Granitic rocks of the Coen and Cape Weymouth 1:250 000 sheet areas, Cape York Peninsula, north Queensland: reconnaissance, field, petrographic and geochemical data by J Knutson, R J Bultitude, S-S Sun
Granitic Rocks of the Coen and Cape Weymouth 1:250 000 Sheet Areas, Cape York Peninsula, North Queensland: reconnaissance, field, petrographic and geochemical data

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J Knutson (AGSO), R J Bultitude (GSQ), S-S Sun (AGSO)

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Executive Director: Harvey Jacka

DEPARTMENT OF MINERALS AND ENERGY
(formerly DEPARTMENT OF RESOURCE INDUSTRIES, QUEENSLAND)

Minister: The Hon. Tony McGrady, MP
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Contents

SUMMARY ............................................. v
INTRODUCTION ........................................ 1
  Previous Work ..................................... 1
  Nomenclature ..................................... 1
CAPE YORK PENINSULA BATHOLITH .................... 2
  Field Relationships and Petrography ............... 2
SILURO-DEVONIAN I-TYPE GRANITES .................. 5
BLUE MOUNTAINS SUPER SUITE ....................... 5
  Blue Mountains suite ............................. 5
  Granite I ........................................ 5
  Granite II ........................................ 5
  Granite III ....................................... 5
  Granodiorite ..................................... 6
  Morris Adamellite ................................ 6
SILURO-DEVONIAN S-TYPE GRANITES ................. 7
KINTORE SUPER SUITE ................................ 7
  Ebagoola Suite ................................... 7
  Kintore Granite .................................. 7
  Lankelly Suite ................................... 8
  Lankelly Granite .................................. 8
  McIlwraith granite ............................... 9
  Granite I .......................................... 9
  Granite II ........................................ 9
  Granodiorite .................................... 10
  Buthen Buthen granite ............................ 10
  Granite I .......................................... 10
  Granite II ........................................ 10
PERMO-CARBONIFEROUS I-TYPE GRANITES ............. 11
WEYMOUTH SUPER SUITE .............................. 11
  Weymouth suite .................................. 11
  Weymouth Granite ................................ 11
  Portland Roads granite ............................ 12
  Wolverton Adamellite ............................. 13
  Unassigned granite ............................... 13
  Twin Humps Adamellite ......................... 14
UNASSIGNED GRANITIC ROCKS OF THE CYPB ......... 14
  Coen 1:250 000 Sheet area ...................... 14
  Diorite and Granodiorite ....................... 14
  Cape Weymouth 1:250 000 Sheet area .............. 15
  Diorite I ......................................... 15

© Australian Geological Survey Organisation 1994
Diorite II .................................................. 16
Gabbro .................................................. 16

GEOCHEMISTRY ........................................... 17
KINTORE SUPERSUITE .................................. 21
BLUE MOUNTAINS SUPERSUITE ...................... 26
WEYMOUTH SUPERSUITE ............................... 27
Weymouth and Portland Roads granites ............. 27
Wolverton-Twin Humps and unassigned granites .... 27
Unassigned diorites ...................................... 27

Nd Isotope Results ....................................... 29

EMPLACEMENT HISTORY AND SUMMARY ................ 29
MINERALISATION POTENTIAL ............................. 31
ACKNOWLEDGMENTS ...................................... 33
SUMMARY

The basement geology of the Coen and Cape Weymouth 1:250 000 Sheet areas (COEN and CAPE WEYMOUTH) is dominated by the granitic rocks of the north-trending Cape York Peninsula Batholith (CYPB), which forms much of the Coen Inlier. The northern part of the CYPB is divided by chemistry and age into the Siluro-Devonian S-type Kintore Supersuite and I-type Blue Mountains supersuite, and the Permo-Carboniferous I-type Weymouth supersuite and a number of unassigned rocks.

In the COEN area, the CYPB was emplaced into greenschist to upper amphibolite grade rocks of the Holroyd, Coen and Sefton Metamorphic groups (Trail & others, 1968; Blewett & others, 1992). In the CAPE WEYMOUTH area the CYPB intrudes the Sefton Metamorphic Group and the Permo-Carboniferous Janet Ranges Volcanics.

The Kintore Supersuite has been informally divided into the Kintore Granite, Lankelly Granite, McIlwraith granite and granodiorite, and Buthen Buthen granite. Kintore Supersuite rocks range from biotite granodiorite to biotite-muscovite and muscovite granite and leucogranite and, with the exception of the porphyritic Lankelly Granite, are mostly aphyric and medium to coarse grained.

The Blue Mountains supersuite comprises granite, leucogranite and granodiorite. Coarse-grained, porphyritic, sometimes pinkish-grey granite is the most common Blue Mountains rock type. Phenocrysts are microcline perthite, plagioclase and, more rarely, hornblende. Allanite up to 2.5 mm long is a prominent accessory mineral.

The Permo-Carboniferous I-type Weymouth supersuite comprises granodiorite, and granite. Pinkish-grey, porphyritic hornblende-biotite granite is the most conspicuous rock type. Perthite phenocrysts are up to 2 cm long, and allanite is a prominent accessory phase.

Diorite and granodiorite of unknown affinities crop out in a number of areas, but most commonly are areally associated with Weymouth supersuite rocks. They are mostly hornblende and biotite-rich, with pyroxene (mostly strongly altered) being common in some samples.

The S-type granites are distinguished from the I-type granites geochemically by higher aluminium saturation index (ASI), Al2O3, K2O and P2O5, and lower Fe2O3 versus FeO(total), Na2O and U. Chemical trends for the Siluro-Devonian and Permo-Carboniferous I-type granites mostly overlap. Higher $\varepsilon_{Nd}$ values for the Weymouth supersuite distinguish it from the Blue Mountains supersuite.

Geochemical trends within the Kintore Supersuite indicate that its compositional evolution was largely controlled by restite removal, whereas trends for the Weymouth and Blue Mountains suggest some control by fractional crystallisation. Marked increases in Rb, U, and decrease in K/Rb in rocks with $<73\%$ SiO2 in all three supersuites reflect crystal fractionation processes.

Evidence that crystal fractionation processes have generally been more important and more prolonged in the I-type granites than in the associated S-type granites suggests that any economic mineral potential is most likely to be associated with the former. This is supported by the overall distribution of Au and Sn mines/prospects and stream sediment anomalies which generally show a close correlation with both Siluro-Devonian and Permo-Carboniferous I-type granites.

Depleted mantle model ages and $\varepsilon_{Nd}$ values indicate that the source rocks for all Siluro-Devonian granites contained a greater proportion of evolved Proterozoic crust than the Permo-Carboniferous I-type granites. This is supported by zircon (SHRIMP) geochronology which indicates the Siluro-Devonian granites generally have a more abundant and older population of inherited zircons than the Permo-Carboniferous granites (Black & others, 1992).
INTRODUCTION

This record describes granites of the Cape York Peninsula Batholith (CYPB) in the COEN and CAPE WEYMOUTH sheet areas. The study forms part of the North Queensland National Geological Mapping Accord (NGMA) project undertaken jointly by the Australian Geological Survey Organisation and the Geological Survey of Queensland. The NGMA, endorsed by the Australian (now Australian and New Zealand) Minerals and Energy Council in August 1990, is a joint Commonwealth/State/Territory initiative to produce, using modern technology, a new generation of geoscience maps, data sets, and other information on strategically important regions of Australia, over the next 20 years.

The results of analytical work on samples collected during a reconnaissance prior to scheduled mapping are presented here. Problems with land access resulted in the southwards relocation of the mapping program (Record 1992/75). Consequently it is only possible to discuss the spatial distribution and relationships of granitic units within the region in general terms. Nevertheless, the new geochemical, petrographic and isotopic information provides a clearer picture of the nature and evolution of the northern part of the CYPB than was previously available.

Airborne gamma-ray spectrometries flown in 1986 give an indication of the distribution of the I- and S-type granites. Some of the more differentiated I-type granites have relatively high total K + Th + U and produce bright white-tone combined images. These contrast with the red and pink pseudocolour response typical of most S-type granites. White-tone areas within S-type granites may represent areas of unmapped I-type granites or more differentiated S-type granites.

COEN and CAPE WEYMOUTH are located in the central and northern area of the Coen Inlier, between 142°45' and 143°40' E and 13°50' and 14° S. The town of Coen, which is the main supply and communication centre of the region, is located in the southern part of COEN. It is serviced by the Peninsula Developmental Highway (earth formation) and by regular air services from Cairns. The Lockhart River Community in the Iron Range area of CAPE WEYMOUTH is the main service centre in the northern part of the Coen Inlier. It is reached by an earth formation road, branching off the Peninsula Development Highway, and by regular air services from Cairns.

Previous Work

The northern part of the Coen Inlier (north of latitude 14°S) has a long history of geological investigations. The first significant study followed the discovery of alluvial gold at Coen in 1876, which resulted in R.L. Jack undertaking a geological expedition in the area during 1879 and 1880. Further gold discoveries ensured a continued interest in the area, although no regional studies were undertaken until 1967. The Bureau of Mineral Resources (now AGSO) and the Geological Survey of Queensland carried out a systematic survey of the Coen Inlier in the late 1960s (Whitaker & Willmott, 1968, Trail & others, 1969; Willmott & others, 1973, Whitaker & Gibson, 1977) which included a reconnaissance petrographical and geochemical study of the CYPB. Reconnaissance gravity surveys (Goodspeed & Williams, 1959; Dooley, 1965; Shirley & Zadoroznyj, 1974) and airborne magnetic and gamma-ray spectrometric surveys were also carried out by BMR at that time.

Nomenclature

In broad terms the classification of Chappell and White (1974, 1984) for the Lachlan Fold Belt, Chappell (1978) and Hensel et al. (1985) for the New England Fold Belt and Champion et al. (1990) for North Queensland has been adopted. Thus granites are allocated to supersuites, associations and groups on geological, petrographical and geochemical criteria. The
The reconnaissance nature of the 1990 field work is a limiting factor in the subdivision of the granites into discrete plutons and to attaining a more complete understanding of the magmatism in the Coen Inlier. This is particularly so for the Mcllwraith and Buthen Buthen granites, and the Wolverton, Wigan and Twin Humps Adamelites.

Nomenclature follows the guidelines of the IUGS Subcommission on the Nomenclature of Igneous Rocks (Le Maitre, 1989). The term granite is used for both monzogranite and syenogranite.

Many rock unit names (eg Mcllwraith granite) will not be formalised until additional field and laboratory studies have taken place. Informal units are denoted by the use of lower case letters for the rock type after the geographic descriptor.

