Mineral Provinces

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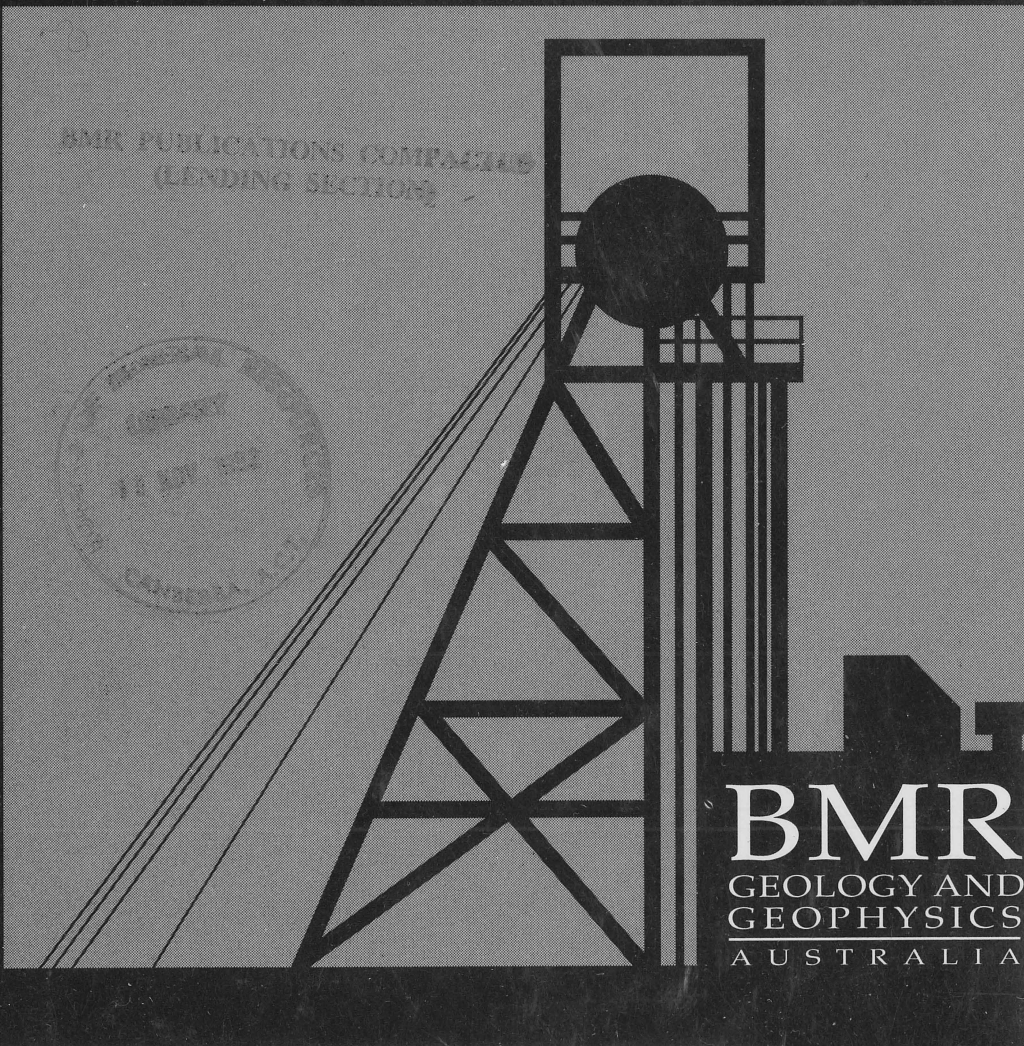
The stratigraphy of metamorphic rocks of the Ebagoola 1:250 000 sheet area in Cape York Peninsula, north Queensland.
Record 1992/74

AUSTRALIA



BMR
GEOLOGY AND
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AUSTRALIA

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MINERALS AND LAND USE PROGRAM
BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

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AGSO

AUSTRALIAN GEOLOGICAL
SURVEY ORGANISATION

DEPARTMENT
OF RESOURCE
INDUSTRIES

A contribution to the National Geoscience Mapping Accord
NORTH QUEENSLAND PROJECT

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Minerals and Land Use Program

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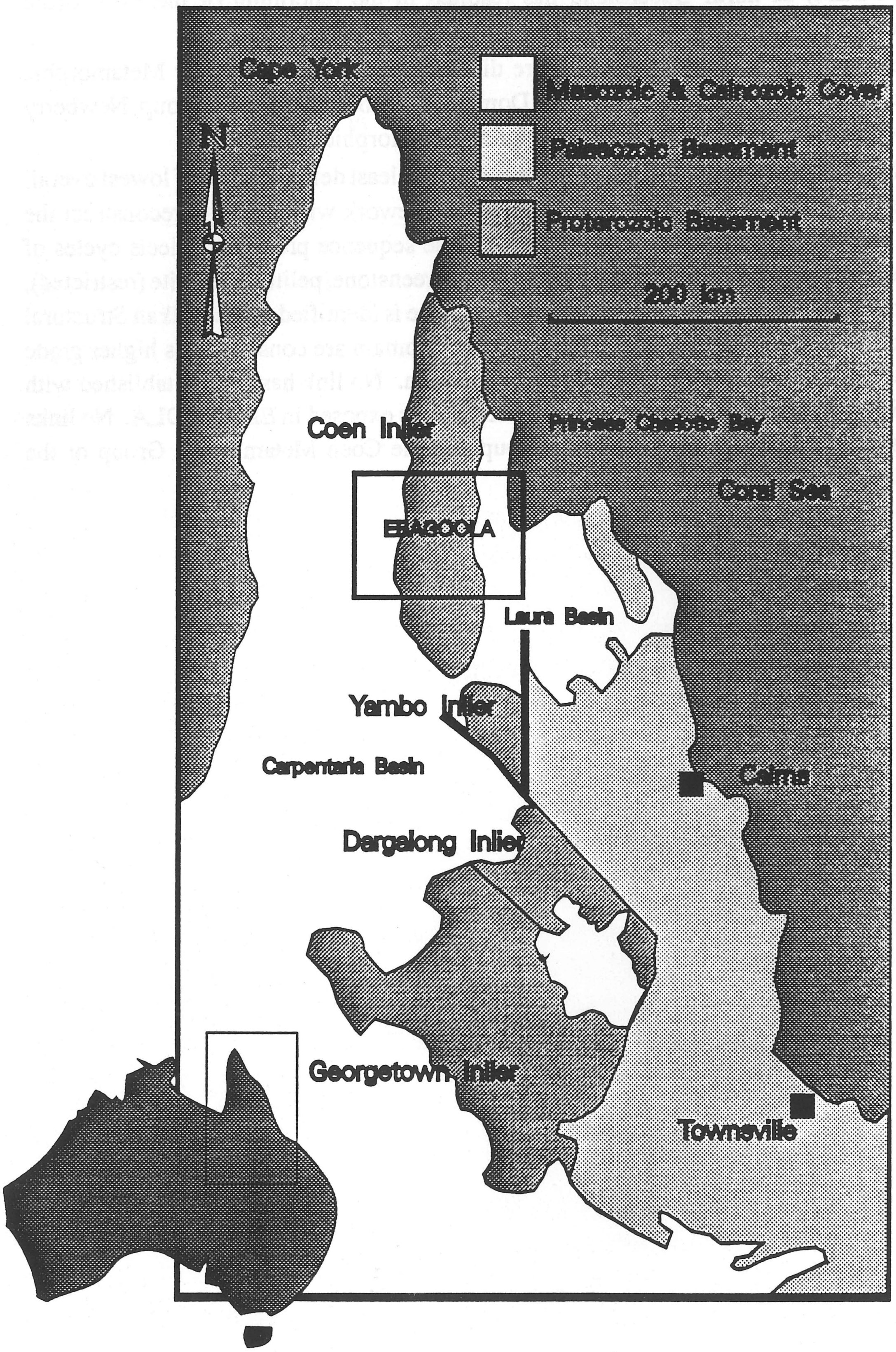
ABSTRACT

Recent mapping by the Australian Geological Survey Organisation (formerly the Bureau of Mineral Resources) and the Geological Survey of Queensland in the Ebagoola 1:250 000 sheet area (EBAGOOLA) of north Queensland has resulted in the redefining of the Proterozoic metamorphic units.

The metamorphic rocks of EBAGOOLA are divided into the Edward River Metamorphic Group, Holroyd Group (with Lukin and Kalkah Domains), Coen Metamorphic Group, Newberry Metamorphic Group as well as a number of assigned metamorphic rocks.

In the Holroyd Group, the Lukin Structural Domain is the least deformed and of lowest overall metamorphic grade and thus provides a stratigraphic framework with which to reconstruct the stratigraphy and hence correlate between domains. The sequence probably reflects cycles of sedimentation and consists of:– pelite, psammite, pelite, greenstone, pelite, psammite (restricted), pelite, psammite, pelite. A similar but incomplete sequence is identified in the Kalkah Structural Domain to the east. The rocks in the Kalkah Structural Domain are considered as higher grade equivalents to the formations defined in the Lukin Domain. No link has been established with the Edward River Metamorphic Group, which is very poorly exposed in EBAGOOLA. No links have been established between the Holroyd Group and the Coen Metamorphic Group or the Newberry Metamorphic Group.

FIGURE 1
The four Proterozoic Inliers of north Queensland.
EBAGOOLA is outlined.



INTRODUCTION

This report is a contribution to the North Queensland NGMA Project, and is based on geological field work conducted in 1990 and 1991, as well as the results of a 400 m line-spacing airborne geophysical survey (magnetics and radiometrics) in 1990 over EBAGOOLA (Fig. 1). The report describes the stratigraphy and lithology of the metamorphic units of EBAGOOLA.

The Ebagoola 1:250 000 sheet area SD54/12 (referred to below as EBAGOOLA) lies in Cape York Peninsula, north Queensland, between latitudes 14°S and 15°S and longitudes 142°30' and 144° E, between the Coen 1:250 000 sheet area to the north and the Hann River 1:250 000 sheet area to the south. Elevation on EBAGOOLA ranges from sea level to 450 m.

Access is provided by the main Peninsula Development Road, an all-weather gravel road that links Cairns (some 500 km SSE) with Weipa (255 km NW) and Cape York. Coen airport is served by regular flights from Cairns.

Other access is provided by minor station tracks that lead off the Peninsula Development Road and by a limited number of very rough, and largely overgrown, mineral exploration tracks. The bush ranges from rain forest to open scrub, and is generally too dense to drive cross-country, so most traverses were done on foot. A track map for the Coen Inlier is given by Trail and Blewett (1991).

Most of the mapping was compiled on 1:50 000 scale colour aerial photography that was acquired in 1991. Photography of a 15-km belt along the northern margin of Ebagoola was not acquired, due to poor flying weather, and the geology of this area was compiled on 1970 1:84 000 scale RC9 panchromatic photography. Some very poor, and very nominal 1:20 000 scale, colour photography over the NE part of the Ebagoola 1:100 000 sheet area was also used. Topographical maps of the Royal Australian Survey Corps 1:100 000 series for the Ebagoola, Strathburn, Strathmay, Princess Charlotte Bay, Marina Plains and Kalkah (7569, 7469, 7468, 7669, 7659 and 7568) sheets were used as base maps, with individual site positioning by the use of Pro Nav Global Positioning Systems (GPS), both hand-held and vehicle-mounted receivers.

EBAGOOLA is covered by a 1967 BMR regional gravity survey on 10 km spacing, and by airborne magnetics (Fig. 2) and radiometrics (Fig. 3) flown at 400 m line-spacing for BMR in 1990. Images, profiles and contour maps from the two latter data sets were used extensively during the 1991 field-mapping program and subsequent interpretation of the geology.

Details of a database comprising all BMR/GSQ geological field observations for EBAGOOLA collected in 1991 and 1990, together with some collected in 1966, are outlined by von Gnielinski and Blewett (1992). Reference is made to the site numbers throughout this text, and the database is available for purchase at BMR and GSQ sales centres.

The metamorphic rocks of EBAGOOLA crop out in three principal, NNW-oriented belts that are separated by granites of the Cape York Peninsula Batholith or CYPB (Willmott et al., 1973). Willmott et al. (1973) defined the Holroyd Metamorphics as forming the western belt, while the Coen Metamorphic Group forms the central and eastern belts.

The metamorphic rocks were described in detail by Trail et al. (1968), who divided them into the Holroyd and Dargalong Metamorphics. These were further subdivided into the Kalkah-type, Lukin-type, Pollappa-type and Pretender-type schists (Holroyd Metamorphics), and the Arkara-type gneiss and Pombete-type schist (Dargalong Metamorphics). These subdivsions were not published in the resulting BMR Bulletin (Willmott et al., 1973) or on the first edition Ebagoola 1:250 000 geological map (Whitaker & Gibson, 1977a). The name Holroyd Metamorphics was retained, but the higher-grade metamorphics were renamed the Coen Metamorphic Group by

Willmott et al. (1973) in EBAGOOLA; Dargalong Metamorphics continued to be used for the high-grade rocks in the Yambo Inlier to the south.

The structural and metamorphic geology of EBAGOOLA is discussed by Blewett (1992) and the geology of the igneous rocks is discussed by Mackenzie & Knutson (1992).

STRATIGRAPHY

A number of changes are proposed for the stratigraphy of EBAGOOLA that was published by Willmott et al. (1973). The metamorphic rocks of EBAGOOLA are now divided into the Edward River Metamorphic Group, Holroyd Group, Coen Metamorphic Group, Newberry Metamorphic Group and undifferentiated metamorphic rocks (Fig. 4). Figure 4 is a schematic sketch of the distribution of the major rock groups in EBAGOOLA. Figure 5 is a unit relationship diagram to illustrate the almost intact stratigraphy of the Lukin Structural Domain and the correlation with the more highly deformed and metamorphised equivalents in the Kalkah Structural Domain.

The Edward River Metamorphic Group is poorly exposed along the south western edge of the outcropping Coen Inlier. It was originally included in the "Holroyd Metamorphics" as defined by Willmott et al. (1973). Two units (of formation rank) have been defined and a further 2 domains have been recognised on the basis of their geophysical characteristics. The metamorphics occupy approximately 1000 km^2 on EBAGOOLA, of which less than 40 km^2 crops out.

The Holroyd Group crops out over 3500 km^2 in the western third of EBAGOOLA and comprises all the rocks previously assigned to the Holroyd Metamorphics (by Willmott et al. 1973) except the western edge of Edward River Metamorphic Group. The Holroyd Group is divided into the Lukin Structural Domain and Kalkah Structural Domains. A near complete stratigraphic succession of nine formations has been defined in the Lukin Structural Domain (Fig. 5) which is predominantly slate and phyllite of low metamorphic grade and quartzite with a low magnetic response. These units' more deformed and metamorphosed equivalents are recognised in the Kalkah Structural Domain (Fig. 5), where a less complete stratigraphy of predominantly gneiss and schist with a high magnetic response (Fig. 2) occurs. The Kalkah Structural Domain is divided into four shear zone-bounded subdomains (Fig. 5). The units within these subdomains are assigned unique letter symbols (e.g. **Pkl, Pku**) to indicate the range of rock types across the Kalkah Structural Domain (Fig. 5 and Table 1).

The rocks of the Coen Metamorphic Group are redefined to include only the central belt of metamorphic rocks in EBAGOOLA; they are bounded on the east by the Coen Shear Zone and granites of the Cape York Peninsula Batholith. The Coen Metamorphic Group crops out over 700 km^2 and is subdivided into a number of metamorphic units.

The Newberry Metamorphic Group is poorly exposed, but based on estimates from the aeromagnetics occupies over 2000 km^2 in the eastern third of EBAGOOLA. Trail et al. (1968) originally defined these rocks as Dargalong Metamorphics (Fig. 1) which were correlated with the rocks of the Dargalong and Yambo Inliers to the south. Willmott et al. (1973) later included them with their Coen Metamorphics further west (redefined above). The Newberry Metamorphic Group is divided into a number of metamorphic units.

Wellman (1992) used geophysical data to divide units of concealed and unidentified metamorphic rocks on the western and eastern margins of EBAGOOLA. Some of the geophysical units he defined may crop out in the MacIlwraith Range and Rocky River regions of COEN.

FIGURE 2
Grey scale aeromagnetic data (400 m line-spacing) for EBAGOOLA

FIGURE 3
Red (K), Blue (Th), Green (U) composite radiometric image for EBAGOOLA

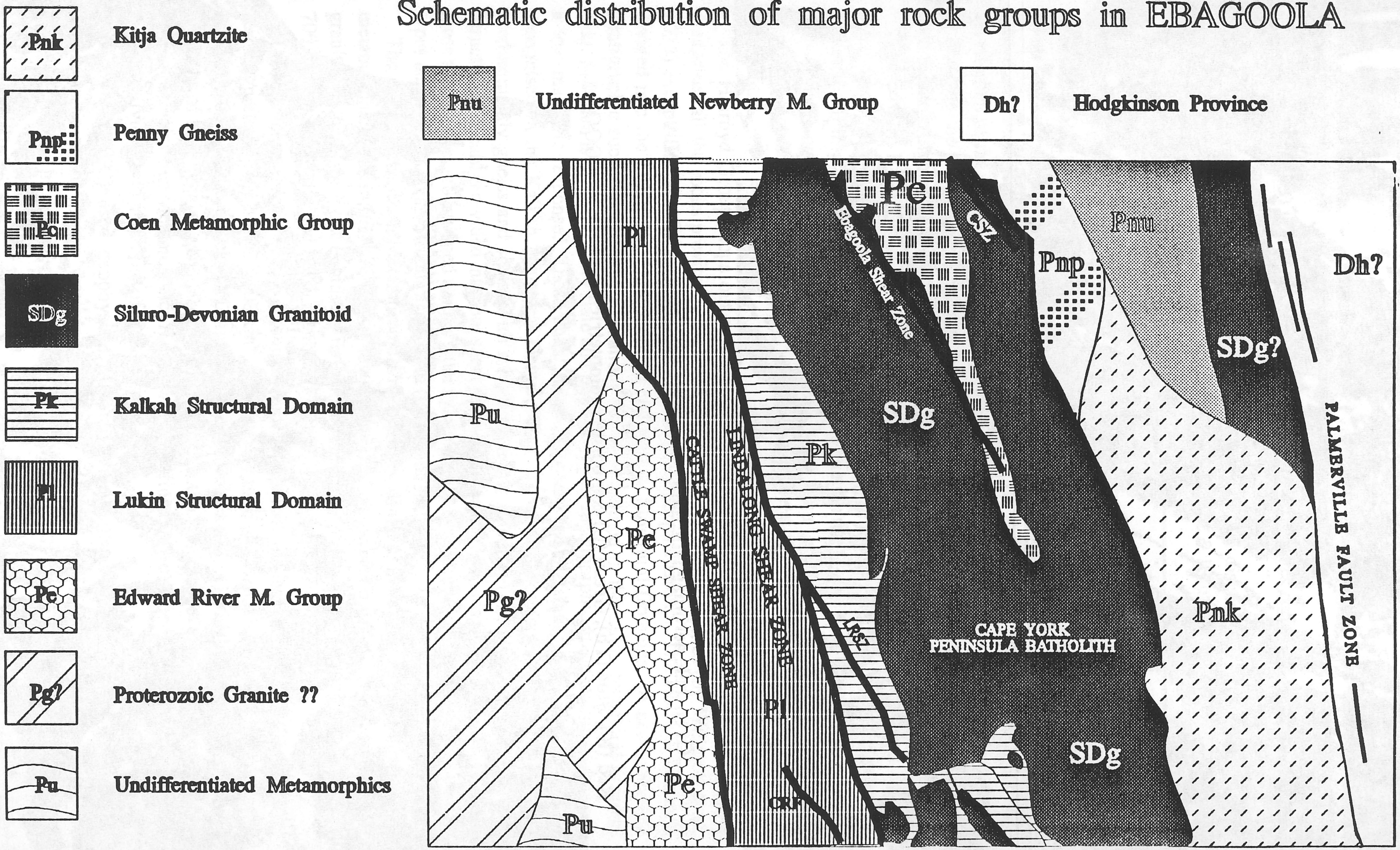
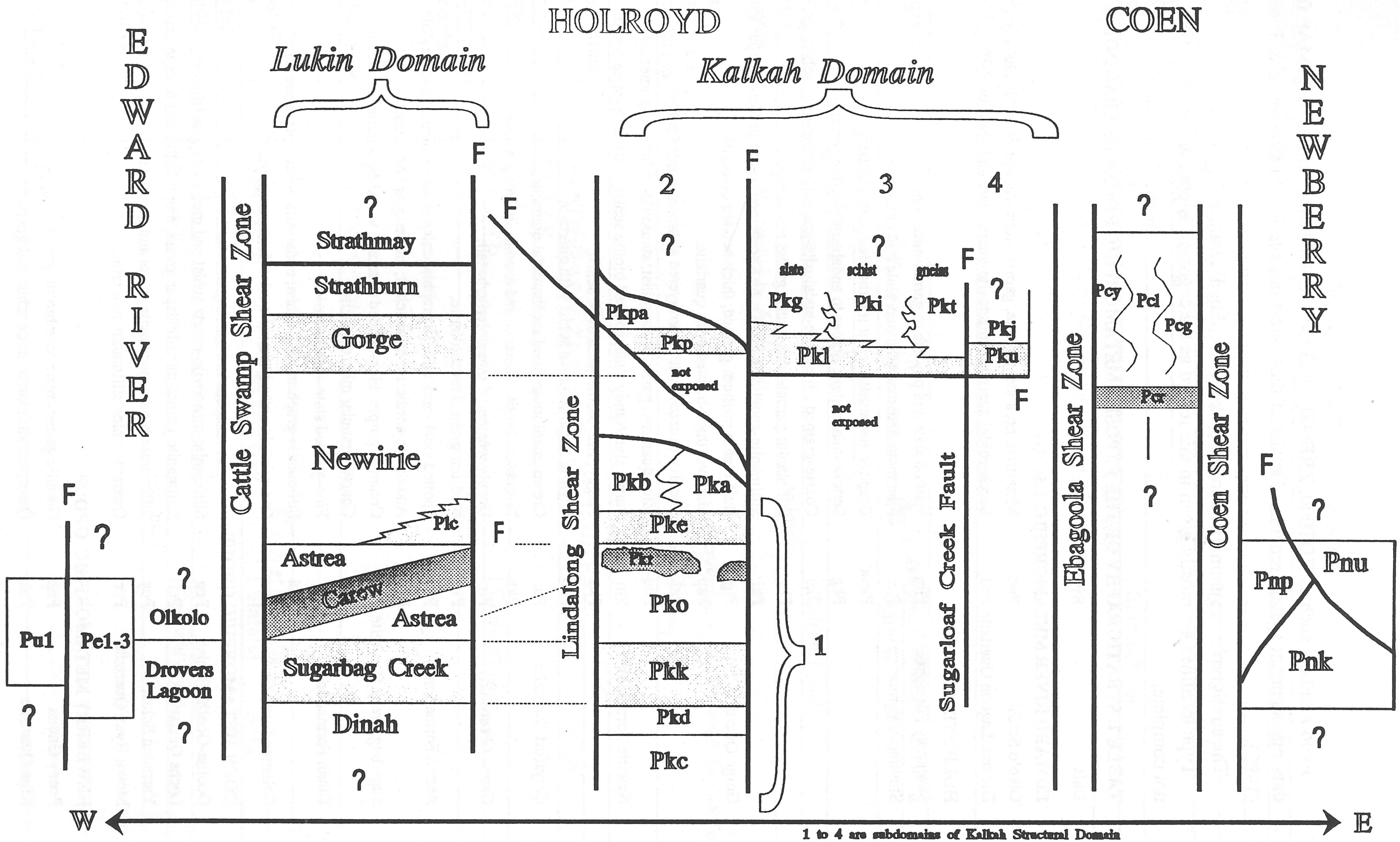


