# BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

**RECORD** 1980/63

BMR Microform MF 152

GEOLOGY OF THE NORTHERN ARUNTA BLOCK, NORTHERN TERRITORY

by

A.J. STEWART, L.A. OFFE, A.Y. GLIKSON,

R.G. WARREN & L.P. BLACK

1980

## ABSTRACT

The Arunta Block is the region of Proterozoic crystalline rocks in the southern part of the Northern Territory of Australia. It is surrounded mostly by younger sedimentary cover, but in the northwest it grades into schist and gneiss of The Granites-Tanami Block, and to the north into metasediments of the Tennant Creek Block. The northern Arunta Block comprises a tripartite ensialic sequence beginning with mafic and felsic volcanics and pelitic and calcareous sediments, metamorphosed to granulites at about 1650 Ma. These were followed by mixed psammitic, pelitic, and calcareous sediments and subordinate mafic flows and sills, metamorphosed at about 1350 Ma to facies ranging from greenschist to granulite. These are unconformably overlain by mature quartzite, shale, and carbonate, also metamorphosed to greenschist to granulite facies at about 1100 Ma. Granitic intrusion into all three divisions occurred from 1600 to 900 Ma, and introduced tin, tungsten, and uranium into the region. This was followed by intermittent shallow-water clastic sedimentation in the Ngalia Basin until about 350 Ma. The Arunta rocks were then retrogressively metamorphosed and thrust over the Ngalia sediments. Renewed tectonism in the Tertiary included warping and block faulting. The long history of tectonism in the Arunta Block may result from its position at the intersection of several linear zones of intracontinental mobility, including the Albany-Fraser Range lineament in Western Australia, the Torrens Fracture Zone in South Australia, and the Trans-Australia Zone extending from northwest to southern Australia.

CONTENTS

DESCRIPTIONS OF ROCK UNITS (contd)

DESCRIPTIONS OF ROCK UNITS (contd)

MINERAL OCCURRENCES OF ECONOMIC INTEREST (contd) page

## Figure captions (condensed)

Fig. 18: Banded pelitic granulites of Aileron metamorphics.

19: Garnet-bearing granulites of Aileron metamorphics.

20: Interlayered beds of Wickstead Creek beds.

21. Laminated calc-silicate of Wickstead Creek beds intruded by pegmatite.

22: Drag folds in Wickstead Creek beds.

23: Cylindrical folds in Wickstead Creek beds.

24: Boudinage in Wickstead Creek beds.

25: Boudins of calc-silicate intruded by pegmatite, Wickstead Creek beds.

26: Cleavage pencils in Lander Rock beds.

27: Granofels and quartzite of Lander Rock beds.

28: Hornfels of Lander Rock beds containing clasts of hornfelsed metasiltstone.

29: Blocks of hornfels of Mount Stafford beds in granite of Anmatjira Orthogneiss.

30: Spotted hornfels of Mount Stafford beds.

31: Layered hornfels of Mount Stafford beds.

32: Boudinaged hornfels of Mount Stafford beds.

33: Geological map of unconformity between Lander Rock beds and Mount Thomas Quartzite.

34: Rafts of Mount Thomas Quartzite in orthoschist of Warimbi Schist.

## SUMMARY

The Arunta Block is the region of Proterozoic crystalline basement rocks that extends across the Northern Territory of Australia between Alice Springs and Barrow Creek. It is surrounded on most sides by younger sedimentary cover, but in the northwest it passes transitionally into similar crystalline schist and gneiss of The Granites-Tanami Block, and to the north into slate, schist, and quartzite of the Tennant Creek Block. The northern part of the Arunta Block includes rocks belonging to all three Divisions of the tripartite scheme of Arunta stratigraphy introduced by Shaw & Stewart (1975).

In the northern part of the Arunta Block, outcrops belonging to Division 1 are of restricted extent, and form an uplifted fault block, as well as rafts and enclaves in granitic orthogneiss. The rocks include mafic, felsic, and pelitic granulites, minor amounts of marble and calc-silicate rock, and small intrusive bodies of charnockite. The metamorphism is dated at about 1650 Ma. Division 2 is very extensive, and makes up the major part of the northern Arunta Block. It consists mostly of metamorphosed and highly folded micaceous sandstone, shale, lesser amounts of calc-silicate rock, and a few flows or sills of mafic igneous rock. Metamorphism (dated at about 1350 Ma) is generally greenschist in facies, but rises to granulite in the southeast of the area. Division 3 unconformably overlies Division 2, and crops out as elongate synclines and fault slices composed of orthoquartzite above a basal pebbly arkose, followed by shale and a lenticular carbonate member. In the major area of outcrop, the Reynolds Range, these rocks are intercalated with sills and a possible flow of silicic igneous rock, and are intruded by a lopolith of granite porphyry. Metamorphism was co-eval with that in Division 2, and shows a similar rise in grade from greenschist in the northwest to granulite in the southeast. Intruding all three Divisions are batholiths and smaller masses of granitic rock, including foliated orthogneiss with feldspathic augen, and massive or flow-textured porphyritic or even-grained granite. The granitic rocks are dated at 1600 to 900 Ma; some, particularly the orthogneisses, may have been intruded and metamorphosed before Division 3 was deposited. Tectonism occurred again at about 900 Ma, with Rb-Sr isotopic homogenisation of at least one granitic orthogneiss (the Boothby Orthogneiss,

near Aileron). This appears to have been the northernmost limit of extensive metamorphism and migmatisation centred in the southern part of the Arunta Block (the Chewings Range-Ormiston Gorge area), and was followed soon after by the initial downsagging of the Ngalia Basin, which lies across the central part of the Arunta Block, along the southern edge of the mapped area. Sedimentation in the Ngalia Basin ceased in the Palaeozoic, at about 350 Ma, and was followed by southward thrust-faulting of the Arunta crystalline rocks over sediments of the Basin. Resetting of Rb-Sr and K-Ar mineral isotopic systems, and major faulting throughout the remainder of the northern Arunta Block accompanied the thrusting. For the remainder of the Palaeozoic, and during the Mesozoic, the area was eroded and peneplaned, supplying detritus to the Eromanga and Canning Basins to the east and west, respectively. Epeirogenic movements in the late Mesozoic and/or early Tertiary led to alluvial deposition of gravel, sand, silt, clay, and coaly sediments in small non-marine basins overlying the northern Arunta Block, and were interspersed with episodes of deep weathering which produced laterite and silcrete horizons.

The northern Arunta Block lacks the characteristics of an ensimatic depositional and tectonic environment, such as ophiolites, glaucophane schist, serpentinite sheets, chert, turbidite, argillite, volcanoclastic conglomerate, andesite, and paired metamorphic belts. Instead, it is characterised by mafic and felsic meta-igneous rocks, abundant quartzose and rather fine-grained metasediments, and low-pressure metamorphism. Hence, the northern Arunta Block is interpreted as part of an early Proterozoic ensialic geosyncline floored by continental crust of Archaean or Early Proterozoic age. The Arunta Geosyncline then proceeded through a rather long-lived geosynclinal evolution, involving sedimentation, vulcanism, folding, metamorphism and granite intrusion lasting about 750 Ma (1650-900 Ma). Epeirogenic movements continued for another 550 Ma, resulting in episodes of shallow marine deposition interspersed with tilting and folding, and culminating in extensive thrust-faulting and retrogressive metamorphism in the late Palaeozoic.

# INTRODUCTION (L.A.O.)

## General

In 1971, a Bureau of Mineral Resources field party began semi-detailed mapping of the northern part of the Arunta Block in the Northern Territory of Australia. At the end of 1976, semi-detailed mapping of the Aileron, Tea Tree, Reynolds Range, Denison, and Mount Peake 1:100 000 Sheet areas (henceforth denoted by upper case names), and reconnaissance mapping of the Mount Theo, Mount Solitaire, Lander River, and the remainder of Mount Peake 1:250 000 Sheet areas had been completed. The area mapped is approximately 64 000 $km^2$, roughly the size of Tasmania.

## Location and Access

The location of the area mapped is shown in Fig. 1. Access is provided by station tracks and graded earth roads, which link homesteads in the area with the Stuart Highway (Fig. 2). Mount Solitaire and most of Mount Theo and Lander River Sheet areas lie within the Tanami Desert.

## Survey Method

Most of the area was mapped using four-wheel-drive vehicles on regular five-day traverses away from a base camp. Mount Solitaire, Mount Theo, Lander River, and the northwestern portion of Mount Peake Sheet areas were mapped almost completely by helicopter. Two one-day helicopter traverses were made in the less accessible parts of the Yalyirimbi and Anmatjira Ranges (REYNOLDS RANGE and DENISON).

Vertical colour aerial photographs of AILERON, TEA TREE, REYNOLDS RANGE, DENISON, and MOUNT PEAKE at approximately 1:25 000 scale were taken in 1971 and 1972 for the Bureau of Mineral Resources. The photographs can be obtained through the Division of National Mapping. The geological data were plotted on transparent overlays, and later transferred to enlarged orthophotomap overlays. These were then reduced to 1:100 000 scale and the final map drafted.

Mount Theo and Mount Peake 1:250 000 maps were compiled at 1:50 000-scale on black and white photographs taken in 1950. Mount Solitaire and Lander River Sheet areas were produced by amending the

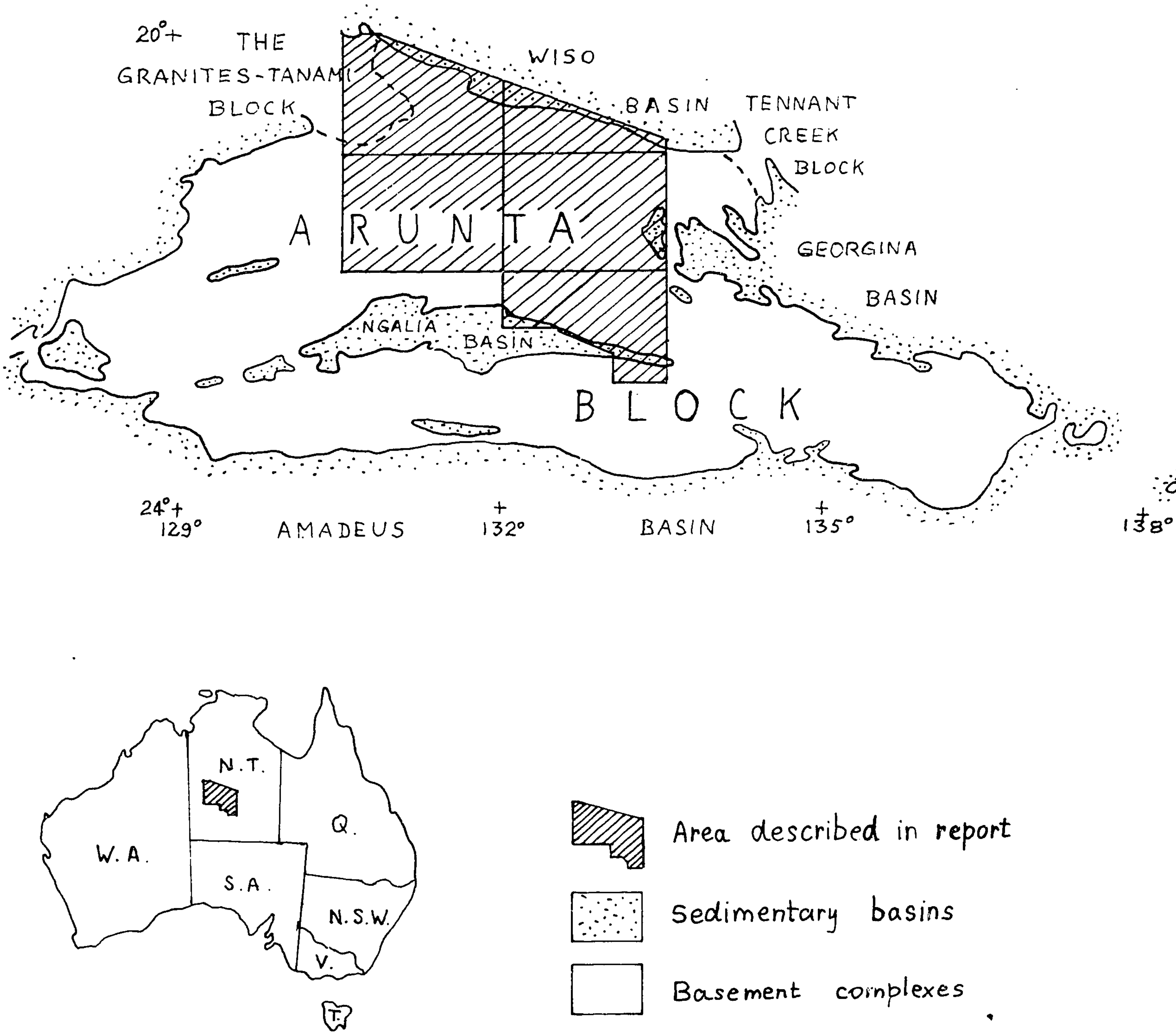



Fig. 1 : Sketch map of Arunta Block, showing location of area described in report.

16/NT/2

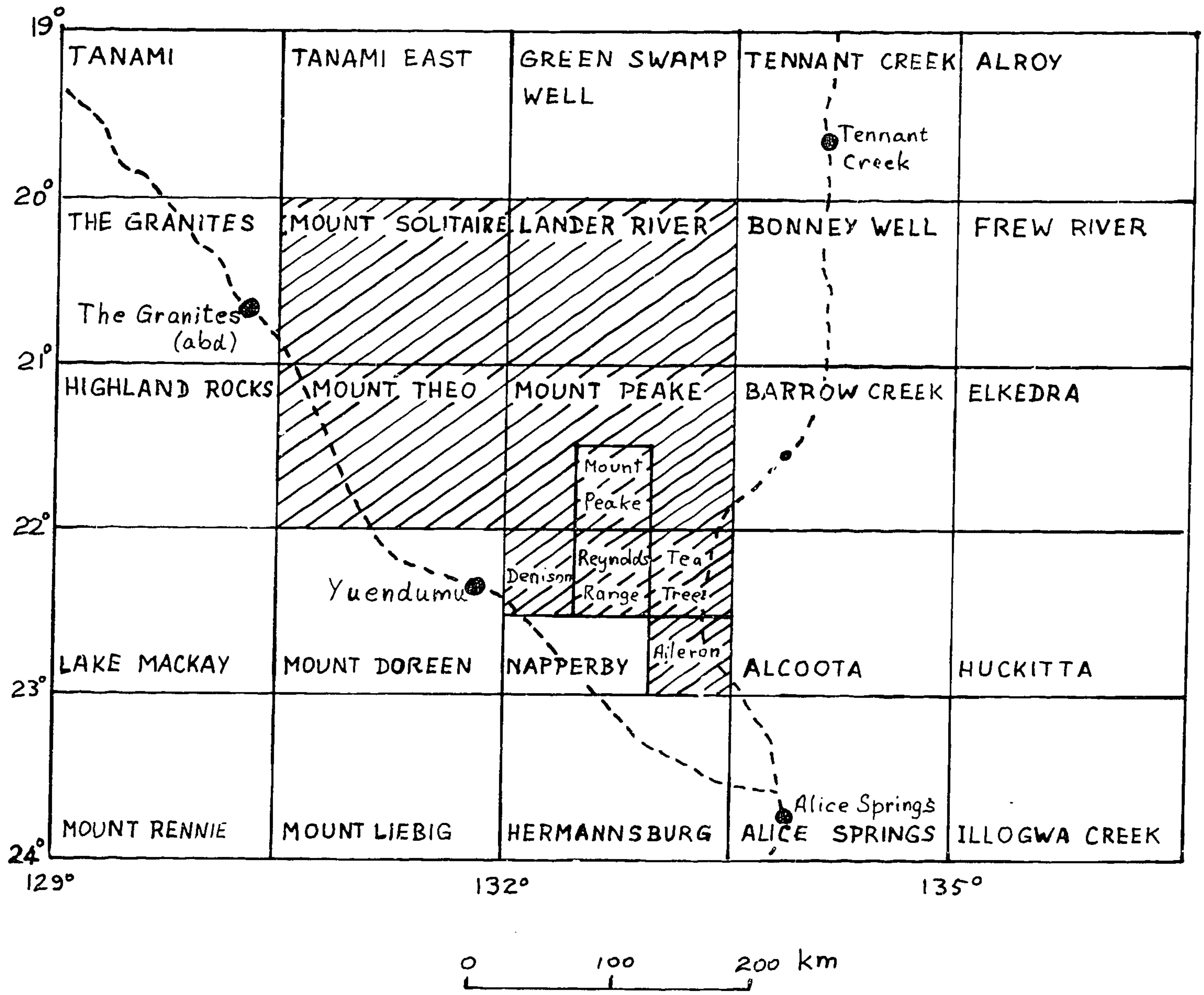



Fig. 2 : Locality map showing mapped 1:100 000 and 1:250 000 sheet areas (diagonal ruling) and 1:250 000 series.

16/NT/3

1:250 000-scale photo-interpretation maps of Perry, prepared from 1:50 000-scale photographs (Rivereau & Perry, 1965).

Miscellaneous

The descriptions of rock units in this report were prepared following thin-section examination, and in some instances chemical analysis and X-ray diffraction of samples collected in the field. The thin sections are stored in the BMR Northern Arunta Project archives, together with descriptions of each thin section on the back of the relevant sample submission card. Chemical analyses were done by the Australian Mineral Development Laboratories, Adelaide. Major elements were analysed by a combination of wet chemical and X-ray fluorescence methods. Trace elements were analysed as follows: Li, Co, Ni, and Zn by total solution in hydrofluoric acid, followed by atomic absorption spectrophotometry: Be, B, and F by 'high-quality analysis'; and Rb, Sr, Y, Sn, Ba, W, Th, and U by X-ray fluorescence. Grid references (GR) on 1:100 000 Sheets are given as four digits (map sheet number) followed by six digits (easting and northing); grid references on 1:250 000 Sheets are given by eight digits (easting and northing) only.

The 1:100 000 map sheet numbers are as follows: 5353 - DENISON: 5452 - NAPPERBY; 5453 - REYNOLDS RANGE: 5454 - MOUNT PEAKE; 5552 - AILERON: 5553 - TEA TREE.

Copies of water bore logs for Mount Theo, Mount Peake, and Napperby 1:250 000 Sheet areas are held at BMR, Canberra.

The Rb-Sr isotopic dates included in the various rock unit descriptions are the raw numbers obtained by the normal isochron method, usually rounded off to the nearest 10 Ma. A Rb decay constant of $1.42 \times 10^{-11}\ y^{-1}$ has been used throughout. No assessment of the geological significance of the dates has been made at this stage; this will be the subject of a separate paper by Black & others on the geochronology of metamorphism in the Arunta Block.

Previous Geological Investigations

Previous geological investigations in the Napperby 1:250 000 Sheet area up to 1970 were summarised by Evans (1972), and in the other Sheet areas up to and including 1976 by Stewart (1976 - Mount Theo), Offe & Kennewell (1978-Mount Solitaire), Kennewell & Offe (1979-Lander River), and Offe (1978-Mount Peake). Otter Exploration N.L. have investigated the southeast of the Mount Peake 1:250 000 Sheet area (Kojan, 1979), and at the time of writing (January 1980), CRA Exploration Pty Ltd hold a lease in the southeast of the Mount Peake 1:250 000 Sheet area.

Evans & Glikson (1969) have summarised previous geological investigations up to and including 1967 in the four 1:100 000 Sheet areas which are part of the Napperby 1:250 000 Sheet area. In 1968, geologists from the Bureau of Mineral Resources (BMR) mapped the Ngalia Basin in the southern part of the Napperby 1:250 000 Sheet area, and during this time some reconnaissance mapping of the basement rocks was done. They identified greenschist facies metasediments in the Reynolds Range, and amphibolite-granulite facies metasedimentary and meta-igneous rocks in the Anmatjira Range, separated by a major zone of shearing and intrusive granite. The effect of retrogressive metamorphism is pronounced in the high-grade belt, but can also be seen to various degrees in the granite intrusives, acid porphyries, and dolerite and basaltic dykes.

A brief account of the early results of the BMR survey that began in 1971 was presented by Shaw & Stewart (1975), and Warren & others (1974), and Stewart & Warren (1977) reviewed the mineral deposits and economic potential of the area. Lowder & Webb (1972) determined K-Ar isotopic dates on several samples from the Reynolds and Anmatjira Ranges, and Kemp (1976) described fossil pollens from Tertiary sediments overlying the Ngalia basin near Napperby homestead, and discussed their climatic significance. The geology and geophysics of the Ngalia Basin itself, which occupies the central part of the Napperby 1:250 000 Sheet area, were briefly described by Wells & others (1972), and are being described in full by Wells & Moss (in prep.). Formal definitions of all named rock-units in the Arunta Block are set out in Stewart & others (1980), and a commentary on a special 1:100 000 map showing the geology of REYNOLDS RANGE and the adjoining parts of MOUNT PEAKE, TEA TREE, and AILERON is presented by Stewart (in press).

Geologists from the Resident Geologists' Office at Alice Springs made brief investigations of the Mount Allan tin mine (Grainger, 1968;

Fruzzetti, 1969, 1970) and of the nickel and chromium occurrence near Native Gap (Morlock, 1973).

A number of exploration companies have investigated the area. McMahon & partners (1968) described talc near Mount Freeling, in AILERON. As part of the search for uranium, Tanganyika Holdings Ltd investigated the area north and northeast of the Reynolds Range (Davies, 1973; Partridge, 1973), and CRA Exploration Pty Ltd drilled six holes to basement in the Tea Tree Basin, in the centre of TEA TREE (O'Sullivan, 1973). Central Pacific Minerals N.L. investigated the western part of REYNOLDS RANGE and southern part of DENISON for uranium (Schindlmayr 1973; Green, 1978a), and the northwestern part of AILERON for uranium and base metals (Green 1977, 1978b). Otter Exploration N.L. have investigated areas in the west of TEA TREE and northeast of REYNOLDS RANGE, principally for uranium and tin (Kojan, 1979), Pacminex Pty Ltd have investigated the southeast of REYNOLDS RANGE for uranium, tungsten, and base metals (Allen, 1978), and the Australian and New Zealand Exploration Co. examined the northern half of DENISON and the northwest of REYNOLDS RANGE for uranium (Davies, 1979) and tungsten (Lockhart, 1979).

In 1958, the geophysical section of the Bureau of Mineral Resources conducted an airborne magnetic and radiometric survey of the northern parts of DENISON and REYNOLDS RANGE (Carter, 1960), and a similar survey of the Mount Peake and Napperby 1:250 000 Sheet areas was made in 1976. The data are available at 1:250 000-scale through the Copy Service of the Australian Government Printer.

## Physiography

The physiography is briefly described in Evans & Glikson (1969), Evans (1972), Stewart (1976), Offe (1978), Offe & Kennewell (1978), and Kennewell & Offe (1979). Perry & others (1962) included the area in their land research survey around Alice Springs in 1956-7.

## REGIONAL GEOLOGICAL SETTING (A.J.S.)

The Arunta Block is the region of igneous and metamorphic rocks in the southern part of the Northern Territory, about 1000 km east-west by 400 km north-south. It passes northwards into The Granites-Tanami and Tennant Creek Blocks, and is basement to the Late Proterozoic to mid-Palaeozoic Amadeus, Ngalia, and Georgina Basins (Fig. 1). The Block consists of an Early Proterozoic (or older) discontinuous sequence of sedimentary and volcanic rocks which evolved to a stable craton through episodes of multiple deformation, regional metamorphism, and granite intrusion at around 1760, 1645, 1570, and 1400 Ma. Following cratonisation, the Block was affected by two further intracontinental tectonic events, the first at around 1050-900 Ma, when plate tectonics seems to have started at many places around the world, and the second at about 335 Ma, in response to full-scale plate tectonic activity elsewhere in Australia.

Primarily to simplify presentation, the metamorphic rocks of the Arunta Block have been grouped into three Divisions. Throughout the Arunta Block, mafic and felsic granulites form what appear to be the stratigraphically lowest rocks, and in all but the southwest part of the Block, they are followed upwards by pelitic granulite and/or gneiss, and then in the southeast by calcareous rocks and marble. The entire assemblage is called Division 1. Division 2 is characterised by a greater proportion of pelitic, psammitic, and calcareous metasediments, which in the northwest of the Block are but weakly metamorphosed to slate, schist, micaceous metasandstone, and epidote-rich calc-silicate rock. Small amounts of metamorphosed intermediate to basic flows or sills are also present in this area. Elsewhere, the metamorphic grade is higher, calcareous rocks are scarcer, and the Division comprises pelitic and quartzofeldspathic gneisses, amphibolite, and granulite. Division 2 is almost everywhere in fault contact with Division 1, but in one area in the Arltunga Nappe Complex, in the southeast of the Block, the Cavenagh metamorphics of Division 2 appear to conformably overlie the Hillsoak Bore metamorphics of Division 1 (Shaw & others, in preparation).
Division 3 shows a still greater degree of sedimentary evolution, and comprises mature orthoquartzite with a basal conglomerate, shale, limestone, and dolomite. In the northwest of the Block, these rocks are

only very weakly metamorphosed, and rest with an angular unconformity on slate and metasandstone of Division 2. Metamorphic grade and intensity of deformation increase to the southeast, and so in most areas Division 3 is represented by metaquartzite, schist, pelitic gneiss or granofels, and a small amount of marble or calc-silicate rock. Metamorphic grade reaches granulite facies in the Aileron area. In the northeast of the Block, near Mount Bleechmore, schist and metaquartzite of Division 3 rest on granulite of Division 1 (Shaw & others, in preparation).

It must be noted that large areas of the exposed Arunta Block are separated by superficial Cainozoic cover. Hence, the rocks of each Division cannot be traced as continuous units throughout the Block, and there is no guarantee that similar rocks assigned to a particular Division are truly chronological correlatives. Furthermore, isotopic dates as yet have given only times of metamorphism, not sedimentation, and so chronostratigraphic correlation is not feasible at this stage. It is quite possible that the rocks of the three Divisions in the various areas of the Arunta Block belong to separate and unrelated tripartite sequences. Nevertheless, because of the broad similarities in the sequences in each area, and in the absence of evidence to the contrary, we suggest that the three Divisions are chronological and stratigraphic correlatives, at least in broad, regional terms.

All three Divisions are intruded by granite, ranging in age from about 1760 to 900 Ma. The oldest granites were intruded under pretectonic or syntectonic metamorphic conditions, and are augen orthogneisses, although they still retain evidence of magmatic intrusion. Later granites are commonly porphyritic. Other igneous intrusions include intermediate, basic, and ultrabasic dykes, and, in the southeast of the Arunta Block, a differentiated dioritic complex, a differentiated ultrapotassic complex, and a carbonatite (Shaw & others, in preparation).

## DESCRIPTIONS OF ROCK-UNITS

### Unassigned metamorphic rocks (pG) (A.J.S.)

In the northeast of MOUNT PEAKE, poorly exposed, steeply dipping phyllite containing muscovite and biotite crops out as low rises partly covered by quartz and ferricrete gravel. These exposures had not been visited when the MOUNT PEAKE Preliminary Edition was prepared in 1973. However, they were subsequently visited during mapping of the Mount Peake 1:250 000 Sheet area in 1974, and are shown as Lander Rock beds on that Sheet.

In the Mount Theo 1:250 000 Sheet area, low hills in the southeast and southwest have not been visited, but are probably composed of schist and gneiss (Stewart, 1976). An isolated strike ridge 34 km west of Chilla Well, near the centre of the western edge of the Sheet area, was visited in 1976, and consists of fine-grained metaquartzite.

Small areas mapped as pG in the northern part of REYNOLDS RANGE, near Rabbit Well in AILERON, and in the southern part of DENISON have not been examined on the ground.

### Metabasalt and amphibolite (pGb) (L.A.O.)

On the southern side of Mount Browne in the southeast of Mount Peake 1:250 000 Sheet area, a lens of metabasalt crops out: it is surrounded by granite and unconformably overlain by a granule and pebble bed of the Central Mount Stuart Formation. The metabasalt is fine to medium-grained, and consists of chlorite and ?talc pseudomorphs after amphibole, plagioclase, calcite, quartz, opaque grains, leucoxene, and apatite. Near the unconformity the rock is veined by calcite, and opaque material fills veinlets at the unconformity surface itself (74110069-0070).

Amphibolite was cored from the bottom of BMR Stratigraphic hole No. 4 (GR688658) in the Mount Theo 1:250 000 Sheet area. The rock is fine to medium-grained, schistose, and composed of green poikiloblastic hornblende (40%), sericitised andesine (30%), biotite (15%) partly altered to chlorite and sphene, quartz (10%), clear pink sphene (5%), and accessory apatite and opaque grains (72110331).

Quartzofeldspathic gneiss (p€f) (A.J.S.)

Quartzofeldspathic gneiss, together with small amounts of granitic gneiss, porphyroblastic gneiss, biotite gneiss, sillimanite schist, and retrogressively metamorphosed rock crops out as low scrubby ridges in the northern part of DENISON, and probably extends northwards below Cainozoic cover into the southern part of the adjoining Mount Peake 1:250 000 Sheet area. There are six areas of exposure. The largest is centred on Claypan Dam, at the northern edge of DENISON, and extends latitudinally for about 6 km each side of the dam. A smaller area is centred on Beantree Dam, 10 km southwest of Claypan Dam, and a third is situated immediately north of Mount Treachery. On the generalised 1:500 000 Solid Geology Map, and in Figure 3, the three areas have been combined into a single large outcrop surrounding a body of Wickstead Creek beds. The three other exposures are situated 5 km west-northwest of Beantree Dam, 5 km south of Mount Denison homestead, and 12 km east-southeast of Mount Treachery, respectively.

The quartzofeldspathic gneiss unit is seen in contact with other stratigraphic units only at sample locality E880 (GR5353-210572), 2.5 km northeast of Mount Treachery. Here, the gneiss adjoins schistose silliamanite-biotite gneiss and coarse-grained metaquartzite of the Wickstead Creek beds. The contact is concordant, and fold axes in both gneiss and metasediment are parallel and plunge gently east. Hence, the two units may be conformable. A further 2.5 km north of there, at sample locality E877 (GR5353-205596), three elongate exposures of porphyroblastic gneiss parallel the strike of several ridges of metaquartzite of the Wickstead Creek beds to the south, again consistent with a conformable relationship. Cross-bedding in the metaquartzite indicates that it stratigraphically underlies the gneiss. In contrast to these indications of stratigraphic conformity, the quartzofeldspathic gneiss 5 km west-northwest of Beantree Dam intrudes schist of the Mount Stafford beds along its northwestern margin. The quartzofeldspathic gneiss 5 km south of Mount Denison homestead is intruded by coarse porphyritic granite of the Wangala Granite; dykes of the Granite invade the gneiss, and xenoliths of gneiss are enclosed in the Granite. At sample locality E871 (GR5353-138614), 8 km northwest of Mount Treachery, quartzofeldspathic gneiss is intruded by an elongate body of basic rock retrogressively metamorphosed to epidote-chlorite-quartz schist. Dykes of pegmatite and rare aplite intrude the gneiss; the dykes are folded, and their axial planes parallel the foliation in the gneiss.

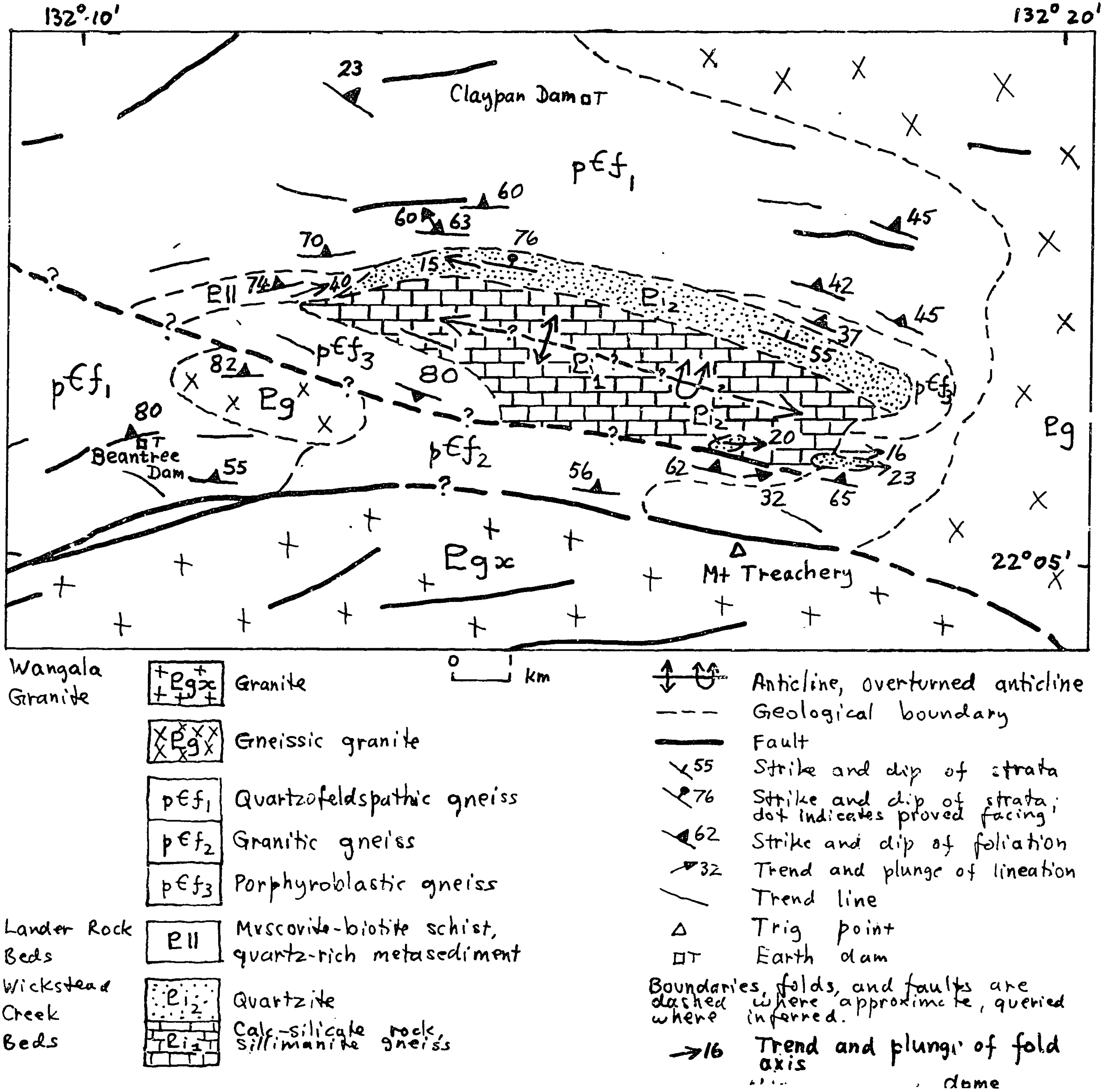



Fig. 3 : Geological sketch map of largest outcrop of quartzofeldspathic gneiss dome surrounding antiformal core of Wickstead Creek Beds in northern part of DENISON.

Quartzofeldspathic gneiss is by far the most abundant rock-type of this unit. It is generally fine to medium-grained, rarely coarse-grained, and strongly invested with a penetrative foliation, and in places a lineation also. As a rule, layering is weak and poorly defined (Fig. 4), but the rock does contain a small number of coarse leucocratic quartz-feldspar layers several centimetres thick which commonly have dark biotite-rich margins (Fig. 5). These layers are in places concordant with the foliation, and elsewhere they cut the foliation at a low angle. A few lenticular feldspar or muscovite megacrysts are present in some exposures, but are uncommon. The gneiss is composed of microcline (about 50%), quartz (25%), andesine $An_{32-38}$ (20%), muscovite (3%), biotite (2%), and accessory apatite and zircon (74920857, -0870, -0872). In the northeast of the largest body, the rock is adamellitic in composition; muscovite is absent, biotite makes up 10 percent of the rock, and andesine is calcic, $An_{48}$ (74920875). The southeast and southwest parts of the largest body of gneiss commonly contain pods and masses up to several metres across of coarse-grained biotite rock. The biotite masses carry unusually abundant apatite and zircon, totalling up to 2 percent of the rock (74920866), and also contain up to 26 ppm uranium (Table 21). In contrast to the large main body, the quartzo-feldspathic gneiss 5 km south of Mount Denison homestead contains more mica (up to 15 percent each of biotite and muscovite) and more quartz (up to 45 percent). The quartz in one sample forms polycrystalline lenses which appear to be flattened and recrystallised pebbles (74920660). Tourmaline is also abundant in this body, and forms pods which are foliated and folded concordantly with the enclosing gneiss. Sillimanite schist is also present.

Granitic gneiss crops out in the southern part of the largest outcrop area of quartzofeldspathic gneiss, 2.5 km west-northwest of Mount Treachery (Fig. 3). The rock is fine-grained, strongly foliated, and in places more distinctly banded than the quartzofeldspathic gneiss.

Porphyroblastic gneiss crops out in two separate areas inside the large body of quartzofeldspathic gneiss (Fig. 3). The rock is granitic in composition, and in general resembles the quartzofeldspathic gneiss except for the presence of flattened megacrysts of andesine rimmed with oligoclase (74920877).

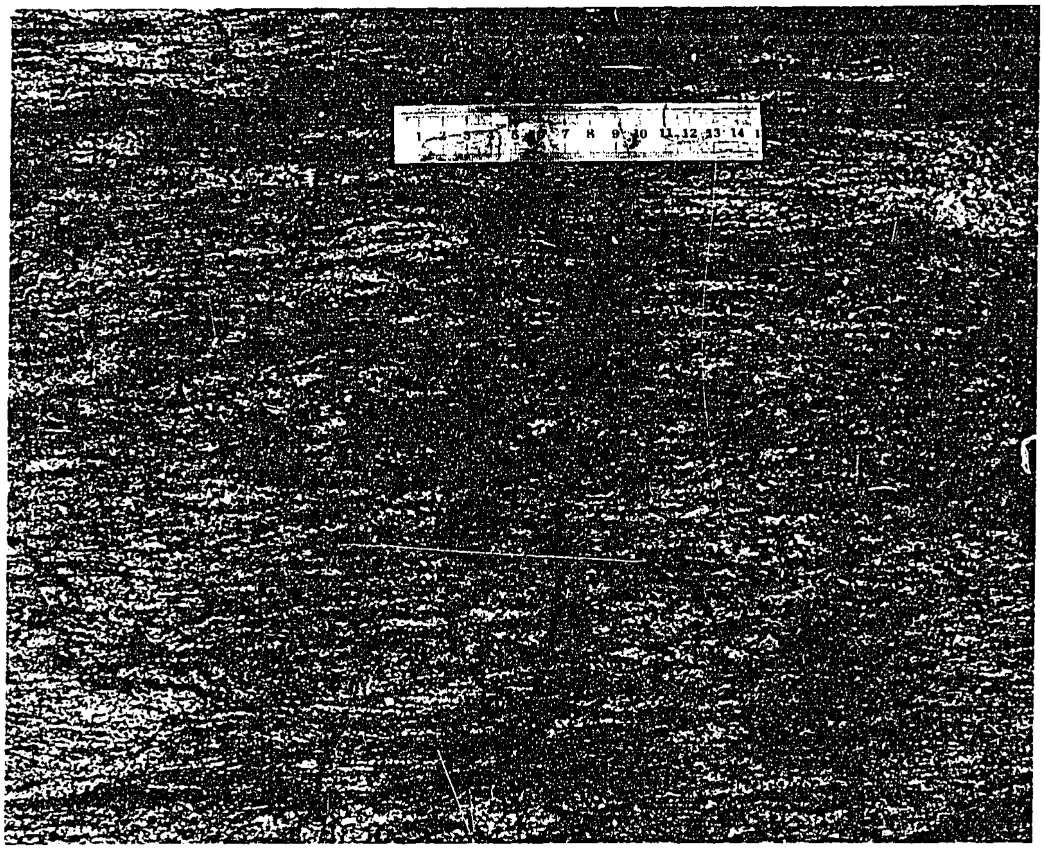


Fig.4: Quartzofeldspathic gneiss showing strong wavy foliation and weak layering; GR5353-220595, 7 km southeast of Claypan Dam. Neg. M/1780/22

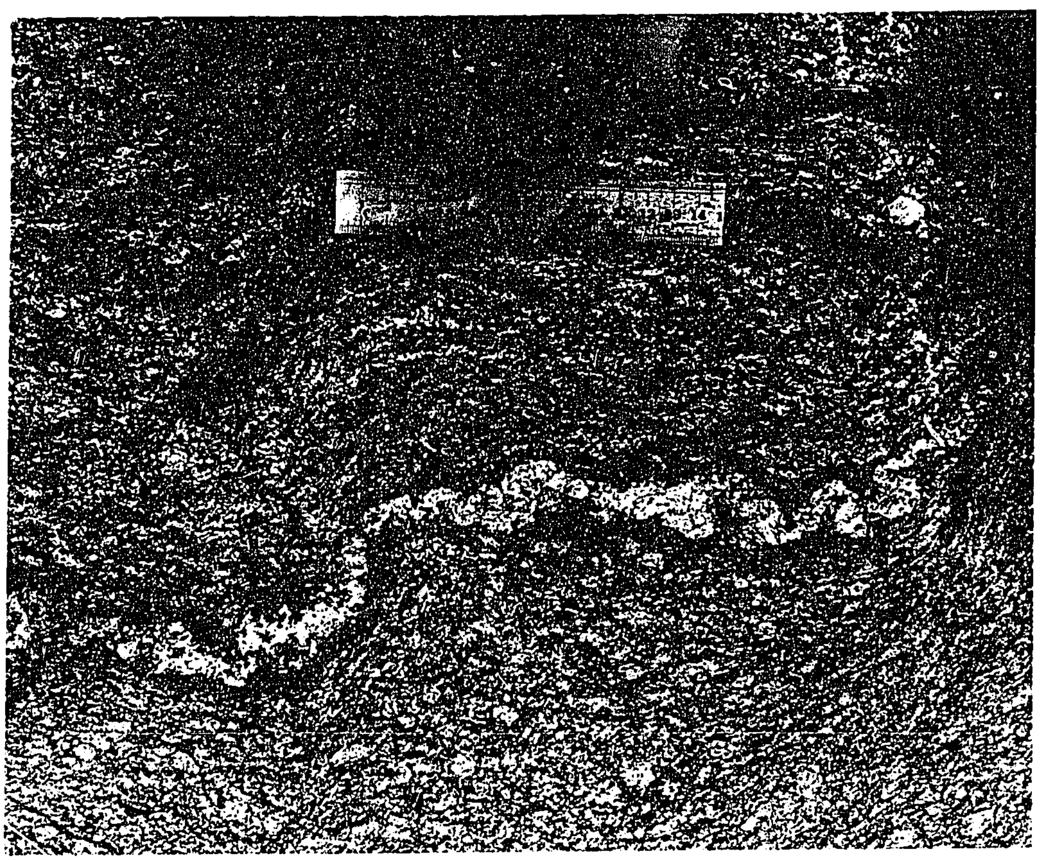


Fig. 5: Leucocratic quartz-feldspar layer with biotite-rich margin in quartzofeldspathic gneiss; shows upright folding. GR5353-210573, 2.5 km northeast of Mount Treachery. Neg. M/1780/32

Biotite gneiss forms a single body 1.5 km north of Mount Treachery, and is a fine-grained quartz-feldspar biotite gneiss containing coarse segregations of quartz and feldspar.

Retrogressively metamorphosed rock crops out at the western end of the gneiss 5 km south of Mount Denison homestead, and is a fine-grained muscovite-quartz orthoschist containing lenses of pegmatite.

The most characteristic structural element of the quartzo-feldspathic gneiss is a strong foliation defined by biotite films and leucocratic layering. The foliation commonly shows a wavy appearance (Fig. 4). It is axial plane to steeply plunging folds in the leucocratic layers. The folds range from tight through isoclinal to ptygmatic elasticas (Figs. 6, 7, 8). A second generation of folds has been observed in the gneiss; they are upright open folds (Figs. 5, 9), kink bands, or reclined chevron folds (Figs. 10, 11). Quartz veins intruded into the gneiss are foliated or fracture-cleaved, and pegmatite veins intruded into the gneiss 5 km south of Mount Denison homestead are folded and cleaved concordantly with the gneiss. Elsewhere, e.g. at GR5353-208610, 5 km southeast of Claypan Dam, large concordant pegmatites containing xenoliths of the surrounding gneiss are massive. Within 50 m of faults, the gneiss is markedly schistose, flaky, and sericitic.

The large body of gneiss appears to be an elongate dome which plunges at about 20$^{\circ}$ east in the east, and about 15$^{\circ}$ west in the west, and surrounds an antiformal core of metasedimentary Wickstead Creek beds (Fig. 3). Part of the southern side of the metasedimentary core is faulted against the adjoining gneiss. Foliation in the gneiss dips north at about 50$^{\circ}$ on the northern flank of the dome, and about 80$^{\circ}$ south on the southern flank. The outcrops of gneiss 5 km south of Mount Denison homestead and 12 km east-southeast of Mount Treachery appear to be rafts enclosed in granite, as far as the limited exposure enables us to tell.

