartzite (up to about 8 cm across). The more competent units are commonly brecciated and quartz-veined adjacent to faults. Joint planes and fractures in a brecciated quartzite lense within Ꞓea$_m$ 1.5 km south of the Mount Hope mines are lined with black tourmaline.

About 15 km east of Kurbayia railway siding, at GR 729708, Ꞓea overlying Magna Lynn Metabasalt, consists mainly of pink, deeply weathered, laminated to thin-bedded, tuffaceous metasediments and some interlayered flow-banded acid lava flows containing small quartz and feldspar phenocrysts. The tuffaceous metasediments contain pink feldspar grains up to about 1 cm long and rare quartz crystals in soft pale grey non-quartzose matrix. They are overlain by thin unit of mainly pale brown to dark red-brown feldspathic arenite which is thin to thick-bedded, fine to medium-grained, ferruginised, and extensively silicified.

Ꞓea$_q$ is strongly faulted around Bowlers Hole Dam (GR 771635), and the boundary between it and schistose micaceous meta-arenite mapped as Ballara Quartzite is difficult to define accurately.

Few sedimentary lenses have been mapped separately in the Argylla Formation exposed in east because of the difficulty in distinguishing them from interlayered acid volcanics on aerial photographs.

Structure and metamorphism. Mainly steeply dipping; general lack of marker beds makes overall structure difficult to decipher. Some folding is evident, and the formation has been extensively faulted. Faults trending roughly north are cut by a later conjugate set, commonly quartz-filled, trending mainly northeast and northwest; the northeast-trending faults (e.g., the Fountain Range Fault) tend to be the more prominent.

A major syncline is apparent in the northern central part of the sheet area north and south of Lady Fanny mine; the core of this syncline is occupied by calc-silicate rocks of the Corella Formation; a marker unit (in the Argylla Formation) of metamorphosed quartzose and feldspathic arenite is present along part of the eastern limb of the syncline, and cross-bedded, east-facing, arenaceous metasediments occur in the upper part of the Argylla Formation on the western limb.

A weak to strong foliation and development of biotite in the extensively recrystallised acid volcanics indicate probable upper greenschist facies regional metamorphism. Amphibolite facies rocks may be present in a narrow north-trending belt passing through the Mount Hope mines from west of Duchess to Fountain Range Fault; basic rocks in this belt commonly contain green hornblende, and cordierite, anthophyllite, and garnet occur in some interbedded sediments. Adjacent to many faults and basic dykes the volcanics are extensively altered to quartz-muscovite-biotite schists which commonly contain sparse small scattered remnant feldspar and quartz phenocrysts.

Stratigraphic relations. Conformably overlies and interfingers with Magna Lynn Metabasalt in the north; overlain, apparently concordantly, by Ballara Quartzite (the basal unit of the Mary Kathleen Group) near the Mount Hope mines, by Marraba Volcanics in the east, and by Corella Formation in the central part of the area east, northeast, and south of the Mount Hope mines. Intruded by metadolerite dykes and, in central part of Sheet area, also by veins of non-foliated tourmaline-bearing quartz-feldspar pegmatite and white to pink, fine to medium-grained, non-foliated to foliated leucogranite that may be related to the Mairindi Creek Granite. Pegmatite veins, possibly related to Wimberu Granite, are common in the east.

Interfingering Argylla Formation and Magna Lynn Metabasalt are well displayed north of the Bowlers Hole Granite outcrop, near the northern border of the Sheet area. Here acid volcanics mapped as Argylla Formation, comprising thin beds of pink to pale grey tuff - which contain variable amounts of dark basic material - and thick bands of foliated acid porphyry (ignimbrite) with some massive to bedded agglomerate, are interlayered with partly amygdaloidal basic lava and minor laminated basic tuff mapped as Magna Lynn Metabasalt. At one exposure (GR 769766) acid volcanics visibly pass along strike into metabasalt lava; the contact is marked by a zone several metres wide in which globular basic fragments (scoriaceous basalt 'spatter') are enclosed in pink altered acid 'tuff' - covincing evidence of local contemporaneous acid and basic volcanism.

Mineralisation. Several small abandoned copper mines occur within the formation, the largest being the Lady Fanny and Mount Hope groups of mines. Mineralisation is localised mainly along faults and is generally associated with zones of shearing and quartz veining. Ore minerals, mainly malachite, chrysocolla, and azurite, but also some native copper, chalcocite, cuprite, chalcopyrite and pyrite, are concentrated in quartz veins and in adjacent biotite schists which appear to be partly highly sheared and altered intermediate to acid volcanics and partly much altered dolerite. Mainly enriched oxidised zones have been worked. Production of cupriferous silica flux from the Mount Hope group of mines for Mount Isa Mines Ltd began on a substantial scale in 1967 and ceased about 1973 (Brooks, 1977).

Age. Proterozoic - probably Carpentarian (Derrick & others, 1976a).

Correlation. Correlated with the Argylla Formation mapped in the Mary Kathleen and Marraba 1:100 000 Sheet areas.

Remarks. The formation, defined by Derrick & others (1976a) as the upper part of the Tewinga Group in the Mary Kathleen and Marraba 1:100 000 Sheet areas, consists mainly of acid volcanic rocks which are inferred to be extrusive because they commonly show well-developed banding and contain scattered lenses of interbedded sediments. No eruptive centres have been recognised. Part of the formation in the north is similar lithologically to Standish Volcanics in the south of the Sheet area.

Bushy Park Gneiss

(new name)

Map symbol. Ꝑgy.

Nomenclature. Named after Bushy Park pastoral lease, northwest of Duchess township. Previously mapped as Argylla Formation, Corella Formation, and Kalkadoon Granite (Carter & others, 1961; Carter & Öpik, 1963).

Distribution. Crops out in two discontinuous north-trending belts up to about 2 km wide in central part of Sheet area.

Type locality. Railway cutting 11 km northwest of Duchess township; at about GR 750460.

Topographic expression and airphoto characteristics. Forms low, undulating to hilly terrain. Medium tones on aerial photographs.

General lithology. Medium to coarse quartz-feldspar-biotite (granitic) gneiss and augen gneiss; minor coarse biotite granite, fine-grained basic schist (metabasalt), quartzite, microgranite, tourmaline-bearing pegmatite.

Details of lithology. Mainly strongly foliated, white to pink, medium to coarse quartz-feldspar-biotite (granitic) gneiss which locally forms large massive to bouldery outcrops. The gneiss contains abundant to sparse, large (up to about 4 cm long) pink to white, euhedral to subrounded and lensoid (augen) potash feldspar grains which in places are partly or completely recrystallised to finer-grained aggregates; extensively epidotised in a few places; biotite ranges from sparse to abundant, and tends to be concentrated in thin irregular bands; small rounded mafic inclusions rich in biotite are common - large blocks of biotite and amphibole schist and recrystallised ?acid volcanics are less common; some strongly foliated, fine-grained, white to pink leucocratic gneiss is present locally, for example, in the Mount Hope area.

North-northwest and south of the Mount Hope mines, unit also includes large bouldery outcrops of massive, weakly to moderately foliated, medium to coarse biotite granite containing phenocrysts of pale to dark pink feldspar and clots of biotite. Granite in north contains rounded mafic xenoliths, up to about 6 cm across, and is highly sheared and foliated to west, where it is cut by a major fault; granite in south has fine-grained, non-foliated, leucocratic margins.

Structure and metamorphism. Well-developed vertical to steeply westward-dipping gneissic foliation generally present; numerous northeast-trending faults cut eastern belt.

Stratigraphic relations. Gneissic rocks of the eastern belt are intimately interlayered with fine-grained basic schists tentatively mapped as part of the Argylla Formation (Bea_m?); those of the western belt are faulted against gneisses of the Tewinga Group. The unit is cut by numerous veins of fine-grained, white to pale pink, even-grained to porphyritic (in pink feldspar), biotite-poor to biotite-rich, non-foliated to strongly foliated granite; also by veins (commonly boundinaged) of coarse quartz-tourmaline rock, tourmaline-bearing quartz-feldspar pegmatite, and quartz, and by basic dykes which are now mainly schistose amphibolite except north-northwest of Mount Hope, where some massive, non-schistose amphibolitic metadolerite is present.

Age. Proterozoic.

Correlation . Probably equivalent, at least in part, to gneiss mapped as undivided Tewinga Group. Granite may be equivalent to the Wonga Granite mapped in the Mary Kathleen and Marraba 1:100 000 Sheet areas to the north and northeast.

Mineralisation. Quartz veins cutting quartzofeldspathic gneisses and associated basic schists in the Mount Hope area contain abundant traces of secondary copper mineralisation. Some deposits have been mined, mainly by open-cut methods, the siliceous ores being sold to Mount Isa Mines Ltd for use as a smelter flux.

Remarks. In a few places in the eastern belt the unit is little foliated and appears to be granite. However, in most places, it consists of strongly foliated gneisses which are interlayered with basic schist (mainly metabasalt) and quartzite; these gneisses may represent metamorphosed acid porphyry sills or acid volcanics, or possibly lenses and pods of syntectonic granite. The gneisses of the western belt generally form more massive, uniform outcrops than adjacent gneisses mapped as undivided Tewinga Group.

Malbon Group

Two formations of this group, the Marraba Volcanics and Mitakoodi Quartzite, crop out in the Sheet area. The group is defined by Derrick & others (1976d). We regard it as part of the basement Tewinga package.

Marraba Volcanics

Map symbols. Ᵽna, Ᵽnc, Ᵽnt.

Nomenclature. Named after Marraba railway siding, in the southern part of the Cloncurry 1:250 000 Sheet area. Defined by Carter & others (1961); redefined and subdivided into three members by Derrick & others (1976d), two of which are recognised in the Duchess Sheet area.

Distribution. Narrow north-northeast-trending belt, maximum width about 1.5 km, in the northeast.

Reference locality in Sheet area. About 17 km north-northeast of Boundary Bore.

Mapped as Argylla Formation by Carter & others (1961), and Carter & Öpik (1963).

Thickness. 0 to about 700 m; thickest north-northeast of Boundary Bore.

Topographic expression and airphoto characteristics. Forms undulating terrain with low rises, hills, and ridges. Dark tones on aerial photographs.

General lithology. Amygdaloidal and massive metabasalt, metasiltstone, biotite schist, chlorite schist, fine-grained schistose amphibolite, fine grained quartzite.

Details of lithology. Ᵽnt - Timberoo Member. Mainly deeply weathered, pale brown to buff, schistose, micaceous metasiltstone; poorly exposed; steeply dipping; maximum thickness about 130 m.

Pnc - Cone Creek Metabasalt Member. Mainly highly sheared, schistose, dark green to black, fine-grained amphibolite (massive and amygdaloidal metabasalt) with zones of fine-grained chlorite-biotite schist commonly showing kink banding; films of malachite, with some azurite, common along partings in metabasalts, and rare grains of chalcopyrite observed in amygdales and fractures; minor interbedded metasiltstone and red-brown, fine-grained quartzite lenses; cut by veins of quartz and calcite; maximum thickness about 150 m.

Pna - Undivided Marraba Volcanics. Metabasalt, fine-grained schistose amphibolite, metasiltstone; minor chlorite schist, biotite schist, fine-grained quartzite.

Structure and metamorphism. Highly sheared and schistose; regionally metamorphosed probably to middle to ?upper greenschist grade.

Stratigraphic relations. Concordantly overlies, and in places appears to interfinger with, metasediments and acid metavolcanics assigned to the Argylla Formation. Overlain concordantly, probably conformably, by Mitakooki Quartzite. Intruded by dykes and irregular bodies of metadolerite.

Age. Proterozoic.

Correlation. Correlated with the Marraba Volcanics of the Marraba and Malbon 1:100 000 Sheet areas. May be equivalent at least in part to the predominantly metabasalt unit (Pea_m) of the Argylla Formation. Perhaps significantly, Marraba Volcanics mapped in the eastern part of the Malbon Sheet area have been reported to contain some acid volcanic units (Noon, 1978).

Mineralisation. Traces of Cu mineralisation - mainly malachite and azurite, less commonly chalcopyrite, with pyrite, - found in numerous places in the metabasalts.

Remarks. The middle member of the Marraba Volcanics, the Mount Start Member (Derrick & others, 1976d), which consists mainly of quartz arenite, calcareous arenite, and quartzite, has not been recognised in the Duchess 1:100 000 Sheet area, nor in the Malbon 1:100 000 Sheet area to the east (Noon, 1978).

Mitakoodi Quartzite

Map symbols. Ꝑnm, Ꝑnm$_b$.

Nomenclature. Defined by Carter & others (1961) and revised by Derrick & others (1976d). Named after Mitakoodi railway siding, Cloncurry 1:250 000 Sheet area.

Distribution. Crops out in a north-northeast-trending belt up to about 2.5 km wide in the east and northeast; extends north into the adjacent Mary Kathleen and Marraba Sheet areas; also crops out in the Malbon Sheet area to the east (Noon, 1978).

Reference section in sheet area. In northeast, between GR 945765 and GR 957744.

Topographic expression and airphoto characteristics. Strike ridges and rounded hills of moderate relief on arenaceous units; valleys and gently undulating terrain on the less resistant rock types. Red-brown to buff tones on colour aerial photographs.

Thickness. Probably at least 470 m in northeast; maximum thickness of about 1725 m in the Marraba Sheet area to the northeast (Derrick & others, 1971).

General lithology. Regionally metamorphosed fine to medium feldspathic arenite, quartz arenite, calcareous arenite, limestone, impure limestone siltstone, and rare basalt.

Details of lithology. Ꝑnm. Lower part of formation: predominantly massive to blocky, cross-bedded, white, pink, pale brown and red-brown, fine to medium, variably feldspathic meta-arenite; minor quartzose meta-arenite, calcareous meta-arenite and micaceous metasiltstone; rare highly deformed conglomerate; arenites are silicified to friable, mainly medium to thick-bedded, commonly extensively brecciated and quartz-veined. Upper part of formation: interbedded sequence of following rock types - black, dark grey and dark brown, massive to thin-bedded, coarsely recrystallised limestone (partly sideritic?) and impure limestone; grey silicified schistose micaceous metasiltstone; thin to medium-bedded, fine-grained, cross-bedded, feldspathic, quartzose, calcareous, and labile meta-arenite; minor fine-grained schistose amphibolite (metabasalt) and pale brown to buff calc-silicate rocks containing scapolite; scattered thin veins of coarse calcite. Calcareous units commonly show small-scale folds and crenulations.

Ɛnm$_b$. Thin lenses of metabasalt in upper part of the formation 3 km north-northeast of Boundary Bore consists of poorly exposed, fine-grained, black to dark grey, epidote-bearing amphibolite; farther north consists of fine biotite schist, schistose, massive and amygdaloidal metabasalt, and minor micaceous metasiltstone.

Structure and metamorphism. Intensely sheared and complexly faulted and folded. Regionally metamorphosed probably to middle to ?upper greenschist facies.

Stratigraphic relations. Concordant on Marraba Volcanics and, north of Boundary Bore, on Argylla Formation; gradational contact with overlying Overhang Jaspilite; faulted against Corella Formation; extensively intruded by dolerite, now mainly non-foliated coarse-grained amphibolite, and metadolerite with well-preserved ophitic texture. Several feldspar porphyry bodies less than 10 m thick mapped as dykes within the formation about 9.5 km north-northeast of Boundary Bore are probably intrusive but may be extrusive.

Age. Proterozoic.

Correlation. May be at least partly equivalent to Ballara Quartzite.

Mineralisation . None known in Sheet area.

Remarks. The Mitakoodi Quartzite forms the upper part of the Malbon Group (Derrick & others, 1976d). Carter & others (1961) correlated the formation with arenaceous lenses in the Eastern Creek Volcanics of the Haslingden Group but we consider that it is probably much older than the Haslingden Group.

The arenites of the lower part of the Mitakoodi Quartzite may be shallow-water marine deposits. The increasing abundance of siltstone and calcareous sediments upwards in the sequence may result from deeper-water sedimentation on a stable shelf adjacent to a subdued landmass.

Mary Kathleen Group

This group, defined by Derrick & others (1977a), is represented in the Sheet area by, from oldest to youngest, Ballara Quartzite, Overhang Jaspilite, and Corella Formation. We consider that these three formations belong to the basement Tewinga package of rocks, and to antedate the Haslingden Group. However, Derrick & others (1977a, b) regard the Mary Kathleen Group in Sheet areas to the north as unconformable on the Tewinga Group and younger than the Haslingden Group.

Ballara Quartzite

Map symbol. Ꞓkb.

Nomenclature. Named after the now abandoned railway siding and township of Ballara, in the southern part of Cloncurry 1:250 000 Sheet area (Carter & others, 1961). Previously mapped in Duchess Sheet area as Ballara Quartzite Argylla Formation, and Deighton Quartzite by Carter & Öpik (1963).

Distribution. Several small outcrops in the central-northern part of the Sheet area.

Reference section in Sheet area. Northeast of Bushy Park homestead, from about GR 713547 to GR 710538.

Topographic expression and airphoto characteristics. Forms ridges and flat-topped hills. Medium to dark tones on aerial photographs.

Thickness. About 450 m in the reference area.

General lithology. Sericitic, feldspathic, and quartzose meta-arenite; minor calc-silicate granofels, cordierite-anthophyllite schist, ?metapelite, scapolite-biotite schist, grit.

Details of lithology. In the reference section, overlying Argylla Formation, the formation consists mainly of sericitic, feldspathic, and quartzose meta-arenite which is mainly white to dark brown and red-brown, thin to medium-bedded, fine to medium-grained, and locally cross-bedded; commonly friable, and contains scattered thin black bands and small aggregates rich in heavy minerals; minor dark grey to brown labile meta-arenite; extensively ferruginised and capped by thin discontinuous layers of laterite rubble on planated ridges. The meta-arenites in the upper part of the formation are interlayered with laminated to medium-bedded, grey scapolite-rich calc-silicate granofels, cordierite-anthophyllite schist, scapolite-biotite schist, and laminated dark grey siliceous ?metapelite containing altered ?pyrite cubes and abundant small biotite flakes.

