Mineral Provinces

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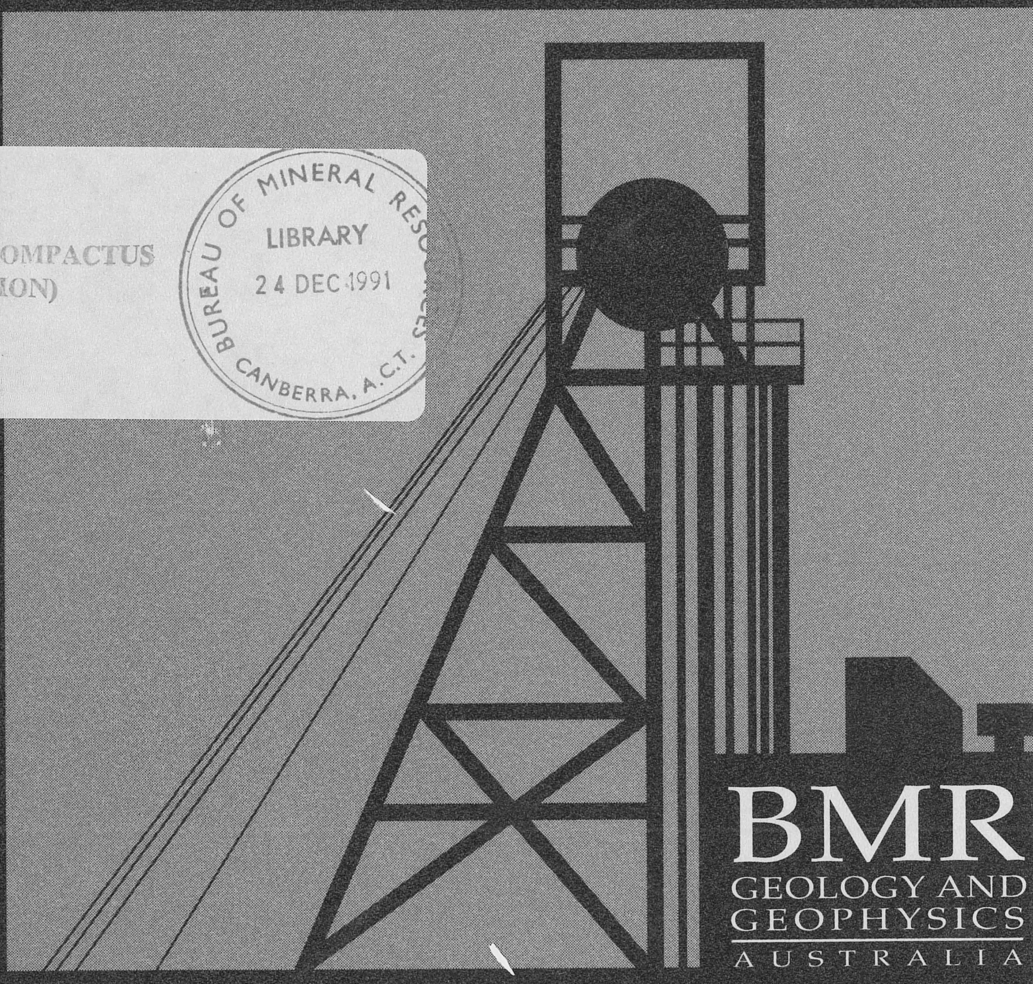
North Queensland Project 1990 Geological Reconnaissance of the Coen Inlier, Cape York Peninsula, Queensland
Record 1991/99

AUSTRALIA



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

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A Contribution to the National Geoscience Mapping Accord

DEPARTMENT OF RESOURCE INDUSTRIES

BMR GEOLOGY AND GEOPHYSICS AUSTRALIA

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D.S. Trail and R.S. Blewett

Geoscience for Australia's Future

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SUMMARY

This report describes the preliminary results of 1990 investigations into the structure of the metamorphic rocks in Cape York Peninsula by the North Queensland Project of the Commonwealth Bureau of Mineral Resources and the Queensland Department of Resource Industries. Other reports will cover regolith mapping, stream-sediment geochemistry, metallogenic mapping, granite petrology and geochemistry, and remote-sensing interpretation.

Access for vehicles throughout the northern Coen Inlier is restricted to tracks by dense vegetation. Access to some aboriginal land comprising the Lockhart River and Aurukun DOGIT areas, and Merapah Pastoral lease was not granted to members of the project. The Coen Metmorphics comprise gneiss, migmatite, schist, quartzite, amphibolite and calc-silicate rocks in the amphibolite facies of metamorphism. Prograde climax metamorphism was associated with D1. F1 folds are commonly tight to isoclinal, gently E- plunging, upright and have an axial-planar S1 schistosity. S1 is transposed by D2 to a NNW-trending sub-vertical orientation. F2 folds are upright, asymmetric and have variably plunging chevron- like hinge zones and a well developed, steeply dipping NNW to N-trending S2 crenulation cleavage. Retrogression is associated with M2 metamorphism. Structures parallel to D2 in the metamorphic rocks appear to overprint some Siluro-Devonian granites.

Some of the major ductile shear zones trending NNW have a spatial relationship with gold mineralisation. These en-echelon belts up to 3 km wide have well developed S-C mylonites, all with a sinistral west-over-east sense of shear. The mylonites dip steeply ENE and define oblique-slip normal shear zones. Stretching lineations on Samarium pitch moderately to steeply NNW. An L-S tectonic fabric is visible in rhyolite dykes along the Coen and Ebagoola Shear Zones; the dykes are also invaded by quartz veins and in one case overprinted by a crenulation cleavage parallel to S2 in the metamorphic rocks. The mylonites overprint granites that cross-cut S1, and are overprinted by a crenulation cleavage which is strongly transposed into mylonitization, suggesting maintenance of sinistral shearing with reduced dip-slip movement, and foliation progressively formed and deformed in an active shear zone.

Open to tight F3 folds are typically mesoscopic, upright and trend E-W to NE-SW. Rare low-angle F4 axial surfaces with a gentle easterly plunge overprint D3 structures.

The Archer River Shear Zone, a z-shaped sigmoidal extension of the Coen Shear Zone, is a sinistral transpressional jog, with conjugate quartz vein sets and horse-tail duplexes typical of strike-slip fault systems.

Gneiss and schist of granitic composition at Hull Creek resemble the Coen Metamorphics. Structures trend dominantly north-northeastward and the metamorphics are cut by undeformed basic dykes.

The Sefton Metamorphics at Mount Carter range from barely recrystallised low greenschist facies to high greenschist or amphibolite facies, in a large F2 synform. F1 folds are tight to isoclinal and plunge broadly eastwards; F2 folds are tight and strongly asymmetric, and trend between north and northwest. F3 folds are asymmetric kink folds plunging northeast or southwest.

***Footnote*:**

D — deformation	1, 2, 3 etc.—deformation events, chronological order
F — folding	M — mylonite
S — schistosity	S–C — S — foliation, C — shear plane
C — shear plane	L–S —S — foliation, L — lineation

The Sefton Metamorphics at Iron Range are deeply weathered and poorly exposed. In the west, slightly recrystallised quartzite, argillite and metagreywacke include metaconglomerate derived from granite, and thin-bedded quartzite alternates with marble. Fold axes and lineations plunge northwest and southeast, but the predominantly northeasterly strike of S1 foliation suggest re -folding on north or northeast-trending axes. The previously mapped greenstone is poorly exposed, and contains both acid igneous rocks and calcareous sediments.

Gold mineralisation at Iron Range may be strata-bound. The hematite and manganese-bearing schist sequence has been interpreted as partly exhalative by Teluk (1984). Sulphide (-quartz) vein breccias of possible epigenetic origin also contain some gold, and normal and reverse strike-faulting are identified with mineralisation. Recent exploration has not repeated discoveries of the rich lodes worked between 1935 and 1942, and these may have been products of near-surface enrichment. Small quantites of gold were also mined from Early Permian granite at Scrubby Creek near Iron Range.

The Holroyd Metamorphics are cut by a major ductile shear zone with the same sinistral west-over-east sense found in the Ebagoola and Coen Shear Zones. A marked westward decrease in metamorphic grade across the zone confirms it as a post-metamorphic feature. S1 and S2 cleavages were recognised in indrated sedimentary rocks; some beds are inverted. A quartzite associated with greenstone contains spherules which may represent tektites. Saccharoidal quartzites define macroscopic F2 folds.

S1, the dominant foliation, is refolded about tight to isoclinal NNW to N-trending F2 axes. Syn-D1 garnet is rotated; muscovite and biotite define S1 and are overprinted by S2 crenulation cleavage. Three phases of deformations are visible in the 20-km long macroscopic fold patterns of the greenstone, quartzite and schist. The D1 sheet strike is E-W and is isoclinally folded about N-S F2 axes, which are refolded about open NE-trending folds, consistent with patterns of deformation over a distance of 250 km northwards.

The established structural history suggests that the second phase of deformation of the metamorphics may have affected both Siluro-Devonian granites, and rhyolite dykes previously thought to be Permian. If the metamorphic rocks are Precambrian, then either they were not significantly deformed until early to middle Paleozoic times, or an interval of at least several hundred million years intervened between the first and second phases of deformation.

The Sefton Metamorphics, or a part of them, may be distinctly younger than the other metamorphic units, and represent sediments accreted to the Australian continent during a Siluro-Devonian episode of subduction which also generated granitoids. However, this unit contains banded iron formation, which is typically Precambrian, and the deformation history of all three metamorphic units is similar. Further study is needed to clarify the early geological history, careful sampling for zircons should be done in any acid volcanic rocks found in the metamorphic sequences.

The Lockhart River DOGIT and adjacent area are prospective for gold, and a systematic resource assessment of this region should be completed for the benefit of the aboriginal community.

INTRODUCTION

The North Queensland Project was formed as a collaborative effort between the Minerals and Land Use Program of the Commonwealth Bureau of Mineral Resources, and the Geological Survey Program of the Department of Resource Industries, Queensland. The primary aim of this project is to expand and consolidate the geoscientific knowledge base for North Queensland in terms of maps and integrated data sets. It will also contribute to the proposed Commonwealth/Queensland Government study of Cape York Peninsula land use (CYPLUS).

Mounting land-use pressure from National Parks, aboriginal land claims, mineral and oil exploration, and proposed developments for tourist facilities, a large defence airstrip and a spaceport, is impinging mainly on the northern half of the Coen Inlier (Figure 1). Consequently the reconnaissance field investigations undertaken between 1 July and 30 September, 1990 were concentrated there, in the Coen and Cape Weymouth 1:250 000 sheet areas.

Disciplines involved in the reconnaissance were basement geology, regolith mapping, stream-sediment geochemistry, metallogenic mapping and remote sensing interpretation. A base camp with support facilities to accommodate 30 persons was constructed in the Coen 1:250 000 sheet area on Peach Creek near the Peninsula Development Road crossing of the Archer River. Data were gathered by up to 12 traverse parties. Each party generally consisted of one scientist or technician and one field assistant travelling together in a four-wheel-drive vehicle, working out of the base camp each week on traverses of about 5 days duration.

At least half a day's travel was required to reach the central and northern parts of the Cape Weymouth 1:250 000 sheet area. Consequently a small fly camp was established for ten days in the central part of the Cape Weymouth sheet area, in an abandoned mining camp, resulting in a considerable increase in efficiency and decrease in travel time for geoscientists working around Iron Range. Fly camps of this type would be an advantage in any similarly remote, complex area.

Access

Access for vehicles throughout the entire region investigated in 1990 was restricted by dense vegetation and was considerably more difficult in the north and east. In the rain forest around Iron Range, and in most other places in the Coen Inlier within the Cape Weymouth 1:250 000 sheet area it is effectively impossible to use vehicles away from existing tracks. Within the Coen 1:250 000 sheet area off-track travel by 4-wheel drive vehicle is very slow and commonly results in tyre and body damage. Access therefore depends largely on the presence of tracks, which are more common in the less densely vegetated southern and western parts of the area investigated. The distribution of trafficable tracks found in 1990 is shown in Figure 2.

Because of a lack of tracks the northern part of the Coen 1:250 000 sheet area is particularly difficult to access by vehicle; two examples, Mount Carter and the headwaters of Hull Creek (Figure 4) are discussed below. The headwaters of the Wenlock River, between these two, is a third area into which a track may have to be prepared.

The belt of metamorphic rocks east of Hull Creek, in the north-central part of the Coen 1:250 000 sheet area, forms a ridge trending north-northeast between Falloch Creek and Mount Carter. The complete absence of tracks between Falloch Creek and Mount Carter, and dense vegetation together make access very difficult. In the first-pass BMR/GSQ geological survey of the Coen 1:250 000 area in 1967, a single six-day traverse of the southern part of the belt was made using pack-horses, and the northern end of the belt was visited by helicopter.

In 1990 two attempts were made to access the southern part of the belt by four-wheel drive vehicle, resulting in some damage to tyres and bodywork; about 10 km of the 30 km length of the belt was covered, terminating at the southern boundary of the Lockhart River DOGIT (Deed of Grant in Trust) area. To facilitate future access to this area for the several multi-disciplinary teams which require to visit it, a rough track should be prepared in advance extending from the Buthen-Buthen road south of Falloch Creek to a suitable camp site from which the area can be properly covered by parties working on foot.

The large massif of Mount Carter on the northern margin of the Coen 1:250 000 sheet area reaches an altitude of only 665m, but is one of the least accessible parts of this difficult sheet area. The mountain was largely mapped in 1967 by using a light helicopter to position and recover geologists on walking traverses of one to three days duration.

The mountain can be reached by a little used track which branches southwards from the main Wenlock/Portland Roads track 3.2km east of the Wenlock River crossing, and runs for 25km to an abandoned outstation of the Lockhart River Community, in the headwaters of Sefton Creek. With some difficulty a short-wheelbase four-wheel drive vehicle may be driven across country a further five kilometres eastward to the foot of the long south west ridge of Mount Carter, and the base of the mountain may be followed eastward by vehicle for at least another seven kilometres, along the south side of Sefton Creek.

Access can also be gained to the lower reaches of an unnamed tributary of the Lockhart River which rises on the northeast spur of Mount Carter and has cut deeply into the bench which lies between the eastern foot of the mountain and the top of the escarpment forming the western side of the Lockhart River valley. At the foot of the escarpment this tributary is crossed by a good track which runs from the Lockhart River Community settlement to the community outstation at Nundah, in the Lockhart River valley.

Although the bed of the tributary is covered by thick sand, steep side-streams which fall into it from the above bench display good exposures of the metamorphic rocks extending northeastwards from Mount Carter. However, the tributary traverses about 10 km of rough densely timbered country, which must be covered on foot, between the track and the northeast spur of Mount Carter proper.

The two points of access described above, respectively to the western and eastern slopes of the mountain, are 20km apart. No other suitable tracks were found in 1990, but a company report on a search for uranium in the early eighties records the making of a track from Sefton Creek near the Lockhart River Community outstation, northeastwards into the headwaters of the Pascoe River. This track should be sought out and improved to give useful access to the northwestern part of Mount Carter.

Access could also be gained by extending a rough track along the southern flank of the mountain from the end of the track along Sefton Creek, so that parties may work on foot from several suitable camp sites in the upper reaches of this creek. Parties may also be positioned by helicopter at a few other sites on the mountain, as in 1967, but a helicopter reconnaissance would first be needed to locate suitable landing sites.

Access to some aboriginal land was denied to the Project, principally to the Aurukun DOGIT (Deed of Grant in Trust) Lands, to Merapah Pastoral Lease, which is held by an aboriginal group, and to the Lockhart River DOGIT pending the decision of the community on project access. A high degree of co-operation was achieved with aboriginal elder Thomas Creek of Coen, who guided project members in the McIlwraith Range and freely supplied other valuable information. Gerry Pascoe and Rex Moses of the Lockhart River Community also provided much useful information on traditional landholding, as did Margaret Sellars of Coen. Isaac Hobson and his Council and office staff at the Lockhart River Community, particularly Calvin Hastie, willingly and amicably discussed the access problems whenever requested and maintained good relations and open communication with the project throughout the field season.