The mineral assemblage in the quartzofeldspathic gneiss is indicative of the middle amphibolite metamorphic facies. The concordant relationship of the gneiss with the Wickstead Creek beds is consistent with a sedimentary or volcanic origin, but if so, no traces of its original

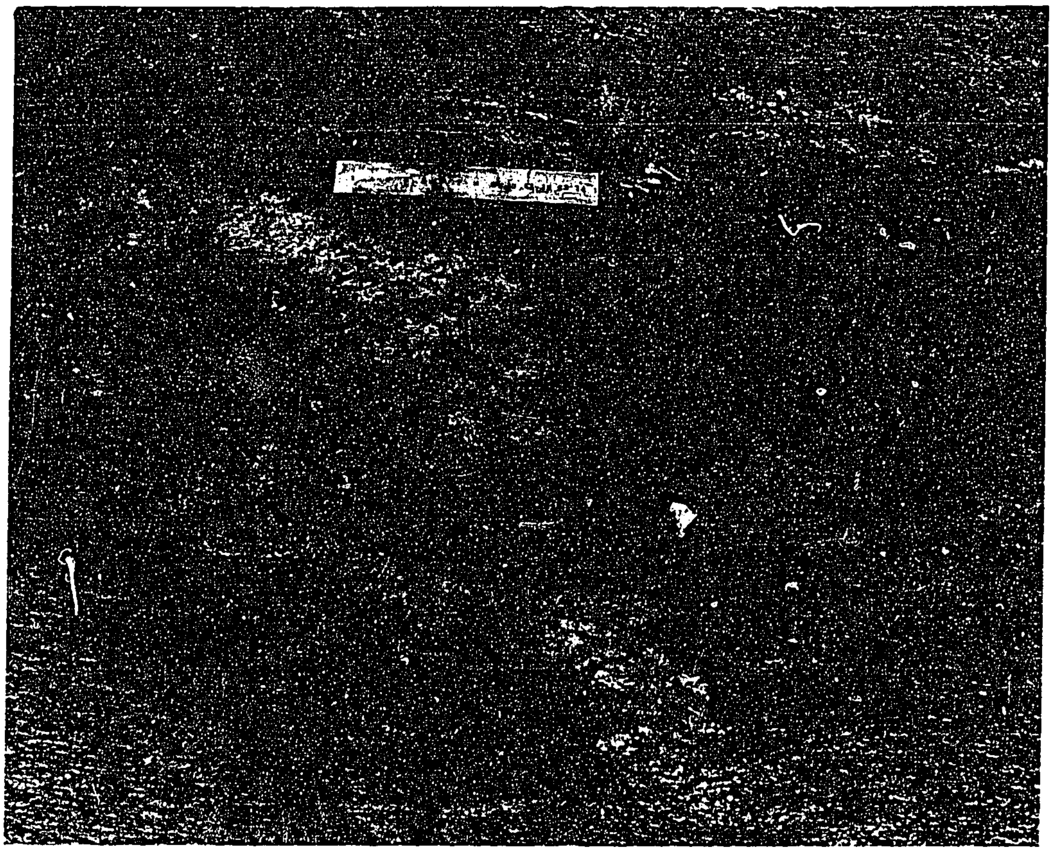


Fig. 6: Tight folds and elasticas in discordant leucocratic layer in quartzofeldspathic gneiss. GR5353-135610, 3.5 km southwest of Claypan Dam. Neg. M/1780/8

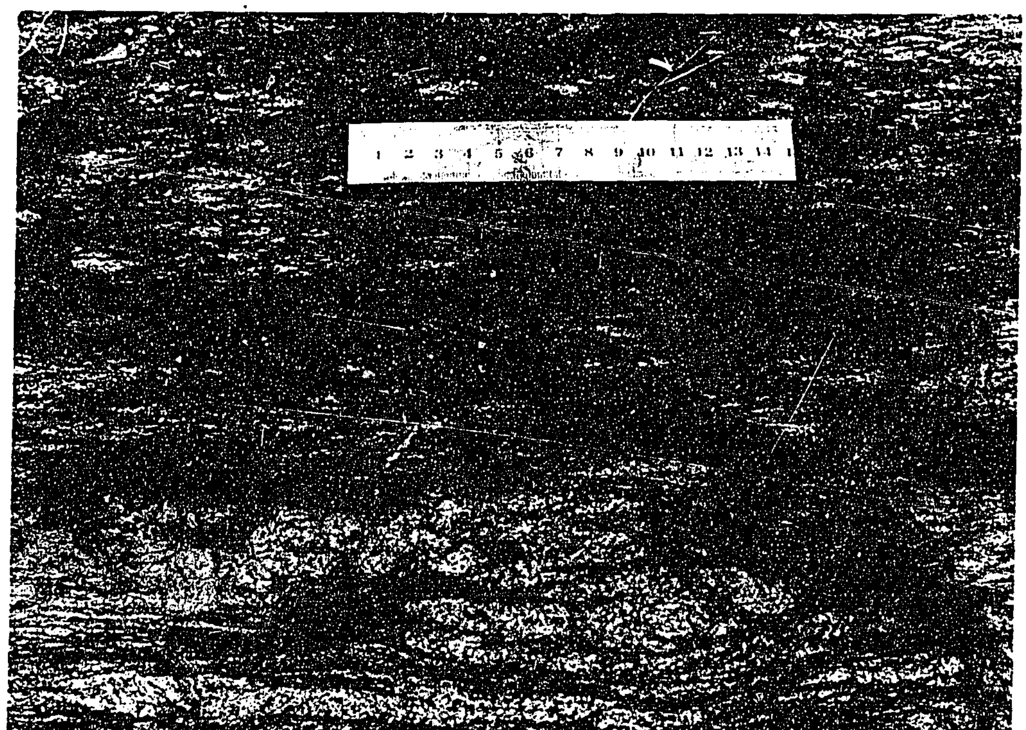


Fig. 7: Isoclinal folds in concordant leucocratic layer in quartzofeldspathic gneiss. GR5353-119606, 5.5 km southwest of Claypan Dam Neg. M/1781/72

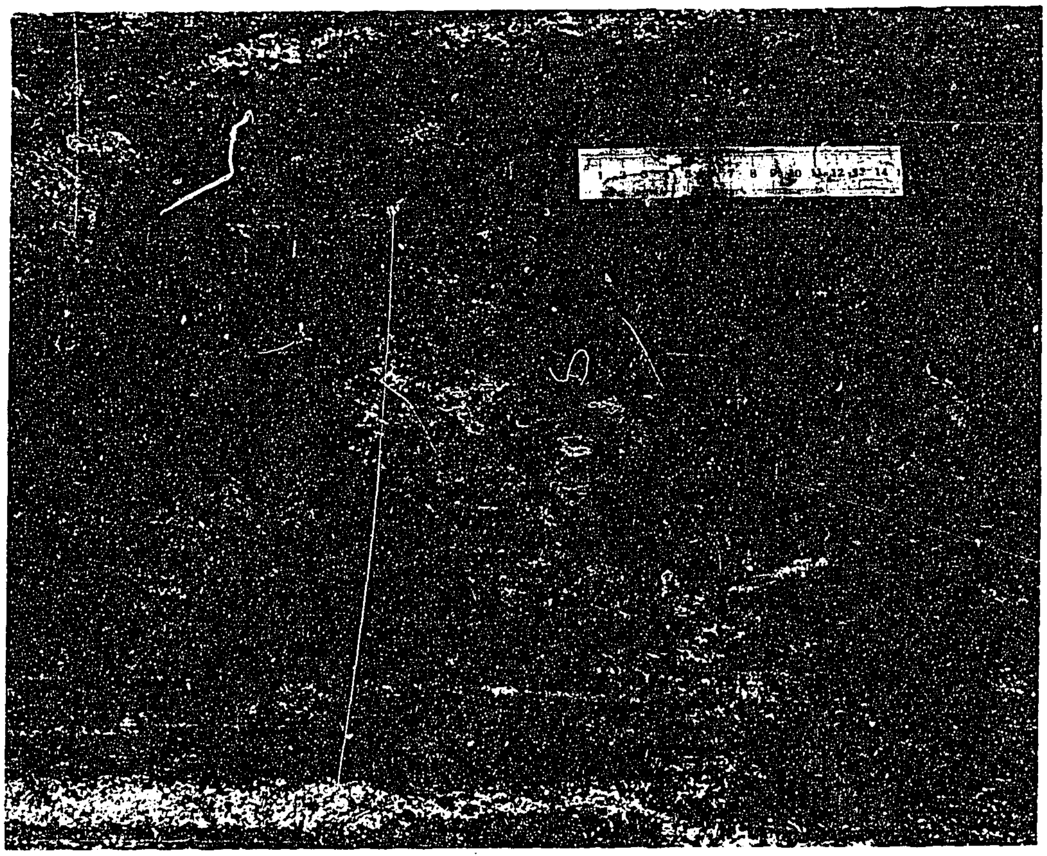


Fig. 8: Ptygmatic isoclinal folds and elasticas in partly concordant, partly discordant leucocratic layer in quartzofeldspathic gneiss. GR5353-135610, 3.5 km southwest of Claypan Dam.
Neg. M/1780/12

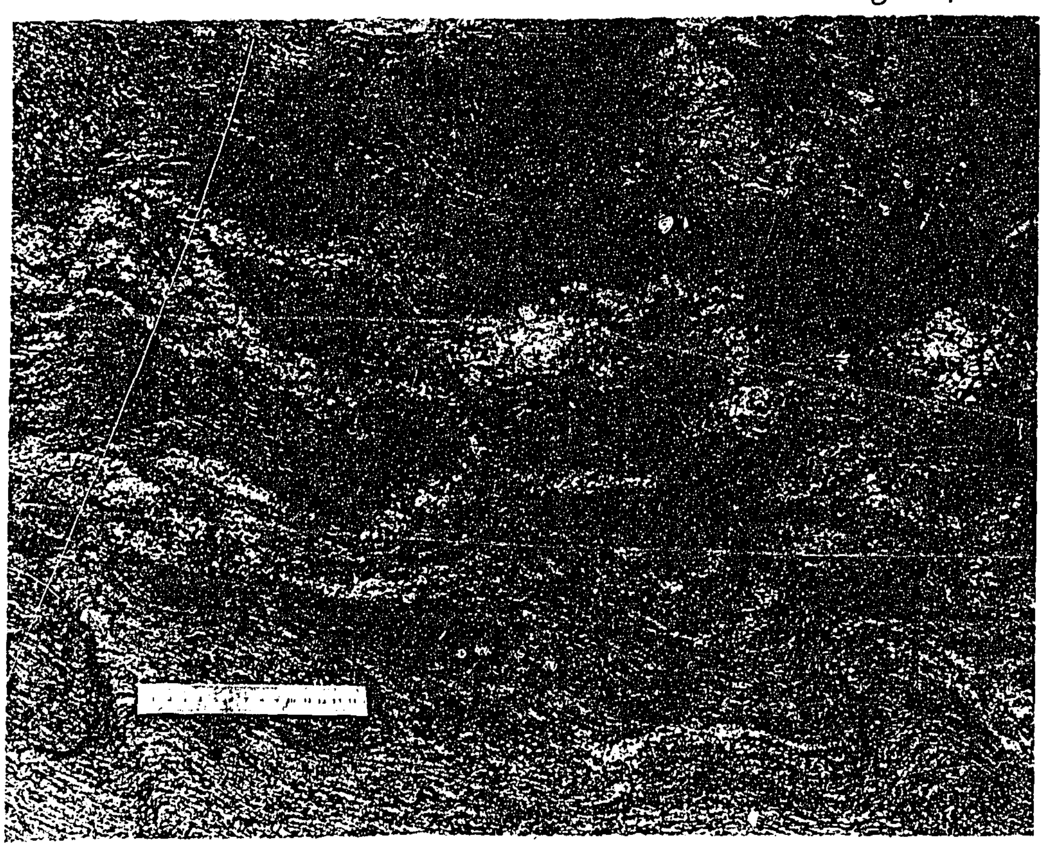


Fig. 9: Double folds in quartzofeldspathic gneiss, showing earlier tight to isoclinal set folded by later open upright set. GR5353-210573, 2.5 northeast of Mount Treachery.
Neg. M/1780/30


Fig. 10: Reclined chevron folds in quartzofeldspathic gneiss. GR5353-210573, 2.5 km northeast of Mount Treachery.
Neg. M/1780/38

Fig. 11: Double fold in leucocratic layer in fine-grained quartz-feldspathic gneiss. GR5353-104574, 1.5 km east of Beantree Dam.
Neg. M/1781/66

nature, such as sedimentary structures or volcanic textures, have survived the metamorphism. The presence of sillimanite schist, metamorphosed pebbles, and the greater content of quartz in the gneiss 5 km south of Mount Denison strongly indicate a sedimentary origin for this body at least. On the other hand, the gneiss 5 km west-northwest of Beantree Dam is clearly intrusive, and may be anatectic in origin. The leucocratic pegmatitic partly discordant quartz-feldspar layers in the gneiss may also be the product of partial melting, but equally they could have formed by metamorphic differentiation. The large masses of coarse biotite probably represent metamorphic differentiation on a large scale.

No isotopic dates have been determined on the quartzofeldspathic gneiss unit. Its apparent stratigraphically conformable position above the Wickstead Creek beds suggests Early Proterozoic deposition, or eruption, of the parent rock. They can be correlated with the Lander Rock beds, which overlie Wickstead Creek beds in the centre of the Reynolds Range, 50 km to the southeast. The time of metamorphism is probably Proterozoic - about 1400 Ma - the overall time of regional metamorphism of the Lander Rock beds in REYNOLDS RANGE.

Granitic gneiss (pЄg) (A.J.S.)

Granitic gneiss crops out on the western side of DENISON, and forms prominent broad ridges. The unit extends west into the Mount Doreen 1:250 000 Sheet area. Contacts with other units are not exposed.

The granitic gneiss is characteristically coarse-grained, and is composed of strained and broken microcline, partly recrystallised quartz, andesine, biotite, and a trace of green hornblende (74920687, -0688). Allanite and sphene are abundant accessories in 74920688.

In general, the rock is homogeneous and non-layered, and in its most deformed parts approaches an augen gneiss in texture. In the south, it is nearer medium-grained, and leucocratic layers a few centimetres thick are present; elsewhere in the same area, alternating leucocratic and melanocratic layers are present. In general, the gneiss is strongly foliated and lineated, and biotite forms flat films. In the

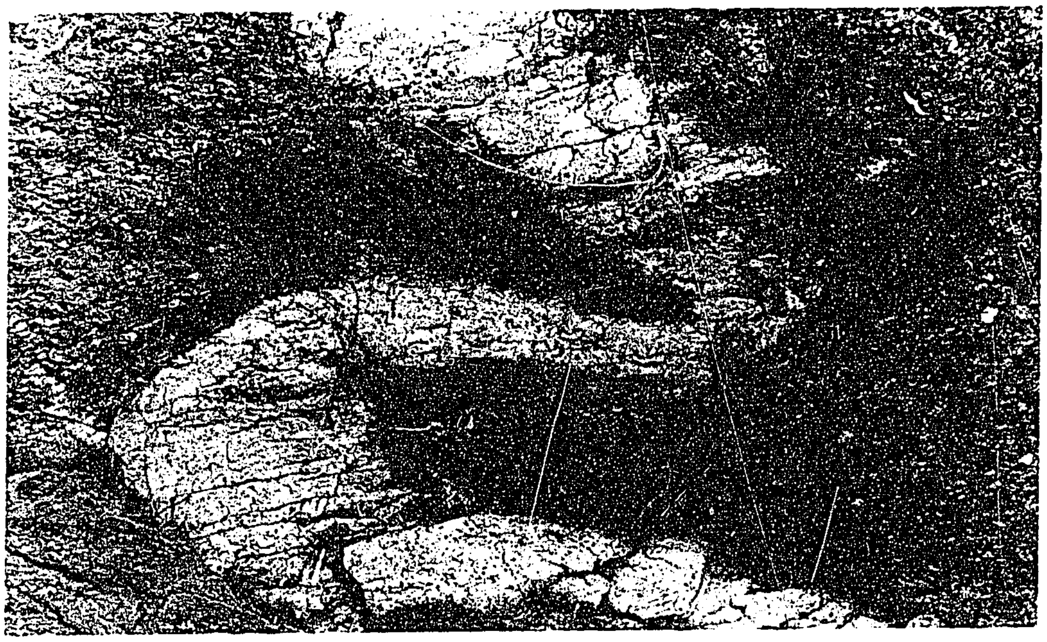


Fig. 12: Fracture-cleavage in folded quartz vein cutting granitic gneiss. GR5353-907499, 2 km west of Four Mile Dam.

Neg. M/1774/38

northeast, however, the rock is strongly lineated but not foliated. The gneiss is cut by quartz and feldspar-quartz veins, and these are slip-folded along a fracture-cleavage which parallels the foliation in the adjoining gneiss (Fig. 12). In thin section (74920689), plagioclase in the veins is found to be cataclastically deformed, microcline forms aligned anhedra, and quartz is partly recrystallised. Approaching the major fault which forms the southern boundary of the unit, the gneiss is cut by veinlets of epidosite, and at the fault itself is converted to muscovite-quartz orthoschist. Small dark fine-grained xenoliths are present in the northeastern part of the unit, and are of biotite adamellite composition (74920692).

The gneiss is evidently a granite which underwent deformation soon after intrusion and consolidation. Its age is unknown, but presumed to be Proterozoic or older (by analogy with other granitic gneisses in the region).

Granitic gneiss (pЄi) (L.A.O.)

Granitic gneiss and schistose muscovite-biotite gneiss form isolated low outcrops in the southwest of REYNOLDS RANGE, and east of DENISON. Because of poor exposure, the relationships with other units are not known. Several small exposures of unit pЄi on the southern margin of TEA TREE are now mapped as unit $Bna_9$ of the Aileron metamorphics.

The gneiss consists of microcline (40%), elongate quartz (30%), plagioclase (20%), biotite (5%) containing zircon, muscovite (5%), and accessory apatite, tourmaline, and opaque grains (72920719). The plagioclase is heavily saussuritised and sericitised. Elongation of quartz (up to 4 mm long) and feldspar (up to 10 mm; 72920720), and alignment of mica flakes define the gneissosity. The age of the gneiss is not known, but is presumed to be Precambrian.

Pelitic granulite (pЄn) (A.J.S.)

Granulite of pelitic composition crops out in the northwest of DENISON and the southwest of the Mount Theo 1:250 000 Sheet area. In the northwest of DENISON, pelitic granulite is exposed at two localities 10 km north-northwest and north of Mount Denison homestead, respectively. The western exposure (GR5353-952585) forms a prominent steep-sided hill, and adjoins a small exposure of sillimanite gneiss of the Lander Rock beds to the northeast. The granulite is intruded by a small mass of granite on the western side of the hill. The hill consists mostly of very coarse-grained massive granulite in which lilac-coloured cordierite, green feldspar, and sillimanite prisms up to 5 cm long are prominent. The pelitic granulite (74920655C) consists of sericitised cordierite (66%), microcline (15%), quartz (10%), red-brown biotite (7%) with opaque particles, idioblastic sillimanite (2%), and accessory amounts of green spinel, rounded zircon, and opaque matter. Siliceous variants (7492-0655D, E) are composed of quartz (80 and 76%, respectively), sericitised cordierite (10 and 15%) and microcline (5 and 0%), biotite (2 and 5%), calcic andesine ($An_{49}$; 3 and 0%), spinel + sericite aggregates (0 & 3%), opaque grains (up to 1%), and accessory sillimanite.

Mafic granulite forms discrete pods and masses a few metres across in the pelitic granulite. The rock is tough, medium-grained, massive, and exhibits green plagioclase in hand specimen. The granulite (74920655B) consists of bytownite ($An_{71}$; 45%), yellow-brown hornblende (20%), non-pleochroic partly altered poikiloblastic orthopyroxene (16%), poikiloblastic clinopyroxene (12%), aggregates of zoisite and actinolite (together 5%) after hornblende, quartz (2%), and accessory red-brown biotite with included opaque particles.

The eastern exposure of pelitic granulites (GR5353-995585) in the northwest of DENISON is, in general terms, similar to the western exposure. It forms a low rise cut by a latitudinally trending fault, and consists dominantly of coarse-grained sillimanite granulite, and lesser amounts of mafic granulite. The granulites are intruded by dark, medium to coarse-grained porphyritic granite containing xenoliths. A prominent mass of vein quartz fills the fault on the eastern side of the exposure.

In the Mount Theo 1:250 000 Sheet area, pelitic granulite crops out at two localities in the southwest. Banded granulite 25 km northeast of Mount Singleton comprises coarse-grained layers about 50 cm thick, and fine-grained blue layers 6 to 10 cm thick. Coarse sillimanite is prominent in hand specimen, and defines a foliation which is generally parallel to the layers; however, the layers are isoclinally folded in places, and here the oriented silliamanite aggregates cut the layers and parallel the axial planes of the folds. The thick layers are composed of fragments of microcline (40%), large garnets (7%) partly altered to muscovite + sillimanite + biotite, large pseudomorphs of sericite (9%) rimmed with sillimanite (20%), cordierite (15%), biotite (7%), quartz (1%), and accessory green spinel and magnetite (72110301A). The thin layers consist of quartz (78%), sillimanite (5%), garnet (5%), cordierite (5%), microcline (5%), biotite (2%), and accessory spinel and magnetite (72110301B).

Felsic granulite is associated with the layered pelitic granulite, but the relationship of the two is unclear. The felsic granulite is massive, and contains megacrysts of blue feldspar and ovoid xenoliths of dark fine-grained rock which may be mafic granulite. The felsic granulite consists of microcline (55%), quartz (23%), antiperthitic plagioclase (12%), garnet (3%) partly altered to biotite and sillimanite, cordierite (3%) partly altered to yellow isotropic material, sillimanite (1%), and accessory green spinel and magnetite (72110301C).

Pelitic granulite forms two low exposures 15 km north of Mount Singleton. The rock has a weak foliation, and is composed of sillimanite (40%), cordierite (20%), porphyroblastic garnet (15%), biotite (10%), quartz (10%), microcline (5%) in pressure shadows beside the large garnets, and accessory magnetite and rounded zircons (72110305). White feldspathic quartite is associated with the granulite.

The pelitic mineral assemblages in these rocks are indicative of upper amphibolite or lower granulite facies; the assemblage in the mafic granulite in DENISON, notably, the two pyroxenes, yellow-brown hornblende, and calcic plagioclase, indicates low granulite facies, and this probably applies to the pelitic rocks also. The presence of sericite, pinite, zoisite, and actinolite indicates later retrogressive metamorphism. The parent rocks to the granulites were presumably pelitic sediments, including shale and impure or shaly sandstone with associated basic igneous rocks. The massive texture of the felsic granulite 25 km northeast of Mount Singleton, its contained xenoliths, and granitic composition indicate that it is of anatectic origin; the presence in it of garnet, sillimanite, and cordierite suggests that it formed by partial melting of the neighbouring pelitic granulite. The times of deposition and subsequent metamorphism of these rocks are unknown; they are lithologically similar to, and may be co-eval with the Weldon metamorphics in REYNOLDS RANGE and TEA TREE.

Schist (p€s$_1$) (A.J.S.)

Sericite-quartz schist crops out at Matthews Knoll, and 1 km north of the Knoll, in the northwest of DENISON. At the peak of the Knoll, the rock is pale blue-green, coarse-grained, and composed of quartz as elongate xenoblastic skeletal grains, aggregates of sericite containing remnants of an unidentified precursor (possibly cordierite), coarser flakes of muscovite, chlorite which is nearly colourless, and accessory zircon and apatite (74920856). On the southern flank of the Knoll, the rock is a feldspathic metapsammite; it has not been thin-sectioned. The schist at the top of the Knoll appears to have formed by deformation and retrogressive metamorphism of a metasedimentary rock, probably part of the Mount Stafford beds to the southwest.

Quartzofeldspathic schist (p€s$_2$) (A.J.S.)

Quartzofeldspathic schist crops out (1) directly north of the Mount Allan tin mine, (2) 15 km west of the mine, and (3) 6 km south of Mount Allan homestead, in DENISON. The rock forms low grassy slopes and hills, and is poorly exposed. In the first two areas, the schist is conformable with rafts of calc-silicate rock of the Wickstead Creek beds, in the Wangala Granite; the two schist (and calc-silicate) outcrops are situated on opposite sides of a major fault, and were originally a single mass. The third outcrop is entirely surrounded by the Ngalurbindi Orthogneiss, and so appears to be a raft also.

The schist north of the Mount Allan tin mine consists of augen of dark grey quartz up to 1.5 cm long, and smaller augen of creamy microcline, in fine-grained schistose grey or cream groundmass of muscovite, recrystallised quartz, microcline, biotite, and opaque grains (74920667). The quartz augen have blebs and embayments of microcline or groundmass material. The rock is lineated as well as schistose, and both lineation and schistosity are folded around gently plunging northeast axes. If the folds formed during the major faulting, their sense of vergence indicates north-block-up fault movement.

The outcrop west of the Mount Allan tin mine has not been examined on the ground, and is identified as quartzofeldspathic schist solely on airphoto appearance.

The outcrop 6 km south of Mount Allan homestead is a zone several metres across of greenish-brown feldspathic sericite schist, and is cut by folded quartz veins.

Both varieties of schist appear to have originated by deformation and retrogressive metamorphism of porphyritic igneous rocks. The time of formation of the schist is unknown, but probably Proterozoic. The rock north of the Mount Allan tin mine markedly resembles the Coniston and Warimbi Schists of the Reynolds Range, which are demonstrably meta-igneous rocks.

Muscovite schist and metasiltstone ($p\mathrm{\epsilon}s_3$) (A.J.S.)

Muscovite schist and metasiltstone crop out in the south of DENISON, 13 km south of Uldirra Hill. The rocks form low steep-sided hills surrounded by quartzose lag gravel and colluvium. The unit is faulted against the Uldirra Porphyry to the north and south, and against the Heavitree Quartzite to the west. It consists mainly of yellow-brown very fine-grained sericite schist cut by quartz veins. The schist is kink-folded about steeply plunging axes; quartz veins are folded, and cut by a fracture cleavage. In the western part of the unit, a layer about 3 km thick of mottled pink and cream augen schist is exposed. The augen are up to 7 mm long, and are composed of strained and partly recrystallised quartz and rare opaque matter (hematite?); they are set in very fine-grained groundmass of recrystallised quartz and muscovite (74920908). In the central part of the unit, interbedded yellow-brown metasiltstone and fine-grained metasandstone are exposed. These rocks are strongly cleaved at a large angle to bedding, and contain small porphyroclasts of quartz and highly flattened and elongate sericitic aggregates.

The bedded rocks appear to be of sedimentary origin, subsequently metamorphosed to greenschist facies. The augen schist may be an orthoschist, representing a retrogressively metamorphosed offshoot from the Uldirra Porphyry to the north, which in this area is markedly hematitic. Their age is Proterozoic or older.

Tyson Creek granulite (Bt) (A.J.S.)

The Tyson Creek granulite is the body of mafic granulite and felsic granulite that crops out in the southeastern part of the Anmatjira Range, in TEA THREE and REYNOLDS RANGE. The name is derived from Tyson Creek, whose headwaters are situated in hills composed of the granulite. The granulite erodes to prominent rounded hills and ridges rising to about 250 m above the surrounding alluvial plain.

No basement is known to underlie the Tyson Creek granulite. It adjoins the Weldon metamorphics with apparent conformity, but which is older is not known. The Tyson Creek granulite is intruded by the Anmatjira Orthogneiss, in which it forms several rafts, the unnamed porphyritic granite $Bg_1$ 3 km northwest of Sandy Creek Bore, the Possum Creek Charnockite, the Aloolya Gneiss, and a cross-cutting dyke of dolerite.

The reference area of the Tyson Creek granulite is located at GR5553-030250, 4 km east-northeast of Pine Hill homestead; in a steep rock face in a creek at this locality, the intrusive relationship of the mafic granulite variant by the Possum Creek Charnockite is well exposed (Fig. 13). Xenoliths 1 - 2 m across of the felsic granulite variant in the Possum Creek Charnockite are well displayed at sample locality 631 (GR5553-953357).

The Tyson Creek granulite consists of two different rock types: (1) mafic granulite, which is the more extensive of the two and forms the host to (2) felsic granulite, which generally occurs as layers and lenses a few centimetres thick in the mafic granulite (Fig. 13). The felsic granulite also forms discrete elongate masses up to 1 km long, and these are shown on the map. The recognition and delineation of these larger masses is based entirely on airphoto interpretation; on the airphotos they appear as areas of small closely spaced red-brown tors reminiscent of granite and easily distinguished from the surrounding mafic granulite, which has a smudgy green appearance.

The mafic granulite variant of the Tyson Creek granulite is a dark grey fine-grained very tough massive rock, and is composed essentially of calcic plagioclase (average of the three thin sections, 53%)

Fig. 13: Layered mafic and felsic granulites of Tyson Creek granulite (left) intruded by Possum Creek Charnockite (right); at reference locality for Tyson Creek granulite, GR5553-030250, 4 km east-northeast of Pine Hill homestead.
Neg. GA/5324

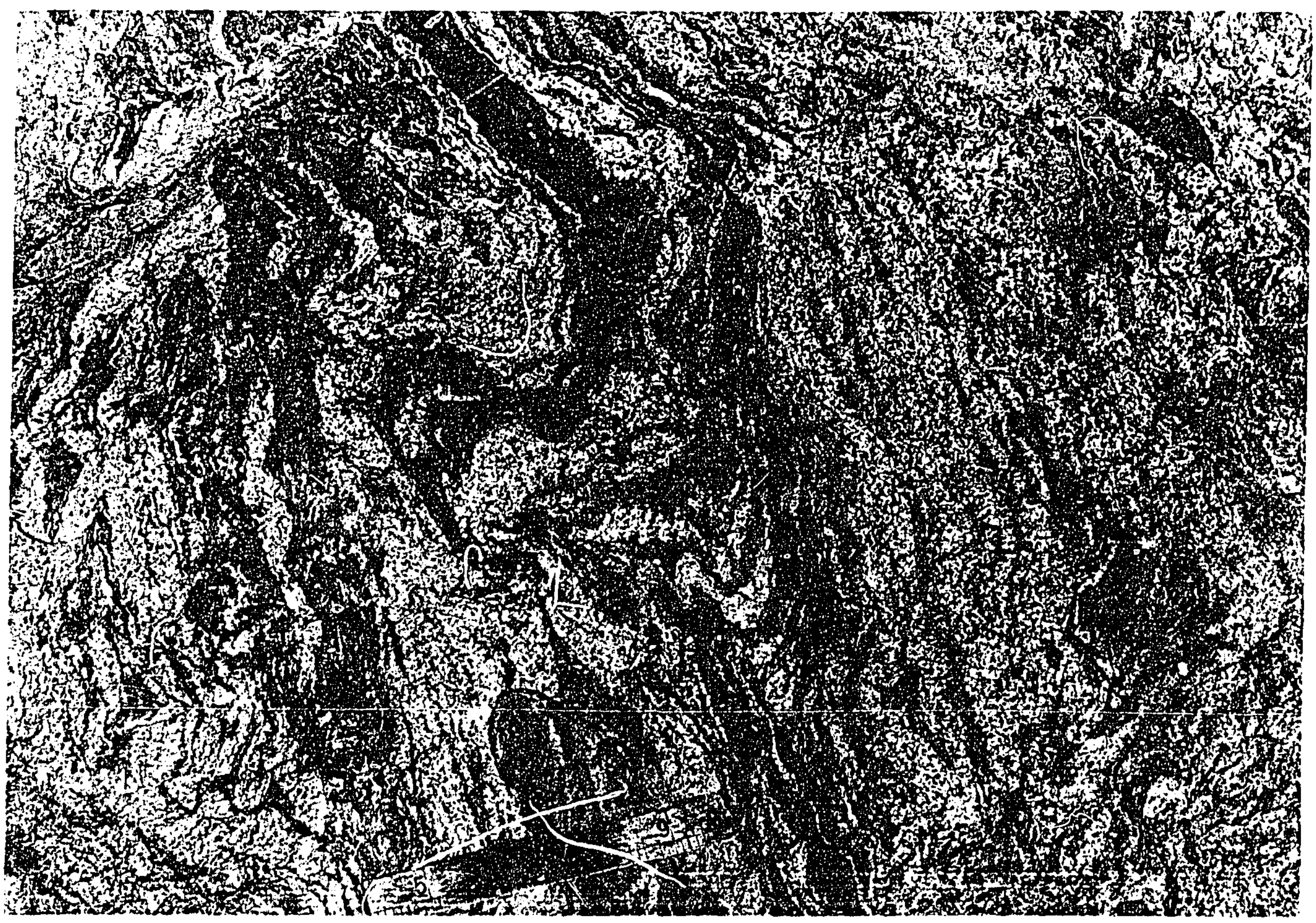


Fig. 14: Coarse-grained layered pelitic gneiss of Weldon metamorphics; dark grey layers are rich in biotite and garnet, mid-grey layers in cordierite, pale grey layers in feldspar and sillimanite. GR5453-898403, 7.5 km northwest of Mount Weldon.
Neg. M/1346/42

which ranges from sodic labradorite ($An_{51}$) to sodic bytownite ($An_{71}$), pale green poikiloblastic clinopyroxene (18%) which is probably diopside, hypersthene (17%) pleochroic from pale red to pale green, biotite (8%), and an opaque mineral (less than 1%) which may be magnetite (71921035, 72920633, -1001C). Brown hornblende (12%) is present in 71921035 and the clinopyroxene makes up only 3% of this rock. Sample 72921001C from the reference locality is deformed and retrograded; plagioclase is sericitised, slightly flattened, and the twin lamellae bent, and pyroxenes are altered to uralitic amphibole next to the cracks in the rock. The deformation and retrogression support the existence of an inferred fault along the southern flank of the Anmatjira Range north of Pine Hill homestead.

The mafic variant from two rafts of Tyson Creek granulite in the Anmatjira Orthogneiss consist of hypersthene, clinopyroxene, brown hornblende, labradorite, and opaque grains (71921054, -1055). As well, actinolite forms uralitic aggregates after pyroxene and amphibole in 71921055.

The felsic granulite variant of the Tyson Creek granulite is a white to pale grey medium-grained massive to weakly foliated rock, which commonly contains small red garnets. It consists (71921042, 72920490) of microperthitic orthoclase (42% and 60%, respectively), quartz (40% and 30%), plagioclase (15% and 5%) which is calcic andesine ($An_{44}$) in -490, but untwinned and intergrown with orthoclase in 71921042, and biotite (3% and less than 1%). Garnet constitutes about 5% of the rocks in which it is present.

The mineral assemblages in the mafic variant of the Tyson Creek granulite are indicative of lower-grade granulite facies of regional metamorphism. Before metamorphism, the unit consisted of mafic igneous rock, possibly basaltic lava flows or sills. The felsic granulite is granitic in composition; the large masses of felsic granulite may be igneous intrusions, or metamorphic segregations, or products of partial melting originating from the mafic granulite. The intimate layering of the two granulites in places (Fig. 13) suggests that the felsic granulite is a metamorphic product, either by partial melting or metamorphic differentiation.

The time of crystallisation of the mafic parent rocks of the Tyson Creek granulite is not precisely known. Lowder & Webb (1972) determined a Middle Proterozoic K-Ar date of 1650 Ma on hornblende from a small body of the mafic granulite variant from the southeastern end of the Anmatjira Range. The parent rocks are therefore older than this.

Correlation of the Tyson Creek granulite with other units in the area depends on the extrapolation of circumstantial evidence. The adjoining Weldon metamorphics are speculatively correlated on compositional and stratigraphic grounds with the Lander Rock beds. The latter include small amounts of metamorphosed mafic igneous rocks (flows or sills), which are exposed in the cores of anticlines in the Reynolds Range, and hence are probably situated in the lower part of the Lander Rock beds. If the correlation of the Weldon metamorphics and Lander Rock beds is correct, then the Tyson Creek granulite may be metamorphosed mafic igneous rocks, more extensive than, but equivalent to, those in the lower part of the Lander Rock beds. If this correction is correct, then the Tyson Creek granulite stratigraphically underlies the Weldon metamorphics.

<u>Weldon metamorphics</u> (Be) (A.J.S.)

The Weldon metamorphics are the assemblage of coarse-grained migmatitic gneiss, granofels, and granulite of pelitic composition, accompanied by small amounts of amphibolite and quartzite, which crop out in the southeastern half of the Anmatjira Range, in REYNOLDS RANGE and TEA TREE. The name is derived from Mount Weldon (GR5553-943342), which is composed of migmatitic gneiss of the metamorphics and forms a prominent peak in the Anmatjira Range. The metamorphics erode to a closely textured hilly terrain. Away from the Mount Weldon area, three outcrops of the metamorphics have been mapped in the southeastern part of the Anmatjira Range, and an isolated outcrop has been mapped in the northwestern part of the Range, 5 km southeast of Mount Stafford.

The Weldon metamorphics are not known to overlie any older stratigraphic unit. They are faulted against the Lander Rock beds, and intruded by the Anmatjira Orthogneiss, the Aloolya Gneiss, and by dolerite dykes in the southeastern part of the Anmatjira Range, directly north of Pine Hill homestead. The metamorphics adjoin the

Tyson Creek granulite, but the relationship of the two units is not known; in the absence of evidence either way, the two units are presumed to be conformable formations, now deformed and metamorphosed.

The reference area of the Weldon metamorphics is located in Possum Creek, at GR5453-935383 4 km north of Mount Weldon; the bed of the Creek shows excellent exposure of layered metapelitic gneiss and amphibolite intruded by Anmatjira Orthogneiss.

The Weldon metamorphics in the reference area and throughout the main mass of the unit are a migmatitic gneiss of pelitic composition (Ɛei on Preliminary maps, $Ɛe_1$ on The Geology of the Reynolds Range Region 1:100 000 Special Map). A granofels variant (Ɛef, $Ɛe_2$), two granulites (Ɛen, $Ɛe_3$; Ɛeq, $Ɛe_4$), and an amphibolite (Ɛea, $Ɛe_5$) have also been recognised and mapped.

The main mass of Weldon metamorphics is a coarse-grained <u>migmatitic gneiss</u> (Ɛei, $Ɛe_1$) (Fig. 14) which, on fresh surfaces (well displayed at the reference area), has a striking red, white, and blue appearance, corresponding to layers rich in garnet, feldspar + sillimanite, and cordierite, respectively. The rock has a coarse granoblastic texture, and consists essentially of quartz (average 47%), cordierite (23%) which is generally turbid and partly altered to pinite, orthoclase (13%), biotite (7%) and garnet (6%) which are both partly altered to chlorite, oligoclase (3%), and acicular sillimanite (1%) (7290528, -0567, -0569).

<u>Pelitic granofels</u> (Ɛef, $Ɛe_2$) is an extensive variant of the Weldon metamorphics, and is a dark brownish-black coarse-grained massive to coarsely lineated pelitic granofels composed mostly of cordierite. Quartz and feldspar are present in some samples, absent in others. The most typical samples (72920525, -0547) consist essentially of cordierite (70% and 82%, respectively) fringed with sillimanite, biotite (25% and 10%) and associated magnetite, which is also fringed with sillimanite,; detrital zircon is an abundant accessory. Large poikiloblasts of plagioclase (5%) are present in 72920525, and coarse acicular sillimanite (7%) makes up the remainder of 72920547. The quartz-bearing granofels consists of quartz (58%), cordierite (30%), biotite (7%), garnet (3%),

and sillimanite (2%) (72920620). The feldspathic varieties have the same mineral assemblage as the main mass (Bei; $Be_1$) of Weldon metamorphics, but are massive in texture (72920545). In this particular sample, cordierite forms light blue ovoids with a greasy lustre; the ovoids are up to 30 mm long, and have beard-like sheafs of coarse fibrous sillimanite at each end.

Felsic granulite (Ben, $Be_3$) forms a group of lenticular outcrops interlayered with the main mass (Bei) of Weldon metamorphics in the southeastern part of the Anmatjira Range, 3 km north of Pine Hill homestead; a lenticular mass of similar rock is present at the southeastern tip of the Range. The rock north of Pine Hill homestead is pale reddish-brown, medium to coarse-grained, and lineated, and consists of orthoclase (60%), cordierite (30%), biotite (5%), sillimanite (5%), dark green spinel (about 1%), and detrital zircon (72920598). The mass at the southeastern tip of the Range is 9 km long and up to 1 km wide, and comprises very coarse-grained pale mottled grey and brown granulite and granofels which are massive to thickly layered and very tough; a contorted lens of amphibolite is also present. The following assemblages were noted in thin sections of the granulite:

72920573A: quartz (77%), cordierite (20%), biotite (2%), sillimanite (1%).
573B: cordierite (60%), orthoclase (27%), sillimanite (10%), biotite (3%).
573C: cordierite (96%), biotite (3%), sillimanite (1%).

Psammitic granulite (Beq, $Be_4$) forms a large area between the two outcrops of felsic granulite (Ben) in the southeastern part of the Anmatjira Range. The outcrop is most accessible at its southeastern end, 3 km northwest of Sandy Creek Bore. The rock is finely to coarsely layered, medium-grained and composed essentially of quartz (average 56%), cordierite (21%), and orthoclase (16%); the remainder of the rock consists of various amounts of biotite (0-5%), sillimanite (up to 4%), plagioclase (up to 4%), garnet (up to 2%), and accessory magnetite (71921034, -1043, -1044, 72920488).

Amphibolite (Bea, $Be_5$) in the Weldon metamorphics forms discrete lenticular pods and layers generally a few metres long; several larger outcrops between 1 and 2 km long are shown on the map. The rocks are dark greenish-black, medium-grained, massive or lineated, and are composed essentially of greenish-brown or brown hornblende and twinned labradorite (72920529 -0570); 72920570 also contains clinopyroxene and orthopyroxene. The amphibolites are meta-igneous rocks.

Quartzite in the Weldon metamorphics forms masses a few metres thick by several tens of metres long, but they are nowhere large enough to be mapped. The rocks are pale grey-brown, fine-grained, massive, and show no trace of bedding. They are composed essentially of quartz (65 to 93%), biotite (1 to 5%), and detrital zircon; garnet is also generally present (72920543, -0546, -0548). Bytownite (10%) and compound grains of pyroxene (2%) comprising cores of orthopyroxene and sharply defined rims of clinopyroxene are present in sample 72920546. Aggregates of andalusite and muscovite and an isotropic substance in sample 72920548 are probably alteration products after cordierite.

The abundance of cordierite, sillimanite, garnet, and biotite in the Weldon metamorphics indicates that before metamorphism, the unit consisted mostly of shale, shaly sandstone or greywacke, and lesser amounts of impure quartzite and mafic igneous rock. The main mass of metamorphics (Bei) contains abundant quartz and plagioclase, and was probably a greywacke, whereas the felsic variant (Ben) contains no free quartz and was probably a more shaly rock; the psammitic variant (Beq) may have been something in between.

The metamorphic mineral assemblages in the Weldon metamorphics are compatible with either the highest subfacies of the amphibolite facies, where quartz and muscovite have reacted to sillimanite and orthoclase, or with the lowest subfacies of the granulite facies. In the northwestern part of the main mass of Weldon metamorphics (Bei), the rock is migmatitic and the plagioclase is oligoclase, together indicating the amphibolite facies. In the southeast of the unit, the rocks are dense, massive, coarse-grained, and granulitic in appearance. In addition, the mafic rocks of the ajoining Tyson Creek granulite contain metamorphic hypersthene. Hence, this part of the Weldon metamorphics belongs to the granulite facies. The Weldon metamorphics were presumably metamorphosed at the same time as the Tyson Creek granulite and must be older than the Anmatjira Orthogneiss, which is dated at about 1600 ± 100 Ma. The parent sediments were probably deposited in the Early Proterozoic or earlier. No exact correlation with other units in the area is evident, but the pelitic composition of the metamorphics, the presence of small amounts of impure quartz sandstone and mafic igneous rock, the absence of any known basement, and the proximity of the Lander Rock beds are consistent with the Weldon metamorphics being a highly metamorphosed part of the Lander Rock beds, now upfaulted beside them.

Undivided mafic rock (Ɛm) (A.J.S.)

This unit appears only on the Preliminary editions of REYNOLDS RANGE and TEA TREE, and forms enclaves in the Anmatjira Orthogneiss. The rock is mafic granulite (71921055), and is now mapped in with the Tyson Creek granulite.

Possum Creek Charnockite (Ɛnp) (A.J.S.)

The Possum Creek Charnockite is the hypersthene granite that crops out as a number of discrete masses in the southeastern part of the Anmatjira Range, in TEA TREE. The name is derived from Possum Creek, which flows past the type locality of the Charnockite, at GR5553-952391 (sample locality 628). The Charnockite forms prominent hills and ridges covered with rounded joint-blocks, and forms the second-highest peak in the Anmatjira Range, Mount Finniss.

The Possum Creek Charnockite intrudes, and is therefore younger than, the Tyson Creek granulite (Fig. 13). Four of the Charnockite masses crop out within the Aloolya Gneiss, but, although a contact of the two rocks was observed at GR5553-992334, 5 km south-southwest of Bluebush Bore, no intrusive relationship could be determined, the trace of the contact being quite straight and regular. The foliation in the Charnockite next to the Gneiss is drag-folded, suggesting that the Charnockite is intruded by, and therefore older than the Gneiss, but 1.5 m from the contact into the Charnockite, an intrusive pegmatite dyke is present, and the sense of vergence of the drag-folds reverses across the pegmatite (Fig. 15). Hence, both regions of drag-folded Charnockite could have been deformed during movement of the pegmatite body alone (to the right in Figure 15).

The charnockite is a medium-grained, strongly foliated rock, which is speckled brown and black on weathered surfaces, but white and greyish-brown where fresh. The rock is generally heterogeneous, and contains schlieren, up to 15 cm long, composed of coarse-grained quartz and potassium feldspar; the schlieren commonly have rounded ends. The rock is characterised by the presence of ovoid augen of feldspar up to 4 cm long, spaced about 10 to 30 cm apart; many of these are mantled, with a kernel of grey perthite surrounded by a shell of orange plagioclase (Fig. 16). Dark flattened xenoliths are common in the Charnockite (Figs. 16, 17).

The charnockite has an allotriomorphic texture, and consists essentially of perthitic potassium feldspar (average of three thin sections, 52%), antiperthitic plagioclase (21%), quartz (18%), hypersthene (5%), hornblende (3%), and opaque iron oxide (1%) (72920491, -0572, -0628). The potassium feldspar in samples 72929491 and 72920628 is mostly microcline, but some of it in these two samples, and all of it in sample 72920572, has a 2V of about $5^{o}$, and is therefore identified as sanidine. The plagioclase component of the perthite occurs as discrete equant blebs of andesine, commonly with outlines parallel to the crystal structure of the host. The plagioclase in the body of the rock and forming the shells of the mantled feldspars is also andesine, $An_{38}$ in sample 72920572, $An_{49}$ in sample 72920628. The andesine is an antiperthite, and contains numerous equant to elongate subhedral blebs of potassium feldspar. Hypersthene is the dominant mafic mineral in the Charnockite, and constitutes 8 percent of the rock in sample 72920491; it generally forms discrete subhedral to anhedral stubby to elongate prismatic grains, but a few large skeletal poikilitic crystals were also observed. It is markedly altered along grain margins and cleavage cracks to limonite or hematite. In samples 72920491 and 72920572, wherever hypersthene is in contact with plagioclase, it is altered to blue-green hornblende + opaque iron oxide; in sample 72920628, the hypersthene is altered along cracks and cleavages to red-brown biotite. Primary hornblende is present in samples 72920572 and 72920628, and forms stubby equant subhedral to anhedral grains, and is pleochroic from greenish-brown to brown. It contains abudnant specks of opaque iron oxide in sample 72920572, and is markedly altered to green chlorite + opaque iron oxide in sample 72920628. Large grains of primary opaque iron oxide are an

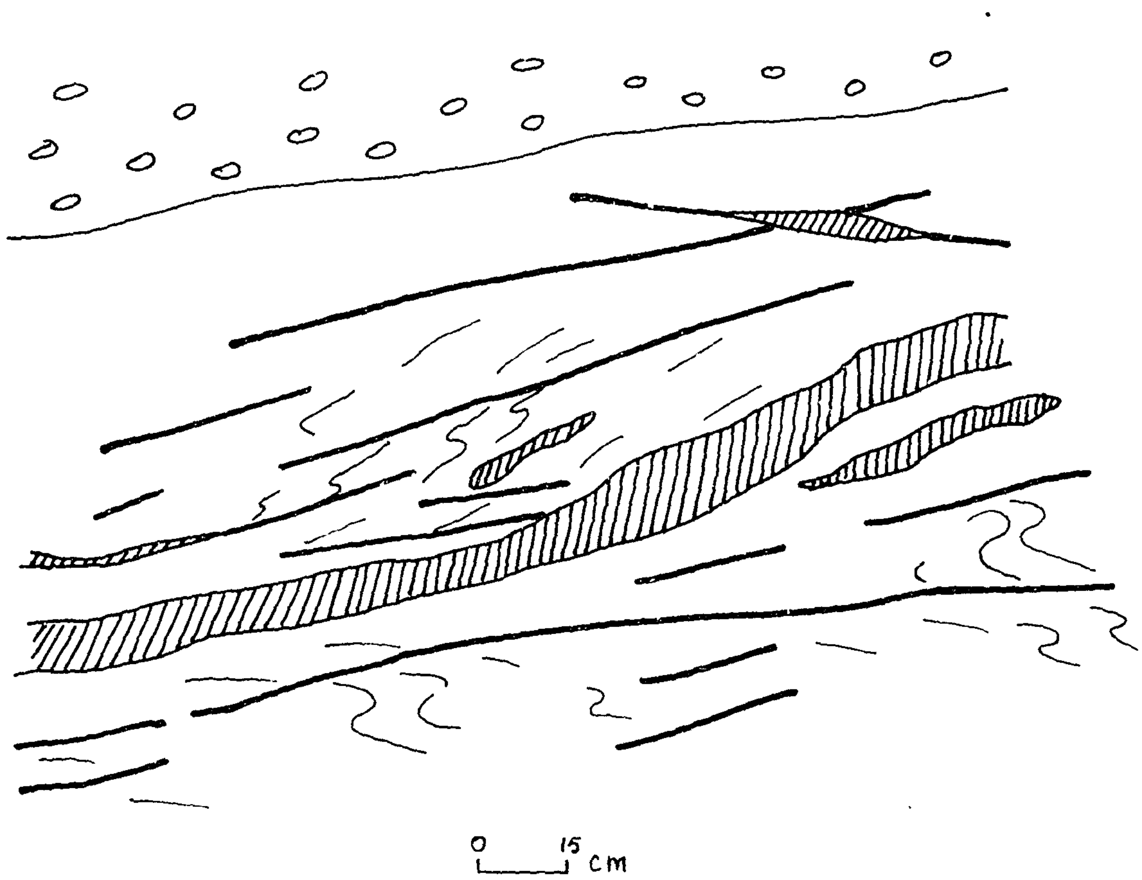



Fig. 15 : Contact between Possum Creek Charnockite (blank) and Aloolya Gneiss (ellipses) at GR 5553-991334, showing reversal in sense of vengence of folds in foliation in Charnockite across pegmatite dyke (ruled). Thick lines are thin dykes of pegmatite.

16/NT/5

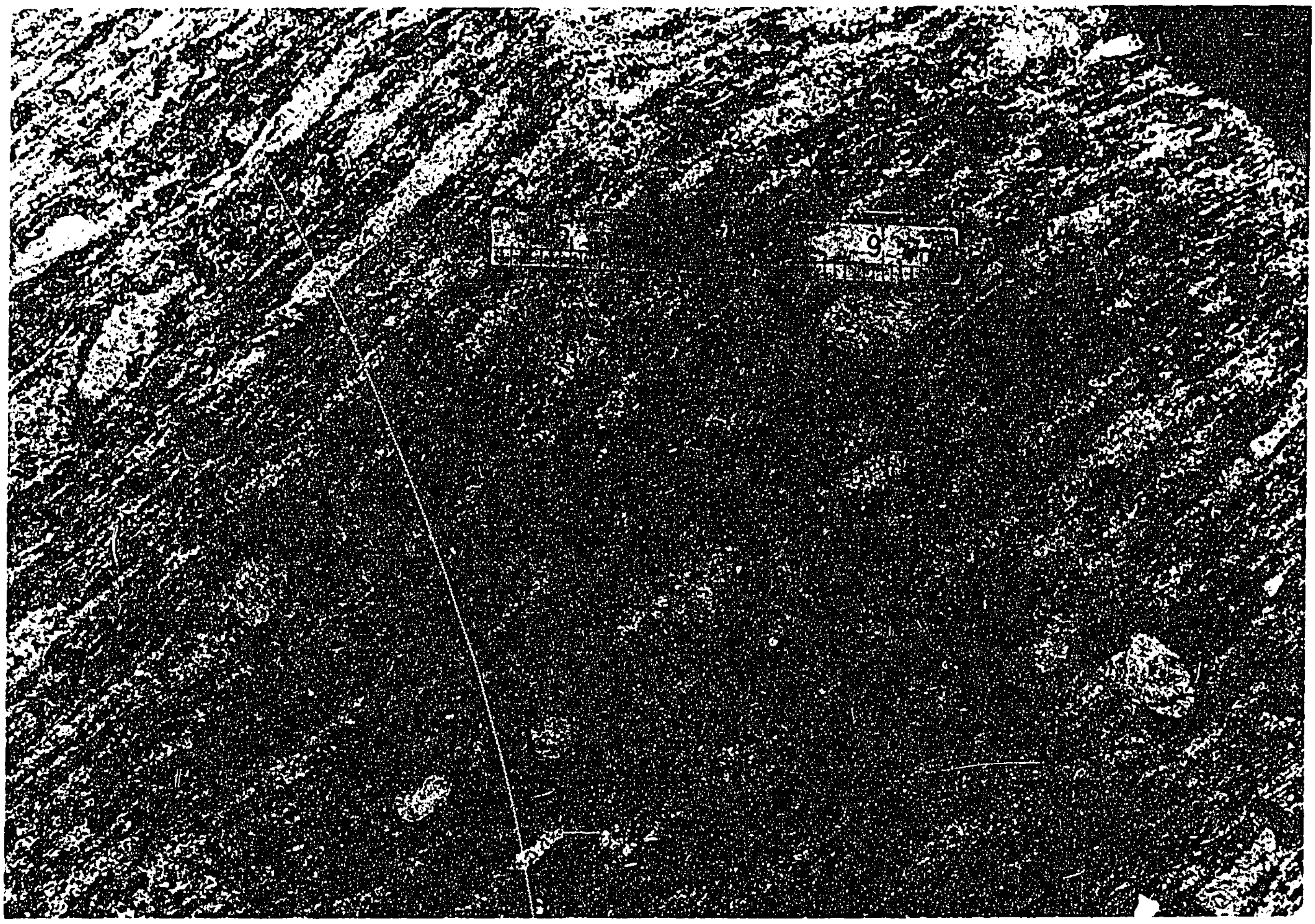


Fig. 16: Possum Creek Charnockite at type locality, GR5553-952391, 7 km west of Bluebush Bore; shows mantled feldspars with kernels of perthite (pale grey) and shells of plagioclase (dark grey). Scale is 15 cm long Neg. M/1376/30

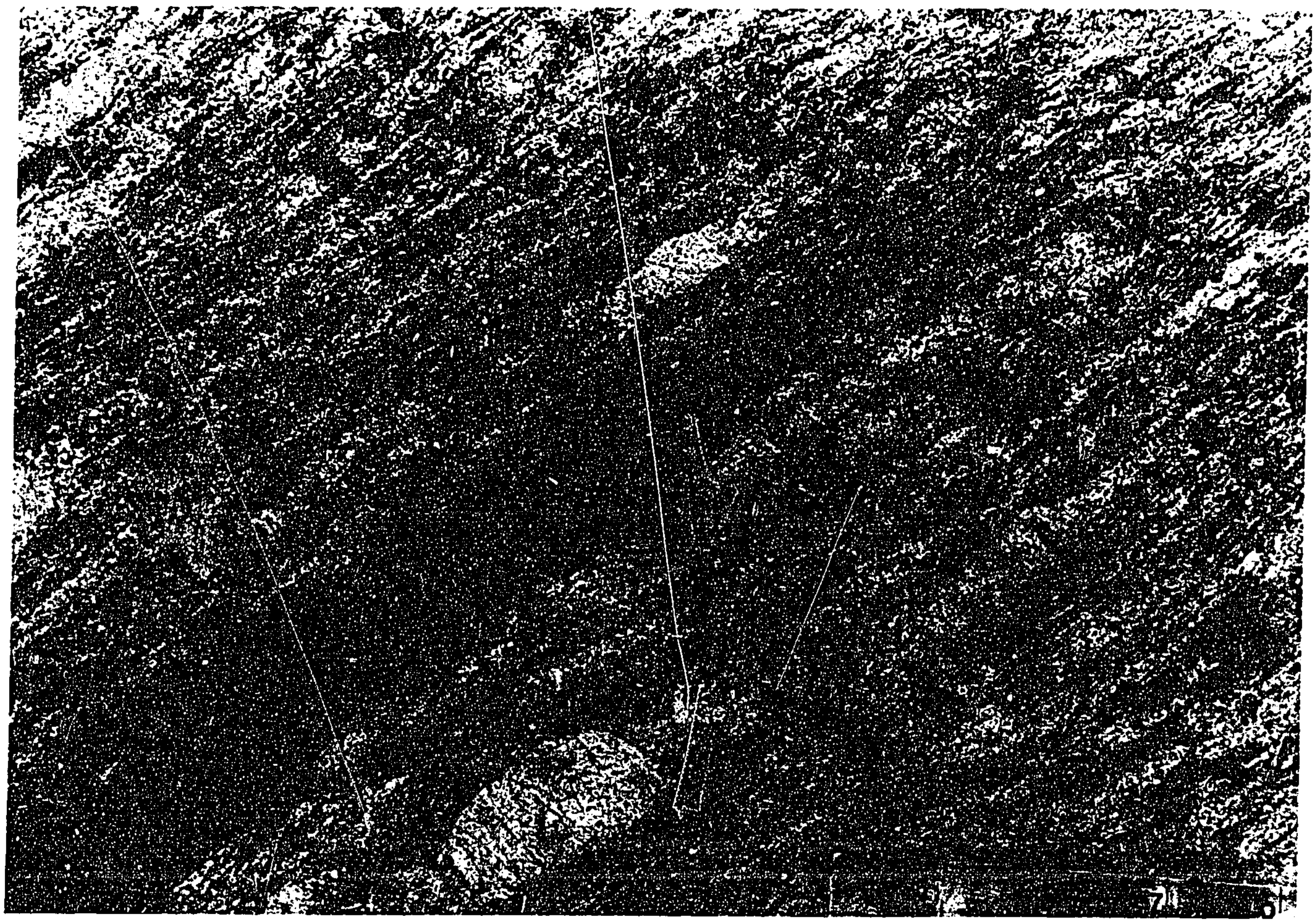


Fig. 17: Possum Creek Charnockite at type locality, showing dark flattened xenolith, large perthite augen (pale grey) and smaller plagioclase grains (dark grey). Scale in inches. Neg. M/1376/31.

abundant accessory in all the samples, and the mineral forms about 2 percent of sample 72920491. The other accessories include zircon, apatite (particularly abundant and conspicuous in sample 72920491), clinopyroxene in sample 72720572, and biotite in sample 72920628, where it is closely associated with hornblende.