West of the Mount Hope mines the formation consists of schistose, friable, white to pale brown and red-brown, fine to medium-grained sericitic meta-arenite, and minor feldspathic and quartzose meta-arenite, sericite schist, and friable, coarse-grained gritty to conglomeratic meta-arkose in which clasts of quartzite, quartzose meta-arenite, and vein quartz up to about 6 cm across are enclosed in a matrix of fine sericite and coarse angular quartz, feldspar, and lithic grains. North of the Mount Hope mines the formation comprises highly friable sericitic and calcareous meta-arenite and quartzite which are white, pale brown, and buff, thin to thick-bedded, variably schistose, fine to medium-grained, and characterised by honeycomb weathering. These rocks commonly show fine banding or layering, and rare cross-bedding, and are extensively brecciated and quartz-veined adjacent to major faults.

Structure and metamorphism. Moderate to steep dips prevail. Cut by numerous, mainly northeast to north-northeast-trending faults, many of which are probably splays and extensions of the Fountain Range Fault. Northeast of Bushy Park homestead the formation has been synclinally folded about a northerly-trending axis. Presence of cordierite-anthophyllite rocks in the upper part of the formation indicates amphibolite-grade regional metamorphism, at least locally was obtained.

Stratigraphic relations. Appears concordant on Argylla Formation northeast of Bushy Park homestead where the upper part of the Argylla Formation consists predominantly of meta-arenite similar to overlying meta-arenite of the Ballara Quartzite; overlain conformably by Corella Formation, the contact being a transition zone separating predominantly arenaceous metasediments below from predominantly calcareous metasediments above.

Age. Proterozoic.

Correlation. May be at least partly equivalent to the Mitakoodi Quartzite - both formations overlie Argylla Formation and are overlain by Corella Formation.

Mineralisation. None known in Sheet area in this formation.

Remarks. The Ballara Quartzite appears to be a lensoid unit occupying depressions in the Argylla Formation land surface.

Overhang Jaspilite

Map symbols. Ꝑkj, Ꝑkj$_{q}$.

Nomenclature . Defined by Derrick & others (1977a). Named after the Overhang manganese mine in the southern part of the Cloncurry 1:250 000 Sheet area. Previously mapped in the Duchess Sheet area as part of the Corella Formation (Carter & Öpik, 1963).

Distribution. Crops out in a narrow discontinuous north to north-northeast-trending belt up to 1 km wide in the east. Extends north into the Mary Kathleen and Marraba Sheet areas; also mapped in the Malbon Sheet area (Noon, 1978).

Reference section in sheet area. In northeast, from GR 942772 to GR 948773.

Topographic expression and airphoto characteristics. Calcareous and siliceous metasediments form rocky hills and strike ridges of moderate relief which are separated by narrow valleys and depressions underlain by metasiltstone. Shows as smooth dark grey tones on black and white aerial photographs, and has a distinctive dark blue-grey coloration on colour aerial photographs.

Thickness. Up to about 860 m; mainly less than about 500 m.

General lithology. Regionally metamorphosed limestone, siltstone, chert, and feldspathic arenite; some hematite-rich layers.

Details of lithology. Ꞓkj. Laminated to thin-bedded, black to dark grey, vuggy, medium to coarse, recrystallised limestone and minor impure limestone; numerous grey, finely recrystallised chert bands generally less than 5 cm thick; also layers up to 1 cm thick of fine-grained hematite-rich metasediments, especially in south, and poorly exposed brown micaceous ?hematitic and ?calcareous metasiltstone; minor laminated to medium-bedded micaceous dark brown fine-grained ferruginous meta-arenite, fine-grained quartzite (common 3 km south of Boundary Bore), calcareous quartzite, calc-silicate granofels, fine biotite schist (?metasiltstone), fine to medium amphibolite, and jaspilite. Interlayered fine-grained quartzite, chert and hematite-rich metasediments predominate west of Bungalien railway siding. The unit is extensively brecciated and veined by coarse calcite, quartz, and hematite. Some 'red-rock' is developed in places, mainly adjacent to faults. Concretionary Fe and Mn oxides are common in fractures and along bedding planes.

Ꞓkj_q. Extensively brecciated, pale pink, fine-grained, ?feldspathic quartzite 3.5 km nroth-northeast of Boundary Bore; appears to overlie Ꞓkj; faulted against Corella Formation.

Structure and metamorphism. Crops out adjacent to the Pilgrim Fault Zone, and is intensely deformed and extensively brecciated. Calcareous units are isoclinally folded about steeply dipping to vertical axes trending mainly north to northeast. Thin chert intercalations commonly show intricate small-scale folds and crenulations. Regional metamorphism is probably middle to upper greenschist grade.

Stratigraphic relations. Appears to be conformable on Mitakoodi Quartzite the contact being gradational; faulted against Corella Formation and, west of Bungalien siding, against Upper Proterozoic to Lower Cambrian Mount Birnie Beds. Intruded by metadolerite.

Age. Proterozoic.

Correlation. Correlated with Overhang Jaspilite mapped in the Mary Kathleen, Marraba, and Malbon Sheet areas. May be equivalent to upper part of Ballara Quartzite underlying Corella Formation in the central part of the Duchess 1:100 000 Sheet area.

Mineralisation. No economic mineralisation known in Sheet area in this formation.

Remarks. Red jaspilite is a rare rock type in the formation in the Sheet area. The presence of uniformly laminated and chemically precipitated sediments may indicate deposition beneath wave base in a stable environment where there was little or no influx of clastic detritus (Derrick & others, 1974).

The formation is of interest to mining company geologists as a possible host to iron and manganese ores.

Corella Formation

Map symbols. Ėkc, and Ėkc with subscripts br, g, r, s, l, b, a, q, i, p, t, and m.

Nomenclature. Formation originally defined by Carter & others (1961), revised by Derrick & others (1977a); type section in the Marraba Sheet area to northeast. Outcrops in Duchess Sheet area generally as shown by Carter & others (1961) and Carter & Öpik (1963).

Distribution. Crops out in a broad north-trending belt in eastern part of area, and in the core of a syncline to west, 8 km north-northeast of Bushy Park homestead.

Thickness. Unknown.

Topographic expression and airphoto characteristics. Landforms range from steep-sided rugged strike ridges to gently undulating terrain; outcrops are pale to dark toned on aerial photographs, and generally have discernible bedding trends. Variety of landforms and airphoto tones reflects wide range of rock types.

General lithology. Consists of calc-silicate rocks and skarns, together with amphibolite, metamorphosed acid and basic volcanics, meta-arenite, mica schist, massive to banded ironstone, and granitic gneiss.

Details of lithology. Ꝑkc. Mainly thin-banded to laminated, fine to coarse, amphibolitic to siliceous calc-silicate granofels; commonly scapolitic; bands are parallel-sided to locally wispy, show honeycomb weathering, and range from white, through shades of pink, red, green and grey, to black; reddening, due to hematite dusting, is variably developed; minerals commonly present are epidote, scapolite, sphene, amphibole, diopside/salite, garnet, quartz, calcite, and feldspar; rare graded bedding and cross-bedding preserved locally; banding generally represents original bedding, but, rarely, is result of structural transposition and metamorphic differentiation (see Chapter on structure and metamorphism). Other rock types present, interlayered with banded calc-silicate rocks, include: white, pink, grey and brown, fine to coarse-grained, calcareous, sericitic, feldspathic and quartzose meta-arenite and quartzite, rarely pebbly; grey metasiltstone; rare conglomerate; dark grey, massive to schistose, medium to coarse amphibolite (mainly ?metadolerite); fine to medium-grained non-schistose to schistose amphibolite, commonly amygdaloidal (mainly ?metabasalt); laminated to thin-banded, fine to coarse para-amphibolite (mainly metamorphosed ?basic tuff); cordierite-anthophyllite rock; pale to dark grey, fine to medium biotite, biotite-muscovite and quartz-biotite schist, in places containing garnet and/or scapolite and, at one locality in the south (GR 855335), sillimanite; laminated to thin-bedded, grey to black, vuggy, recrystallised limestone and impure limestone; pale grey to maroon, massive to banded marble; actinolite schist (e.g., at the Freckle mine south of Duchess, GR 843321); laminated to thin-bedded, cupriferous, dark grey to black ?carbonaceous siltstone (in northeast, GR 926722); extensively recrystallised ?acid volcanics; and, near some faults, minor calc-silicate breccia.

Ꝑkc$_{br}$. Calc-silicate breccia; mapped separately only within Pilgrim Fault Zone in northeast; consists almost exclusively of slightly to extensively brecciated and disrupted, rarely boudinaged, calc-silicate rocks; fragments commonly cemented by calcite; epidote also common; some metadolerite and coarse calcite veins.

Ꝑkc$_{g}$. Albitite and associated diopside/salite-rich calc-silicate rocks; mapped out 9 to 11 km north-northeast of Duchess; white to greenish and medium to coarse.

$\underline{Ƥkc_r}$. Metasomatic, mainly fine to medium-grained calc-silicate rocks containing abundant feldspar, diopside/salite, and scapolite and minor garnet and ?clinohumite; some scapolite-bearing garnetiferous (?para-amphibolite); veinlets of coarse, radiating scapolite crystals common; outcrops shown on map are north of Duchess on east side of main southern body of Burstall-type granite (Ƥgb); also occur elsewhere, for example, adjacent to granite body in northeast, near the Overlander group of mines and prospects, but not delineated on map.

$\underline{Ƥkc_s}$. Garnetite, garnetiferous (?para-) amphibolite, and garnet-diopside/salite skarn exposed within the $Ƥkc_r$ outcrop 11 km north-northeast of Duchess; scapolite common.

$\underline{Ƥkc_1}$. Black weathering, grey to maroon recrystallised limestone; impure limestone and marble, and associated banded scapolitic and garnetiferous calc-silicate granofels; calcareous units characterised by honeycomb weathering; mapped as separate unit only around nose of major fold in northern central part of main Corella Formation outcrop; minor interlayered fine quartzose meta-arenite and quartzite, and thin-banded to laminated para-amphibolite.

$\underline{Ƥkc_b}$. Massive to schistose, fine to medium amphibolite (mainly ?metabasalt), commonly amygdaloidal; minor interlayered banded para-amphibolite probably representing metamorphosed basic tuffs, together with banded calc-silicate rocks, meta-arenite, and quartzite (commonly epidotised); some calc-silicate units contain scattered angular to rounded pebbles of mainly metabasalt and quartzite. In central north of outcrop area (GR 832578) possible pillow lava (may be conglomerate) has mainly rounded (some subangular) blocks up to 60 cm of amygdaloidal and massive metabasalt (amphibolite) and some angular to subrounded fragments of calc-silicate granofels and pale pink and dark grey quartzite and meta-arenite in a matrix of mainly epidote, quartz, and minor grey medium-grained quartzose meta-arenite and coarse crystals of amphibole and scapolite; some of the metabasalt blocks are highly vesicular throughout, whereas others are fairly massive throughout, but many have vesicular centres and finer grained non-vesicular (?chilled) margins; sequence contains irregular lenses of pale pink medium-grained, partly epidotised quartzose meta-arenite and laminated to thin-banded para-amphibolite. Similar, more deformed, rocks crop out farther to northeast (GR 860630).

Unit more extensive than shown on map, but difficult to distinguish from calc-silicate rocks by airphoto-interpretation.

Ꝑkc_a. Pink to mauve, red-brown and grey feldspar porphyry containing small euhedral-subhedral pink to red feldspar phenocrysts in fine-grained extensively recrystallised siliceous groundmass; non-porphyritic metarhyolite and metadacite; most probably extrusive, possibly high-level intrusive; extensively recrystallized with muscovite and chlorite common, and rare scapolite; commonly foliated and partly epidotised; extensively brecciated adjacent to some faults; very similar to units in the Argylla Formation; also, especially in south, pink, medium to coarse, quartzo-feldspathic ('aplitic') granofels which probably represents metamorphosed arkose and acid tuffs, as some shows vague cross-bedding and some contains small feldspar phenocrysts/porphyroblasts. Minor quartzose schist with muscovite ± biotite ± feldspar ± magnetite, banded calc-silicate granofels, and quartzite.

Ꝑkc_q. Quartzose, calcareous, and feldspathic meta-arenites which are white to pink, brown, or pale grey, mainly medium to coarse, and locally show vague cross-bedding and graded bedding; calcareous beds characterised by vuggy appearance. Minor glassy quartzite and interbedded calc-silicate granofels.

Ꝑkc_i. Black to dark grey, massive to finely banded ironstone exposed in the Pilgrim Fault Zone 16 km south-southeast of Duchess; relatively resistant to erosion, and forms upstanding knolls and strike ridges with very dark tones on aerial photographs; consists of quartz, ?hematite, and minor muscovite; some cross-cutting ptygmatic quartz veins. May represent a fault-bounded lens of metamorphosed Overhang Jaspilite.

Ꝑkc_p. Interbedded pink, mauve, and grey quartz-feldspar-mica (biotite ± muscovite) schist (= metapelite), fine to medium quartzite (meta-arenite), and minor banded calc-silicate rocks; mapped as separate unit southwest and south-southeast of Duchess.

Ꝑkc_t. Pink, fine to coarse, quartzofeldspathic gneiss (granitic gneiss), commonly containing feldspar augen, and minor interlayered calc-silicate granofels and para-amphibolite; exposed south-southwest of Duchess. Gneiss has sharp and locally intertonguing contacts with adjacent rocks, and is similar in hand specimen to much of granitic gneiss mapped as individed Tewinga Group to west, and Bushy Park Gneiss to north and northwest.

Ekc$_m$. Sequence of granitic gneiss lenses interlayered with calcareous thickly bedded to laminated calc-silicate granofels, pale massive to banded albitite, basic granofels with regular to swirly banding and locally containing well-developed augen-shaped porphyroblasts of ?salite, banded to possibly agglomeratic para-amphibolite, and hornblende-feldspar-biotite metasiltstone which cleaves readily into thin platy slabs.

Structure and metamorphism. Formation generally has steep to vertical dips and a northerly trend. Several tight major folds with steeply plunging axes are apparent, and the main outcrop area as a whole appears to represent a complex synclinorium. Banded calc-silicate rocks show tight to isoclinal mesofolds and minor folds, and are commonly complexly contorted and crenulated. Many faults cross the outcrop areas, and have resulted in the development of brecciated, sheared, and locally mylonitic rocks. Fine banding in garnetiferous calc-silicate rocks and schistose amphibolite adjacent to granite northeast of Mount Mascotte mine is discontinuous and crenulated, and shows numerous small-scale folds and boudins. Mineral assemblages indicate regional metamorphism mainly to amphibolite grade. The metamorphic grade appears to decrease to the northeast where the rocks are probably mainly ?middle to upper greenschist facies. Contact metamorphic effects generally appear to be restricted to within a metre or so of granite contacts; metasomatic rocks such as skarns are present locally, but are extensive only in the central and northern parts of main outcrop areas.

Stratigraphic relations. To the east, along the Pilgrim Fault Zone, the formation is faulted against Overhang Jaspilite, Mitakoodi Quartzite, and Cambrian rocks, and within this fault zone in the far south it is cut by veins of coarse granite and pegmatite. To the west the formation appears to be conformable on Ballara Quartzite (north-northeast of Bushy Park homestead), and concordant on Argylla Formation and Bushy Park Gneiss, and in the south, near Mayfield homestead, it interfingers with and overlies undivided Tewinga Group gneiss. It is intruded by Burstall-type granite (Pgb); by granite and dolerite of the Mount Erle Igneous Complex; by aplite, feldspar porphyry, and pegmatite probably associated with the granites; by many dykes, small masses, and probably also sills of amphibolitic metadolerite; and by rare ?chalcopyrite-bearing unmetamorphosed basic dykes (dl_6) of the Lakeview Dolerite type. The metadolerites can be divided into two groups: (1) massive to schistose amphibolite with no doleritic textures preserved (and commonly containing scattered grains of ?chalcopyrite); and (2) massive amphibolite with doleritic textures well preserved.

Correlations. Correlated with similarly metamorphosed predominantly calc-silicate rocks mapped as Corella Formation in the adjoining Marraba, Mary Kathleen, and Malbon Sheet areas to the northeast, north, and east (Derrick & others, 1971, 1974, 1977a, b; Noon, 1978). Because it interfingers with acid gneiss similar to gneiss within the Tewinga Group, and appears to be regionally metamorphosed throughout most of the Sheet area to a higher grade than that shown by the Bottletree Formation, Haslingden Group, and Standish Volcanics, we consider that the Corella Formation is partly equivalent in age to the Tewinga Group, and belongs to the Tewinga package of rocks (Blake & others, 1978a).

Mineralisation. Several small copper mines and prospects are situated within the Corella Formation outcrop. Most of the mineralisation occurs as vein-type deposits associated with basic intrusions and/or later faults. In addition, veins of coarse, white to deep salmon-pink calcite are commonly associated with metadolerite intrusives cutting the Corella Formation. The larger veins have been mined as a source of smelter flux. The calcite is thought to have been derived from calcareous metasediments of the Corella Formation (Derrick & others, 1974, 1977b). The calcite veins commonly contain traces of copper mineralisation, secondary iron oxide and quartz, and rarely traces of fluorite and pyrite; many are associated with veins (fault fillings) of dark brown chalcedony. Some calcite veins are partly sideritic and some contain coarse amphibole crystals up to about 40 cm long.

Remarks. The Corella Formation comprises a complex sequence of lithologies dominated by thin-banded impure calcareous sediments probably deposited in a lagoonal or lacustrine environment. The widespread occurrence of scapolite is attributed to regional metamorphism of evaporites within the sequence, implying a shallow-water environment with periodic subaerial exposure during sedimentation.

Bottletree Formation

(new name)

We originally mapped this formation as basal Haslingden Group though it was not defined as part of the group by Derrick & others (1976b). Furthermore, preliminary U-Pb zircon studies on an acid lava flow in the formation have yielded an age slightly older than that determined for the Upper Tewinga Group (Argylla Formation) in the Mary Kathleen Sheet area (Page, 1978). Consequently, the formation is not shown as part of the Haslingden Group on the map, although we regard it as forming part of the same package as the Haslingden Group rocks.

Map symbols. Ᵽht$_{a}$, Ᵽht$_{b}$, Ᵽht$_{cg}$.