CAPE YORK PENINSULA BATHOLITH

The CYPB is the major igneous feature of the Coen Inlier, forming a north-trending body 400 km long and up to 60 km wide (Fig. 1). It consists of S- and I-type granites of Siluro-Devonian age, and Permo-Carboniferous I-type granites and volcanic rocks of the North Queensland Plutonic and Volcanic Province (NQPVP) (Black et al., 1992).

The CYPB batholith in the COEN and CAPE WEYMOUTH map areas constitutes about 80% of the inlier, although up to 30% is covered by a thin veneer of Cainozoic sediments. The Permo-Carboniferous granites are largely confined to the northern part of the Inlier where S-type Siluro-Devonian granites are relatively minor. The intrusion of the Permo-Carboniferous granites into volcanic rocks considered to be largely coeval attests to their emplacement at high crustal levels. Siluro-Devonian S-type granites are dominant in the central and southern part of the inlier, where their deeper level of emplacement is indicated by an absence of co-magmatic volcanics and their close spatial and temporal association with migmatites and high-grade metamorphic rocks.

The western margin of the northern part of the CYPB is concealed beneath Permo-Carboniferous Janet River and Kangaroo Volcanics and Mesozoic and Tertiary sediments. The eastern margin is largely covered by Tertiary sediments and, in some areas, metamorphic gneiss, schist and quartzite of the Sefton and Coen Metamorphic Groups.

Field Relationships and Petrography

As has been observed in the Ebagoola 1:250 0000 Sheet area (EBAGOOLA), there is commonly a gradation within both the S and I-type granites of the CYPB from relatively mafic into more felsic compositions (Mackenzie & Knutson, 1992). Sharp contacts between units of the same supersuite appear to be rare, although this observation is probably influenced by the generally poor outcrop and the reconnaissance nature of this work. The Siluro-Devonian granites tend to form elongate north-trending plutons, similar to those in the EBAGOOLA area.

Granites in the vicinity of shear zones, eg., the Archer River Shear Zone, are commonly foliated. Quartz grains have strong undulose extinction and some subgrain development, and mica flakes are commonly kinked and show undulose extinction in strongly deformed zones. Strong alignment of phenocrysts in some of the porphyritic granites reflects emplacement during regional deformation and/or magma flow adjacent to pluton margins.

Extensive weathering has produced widespread residual, coarse, quartz-rich sand.

The Kintore (S-type), Blue Mountains and Weymouth (I-type) supersuites are identified in the CYPB north of latitude 14° S (COEN and CAPE WEYMOUTH areas). A list of the units assigned to each of these supersuites is in Table 1.
Figure 1. Distribution of igneous rocks in COEN and CAPE WEYMOUTH showing sample locations.

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**Siluro-Devonian Association**

<table>
<thead>
<tr>
<th>Supersuite</th>
<th>Unit</th>
<th>Principal Properties</th>
<th>Distinguishing characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kintore (S-type)</td>
<td>Kintore Granite (redefined Mackenzie &amp; Knutson, 1992)</td>
<td>Equigranular; porphyritic in part; muscovite + biotite ± garnet</td>
<td>Leucocratic, relatively large muscovite crystals.</td>
</tr>
<tr>
<td></td>
<td>Lankelly Granite (redefined Mackenzie &amp; Knutson, 1992)</td>
<td>Variably porphyritic; biotite + muscovite</td>
<td>Phenocrysts generally abundant, commonly aligned; biotite-rich relative to typical Kintore granite.</td>
</tr>
<tr>
<td></td>
<td>Buthen Buthen granite (informal unit)</td>
<td>Leucocratic, equigranular, muscovite + biotite</td>
<td>Fine to medium grained, muscovite-rich</td>
</tr>
<tr>
<td></td>
<td>McLlwrath granite (informal unit)</td>
<td>Equigranular, rarely porphyritic; muscovite + biotite ± sillimanite ± garnet</td>
<td>Variably biotite and muscovite rich; some leucocratic units.</td>
</tr>
<tr>
<td>Blue Mountains (I-type)</td>
<td>Blue Mountains Adamellite (defined by Willmott &amp; others, 1973)</td>
<td>Equigranular, medium to coarse grained; biotite ± hornblende ± allanite.</td>
<td>Leucocratic to mesocratic; sometimes pinkish; biotite generally predominates over hornblende.</td>
</tr>
<tr>
<td></td>
<td>Morris Adamellite (defined by Willmott &amp; others, 1973)</td>
<td>Porphyritic, coarse grained; biotite rich.</td>
<td>Plagioclase phenocrysts up to 4 mm long; abundant dioritic and gneissic enclaves.</td>
</tr>
</tbody>
</table>

**Permo-Carboniferous Association**

<table>
<thead>
<tr>
<th>Supersuite</th>
<th>Unit</th>
<th>Principal Properties</th>
<th>Distinguishing characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weymouth (I-type)</td>
<td>Weymouth Granite (defined by Willmott &amp; others, 1973)</td>
<td>Porphyritic to equigranular, medium to coarse grained; biotite ± hornblende ± allanite.</td>
<td>Typically pink, but some mesocratic areas; perthite phenocrysts up to 3 mm long.</td>
</tr>
<tr>
<td></td>
<td>Portland Roads granite (informal unit)</td>
<td>Equigranular, medium grained biotite ± allanite.</td>
<td>Compared with Weymouth granite is even grained and biotite rich.</td>
</tr>
<tr>
<td></td>
<td>Wolverton Adamellite (defined by Willmott &amp; others, 1973)</td>
<td>Equigranular, variably leucocratic, aplitic in part; biotite</td>
<td>Quartz stringer veins common.</td>
</tr>
<tr>
<td></td>
<td>Twin Humps Adamellite (defined Willmott &amp; others, 1973)</td>
<td>Porphyritic and equigranular, medium to coarse grained, biotite ± hornblende ± allanite.</td>
<td>Commonly pinkish grey, perthite phenocrysts up to 6 mm long.</td>
</tr>
</tbody>
</table>

Table 1.

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SILURO-DEVONIAN I-TYPE GRANITES

BLUE MOUNTAINS SUPERSUITE

Blue Mountains suite

Distribution. Current field work indicates at least four main granitic rock types form the prominent hills known as the Blue Mountains in the northern part of the Coen 1:100 000 map sheet (Fig 1). These granites were defined as the Blue Mountains Adamellite by Willmot & others, (1973) The main range is approximately 7 x 9 km and there are a number of outlying bodies which are probably connected under a cover of residual granitic weathering products.

Topographic Expression. The strong relief of the Blue Mountains contributes to the generally good outcrop of the granitic rocks as platforms, large rounded tors and boulders.

Granite I

Lithology. The dominant rock type in the Blue Mountains area is pale to mid-grey mostly porphyritic, and coarse grained and varies from hornblende-biotite granite to biotite-hornblende granite containing biotite-rich schlieren. Phenocrysts up to 6 mm long consist of plagioclase, microcline perthite and, more rarely, sub-ophitic hornblende. Plagioclase (20-35%) is commonly zoned; cores are moderately altered to sericite and muscovite. All quartz grains (25-35%) are deformed. In some places microcline perthite grains (20-35%) are salmon pink as a result of secondary alteration. Mafic mineral content varies up to 30%. Biotite (pleochroic from straw yellow to dark brown) ranges up to 25-30% in plagioclase rich rocks, but is subordinate to hornblende in microcline perthite rich rocks. Rare to common blue-green hornblende is pleochroic from straw yellow to blue-green and forms aggregates 2-3 cm across. Minor minerals include euhedral, strongly metamict allanite (up to 2.5 mm long), euhedral to subhedral titanite (up to 2 mm long), zircon (commonly as inclusions in biotite), ilmenite, magnetite, and apatite. Secondary minerals include muscovite, sericite, chlorite, epidote and pyrite. Fine to medium grained biotite-rich dioritic xenoliths occur sporadically throughout the unit. Quartz veins are abundant in some areas, and several (such as a major 3-5 m wide saccharoidal quartz vein in the southwestern part of the Blue Mountains) contain scattered oxidised sulphide minerals. Microgranite dykes 3-30 cm thick are also present in some areas.

Granite II

Lithology. A light grey, moderately altered, even grained to slightly porphyritic felsic biotite microgranite crops out along the western side and in the saddle between the western and eastern parts of the Blue Mountains. This rock type is characterised by an interlocking aggregate of quartz and feldspar grains, and has an average grain size of ~ 0.5-0.8 mm. Microcline and quartz total about 40% each, and quartz grains show strained extinction. Zoned plagioclase (5-10%) mostly has cores altered to sericite/muscovite and clear rims, and is up to 5 mm long. Dark brown irregular flakes of biotite (pleochroic straw yellow to dark brown) are slightly chloritised and total <5%. Accessory minerals include zircon, apatite, magnetite and primary titanite. Secondary minerals include muscovite, sericite, chlorite and titanite (associated with chlorite after biotite). A medium-grained (2-3 mm) granophyric granite on the western side of the Blue Mountains has a similar but more felsic mineralogy and possibly contains allanite.

Granite III

Lithology. The abundance of muscovite appears to increase eastwards into a pale grey, medium grained, moderately altered biotite-muscovite granite at the eastern part of the Blue Mountains.
Here plates of muscovite up to 2 mm across form 5-10% of the rock, and at least some are secondary. Straw-yellow to dark-brown biotite with minor chloritic alteration totals about 4-5%; inclusions of metamict zircon are common. Quartz grains with strained extinction and minor recrystallisation along grain boundaries total about 30%. Microcline perthite (20-30%) has an average grain size of about 0.5 mm, but ranges up to 3 mm long. Strongly zoned plagioclase (15-25%) has sericitized cores and clear rims and averages ~1 mm in length. Secondary minerals include chlorite, sericite, titanite, muscovite and epidote. Locally this granite is cut by pegmatite dykes and quartz veins up to 0.5 m thick.

Granodiorite

Lithology. The medium to dark grey moderately altered hornblende-biotite granodiorite has an average grain size of ~0.5 to 1 mm. Euhedral to subhedral, mostly strongly zoned plagioclase has moderately sericitised cores and totals ~40%. Subhedral orthoclase totals 5-10%. Ragged flakes of biotite are pleochroic from straw yellow to brown and total 25-30%. Anhedral hornblende, pleochroic from greenish-yellow to blue-green, totals ~5%. Prominent euhedral to subhedral titanite grains are up to 1 mm long and total ~5%. Allanite is also a prominent accessory mineral along with magnetite, apatite and zircon. Sericite and minor pyrite, chlorite and muscovite are secondary.