Figure 4
Schematic distribution of major rock groups in EBAGOOLA

Figure 5
Unit Relationship Diagram of Metamorphic Rocks of EBAGOOLA.



Field numbers such as ZDT000, ZRB000, QFG000 and 91834000 refer to REGMAP field data management system records. Details of these are available in von Gnielinski & Blewett (1992).

The stratigraphy is summarised in the rock relationship diagram of Figure 5.

Type localities are mostly given in this record as the exposure is poor and type sections are not complete.

TABLE 1. STRATIGRAPHY OF THE EXPOSED METAMORPHIC ROCKS OF EBAGOOLA.

Unit	Symbol	Rock Type
EDWARD RIVER METAMORPHIC GROUP		
Olkolo Schist	Peo	Metasiltstone, slate, phyllite, garnet-muscovite-quartz schist, locally graphitic.
Drovers Lagoon Quartzite	Ped	Saccharoidal quartzite, muscovite-quartz slate and phyllite.
HOLROYD GROUP		
Strathmay Formation	Plm	Spotted slate and phyllite to garnet-mica schist.
Strathburn Formation	Plb	Fine metasandstone/siltstone, slate and phyllite.
	Pkpa	Graphite-andalusite schist interbedded with quartzite.
	Pkg	Sericite-quartz slate, grades to andalusite phyllite/schist.
	Pki	Coarse-grained sillimanite-andalusite-graphite-garnet-mica schist, gneiss.
	Pkt	Sillimanite-garnet-mica-quartz gneiss and schist.
	Pkj	Sillimanite-andalusite-mica schist, some andalusite-garnet-feldspar gneiss.
Gorge Quartzite	Plg	Buff-cream medium-grained, thick-bedded quartzite.
	Pkp	Massive, thick-bedded mica quartzite.
	Pkl	Massive quartzite with interlayered sillimanite-mica schist.
	Pku	Mica quartzite, garnet-mica schist, staurolite-andalusite-garnet schist.
Newirie Formation	Pln	Purple slate/sandy slate; spotted biotite schist, andalusite-mica schist.
	Pka	Flaggy, fine biotite-muscovite schist.
	Pkb	Phyllite to garnet-mica schist with quartzite.
Carysfort Quartzite	Plc	Cream, medium-grained saccharoidal quartzite.
	Pke	Muscovite-biotite quartzite and anadalusite-mica schist.
Carew Greenstone	Plp	Deeply weathered metadolerite/basalt.
	Pkr	Medium-grained metadolerite.
Astrea Formation	Pla	Spotted steel -grey slate to graphite-mica schist, quartzite and phyllite.
	Pko	Andalusite-cordierite-mica schist; garnet-graphite schist.
Sugarbag Creek Quartzite	Pls	Cream to purple thick-bedded quartzite to orthoquartzite.
	Pkk	Coarse, granular mica quartzite.
Dinah Formation	Pld	Fine-grained slate and quartzite.
	Pkd	Sillimanite-graphite-mica schist; andalusite-sillimanite-mica schist.
Coleman River Gneiss	Pkc	Coarse sillimanite-andalusite-mica-feldspar gneiss.
COEN METAMORPHIC GROUP		
Goolha-Goolha Schist	Pcg	Sillimanite-muscovite-quartz schist and muscovite quartzite.
Lochs Gneiss	Pcl	Sillimanite-garnet-mica-feldspar gneiss, amphibolite and feldspar-mica gneiss.
Yarraden Schist	Pcy	Sillimanite-biotite-muscovite schist and quartzite.
Mount Ryan Quartzite	Pcr	Quartzite, mica-sillimanite quartzite.
NEWBERRY METAMORPHIC GROUP		
Penny Gneiss	Pnp	Granitic garnet-muscovite-biotite gneiss.
Kitja Quartzite	Pnk	Quartzite, sillimanite-mica schist and gneiss.

EDWARD RIVER METAMORPHIC GROUP (new name) — Pe

Derivation. The name Edward River Metamorphic Group is derived from the river which is found in the Strathmay 1:100 000 sheet area (7468). The Edward River flows west into the Gulf of Carpentaria.
Distribution. The metamorphics occupy approximately 1000 km^2 along the eastern edge of the Strathburn and Strathmay 1:100 000 sheet areas. Less than 40 km^2 of metamorphic rock crops out.
Boundary Relationships. The Edward River Metamorphic Group is faulted to the east against the Holroyd Group by the Cattle Swamp Shear Zone. The western margin is concealed but thought to be intruded by ?Proterozoic Granite.
Synonymy. The Edward River Metamorphic Group is originally included in the "Holroyd Metamorphics" as defined by Willmott et al. (1973).

The Edward River Metamorphic Group is extremely poorly exposed and is expressed in the aeromagnetic image (Fig. 2) as three elongate belts of rock, respectively with very high, high and patchy magnetisation. The Edward River Metamorphic Group extends southwards for several tens of kilometres into the HANN RIVER; a more complete subdivision of these metamorphics may be possible after re-mapping of HANN RIVER.

The exposed Edward River Metamorphic Group is divided into two metasedimentary units and one of foliated granite.

Drovers Lagoon Quartzite (new name) — Ped (quartzite)

Derivation. The Drovers Lagoon Quartzite is named after Drovers Lagoon (Strathmay 1:100 000 sheet area GR7468-055491)
Distribution. The unit forms a north-trending belt about 30 km long in the southwestern part of EBAGOOLA, cropping out as ridges rising around 40 to 60 m above the surrounding country, but much of the outcrop is covered by weathered siltstone of the Mesozoic Rolling Downs Group (Vine et al., 1967) which is commonly silcrete.
Type Area. The unit is very poorly exposed in EBAGOOLA, the type locality is along Drovers Creek at GR7468-070440.
Lithology. The quartzite ranges from cream and buff to light and mid-grey; accessory muscovite is common. Grain size generally ranges from very fine to granule (lithic clasts), but the rock is generally medium-grained. In some massive beds up to 1 m thick, coarse bases grade up into fine metasandstone. The quartzite commonly has a saccharoidal texture, and a high degree of sorting and roundness.

These well sorted, even-grained quartzites are interbedded with very fine-grained slates and phyllites that are more highly magnetic. Muscovite and quartz are the dominant minerals in the phyllites.
Thickness. The thickness is around 800 m.
Boundary Relationships. The Drovers Lagoon Quartzite is faulted to the west against an unnamed (Pe2) unit of the group and is overlain ?conformably by the Olkolo Schist.
Topographic expression. The quartzite ridges are well defined on the aerial photography.

Olkolo Schist (new name) — Peo (schist)

Derivation. The Olkolo Schist is named after the Olkolo Aboriginal language-group, occupying the southwestern part of EBAGOOLA (Tindale, 1974).
Distribution. The unit is very poorly exposed and deeply weathered with outcrop limited to creek beds and banks; it is largely concealed by flat-lying Mesozoic sediment. The Olkolo Schist

crops out as an elongate unit up to 2 km across and 35 km long in a N-S trending belt parallel to the Cattle Swamp Shear Zone.

Type Area. The type locality is 300 m east of the Strathburn Road GR7468-621063.

Lithology. The schist is a white to pale grey, generally fine to medium-grained, (garnet-) muscovite-biotite-quartz schist. Garnet porphyroblasts are rare and commonly 2-3 mm in diameter (Site 90834004). Feldspar and graphite are minor components, with graphite locally concentrated along S0 forming up to 5 % of the rock mass. The more graphitic schists are commonly only 3 m thick in total, comprising 10 cm thick individual beds. Ferricrete is especially well developed on the schistose regions of the unit.

The phyllite is silver-grey and fine to very fine-grained with a well developed foliation. The rock comprises quartz and muscovite with a trace of graphite. Some phyllites are garnet- bearing.

The metasiltstone/sandstone is light to medium grey, fine-grained, well-bedded and moderately sorted. The dominant minerals are quartz with a fair degree of recrystallization, and muscovite as fine needles. Bedding is well defined and generally dips steeply to the east.

Thickness. The unit is around 1500 m thick.

Boundary Relationships. The Olkolo Schist ?conformably overlies the Drovers Lagoon Quartzite and is faulted (Cattle Swamp Shear Zone) against the Lukin Structural Domain of the Holroyd Group to the east.

Structure. The schist is generally well foliated. The foliation is essentially an S2a crenulation cleavage that is axial planar to tight to isoclinal F2 microfolds of the S1 surface. The resulting intersection lineations (L21) are weak and plunge moderately to steeply to the east. Broad S4 crenulations of this S2a/S1 surface are also recorded (Sites ZRB0010 & 11).

Undifferentiated units — Pel

The aeromagnetic image shows that the greater part of the Edward River Metamorphic Group is concealed by extensive Mesozoic and Tertiary cover. Total radiometric counts are generally low but Wellman (1992) has subdivided the basement under the Carpentaria Basin, using the regional gravity and 400-m line-spacing aeromagnetic data; the concealed area has been mapped as rocks with :

- very high magnetization,
- high magnetization, and
- patchy magnetization.

(Wellman's interpretation based on correlation with the exposed geology is shown in figure 3).

Only a small part of the sub-division with very high magnetization is exposed and is very deeply weathered; a number of poor outcrops of granite and foliated granite/gneiss occur in the headwaters of the Edward River just east of the road to Strathburn homestead. Samples QFG0784 and QFG0761 are biotite-muscovite granites. Strongly foliated, cream to silver, medium to coarse-grained, garnet-biotite-muscovite-feldspar-quartz granitic gneiss is exposed along a 60 m section of the Edward River. The garnet porphyroblasts are generally 1-2 mm in diameter. The layering and foliation in the granitic gneiss are cut by a light grey dolerite dyke (2 m thick).

HOLROYD GROUP (redefined)

The Holroyd Group is named after the Holroyd River which flows from east to west across the top third of EBAGOOLA and drains into the Gulf of Carpentaria. The Holroyd Group is divided into the Lukin Structural Domain and the Kalkah Structural Domain. They will be referred to as Domains throughout the text. The Holroyd Group consists of most of the "Holroyd Metamorphics" as defined by Willmott et al. (1973) except the new Edward River Metamorphic Group. The lower grade more complete sequence in the Lukin Structural Domain provides the basis for defining the named units of the Holroyd Group which have letter symbols with a **Pl** prefix. Higher grade equivalents in the Kalkah Structural Domain are distinguished by a different letter symbol with a **Pk** prefix. In this record the units in the Lukin Structural Domain will be refered by their full name, for example the Astrea Formation. In the Kalkah Structural Domain the correlative units will be refered to by their "parent" followed by the letter symbol in brackets (e.g. Astrea Formation (Pko)).

Extensive faulting mostly subparallel to bedding has resulted in truncated sequences and juxtaposition of contrasting rock types. Consequently the correlations are somewhat speculative. Never the less the simplest and we believe, most likely interpretation of stratigraphic relationships suggest that only one stratigraphic sequence – the **Holroyd Group** is present in the Lukin and Kalkah Domains.

Lukin Structural Domain

The name "Lukin Structural Domain" is modified from the Lukin-type schist of Whitaker & Willmott (1968), which crops out over 1500 km^2 in a N-trending belt between the Cattle Swamp and Lindalong Shear Zones, principally in the southwestern part of EBAGOOLA (Figs 3, 6).

The domain is divided into nine units of slate/phyllite (locally schist) and intercalated quartzite, and a greenstone or metadolerite which intrudes one of the pelite units in the lower part of the stratigraphy (Table 2). Each of these units has the rank of formation (Figs. 5 & 6) and the minimum deposition thickness is not less than 10 km.

The Lukin Structural Domain is less sheared than the Kalkah Structural Domain to the east. A series of macroscale folds repeats the lower units of the domain; these folds project into the upper parts of the sequence but are less well defined. The domain youngs (plunges) northwards, so EBAGOOLA provides an oblique section through the stratigraphy. Deeper levels of the Lukin Structural Domain are exposed in HANN RIVER, where Siluro-Devonian granites are visible at the present erosion surface.

The magnetic image (Fig. 2) shows the Lukin Structural Domain as a relatively "flat" zone between the more highly magnetic Kalkah Structural Domain and Edward River Metamorphic Group. The sill-like body of Carew Greenstone has a greater magnetic response and clearly defines the macroscopic F2 folded pattern (Fig. 2) of the Lukin Structural Domain (Fig. 4).

Lateral facies changes and post-depositional faulting have complicated the stratigraphy. The distribution of the various units of the Lukin Structural Domain is outlined in Figure 6.

TABLE 2. A SIMPLIFIED STRATIGRAPHY OF THE HOLROYD GROUP IN THE LUKIN STRUCTURAL DOMAIN – Pl

Unit	m	Symbol	Rock type
Strathmay Formation	?	Plm	Spotted slate and phyllite to garnet-mica schist.
Strathburn Formation	1000	Plb	Fine metasandstone/siltstone, slate and phyllite.
Gorge Quartzite	1300	Plg	Buff-cream medium-grained, thick-bedded quartzite.
Newirie Formation	3000	Pln	Purple slate/sandy slate; spotted biotite schist, andalusite-mica schist.
Carysfort Quartzite	1000	Plc	Cream, medium-grained saccharoidal quartzite.
Carew Greenstone	1500	Plp	Deeply weathered metadolerite/basalt.
Astrea Formation	1500	Pla	Spotted steel-grey slate to graphite-mica schist, quartzite and phyllite.
Sugarbag Creek Quartzite	1200	Pls	Cream to purple thick-bedded quartzite to orthoquartzite.
Dinah Formation	500	Pld	Fine-grained slate and quartzite.

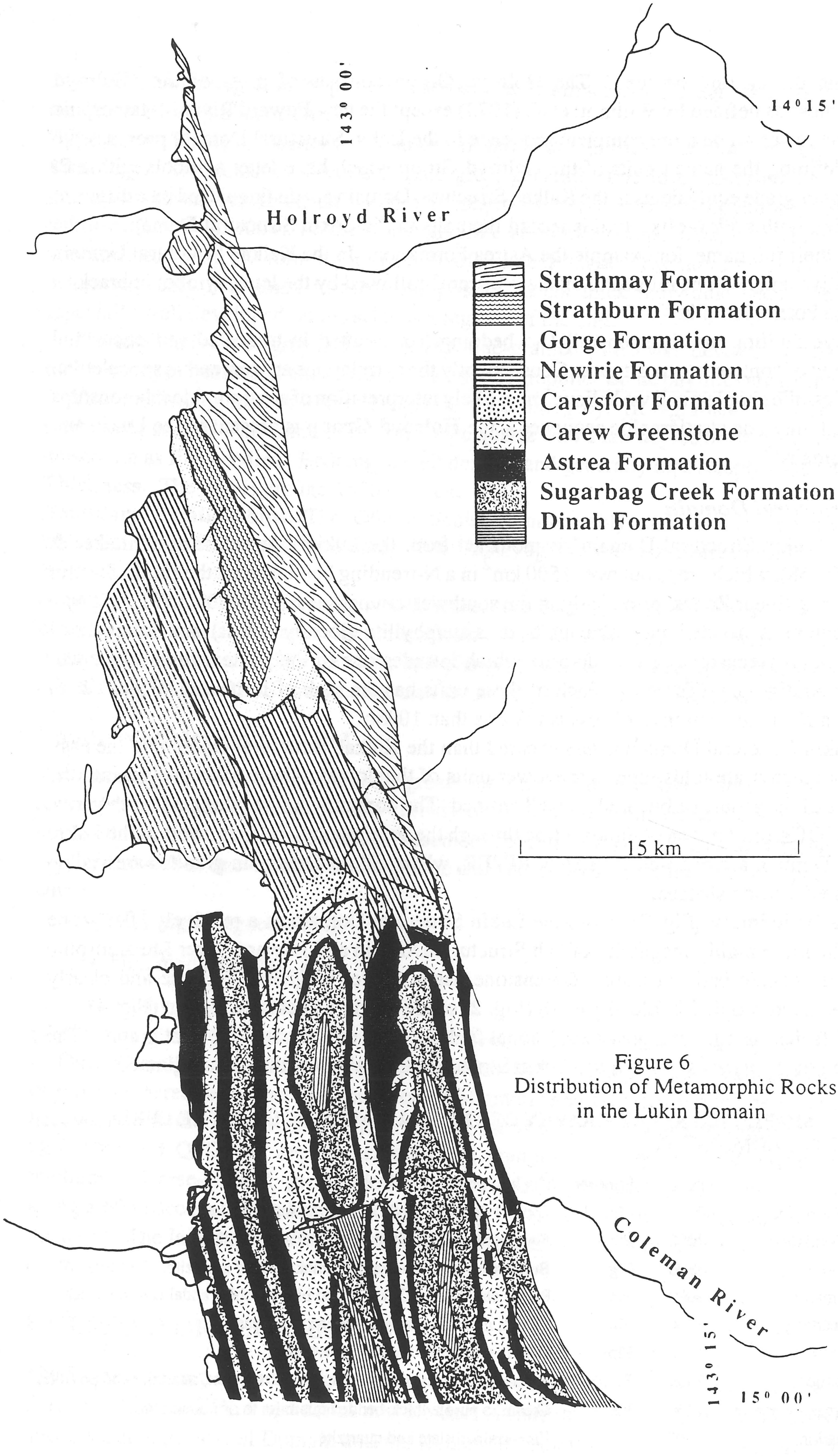


Figure 6
Distribution of Metamorphic Rocks
in the Lukin Domain

Kalkah Structural Domain – Pk

The Kalkah Structural Domain includes the rocks previously (informally) named the Kalkah-type, Pollappa-type and Pretender-type Schists of Trail et al. (1968). The Kalkah Structural Domain consists of the eastern part of the Holroyd Group and extends in a NNW-trending belt through EBAGOOLA. It is faulted to the west by the Lindalong Shear Zone and is intruded and underlain by the Siluro-Devonian granitoids of the Cape York Peninsula Batholith.