Nomenclature. Named after Bottletree Hummock, GR 532756, 6 km north of Malbon Vale homestead. Previously mapped in Sheet area as parts of Leichhardt Metamorphics, Argylla Formation, and Mount Guide Quartzite (Carter & others, 1961; Carter & Öpik, 1963). Mapped as Argylla Formation and Mount Guide Quartzite in southwest corner of adjoining Mary Kathleen Sheet area to north (Derrick & others, 1974, 1977b).

Distribution. Crops out in north-trending belt in western part of Sheet area. Extends northwards into Mary Kathleen Sheet area.

Type section. From GR 513540 to GR 517540, close to the Bushy Park/Top Yappo Bore track. The formation is about 400 m thick here, where all three map units - Ᵽht$_{a}$, Ᵽht$_{b}$, Ᵽht$_{cg}$ - are represented, and relations with Yappo Formation to west and basement rocks to the east are exposed.

Thickness. Ranges from 0 to 3000 m; thickest in northwest.

Topographic expression and airphoto characteristics. Forms mainly low rounded strike ridges and gently undulating terrain. Airphoto tones range from pale and medium (Ᵽht$_{a}$) to dark (Ᵽht$_{b}$).

General lithology. Schistose acid volcanics and interbedded greywacke, greywacke conglomerate, labile conglomerate and grit, arkose, and ?tuffaceous arenite (Eht_a), schistose to massive metabasalt (Eht_b), thick to medium-bedded conglomerate (Eht_{cg}).

<u>Details of lithology</u>. Eht_a. <u>Schistose acid volcanics</u>: pale to dark grey and maroon rhyolitic to dacitic lava containing small feldspar and/or quartz phenocrysts; sparsely to richly porphyritic; feldspar phenocrysts recrystallised in places; groundmass partly to extensively recrystallised; flow-banding well developed at some localities; also thick to thin-bedded and laminated fine to coarse pink and grey tuff containing volcanic quartz and feldspar crystals; minor dark grey, medium-grained meta-arenite and quartzite; acid volcanics commonly highly sheared and extensively recrystallised, particularly adjacent to faults, with development of abundant fine mica. <u>Greywacke and greywacke conglomerate</u>: angular to rounded clasts, ranging in size up to boulders, of quartzite, vein quartz, granite, diorite, mica schist, amphibolite, and phyllite, all derived from nearby Tewinga-Kalkadoon basement, and quartz-feldspar porphyry and altered 'pumice' derived from penecontemporaneous acid volcanics; clasts enclosed in a generally schistose dark grey fine matrix containing abundant metamorphic biotite; beds medium to thick, commonly cross-bedded. <u>Labile conglomerate and grit</u>: consist predominantly of acid volcanic clasts, mainly altered pumice, in a sericitic and feldspathic matrix that is probably tuffaceous. Main conglomeratic beds are mapped out as Eht_{cg}. Pebbles and larger clasts in conglomerates range from undeformed to flattened and elongated; those of altered pumice are generally flattened even where other pebbles are not - being highly vesicular at time of sedimentation, the pumice fragments were probably flattened during initial compaction. Minor schistose to massive metabasalt and associated fine to medium-grained epidotic quartzite and laminated basic tuff are present locally in Eht_a.

Eht_b. Schistose to massive metabasalt: occurs mainly at or near base and <u>top of</u> formation; dark grey to greenish grey, commonly amygdaloidal; minor interlayered epidotic quartzite, laminated basic tuff, and labile conglomerate, grit, and arkose similar to that of Eht_a; some acid volcanic clasts up to 50 cm in conglomerate. Lenses of schistose, labile (commonly biotite-rich) arkosic conglomerate and grit, arkose and some biotite schist and thin to finely banded para-amphibolite at base of lower metabasalt unit shown on map; angular to subrounded clasts, up to about 5 cm, of feldspar, vein quartz, fine-grained actinolite schist, and medium to coarse-grained biotite granite common; deposited in depressions in the Kalkadoon Granite - Tewinga Group land surface.

Structure and metamorphism. Bedding has steep to vertical dips and northerly trends; schistosity/foliation is generally well developed subparallel to bedding. Pebbles in conglomerate bands are intensely deformed in places, especially in north; flattened and elongated quartzite pebbles have long axes several times the length of short axes; at such localities most acid volcanic pebbles are represented by oval to elliptical 'smears' on foliation planes. Regional metamorphism is probably low to middle greenschist grade; main metamorphic minerals developed are fine-grained biotite, white mica, epidote, and chlorite.

Stratigraphic relations. Unconformable on Tewinga Group gneisses and Kalkadoon Granite; overlain conformably by Yappo Formation and Mount Guide Quartzite and locally interfingers with lower part of Yappo Formation. Intruded by basic dykes.

Age. Proterozoic.

Correlations. Partly diachronous with Yappo Formation; equivalent to lower part of Mount Guide Quartzite and part of Argylla Formation mapped in the Mary Kathleen Sheet area to north; no undoubted correlatives known to east.

Mineralisation. None known in Sheet area.

Remarks. Represents acid and basic volcanics, associated volcaniclastic sediments, and probable fanglomerate deposits which were laid down on an irregular surface formed on Tewinga-Kalkadoon basement. The variable thickness of the formation is attributed partly to localised volcanism and partly to deposition of sediments firstly in depressions. Sediments are presumed to have been derived from a landmass to the east, which was probably mountainous at the time, and are either fluvial or shallow marine.

Haslingden Group

Three formations of the Haslingden Group crop out in the western part of the Sheet area. These are, from oldest to youngest, the Yappo Formation (new name), Mount Guide Quartzite, and Eastern Creek Volcanics. The group is conformable on the Bottletree Formation, unconformable on Tewinga Group gneisses, and is in faulted contact with the Surprise Creek Beds.

Yappo Formation
(new name)

Map symbols. Ehy, Ehy_{cg}.

Nomenclature. Yappo Creek (called Yappa Creek in the adjoining Oban 1:100 000 Sheet area to the west) in the central-western part of the Sheet area. Mapped mainly as Mount Guide Quartzite by Carter & others (1961), and Carter & Öpik (1963). Included as part of the Rifle Creek beds (informal name) by Bultitude & others (1976, 1977a, 1977b).

Distribution. Exposed in three main north-trending belts in west; extends into adjoining Mary Kathleen, Oban, and Dajarra Sheet areas.

Type section. In the northwestern corner of the Sheet area, from GR 449769 to GR 486754.

Thickness. Very variable; about 3750 m in northwest, locally less than 100 m in central west, and more than 950 m in southwest.

Topographic expression and airphoto characteristics. Forms fairly subdued undulating terrain, and steep slopes flanking ridges of Mount Guide Quartzite. Medium tones on colour aerial photographs; generally darker than adjacent Mount Guide Quartzite.

General lithology. Quartz-poor labile conglomerate and grit, sericitic, feldspathic, and quartzose arenite with heavy mineral bands, greywacke, greywacke conglomerate, arkose; minor sericite schist, metasiltstone, dark grey medium-grained epidotic quartzite, and pink to grey acid tuff. Thick greywacke conglomerate beds are mapped as Ehy$_{cg}$.

Details of lithology. Arenaceous beds: white, pale brown to red-brown, pale purple, and pale to dark grey, friable to massive, fine to coarse-grained, locally schistose. Conglomerate beds: subangular to well-rounded pebbles, cobbles, and boulders mainly of quartzite and schistose acid volcanics, but also some of metabasalt, amphibolite, and granite and diorite (which can be matched with plutonic rocks exposed in the nearby basement); acid volcanic clasts are flattened and deformed (originally ?pumice fragments), yet other clasts are commonly not deformed; clasts enclosed in labile, sericitic, quartz-poor, locally biotite-rich schistose matrix ranging from greywacke to arkose and commonly forming more than 50 percent of the rock; matrix is mainly arkosic north-northeast of Broadhurst Bore, in the southwest, where pebbles and larger clasts of coarse-grained porphyritic granite, medium-grained porphyritic leucogranite, and vein quartz are common, and associated arenites contain granite-derived coarse rounded to subrounded quartz and feldspar grains.

Pale to dark grey medium-grained greywacke and greywacke conglomerate predominate in northwest. They show cross-bedding and, more rarely, graded bedding. Some thin-bedded to laminated pink to grey acid tuff is also present here: it ranges from fine to coarse and contains sparse to abundant quartz and feldspar 'phenocrysts'.

Structure and metamorphism. Generally steeply dipping and commonly schistose; highly deformed quartzite pebbles present locally. Regionally metamorphosed probably to middle greenschist grade as some metamorphic mica is developed; however, sedimentary structures are generally preserved.

Stratigraphic relations. Unconformable on Kalkadoon Granite; conformably overlies and locally interfingers with Bottletree Formation; overlain conformably by Mount Guide Quartzite. Intruded by basic dykes.

Age. Proterozoic.

Correlations. Correlated with part of the lower Mount Guide Quartzite in the adjoining Mary Kathleen Sheet area (Derrick & others, 1976b).

Mineralisation. None known in Sheet area.

Remarks. Presence of probable pumice fragments in the conglomerates implies penecontemporaneous volcanic activity. The sediments are generally poorly sorted, but show cross-bedding and graded bedding. They appear to consist mainly of locally derived detritus, like those in the underlying Bottletree Formation, and are thought to represent outwash fan deposits, possibly mixed with some lahar and pyroclastic deposits, derived from the east.

The top of the Yappo Formation is placed at the marked topographic break between undulating terrain, formed on Yappo Formation, and upstanding ridges fromed to Mount Guide Quartzite.

Mount Guide Quartzite

Map symbol. Ehg.

Nomenclature. Named by Carter & others (1961) after Mount Guide, which is the highest point in the Mount Isa region and lies in the northwestern corner of the Sheet area. Mapped as Mount Guide Quartzite by Carter & others (1961), Carter & Öpik (1963), and Bultitude & others (1977 a, b).

Distribution. Western part of the Sheet area, mainly in a north-trending belt up to about 5 km wide; extends into adjoining Sheet areas.

Type locality. Around Mount Guide (GR 461729), in the northwest; type section defined by Carter & others (1961) as extending about 3 km east and west of Mount Guide, but this includes parts of the Yappo and Bottletree Formations and crosses part of a large syncline. A better type section, or reference section is from the axis of the syncline northwest of Mount Guide, at GR 448745, to the top of the Yappo Formation northeast of Mount Guide at GR 467735.

Topographic expression and airphoto characteristics. Forms prominent ranges of closely spaced planated strike ridges which have pale tones on aerial photographs.

Thickness. About 1380 m in type area and 1340 m to 1560 m in southwest; thins to east, and only about 250 m thick northwest of Yarraman Dam (GR 593571).

General lithology. Silicified to friable, sericitic, feldspathic, and quartzose arenite; minor pebbly beds, glassy quartzite (?silicified quartz arenite) and gritty arkose.

Details of lithology. Mainly white to buff, grey, and brown, silicified to friable, sericitic, feldspathic, and quartzose arenite, locally with pebbles of quartzite, vein quartz, and mica schist; minor white to grey glassy quartzite (?silicified quartz arenite), arkose and grit; some possible thin basalt lava flows near top (?forerunners to the Eastern Creek Volcanics). The arenites are mainly medium-grained, moderately to well sorted, thin to thick-bedded, commonly cross-bedded (mainly low-angle sets) and ripple-marked, and locally extensively ironstained as a result of lateritic weathering. Medium-grained schistose sericitic labile arenite, locally with abundant biotite, and coarse-grained to gritty and pebbly feldspathic arenite and arkose are common near base.

Structure and metamorphism. Beds moderately to steeply dipping and folded about north-trending axes into several open to tight anticlines and synclines. Cut by numerous faults with mainly small displacements: an earlier group of north-trending, commonly dolerite-filled strike-slip faults; and a later group of northwest-trending, commonly quartz-filled faults; mainly sinistral movement. Regional metamorphism is probably in the greenschist facies, as although the formation is commonly schistose and sericitic, primary sedimentary structures are preserved. Contact metamorphic aureoles less than 25 cm wide, consisting of glassy quartzite, occur adjacent to some dolerite dykes.

Stratigraphic relations. Conformable on Yappo Formation and locally on Bottletree Formation; conformably overlain by Eastern Creek Volcanics. Intruded by swarms of mainly north-trending metadolerite dykes, some of which may be feeders to basalt lavas within the overlying Eastern Creek Volcanics although most appear to postdate the Haslingden Group (Glikson, Derrick, Wilson, & Hill, 1976), and by Garden Creek Porphyry. Locally capped by Tertiary laterite and ferruginous rubble.

Age. Proterozoic.

Correlation. Correlated with Mount Guide Quartzite in adjoining Sheet areas.

Mineralisation. None known in Sheet area.

Remarks. Corresponds to the upper Mount Guide Quartzite and the upper part of the lower Mount Guide Quartzite as mapped in the adjoining Mary Kathleen and Mount Isa Sheet areas (Derrick & others, 1977b; Hill & others, 1975). Probably deposited in a shallow-water, near-shore environment, and derived, at least in part, from the Kalkadoon-Leichhardt basement block to the east.

Eastern Creek Volcanics

Map symbols. Ꝑhe, Ꝑhe?, Ꝑhe$_q$, Ꝑhe$_q$?

Nomenclature. Named after Eastern Creek, a tributary of Gunpowder Creek, in the Camooweal 1:250 000 Sheet area. Defined by Carter & others (1961); subdivided into three members by Derrick & others (1974, 1976b, 1977b; Hill & others, 1975). Mapped previously in Sheet area as Eastern Creek Volcanics.

Distribution. North-trending belts up to about 5 km wide in west; extends into Sheet areas to the north, south, and west.

Reference section in Sheet area. In central-west, from GR 473481 to GR 496485.

Thickness. Maximum of about 225- m in central-west.

Topographic expression and airphoto characteristics. Forms undulating valleys with dark airphoto tones (Ꝑhe), and strike ridges with pale to medium airphoto tones (Ꝑhe$_q$).

General lithology. Massive, vesicular, and amygdaloidal, rarely porphyritic metabasalt, flow-top breccia, fine to medium-grained actinolite and biotite schist; numerous interlayered lenses of epidotic quartzite, sericitic, feldspathic and quartzose arenite, and conglomerate.

Details of lithology. Ḇhe, Ḇhe? pale to dark green and bluish grey amygdaloidal and massive metabasalt lava: mainly rubbly exposures; amygdaloidal, scoriaceous, and brecciated flow margins, commonly extensively epidotised and locally contain traces of chalcopyrite, malachite, and azurite; individual flows range from about 20 m to 40 m thick; locally converted to schistose amphibolite and biotite schist, especially adjacent to faults. Minor thin lenses of white, brown, and grey, medium to coarse epidotic quartzite, and sericitic, feldspathic, and quartzose arenites which are commonly pebbly.

Ḇhe_q, Ḇhe_q? Sedimentary intercalations up to about 200 m thick consisting mainly of thin to medium-bedded sericitic, feldspathic, and quartzose arenite; white, brown, maroon, dark grey; medium to coarse; locally sheared, schistose, brecciated and quartz-veined; locally cross-bedded; silicified to friable; pebbles of quartzite and amphibolite common. Also some epidotic quartzite, labile quartzite containing abundant actinolite? needles, conglomerate, and minor thin actinolite-rich units (metamorphosed ?basic tuffs). Conglomeratic beds contain mainly rounded pebbles of quartzite and flattened clasts, up to about 3 cm, of metabasalt (amphibolite) in a matrix of sericitic feldspathic arenite; some also contain numerous subangular to rounded clasts of little recrystallised porphyritic acid volcanics.

Structure and metamorphism. Crops out mainly in the cores of extensively faulted synclines with north-trending axes. The lavas and interbedded sediments are moderately to steeply dipping and commonly schistose or strongly foliated. Regionally metamorphosed to greenschist facies.

Stratigraphic relations. Conformable on Mount Guide Quartzite; overlain, apparently unconformably, by Surprise Creek Beds.

Age. Proterozoic.

Correlations. Has been correlated with Marraba Volcanics (Carter & others 1961; Plumb & Derrick, 1975; Glikson & others, 1976).

Mineralisation. Traces of copper mineralisation common, but no economic concentrations known in Sheet area.

Remarks. The Eastern Creek Volcanics is the youngest formation of the Haslingden Group present in the Sheet area. Most lavas were probably extruded subaerially (see Glikson & others, 1976), although the presence of numerous sedimentary lenses suggests that some may have flowed into shallow water. The relatively thick (about 150 m) and persistent arenite unit southeast of Malbon Vale homestead may correlate with the Lena Quartzite Member mapped in Sheet areas to the north (Derrick & others, 1976b).

Standish Volcanics

(new name)

Map symbols. Ɇsa, Ɇsa$_1$, Ɇsa$_2$ Ɇsa$_s$, Ɇsb, Ɇss.

Nomenclature. Named after the Standish Ranges, about 30 km southeast of Dajarra, Duchess 1:250 000 Sheet area, by Blake & others (1978a, b). Previously mapped in Duchess Sheet area as Kalkadoon Granite and Argylla Formation (Carter & others 1961, Carter & Öpik 1963); northern part shown as Magna Lynn Metabasalt and Argylla Formation by Bultitude & others (1977b).

Distribution . North-trending belts up to about 5.5 km wide in southwest and central west. More extensive in Dajarra Sheet area to south.

Reference locality in Sheet area. East of McPhee Creek, from GR 623352 to GR 670352.

Topographic expression and airphoto characteristics. Forms low rounded hills and undulating terrain with few trend lines visible. Intercalated sediments locally form prominent strike ridges. Pale to dark tones on aerial photographs.

Thickness. May be about 2500 m thick near Butru railway siding in southwest.

General lithology. Massive felsitic (cherty) acid volcanics (Ɇsa, Ɇsa$_1$), red-brown porphyritic acid volcanics (Ɇsa$_2$), schistose acid volcanics (Ɇsa$_s$), basic volcanics (Ɇsb), and intercalated sediments (Ɇss).

Details of lithology. Ɇsa. Felsitic acid porphyry and minor grey rhyolite and phyllitic fine tuff. The acid porphyry is maroon, pink, pale green and greenish grey; consists of small feldspar and quartz phenocrysts set in a very fine-grained felsitic groundmass; generally massive, but schistose, brecciated, and quartz-veined; also recrystallised, near faults; locally shows vague possible eutaxitic textures.