Relationships Apart from dykes, no contacts have been observed between the various members of the Blue Mountains supersuite or between these and other rocks. Dykes of felsic biotite microgranite cut the coarser grained hornblende-biotite granite in places implying the latter is older, at least in some areas. The biotite-hornblende granodiorite forms a small area within the hornblende-biotite granite and possibly represents an earlier intrusion which was subsequently engulfed by the more evolved granite. Field relationships suggest that small pods/plutons/dykes of felsic biotite microgranite were emplaced mainly around the margins of the earlier intrusions. The biotite-muscovite granite in the southeastern part of the Blue Mountains is probably a discrete intrusion; its more evolved composition suggests it postdates the other granites of the Blue Mountains supersuite.

Age. The pooled zircon U-Pb ion microprobe (SHRIMP) age for the Blue Mountains Adamellite is 407 Ma (Black & others, 1992).

Morris Adamellite

Distribution. The Morris Adamellite crops out to the west of the Archer River Shear Zone in the NW area of the Coen 1:100 000 Sheet area and the SE part of the Wenlock 1:100 000 Sheet area. It is particularly well exposed downstream of the Archer River crossing of the Peninsula Developmental Road.

Topographic expression. The Morris Adamellite forms massive tors and boulders up to many tens of metres in diameter which crop out in a terrain of low to moderate relief. Extensive weathering has produced thick residual deposits of quartz-rich sand.

Lithology. The Morris Adamellite is a light to medium grey, coarse-grained porphyritic biotite granite. Quartz up to 4 mm across totals about 30-40%. It has strained extinction and shows minor recrystallisation at grain boundaries. Strongly zoned plagioclase (25-30%) forms phenocrysts up to 4 mm long (mostly <2 mm) and has marked sericitic alteration to cores. Perthite (20-25%) with some development of microgranophyric intergrowths at grain boundaries, is mostly interstitial to quartz and plagioclase. Biotite (10-15%; pleochroic from straw yellow to fox red) contains abundant metamict zircon. Minor muscovite is mostly enclosed in feldspar, and is probably of secondary origin. Other secondary minerals are sericite, chlorite and carbonate (as rare...
veins). Accessory minerals include zircon, apatite, ilmenite, magnetite and pyrite. The Morris Adamellite has abundant xenoliths of fine-grained porphyritic diorite and fine-grained biotite granite (sensu lato). These enclaves are commonly rounded, and some granite inclusions merge into the host rock suggesting they are marginal quench phases. Small (mostly less than 10 cm long) angular gneissic xenoliths are also present.

**Relationships.** Trail & others (1969) report that the Morris Adamellite is intruded on its northern margins by the Wolverton Adamellite. To the east it appears to have a faulted boundary with sheared Kintore Granite.

**Age.** A zircon U-Pb (SHRIMP) age of 407±8 Ma has been determined for the Morris Adamellite (Black & others, 1992).

**Comment.** The aluminium saturation index (ASI) and mineralogy (ie., absence of hornblende, allanite, and primary titanite) of the Morris Adamellite suggest that it is an S-type granite, as does P₂O₅ content (see Chappell & White, 1992). However it has ε Nd values of -10.8 to -11.1 which are indistinguishable from the Blue Mountains I-type granites of the same age. Depleted mantle model ages (TDM) for the Morris Adamellite are intermediate between S-type granites and the Blue Mountains I-type granites. The classification of the Morris Adamellite is discussed in more detail later.

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**SILURO-DEVONIAN S-TYPE GRANITES**

**KINTORE SUPERSUITE**

**Ebagoola Suite**

**Kintore Granite**

**Distribution.** The Kintore Granite in the southern part of the COEN area extends into the EBAGOOLA area where it is the most widespread granitic rock type. Similar granites forming several discrete plutons to the south and west of Cape Weymouth (Cape Weymouth 1:100 000 Sheet area, northern parts of the Lockhart River and Wenlock 1:100 000 Sheet areas) have also been included in the Kintore Granite. Additional mapping and geochemistry may indicate these granites are separate units within the Kintore Supersuite.

**Topographic expression.** In the Coen area the Kintore Granite crops out poorly in an area of low relief. The moderate relief of the Cape Weymouth area has resulted in good outcrop in the form of tors and boulders. The soil/regolith in both areas is pale grey and consists mainly of coarse, quartzose sand derived from deep weathering of the granite.

**Lithology.** The Kintore Granite is a pale grey, buff to cream, medium to coarse grained, equigranular biotite-muscovite granite. No garnet has been observed in the Kintore Granite in the CAPE WEYMOUTH and COEN areas, although it is common in the granite of the southern part of the EBAGOOLA area. Anhedral microcline totals about 30-35% and has an average grain size of 1-3 mm. Zoned euhedral plagioclase (15-20%) up to 2 mm long, typically shows extensively altered cores and less altered rims. Quartz totals 30-35%. In the Cape Weymouth area quartz grains generally show only minor undulose extinction, although at the northern end of Cape Griffith it is strongly deformed and extensively recrystallised. Euhedral muscovite totals 3-10%. Euhedral to anhedral biotite laths (3-8%), pleochroic from straw yellow to deep fox red, range up to 2 mm long and contain abundant zircon with pleochroic haloes. Apatite up to 0.3 mm across is a minor phase. Alteration varies from minor to strong; secondary minerals include chlorite, titanite.
and sericite. The distribution and abundance of quartz veins is also variable, being particularly common in the more altered rocks.

Pale grey, medium to coarse-grained, porphyritic biotite granite crops out to the west of Portland Roads. It contains 1-2 cm long microcline phenocrysts in a groundmass of quartz, microcline, plagioclase and biotite. Microcline (35%) and quartz (30%) with only minor evidence of strained extinction are the most common minerals. Anhedral to subhedral plagioclase (15%) shows variable degrees of zoning and alteration. Subhedral biotite, pleochroic from straw yellow to brown, totals about 10%, and forms 1-2 mm long flakes and plates enclosing numerous small zircons with pleochroic haloes. Secondary minerals include chlorite, sericite, muscovite, opaque minerals, epidote and titanite. This unit contains rare xenoliths of fine-grained biotite diorite up to 15 cm long with a primary mineralogy similar to the host rock, but the minerals are in different proportions.

Relationships. In the Cape Weymouth area the Siluro-Devonian S-type granites are spatially associated with the Permo-Carboniferous I-type granites, although actual contacts have not been observed. Andesitic and dacitic dykes cut the biotite-muscovite granite on the Portland Roads road, 12 km south of the Pascoe River. The Kintore Granite in the Coen area is intruded by the Twin Humps granite (Willmott & others, 1973).

Age. The Kintore Granite in the EBAGOOLA area has a pooled zircon U-Pb (SHRIMP) age of 406±7 Ma (Black & others, 1992). A zircon U-Pb age of 409±6 Ma has been obtained for the porphyritic biotite granite in the Portland Roads area.

Lankelly Suite

Lankelly Granite

Distribution. The Lankelly Granite crops out in the southern central part of the Coen 1:100 000 Sheet area (Fig. 1) and extends southwards into the Ebagoola 1:100 000 Sheet area. It forms a 28 km by 8 km north-trending belt in the Coen Sheet area.

Topographic expression. In the Coen area where the topography is relatively hilly, the Lankelly Granite crops out well as large rounded tors and boulders. There are extensive rock platforms in Lankelly and Pandanus Creeks.

Lithology. The Lankelly Granite is a light to medium grey muscovite-biotite granite, which is texturally and chemically heterogeneous and variably foliated, with some recrystallisation of quartz grains. It is mainly coarse grained and strongly porphyritic, with aligned microcline perthite phenocrysts averaging 4-6 cm in length (some exceed 10 cm). Typically the granite consists of quartz (25-30%) with strained extinction, phenocryst and groundmass microcline perthite (25-35%), plagioclase (15%) with variable zoning and sericitic alteration, and biotite (5-10%) which is pleochroic from straw yellow to fox red. Minor muscovite (<5%), mostly in feldspar grains and intergrown with biotite, is probably of secondary origin. Secondary titanite, chlorite and ilmenite are also associated with biotite. Main accessory minerals are apatite (up to 0.5 mm long) and zircon. The Lankelly Granite is cut by quartz veins and lenses, as well as dykes of aplite, rhyolite and pegmatite. The pegmatite dykes are up to 3 metres wide; they contain quartz and feldspar up to 20 cm across, and muscovite up to 8 cm across. Flow-banded rhyolite dykes are prominent in some areas of good outcrop. The granite is cut by numerous northwest-trending joints and contains rare subspherical dioritic and gneissic xenoliths up to 20 cm long.

Relationships. The Lankelly Granite intrudes the Coen Metamorphic Group, and is intruded by aplite, pegmatite and rhyolite dykes probably related to the Ebagoola Granite (Kintore Supersuite) and/or the Permo-Carboniferous Twin Humps Granite, which is in close proximity. At one
location (in the Ebagoola 1:100 000 Sheet area) the Lankelly Granite is cut by a dyke of biotite-muscovite granite similar to the Kintore Granite. Elsewhere the Lankelly Granite appears to grade into the Kintore Granite, and no actual intrusive contacts have been found. In the southern part of the McIlwraith Range (in the upper reaches of the Stewart River) the Lankelly Granite has numerous large inclusions of diorite. The granite there is associated with small isolated outcrops of coarse-grained, strongly foliated and altered, biotite-muscovite granite.

Age. Zircon U-Pb (SHRIMP) ages for the Lankelly Granite have been determined at 407±4 to 411±11 Ma (Black & others, 1992).

McIlwraith granite

Distribution. The McIlwraith granites crop out throughout the north-south trending McIlwraith Range (Fig. 1) which is located in the eastern area covered by the Coen and Lockhart River 1:100 000 map sheets. They vary considerably in texture and composition, and extensive field work is required to delineate individual units. Biotite granodiorite generally crops out to the west of the biotite-muscovite granite. Cordierite-sillimanite-garnet-muscovite granite has only been found ~ 8 km ESE of Buthen Buthen, where it is closely associated with biotite-muscovite granite, and in the Leo Creek area where it is associated with allanite-biotite-granodiorite.

Topographic expression. The McIlwraith Range has moderate to strong relief and some areas of good outcrop. Typically the granites form large tors, boulders and, more rarely, extensive rock platforms. High precipitation has resulted in strong weathering, and the development of a deep soil profile and dense vegetation cover.

Granite I

Lithology. The biotite-muscovite granite extends the full length of, and is the dominant rock type, in the McIlwraith Range. It is pale grey, variably altered, mostly equigranular, and medium to coarse grained, with an average grainsize of about 1mm. Quartz and subhedral to anhedral microcline total 35-40% and about 30%, respectively. Quartz has strained extinction and some recrystallisation at grain boundaries. Plagioclase grains (15-20%) generally show some zoning and extensive alteration to sericite and muscovite. Micrographic intergrowths are associated with K-feldspar. Muscovite is slightly more abundant than biotite, which is pleochroic from straw yellow to fox red; together they total about 10-15%. Biotite commonly is partly altered to chlorite. Accessory minerals include zircon and apatite; secondary minerals are sericite, muscovite, chlorite and epidote. In some areas the granite is cut by lensoidal pegmatite dykes (up to 0.5 m across) and quartz veins. A 5 m-thick rhyolite dyke was emplaced along a shear zone within the biotite-muscovite granite at Skae Creek. Amphibolite, and gneissic xenoliths are irregularly distributed throughout the unit. A concentration of amphibolite xenoliths in the north may be indicative of proximity to the granite-country rock contact.