Results of chemical analysis of two samples of the Possum Creek Charnockite are set out in Table 1.

The charnockite shows evidence of patchy retrogressive metamorphism. In the least altered sample, 72920572, hypersthene has reacted with plagioclase and formed blue-green hornblende and iron oxide, and the green-brown primary hornblende in the rock has exsolved particles of iron oxide; all the potassium feldspar in this sample is the high-temperature form, sanidine. In sample 72920491, hypersthene is again partly altered to blue-green hornblende, the primary opaque iron oxide is rimmed with biotite, and the potassium feldspar includes high (sanidine) and low-temperature (microcline) forms. In the most retrograde sample 72920628, hypersthene is altered to red-brown biotite, primary hornblende is partly altered to chlorite and iron oxide, the primary opaque iron oxide is in places rimmed with biotite, and most of the potassium feldspar is the low-temperature form (microcline). Some of the retrogressive changes in the less altered samples (72920491 and -0572) could have been caused by deuteric alteration during cooling, or by later thermal metamorphism. However, the growth of biotite around iron oxide, and the alteration of hypersthene to biotite have been described from areas of thermally metamorphosed hypersthene dacite in Victoria (Edwards, 1932a, 1932b, 1956; Singleton, 1949) and Finland (Sederholm, 1923). These changes are seen in the most altered sample (72920628) of Possum Creek Charnockite, where, in addition, potassium feldspar is nearly all microcline. Sample 72920628 comes from an outcrop of charnockite which is entirely surrounded by the Aloolya Gneiss, and so it appears that the Possum Creek Charnockite has been thermally metamorphosed by, and is therefore older than, the Aloolya Gneiss. The conversion of sanidine to microcline may also be a thermal metamorphic effect; the reverse, thermal metamorphism of microcline to orthoclase, has been described by Wright (1967) and by Steiger & Hart (1967).

Table 1

Results of chemical analysis of two samples of Possum Creek Charnockite.

Major oxides in percent; trace elements in ppm

| Sample Nos<br>Locality | 72920628<br>5553-953391 | 72921001A<br>5553-030250 |
|---|---|---|
| $SiO_2$ | 67.9 | 66.9 |
| $TiO_2$ | 0.93 | 0.93 |
| $Al_2O_3$ | 12.6 | 13.4 |
| $Fe_2O_3$ | 1.18 | 1.80 |
| FeO | 4.85 | 5.15 |
| MnO | 0.07 | 0.07 |
| MgO | 1.43 | 1.19 |
| CaO | 3.44 | 3.45 |
| $Na_2O$ | 2.00 | 1.92 |
| $K_2O$ | 4.30 | 3.96 |
| $P_2O_5$ | 0.19 | 0.32 |
| $H_2O^+$ | 0.34 | <0.02 |
| $H_2O^-$ | 0.06 | 0.01 |
| $CO_2$ | 0.05 | 0.05 |
| $SO_3$ | 0.09 | 0.17 |
| Total | 99.43 | 99.34 |
| S.I. index | 0.92 | 1.03 |
| Li | 20 | 12 |
| Be | 2 | 1 |
| B | 5 | 5 |
| F | 1100 | 230 |
| Co | 58 | 84 |
| Ni | 16 | 20 |
| Zn | 110 | 92 |
| Rb | 250 | 150 |
| Sr | 65 | 90 |
| Y | 40 | 24 |
| Sn | <4 | <4 |
| Ba | 470 | 980 |
| W | <10 | 10 |
| Th | 24 | <4 |
| U | 6 | <4 |

Analysis by Amdel, Rept. AN3095/77

The mineralogical composition of the Possum Creek Charnockite indicates that it is a hypersthene granite, and the field evidence that it is an intrusive magmatic rock. The presence of high-temperature potassium feldspar (sanidine), hypersthene, green-brown primary hornblende, and antiperthitic plagioclase indicates that the charnockite was a high-temperature granite that formed under conditions of the granulite facies of regional metamorphism; it may be the product of partial melting of the deepest part of the Tyson Creek granulite. This is supported by the S.I. indices (Chappell & White, 1974) of the two analysed samples, which are less than 1.1, suggesting a derivation from (meta)igneous rocks.

The Charnockite has not been isotopically dated. Its composition, and relationships indicate that it is only very slightly younger than the Tyson Creek granulite, and hence is probably Middle Proterozoic.

Aileron metamorphics (Ena) (A.Y.G. and A.J.S.)

The Aileron metamorphics comprise felsic granulite, mafic granulite, and small amounts of cordierite gneiss, garnet-biotite gneiss, calc-silicate rock and marble, sillimanite gneiss, quartz-rich meta-sediment, cordierite-garnet rock, quartzofeldspathic gneiss, and amphibolite in the northwest of AILERON. The name is derived from the settlement of Aileron, located near the centre of the outcrop area. The unit extends east into the Alcoota 1:250 000 Sheet area, where it was mapped as unit pGi by Shaw & Warren (1975). Aeromagnetic data suggest that the unit is more widespread than surface exposures indicate, and that it underlies large areas of superficial Cainozoic cover in the southern parts of AILERON and TEA TREE (see Fig. 141, Solid Geology Map). Where exposed, the metamorphics form prominent hills and ridges; Mount Boothby, with a relief of 230 m, is composed of felsic granulite of the unit. The units forms a number of large separate enclaves and rafts, up to 4 km long, in the Boothby Orthogneiss; it also adjoins the northeastern margin of the Napperby Gneiss, and is in contact with and presumably intruded by unnamed granite at two localities 4 and 7 km south of Aileron, respectively. The metamorphics are easily distinguished by their generally fine grain and layered structure from the medium to coarse-grained non-layered granitic gneisses or granite of these three adjoining units. The layering in the metamorphics is invariably parallel to the foliation of the Boothby Orthogneiss. Orthogneiss-granulite boundaries commonly consist of several alternations of concordant bands of granulite and porphyritic gneiss each a few tens of centimetres across. It is interpreted that the gneiss bands have been injected along the metamorphic banding of the granulites.

The reference area for the Aileron metamorphics is a prominent unnamed hill located at 5552-255996 (sample locality D1253, D2071), 6.5 km northwest of Aileron. The lower slopes on the southeastern side of the hill are composed of gently dipping felsic and mafic banded granulites. Northwards, towards the top of the hill, the granulites are invaded by porphyroblastic augen gneiss of the Boothby Orthogneiss. Granitic gneiss adjacent to the granulite abounds in ghost inclusions, schlieren, and xenoliths of granulite in various stages of magmatic digestion. Commonly, the granitic gneiss adjacent to granulite is enriched in biotite compared with that farther from the contacts. Glomeroporphyroblastic augen gneiss and porphyritic granite, showing flow alignment of the phenocrysts, engulf and intrude the granulites. The intrusion is predominantly of a conformable lit-par-lit type, and few discordant contacts were observed. The granitic gneisses include garnet, andalusite, sillimanite, and cordierite, and are thus mineralogically indistinguishable from the felsic granulites.

$\underline{Bna_1}$. This unit consists of felsic granulite, together with smaller amounts of mafic granulite, amphibolite, garnet-biotite gneiss, sillimanite gneiss, cordierite granulite and gneiss, biotite gneiss, orthogneiss, and quartz-rich metasediment. The granulites are fine-grained, uniform, grey to black rocks; plagioclase in weathered rock is brown. The acid to intermediate rocks are often darker in hand specimen than their ratio of melanocratic to leucocratic minerals as seen in thin section would suggest - a result of clouding by microcrystalline components. The rocks include granulite facies assemblages, amphibolite facies assemblages, assemblages transitional between the two, and retrogressed assemblages; the latter occur mainly along sheared contacts with granite.

Both fine-scale metamorphic segregation banding and irregular medium-scale banding, possibly inherited from original bedding, are present.

The fine-scale banding is superposed on the medium-scale banding, however many transitional cases in which segregation banding and original banding cannot be distinguished from each other were seen. Folding is common, but no consistent orientations were measured in this survey.

The metamorphic rocks include biotite-cordierite-andalusite-perthite-quartz felsic granulite, biotite-hypersthene granulite, two pyroxene-labradorite granulite, and amphibolite. The felsic granulites 1.5 km northwest of Mount Boothby (73922066, -2067, -2069) display different proportions of the same components. They are fine-grained commonly banded rocks, containing granoblastic perthite, cordierite, and quartz and biotite which displays preferred orientation (73922067) or is oriented at random (73922066). The biotite is commonly replaced by anhedral andalusite. The cordierite is rimmed by pinite, has yellow pleochroic haloes around inclusions of zircon, and is distinguished from feldspar and quartz by its somewhat clouded uneven surface. The K-feldspar is invariably perthitic. Accessorites include micro-crystalline sillimanite, zircon, epidote, chlorite and iron oxides. Irregular grains of vermicular andalusite develop exclusively at the expense of biotite. A coarse-grained equivalent of these rocks is represented by sample 73922068, which includes microcrystalline acicular sillimanite, but little or no K-feldspar, and specimens 73922073A & B which abound in quartz. Sample 73922073A is a banded biotite-rich variety. Sample 73922068 shows extensive replacement of cordierite by chlorite and biotite, and of biotite by sillimanite, signifying polymetamorphism.

Hypersthene-rich biotite-quartz-andesine granulite was recorded at the reference area for the unit (73922071A). The hypersthene is clearly developed at the expense of biotite. The same outcrop includes bands of clinopyroxene-hornblende-andesine granulite (73922071C) with accessory iron oxides, and minor biotite. Textural relations suggest a replacement of the hornblende by pyroxene. Basic rocks 2.5 km south of the reference area include biotite-rich clinopyroxene-quartz-andesine granulite (73922074B). The textural relationships between the pyroxene and the biotite are equivocal, but mostly the pyroxene is believed to be younger. Lower-grade metamorphosed basic rocks also occur, including quartz-bearing hornblende-plagioclase amphibolite (73922070C, 2 km south of the reference area), and quartz-biotite-hornblende-plagioclase rock 73922074C). The biotite is texturally older than the hornblende. The latter specimen occurs within the same outcrop as basic granulite (73922074B), indicating a marked change in metamorphic conditions over a short distance.

Mafic granulite (73922075) 3 km west of Prowse Gap consists of medium-grained poikiloblasts of clinopyroxene which enclose anhedral multiply twinned labradorite. Phlogopite is a common constituent (z-yellow brown); in most instances it is somewhat clouded and replaced by pyroxene, whereas in other cases it looks fresh and protrudes into the pyroxene. Relict pale actinolite is also very common and is texturally younger than the phlogopite. Certain bands in the rock consist almost exclusively of amphibole and plagioclase. Iron oxide is accessory.

$Ena_2$. Outcrops of granulite in the Rabbit Well area outline a dome intruded by granites to the north and to the south. The granulites include interbanded mafic and felsic varieties, mafic types being more abundant than in other parts of AILERON. The rocks include medium-grained granoblastic biotite-hornblende-hypersthene-diopside-labradorite granulite (73922032B, 72921212) and hornblende-hypersthene-diopside-andesine granulite (72921231). The order of crystallisation is biotite first, then amphibole, then pyroxene. Quartz and iron oxide are minor components. Bands of felsic granulite and gneiss interbanded with the basic rocks include granoblastic biotite-quartz-potash-feldspar-oligoclase rocks. Quartzofeldspathic garnet gneiss is exposed around the southern margin of the mafic granulite dome; the rock is very strongly foliated, and the garnet is concentrated in dark layers up to 4 m long by 10 cm wide.

$Ena_3$. Pelitic and mafic gneisses are exposed 500 m west of Prowse Gap, between two ridges of Boothby Orthogneiss. Two small exposures 2 km southeast of Mount Boothby are photo-interpreted only, and are labelled as cordierite gneiss solely on their similar photo-appearance to the cordierite gneiss of the Nolans Dam metamorphics, 5 km to the south.

$Ena_4$. Coarse-grained spinel-bearing biotite-sillimanite-perthite-cordierite gneiss (72921223A) occurs at the eastern edge of AILERON: the sample site is located in the adjoining Alcoota 1:250 000

Sheet area (GR346490). The rock has two generations of biotite, (1) early brown biotite (replaced by andalusite) and (2) younger green biotite, which occurs either as veins in garnet or as alteration of early biotite - signifying retrogression. Replacement of cordierite by pinite, biotite and sillimanite is common. A similar, garnet-rich rock is represented by specimen 72921223D, where brown biotite forms inclusions in garnet, and green biotite forms veins through the garnet; sillimanite postdates the garnet, and is altered by the green biotite.

Mafic granulites are also common in this area. They include clinopyroxene-hornblende-labradorite assemblages (72921223B), hornblende-hypersthene-diopside-andesine assemblages (72921223C), and diopside-labradorite-hornblende assembles (72921233). Calc-silicate rock is a minor component of the unit.

$Ena_5$. Calc-silicate rock, accompanied by lesser amounts of sillimanite gneiss, garnet-biotite gneiss, cordierite gneiss, mafic graunulite, and quartzite, is exposed at five localities between Laughton Lagoon and the eastern margin of AILERON. A separate exposure of calc-silicate rock and marble is located 2.5 km west of Prowse Gap. The calc-silicate rocks east of Laughton Lagoon include sphene-bearing garnet-diopside rock (72921225A),epidote-plagioclase-diopside rock (72921225B), sphene-rich poikiloblastic diopside-epidote-labradorite rock (72921225D), and garnet-scapolite-sphene-epidote-diopside-plagioclase rock (72921225E). Minor components include biotite, chlorite, and carbonate. An unusual pelitic rock-type observed is garnet-muscovite schist (72921235) which includes scapolite and epidote as accessories. Banded plagioclase-clinopyroxene rock (72921225C) with fine-scale banding, and biotite-amphibole-hypersthene-clinopyroxene-andesine rock (72921226) are also present. Commonly, pyroxene develops at the expense of biotite and hornblende in these rocks, although in some specimens the biotite shows apparent younger relations. Various stages of replacement of hornblende by pyroxene are displayed.

Spinel-forsterite marble (72921228A, B, E) consists of oval, fine- to medium-grained, partly to completely serpentinized grains of forsterite set in a mosaic of carbonate. The serpentine forms rectilinear patterns inherited from its development along cracks in the original olivine. Green spinel and opaques are common accessories. The spinel replaces carbonate, indicating the dolomitic composition of the latter. Minor alteration of spinel to biotite along cracks is common. There is no alteration of olivine, serpentine or spinel by carbonate, which confirms that the carbonate is the older phase, and that the rock is a spinel-forsterite marble rather than an altered ultramafic igneous rock. In associated rocks xenoblastic porphyroblasts of diopside replace actinolite (72921228D), and muscovite (72921228F).

Corundum-tourmaline-biotite-orthoclase-plagioclase rock (72921228C) has been also recorded from the locality where spinel-forsterite marble occurs. The corundum is intergrown with opaque oxide, suggesting retrogression from spinel. Spinel, apatite, zircon, and clinozoisite are minor components. No quartz is present, and the rock is compositionally akin to metamorphosed syenite. R.G.W. considers it to be a metasomatic reaction product of the forsterite marble and adjacent Boothby Orthogneiss.

$\underline{Bna_6}$. Sillimanite-garnet-biotite gneiss, amphibolite, and garnet amphibolite crop out 5 km southeast of Mount Boothby, and form an enclave in Boothby Orthogneiss. The Mount Boothby Tungsten Prospect is located in the contact zone of the pelitic gneiss and orthogneiss, near the western end of the enclave.

$\underline{Bna_7}$. Quartz-rich metasediment is exposed on the western side of Harry Dam, 13 km southeast of Aileron. The exposure is mainly biotie-sericite-quartz schist, medium-grained and granulated (Evans & Glikson, 1969, p. 30; 68660057B). Three exposures 4 km northwest of Harry Dam have not been visited. Three other exposures adjacent to the Stuart Highway 5 km north of Aileron are mapped as quartz-rich metasediment, but the only sample thin-sectioned consists of sapphirine, phlogopite, muscovite, corundum, and spinel; quartz is absent (72921235).

$\underline{Bna_8}$. Cordierite-garnet granulite, with smaller amounts of cordierite granulite and garnet-muscovite gneiss, forms a prominent elongated dark grey hill about 5 km southeast of Aileron. The rocks include spinel-bearing biotite-sillimanite-garnet-quartz-cordierite-microperthite granulites (71921079. -1081, -1082; Fig. 18). Garnet, andalusite, and sillimanite replace biotite. Similar rocks containing coarse-grained porphyroblasts of garnet are represented by specimen 71921080 (Fig. 19), which contains both K-feldspar and oligoclase, and which shows abundant replacement of biotite by vermicular andalusite. Muscovite-biotite-quartz schists with remnants of garnet and cordierite, retrogressed from higher-grade rock, are common in this area (-1083); the rocks show replacement of biotite by muscovite.

The second major exposure of cordierite-garnet granulite is located 12 km east-southeast of Aileron. The most abundant rock-type (68660056A) comprises coarse porphyroblasts of garnet and andesine in a fine to medium-grained banded groundmass of biotite, cordierite, orthoclase, quartz, and sillimanite (Evans & Glikson, 1969, p. 45).

$\underline{Bna}_9$. Two exposures of quartzofeldspathic gneiss are located 7 and 10 km west-northwest of Prowse Gap, respectively. The rock consists of quartz, perthite, plagioclase, cordierite, sillimanite, relatively minor andalusite (developed at the expense of biotite), accessory iron ore, spinel, and zircon, and minor alteration products such as pinite (rims around cordierite) and chlorite (68660058A, -B). Sample 72921234 is a biotite and cordierite-rich granofels. Quartzo-feldspathic gneiss also forms several exposures 8 km south-southwest of Aileron; it is fine-grained, generally leucocratic but with some darker layers, and is associated with massive quartzite.

$\underline{Bna}_{10}$. Amphibolite has been identified solely by photo-interpretation at GR5552-423849, 16 km southeast of Aileron.

The mineral assemblages in the pelitic rocks of the Aileron metamorphics are compatible with either upper amphibolite or low granulite (hornblende granulite) facies. In most areas, associated mafic rocks contain assemblages of the hornblende granulite facies, e.g. hornblende-hypersthene-clinopyroxene-andesine (72921231), and biotite-hornblende-hypersthene-clinopyroxene-andesine (72921226), and this is probably the most widespread facies in AILERON. Textural relationships between some of the minerals in the Aileron metamorphics, such as andalusite around biotite, biotite replaced by sillimanite or pyroxene, biotite older than (and so possibly replaced by) hornblende, phlogopite and hornblende both

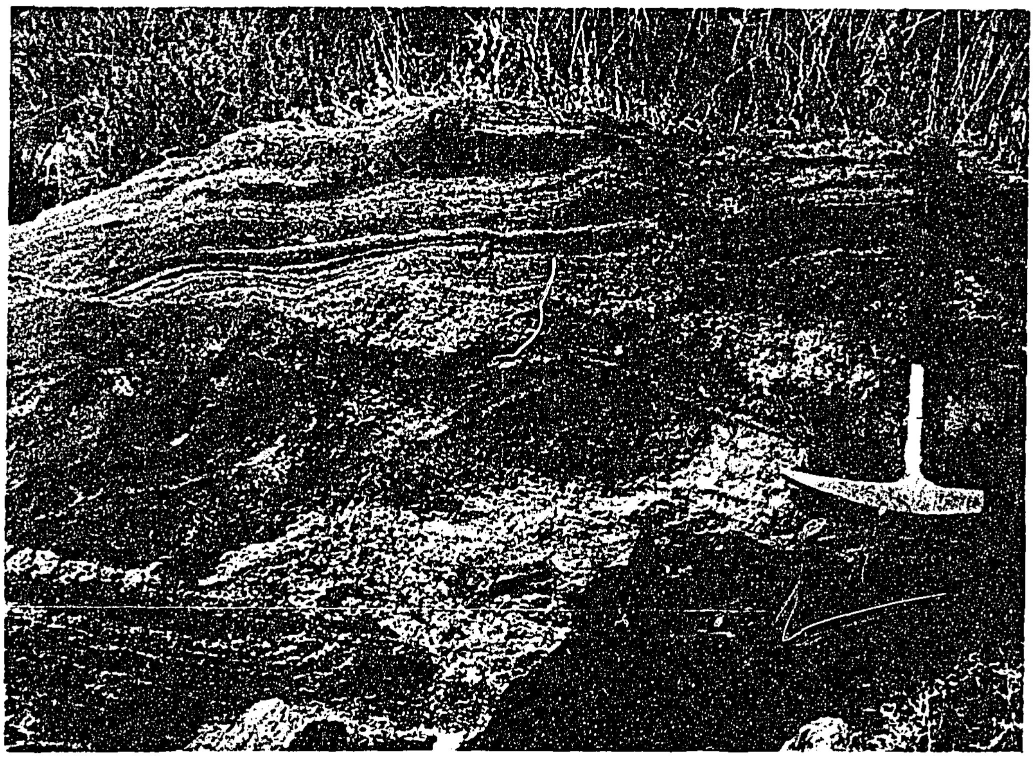


Fig. 18: Banded pelitic granulites of unit $Ena_8$ of Aileron metamorphics, locally intruded by quartz-feldspar veins. GR5552-348917, 6 km southeast of Aileron.
Neg. GA/8147.

Fig. 19: Garnet-bearing banded pelitic granulites of unit $Ena_8$ of Aileron metamorphics. GR5552-348917, 6 km southeast of Aileron
Neg. GA/8166.

replaced by pyroxene, and actinolite replaced by diopside, indicate two episodes of metamorphism, an earlier one of moderate-grade followed by a later one of higher grade.

Mafic assemblages of the upper amphibolite facies do occur in several places, however, e.g. biotite-hornblende-plagioclase (73922074C), diopside-hornblende-andesine (73922071C), biotite-diopside-andesine (73922074B), and diopside-hornblende-labradorite (72921223B); these are commonly closely associated with granulite assemblages. Rocks of definitely lower grade are restricted to the Harry Dam area, east of Aileron, where such assemblages as epidote-plagioclase-diopside (72921225B), sphene-diopside-epidote-labradorite (72921225D) in $Ɛna_5$, and biotite-sericite-quartz in $Ɛna_7$, indicate low to middle amphibolite facies.

The absence of primary textures and structures, and the highly metamorphosed state of the Aileron metamorphics preclude a confident assignment of origin to any of the rock-types in the unit. The felsic and mafic granulites may be metamorphosed acid and basic volcanics respectively; the other rock-types more certainly began as pelitic or calcareous sediments, accompanied by small amounts of impure quartz sand. Felsic granulite from sample locality 73921021, 0.75 km east of Mount Boothby, has given a Rb-Sr whole-rock isochron date of about 1670 Ma (initial $^{87}Sr/^{86}Sr$ ratio = 0.715), and felsic and mafic granulites from locality 73921022, 2.5 km south of Rabbit Flat Dam gave a similar date of about 1650 Ma (IR = 0.808). The Aileron metamorphics are tentatively correlated on lithological similarity with the Tyson Creek granulite and Weldon metamorphics in TEA TREE and REYNOLDS RANGE.

<u>Nolans Dam metamorphics</u> (Ɛnn) (A.Y.G. and A.J.S.)

The Nolans Dam metamorphics consist of cordierite gneiss and quartzofeldspathic gneiss, accompanied by smaller amounts of garnet-biotite gneiss, sillimanite gneiss, muscovite schist, quartzite, and retrogressively metamorphosed rock, that crop out between Nolans Dam (whence the name) in the north, and Bluebush Swamp in the south, a distance of about 8 km in the north-central part of AILERON. The rocks form hilly country of low relief, and are easily distinguished by their fine grain and dark colour from the surrounding granitic gneiss of the Napperby Geniss. The Nolans Dam metamorphics intertongue with schist of the Lander Rock beds 1.5 km south of Nolans Dam, and the relationship appears to be concordant and may be conformable. The metamorphics are intruded by the Napperby Gneiss along their eastern and southern margins.

The reference area for the Nolans Dam metamorphics is located at GR5552-248955, an area of hills and gullies which includes sample localities 73922039, -2040, -2041. There the cordierite gneiss is commonly garnet-bearing, and shows well developed metamorphic segregation banding. The common mineral assemblages include cordierite, andalusite, garnet, biotite, plagioclase, orthoclase, and quartz (73922037A, -2038, -2039, -2040, -2041). The andalusite is microcrystalline and vermicular, and replaces biotite. The latter is light green and rich in exsolved iron oxide. The textures are granoblastic to gneissic, and porphyroblastic where garnet is coarse grained.

Towards the northwest, the gneiss becomes increasingly sheared and retrogressed; the rocks retain the original metamorphic banding, but consist of aggregates of microcrystalline muscovite and biotite pseudomorphous after feldspar, and lenses and bands of mosaic quartz (73922042). With further shearing the rocks are converted to muscovite-quartz schist (72921205, -1206).

Quartzofeldspathic gneiss forms a lens up to 400 m wide that crops out along the central zone of the Nolans Dam metamorphics. The gneiss has a distinctly banded appearance on the airphotos, in contrast to the uniform tone of the cordierite gneiss. The rock is medium to coarse-grained, leucocratic, and biotite-bearing. Foliation strikes northeast, at a high angle to the north or northwesterly trend of the macroscopic banding.

The mineral assemblages of the Nolans Dam metamorphics are characterised by cordierite, and andalusite or sillimanite. Andalusite is vermicular, and in all samples surrounds biotite. Hence, the equilibrium assemblage appears to be cordierite and sillimanite, and this, together with the absence of muscovite (except in retrogressed areas) indicates an assemblage of the upper amphibolite facies of metamorphism. The andalusite reaction rims suggest a second episode of metamorphism.

Before metamorphism, the Nolans Dam metamorphics were presumably a pelitic sediment, such as shale or impure sandstone. The origin of the quartzofeldspathic gneiss is not known. The metamorphics have not been dated, but their close association and intertongueing relation with Lander Rock beds to the northwest suggests that the Nolans Dam metamorphics are the same age as the Lander Rock beds, i.e. Middle Proterozoic, or older.

Mount Charles beds (Ḇtc) (L.A.O.)

The Mount Charles beds, one of the oldest units exposed in The Granite-Tanami Block, are defined by Blake & others (1975) as low-grade metasediments and metavolcanics. The unit is locally complexly folded and characteristically consists of chert, silicified siltstone and phyllitic siltstone. Locally greywacke, siltstone, shale, quartzite, gossanous quartz-ironstone, jaspilite, altered basic volcanics, and acid porphyry crop out (Blake & others, 1980).

The Mount Charles beds crop out in the western part of the Mount Solitaire Sheet area as low rounded and partly dissected rubbly hills and ridges, consisting of white, grey and pink meta-quartzite, partly ferruginised metamorphosed quartz sandstone, purply-brown silty shale, grey slate and weathered granular or laminated rock which may be tuffaceous.

Blake & others (1980) correlated the beds with metamorphic rocks of the Arunta Block. Mapping of the northern part of the Arunta Block has confirmed this correlation, and shown lithological and structural similarities between the Mount Charles beds, and the Lander Rock beds of the Arunta Block. In the northern part of the Arunta Block, the Mount Charles beds are a sandy facies equivalent of the Lander Rock beds (Stewart, 1976; Offe & Kennewell, 1978).

In the Mount Solitaire Sheet area resistant metaquartzite forms the main part of the outcrops, and generally consists of medium to coarse interlocking quartz grains with minor detrital tourmaline, biotite and/or muscovite. Metamorphosed quartz sandstone is partly recrystallised, friable, and in places ferruginised along parting planes and joints. Slightly metamorphosed silty shale and dark grey slate occur in places interbedded with the metaquartzite layers. Laminated, yellow and maroon spotted rock crops out at the trig point at De Bavay Hills, and about 12 km to the southwest. This rock type contains about 10 to 15 percent fine-grained angular quartz in a clay matrix (75110407) and may be tuffaceous in origin.

The Mount Charles beds are commonly tightly folded on a mesoscopic scale. Bedding is defined by colour laminations in the metaquartzite and lithologic layering and in most exposures parallels the foliation. The foliation is moderate to steep dipping, appears to be axial plane to the tight folds, and is locally folded. The beds are a low-grade metamorphosed interbedded sequence of probable marine sediments consisting of quartz sandstone, siltstone, shale, and minor beds of tuffaceous rock.

The Granites Granite i trudes the Mount Charles beds in The Granites Sheet area (Kleeman, 1934; Hossfeld, 1940; Blake & others, 1980) and is 1742 $\pm$ 23 Ma old (Page & others, 1976). The Mount Charles beds are therefore Middle Proterozoic or older. The beds are lithologically correlated with slighly metamorphosed sandstone, subgreywacke, quartzite, and slate of unit Bla in the Mount Theo 1:250 000 Sheet area.

Unnamed Sandstone (Bla (A.J.S.)

Slightly metamorphosed sandstone, subgreywacke, quartzite, and slate crop out at Keyser Hill, Turners Dome, the Kalga, Ngadiri, and Yinabalgu Hills, and McDiarmid Hill, in the Mount Theo 1:250 000 Sheet area. The exposures may be parts of a single continuous outcrop, and are generally strongly weathered and ferruginised. The freshest exposures are at Mount Theo itself, in the Yinabalgu Hills, where prominently folded yellow-brown fine-grained weakly cleaved poorly sorted silty metasandstone forms steepsided hills and ridges with a relief of 120 m. The metasandstone is composed of quartz (95%) as sub-angular to subrounded serrated grains, and as a very fine-grained recrystallised matrix, accompanied by limonite (4%), sericite (1%). and detrital grains of zircon, sphene, and flaky muscovite (72110323). Subgreywacke is similar, but contains less quartz (85%) and more sericite (14%); limonite (1%), tourmaline, zircon, rutile, and sphene are accessory (72110319).

Quartzite is exposed at Turners Dome, and is similar to the metasandstone, except that it lacks the fine-grained quartz matrix, although fine sericite (5%) and limonite are still present (-0315). Quartzite also crops out as a structural basin in the centre of the Yinabalgu Hills, and may be unconformable on the underlying subgreywacke. Reddish-purple slate is exposed on the north side of McDiarmid Hill, and is very fine-grained and sericitic.

The metasediments originated as impure sand, silty sand, and clay, and were subsequently metamorphosed to low greenschist facies. Because of poor exposure, no relations with any other units are known. The sediments markedly resemble the Mount Charles beds in the adjoining Mount Solitaire 1:250 000 Sheet area to the north. In addition, they may be a sandy facies of the Lander Rock beds in the south of the Mount Theo Sheet area. If an unconformity is present below the quartzite basin in the Yinabalgu Hills, the quartzite may be a correlative of the Mount Thomas Quartzite. Because of its metamorphosed condition and similarity to the Mount Charles beds, the unit is regarded as Middle Proterozoic or older.

Wickstead Creek beds (Ei) (A.Y.G. and A.J.S.)

The Wickstead Creek beds are the unit of calc-silicate rock, schist, and minor granofels that crop out chiefly in the northwest of AILERON and northeast of NAPPERBY; smaller isolated outcrops of similar rocks in the south of REYNOLDS RANGE and centre and north of DENISON have also been assigned to this unit. In AILERON, the beds crop out in two WNW-striking elongated belts: the southern belt occurs between Wickstead Creek (whence the name) in the east and Wallaby Creek in the west, and the northern belt westwards from about 3 km north of Anna's Reservoir. Towards their western extremity in NAPPERBY, both zones are extensively intruded by and form inclusions within the Napperby Gneiss. The inclusions form an almost continuous string, interpreted as remnants of an originally continuous mass. The type locality of the beds is at GR5552-065980, 3 km southwest of Anna's Reservoir, where prominent hills of the beds provide good exposures.

The southern outcrops of the Wickstead Creek beds are discontinuously exposed along the southern flank of the Mount Freeling massif, and are extensively intruded by deformed migmatitic granite of the Napperby Gneiss. The quartzite-calc-silicate rocks commonly occur as strongly folded and faulted roof pendants above the migmatitic granite e.g. 2 km southwest of Mount Freeling, and are densely intruded by tourmaline-rich coarse-grained porphyritic microcline pegmatites related to this granite. The deformation associated with the intrusion results in a highly irregular attitude of the faulted blocks, which are in places reduced to mega-breccia of rafts and roof pendants. Consequently, no thickness estimates of the southern outcrop zone is possible. At its northern boundary, the beds grade into schist and gneiss of the Mount Freeling schist, which in places contain calc-silicate intercalations.

The northern outcrops of the Wickstead Creek beds in AILERON are more continuous, and are intruded by granite mainly from Mount Dunkin westward. The outcrop is up to 1 km wide, and dips approximately $60^{\circ}$ northward. Where the rocks are intruded by granite i.e., south of Mount Dunkin, complicated roof pendant block structures prevail. The southern boundary of the beds adjoins the northern margin of the Mount Freeling schist, and northwest of Mount Dunkin, the beds are in contact with the Mount Dunkin schist, apparently conformably. Two small elongate outcrops of Wickstead Creek beds 5 km northeast of Anna's Reservoir form conformable lenses in schist of the Lander Rock beds. This relationship is again exposed 2 km northwest of Mount Thomas, in REYNOLDS RANGE, where calc-silicate rock of the Wickstead Creek beds is exposed in the core of an antiform in the Lander Rock beds.

The Wickstead Creek beds comprise diopside or tremolite-bearing calc-silicate rock (Figs. 20, 21) and epidote-rich green quartzite, which tend to display complex contorted tight folding (Figs. 22, 23) and boudin structures, indicating a highly plastic behaviour of the strata (Figs. 24, 25). Biotite-rich calc-silicate rock, and minor pelitic schist and gneiss are incorporated in the sequence.

The southern outcrops in AILERON include rocks which are banded on the mesoscopic scale into tremolite-epidote bands, biotite-rich bands, and epidote-quartz bands, the latter tending to form light-coloured lenses or augen between the more plastic biotite schist. Mostly the rocks are microcrystalline to fine-grained, although less commonly the epidote is of


Fig. 20: Interlayered beds of finely laminated diopside-epidote-tremolite-quartz rock (light) and biotite-rich metasiltstone (dark) of Wickstead Creek beds. GR5552-070984, 2 km west of Wickstead Creek. Neg. GA/8156.

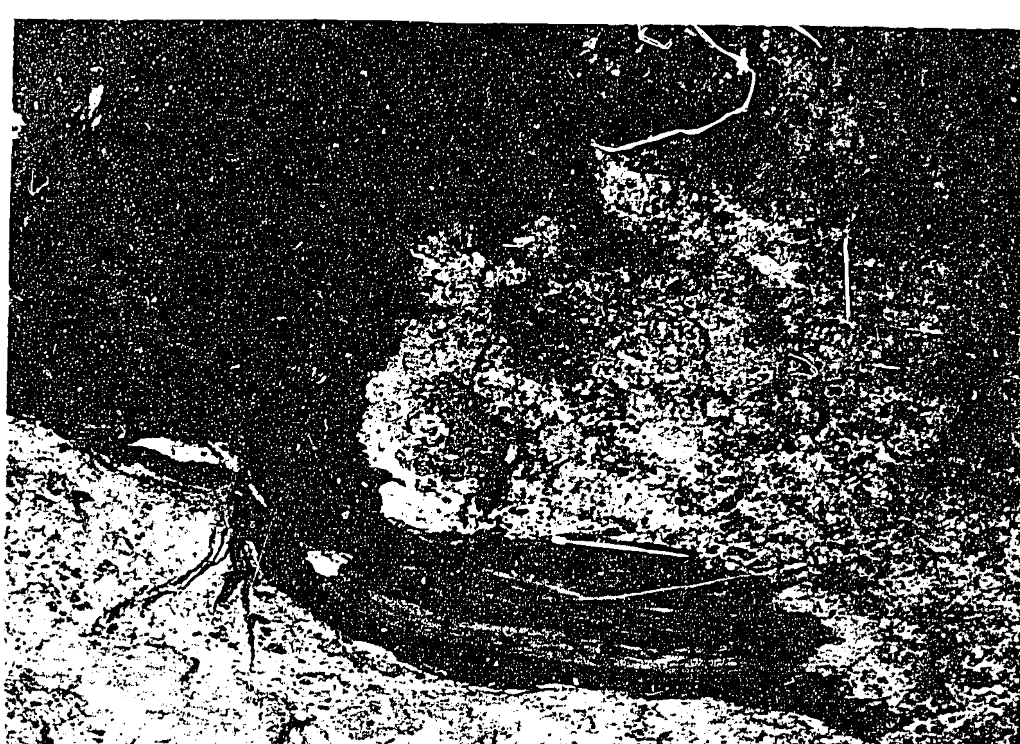


Fig. 21: Finely laminated epidote-diopside-tremolite-quartz calc-silicates of the Wickstead Creek beds intruded by pegmatite, Wallaby Creek. GR5452-938055. Neg. GA/8162.

Fig. 22: "Parasitic" drag folds in epidote quartzite (light) and biotite schist (dark) of the Wickstead Creek beds. Note the decollement style of folding. GR5552-035012, 1.5 km southwest of Mount Freeling. Neg. GA/8139.

Fig. 23: Cylindrical folds in interbedded epidote quartzite, diopside rock, and biotite schist of the Wickstead Creek beds, Wallaby Creek. GR5452-938055. Neg. GA/8160.

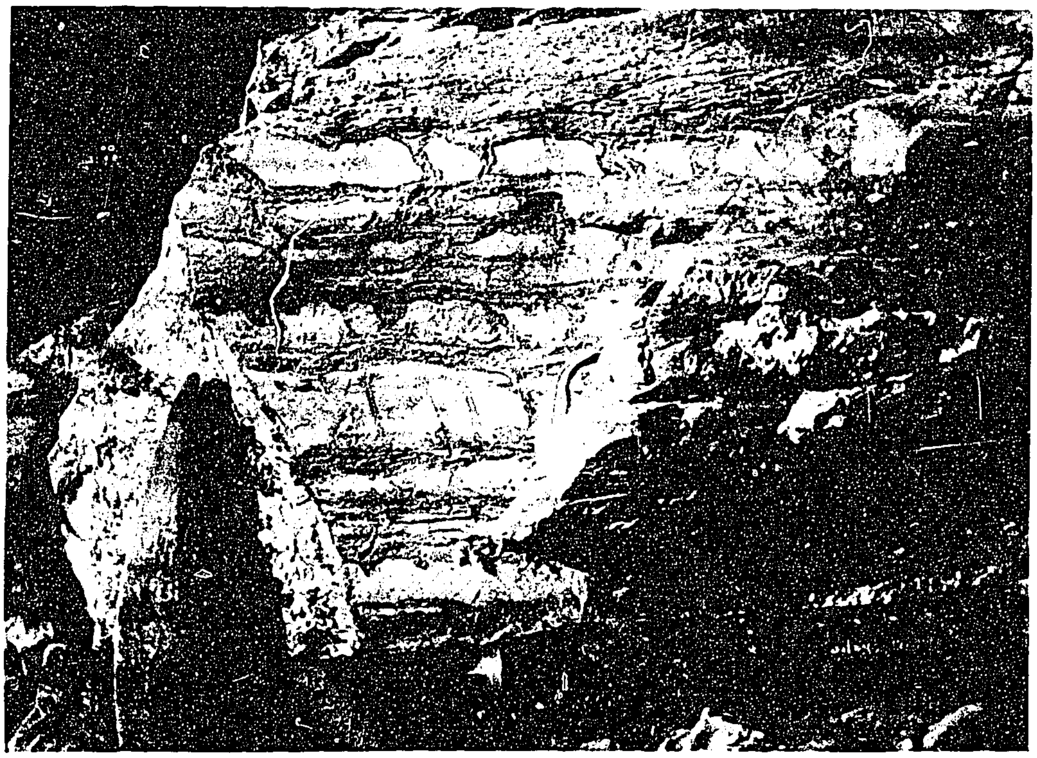


Fig. 24: Boudinage in interbedded calc-silicate (light) and biotite schist (dark) of the Wickstead Creek beds, GR5552-035012, 1.5 km southwest of Mount Freeling. Neg. GA/8141.

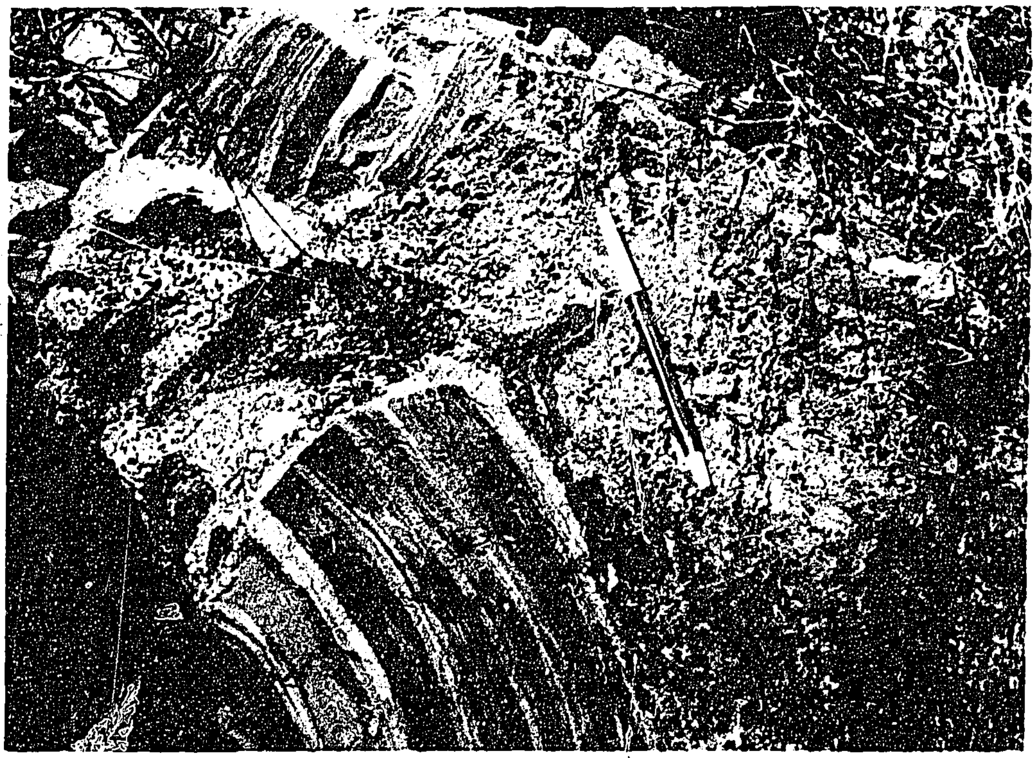


Fig. 25: Detached boudins of calc-silicate, intruded by pegmatite. Wickstead Creek beds, west of Wallaby Creek. GR5452-940038. Neg. GA/8142.

intermediate grain size. Texturally, the epidote is younger than and replaces tremolite. Calcic plagioclase, sphene and iron ores are the main accessories (73922001). Diopside-plagioclase rocks and garnet-diopside-calcic plagioclase rocks (73922002) are abundantly associated with the epidote quartzites. The garnet occurs in clusters; it tends to be yellowish and is texturally younger than the diopside, which is texturally younger than tremolite. Quartz, sphene and iron ores are common minor constituents.

The rocks of the northern outcrop zone comprise chlorite-tremolite-carbonate rocks (72921218), and towards the east grade into minor epidote quartzites intercalated with abundant biotite-sillimanite-quartz-plagioclase-microcline granofels (72921216, 73922026B, -E) considered as higher-grade derivatives of biotite schist. Metamorphically retrograded equivalents of the microcline granofels are represented by sericite-quartz schist, in which clouded relics of microcline and relict biotite are retained, and texturally younger muscovite may occur (73922027).

The two isolated lenses of Wickstead Creek beds 5 km northeast of Anna's Reservoir consist mainly of altered phlogopite-tremolite-actinolite rocks (72921204B). Actinolite forms rims around tremolite, indicating a prograde reaction involving addition of iron. Retrograde reactions are indicated by a replacement of amphibole by phlogopite, and clouding of the amphibole. Less common rocks include tremolite-clinozoisite-prehnite-microcline-quartz assemblages (72921204D), which are interpreted as banded quartzite-calc-silicate rocks. The clinozoisite is rimmed by epidote.

In REYNOLDS RANGE, isolated outcrops of Wickstead Creek beds have been mapped between the Yalyirimbi and Reynolds Ranges, in the southern part of the Sheet area. Calc-silicate rock makes up the outcrops at sample locality 72920646 (GR5453-715165), and consists of garnet, zoisite, diopside, and quartz. At GR5453-680283, the rocks are rich in epidote and quartz, and epidote, amphibole, and microcline are the chief components of the outcrop at GR5453-615334. In the outcrops at GR5453-633707 and GR5453-590268 brown metaquartzite, some containing sillimanite, is the major rock-type.

In NAPPERBY, rafts of Wickstead Creek beds in the Napperby Gneiss comprise calc-silicate rock, calc-silicate marble, quartzite, and biotite schist. The rafts are intruded by dykes and veins of pegmatite.

In DENISON, isolated outcrops assigned to the Wickstead Creek beds are located in widely separated parts of the Sheet area. In the north, several exposures of calc-silicate rock, quartzite, and schist crop out in the core of the postulated dome of quartzofeldspathic gneiss of unit p6f. Laminated calc-silicate rock is exposed at sample locality 74920882, 2 km north of Mount Treachery, and consists of labradorite, quartz, epidote, and biotite. This is overlain by a few metres of thick-bedded fracture-cleaved white quartzite. Other exposures of quartzite occur 2.5 km northeast, 4 km north-northeast, and 6.5 km northwest of Mount Treachery; these rocks are coarse-grained, blocky, and recrystallised, but retain faint but recognisable bedding, including cross-bedding at GR5353-151605, 6.5 km NW of Mount Treachery. Sillimanite schist (74920881), biotite hornfels, and impure dark quartzite are exposed 1.5 km north of Mount Treachery, and form an interbedded sequence which shows prominent thickening and thinning of beds, and in places boudinage of the tougher quartz-rich beds. About four thin concordant calc-silicate bands up to 15 cm wide occur within schistose muscovite-biotite-bearing granitic gneiss 2.5 km northwest of Naval Action Dam at GR5353-251620. These bands are composed of epidote-plagioclase and quartz-plagioclase (labradorite) and contain a small amount of hornblende, sphene, clinozoisite, and opaque grains (E827). A similar concordant calc-silicate band within granitic gneiss 4.2 km north of Boundary Dam at GR5353-348586 consists of plagioclase, quartz, and lesser amounts of amphibole, epidote, clinozoisite, sphene, apatite, muscovite, biotite, allanite, and zircon (specimens 74920939A & B). This specimen locality is not marked on DENISON but corresponds to the position occupied by, and incorrectly labelled, aplite dyke (apl).

Impure quartzite forms three small hills 4 km west of Beantree Dam, in the northwest of DENISON. The rock is coarse-grained, tough, and contains abundant sericite which may have replaced feldspar, and small amounts of garnet, zoisite, chlorite, biotite, and an opaque mineral (74920858).

At the Mount Allan tin mine and vicinity, interbedded calc-silicate rocks, serpentine marble (74920669), and sericitic quartzite (74920668) are tightly folded. Some individual laminae in the calc-silicate are made of diopside, some of tremolite, and some of sphene-tremolite-microcline-muscovite-quartz (74920669).

At Brookes Well, 14 km east of Mount Allan, calc-silicate rock consists of various amounts of quartz, clinopyroxene, light green amphibole, clinozoisite, epidote, and accessory sphene and muscovite (74920849, -0850). The rock is conformable with micaceous metasandstone of the Lander Rock beds to the north. Interlayered calc-silicate rock (epidote, quartz, tremolite, actinolite; -0927) and quartz-rich meta-sediment crop out 2 km west of Brookes Well. Quartzite is exposed 8 km west and 3 km north-northwest of Brookes Well, and is reddish-brown to light brown, coarse-grained, and sericitic. The rocks are markedly deformed, and display strong foliation, lineation, rodding, and fracture cleavage.

Fine-grained laminated calc-silicate rock crops out adjacent to foliated porphyry, 5.5 km east-northeast of Crown Hill. The calc-silicate consists of quartz, saussuritised plagioclase, hornblende, epidote, and accessory chlorite and calcite (74920814).

The assemblages in the Wickstead Creek beds in the type area in AILERON and vicinity are characterised by epidote, tremolite, diopside, and garnet, and these indicate conditions of the lowest amphibolite facies. In contrast, pelitic rocks intercalated with the calc-silicates in the northern outcrop zone in AILERON contain abundant sillimanite but no muscovite, indicating upper amphibolite facies. In REYNOLDS RANGE and DENISON, metamorphic grade is generally low to middle amphibolite facies.