Ꝑsa$_1$. Mainly quartz-feldspar and feldspar porphyries (rhyolitic to ?dacitic); similar to Ꝑsa; pale grey, dark grey, greenish grey, dark brown, red-brown, maroon, pink; contain sparse to abundant small euhedral quartz and larger white to pink feldspar phenocrysts in a very fine-grained felsitic ('cherty') groundmass. Some non-porphyritic units and zones also present. Flow banding visible in places. Mainly massive, but foliated, schistose, brecciated, quartz-veined, and recrystallised near faults and adjacent to Kalkadoon Granite. Intruded by numerous, mainly north to northeast-trending metadolerite dykes, at least some of which may have been feeders to basalts of Ꝑsb.

Ꝑsb. Mainly metabasalt: actinolite-?biotite schist with amygdaloidal zones; perhaps best exposed in the bed of Wills Creek 2.5 km north of Bushy Park homestead; dark grey-green to green-black; fine-grained; quartz-veined; amygdales commonly filled with pink feldspar and quartz. Also numerous thin lenses of intercalated metasediments and minor flow-top breccia, dark green chlorite schist, and chlorite-biotite schist. Traces of epidote and copper minerals (mainly chalcopyrite, malachite, azurite, chrysocolla) common. Some cross-cutting veins of rose calcite. Flow-top breccias contain angular fragments of amygdaloidal metabasalt and fine-grained amphibolite, commonly in a matrix of mainly fine-grained dark grey epidotic quartzite. Most sedimentary lenses are less than 5 m thick, and consist mainly of pale, locally silicified and glassy, fine to coarse quartz arenite and quartzose meta-arenite which are extensively epidotised or ferruginised, commonly brecciated and locally friable; some beds contain small irregular cavities. A few medium to coarse metadolerite (amphibolite) intrusions are present.

Some highly sheared, dark red-brown porphyries are poorly exposed near the top of this unit west of Bell White Tank (GR 673421); in these, feldspar phenocrysts up to about 1 cm long, and in some bodies also subordinate smaller quartz phenocrysts, are enclosed in an extensively recrystallised fine-grained groundmass. Individual bodies are generally less than 5 m thick, and may represent feeder dykes to units in overlying acid volcanics of Ꝑsa$_2$, but could be thin acid volcanics interlayered with the basic volcanics.

Ꝑss. Two main belts mapped. The more westerly, about 250 m thick, underlies Ꝑsb southwest of Bushy Park homestead; it consists of extensively ferruginised, silicified, brecciated and quartz-veined, ridge-forming feldspathic and quartzose meta-arenite, together with poorly exposed schistose metasiltstone and minor grey schistose labile meta-arenite, medium to coarse biotite schist, and ?hematitic metasiltstone. The meta-arenites range from white to dark brown and blue-grey, fine to medium-grained, and medium to thick-bedded, and show cross-bedding (beds face east).

The other Ꝑss belt, east of Ꝑsb, locally interfingers with acid volcanics mapped as Ꝑsa$_2$. It consists of deeply weathered and extensively ferruginised feldspathic, quartzose, and ferruginous meta-arenite; poorly exposed grey slightly schistose, micaceous metasiltstone; and minor conglomerate, gritty feldspathic meta-arenite, grey labile meta-arenite, pink labile feldspathic meta-arenite, meta-arkose, and porphyritic acid volcanics. The meta-arenites are fine to medium-grained, thin to thick-bedded, cross-bedded (east-facing); ripple-marks, thin dark heavy mineral bands, small irregular cavities, and cross-cutting quartz veins are present locally. Conglomerate forms lenses less than 10 m thick, and consists of rounded clasts up to 30 cm of mainly white to grey medium-grained quartzite and feldspathic quartzite and subangular clasts up to 15 cm across of metasiltstone and rare biotite schist in a commonly schistose and sericitic feldspathic to quartzose matrix. Interbedded acid volcanic units are red-brown, and consist of generally abundant feldspar and subordinate quartz phenocrysts in a recrystallised groundmass, and commonly contain numerous lithic fragments, mainly of dark grey fine mica schist. Cappings less than 1 m thick of lateritic ironstone rubble are present in places, and there are a few cross-cutting metadolerite dykes.

Ꝑsa$_2$. Mainly much weathered red-brown schistose acid volcanics containing abundant euhedral pink feldspar phenocrysts up to about 1 cm long, and subordinate smaller euhedral quartz phenocrysts set in a recrystallised sericitic groundmass; minor fine to medium-grained quartz-muscovite ± biotite schist near faults; cut by quartz veins but not visibly intruded by any basic dykes.

Ꞓsa$_s$. Mainly highly schistose and extensively recrystallised porphyritic acid volcanics and quartz-muscovite $\pm$ biotite schist (?metatuff); very minor lenses up to about 10 m thick of white medium-grained, extensively brecciated quartzite, feldspathic meta-arenite, and sericitic meta-arenite. The acid volcanics commonly contain abundant phenocrysts of feldspar and have a fine quartzofeldspathic groundmass rich in biotite. They appear to become slightly less schistose and recrystallised, and more obviously porphyritic, away from poorly exposed contacts with Tewinga Group gneiss. Ꞓsa$_s$ is restricted to the eastern margin of the Standish Volcanics outcrop, and appears to be an intensely sheared and recrystallised equivalent of Ꞓsa$_2$ volcanics. The contact between it and Tewinga Group rocks may mark a major and at present unmapped north-trending fault zone.

Structure and metamorphism. Outcrops may represent keels of extensively faulted synclines. Beds are mainly moderately dipping and sedimentary structures such as cross stratifaction and ripple marks are fairly well preserved. Regionally metamorphosed to mainly ?lower-?middle greenschist facies.

Stratigraphic relations. Probably faulted against Tewinga Group rocks; possibly unconformable on Kalkadoon Granite; and probably unconformably overlain by sediments tentatively assigned to Stanbroke Sandstone. Intruded by basic dykes. Interpreted as unconformably overlying Kalkadoon Granite in the adjoining Dajarra Sheet area to the south by Blake & others (1978).

Possible unconformable contacts between Ꞓsa and coarse-grained slightly porphyritic (in pale pink feldspar) non-foliated biotite granite mapped as Kalkadoon Granite are evident at several places along the western margin of the eastern belt of Standish Volcanics: e.g., (1) south of the Bushy Park-Urandangi track, at GR 639480, where slightly sheared acid volcanics are exposed within 2 m of aplite-veined massive granite; no aplite veins cut the acid volcanics; (2) west of Butru railway siding in the south, where Ꞓsa$_1$ is faulted against Kalkadoon Granite to the west, but some small acid volcanic remnants occur west of the fault; these remnants are highly sheared, but are not intruded by any granitic veins, although many aplitic and microgranitic veins cut the associated granite; the granite is also cut by a few dyke-like bodies of feldspar porphyry that may represent feeders for some of the acid volcanics.

Ꝑsa$_1$ may be intruded by poorly exposed small pods (not shown on map) of non-foliated leucocratic biotite granite east of Quartpot Tank (GR 602356), and by medium-grained, biotite-rich granodiorite or diorite (shown as Ꝑg$_d$ on the map) northwest of Ashover homestead. The leucocratic granite may be related to the Wills Creek Granite of the Dajarra Sheet area (Blake & others, 1978b). The granodiorite or diorite near the Standish Volcanics contains abundant xenoliths, including some up to 50 cm across of grey, fine-grained rocks that may be recrystallised acid volcanics.

Age. Proterozoic.

Correlation. Correlated with the Standish Volcanics mapped in the Dajarra Sheet area to the south.

Mineralisation. Basic volcanics of Ꝑsb contain traces of malachite, azurite, chrysocolla, and rare chalcopyrite, and several small mines or prospects are located in this unit. The copper mineralisation is generally concentrated in faults or shear zones, and is commonly associated with secondary iron oxides and chalcedony.

Remarks. In the southwest the formation consists of distinct lithologic and stratigraphic units. Acid volcanics of Ꝑsa$_1$ at the base are overlain by a lens of sedimentary rocks, mapped as Ꝑss, above which is a sequence of basic volcanics, Ꝑsb, overlain in turn by more acid volcanics, Ꝑsa$_2$, and associated sedimentary rocks, Ꝑss. Numerous metadolerite dykes intrude Ꝑsa$_1$ but only a few cut the overlying units, perhaps because many of the dykes represent feeders to the Ꝑsb lavas. The succession here is strikingly similar to the sequence mapped as Leichhardt Metamorphics, Magna Lynn Metabasalt, and Argylla Formation in the north, between GR 710665 and GR 737700.

Stanbroke Sandstone

(new name)

Map symbol. Pb?

Nomenclature. Named after Stanbroke homestead in the Dajarra 1:100 000 Sheet area. Previously mapped as Argylla Formation (Carter & others, 1961; Carter & Öpik 1963).

Distribution. Belt about 5.5 km long and up to 700 m wide in southwest; forms more extensive outcrops in the Dajarra Sheet area to south.

Reference section in Sheet area. About 9.5 km northwest of Ashover homestead.

Topographic expression and airphoto characteristics. Forms strike ridges and valleys. Medium tones on aerial photographs (dark brown to red-brown on colour aerial photographs).

Thickness. About 300 m maximum.

General lithology. Quartz and feldspathic arenite, arkose, metasiltstone, and conglomerate.

Details of lithology. Quartz arenite and feldspathic arenite: ridge-forming; white, pale brown and pale grey; fine to medium-grained; thin to thick-bedded; commonly cross-bedded; many beds with small irregular cavities. Arkose: fine to medium-grained. Metasiltstone: poorly exposed; thin-bedded to laminated; pale grey to red-brown; extensively ferruginised. Conglomerate: present at base of formation in north; clasts, mainly about 3 cm but some up to 30 cm, mostly of white to pale brown medium-grained feldspathic and quartzose arenite, and extensively altered schistose acid volcanics; some probable basic volcanic clasts; matrix white to pale brown, fine-grained, schistose, and sericitic, with scattered laths of altered ?feldspar up to 1 cm long.

Basal part of formation in south consists mainly of arkose. Minor rock types present locally include pale brown schistose sericitic arenite, sericite schist, limestone, and phyllite (near fault).

Structure and metamorphism. Crops out in keel of partly fault-bounded syncline; beds in west have moderately steep dips (25^{o}-40^{o}), and are not highly deformed. Probably lower greenschist facies of regional metamorphism. Schistose rocks formed mainly by shearing and faulting.

Stratigraphic relations. Overlies Standish Volcanics, probably unconformably. Does not appear to be intruded by any basic dykes.

Age. Proterozoic.

Correlation. Probably a correlative of the Surprise Creek Beds to the north.

Mineralisation. None known in Sheet area.

Remarks. May represent shallow marine deposits.

Surprise Creek Beds

Map symbols. Pr, Pr_t, Pr?

Nomenclature. Named after Surprise Creek, a tributary of the Leichhardt River in the Cloncurry 1:250 000 Sheet area; defined by Carter & others (1961). Previously mapped in the Duchess Sheet area as Mount Guide Quartzite (Carter & others, 1961; Carter & Öpik, 1963).

Distribution. Two north-northwest-trending belts up to about 2 km wide and about 5 km apart in northwest, and a narrow discontinuous northeast-trending belt about 7 km east-northeast of Woonigan railway siding. Forms more extensive exposures in Sheet areas to north.

Reference section in Sheet area. About 6 km south-southeast of Malbon Vale homestead, around GR 560636.

Topographic expression and airphoto characteristics. Forms extensively dissected planated strike ridges and narrow valleys. Medium to dark tones on aerial photographs.

Thickness. At least 700 m thick 6 km north of Yarraman Well, at GR 558577.

General lithology. Feldspathic and quartz arenite, siltstone, minor conglomerate.

Details of lithology. Pr. Mainly white, brown, and red-brown, thin to medium-bedded, fine to medium feldspathic arenite and silicified quartz arenite, commonly containing abundant clay grains (altered ?feldspar) and having a clay-rich matrix; minor conglomerate, coarse arenite and grit, sericitic arenite, laminated pale brown, pale yellow, dark red-brown, and purple siltstone, and thin-bedded, black to dark grey ?hematitic shale. Some arenites show ripple marks and poorly developed cross-bedding. Intense ironstaining in places is a result of lateritic weathering.

Interbedded conglomerate and schistose and brecciated feldspathic arenite at the base of the unit overlie schistose metabasalt tentatively mapped as Eastern Creek Volcanics 4.5 km east-northeast of Kurbayia railway siding. The conglomerate contains abundant rounded to subangular clasts up to 1 m of mainly quartzite, quartz arenite, and acid volcanics, and has a pale grey to pale brown schistose labile fine-grained matrix; many acid volcanic clasts are flattened, perhaps because they were originally pumice fragments (implying penecontemporaneous volcanism), and consist of small quartz phenocrysts enclosed in a soft labile schistose matrix. Basal conglomerate 6 km to the south contains rounded clasts up to 25 cm of feldspathic arenite and minor quartzite and quartz arenite in a white to purple labile matrix; no undoubted acid volcanic clasts were observed here.

Ɛr? A sequence of sericitic, feldspathic, and quartzose arenites, dark sericitic, ferruginous, and calcareous siltstone, fine-grained carbonate rocks, and minor interbedded conglomerate, arkosic grit, fine-grained labile arenite, and mica schist is exposed in the belt east-northeast of Woonigan railway siding, where the outcrop consists mainly of a narrow northeast-trending fault-bounded ridge. The arenites here are white, pale brown, buff, red-brown, and grey; thin to thick-bedded; commonly contain abundant small pink clay pellets (altered ?feldspar grains); and locally show fine banding and poorly developed cross-bedding. The calcareous sediments - mainly siltstone, silty limestone, recrystallised limestone, marl, and minor calcarenite and ?calcareous arenite - are laminated to massive and commonly manganiferous; some contain fine bands rich in ?hematite or ?magnetite. The conglomerate beds contain subrounded to rounded clasts up to about 2 cm of vein quartz, fine-grained ferruginous feldspathic arenite, and basic schist in a gritty arkosic matrix in which abundant clay grains, probably representing altered feldspar, are present. The arenites are commonly extensively brecciated and silicified, particularly adjacent to the bounding faults. A northeast-trending schistosity is developed in the less competent beds. In places the calcareous units are deformed plastically, and associated arenites show complex small-scale folding.

Pr$_t$. Mainly laminated fine-grained pale brown, pale yellow, and dark red-brown feldspathic siltstone (?tuff).

Structure and metamorphism. Beds are steeply dipping, tightly folded, extensively brecciated and sheared, and cut by numerous faults and quartz veins, but do not appear to have been affected by more than ?lower greenschist facies regional metamorphism. They are preserved in elongate blocks faulted against Kalkadoon Granite, Tewinga Group rocks, and Mount Guide Quartzite. Near faults a strong cleavage/schistosity has formed, and muscovite and chlorite have developed; richly feldspathic beds tend to be more schistose than quartzose beds, which are extensively brecciated instead.

Stratigraphic relations. Unconformable on Kalkadoon Granite; overlies, apparently concordantly, schistose metabasalt and intercalated metasediments tentatively mapped as Eastern Creek Volcanics (Ehe?). Faulted against undivided Tewinga Group rocks, Magna Lynn Metabasalt, acid volcanics tentatively mapped as Leichhardt Metamorphics (Eel?) and Argylla Formation (Eea?), and Mount Guide Quartzite. Remnant cappings of Tertiary laterite present in places. Appears to be intruded east-northeast of Woonigan siding by two basic dykes (may be lava flows); one consists of fine-grained epidotic metadolerite, the other of little altered fine-grained dolerite characterised by a hackly fracture.

Age. Proterozoic.

Correlation. Correlated with Stanbroke Sandstone.

Mineralisation. None known in Sheet area.

Remarks. The Surprise Creek Beds east of Kurbayia railway siding are faulted against very fine-grained, pale grey to pale green, 'cherty' acid volcanics tentatively assigned to the Leichhardt Metamorphics but similar in lithology and metamorphic grade to the Standish Volcanics.

The sequence east-northeast of Woonigan siding has also been tentatively mapped as part of the Surprise Creek Beds because it has undergone only very low-grade regional metamorphism (?lower greenschist facies), because it has a lithology similar to Surprise Creek Beds mapped in the Mary

Kathleen Sheet area (Derrick & others, 1974, 1977b), and because it is preserved as a narrow fault-bounded linear belt.

BRIEF NOTES ON LATE PROTEROZOIC AND PHANEROZOIC SEDIMENTS

Late Proterozoic (Vendian?) to Middle Cambrian rocks of the Burke River Outlier succession

Sedimentary rocks of the Burke River Outlier succession crop out mainly east of the Pilgrim Fault Zone, in the southeastern corner of the Sheet area, but some isolated remnants are exposed southwest of Duchess township. They are predominantly flat-lying to gently dipping, except immediately adjacent to faults, and rest with marked angular unconformity on folded and regionally metamorphosed rocks of the Cloncurry Complex. The succession was mapped by a joint BMR-GSQ field party in 1967 (de Keyser, 1968, 1972) and has not been examined in detail by us.

The Mount Birnie Beds, at the base of the succession, range in age from probably late Proterozoic (Vendian) to early Middle Cambrian (Ordian) (de Keyser, 1968, 1972; J.H. Shergold, BMR, personal communication, 1978). They crop out around the margins of the Burke River Outlier, and are probably best developed 8 to 10 km east-northeast of Duchess township, where a basal tillite, the Little Burke Tillite of de Keyser (1972), is present. This tillite is well exposed in a section cut into the eastern bank of the Little Burke River.

Mount Birnie Beds

Map symbols. €lb, €lt.

Nomenclature. Named after Mount Birnie, Dajarra 1:100 000 Sheet area; defined by de Keyser (1968).

Distribution. Around margins of the Burke River Outlier.

Thickness. Clb ranges in thickness from 0 to about 200 m; Little Burke Tillite member ranges from 0-20 m thick.

Topographic expression and airphoto characteristics. Form cuestas and mesas; smooth medium tones on aerial photographs.

General lithology. Sandstone, conglomerate, shale, mudstone and dolomite (€lb); minor tillite (€lt). Tillite (Little Burke Tillite) is present at base of unit 8 to 10 km east-northeast of Duchess township and is well exposed in eastern bank of Little Burke River.