Granite II

Lithology. The cordierite-sillimanite-garnet-muscovite granite is a moderately to strongly altered, coarse grained, foliated, light grey felsic rock with numerous mica-rich lenses. Quartz totals about 30-35% and forms interlocking grains up to 3-4 mm across, commonly with deformation lamellae. Grains of microcline up to 8 mm across total about 40%. Clear anhedral plagioclase (5-10%) is not zoned and is interstitial to microcline and quartz. Plates of muscovite up 1.5 mm across total about 5%, and straw yellow to fox-red biotite about 3%. Sillimanite needles and rods up to 0.5 mm long account for another 5%. Cordierite has been completely pseudomorphed by aggregates of pinite 3 mm across. Pink garnet 1-2 mm across is sporadically distributed. Apatite forms prominent euhedral grains up to 1 mm across. Secondary minerals include sericite, muscovite and chlorite.
Granodiorite

**Lithology.** This medium grey, medium grained, equigranular *biotite granodiorite* is commonly foliated. The foliation is defined by the alignment of ragged straw-yellow to fox-red biotite laths (10-20%, and up to 1.5 mm long), which are concentrated in irregular lenses up to several centimetres across. In some areas where this rock is moderately deformed, strained quartz (20-30%) is incipiently recrystallised along grain boundaries. Microcline perthite (15-20%) ranges up to 4 mm across but is mostly 2 mm. Strongly zoned plagioclase (20-25%), with altered cores and clear rims, forms euhedral to subhedral grains mostly enclosed within microcline perthite. Minor muscovite is probably all secondary. Other secondary minerals are sericite, epidote, chlorite and titanite. Zircon, with pleochroic halos, and apatite are common accessory minerals.

**Relationships.** The McIlwraith granites intrude gneisses of the Coen Metamorphic Group and in turn are cut by basaltic and rhyolitic dykes of unknown age. The rhyolites most likely were emplaced along pre-existing shear zones in the Late Palaeozoic, along which there has been minor subsequent movement.

**Age.** The McIlwraith granites have mineralogical and geochemical characteristics of the Kintore Supersuite. They were probably emplaced at about the same time as other members of the supersuite (ie., ~ 407 Ma).

Buthen Buthen granite

**Distribution.** The Buthen Buthen granites form a prominent range adjacent to the coast and to the east of the McIlwraith Range (Fig. 1). The described granites are from a restricted area in the vicinity of Buthen Buthen. Granitic rocks also form the ranges extending north of the Macrossan Range to Lloyd Bay, but the absence of ready access precluded sampling.

**Topographic expression.** The Macrossan Range has moderate to strong relief, and there are some good rock exposures in creek beds. However, high precipitation and thick vegetation results in strong weathering, so that away from creek beds there is a thick cover of soil and residual sand, and exposures are generally poor.

Granite I

**Lithology.** This light grey, medium grained, equigranular *muscovite-biotite leucogranite* has an average grain size of 1-2 mm and contains 35-40% quartz, 20-25% zoned plagioclase with strongly sericitised cores, 15-20% K-feldspar, 5% biotite (pleochroic from straw yellow to fox red), and less than 3% muscovite. Granophyric intergrowths with groundmass quartz are common around the margins of K-feldspar grains. Secondary minerals include sericite, muscovite, and chlorite. Accessory minerals are zircon and apatite.

Granite II

**Lithology.** The *biotite-muscovite leucogranite* is mostly coarse grained (average grain size 3-4 mm) although there are zones (possibly marginal) where it is relatively fine grained and closely jointed. It is variably foliated with quartz, feldspar and biotite-rich bands. It consists of strongly deformed quartz (35-40%), microcline perthite (20-30%), plagioclase (15-20%) which is variably zoned and altered, muscovite (5-10%), and chloritized biotite (<3%). Accessory minerals are zircon and apatite. Sericite and chlorite are common secondary minerals. The most intensely deformed and altered parts of the unit are cut by stringer quartz veins.

**Relationships.** The relationship between the two granites is uncertain. The *biotite-muscovite leucogranite* appears to intrude the *muscovite-biotite leucogranite* in the saddle of the range 4 km
SE of Buthen Buthen. 1.2 km NE of Buthen Buthen muscovite-biotite leucogranite intrudes amphibolite, calc-silicate rocks and minor schist of the Coen Metamorphic Group; all units are cut by abundant quartz veins. The amphibolite shows evidence of at least two generations of deformation and is cut by dykes of muscovite-biotite leucogranite parallel and at high angles to the dominant foliation. The dykes are essentially undeformed. The muscovite-biotite leucogranite is closely associated with migmatis and amphibolite elsewhere in the same area. Biotite-muscovite leucogranite becomes more abundant farther away from the contact.

Age. The Buthen Buthen granites have mineralogical and geochemical characteristics of the Kintore Supersuite. They were probably emplaced at about the same time as other members of the supersuite (i.e., ~407 Ma).

PERMO-CARBONIFEROUS I-TYPE GRANITES

WEYMOUTH SUPERSUITE

Weymouth suite

The majority of granites in the Cape Weymouth area belong to the Permo-Carboniferous I-type Weymouth supersuite, although Siluro-Devonian S-type granites of the Kintore Supersuite are prominent in some areas. I-type rocks include allanite-biotite-hornblende granite, allanite-hornblende-biotite granodiorite, and biotite (+ allanite) granite.

Weymouth Granite

Distribution. The Weymouth Granite crops out in the eastern part of the Cape Weymouth 1:100 000 Sheet area and in the north-western corner of the adjoining Lockhart River 1:100 000 Sheet area (Fig. 1). The 1990 field work has identified several distinct lithological types within the Weymouth Granite as delineated in the BMR-GSQ survey of the Coen Inlier in the late 1960s (Whitaker & others, 1973). These almost certainly are from discrete plutons but the reconnaissance nature of the 1990 field work has meant boundaries could not be delineated. A texturally distinct Weymouth-type granite (previously described as a hybrid granite by Trail & others, 1969) crops out south of the Pascoe River in the southeastern corner of the Cape Weymouth 1:100 000 Sheet area.

Topographic expression. The Weymouth Granite is characterised by good exposures in an area of moderately strong relief. Massive tors and rock platforms many metres across are common, particularly in the vicinity of creeks, and there are excellent exposures along the coast (e.g., at Cape Weymouth). The unit crops out in an area of moderate relief in the vicinity of the Pascoe River where it forms abundant boulders and tors typically 1-3 m diameter.

Lithology. The Weymouth Granite typically consists of pinkish grey, medium to coarse-grained, porphyritic allanite-hornblende-biotite granite. Pink perthite phenocrysts (30-40%) are up to 2-3 mm long. Strongly zoned, euhedral plagioclase phenocrysts (20-30%), mostly 1-2 mm long but up to 6 mm, mostly have sericitic alteration to cores and clear rims. Quartz (25-35%) commonly shows some evidence of strained extinction. Biotite and hornblende commonly form aggregates 1-3 mm across. Biotite, pleochroic straw yellow to dark brown, and blue-green hornblende together total between 10-15%, with biotite mostly being much more abundant than hornblende. Accessory minerals are allanite, titanite, zircon, magnetite and minor apatite. Secondary minerals include chlorite, sericite and muscovite. Fine-grained xenoliths of biotite-hornblende diorite up to 30 cm across are common in some areas, particularly in the area south of Cape Weymouth.
A more mafic unit of the Weymouth granite is a dark grey, medium grained, equigranular to porphyritic allanite-biotite-hornblende granodiorite which forms scattered outcrops in the Cape Weymouth and West Claudie River areas and north of the Pascoe River. Perthite phenocrysts (20%) are up to 2 cm long, and variably sericitized. Euhedral zoned plagioclase (25-30%) ranges up 4 mm long and mostly has some sericite in the cores, although some grains are quite clear. Quartz (20%) is mostly undeformed, with only minor evidence of strained extinction. Microgranophyric intergrowths of quartz and K-feldspar are present in some samples. Blue-green hornblende 1-2 mm long totals about 20% and biotite (pleochroic from straw yellow to dark brown) totals about 10%. Accessory minerals include allanite, apatite, zircon, and magnetite.

Chlorite, epidote and sericite are the most common secondary minerals.

Light grey medium-grained allanite-hornblende-biotite granite south of the Pascoe River has a bimodal grainsize. The rock has an overall average grain size of 0.5-1.0 mm with sparse, strongly zoned, and partly reconstituted plagioclase phenocrysts. Additionally, there is a multitude of smaller (0.25-0.50 mm) zoned plagioclase euhedra. Subhedral blue-green hornblende totals 5-10%, and ranges up to 2 mm—most are about 0.5 mm long. Minor straw-yellow to dark-brown biotite totals about 2%. Quartz totals about 20% and shows only minor evidence of deformation. Plagioclase has three grain sizes: phenocrysts up to 6 mm long; strongly zoned groundmass euhedra up to 1 mm long; and zoned euhedra averaging 0.25 mm long enclosed within the coarser and later groundmass minerals. Simply twinned K-feldspar totals about 20%. Accessory minerals are allanite, zircon and apatite. Secondary minerals include sericite and chlorite.

Relationships. The Weymouth Granite is cut by pegmatite and rhyolite dykes and by the Portland Roads granite. It is also closely associated with diorite at Ogilvie Hill and a gabbro at Chili Beach. In the Cape Weymouth area the Weymouth Granite contains abundant rounded inclusions similar to the Ogilvie Hill diorite. Rhyolite of the Janet Ranges Volcanics is contact metamorphosed where intruded by granite.

Age. The pooled zircon (SHRIMP) U-Pb age for the Weymouth Granite is 285±4 Ma (Black & others, 1992).

Portland Roads granite

Distribution. The Portland Roads granite crops out sporadically in the Scrubby Creek and Portland Roads areas where it is closely associated with both the Weymouth and Kintore granites.

Topographic expression. Coastal outcrops of the Portland Roads granite are prominent. Away from the coast it crops out rather poorly, mostly as boulders 2-3 m diameter, in an area of low to moderate relief where deep weathering has produced a blanket of residual quartz-rich sand.