Airphotos, Base Maps & Positioning Systems

RC 9 air photographs at approximately 1:85 000 scale taken during the period 1969 to 1974, were used for route-finding and plotting. The 1:100 000 topographic maps made from these airphotos by the Royal Australian Survey Corps and published in the years 1981 and 1982 were used both as base maps and for position-finding in conjunction with the hand-held Magellan Nav 1000 Pro Global Positioning System.

The Magellan GPS system, which uses navigational satellites for position-finding, was of very limited use in 1990 during daylight hours when few satellites were available, but improved during the hours of darkness and gave very accurate results in 2-dimensional mode. In 3-dimensional mode altitudes provided by the system differed in some places by between 50 and 100 m from estimated altitude and, even allowing for an abnormally large geoid/spheroid separations (up to 40m), were clearly inaccurate. Dense forest canopy also inhibited or severely restricted the use of the Magellan System. As daytime navigational-satellite coverage has reportedly improved for the Australian region since 1990, Global Positioning Systems will again be used for position and route finding during 1991.

A set of 270 coloured airphotos at 1:20 000 scale, covering the Coen and Hamilton (Ebagoola) Goldfields and taken in 1986 by QASCO for Saracen Minerals N.L., was purchased to facilitate 1:100 000 structural mapping of the goldfields. Owing to high sun-angle these photos are of limited use for geological interpretation but were very valuable for positioning and navigation.

Acknowledgments

Ross Pope of Portland Roads was of great assistance to the Project in guiding members to old mines, providing transportation to Cape Griffith and communicating a great deal of valuable information. Bill Jackson of Wolverton Holding generously allowed the project to set up a large base camp on his land and provided much valuable information. Information was also supplied by:

Kevin Jackson, Paddy Shepherd, Barry Shepherd, Herb Hughes, Ted Youngman, Mia Lennon, Des Taylor, Jim Quinn, and Rob Evans. Rhys Gardiner, consulting geologist of Coen, enthusiastically discussed aspects of the local geology with us on several occasions, and provided other assistance.

As mentioned above, a great deal of valuable information and guidance was provided by aboriginal elders Thomas Creek of Coen and Gerry Pascoe of Lockhart River.

RESULTS

Results of regolith mapping, being prepared by the BMR Regolith Group, and of the stream-sediment geochemistry survey (Cruikshank, in prep.) will be described elsewhere; both covered the Coen Inlier north of latitude 15 degrees South, with reconnaissance traverses to Bamaga and Weipa. A systematic investigation of the structure and rocks of the Coen Metamorphics, including a 1:100 000 geological map, covering between 2500 and 3000 sq km along the Coen Shear Zone in the Coen and Hamilton Gold fields, has been reported separately by Blewett and von Gnielinski (1991a,b); a summary of some results of this work is given below. Knutson (in prep.) will present the results of 1990 geochemical and petrological investigations of the granitic rocks of the northern Coen Inlier, and Black (in prep.) will provide the latest results from isotopic dating.

The results of 1990 reconnaissance work in basement geology presented here are (Figures 3 & 4):

- a summary of structural and other observations made in the Coen Metamorphics
- preliminary investigation of the Iron Range district (including the Claudie River Gold and Mineral Field), combined with exploration-company data
- reconnaissance traverses in remote parts of the northern Coen Inlier such as Mount Carter, Hull Creek, and the Mullumbidgee gold prospect
- reconnaissance of Archer River Shear Zone, and of the Holroyd Metamorphics in the Ebagoola 1:250 000 sheet area.

Brief visits were also made for familiarisation to the Carboniferous and Permian sedimentary, volcanic and granitic rocks which form the northernmost part of the Coen Inlier in the Cape Weymouth 1:250 000 area, but only the granitic rocks (Knutson, in prep.) were sampled and investigated in any detail.

Coen Metamorphics

A more detailed appraisal of the Coen Metamorphics may be found in Blewett and von Gnielinski (1991b), which relates to the new 1:100 000 mapping of the central belt of the Coen Metamorphics around, and to the south of Coen.

The Coen Metamorphics are divided into a number of partly gradational rock types. In order of abundance these are:

- muscovite-biotite-quartz schist
- (± sillimanite)-muscovite (± biotite)-quartz schist
- quartz-feldspar-biotite gneiss
- (± garnet) (± sillimanite)-biotite-quartz-feldspar gneiss
- quartzite
- amphibolite
- calc-silicate schist

Gneiss

Gneiss crops out over 300 km^2, in three main NNW-SSE elongate zones within the central Coen metamorphic belt (Figure 3). It is also intimately interleaved with schist and to a lesser extent quartzite of the Coen Metamorphics in other parts of the belt and within the dominantly gneissic areas. Gneiss also crops out among the granites, commonly as thin screens 10 to 30 metres wide.

The strong gneissic layering is predominantly NW-SE trending and consists of quartzo-feldspathic layers with or without garnet and sillimanite, alternating with layers of biotite with or without garnet and opaques. Garnet is not developed across the area regionally; kyanite occurs locally, a mineral not previously recorded (cf. Willmott and others 1973). Layering is commonly 1-2 cm thick and is generally continuous, although shearing (mylonitization), folding and transposition disrupt it. Micas are aligned parallel to and partly define the gneissic layering.

The grainsize is generally medium to coarse and even, though aggregates (augen) of undulose quartz and sericitized feldspar are common. Garnets are colourless to light pink, and generally 1mm in diameter. Biotite is commonly overgrown by chlorite. Other secondary minerals include epidote and opaques which are associated with the biotite melanosome. Accessory minerals include monazite, zircon, apatite, sphene and opaque minerals. Sillimanite is mostly altered to muscovite and near the Coen Shear Zone on Station Creek andalusite was recorded with well developed chiastolite crosses.

The leucosome component is granitic in composition. Apophyses of granite-pegmatite from layer-parallel leucosome show that there is an intrusive source for at least some of the gneissic protolith and suggest a later granitic addition to the gneiss. The pegmatites are typically lacking in biotite and show a higher muscovite content.

Along the Coen River crossing of the old Coen/Polappa road, pegmatite sweats derived from migmatization transect amphibolite pods and overprint the gneissic layering. The migmatites and associated pegmatite sweats are overprinted by the Kintore Adamellite at this locality, and by aplites at others, suggesting that at least some phases of the Cape York Peninsula Batholith are post metamorphic-climax. Some granitic leucosome pods have phyllosilicates enveloping the leucosome, rather than being overprinted by the pods. The gneiss is often associated with sillimanite schist and is possibly gradational into the latter. The trends of S_1 in both the closely associated schists and regional patterns are usually parallel to that of the gneissic layering. The gneissic layering trends NW to NNW and dips steeply, as does S_1.

Schist

Biotite-muscovite-(sillimanite-)quartz schist comprises most of the Coen Metamorphics; it is silvery grey where fresh but is commonly deeply weathered and purple-brown. The schist is generally fine-grained, locally medium-grained, and has a strong penetrative schistosity, commonly with one or two generations of crenulation cleavage.

The schist defines the outer edge of the belt of metamorphic rocks and is juxtaposed with the Kintore Adamellite to the west by the Ebagoola Shear Zone and with the Lankelly Adamellite to the east by the Coen Shear Zone. Sillimanite is common (mostly pseudomorphed by muscovite) as fine needles or bunches of needles, and may have a strong preferred alignment. Sillimanite is a D_1 mineral as it is found within the S_1 schistosity and over printed by the S_2 crenulation cleavage. Graphitic shears are common within the schists; many are exposed in exploration costeans.

Muscovite pseudomorphs of sillimanite and chloritization of biotite are common in thin section. Occasional cores of sillimanite are preserved. Quartz is generally strained and/or recrystallized. Less common are garnet, plagioclase, potash feldspar and opaque minerals.

Quartzite

Quartzites are less common in the Coen Metamorphics than in the lower grade Holroyd Metamorphics (Willmott and others 1973) to the SW. They comprise grey to white, saccharoidal, medium-grained quartzites that crop out as narrow (5m) ridges within the schists and more locally the gneisses. Muscovite is commonly associated with the quartzite and defines metamorphic foliations.

The quartzite ridges have strike lengths up to 5 km (NNW- trending) and show no evidence for macroscopic fold closures (unlike the ridges in the Holroyd Metamorphics to the SW). The thickness of most quartzite beds precludes their discrimination on the 1:100 000 scale map, although a quartzite ridge is mapped through Mount Ryan.

Amphibolite

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

Calc-silicate rocks

Calc-silicate rocks recorded by company geologists and in Willmott and others (1973), are recessive. There are large out crops to the NE of the study area around the headwaters of the Peach Creek according to Willmott and others (1973). Calc-silicate rocks were also noted in the Macrossan Range (grid ref 7676.85237), about 10km northwest of Mullumbidgee (Figure 4), in 1990 by Dr. J. Knutson (pers. comm.).

Structure

This section provides a summary of 1990 investigations into the structure of the Coen Inlier. A schematic sketch of fabric elements for the inlier is given in Figure 5.

In the main outcrop of the Coen Metamporphics, extending from the Coen to the Hamilton (Ebagoola) Goldfield, F_1 folds are commonly tight to isoclinal, gently NW-plunging, upright and have an axial planar S_1 schistosity with local associated shallow lineations. In many areas, S_1 is transposed by D_2 to a NNW- trending sub-vertical orientation.

Prograde metamorphic climax is associated with D_1, shown by common sillimanite and local kyanite. The sillimanite is largely pseudomorphed by muscovite.

F_2 folds are upright, asymmetric, have variably plunging chevron-like hinge zones and a well developed steeply-dipping NNW to N-trending S_2 crenulation cleavage (Figure 5, B & D). Mesoscopic folds are common; in contrast to the Holroyd and Sefton Metamorphics, macroscopic folds are rare. These plunge gently and have large amplitude to wavelength ratios. D_2 structures appear to overprint some of the granites of the Cape York Peninsula Batholith. Retrogression is associated with M_2 metamorphism.

Major ductile shear zones that trend just north of NNW are common in the Coen Inlier; many of them have a spatial relationship with gold mineralization. For example the Coen Shear Zone (CSZ), and associated Archer River Shear Zone (ARSZ, Figures 3, 4) have a combined strike length of 150 km, and a number of old workings lie along or adjacent to this structure. The 100 km long Ebagoola Shear Zone (ESZ) also hosts a number of gold workings. A well developed restraining bend and strike-slip duplex is developed north of the Archer River. The BMR 1990 aeromagnetic survey defines the western edge of the Coen Inlier and shows that the shear zones are truncated against a N-trending, magnetically featureless area, that is interpreted as granite.

These shear zones are discrete en-échelon belts up to 3 km wide, and have well developed C-S mylonites (Figure 5 E & F) all of which display a sinistral west-over-east sense of shear. Mylonites dip steeply, on average to ENE (86^{0} to 067), and presently define oblique-slip normal shear zones. Stretching lineations on S_m pitch moderately to steeply NNW (average 65^{0} to 333).

An intense L-S tectonite fabric (D_m) is visible in many steeply-dipping rhyolite dykes along the Coen Shear Zone and Ebagoola Shear Zone. These are commonly invaded by sub-parallel steeply-dipping quartz veins and a costean SW of Coen reveals a quartz vein and rhyolite dyke that are F_2 folded and overprinted by S_2. This demonstrates that the quartz veins of at least one generation are not simple linear bodies, but are complexly folded.

Most of the shear zones appear, however, to be rectilinear (a function of post-D_2 reactivation) and the mylonitic foliation is locally a composite of at least two generations of movement (all sinistral west-over-east). The timing of shear-zone development is post-D_1 because mylonites overprint granites that cross-cut S_1 (Figure 5 D). Mylonites are also clearly overprinted by a N-S trending S_2? crenulation cleavage with an S-shaped asymmetry viewed north (Figure 5 E). This crenulation of 'S_{m1}' is itself strongly transposed into a second generation of myloniti zation with a sinistral sense of shear. The S-shaped asymmetry and steep plunge of F_{2m} folds (Figure 5 E) suggest maintenance of the sinistral shearing with reduced dip-slip movement. They also point to progressive deformation, where foliations were formed and were being deformed within an active shear zone.

Open to tight F_3 folds and a less well developed S_3 crenulation cleavage are common in the Holroyd and Sefton Metamorphics and to a lesser extent in the "shearing dominated" Coen Metamorphics. These are typically mesoscopic, upright, E-W to NE- SW trending structures (Figure 5 C). Rare low-angle F_4 axial surfaces with shallow E plunges overprint D_3 structures.

Metamorphism

The metamorphic grade is relatively constant in the Coen Metamorphics with sillimanite as a common mineral in schist and gneiss. Some gneiss is also garnet-sillimanite rich. The presence of migmatite and melts along the Coen River is consistent with the upper amphibolite facies reported by Willmott and others (1973).

Kyanite is also recorded at the southern tip of outcrop of the Coen Metamorphics, as waxy blue blades 8-10 cm long and 0.5 cm wide, pitching steeply within the gneissic foliation. The kyanite is pseudomorphed by muscovite.

The granites (eg. Kintore Adamellite) cut the gneissic layering which is partly defined by aligned sillimanite needles, implying that much of the granite emplacement was post-metamorphic climax.

Sillimanite porphyroblasts occur as bunches generally 1-2 cm long and are overprinted by the S_2 crenulation cleavage (Figure 5 A) and contained by the S_1 schistosity. The acicular habit occasionally shows a strongly preferred orientation (L_{11}). Sillimanite is generally pseudomorphed by muscovite in bunches several centimetres long and little fresh sillimanite is visible in thin section.

Garnet is unevenly distributed and may constitute up to 20% of the gneiss. Garnet also overgrows the gneissic layering (melanosome/leucosome) suggesting that climax metamorphism and development of gneissic layering are not coeval. Extensional shear bands also overprint the garnets. The garnets are generally less than 0.5 cm in diameter, but are locally up to 2 cm in diameter.

?Coen Metamorphics - Other Outcrops

Scattered outcrops of poorly exposed Coen Metamorphics crop out to the east of the Great Dividing Range, where BMR's 1990 aeromagnetic survey of the Ebagoola 1:250,000 sheet area, at 400m line spacing, reveals a NNW-trending linear belt up to 18 km in width that extends from top to bottom of the Ebagoola 1:250 000 sheet. The western margin of this belt may be an extension of the Coen Shear Zone, giving the fault a combined strike length of over 200 km. Due east of Yarraden Station the belt swings to a NNE orientation, while linear features trend NNW, subparallel to the belt strike. In this region of NNE strikes, small offsets (1km) of the NE-trending lineaments occur. There appear to be NW- SE sinistral faults to the north and along strike from a mapped splay of the Coen Shear Zone. The faults in the south are principally E-W trending and have dextral offsets.

Minor outcrops of gneiss and schist, interpreted as Coen Metamorphics, were recorded in the headwaters of Wrights Creek, a tributary of Geikie (or Hull) Creek, in the southwestern part of the Lockhart River 1:100 000 sheet (7571). These may be part of a more extensive belt of gneiss that correlates or connects with similar rocks in the southern tip of the Hull Creek block (Figure 4). The Wrights Creek rocks were initially mapped as Holroyd Metamorphics, while the Hull Creek rocks were considered to be Sefton Metamorphics by Willmott and others (1973). Small boulders of polydeformed gneiss in Peach Creek west of Birthday Mountain, may be from the Coen Metamorphics.

Archer River Shear Zone

The Archer River Shear Zone (ARSZ, Figure 4) received a short visit in the 1990 field season to determine whether the shear sense was consistent with the Coen Shear Zone. The area visited included the water-washed exposures of Hull Creek (incorrectly shown on the 1:100 000 topographical map as Geikie Creek, see Figure 4), Granite or Tin Creek and the area north towards Bald Mountain. Access was aided by numerous exploration tracks (Figure 2), many over five years old, although mapping of these was time consuming.

The existing 1:250 000 geological map for Coen shows the Archer River Shear Zone to juxtapose Holroyd Metamorphics and Kintore, Morris and Wolverton Adamellite. The short visit confirmed this but recognised that there were probably also other types of granite present. One of the granites recorded a consistently high magnetic susceptibility reading of 2500 SI units, with magnetite visible in thin section. Coen Metamorphics were also recognised in place of the Holroyd Metamorphics shown on the geological map, near the scheelite deposits of Wrights Creek (Willett, 1979).