The Wickstead Creek beds are clearly an interbedded sequence of metamorphosed limestone, dolomite, shale, and quartzite, and their close and conformable relationship with the Lander Rock beds indicate that the Wickstead Creek beds are a near-shore shallow calcareous facies of that unit. No isotopic dates have been determined on the Wickstead Creek beds, but they must be the same general age as the Lander Rock beds, i.e. Middle Proterozoic or older.

Lander Rock beds (Ell) (A.J.S., A.Y.G., and L.A.O.)

The Lander Rock beds are composed of weakly metamorphosed sandstone, siltstone, shale, slate, and small amounts of phyllite, quartzite, chert and amphibolite, together with their higher-grade metamorphic equivalents, and crop out mainly along the northern flank of the Reynolds Range, in AILERON, TEA TREE, and REYNOLDS RANGE. Smaller areas of outcrop have been mapped in DENISON, and in the Mount Peake, Mount Theo, Mount Solitaire, and Lander River 1:250 000 Sheet areas. They have also been recognised but not yet mapped in the northern part of the Mount Doreen 1:250 000 Sheet area. The name of the unit is derived from Lander Rock (GR5453-822370), which is a prominent hill composed of schist and metasandstone of the Lander Rock beds situated between the Reynolds and Anmatjira Ranges. In general, the beds form low to moderately high rounded hills with a maximum relief of about 100m.

No basement to the Lander Rock beds is known. The beds are faulted against the Weldon metamorphics and Tyson Creek granulites in the Anmatjira Range, and are overlain with an angular unconformity by the Mount Thomas Quartzite of the Reynolds Range Group. In DENISON, the Lander Rock beds adjoin the Mount Stafford beds, and the relationship appears to be one of rapid lithological facies change from one unit to the other. In the same area, the Lander Rock beds also adjoin the quartzofeldspathic gneiss pЄf, and the relationship here may also be one of lithofacies equivalence together with higher metamorphic grade. The Lander Rock beds are intruded by the Anmatjira, Mount Airy, and Yaningidjara Orthogneisses, by the Harverson Granite, by various small bodies of unnamed granite, and by an offshoot of the Warimbi Schist in the Reynolds Range.

Because of ubiquitous folding, there is neither a measured section nor a type section of the Lander Rock beds. The type locality and reference area are at Lander Rock. The total thickness of the beds is unknown, but a minimum thickness of 1000 m has been estimated (from airphoto measurements and dip information) on the northern limb of a large antiform in the centre of the Reynolds Range, 4 km northwest of Mount Thomas.

The Lander Rock beds are everywhere metamorphosed and deformed; the grade rises from lowermost greenschist facies in the northwest (Mount Gardiner - Giles Range area), to high amphibolite/low granulite in the southeast (Mount Airy area). The beds have been divided into twelve sub-units.

$\underline{El1}_1$. Micaceous sandstone, siltstone, shale, and slate crop out in the valley between the northwestern end of the Reynolds Range and the Anmatjira Range. The rocks are brownish-grey to pinkish-brown where weathered, but dark grey on fresh surfaces. They are fine to medium-grained, and generally poorly sorted; clayey ferruginous siltstone and shale, and silty clayey sandstone are abundant. A weak cleavage is common in all the rocks; cleaved metaclaystone 4 km east of Mount Gardiner (Fig. 26) comprises red laminae rich in hematite, alternating with thin green beds composed almost entirely of very fine-grained scaly sericite (72920501). In DENISON, slate, hornfels, and retrogressive sericite-quartz rock crop out 2.5 km southeast of Matthews Knoll.

$\underline{El1}_{1a}$. Five kilometres northeast of Lander Bore, an arcuate outcrop of grey to greenish-brown phyllite, with smaller amounts of slate, micaceous siltstone with andalusite porphyroblasts, and sandstone is mapped as Lander Rock beds on general lithological similarity. On its eastern side, the outcrop includes a mass ($\underline{El1}_{1b}$) of white very fine-grained orthoquartzite with chert laminae (72920507). The phyllite is intensively intruded by small irregular sill-like bodies of melatonalite (misidentified as hornblende diorite) (72920506 A, B).

$\underline{El1}_2$. Micaceous sandstone, cleaved siltstone, and andalusite slate crop out immediately southwest of $El1_1$, and 3 km northwest of Mount Thomas; they form an anticlinorium which extends right through the Reynolds Range. Most of the rock-types resemble those near Mount Gardiner, but slate assemblages are of slightly higher metamorphic grade, and include abundant andalusite idioblasts and biotite in the groundmass (72920466B, -0478). Sample -0466B also contains large pseudomorphs of limonite + sericite + chlorite, which may be retrograded cordierite. Phyllite is also abundant in this area, and carbonaceous siltstone is present in the subsurface near the abandoned Reward Mine (Australian Geophysical, 1967). Slate and cleaved sandstone of the Lander Rock beds near the Harverson Granite 3.5 km northeast of Harverson

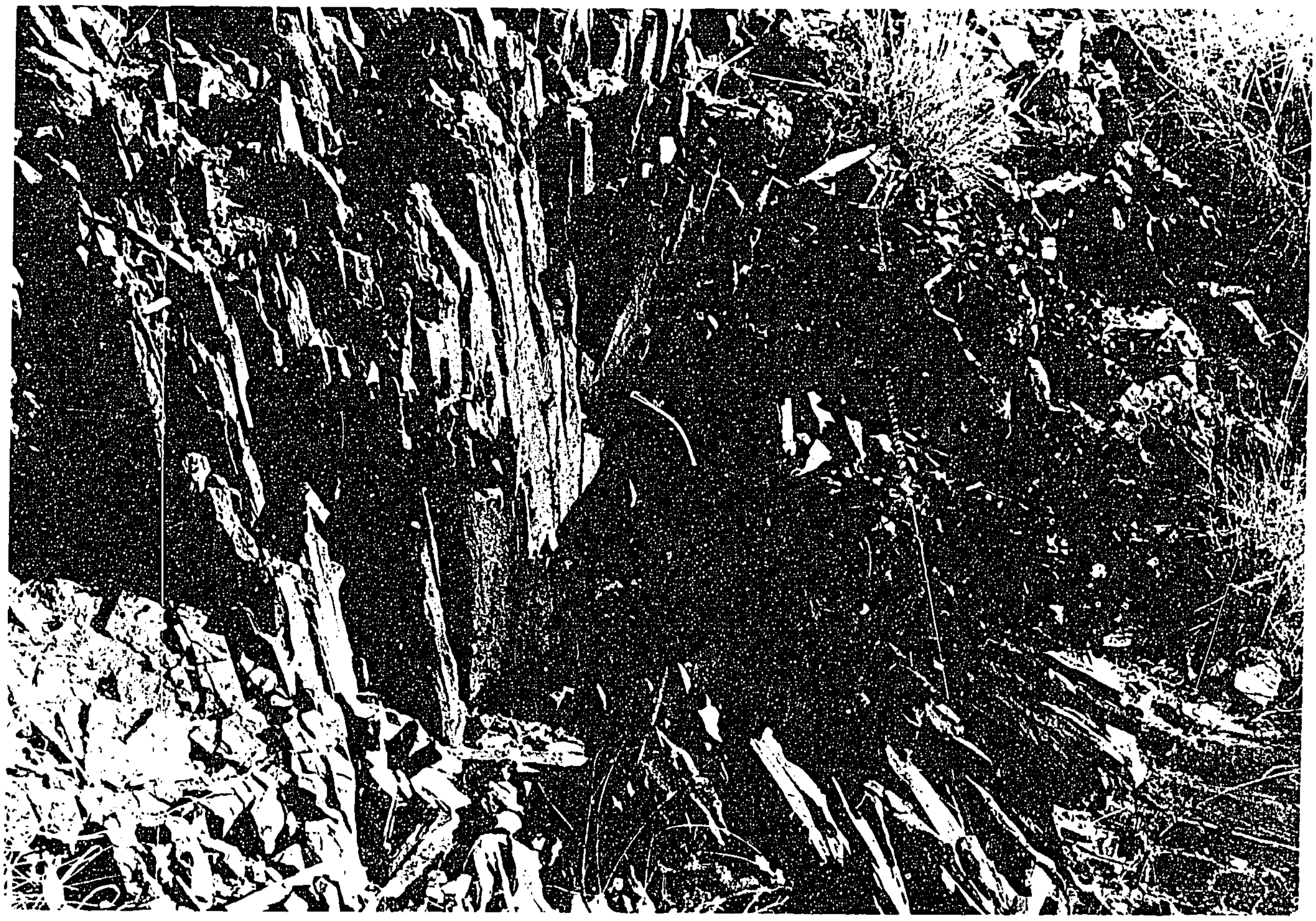


Fig. 26: Cleavage pencils in metaclaystone (slate), Unit 1 of Lander Rock beds. GR5453-609460, 4 km east of Mount Gardiner. Neg. M/1342/14.

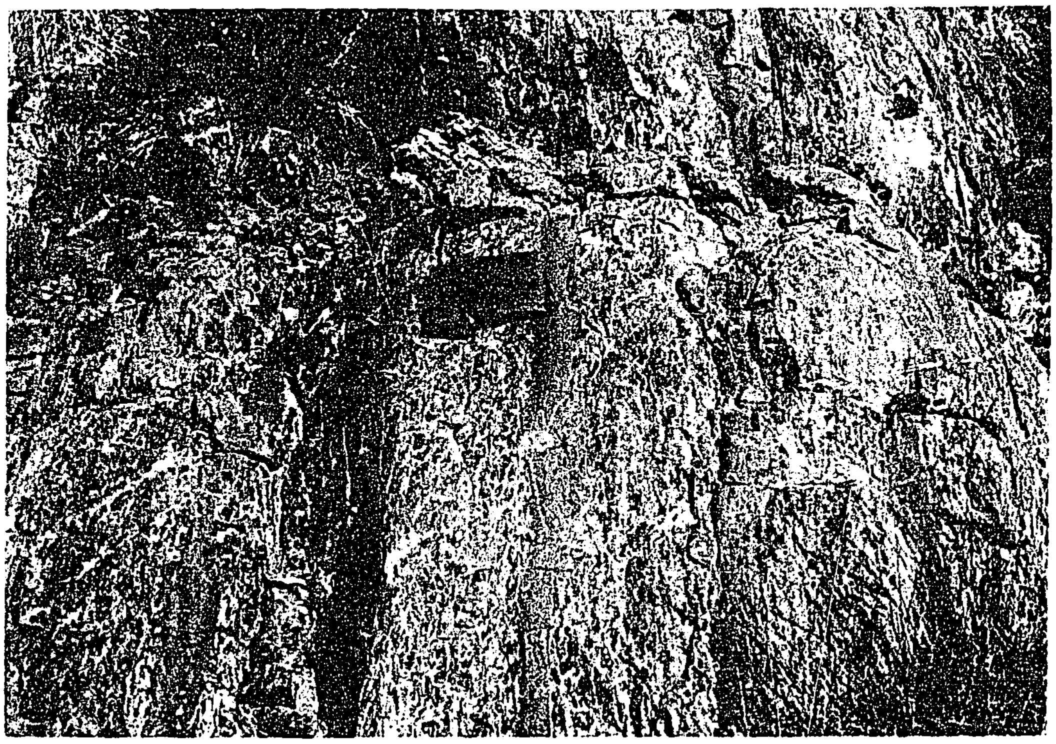


Fig. 27: Interbanded coarse-grained cordierite-sillimanite granofels, fine-grained cordierite-biotite-perthite rocks, and tourmaline-rich quartzite in Unit 9 of the Lander Rock beds. GR5552-048088, 4.5 km east-northeast of Mount Dunkin. Neg. GA/8177.

Pass are recrystallised to weakly schistose biotite hornfels (-0405), containing blue idioblasts of andalusite up to 2 cm long.

$\underline{Ell_3}$. Schist, phyllite, and andalusite hornfels crop out southwest of $Ell_2$, i.e. from the immediate vicinity of Harverson Pass to about 10 km southeast from there, between porphyritic microgranite of the Mount Airy Orthogneiss, and the northern side of the Reynolds Range. A lens (-0426) of fine-grained quartz (60%) and tourmaline (40%) was collected from the phyllite. A raft of Lander Rock beds enclosed in the porphyritic microgranite 5.5 km east-southeast of Harverson Pass consists of greenish-grey pebbly hornfels and metaconglomerate (-0421), comprising small pebbles of quartz and quartzite in a matrix of muscovite and biotite.

A second outcrop area of $Ell_3$ is located 15 km northwest of Harverson Pass, on the southern side of the Reynolds Range. Rock-types include crenulated quartz-muscovite schist, tourmaline-muscovite schist, sericite quartzite, biotite quartzite, and tourmaline quartzite.

In AILERON, rocks assigned to $Ell_3$ crop out discontinuously for 18 km from the Woodforde River in the northwest to Nolans Dam. The rocks are mostly biotite-muscovite schist, with sparse interbeds about 10 cm thick of cross-bedded micaceous quartzite, some with abundant tourmaline. Cordierite-bearing gneiss is associated with the schist 2 km west of Nolans Dam; quartz-rich metasediment in the same area is strained and brecciated (71911207). Quartz-rich metasediment also crops out 2 km southwest of Nolans Dam, and includes sillimanite-biotite-quartz schist showing alteration of sillimanite to chlorite (-1209).

$\underline{Ell_4}$. At Lander Rock and vicinity, the beds are a monotonous sequence of lineated biotite-muscovite schist with blue andalusite porphyroblasts commonly replaced by sericite (71921076, -7; 72920628), metasandstone consisting of partly recrystallised quartz, biotite, and muscovite (-0625B), and metaquartzite. Sillimanite is present in the schist at GR5453-860377, 4 km east of Lander Rock. Several large pegmatites up to 1 km long intrude the beds in this area; the pegmatites are coarsely foliated and retrogressively metamorphosed.

Ell$_5$. From 5 km east-southeast of Lander Rock to 9 km northwest of Pine Hill homestead, the Lander Rock beds are composed dominantly of coarse-grained sillimanite-biotite-muscovite schist with the sillimanite forming conspicuous white sheafs of fibres up to 5 mm long. Also present in the schist are concordant lenses of mafic rock up to 2 m long, composed of retrogressively metamorphosed dolerite; clinopyroxene is partly altered to hornblende, and this in turn is partly altered to biotite (-0609B). In the contact zone between Ell$_5$ and the northern margin of the Mount Airy Orthogneiss at GR5453-870350, the beds comprise biotite schist and schistose hornfels, with pale brown quartzite interbeds. Large xenoliths up to 20 m long in the granite consist of coarse-grained spotted schist, and carry feldspar porphyroblasts in their border zones.

In DENISON, Ell$_5$ is exposed in the northwest corner of the Sheet area, and forms three outcrop areas separated by areas of Mount Stafford beds; a fourth outcrop of Ell$_5$ is surrounded by quartzofeldspathic gneiss of unit pЄf. The Lander Rock beds consist of interbedded schist or gneiss consisting of various amounts of sillimanite, muscovite, biotite, feldspar, and quartz. Sillimanite-biotite-cordierite gneiss is also present at sample locality E855, 2 km south of Mathews Knoll, and feldspathic quartz-rich metasediment accompanies the schist 16 km east-southeast of the Knoll.

Ell$_6$. Amphibolite is a widespread although not very abundant rock-type in the Lander Rock beds. It is most common in the central part of the Reynolds Range, where several exposures of amphibolite crop out in the axial zones of antiforms. Amphibolite is also exposed 1.5 km east of Harverson Pass, 3.5 km northeast of Lander Bore, 2.5 km north of Algamba Bore, 7 km west of Nintabrinna Bore, and 5 km northwest of Mount Gardiner. Three of the four antiformal outcrops in the centre of the Reynolds Range parallel the bedding of the Lander Rock beds. The largest mass of amphibolite is 7 km long and up to 200 m wide. The amphibolite is dark green, tough, medium-grained, dense, massive to weakly foliated (but not layered), and consists essentially of hornblende (about 80%), andesine (15%) and opaque and secondary minerals (5%) (72920725A). The amphibolites are metamorphosed igneous rocks, and presumably originated as mafic flows or sills.

Fine-grained amphibolite is exposed at several places in the eastern part of the Mount Peake 1:250 000 Sheet area. Two sills crop out at the northern and southern ends of the Walabanba Hills, and are composed of clinopyroxene, labradorite, biotite, quartz, and ilmenite; the rock is partly retrogressed to actinolite, chlorite, epidote, and sphene (74110344A). A partly brecciated coarse-grained amphibolite plug crops out 15 km northeast of Conical Hill, and is composed of ?actinolite partly altered to biotite, olivine partly altered to iddingsite, orthopyroxene, saussuritised plagioclase, and calcite (74110221). Porphyritic granodiorite crops out on the northeast side of the plug, and contains angular blocks up to 10 cm across of altered amphibolite.

$\underline{B11_7}$. Biotite-feldspar-quartz gneiss is exposed in the northern part of TEA TREE, between Tea Tree and Nancy Hill, and in the eastern part of the Ennugan Mountains. Aeromagnetic data suggest that the unit is of considerable extent below Cainozoic cover in the northern half of TEA TREE, and is so depicted in Fig. 141 (Solid Geology Map). The rock is generally a schistose gneiss, and in the east (sample locality E779) contains porphyroblasts which may be weathered andalusite. In the centre and west of the outcrop area (E780, -1), the gneiss is banded, and intruded by numerous veins of granite, in places cross-cutting, elsewhere in lit-par-lit fashion.

$\underline{B11_8}$. Interlayered biotite gneiss and schist, chlorite schist, and amphibolite crop out in the small area extending from 4 km northwest of Pine Hill homestead in TEA TREE to the western margin of the Sheet area. The biotite gneiss layers contain feldspar augen up to 10 cm long, and are granitic in composition (71921001). The layers commonly contain lenses of amphibolite composed of actinolite, clinozoisite, and fractured labradorite (-1002). Biotite schist also contains feldspar augen, and in thin section (-1004) is found to be a granitic orthoschist. Interlayered with these rocks is soft chlorite schist and quartzofeldspathic schist; a sample of the latter consists of quartz, andesine ($An_{42}$), and epidote (-1003). Fine-grained massive amphibolite forms interlayers in the sequence, and is a metadolerite composed of green-brown hornblende and labradorite (-1006).

$\underline{B11_9}$. Metapelitic <u>granofelses</u> crop out in the southeast of REYNOLDS RANGE, the southwest of TEA TREE, and the northwest of AILERON, along the northeastern side of the Reynolds Range itself. The sequence includes mainly well banded gneiss-granofels rocks comprising mottled coarse-grained biotite-sillimanite-cordierite gneiss bands, grey fine-grained biotite-cordierite-rich bands, and black tourmaline-rich quartzite bands (Fig. 27). Individual bands are approximately 10-50 cm thick. Retrogressed gneisses consisting of a sericite-chlorite-quartz assemblage still retaining gneissic and granofelsic textures are common. Gneisses described in thin-section include biotite-cordierite-sillimanite-quartz gneiss (72921202), and andalusite-biotite-cordierite-perthite-quartz granofels (73922051). Hornblende-granulite facies aluminous spinel-bearing rocks occur near the contact with the Woodforde River beds, showing large-scale crenulation atypical of the more quartzose amphibolite-facies paragneiss. The mineral paragenesis comprises sillimanite, cordierite, biotite, oligoclase, perthite, and quartz. The spinel forms rims around iron oxides. Unstable relics of lower metamorphic grade include biotite (Z=brown), which is replaced by vermicular andalusite, sillimanite, and cordierite. Minor green biotite and chlorite, which display transitional optic characteristics into each other, replace the original brown biotite, indicating weak retrograde metamorphism. The rocks thus display uncompleted prograde and retrograde metamorphic reaction sequences.

The coarse-grained gneisses consist of xenomorphic porphyroblasts of cordierite, which commonly abound in microcrystalline inclusions of well aligned acicular sillimanite, which postdates the cordierite. The sillimanite also forms medium-grained sheaf-like aggregates. Biotite is abundant, and is commonly replaced by cordierite, and also by aggregates of andalusite of a characteristic vermicular texture. Examples are specimens 73921246 and -2047B.

The fine-grained granofels consists of perthite, quartz, cordierite, oligoclase, garnet, and biotite, in a fine-to medium-grained granoblastic texture. Biotite clots are partly replaced by andalusite (-2051). The ratio of quartz to alumino-silicate varies considerably, with some rocks having over two-thirds quartz (-2047B), and others having a higher proportion of feldspar (-2048, -2051).

Quartzofeldspathic schist, cordierite gneiss, and biotite quartzite are interbedded in a ridge 10 km southeast of Aileron. The gneiss is composed of quartz, cordierite, potassium feldspar, biotite, muscovite, sillimanite, and andalusite (7621257).

Retrogressed equivalents of the paragneisses are represented by specimens -2049 and -2050. In the first rock the original alumino-silicates were replaced by microcrystalline clouded aggregates of chlorite, albite and quartz, and the biotite shows strong replacement at its rims by cryptocrystalline material. In the second specimen the original alumino-silicates are completely replaced by muscovite. The original high-grade nature of the rock is still recognizable from their segregated textures, with aggregates of quartz distinct from foliated aggregates of mica, chlorite and microcrystalline quartz and albite. Intercalated basic bands include foliated amphibolite, composed of hornblende, actinolite, albite, quartz and opaques (72921211B) and biotite-bearing quartz-andesine-amphibole rocks (72921211A). Retrogressed granofels or gneiss near faults is also represented by andalusite-quartz schist (-1208A) and muscovite and chlorite-bearing quartzite (-1208B).

A petrologically interesting occurrence of spinel, sapphirine, phlogopite, anthophyllite, cordierite, and hypersthene-bearing rocks was sighted about 1.5 km west of the Woodforde River (72921232, 73921247A, -1247B, -1248). The sapphirine occurs as rims around spinel. The textures of these rocks indicate an early assemblage of cordierite-phlogopite-orthopyroxene-spinel $\pm$ sapphirine, of the upper granulite facies, followed by formation of anthophyllite and gedrite during lower granulite facies conditions. The surrounding gneisses straddle the upper amphibolite-lower granulite boundary.

$\underline{\text{Bll}_{10}}$. Orthoclase-rich granofelses are exposed next to the southern margin of the Yaningidjara Orthogneiss in TEA TREE, and in three areas (GR5552-090070, -150060, and -170030) in the north of AILERON. The rocks are fine to medium-grained, weakly layered, and composed of orthoclase, cordierite, sillimanite, and biotite (72920481, -0482, 73922057). Garnet is also present in the outcrop at GR5353-195039 (73922065). Amphibolite is interlayered with the granofels at GR5353-130055, and consists of hornblende, actinolite, tremolite, anthophyllite and andesine (72921203, -1210A, B). The textural relations between the different amphibole types indicate a pseudomorphous retrograde replacement of pyroxene by tremolite (-1203), prograde replacement of tremolite by blue-green amphibole, and of both latter minerals by green-brown hornblende (-1203). Also apparent are retrograde replacement of hornblende by actinolite, clouding of the hornblende by cryptocrystalline components (-1210A), and replacement of anthophyllite by actinolite (-1210B). Polyphase metamorphism is thus apparent in these rocks.

In the Mount Peake 1:250 000 Sheet area, Lander Rock beds are exposed mainly in the southeastern quadrant of the area; smaller areas of outcrop are located in the northern part and in the southwestern corner. The beds around Central Mountain, in the southeast corner of the Sheet area, consist of biotite schist and gneiss, sillimanite-muscovite-biotite schist, and rare interlayers of amphibolite. The rocks are commonly intruded by veins and pods of pegmatite and granite; rafts of schist in the granite at GR316580 contain abundant tourmaline (74110046). At the top of Central Mountain itself, pods of a green soap-like rock in the sillimanite schist are composed chiefly of sericite, with smaller amounts of corundum, tourmaline, biotite, and muscovite (-0052).

In the Walabanba Hills, north of Central Mountain, the Lander Rock beds consist dominantly of schist composed of biotite, muscovite, and quartz in various proportions (74110089B, -0096, -0098); sericite after andalusite occurs in some samples (-0089, -0100B). Hornfels is interbedded in the schist, and consists of quartz, with smaller amounts of oligoclase, biotite, muscovite, and microcline (-0087, -0089A, C, -0099, -0100A, -0343B, -0344B), and sphene (-0091). Two small outcrops at localities 30616039 and 30686045 are incorrectly shown on the map as granite; they are biotite-oligoclase-quartz hornfels containing angular clasts of hornfelsed siltstone (Fig. 28).

In the Mount Peake-Conical Hill-Mount Rennie area, north of the Walabanba Hills, the Lander Rock beds consist of interbedded two-mica schist (74110222), feldspathic hornfelses (-0212, -0227), and smaller amounts of feldspathic metasandstone (-0225), metasiltstone, and

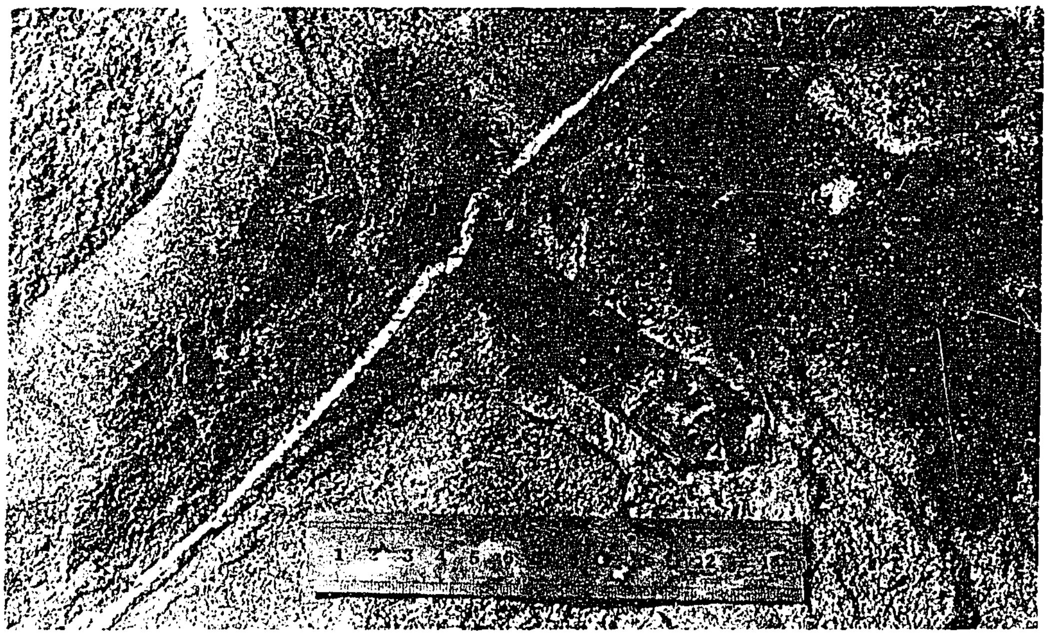
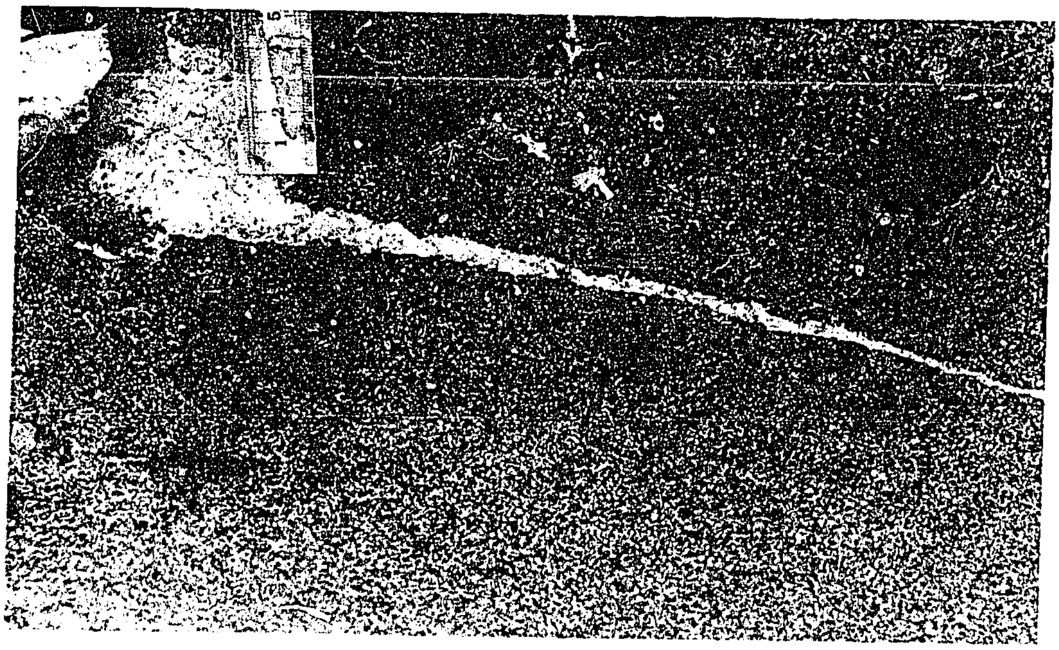


Fig. 28: (a, above; b, below): biotite-oligoclase-quartz hornfels of Lander Rock beds containing clasts of hornfelsed metasiltstone, 2 km southeast of Mount Peake Dam, Mount Peake 1:250 000 Sheet area. Mistakenly mapped as granite containing xenoliths (GR30616039).

Neg. M/1724/21



Neg. M/1724/23.

phyllite (-0235). Amphibolite pods crop out in a few places (GR30036285, 30086190), and the metasediments are commonly veined by granite, pegmatite, and quartz.

In the northeast of the Mount Peake 1:250 000 Sheet area, exposures are small and isolated, and consist mostly of micaceous hornfels containing sillimanite and andalusite (74110179, -0189). At Fotheringham Hill, pebbly metasandstone (-0172) containing andalusite, quartzite, and two-mica schist crop out. In the northwest of the Sheet area, the Lander Rock beds 1.5 km northeast of the Wanabanda Hills consist of muscovite schist and folded interbeds of quartzite; fine-grained masses of tourmaline rock are also present.

In the Mount Solitaire 1:250 000 Sheet area, exposures in the central part of the area are strongly weathered and silicified. Biotite-quartz-albite-microcline gneiss (75110403) crops out at GR71457630, and biotite-quartz-plagioclase gneiss (75110469) at GR77177218.

In the Lander River 1:250 000 Sheet area, hornfels containing cordierite, sillimanite, andalusite, and garnet is exposed at GR238710 and 258705; the hornfelses adjoin dolerite, metadolerite, and granite.

In the Mount Theo 1:250 000 Sheet area, Lander Rock beds are exposed in the southern part of the area, and at Sowden Hill, near the centre. The rocks are chiefly biotite-muscovite schist (72110311A), and smaller amounts of tourmaline-muscovite schist (-0316C) and feldspathic metasandstone (-0312B). Cordierite hornfels (-0328) is exposed at Chilla Well airstrip, and oligoclase hornfels (-0324B) and andalusite schist at Gida Gida Hill, in the southeast of the area.

Metamorphic facies in the Lander Rock beds ranges from lowermost greenschist to high amphibolite - low granulite. The lowest-grade rocks are located in the centre of REYNOLDS RANGE, and pelitic rock-types are typified by slate and phyllite containing sericite, and rare biotite and andalusite. Towards the southeast, into TEA TREE and AILERON, the rocks become coarser-grained schist, gneiss, or granofels, and successive pelitic mineral assemblages are characterised by muscovite-biotite-andalusite, muscovite-biotite-sillimanite, and orthoclase-biotite-sillimanite-cordierite-garnet. Away from this area, metamorphic grade is generally greenschist, as in Mount T' ɜo and the central part of Mount Peake, rising to mid-amphibolite in the southeast of Mount Peake.

In contrast to the pelitic rocks, the basic rocks, being an originally high-temperature igneous mineral assemblage, show various degrees of retrogression. In the central part of Mount Peake, the basic rocks are characterised by actinolite-chlorite-epidote; elsewhere, they are generally at mid-amphibolite facies (hornblende-andesine). Superimposed on these early metamorphic assemblages, in both the pelitic and basic rocks, are a later set of patchy retrogressive effects, such as sericite after andalusite, chlorite after sillimanite, and actinolite, chlorite, and albite in hornblende amphibolite. These effects are particularly evident in the Reynolds Range itself.

The composition, monotonous uniformity, and wide extent of the Lander Rock beds indicate that they originated as a flood of terrigenous detritus derived by erosion of a largely granitic terrain. Deposition was interrupted at times by irruption of basaltic flows or sills. In general, the absence of conglomerate and recognisable graded bedding militates against the beds being a turbidite sequence; rather, they appear to be the filling of an ensialic geosyncline.

Samples of metasandstone and schist (73921024) from GR5453-667424 in the Reynolds Range gave an imprecise Rb-Sr whole-rock date of about 1400 Ma. Isotopic Rb-Sr dates on the Anmatjira Orthogneiss, which intrudes the Lander Rock beds, are 1600 ± 100 Ma. Hence, the Lander Rock beds are Middle Proterozoic or older. They are lithologically correlated with the Delny Gneiss (biotite-muscovite gneiss and schist, meta-psammite, meta-pelite, and amphibolite) of the Alcoota 1:250 000 Sheet area to the east (Shaw & Warren, 1975), and with the Mount Charles beds (greywacke, siltstone, quartzite, chert, and basic volcanics) of The Granites and Tanami 1:250 000 Sheet areas to the northwest (Blake, Hodgson, & Muhling, 1973; in press). All these formations are unconformably overlain by quartzite, and are intruded by granites of Early to Middle Proterozoic age.

Mount Freeling schist (Ef) (A.Y.G. and A.J.S.)

The Mount Freeling schist is the unit of muscovite-biotite schist and small amounts of quartzite, quartzofeldspathic schist, cordierite granulite, cordierite gneiss, quartz-rich metasediment and sillimanite schist that crops out in the northern part of AILERON. The main outcrop area extends roughly east and west of Anna's Reservoir for 20 km; a smaller outcrop is located immediately south of Bluebush Swamp. The unit forms rugged hills and gullies, and is named after Mount Freeling, which is composed of typical schist of the unit, and, with a relief of about 330 m, is the highest peak in the Sheet area. Along its southern margin, the unit lies above the Wickstead Creek beds with apparent conformity. At GR5552-100041, the unit adjoins schist of the Lander Rock beds, and there appears to be a gradual transition from one unit to the other. The schist is intruded by numerous small granite bodies, and by the Napperby Gneiss at the eastern and western ends of the main outcrop area.

The reference area for the Mount Freeling schist is located at GR5552-086020, 1 km north of Anna's Reservoir; here interbedded schist, quartz-rich metasediment, sillimanite schist and gneiss, and quartzite are well exposed on the sides of the gully cut by the stream that flows south into the Reservoir.

In outcrop, the Mount Freeling schist is characterised by partial to complete obliteration of primary bedding and other original depositional features. The rocks range from massive granofels and gneiss, through partly retrogressed schist to strongly schistose retrogressed derivatives. Quartzite beds are intercalated with these rocks. A thick lens of well bedded quartzite interbedded with sillimanite schist occurs about 3 km northeast of Anna's Reservoir.

Amphibolite-facies assemblages include poikiloblastic sillimanite-quartz-biotite-microcline gneiss (72921219), sillimanite-cordierite-quartz gneiss (73922017A), biotite-cordierite-quartz gneiss (-2017B), and garnet-biotite-sericite-quartz schist (-2023). Retrogressed and partly retrogressed derivatives of these rocks abound in poorly foliated, randomly oriented microcrystalline sericite and chlorite, replacing sillimanite, feldspar, garnet and other unidentified minerals (-2008A, B, -2022B, -2023). Tourmaline is a common accessory in retrogressed rocks, possibly signifying hydrothermal activity. Prograde biotite is commonly retained in the retrogressed rocks, however, it is extensively altered and clouded by iron oxides (-2008A). Sillimanite may be partly retained as clouded armoured relics in unfoliated to strongly foliated microcrystalline aggregates of sericite and chlorite (-2008), or as needle-like inclusions in quartz (-2022B). Other rock types include fine-grained quartzitic rocks (-2018), cataclastic biotite quartzite (-2005), biotite-quartz metasiltstone (-2009), and biotite-perthite-quartz metasiltstone (-2016B).

Cordierite granulite crops out in the hills 2 km northwest of Rabbit Well, and consists of sillimanite, biotite, cordierite, plagioclase, quartz, and accessory epidote, perthitic orthoclase, and allanite. Garnet-bearing schist (68660108) and quartzite are interbedded with the granulite. These high-grade rocks are bounded to the north by a zone of metamorphically retrogressed rock, and this is followed to the north by two-mica schist with kyanite-quartz veins and andalusite-biotite schist (-2012, -2014).

The prograde assemblages in the Mount Freeling schist typically comprise sillimanite, cordierite, biotite, garnet, microcline or orthoclase, and in some samples, andalusite. Hence, the rocks were progressively metamorphosed under conditions of the upper amphibolite facies. Retrogressive metamorphism is widespread, and is manifested by the replacement of sillimanite and feldspar by microcrystalline aggregates of sericite and chlorite, indicative of greenschist facies conditions. Before metamorphism, the parent rocks of the Mount Freeling schist were probably an interbedded assemblage of shale and sandstone.

The Mount Freeling schist has not been dated; its conformable relationship above the Wickstead Creek beds, and its transition into the Lander Rock beds, suggests that the schist is of about the same age as the Lander Rock beds, namely Middle Proterozoic or older.

Mount Dunkin schist (Ed)

The Mount Dunkin schist consists of sillimanite schist and gneiss, and small amounts of biotite schist, quartzite, and calc-silicate rock, and crops out in the northwest of AILERON, immediately south of the Woodforde River. The unit forms rough hilly country, and is named after

Mount Dunkin (GR5552-010070), a sharp peak with a relief of 250 m, in the southwestern part of the outcrop area. Mount Dunkin is also the reference area for the unit. The unit lies conformably above calc-silicate rock of the Wickstead Creek beds, and is faulted against the Lander Rock beds and Woodforde River beds. It also adjoins and is probably intruded by two elongate bodies of granite, and is intruded by the Napperby Gneiss.

The major rock-type of the unit is sillimanite schist, which is grey, soft, weakly and irregularly foliated, and in places spotted or 'knotty'. With increase in grainsize and incoming of feldspar, the rock becomes sillimanite gneiss. The schist usually consists of quartz, sillimanite, biotite, opaque grains, and andalusite (71921088). The gneiss is similar, but also contains microcline and green spinel (-1085). A minor variant of the gneiss contains abundant cordierite, biotite, sillimanite, andalusite, and a small amount of quartz, but no feldspar (73922028). The andalusite in some specimens is partly replaced by sericite, forming the spots or 'knots'.

Dark biotite schist and feldspathic biotite schist are subsidiary rock-types in the Mount Dunkin schist; impure fine-grained black quartzite containing microcline and biotite is also present. Greenish to white quartzite and calc-silicate rock are less common rock-types; the calc-silicate rock consists of quartz, clinozoisite, microcline, and actinolite (71921090); chondrodite-forsterite-calcite marble is also present (-1087) at one locality near Mount Dunkin. The assemblages in all these rock-types indicate that metamorphism took place under conditions of the upper amphibolite facies. Before metamorphism, the unit was probably a sequence of shale, impure sandstone, and dolomite.

No isotopic dates have been determined on the Mount Dunkin schist. Its conformable relationship with the Wickstead Creek beds indicates that it is of the same general age, i.e. Middle Proterozoic. It is intruded by, and therefore older than the Napperby Gneiss, which is dated at 1600-1500 Ma. It is correlated with the Lander Rock beds, and is probably a shaly facies of them.

Mount Stafford beds (Bls) (L.A.O.)

The Mount Stafford beds are the discrete and distinctive rock unit consisting of thin to medium to thick-layered fine-grained grey-green to black, quartz-biotite-andalusite-microcline-cordierite hornfels, and even-grained and porphyroblastic cordierite-rich hornfels which crops out in the northwest of REYNOLDS Range, the southwest of MOUNT PEAKE, and the northwest of DENISON. The reference section is situated 1.5 km east of Tin Bore (GR5453-499621). The name is derived from Mount Stafford, the highest point in the Yundurbulu Range, which has been named from the aboriginal for 'black stones'. In the Yundurbula Range the beds form steep high hills in the northeast passing into low rounded rubbly hills to the southwest.

No basement to the Mount Stafford beds is known in the area, and no formations are known to overlie it. In DENISON, the unit surrounds pods of sillimanite gneiss of the Lander Rock beds. It is intruded by granite, and by dolerite dykes and sills. East of Mount Stafford, porphyritic rapakivi granite of the Anmatjira Orthogneiss, and unnamed even-grained granite intrude the beds along a contact zone which is grossly conformable to the layering of the hornfels. Rapakivi granite of the Anmatjira Orthogneiss also crops out along the northern margin of the Yundurbulu Range, and here the contact zone is about 1 km wide and consists of blocks of dark, fine-grained hornfels in a granite matrix (Fig. 29). A late tourmaline-bearing granite variant of the Anmatjira Orthogneiss intrudes the rapakivi granite, and forms dykes and possibly also fault fillings in the hornfels.

The thickest estimated section of hornfels is located 1 km north-northwest of Tin Bore, and is about 1300 m thick.

The Mount Stafford beds lack significant marker beds, and sedimentary structures (bedding and cross-bedding) have been observed only in one meta-quartzite layer. At least two main rock-types can be distinguished.

1) Spotted and even-grained hornfelses.

In outcrop the spotted hornfels is characterised by rectangular pits, up to 10 mm across, formed by weathering of altered cordierite (Fig. 30). Leucocratic varieties are speckled with green spots (about

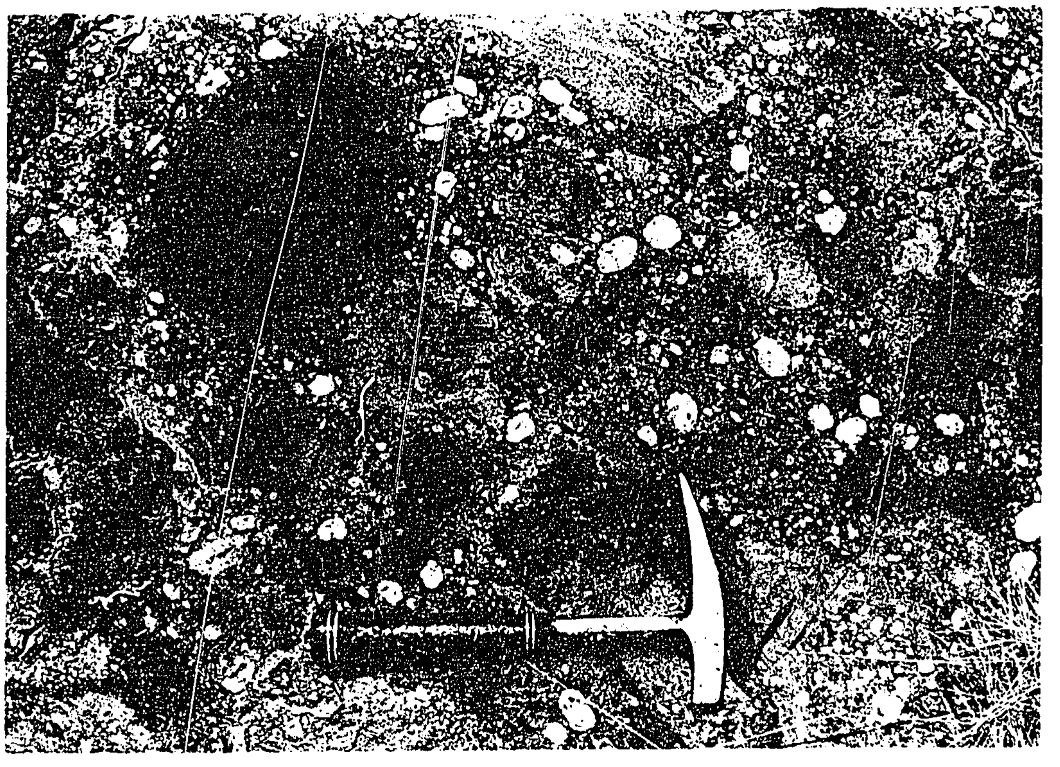


Fig. 29: Blocks of hornfels of Mount Stafford beds in granite of Anmatjira Orthogneiss, GR5454-531688, Yundurbulu Range. Neg. M/1662.

Fig. 30: Spotted hornfels, Mount Stafford beds, GR5353-995565, 6.5 km north of Mount Denison homestead. Neg. M/1774/64

2 mm diameter) of chlorite and sericite (after cordierite) in a white matrix of muscovite, quartz, and feldspar. The even-grained hornfels is generally very fine-grained and dark green, and consists of cordierite (50–70%), commonly as round, multiply and sector twinned, poikiloblastic grains, reddish-brown biotite (up to 20%) with zircon inclusions, and anhedral andalusite (up to 20%) associated with the biotite. Quartz is present in almost every specimen, but ranges markedly from near zero to nearly 100 percent of the rock. Plagioclase and microcline are minor constituents (up to 10%); rounded tourmaline grains are accessory. The cordierite is partly to completely replaced by chlorite and sericite. In the northeastern part of the area some of the hornfelses contain less cordierite and more microcline (up to 30%), plus small amounts of sillimanite, garnet, and green spinel, indicating a higher metamorphic grade.

2) Layered hornfels

The layered hornfels is strongly indurated, and consists characteristically of fine-grained, foliated, dark grey-green to black layers alternating with fine to medium-grained spotted cream-coloured layers (Fig. 31). The dark layers consist of cordierite and quartz (together making up 80 to 85% of the layer), biotite (up to 15%) as small blades aligned parallel to the layering and containing accessory zircon, andalusite (associated with the biotite), muscovite (up to 5%) and minor opaques. The light-coloured layers consist of cordierite and microcline (together making up 55 to 80%), biotite (up to 15%) with zircon inclusions, plagioclase (up to 20%), andalusite (associated with the biotite and up to 15%), quartz (up to 5%), chlorite (from the alteration of biotite), muscovite, rounded tourmaline, and opaques. In sample 72920745, 2.5 km east-northeast of Mount Stafford, hypersthene is present in the dark fine-grained layers and green spinel is present in both dark and light-coloured layers. The cordierite is commonly poikiloblastic and sector twinned, and is everywhere partly altered to pinite.

In DENISON, hornfels of the Mount Stafford beds crops out in the northwest. Most exposures show the prominent layering characteristic of the unit, comprising pale spotted layers rich in cordierite, and dark layers containing widely varying amounts of quartz and cordierite. Typical assemblages in the pale spotted layers include:

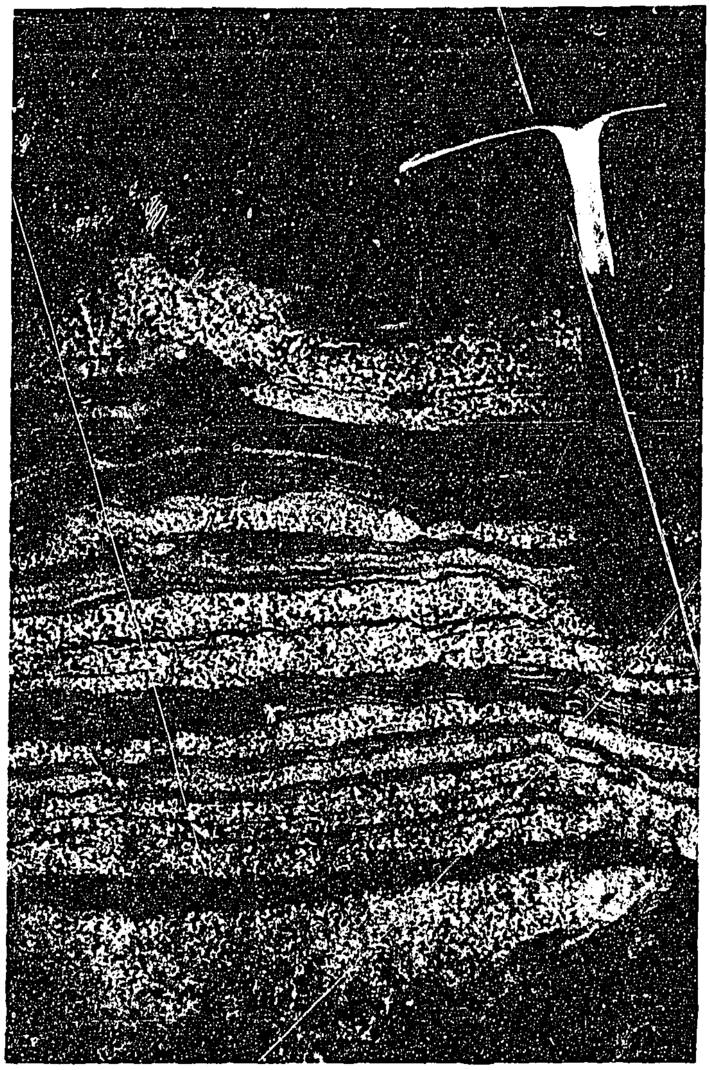


Fig. 31: Layered hornfels of Mount Stafford beds, Yundurbulu Range, GR5454-485683, 9 km southwest of Leichhardt Bore Neg. GA/5336.

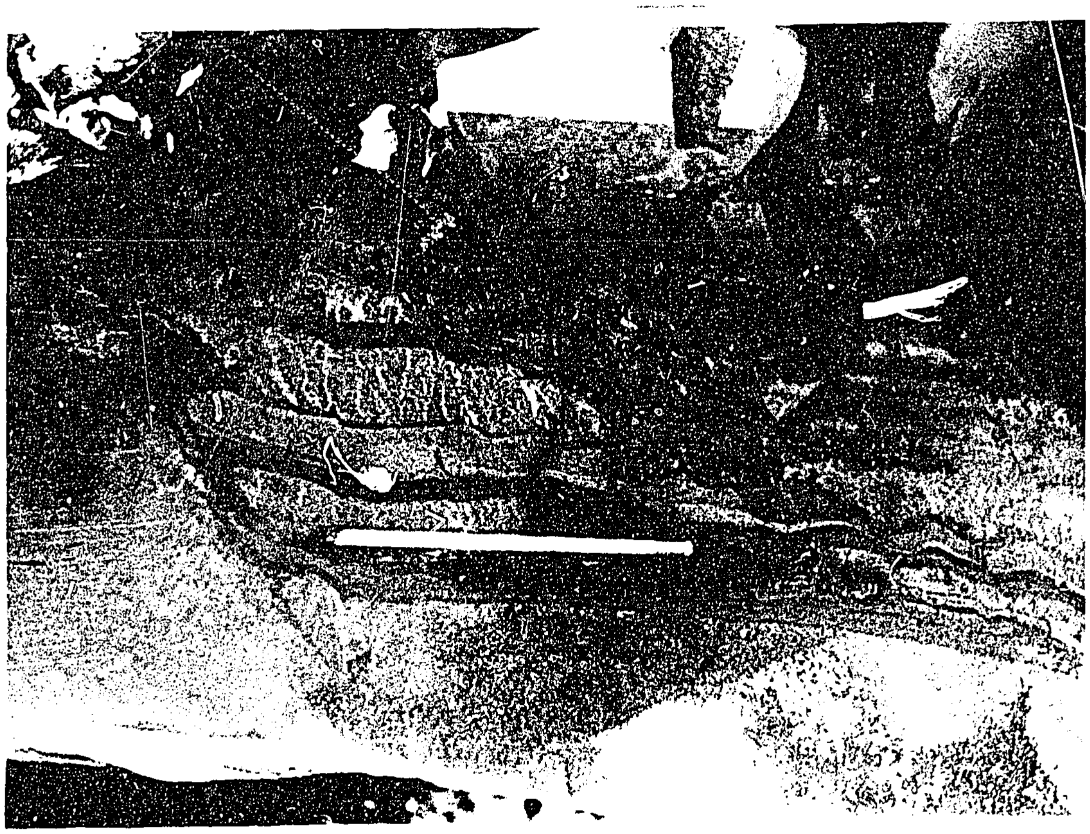


Fig. 32: Boudinaged and faulted layered hornfels, Mount Stafford beds. Pencil is 15 cm long. GR5454-465700, 9 km southwest of Leichhardt Bore. Neg. M/1662

Biotite-sillimanite-garnet-microcline-cordierite hornfels (74920696)
Biotite-sillimanite-magnetite-microcline-cordierite hornfels (-0699)
Spinel-biotite-garnet-magnetite-hypersthene-microcline-quartz-cordierite hornfels (-0700).