Lithology. The Portland Roads granite is a light grey biotite-(±allanite) granite. It is equigranular and medium grained with an average grain size of about 1-2 mm. Both perthite (30-35%) and plagioclase (20-25%) show some degree of sericitization and the latter is commonly zoned, resulting in a decrease in sericite towards the rim. Plagioclase forms euhedral grains up to 2 mm long, as well as smaller (0.5 mm) subhedral grains within perthite. Microgranophyric intergrowths are present in some samples. Quartz with undulose extinction totals 30-40%. Biotite (pleochroic from straw yellow to dark brown) totals 10% and ranges up to 2 mm long. Allanite, up to 1mm long, but more commonly 0.5mm, and euhedral titanite are present in some samples. Zircon and apatite are not as common as in the S-type biotite granites of the Kintore Supersuite. Secondary minerals include sericite, chlorite and opaque minerals.

Relationships. The Portland Roads granite intrudes the Weymouth granite south of Portland Roads. It contains inclusions texturally and mineralogically similar to the Weymouth type granite described as "hybrid" by Trail & others, 1969.
Age. By association with the Weymouth granite, the Portland Roads granite is considered to be about 285 Ma old.

**Wolverton Adamellite**

**Distribution.** The Wolverton Adamellite occurs to the north of the Morris Adamellite in the western part of the Lockhart River 1:100 000 Sheet area.

**Topographic expression.** The Wolverton Adamellite crops out in an area of low to moderate relief. In the latter there are some good exposures in the form of scattered tors and rock platforms. Strong weathering has produced a quartz-rich residual sand cover.

**Lithology.** The Wolverton Adamellite shows a textural and compositional range from biotite aplite to biotite leucogranite and biotite granite. In some areas it is cut by a network of subvertical to vertical stringer quartz veins up to 10 cm thick, trending ~ 150°, and less commonly, ~ 180°. The granite typically consists of 30-35% quartz with strained extinction, 35-40% perthite, 20-25% plagioclase, minor biotite and accessory zircon. Secondary minerals include sericite, muscovite and chlorite. Plagioclase forms strongly zoned grains with marked sericitic alteration in the cores, as well as to relatively clear unzoned euhedral. Microcline perthite also show some development of sericitic alteration. Quartz-feldspar microgranophyric intergrowths are present in some samples. The greenish-brown biotite, partly altered to chlorite, has inclusions of metamict zircon. Grain size ranges from ~ 0.24 mm in the apites to ~ 2 mm in the granites. Cassiterite has been identified in veins and lodes within the Wolverton Adamellite, and alluvial tin is present in a number of creeks draining its southeastern margins (Denaro & Morwood, 1992a, b).

**Relationships.** The Wolverton Adamellite is bound in the north and northeast by the Weymouth Granite and in the south by the Morris Adamellite although no actual contacts have been observed. Its western margin is largely obscured by Mesozoic sedimentary rocks.

Age. It is inferred to be about 285 Ma old. This is based on the observation that the Weymouth Granite, and other Permo-Carboniferous granites, have initial \( \varepsilon_{\text{Nd}} \) values distinctive from the Siluro-Devonian granites of the CYPB.

**Unassigned granite**

**Distribution.** An unassigned granite crops out north and northeast of the Wolverton Adamellite in the northwestern part of the Lockhart River 1:100 000 Sheet area. It could be included within the Wolverton Adamellite as there appears to be a transition between these biotite+hornblende granites and leucogranites and similar leucogranites identified as Wolverton Adamellite. Reconnaissance mapping undertaken in the late 1960s identified the granites in this area (Wigan Adamellite, Willmott & others, 1973) as being of Siluro-Devonian age, although later Rb-Sr age determinations by Cooper & others (1975) indicated an age of 283 Ma. Both petrographic and geochemical criteria indicate the rocks sampled in this area during the present study are I-type granites and most likely of Permo-Carboniferous age. This suggests that both Siluro-Devonian and Permo-Carboniferous granites are present in the area previously mapped as Wigan Adamellite. Airborne gamma-ray spectrometric imagery of the area supports, but does not confirm, this suggestion.

**Topographic expression.** The topography in this area is characterised by low relief terrain and granite crops out sporadically as rounded boulders less than 1 m diameter. The area is deeply weathered and covered by residual quartz-rich sand.

**Lithology.** This is a light pinkish grey, medium to coarse-grained granite, with an average grain size of 1-2 mm. Plagioclase totals 30-35%, ranges up to about 4 mm long, and is mostly strongly zoned with variable sericitic alteration. Orthoclase perthite is mostly interstitial and totals about
20-30%, and quartz with strained extinction totals about 30-35%. Irregular plates of altered greenish-brown biotite are typically 1-2 mm across and total between 15-20%, and euhedral blue-green hornblende up to 2 mm long totals 2-5%. Accessory apatite, zircon and opaques are present. Secondary minerals include sericite, chlorite, epidote and opaques.

A granophyric leucogranite in the Sefton Creek area consists of quartz, quartz-K-feldspar granophyric intergrowths, microcline perthite, plagioclase and brown biotite. Secondary minerals include sericite, chlorite and opaques.

Relationships. Xenoliths similar to the Wolverton Adamellite and this unassigned granite are present in the Weymouth Granite.

Age. This unassigned granite has similar ɛNd values to the Weymouth and Wolverton granites. These are distinctly higher than those for the Siluro-Devonian granites, and suggest a Permo-Carboniferous age—similar to that reported for the Wigan Adamellite by Cooper & others (1975).

**Twin Humps Adamellite**

**Distribution.** The Twin Humps Adamellite forms a prominent ranges north of the township of Coen (Fig 1). As elsewhere, additional field work is necessary to delineate the distribution of textural types and individual plutons.

**Lithology.** The Twin Humps Adamellite is an even grained to porphyritic pinkish grey, medium to coarse-grained hornblende-biotite leucogranite. Microcline perthite phenocrysts total about 30-40%, and are up to 4-6 mm long. They commonly enclose euhedral, strongly zoned and sericitized plagioclase grains averaging 0.5-1.0 mm in length and totalling about 10-20%. Deformed quartz totals about 20-30%. Euhedral green-brown hornblende and brown biotite up to 2 mm long total less than 5%. Allotrite, up to 1 mm long, and zircon are prominent accessory minerals.

**Relationships.** The Twin Humps Adamellite forms two discrete bodies. The north-trending body is bound on the south and southwest by Coen Metamorphic Group, on the east by the Lankelly Granite and on the north and northwest by the Kintore Granite. The east-trending body is bound on the north and east by the Kintore Granite and on the west and south by Lankelly Granite.

**Topographic expression.** The Twin Humps Adamellite is characterised by terrain of moderate to high relief, and forms numerous large rounded boulders and tors up to several metres in diameter.

**Age.** A zircon U-Pb (SHRIMP) age of 285±9 Ma has been determined for the Twin Humps Adamellite (Black & others, 1992).

**UNASSIGNED GRANITIC ROCKS OF THE CYPB**

**Coen 1:250 000 Sheet area**

**Diorite and Granodiorite**

**Distribution.** Diorite and granodiorite of unknown affinities crop out in the central eastern area of the Rokeby 1:100 000 Sheet area. The diorite forms scattered boulders along the Rokeby road (GR 7086 84821) over an area of a few square kilometres, and was previously mapped as Flyspeck Granodiorite (Trail & others, 1969). The granodiorite forms a prominent hill east of the road at GR 7157 84792 where it was previously mapped as Kintore Adamellite. An isolated area of granodiorite also crops out in the Leo Creek area in the southern part of the McIlwraith Range (Coen 1:100 000 Sheet area).
Lithology. The strongly altered, equigranular, *pyroxene-hornblende-biotite diorite* consists of pyroxene up to 1 mm across, mostly replaced by blue-green amphibole, fox-red biotite, strongly sericitized plagioclase, K-feldspar and quartz. Mafic minerals total about 30-40% and twinned, sometimes ophitic, hornblende ranges up to 3 mm long. Biotite flakes total 10-15% and are commonly partly replaced by muscovite. Euhedral to subhedral strongly sericitized plagioclase totals about 40%. Strong alteration of all feldspars precludes the positive identification of K-feldspar. Strongly deformed quartz totals about 5%. Amphibolite xenoliths are abundant, as are stringer veins of carbonate. Secondary minerals include sercite, muscovite, carbonate, chlorite and titanite.

The *porphyritic biotite granodiorite* has a well developed foliation with numerous aligned euhedral microcline phenocrysts up to 2 cm long. Foliated straw-yellow to fox-red biotite flakes (7-10%) average 1 mm long. They are characterised by abundant inclusions of metamict zircon. Quartz totals 10-15%; original large grains have recrystallised to micrograins as a result of deformation. Clear euhedral to subhedral plagioclase totals 25-35%, averages 1-2 mm long and is essentially unzoned. Anhedral matrix and euhedral phenocrist microcline/microperthite totals 40-45%; there is minor development of microgranophyric intergrowths at grain boundaries. Accessory minerals include zircon, apatite, monazite, and opaque minerals. Secondary minerals are minor muscovite, sercite, and pyrite. Anastomosing pegmatite dykes are common; some have been disrupted by deformation.

In the Leo Creek area a fine to medium-grained, strongly altered *biotite granodiorite* has rare phenocrysts of zoned, strongly sericitised plagioclase (up to 4 mm long) in an even-grained groundmass (averaging 0.5 to 1.0 mm) of quartz, feldspar and biotite. Quartz forms irregular interlocking grains with strained extinction and totals 20-25%. Euhedral to subhedral groundmass plagioclase (25-30%) is also strongly sericitised and variably zoned. K-feldspar with simple twinning totals 15-20%. Mostly ragged grains of biotite, pleochroic straw yellow to fox red, total 15-20% and contain abundant metamict zircon. Accessory minerals include allanite, zircon and apatite; secondary minerals are sercite, chlorite, titanite and iron oxide.

Relationships. Further work is needed to determine the relationship of these granitic rocks with other rocks of the CYPB.

Topographic expression. The Rokeby diorite underlies an area of low relief, mostly with moderate to poor outcrop, and forms scattered boulders associated with a deep red-brown soil/regolith cover. The granodiorite in the same area forms a prominent small hill. The Leo Creek granodiorite crops out in an area of high relief and there are good exposures in creek beds. However, high precipitation has resulted in a deep weathering profile and sparse outcrop on the thickly vegetated hills.

Age. The age of these rocks is not known, but they are probably Siluro-Devonian. The *pyroxene-hornblende-diorite* has an $\varepsilon_{N_A}$ value similar to the Blue Mountain I-type granites and distinctly lower than the Permo-Carboniferous I-type granites.

Cape Weymouth 1:250 000 Sheet area

Diorite I

Distribution. A diorite covers an area of approximately 15 km$^2$ centred on Ogilvie Hill ~10 km SW of Cape Weymouth (northeastern part of the Cape Weymouth 1:100 000 Sheet area). It is one of a several small diorite bodies within and marginal to the Weymouth and Wigan granites (Trail & others, 1969).
Topographic expression. This diorite forms low hills with moderate relief characterised by dark red soils and deep weathering. It crops out as abundant dark grey boulders mostly 1-2 m diameter.