Structure and metamorphism. Flat-lying except in immediate vicinity of some faults. Not regionally metamorphosed.

Stratigraphic relations. Unconformable on other Precambrian units; overlain apparently concordantly by Cambrian formations of the Burke River Outlier succession. Not intruded by granite or basic dykes.

Age. Probably Proterozoic (Vendian) to early Middle Cambrian (Ordian) (de Keyser, 1968, 1972; J.H. Shergold, BMR, personal communication, 1978); most of unit probably Cambrian.

Correlations. Tillite at base is correlated with late Proterozoic tillite exposed in the Georgina Basin (de Keyser, 1972; J.H. Shergold, BMR, personal communication, 1978).

Remarks. The Mount Birnie Bess are a composite unit at the base of the Burke River Outlier succession.

Thorntonia Limestone, Roaring Siltstone, Devoncourt Limestone, Selwyn Range Limestone, and O'Hara Shale

Map symbols. €mt, €mt_t, €mr, €md, €mw, €uh.

Nomenclature. Units named and defined by de Keyser (1968).

Distribution. Mainly in southeast, east of the Pilgrim Fault Zone; some small isolated remnants southwest of Duchess township.

Thicknesses (maximum). €mt_t + €mt = 18 m; €mr = 75 m; €md = 210 m; €mw = 37 m; €uh = 85 m.

Topographic expression and airphoto characteristics. Form plains, low subdued cuestas, and some mesas. Pale to dark tones on aerial photographs.

General lithology. Sandstone, conglomerate, shale, siltstone, limestone-chert, dolomite and dolomitic limestone commonly with chert nodules, marl, calcilutite, chert.

Structure and metamorphism. Flat-lying except near some faults. Not metamorphosed.

Relations. Essentially concordant, commonly interfingering, sequence. Not intruded by granite or basic dykes.

Age. Mainly Middle Cambrian.

?Mesozoic sediments

Map symbol. M.

Distribution. Small outcrops in northwest and southwest previously mapped as undifferentiated Palaeozoic (Carter & Öpik, 1963).

Topographic expression and airphoto characteristics. Forms remnant cappings on mesas. Medium tones on aerial photographs.

Thickness. Maximum about 15 m.

General lithology. Conglomerate, grit, arenite, and minor claystone.

Details of lithology. Mainly pebble and boulder conglomerate and locally cross-bedded grit at base, overlain by and interbedded with cross-bedded arenite and rare white to pale grey claystone. The conglomerate contains rounded to angular clasts up to 60 cm of white to pale grey quartz arenite, white to ironstained feldspathic arenite, quartzite, vein quartz, and subordinate glassy quartzite, schistose sericitic quartzite, and possible granite (now kaolinised); some arenite lenses generally less than 10 cm thick are also generally present. Arenite overlying and forming the matrix of the conglomerate is friable, ferruginous to bleached, and medium to coarse and partly gritty to pebbly; it has generally abundant clay.

Structure and metamorphism. Essentially flat-lying and unmetamorphosed.

Relationships. Unconformable on underlying units. Contacts with bleached and extensively kaolinised Kalkadoon Granite are well exposed in northwest.

Age. Probably Mesozoic.

Remarks. Skwarko (1966) included the ?Mesozoic sediments of the Duchess 1:250 000 Sheet area with the Cretaceous Mullaman Beds, which consist of a non-marine sequence overlain by marine beds. The sediments in the Duchess 1:100 000 Sheet area are probably mainly fluviatile.

Weathered bedrock

Map symbol. Tc.

Distribution. Small outcrops in south.

Topographic expression and airphoto characteristics. Forms remnant mesa cappings characterised by medium to dark tones on aerial photographs.

Thickness. Up to about 10 m.

Lithology. Bleached to ironstained kaolinised bedrock in which original textures and structures are readily visible.

Relationships. Locally capped by laterite.

Age. Probably Tertiary.

Remarks. Probably represents lower parts of lateritic weathering profiles formed in situ under relatively stable conditions during the Tertiary (Twidale, 1964).

Laterite

Map symbol. Tl.

Distribution. Northwest, west and southeast.

Topographic expression and airphoto characteristics. Occurs as small remnant cappings on Mount Guide Quartzite and Standish Volcanics in the west, on Surprise Creek Beds in the northwest, and on Cambrian rocks (O'Hara Shale) in southeast; characterised by dark tones on aerial photographs.

Thickness. Generally about 3 m.

Lithology. Massive, layered and pisolitic lateritic ironstone; nor original structures or textures preserved.

Age. Probably Tertiary (Twidale, 1964).

Remarks. Directly overlies bleached and ferruginised bedrock.

Unconsolidated sediments

Map symbol. Cz.

Distribution. Widespread in Sheet area, especially in the valleys of Wills Creek and some of its tributaries.

Topographic expression and airphoto characteristics. Present on plains and footslopes and in depressions. Pale to medium tones on aerial photographs.

Thickness. Up to 15 m locally.

Lithology. Unconsolidated sand, silt, and gravel; alluvial, colluvial, and residual.

Age. Probably partly Tertiary and partly Quaternary.

Remarks. Form a thin and impersistent cover on many areas shown as bedrock on the 1:100 000-scale geological map.

DESCRIPTIVE NOTES ON INTRUSIVE ROCK UNITS

Kalkadoon Granite

Map symbols. Pgk, Pgk_d, Pgk_m, Pgk?

Nomenclature. Defined by Carter & others (1961); named after Kalkadoon Copper mine, in the Dobbyn 1:250 000 Sheet area. Not as widespread in the Duchess 1:100 000 Sheet area as mapped previously (Carter & others, 1961; Carter & Öpik, 1963).

Distribution. Crops out extensively in western half of Sheet area; outcrops continue north and south into adjoining Sheet areas.

Reference area. Near GR 530495, where Kalkadoon Granite intrudes Tewinga Group to southeast and is overlain by Bottletree Formation to west.

Topographic expression and airphoto characteristics. Landforms range from moderately rugged terrain with tors and spheroidal boulders to gently undulating plains with scattered bouldery outcrops; outcrop areas have close to open dendritic drainage patterns, and show as mainly moderate tones on aerial photographs.

General lithology. Massive to locally foliated biotite granite and granodiorite, commonly porphyritic (Pgk); diorite (Pgk_d); massive to foliated xenolithic granite and migmatitic gneiss (Pgk_m); minor leucogranite, microgranite, aplite, pegmatite.

Details of lithology. Pgk. Mainly pink to grey, medium to coarse biotite granite and granodiorite; colour index generally less than 20; commonly contains euhedral, tabular, white to pink feldspar phenocrysts, 1 to 5 cm long, which in places show a 'flow' alignment; traces of hornblende and altered allanite in some rocks; mainly massive but locally foliated, and is sheared near faults; primary biotite crystals commonly recrystallised to fine aggregates and partly altered to chlorite and/or epidote; xenoliths, up to 1 m of mainly pale to dark grey fine to medium-grained mafic rocks, schist, gneiss, extensively recrystallised acid volcanics (commonly represented by siliceous, even-grained quartzitic rocks), and rare epidotic quartzite are present locally. Includes small patches of porphyritic and even-grained biotite microgranite, biotite-rich contaminated granite, and medium-grained locally xenolithic diorite; cut by veins of aplite, medium to coarse leucogranite, and leucocratic pegmatite.

$\underline{Pgk_d}$. Grey, medium to fine, mainly even-grained diorite; generally massive; single sample examined in thin section (77530225) has a colour index of about 30, and consists mainly of largely altered subhedral plagioclase, pale green amphibole, leucoxene, and interstitial and partly micrographic quartz and microcline.

$\underline{Pgk_m}$. Granite and granodiorite similar to that of Pgk - except more richly xenolithic - and generally foliated, and relatively rich in biotite - together with extensively veined and strongly foliated biotite-rich porphyritic to even-grained granodiorite, diorite, and migmatitic gneiss containing numerous large and small inclusions; xenoliths/inclusions/schlieren consist of dioritic rocks, greyish acid gneissic metavolcanics, even-grained quartz-biotite ('aplitic') rocks (?recrystallised acid volcanics), biotite schist, feldspathic quartzite, epidotic quartzite, granitic meta-arkose, and metadolerite; foliation is locally crenulated; numerous cross-cutting veins of fine to coarse, rarely xenolithic, mainly leucocratic, porphyritic and even-grained biotite granite; pegmatite veins also common; minor aplite veins.

<u>Pgk?</u> Small outcrop area in southwest, 7 km south-southeast of Broadhurst Bore, of medium to fine schistose to gneissic chloritic granite containing pink feldspar phenocrysts.

<u>Structure and metamorphism</u>. Foliation, where evident, generally trends north and is steeply dipping. Numerous faults and shear zones cut outcrops. Widespread recrystallisation and alteration of biotite indicate moderate-grade regional metamorphism.

<u>Relations</u>. Intrudes and forms migmatites with undivided Tewinga Group; inferred to intrude Leichhardt Metamorphics north-northwest of Bushy Park Homestead; contacts faulted with Magna Lynn Metabasalt and Argylla Formation. Unconformably overlain in west by Bottletree and Yappo Formations and in north by Surprise Creek Beds; inferred to be unconformably overlain by

Standish Volcanics in south. Intruded by innumerable schistose to massive basic dykes and locally by acid (feldspar ± quartz) porphyry dykes (e.g., near GR 625765).

Age: Early Proterozoic. U-Pb zircon age of about 1860 m.y. (Page, 1976, 1978).

Correlations. Part of batholith mapped as Kalkadoon Granite in Mary Kathleen Sheet area to north (Derrick & others, 1974, 1977b) and Dajarra Sheet area to south (Blake & others, 1978b).

Mineralisation. A few small disused copper mines occur within outcrops of Kalkadoon Granite close to cross-cutting basic dykes.

Remarks. Kalkadoon Granite forms a complex batholith containing the oldest known granites in the Mount Isa region. However, it may also contain some relatively young plutons; there are no reliable age dates for the Kalkadoon Granite in the Duchess or Dajarra Sheet areas. It probably represents syn-tectonic (foliated) and immediately post-tectonic (massive) intrusions associated with the first and main regional metamorphic event to affect the Tewinga Group. The granite shows mesozonal and catozonal features (Buddington, 1959), and was probably emplaced many kilometres below the surface.

Bowlers Hole Granite
(new name)

Map symbol. Ꞓgo.

Nomenclature. Named after Bowlers Hole dam (GR 771635) in the central-north of the Sheet area. Previously mapped as Kalkadoon Granite (Carter & others, 1961; Carter & Öpik, 1963).

Distribution. Crops out over an area of about 15 km^2 in the north.

Type section. From GR 766740 to GR 798723.

Topographic expression and airphoto characteristics. Forms bouldery hills and undulating terrain. Medium to pale tones on aerial photographs.

General lithology . Foliated biotite granite.

Details of lithology. Mainly pink, medium to coarse, extensively recrystallised and slightly porphyritic foliated biotite granite; minor microgranite, gneissic granite, and aplite; rare mafic-rich ?contaminated granite. Foliation defined by alignment of fine biotite flakes. Sparse small mafic xenoliths commonly present, as also are numerous thin quartz veins; epidote veins occur locally.

Structure and metamorphism. The granite has a moderately to steeply dipping foliation. Extensive recrystallisation indicates moderate grade regional metamorphism. The granite appears to have been emplaced forcefully, mainly by pushing aside and doming the country rocks, and is probably a relatively high-level, epizonal intrusion. Massive metabasalt adjacent to the contact has been converted in places into fine-grained amphibole schist.

Relations. Intrudes Magna Lynn Metabasalt and probably Argylla Formation. Metabasalt adjacent to the contact is cut by veins and small pods of foliated biotite microgranite and aplite. Several mainly schistose amphibolitic dykes cut the granite.

Age. Proterozoic.

Correlation. Possibly related to the Mairindi Creek Granite northwest of Duchess township.

Mineralisation. None known.

Remarks. May be an intrusive equivalent of acid volcanics within the Argylla Formation.

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Mairindi Creek Granite
(new name)

Map Symbol. Ꝑgr.

Nomenclature. Named after Mairindi Creek, which drains the country adjacent to the southeastern margin of the granite - northwest of Duchess township. Previously mapped as Kalkadoon Granite (Carter & others, 1961; Carter & Öpik, 1963).

Distribution and type locality. Crops out over about 20 km^2, 9 km northwest of Duchess. This is the type locality.

Topographic expression and airphoto characteristics. Forms dissected, bouldery, hilly terrain. Medium to dark tones on aerial photographs.

General lithology. Strongly foliated, white, pink, and buff, moderately porphyritic biotite granite.

Details of lithology. Foliated biotite granite: mainly medium to coarse-grained; but slightly finer-grained near margins; contains scattered phenocrysts of pink feldspar and colourless quartz, and traces of ?allanite and fluorite; cut by thin aplite and quartz veins.

Structure and metamorphism. Well-developed, steeply dipping to vertical, northwest-trending foliation defined mainly by parallel alignment of biotite flakes and aggregates. The foliation is crenulated in places, the crenulations having wavelengths of about 30 cm and amplitudes of about 10 cm. The granite, appears to have been emplaced mainly by pushing aside and doming the country rocks. Metabasalt adjacent to the contact has been converted into fine to medium-grained amphibole schist - some of the interlayered sediments are garnetiferous.

Stratigraphic relations. Aplite, quartz, and rare leucocratic microgranite veins associated with the granite intrude adjacent metabasalt tentatively assigned to the Magna Lynn Metabasalt and Argylla Formation. Numerous mainly northwest trending basic dykes intrude the granite; some are of massive amphibolite with doleritic textures preserved; others, which may be older, consist of schistose amphibolite and biotite schist.

Age. Progerozoic.

Correlation. May be equivalent to the Bowlers Hole Granite in the north of the Duchess Sheet area.

Mineralisation. None known.

Remarks. The presence of fluorite in the granite is perhaps significant: fluorite has not been reported in the Kalkadoon Granite, but trace amounts are fairly common in the Burstall and Sybella Granites.

Wimberu Granite

Map symbol. Ɛgm.

Nomenclature. Named after Wimberu holding, Duchess 1:250 000 Sheet area; defined by Carter & others (1961). Previously mapped in Sheet area as Argylla Formation (Carter & others, 1961; Carter & Öpik, 1963). Area of Wimberu Granite shown around Bungalien railway siding on the Duchess 4-mile map (Carter & Öpik, 1963) is now remapped as Argylla Formation.

Distribution. Crops out on eastern margin of Sheet area about 6.5 km east of Boundary Bore.

Remarks. We have not examined it in the field. Forms part of a large body extensively exposed in the adjacent Malbon Sheet area to the east. According to Noon (1978), it consists of grey-brown coarse biotite granite and brown fine to medium granite intruded by aplite and pegmatite veins; it contains small blebs of sphene and, near its margins, xenoliths of grey schist and acid volcanics (Noon, 1978); it intrudes Argylla Formation and is overlain by Cambrian sediments (Noon, 1978). Numerous pegmatite and leucocratic microgranite veins and pods cutting the Argylla Formation east and northeast of Boundary Bore are probably related to this granite.

Burstall-type granite (?Burstall Granite)

Map symbols. Ꝑgb, Ꝑgb$_p$.

Nomenclature. Burstall Granite, is named after Mount Burstall, in the Cloncurry 1:250 000 Sheet area, and is defined by Derrick & others (1978). Previously mapped in Sheet area as Wonga Granite (Carter & others, 1961, Carter & Öpik, 1963).

Topographic expression and airphoto characteristics. Forms rounded, bouldery hills and irregularly dissected plateaus which have pale to medium tones on aerial photographs.

General lithology. Leucocratic granite, microgranite and aplite (Ꝑgb); tourmaline-bearing pegmatite (Ꝑgb$_p$); some small inclusions (pendants) of Corella Formation rocks.

Details of lithology. Ꝑgb. Leucocratic granite: pink to grey; medium to coarse; even-grained to slightly porphyritic (in pale pink feldspar); massive to foliated; contains biotite, amphibole, and traces of fluorite; biotite predominates in granite forming central parts of main intrusions.

Leucocratic microgranite: forms margins of intrusions; white to pink; commonly closely jointed; very rarely xenolithic; strongly foliated (primary flow foliation); patchily porphyritic; locally forms veins and pods intruding adjacent Corella Formation metasediments and metadolerite masses; grades inwards into leucocratic granite; commonly partly recrystallised; locally cut by quartz-pink feldspar pegmatite veins. Intrusive contacts with adjacent country rocks are generally sharp, but narrow marginal migmatites (mixed rocks) are developed northeast of the Revenue group of mines.

The granite intrusions are cut by late-stage quartz-pink feldspar pegmatite (more common cutting Corella Formation rocks) containing tourmaline and, rarely, rose quartz, and also by white to pale pink aplite and thin fluorite and quartz veins. Some quartz veins have margins of chalcedony or agate, and interiors partly filled with small inward-growing quartz and amethyst crystals.

Burstall-type granite associated with Myubee Gabbro appears to be a contaminated variety. It is medium-grained, strongly foliated, relatively rich in hornblende and especially biotite, and contains sparse angular xenoliths, up to 30 cm of coarse-grained, porphyritic hornblende granite. Around the southern margin of the gabbro, it intrudes poorly exposed small masses (?pendants) of coarse-grained, non-foliated, hornblende granite containing pale pink feldspar phenocrysts up to 5 cm long. The granite and adjacent calc-silicate rocks of the Corella Formation are cut by pegmatite veins containing ?amphibole and, in places, sparse zoned garnet crystals up to 10 cm.

The Burstall-type granites are generally highly potassic, and contain abundant microcline (commonly showing signs of inversion from orthoclase); also present are orthoclase, plagioclase (generally oligoclase), ferrohastingsite, biotite, chlorite, quartz, and metamict zircon. An analysed sample from the granite associated with the Myubee Gabbro contains 72.20% SiO_2, 0.23% TiO_2, 13.58% Al_2O_3, 0.64% Fe_2O_3, 1.80% FeO, 0.03% MnO, 0.42% MgO, 1.25% CaO, 3.30% Na_2O, 5.28% K_2O, 0.10% P_2O_5, 0.78% H_2O^+, 0.08% H_2O^-, 0.20% CO_2; it is slightly corundum-normative.