The Archer River Shear Zone forms a Z-shaped sigmoidal extension of the Coen Shear Zone, and is dominated by brittle quartz veins. Mylonites (described above) show two distinct movements although these are considered to be the result of progressive shearing. Stretching lineations on the mylonites indicate principally dip-slip movement with west-over-east sense. The horizontal plane indicates a sinistral component, consistent with the Coen Shear Zone, and the Archer River Shear Zone has the geometry of a sinistral transpressional jog.

The quartz veins define sharp airphoto lineaments, are up to 5 m wide (in float), dip steeply and trend N-S to NNE-SSW. Conjugate vein sets and horsetail duplexes typical of strike-slip fault systems (Price and Cosgrove, 1990) occur. The area would be suitable for a detailed study of palaeostress; a cursory investigation suggests ^{1} was oriented just west of north during quartz vein formation.

Hull Creek

Trail and others (1969) describe the belt of metamorphic rocks on the eastern side of Hull Creek (Figure 4) as undifferentiated rocks within the Sefton Metamorphics, composed dominantly of muscovite-quartz schist and quartzite with biotite-bearing rocks in places. They describe sillimanite pseudomorphs and muscovite porphyroblasts with no preferred orientation from the muscovite-quartz schist, and state that biotite-quartz-feldspar gneiss occurs in various bodies of undifferentiated Sefton Metamorphics near contacts with granitic rocks. They also note some amphibolite in the metamorphics. Trail and others (1969) believed that the muscovite-quartz schist and quartzite at the northern end of the belt are continuous with schist and quartzite at Mount Carter.

Traverses made (also by Trail) in 1990 in the southern part of the belt, record medium to coarse-grained muscovite-biotite- quartz-feldspar gneiss, which grades into foliated granitic rocks towards the eastern side of the belt. Samples collected in 1990 (90831047, 90831049) and a re-examination of thin sections cut in 1967, reveal that the gneiss and schist generally have a granitic composition, although mica quartzites also occur within them. In the granitic gneiss and schist, quartz, usually coarse and granular, is the dominant mineral; feldspar, locally identified as microcline or plagioclase (?oligoclase), is common only in a few sections, and can be seen in some to be largely altered to muscovite. Muscovite and biotite generally occur together; in the schist and gneiss they form bands in which the micas are generally aligned parallel to the margins: in some a few well formed crystals of muscovite cut across the bands.

Several mafic dykes in the metamorphics strike due east and range up to 5m in thickness. Although the dykes are not evidently deformed they may be metamorphosed, as some of them are hornblende-quartz rocks in which an ophitic texture is preserved; in others plagioclase is the most abundant mineral with quartz only locally developed, but again with amphibole replacing pyroxene in an ophitic texture.

The metamorphic rocks of the Hull Creek belt resemble more closely the coarse schist and gneiss of the Coen Metamorphics than the fine-grained schist and phyllite of the Sefton Metamorphics, as described by Willmott and others (1973). It is also possible that the gneiss and schist at Hull Creek are largely deformed granitic rocks. However, the northern part of the Hull Creek belt must be re-visited to test the possibility of continuity with the low-grade Sefton Metamorphics at Mount Carter, as proposed by Trail and others (1969).

The north to northeast strike of the predominant foliation in the metamorphics at Hull Creek is generally concordant with the strike prevailing in the eastern part of the Mount Carter massif. A stereographic plot of about 50 observations of folia tion from the Hull Creek area (Figure 6) reveals a strike largely between north-northwest and northeast, and moderate to steep dips to both west and east. The few fold axes and lineations recorded plunge moderately to gently south-southwestwards, parallel to the elongation of the Hull Creek ridge. S_1 was not distiniguished from S_0 in the field. They are probably parallel and both lie along a girdle whose pole is defined by the fold axes trending north-northeast and south-southwest, consistent with the trends of F_2 folds in other parts of the Coen Inlier (Blewett & von Gnielinski, 1991a,b). Although D_2 appears to affect the Siluro- Devonian granitic rocks, there is a possibility that these gneissic rocks represent an earlier, perhaps

Precambrian generation of granite, and they should be sampled for U/Pb dating of zircons in future field seasons.

The planned airborne magnetic and radiometric survey of the Coen 1:250 000 sheet area will also help with the mapping and correlation of this and other isolated bodies of metamorphics in the central part of the Coen 1:250 000 sheet (SD54/08), where large areas of Tertiary "cover" mapped in the 1960s have recently been recognised as only thin sand, by the BMR Regolith Group (C.F. Pain, pers. comm., 1990).

Sefton Metamorphics

The Sefton Metamorphics (Willmott & others, 1973) comprise the low-grade metamorphic rocks which crop out in the Cape Weymouth and the northern part of the Coen 1:250 000 sheet areas (Figure 3). In 1990 several short traverses were made on the southern slopes of Mount Carter (Figure 4), a massif of Sefton Metamorphics on the northern margin of the Coen sheet area. Many short traverses were also undertaken in the Iron Range area (Figure 4), where the Sefton Metamorphics crop out over a wide area but are generally poorly exposed.

Mount Carter

The mountain lies wholly within the Lockhart River DOGIT area, and reconnaissance traverses on and around it in 1990 were carried out before approval for fieldwork in the DOGIT was withdrawn.

Several short traverses were undertaken in 1990 in the southwestern part of Mt Carter, adjacent to Sefton Creek. In Sefton Creek itself, rocks of low metamorphic grade crop out, typically light green-grey, fine-grained banded quartzite inter layered with thin layers of dark grey, graphitic and micaceous argillite, which has a phyllitic appearance where muscovite is abundant; millimetre-scale laminae of sand are common in the argillite. Medium-grained metagreywacke with lithic grains occurs in places; layering in all rock types is generally no more than a few centimetres thick. In lithology, degree of deformation and metamorphic grade, these rocks distinctly resemble the low-grade metamorphics exposed along the West Claudie River in the Iron Range area (Figure 4 & see below).

Two thin sections of rocks from Sefton Creek are a phyllitic muscovite-biotite quartzite (90831005) and a graphite-biotite- muscovite-quartz phyllite (90831006). In both rocks the quartz grains are only roughly sutured and are incompletely recrystallised. Thin (1-3mm) beds (S_0) within both sections are characterised by quartz grains of a particular size (variously fine, medium or coarse), containing abundant well formed laths of biotite and muscovite with a strong preferred orientation either parallel to or at angles up to 30 degrees from the quartz layers; the latter may represent an S_1 cleavage. In the phyllite some layers are up to 80% mica and a few dark bands have anastomosing webs of graphite, also broadly parallel to the micas. The anastomosing graphite flakes probably reflect a fold pattern, and some of the muscovite in the phyllite is tightly kinked; these kinks are not evident in hand-specimen.

A basic dyke (90831026) in these low-grade rocks is an ophitic aggregate of fresh but ragged plagioclase (andesine?) and uralite.

In the northern tributaries of Sefton Creek, the argillite is replaced by a thick fine to medium-grained schist or phyllite, dominantly composed of muscovite with some quartz, and containing concordant layers of massive quartz up to a few centimetres thick. Four thin sections of these rocks (90831022, 90831023, 90831024, 90831028) are composed dominantly of well sutured, completely recrystallised quartz. In one (90831028) the quartz is strongly deformed and locally well oriented; abundant, small laths of muscovite parallel the quartz orientation, and discontinuous bands and schlieren of muscovite with chlorite or biotite are in several places disrupted by folding or shearing.

The remaining three contain a mineral identified as andalusite in the 1967 survey, but which may be colourless chloritoid or an amphibole such as gedrite. A Laser-Raman microprobe examination gave a pattern incompatible with andalusite (T.P. Mernagh, BMR, pers. comm., 1991). This mineral forms large and small prisms in both the quartz and in bands of muscovite; both the muscovite and the unknown mineral generally have the same preferred orientation, though the muscovite layers are kinked in 90831022. Small basal sections of tourmaline are evident in this section and 90831023.

In the argillite and quartzite of Sefton Creek, bedding is clearly recognisable, cut by at least one and possibly two cleavages. The bedding dips moderately to steeply either to the northeast and east or to the southwest and west, and is clearly folded; locally the quartzite layers are broken into boudins.

In the phyllite exposed to the north, the structure is more complex. F_1 folds of bedding are tight, isoclinal and commonly transposed. F_2 folds are strongly asymmetric and tight. F_3 folds are identified as spaced, z-asymmetric kink folds with a gentle plunge and a steep axial surface. The F_2 folds are locally re folded by open folds, with an east-west axis and moderately dipping axial surface, identified as F_4.

Stereographic projection (Figures 7 & 8) of structural data shows a spread of F_1 fold axes and L1 lineations plunging between northeast and east-southeast at a moderate angle (fig. 7). Although a wide spread is shown by poles to S_1 foliation (Figure 8), these are broadly in accord with the F_1 fold axes plunging east ward, though some of the foliation planes strike northwards. A plot of poles to bedding (S_0, Figure 8) presents a widespread of gently to moderately dipping planes, the bulk of which strike from northeast through north to northwest, and which generally dip eastward, though a considerable number dip westward.

The axes of the F_2 folds, and the L2 lineations, generally plunge at moderate angles between south and southeast or between north and northwest (Figure 7). The S_2 foliation which dips moderately to steeply eastward (a few dip westward) and strikes from northwestward through north to northeast, is probably the axial- plane foliation related to these folds.

The F_3 fold axes and lineations (Figure 7) plunge at moderate angles either northeastward or southwestward and poles to S_3 foliation (Figure 8) define a rather steep foliation plane dipping southeastwards. Only two F_4 folds were observed, plunging gently east-southeastward, with an axial plane dipping moderately towards the northeast.

The scatter of the S_1 and S_0 foliations may be the result of re-folding by F_2 about north-northwest and south-southeast trends. However, the concordance in eastward plunge in F_1 fold axes and L1 lineations strongly suggests that S_0 was initially folded along broadly east-trending axes.

The plot of the northeast-southwest trend of the F_3 fold axes and L3 lineations is well separated from the plot of the north-northwest-trending F_2; the rather open and gentle, east- southeast-trending F_4 folds are distinct again.

F_1 and F_2 folds were identified in the field as tight to isoclinal, and tight and strongly asymmetric respectively. F_3 folds are asymmetric kink folds which plunge gently.

A single short traverse was made northeast of Mount Carter, on the escarpment west of the Lockhart River (Figure 4). Here gneissic rocks comprising interlayered quartzite, mica schist and amphibolite are of considerably higher metamorphic grade than the schist and phyllite forming the southwest part of the mountain (where a northward increase in grade of metamorphism was noted).

In the escarpment, amphibolite and muscovite-biotite-quartz rock are interlayered with quartzite or with bands of massive quartz; small (5 by 20cm) pods of blue quartz are prominent in one exposure. A thin section from a gneissic amphibolite 30m thick is a plagioclase-quartz-hornblende rock (90831014) with a poor preferred orientation in the hornblende (75%), rounded interstitial quartz grains (20%) and a few larger crystals of altered plagioclase. A second section from the same exposure is a chlorite-quartz-actinolite schist or amphibolite (90831015) composed dominantly of tremolite/actinolite (80%) with a good preferred orientation, scattered parallel crystals of chlorite and biotite(?) (5%) and patches and lenses of rounded quartz (15%). This amphibolite may be linked to the greenstone recorded more or less along strike about 20km to the north in the Cape Weymouth 1:250 000 sheet area, but amphibolites are also common in gneissic granite on the eastern side of the Lockhart River valley (Willmott & others, 1973).

The strike of foliation (11 readings) in the escarpment northeast of Mt Carter ranges between north-northeast and east-northeast, with moderate to steep northwesterly dips, consistent with earlier observations and mapping (Willmott and others, 1973). Only three lineations and one fold axis were noted; all plunge gently northeast or southwest. Foliation is deformed around the northeast-trending fold axes in asymmetric kink folds, and possibly represents the F_3 event noted at Sefton Creek.

The notebook record of a traverse made in 1967 in the north western part of Mount Carter, a part not visited in 1990, describes the metamorphics there as schist and quartzite with various amounts of muscovite, graphite, chlorite and possibly hematite in one exposure. Several exposures of generally fine-grained acid or basic igneous rocks may be volcanics within the schist but are more likely to be dykes; they are not evidently deformed and they become more common towards the faulted contact of the metamorphics with the Weymouth Granite.

The strike of the schistosity in the 1967 record trends generally between northwest and north, and dips are steep both to the east and west. The schistosity is commonly folded by small open to moderately tight drag folds which generally plunge northwards. A good intersection lineation is developed between the crenulation cleavage and schistosity. Irregular bodies of massive milky quartz parallel the schistosity, and the rocks also contain thin quartz veins in places.

Iron Range

The metamorphic rocks of the Iron Range region are generally deeply weathered and support dense tropical rainforest. Reconnaissance of the region in 1990 was directed at various points, such as stream beds and abandoned mines, wherever this rather poorly exposed unit might be examined (Figure 4).Part of the outcrop of the greenstone unit, as shown on the 1:250 000 geological map published in 1977, was also examined to assist with re-processing and interpretation of satellite imagery, at the request of the BMR remote sensing group.

Information compiled by von Gnielinski and others (1991) from exploration company reports lodged with the Geological Survey of Queensland was checked in the field in 1991 by various officers of the Mineral Geology section of the Geological Survey; these results will be reported separately. A considerable quantity of core recently drilled by mineral exploration companies in the Iron Range area was salvaged by von Gnielinski and returned to Brisbane for storage in the Core Library of the Department of Resource Industries.

Trail and others (1969) describe the Iron Range Schist as predominantly muscovite-quartz schist and muscovite quartzite with subordinate very fine-grained graphite-muscovite-quartz schist and phyllite, hematite-quartz schist and magnetite quartzite, at least one layer of greenstone, and small lenses of calc-silicate rock. Willmott and others (1973) replaced the name Iron Range Schist with Sefton Metamorphics; they also record Reid's (1959) observation that mica schist in some BHP drill cores contains 20% calcite in addition to quartz, muscovite, biotite and chlorite. This calcite is not normally seen in surface samples. A magnetite-glaucophane-amphibole rock recorded in BHP drilling at Black Hill was identified as an altered basic igneous rock by Lee and Forsythe (1961).

The sequence examined during the 1990 reconnaissance in the West Claudie River and in the southern Scrubby Creek, 5km south of the West Claudie River (there are two Scrubby Creeks in the Cape Weymouth 1:100 000 sheet, see Figure 4), consists of interlay ered quartzite, metagreywacke, argillite, and slate or phyllite; the metagreywacke contains a bed of small-pebble conglomerate.

In the southern Scrubby Creek, slaty sericite-quartz phyllite, locally rich in graphite, is interlayered with sericite quartzite and metagreywacke, with feldspar and lithic fragments, which contains at least one layer of metaconglomerate. The slaty phyllite is the more abundant rock type. The metagreywacke forms beds from 1 cm to over 10 m in thickness, while the interlayered phyllite beds are generally less than 10 cm thick; the sequence in a large outcrop resembles a thin-bedded turbidite.

In thin section the metaconglomerate (90831009) is a granular mass of fine to coarse-size quartz (70%) with scattered large and small crystals of oligoclase (10%) and perthitic orthoclase or microcline (5%). Muscovite (15%) is common as small crystals among the fine quartz, together with a few large broken garnet? crystals. In thin section the metaconglomerate strongly resembles sheared granite, but also contains small pebbles of vein quartz and black slate or argillite. It is evidently derived largely from a granitic source. Pyrite is abundant in one metagreywacke as aggregates up to 5 mm on joint planes, and a 2m thick quartz vein occurs in another.

Dykes of rhyolite, with local flow-banding, and of medium-grained hornblende diorite up to several metres thick are scattered throughout the outcrop in Scrubby Creek; they become more abundant as the granite contact at the head of the creek is approached. Both rhyolitic and doleritic rocks occur in the lower reaches of the creek, in the outcrop of the greenstone as mapped by Trail and others (1969).

Upstream towards the Weymouth Granite, the metagreywacke is recrystallised to an even-grained quartzite with pyrite and prominent iron-staining. The granite at the margin has only small feldspar phenocrysts, but these become larger within a short distance of the contact.