Lithology. Dark grey, fine to medium grained pyroxene-hornblende diorite is the typical rock type. The diorite contains ophitic blue-green to brown hornblende (30-40%) up to 2-3 mm across with rare residual cores of clinopyroxene. Locally it is intergrown with and partly replaced by biotite (15%), which is pleochroic from straw yellow to fox red. Euhedral to subhedral orthopyroxene, pleochroic from pink to pale green, totals up to 10%. Clear euhedral plagioclase (15-25%) mostly varies from 0.5-2 mm long; interstitial quartz and K-feldspar total about 5-10%. Apatite, opaques, sericite, muscovite, and chlorite are also present.

Fine grained biotite-hornblende diorite cropping out 0.5 km south of Cape Weymouth is similar to but more hornblende-rich than diorite xenoliths in the allanite-hornblende-biotite granite (Weymouth granite). It forms a pod several hundred metres across and is possibly an earlier more mafic unit of the Weymouth Granite. Phenocrysts of plagioclase (up to 4 mm long) and perthite are enclosed in a matrix of hornblende and biotite (35-45%), plagioclase (30-35%), K-feldspar (10%), and quartz (<5%). Titanite is accessory.

Relationships. If the dioritic inclusions in the Weymouth and Portland Roads granites are related to the diorite intrusions, then the dioritic rocks are probably either older or coeval with the more felsic granites.

Age. The Ogilvie Hill diorite is considered to be about 285 Ma old based on its association with the Weymouth Granite.

Diorite II

Distribution. A diorite crops out over a small area north of Garraway Creek and west of the road to Wattle Hills homestead in the NE part of the Cape Weymouth 1:100 000 Sheet area.

Topographic expression. The diorite at Garraway Creek crops out as abundant small boulders (20 cm - 75 cm) in an area of low relief and dark-red soils.

Lithology. The dark grey, coarse-grained biotite-hornblende diorite is moderately to extensively altered. Blue-green hornblende totals about 25-30%, and is extensively altered to chlorite. Straw-yellow to dark-brown biotite (5%) is also commonly altered to chlorite. Concentrations of mafic minerals average 4 mm across with individual grains being up to 2 mm long. Strongly sericitized and zoned plagioclase (35-40%) cores, surrounded by narrow less altered rims, average about 2 mm long. Interstitial K-feldspar and quartz total about 5-10% and there is minor development of microgranophytic intergrowths. Subhedral to anhedral opaques total about 2%. Accessory minerals are zircon and apatite and secondary minerals comprise chlorite, sericite, opaques and carbonate.

Relationships. Diorite similar to that at Garraway Creek intrudes the Permo-Carboniferous Janet Ranges Volcanics (Trail & others, 1969).

Age. The intrusive relationship of this diorite with the Janet Ranges Volcanics suggests a Permo-Carboniferous or younger age.

Gabbro

Distribution. A hornblende-pyroxene gabbro crops out over only a few tens of square metres at the northern end of Chili Beach, 1.5 km south of Cape Weymouth.

Topographic Expression. The gabbro crops out in the intertidal zone as low rock platforms and boulders over a small area.
Lithology. This hornblende-pyroxene gabbro is a dark grey, coarse grained rock with at least 50-60% hornblende. Hornblende has two distinct habits. Large ophitic plates range up 1 cm across, have opaque exsolution lamellae and abundant inclusions of subhedral to anhedral clinopyroxene averaging 0.3 mm long. Hornblende also forms zoned euhedral interlocking grains about 1-2 mm long, again with abundant clinopyroxene inclusions. Clinopyroxene is irregularly distributed and totals 5-10%. Strongly sericitized plagioclase, plus K-feldspar and quartz total about 10% and occur in interstices. Rare larger plagioclase grains are up to 2 mm long. Anhedral opaques total about 5%. Secondary sericite and iron oxides are present.

Relationships. Trail & others (1969) reported the gabbro to be intruded by the Weymouth Granite.

Age. The age of this gabbro is unknown.

GEOCHEMISTRY

Geochemical data support the mineralogical classification of the granites in the northern part of the Coen Inlier into I- and S-types. With the exception of the Morris Adamellite, all plot in discrete fields on a SiO₂ versus ASI diagram (Fig. 2). I-type granites typically are more oxidised than S-type granites (Fig. 3), and both show a trend of increasing Fe₂O₃/(FeO + Fe₂O₃) with increasing SiO₂. The I- and S-type division is also apparent on SiO₂ variation diagrams (Fig. 4) which show the former mostly have lower Al₂O₃, P₂O₅ and Sr, and higher Na₂O+K₂O values at a given SiO₂ content. The S-type granites have a relatively restricted range of SiO₂ values from 63-74%, compared with the I-type granites (56-76% SiO₂). Granitic rocks of the I-type Weymouth...
supersuite fall into two groups, with SiO₂ contents between 66-70%, and 73-76% respectively. In contrast SiO₂ in the Blue Mountains supersuite is mostly in the range 69-74%. The majority of rocks plot in the granite and granodiorite fields on a CaO-Na₂O-K₂O diagram (Fig. 5), with a lesser number of samples plotting in the tonalite field.

The Blue Mountains supersuite granites generally have higher K₂O, Rb/Sr, Rb, U, Th, Ce, La, Nb, Nd, W (and to a lesser extent Sn) than those of the Weymouth supersuite, whereas FeO(total), TiO₂/MgO, Na₂O, and Y tend to be higher in the latter. The granitic rocks of the Kintore Supersuite generally show a greater degree of scatter on variation diagrams than those of the Blue Mountains and Weymouth supersuites, suggesting they represent a number of unmapped discrete plutons derived from heterogeneous source rocks. Plots of Sr and Ba versus Rb for the Kintore Supersuite McIlwraith granites show evidence of late-stage K-feldspar fractionation. Similar plots for the Blue Mountains and Weymouth supersuites show the same trends of increasing Rb with decreasing Sr and Ba.

Geochemical characteristics of the Blue Mountains and Weymouth supersuites show some similarities to A-type granites (Loiselle & Wones, 1979; Collins & others, 1982; White & Chappell, 1983; Eby, 1990). They have high Ga (as does the Kintore Supersuite), Ce, and relatively high Zr, although the latter is mostly lower than is typical for A-type granites. Other elemental abundances used to distinguish A- from I-type granites, such as high Y, Zn and Nb, and low Al₂O₃, CaO and MgO, are more typical of I-type granites, especially in the less evolved rocks. However, some specific samples may indeed satisfy A-type classification related to assimilation and fractional crystallisation (AFC) of mafic magmas.

Average whole rock analyses for the different granite units are given in Table 2.
Figure 4. Selected chemical variation diagrams showing trends for Siluro-Devonian and Permo-Carboniferous I- and S-type granites of the CYPB (Symbols as for Figure 2).
Figure 4. continued
Figure 5. CaO-Na₂O-K₂O plutonic rock classification (A.J.R. White, pers. comm., 1988). Symbols as for Figure 2.

KINTORE SUPERSUITE

The Kintore Supersuite in the northern part of the Coen Inlier comprises four major units: Kintore, Lankelly, McIlwraith and Buthen Buthen (Fig. 1). SiO₂ ranges from 63.1% to 74.4%, but most samples contain more than 70% SiO₂. Some compositional variations with SiO₂ for the I- and S-type granites are shown in Figure 6. There is considerable scatter within the Kintore Supersuite and additional samples are needed to more precisely define discrete granitic units and geochemical trends. Apart from K₂O, Rb and Pb, all elements either decrease with increasing SiO₂ content or show no clear correlation. The moderate to high K₂O contents (2% to 5.77%, but mostly 3%), and moderately low Na₂O values (2.19% to 3.70%), are consistent with a supracrustal origin (see Chappell & White, 1974, 1984). CaO, MgO and FeO(total) values are mostly low and average about 2%, 0.5% and 2.5%, respectively, at 70% SiO₂. P₂O₅ shows some scatter, but mostly decreases with increasing SiO₂ from a maximum of 0.19% (Fig. 4).

Th and U contents are highly variable, particularly at high SiO₂ values (Fig. 6). They range from 6 to 64 ppm (average 25 ppm) and 1 to 23 ppm (average 6 ppm) respectively. There are marked, systematic decreases in Zr, La and Ce with increasing with SiO₂, from 238 to 35, 65 to 8 and 130 to 18 ppm, respectively. The ferromagnesian trace elements (Sc, V, Cr, Ni, Mn, Cu and Zn) in the different units of the Kintore Supersuite generally show only weak trends. Low Ni and Cr, mostly less than 2 and 5 ppm, respectively, are similar to those in the Mesoproterozoic (Calymmian) Esmeralda Supersuite in the Georgetown Province (Champion, 1991) and contrast markedly with
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| Ba | 243 | 478 | 563 | 334 | 13 | 460 | 510 | 740 |
| Li | 20 | 46 | 45 | 42 | 182 | 11 | 31 | 32 |
| Rb | 61 | 209 | 172 | 197 | 892 | 127 | 102 | 254 |
| Sr | 258 | 128 | 176 | 166 | 4.0 | 49 | 346 | 143 |
| Pb | 10 | 30 | 13 | 27 | 63 | 26 | 11 | 30 |
| Th | 6.5 | 22 | 24 | 11 | 40 | 27 | 23 | 43 |
| U | 2.5 | 6.4 | 6.0 | 5.5 | 13 | 2.0 | 3.0 | 10 |
| Zr | 242 | 244 | 215 | 99 | 85 | 248 | 397 | 230 |
| Nb | 7.0 | 11 | 12 | 8.0 | 22 | 7.0 | 25 | 17 |
| Y | 26 | 42 | 20 | 16 | 94 | 23 | 35 | 23 |
| La | 20 | 39 | 47 | 16 | 15 | 108 | 80 | 61 |
| Ce | 38 | 77 | 81 | 31 | 35 | 194 | 149 | 114 |
| Nd | 20 | 36 | 33 | 13 | 23 | 79 | 61 | 44 |
| Pr | 2.3 | 7.3 | 7.0 | 3.0 | 5.0 | 19 | 13 | 9.3 |
| Sc | 35 | 12 | 9.0 | 8.0 | 4.0 | 5.0 | 19 | 9.00 |
| V | 143 | 21 | 41 | 26 | 1.0 | 2.0 | 102 | 27 |
| Cr | 105 | 3.2 | 17 | 4.0 | .5 | .5 | 7.0 | 5.7 |
| Co | 26 | 6.3 | 9.0 | 3.0 | - | - | 14 | 3.0 |
| Ni | 34 | 1.1 | 7.0 | .5 | .5 | .5 | 4.0 | 2.5 |
| Cu | 14 | .9 | .5 | .5 | .5 | .5 | 9.0 | 3.6 |
| Sn | 84 | 60 | 71 | 20 | 39 | 43 | 95 | 50 |
| Sn | 1.3 | 3.1 | 1.0 | 1.0 | 22 | 1.0 | 3.0 | 2.5 |
| W | 4.9 | 6.7 | 3.0 | 1.5 | 19 | 3.0 | 1.5 | 2.8 |
| Mo | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Ga | 20 | 21 | 19 | 18 | 25 | 18 | 23 | 20 |
| As | 1.8 | 2.5 | 1.0 | 1.5 | 2.5 | 1.5 | 2.5 | 1.0 |
| S | 550 | 57 | 50 | 50 | 50 | 50 | 300 | 113 |
| Be | 1.5 | 3.3 | 2.0 | 3.0 | 10 | - | 2.0 | 3.3 |
| Ag | 2.8 | 2.2 | 2.0 | 2.0 | 2.0 | 1.0 | 2.0 | 2.0 |
| Bi | <2 | <2 | <2 | <2 | 9.0 | 1.0 | 1.0 | 1.0 |
| Hf | 6.5 | 7.3 | 7.0 | 3.0 | 3.0 | 9.0 | 11 | 6.7 |
| Ta | 1.3 | 1.3 | 1.0 | 1.0 | 4.0 | 1.0 | 1.0 | 1.8 |
| Cs | 3.1 | 3.9 | 4.0 | 6.0 | 23 | 1.5 | 1.5 | 2.7 |
| Ge | 1.3 | 1.3 | .5 | 1.5 | 2.5 | .5 | 1.5 | 1.3 |