$\underline{Egb_p}$. Abundant closely spaced tourmaline-bearing, graphic quartz-pink feldspar pegmatite veins cutting calc-silicates of the Corella Formation. The veins are generally less than 10 m but range up to 50 m in thickness, are mainly straight-sided and apparently undeformed, cut across bedding, foliation and fold structures in the Corella Formation metasediments, and have sharp contacts and commonly chilled margins. They are assumed to be related to the Burstall-type granite, because although some pegmatite veins cut the granite and were obviously intruded after the granite was emplaced, a few appear to be marginal facies of the granite and merge into it.

Two groups of pegmatite veins cut the Corella Formation south of Mount Mascotte mine. One group is not deformed, contains tourmaline, has chilled margins, and is assumed to be related to Burstall-type granite. The other group consists of biotite-bearing quartz-white feldspar pegmatite veins less than 0.5 m thick which have been intensely deformed, disrupted, and boudinaged; these veins are probably much older and unrelated to Burstall-type granite.

Structure and metamorphism. Emplaced as elongate pods and sill-like bodies roughly concordant with enclosing Corella Formation rocks, probably at relatively high crustal levels. Contact metamorphic effects virtually restricted to slight hornfelsing within a metre or less of intrusive contacts.

The intrusions are cut by numerous, commonly quartz-filled, north-northeast to northeast-trending faults with small horizontal and vertical displacements. They have probably been regionally metamorphosed to greenschist grade. Granite margins commonly show a steep, northerly trending foliation that may represent primary flow banding. However, some intrusions were clearly deformed after emplacement. A gneissic foliation characterising the intrusion northeast of the Revenue group of mines shows crenulations with wavelengths of about 30 cm and amplitudes of about 15 cm; the assertions of Carter & others (1961), and Joplin & Walker (1961) that this crenulated gneissic granite represents metasomatised calc-silicate rocks are rejected by two of us (R.J.B., P.J.T.D.), because contacts between calc-silicate rocks of the Corella Formation and crenulated granite are sharp (resolvable within 1 to 2 cm) and appear cross-cutting.

Stratigraphic relations. Intrudes Corella Formation and amphibolitic dolerite masses as 'dl_a'; intruded by an undeformed dolerite dyke (dl_6); relation with the Myubee Gabbro is equivocal (see section on Myubee Gabbro).

Age. Proterozoic - probably Carpentarian.

Correlation. Correlated with Burstall Granite mapped in Sheet areas to north (Derrick & others, 1978), and with granite of the Mount Erle Igneous Complex near Duchess.

Remarks. These granites can be confidently correlated with the Burstall Granite to the north. However, outcrops in the Duchess Sheet area are well away from the type area of this granite, and each intrusion should perhaps be given a separate name.

In many places adjacent to the intrusions the Corella Formation rocks have been extensively metasomatised, for example, southeast of Green Creek Tank (GR 795521) and west of Overlander North mine (GR 865735), where K-feldspar, scapolite-pyroxene, and garnet-rich bands have formed in the calc-silicate rocks. Similar metasomatic rocks have been described at localities in Sheet areas to the north, as at Mary Kathleen, where the uranium mineralisation is thought by Derrick (1977) to be related to a skarn-forming metasomatic event related to the intrusion of Burstall Granite and associated rhyolite dykes.

Mount Erle Igneous Complex

(new name)

Map symbols. Pgd, Pgd_o, Pgd_m, Pgd_p.

Nomenclature. Named after Mount Erle, GR 825296, Duchess 1:100 000 Sheet area. Previously mapped partly as undifferentiated granite and partly as Corella Formation by Carter & others (1961) and Carter & Öpik (1963), and as Duchess granite (informal name) by Blake & others (1978a).

Distribution. Elongate area of about 30 km^2 extending from 2 km north to 12 km south of Duchess township in the southeast of the Sheet area.

Type locality. Railway cutting 300 m west-southwest of Duchess post office, at GR 818378.

Topographic expression and airphoto characteristics. Forms undulating terrain with some steep-sided hills; cut by ridge-forming quartz veins. Irregular pattern of pale and dark tones on aerial photographs.

General lithology. Granite, dolerite, and heterogeneous dioritic hybrids; minor aplite, feldspar porphyry, quartz-feldspar pegmatite, and inclusions of Corella Formation rocks.

Details of lithology. Pgd. Mainly granite: pink to pale grey; medium to fine; up to 10 percent biotite and hornblende; small feldspar phenocrysts and scapolite present locally; small mafic xenoliths common; generally weakly to strongly foliated; schistose locally along faults; some late-stage cross-cutting aplite veins.

Pgd_o. Mainly dolerite. dark grey; mostly fine to medium but locally coarse and gabbroic; non porphyritic; foliated only near faults; cut by granite veinlets.

Pgd_m. Intimate mixture of granite, dolerite, and dioritic hybrids. Dolerite forms rounded pillow-like inclusions and angular fragments enclosed in, and veined by granite; the pillow-like inclusions range from less than 1 m to several metres across, have intricately crenulate contacts with surrounding granite, and in some places appear to become finer grained (?chilled) at their margins; the angular dolerite inclusions are interpreted as pieces of fragmented pillows. Dioritic hybrid rocks are pale to medium grey, medium-grained, and intermediate in composition between the dolerite and granite; they are cut by paler granite veins which have diffuse to sharp contacts. The features observed are attributed to intrusion of dolerite into granitic melt, rather than into granitic rock; the granite component of the complex either had not become crystalline rock when it was intruded by the dolerite magma, hence it may be only slightly older than the dolerite, or it was melted and remobilised by the intruding dolerite magma, in which case it may be much older than the dolerite component of the complex (compare Blake & others, 1965; Blake, 1966).

Minor rock types. Pegmatite (Pgd_p): coarse graphic quartz-feldspar pegmatite similar to pegmatites associated with Burstall-type granite to north. Aplite: pale pink, fine-grained, even-grained. Feldspar porphyry: small pink feldspar phenocrysts in pink fine groundmass; mainly occurs as veins and dykes cutting adjacent Corella Formation rocks. Inclusions of Corella Formation rocks: angular fragments, some several metres across, of pink to grey and commonly banded calc-silicate granofels and dark grey banded para-amphibolite; sharp contacts with enclosing and veining granite, sharp to diffuse contacts with enclosing dolerite; largely confined to margins of intrusive complex.

Description of type locality. Typical granite, hybrid rocks, and dolerite, including good examples of dolerite pillows, exposed in railway cutting.

Structure and metamorphism. Steep, northerly trending foliation generally evident in granite but not in dolerite and areas of intimate granite-dolerite mixing except near faults. The complex is cut by several north to northeast-trending faults, e.g., the Railway and Juenburra Faults, most of which are quartz-filled. Away from faults the dolerite appears little metamorphosed, and primary minerals, including olivine, and igneous textures are preserved.

Stratigraphic relations. Intrudes Corella Formation. Thermal metamorphic effects appear to be restricted to within a metre or so of intrusive contacts, where the Corella Formation commonly consists of white massive calc-silicate hornfels rather than banded calc-silicate granofels. Cross-cutting veins of granite, aplite, and feldspar porphyry locally penetrate many metres into Corella Formation rocks. A quartz-feldspar pegmatite dyke cuts the complex at the southern end of the Ivanhoe Lode, near GR 811366.

Age. Proterozoic. The granite may be somewhat older than the dolerite, because it, but not the dolerite, is generally foliated; possibly it is a synorogenic intrusion, perhaps contemporaneous with the main regional metamorphism of the Corella Formation. The dolerite and at least the late-stage granite veins, however, postdate the main regional metamorphism in the area, because they cut across the foliation of Corella Formation rocks.

Correlations. The granite component is correlated with petrographically and structurally similar Burstall-type granite intrusions to north. The dolerite is probably similar in age to other little-altered basic intrusions in the area, such as the dolerite associated with intrusive breccias (Mount Philp Breccia), the Myubee Gabbro east-northeast of Bushy Park homestead, and the Lunch Creek Gabbro in the Marraba Sheet area (Derrick & others, 1971, 1978). Primary minerals and igneous textures are well preserved in all these bodies, and the rocks commonly contain primary biotite and, more rarely, olivine. However, Derrick & others (1971, 1978) interpret the field relations as indicating that the Burstall Granite intrudes the Lunch Creek Gabbro.

Mineralisation. Host rocks for most of the copper mineralisation near Duchess, including that at the Duchess mine.

Remarks. The complex appears to have been intruded to a relatively high level in the crust - it consists mainly of medium to fine, rather than coarse igneous rocks, it has few associated pegmatites, and adjacent country rocks show only minor thermal metamorphic effects.

Myubee Gabbro

(new name)

Map symbol. Ꞓbm.

Nomenclature. Named after Myubee railway siding, 13.5 km northwest of Duchess township. Previously mapped as metadolerite (Carter & others, 1961; Carter & Öpik, 1963).

Distribution and type locality. Forms a small circular body (?stock) about 1 km in diameter at GR 782539, 9 km northeast of Myubee railway siding.

Topographic expression and airphoto characteristics. Forms bouldery hills characterised by grey to dark red-brown tones on colour aerial photographs.

General lithology. Medium to coarse non-foliated gabbro.

Details of lithology. Massive gabbro, olivine-rich norite, hornblende gabbro, hornblende leucogabbro; some dark grey, fine-grained schistose amphibolite around margins. Scattered flakes of primary biotite are common in most rock types. Small lenses and pods of gabbroic to dioritic pegmatoid rich in dark green hornblende and white plagioclase crystals (up to 2 cm long) occur in leucogabbro. Layering defined by alternating mafic and felsic bands is common, especially in central part of intrusion. The gabbro displays a general range in chemical composition from 45% SiO_2 and 21.5% MgO (olivine-rich norite) to 50.8% SiO_2 and 5.9% MgO (hornblende leucogabbro). A pegmatoidal specimen analysed contains 57.8% SiO_2. Most analysed rocks are strongly olivine-normative, but some are quartz normative; all contain normative hypersthene.

Structure and metamorphism. Appears to form a small stock intruding Corella Formation. Gabbroic rocks in central part are not foliated and show few obvious metamorphic effects. In some rocks olivine is surrounded by optically continuous rims of primary orthopyroxene, evidence of reaction between olivine and liquid. In other rocks there are well-developed coronas between olivine and plagioclase grains. These coronas consist of an inner zone of granular hypersthene and an outer zone of symplectite formed of radiating fine prismatic pale green hornblende (?pargasite-?ferrohastingsite) and very fine-grained, almost submicroscopic, green spinel. Such coronas are attributed to subsolidus reaction between olivine and plagioclase during metamorphism (e.g., England, 1974).

Adjacent calc-silicate rocks have been contact-metamorphosed; they contain large porphyroblasts of garnet, together with smaller grains of wollastonite, vesuvianite, plagioclase, diopside, scapolite, and sphene.

Stratigraphic relations. Intrudes Corella Formation and is either intruded by Burstall-type granite or forms a net-vein complex with this granite (cf., Mount Erle Igneous Complex).

Age. Proterozoic.

Correlation. May be correlated with the Lunch Creek Gabbro in the Marraba Sheet area (Derrick & others, 1978), and with dolerite of the Mount Erle Igneous Complex near Duchess.

Mineralisation. None known.

Remarks. The presence of unaltered olivine and primary mica in the gabbro is noteworthy. The relation between the gabbro and granite of the Burstall Granite-type is the subject of some debate at present.

Mount Philp Breccia

(newly revised name)

Map symbol. Ꝑdb.

Nomenclature. Named after Mount Philp in the southern part of the Cloncurry 1:250 000 Sheet area. Previously mapped in Sheet area as Mount Philp Agglomerate and Corella Formation (Carter & others, 1961; Carter & Öpik, 1963).

Name changed from Mount Philp Agglomerate to Mount Philp Breccia because the unit is intrusive, not extrusive.

Distribution. Main outcrops 7-14 km south-southeast of Duchess township and in northeastern corner of the Sheet area; some small outcrops north and south of Duchess; restricted to within the general outcrop area of the Corella Formation; extends into the Mary Kathleen Sheet area to the north, where it has been mapped as Mount Philp Agglomerate (Derrick & others, 1977a, b).

Type section. Near the abandoned township of Ballara, in the Mary Kathleen Sheet area (Carter & others, 1961).

Topographic expression and airphoto characteristics. Forms rugged hilly country in the northern part of the Sheet area, and more subdued undulating country in the south. Characterised by medium and dark tones on aerial photographs.

General lithology. Breccia, dolerite, gabbro.

Lithology. Breccia: disoriented and mainly angular fragments of foliated and banded Corella Formation - type rocks in a non-foliated pink to red igneous matrix. The fragments range in size from less than 1 mm to more than 10 m, and consist of amphibolitic and locally amygdaloidal metabasalt, banded calc-silicate granofels, quartzite, feldspathic quartzite, amphibolitic schist, and quartz-feldspar pegmatite. The matrix is composed of stubby euhedral prismatic phenocrysts less than 1 cm long of pale green amphibole showing weak concentric zoning enclosed in a fine groundmass formed of hematite-dusted albite and, in places, minor epidote, quartz, and calcite. The proportion of matrix to fragments in the breccia ranges from less than

10 percent to more than 90 percent of the breccia in different exposures. Cross-cutting veins of coarse calcite and graphic quartz-feldspar pegmatite occur locally.

Dolerite and gabbro: irregular bodies intruding breccia; massive (not foliated); locally cut by thin leucocratic veinlets; plagioclase phenocrysts common in dolerite. At exposures near Pelican Waterhole (GR 933792) just north of the Duchess Sheet area, the basic bodies have irregular bulbous and crenulated intrusive contacts with chilled margins, indicating that they were probably intruded before the breccia had solidified. The highly irregular form of the basic intrusions here and elsewhere in the breccia is in marked contrast to the normal tabular form of basic dykes and sills intruding other units. Dolerite associated with the main breccia body south-southeast of Duchess township consists of ophitic clinopyroxene (?augite), calcic plagioclase, and minor opaques, uralitic green hornblende, and intertitial scapolite; the scapolite probably resulted from contamination by adjacent (?scapolitic) rocks of the Corella Formation - i.e., from chlorine metasomatism.

Structure and metamorphism. The breccia bodies are thought to be more or less vertical pipe and fissure-fillings. The alkali-rich (albite-bearing) acid matrix of the breccia and the associated dolerite and gabbro intrusions has primary igneous textures and mineralogy preserved, and is not foliated. In contrast, the fragments in the breccia are of banded and foliated metamorphic rocks derived from the Corella Formation. Hence the breccia must have been formed after the Corella Formation had been metamorphosed and deformed.

Stratigraphic relations. The breccia cuts Corella Formation and is intruded by basic bodies.

Age and correlations. The breccia is Proterozoic, and was probably formed at about the same time as the associated dolerite and gabbro intrusions were emplaced. These basic rocks may be correlatives of the little-altered basic intrusions of the Mount Erle Igneous Complex and the Myubee Gabbro.

Mineralisation. None known in Sheet area.

Remarks. The igneous matrix of the breccia may represent a partial melt derived from rocks of the Corella Formation at depth, the melt being formed during the passage through this formation of the basic magma which formed the closely associated dolerite and gabbro intrusions. The breccias may have been emplaced as diatremes.

Garden Creek Porphyry.

Map symbol. Ᵽgp.

Nomenclature. Named after Garden Creek, a tributary of Wills Creek north-east of Dajarra, in the Dajarra 1:100 000 Sheet area (Blake & others, 1978b). Mapped as Kalkadoon Granite by Carter & others (1961), and Carter & Öpik (1963).

Distribution. Narrow north-trending outcrop within Mount Guide Quartzite in southwest, extends south into the adjoining Dajarra Sheet area.

Type locality. About 5.5 km northeast of Dajarra in the Dajarra 1:100 000 Sheet area.

Thickness. Maximum about 200 m.

Topographic expression and airphoto characteristics. Forms relatively low bouldery ridges and undulating terrain bounded by higher planated ridges of Mount Guide Quartzite. Medium to dark tones on aerial photographs.

General lithology. Porphyritic microgranite; minor metadolerite (at margins).

Details of lithology. Microgranite: massive to locally sheared and quartz-veined; pink to dark grey fine felsic groundmass; contains euhedral to subhedral phenocrysts of pink to white feldspar, some more than 1 cm long, and smaller, rounded phenocrysts of glassy quartz; small dark biotite-rich xenoliths commonly present, some of which contain small feldspar phenocrysts/porphyroblasts; generally forms spheroidal boulders.

Metadolerite: more readily eroded than the microgranite, and generally poorly exposed; dark grey to black; fine to medium-grained; non-porphyritic; massive to locally schistose; amphibolitic.

Structure and metamorphism. Forms a steeply dipping dyke-like body cut by numerous faults; locally sheared and quartz-veined. Chloritic alteration is common, indicating probable greenschist facies regional metamorphism.

Relations. Intrudes Mount Guide Quartzite, apparently more or less concordantly (so could be a sill rather than a dyke). Actual contacts generally obscured by superficial debris; thin zone of contact-metamorphosed medium-grained glassy quartzite observed at one locality.

Age. Proterozoic.

Correlation. The microgranite is much younger than Kalkadoon Granite (which is overlain unconformably by Mount Guide Quartzite), and may be related to part of the Sybella Granite exposed in the Oban Sheet area to west (Mock, 1978).

Mineralisation. None known.

Remarks. May represent a composite dyke, as the microgranite is almost invariably bounded by margins of dolerite up to about 30 m thick; if so the dolerite and microgranite would have been intruded more or less together (Blake & others, 1965).

Unnamed granodiorite

Map symbol. Pg_d.

Distribution. An elongate body about 7.5 km northwest of Ashover homestead, in the southwest, and a small pod near the central-northern boundary of the Sheet area.

Previous literature. Previously mapped as Argylla Formation and Kalkadoon Granite (Carter & Öpik, 1963).

Topographic expression and airphoto characteristics. Forms low undulating terrain with scattered bouldery hills. Medium to dark tones on aerial photographs.

Lithology. Medium-grained, non-foliated to strongly foliated, slightly to richly porphyritic granodiorite and some possible diorite; minor biotite granite. The southwestern body contains small white feldspar phenocrysts and numerous xenoliths - mainly small angular fragments of biotite-rich mafic rocks, but also some subrounded to rounded fragments up to about 15 cm - and in marginal zones, blocks up to 50 cm of grey recrystallised probable acid volcanics. Some much weathered massive coarse-grained and slightly porphyritic biotite granite is poorly exposed in the northern part of the outcrop; it has not been seen in contact with the granodiorite.