In the West Claudie River bedded and massive quartzite and metamorphosed greywacke or arkose alternate with argillite in which a poorly developed slaty cleavage is generally sub-parallel to bedding. The argillite is probably the more abundant rock, though the metagreywacke is more prominent.

In thin section there is little sign of recrystallisation in quartz grains in these rocks; in layered argillite or metasiltstone (90831033); the muscovite flakes are generally parallel to the bedding, expressed by graphitic layers, but are also locally deformed. Graded and cross-bedding are evident in graphitic layers in this section. These layers also reveal shearing sub-parallel to bedding.

A section of pebbly metagreywacke (90831035) consists of large and medium-sized, angular to round grains of quartz and feldspar and curved muscovite flakes, in an abundant fine-grained, granular matrix of muscovite and quartz, with scattered pebbles or granules of fine-grained quartzite and bedded graphitic argillite. Pebbles of milky quartz are also evident in the outcrop, where all the pebbles have a marked preferred orientation. The granular matrix of quartz, feldspar and muscovite resembles sheared granite, and the metasediment was probably derived from a granitic source; it resembles closely the metaconglomerate exposed 5km to the south, in southern Scrubby Creek (see above).

In two exposures argillite streaks, which are either deformed clasts or lenses, outline moderately tight, Z-asymmetric folds. These may be F_2 folds related to a coarse S_2 cleavage developed at a considerable angle to the sub-parallel S_0 represented by the argillite streaks, and S_1 represented by schlieren in the quartzite layers.

In plots of structural observations made along the West Claudie River and the southern Scrubby Creek, S_0 (bedding) planes (Figure 9) dip from moderately to steeply westwards through gently northwards to moderately to steeply eastwards, suggesting folding along north-trending axes. S_1 dips either moderately to gently northwestward or gently to steeply eastward and southeastward, suggesting re-folding of these (axial-plane) foliation planes on northeast-trending axes. The fold axes and lineations (Figure 9) recorded in the West Claudie River region are sub-parallel and probably represent only one event; these plunge moderately to gently northwestwards or southeastwards.

The northwest-southeast orientation of the fold axes and lineations suggests that they also have been refolded along northeast-trending axes. Although no folds with these trends were recorded in the Claudie River region, the presence of F_3 fold axes with a northeasterly orientation in Sefton Metamorphics at Mount Carter suggests that the same deformation has re-folded earlier structures in the West Claudie River section.

Altogether the foliation planes at Claudie River suggest folding along a north-south trending axis, but the S_1 and S_2 plots taken together without S_0, have a strong preferred north-northeasterly strike, perhaps reflecting the trend of the axial planes of folds preceding the northwest-southeast trending fold axes and lineations seen in Figure 9. Possibly the wider range of orientation of the S_0 planes reflects several phases of folding. The northwest-southeast trends preserved in the fold axes and lineations suggest a fold direction which is not evident in foliation planes. If the largely gently to moderately dipping, re-folded S_1 planes and the fold axes are restored to horizontal about an axis trending northeast-southwest, the S_1 foliation may be interpreted as the axial plane foliation of an episode of recumbent folding on near-horizontal northwest-southeast trending F_1 axes. This does not account for the pattern of S_0, however, which suggests upright folding on axes trending north and south.

Few mesoscopic folds were recognised in traverses in the West Claudie River and southern Scrubby Creek. Major lithological boundaries, between marble and quartzite or argillite and metagreywacke, revealed broad open folds plunging at 50 or 60 degrees to the east or northeast. Minor folds recorded in the argillite/greywacke sequence are monoclinal or moderately tight, z-asymmetric folds plunging gently to moderately steeply to the northwest or southeast. Minor folds in the marble/quartzite sequence south of the West Claudie River are moderately tight s-asymmetric folds plunging 50 or 60 degrees to the north-northeast or south-southeast.

The greenstone distinguished within the Sefton Metamorphics at Iron Range is described by Willmott and others (1973) as massive rock comprising metadolerite and probably altered lava. A re-examination of the greenstone outcrop immediately north and south of the Wenlock/Portland Roads road confirmed that it is very poorly exposed; apart from some coarse dioritic rock on the margin of the granite boss forming Max's Ridge and a weathered chloritic schist in the road cutting north of the new Claudie River bridge, only chert and marble were found, locally cut by acid dykes. It is difficult confidently to correlate these rock types directly with the unit mapped near Max's Ridge in the processing of the Thematic Mapper Landsat image by BMR remote sensing section.

Three kilometres west-southwest of the junction of the Wenlock/Portland Roads road with the road to Lockhart River Airport, a single, isolated exposure of black, banded actinolite?- graphite-calcite rock was located. It consists (90831037) of oriented, small sub-circular aggregates of graphite and calcite, scattered small crystals and aggregates of calcite, and poorly defined veins and feathery aggregates of actinolite (or antigorite?).

South of the road, in a small southern tributary of the West Claudie River, thin-bedded intervals of quartzite, over 10 m thick, alternate with intervals of similar thickness consisting of medium-bedded marble. A thin section of the quartzite (90831042) shows 1 to 5mm layers of coarsely sutured, recrystal lised quartz alternating with similar layers of chlorite- epidote/zoisite? rock; flakes of muscovite are scattered in both quartz and dark mineral layers. The marble in thin section (90831043, 90831044) appears as an aggregate of unstrained calcite crystals with small patches of epidote-tremolite rock representing the thin disrupted and folded brown clayey layers seen in hand-specimen.

At Mackenzie Creek, a tributary of the northern Scrubby Creek (Figure 4), muscovite-quartz phyllite or schist is interlayered with quartzite. A widely spaced crenulation cleavage cuts the schistosity in the phyllite.

Gold Mineralisation

In recent years the Iron Range region has been examined by several companies seeking economic gold mineralisation. Regional stream-sediment geochemistry carried out during the 1990 reconnaissance (Cruikshank, in prep.) also shows enhanced gold values in this region.

Dampier Mining (1978a) reported that the gold in the metamorphic rocks is strata-bound, principally within one sequence of specular hematite schist, laminated specular hematite quartzite and carbonate schist. The mineralised sequence reportedly ranges in thickness from 30m in the north to 100m in the Gordons Mine area, near the junction of the roads from Portland Roads and from the airport. This mineralised sequence may be repeated farther east, on the eastern flank of a major synform (Figure 10).

Further work by Dampier Mining (1978b) revealed that the zones of low-grade gold mineralisation located do not persist along strike, and that sufficient ore reserves for mining are unlikely to occur. In a drill hole at the Northern Queen mine Dampier (1978b) notes that two ash beds were logged, consisting of fine-grained siliceous material with a few pumice shards and grains to 1 mm diameter of green volcanic glass; the hole bottomed, at 75m, in gneissic quartz-biotite rock. The presence of unaltered pumice and volcanic glass is highly anomalous in the metamorphic sequence drilled. The (gold-bearing?) quartzite mentioned in this report is also said to be tuffaceous in places. Dampier (1978b) also identifies gold mineralisation with normal and reverse strike faulting which followed folding, metamorphism and the emplacement of granite.

It can be concluded that Dampier (1978a) has identified an association of gold mineralisation with at least one metamorphic or tectono-stratigraphic unit - the sequence of hematite schist, hematite quartzite and carbonate schist - within the hematite-quartz schist of the Sefton Metamorphics. Folding after metamorphism on roughly north-trending axes may have produced repetition of the mineralised interval to the east. The source of the gold within this unit remains unknown. A detailed record and analysis of the complex structures seen in the hematite-quartz schist in mines and prospects along the outcrop of this interval should result in a better understanding of gold mineralisation at Iron Range.

Broadhurst and Rayner (1937) recorded that gold-bearing quartz reefs in the schist zone east of the iron-bearing rocks at Iron Range were small but rich. They also note that some of these reefs have components along and across the schistosity, and where they intersect, short ore shoots have formed. They record that in the northern part of the schist zone some of the lodes are composed of crushed sericite schist with quartz stringers, and predict that in the primary zone the ore shoots would prove to be lenses of silicified schist impregnated with sulphides, chiefly arsenopyrite; this suggests that mineralization occurred at a late stage in the structural history.

Rayner (1937) noted the discovery of a wide body of sulphide ore at the Peninsula Hope mine. A later CSIRO (1953) investigation of ore from this mine describes sulphide minerals, chiefly arsenopyrite and pyrite, in chlorite schist, quartz and carbonate. The head assay of the ore per ton was (converted from penny weights) 18 gm gold, 1.8gm silver, 4.4% arsenic, 20.7% iron, 9.79% sulphur and less than 0.05% copper. The gold particles are associated with pyrite and arsenopyrite crystals, and some gold occurs in veins cutting the arsenopyrite.

Teluk (1984) reporting on work by Newmont Holdings Pty Ltd in the Iron Range area, subdivided the Sefton Metamorphics cropping out east of the junction of the Portland Roads and Airport roads, as listed below (oldest unit first). It must be emphasised that these are informal names of convenience, and that publication in this record should not accord them any official status:

Iron Range group (2000m thick)

- Wait-a-while schist (700m thick)

  sericite & quartz-sericite schist.

- Lamond Hill iron formation

  oxide-facies banded iron formation with finely banded alternate silica and hematite-magnetite.

- Scrubby Creek formation

  quartz-sericite schist, sericite schist, sericitic quartzite, quartzitic schist with several interbedded iron-silica rich exhalative horizons.

Teluk believes that the Scrubby Creek formation shows a cyclic pattern of sedimentation alternating between detrital and exhalative conditions. Within the Scrubby Creek formation the differentiated six members on the basis of their exhalative components, such as silicate-sulphide-silica and oxide-silicate-silica, listed oldest first below:

- Bamboo Flats member (silicate-silica-sulphide)

  ferruginous & gossanous quartz-sericite schist & saccharoidal quartzite.

- Black Ridge beds (silicate-sulphide-silica)

  strongly ferruginous & gossanous quartz, sericite, chlorite schist & banded sericitic, chloritic saccharoidal quartzite; sulphide concentrations.

- Window Tree member (oxide-silicate-silica)

  banded & schistose hematitic quartzite, banded iron formation & quartz-sericite schist.

- Northern Queen member (silicate-silica-sulphide-oxide-carbonate)

  banded & foliated siliceous, chloritic, hematitic & sulphidic quartz-sericite schist and minor saccharoidal quartzite.

- Junction Ridge member (silica-silicate-sulphide)

  banded & foliated siliceous (sic) & saccharoidal, hematitic & gossanous quartzite and minor quartz-sericite-chlorite schist.

- Waters Edge quartzite (silica-oxide-silicate-sulphide)

  well banded saccharoidal & sericitic, chloritic & hematitic quartzite with minor schist; intercalated BIF towards base & northwards.

As all the members are essentially composed of quartzite and sericite-quartz schist this classification could not readily be applied in the field in these poorly exposed rocks without extensive excavation and drilling. Nevertheless, Teluk's imaginative attempt to interpret the sequence and the mineralisation in terms of sedimentation of clastic, chemical and exhalative components deserves recognition and further consideration.

Teluk further places this succession as dipping and younging eastwards on the western limb of a large north-plunging syncline, and infers a major thrust (Ironclad Thrust Zone) between the Lamond Hill formation and Scrubby Creek formation, demonstrated by dip reversals, brecciation and vein mineralisation along the contact, by doubling in the thickness of the Lamond Hill formation, and by truncation of the Scrubby Creek formation in this zone. He summarises the history of deformation as:

- D_1—metamorphism, regional folding, development of schistosity, 1st generation of foliation-concordant quartz (-sulphide) veins.
- D_2—metamorphism, mesoscopic folding with weak axial plane cleavage (S_2), transgressive quartz veins, folding and boudinage of earlier quartz veins, some remobilisation of sulphides.
- D_3—retrogressive metamorphism, Ironclad Thrust Zone formed, meso-macroscale folding and thickening of Lamond Hill formation; sulphide breccias developed?
- D_4—brittle cross-fracturing, glossy crystalline (not saccharoidal) quartz veins.

Teluk classified mineralisation as:

- (?epigenetic) sulphide (quartz) vein-breccias of the Lamond Hill formation, and
- stratabound/stratiform occurrences within the Scrubby Creek formation.

In the first the host rocks are sheared and brecciated saccharoidal quartzites (interpreted as siliceous exhalites) and banded iron formation. The mineralisation is podiform and lenticular massive sulphide breccia, and sulphide-quartz veins and breccia;

commonly the massive sulphides have dismembered the bedded quartzite/banded iron formation sequences; Teluk notes the lack of a sulphide facies in the banded iron formation indicates an epigenetic source for the gold.

In the Scrubby Creek formation the Northern Queen member is the principal mineralised interval, with strongly sulphidic layered silica-chlorite-carbonate exhalites in host rocks dominantly composed of chloritic and siliceous schists (detrito- exhalites) with minor banded iron formation and possibly andesitic volcanics.

The almost complete absence of base metals from the sulphide mineralisation is noted in many reports; these also confirm that arsenopyrite and pyrite are the dominant and almost the only sulphide minerals, and that arsenic is the only element showing any correlation with gold.

Cran (1985) also reporting for Newmont, notes that drilling has been conducted at Iron Range only in the vicinity of old mines, reflecting a tacit assumption that the early prospectors had located all the best gold mineralisation. He recommended E.M. surveys to aid in locating concealed mineralisation, in view of the poor outcrop. An E.M. survey was later carried out and a single hole drilled in an anomaly gave negative results. Stream-sediment and soil sampling led to further drilling, after which Newmont withdrew, concluding that gold in the new prospects so defined was confined to narrow discontinuous quartz-sulphide veinlets, and that tropical weathering had resulted in near-surface enrichment providing the rich ore originally mined here.

The almost complete soil cover in the Iron Range region may well conceal substantial gold mineralisation, but so far neither geophysics, hampered by the widespread ferruginous bedrock, nor geochemistry has yet indicated a worthwhile concealed deposit. The gold deposits of Iron Range may have formed in an ocean- floor sequence in which chert and exhalative iron and manganese deposits were interlayered with clay and cherty limestone, and were later scraped off westward-subducting ocean floor to be stacked against a clastic, (proximal turbidite?) member of the Sefton Metamorphics exposed along the West Claudie River and the upper reaches of the southern Scrubby Creek. Alternatively the latter rocks, with their abundant granitic detritus, may represent a contemporaneous foreland basin encroached on by an advancing and deforming accretionary prism of largely oceanic sediment. The second interpretation would be favoured if, as seems likely, the structural complexity and metamorphic grade of the clastic sediments exposed along the West Claudie River are considerably less than those of the ferruginous gold-bearing metamorphics of Iron Range. The apparent absence of gold from the Sefton Metamorphics of the West Claudie River also supports the second possibility.

The occurrence of small quantities of mineable gold in Weymouth Granite dated as Early Permian by the K/Ar method on biotite (Willmott and others, 1973) and by U/Pb on zircon (Black and others, in prep.), raises the possibility that the gold mineralization may be no older than Early Permian, and that the tectono-stratigraphic interval adjacent to the iron-rich schist of the Sefton Metamorphics has simply trapped Early Permian gold-bearing fluids sourced in or mobilised by the granite.

Holroyd Metamorphics

The Holroyd Metamorphics (Willmott and others, 1973) comprise the largely low-grade metamorphic rocks exposed along the western margin of the Coen Inlier (Figure 3).

Reconnaissance in the Holroyd Metamorphics in 1990 provided observations of structure and rock-types which will be incorporated in the results of the proposed 1991 survey of the Ebagoola 1:250 000 sheet area. The principal advance on the findings of the 1966 survey was the identification of a major fault, (previously noted by some companies) in the Lukin River upstream from The Gorge, as a ductile shear zone with the consistent sinistral west-over-east shear sense found also in the Ebagoola and Coen Shear Zones (Blewett & von Gnielinski, 1991, a & b). A marked decrease in metamorphic grade westward across this shear zone confirms that it is a post-metamorphic (D_2?) feature, as are the other two zones.

The rocks examined during the 1990 reconnaissance were predominantly those mapped in 1966 as "Lukin-type schist" by Trail and others (1968), which range from indurated and cleaved sericitic mudstone and siltstone with recognisable bedding, along the western margin of the outcrop, to coarse-grained knotted or spotted andalusite-bearing mica schist, with local garnet, in the east.