The Kalkah Structural Domain is of higher metamorphic grade than the Lukin Domain. It is predominantly schist grading into gneiss towards the east (contact with the Cape York Peninsula Batholith) and quartzite. There is a regional aureole style of metamorphism that is prograde andalusite to sillimanite – high temperature/low pressure.

The Kalkah Structural Domain is dominated by NNW and NW-trending shear zones that are earlier and later (respectively) than the intrusion of the Cape York Peninsula Batholith. Macroscale fold closures are less well developed in the Kalkah Domain. The shear sense was predominantly sinistral top to the west, with the Lindalong Shear Zone juxtaposing amphibolite facies metamorphics with greenschist facies metamorphics.

The Kalkah Structural Domain has a high magnetic response, with belts of rock separated by non-magnetic shear zones. The gravity inflexion is west of the eastern granite contact demonstrating the westerly dip of the Cape York Peninsula Batholith under the Kalkah Domain.

The Kalkah Structural Domain has been subdivided into four fault-bounded subdomains (Figs 3,7) that are separated from each other by major north-northwest-trending faults; units within the Subdomains are listed in Table 3.

Subdomain 1 consists of the rock-types exposed between the Lindalong Shear Zone and the Lucy Swamp/Lukin River Shear Zones. Subdomain 1 predominantly consists of schist with the Newirie Formation (Pkb) as the lowest metamorphic grade ranging to the high-grade Coleman River Gneiss. Subdomain 1 is the lowest tectono-stratigraphic level in the Kalkah Structural Domain and is correlated with its lower metamorphic grade equivalents in the Lukin Domain. The units (variants) found in Subdomain 1 include:– the Coleman River Gneiss, Dinah Formation (Pkd), Sugarbag Creek Quartzite (Pkk), Astrea Formation (Pko), Carew Greenstone (Pkr); Carysfort Quartzite (Pke), and the Newirie Formation (Pka) & (Pkb).

Subdomain 2 occurs within the duplex structure on the eastern side of the Lindalong Shear Zone; it contains the Gorge Quartzite (Pkp) and the interlayered Strathburn Formation (Pkpa).

Subdomain 3 extends from the eastern side of the above duplex to the contact of the Kalkah Structural Domain with the Cape York Peninsula Batholith. It contains the Gorge Quartzite (Pkl) which is overlain by Pki, Pkg, and Pkt – all lateral depositional and subsequent metamorphic facies equivalents of the Strathburn Formation.

Subdomain 4 occurs in the far south east between the Cape York Peninsula Batholith and the Sugarloaf Fault, and contains the Gorge Quartzite (Pku), overlain by the Strathburn Formation (Pkj).

TABLE 3. A SIMPLIFIED STRATIGRAPHY OF THE HOLROYD GROUP IN THE KALKAH STRUCTURAL DOMAIN

Unit	Symbol	Rock Type
SUBDOMAIN 4		
Sugarloaf Creek Fault		
Strathburn Formation	Pkj	Sillimanite-andalusite-mica schist, some andalusite-garnet-feldspar gneiss.
Gorge Quartzite	Pku	Mica quartzite, garnet-mica schist, staurolite-andalusite-garnet schist.
SUBDOMAIN 3		
fault		
Strathburn Formation	Pkr	Sillimanite-garnet-mica-quartz gneiss and schist
Strathburn Formation	Pki	Coarse-grained sillimanite-andalusite-graphite-garnet-mica schist, gneiss.
Strathburn Formation	Pkg	Sericite-quartz slate, grades to andalusite phyllite/schist.
Gorge Quartzite	Pkl	Massive quartzite with interlayered sillimanite-mica schist.
SUBDOMAIN 2		
Lukin River Shear Zone		
Strathburn Formation	Pkpa	Graphite-andalusite schist interbedded with quartzite.
Gorge Quartzite	Pkp	Massive, thick-bedded mica quartzite
fault		
SUBDOMAIN 1		
Lukin River Shear Zone		
Newirie Formation	Pkb	Phyllite to garnet-mica schist with quartzite.
Newirie Formation	Pka	Flaggy, fine biotite-muscovite schist.
Carysfort Quartzite	Pke	Muscovite-biotite quartzite and anadalusite-mica schist.
Carew Greenstone	Pkr	Medium-grained metadolerite.
Astrea Formation	Pko	Andalusite-cordierite-mica schist; garnet-graphite schist.
Sugarbag Creek Quartzite	Pkk	Coarse, granular mica quartzite.
Dinah Formation	Pkd	Sillimanite-graphite-mica schist; andalusite-sillimanite-mica schist.
Coleman River Gneiss	Pkc	Coarse sillimanite-andalusite-mica-feldspar gneiss.
Lindalong Shear Zone		

Coleman River Gneiss (new name) — Pkc (gneiss)

Derivation. The Coleman River Gneiss is named after the Coleman River in the Kalkah 1:100 000 sheet area. The river flows west across the southern part of EBAGOOLA into the Gulf of Carpentaria.

Distribution. The unit crops out near the Curlew Range north of Opera Hill. A small gneiss body also crops out in the Coleman River at the junction with Lucy Creek.

Type Area. The type locality is in the Curlew Range north of Opera Hill GR7568-358588.

Lithology. It is a red to grey, medium to coarse-grained sillimanite-andalusite-mica-feldspar gneiss which contains graphite in places.

Thickness. The main outcrop near the Curlew Range is intensely sheared and estimates of thickness are very tentative. The unit is exposed for greater than 2000 m across-strike.

Boundary Relationships. The unit appears to pass conformably into the Sugarbag Creek Quartzite (Pkk) to the east so may correlate in part with the Dinah Formation. The western

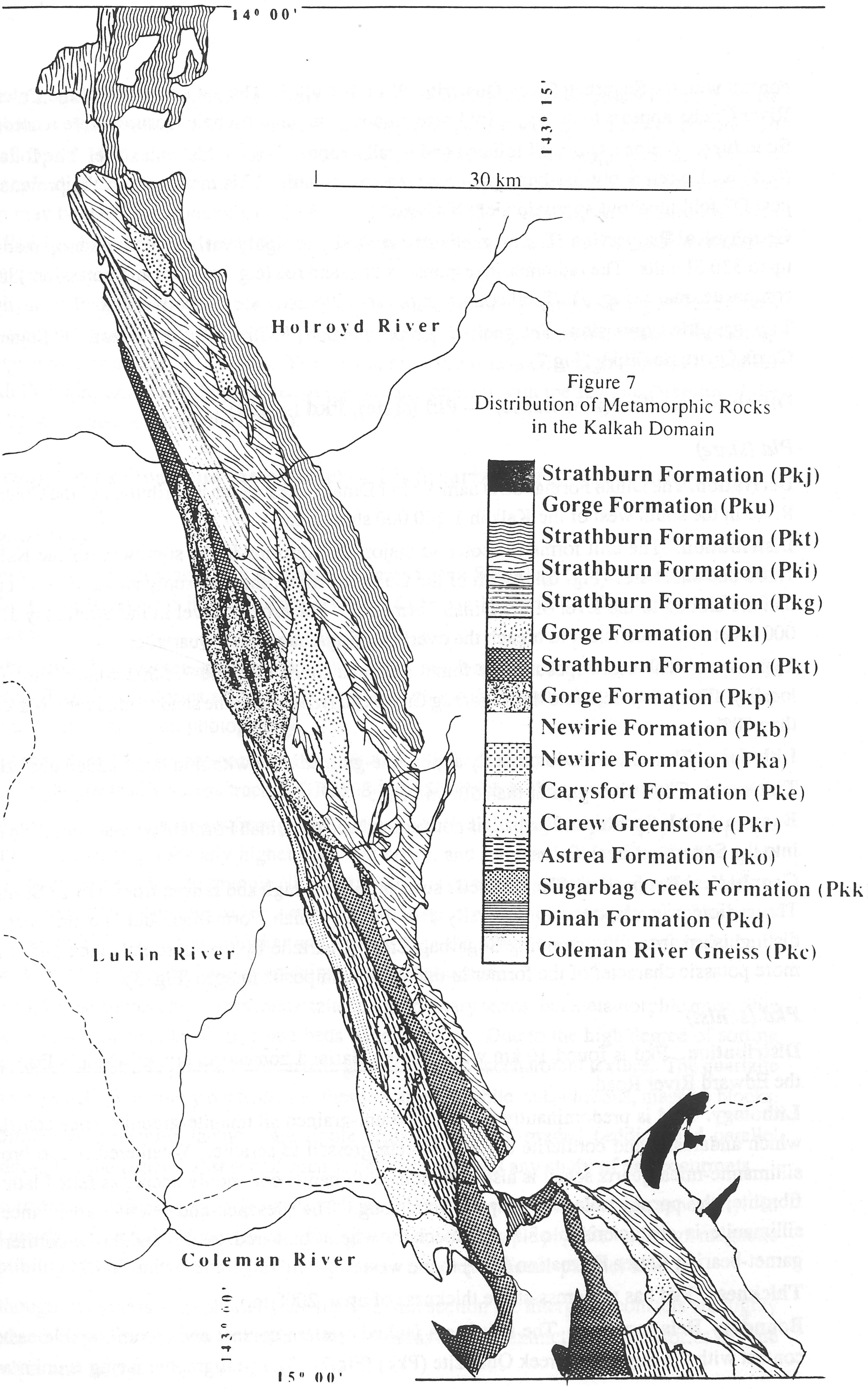


Figure 7
Distribution of Metamorphic Rocks in the Kalkah Domain

contact with the Sugarbag Creek Quartzite (Pkk) is faulted. The outcrop shape of the Coleman River Gneiss appears to occupy a fold core, although no macroscopic closures were recorded.

Structure. The gneiss is well foliated and locally approaches a schist in texture. The foliation (S2a) is also relatively flat-lying in some areas of the unit. This may point to the presence of post D2 folding about approximately N-S axes.

Geophysical Properties. The magnetic susceptibility is highly variable with outcrop readings up to 330 SI units. The radiometric response is blue and red (e.g. uranium and potassium) in the composite image (Fig. 3). Total counts on the scintillometer are typically 7 cps.

Topographic expression. The gneiss is a recessive body "within" the more resistant Sugarbag Creek Quartzite (Pkk) (Fig.7).

Dinah Formation (new name) — Pld (slate), Pkd (schist)

Pld (slate)

Derivation. The Dinah Formation is named after Dinah Creek which is a tributary of the Coleman River in the south west of the Kalkah 1:100 000 sheet area.

Distribution. The unit forms the cores to major F2 antiforms in the southwest of the Kalkah 1:100 000 sheet area (Fig. 6). North of the Coleman River, there are only two anticlinal cores that are eroded to the level of the Dinah Formation. The erosion level in the Strathmay 1:100 000 sheet is not sufficient to breach the overlying Sugarbag Creek Quartzite.

Type Area. The best exposures are found in Dinah Creek GR7568-235502 which is the type locality. The unit passes into the Sugarbag Creek Quartzite where the sand to mud ratio is greater than 50%.

Lithology. The unit is predominantly a grey fine-grained slate with thin interbedded quartzites.

Thickness. The unit is greater than 500 m thick.

Boundary Relationships. The base is not exposed and the Dinah Formation passes conformably into the Sugarbag Creek Quartzite.

Geophysical Properties. The magnetic susceptibility is high and ranges from 9 to 17 SI units. The radiometric response is generally low in the Dinah Formation, but the unit can be distinguished from the overlying Sugarbag Creek Quartzite by the more reddened and hence more potassic character of the former in the colour composite images (Fig. 3)

Pkd (schist)

Distribution. Pkd is found 10 km west of Glen Garland homestead around Doug's Dam and the Edward River Road.

Lithology. Pkd is predominantly a grey, medium-grained sillimanite-graphite-mica schist, in which andalusite and cordierite are largely retrogressed to sericite. Weathered red to brown sillimanite-mica-quartz schist is also common. Sillimanite commonly occurs as felted laths of fibrolite; the porphyroblasts are up to 1 cm long. The presence and relative abundance of sillimanite is characteristic of Pkd, especially when compared to the andalusite-cordierite-garnet-bearing Astrea Formation (Pko) to the west.

Thickness. Pkd has an across-strike thickness of up to 2000 m.

Boundary Relationships. The unit has a faulted western contact and a conformable eastern contact with the Sugarbag Creek Quartzite (Pkk) (Fig.7). The stratigraphic facing is unknown.

Structure. Pkd is faulted against the Coleman River Gneiss; however, schists within the gneiss are similar to Pkd. A well developed schistosity defined by S2a occurs. In the western outcrop (NE of Opera Hill), the S2a schistosity is sub-horizontal with dips ranging from 5 to 15°. Low-angle dips are also recorded in the Coleman River Gneiss just west of this area, and the region may be the hinge zone of a macroscopic F2 or F3 fold. However, no fold closures were identified to support this, nor was the low-angle foliation overprinted by a second crenulation cleavage.

Geophysical Properties. The radiometric response is moderate (7 cps) with light blue colours in the composite imagery (Fig. 3). The magnetic susceptibility is low to moderate with outcrop readings typically around 10 SI units. The overall response is generally high (like the rest of the Kalkah Domain) and this is highlighted at the western contact with the Kintore Granites of the Cape York Peninsula Batholith (Fig. 2).

Sugarbag Creek Quartzite (new name) — Pls (quartzite), Pkk (quartzite)

Pls (quartzite)

Derivation. The Sugarbag Creek Quartzite is named after Sugarbag Creek which drains west into the Lukin River near its confluence with the Coleman River in the Strathmay 1:100 000 sheet area.

Distribution. The Sugarbag Creek Quartzite crops out largely in the cores of the major F2 antiforms (Fig. 6), and forms ridges up to 80 m high above the surrounding country; it is easily distinguished on the aerial photography.

Type Area. Good exposures occur in the hills 4 km SSE of the Astrea Homestead, just to the west of the homestead's access track at GR7568-220650 which is the type locality.

Lithology. The quartzite ranges from purple to cream, buff, light grey and mid-grey, with purple common in the stratigraphically higher beds and cream and buff in the lower beds. The grain size ranges from very fine to granule (lithic clast), but is commonly medium. In some thick to very thick beds (2 m) there are very coarse bases grade up to very fine metasandstone. The upper beds of the unit are commonly thicker and coarser than the lower ones and it appears to be in general a thickening-upward and coarsening-upward sequence.

The rock type approaches an orthoquartzite in sedimentary terms, but metamorphic muscovite and rare iron-stained spots occur; some beds have feldspar. Due to the high degree of sorting and overall roundness of grains, the quartzite generally has a saccharoidal texture. The quartzite is also recrystallized in many outcrops and these weather to white, sub-vitreous, massive blocks.

Sedimentary structures include rare ripple cross-lamination, graded bedding and parallel lamination, but the general absence of such structures frustrates any study of palaeocurrents.

The rocks are generally even-grained, well sorted and the grains have a high sphericity. In places quartzite is interbedded with very fine-grained spotted purple phyllite with high magnetic susceptibility (23 SI units). Some phyllites preserve thin depositional-parallel laminae.

Although roundness and sphericity are high, in thin section the intergrain contacts are highly sutured and the grains are strongly strained and undulous through extinction. Accessories include tourmaline and zircon as well as opaques.

Thickness. The unit is up to 1200 m thick and thins to 500 m which may reflect depositional thickness variation, limb thinning or undefined faulting and/or folding.
Boundary Relationships. The Sugarbag Creek Quartzite conformably overlies the Dinah Formation and is conformably overlain by the Astrea Formation.
Structure. The quartzite beds are generally poorly foliated. A well developed schistosity (S1) is seen in the interbedded pelitic horizons. Garnet and biotite (M2?) occur in some interbedded phyllite, while hematite masses after garnet(?) are syn-D1 and are confined to the axial regions of F1 folds (Site 91834423).
Topographic expression. The resistant quartzite beds form linear ridges from 10 to 100 m above the surrounding terrain. The unit is relatively easily distinguished on the aerial photography.
Geophysical Properties. The quartzite beds are unusually high (for the region) in magnetic susceptibility with readings up to 25 SI units and an average of 15 SI units. They are clearly visible on the magnetics image (Fig. 2) as "texture" surrounded by the better defined greenstone unit. The radiometric response is generally low, and pale green/blue colours on the colour composite image (Fig. 3) show that there is little potassium associated with this unit.

Pkk (quartzite)

Distribution. Pkk forms the bulk of Subdomain 1. It stretches from the Lukin River in the north to the southern boundary of the Kalkah 1:100 000 sheet area and from the Lindalong Shear Zone in the far south west to the Lucy Swamp Shear Zone (an extension of the Lukin River Shear Zone) in the west (Fig. 7).
Lithology. Pkk is dominated by purple to brown and pink, medium to coarse-grained mica quartzite. The quartzites have a granular texture where not overprinted by a strong foliation. Some quartzites are more like psammitic schists and contain muscovite and biotite; others have rare garnet. Parallel laminae are the only recorded sedimentary structures in the medium to thick-bedded quartzites. The muscovite and biotite are concentrated along the S2a surface, and biotite is commonly aligned within this surface.

The quartzites are interbedded with brown to red/purple, fine-grained sillimanite-mica-quartz schists similar to those described as the Dinah Formation (Pkd). Some schists are andalusite-graphite-cordierite(?)-bearing. The interbedded schists to the southwest are probably of lower metamorphic grade and tend to be muscovite-biotite-bearing schists.
Thickness. The thickness is difficult to calculate as all contacts are faulted. Some slices of Pkk are up to 2000 m in across strike thickness.
Boundary Relationships. Pkk conformably overlies the Dinah Formation (Pkd) and has faulted upper contacts with the Astrea Formation (Pko) to the west and the Newirie Formation (Pka) to the east.
Structure. The foliation ranges from a weak fracture cleavage to a schistosity in the finer grained more pelitic quartzites. The schistosity is seen as a fine crenulation foliation with an earlier S1 foliation within the Q-domains. The intersection between S0 (bedding) and S2a commonly creates a well developed intersection lineation.
Topographic expression. The quartzite generally forms high ground with a highest point of 256 m in the Curlew Range.
Geophysical Properties. The magnetic susceptibility is highly variable with some quartzites giving readings up to 30 SI units. The radiometric response is low, characterised by green/blue colours in the composite imagery (i.e. thorium and uranium), with total counts around 4-5 cps.

There is a distinctive brown colouration (Fig. 3) in Pkk around the Curlew Range. This suggests more potassium in this area, i.e. the presence of granite or gneiss.

Astrea Formation (new name) — Pla (slate), Pko (schist)

Pla (slate)

Derivation. The Astrea Formation is named after the pastoral holding of Astrea (Ebagoola 1:250 000 Cadastral Map).

Distribution. It crops out in the south west corner of the Kalkah 1:100 000 sheet area and in the south east corner of the Strathmay 1:100 000 sheet area as a series of N-S trending belts that are repeated by three anticline/syncline pairs.

Type Area. The type locality is located in Willie Creek, 2 km south of the Astrea homestead (GR7568-200681).

Lithology. The dominant rock type is a grey, fine to very fine-grained slate. Locally the slate carries spots less than 1 mm in diameter, but higher metamorphic grade, for example steel grey, fine-grained graphite-muscovite schist, has been recorded. Some more psammitic beds are metasiltstones and commonly only have a weak fracture cleavage. Minor laminated and ripple cross-laminated metasandstones are interbedded with the slate beds.