Structure and metamorphism. A steep northerly trending foliation is strongly developed adjacent to faults.

Stratigraphic relations. May intrude Standish Volcanics in southwest, and probably intrudes Leichhardt Metamorphics in north. Numerous dykes of schistose amphibolite and massive, non-foliated amphibolite cut the granodiorite.

Age. Proterozoic.

Remarks. Relations with adjacent rocks are uncertain, as contacts either faulted or not exposed.

STRUCTURE AND METAMORPHISM

Folding

Basement rocks (Tewinga package)

The first folding event (F_1) recognised in the Sheet area affected only the basement package of rocks (the Tewinga, Malbon, and Mary Kathleen Groups, and Kalkadoon Granite), and was associated with middle to upper greenschist and amphibolite grade metamorphism.

F_1 folds are best developed in thin-bedded and relatively incompetent rocks of the Corella Formation and Overhang Jaspilite, and also in thin-banded quartzite within undivided Tewinga Group in the southwest. In these rocks the F_1 folds are represented by mesoscopic to megascopic tight to isoclinal folds. Doubly-plunging folds are common, but a general northward plunge predominates. Variations in plunge direction may be due to inhomogeneities in strain during the folding and also, in the Corella Formation, to the plastic nature of the deforming rocks. Within thick marble beds of the Corella Formation, rootless intrafolial folds which have limbs parallel to bedding, are evident in places; these are interpreted as parasitic F_1 folds formed within the limbs of larger-scale F_1 folds.

Mesoscopic F_1 folds, except where quartz veins are tightly folded, are rare within massive competent units such as the Leichhardt Metamorphics, Argylla Formation, and Magna Lynn Metabasalt, although these units, like the other units of the Tewinga Group, are folded on a regional scale. One probable major F_1 fold is present south of the Fountain Range Fault in the central part of the Sheet area, where Corella Formation crops out in the core of a north-plunging syncline. Another is the regional synclinorium to the east, where a broad north-trending belt of Corella Formation is flanked by rocks of the Argylla Formation.

Axial-plain foliations (S_1) associated with F_1 folds occur in all rocks of the basement package, although they are commonly not well developed in Kalkadoon Granite. S_1 generally trends north and is typically defined by a preferred dimensional orientation of mineral grains and aggregates. With increasing intensity of deformation, S_1 develops into a penetrative fracture cleavage. In quartzofeldspathic gneisses of the Tewinga Group and Corella Formation, S_1 is defined by preferred alignments of feldspar augen. A mineral elongation lineation is locally developed within S_1 planes in metasediments of the Corella Formation, more or less parallel to the axes of mesoscopic F_1 folds. Bedding-cleavage intersections in thin-bedded calc-silicate rocks are parallel to local F_1 fold axes.

Rarely, metamorphic differentiation in laminated calc-silicate rocks has given rise to thin hornblende-rich bands which are aligned parallel to S_1 and cut across folded bedding. In some calc-silicate rocks the interlayered mafic and felsic bands may also be due to metamorphic differentiation, rather than representing original bedding.

At one location within the Corella Formation 6 km south-southwest of Duchess, intense transposition and attenuation of fold limbs has occurred in a narrow (30 cm) zone, producing a layered band roughly parallel to S_1. This layered band is indistinguishable from primary bedding (S_0), except that it can be seen to cut across the surrounding folded beds. Similar features were not observed elsewhere, and it is considered unlikely that such transposition layering parallel to S_1 is a widespread feature within the Corella Formation. An effect of F_1 transposition that may be more widespread is the separation of previously continuous bands into a number of discontinuous lenses within which there may be little evidence of folding. Thus some amphibolite and quartzofeldspathic gneiss lenses within the Corella Formation, for example, may not represent sedimentary or volcanic intercalations but instead may be slivers of older units. Similarly, tightly interfingering lithological contacts parallel to S_1 may be tectonic rather than sedimentary.

Post-F_1 folding has been recognised in only a few isolated areas within the Corella Formation. Apparently chaotic second-generation folding occurs in a small much faulted area 2 km east of ?Mount Morah mine (GR 845608). Another example of second-generation folding occurs in para-amphibolites 8 km northwest of Trekelano mine (GR 859238); under the microscope these rocks show regular fine crenulations of biotite plates at right angles to S_1. Some second-generation folding is clearly related to granite intrusion. A good example occurs in the eastern-central part of the Sheet area, west of the main Burstall-type granite pluton. In this area calc-silicate rocks and para-amphibolites appear to have been plastically squezed into their present U-shaped outline, parallel to the granite margin, resulting in the formation of a southwest-plunging syncline in the northern part of the structure and a northwest-plunging syncline to the south. Second-generation axial-plane features occur in the hinge zone of the southern syncline, where thin discontinuous wispy diopside-hornblende banding cuts at right-angles across thick-bedded para-amphibolites.

Bottletree Formation, Haslingden Group, and younger rocks

Only one generation of folding is evident in the Haslingden Group; it postdates F_1 and was less intense. The folds are large, tight to isoclinal, upright anticlines and synclines with north-trending axes, and are associated with a mainly lower greenschist facies regional metamorphism. Similar styles of folding associated with a similar grade of metamorphism occur in the Standish Volcanics, Stanbroke Sandstone, and Surprise Creek Beds, and were probably formed during the same major tectonic event.

Faulting

The faults in the area can be divided into two main sets, a northerly-trending set and a conjugate set of faults trending northeast and northwest.

Northerly trending faults

Faults trending between north-northeast and north-northwest occur throughout the Sheet area. Most of these are normal or high-angle reverse faults developed along lithological boundaries parallel to bedding and foliation trends. Such faults are most evident within outcrops of Tewinga Group rocks and Haslingden Group rocks below the Eastern Creek Volcanics. The Juenburra Fault, which cuts the Mount Erle Igneous Complex south-southwest of Duchess, also belongs to this group; according to Walker (1960) this fault has a dextral displacement of about 400 m.

In general the northerly trending faults are the oldest faults mapped in the area, because they are displaced by faults of the conjugate set. Major exceptions are the faults of the Pilgrim Fault Zone in the east, along the western boundary of the late Proterozoic-early Palaeozoic Burke River Outlier. However, this fault zone is probably controlled by a deep-seated crustal discontinuity which was active during the Proterozoic.

Faults trending northeast and northwest

This conjugate set of faults includes the youngest faults in the area, with the exception of those forming the Pilgrim Fault Zone. Northwest-trending faults are well developed in the western half of the Sheet area, whereas the northeast-trending faults are particularly well developed in the east. Several of the faults have associated splays. Some are quartz-filled and form prominent steep-sided narrow ridges. The faults are more or less vertical, and movement along them appears to have been predominantly strike-slip - dextrally along those trending northeast, and sinistrally along those trending northwest. The northeast-trending Railway Fault southwest of Duchess has a lateral dextral displacement of about 2 km. Vertical movements have also taken place along some faults; for example, across the Fountain Range Fault, the longest northeast-trending fault in the area, a south-block-down movement has resulted in the juxtaposition of Corella Formation rocks to the south against Argylla Formation rocks to the north. The juxaposition of these two formations also represent a lateral dextral displacement along the fault of about 25 km (Derrick & others, 1977b).

Most faults of the conjugate set are probably more or less similar in age, although a few of those trending northeast, such as the Fountain Range Fault, clearly postdate most northwest-trending faults. The northeast-trending faults also generally appear to longer than the latter. The Fountain Range Fault which is marked by a massive quartz ridge in the north-east, extends southwest into the central part of the Sheet area; related faults of similar trend continue southwest beyond the boundary of the Sheet area.

The movements along the conjugate set of faults indicate an overall east-west compression. The dihedral angles between the fault planes do not agree with the classical model developed by Anderson (1951), but this inconsistency could be due to the rocks of the area being anisotropic as a whole, and perhaps to possible crustal inhomogeneities at depth.

Metamorphism

Tewinga, Malbon, and Mary Kathleen Groups

Metamorphic mineral assemblages developed in the Tewinga, Malbon and Mary Kathleen Groups indicate mainly middle to upper greenschist and amphibolite-grade regional metamorphism. The Tewinga Group rocks typically consist of biotite $\pm$ hornblende $\pm$ epidote $\pm$ quartz + microcline + plagioclase. Garnet occurs in some quartzofeldspathic gneisses of the undivided Tewinga Group and in gneissic acid volcanics of the Argylla Formation, and possible porphyroblastic andalusite is present in a sample of gneiss collected from the southwest.

Typical metamorphic minerals in calc-silicates of the Corella Formation are alkali feldspar, scapolite, calcite, hornblende, diopside/salite, epidote, quartz, plagioclase, and sphene; less common are muscovite, biotite, zircon, apatite, and iron oxides. In more basic rocks typical minerals include diopside, hornblende, alkali feldspar, plagioclase, epidote, and iron oxides. The presence of hornblende (rather than tremolite/actinolite) and diopside is typical of amphibolite grade regional metamorphism. Sillimanite occurs in pelitic schist in the southeast, and indicates some moderate to high amphibolite-grade metamorphism, in which temperatures exceeded 500°C and pressures were probably between 1 and 4 kilobars (Winkler 1970). Cordierite and anthophyllite occur in rocks of the Ballara Quartzite in the core of a syncline in the centre of the Sheet area south of the Fountain Range Fault, and also in rocks mapped as Argylla Formation at GR 787668; these may be a result of magnesium metasomatism, or of an abnormally high local heat flow, perhaps related to a granite intrusion.

There appears to be little evidence of more than one major period of regional metamorphism affecting the Tewinga, Malbon, and Mary Kathleen Group: the later, generally lower-grade, regional metamorphic event that effected the Bottletree Formation, Haslingden Group, Standish Volcanics, Stanbroke Sandstone, and Surprise Creek Beds in the Sheet area appears to have had little retrogressive effect on the rocks of these groups. Possible polymetamorphic textural features are limited to the bending of micas around some porphyroblasts and poikiloblasts. Some retrograde metamorphism has resulted in sericitisation of feldspar, minor chloritisation of biotite, and possibly the development of epidote.

Contact metamorphism and associated metasomatism of calc-silicate rocks of the Corella Formation adjacent to Burstall-type granite plutons has resulted in the local production of skarns. These are vaguely banded diopside/salite-feldspar-scapolite rocks, some of which also contain garnet and/or ?clinohumite. In most places no contact metamorphic effects were recognised for more than a metre or so away from the granite margin. The general absence of wollastonite and the presence of clinopyroxene rather than orthopyroxene indicates that most of the contact metamorphic rocks belong to the hornblende-hornfels facies. However, calc-silicate rocks adjacent to the Myubee Gabbro/Burstall-type granite complex northwest of Green Creek Tank contain abundant wollastonite (together with vesuvianite, garnet, sphene, plagioclase, clinopyroxene and scapolite), which probably indicates that a higher contact metamorphic grade was reached in this area.

Bottletree Formation, Haslingden Group, and younger rocks

A mainly lower-middle greenschist facies regional metamorphic event has affected the Bottletree Formation, Yappo Formation, Mount Guide Quartzite, Eastern Creek Volcanics, Standish Volcanics, Stanbroke Sandstone and Surprise Creek Beds. In the Haslingden Group a schistosity, commonly defined by white mica, has been developed, but original sedimentary structures such as cross-bedding are still preserved. Extensive recrystallisation, brecciation, and shearing, with the development of white mica and chlorite, has taken place in fault zones.

Thermal metamorphic effects are restricted to the development of hornfelsed glassy quartzite and greywacke within the Haslingden Group immediately adjacent to some basic dykes.

Unlike the Tewinga Group and Corella Formation rocks, the Haslingden Group and younger rocks in the Duchess 1:100 000 Sheet area have not been extensively recrystallised, and are generally of lower metamorphic grade.

SUMMARY OF GEOLOGICAL HISTORY

The earliest events recorded in the Sheet area are volcanism, sedimentation, and probably some plutonism represented by the Tewinga Group, Bushy Park Gneiss and, in our opinion the Malbon and Mary Kathleen Groups, which we interpret as being equivalent in part to the Tewinga Group. Volcanism probably took place from many different, mainly subaerial, eruptive centres and resulted in the eruption of acid tephra, acid and basic lava flows, and minor basic tuff. The sediments probably consisted mainly of shallow-water quartzose, feldspathic, and tuffaceous sands, and finer, bedded evaporitic and impure calcareous deposits which may have been laid down in a lagoonal environment. These finer deposits are represented by the Corella Formation and Overhang Jaspilite. Volcanic rocks interfinger with the sediments locally. U-Pb zircon ages of 1865 $\pm$ 3 m.y. and 1777 $\pm$ 7 m.y. are given by acid volcanics mapped as Leichhardt Metamorphics and Argylla Formation, respectively, in the Mary Kathleen Sheet area to the north (Page, 1976, 1978).

Some time after the sedimentation and volcanism had taken place, the rocks of the Tewinga, Malbon, and Mary Kathleen Groups were tightly to isoclinally folded and regionally metamorphosed to middle to upper greenschist and amphibolite grade. This tectonism was accompanied and closely followed by the emplacement of the Kalkadoon Granite batholith. Much of this granite is not foliated and was probably explaced after the main folding event, but locally phases of the kalkadoon Granite formed migmatites with the country rocks. The Kalkadoon Granite shows the characteristics of mesozonal rather than epizonal intrusions (Buddington, 1959), and was probably emplaced many kilometres below the surface. According to Page (1976, 1978) Kalkadoon Granite in the Mary Kathleen Sheet area crystallised $1862 {}^{+27}_{-21}$ m.y. ago; hence it could be comagmatic with some of the Leichhardt Metamorphics of the Tewinga Group.

This folding and regional metamorphism of the Tewinga, Malbon, and Mary Kathleen Groups and the emplacement of the Kalkadoon Granite batholith represent a major orogenic event, during which the area was probably uplifted to form a mountainous landmass. The uplift was followed by a period of subaerial denudation that was long enough to result in the exposure of amphibolite-grade metamorphic rocks and the unroofing of part of the Kalkadoon Granite batholith. In the western part of the Sheet area a major unconformity now separates these crystalline rocks from overlying Precambrian units.

Sedimentation, initially accompanied volcanism, resumed in the western part of the Sheet area with the deposition of the Bottletree and Yappo Formations. Evidence for the penecontemporaneous volcanic activity is given by the presence of interlayered acid and basic lava flows and tuffs and labile conglomerate containing abundant volcaniclastic detritus in the Bottletree Formation, and by the presence of similar conglomerate in the Yappo Formation. Many (but not all) of the acid volcanic clasts in the conglomerates are extensively flattened and are probably altered and compressed pumice fragments. More extensive basic volcanism took place later in Haslingden Group time when the basic lavas of the Eastern Creek Volcanics were erupted. The Haslingden Group sediments appear to be shallow-water deposits and were derived, at least partly, from a landmass to the east.

Some of the acid and basic volcanics in the central part of the Sheet area, mapped as Leichhardt Metamorphics, Magna Lynn Metabasalt, and Argylla Formation of the Tewinga Group, may also have been erupted during Bottletree Formation - basal Haslingden Group time. Preliminary U-Pb zircon studies on an acid volcanic unit in the Bottletree Formation yield an age somewhat older than that determined for the Argylla Formation in the Mary

Kathleen Sheet area. However, the Argylla Formation in the Duchess Sheet area has not been isotopically dated; only migmatitic gneiss of the undivided Tewinga Group has been sampled for age dating.

The acid and basic volcanism and associated sedimentation represented by the rocks of the Standish Volcanics are though by us to have taken place some time after the deposition of the Haslingden Group; the Standish Volcanics are not found in contact with Haslingden Group rocks, but they generally appear less metamorphosed. The volcanic activity may have been associated with the intrusion of some of the many basic dykes that cut the Haslingden Group and older rocks, and also with some acid intrusions, such as the Garden Creek Porphyry (which intrudes the Mount Guide Quartzite), and with the acid porphyry dykes which intrude Kalkadoon Granite. It was followed, probably after a period of erosion, by the deposition of the Stanbroke Sandstone and Surprise Creek Beds.

Plutonism, resulting in the emplacement of the Burstall-type granite, Mairindi Creek Granite, Bowlers Hole Granite, Mount Erle Igneous Complex, Myubee Gabbro, Mount Philp Breccia, Wimberu Granite, unnamed granodiorite, and numerous dykes and small masses of dolerite, probably took place at various times between the onset of the first orogenic event, when the Tewinga Group and its part-correlatives were deformed and metamorphosed, and the deposition of the Surprise Creek Beds. However, none of these intrusions have been isotopically dated, and none (except for some dykes and small masses of dolerite) are seen in contact with rocks younger than the Tewinga Group and Corella Formation; consequently some may post-date the Surprise Creek Beds.

The second main period of folding and regional metamorphism recognised in the Sheet area took place some time after the deposition of the Surprise Creek Beds. During this event the Haslingden Group, Standish Volcanics, Stanbroke Sandstone and Surprise Creek Beds were openly to tightly folded, and were regionally metamorphosed mainly to lower to middle greenschist grade. Some of the faults mapped in the area may have been active at this time, but most appear to be post-folding. The regional metamorphism probably caused some local retrogression in the previously metamorphosed rocks. It may be the event dated by Richards, Cooper, & Webb (1963) at about 1400 m.y. (K-Ar mica age determinations). This metamorphic event appears to have affected all the basic and acid intrusions in the Sheet area except for the scarce dykes of the Lakeview Dolerite type (dl_6); these are probably the youngest igneous rocks present in the Sheet area.

The second orogenic event, like the first, is presumed to have been accompanied by uplift, with the formation of a mountainous landmass. Once again the area was subjected to a long period of subaerial erosion. This period probably lasted until almost the end of the Proterozoic, when the oldest sediments of the Mount Birnie Beds, at the base of the Burke River Outlier succession, were deposited. A major unconformity occurs at the base of this succession, which may have covered most or all of the Sheet area. However, only small remnants of the succession are preserved west of the Pilgrim Fault Zone. The Burke River Outlier succession is more or less flat-lying, except near some faults, where it has been displaced and locally deformed. It is not metamorphosed, indicating that no major Phanerozoic tectonism has occurred in the area.