The dark layers include:

Sillimanite-biotite-quartz-microcline hornfels (-0696)
Garnet-spinel-magnetite-microcline-cordierite hornfels (-0699).

In the southwest of the outcrop area, about 5 km northwest of Mount Denison homestead, andalusite hornfels (-0694) and sillimanite hornfels (-0695C) are the major rock-types; the sillimanite hornfels is in places retrogressively metamorphosed to sericite-rich rocks (-0695B), and this has largely obliterated the normal prominent layering. Retrogressively metamorphosed non-layered hornfels is also commonly interlayered with unaltered layered hornfels in the northeast of the outcrop area, 4 km southwest of Matthews Knoll. Each interlayer is a few metres thick. The retrograded rocks are characteristically greenish-brown sericite-quartz schist (-0698B, -0852), sericite schist, and sericitic metasandstone (-0697B). The sericite has replaced cordierite, hypersthene, and microcline (-0700B), but generally other constituents, such as spinel, biotite, garnet, and magnetite, survive the retrogression.

Mafic rock is a rare component of the Mount Stafford beds in DENISON. Amphibolite is exposed at GK5355-996594, 4.5 km southwest of Matthews Knoll, and is associated with retrogressively metamorphosed hornfels. The amphibolite consists mainly of tremolite and actinolite (together 75%), labradorite ($An_{68}$; 15%), clinozoisite (5%), cummingtonite (2%), biotite (2%), opaque grains (1%), and trace amounts of hornblende and quartz (-0697A).

The major structure in the Mount Stafford beds in REYNOLDS RANGE is a set of northwest-trending folds which are prominent in the southwestern part of the area, but die out to the northeast where the beds maintain a gentle northward dip towards the rapakivi granite of the Anmatjira Orthogneiss. In the east, a steeply north-plunging antiform is faulted along its western limb. Faults are numerous, and generally trend northwest in the folded areas; in the gently dipping area to the north, the faults strike in various directions, and are filled with quartz or granite. In places, the layered hornfelses are kinked, faulted, or boudinaged on the mesoscopic scale (Fig. 32).

The Mount Stafford beds were deposited in a deep marine environment as sandy silts and clays which after induration were intruded by mafic igneous rocks. The sediments were later altered and recrystallised during intrusion of the Anmatjira Orthogneiss to the northeast, the degree of alteration decreasing southward with distance from the granite. Hypersthene, spinel, and sillimanite in the altered sediments, and pyroxene in the mafic igneous rocks enclosing feldspar and hornblende, indicate that conditions of the pyroxene hornfels facies were attained in the northern part of the area, adjacent to the granite. Regional retrogression to greenschist facies overprints the contact metamorphic aureole.

Although it is not common for granite bodies to thermally metamorphose sediments as far as pyroxene hornfels, several examples are well documented from other parts of the world (e.g. Oslo Region, Norway, and Comrie Aureole, Scotland) and as the metamorphic aureole adjoins the rapakivi granite to the north, and as the grade of the thermal metamorphism rises towards the granite, we conclude that the pyroxene hornfels aureole formed in response to the heat given out during the cooling of the rapakivi granite. Because of the concentration of folds to the southwest of the Yundurbulu Range, and the increase in metamorphic grade and induration of the sediments to the northeast, the granite may be present at a shallow depth below the present hornfels outcrop as far south as the northwest-trending folds; in other words the folds are marginal to the granite body and the flat-lying hornfels may be remnants of the roof rocks above the granite, now altered, recrystallised, distended and faulted. Boudins observed in some of the layered hornfels (Fig. 32) are consistent with doming and distension applied to the sediments from the underlying granite during intrusion.

An imprecise Rb-Sr isotopic date of 1600 ± 100 Ma has been recorded from the Anmatjira Orthogneiss, which intrudes the Mount Stafford beds. Thus the beds are Middle Proterozoic or older.

Unnamed sandstone (Ɛs) (L.A.O).

Unnamed sandstone (Ɛs) crops out at Mount Bennet, a low isolated ridge in the south of the Mount Solitaire Sheet area. It is extensively quartz-veined, light brown, and consists of rounded quartz grains up to 1 mm across in a fine-grained quartz matrix (75110480). Pale bluish-green turquoise, identified by X-ray diffraction (G.W.R. Barnes, BMR, pers. comm. 1975), coats some broken quartz surfaces. Because of its isolated position, no relation between the unnamed sandstone and other units is known. It may be equivalent to the Proterozoic Mount Thomas Quartzite which unconformably overlies the Lander Rock beds to the southeast, or it may be equivalent to part of the early Proterozoic or Carpentarian sequence which unconformably overlies the Mount Charles beds to the west, in The Granites and Tanami Sheet areas.

REYNOLDS RANGE GROUP (Ɛr) (A.J.S.)

The Reynolds Range Group is the conformable sequence of metamorphosed quartzite, shale, and dolomite which crops out along the entire length of the Reynolds Range, in the northern part of the Napperby 1:250 000 Sheet area. The Group comprises the Mount Thomas Quartzite, the overlying Pine Hill Formation, the Algamba Dolomite Member of the Pine Hill Formation, and the Woodforde River beds.

Mount Thomas Quartzite (Ɛrt) (A.J.S.)

The Mount Thomas Quartzite is the unit of quartzite, shale, arkose, and conglomerate which crops out in the Reynolds and Giles Ranges in AILERON, TEA TREE, REYNOLDS RANGE, DENISON, and in the Mount Peake 1:250 000 Sheet area. The unit also crops out in the Wabudali Range, on the boundary of the Mount Theo and Mount Doreen 1:250 000 Sheet areas. The name is derived from Mount Thomas (GR5453-733332) which is composed of Mount Thomas Quartzite, and forms the highest peak in the Reynolds Range, with a relief of about 400 m. The Quartzite forms steep-sided resistant ridges and hills. The unit is everywhere regionally metamorphosed; the least metamorphosed rocks are at low greenschist facies in the Giles Range and northwestern parts of the Reynolds Range, and grade rises southeastwards from there and reaches granulite facies in AILERON.

The Mount Thomas Quartzite overlies the Lander Rock beds with an angular unconformity, which is well exposed at numerous places along the northeastern flank of the Reynolds Range (Fig. 33). The Quartzite is conformably overlain by the Pine Hill Formation. In the southeast of REYNOLDS RANGE, the Quartzite splits into two tongues separated by muscovite schist and pelitic granofels of the Pine Hill Formation. The Quartzite is intruded by sills of retrogressively metamorphosed microgranite, the Coniston and Warimbi Schists. In the Mount Thomas area, the Schists contain numerous rafts of the Quartzite (Fig. 34); Mount Thomas itself is a large quartzite block almost completely surrounded by microgranite. Ten kilometres southeast of Harverson Pass, the porphyritic microgranite border phase of the Mount Airy Orthogneiss has intruded concordantly along the northern margin of the Mount Thomas Quartzite, removing the Lander Rock beds from below the unconformity, but not transecting the Quartzite itself. In the southeastern corner of REYNOLDS RANGE, the Napperby Gneiss intrudes the Mount Thomas Quartzite; the Quartzite forms resistant masses which project into the Gneiss. There is no measured section of the Mount Thomas Quartzite. The type section (AX-1; base at GR5453-777516, top at -763309; Fig. 35) is located 4 km southeast of Mount Thomas.

<u>Brt</u>$_1$. In the northwestern part of the Reynolds Range (Fig. 35), and in the Giles Range, the Mount Thomas Quartzite is about 235 m thick, and consists largely of <u>orthoquartzite</u>, white, cross-laminated, and fine-grained. Up to 10 m of pebbly <u>arkose</u> and cobble <u>conglomerate</u> are present at the base of the unit, and comprise clasts up to 25 cm across of coarse-grained white quartzite, shale, and rare fine-grained greenish-blue quartzite in a coarse-grained poorly sorted matrix of arkose or feldspathic sandstone (Fig. 36). Over much of its extent on the southern flank of this part of the Reynolds Range, the arkose and conglomerate are separated from the upper part of the Mount Thomas Quartzite by orthoschist of the Coniston Schist. Hematite is abundant in the upper part of the unit, and is uniformly disseminated through thick beds of medium to coarse-grained quartzite, to which it imparts a distinctive blue-grey colour; the hematite quartzite is not a laminated banded iron formation. Lutite beds are absent from the unit.

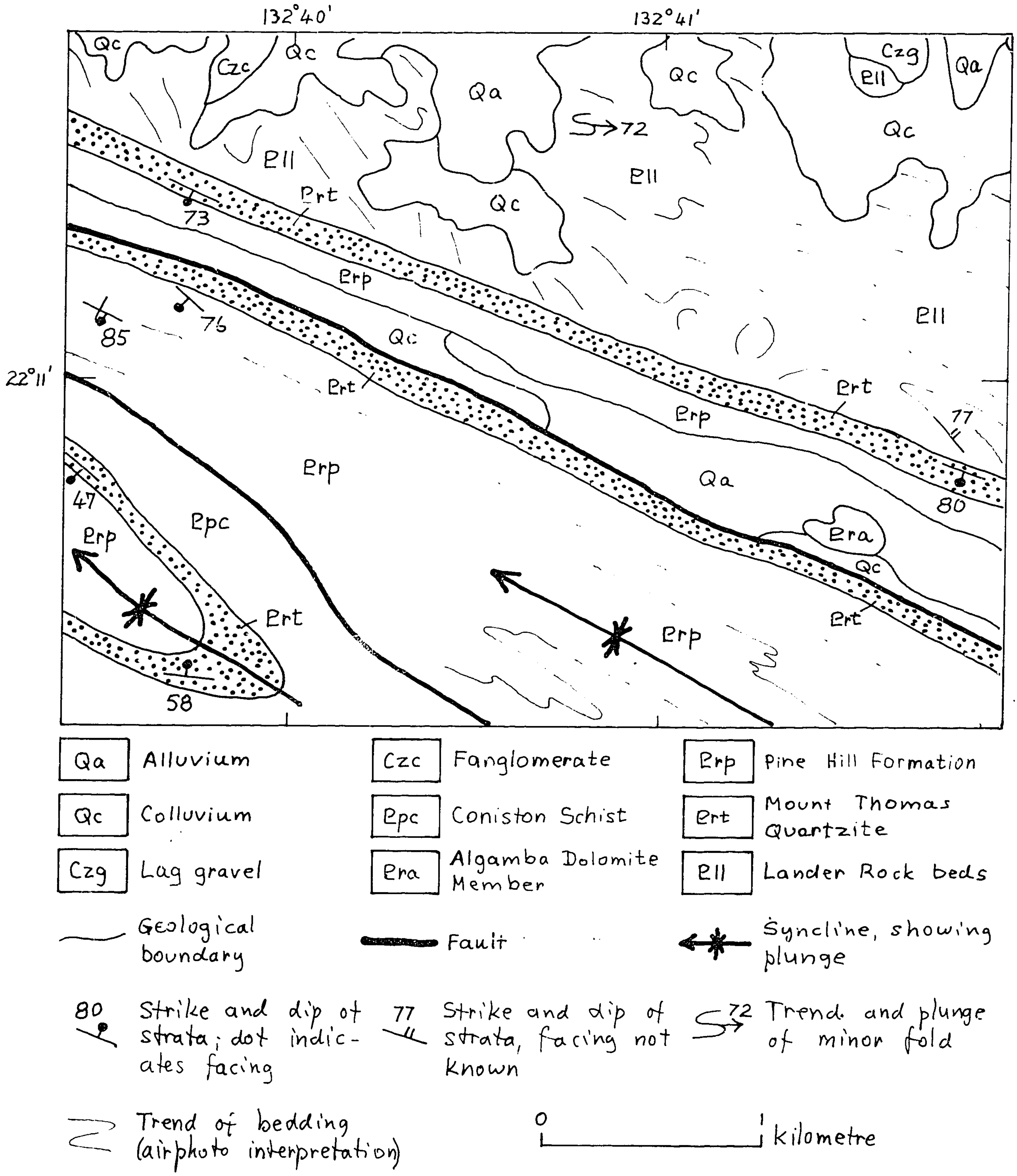



Fig. 33 : Geological map at photo-scale (ca 1:25 000) of northeastern flank of Reynolds Range, 3 km east of Mount Gardiner, showing unconformity between Lander Rock beds (Ell) and Mount Thomas Quartzite (Ert).

Fig. 34: Rafts of Mount Thomas Quartzite surrounded by orthoschist of Warimbi Schist, northern slope of Mount Thomas. GR5453-732338.

Neg. M/1248

$\underline{Brt_2}$. At the type-section in the central part of the Reynolds Range (Fig. 35), the Mount Thomas Quartzite consists mostly of pinkish-brown thin-bedded sandstone, which is weakly schistose, cross-laminated (Fig. 37) and contains a small amount of detrital muscovite. The unit contains two interbeds of siltstone and shale which are commonly balled up (Fig. 38), weakly cleaved, and contain blue-grey porphyroblasts of andalusite (71920408-9). In places the cleavage is stronger and the rocks are typical slates (Fig. 39). The total thickness at the type-section, estimated from airphoto measurement and dip information, and excluding the microgranite sills, is 850 m. Away from the type section, at Mount Thomas itself and in the area immediately southwest from there, most of the unit consists of white fine-grained orthoquartzite with prominent blue laminae of tourmaline (72920449). In some places, particularly but not exclusively in the axial zones of folds, the quartzite beds show a rough splintery cleavage oblique to bedding (Fig. 40). The cleaved quartzite (-0449) consists of small elongate grains with a moderate preferred dimensional orientation and a strong preferred lattice orientation (indicated by the gypsum plate), plus accessory muscovite, tourmaline, and zircon. A distinctive green thick-bedded quartzite is commonly present in the middle of the unit; the colour arises from pale green chlorite, which constitutes about 10 percent of the rock (71920440). Conglomerate is present at the base of the green quartzite bed at localities GR5453-735336, and -733278, and more conglomerate, near the top of the Mount Thomas Quartzite, is present 4.5 km west of Harverson Pass, at GR5453-713310 (Fig. 41) and -728316.

$\underline{Brt_3}$. In the southeastern part of REYNOLDS RANGE, the Mount Thomas Quartzite is about 550 m thick (Fig. 35), and consists of the same rock-types as at the type-section, viz., pinkish-brown metaquartzite which is generally coarse-grained, cross-bedded, ripple-marked, and displays soft-sediment structures such as slumping. The two lutite beds are thicker in this area, and are composed of fine to coarse-grained muscovite schist with quartz lenses up to 10 cm long.

$\underline{Brt_4}$. In TEA TREE and AILERON, the Mount Thomas Quartzite is strongly metamorphosed to blue or brown very coarse-grained metaquartzite containing small amounts of biotite and rutile (72920651). Bedding is almost totally obliterated, and in places the quartzite is strongly rodded (Fig.42).

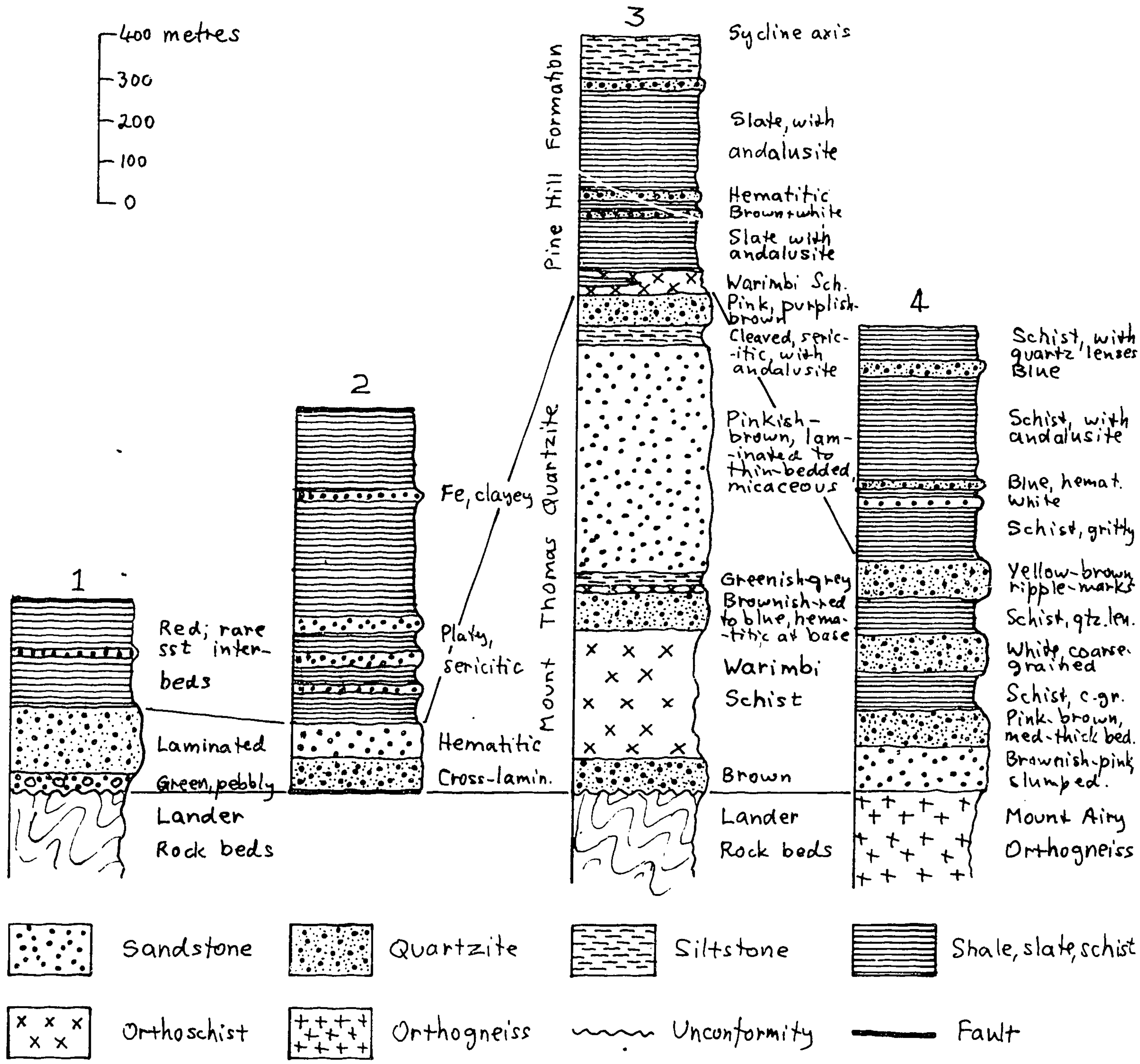



Fig. 35 : Diagrammatic columnar sections through Mount Thomas Quartzite, and Pine Hill Formation, Reynolds Range, N.T. Thicknesses estimates only.
Column 1: 3 km east of Mount Gardiner; base at GR5453-590460
Column 2: Crops out immediately above column 1 because of faulting; base at GR5453-588456
Column 3: Type sections of Mount Thomas Quartzite, Pine Hill Formation, and Warimbi Schist, 4 km east of Mount Thomas; base at GR5453-775316
Column 4: 12 km southeast of Harverson Pass; base at GR5453-860213

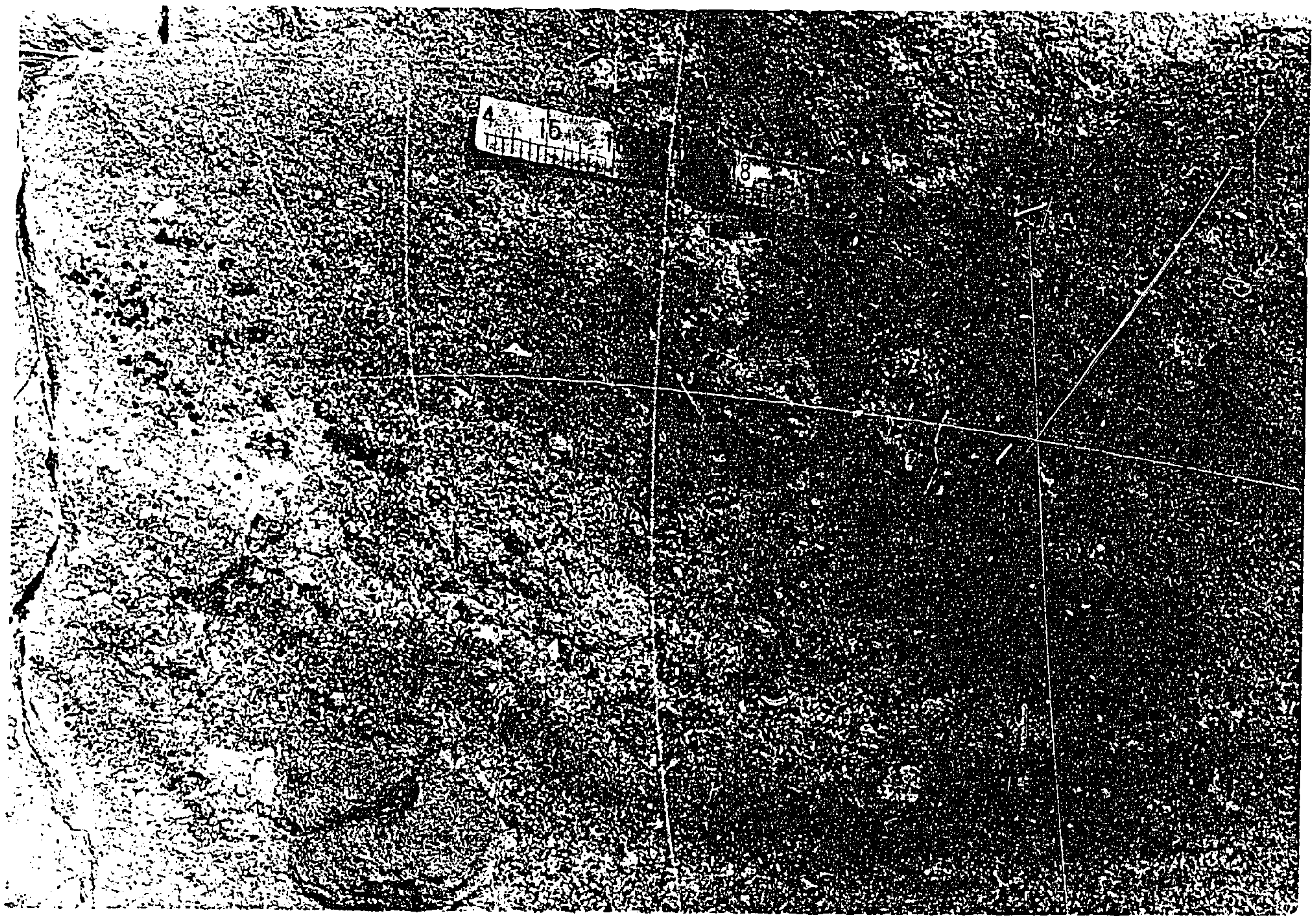


Fig. 36: Basal pebbly arkose of Mount Thomas Quartzite GR5453-678447, 6 km east-southeast of Mount Gardner.

Neg. M/1342/12

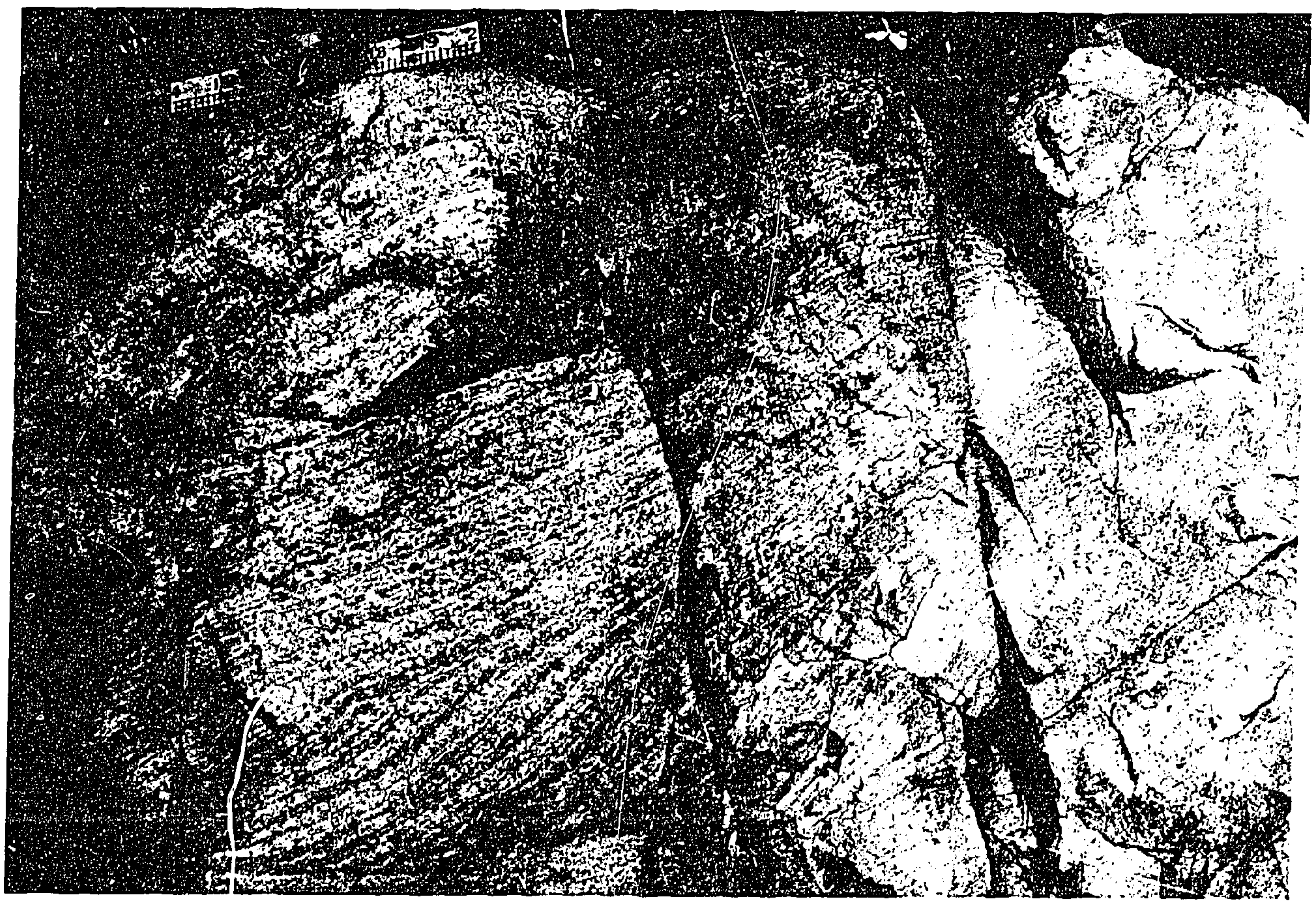


Fig. 37: Mount Thomas Quartzite, showing cross-lamination; in type-section, between main (350 m) sill and 6 m sill of Warimbi Schist. GR5453-769315, 4 km east of Mount Thomas.

Neg. M/1246/2

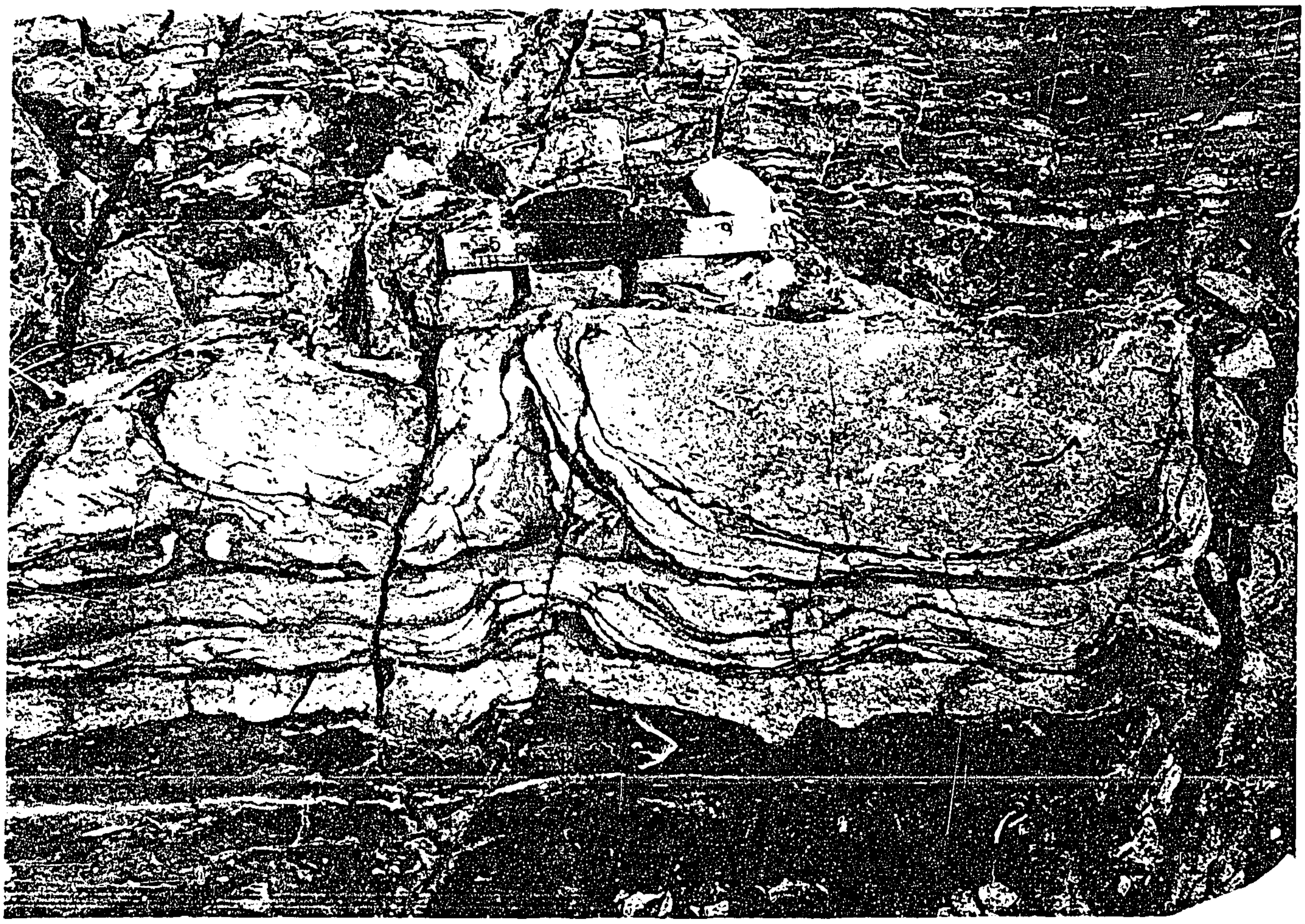


Fig. 38: Balled-up fine sandstone in siltstone of Mount Thomas Quartzite. GR5453-755340, 2 km east-northeast of Mount Thomas. Scale 15 cm long Neg. M/1243/2.

Fig. 39: Slate in Mount Thomas Quartzite, showing bedding (vertical), cleavage (diagonal - top left to bottom right), and andalusite porphyroblasts (small white rectangular spots). GR5453-764313, 4 km southeast of Mount Thomas, in type section. Scale 15 cm. Neg. M/1247/7.

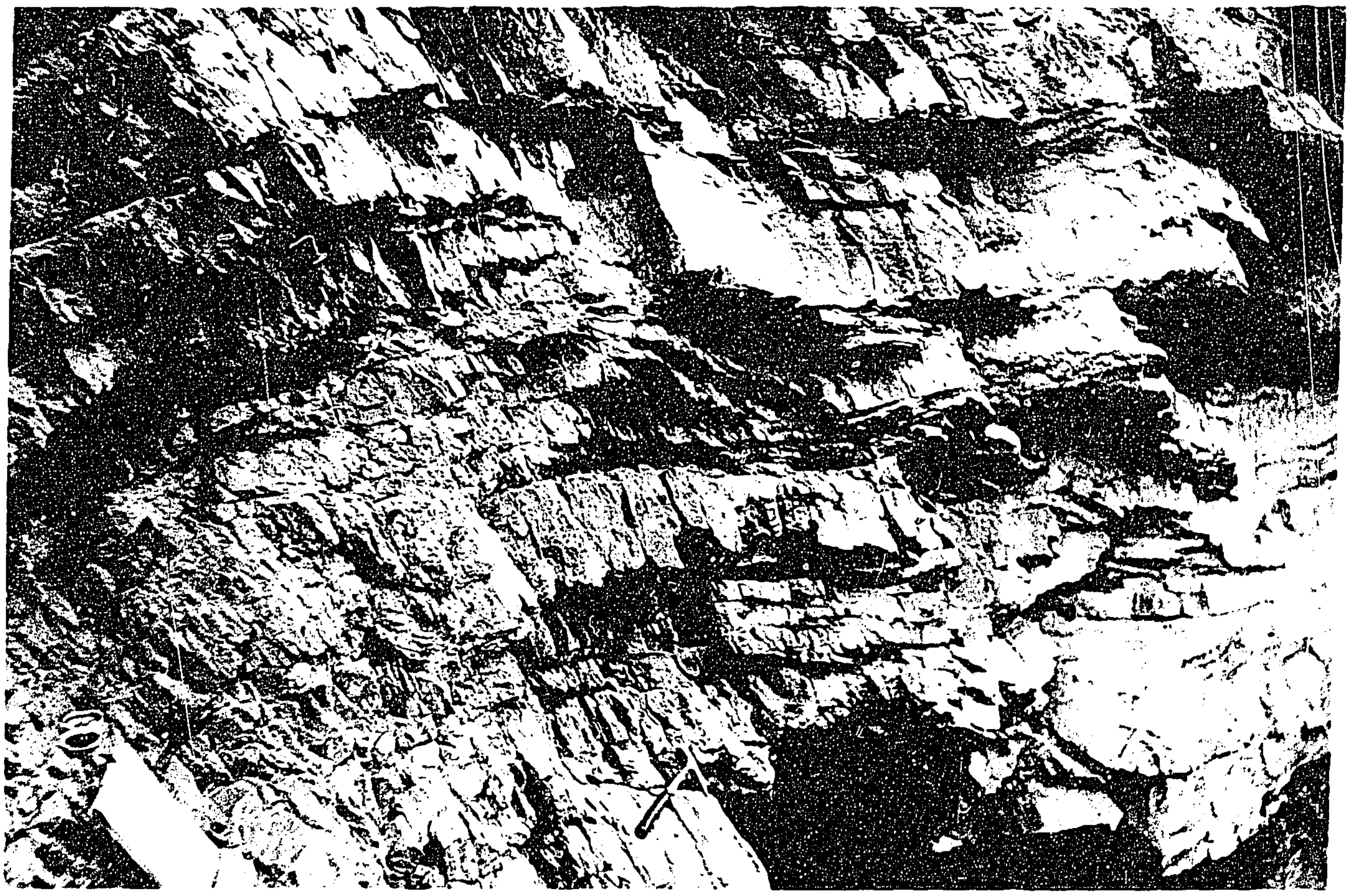


Fig. 40: Fracture cleavage in Mount Thomas Quartzite, GR5453-892182, 16.5 km southeast of Harverson Pass.
Neg. M/1414/6.

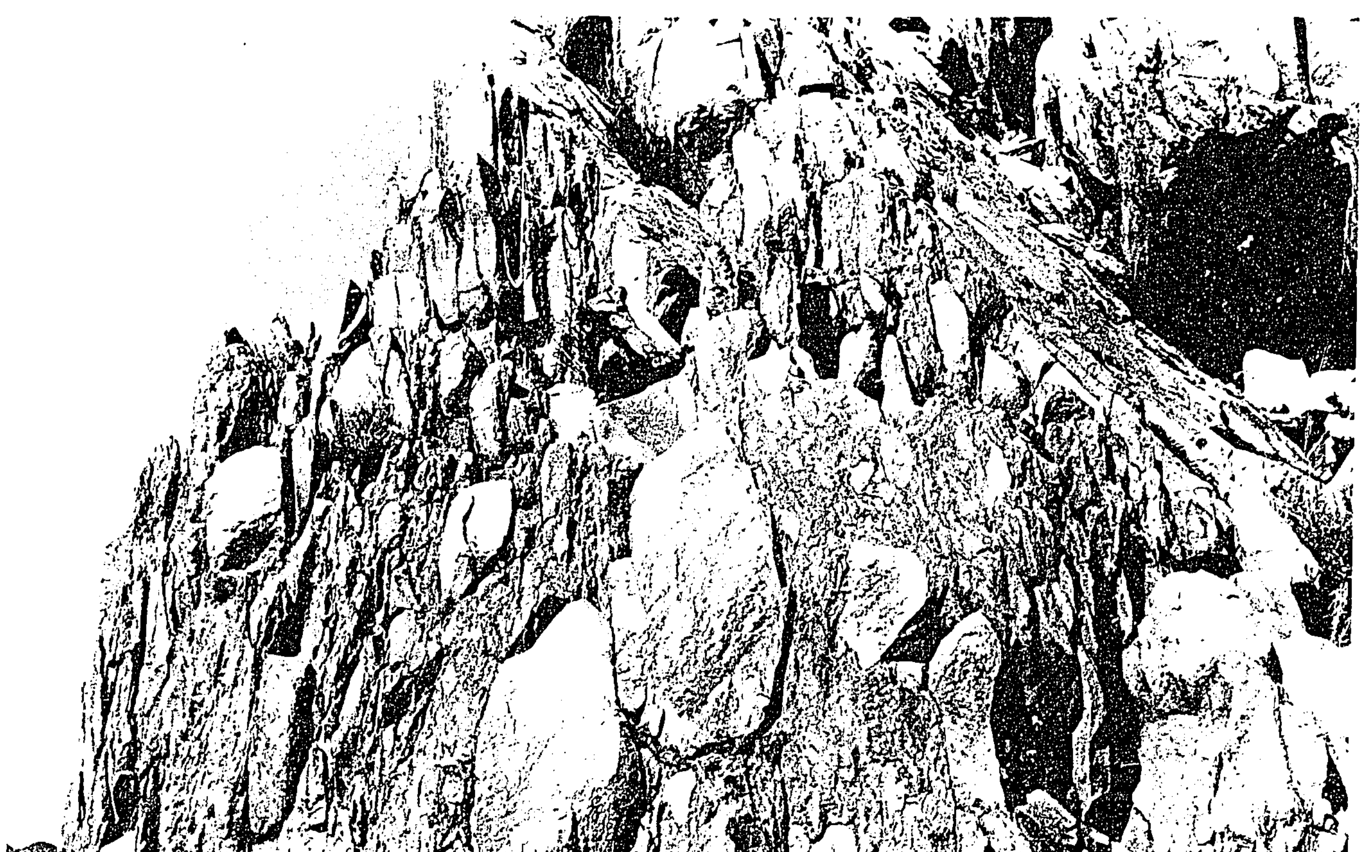


Fig. 41: Flattened conglomerate in Mount Thomas Quartzite, GR5453-713310, 4.5 km west of Harverson Pass. Largest boulder is 45 cm long.
Neg. M/1359/6.

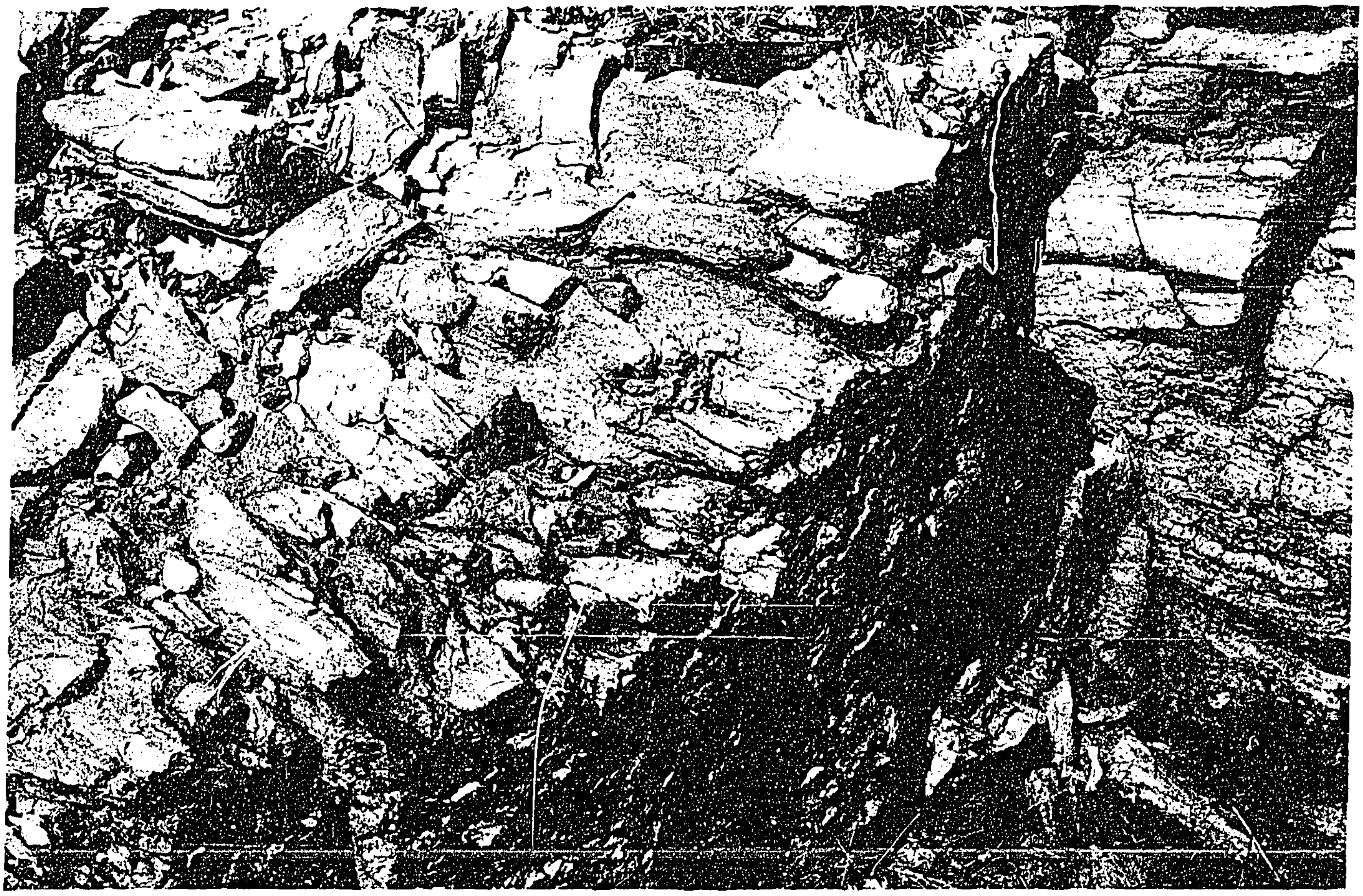


Fig. 42: Rodding in Mount Thomas Quartzite; a (above) GR5553-947123, 7 km west of Mount Airy; b (below) GR5553-965112, 5 km west-southwest of Mount Airy.

Neg. M/1244/11.

Neg. M/1244/7.

The mineral assemblages in the Mount Thomas Quartzite show a gradual rise in metamorphic grade from northwest to southeast. In the northwest and central parts of the Reynolds Range, i.e. northwest of Harverson Pass, the assemblage in the lutite beds of the unit is sericite-chlorite-biotite ± andalusite, indicating low to middle greenschist facies. Southeast of Harverson Pass, micas coarsen but no higher grade aluminous minerals appear in the lutites (which in this area are mapped as an extension of the Pine Hill Formation). In the southeastern corner of REYNOLDS RANGE, however, the tongue of lutite of the Pine Hill Formation that crops out between the two ridges of Mount Thomas Quartzite is metamorphosed to a high amphibolite or low granulite assemblage, and this facies continues into TEA TREE and AILERON. The transition between the greenschist and high amphibolite/low granulite facies is located at GR5453-922174, and is marked by retrogression of cordierite, microcline, and sillimanite to pinite and sericite aggregates. The expected prograde low and middle amphibolite facies assemblages between the greenschist and high amphibolite/low granulite assemblages are absent.

In the Mount Thomas-Harverson Pass area of REYNOLDS RANGE, the lutite beds of the Mount Thomas Quartzite carry numerous porphyroblasts of andalusite up to 1 cm across. In all cases, a sill of porphyritic microgranite crops out within a few metres; hence, the andalusite is a thermal metamorphic mineral.

No fossils have been found in the Mount Thomas Quartzite, and no isotopic dates have been determined on any of the rock types in the formation. An imprecise Rb-Sr isochron on the Napperby Gneiss, which intrudes the Mount Thomas Quartzite in the southeast of REYNOLDS RANGE, gives a date of 1600 to 1500 Ma. Hence, the Mount Thomas Quartzite is Middle Proterozoic or older.

Pine Hill Formation (Ɇrp) (A.J.S.)

The Pine Hill Formation is the unit of red-brown to greyish-green shale, slate, siltstone, and quartzite and their metamorphosed equivalents which crops out in the Giles and Reynolds Ranges in DENISON, REYNOLDS RANGE, TEA TREE, and AILERON, and in the Wabudali Range, in the Mount Theo and Mount Doreen 1:250 000 Sheet areas. The name is derived from Pine Hill homestead (GR5553-996231) in the southwest of TEA TREE.

In the northwest of the Reynolds Range, the Formation forms hilly country, but in the southeast of the Range it underlies valleys from which rise a few narrow ridges of sandstone or quartzite. In TEA TREE and AILERON, high-grade metamorphic granofels of the Formation forms high hills and ridges.

The Pine Hill Formation conformably overlies the Mount Thomas Quartzite, and also interfingers with it in the southeastern part of the Reynolds Range. The lower tongue of Quartzite lenses out at the Woodforde River, in AILERON, and the Pine Hill Formation directly adjoins the Lander Rock beds for about 500 m. The Formation contains two large conformable lenses of dolomite, the Algamba Dolomite Member. The formation is overlain by the Woodforde River beds, but as the top of the beds is faulted, it is possible that the beds originally formed another lens in the Pine Hill Formation. The Formation is intruded by the Warimbi Schist in several places, and in the southeast of REYNOLDS RANGE by the Napperby Gneiss.

The type section of the Pine Hill Formation (AX-2) is located directly above the type section of the Mount Thomas Quartzite, in the Reynolds Range (Fig. 35). The base of the section is at GR5453-761313, and the top at -756311.

$Erp_1$. In the type section (Fig. 35), the Pine Hill Formation is about 570 m thick, and consists mostly of weakly metamorphosed interbedded shale, sericite slate with andalusite prophyroblasts, siltstone, and minor fine-grained sandstone. The rocks are greyish-green when fresh, but weather red-brown, and are generally highly folded and weakly cleaved (Figs. 43, 44, 45, 46). The cleavage in the sandstone and siltstone beds arises from mild flattening of the quartz grains into oriented lenses, and the growth of small muscovite flakes along the margins of these grains. The Formation includes a prominent marker horizon defined by a pair of quartzite beds separated by a few metres of shale; the lower quartzite is about 3 m thick, white, flaggy and laminated; the upper quartzite is of similar thickness, blue, massive, and composed essentially of quartz (90%) and hematite (10%) in elongate aggregates parallel to the bedding (72920437).

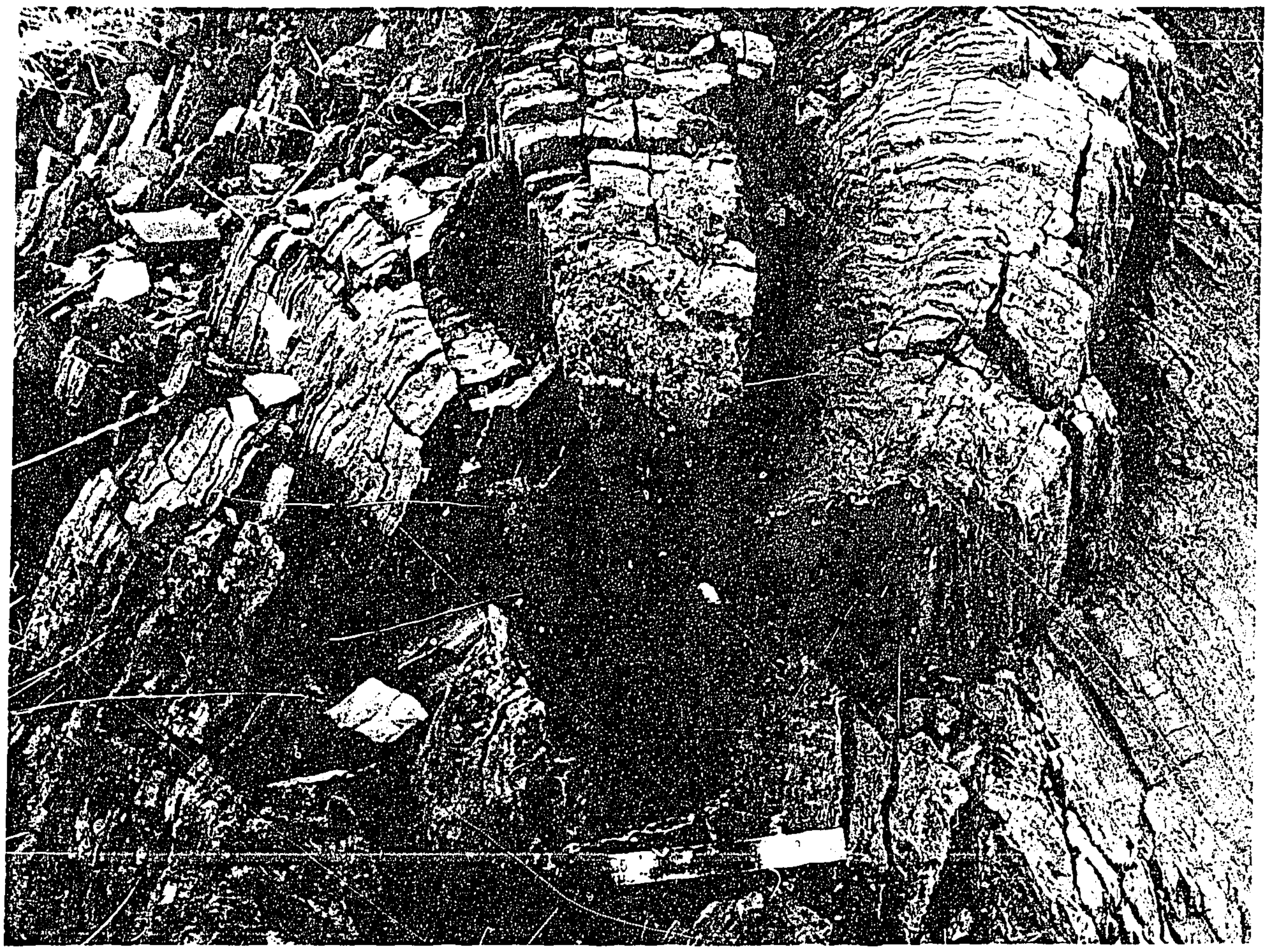


Fig. 43: Mullions in core of steeply plunging fold in fine-grained sandstone of Pine Hill Formation. GR5453-751319, 2.5 km southeast of Mount Thomas. Scale 15 cm long.
Neg. M/1247/2.