The Astrea Formation that lies above the Carew Greenstone sill ranges upwards from psammitic to pelitic rocks. Small outliers of medium to coarse-grained, cream coloured quartzites crop out in the synclinal axes of the major F2 folds just west of the Coleman River Fault (Fig. 6). A narrow sliver of Astrea Formation is also found west of the Lindalong Shear Zone forming the eastern limb of a major N-trending F2 anticline. Light grey, medium-grained quartzites and interbedded mica schist crop out adjacent to the greenstone contact. Metamorphic grades are variable, especially close to the sill, for example an outcrop along Dinah Creek in the Kalkah 1:100 000 Sheet (Site 91834420) is a garnet-actinolite(?)-biotite-muscovite schist. The garnet is up to 2 mm in diameter, is enveloped by a strong S2a crenulation cleavage and displays a well developed pressure shadow. A steep NNW-plunging mineral lineation is defined by alignment of biotite and actinolite(?).

The unit generally becomes finer grained and more pelitic up section with grey to maroon or purple, fine to very fine-grained slate as the most common rock type. Some slates have rounded, pale coloured spots less than 1 mm in diameter that consist of quartz and muscovite probably after cordierite.

Thickness. Marked thickness changes are a function of the discordance of the 1 km thick Carew Greenstone which at its lowest level (stratigraphically) is near the base of the Astrea Formation and at its highest level is in contact with the overlying Carysfort Quartzite. The Astrea Formation has an estimated thickness of 1500 m.

Boundary Relationships. The Astrea Formation is folded with and conformably overlies the Sugarbag Creek Quartzite (Fig. 6) and is overlain conformably by the Carysfort Quartzite. The Carew Greenstone transects the unit by nearly 1500 m from near the base to the top where the greenstone is in direct contact with the overlying Carysfort Quartzite.

Structure. Foliation variation is partly a function of lithology change, and ranges from a weak parting or fracture cleavage to a moderately well formed schistosity. The slates are generally well foliated and locally crenulated although the crenulation is only seen as the two surfaces intersect along the slaty foliation. A stretching lineation is also present.

Topographic expression. The unit is recessive.

Geophysical Properties. The magnetic susceptibility is generally around 20 SI units, while total counts are commonly around 5 cps. The unit is very pale blue on radiometric colour composite images (Fig. 3).

Pko (schist)

Distribution. Pko crops out in four main NNW-trending, elongate belts (Fig.7), with the largest region (42 km strike length) stretching from the Coleman River in the south to 12 km north of the Lukin River. Small rafts of Pko are also found within the Warner Granite (MacKenzie & Knutson, 1992) along the Lucy Swamp Shear Zone (Blewett, 1992).

The unit is only exposed in Subdomain 1.

Lithology. Pko is typically a brown, medium to fine-grained andalusite-cordierite-mica-quartz schist ranging to a grey, medium-grained garnet-mica-graphite schist. Garnet porphyroblasts are up to 2 mm in diameter, while cordierite is seen as pale-coloured ellipsoids up to 1 mm in diameter. The biotite is commonly aligned; some have steep-plunging elongation azimuths.

The schists are interbedded with more psammitic, "flaggy" thin-bedded rocks with quartz and muscovite as typical mineralogy. Parallel laminae were the only recorded sedimentary structures in these beds. As the schist is more recessive, the flaggy psammites are preferentially exposed.

Fine-grained, grey, garnet-mica phyllitic schist is also common. Interbedded psammitic schist tends to be thin to medium-bedded, and the sequence may have represented sand, mud and silt interbeds.

At one locality along Fish Creek (Site 91834111), porphyroblasts of andalusite (chiastolite variety) with intergrowths of sillimanite are present in addition to garnet, muscovite and biotite in the schist. This andalusite/sillimanite-bearing schist is commonly associated with black graphite schist. The andalusite porphyroblasts are up to 3 cm long. Cordierite spots are recorded in the "knotted" schists with some porphyroblasts up to 2 cm in diameter.

There are a number of small (1-2 m thick) metadolerite bodies throughout the unit north of the Lukin River. Some are strongly foliated with acicular actinolite(?) along the foliation; these are interpreted as small bodies of the larger Carew Greenstone (Pkr).

The small rafts of Pko in the Warner Granite are hornfelsed. Little remains of the schistosity, the rock being hard-baked and severely reddened.

Thickness. Pko ranges from 1500 to 1800 m in across strike thickness, although internal thickening may account for difference between the higher grade equivalent and the Astrea Formation as defined in the Lukin Domain.

Boundary Relationships. Pko has a faulted contact with the Sugarbag Creek Quartzite (Pkk) and passes conformably (at least around the Lukin River) into the Carysfort Quartzite (Pke). The unit has "internal" boundaries where disaggregated bodies of metadolerite are identified as the Kalkah Structural Domain equivalents of the Carew Greenstone in the Lukin Domain.

Structure. The foliation is a well developed steeply dipping S2a schistosity; it is commonly a composite of S1 and S2a where S1 is visible as a slightly oblique foliation between microlithons of the Q-domain (quartz). An alignment of biotite within S2a defines a lineation locally. Many of the boundaries are deformed by D2b and D2c shear zones (Blewett, 1992).

Geophysical Properties. The magnetic susceptibility generally ranges from 10 to 17 SI units; this moderate level is reflected in the high response seen in the Kalkah Structural Domain generally (Fig. 2). The total radiometric counts are low.

Carew Greenstone (new name) — Plp (metadolerite), Pkr (metadolerite)

Plp (metadolerite)

Derivation. The Carew Greenstone is named after Carew Parish which is located in the Kalkah 1:100 000 sheet area.

Distribution. The greenstone is exposed in the SW corner of the Kalkah 1:100 000 sheet area and in the SE corner of the Strathmay 1:100 000 sheet area.

Type Area. The unit is very poorly exposed and generally deeply weathered. The type locality is close to the base of the Astrea Formation which may be found along the creek that is subparallel to the station track serving Astrea Holding (GR7568-244607).

Lithology. The unit is generally deeply weathered, but a few rubbly or spheroidally weathered outcrops show it to be a fine to medium-grained, greenish black equigranular metabasalt/dolerite. The greenstone commonly weathers to a speckled, pale khaki colour with iron-bearing minerals leached and feldspar remaining.

The rock (e.g. 91834041b) has been totally recrystallized with a fine grained groundmass overprinted by "felted", strongly pleochroic actinolite. Quartz fills a number of spherical vug-like bodies with sharp contacts with the groundmass. Willmott et al., (1973) named the unit *greenstone* and described the mineralogy as being a tremolite actinolite or altered hornblende rock with plagioclase, quartz, clinoziosite, sphene, chlorite, biotite, sericite and carbonate.

An outcrop (Site 9083006b) 3 km east of the Astrea homestead and along the track to Eighteen Mile Lagoon consists of a coarse-grained metabasalt associated with a white, cherty siliceous rock. The siliceous rock consists of quartz with 1-2 mm diameter spherical masses of clinoziosite and lesser calcite; the spherules make up nearly 50% of the rock and some spherules are slightly flattened. The origin of this rock is unknown.

Thickness. It is up to 1500 m thick.

Boundary Relationships. The Carew Greenstone is a folded sill-like body that cuts up the Lukin Structural Domain stratigraphy (Fig. 6) from near the base of the Astrea Formation to the overlying Carysfort Quartzite. The intrusive nature is also supported by the presence of the disaggregated stringers of greenstone that crop out in HANN RIVER to the south (Whitaker & Gibson, 1977).

Structure. The greenstone is generally unfoliated although a weak fracture cleavage occurs in places. The unit has well developed macroscopic F2 folds with two anticlines separated by a syncline and a third anticline with a sheared complementary syncline.

Topographic expression. The Carew Greenstone is characterised by a recessive reddened area on the colour aerial photography.

Geophysical Properties. It is well defined on the aeromagnetics (Fig. 2) as it is surrounded by less magnetically susceptible material, while it has a very low response in the radiometrics (Fig. 3), it is consequently mapped with a high degree of accuracy. A deep red soil (regolith) development is also common, although not invariably so. The magnetic susceptibility is commonly around 60 SI units, and ranges up to 1500 SI units. Scintillometer total counts are around 2 to 5, reflecting the airborne radiometric data which reproduce as black on the colour composite images (Fig.2b).

The 1991 BMR stream-sediment survey shows high copper values coinciding with the outcrop of the Carew Greenstone.

Pkr (metadolerite)

Distribution. Pkr is a very poorly exposed in the Kalkah Domain, and the unit mostly crops out within the Astrea Formation (Pko). Another small metadolerite body is exposed in the Sugarbag Creek Quartzite (Pkk) just west of the Lukin River Shear Zone where it crosses the Lukin River. A small body 2000 m long by 200 m wide crops out in the Carysfort Quartzite (Pke) approximately 2.5 km east of The Gorge.

The unit has transgressed a greater thickness of original sedimentary stratigraphy in the Kalkah Structural Domain than in the Lukin Structural Domain where it is basically confined to the 1500 m of the Astrea Formation.

Lithology. The metadolerite is dark grey, medium-grained and has an equigranular texture. Pkr is generally weakly foliated or unfoliated and comprises hornblende and feldspar. A small body (Site 91834093A) near the Lukin River contains abundant hornblende, feldspar (some microcline) and rare allanite.

Thickness. The unit is characterised by a deep red soil development, and darker colouration on aerial photographs (from dense vegetation). An estimate of the true thickness is not possible due to the very poor exposure and reliance on aerial photograph and aeromagnetic patterns.

Boundary Relationships. No contacts were actually located in the field, the boundary relationships are considered to be mostly intrusive. The southern extension of the Gorge Fault transects one of the Carew Greenstone bodies.

Geophysical Properties. The radiometric response is low with outcrop readings of 2 cps. The magnetic susceptibility is around 50 SI units, a similar value to the Carew Greenstone in the Lukin Structural Domain to the west, and the high response on the aeromagnetic image (Fig. 2) reflects this high susceptibility.

Carysfort Quartzite (new name) — Plc (quartzite), Pke (quartzite)

Plc (quartzite)

Derivation. The Carysfort Quartzite crops out in the Parish of Carysfort (Ebagoola 1:250 000 Cadastral Map).

Distribution. It is exposed in two regions in the far west of the Kalkah 1:100 000 sheet area and extends into the eastern margin of the Strathmay 1:100 000 sheet area. The unit crops out 2.5 km NE as well as less than 1 km west of the homestead on Astrea Holding. The unit is concealed on the Strathmay 1:100 000 sheet area and is thought to be parallel to the Lukin River along the western limb of a major anticline.

Type Area. Good exposures of quartzite are found 3 km NE of the Astrea Holdings homestead and the type locality is given as GR7568-229710.

Lithology. The unit is predominantly a cream coloured, medium-grained, saccharoidal quartzite with minor interbedded slate and phyllite.

Thickness. There is a maximum thickness of about 1000 m.

Boundary Relationships. The base of the unit is a conformable contact with the Astrea Formation, this contact is in some places replaced by the Carew Greenstone as the sill has cut up through the top of the Astrea Formation. The top of the unit is probably conformable and may interfinger with the overlying Newirie Formation. In the far west of the Lukin Structural

Domain in the Strathmay 1:100 000 sheet area, the Astrea Formation is conformably overlain by the Newirie Formation (this relationship is largely concealed by Mesozoic cover).

Structure. It is generally poorly foliated although it has well spaced joints which locally concentrate iron staining. Some interbedded, more pelitic rock types tend to be well crenulated (by S2a) garnet-muscovite phyllites, or spotted slates. The very fine-grained quartzites have a spaced S2a crenulation cleavage.

Topographic expression. The quartzite crops out as low ridges but is poorly exposed to the west and is covered by alluvium from the Lukin River (Fig. 6).

Geophysical Properties. The magnetic susceptibility is very low with readings typically below 2 SI units. This low level of susceptibility is visible on the magnetic image (Fig. 2) as an area of flat character north of the main folded greenstone. The potassium count is higher than many units of the Lukin Structural Domain and the composite image tends reflect this in the pink colouration associated with this unit (Fig. 3).

Pke (quartzite)

Distribution. Pke forms a NNW-trending up belt that is parallel to the Lindalong Shear Zone and is exposed in an area that is up to 1.5 km across and 27 km long. The unit is located less than 2 km to the east of The Gorge (on the Lukin River) and approximately 4 km to the east of the Astrea Holding's homestead in the southern part of the outcrop.

Lithology. The lithology is predominantly a white, recrystallised or saccharoidal quartzite with muscovite, biotite and limonite-staining. Zircon occurs as an accessory. The quartzites are generally medium-bedded and fine to medium-grained. They are interbedded with recessive schist which ranges from highly magnetic (100 SI units) carbonaceous/graphitic schist or phyllite, to a more common brown, medium-grained andalusite-muscovite-biotite schist, lithologically similar to the Astrea Formation (Pko).

A small elongate metadolerite body up to 300 m thick crops out in the quartzite near the Lukin River. The metadolerite is dark green, medium to coarse-grained and occasionally displays a weak foliation. These represent metamorphosed gabbros and dolerites of the Carew Greenstone (Pkr).

Thickness. Pke is up to 1000 m thick.

Boundary Relationships. The unit dips steeply and passes conformably from the Astrea Formation (Pko) to the east, so the stratigraphy youngs to the west in this region. The upper (western) boundary of Pke in the Kalkah Structural Domain is marked by the Lindalong Shear Zone. Small bodies of the Carew Greenstone (Pkr) intrude the unit near the Lukin River.

Topographic expression. Pke is poorly exposed, forms a low NNW-trending ridge line.

Geophysical Properties. The NNW-oriented fabric visible on the magnetics (Fig. 2) distinguishes the unit from the less magnetic Lukin Structural Domain to the west. The radiometric response is generally low on total counts (Fig. 3).

Newirie Formation (new name) — Pln (slate), Pkb (phyllite), Pka (schist)

Pln (slate)

Derivation. The Newirie Formation is named after Newirie Creek which flows west into the Lukin River in the Kalkah 1:100 000 sheet area.

Distribution. It is an extensive unit in the north west corner of the Kalkah 1:100 000 sheet area and in the north east corner of the Strathmay 1:100 000 sheet area it crops out north of Astrea Holding's homestead and Alec Creek on the Strathmay 1:100 000 sheet area. A small outcrop is also found on the southern part of the Strathburn 1:100 000 sheet area.

Type Area. Good exposures of slate and phyllite may be found in the type locality of Newirie Creek which is located north of Astrea homestead at GR7568-182747.

Lithology. The dominant rock type is a grey to purple, fine to very fine-grained slate or sandy slate. Bedding is thin to very thin with intercalated fine to medium-grained, green metasandstone. Spectacular symmetrical rippled bedding surfaces have been recorded in the unit. However, parallel laminae and ripple cross laminae are more common. In the southeast of the outcrop, the Newirie Formation is dominated by quartzite that forms higher ground than the slate. This quartzite passes laterally along strike (through an antiform/synform pair) into the slate typical of the unit. The lithostratigraphy is clearly not "layer-cake" and a lateral facies variation probably exists.

The southwestern parts of the Newirie Formation show very low grades of metamorphism occur and rock types include indurated mudstone, siltstone and sandstone. The sandstones are generally medium-bedded with an average thickness of 20 cm, and are interbedded with siltstones on a millimetre scale, ranging down to laminae.

Spotted tourmaline-bearing biotite-muscovite-quartz schist (Site ZDT0276) is well developed about 9 km ESE of Strathburn homestead. The presence of tourmaline and of discordant ridges of massive quartz suggests this location may be underlain by granite. The rock type is predominantly a silvery grey to maroon, fine to medium-grained phyllite that grades into schist. The phyllites are muscovite-biotite-quartz rocks, with biotite porphyroblasts 1-2 mm long. The schists are predominantly garnet-andalusite (now sericite)-cordierite(?)-muscovite-biotite rocks (e.g. Site QFG0758). These are common in a series of low NNW-trending ridges. The andalusite occurs as prismatic porphyroblasts up to 5 cm long, while the rest of the rock comprises fine-grained muscovite and quartz with scattered biotite. These andalusite-bearing rocks are rather anomalous in terms of the general low grade and greenschist facies metamorphism of the Lukin Domain.

Thickness. It is a recessive unit probably at least 3000 m thick.

Boundary Relationships. The Newirie Formation appears to conformably overlie and partly interfinger with the Carysfort Quartzite (Fig. 6). It passes conformably into the Gorge Quartzite.

Structure. The unit is generally weakly crenulated to well foliated with a slaty cleavage (S1) which refracts through laminae indicating a variation in competence. In some areas the foliation is a crenulation cleavage with acute intersections between S1 and S2a creating an S-C-like fabric. The strong foliation also is available for reactivation and small "thrusts" are locally developed along S1 surfaces. F4 folds are well developed in the Newirie Formation, typically along Newirie Creek. Lineations tend to be the product of intersection rather than a mineral alignment or stretching lineation.

Geophysical Properties. The slate generally has low magnetic susceptibility (10 SI units), although locally up to 60 SI units have been recorded. The low susceptibility is clearly shown on the magnetic image as a broad flat zone with little texture (Fig. 2). The total radiometric count is also low, with pale to whitish colours in the composite image (Fig. 3), although the potassium channel (and thorium in the west) is higher than in many of the other units of the Lukin Structural Domain.

Pkb (phyllite)

Distribution. Pkb is only found in Subdomain 1 of the Kalkah Structural Domain (Fig. 7). It is faulted to the west against the Lukin Structural Domain (Astrea Formation) by the Lindalong Shear Zone and faulted to the east against the Astrea Formation (Pko) by the Gorge Fault.

Lithology. It is typically a brown to mid-grey, fine-grained phyllite. The mineralogy is predominantly quartz and muscovite with local spots of cordierite(?) and porphyroblasts of garnet up to 1 mm in diameter. The phyllite grades into a garnet-muscovite schist, with muscovite (after andalusite)-quartz schist also present. Garnet is locally intergrown with quartz (Site 90834009A), and is generally found in the P-domain in thin section. The alternation between P (phyllosilicate) and Q (quartz)-domains probably reflects original bedding; in one example bedding is visible in hand specimen (Site 90834009A).

The phyllite is thin-bedded with intercalated fine-grained to recrystallized, cream to pink quartzite. The quartzite beds do not generally develop a foliation. Most interbedded quartzites are thin-bedded; some are thick and massive.

Thickness. Pkb is internally thickened by a macroscopic F2 fold giving a maximum thickness of approximately 2500 m. At least 500 m of section has been removed by the Lindalong Shear Zone and/or the Gorge Fault.

Boundary Relationships. Pkb is confined to a triangular shaped zone that is defined by the Lindalong Shear Zone to the west and the Gorge Fault to the east. These faulted contacts juxtapose Pkb against the Astrea Formation and the higher grade Astrea Formation (Pko) west and east respectively. The unit is intruded by the Lindalong Granite (Mackenzie & Knutson, 1992) to the south.

Structure. Pkb is generally well foliated with a composite S1/S2a foliation that is locally overprinted by a N-striking S3 crenulation. Garnet and andalusite porphyroblasts are clearly overprinted by the S3 foliation.

Geophysical Properties. The magnetic susceptibility is high on the aeromagnetic image (Fig. 2) with outcrop readings ranging from 15 SI units. The radiometric total counts are commonly moderate (7 cps), with blue and green colours in the composite radiometrics image (Fig. 3).

Pka (schist)

Distribution. Pka is a poorly exposed, fault-bounded unit that forms north eastern margin of Subdomain 1 (Fig. 7). The unit extends from Curlew Creek in the south to approximately 4 km SSE of Eighteen Mile Lagoon and has an eastern (upper?) contact marked by the southern extension of the Lukin River Shear Zone.

Lithology. The unit is predominantly a brown to grey "flaggy", fine-grained biotite-muscovite-quartz schist. The schistosity is a moderately well developed composite of S1 and S2a. The unit is distinguished by being more biotite-rich than the Astrea Formation (Pko) and the Newirie Formation (Pkb). It is however, a correlative or a lateral facies variant of Pkb and the Newirie Formation defined in the Lukin Domain. Pka contains no garnet, sillimanite or andalusite.

Thickness. It has an across strike thickness of 1500 m so at least 1500 m of the unit has been removed by the Lukin River Shear Zone.

Boundary Relationships. The unit is fault bounded with the Sugarbag Creek Quartzite (Pkk) to the west and the Strathburn Formation (Pki) to the east in subdomain 3. The unit is intruded by two small (km^2) bodies of the Barwon Granite (Mackenzie & Knutson, 1992).