The 1990 reconnaissance confirmed that S_1 and possibly S_2 cleavage could be recognised in the indurated mudstone and siltstone, and that some beds were inverted; broad folds and minor faults were also recognised.

Rock types

Greenstone together with quartzite forms prominent elongated folds over 20 km long in the southwestern part of the Ebagoola 1:250 000 sheet area. Although easily delineated on airphotos, the greenstone is poorly exposed; one outcrop is a massive medium-grained and even-grained aggregate of actinolite and chlorite, with trains of small, sub-spherical amygdale-like bodies. This is closely associated with a cherty fine-grained quartzite crowded with small (2mm) sub-spherical bodies consisting of clinozoisite and calcite, which may be spherules in an acid volcanic rock, or may represent a tektite deposit (A. Glikson, BMR, pers comm., 1991) as found in association with Archaean greenstones in Western Australia and South Africa.

Small slivers of low-grade slates and quartzites closely associated with granitic rocks along the Archer River Shear Zone are ascribed to the Holroyd Metamorphics. Sedimentary structures are locally preserved and include graded bedding and parallel and flaser laminae.

The Holroyd Metamorphics have a higher proportion of saccharoidal quarztite than the Coen or Sefton Metamorphics, which forms distinctive ridges that define macroscopic F_2 folds. These folds plunge gently and have large amplitude to wavelength ratios.

Structure

The dominant foliation in the Holroyd Metamorphics is S_1, refolded about tight to isoclinal NNW to N trending F_2 axes. Garnet is common and is syn-D_1, and locally shows evidence of having rotated. Symmetrical-sigmoidal traces of S_1 through garnet/quartz porphyroblasts (1-2 mm diameter) suggest that the internal foliation (S_i) is the same as the external foliation (S_e), rather than an earlier foliation (cf. Bell 1985). Relict bedding is visible in the garnet-muscovite-biotite schist as reflected in the alternation of P and Q domains in thin section. Graphite is present as an accessory and occasionally as the dominant mineral in graphite schist.

Muscovite and biotite define S_1 and are overprinted by S_2 crenulation cleavages. S_2 is locally defined by new biotite growth. Local andalusite is largely pseudomorphed by muscovite and sericite.

Linear features have strike lengths of over 50 km within the main western belt of the Holroyd Metamorphics (visible in the 400m line-spacing aeromagnetics). Isoclinal folding of some linear features thought to represent stratigraphic units is consistent with macroscopic folding visible on the airphotography and Landsat TM images. Three phases of deformation are visible in the fold patterns of the greenstone, quartzite and schist in the south-central Holroyd Metamorphic belt (Figure 11). The D_1 sheet strike is E-W and is isoclinally folded about N-S F_2 axes, which are refolded about open NE-trending F_3 folds (Figure 5). The geometry of the macroscopic fold interference patterns is consistent with the patterns of deformation recorded between here and Iron Range, 250 km to the north.

Granitic Rocks

The main granitic rocks in the Coen Inlier are the Siluro-Devonian granitoids dated both by K/Ar (Willmott and others, 1973) and Rb/Sr (Cooper and others 1975) methods. These ages have been largely confirmed by the U/Pb ion-probe method for a number of units (Black and others, in prep.).

This report compiles only field observations made by the authors during the 1990 reconnaissance. A detailed report on the granitic rocks of the northern Coen Inlier, including geochemistry, is being prepared by Dr J. Knutson.

The three main granitic units, the Kintore and Lankelly Adamellites and the Flyspeck Granodiorite (named by Whitaker and Willmott, 1968), may be found in close proximity in isolated out crops, along with gneiss and schist.

It does appear that Flyspeck-type (or certainly more mafic) rocks predate the Lankelly and Kintore-type rocks as diorite and granodiorite xenoliths and 'rafts' incorporated within the Kintore and Lankelly Adamellites. The correlation between these mafic bodies and the Flyspeck Granodiorite (Trail and others 1968, 1969) may be incorrect, and these more mafic bodies may represent an as yet undefined and discrete intrusive body. Contacts between Kintore Adamellite and Flyspeck Granodiorite are sharp.

The largest exposure of Flyspeck Granodiorite (Whitaker and Willmott 1968) is in the southwest of the area around Old Bamboo homestead and south towards the type area of Flyspeck Creek. Lesser bodies (interpreted) crop out just north of Coen and along the Coen River. The 1:250 000 geolgical map of Ebagoola (published in 1977) incorrectly shows Flyspeck Granodiorite along the Coen Shear Zone near the Port Stewart/Old Coen road junction. This is now mapped correctly as Lankelly Adamellite on the preliminary 1:100 000 scale geological map by Blewett and von Gnielinski (1991).

The most common lithology in the Kintore Adamellite is an equigranular fine to medium-grained muscovite adamellite, commonly with some biotite and with or without a foliation. The rock is commonly deeply weathered, and areas previously mapped as quartzose sand (TQs) around the Ebagoola Shear Zone are in fact strongly sheared and altered Kintore Adamellite or a similar granitic rock. The unit is foliated in many places, with well developed mylonites along the Ebagoola Shear Zone and along the Archer River Shear Zone.

In thin section, the rock comprises anhedral quartz, K- feldspar, plagioclase (twinned oligoclase or andesine), muscovite and lesser biotite. The biotite is commonly replaced by chlorite. Common accessories are pale pink garnet (in the leucocratic areas), zircon and apatite.

Also mapped as Kintore Adamellite are the irregular bodies, veins and dykes of garnet-muscovite granite and associated pegmatite and layered aplite which commonly occur in proximity to or intrude the Coen Metamorphics.

The Lankelly Adamellite (Whitaker and Willmott, 1968) is a porphyritic rock ranging from an almost equigranular biotite adamellite, with some muscovite, to a medium to coarse, strongly biotite-muscovite adamellite with abundant large K-feldspar phenocrysts.

The Coen Shear Zone partly juxtaposes the Lankelly Adamellite and Coen Metamorphics to the east and north of Coen, but to the south, Lankelly Adamellite occurs on both sides of the shear zone, displaying a well developed mylonitic foliation.

The K-feldspar phenocrysts are occasionally 10-12 cm long, but more commonly 3-5 cm in length. Flow alignment is also common and generally oriented NNW, parallel to mylonites and foliations. The phenocryst distribution ranges from almost 100% of the rock to almost absent, often over short distances. Rhyolite dykes up to a few metres thick, with good flow structure and local brecciation, locally cut the adamellite. Minor aplites also occur.

Quartz (generally strained), microcline and andesine, yellow to reddish brown biotite, muscovite and accessory apatite and zircon are present in thin section. Quartz, mica and plagioclase form inclusions in microcline.

Dykes

Rhyolite dykes are generally <1m thick and trend NW-SE to NNW-SSE over strike-lengths of several hundred metres throughout the area. They are common near the major shear zones and are themselves locally strongly foliated and lineated. There appears to be a spatial link between the development of shear zones, rhyolites, quartz veining and local gold mineralization.

Willmott and others (1973) described dykes ranging from rhyolite through rhyodacite to andesite. They are commonly flow banded. The rhyolites are fine-grained and comprise quartz, feldspar and accessory mica (altered to chlorite).

Locally, rhyolite bodies occur as plugs, the largest of which is found 10 km to the north of Yarraden as an elongate body 500 m wide by 4 km long. The mineralised hill of 'Spion Kop' was previously mapped as Flyspeck Granodiorite, but in fact consists of brecciated rhyolite-rhyodacite that intrudes Lankelly Adamellite, and was 'fed' by a series of almost N-S trending dykes (over 5 km uninterrupted strike length) from the south. Another lens-like pod of rhyolite also occurs 3.5 km SE of Coen and has been extensively costeaned. This rhyolite is strongly L_{22} (?) lineated. These rhyolitic dykes and plugs have received interest from a number of exploration companies.

The age of the rhyolite was considered Permo-Carboniferous by Willmott and others (1973); new dating will test this (as discussed below).

Quartz veins

Quartz veins are common near major shear zones. They form clear lineaments on aerial photographs, are steeply dipping and trend NNW-SSE. Some quartz veining may be 'early' (pre-D_2), as a costean 14 km west of Coen revealed tightly F_2 folded (as a synform) quartz veins with a moderate plunge and NNW-trending, steeply dipping axial surface. The quartz vein overprints a highly altered rhyolite dyke (similar to those described above) with an acute intersection.

Vein quartz has also been mylonitized together with the Kintore Adamellite along the Ebagoola Shear Zone, while later quartz veins, although principally parallel to the mylonitic foliation, have cross-cutting offshoots showing a later stage of development.

Mullumbidgee Gold Prospect

The Mullumbidgee gold prospect (Figure 4) is located towards the eastern margin of the northern part of the McIlwraith Range.

This was visited in 1990 in conjunction with a metallogenic mapping party from the Geological Survey of Queensland. Using a prospecting track bulldozed in the late 1980s, vehicles were driven from the Buthen-Buthen road between Attack Creek and Skae Creek, through the recently abandoned alluvial workings along Skae Creek and over the crest of the McIlwraith Range, to the headwaters of one of the many streams running eastward into the lower Nesbit River valley. The remaining 7 km to the Mullumbidgee Prospect was covered on foot. Future work on the crest of the range will also largely have to be done on foot because of the dense, stunted forest, and Global Positioning Systems are required for accurate positioning in this terrain. The extensive grass clearings at Mullumbidgee and a few other locations could be used as helicopter landing sites, to position parties in small fly camps, so that they could work on foot around these clearings for several days.

The prospect consists of two quartz lodes in plutonic country rocks which range from granitic to dioritic; at least one andesite dyke is also present. The lodes trend northwards and appear on the surface to be in the region of two metres thick. The quartz is locally rusty, gossanous or pyritic, but is generally massive. At one place in the western lode one very small piece of free gold was observed.

DISCUSSION

In 1990, the deformation history of metamorphic rocks was perhaps most clearly seen in the Sefton Metamorphics at Mount Carter, where the sequence of deformation is not complicated by granite intrusion. Here, the first regional deformation was folding on axes trending broadly eastwards. This probably preceded or accompanied regional metamorphism in which the facies changed northwards from low to moderately high greenschist. The second deformation produced tight, asymmetric folds, probably along axes trending north-northwestwards, and succeeded the regional metamorphism. The third phase of deformation is expressed as asymmetric kink folds plunging gently northeast or southwest.

Elsewhere in the Coen and Ebagoola 1:250 000 sheet areas, granitic rocks of the Cape York Peninsula Batholith, which have yielded Siluro-Devonian-Carboniferous Rb/Sr ages (Cooper and others, 1975) and U/Pb ages (Black & others, in prep.) appear to be affected by the second phase of regional deformation (Blewett & von Gnielinski, 1991,a,b). The Kintore and Lankelly Adamellites especially are locally strongly mylonitized and have "F_2" folded contacts and mylonitic foliations, and are "early" in terms of the relative structural chronology of events. D_2 has a similar style in both the Coen and the Georgetown Inliers (Blewett & von Gnielinski, 1991b), both have N-S trending, upright folds, steeply dipping axial planar crenulation cleavages and tight to isoclinal interlimb angles. Cooper and others (1975) also record a re-set of both total rock and mineral Rb/Sr systems in the Coen Metamorphics at about 370 Ma, during the Devonian igneous activity comprising intrusion of the Cape York Peninsula Batholith.

The occurrence in the Holroyd Metamorphics of sillimanite unaffected by the first deformation but locally deformed by the second, may result from recrystallisation accompanying the granite intrusion and therefore tends to support an age for the second recorded deformation post-dating the emplacement of the Cape York Peninsula Batholith.

The ages of deposition of the sediments represented by the Holroyd, Coen and Sefton Metamorphics, and of their initial deformation and metamorphism, are effectively unknown. The apparent Rb/Sr age 1500Ma obtained in the Holroyd Metamorphics by Cooper and others (1975), and Nd/Sm model ages between 1900 and 2100 Ma obtained from the Coen Metamorphics by McCulloch (1987) may reflect the ages of the continental crust comprising the provenance of these rocks, rather than the age of formation of the rocks themselves (Dr L.P. Black, BMR, pers. comm., 1991).

Although there is no direct evidence for a Precambrian age for the metamorphics of the Coen Inlier, they do contain rock types such as metabasalt and metadolerite (greenstone) in the Holroyd Metamorphics and banded iron formation in the Sefton Metamorphics, which are typical of Precambrian sequences else where in Australia.

The history of deformation so far established in the Sefton and Coen Metmorphics (Blewett & von Gnielinski, 1991a,b) suggests that the second phase of deformation of these rocks occurred after the intrusion of the Siluro-Devonian granitic rocks. If the metamorphic rocks are Precambrian, then either they were not significantly deformed or metamorphosed until Early Paleozoic times, or an interval of at least several hundred million years intervened between the first and second deformation. So far, a search for Precambrian granitoids in the Coen Inlier has been unsuccessful; the recent work of Black and others (in prep.) on U/Pb ages of zircons in the granitic rocks has yielded only Paleozoic ages. Proterozoic granites (1550 Ma) are fairly common in the Georgetown Inlier (Black and McCulloch 1990); for example the Esmeralda, Forest Home, Forsayth, Mistletoe and Lighthouse Granites. The apparent lack of granitoids of this age in the Coen Inlier requires further investigation, perhaps by zircon-dating of the gneissic rocks of granitic composition within the re-set Coen Metamorphics.

It is also possible that the Sefton Metamorphics are not related to the Coen and Holroyd Metamorphics, but represent a younger and quite separate sedimentary prism of mixed shelf, slope and oceanic deposits, accreted to the margin of a continent (represented by the much older Holroyd and Coen Metamorphics) in early to middle Paleozoic times. The first deformation of the Sefton Metamorphics could have occurred shortly before the subduction-related emplacement of the Cape York Peninsula Batholith in this continental margin, and may not have affected the Holroyd Metamorphics of the continental hinterland, though the re-set Coen Metamorphics on the continental margin may have been deformed. The deformation of the Sefton Metamorphics at Iron Range, as interpreted by exploration companies (e.g. Teluk, 1984) also took place over an interval of time in which granitic rocks were intruded.

Close investigation of the deformation history of the Holroyd Metamorphics and associated granitoids during the 1991 field season, together with careful sampling for isotopic age determination should enable a detailed and accurate history of deforma tion and intrusion to be constructed for Cape York Peninsula. In particular an intensive search should be carried out for tuffaceous deposits within all the metamorphic units, to recover zircons which are not derived from pre-existing rocks (Dr L.P. Black, BMR, pers comm., 1991).

CONCLUSIONS

Sequences of deformation seen respectively in the Sefton, Coen and Holroyd Metamorphics appear to be similar, and the second phase of deformation in each appears to post-date emplacement of the Cape York Peninsula Batholith. However the ages of the original rocks and of the first phase of deformation and metamorphism are not yet clear.

The recent confirmation by Black and others (in prep.) of Paleozoic ages for all granitic rocks so far investigated, raises problems with the history of deformation observed in the Holroyd Metamorphics in particular, where a gap of at least several hundred million years may be inferred between the first and second deformation events.

The Sefton Metamorphics may be distinctly younger than the Coen and Holroyd Metamorphics, and may have accreted to the Australian continent during an early to middle Paleozoic episode of subduction which also generated the Cape York Peninsula Batholith. The thick banded iron formation in the Sefton Metamorphics at Iron Range, however, is typical of Precambrian sequences else where in Australia.

Further study is needed to clarify the geological history of the region. Fieldwork planned for 1991 in the southern part of the Coen Inlier, including structural analysis of the Holroyd Metamorphics and careful sampling for U/Pb age determination on zircon, particularly in any tuffs interlayered with the metamorphics, should considerably advance our understanding. However, further study in the northern part of the Coen Inlier, of the Sefton Metamorphics, particularly at Iron Range, and of the deformed but unmetamorphosed Carboniferous Pascoe River beds, in the Cape Weymouth 1:250 000 sheet area, must also be undertaken, to determine the structural regime that prevailed before and after the emplacement of the Cape York Peninsula Batholith.