Fig. 44: Cleaved shale (slate) and tightly folded sandstone of Pine Hill Formation. GR5453-634413, 8 km southeast of Mount Gardiner. Scale 15 cm long.
Neg. M/1342/10.

Fig. 45: Disharmonic steeply plunging fold in Pine Hill Formation, showing thickening of central bed in core of antiform at right, and refraction of cleavage in graded lower bed. GR5453-752318, 2.5 km southeast of Mount Thomas.
Neg. M/1247/5.

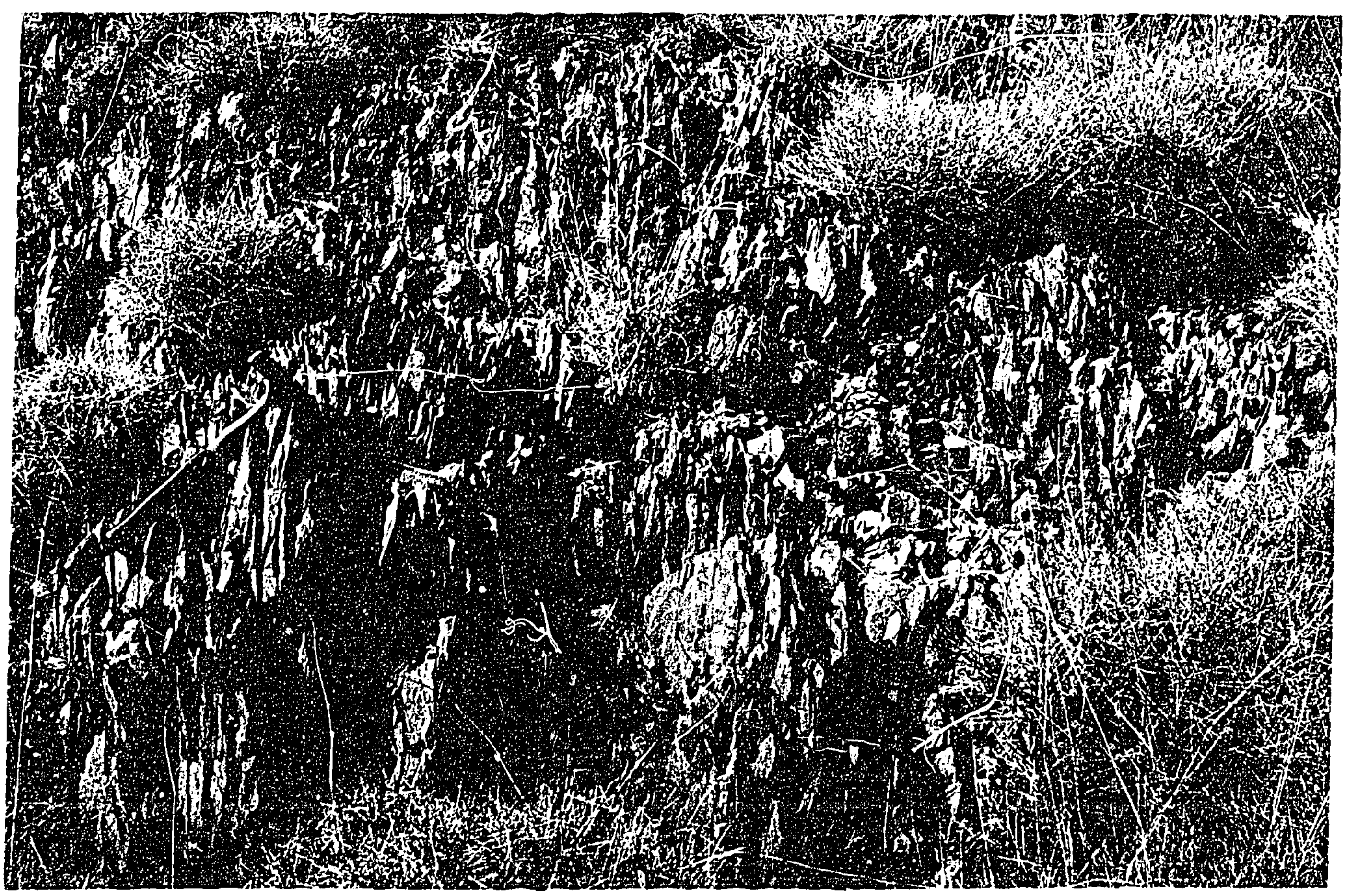


Fig. 46: Vertical cleavage in slate of Pine Hill Formation, GR5453-740345, 1 km northeast of Mount Thomas.
Neg. M/1245/5

In the northwest of the Reynolds Range (Fig. 35), the Pine Hill Formation is only about 260 m thick, and consists mostly of shale with rare sandstone interbeds.

Erp$_2$. In the southeast of the Reynolds Range (Fig. 35), the Formation consists of coarse-grained muscovite schist, in places with andalusite porphyroblasts, and interbeds of coarse-grained metaquartzite. The marker horizon of white and blue quartzites is also present. The thickness of the Formation cannot be determined because of repeated faulting, but it appears to be about the same as the type section.

Erp$_3$. In the southeast corner of REYNOLDS RANGE, and in TEA TREE, the Pine Hill Formation consists of massive to layered granofels composed of quartz, cordierite, microcline, biotite, and sillimanite (72920649, 75920925) containing isoclinally folded blebs of pegmatite. The transition zone between Erp$_3$ and Erp$_2$ is a zone of retrogression marked by gradually increasing replacement to the northwest first of cordierite (-0926), and, then of sillimanite and microcline by muscovite, forming quartz-biotite-muscovite schist (-0927, -0928). Five km east of Mount Airy, garnet gneiss with sillimanite and cordierite (73921243), felsic granulite (73922054, -2055), and cordierite gneiss (-2056) make up the Pine Hill Formation in the large synform that straddles the boundary of TEA TREE and AILERON. The gneisses contain green patches up to about 3 cm across elongated parallel to the foliation. These patches consist of fine-grained aggregates of muscovite and chlorite, containing in places altered relicts of feldspar. Other retrogressive effects include alteration of feldspar by sericite, and of garnet by chlorite, mainly along cleavage and fracture planes.

In AILERON, the Pine Hill Formation typically consists of coarse-grained cordierite granulite which contains sillimanite, potassium feldspar, quartz, and biotite (73922031). The rocks are dark and greasy in appearance, and lilac-coloured cordierite is visible in some hand specimens (72920578). At locality 72920575 (GR5552-131068) kornerupine forms grey porphyroblasts several centimetres long in cordierite granulite; the kornerupine is altered along cracks and cleavages to tourmaline, biotite, and corundum. Table 2 presents results of electron microprobe analyses of one large kornerupine grain and also a small

Table 2: Electron microprobe analyses of large kornerupine grain (6 analyses) and small kornerupine grain, sample 72920575 near Aileron. Total Fe expressed as FeO.

| Sample site | Margin | Core | Near edge | Interior | - | - | Small separate grain |
|---|---|---|---|---|---|---|---|
| $SiO_2$ | 29.04 | 29.21 | 29.45 | 29.22 | 29.40 | 28.77 | 29.28 |
| $TiO_2$ | 0.10 | 0.18 | 0.11 | 0.11 | 0.00 | 0.10 | 0.11 |
| $Al_2O_3$ | 43.40 | 43.77 | 43.44 | 43.77 | 43.82 | 43.66 | 43.07 |
| FeO | 8.24 | 8.56 | 8.09 | 8.36 | 8.42 | 7.99 | 8.42 |
| MgO | 14.29 | 14.63 | 14.59 | 14.61 | 14.74 | 14.15 | 14.31 |
| $Na_2O$ | 0.18 | 0.24 | 0.21 | 0.22 | 0.19 | 0.18 | 0.26 |
| Total | 95.25 | 96.58 | 95.88 | 96.27 | 96.57 | 94.85 | 95.45 |

NUMBERS OF IONS ON BASIS OF 21 OXYGENS

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Si | 3.60 | 3.58 | 3.62 | 3.59 | 3.60 | 3.58 | 3.63 |
| Ti | 0.01 | 0.02 | 0.01 | 0.01 | 0.00 | 0.01 | 0.01 |
| Al | 6.34 | 6.32 | 6.30 | 6.33 | 6.32 | 6.40 | 6.29 |
| Fe | 0.85 | 0.88 | 0.83 | 0.86 | 0.86 | 0.83 | 0.87 |
| Mg | 2.64 | 2.67 | 2.68 | 2.67 | 2.69 | 2.63 | 2.64 |
| Na | 0.04 | 0.06 | 0.05 | 0.05 | 0.04 | 0.04 | 0.06 |

Analyst: R.G. Warren (BMR).

nearby grain in the same thin section (72920575). The low oxide totals reflect the presentation of total iron as FeO, and the lack of boron and water determinations. The analysed kornerupines resemble kornerupine from the Strangways Range, in the southeast Arunta Block (Woodford & Wilson, 1976). Kornerupine from Madagascar (Knorring & others, 1969) contains considerably less iron and more magnesium.

Small amounts of mafic rock are interlayered with the metapelites; one sample (72921251) consists of hypersthene, clinopyroxene, labradorite, and microcline.

As in the Mount Thomas Quartzite, the mineral assemblages in the Pine Hill Formation indicate a rise in metamorphic grade from low greenschist facies in the Giles Range and northwest and central Reynolds Range, through a zone of retrogression near the boundary of REYNOLDS RANGE and TEA TREE, to low granulite facies in TEA TREE and AILERON. Superimposed on the high-grade assemblages are retrogressive effects such as partial chloritisation of biotite, and pinitisation of cordierite. In the central part of the Reynolds Range, the andalusite porphyroblasts in slate are found only in proximity to the Warimbi Schist, and hence are a product of thermal metamorphism.

No fossils have been found in the Pine Hill Formation. Samples of schist (73921025) from GR5453-660405 in the Reynolds Range gave an imprecise Rb-Sr isochron date of about 1100 Ma. The unit is intruded by and hence older than the Napperby Geniss in the southeastern corner of REYNOLDS RANGE, and Rb-Sr whole rock isochrons on sample (72921017-1019) of the Gneiss give an imprecise age date of 1600 to 1500 Ma. Hence the Pine Hill formation is Middle Proterozoic or older.

Algamba Dolomite Member (Bra) (A.J.S.)

The Algamba Dolomite Member is the unit of grey-brown dolomite and limestone which crops out intermittently in the REYNOLDS RANGE. The name is derived from Algamba Bore (GR5453-791381) 12 km east of the nearest exposure of Algamba Dolomite. The member has a subdued topographic expression, and forms low rocky rises characterised by a cover of spinifex grass; in many areas the carbonates are concealed beneath a veneer of laterite.

The Algamba Dolomite Member crops out as two large conformable lenses in the middle of, and entirely enclosed in, the Pine Hill Formation; the two outcrops are interpreted as parts of the one lens, separated by folding and erosion. The Member is in intrusive contact with the Warimbi Schist at two localities, 5 and 9 km southeast of Harverson Pass.

There is no measured section of the Algamba Dolomite Member; the type section (AX-3) is located in the northwestern part of the Reynolds Range, 5.5 km southwest of Lander Bore; the base of the type section is at GR5453-670408, and the top at -667404. The total thickness of the Member at the type section is estimated from airphoto measurements and dip information at 425 m. In the southeastern part of the Reynolds Range, the Member is estimated to be 700 m thick. The best exposures of the Algamba Dolomite Member are in the northwestern part of the Reynolds Range. Here the Member consists chiefly of pink to grey-brown fine-grained dolomite with small vuggy patches of coarser-grained dolomite. The rock has a distinctive wavy irregular lamination which has an overall parallelism to the strike of the dolomite outcrops, and may be original bedding subsequently obliterated by recrystallization. Limestone is a minor rock-type in the type section and is pinkish-cream to grey, irregularly laminated, fine-grained, and composed of recrystallized calcite, quartz, hematite, and detrital muscovite (71921017). In the southeastern part of the Reynolds Range, the Member is poorly exposed because of extensive laterite cappings. Where exposed (at sample locality 72920737), the dolomite is brown, and slightly coarser-grained than in the type area.

Neither fossils nor stromatolites have been found in the Algamba Dolomite Member. Because it forms a large lens in the Pine Hill Formation, it is the same age, i.e. Middle Proterozoic or older. The Member is correlated with the marble and calc-silicate of the Woodforde River beds in the southwestern part of TEA TREE, as the two units occupy similar stratigraphic positions with respect to the Pine Hill Formation.

Woodforde River beds (Eo) (A.J.S. and A.Y.G.)

The Woodforde River beds are the unit of marble, calc-silicate rock, quartzite, and sillimanite schist that crops out in the northwest of AILERON and southwest of TEA TREE. The unit underlies the valley of

Fig. 47: Folded and boudinaged calc-silicate laminae in marble, Woodforde River beds. GR5552-021086, 2 km north-northeast of Mount Dunkin.

Neg. M/1945/34A.

the main upper tributary of the Woodforde River, after which it is named. The northern boundary of the beds is conformable above cordierite granulite of the Pine Hill Formation; the southern boundary lies conformably against Mount Thomas Quartzite, in the west, whereas in the east it is faulted against the Mount Dunkin schist, and granulite. The unit is intruded by several bodies of granite.

The eastern exposures of the unit consist mainly of tremolite-clinozoisite-quartz-calcite marble, microcline-diopside marble (72921214) and forsterite marble. The western exposures comprise a wide range of calc-silicate and marble types (Fig. 47), including garnet-epidote-plagioclase-microcline granofels (71921046), biotite-muscovite-epidote-plagioclase-microcline-quartz granofels (-1047), magnetite-hypersthene-cummingtonite-cordierite granofels (-1048, -1052), forsterite and talcose marbles with pseudomorphs of carbonate and iron oxide after olivine (-1049, -1050), and diopside-actinolite-microcline-plagioclase-carbonate rock (-1051). The rocks are strongly folded.

Quartzite in the Woodforde River beds forms several thin intercalations that crop out along the axial zone of the unit. The rock is white, grey, or pale blue, coarse to very coarse-grained, platy to thin to thick-bedded, and has a translucent glassy appearance. Muscovite is a minor constituent.

Sillimanite schist crops out between the quartzite ridges; the schist also contains feldspar and is much weathered.

The mineral assemblages in the calcareous rocks of the Woodforde River beds are indicative of metamorphic conditions ranging from low to upper amphibolite facies. The carbonate-limonite pseudomorphs after olivine in some samples are probably a product of weathering; laterite caps marble at several places in the unit.

The Woodforde River beds were a calcareous lens that presumably formed as the off-shore limey facies of the Reynolds Range Group. The beds are correlated with the Algamba Dolomite Member of the Pine Hill Formation in REYNOLDS RANGE, as the two carbonate units occupy the same stratigraphic position in the Reynolds Range Group. Hence, the Woodforde River beds are Middle Proterozoic or older.

Discussion (A.J.S.)

The Reynolds Range Group, with its upward gradation from pebbly arkose through quartzite with minor shale, then shale with minor quartzite, to carbonate rock, appears to be a typical shallow-water sequence laid down during a marine transgression on to a continental shelf. The arkose and quartzite units are presumably near-shore strandline deposits, the shale probably represents the deeper-water facies farther off-shore, and the carbonate may have resulted from the establishment and growth of algal gardens in clear water when terrigenous sedimentation ceased. The hematite quartzites are recrystallised detrital quartz sands with a high content of heavy minerals, not metamorphosed banded iron formation of chemical origin. The lowest formation of the Group, the Mount Thomas Quartzite, shows sudden and marked differences in lithology and thickness between the Mount Thomas area and the northwestern part of the Reynolds Range, and the overlying Pine Hill Formation shows a similar change in thickness between the two areas. The changes coincide with an anticlinorium in the Lander Rock beds, which extends completely through the Reynolds Range, suggesting that an area of high ground such as a shoal or island existed in the Reynolds Range sea, and caused differences in sedimentation in different areas.

The Reynolds Range Group is correlated on lithological grounds with the Ledan Schist and Utopia Quartzite of the Alcoota 1:250 000 Sheet area to the east (Shaw & others, 1975), and with the Pargee Sandstone of The Granites and Tanami 1:250 000 Sheet areas to the northwest (Blake, Hodgson, & Muhling, 1973). All these quartzite formations unconformably overlie pelitic or metapelitic rocks, and are intruded by granites of Early to Middle Proterozoic age.

Yakalibadgi Microgranite (Egk) (L.A.O.)

This body crops out on the southwestern side of the Reynolds Range and extends from the vicinity of Mount Thomas to Mount Gardiner in REYNOLDS RANGE. Away from the Range the exposure is poor. The unit consists of metamorphosed medium-grained granite near Mount Thomas, and grades northwest into metamorphosed porphyritic microgranite and biotite orthoschist, and west into biotite-muscovite orthoschist. The name is derived from Yakalibadgi Hill, 1.5 km southwest of Blockhill Bore, in the northwestern part of REYNOLDS RANGE. The type locality is a good exposure of dark grey microgranodiorite with small biotite-rich xenoliths located at GR5453-660366, 8 km northwest of Mount Thomas.

The Microgranite intrudes the Lander Rock beds south of Mount Gardiner and west of Mount Thomas. No intrusive relationship into the Reynolds Range Group is seen, and so the Group may rest non-conformably on the Microgranite. Elsewhere, however, the base of the Mount Thomas Quartzite has acted as a barrier to younger granitic intrusions (e.g. the microgranite border phase of the Mount Airy Orthogneiss), and hence the Yakalibadgi Microgranite may have been emplaced against the Reynolds Range Group as well. Deformation and low-grade metamorphism of the contact of the Microgranite and Reynolds Range Group preclude certainty of the relation either way. Xenoliths, possibly of Lander Rock beds, occur in several areas. They are characteristically recrystallised fine-grained quartz-rich sandstones.

Metamorphosed medium-grained granite near Mount Thomas consists of partially recrystallised microcline, quartz, and sericitised plagioclase with clots and stringers of chloritised biotite, muscovite, and opaque grains. Metamorphosed porphyritic microgranite (72920722) consists of larger grains (up to 1.5 mm) of ragged quartz and heavily sericitised plagioclase in a fine-grained matrix of quartz-microcline-plagioclase-biotite-muscovite. Retrogressed and sheared parts of this unit crop out as mica schist. Sample 72920716 consists of quartz (65-70%), biotite (15-20%), sericitised feldspar (5-10%), and muscovite (5%).

The chemical composition of three samples of Yakalibadgi Microgranite are shown in Table 3. Although the three analysed samples were described in the field as metamorphosed granite, metamorphosed microgranite, and schist, the chemical composition of each sample is similar and comparable to average granodiorite (Nockolds, 1954), modified by the loss of sodium and calcium. In addition the Microgranite is unusually high in iron.

The unit shows varying degrees of deformation, and is everywhere partially metamorphically retrogressed. Masses of microgranite form remnants within the orthoschist, and in turn grade into a coarser

Table 3: Results in percent of chemical analysis of three samples of Yakalibadgi Microgranite.

| Sample no.* <br> Locality | 0722 <br> 5453-608407 | 0726B <br> 5453-661367 | 0716 <br> 5453-531452 | Average <br> Granodiorite** |
|---|---|---|---|---|
| $SiO_2$ | 66.75 | 67.56 | 68.98 | 66.88 |
| $TiO_2$ | 0.84 | 0.78 | 0.64 | 0.57 |
| $Al_2O_3$ | 13.00 | 13.13 | 13.20 | 15.66 |
| $Fe_2O_3$ | 1.58 | 1.02 | 1.64 | 1.33 |
| FeO | 5.95 | 5.83 | 4.20 | 2.59 |
| MnO | 0.09 | 0.10 | 0.09 | 0.07 |
| MgO | 0.95 | 0.95 | 0.82 | 1.57 |
| CaO | 2.08 | 2.20 | 1.68 | 3.56 |
| $Na_2O$ | 1.78 | 1.69 | 2.28 | 3.84 |
| $K_2O$ | 4.56 | 4.26 | 4.05 | 3.07 |
| $P_2O_5$ | 0.22 | 0.22 | 0.18 | 0.21 |
| $H_2O^+$ | 0.79 | 0.80 | 0.90 | 0.65 |
| $H_2O^-$ | 0.15 | 0.63 | 0.18 | - |
| $CO_2$ | 0.05 | 0.05 | <.05 | - |
| $SO_3$ | 0.09 | - | - | - |
| Total | 98.88 | 99.23 | 98.84 | 99.90 |
| S.I. index | 1.18 | 1.23 | 1.23 | - |

Analyses: A.M.D.L., Report AN4846/74

* Preceded by 7292

** Nockolds (1954)

non-foliated metamorphosed granite near Mount Thomas. The chemical analyses of the three rock types are very similar, and suggest that these different rock types were produced from the one body. The S.I. indices of the analysed samples are substantially greater than 1.1, suggesting a derivation from sedimentary material.

The Yakalibadgi Microgranite is younger than the Lander Rock beds (Middle Proterozoic or older), almost certainly younger than the Mount Thomas Quartzite, and older than the regional metamorphism of the Mount Thomas Quartzite which was subsequently intruded by the Napperby Gneiss and the Mount Airy Orthogneiss. The Napperby Gneiss has been imprecisely dated at 1600-1500 Ma. A K-Ar date of 920 m.y. (Lowder & Webb, 1972) on biotite from the southwestern part of the body is probably partly reset by the Alice Springs Orogeny (Carboniferous). Hence the Yakalibadgi Microgranite is probably Early or Middle Proterozoic.

Coniston Schist (Ꞓpc) (L.A.O.)

The Coniston Schist is the grey to grey-green biotite-sericite-quartz orthoschist which crops out in the northwestern part of REYNOLDS RANGE northwest of Mount Thomas. The name is derived from Coniston homestead, which is situated near the northwestern end of the Reynolds Range. The type locality is situated at GR5453-652400, where there are clear exposures in the creek bed at the bottom of a steep sided gully. The Schist falls away as hill slopes and valleys from the resistant ridge of Mount Thomas Quartzite which forms the highest part of the Range. The unit is called Coniston Porphyry on the preliminary edition of REYNOLDS RANGE and TEA TREE.

The Coniston Schist (Fig. 48) is a large, deformed and retrogressively metamorphosed igneous body intercalated in the Reynolds Range Group. Throughout most of its extent it crops out with apparent conformity between the basal conglomerate and the main quartzite mass of the Mount Thomas Quartzite. In places the Schist is intercalated with conglomerate and hematite-quartz sandstone. A few thin lenses of Schist are intercalated with the Lander Rock beds below the basal conglomerate of the Mount Thomas Quartzite.

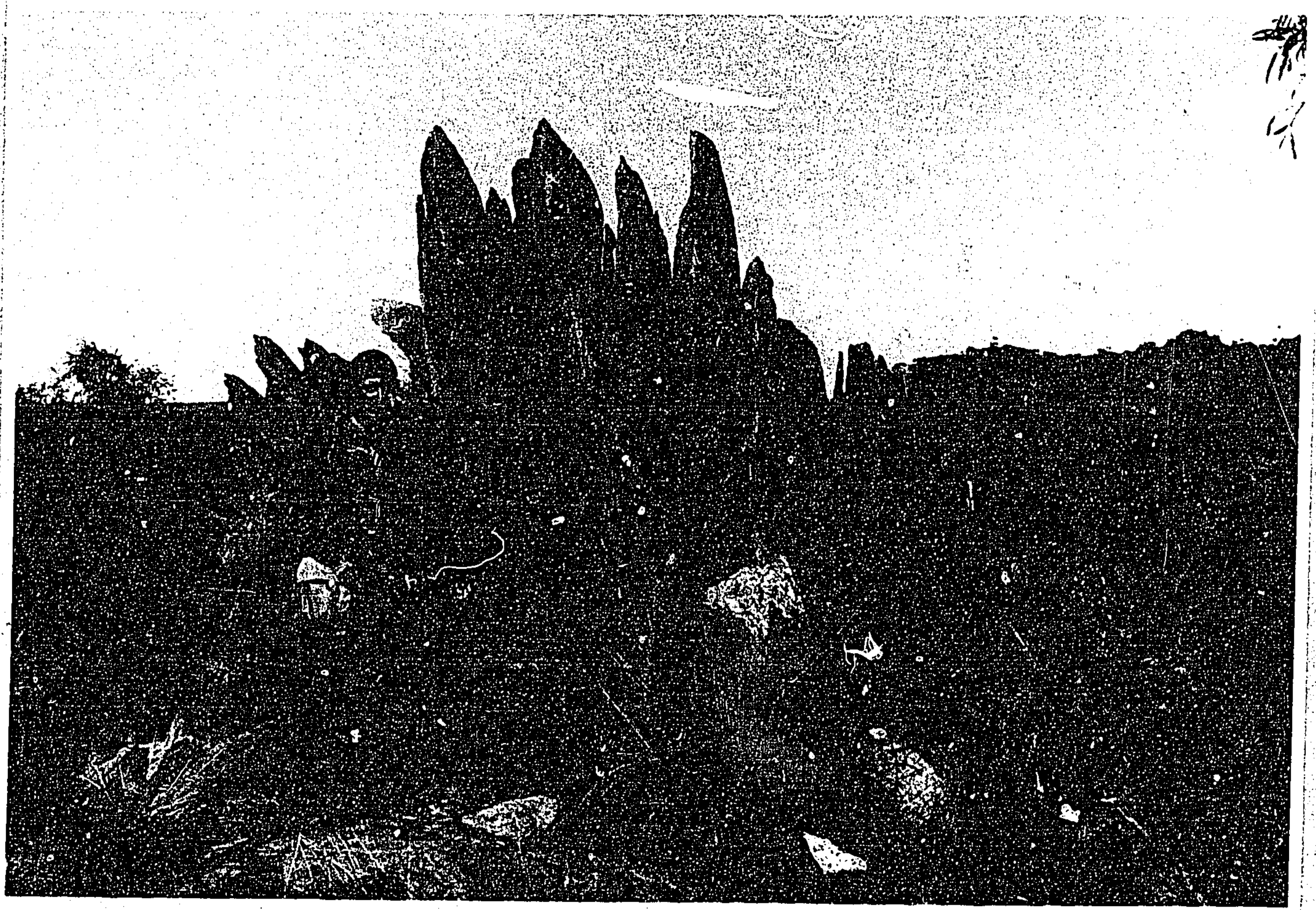


Fig. 48: Steeply dipping orthoschist of Coniston Schist. GR5453-583450, 2 km southeast of Mount Gardiner.
Neg. M/1342/42.

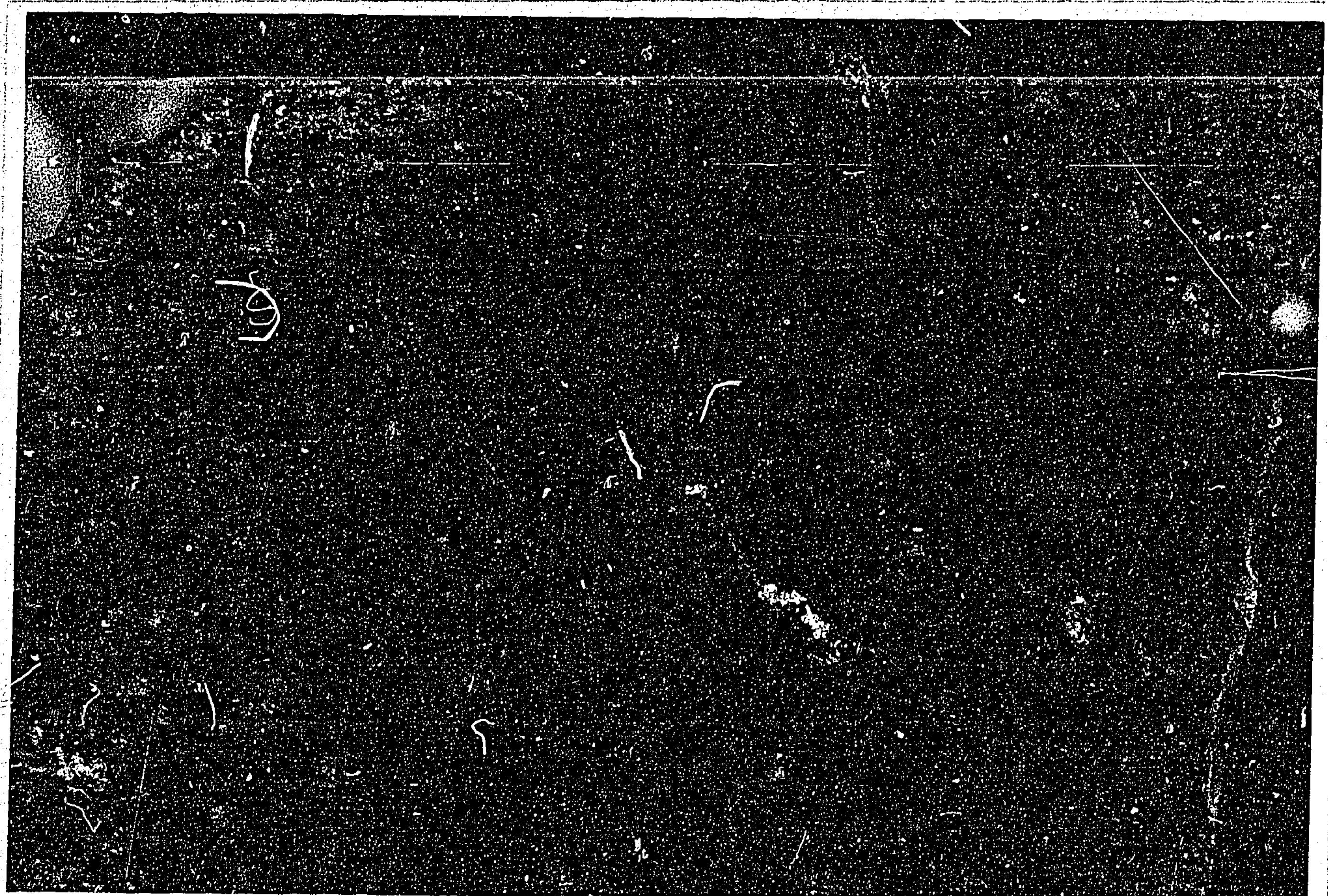


Fig. 49: Orthoschist of Coniston Schist, showing quartz and feldspar augen in schistose matrix. GR5453-579439, 2 km south-southeast of Mount Gardiner. Scale divisions are 1/8 inch (3.175 mm).
Neg. M/1342/30.

The Coniston Schist is 620 m thick at GR5453-532472 near Mount Gardiner, in the northwestern part of the Reynolds Range; at this locality, the upper and lower contacts of the Schist are preserved, which is not the case at the type locality. The thickness is estimated from airphoto measurements and dip information, but takes no account of any change in thickness caused by the deformation of the parent sill.

In hand specimen (Fig. 49) the schist is commonly grey to grey-green and contains clear quartz augen (up to 7 mm long) in an aphanitic schistose matrix of quartz, sericite, and biotite. The quartz augen have serrated boundaries, and are composed either of single grains or of mosaic aggregates of grains. The quartz augen display numerous corrosion embayments, and extinction under crossed nicols is strain-free. The matrix of the Schist consists of quartz (60 to 70%), sericite (commonly 20%), biotite aggregates (commonly 5 to 10%) partly altered to chlorite, minor epidote, sphene, and leucoxene. In less altered specimens, grains of albite (up to 3 mm) and potash feldspar are present.

The bulk chemical composition of the Coniston Schist (Table 4) approximates rhyolite. However compared with analyses of average alkali rhyolite (Nockolds, 1954) the Coniston Schist is depleted in sodium and calcium, and has gained magnesium and water. These losses preclude the calculation of any meaningful S.I. index.

The conformable relation of the Coniston Schist to the Mount Thomas Quartzite suggests that the igneous parent of the Schist was an acid volcanic erupted during deposition of the Quartzite. Elsewhere, however, as noted in the section above on the Yakalibadgi Microgranite, the Mount Thomas Quartzite is known to have formed a barrier to igneous intrusion, namely, the Mount Airy Orthogneiss, which deformed the Quartzite but did not breach it. Hence, it is possible that the igneous parent of the Coniston Schist was emplaced as a sill into the Mount Thomas Quartzite.

The Coniston Schist is either the same age as, or younger than the Reynolds Range Group, of Middle or Early Proterozoic age. Orthoschist samples (73921026) from GR5453-659401 in the Reynolds Range gave an imprecise Rb-Sr age of about 1350 Ma (with an initial $^{87}Sr/^{86}Sr$ ratio of about 1).

Table 4: Results of chemical analysis (in percent) of five samples of Coniston Schist.

| Sample nos* Locality | 0495 5453-631410 | 0503 -583450 | 0504 -579439 | 0556 -691330 | 0708 -540475 | Average Alkali Rhyolite** |
|---|---|---|---|---|---|---|
| $SiO_2$ | 74.90 | 74.5 | 74.6 | 77.68 | 73.60 | 74.57 |
| $TiO_2$ | 0.33 | 0.39 | 0.10 | 0.31 | 0.36 | 0.17 |
| $Al_2O_3$ | 12.60 | 12.3 | 13.4 | 12.02 | 13.56 | 12.58 |
| $Fe_2O_3$ | 1.51 | 2.05 | 1.65 | 1.24 | 1.33 | 1.30 |
| FeO | 1.39 | 1.00 | 0.15 | 0.97 | 0.95 | 1.02 |
| MnO | 0.01 | 0.01 | 0.01 | 0.01 | <0.01 | 0.05 |
| MgO | 1.42 | 2.25 | 0.74 | 0.82 | 1.09 | 0.11 |
| CaO | 0.29 | 0.15 | 0.08 | 0.25 | 0.84 | 0.61 |
| $Na_2O$ | 0.12 | 0.10 | 0.12 | 0.06 | 0.06 | 4.13 |
| $K_2O$ | 5.07 | 3.95 | 7.30 | 4.36 | 4.91 | 4.73 |
| $P_2O_5$ | 0.21 | 0.20 | 0.02 | 0.21 | 0.20 | 0.07 |
| $H_2O^+$ | 1.61 | 2.45 | 1.55 | 1.45 | 2.05 | 0.66 |
| $H_2O^-$ | 0.15 | 0.28 | 0.07 | 0.17 | 0.19 | - |
| $CO_2$ | 0.05 | 0.10 | 0.05 | <0.05 | 0.45 | - |
| $SO_3$ | - | - | - | - | <0.01 | |
| Total | 99.66 | 99.7 | 99.8 | 99.55 | 99.59 | 100.00 |

Analysts: Amdel, Report AN346/73 (Samples 503 and 504)
Amdel, Report AN4846/74 (Samples 495, 556, and 708)

* Preceded by 7292

** Nockolds (1954)

The Reynolds Range group was intruded and deformed by the Mount Airy Orthogneiss and Napperby Gneiss, and the latter has been dated at 1600-1500 Ma. Hence, the pre-metamorphic parent of the Coniston Schist was probably emplaced in the Early or Middle Proterozoic.

Warimbi Schist (Ɛpw) (A.J.S.)

The Warimbi Schist is the body of grey to grey-green speckled orthoschist which crops out in the central part of the Reynolds Range, REYNOLDS RANGE. The name is derived from the Warimbi Hills, between Pine Hill homestead and the Reynolds Range, in the southeast corner of REYNOLDS RANGE; 'Warimbi" is the aboriginal for 'Pine Hill'. The nearest outcrop of Warimbi Schist is 16 km west of Pine Hill homestead, and no Schist actually crops out in the Warimbi Hills, The Schist underlies spinifex-covered valleys in the Reynolds Range (Fig. 50), and erodes to a very rough surface of small projecting knife-like ridges (Fig. 51). The unit is called Warimbi Porphyry on the Preliminary edition of REYNOLDS RANGE and TEA TREE.

The Warimbi Schist is a body of retrogressively metamorphosed and deformed porphyry which intrudes all three units of the Reynolds Range Group. The main intrusion is a thick lopolith emplaced into the Mount Thomas Quartzite (Fig. 52a and b), and there are two thinner sills at higher levels in the Quartzite (Fig. 35). The lopolithic form of the main intrusion can be seen from inspection of the Reynolds Range 1:100 000 Sheet, because folding of the Reynolds Range Group into an isoclinal syncline has tilted the Porphyry body so that its present outcrop (Fig. 52a) amounts to a cross-sectional view (Fig. 52b). Five hundred metres northeast of Harverson Pass, the Warimbi Schist is in contact with the Lander Rock beds at the bottom of the lopolith, and thence rises gradually up-section through the Mount Thomas Quartzite with increasing distance along strike, southeast and northwest from the Pass. Six kilometres southeast of the Pass, the Schist breaks through the top of the Mount Thomas Quartzite, and spreads out into the overlying Pine Hill Formation like a squat mushroom one end of which touches the Algamba Dolomite Member. The two subsidiary sills of Warimbi Schist have been mapped northwest of Harverson Pass. The lower sill is an off-shoot from the main lopolith, whereas the upper sill has no visible connection with the main lopolith, and intruded along the contact of the Mount Thomas Quartzite and Pine Hill Formation.

Fig. 50: Spinifex-covered slope of Warimbi Schist, showing prominent jointing dipping gently right. Mount Thomas Quartzite in background. GR5453-811256, 5.5 km southeast of Harverson Pass.

Neg. M/1249/3

Fig. 51: Steeply dipping sharp ridges of orthoschist of Warimbi Schist. GR5453-823249, 6 km southeast of Harverson Pass.

Neg. M/1249/5

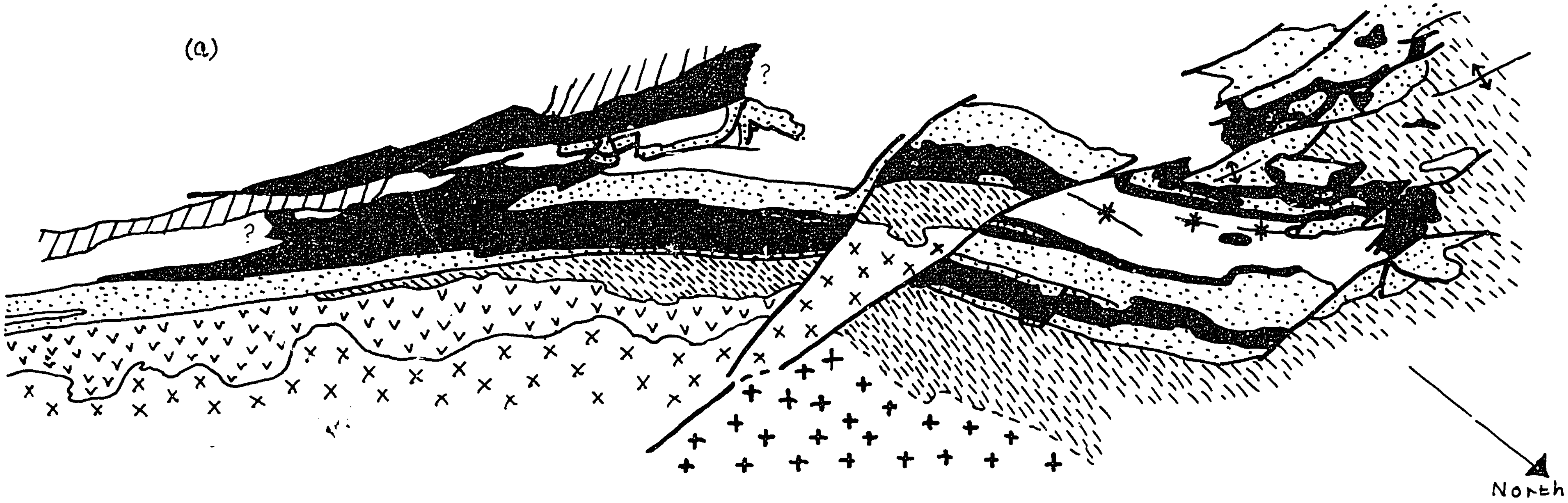
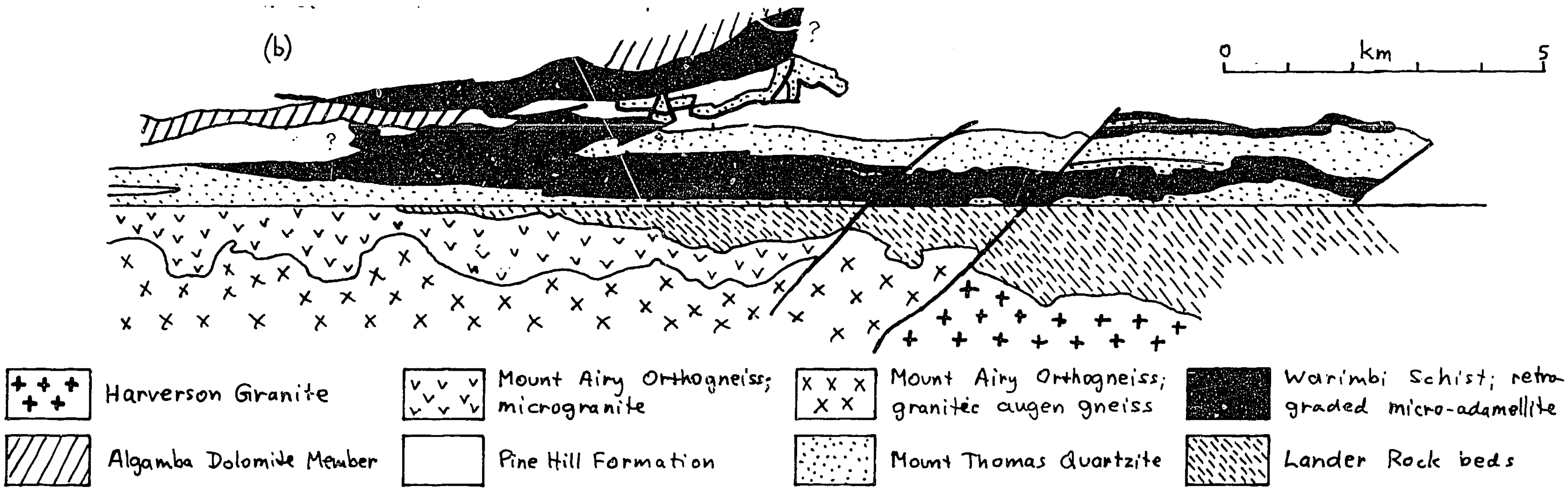



Fig. 52 : (a) Geological map of Warimbi Schist. (b) Restoration of lopolithic form of Warimbi Schist; (a) has been redrafted with base of Mount Thomas Quartzite straightened by removal of folds and faults. Portion of Schist on SW side of syncline not shown. Queries indicate areas of no exposure.






16/NT/8

No feeder dyke for the lopolith has been recognised, and it may have been eroded away above the present ground level, or may still be situated out of sight below the present ground level. On the other hand, it is, or was, presumably located near the bottom of the lopolith near Harverson Pass, and so may have become the locus for one of the major wrench faults in this area (Fig. 52a), itself being obliterated during the faulting.

There is no measured section of the Warimbi Schist; the type locality (GR5453-772315) is situated 3 km east of Mount Thomas, and is interpolated into the type section of the Mount Thomas Quartzite, which crops out stratigraphically above and below the Schist. The thickness of the main lopolith at the type locality is estimated (from air-photo measurement and dip information in the neighbouring Mount Thomas Quartzite) at 350 m; the lower and upper sills at higher stratigraphic levels in the same area are 6 m and 50 m thick, respectively. Five kilometres southeast of Harverson Pass, the main lopolith is 650 m thick, and where it breaks through into the Pine Hill Formation the Schist has a maximum thickness of 1000 m.

The Schist in hand specimen is phyllonitic (Figs 53, 54), and consists of blue-grey or brown augen of quartz in a fine-grained grey to grey-green schistose feldspathic groundmass streaked with dark elongate smeary aggregates of biotite. At locality C654 (GR5453-757343), the rock is undeformed (Figs 55, 56), and consists of pinkish-brown quartz phenocrysts and clots of fine-grained biotite in a grey-green aphanitic groundmass. The quartz aguen are single crystals with deep narrow corrosion embayments; many of the crystals are round, broken, and fragmented, but a few are euhedral bipyramids (72920466A). Biotite forms oriented elongate clots or aggregates of many small flakes which are generally themselves randomly oriented inside each clot; hematite and zircon are common accessories in the biotite aggregates. The groundmass of the rock consists of fine-grained recrystallised quartz, forming lenticles of different grain size (72920466A) or a polygonal mosaic (72920407), muscovite in small oriented flakes, and a minor amount of biotite. The overall modal composition of the rock is quartz (57%), muscovite (30%), biotite (13%). Feldspar is generally absent and presumably underwent retrogressive alteration to quartz and muscovite;

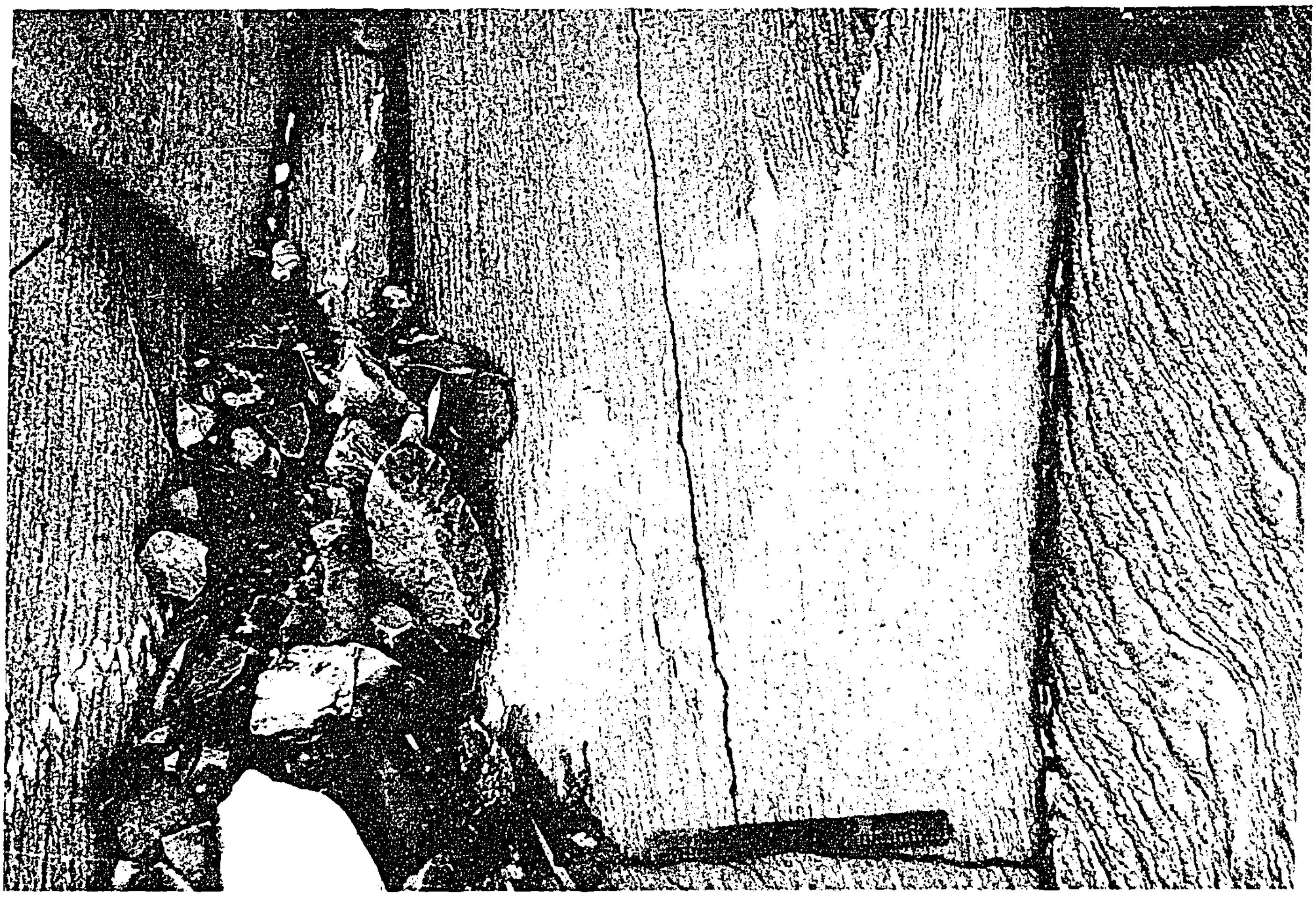


Fig. 53: Orthoschist of Warimbi Schist, showing shear-folded quartz veins, GR5453-800254, 4.8 km southeast of Harverson Pass. Scale 15 cm.
Neg. M/1242/6.