Geophysical Properties. Pka has a blue (uranium) response on the radiometrics image (Fig. 3). The faint red colouration is the effect of the small, potassium-rich bodies of Kintore Granite (K1) within the unit.

Gorge Quartzite (new name) — Plg (quartzite), Pkp (quartzite), Pkl (quartzite), Pku (quartzite)

Plg (quartzite)

Derivation. The Gorge Quartzite is named after "The Gorge" which is a geomorphic feature of the Lukin River where it cuts the unit in the Kalkah 1:100 000 sheet area.

Distribution. The Gorge Quartzite extends from The Gorge on the Lukin River in the south to Middle Branch Creek in the Strathburn 1:100 000 sheet area in the north (Fig. 6). The unit can be traced for a further 6 km under the Mesozoic cover with the aid of aeromagnetic data.

Type Area. The type locality is located 9.5 km east of the road servicing Strathburn Homestead in the headwaters of the Edward River at GR7468-090909.

Lithology. The lithology is dominated by quartzite, which is cream to buff coloured and medium-grained, with a saccharoidal texture where not totally recrystallised. Muscovite is also present. Bedding tends to be 1-2 m thick with no visible internal structure. A foliation is generally absent in the purest quartzites.

Thickness. The unit is approximately 1300 m thick.

Boundary Relationships. The base of the Gorge Quartzite is conformable with the Newirie Formation and the unit passes conformably into the Strathburn Formation. In the north west corner of the Kalkah 1:100 000 sheet area, the top of the Gorge Quartzite is juxtaposed with the Strathmay Formation across the major NNW-oriented Gorge Fault (Fig.4). Elsewhere, the top of the Gorge Quartzite is conformable with the Strathburn Formation, which lies in a broad synform outlined by ridges of Gorge Quartzite (Fig. 6). These units are folded by F2 macroscopic folds that are complementary to the F2 folds defined by the greenstone to the south.

Structure. The unit is broadly folded about a tight syncline that is complementary to folds further south. The syncline is truncated to the east by the Gorge Fault – a linear NNW-trending feature with an unknown shear sense.

Topographic expression. The Gorge Quartzite forms a ridge 200 m above the surrounding country that trends in a NNW direction.

Geophysical Properties. The magnetic susceptibility is generally low in the hand specimens examined; however, the unit is well defined on imagery by a curvilinear series of highs (Fig. 2); the cause of these is not known. Total radiometric counts are low (Fig. 3); The counts from the "separates" for potassium and thorium are especially low, and deep blue colours are a feature of this unit in the separates.

Pkp (quartzite)

Distribution. Pkp crops out at the corners of the Strathburn, Ebagoola and Kalkah 1:100 000 sheet areas. The unit extends from just south of Eighteen Mile Lagoon on the Lukin River in a series of NNW-trending ridgesover 20 km to just south of the Holroyd River.

Spectacular exposures are found above the plunge pool of Pollappa Falls in the Ebagoola 1:100 000 sheet area and through the gorges dissected by the superimposed drainage of Fish Creek in the Kalkah 1:100 000 sheet area.

Lithology. Pkp consists of several layers of quartzite up to 30 m thick interlayered with graphitic schist of similar thickness. The quartzite ranges from white to pink, cream and shades of grey. It is composed almost entirely of quartz, with scattered muscovite crystals and a few biotite crystals locally. It is commonly medium-grained, and although the thick layers appear massive and recrystallized, centimetre-scale layering can be made out on weathered surfaces. Flaggy layers in the massive material may reflect close jointing, shearing or original depositional layering. Near the contacts of thick quartzite with interlayered graphitic schist, thin 10 to 15 cm layers of hematite-muscovite quartzite occur in the schist. Andalusite-graphite schist is also interleaved with the massive quartzite beds in a few places.

Cobbles and boulders of tourmaline-bearing pegmatite are common in small streams cutting the quartzite outcrop; the pegmatite consists largely of quartz and muscovite with scattered crystals of biotite and tourmaline. Small amphibolite dykes up to 2 m thick are also found within the unit.

Thickness. The likely repetition of quartzite layers within this complex structure makes an accurate estimate of thickness very difficult; it is approximately 500 m thick. This estimate is a minimum as the base is faulted against the Lukin Structural Domain by the Lindalong Shear Zone – it places the Gorge Quartzite over the Strathmay Formation.

Boundary Relationships. The western boundary or lowermost part of Pkp is faulted against the Strathmay Formation by the Lindalong Shear Zone. Pkp passes conformably into the Strathburn Formation (Pkpa) and is interbedded with pelite that is similar to the overlying unit. A splay of the Lukin River Shear Zone (part of a strike-slip duplex) truncates Pkp in the south and south east and juxtaposes it with schists of the Strathburn Formation (Pki), the Barwon Granite (Mackenzie & Knutson, 1992) and different levels of the Gorge Quartzite (Pkl).

Structure. The unit may be confined to an oblique-slip duplex (Blewett, 1992) comprising upright isoclinal antiforms separated by anastomosing faults which largely cut and replace the synforms. The massive quartzite beds in the unit rarely take up a foliation, while S2a is the principal foliation in the interbedded schist.

Topographic expression. The quartzite beds of Pkp form abrupt north-northwest-trending bevelled ridges extending over 20 km along strike and over a strike-width of 5 km. The ridges rise over 400 m above sea level and are separated by steep valleys occupied by the interlayered Strathburn Formation (Pkpa).

Geophysical Properties. The aeromagnetic response of Pkp is generally high in amplitude. The magnetic susceptibility of the quartzite itself is low (1-2 SI units), but one fresh outcrop of graphitic schist returned values between 15 and 115 SI units, possibly explaining the strong response on the imagery. Both quartzite and schist layers return low radiometric counts (less than 12); on the imagery the quartzite is traceable as dark bands and in places the interlayered schists register a weak potassium signature.

Pkl (quartzite)

Distribution. Pkl crops out in subdomain 3 and extends NNW for 25 km from the Lukin River almost to the Holroyd River (Fig. 7), and occurs again farther north as two large, fault-bounded, boudin-like masses about 1000 m across and 4-6 km long, within the schists of the Strathburn Formation (Pki) on its boundary with the gneisses of the Strathburn Formation (Pkt). Pkl also crops out NE of Glen Garland homestead and extends south for 22 km to the southern boundary of the Kalkah 1:100 000 sheet area. This belt of quartzite extends SSE into HANN RIVER.

Lithology. Pkl consists of quartzite interlayered with (sillimanite-) (garnet-) muscovite-quartz schist. The quartzite is dark grey to brown, medium to coarse-grained, massive, saccharoidal or equigranular; it generally contains a little muscovite and in places biotite and garnet. The quartzite tends to be finer grained in the south than in the north. The interlayered (sillimanite-) muscovite-quartz schist commonly contains knots of andalusite up to 6 cm long. In less deformed areas, the quartzite is even-grained with moderately well sorted grains.

South of the Holroyd River and to the east of Pollappa Creek , Pkl consists of one 20 m-thick layer of quartzite and many thinner layers interbedded with sillimanite?-muscovite-quartz schist, containing some graphite and/or hematite locally. Biotite is present in the quartzite near the small body of granite 7 km south of the Holroyd River.

Thick quartzite is locally underlain by muscovite-quartz schist which contains a little graphite and hematite and a few needles which may be sillimanite. The rock is a crushed fine-grained aggregate of quartz, sericite, graphite and hematite, with scattered larger undeformed muscovite crystals and large rounded sericite pseudomorphs. The thick quartzite layer is overlain by coarser sillimanite-muscovite-quartz schist and some sillimanite?-muscovite-biotite-quartz gneiss; metamorphic grade appears to increase "upwards" in the section. Thinner layers of quartzite are common both above and below the thick layer. In the northern fold several layers of quartzite ten or so metres thick are separated by thinner layers of muscovite-quartz schist.

Thickness. The thickness in subdomain 3 is difficult to accurately estimate, it is considered to be approximately 1000 m thick.

Boundary Relationships. All boundaries of Pkl with other metasedimentary units are faulted. However, Pkl and the Strathburn Formation (Pkt) contain thick layers of schist identical to the Pki variety of the Strathburn Formation, and the boundaries are to some extent gradational.

Structure. Small-scale, upright isoclinal folds and strong rodding plunge gently southward. The two boudin-like masses of Pkl north of the Holroyd River represent a large-scale F2 antiform with a wave-length of about 0.5 km, each defined by a quartzite layer about 20 m thick. The southern fold is a moderately open structure with limbs dipping between 30 and 45 degrees west and east respectively, and with an axis plunging gently north-northwestwards. The northern fold appears to be isoclinal, but a strong axial plane cleavage striking NNW complicates interpretation of the structure. Both limbs appear to dip eastwards at angles between 45^o and 85^o, and the fold probably plunges gently SSE. Both folds appear to be bounded to the east and west by strong north-northwest-trending faults. The unit does not show evidence of macroscopic folding in the southern outcrops of the Kalkah 1:100 000 sheet area, where it has faulted contacts with the Sugarbag Creek Quartzite (Pkk) of Subdomain 1, across the Lucy Swamp Shear Zone, and with the Strathburn Formation (Pki).

The foliation intensity in the quartzite ranges considerably, with textures from saccharoidal to schistose. The dominant foliation is the S2a schistosity, revealed as a crenulation cleavage where S1 surfaces are preserved. Lineations and rodding are also present; outcrops near the Lucy Swamp Shear Zone have intense rodding that plunges gently towards the east.

Geophysical Properties. On the aeromagnetic image Pkl gives a strong response similar to the Gorge Quartzite (Pkp); the radiometric response of both quartzites (commonly below 5 cps) is also very weak, producing dark bands or patches (Fig. 3).

Pku

Distribution. Pku crops out in the south western corner of the Holroyd Group on the Kalkah 1:100 000 sheet area and extends from the Edward River Mission Road in the north to the south east corner of the sheet area. The unit is exposed over 22 km in a NNW-trending belt that is 2 km wide.

Lithology. It consists of interbedded schist and quartzite, which ranges from red and brown to silver and dark grey to black and is generally medium-grained to coarse-grained. Assemblages are :

- garnet-mica-hematite schist
- andalusite-staurolite-garnet-graphite-mica schist, and
- staurolite-chloritoid-garnet-mica schist (Site 91834218).

Interbedded with the schist are thin horizons of muscovite-bitotite quartzite.

Trail et al. (1968) describe as Kalkah-type schist a spectacular very coarse-grained schist on the southeastern slopes of Manganese Hill – a garnet-staurolite-muscovite-quartz schist, with idioblastic garnet up to 10 mm across and xenoblastic staurolite in laths up to 8 mm long. In 91834218, the staurolite porphyroblasts are up to 2 cm across. Much of the staurolite is retrogressed to randomly oriented, prismatic (1 mm) chloritoid with sericite and coarse recrystalized quartz. The relics of staurolite preserve S1 with intergrown blebs of fine quartz. The zones of retrogression are perpendicular to the schistosity and are 1-2 mm wide.

Thickness. Pku has an estimated thickness of 1300 m, which is consistent with the thickness of the Gorge Quartzite in the Lukin Domain.

Boundary Relationships. Pku is conformably overlain by the more recessive Strathburn Formation (Pkj). The unit is faulted to the west against the schists of subdomain 3 and is intruded by granitoids of the Cape York Peninsula Batholith to the east.

Structure. The intensity of the schistosity varies with quartz content, which is a function of original lithology. The foliation is a composite of S1 and S2a with a trapezoidal intersection. The Lucy structural block (Blewett, 1992) is unusual in that it is macroscopically folded about E-W trending F4 folds, so E-W to NE-SW S4 crenulation cleavages are present. An intersection lineation between S2a and S4 plunges moderately SW, while a mineral lineation developed by the alignment of muscovite and biotite is also common.

Topographic expression. It is a resistant unit forming ridges and hills up to 311 m above sea level at Manganese Hill 3.5 km north east of Wolfram Swamp. Linear ridges extend south-southeast from the Coleman River to the edge of the Great Divide escarpment at Sugarloaf Creek (Fig. 7).

Geophysical Properties. The radiometric response is moderate with outcrop readings of around 7 cps and a green/blue (thorium/uranium) colouration on the composite image (Fig. 3). Studying the radiometric "separates" reveals Subdomain 4 as a whole has a lower uranium count and higher thorium count than the Subdomain 3 rocks to the west. The magnetic susceptibility is low to moderate with readings less than 10 SI units being typical. This is not reflected in the aeromagnetic image which is high for the Kalkah Structural Domain generally (Fig. 2b).

Strathburn Formation (new name) — Plb (slate), Pkpa (schist), Pkg (slate), Pki (schist), Pkt (gneiss), Pkj (schist/gneiss)

Plb (slate)

Derivation. The Strathburn Formation is named from the pastoral holding of Strathburn (Ebagoola 1:250 000 Cadastral map).

Distribution. The unit crops out principally in the core of the synform outlined by the Gorge Quartzite (Fig. 6) in the head-waters of the Edward River, from where the unit extends for 18 km north-northwestwards to Boggy Creek, about 15 km east-northeast of Strathburn Homestead (Fig. 6). There is no road access to the Strathburn Formation.

Type Area. The type locality is in the axial regions of a macroscopic F2 syncline at the headwaters of the Edward River at GR7468-110897.

Lithology. The lithology ranges from very low-grade, scarcely foliated siltstone and mudstone through slate to phyllite. Typically beds of mudstone up to 5 cm thick alternate with beds of siltstone or sandstone up to 50 cm thick; cross-bedding was seen in one siltstone (Site QFG861); colour ranges from cream and grey to green, red, purple and blue. The slate and muscovite-quartz phyllite of the Strathburn Formation are generally very fine-grained and have few spots, unlike the adjacent biotite and garnet-bearing rocks of the Strathmay Formation, on the eastern side of the Gorge Fault.

Thickness. The top of the unit is not exposed, and the entire unit appears, on the aeromagnetic image, to be cut out northwards against the Gorge Fault and the Strathmay Formation. The maximum exposed thickness of the unit is likely to be about 1000 m.

Boundary Relationships. The Strathburn Formation conformably overlies the Gorge Quartzite, the top is not exposed. The unit is faulted to the east against the Strathmay Formation by the NNW-trending Gorge Fault.

Structure. Foliation in the unit is commonly weak; in the large synform outlined by the Gorge Quartzite foliation and bedding clearly follow the large F2 fold; minor F2 kink folds or crenulation cleavage were recorded in a few exposures.

Topographic expression. The unit is recessive and exposures are few in the northern part, where it is partly covered by Mesozoic sediments and later ?Tertiary gravel.

Geophysical Properties. The unit has a low magnetic susceptibility; its radiometric response is moderately high, though perhaps not so high as other pelitic units of the Lukin Domain. The potassium count is high and the unit may correlate with the Strathmay Formation found across the Gorge Fault to the east.

Pkpa (schist)

Distribution. Pkpa crops out in subdomain 2; it extends from 11 km north of the Holroyd River on the Strathburn 1:100 000 sheet area to near Fish Creek some 30 km in the south on the Kalkah 1:100 000 sheet area. The bulk of the unit crops out in the north, where it is stratigraphically above the Gorge Quartzite (Pkp). Small lenses or interbedded members of schist that are indistinguishable from the larger body are found in the valleys between the main quartzite ridges formed by the Gorge Quartzite (Pkp).

Lithology. The schist is commonly intensely weathered to a structureless aggregate of red or purple clay; the resemblance of this to a burned or oxidised coal seam suggests that oxidation of the graphite destroys the texture of the schist.

In the rare fresh exposures the schist (ZDT 247, 250, 285) consists of small well sutured quartz grains with smaller interstitial flakes and in places stringers of graphite, muscovite and hematite; one sample contains scattered grains of greenish zircon. Porphyroblasts of muscovite with no preferred orientation may be pseudomorphs of andalusite; altered andalusite? partly replaced by quartz, muscovite and biotite occurs in one thin section and another contains small needles which may be sillimanite. One thin section (ZDT 285A) is cut by thin veins of a spherular mineral which may be siderite or a form of chlorite.

In the extension of Pkpa north of the Holroyd River, blue-grey medium-grained spotted phyllite and fine-grained knotted schist look more like the adjacent Strathburn Formation (Pkg) than the typical coarse, richly graphitic Pkpa variety. However, they are mapped as Pkpa because of the clear continuity across the Holroyd River seen on the aeromagnetic image. The fine schist and phyllite are interlayered with quartzite bands up to 1m thick, some of which are black and carry muscovite porphyroblasts 1-2 cm across. Layers of muscovite-quartz pegmatite in the phyllite resemble those in Pkpa south of the Holroyd River.

Thickness. The thickness cannot be accurately estimated as it is isoclinally folded as well as faulted. Individual layers of schist interbedded with the quartzite appear to range from 5 to 100 m in thickness. Between the top of the Gorge Quartzite (Pkp) and the fault that juxtaposes Subdomain 2 and 3 at least 500 m of Pkpa is exposed. This fault has cut out at least 500 m of the Strathburn Formation in this region and "doubles-up" the unit thickness by placing the Strathburn Formation (Pkg) on Pkpa of the same "parent" formation.

Boundary Relationships. The boundary between Pkpa and the Strathburn Formation (Pkg) to the east lies along a major NNW-trending fault. The base of Pkpa passes conformably from the Gorge Quartzite (Pkp) and may even partly interfinger with the latter.

Structure. The unit displays a well developed S2a schistosity.

Topographic expression. It is a recessive unit and is generally poorly exposed.

Geophysical Properties. The schists are moderately magnetic with susceptibilty ranging from 20 to 36 SI units. This is in contrast to the non-magnetic quartzites that they are commonly associated with. Total radiometric counts are generally low.

Pkg (slate)

Distribution. Pkg is located in subdomain 3 and crops out from 7 km south of the Holroyd River extending some 40 km NNW to just south of Pretender Creek on the Strathburn 1:100 000 sheet area. It also crops out in the south east corner of the Kalkah 1:100 000 sheet area.

Lithology. The lithology is essentially a blue-grey (graphite-)sericite-quartz slate. The slate commonly contains small andalusite spots or pseudomorphs; in a few places it contains biotite and it may locally be represented by phyllite or fine-grained schist. Its boundary with the Strathburn Formation (Pki) is gradational. Along its eastern, gradational boundary with the Strathburn Formation (Pki), the grade of metamorphism is noticeably higher and the unit is represented generally by a spotted phyllite or even a fine-grained schist; biotite partly replaces the sericite in two samples (ZDT 337 & 357) from here. On the western boundary of the slate with the Strathburn Formation (Pkpa), layers of quartzite up to 10 m thick are interlayered with blue-grey spotted phyllite and knotted schist with many andalusite porphyroblasts. The quartzite layers also contain large, 2-3 cm muscovite porphyroblasts in places. Muscovite-quartz pegmatite layers up to 1.5 m thick are also present in the spotted phyllite.

In a few exposures it contains scattered layers of fine to medium-grained muscovite-bearing quartz metasandstone from 1-8 cm thick; these are not evident in the higher grade phyllitic or schistose rocks. Concordant isolated layers of massive or very coarse grained white quartz or quartzite up to several metres thick occur in Pkg in close association with andalusite spots and with schistose or phyllitic texture, most commonly near the contacts of Pkg with the Pki and the Pkpa varieties of the Strathburn Formation.

Thin quartz veins with coarse cassiterite occur near the contact of the slate with the schist facies of the Strathburn Formation (Pki), about 2.5 km south of the Yarraden/Aurukun road (Ewers and Bain, 1992). This contact is gradational; spotted phyllite increases steadily in grain-size towards the schist over a distance of only 50 to 100 m, in low hills north of the Yarraden/Aurukun road, and thick bodies of white quartz, parallel to foliation, are common.

Thickness. The across strike thickness is at least 2 km.

Boundary Relationships. It is faulted to the west and east.

Structure. The unit is generally foliated by a single (S2a) cleavage, which dips steeply NNE or WSW; the few fold axes and lineations observed plunge gently either NNW or SSE.

Geophysical Properties. On the aeromagnetic data (Fig. 2) the Pkg unit has a strong response, with TMI at around the same high level as the Strathburn Formation (Pki) and Gorge Quartzite (Pkp). However, typical magnetic susceptibility readings range from 5 to 10 SI units. On radiometric imagery Pkg has a notably low response (Fig. 3), similar to that of the Gorge Quartzite (Pkp) and considerably lower than both the Strathburn Formation (Pki) and Strathmay Formation. The scintillometer recorded only a low response of around 10 cps.