To date gold has been the only mineral extracted on any sizable scale from the igneous and metamorphic rocks of the region. The regional geochemical work carried out in 1990 (Cruikshank, in prep.) will provide valuable background for resource assessment and synthesis of past exploration activity, as well as indicating broad targets for further exploration. It is clear that the Lockhart River DOGIT area and the adjacent region have some potential for gold mineralisation, and a systematic assessment of the resources of this region should be of considerable value to the aboriginal community.

An image of total magnetic intensity produced by the BMR 1990 airborne magnetic and radiometric survey reveals a north-northwest-trending belt which bears a broad resemblance to the Coen Metmaorphics, extending under sand cover from the southern to the northern margin of the Ebagoola 1:250 000 sheet area.The belt may represent a repetition of the Coen Metamorphics and a careful examination of the little available outcrop in this area should be carried out in 1991.

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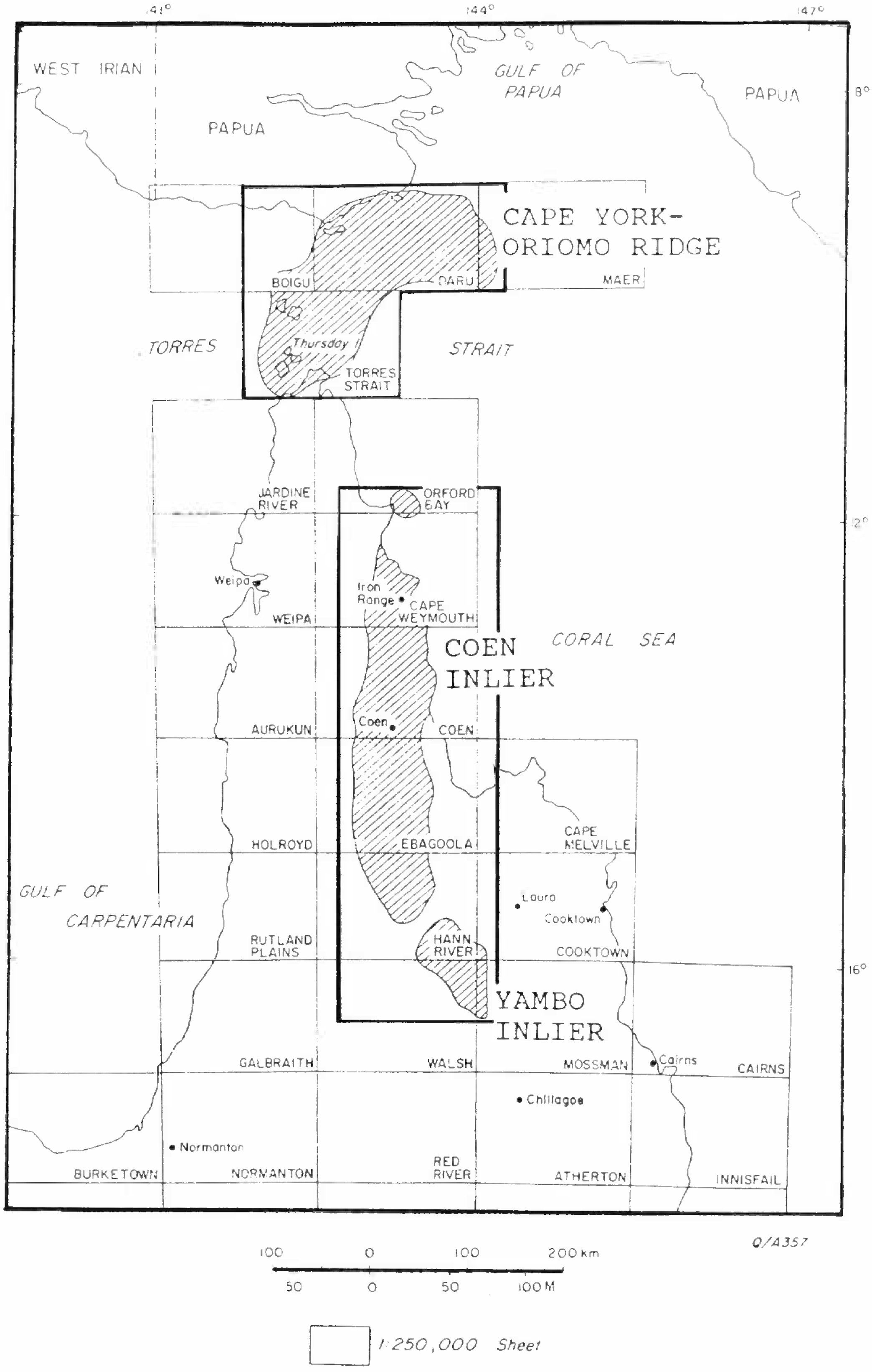

Figure 1. Locality map and Sheet index.

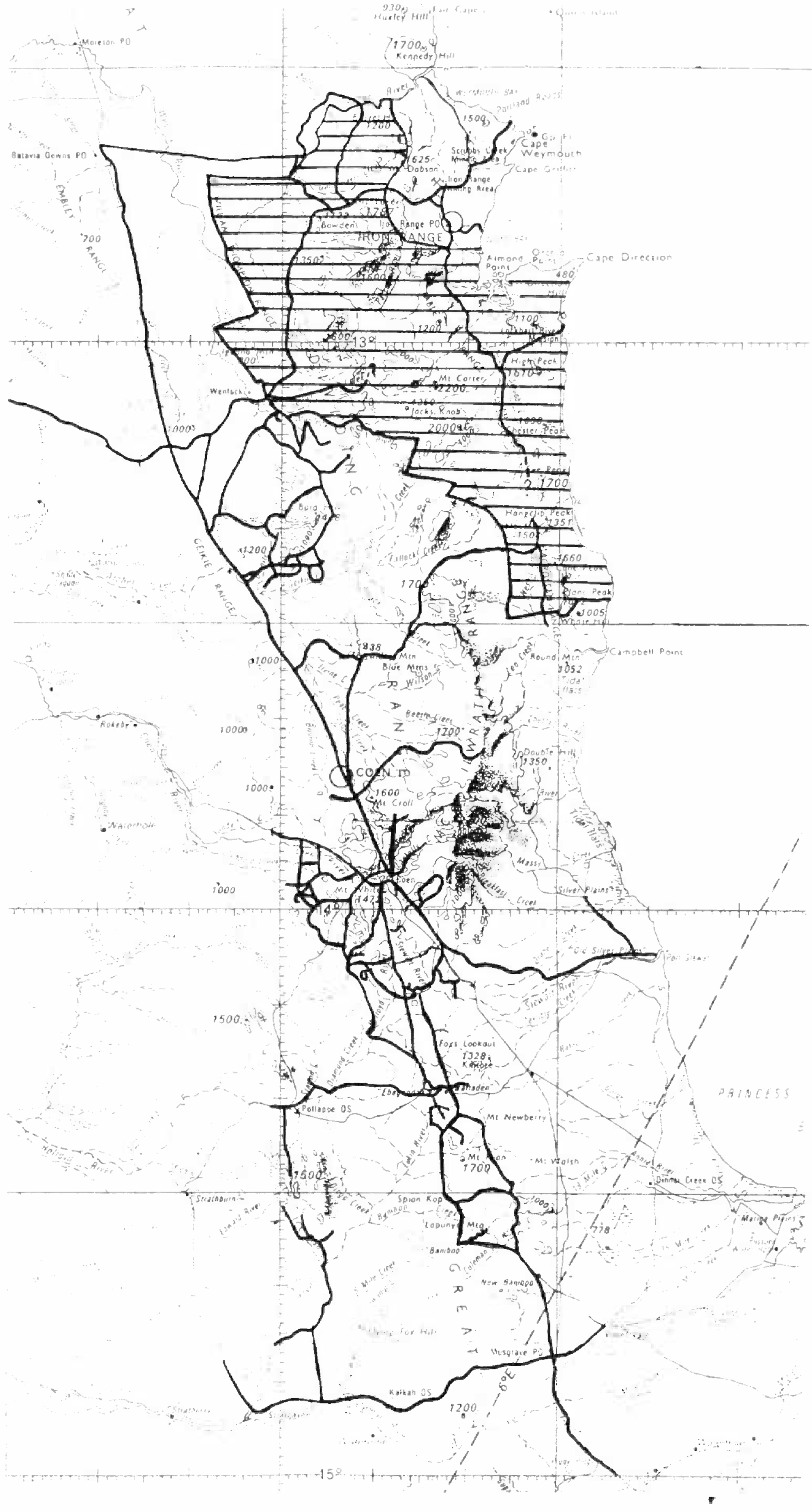

Figure 2. Tracks used in 1990 reconnaissance

Lockhart River Community Deed of Grant in Trust area.

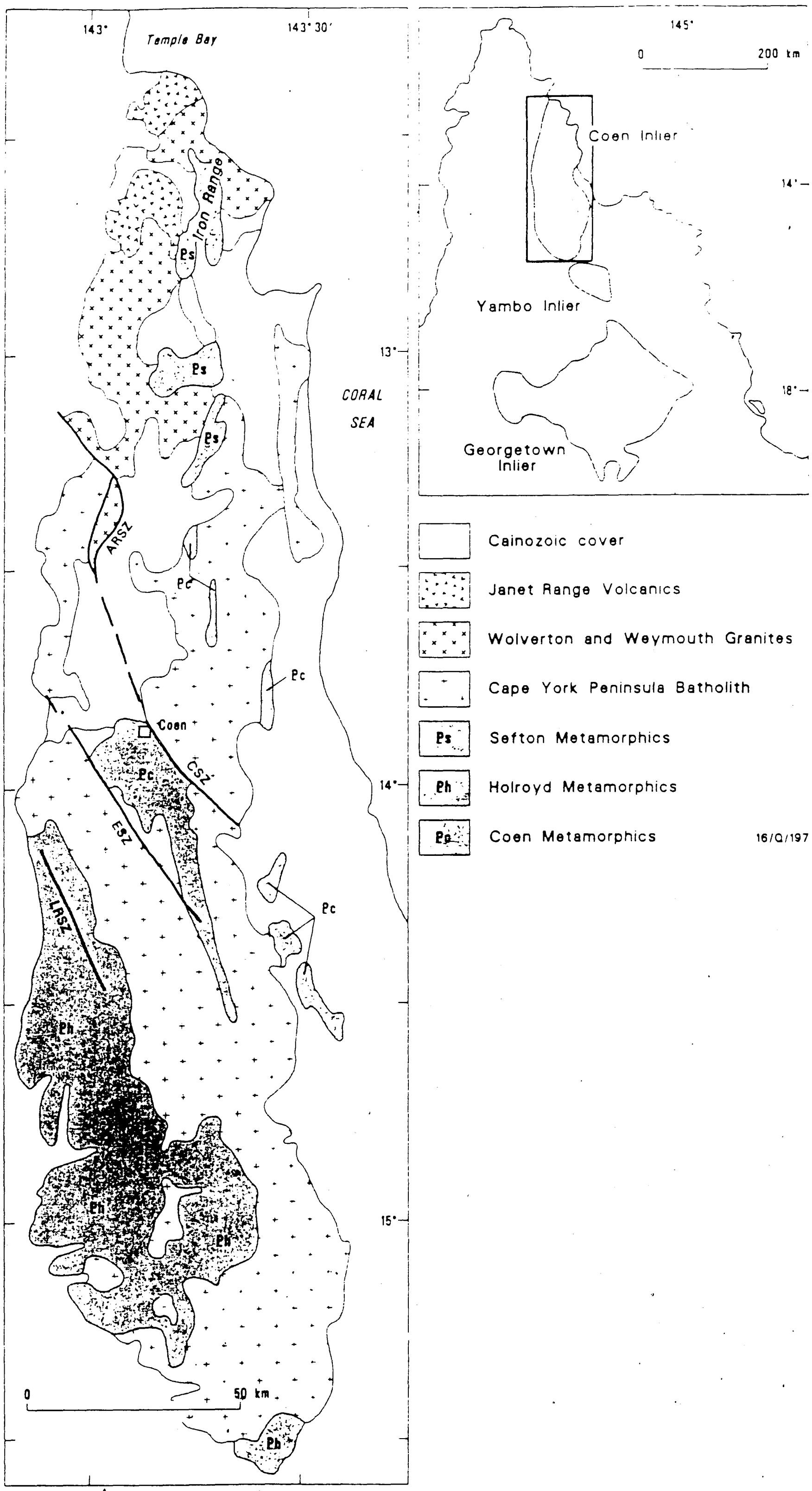

Figure 3. Coen Inlier – major geological sub-divisions.