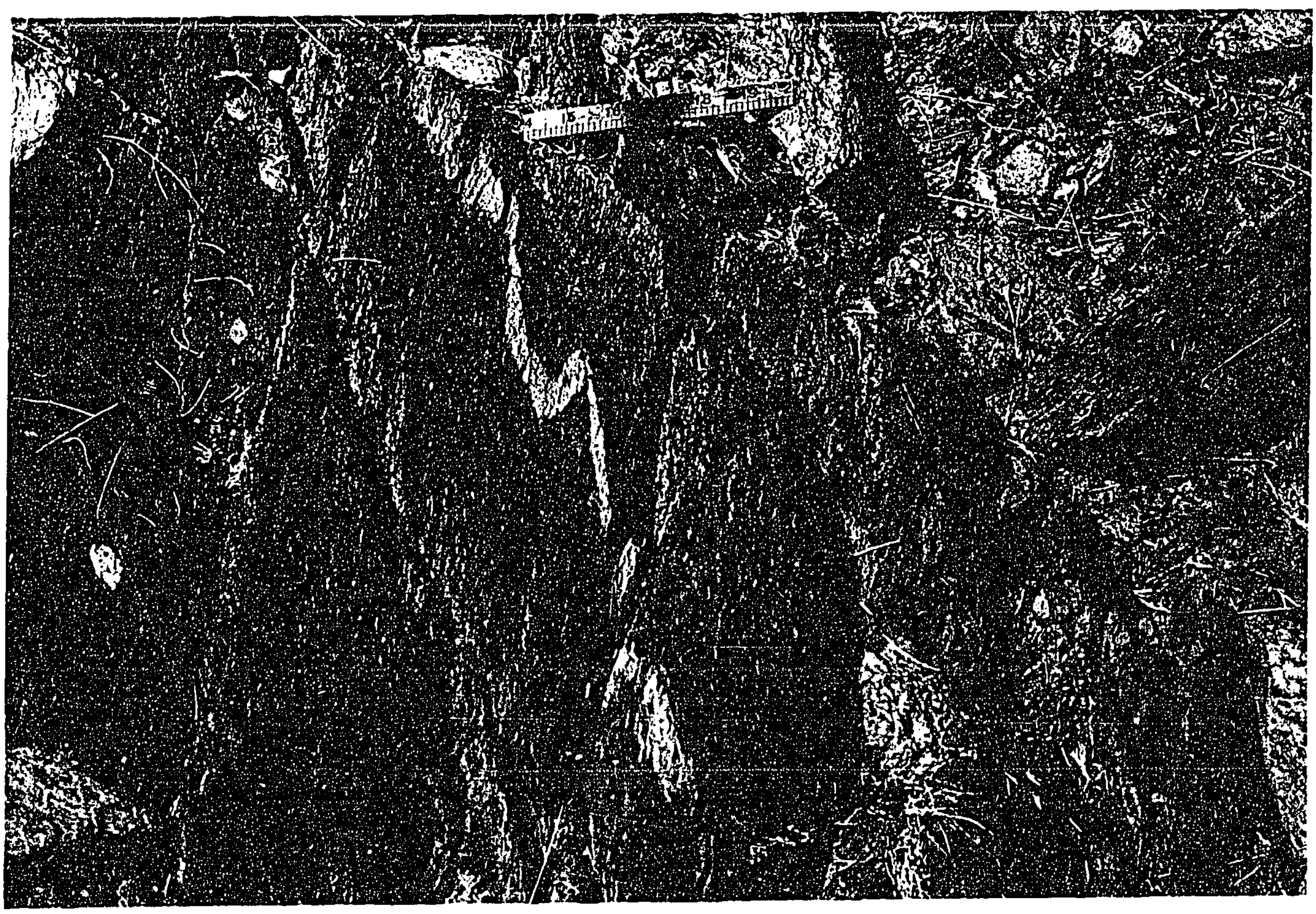


Fig. 54: Orthoschist of Warimbi Schist, showing folded and cleaved vein of leucocratic rock, GR5453-803240, 6.3 km southeast of Harverson Pass. Scale 15 cm.
Neg. M/1249/6.

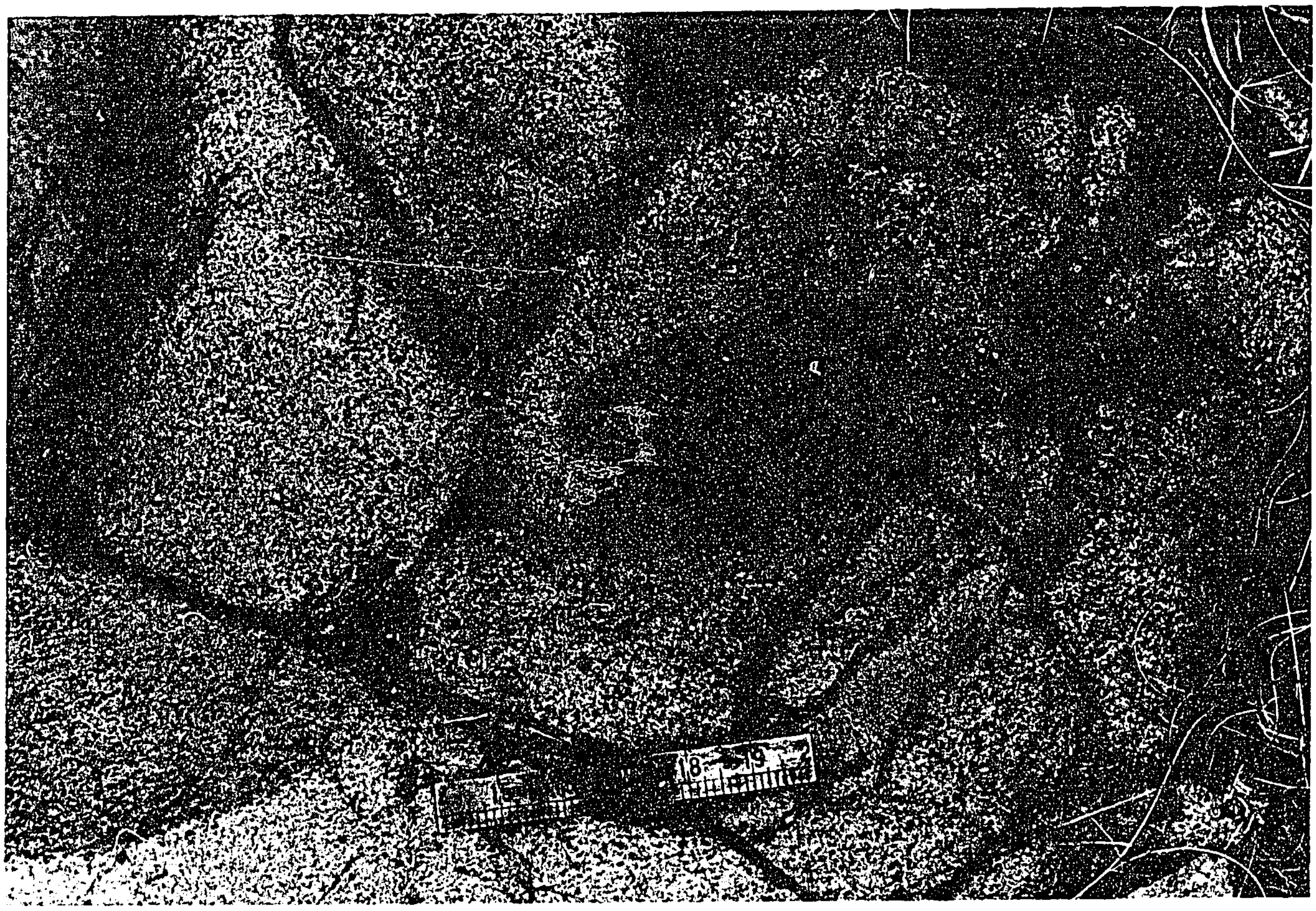


Fig. 55: Massive porphyritic microadamellite of Warimbi Schist containing rounded xenolith (centre) and angular inclusion rimmed with hematite (between xenolith and right-hand end of 15 cm scale. GR5453-756342, 2.5 km east-northeast of Mount Thomas.
Neg. M/1412/26.

Fig. 56: Xenoliths rimmed with hematite in massive porphyritic microadamellite of Warimbi Schist. Same locality as Fig.55. Scale 15 cm
Neg. M/1412/28.

phenocrysts of partly weathered feldspar were, however, observed at a few localities. The Schist approximates an adamellite in chemical composition (Table 5), but is richer in iron and magnesium, and has lost nearly all its sodium and calcium. These losses preclude the calculation of any meaningful S.I. index.

The relations, form, petrographic textures, chemical composition, and presence of xenoliths of country rock (Figs 55, 56) show that the Warimbi Schist originated as a lopolith of porphyritic microadamellite. The time of emplacement is not known exactly; a single sample of muscovite from the Schist gave a K-Ar date of 1370 m.y. (Lowder & Webb, 1972), but this dates only the retrogressive metamorphism or an even younger event, because of the widespread disturbance of all K-Ar isotopic clocks in the Arunta Block during the Carboniferous Alice Springs Orogeny. The lopolith is younger than the Reynolds Range Group, of Early or Middle Proterozoic age, but appears to have been deformed and retrogressively metamorphosed simultaneously with the Reynolds Range Group, which was subsequently intruded by the Mount Airy Orthogneiss and Napperby Gneiss. The latter has given an imprecise Rb-Sr whole-rock isochron date of 1600-1500 Ma, and so the lopolith is older than this, and is probably Middle Proterozoic.

Unnamed granite (Eg) (A.J.S. and L.A.O.)

Unnamed granite includes all those granites which have not been assigned to any named granite unit. It occurs in all the 1:100 000 and 1:250 000 Sheet areas included in this survey. In general, it forms low rounded hills, pavements, or piles of spheroidal boulders.

In REYNOLDS RANGE, unnamed granite crops out north of the Giles Range and southwest of the Yundurbulu Range. It contains microcline phenocrysts up to 1.5 cm (40%), quartz (25-30%), sericitised and saussuritised plagioclase (15%), muscovite (7%), biotite (3%) containing zircon, and minor fluorite and apatite (72920743). The granite is distinguished by the alignment of feldspar laths, and probably intrudes the Mount Stafford beds, although no contact is seen. It has a similar appearance to the porphyritic border phase of the Anmatjira Orthogneiss about 4 km southeast of Mount Stafford.

Table 5: Results in percent of chemical analysis of four samples of Warimbi Schist.

| Sample no.* Locality | 0407 5454-773317 | 0432 5453-815249 | 0439 5453-800254 | 0654 5453-757343 | Average** adamellite |
|---|---|---|---|---|---|
| $SiO_2$ | 69.97 | 70.23 | 71.15 | 70.08 | 69.15 |
| $TiO_2$ | 0.72 | 0.67 | 0.59 | 0.73 | 0.56 |
| $Al_2O_3$ | 13.46 | 13.53 | 12.07 | 14.53 | 14.63 |
| $Fe_2O_3$ | 2.16 | 1.41 | 1.26 | 3.87 | 1.22 |
| FeO | 4.15 | 3.40 | 4.83 | 1.56 | 2.27 |
| MnO | 0.04 | 0.03 | 0.04 | 0.01 | 0.06 |
| MgO | 1.70 | 1.81 | 3.47 | 1.67 | 0.99 |
| CaO | 0.21 | 0.27 | 0.26 | 0.17 | 2.45 |
| $Na_2O$ | 0.32 | 2.85 | 0.00 | 0.16 | 3.35 |
| $K_2O$ | 4.24 | 2.92 | 2.25 | 4.14 | 4.58 |
| $P_2O_5$ | 0.21 | 0.15 | 0.19 | 0.22 | 0.20 |
| $H_2O^+$ | 2.01 | 1.55 | 3.28 | 2.80 | 0.54 |
| $H_2O^-$ | 0.15 | 0.23 | 0.12 | 0.20 | - |
| $CO_2$ | 0.05 | 0.05 | 0.05 | <0.05 | - |
| $SO_3$ | - | - | - | - | - |
| Total | 99.39 | 99.11 | 99.56 | 100.24 | 100.00 |

* Preceded by 7292

** Nockolds (1954)

Amdel Rept. AN4846/74

In TEA TREE, granite crops out in the southwest, where it intrudes the Woodforde River beds. The rock is foliated, and contains numerous round nodules up to 7 cm across of tourmaline + garnet in leucocratic pegmatitic parts of the granite. A tongue of foliated granite which is largely retrogressed to orthoschist intrudes the Lander Rock beds in the southwest of TEA TREE, and extends south into AILERON. Other outcrops of granite intrude the same beds in the north of TEA TREE.

Elsewhere in AILERON, granite forms numerous lenticular masses ranging from 0.5 km to 10 km in length. Most of the lenses parallel the regional northwest or north-northwest trend of the surrounding Lander Rock beds or Mount Freeling or Mount Dunkin schists. Small bodies of granite have been mapped in association with felsic and mafic granulites of the Aileron metamorphics 7 km south and southwest of Aileron. Granodiorite forms a discrete body 4 km south of Aileron, and is rich in biotite. It also contains strongly aligned feldspar phenocrysts and small dark xenoliths. Unnamed granite also crops out extensively in the south of AILERON, but in general is poorly exposed. The unit is mostly coarse-grained granitic gneiss including augen and banded varieties, and subordinate amounts of granite.

Unnamed granitic gneiss and gneissic granite in the northeast of DENISON extend east into the northwest of REYNOLDS RANGE, and north into the southern part of the Mount Peake 1:250 000 Sheet area. The rocks are medium to coarse-grained, strongly foliated, and contain both biotite and muscovite. The unit is intruded by pegmatite, aplite, and quartz-magnetite veins, and includes amphibolite bodies and thin layers of calc-silicate rock (74920827). Adjacent to the Giles Range, the unit is a schistose muscovite-biotite gneissic granite, and contains micaceous xenoliths. Granite north and northwest of Naval Action Dam, and in the adjacent Mount Peake Sheet area to the north, is strongly foliated, and contains ovoid to subhedral feldspars up to 3 cm long. The feldspars comprise a colourless translucent core and an opaque white mantle. One kilometre north of Naval Action Dam, the gneissic granite has a concordant contact against laminated quartzofeldspathic gneiss of unit p$\Theta$f.

Several small outcrops of unnamed granite have been mapped in the northwest of DENISON. Anatectic granite is exposed at GR5353-951584,

Fig. 57a: Foliated cordierite-bearing granite containing lenticular xenoliths of pelitic hornfels of Mount Stafford beds. GR5353-005592, 10 km north of Mount Denison homestead.

Neg. M/1781/4

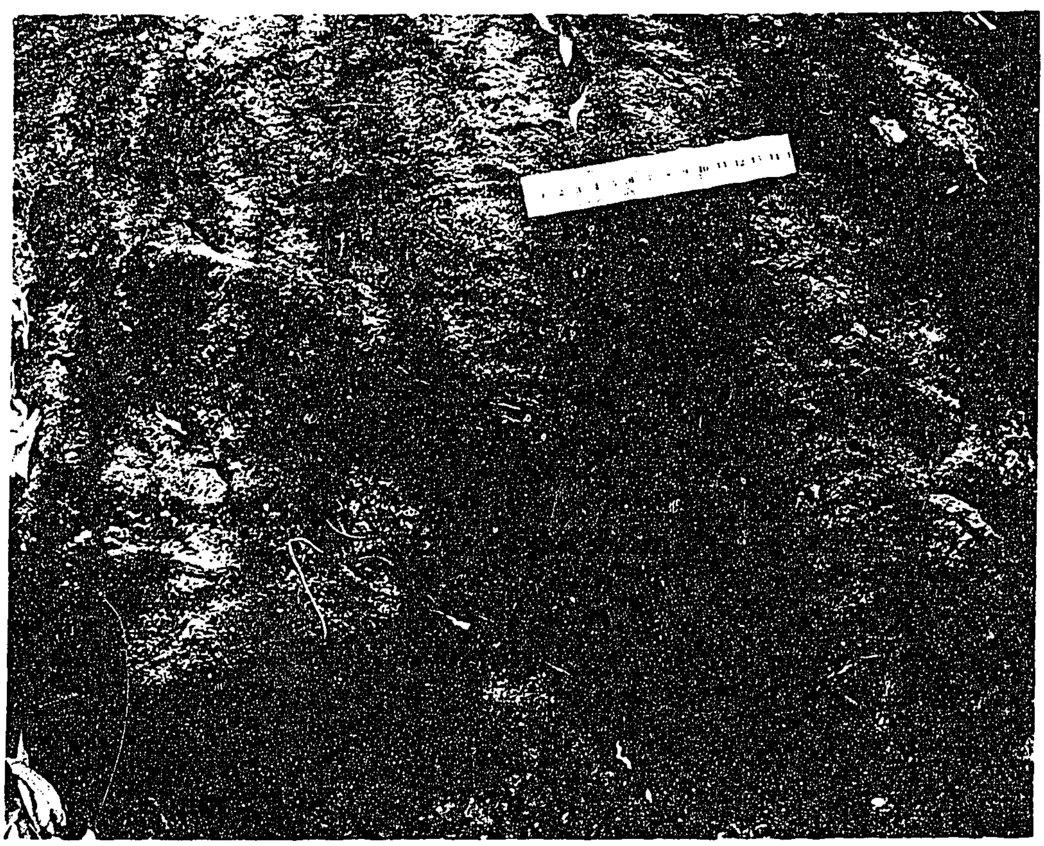


Fig. 57b: As above, same locality. Neg. M/1781/2

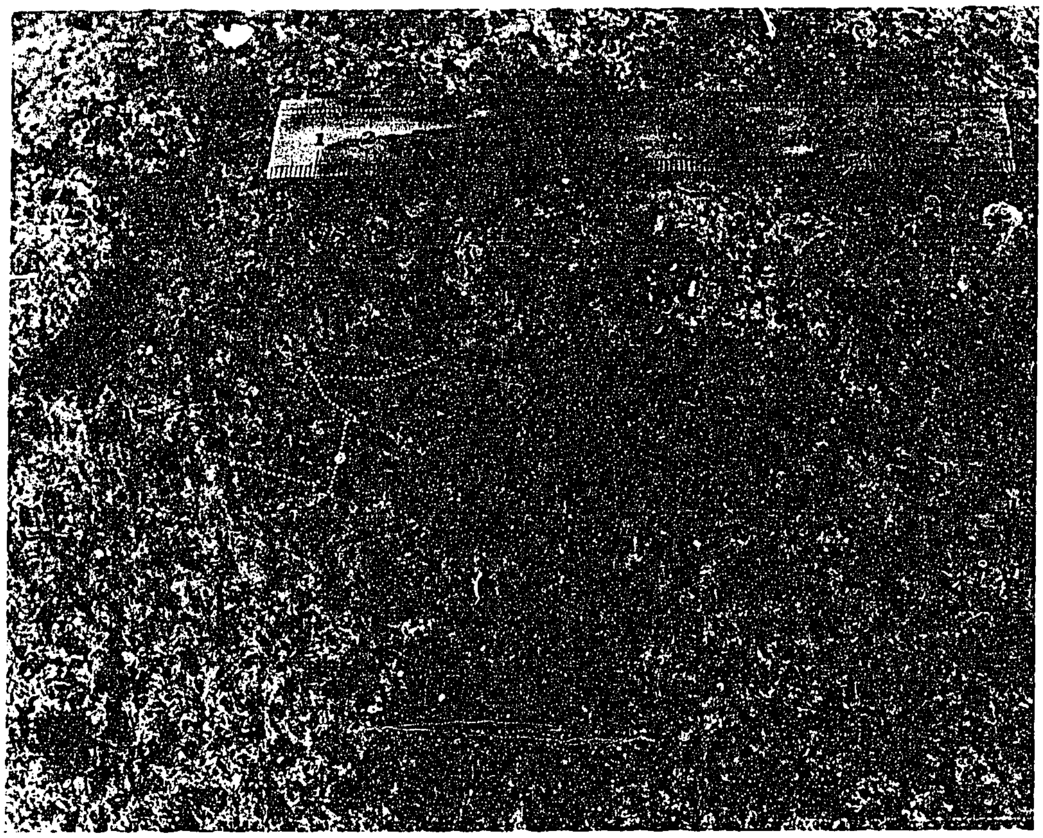


Fig. 58: Leucogranite with mantled feldspars, GR5353-030060, 6.5 km northwest of Beantree Dam.

Neg. M/1781/8

Fig. 59: Zoned hornfels xenolith in leucogranite of Fig. 58; full description in text.

Neg. M/1781/12

10 km north-northwest of Mount Denison homestead, on the western side of a prominent hill of pelitic granulite. The rock is brown, coarse-grained, weakly foliated, and composed of poikiloblastic microcline (45%), quartz (29%), cordierite (10%) which in places is pinitised and elsewhere converted to a yellow isotropic substance, myrmekitic andesine (8%; $An_{45}$), biotite (5%) intergrown with sillimanite (2%), anhedral garnet (1%), and accessory rounded zircon (74920655A). The granite contains small xenoliths composed of sillimanite and biotite, patches of coarse pegmatitic material, and occasional megacrysts of potassium-feldspar. In places dark schlieren are present, and grade into layers. The rock has formed by partial melting of the adjacent pelitic granulite, and the cordierite, sillimanite, and garnet grains are probably refractory xenocrysts. A similar anatectic cordierite-bearing granite forms large tough boulders surrounded by hornfels of the Mount Stafford beds at GR5353-005592, 8.5 km west-northwest of Beantree Dam. The rock is faintly layered, and contains lenticular xenoliths of metapelitic hornfels (Fig. 57a, b) and large megacrysts of pale yellow potassium feldspar. In places it is retrograded to biotite-quartz-sericite rock, with remnants of oligoclase and small "shard-shaped" grains of quartz in the sericite (74920851B).

Tourmaline-garnet-biotite leucogranite (74920854A) forms a small body at GR5353-030600, 6.5 km northwest of Beantree Dam, and intrudes quartzite and cordierite hornfels of the Mount Stafford beds to the north. The rock contains mantled feldspars (Fig. 58), and zoned xenoliths of hornfels. In one xenolith (Fig. 59) (74920854B), the core consists of garnet, sillimanite, biotite, microcline, and cordierite; the rim is similar, but lacks garnet. The adjoining granite is contaminated with garnet, sillimanite, and cordierite xenocrysts.

Adamellite and trondhjemite form a prominent hill (GR5353-910517) on the western edge of DENISON, 8 km west-northwest of Mount Denison homestead. Most of the hill is composed of pale medium-grained, very tough biotite adamellite with a micrographic intergrowth of quartz and microcline. The rock contains a large assortment of accessory minerals including metamict allanite, orange monazite, euhedral tourmaline, epidote, clinozoisite, zircon, muscovite, apatite, and opaque grains (74920693A). The trondhjemite forms narrow elongate rafts and xenoliths in the adamellite; it consists of subhedra of plagioclase ($An_{50}$ core; $An_{38}$ rim), some of which are partly recrystallised to mosaics of small indistinct grains, quartz which is also partly recrystallised, abundant biotite, and blue-green hornblende (74920693B).

Melagranodiorite, leucogranite, and rapakivi granite together form a composite body 5 km west of Beantree Dam, in DENISON. The melagranodiorite (Fig. 60) is a handsome black and gold rock, coarse-grained, and contains xenoliths of hornfels of the adjacent Mount Stafford beds at GR5353-034573 (E862). The melagranodiorite contains abundant biotite, coarse red-brown garnet, and the plagioclase is calcic andesine ($An_{46,\ 49}$) (74920859, -0862A). The leucogranite is coarse-grained, and contains muscovite and fine garnet. The plagioclase is sodic andesine ($An_{30,\ 32}$) (74920860, -0862B). The rapakivi granite is coarse-grained and muscovite-bearing (74920863); the mantled feldspars are ovoid and up to 1.5 cm long. The relationships of the melagranodiorite and leucogranite are equivocal; at GR5353-038576, the melagranodiorite contains several xenoliths of the leucogranite, whereas at GR-34573 the melagranodiorite is intruded by the leucogranite. The rapakivi granite contains xenoliths of the leucogranite at sample locality E863 (GR5353-032569).

Medium to coarse-grained muscovite-biotite granite forms a discrete body 2 km northeast of Beantree Dam. The rock is weakly foliated, contains a few dark xenoliths and is cut by numerous veins of aplite. The veins are contorted in places, and displaced by up to 15 cm along early healed joints.

Porphyritic granite in the southern part of DENISON, is well exposed only at a locality 6 km northeast of Smiths Gift Bore. Here, the rock is blue-grey, fresh, tough, and contains numerous equant euhedral to subhedral phenocrysts of potassium feldspar which are aligned in a platy or linear flow structure. Xenoliths are abundant, and similarly aligned. The ock contains prominent grains of allanite (74920905A). Aeromagnetic data suggest that granite crops out extensively below Cainozoic cover in the southern part of DENISON, and is so shown on the 1:500 000 scale 'Interpretation of Pre-Cainozoic Geology' map beside the Denison 1:100 000 sheet.

Fig. 60: Melagranodiorite containing hornfels xenoliths, GR5353-034573, 5 km west of Beantree Dam.

Neg. M/1781/22

Unnamed granite crops out along the western margin of the Uldirra Porphyry, in the south of DENISON. The western part of the granite is massive, has a grainsize at the lower end of the coarse-grained scale, and contains numerous small dark equant to elongate xenoliths. Thin-section examination (74920901) suggests the rock is a granodiorite (with sphene and allanite), and it is so mapped. Chemical analysis of the same sample (Table 6), however, indicates it is an adamellite. The remainder of the body is mapped as granite. At the northern end (locality 74920902), the rock is a massive, coarse-grained, deuterically altered micrographic leucogranite containing clots of tourmaline up to 2 cm across (-0902A). A chemical analysis of this rock is presented in Table 6. Unnamed granite (-0933) forms a small body below deeply weathered cappings in the northern part of the Uldirra Porphyry, and its analysis appears in Table 6 also. These two bodies may be related to the Uldirra Porphyry, and this is supported by the roughly comparable S.I. indices of the unnamed granite (1.07, 1.07, 1.06) and Uldirra Porphyry (1.03).

In MOUNT PEAKE, unnamed granite unconformably underlying the Vaughan Springs Quartzite of the Nanga Range is strongly foliated in most exposures. It generally consists of quartz grains in a chlorite-biotite-muscovite matrix, or elliptical bodies of recrystallised feldspar lying in a foliated quartz granule and sericitic matrix. Less deformed outcrops of granite consist of feldspar phenocrysts in a biotite-feldspar-quartz matrix. Dark grey quartz-rich xenoliths are common in parts of the granite. A sliver of black slate (72110146) about 40 m long is enclosed by granite on the eastern side of the Nanga Range.

East of the Nanga Range, larger bodies of granite crop out. They are commonly porphyritic, and consist of perthitic microcline phenocrysts, plagioclase, strained quartz, biotite, and minor fluorite, apatite, muscovite, zircon, epidote, and opaque minerals (72110149). Biotite is partly altered to chlorite, plagioclase is saussuritised and sericitised, and ilmenite is partly altered to sphene. The granite has been deformed and retrogressively metamorphosed.

North of the Mau Hills, foliated granite consists of perthitic microcline, strongly sericitised and saussuritised sodic plagioclase,

Table 6: Results of chemical analysis of three samples of Unnamed Granite from DENISON. Major oxides in percent; trace elements in ppm.

| Sample no.* | 0901 | 0902A | 0933 |
|---|---|---|---|
| Locality | 5353-145271 | -170265 | -221254 |
| $SiO_2$ | 70.3 | 74.4 | 78.0 |
| $TiO_2$ | 0.50 | 0.35 | 0.17 |
| $Al_2O_3$ | 13.2 | 12.6 | 12.2 |
| $Fe_2O_3$ | 0.82 | 0.62 | 0.02 |
| FeO | 3.15 | 1.45 | 0.25 |
| MnO | 0.04 | 0.01 | <0.01 |
| MgO | 0.63 | 0.48 | 0.14 |
| CaO | 1.71 | 1.00 | 0.29 |
| $Na_2O$ | 2.35 | 2.68 | 4.88 |
| $K_2O$ | 5.33 | 5.34 | 2.98 |
| $P_2O_5$ | 0.14 | 0.11 | 0.10 |
| $H_2O^+$ | 1.00 | 0.91 | 0.29 |
| $H_2O^-$ | 0.10 | 0.05 | 0.05 |
| $CO_2$ | 0.10 | 0.05 | 0.05 |
| $SO_3$ | 0.01 | <0.01 | <0.01 |
| Total | 99.4 | 100.1 | 99.4 |
| S.I. index | 1.07 | 1.07 | 1.06 |
| Li | 25 | 5 | 5 |
| Be | 3 | 4 | 2 |
| B | 20 | 10 | 20 |
| F | 1300 | 900 | 340 |
| Co | 54 | 66 | 76 |
| Ni | 4 | 4 | <2 |
| Zn | 56 | 18 | 13 |
| Rb | 340 | 300 | 160 |
| Sr | 70 | 55 | 36 |
| Y | 55 | 50 | 40 |
| Sn | 10 | 14 | 20 |
| Ba | 740 | 620 | 410 |
| W | <10 | 15 | <10 |
| Th | 34 | 36 | 32 |
| U | 4 | 12 | 16 |

* Preceded by 7492

Analyses by Amdel Rept AN3095/77

recrystallised quartz, biotite, and minor apatite, chlorite, muscovite, and sphene-rimmed opaques (72110152). The foliation is caused by the preferential alignment of elongated quartz grains. Parts of the granite are strongly porphyritic with feldspar crystals reaching 5 cm long. Fine-grained biotite-quartz-feldspar xenoliths are aligned with their longest axes parallel to the granite foliation.

Granite northeast of the Mau Hills (near Liechhardt Bore) consists of large strained quartz grains (up to 5 mm length) and smaller polygonal quartz grains (0.2 mm across), perthitic microcline, plagioclase, biotite, and minor muscovite and apatite (72110153). Biotite has marginally altered to chlorite, and the plagioclase cores are commonly sericitised and saussuritised. Shear zones cutting the granite have produced phyllonite. The granite contains numerous fine-grained biotite-rich xenoliths. Dykes of aplite and feldspar porphyry intrude the granite.

In the southeastern part of the Mount Peake 1:250 000 Sheet area, the unnamed granite is generally medium to fine-grained and leucocratic. It commonly contains abundant coarse muscovite, and is usually strongly weathered, especially underneath the Amesbury Quartzite Member. On the northeast slope of Mount Judith, the granite is mixed with and intrusive into biotite gneiss and migmatite. In the Central Mountain area, the granite forms only small bodies, and is accompanied by abundant pegmatite. At Black Hill, the granite consists of altered sodic plagioclase and perthitic microcline (together 56%), quartz (30%), chloritised biotite (7%), hornblende (7%), epidote, zircon and allanite (74110197). A xenolith in this granite consists of fine-grained hornblende (40%), plagioclase (30%), quartz (15%), biotite (10%), epidote, clinozoisite, sphene, and microcline.

Immediately north of Conical Hill and west of Mount Rennie, in the centre of the Mount Peake Sheet area, medium-grained granite is bleached and silicified, and forms dissected, flat-topped exposures about 5 m high, capped by silcrete scree (74110210) and surrounded by an apron of white angular quartz sand. The granite consists of tourmaline, muscovite, quartz, biotite, and silicified clay after feldspar. Porphyritic granodiorite crops out on the northeast flank of an amphibolite outcrop at GR30356320, 15 km northeast of Conical Hill. It consists of sericitised plagioclase laths up to 1.5 cm long in a fine-grained quartz-feldspar-biotite groundmass (-0218). About 2 km east of Conical Hill, porphyritic granite intrudes and thermally metamorphoses Lander Rock beds.

Deformed and partly retrogressed fine to medium-grained granite crops out in the north of the Mount Peake 1:250 000 Sheet area, and in places is cut by granite dykes. The rock consists of microcline (perthitic in places; 35%), recrystallised quartz (35%), sericitised and saussuritised plagioclase (25%), partly chloritised biotite (5%), muscovite (up to 4%), and minor zircon and apatite (74110183, -0184). Xenoliths of fine-grained biotite-quartz-plagioclase rock are common at sample locality 183.

In the Mount Theo 1:250 000 Sheet area, muscovite granite crops out on the flanks of the Wabudali Range, and intrudes the Lander Rock beds and Reynolds Range Group. Deformed and retrogressed granite (72110314B) is exposed adjacent to the major quartz-filled fault forming Mount Campbell.

Unnamed granite crops out in the central and southern parts of the Mount Solitaire and Lander River 1:250 000 Sheet areas, respectively, and intrudes the Lander Rock beds at a number of localities. At East Granites, in the west of the Mount Solitaire Sheet area, porphyritic unnamed granite is intruded by The Granites Granite. In the Mount Solitaire Sheet area, the granite is strongly foliated, and contains phenocrysts of microcline and sodic plagioclase; the phenocrysts are up to 8 cm long on the northeast margin of the granite area (e.g. sample localities 472, 494, and 496). To the southwest (e.g. localities 468, 486, and 505), the granite is less foliated, and feldspar phenocrysts reach only 2 cm long. Fine to medium-grained granite crops out in the south of the Lander River Sheet area, and locally contains feldspar phenocrysts are up to 3 cm long. Adjacent to the Jarra Jarra Range, in the southeast, gneissic muscovite granite contains feldspar augen up to 2 cm long. In both Sheet areas the granite is deformed and retrogressed; plagioclase is partly saussuritised and sericitised, biotite is partly altered to chlorite, quartz is recrystallised, and some plagioclase twin lamellae are deformed. The granite commonly contains xenoliths of fine to medium-grained biotite-quartz-feldspar rock, up to about 1 m in length.

Because of the isolated nature of the outcrops and the lack of contact with other units, the age or ages of the various granite types assigned to the unnamed Granite is generally unknown; the unit may comprise several granites of different ages. At East Granites, The Granites Granite has been dated at 1742 +23 Ma (Offe & Kennewell, 1978), and so the unnamed granite at this locality is Middle Proterozoic or older.

Unnamed granite (Ᵽg$_1$) (A.J.S.)

This granite forms prominent bouldery hills at the southeastern end of the Anmatjira Range. It adjoins and presumably intrudes the Tyson Creek granulite, although the field relationship of the two rocks was not observed. The rock is a pale grey, very coarse-grained gneissic augen granite with ovoid megacrysts of feldspar, abundant red garnet, and black mica visible in hand specimen; a few euhedral megacrysts of feldspar are also present.

The rock consists of perthitic potassium feldspar with a moderate 2V (microcline) in sample 71921037, and a very low 2V (sanidine) in sample 72921004, quartz which is strained and partly recrystallised, antiperthitic andesine ($An_{44}$) which is bent and fractured and forms myrmekite where it touches potassium feldspar, red-brown biotite in streaky aggregates, and garnet in large anhedral blebby poikiliths; cracks in the garnet are filled with pale green to yellow biotite. Accessary minerals include opaque iron oxide, rounded zircons, and large grains of apatite. A third sample of the granite (71921039) contains abundant hypersthene rimmed with biotite, but no garnet. The opaque iron oxide in this sample is also rimmed and crusted with fine-grained biotite. The potassium feldspar has a very low 2V (sanidine). The rock is a charnockite, but in other respects, such as grain-size, texture, and proportions of major minerals, it is similar to samples -1037 and -1004.

Results of chemical analysis of one sample of the granite are set out in Table 7.

Table 7: Results in percent of chemical analysis of one sample of unnamed granite $Bg_1$. Major oxides in percent; trace elements in ppm.

| | |
|---|---|
| Sample no. | 72921004 |
| Locality | 5553-068231 |
| $SiO_2$ | 69.3 |
| $TiO_2$ | 0.45 |
| $Al_2O_3$ | 15.5 |
| $Fe_2O_3$ | 0.32 |
| FeO | 2.40 |
| MnO | 0.03 |
| MgO | 0.84 |
| CaO | 1.98 |
| $Na_2O$ | 2.03 |
| $K_2O$ | 6.64 |
| $P_2O_5$ | 0.12 |
| $H_2O^+$ | 0.21 |
| $H_2O^-$ | 0.01 |
| $CO_2$ | 0.05 |
| $SO_3$ | <0.01 |
| Total | 99.9 |
| S.I. index | 1.12 |
| Li | 25 |
| Be | 1 |
| B | 5 |
| F | 600 |
| Co | 52 |
| Ni | <4 |
| Zn | 53 |
| Rb | 260 |
| Sr | 130 |
| Y | 30 |
| Sn | <4 |
| Ba | 1050 |
| W | <10 |
| Th | 26 |
| U | <4 |

Analysis by Amdel Rept AN3095/77

The presence of garnet and hypersthene in this granite indicates a deepseated origin in a granulite-facies environment, when regional metamorphism was most intense. The S.I. index (1.12) and abundance of garnet indicate an origin by melting of sedimentary rocks. The hypersthene may have formed by reaction of the garnet with early-formed feldspathic melt (cf. Edwards, 1936). Both the hypersthene and garnet granites are retrogressively metamorphosed; hypersthene, garnet, and primary iron oxide are partly altered to biotite, primary biotite contains exsolved particles of iron oxide, and quartz is partly recrystallised.

The granite (sample 72921004) has given a Rb-Sr whole-rock date of 1424 ± 58 Ma (Middle Proterozoic) with a $^{87}Sr/^{86}Sr$ initial ratio of 0.745.

Anmatjira Orthogneiss (Bga) (A.J.S.)

The Anmatjira Orthogneiss is the coarse-grained granitic augen gneiss which crops out along the entire length of the Anmatjira Range (whence the name), in REYNOLDS RANGE and TEA TREE, and on the northern flank of the Yundurbulu Range in the southern part of MOUNT PEAKE. The Orthogneiss forms rugged hills, which rise to 200 m above the surrounding alluvial plains, and show the rounded tors and extensive domal surfaces typical of granitic terrain (Fig. 61).

The Anmatjira Orthogneiss intrudes the Lander Rock beds along the southern flank of the Anmatjira Range, the Mount Stafford beds in the southern part of the Yundurbulu Range, and the Weldon metamorphics, Tyson Creek granulite, and probably the Possum Creek Charnockite in the south-eastern part of the Anmatjira Range. The Orthogneiss is intruded by vein quartz and by dykes of pegmatite, aplite, microgranite, and amphibolite.

The type locality of the Anmatjira Orthogneiss is at Ingallan Spring (GR5453-793496) on the northern side of the Anmatjira Range. Here, the Orthogneiss is well exposed as clean rock bars in the bed of the creek, cut by dykes of pegmatite and aplite (Fig. 62).

The Anmatjira Orthogneiss is a coarse-grained grey granitic augen gneiss. It is everywhere foliated (Fig. 62) and usually also lineated, except at the northwestern end of the Yundurbulu Range (Fig. 63). It consists essentially of microcline, plagioclase, quartz, biotite, and

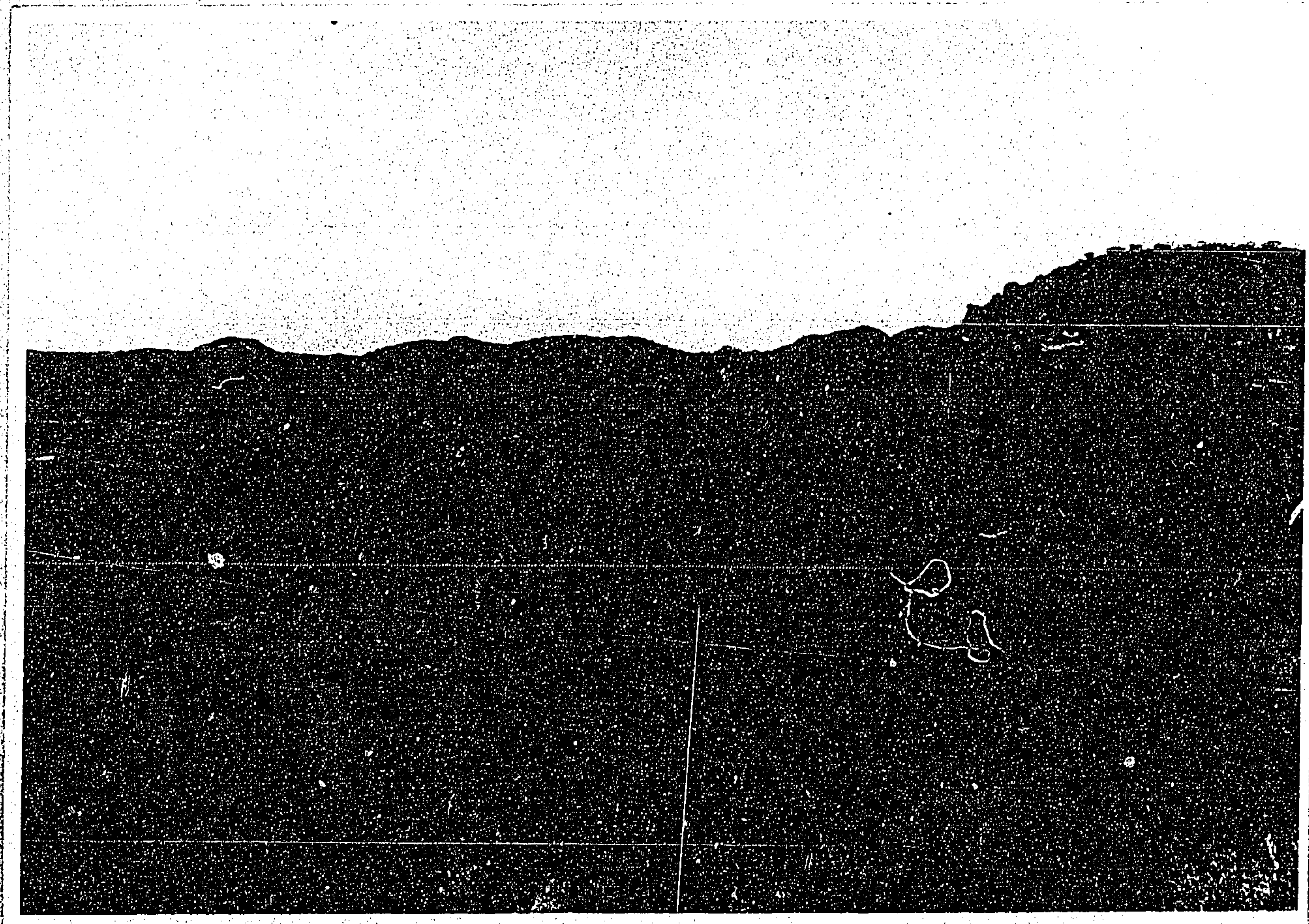


Fig. 61: Typical landscape in Anmatjira Orthogneiss, showing Orthogneiss hills rising abruptly out of alluvial plain. GR5453-863455, 8 km east-southeast of Ingallan Spring.

Neg. M/1346/4.

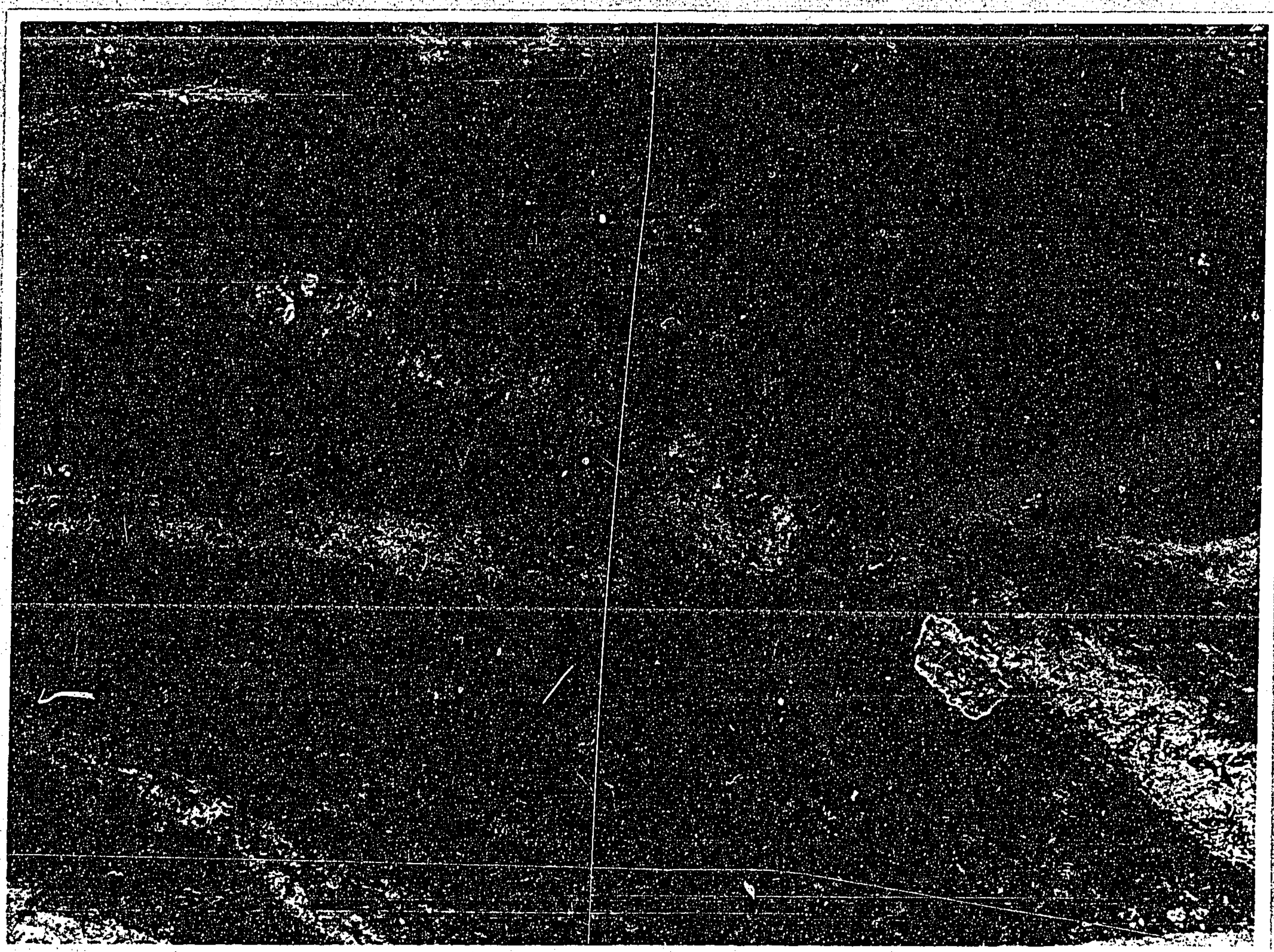


Fig. 62: Anmatjira Orthogneiss at type locality at Ingallan Spring, showing coarse-grained foliated augen gneiss cut by vein of coarse feldspar (directly above hammer), then by vein of pegmatite with core of quartz and tourmaline. GR5453-794499.

Neg. M/1412/63.

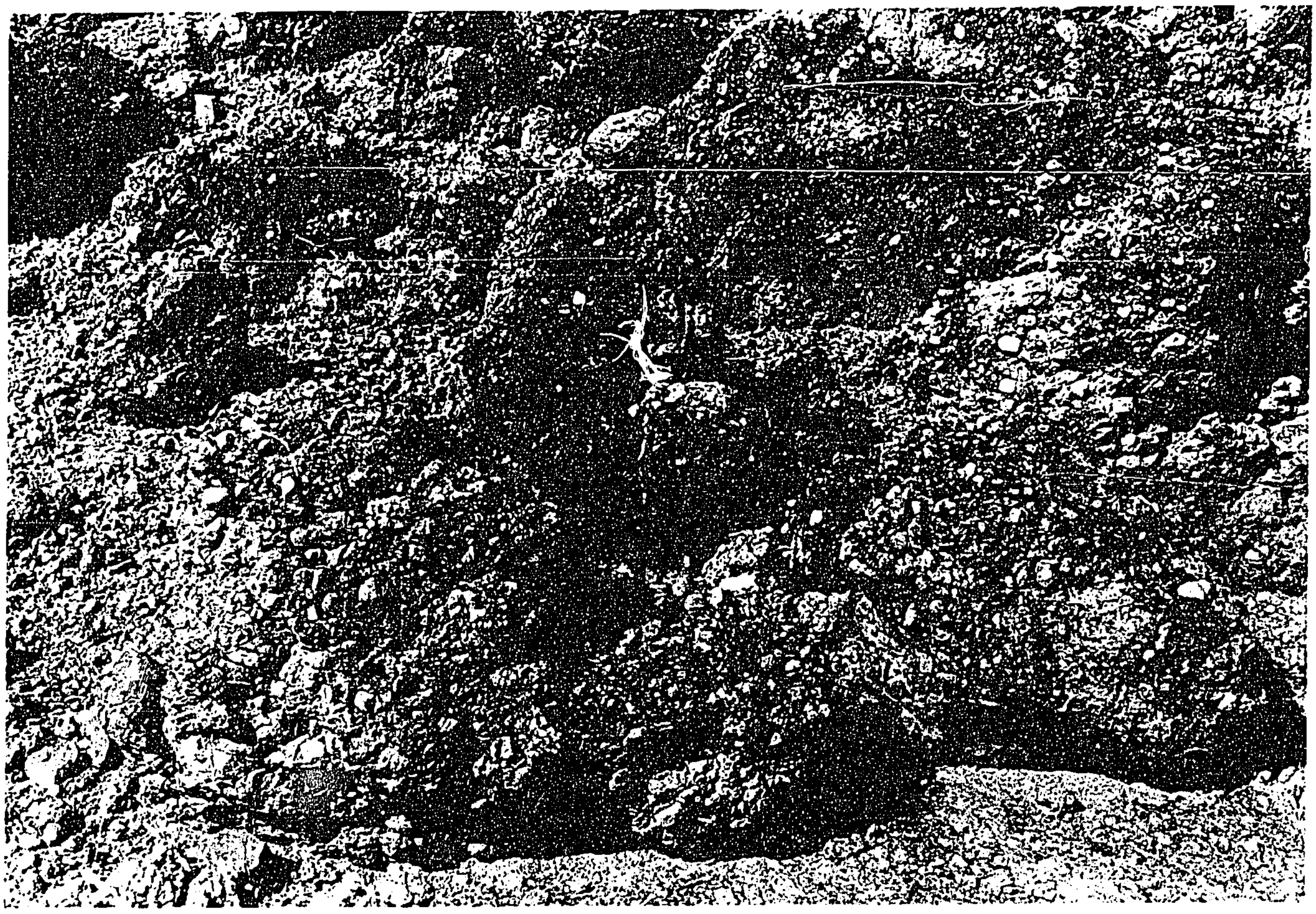


Fig. 63: Massive rapakivi granite at northwestern end of Anmatjira Orthogneiss, showing large potassium feldspar ovoids (5 cm diameter) weathering out. GR5454-485722, 6 km southwest of Leichhardt Bore. Neg. M/1342/74.