Pki (schist)

Distribution. Crops out only in subdomain 3 as a NNW-trending belt about 5 km wide, over a strike length of 60 km. It extends from the headwaters of Pretender Creek in the Strathburn 1:100 000 sheet area southwards beyond the Coleman River in the Kalkah 1:100 000 sheet area (Fig.7).

Lithology. It consists of schist, gneiss and quartzite. Exposures mapped as schist in this unit are commonly intensely weathered, and some may be gneiss; the proportion of gneiss in the unit also increases eastward, and overall may be as much as half. However, the unit is generally recessive and ridges are formed by quartzite layers rather than gneiss, so it has been assumed that the most abundant rock type is schist. The unit forms a large proportion of what Trail et al. (1968) called the *Pollappa-type Schist.*

Pki is typically a medium to coarse-grained deeply weathered, grey to red schist composed essentially of muscovite and quartz, commonly accompanied by biotite and generally also containing a small proportion of graphite, sillimanite or garnet; although sillimanite was frequently recorded in the field, in thin section it is not common and is generally only represented by thin wisps in association with muscovite. Sillimanite appears to be more common in the south, although fibrolite bunches up to 2 cm long were recorded from schists east of Pollappa Falls (Site 91834163) with a good example 3 km SE of Cockers Knob (Site 91834205).

Coarsely knotted andalusite schist with chiastolite crosses is common. Andalusite generally occurs as porphyroblasts up to 2 cm across that are commonly replaced by sericite, with chiastolite zoning preserved (Site 91834068). Some andalusite has intergrowths of tabular sillimanite; this is well demonstrated in sample 91834205 which also contains abundant fibrolitic sillimanite porphyroblasts. Some andalusite prisms appear to have had a pressure shadow effect on S2a, implying pre to syn-D2 development of andalusite. The largest andalusite prisms are 7 cm in length. Cordierite is also common as elliptical porphyroblasts up to 3 mm in diameter, but it is largely retrogressed to muscovite/sericite.

Garnet is common with porphyroblasts 1-2 mm in diameter. There is a large range of porphyroblasts, with rapid changes from garnet-rich to andalusite-rich horizons, which may reflect protolith mineralogy. There is also a large range in grainsize at any single outcrop, and the schist can be described as fine, medium and coarse-grained.

A small ridge adjacent to the road 3 km north of Pollappa Falls comprises a brown, fine-grained, tourmaline-garnet-muscovite-bioite-hematite schist (Site 90834080). The rock contains abundant porphyroblasts up to 3 mm in diameter. They comprise an intergrowth of garnet, quartz, hematite and lesser tourmaline and preserve curved inclusion trails. The trails "snow-ball" up to 90° in terms of an internal change in orientation. They may reflect a relic of S1 as the porphyroblasts overgrew the early oblique foliation (cf. Bell & Hayward, 1991 and references therein), or a rotation of the garnet and foliation under a shear couple (cf. Hanmer & Passchier, 1991). Small sub-millimetre prisms of pleochroic tourmaline are common and amount to almost 10% of the rock.

At a locality 3 km north of Cockers Knob, cordierite porphyroblasts 4-5 mm across are almost entirely overgrown by retrogressive decussate muscovite. The rock is graphite-rich and many of the ghost porphyroblasts show relict surfaces (S1) defined by aligned blebs of graphite that are now totally overgrown by muscovite. Nearby, porphyroblasts of very coarse, decussate muscovite with inclusion trails of graphite are partly altered to sericite (Site 91834187).

Five and a half kilometres east of Pollappa Falls (Site 91834163) a purple, medium-grained schist contains pale sericite pseudomorphs after sillimanite(?) that are now partly overgrown by 1 mm long needle-like laths of tremolite-actinolite.

Kyanite was found at only one site (Site 91834068A) in the Holroyd Group, on the Lukin River north of Cockers Knob (Kalkah 1:100 000 sheet area). The kyanite porphyroblasts are waxy-blue blades up to 3 cm long, that are randomly oriented within the S2a foliation and are largely retrogressed to muscovite/sericite. The presence of kyanite indicates local regions of higher than the average pressure, in contrast to the andalusite/sillimanite transition is generally seen in EBAGOOLA.

Layers of muscovite(-garnet) quartzite up to 10 m thick (adjacent to the contact with the Gorge Quartzite (Pkl)) are common in the schist. In the southern outcrops near the Coleman River, thin to medium bedded schist and quartzite are interlayered. Most quartzite is grey, cream or pink, foliated to recrystallized muscovite-bearing rock.

Some grey garnet-mica schist is interleaved with fine-grained, grey to black graphite-mica schist and andalusite-garnet-graphite-mica schist. The foliation in the graphite schist is commonly phacoidal, and may be overprinted by a spaced S3 crenulation. The graphite-dominated schists tend to be recessive and where exposed are commonly less than 10 m thick. Due to the paucity of outcrop and the 1:50 000 scale of compilation, it was not possible to isolate and map out these small graphitic members and they have been mapped together with the more commonly exposed micaeous schist described above. The distribution of graphite-rich schist can be found in the EBAGOOLA REGMAP database under the "MIN" datatype (see von Gnielinski & Blewett, 1992).

Only one rock was found to contain very little quartz; it is described as a tourmaline-graphite muscovite schist (Site ZDT0302). Actinolite was also observed (Site 91834470) in association with garnet and mica.

Eastward towards the Strathburn Formation (Pkt) muscovite-quartz schist is replaced as the dominant rock type by biotite-quartz-feldspar gneiss; the proportion of gneiss in Pki rises, and its contact with the gneiss is undoubtedly gradational and indistinct. Where the Yarraden/ Aurukun road cuts the prominent ridge of schist north of the Holroyd River, a garnet-biotite-plagioclase-quartz-muscovite gneiss (Site ZDT0326) is interlayered with sillimanite(?)-muscovite-quartz schist.

Boundary Relationships. The contact with the Gorge Quartzite (Pkp) coincides with a major fault – the boundary between subdomain 2 and subdomain 3. The Strathburn Formation (Pkpa) however, contains the same rock types that characterise Pki, and layers of quartzite several metres thick occur near its western boundary, implying that a stratigraphic gradation may exist between the two units.

The boundary between Pki and the Strathburn Formation (Pkg) is queried on the map south of the Holroyd River, where it is completely covered by regolith. North of the Holroyd River, the boundary is marked by a decrease in grain size over a short distance across strike – typically 50 to 100 m – in which medium-grained andalusite-bearing muscovite-quartz schist of Pki grades into spotted phyllite which in turn grades westwards into a sericite-quartz slate.

Structure. Structure is dominated by the NNW-trending D2 fabric. In one exposure S2a appears as a strong, curved crenulation cleavage superimposed on a north-northeast-trending cleavage with strong rodding and quartz boudins plunging moderately steeply northeastwards; in this outcrop chiastolite porphyroblasts grow across the crenulated muscovite and appear to post-date the deformation. However, large bodies of granitic rock, up to 1 km across and 5 km along strike, within Pki, are strongly oriented and commonly foliated, and are bounded by faults and by mylonite zones several metres thick, parallel to S2a.

Quartz reefs and locally quartz boudins as well as pegmatite pods are present in the schist. The quartz boudins crop out in the Coleman River and are parallel to the S2a schistosity and overprinted by an S3 crenulation. Ptygmatic folding (F2) of quartz veins reveals a significant degree of shortening at least locally during the D2 event.

Mineral lineations are variable. Muscovite porphyroblasts in the matrix of the schist, like the above chiastolite, commonly have no preferred orientation. However, some locations show a mineral lineation defined by sillimanite, now largely muscovite, that plunges moderately to the east.

The presence of brecciated sillimanite-muscovite-quartz schist in places, associated with a 10 m-thick quartz reef in one, reveals that the NNW-trending major faults post-date the M2 thermal climax.

Geophysical Properties. The quartzites have low magnetic susceptibility and low total radiometric counts; despite the unit having a moderately strong signature on the aeromagnetic imagery, magnetic susceptibility of outcrops ranges between 5 and 15 SI units. On the airborne-radiometric image the schist also has a moderate, patchy response indicating the presence of potassium and perhaps some uranium; this contrasts with the low radiometric response from the adjacent Gorge Quartzite (Pkp and Pkl). Outcrop response of the schist to the scintillometer ranges from 8 to 15 cps.

Pkt (gneiss)

Distribution. Crops out in subdomain 3 as a belt between 0.5 and 7 km wide along the western margin of the Cape York Peninsula Batholith, from the headwaters of Pretender Creek in the

Strathburn 1:100 000 sheet area SSE for over 60 km to the Lukin River in the Kalkah 1:100 000 sheet area (Fig.7). Trail et al. (1968) named the variety *Pretender-type schist* but described it as having incipient gneissic texture, or as gneissic rocks with a schistose matrix.

Lithology. It is a medium to coarse-grained cream or grey to brown muscovite-biotite-quartz gneiss, interlayered with schist. It is commonly deeply weathered, the interlayered schist in particular, and exposure is generally poor and largely confined to deeply incised creek beds. Ridges within the gneiss outcrop are commonly formed by quartzite or quartz-rich layers, generally less than 10 m thick; in a few places near the granite contact gneiss forms small tors on ridges.

The gneiss is typically composed of folia of muscovite and biotite alternating with schlieren of quartz commonly containing some feldspar; knots, rods and augen of quartz (and feldspar) are common. Porphyroblasts of muscovite occur in places; feathery or fibrous material, even quite large crystals, resembling sillimanite are seen in thin section to consist of fine muscovite. Both potash feldspar and some plagioclase occur; the potash feldspars have sericitized centres.

In a few exposures knots of andalusite are present in the schist, but these are rare. A small amount of graphite is commonly present in interlayered schist and the gneiss, providing a link in composition with the Pki and Pkpa varieties of the Strathburn Formation. Garnet also occurs, and garnet aplite is interlayered with gneiss near its contact with the Cape York Peninsula Batholith. Lenses of pegmatite common in the gneiss, particularly near granite, are generally coarse massive aggregates of muscovite and quartz.

The gneiss grades into or has sharp contact with the other major rock types in the unit, which are (biotite-) muscovite-quartz schist and quartzite; for example in the ridges at the head of Bushy Creek 4 km north of the Holroyd River, 10 m of quartzite separates granitic biotite-quartz-feldspar gneiss from andalusite-bearing graphite-muscovite-biotite-quartz schist. The interlayered schist generally resembles the Pki variety of the Strathburn Formation.

The interbedding of gneiss, schist and quartzite demonstrate a sedimentary protolith for at least some of the gneiss. Bedding is visible within the gneiss as compositional layering; in one example in Dingo Creek (Site 91834179c) a 1 cm thick quartzite band within more pelitic gneiss has garnet overgrowth of the bedding surface.

Thickness. It is not possible to provide an estimate of the thickness in subdomain 3. The across strike thickness ranges from 0.5-7 km.

Boundary Relationships. The contact of the gneiss with the granitic rocks of the Cape York Peninsula Batholith to the east is sharp and well defined. Pkt has a faulted western margin with the Strathburn Formation (Pki), although it should be noted that schists are gradational into gneiss and Pkt is only a higher metamorphic grade equivalent of Pki.

Structure. Minor folds are common; they plunge gently SSE. Several other tight minor folds plunge steeply eastwards, suggesting that the gneiss or its protolith was deformed before the D2 deformation and the metamorphic climax. The dominant (S2a) foliation at the northern boundary of Ebagoola in both Pkt and adjacent Strathburn Formation (Pki) strikes NNE instead of NNW, and quartz reefs and shear zones in the metamorphics trend likewise.

Geophysical Properties. The magnetic susceptibility tends to be high and this is reflected in the aeromagnetic image (Fig. 2). Outcrop readings of magnetic susceptibility range up to 90 SI units, but values around 20 SI units are more common. The radiometric total counts are moderate, as in many granites of the Cape York Peninsula Batholith, with readings of 7-10 cps. This is reflected in the imagery, where high potassium and thorium values are recorded, especially between the Holroyd and Lukin Rivers (Fig. 3).

Pkj (schist/gneiss)

Distribution. It occurs in subdomain 4 in the southeastern limit of the Holroyd Group. Small pods of Pkj (generally less than 100-200 m across) are scattered through the contact zone with the batholith in southern EBAGOOLA.

Lithology. The unit is predominantly a grey to red, medium to coarse-grained sillimanite-muscovite-biotite schist. Andalusite-garnet-muscovite-biotite schist, and minor muscovite-biotite schistose quartzite are also present; minor amphibolite dykes up to 2 m thick cut the schist in places.

Small bodies of grey, medium to coarse-grained, garnet-biotite-muscovite-feldspar gneiss with gneissic layering 2-3 cm thick occur in the schist. Pods and xenoliths of this gneiss are common and well exposed on water-washed pavements just south of the Edward River Road crossing of the Coleman River.

The relative abundance of sillimanite and the transition from schist to gneiss within Pkj distinguishes it from the underlying Gorge Quartzite (Pku) which has little or no sillimanite, no gneiss and tends to be more psammitic.

Thickness. The top is not exposed so a minimum thickness of 1500 m is estimated.

Boundary Relationships. Pkj lies in the core of a macroscopic F2 synform and has a conformable lower contact with the more psammitic Gorge Quartzite (Pku). The top is not exposed as the unit is intruded by the Cape York Peninsula Batholith.

Structure. The schistosity is an S2a foliation which preserves an S1 surface within the Q domains as an acute intersecting foliation. Mineral alignment of mica and acicular minerals (sillimanite) are fairly common, most plunge shallowly southeastwards.

Geophysical Properties. The radiometric total counts are moderate to high, with readings around 8-10 cps. The magnetic susceptibility is commonly above 10 SI units.

Strathmay Formation (new name) — Plm (schist)

Derivation. The Strathmay Formation is named after the Strathmay 1:100 000 sheet in which part of the unit is located.

Distribution. It crops out in the corners of the Strathmay, Strathburn and Kalkah 1:100 000 sheet areas. It extends from near The Gorge on the Lukin River northwards for 54 km to the headwaters of Goanna Creek (some 12 km north of the Holroyd River).

Type Area. The type area is located in the tributaries of the Fish Creek which flows south into the Lukin River near Eighteen Mile Lagoon. The type locality is at GR7568-167889.

Lithology. The texture ranges from slate to schist. The slate and phyllite are commonly grey (some are black and carbonaceous), fine-grained, and have a finely spaced foliation defined by muscovite growth. The schist is generally found in the lower 2/3 of the unit, with slate and carbonaceous slate more common toward the top.

The lower parts of the unit are dominated by brown to purple, fine-grained, garnet-biotite - muscovite schist. The garnet porphyroblasts are generally less than 1 mm in diameter. One sample of schist (Site 91834129) has hematite, quartz and sericite aggregates after pyrite. The schists are interbedded with grey to purple, fine-grained quartzites, many preserving parallel and ripple cross laminae as well as graded bedding. The quartzites are medium to thin-bedded and show Tb to Te Bouma sequences.

Many phyllites are biotite-bearing with porphyroblasts generally less than 1 mm in diameter. The biotite porphyroblasts are cylindrical aggregates, uncharacteristically well formed without ragged edges.

Thickness. The boundaries are faulted, and the unit has at least 3 "internal" shear zones with fault slices up to 2 km across.

Boundary Relationships. The Strathmay Formation is faulted against the Gorge Quartzite to the south and against the Strathburn Formation to the north by the NNW-trending Gorge Fault as it transects a north plunging syncline. To the east, the unit is faulted against the Kalkah Structural Domain by the Lindalong Shear Zone.

Structure. The foliation is generally an S1 slaty cleavage or schistosity, with or without an S2a crenulation overprint. In the schists, the dominant foliation is a composite of S1 and S2a as there is an acute intersection between the two foliations. A "crinkle" intersection lineation is locally developed between S1 and S2a. There are no recorded stretching lineations on the S1 surface.

Geophysical Properties. The unit is high in potassium and thorium although total counts of hand specimens are not unusually high (Fig. 3). The unit is not well defined on the magnetic image (Fig. 2), despite relatively high susceptibility readings (average of 18 SI units with readings up to 36 SI units).

COEN METAMORPHIC GROUP (redefined)

Derivation. The name is taken from the township of Coen (GR7570-375572) which is located in COEN. The "Coen Metamorphics" were defined by Willmott et al. (1973) to include "all the coarse schist and gneiss to the east of the Holroyd Metamorphics, most of which form inliers within the Cape York Peninsula Batholith". They indicated the type area as being the broad belt which extends 20 km south of Coen (as described below). The name Coen Metamorphic Group is here restricted to their type area, and the metamorphics further east are included in a new group – the Newberry Metamorphic Group.

Distribution. The Coen Metamorphic Group is found in the main N-S trending zone of metamorphic rocks in EBAGOOLA, and is partly defined by the NNW-trending Coen Shear Zone to the east and the Ebagoola Shear Zone to the west (Figs. 4 & 8). The Coen Metamorphic Group crops out as a central pendant in the Cape York Peninsula Batholith. The Coen Metamorphic Group in EBAGOOLA is a 100 km long NNW-trending belt of metamorphics, 22 km across in the north and tapering to less than 2 km in the south (Fig. 8).

Lithology. The group comprises predominantly mid to upper-amphibolite-facies schist and gneiss with lesser quartzite, is highly sheared and contains the important Hamilton Goldfield in EBAGOOLA and Coen Goldfield in COEN. The Coen Metamorphic Group contains a much greater proportion pelitic rocks than the Holroyd Group where at least 35% of the stratigraphy consists of quartzite-dominated units.

The Coen Metamorphic Group contains a higher proportion of thin granite screens than the Holroyd Group; all of the granitic rocks can be correlated to those found in the CYPB (Mackenzie & Knutson, 1992). Many of the contacts within the Coen Metamorphic Group are sheared suggesting structural juxtaposition was important.

The group is deeply weathered and considerably less well exposed than the Holroyd Group.

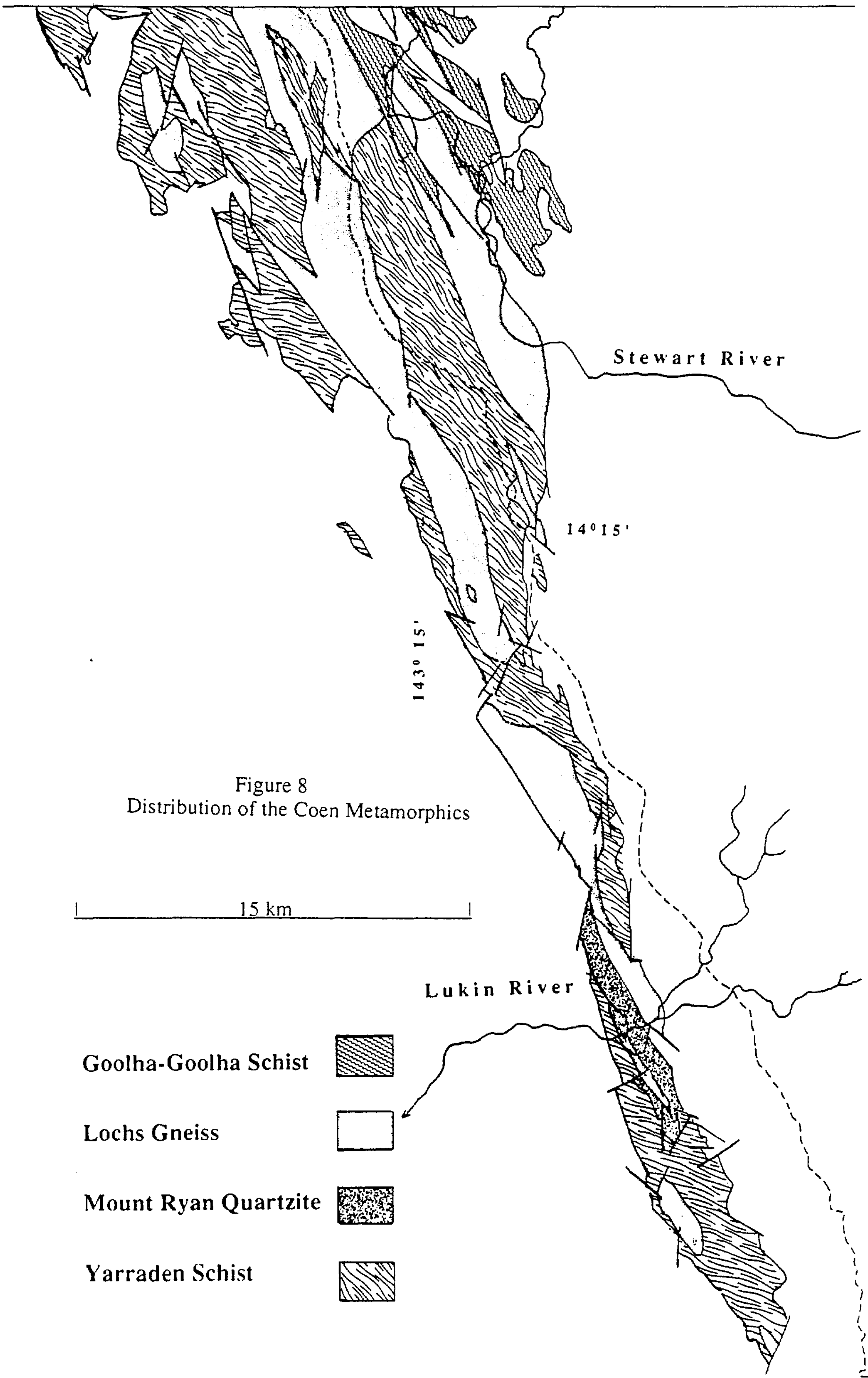


Figure 8
Distribution of the Coen Metamorphics

Boundary Relationships. Four units are defined although the boundary relationships are uncertain. The Lochs Gneiss is gradational into the two schist units and the Mount Ryan Quartzite was the only quartzite large enough to be distinguished at the 1:250 000 scale of mapping.