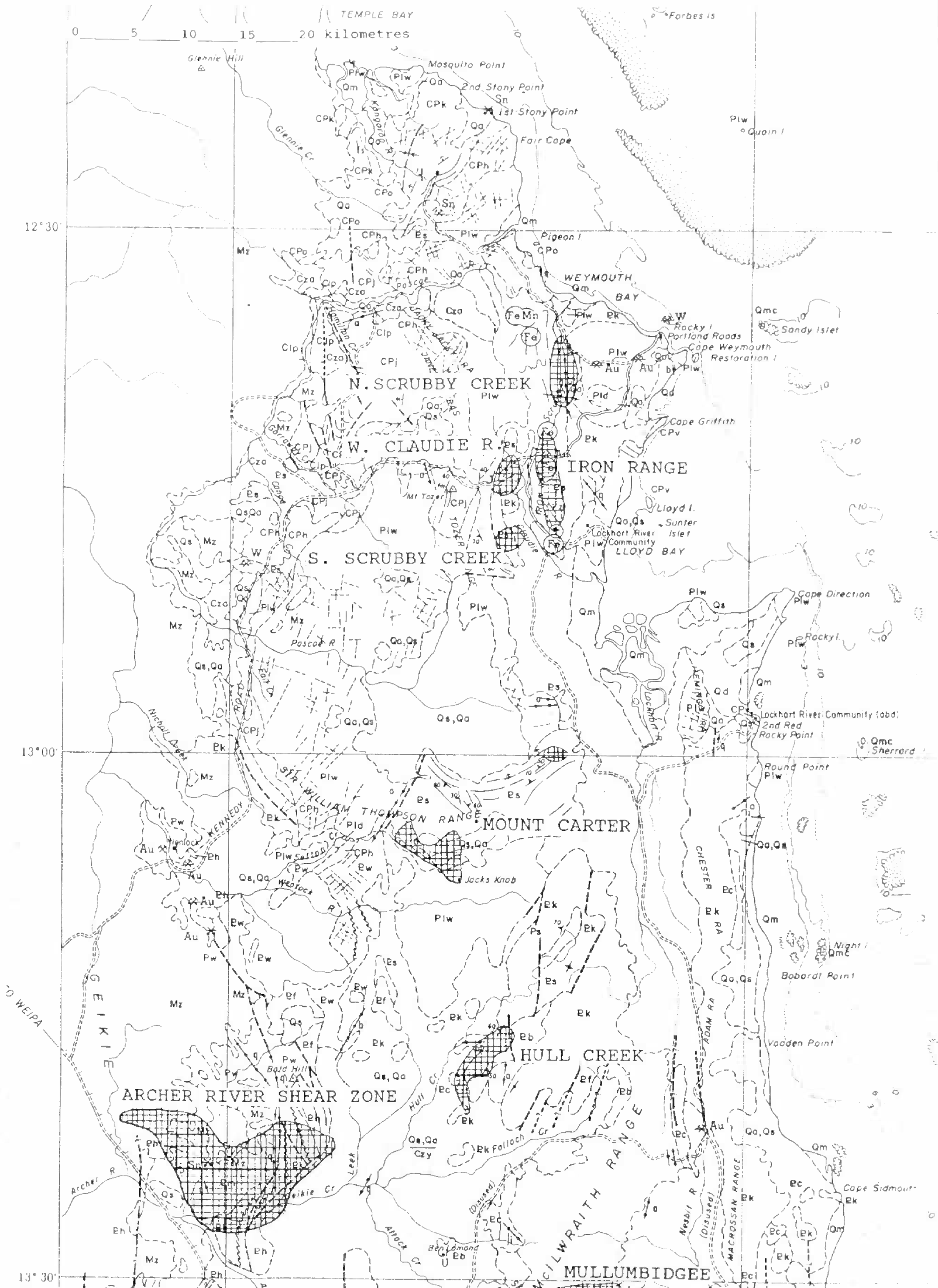

Figure 4. Locations of reconnaissance investigations

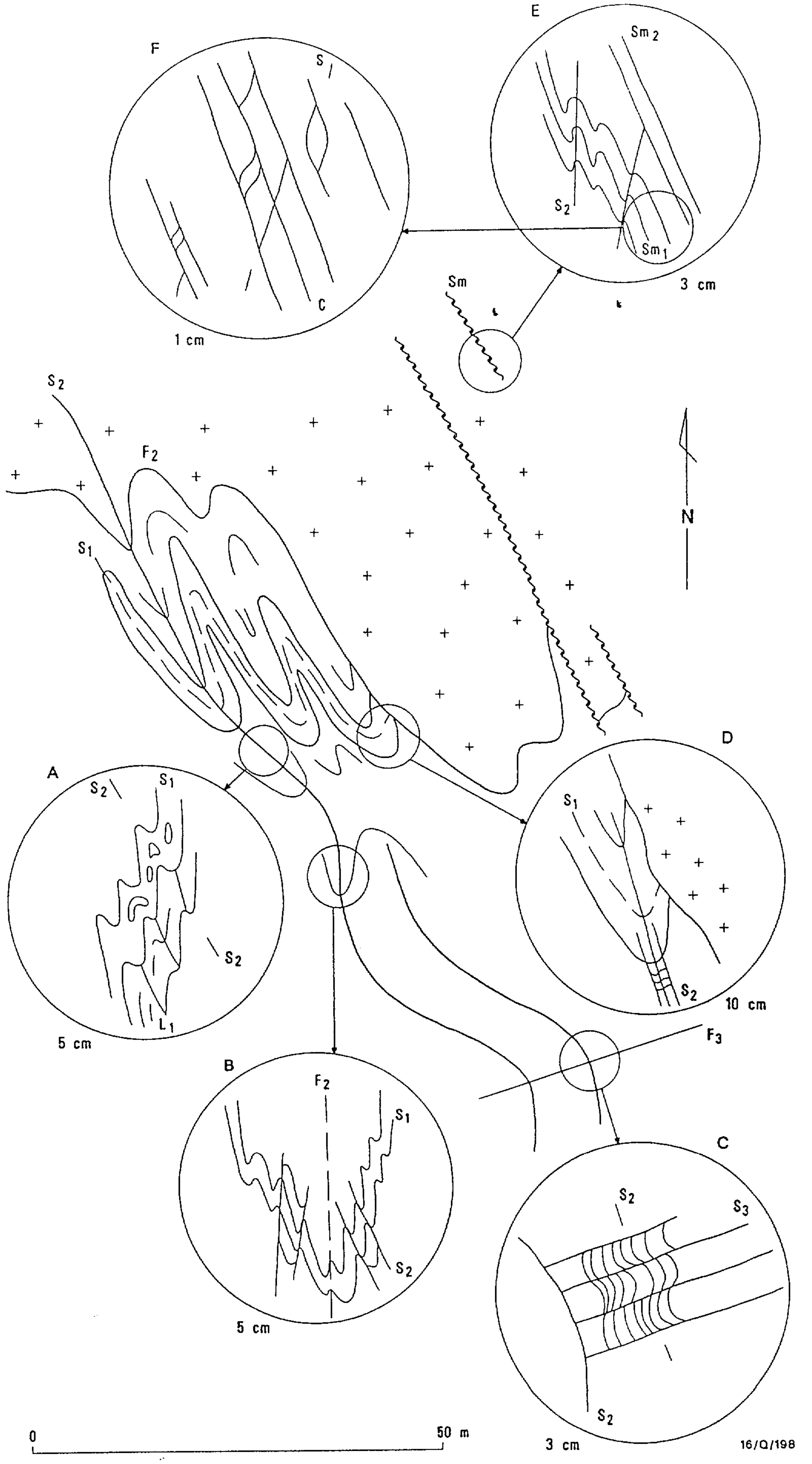

Fig. 5 Schematic fabric element sketch for the Coen Inlier. A: Sillimanite bunches and L_1 lineations overprinted by an asymmetric S_2 crenulation cleavage. B: S_2 overprint of S_1. C: S_3 crenulation of S_2. D: S_1 overprinted by S_2 and cross-cut by granite. E: S_2 overprint of mylonitised (S_{m1}) granite which is overprinted by a second generation of mylonite (S_{m2}). F: Typical C-S fabrics in a sinistral ductile shear zone. S_{1-3} — foliation generation from 1 to 3; F_{1-4} — fold generation from 1 to 4; L_1 — lineation associated with the first generation; M_{1-2} — metamorphic generations 1 and 2; S_{m1-2} — mylonite C-plane generations 1 and 2.

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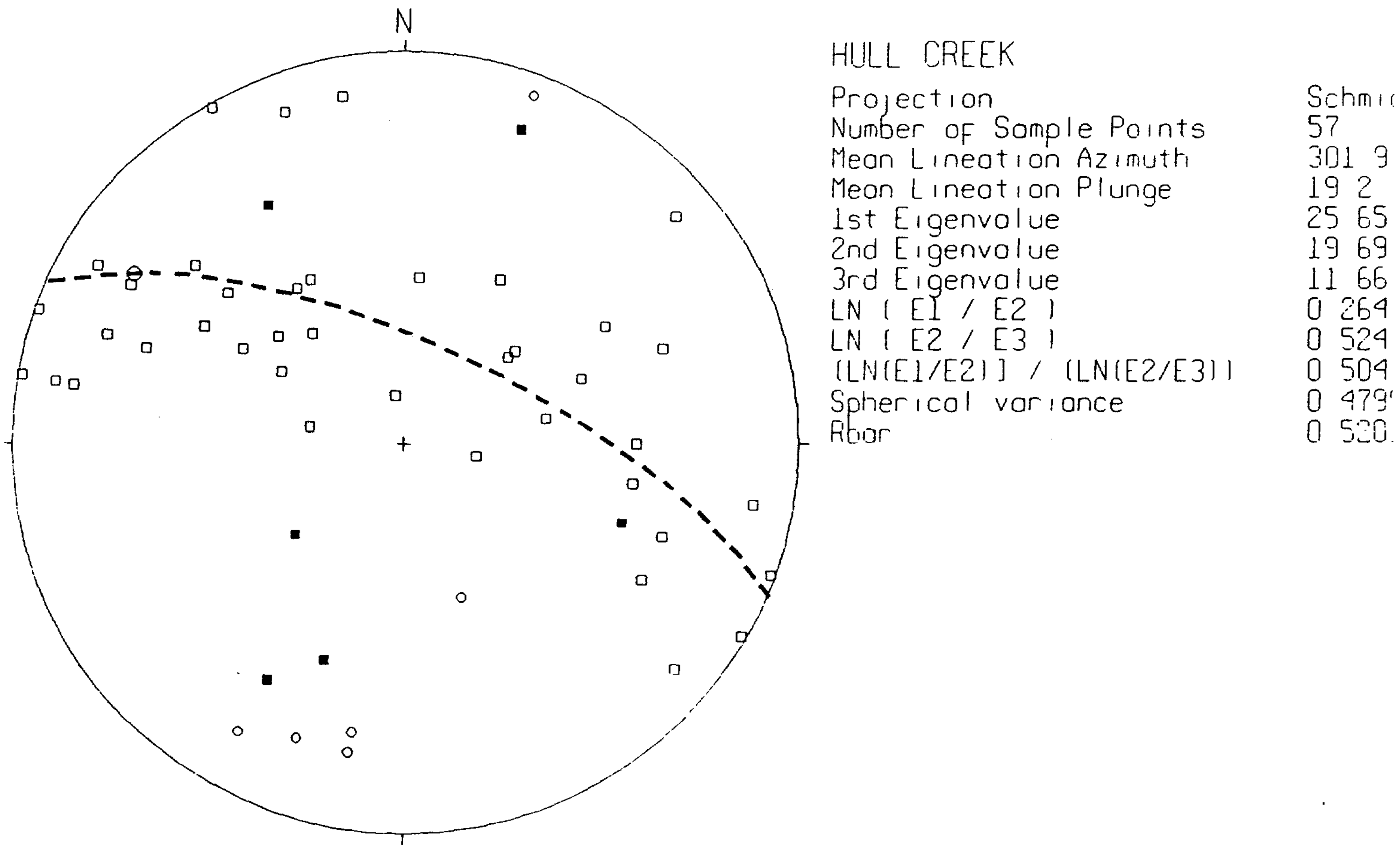
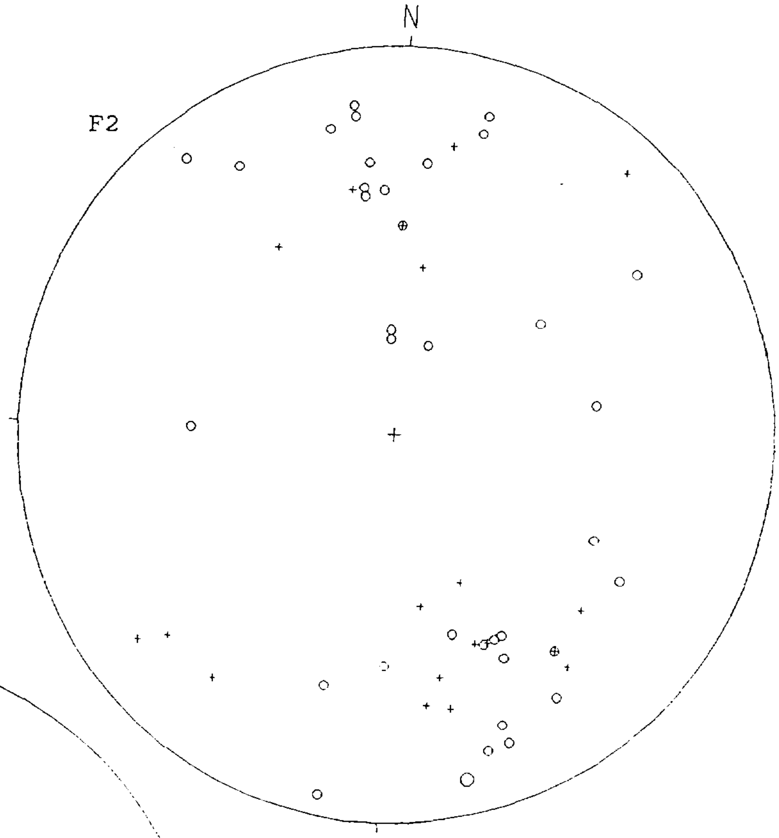
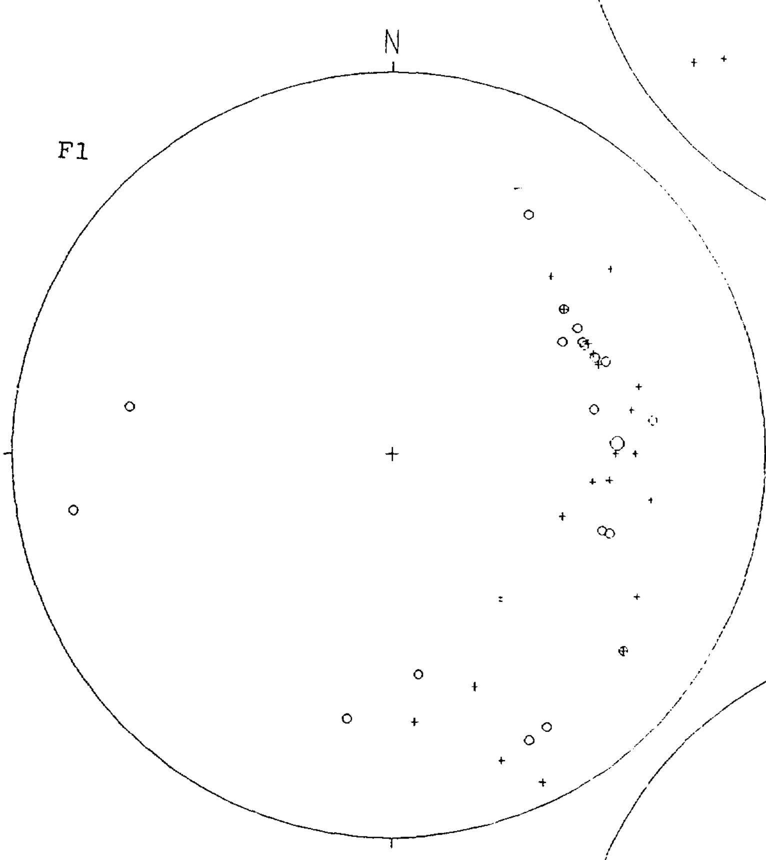


Fig. 6 - Lower-hemisphere stereographic projection (Schmidt) of fold axes, lineations and poles to foliation planes in metamorphic rocks of upper Hull Creek

□ - pole to foliation plane
○ - lineation
■ - fold axis





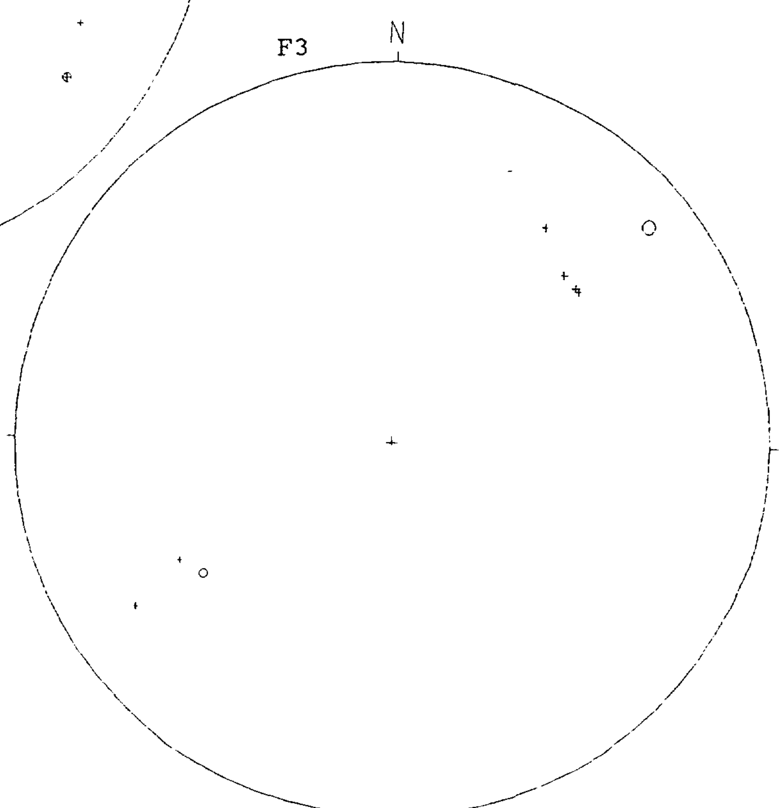


Fig. 7 - Lower-hemisphere stereographic projection (Schmidt) of lineations & fold axes in Sefton Metamorphics at Mount Carter