ECONOMIC GEOLOGY

Concentrations of base-metal, mainly copper, mineralisation are common in the Sheet area, but most of the numerous small mines have long been abandoned. A few are still worked intermittently - mainly in times of high copper prices - by individuals or small groups of miners, the ores being sold to Mount Isa Mines Pty Ltd. Very few of the mines extended far below the zone of secondary enrichment; two notable exceptions are the Duchess and Trekelano mines, both of which were worked economically in the primary sulphide zone down to depths of about 260 m.

Vein deposits of silica (quartz) and coarse calcite ('limestone'), commonly cupriferous, have also been mined in the Sheet area, mainly by the open-cut method, the ores being used as fluxes in smelting operations at the Mount Isa mine. The coarse-grained calcite lenses cut calcareous metasediments of the Corella Formation and associated metadolerite, and are thought to have been derived from calcareous metasediments in the formation by remobilisation of elements during deformation and the intrusion of dolerite (Derrick & others, 1974, 1977b).

Copper mineralisation is concentrated mainly in rocks of the Argylla Formation, Corella Formation, and Mount Erle Igneous Complex exposed in the central part of the Sheet area. Much of the copper mineralisation seems to be localised near contacts between amphibolite (mainly metadolerite) and country rock or in amphibolitic metabasalt; the mineralisation is commonly fault-controlled. Subeconomic, apparently stratabound, concentrations of copper minerals occur in calcareous calc-silicate rocks of the Corella Formation east and southeast of Duchess (in the area around the Freckle and Slingshot prospects, and also in dark grey and black ?carbonaceous siltstone of the Corella Formation in the northeastern part of the Sheet area.

Small lenses of cordierite-rich rock occur in the Corella Formation in the northern part of the Sheet area (at GR 882757); some specimens of cordierite may be of gem quality.

A detailed study of the individual mines has not been undertaken and only selected ones are briefly described below. Little or no information about many of the smaller mines is readily available, and the names of many, especially the older ones, are uncertain. This uncertainty is indicated by a question mark after the mine name on the map.

Brief descriptions of selected mines

Duchess

GR 818374.

References. Broadhurst (1953), Carter & others (1961).

Products. Cu, Au.

Surface workings. Water-filled open cut; worked to depth of 259 m, main shaft sunk to depth of 326 m.

Country rock. Mount Erle Igneous Complex (Egd_m): hornblende-biotite granite, metadolerite, hornblende-biotite schist, thin-banded calc-silicate granofels.

Lode. On shear zone at northern end of Juenburra Fault. Maximum length of 213 m and average width of 1.5m.

Ore and gauge. Chalcocite, malachite, cuprite, bornite (main primary ore mineral), chalcopyrite, calcite, and quartz.

Production. 27 717 tonnes Cu (12.3% Cu), 69 474g Au; from 225 644 tonnes of ore. Mine closed in 1920.

Freckle

GR 842321.

Product. Cu.

Surface workings. Shafts, pits.

Country rocks. Corella Formation (Ꝑkc): actinolite schist.

Lode. Appears to be stratabound, dips 80^{o}W.

Ore. Malachite on dumps.

?Inheritance

GR 863242.

Product. Cu.

Surface workings. Shafts, pits, costeans.

Country rocks. Corella Formation (Pkc): pink and grey mica schist, amphibolite, meta-arkose or aplite; also coarse to pegmatitic granite.

Lode. On shear zone trending 170^{o}.

Ore. Malachite on dumps.

Ivanhoe group

GR 812373.

Product. Cu.

Surface workings. Open stopes, shafts, pits.

Country rocks. Corella Formation (Ꝑkc) and Mount Erle Igneous Complex (Pgd_m): lamina-banded calc-silicate granofels, hornblende-biotite granite, metadolerite.

Lode. Shear zone trending 005^{o}.

Ore and gangue. Malachite, coarsely crystalline calcite, cherty ironstone.

Knobs

GR uncertain; not located during survey; reported to be 16.4 km southwest of Duchess, at $21^{o}28'$S, $139^{o}47'$E.

Reference. Syvret (1966).

Product. Cu.

Surface workings. Two shafts, pits, costeans; maximum depth about 30 m.

Country rocks. Probably undivided Tewinga Group (Ƀe): biotite schist; also two lenses of Kalkadoon Granite.

Ore and gangue. Malachite, chalcopyrite, chalcocite, quartz.

?Lady Barbara

GR 829342.

Product. Cu.

Surface workings. Two shafts, pits.

Country rocks. Mount Erle Igneous Complex (Ƀgd_m): metadolerite, some granite veins.

Lode. On shear zone trending 115°, dipping 85°S.

Ore and gangue. Malachite and quartz on dumps.

Lady Fanny group

Includes Lady Fanny, Landy Fanny North, Bright Lights, and Burke and Wills.
GR 737493 (Lady Fanny).

References. Ball (1908), Shepherd (1946), Syvret (1966), Krosch & Sawers (1974).

Products. Cu, Au.

Surface workings. Open cut, numerous shafts, pits; worked to depth of about 58 m.

Country rocks. Argylla Formation (Ƀea): acid gneiss, biotite schist, hornblende schist, and amphibolite - metamorphosed acid and basic volcanics and dolerite.

Lode. Along series of small faults, commonly dolerite-filled.

Ore and gangue. Malachite, azurite, chrysocolla, cuprite, bornite, chalcocite, chalcopyrite, pyrite, quartz.

Production. Production recorded as early as 1905. To 1965 total recorded production was 2903 tonnes of ore for 237 tonnes of copper (8.1% Cu) and 483 g of gold. Production in the periods 1966-67 and 1969-70 yielded 820 tonnes of ore for 55 tonnes of copper (6.8% Cu).

Mount Hope group

Includes Mount Hope, Mount Hope North, Mount Hope South (or South Hope), Binna Burra, Mount Hope West (not shown on map), and Green's Creek (not shown on map).

GR 765582 (Mount Hope).

References. Brooks (1957, 1977).

Products. Si, Cu.

Surface Workings. Open cuts up to about 30 m deep. In plan approximate dimensions of open cuts are: Mount Hope, 260 m x 43 m; Mount Hope North, 244 m x 24 m; Mount Hope South, 52 m x 33 m; and Mount Hope West, 52 m x 12 m. Worked to depth of 43 m.

Country rocks. Vertically dipping fine-grained biotite schist, schistose amphibolite and rhyolite of the ?Argylla Formation ($Ꝑea_m$?) and fine to medium-grained quartzo-feldspathic Bushy Park Gneiss.

Lode. Quartz veins along northwest to northeast-trending faults.

Ore and gangue. Malachite, cuprite, chrysocolla, chalcopyrite, native copper, azurite, quartz; primary sulphides present at depth of 43 m.

Production. Worked up to mid-1960s on a small scale for Cu. Production of cupriferous silica flux on a substantial scale started in 1967 and ceased in 1973; 309 175 tonnes of ore were produced with an average grade of 74% SiO_2 and 1.9% Cu.

Mount Mascotte

GR 812574.

Reference. Carter & others (1961).

Product. Cu.

Surface workings. Two shafts. Reported to be worked to depth of about 90 m over a length of about 60 m.

Country rock. Corella Formation (Ꝑkc): fine-grained quartz-biotite schist and ?para-amphibolite.

Lode. Fissure vein on north-northeast-trending fault.

Ore and gangue. Secondary ore consists of malachite, chalcocite, and minor cuprite in a gangue of quartz, calcite, and secondary iron oxide(s); primary sulphides are bornite and chalcopyrite. Ore shoots of massive sulphide 30 cm to 1 m thick have been reported.

Production. Recorded production is 4912 tonnes of ore which yielded 882 tonnes Cu (18%) and 7037 g Au. Mainly worked 1914-1920 and 1927-1928.

Nil Desperandum No. 2

GR 728461.

Reference. Krosch & Sawer (1974).

Product. Cu.

Surface workings. Two shafts; worked to depth of about 23 m.

Country rocks. Argylla Formation: biotite schist.

Lode. Fissure.

Ore and gangue. Malachite, azurite, pyrite, and quartz, calcite, iron oxide, mica.

Production. No production has been recorded from Nil Desperandum No. 2. 457 tonnes of ore produced from adjacent Nil Desperandum No. 1 mine in 1920 and 1923 yielded 30.8 tonnes of copper (6.7% Cu). In 1967 and 1971 62 tonnes of ore were produced from the same mine to yield 3.2 tonnes of copper (5.2% Cu).

O'Briens Soak

GR 546523.

Reference. Carter & others (1961).

Product. Ag.

Surface workings. Several small shallow pits.

Country rock. Amphibolite (Carter, & others, 1961) in a sequence of mainly fine to medium-grained granitic to granodioritic gneiss and migmatitic gneiss of the Tewinga Group (Pe_m).

Lode. Narrow fissure filling (Carter, & others, 1961).

Ore and gangue. Naumannite and associated native silver, cerargyrite and calcite.

Production. 8.9 tonnes of ore mined in about 1918 yielded 287 269 g of silver.

Overlander group

Includes Overlander North, GR 865736; Overlander South, GR 862722.

Product. Cu.

Surface workings. Two shafts, several pits and costeans.

Country rocks. Corella Formation: mainly in orthoclase-tourmaline rock adjacent to porphyritic and non-porphyritic acid volcanics (possibly high-level intrusives); also in adjacent brecciated acid volcanics.

Lode. Thin veins and disseminations, possibly stratabound or localised along a north-northeast-trending fault. Mineralised zone is about 10 m thick.

Ore and gangue. Malachite, azurite, chalcocite, chalcopyrite, pyrrhotite, pyrite, and minor calcite veinlets and pods.

Revenue group

Includes Revenue Central (GR 790452), and ?Revenue Extended (GR 789466).

Reference Ball (1908), Krosch & Sawer (1974).

Product. Cu.

Surface workings. Several shafts and open cuts; worked to depth of about 46 m.

Country rocks. Corella Formation (Pkc): calc-silicate granofels, quartzose and kaolinised brecciated schist, biotite schist.

Lode. Fissures, probably fault-controlled.

Ore and gangue. Chalcopyrite, malachite, azurite, chalcocite, cuprite, pyrite, calcite, quartz, jasper, gypsum.

Production. Worked since 1908. 183 tonnes of ore for 23 tonnes of copper (12.6% Cu) from Revenue mine and 18 tonnes of ore for 1.8 tonnes of copper (10% Cu) from Revenue North to end of 1958. In period 1967-71 1891 tonnes of ore were extracted from Revenue Extended, yielding 145 tonnes of copper (7.7% Cu). Production in the period 1970-71 at Revenue Central amounted to 878 tonnes of ore for 61.6 tonnes of copper (7.0% Cu).

?St George

GR 828356.

Reference.	Walker (1960).
Product.	Cu.
Surface workings.	Shaft, pits.
Country rocks	Corella Formation (Ꝑkc); laminated calc-silicate granofels, cherty gossanous ironstone; also granite veins.
Lode.	Fissure trending 170°.
Ore and gangue.	Malachite, calcite, quartz.
Production.	113 tonnes of ore.

Semigem

GR 677349.

Product.	Limestone.
Surface workings.	Two partly water-filled open cuts.
Country rocks.	Corella Formation (Pkc): pink and grey banded calc-silicate granofels.
Lode.	Fissure, sub-vertical.
Ore.	Coarsely crystalline pink to white calcite.

Trekelano

GR 859238.

References.	Shepherd (1953), Carter & others (1961).
Products.	Cu, Au.
Surface workings.	Open cut, shafts; worked to depth of 263 m.
Country rocks.	Corella Formation (Pkc): hornblende-biotite schist, amphibolitic granofels, red and grey banded calc-silicates, scapolite-pyroxene granofels, aplitic granite.
Lode.	Shear zone dipping 65°W, 30 m wide; orebody plunges steeply north. Ore mined over a maximum length of about 122 m and width of 34 m.
Ore and gangue.	Chalcocite, malachite, chrysocolla, tenorite, chalcopyrite, pyrite/marcasite, calcite; minor quartz stringers.

Production. 206 988 tonnes ore, 22 558 tonnes Cu (10.9% Cu), 386 138 Au. Lode discovered in 1907; mine closed in 1943 (main period of production from 1928 to 1943).

?H.B.

Location. GR 904253.

Product. Cu?

Workings. Open cut, shaft.

Country rocks. Corella Formation: calc-silicate granofels, marble.

Lode. Fissure trending ?180°.

Ore and gangue. Malachite, calcite and quartz on dump.

Some unnamed mines

Location. GR 777278.

Product. Cu.

Workings. Shafts.

Country rocks. Corella Formation (Ᵽkc): banded calc-silicate granofels.

Ore. Malachite on dump.

Location. GR 790349.

Product. Cu.

Workings. Shaft.

Country rocks. Corella Formation: streaky amphibolitic granofels (?metabasalt), also brecciated amphibolite (metadolerite).

Lode. Fissure along vertical shear zone.

Ore and gangue. Malachite and coarsely crystalline calcite on dump.

Location. GR 797358.

Product. Cu.

Workings. Shaft, open cut.

Country rocks. Corella Formation (Ᵽkc): orthoamphibolite, amphibolitic calc-silicate granofels.

Lode. Fissure trending 160°.

Ore and gangue. Malachite, azurite, chrysocolla, and calcite on dump.

WATER RESOURCES

None of the streams in the Duchess Sheet area are perennial; they flow for only short periods after heavy rain. Some of the larger watercourses, particularly those in the more rugged country in the north, such as the Malbon River and Spring Creek, have a number of waterholes fed by springs, many of which may cease to flow towards the end of the dry season or in times of drought. Over most of the Sheet area, particularly those parts underlain by granitic and metamorphic rocks, water for stock is mainly surface run-off stored behind low earthen dams across watercourses, or in large holes ('tanks') excavated in the watercourses. Fairly reliable supplies of underground water are contained in the lower Palaeozoic sediments in the southeast. Supplies of soakage water are obtained from wells and bores sunk in thick sandy sediments along the Burke River and Wills Creek and their main tributaries. Elsewhere most of the successful bores are sited on, or adjacent to, faults.

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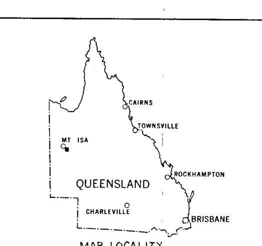

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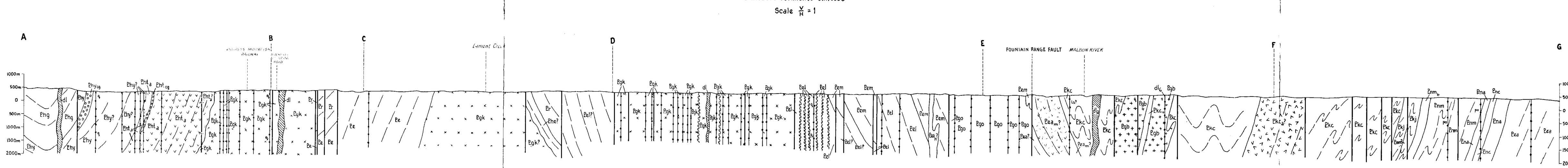

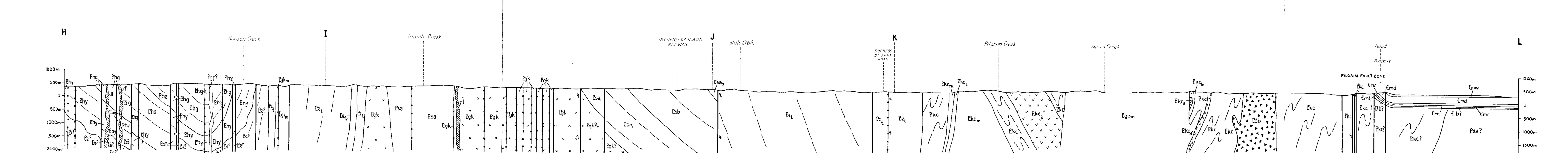

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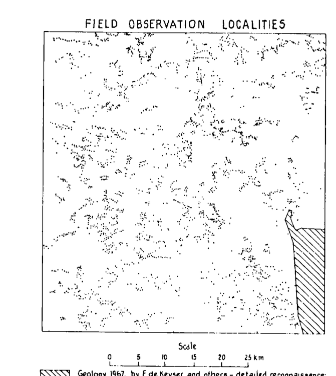

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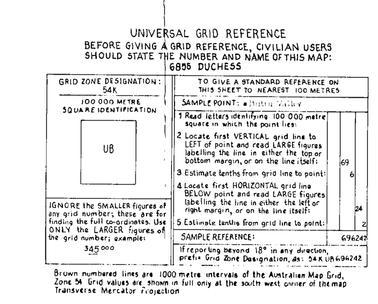

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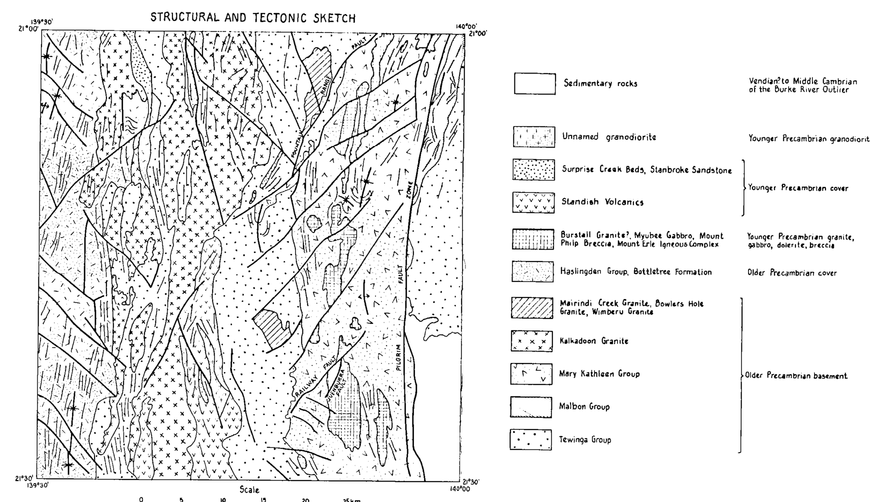

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