Structure. No macroscale folds have been identified. The group is highly deformed by numerous N to NNW-trending shear zones. Few shear zones are exposed, but they are thought to be D2b in age (Blewett, 1992).

Geophysical Properties. The airborne radiometrics and magnetics were not easy to interpret in the Coen Metamorphic Group compared to the Holroyd Group. The degree of weathering in the Coen Metamorphic Group is greater, which may partly explain the difficulties found with the radiometrics.

TABLE 4. A SIMPLIFIED STRATIGRAPHY OF THE COEN METAMORPHIC GROUP

Unit	Pc	Rock type
Goolha-Goolha Schist	Pcg	Sillimanite-muscovite-quartz schist and muscovite quartzite.
Lochs Gneiss	Pcl	Sillimanite-garnet-mica-feldspar gneiss, amphibolite and feldspar-mica gneiss
Yarraden Schist	Pcy	Sillimanite-biotite-muscovite schist and quartzite
Mount Ryan Quartzite	Pcr	Quartzite, mica-sillimanite quartzite

Yarraden Schist (new name) — Pcy (schist)

Derivation. The Yarraden Schist is named after the pastoral holding of Yarraden (GR7569-485167) which is located in the Ebagoola 1:100 000 sheet area.

Distribution. It forms much of the western two-thirds of the Coen Metamorphic Group; it stretches from the central northern margin of EBAGOOLA in a series of NNW-oriented slivers to near Lapunya Mount in the Kalkah 1:100 000 sheet area.

Type Area. The type locality is located 1 km west of Yarraden homestead at GR7569-480170.

Lithology. The lithology is dominated by a fine to medium-grained, silvery grey to purple-brown weathered sillimanite-biotite-muscovite-feldspar-quartz schist. Sillimanite-muscovite-hematite schist, and sillimanite-garnet-muscovite-feldspar schist also occur. The unit can be differentiated from the Goolha-Goolha Schist by the greater variability in mineralogy and a significant content of biotite, garnet and feldspar. The Goolha-Goolha Schist tends to be coarser-grained and muscovite-dominated.

Chlorite replaces biotite, and quartz is generally strained and/or recrystallized. Less common constituents are garnet, plagioclase, potash feldspar and opaque minerals. Accessories include monazite, zircon, apatite and rutile; opaques and graphite are aligned parallel to the schistosity (Willmott et al., 1973).

Thickness. The contacts are either gradational or faulted, with fault slices up to 2 km in their across strike thickness. No younging directions have been located.

Boundary Relationships. The Yarraden Schist is faulted against the Goolha-Goolha Schist to the east by the Stewart River Fault, and is intruded by the Cape York Peninsula Batholith to the west and southeast. It is interleaved with gneiss that is indistinguishable from the Lochs Gneiss, but as the schists west of the Stewart River Fault differ from the Goolha-Goolha Schist, the name Yarraden Schist is applied west of the fault. The unit extends northwards into COEN and south into the Kalkah 1:100 000 sheet area.

Structure. The unit is generally deeply weathered, but still maintains a strong penetrative S2a schistosity with commonly one or two generations of crenulation cleavage. Locally the S2a schistosity dips at moderate to low angles; this may be a function of F3 macroscopic folding, but no overprinting crenulations are found to indicate such a relationship. The abundant sillimanite is locally aligned within S2a with sufficient intensity to produce an L-S tectonite.

Thin, highly sheared slivers of Yarraden Schist crop out along segments of the Ebagoola Shear Zone. These commonly have a composite S-C fabric giving a sinistral shear sense that is consistent with that found in the granites along the fault. In sample 90834056 from just north of Tadpole Creek, quartz is ribboned to aspect ratios of 2 mm by 0.1 mm. The shear or C-planes of the shear zone overprint muscovite that defines the regional S2a schistosity.

Geophysical Properties. The magnetic susceptibility generally ranges between 10 and 20 SI units (average around 15 SI units). The total radiometric response is moderate with typical outcrop readings around 7 cps, with thorium being particularly high in the Yarraden Schist (Fig.2b).

Mount Ryan Quartzite (new name) — Pcr (quartzite)

Derivation. The Mount Ryan Quartzite is named after Mount Ryan, a 420 m high hill located 1 km south of the Lukin River on the Ebagoola 1:100 000 sheet area.

Distribution. Crops out as a 1 km wide and 12 km long, NNW-trending ridge of quartzite and lesser schist, that rises to 400 m above sea level in the southern part of the Ebagoola 1:100 000 sheet area (Fig. 8). It is the only area of volumetrically significant quartzite in the Coen Metamorphic Group, but it is lithologically similar to the thin quartzites found throughout the Goolha-Goolha Schist.

Type Area. The type locality is located at Mount Ryan GR7569-511029.

Lithology. The lithology is essentially a white to cream, medium to coarse-grained foliated quartzite with minor muscovite and biotite. There is a large proportion of vein quartz in the region where the unit crops out.

Thickness. The unit is up to 1 km thick.

Boundary Relationships. The western contact is partly faulted and partly ?conformable with the Yarraden Schist and its higher grade equivalent(?) the Lochs Gneiss. The eastern contact is faulted by the extension of the Ebagoola Shear Zone.

Structure. It is difficult to ascertain the stratigraphic position of any of the units of the Coen Metamorphic Group. The current outcrop shape may be an oblique section through a group that "youngs" to the north (similar to the Holroyd Group), and the most southern outcrops define the top of the Cape York Peninsula Batholith. If this is true, then the Mount Ryan Quartzite occurs near the base of the Coen Metamorphic Group.

Geophysical Properties. The quartzite has low radiometric total counts, with readings of 1-3 cps and is characterised by a very dark brown to black colouration on the composite radiometric image (Fig. 3). The magnetic susceptibility ranges from 1 to 11 SI units.

Goolha-Goolha Schist (new name) — Pcg (schist)

Derivation. The Goolha-Goolha Schist is named after the abandoned Goolha-Goolha mine (GR7569-412507) which is located on the northern margin of the Ebagoola 1:100 000 sheet area.

Distribution. It is found in a number of fault-bounded slivers that form NNW-oriented ridges between the topographically lower gneiss and granite dominated areas between the northern margin of EBAGOOLA and the old Coen Road in the south.

Type Area. The type locality is located near where a tributary of Horseshoe Creek intersects the old Telegraph Line at GR7569-438473.

Lithology. The lithology is dominated by red, purple and brown-weathered, fine-grained sillimanite-muscovite-quartz schist; rare fresh rock is generally grey. Some schists also contain feldspar and/or actinolite; one atypical exposure on the old Coen/Laura road is weathered sillimanite-biotite-graphite-muscovite schist. Bunches of sillimanite are commonly 1-3 mm long; fibrolite bunches range up to 1 cm long; sillimanite needles are variably aligned within S2a. It is characterised by a scarcity or absence of biotite, garnet and andalusite; biotite is found in some of the small gneissic outcrops which in places grade into schist, and 1-2 mm garnets occur in a few exposures. Small bodies of granite are also common in the schist.

The schist is locally interbedded with thin to medium-bedded white saccharoidal quartzite (less quartzite is found in the Lochs Gneiss). The quartzite is generally completely recrystallized, hard and resistant to weathering and forms strike-parallel bands up to 5 m thick which crop out as narrow, elongate ridges. Sillimanite, muscovite and biotite have been recorded from quartzites within the Goolha-Goolha Schist. Except for the Mount Ryan Quartzite, the quartzite bands are generally too thin to be mapped even at 1:50 000 (airphoto) scale. Muscovite, a minor component of the quartzite, is commonly aligned defining metamorphic foliations (especially S2a). The NNW-trending quartzite ridges have strike lengths up to 5 km but show no evidence of macroscopic fold closures, unlike the more abundant quartzites of the Holroyd Group.

Thickness. Many of the contacts are faulted. The unit has a large number of small fault-bounded slivers of Kintore Granite as well as a number of bodies of Llankelly Granite (Mackenzie & Knutson, 1992). The thickness cannot be reliably determined.

Boundary Relationships. The Goolha-Goolha Schist may grade in part into the Lochs Gneiss. Other areas have faulted contacts between schist and gneiss dominated outcrops. The Goolha-Goolha Schist is shallowly underlain by the Cape York Peninsula Batholith.

Structure. Schistosity is defined by an S2a foliation, which can locally be seen to crenulate an earlier S1 surface. The S2a schistosity is commonly overprinted by S3 and S4 crenulations and associated folds. Sillimanite is a D2 mineral because it is found within the S2a schistosity and is overprinted by the S3 crenulation cleavage. Pegmatites are locally parallel to S2a in the schists and are folded by F3. Graphitic shears are common within the schists, many exposed in exploration costeans.

Lochs Gneiss (new name) — Pcl (gneiss)

Derivation. The Lochs Gneiss is named after Loch's Creek which flows north into the Coen River from the Ebagoola 1:100 000 sheet area.

Distribution. It is distributed throughout the Coen Metamorphic Group as a series of NNW-oriented slivers up to 3 km thick.

Type Area. The type locality is located less than 1 km SE of the abandoned town of Ebagoola at a dam and open cut mine shaft (GR7569-450167).

Lithology. The Lochs Gneiss is predominantly a grey biotite-muscovite-feldspar gneiss. Spectacular exposures of sillimanite-(garnet-)mica-feldspar gneiss are also found in a number of stream cuttings. Sillimanite gneiss is not overly common; most sillimanite in the Coen Metamorphic Group is found in the Goolha-Goolha Schist.

The gneiss is generally medium to coarse-grained, equigranular and commonly contains aggregates (augen) of undulous quartz and sericitized feldspar. The mica are aligned parallel to and partly define the gneissic layering; biotite is commonly overgrown by chlorite. The potash feldspar is somewhat sericitized and generally has a graphic intergrowth with quartz.

Garnet where present is colourless to light pink. Trails of garnet are parallel to the trends of the leucosome/melanosome contacts, or occurs as scattered small porphyroblasts 1 mm in diameter. Sillimanite occurs as 1 to 2 mm laths though bunches range up to 8 cm in length. It is variably aligned, with well developed L-S fabrics in some outcrops and a random arrangement in others. The sillimanite is mostly altered to retrograde muscovite formed during the M3 event. Chiastolite is rare in the Coen Metamorphic Group, but occurs in the Lochs Gneiss near the Coen Shear Zone in Station Creek. Kyanite occurs at a single location in the southernmost gneiss outcrop, in the Kalkah 1:100 000 sheet area (Site ZRB0377); the kyanite is pseudomorphed by fine sericite.

Secondary minerals include epidote and opaques which are associated with the biotite melanosome. Accessory minerals include monazite, zircon, apatite, sphene, and opaque minerals.

Gneissic layering or banding (SG) is generally well developed, with a leucosome comprising quartz and feldspar, and a biotite-rich melanosome. The gneissic layering is generally thin, with 1-3 cm alternations of melanosome and leucosome; the leucosome tends to be thicker. The trends of S2a in the closely associated schist are usually parallel to the gneissic layering, which trends NW to NNW and like S2a generally dips steeply. The leucosome component is granitic in composition; apophyses of granite-pegmatite from layer-parallel leucosome show that there is an intrusive source that was derived in-situ or locally for at least some of the gneiss and suggest a later granitic addition to the gneiss, before the emplacement of the Cape York Peninsula Batholith. The granitic pegmatites are typically lacking in biotite and show a higher muscovite content.

The gneiss is commonly intruded by 2-3 m thick, coarse-grained leucocratic, garnet-bearing pegmatite dykes. These dykes are probably intrusions from the Ebagoola Granite phase of the batholith. Gneiss may grade into migmatite and develop pegmatite sweats as seen at the Coen River at the crossing of the Old Pollappa Road (Blewett & von Gnielinski, 1991), where the pegmatites are overprinted by Siluro-Devonian granite. This indicates that at least some phases of the Cape York Peninsula Batholith post-date the metamorphic peak. Less spectacular migmatites occur intermittently through the mapped areas of Lochs Gneiss. In some granitic leucosome pods, phyllosilicates envelop the melanosome and are not overprinted by the pods.

Minor greenish-black amphibolite dykes, pods and boudins, concordant with gneissic layering, are generally 1 to 2 m long and 20 to 30 cm thick. They are medium-grained and semi-equigranular, and are composed of large subhedral, pale yellow to greenish brown hornblende, plagioclase and quartz with opaque minerals, sphene and apatite as common accessories.

A gneiss (Site 90834043b) near the disused telegraph-line track northwest of Horseshoe Creek, is composed of highly sericitised plagioclase and potassium feldspar, biotite, sericite and quartz, interlayered with hornblende and sericite in bands less than 1 cm thick. Small hornblende grains are also scattered through the leucosome bands. Chlorite replaces biotite and the amphibole is intergrown with potassium feldspar. The mica is aligned more strongly in the melanosome than the leucosome. The layering is overprinted by the intrusion of a body of Llankelly Granite, a pluton from the Cape York Peninsula Batholith (Mackenzie & Knutson, 1992).

Thickness. It is not possible to estimate the thickness.

Boundary Relationships. In many places it is apparent that coarse Yarraden-like schists grade into zones of gneiss (Lochs Gneiss). Therefore the difference between gneiss and schist reflects metamorphic grade changes where the increasing abundance of pegmatite (leucosome) is the product of local melting. The gradation between schist and gneiss is well displayed at the "Main Roads" dam, the turn off to which is located just south of the junction between the Port Stewart Road and the Peninsula Development Road (Site ZRB0469).

Structure. The structure of the gneiss is generally a simple NNW-trending, steeply dipping layering. Locally the layering is isoclinally folded about NNW-trending axes, and shows variable amounts of transposition. These isoclinal, transposed folds were thought by Blewett & von Gnielinski (1991a) to be F1 but they are probably F2 as M1 metamorphic grades were unlikely to have generated gneiss. Spectacular fold interference patterns are locally developed. The chronology and style of deformation appears to correlate well with that in the Holroyd Group.

Geophysical Properties. The magnetic susceptibility is generally low with readings ranging from less than 10 to 30 SI units. The radiometric total count is moderate to low with values of 6-10 cps. Surprisingly the potassium count in the Coen Metamorphic Group is lower in the Lochs Gneiss than in the schists, which have little feldspar, and the distribution of potassium (Fig. 3) is consistent with the mapped pattern of schist and gneiss.

Calc-silicate schist

Calc-silicate schist recorded by Willmott et al, (1973) is recessive and was not located in this study.

NEWBERRY METAMORPHIC GROUP (new name) — Pn

Derivation. The Newberry Metamorphic Group is named after Mount Newberry a hill over 240 m above sea level that is located on the eastern of the Ebagoola 1:100 000 sheet area. It was originally named Dargalong Metamorphics by Trail et al. (1968), but was later included in the "Coen Metamorphics" by Willmott et al. (1973).

Distribution. The group comprises poorly exposed metamorphic rocks which crop out discontinuously as a south-southeast-trending belt 80 km long, from Little Stewart Creek on the northern boundary of EBAGOOLA (Fig. 4). This group of rocks is exposed in Little Stewart Creek, Penny Creek and their tributaries, although extensively intruded there by granitic and doleritic rocks. The only other substantial, fresh and representative exposure of this unit occurs in Eel Creek at the crossing of the abandoned Telegraph Line. Elsewhere it is represented by ridges of resistant quartzite and by small exposures generally of deeply weathered gneiss in creeks incised in low rises east of the Telegraph Line.

The very poorly exposed Newberry Metamorphic Group together with a yet more extensive area of un-named concealed metamorphic rocks is found to the east as a N-S oriented belt over 30km wide (Fig. 4), largely covered by young alluvial fans and the sedimentary rocks of the Laura basin.

Lithology. Because of the scarcity of quartzite in the Penny Creek/Little Stewart Creek area, and the prevalence of quartzite elsewhere, the Newberry Metamorphic Group is sub-divided into the Penny Gneiss – applied to the gneiss of Penny Creek and surroundings and including an isolated outcrop on the southern margin of EBAGOOLA – and the Kitja Quartzite covering the quartzitic rocks extending down the eastern margin of the Cape York Peninsula Batholith.

The Newberry Metamorphic Group rocks were largely mapped as Saraga-type schist (of the Dargalong Metamorphics) by Trail et al. (1968), and described as a unit composed of muscovite-quartz schist and quartzite, distinguished by quartzite bands forming steep hills rising to 300 m. The name was abandoned by Willmott et al. (1973) and the rocks were placed by them in the Coen Metamorphic Group, a widespread unit of medium-grade metamorphic rocks extending for about 300 km along the eastern margin of the Coen Inlier.

Geophysical Properties. The aeromagnetic data (Fig. 2) clearly show the extent of the Newberry Metamorphic Group with their high amplitude response relative to the eastern part of the Cape York Peninsula Batholith. The gravity data indicate that the contact of the batholith and the Newberry Metamorphic Group is subvertical (Wellman, 1992).

TABLE 5. SIMPLIFIED LITHOLOGY OF THE NEWBERRY METAMORPHIC GROUP

Unit	Symbol	Description
Penny Gneiss	Pnp	Granitic garnet-muscovite-biotite gneiss
Kitja Quartzite	Pnk	Quartzite, sillimanite-mica schist and gneiss

Kitja Quartzite (new name) — Pnk (quartzite/gneiss)

Derivation. The Kitja Quartzite is named after the parish of Kitja which is located on the Ebagoola 1:250 000 Cadastral Map.

Distribution. The unit occupies roughly 1600 km^2 in N-S trending belt in the eastern third of EBAGOOLA. The Kitja Quartzite is largely concealed and its boundaries are mapped with the aid of aeromagnetic data. The Kitja Quartzite extends from Terrible Creek in the north some 80 km to the southern margin of EBAGOOLA, and is on average 20 km wide.

Type Area. The type locality is located in the hills which are cut by Scrubby Creek at GR7668-779915 which is 12 km WSW of Lilyvale Homestead.

Lithology. The unit is generally a white to light pink coarse-grained rock, forming layers over 100 m thick, as prominent ridges east of the abandoned Telegraph Line. The quartzite is apparently massive but commonly displays on weathered surfaces a centimetre-scale layering which reflects the S2a foliation. A quartzite layer about 120 m thick which crops out south of Scrubby Creek is an inequigranular rock with large grains up to 1.5 cm long, elongated in the dominant S2a strike direction; the large grains may represent small pebbles in the original sediment. A coarse cleavage or jointing in this and a few other exposures generally strikes W or SW and has been referred to S4.

The quartzite generally contains a small amount of muscovite, less than 5 % of the rock, and some also contains a little hematite; the latter is commonly moderately magnetic, while rocks without hematite have a very low magnetic susceptibility. In a few exposures, layers at least a metre thick of weathered ferruginous muscovite-quartz schist are contained in the quartzite.