o - lineation
+ - fold axis

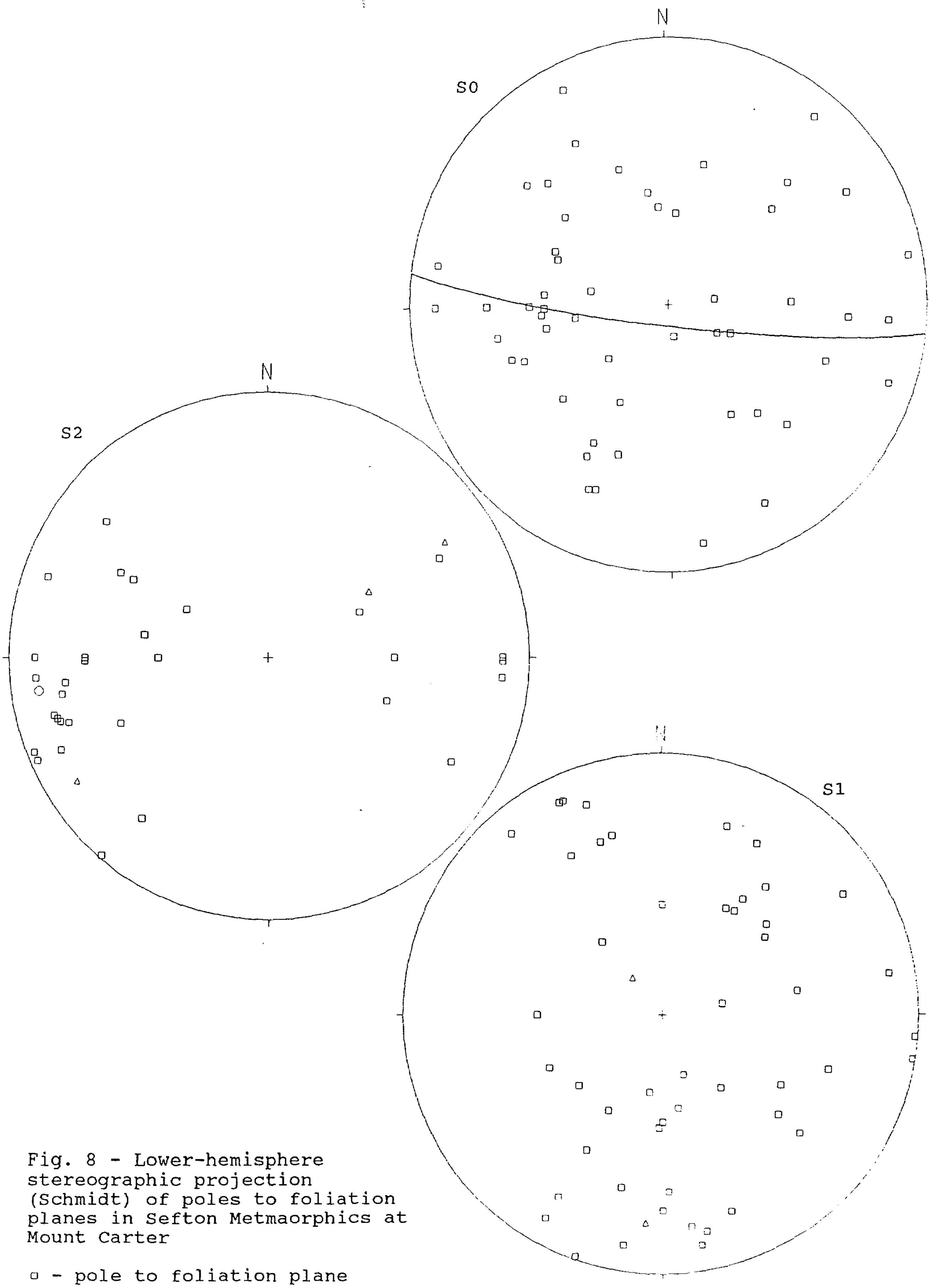
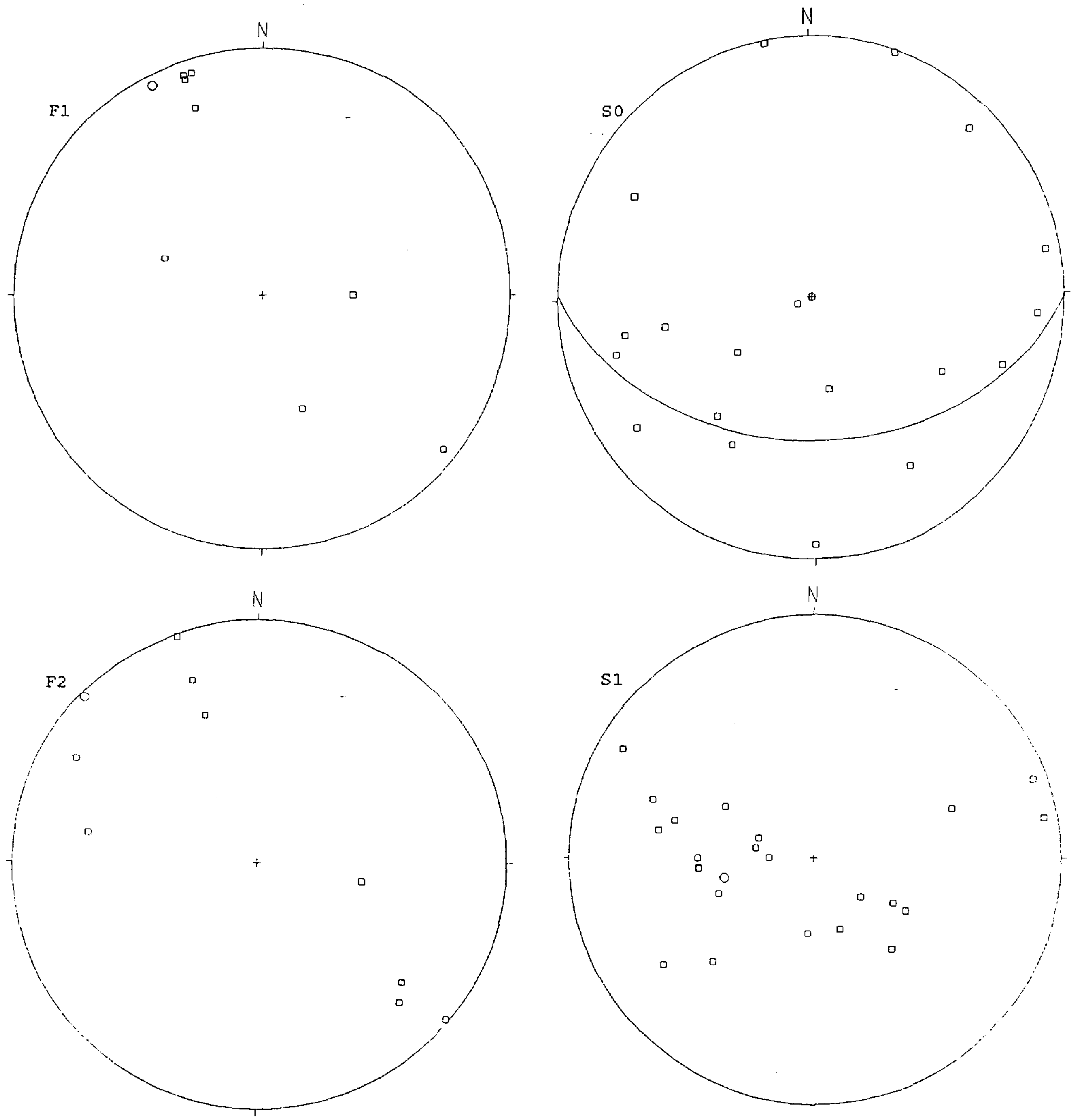


Fig. 8 - Lower-hemisphere stereographic projection (Schmidt) of poles to foliation planes in Sefton Metmaorphics at Mount Carter

□ - pole to foliation plane

△ - pole to axial plane of fold



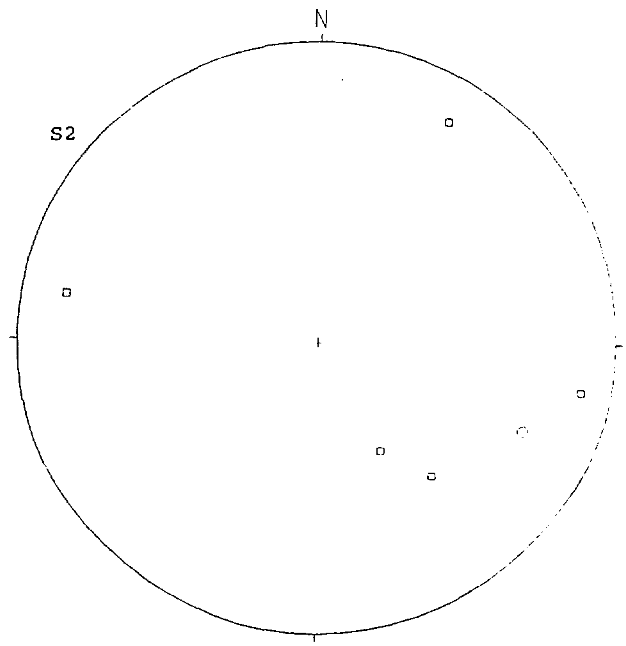


Fig. 9 - Lower-hemisphere stereographic projection (Schmidt) of lineations, fold axes, and poles to foliation planes in Sefton Metmaorphics in West Claudie River, Iron Range

▫ - lineation or fold axis, F1, F2

○ - pole to foliation plane, S0, S1 ,S2

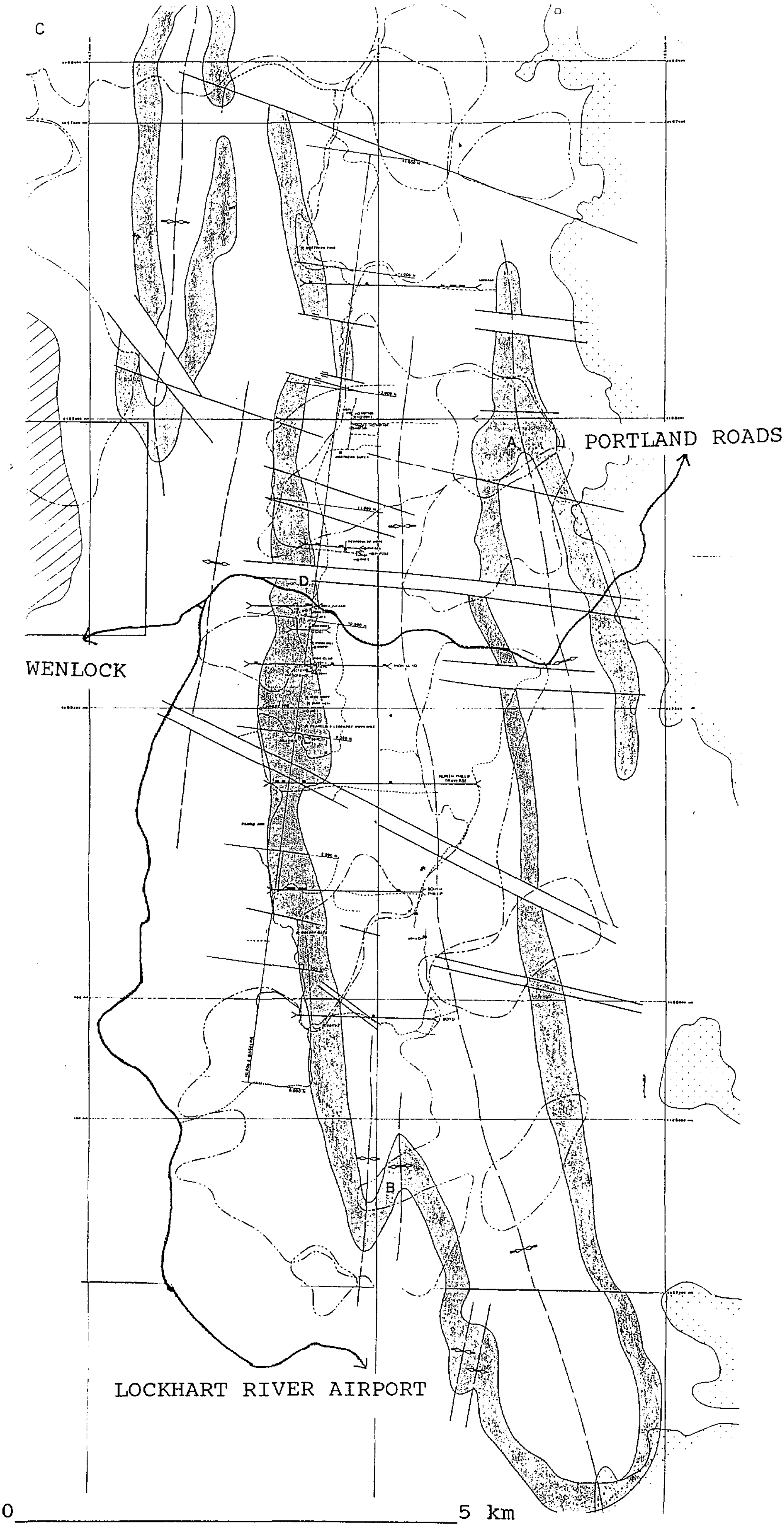


Figure 10. Major synform in hematite-quartz schist at Iron Range (after Newmont Australia).

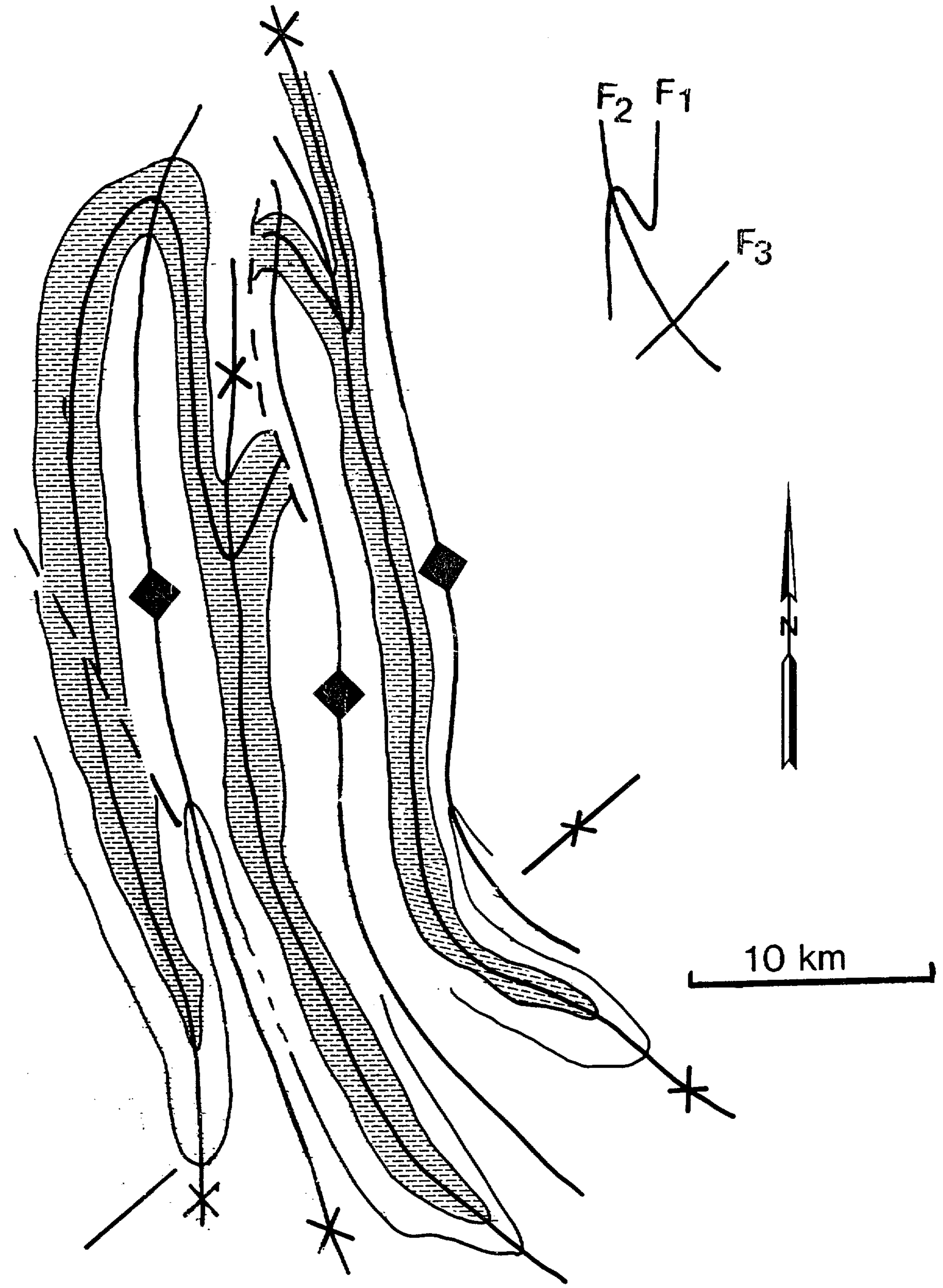


FIGURE 11

Macroscopic $F_1/F_2/F_3$ interference pattern as shown by the patterned greenstone surface form in the southern exposure of the Holroyd Metamorphics in Ebagoola 1:250,000 geological map (SD54/12). Redrawn after Whitacker and Gibson (1977).