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| Ba             | 420          | 644         | 693             | 578               | 756            | 461             |
| Li             | 87           | 25          | 44              | 40                | 23             | 36              |
| Rb             | 338          | 162         | 225             | 232               | 155            | 225             |
| Sr             | 116          | 363         | 227             | 179               | 361            | 167             |
| Pb             | 52           | 20          | 40              | 32                | 29             | 28              |
| Th             | 36           | 15          | 23              | 28                | 10             | 24              |
| U              | 19           | 5.0         | 5.7             | 5.6               | 2.8            | 6.1             |
| Sr             | 226          | 173         | 149             | 160               | 87             | 161             |
| Nb             | 22           | 14          | 13              | 14                | 10             | 15              |
| Y              | 37           | 42          | 10              | 14                | 7.0            | 13              |
| La             | 53           | 51          | 40              | 42                | 22             | 41              |
| Ce             | 103          | 106         | 77              | 84                | 42             | 82              |
| Nd             | 47           | 54          | 33              | 37                | 17             | 36              |
| Pr             | 10           | 9.0         | 7.2             | 7.3               | 2.3            | 7.3             |
| Sc             | 10           | 31          | 6.3             | 6.8               | 5.0            | 9.3             |
| V              | 28           | 180         | 15              | 19                | 6.0            | 37              |
| Cr             | 4.0          | 72          | 4.0             | 2.8               | 1.5            | 7.4             |
| Co             | 4.0          | 15          | 8.3             | 4.0               | 2.0            | 6.1             |
| Ni             | 3.0          | 7.0         | 2.4             | 1.2               | 0.33           | 3.6             |
| Cu             | 1.0          | 6.0         | 1.1             | 0.50              | 0.50           | 1.11            |
| Sn             | 44           | 97          | 51              | 56                | 31             | 71              |
| Sn             | 7.0          | 7.0         | 2.3             | 1.9               | 1.0            | 1.4             |
| W              | 6.0          | 4.0         | 2.6             | 2.6               | 2.0            | 2.4             |
| Mo             | <2           | <2          | <2              | <2                | <2             | <2              |
| Ga             | 20           | 23          | 20              | 21                | 19             | 22              |
| As             | 2.5          | 2.0         | 0.83            | 0.85              | 0.83           | 0.82            |
| S              | 50           | 500         | 85              | 50                | 50             | 79              |
| Be             | 3.0          | 1.0         | 1.3             | 2.9               | 2.5            | 3.0             |
| Ag             | 2.0          | 2.0         | 1.6             | 1.9               | 1.7            | 2.0             |
| Bi             | 1.0          | 2.0         | 1.9             | 1.3               | 1.0            | 1.0             |
| Hf             | 6.0          | 5.0         | 4.9             | 4.8               | 3.0            | 5.7             |
| Ta             | 3.0          | 1.0         | 1.5             | 1.6               | 2.3            | 2.0             |
| Cs             | 16           | 11.0        | 3.3             | 1.9               | 1.5            | 2.5             |
| Ge             | 1.5          | 2.0         | 1.1             | 1.1               | 1.2            | 1.3             |

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Figure 6. Selected chemical variation diagrams showing trace element trends for Siluro-Devonian and Permo-Carboniferous I- and S-type granites of the CYPB (Symbols as for Figure 2).
Figure 6. continued
the Siluro-Devonian S-type granites of the Lachlan Fold Belt and the Mesoproterozoic Forsayth Supersuite of the Georgetown Province, where high values are attributed to contributions from pelitic source rocks (Hine & others, 1978; Chappell and White, 1984; Champion, 1991).

Restite unmixing rather than crystal fractionation was probably the main control in the evolution of the granitic rocks of the Kintore Supersuite. Most have Rb values of, <300 ppm), although slightly elevated Rb values in two samples (452 and 441 ppm, respectively ) suggest a greater degree of crystal fractionation in these representatives of the McIlwraith and Kintore granites. U contents in these two rocks, 13 and 22.5 ppm, respectively, are also significantly higher than the other samples.

**BLUE MOUNTAINS SUPERSUITE**

SiO₂ in the granites of the Blue Mountains supersuite ranges from 60.4 to 77%, although the majority of samples have values between 66% and 76%. Most samples plot in the granodiorite and granite fields of the CaO-Na₂O-K₂O diagram (Fig 5). Trace elements, with the exception of Rb, Th, U, and Pb, tend to decrease with increasing SiO₂ content (Fig. 6), although Nb, Y, Cr, La, Ce, Nd, Pr, Sn and W have a wide range of values and no apparent systematic trends. K₂O increases up to about 73% SiO₂ and then sharply decreases with further increase in SiO₂. Two strongly porphyritic granodiorites have K₂O in excess of 6%.

The incompatibility of the trace elements Rb, Pb, U and Th is indicated by their strong increase with increasing SiO₂ content (Fig. 6). Rb increases from 102 to 368 ppm and Pb from 18 to 45 ppm. U and Th are high, ranging from 3 to 22 ppm and 10 to 86 ppm, respectively, and there is a
marked increase in both elements at SiO₂ greater than 70%. Apart from a single diorite sample, there is a strong negative correlation of Zr and SiO₂ (Fig. 6). Generally high Zr values (223 to 597 ppm), suggest A-type affinities. Ce and La range from 18 to 67 ppm and 8 to 99 ppm.

WEYMOUTH SUPERSUITE

Weymouth and Portland Roads granites

The intrusive rocks of the Weymouth and Portland Roads granites range widely in composition, with SiO₂ varying from 56.6% to 73.9%. AsI, K₂O, Rb, Th and Pb increase steadily with SiO₂, whereas TiO₂, Al₂O₃, P₂O₅, CaO, MgO, FeO(total), Nb, Sc and V decrease. Zr initially increases to about 67% SiO₂ and then steadily decreases. Similarly, Ba increases to about 65% SiO₂ and then decreases with increase in silica. These trends are consistent crystal fractionation, and a steady decrease K/Rb with increasing SiO₂ (Fig. 7), particularly in the more SiO₂-rich granites in which K/Rb ratios are as low as 123, suggests K-feldspar was a fractionating phase.

Wolverton-Twin Humps and unassigned granites

There are only single analyses of each of these three granites, so any conclusions are constrained by these limited data. The unassigned granite in the Wigan Adamellite area is geochemically very similar to granites of the Weymouth supersuite with similar SiO₂ contents, although on variation diagrams it mostly plots slightly away from the main trend. This is particularly so for Ce, La, and Nd which are significantly lower in the unassigned granite.

The Wolverton Adamellite, with a SiO₂ content of 76.5%, is the most fractionated rock of this study. It has low TiO₂, MgO, CaO and P₂O₅ and is strongly depleted in Ba and Sr. In contrast it is enriched in the incompatible LIL elements, Rb (892 ppm), Th, U, and Pb, as well as Li, Y, Sn, W and Ga (Table 2). Consistent with its fractionated character, the Wolverton Adamellite has higher K₂O (4.47%) than most other Permo-Carboniferous I-type granites of the Coen Inlier. However, K₂O is lower than those of the Twin Humps Adamellite and the Siluro-Devonian I-type Blue Mountains Adamellite. More evolved members of the Blue Mountains Adamellite also have geochemical trends (low Ba and Sr, high Rb and U) indicative of crystal fractionation, however, compared with the Wolverton Adamellite, they have very low Sn and W (<2 ppm versus 22 ppm, and 5 ppm versus 19 ppm, respectively).

The geochemistry of the Permo-Carboniferous Twin Humps Adamellite (based on one analysis) in the southern part of the COEN area is markedly different to coeval rocks to the north. It has lower Na₂O, Li, Rb, and U, and higher K₂O, La, Ce and Nd than the Weymouth, Wolverton and unassigned granites, and more closely resembles the Siluro-Devonian granites of the Blue Mountains Adamellite. More evolved members of the Blue Mountains Adamellite also have geochemical trends (low Ba and Sr, high Rb and U) indicative of crystal fractionation, however, compared with the Wolverton Adamellite, they have very low Sn and W (<2 ppm versus 22 ppm, and 5 ppm versus 19 ppm, respectively).

Unassigned diorites

SiO₂ in the gabbroic and dioritic rocks in the CAPE WEYMOUTH area ranges from 50.91 to 59.62%. Most show moderate to strong chloritic and sericitic alteration and pyrite is prominent in some samples. TiO₂ varies from 0.56 to 1.16%, FeO(total) from 7.12 to 8.95%, MgO from 8.16 to 1.43%, and CaO from 10.56 to 4.82%. Zr and Ga values are high in the most SiO₂-rich sample (641 ppm and 24 ppm, respectively). Although geochemical trends for the dioritic rocks on some variation diagrams are consistent with a crystal fractionation relationship with the more evolved granites of the Weymouth supersuite, conclusive evidence for this is lacking at this stage.
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$\varepsilon_{\text{Nd}} = \left( \frac{^{143}\text{Nd}/^{144}\text{Nd}_{\text{sample}}}{^{143}\text{Nd}/^{144}\text{Nd}_{\text{chondrite}}} \right) \times 10^4$

# TDM calculated following McCulloch (1987), in which the mantle depletion began at 2.7 Ga. Model ages are presented only for granites with $^{147}\text{Sm}/^{144}\text{Nd} = 0.11 \pm 0.001$. Samples with $^{147}\text{Sm}/^{144}\text{Nd}$ outside this range have been affected by crystal fractionation.