Almost the only fresh exposure of metamorphic rocks east of the Telegraph Line south of the Stewart River occurs at the Telegraph Line crossing of Eel Creek, where a light and dark banded gneiss crops out (Sites ZDT0157A,B,C,D). The light-coloured layers consist of muscovite quartzite and pegmatite; they are predominantly composed of coarse-size strained quartz crystals accompanied by feldspar and muscovite; large blocky feldspar crystals are developed in the pegmatitic parts of the light layers. The dark layers mainly consist of smaller quartz crystals with equigranular feldspar (oligoclase and K-feldspar), parallel laths of biotite and muscovite (associated with sillimanite in one section), and rounded and corroded fragments of garnet. The bands generally range from 0.5 to 10 cm in thickness but some are 50 cm thick. Irregular dykes of pegmatite up to 3 m thick strike NE. Both at Eel Creek and other exposures, large plates of muscovite with random orientations can be seen in the quartzite and schist, in addition to smaller parallel muscovite crystals.

Upstream in Eel Creek, towards the granite escarpment, both the gneiss and the granite are cut by dykes and sill-like bodies of pegmatite between 1 and 20 cm thick; the sill-like bodies commonly dip gently eastward.

A single small exposure of recessive tremolite-actinolite schist (Site ZDT0151) 5.5 km south of Mt Newberry is described by Trail et al. (1968) as a calc-silicate rock made up of tremolite with lesser amounts of talc and muscovite.

East of Mount Newberry several occurrences of dolerite within the Kitja Quartzite are lines of boulders thought to represent dykes up to several metres thick. These are mainly massive rocks (Sites ZDT0125, 155, 173) in which relatively fresh plagioclase (labradorite) has an ophitic relationship with a yellow-brown, uralitic? hornblende. A few small remnants of pyroxene are generally present and a little secondary quartz; in one section red-brown biotite is associated with the hornblende. One rock has a few crush zones, but they appear otherwise to be undeformed. A few small boulders of weathered leucogranite are associated with one of the dolerite occurrences.

Interpretation of the aeromagnetics by Wellman (1992) resulted in the sub-division of the Newberry Metamorphic Group into the layered Kitja Quartzite and a largely concealed variant which lacks layering in the aeromagnetic imagery. The sole exposure of this variant occurs on a small hill 7 km northeast of Musgrave on the Lakeland road; it consists of coarse quartzite and deeply weathered sillimanite?-muscovite quartz gneiss or schist, similar to the metamorphics described above. Although the airphoto shows a clear north-northwest, S2a trend for the low quartzite ridges here, the foliation trends display a considerable range in the exposures, from north-northwest to west-northwest. The lack of regular layering in the aeromagnetic image may result from deformation reflected in this range in trends; alternatively it may indicate a lack of the very thick quartzite layers present in the Kitja Quartzite, also suggested by the lack of exposure and relief.

Thickness. No estimate can be made of the overall thickness.

Boundary Relationships. The only boundaries exposed around the Kitja Quartzite are those on its western side, against the granitic rocks of the Cape York Peninsula Batholith. The granitic rock at the contact is generally an equigranular muscovite or biotite-bearing granite, and near the contact thin (50 cm) sill-like bodies of muscovite pegmatite within the granite dip gently eastward. These occur to a lesser extent in the metamorphic rocks, where they are also less regular; in both granite and metamorphics they are accompanied by irregular masses of similar pegmatite. A large 1 km thick body of muscovite-quartz schist and quartzite contained in granite about 4 km west of Mount Newberry appears to be surrounded by an envelope of pegmatite.

The northern contacts are sheared, while the eastern contact passes into "undifferentiated" Newberry Metamorphic Group. These contacts are concealed and interpretation is made from geophysical data sets.

Structure. The structure of the Newberry Metamorphic Group is dominated by the D2 fabric. This is reflected in the NNW trends of the quartzite ridges and in the aeromagnetic image. Rodding in weathered schist generally plunges gently NNW or SSE, parallel to the few minor open to isoclinal F2 folds. Some of the breaks in the ridges are caused by faults, identified with north-trending breaks in the banding in the aeromagnetic image. Three kilometres southeast of Mount Newberry a break in the trend of the ridges to the south is reflected in the foliation measured in the metamorphics. These follow the nose of an elongate large-scale F2 fold that is visible in both aeromagnetic and radiometric images. North of Mount Newberry the layering in the aeromagnetic image trends due north to north-northeast, parallel to trends on air photographs (though rocks are represented at the surface only by quartz or quartzite rubble).

The undeformed nature of the gently dipping sill-like bodies of pegmatite common in the granitic rocks near their contact with the Kitja Quartzite indicates that no strong deformation has occurred since the emplacement of the pegmatite. A sizeable hot spring with water at about 60°C, is located within the granitic rocks close to their contact with the metamorphics 4 km southeast of Mount Walsh and suggests that fracturing may be associated with the contact here.

Geophysical Properties. The bulk of magnetic susceptibility readings taken on the quartzite and schist are low (10 SI units). A very few readings taken on magnetite-bearing quartzite range up to 400 SI units, and these, and the presence of amphibolites in places, are the only obvious reasons for the highly magnetic character of the Newberry Metamorphic Group on the aeromagnetic image.

No mineralisation has been recorded in the Newberry Metamorphic Group; splays of the Coen Shear Zone may intersect the Newberry Metamorphic Group in the neighbourhood of Mount Newberry, but this region was probably investigated by conventional prospecting techniques following the discovery of gold at Coen, with no evident result.

Penny Gneiss (new name) — Pnp (gneiss)

Derivation. The Penny Gneiss is named after Penny Creek which is found in the Ebagoola 1:100 000 sheet area as a tributary of Little Stewart Creek. Both flow south into the Stewart River en route to the Coral Sea at Port Stewart.

Distribution. It is poorly exposed and is located in the far NW of the Newberry Metamorphic Group between Balclutha Creek in the south and the northern margin of EBAGOOLA. The unit extends as far east as Dinner Creek where its contact is a shear zone juxtaposing undifferentiated metamorphic rocks (Wellman, 1992). The western margin is a sinuous intrusive contact with the Cape York Peninsula Batholith and it generally occurs just east of the base of The Great Escarpment.

Type Area. The type area is north of the Stewart River, in the Little Stewart Creek/Penny Creek region.

Lithology. The gneiss of the Newberry Metamorphic Group is almost everywhere closely associated with granite, pegmatite and amphibolite or dolerite. Trail et al. (1969) described these metamorphics as Saraga-type schist, consisting predominantly of muscovite-quartz schist with less abundant quartzite and minor interbanded biotite-quartz-feldspar and amphibolite. The 1991 survey of this area (also undertaken largely by Trail) revealed in Little Stewart Creek and Penny Creek mainly gneissic rocks containing abundant amphibolite, granite and pegmatite; schist is not common, probably because it is recessive, and quartzite is not a prominent rock type. These gneissic metamorphics are here named the Penny Gneiss.

The Penny Gneiss most commonly exposed is a light and dark banded muscovite-biotite-feldspar-quartz rock (Site ZDT0219); in two of three thin sections (Sites ZDT0225, 228A) the biotite is largely altered to chlorite. Quartz makes up more than 50% of the gneiss, predominating in the leucosome where it contains a small amount of plagioclase (oligoclase) and potash feldspar (microcline, myrmekite). The dark bands are characterised by muscovite and biotite or chlorite, generally parallel to the banding; some muscovite and chlorite diverge, in thin section ZDT 228A. Mica-rich bands range up to 40 cm thick and contain boudins of quartz or quartzite in places which generally plunge NNW, parallel to F2 axes. Pods of muscovite pegmatite are common in the light-coloured, quartz-rich bands. In only one exposure, in Little Stewart Creek, 2 cm radial growths of ?andalusite occur in a muscovite-rich layer in the gneiss intruded by granite and pegmatite.

In sample 90834091 – a biotite-muscovite-feldspar gneiss – plagioclase and potash feldspar are both present, some displaying a granophyric texture indicative of a granitic addition to the gneiss by leucosome generation on melting. Both feldspar types are generally highly altered by sericite. The gneissic layering is highlighted by the alignment of muscovite and biotite and much of the quartz is strained. In sample 90834030, a sillimanite-biotite-muscovite-feldspar gneiss from the headwaters of Little Stewart Creek, granophyric texture is again evident in sericitized potash feldspar; sillimanite is overgrown by muscovite and most quartz is undulous through extinction with development of subgrains and recrystallization.

About 3 km north of the northern boundary of the Ebagoola 1:250 000 sheet area, in the northern continuation of the outcrop of the Penny Gneiss in the headwaters of Station Creek, weathered granitic muscovite-quartz-feldspar gneiss contains metre-scale boudins of tremolite marble (Site ZDT0220A), as well as a 0.5 m band of foliated amphibolite. This is probably related to the much larger occurrence of calc-silicate rocks recorded by Trail et al. (1969) and Willmott et al. (1973) 25 km farther north in the Coen Metamorphic Group in the head of Peach Creek. Similar marble is also described by Trail and Blewett (1991) from the Sefton Metamorphics, 130 km farther north on the Cape Weymouth 1:250 000 sheet area.

Amphibolite is common in the Penny Gneiss, generally as boulders close to most exposures of gneiss; in a few gneiss exposures bodies of amphibolite are exposed in situ.

The amphibolite occurs as:

- lenses within gneiss typically 10 to 20 cm thick and 1 to 2 m long, concordant with S2a foliation,
- lenses similar to the above, generally concordant with S2a, but displacing some bands,
- larger (1m thick) bodies of amphibolite within and disrupted by pegmatite and granite.

In general the amphibolite contained in gneiss has a faintly streaky appearance, caused (Site ZDT0218) by ill-defined layers of quartz, sericite and ?feldspar alteration products; otherwise this thin section is predominantly composed of large, parallel green hornblende crystals associated with a few laths of biotite and some magnetite.

A thin section of one (Site ZDT0208) reveals two preferred orientations; sub-parallel crystals of green hornblende, combined with small quartz crystals and clumps of highly altered feldspar, are cut by divergent streaks of hornblende suggesting later shearing. In the gabbro-like occurrence in Penny Creek (Site ZDT0228B) there is no preferred orientation; large randomly oriented crystals of pale yellow-green hornblende contain blebs of quartz, and are intergrown with an altered matrix of quartz, sericite and some hornblende; blebs of magnetite/hematite are common.

The presence of irregular disconnected metre-scale bodies of amphibolite in layers of granite and pegmatite suggests that amphibolite bands or intrusions within gneiss were too refractory for conversion to granite at the time of granite emplacement. The occurrence of tremolite marble as metre-scale boudins within granitic gneiss strengthens this interpretation.

Granite and associated pegmatite and aplite are abundant within the Penny Gneiss north of the Stewart River; in the western and southern parts of the outcrop, granite forms at least 30% of rock exposed and is probably more abundant than this. The muscovite or muscovite-biotite granite is generally coarse-grained and even-textured; only one exposure contains large feldspar phenocrysts, and one other contains garnet in granite patches about 1 cm across. The pegmatite is almost everywhere a muscovite-bearing, quartz-rich rock.

The granite bodies or layers within the gneiss range in thickness from 1 cm to over 30 m. They are commonly irregular but many conform roughly to the prevailing S2a foliation, and dip steeply eastward or westward; in only one exposure in Little Stewart Creek (Site ZDT0235) layers of granite in gneiss dip gently westward at about 20 degrees, conforming to the gentle dip of pegmatite bands in nearby large granite exposures. Layers and lenses of gneiss in granite and pegmatite are also common, ranging between 1 and 50 m thick. The contact between gneiss and granite is commonly a zone of pegmatite several centimetres thick. In a few places at the contact a lit-par-lit relationship occurs, in which layers of granite a few centimetres thick alternate with layers of gneiss of similar thickness. In one exposure in Little Stewart Creek an amphibolite layer over 20 m thick is cut by veins 2 to 10 cm thick of dioritic biotite-hornblende rock.

Pegmatite within the gneiss commonly occurs as irregular bodies, at scales ranging from centimetre within the leucosome, to several metres. Near contacts between granite and gneiss, pegmatite layers from a few centimetres to more than one metre thick commonly dip only gently or are sub-horizontal. In one granite exposure these pegmatite layers are interconnected by short dykes, isolating lenses of granite about 2 m by 20 cm in a large-scale net-vein relationship.

A small outcrop of metamorphic rocks in Noorko Creek near the southern margin of EBAGOOLA and on the eastern margin of the Cape York Peninsula Batholith was described as Coen Metamorphic Group by Willmott et al. (1973). As the rocks exposed are similar to the Penny Gneiss, and have been grouped on the aeromagnetic imagery by Wellman (1992) with the Newberry Metamorphic Group, they have been mapped as Penny Gneiss.

In Noorko Creek, weathered rocks exposed are strongly sheared, gneissic muscovite granite, biotite-quartz schist and some dolerite. The schist contains 5 cm thick layers of quartz boudins alternating with biotite-rich layers; if fresh the rock might be classed as a gneiss. Tight chevron folds of layering in the schist plunge gently southwards, and foliation dips very steeply east or west in the both the schist and the mylonitic granite. A 5 cm aplite vein parallels the foliation in the granite. The contact of schist and granite dips steeply east-southeastwards, and at the contact 20 cm pods of schist occur in the granite, and 20 cm pods of granite occur in the schist; the contact appears to be a shear plane. The relationship of the dolerite to these rocks is not seen.

Thickness. It is not possible to accurately determine the thickness of the Penny Gneiss.

Boundary Relationships. The eastern contact is a shear zone juxtaposing undifferentiated metamorphic rocks (Wellman, 1992) and the Penny Gneiss. The western margin is a sinuous intrusive contact with the Cape York Peninsula Batholith. The 20 km long boundary between Penny Gneiss and Kitja Quartzite is entirely concealed and has been derived from the aeromagnetic image; the boundary has been drawn where the strongly lineated signature of the Kitja Quartzite gives way to the less strongly lineated Penny Gneiss.

Structure. Some gneisses show well developed composite S-C fabrics suggesting that some of the strong layering was shear induced on metamorphosed igneous intrusions. Near the contact between the Penny Gneiss and the granitic rocks of the Cape York Peninsula Batholith, and particularly near the Coen Shear Zone, gneissic mylonite is locally developed in the granitic rocks within the metamorphics; one example displays augen of granite in a banded mylonitic matrix. Away from the contact, mylonite is rare.

In the Penny Gneiss the regional S2a foliation swings from its predominant NNW orientation to strike slightly east of north; this is shown by trends on both aerial photographs and aeromagnetic images. Minor folds ranging from open to isoclinal and some tight chevron folds of foliation, as well as lineations such as the very common rodding on quartz boudins, are effectively all oriented either north or south, typical of F3 folding.

Only two observations of fracture cleavage could be attributed to deformation later than D2, striking ESE and NE respectively; a single kink fold plunges moderately steeply towards WNW.

Geophysical Properties. The magnetic response of the Penny Gneiss is moderately high, as seen on the aeromagnetic imagery, though not as strong as the response of the Kitja Quartzite farther south (Fig. 2). The lack of quartzite north of the Stewart River, together with the abundance of granitic rock is thought to be responsible for the lower magnetic response; there is no strong effect evident from the common presence of highly magnetic amphibolite and dolerite.

The radiometric response of all rocks tested in this are was low. The radiometric image clearly reveals the presence of granitic rocks among the metamorphics as shown by the pink stripes trending north by east, parallel to the regional strike (Fig. 3).

Other. The Coen Shear Zone, which separates the southwestern margin of the Penny Gneiss outcrop from the granitic rocks of the Cape York Peninsula Batholith, is associated with gold mineralization near Coen town (20 km to the NW). Gold has been mined close to the shear zone only 5 km from the gneiss outcrop. The abandoned Klondyke goldmine in the Coen 1:250 000 sheet area is reputed to be near the contact of the Penny Gneiss and the Llankelly Granite.

Concealed Metamorphic Rocks — Pu2, Pu3, Pu4a &b

With the aid of geophysical data, Wellman (1992) has inferred the presence of concealed metamorphic and igneous rocks under the coastal plain around Princess Charlotte Bay, extending westwards towards the outcrop of the Newberry Metamorphic Group. He has sub-divided the concealed metamorphic rocks on the basis of metamorphic grade (inferred from comparison with the magnetic character of exposed units) and high or low magnetization. The sub-divisions are separated from each other, and from the outcropping Newberry Metamorphic Group, by major linear discontinuities or faults. These sub-divisions cannot readily be correlated with metamorphics exposed on the Coen 1:250 000 sheet to the north, although it is tempting to link the unit characterised by high metamorphic grade and high magnetization with the gneiss described by Trail et al. (1969) at Rocky River, 15 km north of the northern boundary of EBAGOOLA.

SEDIMENTOLOGY AND THE PROVENANCE AND PROTOLITH OF THE METAMORPHIC ROCKS OF EBAGOOLA

The most complete stratigraphy in EBAGOOLA occurs in the Lukin Structural Domain where a continuous and conformable succession of at least 10 km of sediment accumulated. Many of the rock-types include low-grade metasandstone/quartzite and slate or metasiltstone. Most units (e.g. Dinah, Astrea, Newirie and the Strathburn Formations) are thin-bedded and fine-grained suggesting quiet water and distal environments of deposition. These more pelitic units are intercalated with more psammitic units (e.g. Sugarbag, Carysfort and Gorge Quartzites). The psammitic units tend to be thick-bedded, medium-grained, well-sorted metasandstones and are more typical of shallow water high energy environments. Many of the thick-bedded horizons are massive, with pure white quartzite beds up to 2 m thick.

Sedimentary structures are poorly developed throughout the metamorphic rocks of EBAGOOLA, and are typically absent. The most spectacular sedimentary structures are the rippled surfaces of sandstone horizons within the Newirie Formation. These sedimentary structures are symmetrical ripples with bifurcating hinges, and when restored to the horizontal (the fold axes plunge only gently), they suggest an east or west directed palaeoflow or a N-S oriented shoreline. The environment of deposition could be interpreted as shallow water.

There is an overall decrease in grain size towards the east, as the proportion of quartzite to schist decreases. This is seen from subdomain 1 to subdomain 4 across the Kalkah Domain. Quartzite is a minor component of the Coen Metamorphic Group compared to the Holroyd Group. This scenario may indicate that the Proterozoic basin was oriented N-S with more distal regions located to the east. More data are needed to test this tentative hypothesis.

The Carew Greenstone is very poorly exposed in the Holroyd Group, almost all original igneous textures have been destroyed by deep weathering. The unit was intruded as a 1500 m thick sill that was slightly discordant to the lower part of the stratigraphy. If the Carew Greenstone is not intrusive and is a series of flows, then a complex arrangement of isoclinally folded faults are required to explain the outcrop geometry.

The Coen Metamorphic Group is generally higher in metamorphic grade (upper amphibolite facies) and more deformed than most of the Holroyd Group. No stratigraphic correlations have been attempted between the two Groups of rock. They appear on geochemical (Cruikshank, in prep.) and geophysical evidence to be distinct. The Coen Metamorphic Group has a higher proportion of gneiss than the Holroyd Group. Interbedded schist and quartzite passes gradationally into gneiss in the Pretender and Coleman River Gneisses of the Holroyd Group. They show no evidence of a granitic protolith, their banding reflects the metamorphism of psammite – pelite interbeds with local development of leucosome (granitoid) sweats a function of increasing grades of metamorphism.

The transition from schist dominated to gneiss dominated lithologies in the Coen Metamorphic Group is less clear than in the Holroyd Group. The Lochs Gneiss has a greater proportion of leucosome (granitoid) sweat and reflects the generally higher metamorphic grade of the group compared to the Holroyd Group. In many outcrops it is unclear what the protolith was, however a sedimentary source can be attributed to the gneiss at the type area near Ebagoola township, and also at the Main Roads Dam (just SE of the junction of the Old Coen Road and the new Peninsula Development Road). A petrographic study of the Lochs Gneiss at the Gossan Hill Prospect in the Ebagoola 1:100 000 sheet area led Croxford (1988) to conclude that the protolith was not granitic. He did not identify potassium feldspar or accessories common to granitoids (e.g. zircon).

The Mount Ryan Quartzite is the only psammite of a suitable size to be shown on regional scale maps. The Coen Metamorphic Group is dominated by pelite – now schist – which is in contrast to the relatively quartzite rich Holroyd Group. The schist of the Coen Metamorphic Group may be distal equivalents of the Holroyd Group, and therefore reflect the overall eastward decrease in quartzite.

Samples for whole-rock geochemistry have been collected and are being analysed for majors and trace elements. These new data may improve the knowledge base for the provenance of the metasediments of EBAGOOLA.

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