* At 300 Ma
Nd Isotope Results

Nd isotopic compositions of selected units in the CYPB distinguish the Siluro-Devonian and Permo-Carboniferous granitic rocks (Table 3). Some of the data have already been published in Black & others (1992). In the COEN and CAPE WEYMOUTH areas the Siluro-Devonian rocks have initial $\epsilon_{Nd}$ values (at 400 Ma) ranging from -10.0 to -14.3, whereas the Permo-Carboniferous rocks have higher initial values (at 300 Ma), in the range -5.1 to -8.4 (corresponding to -6.1 to -9.4 at 400 Ma). This characteristic has been used successfully to distinguish Siluro-Devonian granites from Permo-Carboniferous granites of the CYPB. Distinctions between the various Siluro-Devonian granites are less marked, although the I-type granites are mostly more radiogenic than the S-type. The I-type Blue Mountains suite rocks have initial $\epsilon_{Nd}$ values of -10.0 to -11.4 whereas values for the S-type granites range from -12.2 to -14.3. The lowest value of -14.3 was obtained for the sillimanite-garnet-muscovite granite in the McIlwraith Ranges, and contrasts with an average value of -12.3 (range -12.2 to -12.4) for other McIlwraith and Buten Buten granites. However, it is similar to other garnet-bearing Kintore Supersuite rocks in the EBAGOOLA area. The Lankelly Granite has initial $\epsilon_{Nd}$ averages -13.5, similar to values for the same unit in the EBAGOOLA area.

Both S- and I-type granites have similar $^{147}$Sm/$^{144}$Nd ratios (mostly 0.11 ± 0.01) due to light REE enrichment. An exception is the Wolverton Adamellite, which has a $^{141}$Sm/$^{144}$Nd ratio (0.2362) greater than chondritic value (0.1967). This sample is SiO$_2$-rich and has trace element concentrations indicating it is strongly fractionated. The high Sm/Nd ratio of this sample could result from fractionation of a light REE enriched mineral such as allanite (eg. Pimentel & Charnley, 1991).

Depleted mantle model ages (TDM, following McCulloch, 1987) calculated for granites with normal $^{147}$Sm/$^{144}$Nd of 0.11± 0.01, are 2100-1800 Ma for the Siluro-Devonian S-type granites, 1670-1800 Ma for the Siluro-Devonian I-type granites, and 1410 Ma (one sample only) for the Permo-Carboniferous I-type granites. Zircon (SHRIMP) U-Pb geochronology indicates the widespread presence of inherited zircon (cores) in the granites; these range in age from ~ 1450-1800 Ma, with a maximum at 1600 Ma, and a minor component at 2500 Ma. Inherited zircons are generally far more abundant in the S-type granites (Black & others, 1992). These data suggest variable amounts of Precambrian components in the source region for all CYPB magmas.

The transitional I- and S-type characteristics of the Morris Adamellite, as reflected in its mineralogy and geochemistry, are also shown by its $\epsilon_{Nd}$ value and model age. These data suggest the unit may have been derived from a mixed sedimentary and igneous source. The chemical and isotopic characteristics of most of the CYPB granites suggest a mixed igneous-sedimentary source, but in all cases other than the Morris Adamellite, either the igneous or sedimentary source component was strongly dominant.

EMPLACEMENT HISTORY AND SUMMARY

The Siluro-Devonian granitic units in the EBAGOOLA area were emplaced into an active sinistral transpressive tectonic regime (Blewett, 1992), and the presence of abundant migmatitic gneiss, granite containing abundant rafts of gneiss, and evidence of tectonic strain during granite emplacement all indicate syn-metamorphic magma generation at about 400 Ma (Mackenzie & Knutson, 1992).

Regional gravity anomalies and anomaly changes indicate that the Kintore supersuite granites in the eastern part of EBAGOOLA extend to a shallower depth than in the west. Similar data for COEN and CAPE WEYMOUTH suggest the McIlwraith granite extends to a shallower depth.
Figure 8. Simplified granite geology of COEN and CAPE WEYMOUTH showing Au and Sn prospects/mines and assessment of mineral potential of the CYPB.

relative to the Macrossan granite to the east and the Lankelly Granite to the south. The high-level emplacement of the Weymouth supersuite is indicated by its intrusion into broadly coeval rhyolites.

The I- and S- type classification of granitic rocks reflects variations in source-rock provenance and geological history (Chappell and White, 1974, 1984). With the possible exception of the more mafic rocks in the Cape Weymouth area, all the granitic rocks in the COEN and CAPE WEYMOUTH areas are predominantly of crustal derivation. Nd isotope data indicate source rocks have long crustal residence times, although there are significant differences between the Siluro-Devonian and Permo-Carboniferous, as well as I- and S-type granites. U-Pb zircon (SHRIMP) dating (Black & others, 1992) and Sm-Nd isotope studies indicate the Siluro-Devonian S-type granites were derived from a Precambrian sedimentary-dominated crustal protolith. Nd model ages for the Siluro-Devonian and Permo-Carboniferous I-type granites indicate they were probably both largely derived from underplated protoliths of Proterozoic age, as has been proposed for similar granites in the Georgetown region (Black & McCulloch, 1990).
The available U-Pb zircon (SHRIMP) geochronology indicates that both the Siluro-Devonian and Permo-Carboniferous magmatic episodes were relatively short lived. The range of ages for the Siluro-Devonian and Permo-Carboniferous components of the CYPB are 398±10 to 409±6 Ma and 284±4 to 287±8 Ma, respectively (Black & others, 1992). The close juxtaposition of both I- and S-type granites of essentially the same age indicates the tapping of source protoliths at different crustal levels.

Geochemical trends of the S-type granites show only minor evidence of crystal fractionation. Mostly variation diagrams show either a broad scatter, indicative of source heterogeneity, or the straight-line relationships indicative of compositional evolution being largely controlled by restite removal (Chappell and White, 1974, 1984). However, enrichment in Rb, Sn, W, and U, and decreasing Ba and K/Rb in S-type rocks with 70% SiO₂ indicate there was some late-stage fractional crystallisation in these more evolved rocks.

Crystal fractionation was more important in the evolution of the I-type Blue Mountains and Weymouth granites, and is particularly evident in rocks with 73% SiO₂ which show a marked increase in Rb, U and Th, and decrease in Ba, Sr, Ce and La. Geochemical data indicate that the Wolverton Adamellite is the most strongly fractionated of the analysed rocks (Table 2).

**MINERALISATION POTENTIAL**

The northern area of the Coen Inlier has a long history of small-scale Au and Sn mining and the distribution of these mines and prospects is shown on Figure 8. Most are located in the granitic rocks of the CYPB. There are major Au occurrences in the Sefton Metamorphics (Iron Range) and in the Coen Metamorphics in vicinity of Coen; however, in both instances granitic rocks with Au-bearing quartz veins are found in close proximity.

Blevin and Chappell (1992) noted in a study identifying the ore-element associations of granite-related ore deposits in virtually all eastern Australian Palaeozoic fold belts, that Sn mineralisation is commonly associated with S- and I-type granites that have undergone crystal fractionation and are reduced. They found also that Cu and Au are associated with magnetite and/or titanite-bearing, oxidised, intermediate I-type granitic rocks which are members of a crystal-fractionated suite. If these associations are generally valid (as studies elsewhere have suggested, for example, Lehmann, 1982, 1990; Lehmann, et al., 1990; Wyborn, et al., 1987; Champion, 1991; Wyborn, 1993; and Dall’Agnol, et al., 1993), then certain conclusions as to the mineral potential of the northern part of the CYPB can be drawn from our reconnaissance study.

The general absence in the northern part of the Coen Inlier of S-type granites with geochemical trends indicating prolonged fractional crystallisation limits the likelihood of associated Sn mineralisation. However, fractional crystallisation has played a greater role in the evolution of the Weymouth and Blue Mountains supersuite I-type granites, and alluvial Sn is closely associated with the Wolverton Adamellite, one of the more reduced and fractionated units of the former. Stream sediment geochemistry highlights a Sn anomaly radiating out from the Wolverton Adamellite (Fig. 9) reflecting the elevated Sn values in this unit (Table 2). A less marked anomaly to the north of Cape Weymouth reflects the slightly elevated Sn contents in the Weymouth Granite. The Blue Mountains supersuite, which hosts Au-bearing quartz veins in the Blue Mountains area, includes intermediate granitic rocks which typically contain magnetite and titanite, and in some of the most evolved granites pink feldspars are prominent. Au is also present in the Cape Weymouth and Leo Creek areas and intermediate I-type granites are present in both these areas. Stream sediment geochemistry for COEN and CAPE WEYMOUTH shows major gold anomalies in the
Cape Weymouth and Blue Mountains areas, as well as lesser anomalies in a number of other areas (based on digital data released in 1991 for the Coen Inlier north of 14°S).

The distribution of I- and S-type granites in the northern part of the Coen Inlier is shown in Figure 8, along with an assessment of their Au and Sn potential based on granite type, oxidation state and the relative importance of crystal fractionation processes. A limitation to this assessment is the absence of detailed mapping of individual granitic plutons. As crystal fractionation processes appear to have played a greater role in the evolution of both the Siluro-Devonian and Permo-Carboniferous I-type granites, these are generally considered to have a greater ore-mineral potential than CYPB S-type granites. In particular the strongly fractionated Sn-rich Wolverton Adamellite is considered to have high Sn potential. The geochemical characteristics of the Blue Mountains Adamellite and Weymouth supersuite, along with known gold occurrences and stream sediment anomalies, suggests these units have some Au potential. Regional 18O depletion, thought to be associated with epithermal gold mineralisation has been reported from Permo-Carboniferous volcanic rocks associated with the Weymouth Granite in the northern Coen Inlier (Ewers & Cruikshank, 1993).
Although Figure 8 suggests an association between Siluro-Devonian S-type granites and gold mineralisation, the distribution of this mineralisation is likely to be controlled by other factors, such as the presence of unmapped I-type granites and later shear zones. These I-type granites have been identified, particularly in the Wigan Adamellite and McIlwraith granite, but have not been mapped in detail. There is a close correlation between stream sediment Au anomalies and I-type granites of both Siluro-Devonian and Permo-Carboniferous age in the northern part of the CYPB. A scattering of Au-anomalies in some areas mapped as S-type granites also suggests the presence of intermediate I-type granites in these areas.

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