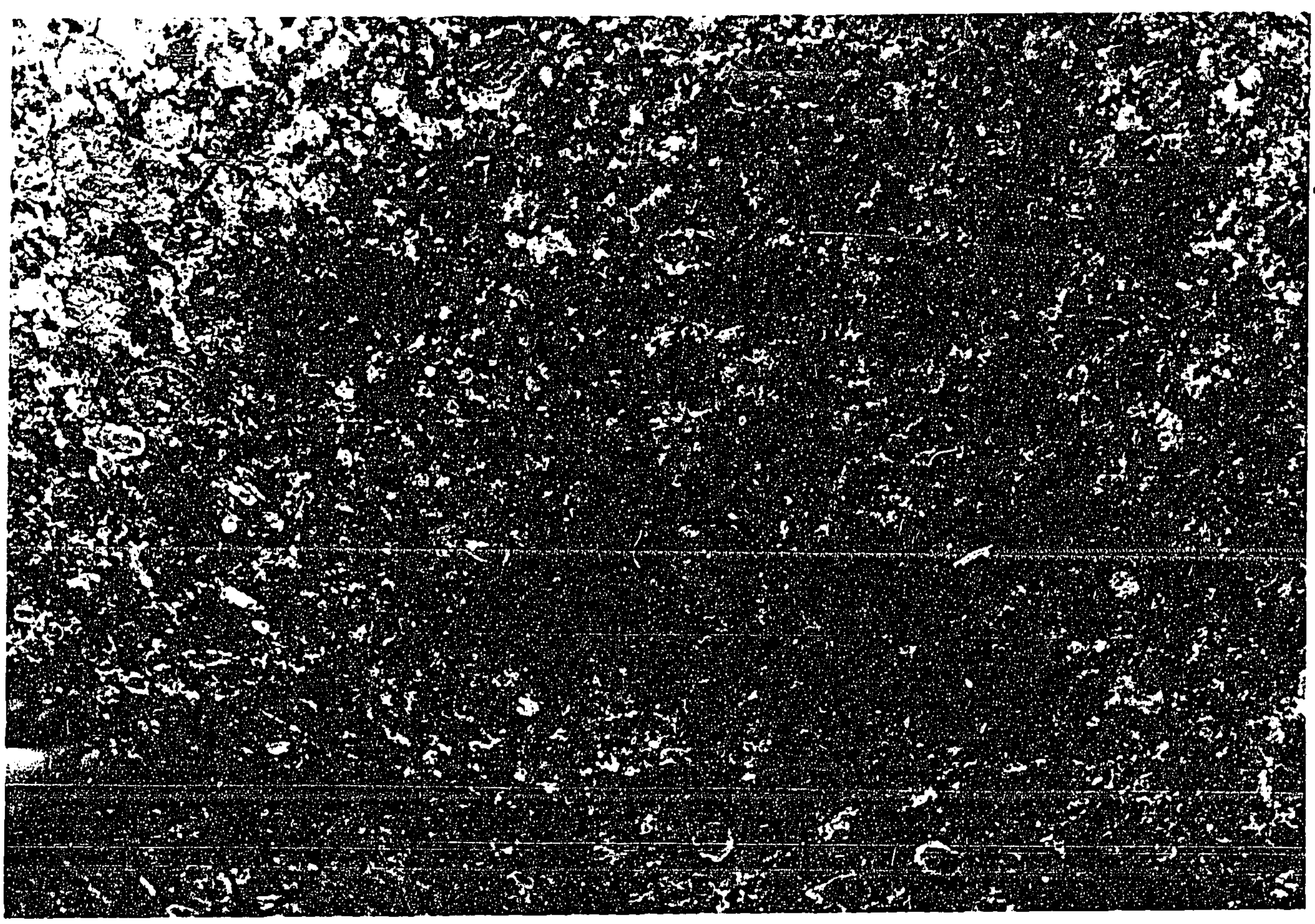


Fig. 64: As above, same locality, showing large ovoids of potassium feldspar, and smaller mantled feldspars comprising kernels of potassium feldspar (dark grey) and shells of sericitised plagioclase (white) Scale 15 cm Neg. M/1342/64.

muscovite; zircon, tourmaline, apatite, ilmenite, allanite, and fluorite are accessory; sericite, clinozoisite, epidote, chlorite, and sphene are secondary (72110203, -0204, -0205, 72920516, -0520, -0521, -0550, -0555A).

Microcline is present as two varieties. In the first variety, it forms large round ovoids up to 10 cm long (Fig. 64), with concentric growth rings outlined by thin layers of sericitised plagioclase, and containing small inclusions of biotite. Many of the ovoids show Carlsbad twinning. In the second variety it forms the cores of subhedral mantled feldspars up to 2.5 cm long, mantled by sericitised plagioclase (Fig. 64). At GR5453-690516, 6 km north of Lander Bore, the mantled feldspars show only partial shells of plagioclase, and these grade into (or from) discrete inclusions of plagioclase inside the cores of microcline (Fig. 65).

Plagioclase also forms white to very pale green subhedral grains between the ovoid and mantled feldspars. The plagioclase is commonly brecciated, and substantially altered to sericite and clinozoisite.

Quartz is everywhere deformed, ranging from strong undulatory extinction to extreme flattening of the grains into ribbons; the grains are partly or completely recrystallised to fine-grained mosaic aggregates of small polygonal strain-free grains.

Biotite and muscovite are commonly found together in streaky elongate aggregates. The biotite is generally altered to chlorite, and is associated in places with epidote.

The various accessory minerals differ in abundance from place to place. Zircon is concentrated in biotite, and is everywhere partly or completely altered to an isotropic material. Tourmaline is blue-green, yellow-brown, or greenish-brown, and forms skeletal anhedra. Apatite is abundant in some specimens, and forms clear colourless broken euhedra. Ilmenite forms thin opaque rods encrusted with sphene. Allanite was seen in only one thin section, and was altered to a brown isotropic substance. Fluorite was also seen in only one sample, and occurred as colourless to purple anhedral masses.

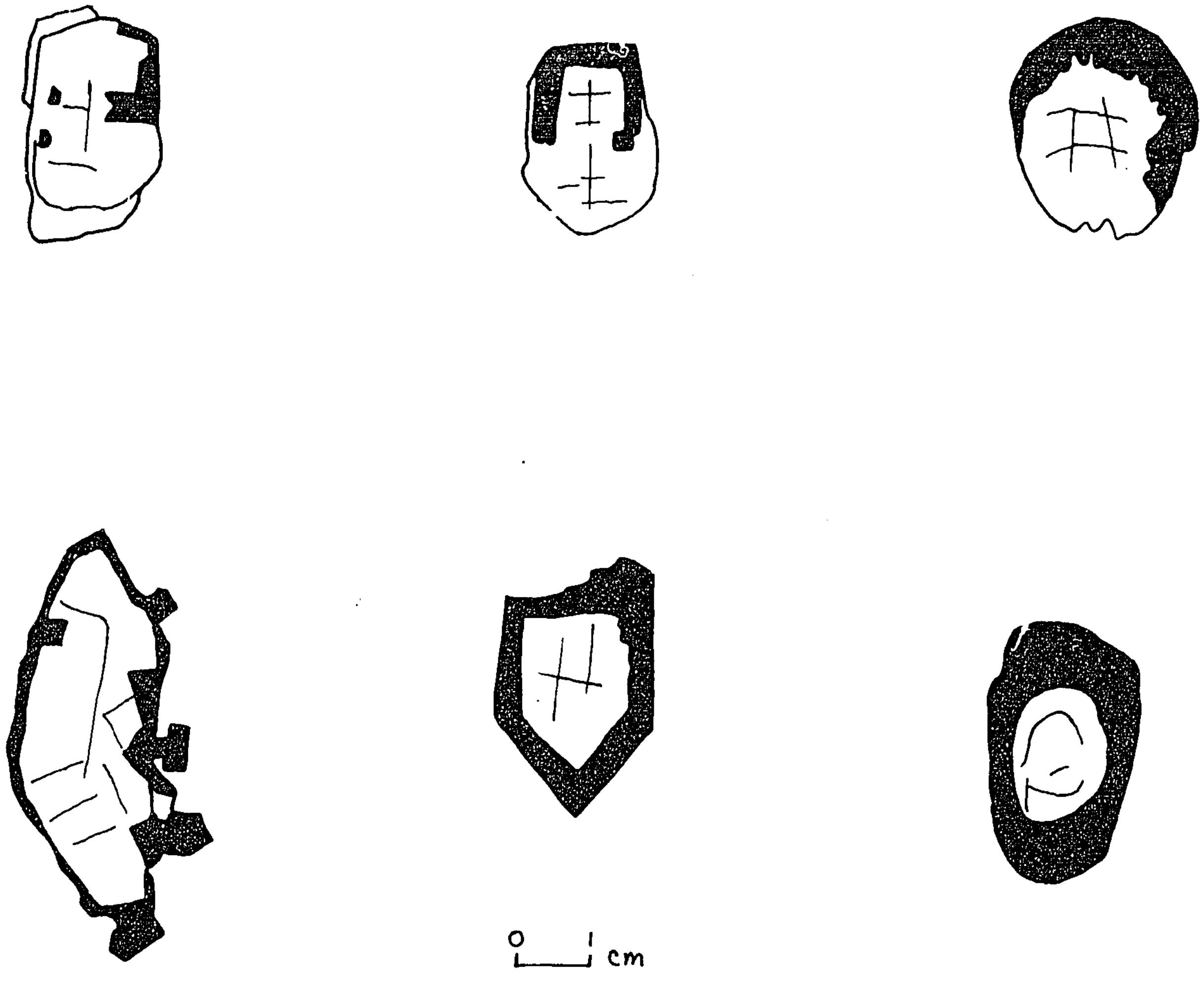



Fig. 65 : Sketches of mantled feldspars in Anmatjira Orthogneiss, showing partial and complete shells of plagioclase (black) around kernels of microcline. GR 5453-698519, 14 km northeast of Mount Gardiner, REYNOLDS RANGE.

Table 8: Results of chemical analysis of five samples of Anmatjira Orthogneiss. Major oxides in percent; trace elements in ppm

| Sample no. Locality | *0204 5454-484722 | *0205 5454-552702 | **0521 5453-795497 | **0550 5453-899450 | **0555A 5453-910422 |
|---|---|---|---|---|---|
| $SiO_2$ | 71.6 | 70.6 | 74.0 | 73.6 | 71.3 |
| $TiO_2$ | 0.44 | 0.54 | 0.40 | 0.39 | 0.35 |
| $Al_2O_3$ | 13.6 | 13.5 | 13.2 | 13.4 | 13.9 |
| $Fe_2O_3$ | 0.61 | 0.54 | 0.67 | 0.47 | 0.65 |
| FeO | 2.50 | 3.25 | 1.95 | 1.85 | 1.75 |
| MnO | 0.04 | 0.04 | 0.04 | 0.01 | 0.02 |
| MgO | 0.67 | 0.90 | 0.59 | 1.55 | 0.48 |
| CaO | 1.76 | 1.80 | 1.16 | 0.41 | 1.25 |
| $Na_2O$ | 2.30 | 2.07 | 3.45 | 5.02 | 2.31 |
| $K_2O$ | 5.46 | 5.53 | 3.31 | 2.11 | 6.83 |
| $P_2O_5$ | 0.12 | 0.12 | 0.12 | 0.10 | 0.11 |
| $H_2O^+$ | 0.54 | 0.81 | 0.72 | 0.83 | 0.50 |
| $H_2O^-$ | 0.04 | 0.03 | 0.06 | 0.03 | 0.04 |
| $CO_2$ | 0.05 | 0.05 | 0.05 | 0.11 | <0.05 |
| $SO_3$ | <0.01 | 0.04 | <0.01 | <0.01 | <0.01 |
| Total | 99.7 | 99.8 | 99.8 | 99.9 | 99.6 |
| S.I. index | 1.08 | 1.09 | 1.17 | 1.22 | 1.05 |
| Li | 85 | 55 | 65 | 8 | 12 |
| Be | 2 | 2 | 7 | 1 | 2 |
| B | 40 | 60 | 25 | 10 | 10 |
| F | 1900 | 1220 | 1580 | 700 | 1240 |
| Co | 62 | 74 | 50 | 64 | 40 |
| Ni | 12 | 14 | 30 | 14 | 12 |
| Zn | 66 | 62 | 45 | 28 | 39 |
| Rb | 460 | 340 | 410 | 190 | 400 |
| Sr | 70 | 75 | 60 | 14 | 65 |
| Y | 38 | 32 | 40 | 20 | 28 |
| Sn | 10 | 8 | 38 | 8 | 8 |
| Ba | 410 | 580 | 320 | 80 | 560 |
| W | <10 | <10 | <10 | <10 | <10 |
| Th | 44 | 44 | 55 | 44 | 38 |
| U | 8 | 10 | 12 | 8 | 4 |

* Preceded by 7211 ** Preceded by 7292

Analyses by Amdel Rept AN3095/77

Results of chemical analysis of five samples of Anmatjira Orthogneiss are shown in Table 8.

The Anmatjira Orthogneiss is cut by veins and dykes of pegmatite and aplite, and these are particularly abundant at the type locality at Ingallan Spring (Figs 62, 66). Many of the pegmatites are zoned, with cores of quartz and muscovite, and marginal zones of tourmaline and feldspar; the tourmaline forms prisms oriented at right angles to the walls of the dykes. Aplite is not as common as pegmatite. It too carries tourmaline, with yellow cores and blue-green rims (72110206), and garnet is present in aplite at Ingallan Spring. The aplite dykes are commonly folded (Fig. 67). A dyke of quartz and fluorite is located at sample locality 72920512 (GR5453-772518), 6 km south of Nintabrinna Bore.

Xenoliths in the Anmatjira Orthogneiss are of three main types:

Metasedimentary xenoliths (72920518, -0531, -0534, -0554) are the most common. They are dark grey, schistose, and many contain feldspar porphyroblasts, some of them mantled (Figs 68, 69). The margins are commonly cuspate (Fig. 69). Many xenoliths are intruded by folded quartz veins. The xenoliths consist essentially of quartz (35%), plagioclase (31%), microcline (23%), and biotite (11%); accessory amounts of apatite, ilmenite, muscovite, and detrital zircon and tourmaline are also present. The xenoliths, although slightly richer in biotite than the Anmatjira Granite, are made entirely of granitic minerals, and are in textural and chemical equilibrium with the granite.

At the northwestern end of the Yundurbulu Range, the contact between the Anmatjira Orthogneiss and the Mount Stafford beds is in places an igneous breccia, wherein numerous dark xenoliths are enclosed in contaminated granite (Fig. 29). Some of the xenoliths are composed of cordierite and andalusite hornfels (72110016A, -0019) whereas others are made of granitic minerals but with a greater proportion of biotite (72110016B, -0016C). Some xenoliths consist of granitic minerals plus cordierite, indicating that hybridisation and digestion have taken place (72110018; Fig. 70). Hydration (probably during cooling of the granite) has converted the hornfelses to chlorite-biotite-quartz-muscovite

Fig. 66: Zoned pegmatite cutting Anmatjira Orthogneiss at type locality, Ingallan Spring. Black prisms are tourmaline. GR5453-794499.

Neg. M/1412/65.

Fig. 67: Folded aplite vein in Anmatjira Orthogneiss, GR5453-770514, 3 km northwest of Ingallan Spring.

Neg. M/1412/37.

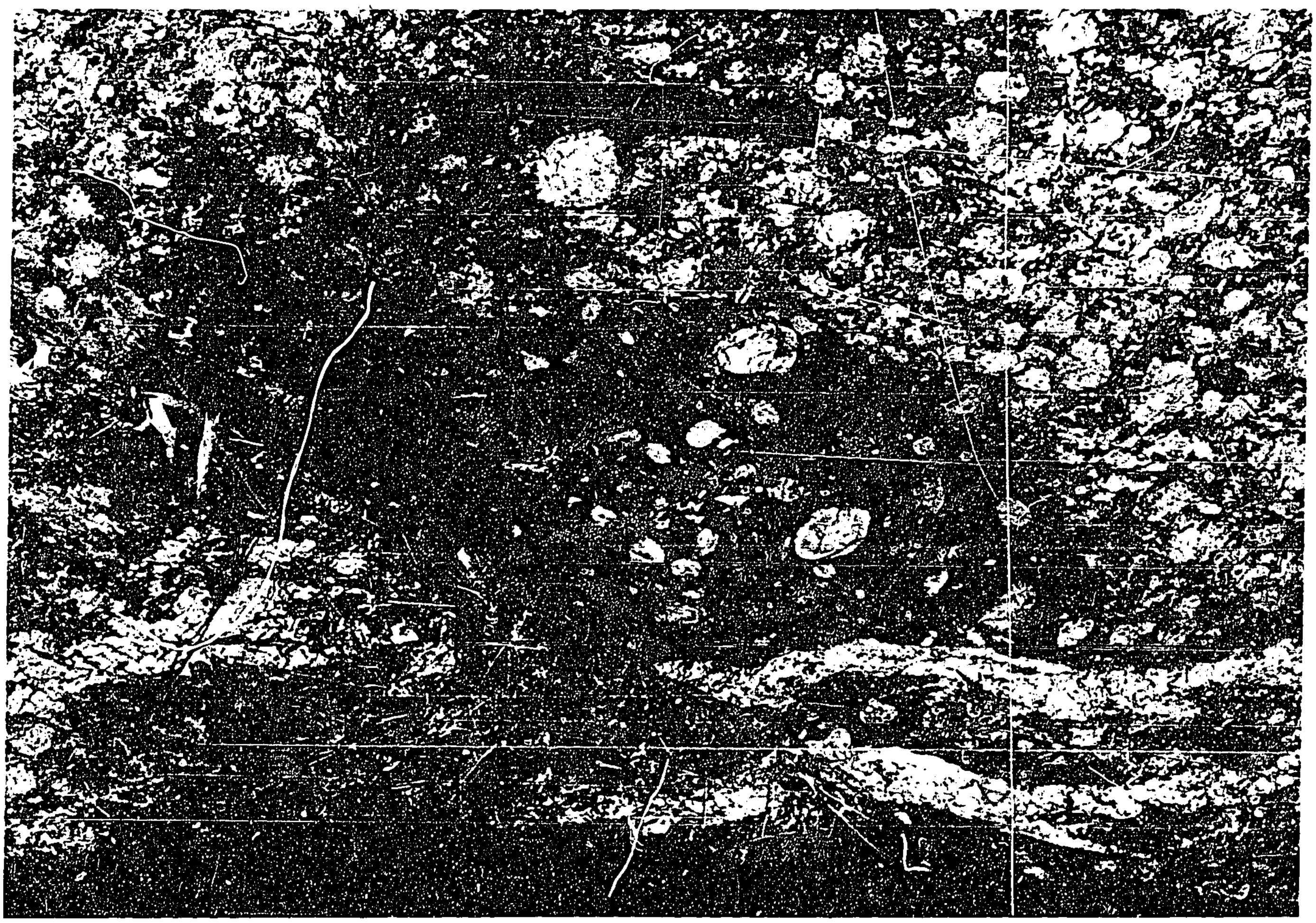


Fig. 68: Metasedimentary xenolith with mantled feldspar porphyroblasts, Anmatjira Orthogneiss. GR5453-794499, Ingallan Spring. Scale 15 cm long

Neg. M/1412/71

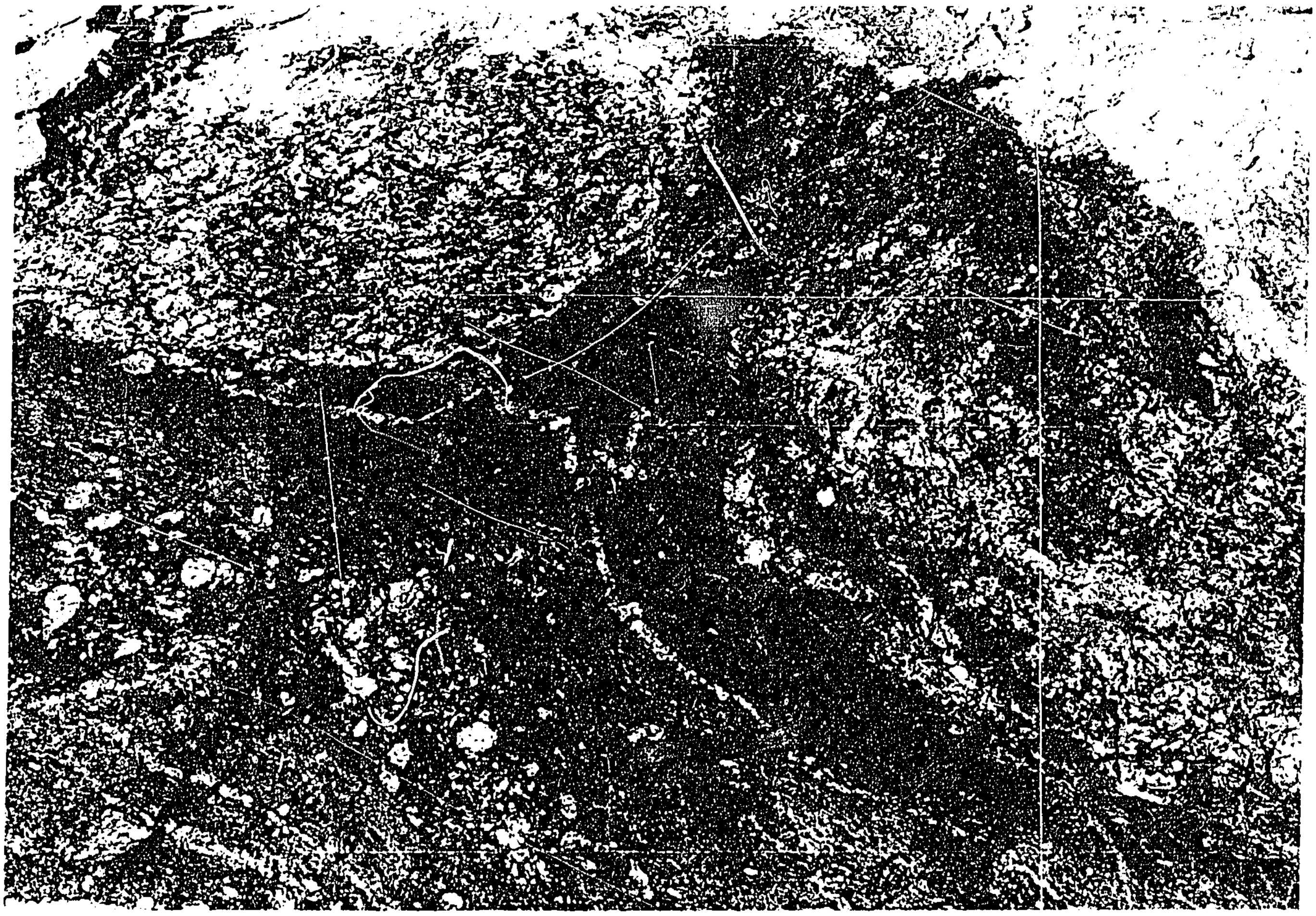


Fig. 69: Cuspate metasedimentary xenolith in Anmatjira Orthogneiss, GR5453-913446, 13 km east-southeast of Ingallan Spring Scale 15 cm

Neg. M/1346/72.

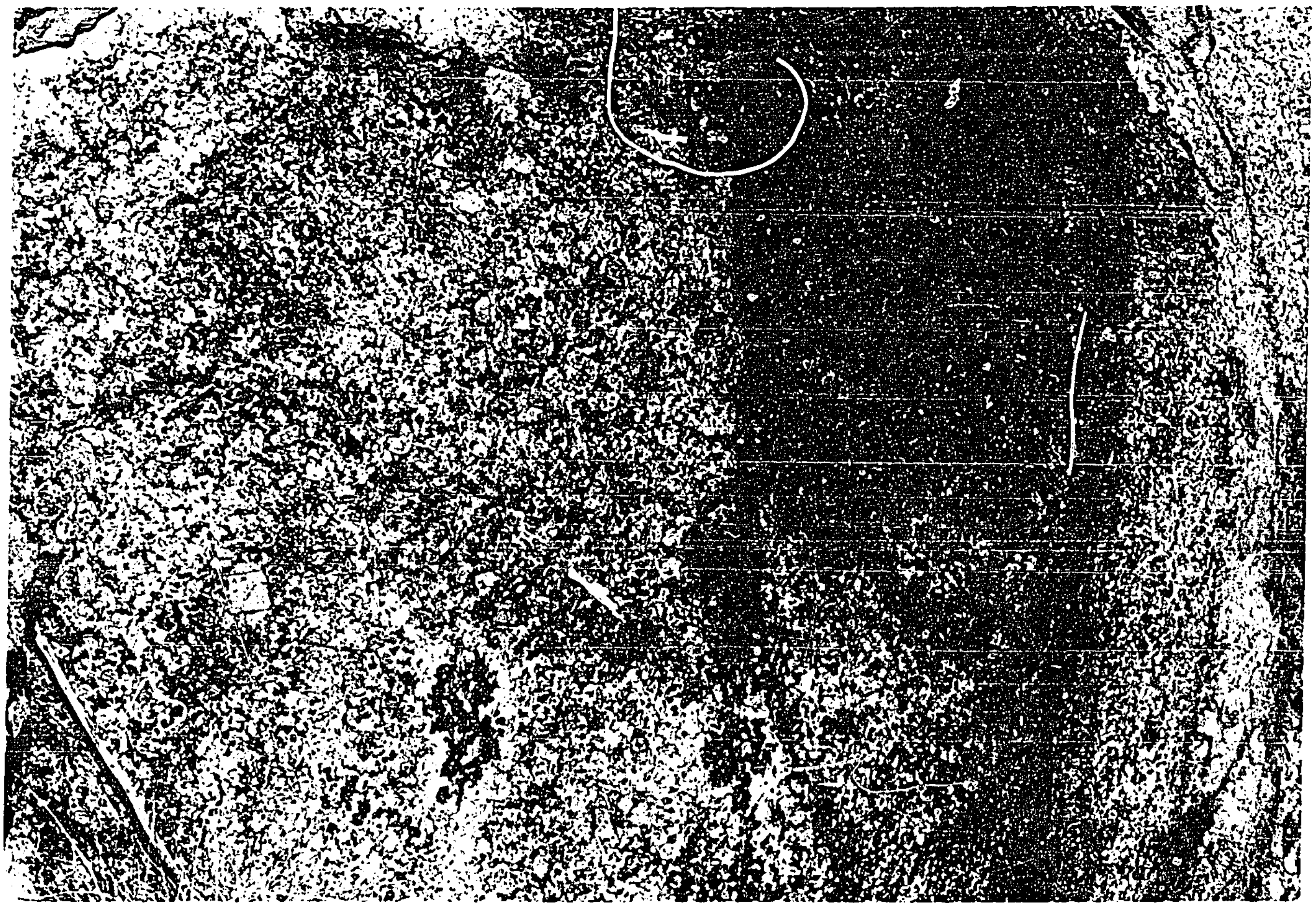


Fig. 70: Partly digested xenolith of Mount Stafford beds in massive rapakivi granite of Anmatjira Orthogneiss. Two nodules of quartz + tourmaline also present. Scale 15 cm long. GR5454-485722, 6 km southwest of Leichhardt Bore.
Neg. M/1342/70.

Fig. 71: Xenoliths of mafic Tyson Creek granulite in granite dyke of Anmatjira Orthogneiss. GR5453-683428, 11.5 km southeast of Ingallan Spring. Scale is 15 cm long.
Neg. M/1346/46.

aggregates (72110019), and the granite and xenoliths made of granitic minerals to quartz-muscovite $\pm$ chlorite $\mp$ biotite assemblages (72110015, -0017).

Fine-grained felsic rock (72920517, -530, -0532) forms elongate rounded xenoliths up to 6 m long at the margin of the Anmatjira Orthogneiss adjacent to the septum of Weldon metamorphics 7 km northeast of Lander Rock. The rocks are white to pale grey, and consist of strained microcline (74%), strained or recrystallised quartz (15%), sericitised plagioclase (8%), and greenish-brown biotite (3%); zircon, apatite, ilmenite rimmed with sphene, and allanite are accessory. Cordierite is present in sample -0530. The xenoliths may be felsic granofels formed by potassium metasomatism of pelitic gneiss or granulite from the Weldon metamorphics.

Amphibolite xenoliths (72920537, -0538) are the least abundant. They are dark grey to black, foliated, and consist essentially of hornblende (40 to 60%), andesine (35%), and quartz (5 to 10%), with accessory opaque minerals; biotite (15%) is present in sample -0537, and the hornblende in sample -0538 is partly altered to clinozoisite and rare biotite, and thus appears to be out of equilibrium with the enclosing granite.

In the granite near the septum of Weldon metamorphics 7 km northeast of Lander Rock, one large xenolith of contorted pelitic gneiss containing amphibolite lenses was seen, and at locality -0536 in the same area, a dyke of contaminated granite intrudes mafic granulite of the Tyson Creek granulite, and contains numerous cuspate xenoliths of retrograded granulite (Fig. 71). Large xenoliths of medium-grained granite are present at the northwestern end of the Yundurbulu Ranges.

The Anmatjira Orthogneiss is cut by steeply dipping dyke-like masses of black, very fine-grained mylonite up to about 50 cm wide. The mylonite ranges from massive and aphanitic (Fig. 72), to strongly foliated and streaky (Fig. 73); both varieties carry porphyroclasts of feldspar, and lenses and ribbons of quartz. In many places where the mylonites cross-cut the orthogneiss, the foliation of the orthogneiss swings over a distance of about 1 m into concordance with the strike of the mylonite (Fig. 74). In other places, the mylonite is bordered by a zone of fractured orthogneiss (Fig. 73); displacements between blocks and slices of gneiss reach several centimetres (Fig. 75). The mylonites are composed of lenses of recrystallised mosaic quartz, and angular to subrounded porphyroclasts of feldspar, some consisting of single grains of microcline or plagioclase, others comprising numerous broken fragments of these minerals, in a fine-grained recrystallised groundmass of quartz, strongly oriented muscovite and biotite, and small lenticular aggregates of sphene (72920522, -0555B). Where the mylonite is bordered by fractured orthogneiss (Fig. 75), the cracks are filled with fine-grained biotite, quartz, and muscovite (72920550), the plagioclase is fragmented and sericitised, and the quartz is recrystallised.

The Anmatjira Orthogneiss is a deep-seated syntectonic batholith intruded during deformation and metamorphism of the surrounding terrain to high-grade gneiss and granulite. It shows classical rapakivi texture (Sederholm, 1923), and the textural evidence shown in Figure 65 suggests that the mantled feldspars originated by exsolution of plagioclase from solid solution in the microcline, followed by migration of the plagioclase to the exterior of the host microcline. The S.I. indices (1.08, 1.09) of the two samples (72110204, -0205) from the northwestern massive portion of the batholith (Yundurbulu Range), indicate an origin by melting of igneous rock. In contrast, the remainder of the batholith appears to have been derived from a heterogeneous mixture of sedimentary and igneous rocks (S.I. indices of 1.17, 1.22, 1.05; Table 8), possibly the deep-seated parts of the Weldon metamorphics and Tyson Creek granulite. The granitic composition of the mylonites, and the drag-folding of the adjacent orthogneiss, suggests that they formed soon after emplacement of the orthogneiss, when the rock was still warm. The mylonites bordered by fractured gneiss presumably formed a little later, when the orthogneiss was cooler.

An imprecise Rb-Sr age of about 1600 ± 100 Ma on whole-rock samples (74110205, -0206) from the northwestern part of the Anmatjira Orthogneiss indicates that it crystallised in Middle Proterozoic time. The unit is correlated with the Yaningidjara, Mount Airy, and Ngalurbindi Orthogneisses.

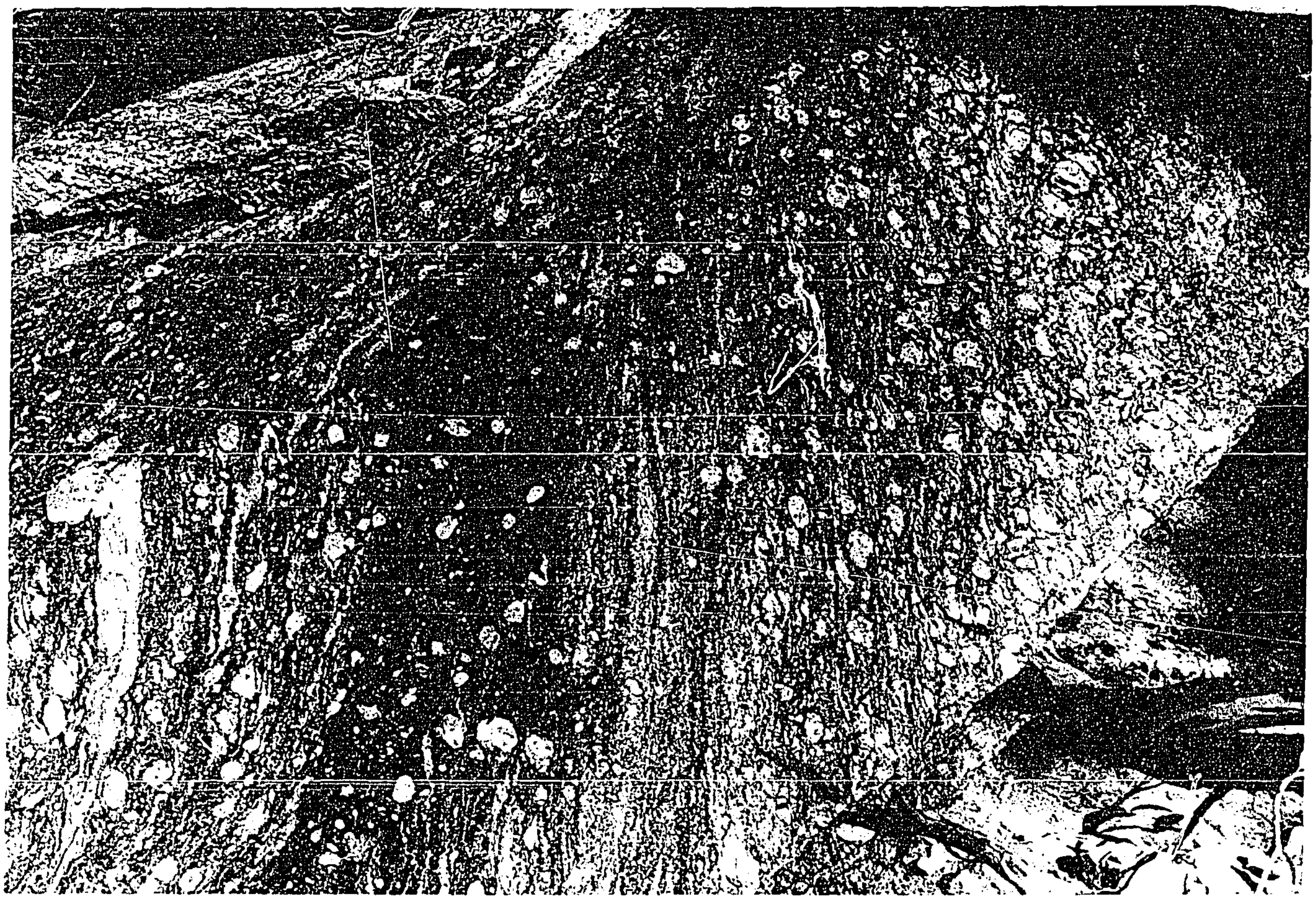


Fig. 72: Aphanitic mylonite (dark) containing round megacrysts of feldspar, bordered on each side by strongly foliated orthogneiss grading out to normally foliated orthogneiss. GR5553-070252, 8 km east-northeast of Pine Hill homestead. Scale is 15 cm long. Neg. M/1412/18.

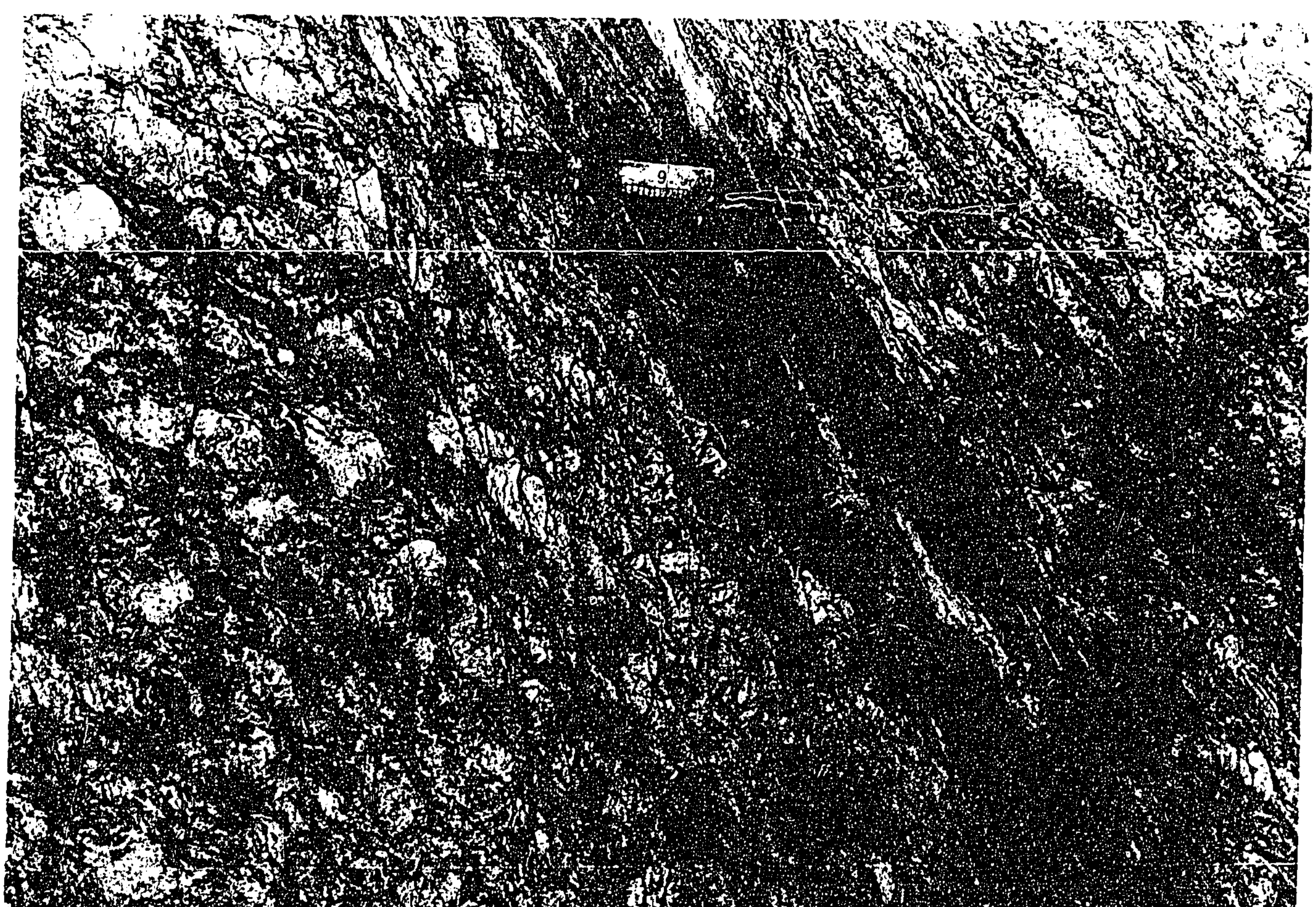


Fig. 73: Streaky mylonite containing lenses of quartz, bordered by zones of fractured orthogneiss. GR5553-944400, 7.5 km west-northwest of Bluebush Bore. Scale 15 cm
Neg. M/1376/30.

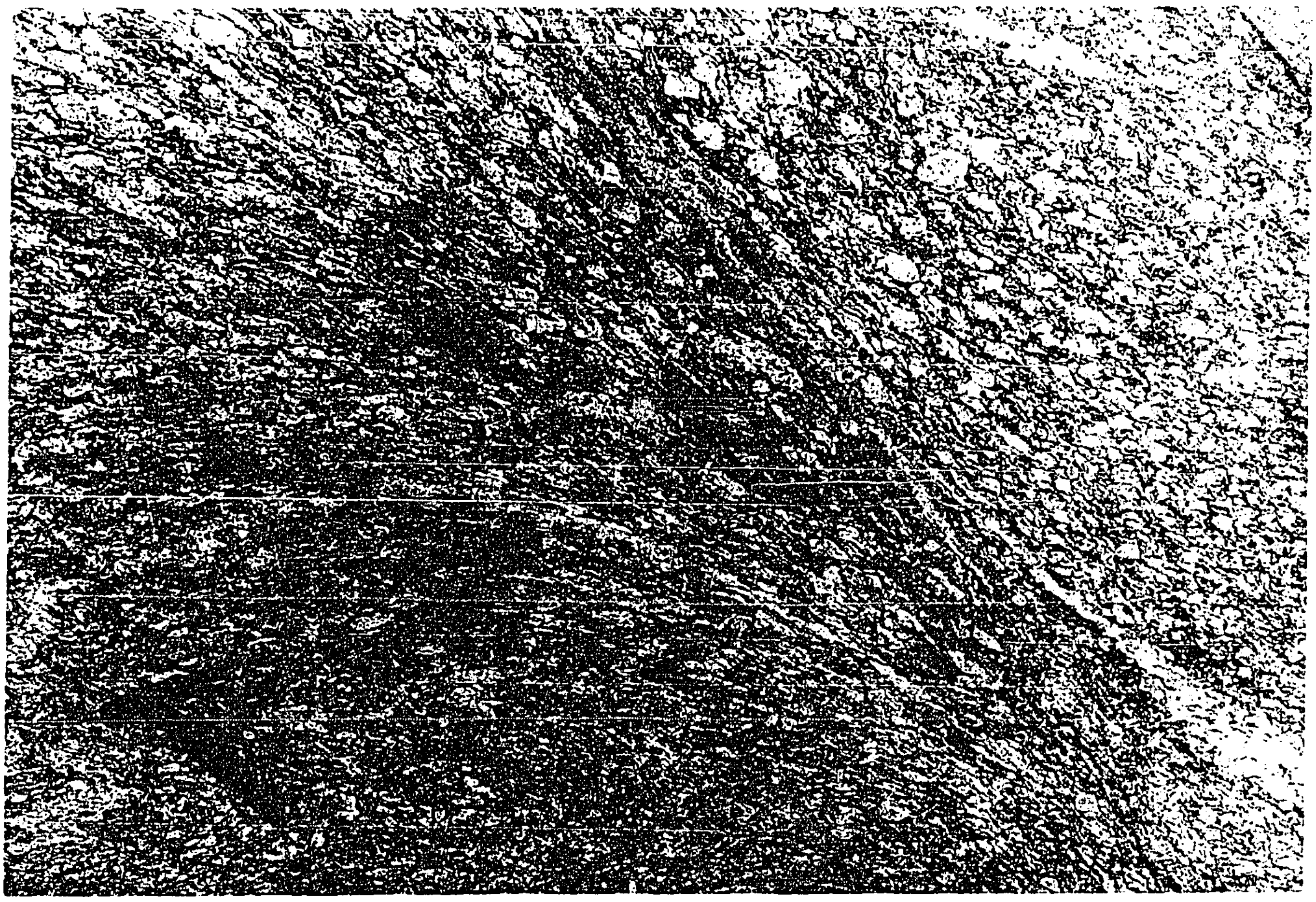


Fig. 74: Mylonitic zone in orthogneiss, showing foliation of orthogneiss strengthening and swinging into concordance with mylonite zone. Hammer is 30 cm long. Same locality as Fig.72. Neg. M/1412/20

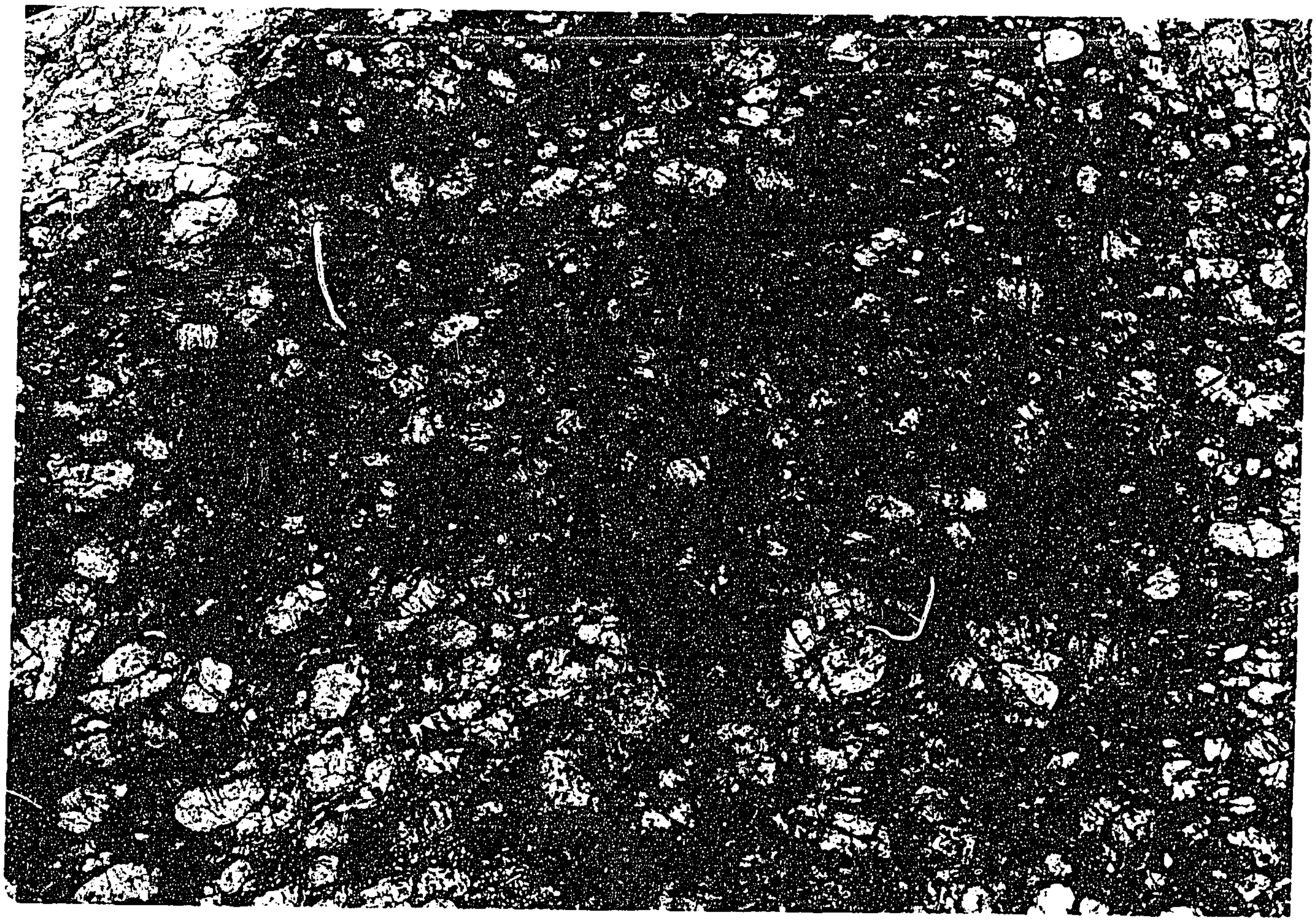


Fig. 75: Fractured orthogneiss adjoining mylonite zone, showing cracked and broken feldspars. Dark material in cracks and between feldspar clasts is fine-grained biotite, quartz, and muscovite. Scale is 15 cm long. GR5453-903440, 12.5 km southeast of Ingallan Spring. Neg. M/1346/66.

Boothby Orthogneiss (Egb) (A.Y.G. and A.J.S.)

The Boothby Orthogneiss is the coarse-grained porphyroblastic granitic augen gneiss with subordinate porphyritic granite that crops out mainly in the northeast of AILERON. The unit extends north into TEA TREE and east into the Alcoota 1:250 000 Sheet area. The name is derived from Mount Boothby (GR5552-248019), which is composed of Boothby Orthogneiss and felsic granulite of the Aileron metamorphics. The Orthogneiss erodes to prominent bouldery hills and inselbergs rising to 230 m above the surrounding plain. The unit intrudes and surrounds large enclaves of the Aileron metamorphics, and intrudes the Lander Rock beds ($El1_9$ and $El1_{10}$). It is faulted against the Napperby Gneiss, and is intruded by amphibolite dykes and quartz veins.

The type locality for the Boothby Orthogneiss is at GR5552-270054, 1 km west of Prowse Gap in the north of AILERON. Here, a ridge shows well exposed augen gneiss with an intrusive contact against cordierite granulite and mafic granulite of the Aileron metamorphics to the north. A reference locality for the porphyritic granite variant is at GR5552-260973, 5 km northwest of Aileron, where a hill shows clear exposures of flow-textured sheets of granite alternating with bands of layered mafic and felsic granulite of the Aileron metamorphics.

The Boothby Orthogneiss is mainly a coarse-grained porphyroblastic augen gneiss (orthogneiss) accompanied by strongly sheared equivalents, and to a lesser extent porphyritic granite with elongate euhedral phenocrysts. Gneissic foliation is well developed, and its intensity is reflected by the degree of flattening of the lenticular feldspar augen. Microcline commonly forms the larger augen whereas plagioclase forms smaller but better crystallised grains. The latter mineral typically weathers brown, whereas the potassium feldspar mostly maintains fresh white surfaces. Rapakivi texture was observed, but appears to be less common than in some outcrops of the Yaningidjara Orthogneiss to the northwest. Schlieren of banded biotite-rich rocks at various stages of desegregation are common, mainly (but not only) near contacts with granulite. The contacts themselves commonly consist of concordant repetitions of granulite and granite bands (Fig. 76), either by concordant injection of granite, or by derivation of granite from granulite by partial melting.

The potassium feldspar augen in the orthogneiss are generally microcline, although untwinned orthoclase is also present. Microperthitic textures may be present. The plagioclase is commonly sericitised to different degrees, whereas the potassium feldspar is relatively unclouded. The Orthogneiss varies from types containing only potassium feldspar to types containing equal amounts of potassium feldspar and plagioclase. Commonly, potassium feldspar exceeds plagioclase, with ratios of 2:1 or 3:1 prodominating. In some samples (e.g. 73922062), plagioclase rims microcline in typical rapakivi fashion. Quartz forms between a quarter and a third of the rock. The most abundant ferromagnesian component is biotite, which normally forms less than 10 per cent of the rock. Chlorite is common, normally as an alteration product of biotite or feldspar. Interleaved chlorite-biotite flakes, and grains showing transitional optical characteristics between these two minerals, are common. Epidote is a minor accessory preferentially associated with biotite. Zircon, apatite, opaque grains, and sphene are accessory. The sphene forms rims around opaque grains (ilmenite ?). Some include muscovite flakes which are clearly younger than the biotite and possibly represent deuteric alteration (68660066). In the east of AILERON, hornblende-biotite-quartz-orthoclase-plagioclase assemblages (72921224), and fine-grained biotite-sillimanite-garnet-oligoclase-microcline-quartz rocks (-1222) are common; they display a compositional banding due to changes in the abundance of biotite.

Results of chemical analysis of one sample of Boothby Orthogneiss are shown in Table 9.

Most samples show little or no effects of metamorphism, apart from strong development of gneissosity. In some areas, however, the presence of sillimanite and/or garnet (72921222, 73922077), testifies to amphibolite facies metamorphic effects. Sheared and crushed cataclastic granites are common, showing extensive recrystallisation of quartz and feldspar at grain margins (72921237), cracks, strain shadows, and varying degrees of sericitisation.

The Boothby Orthogneiss is characterised by mesoscopic to macroscopic interlayering with granulite of the Aileron metamorphics, with the metamorphic rocks showing no consistent orientation. Hence, it is pertinent to examine the petrological relations between the interbanded granulite and orthogneiss (Figs 76,77). There are two possibilities: either the granite was injected allochthonously into the granulite, or it formed by autochthonous or subautochthonous partial melting of the granulite. Had the granite (now orthogneiss) formed by partial melting in situ, dehydration reactions involving replacement of muscovite by sillimanite, and hornblende and biotite by pyroxene could be expected to occur. Whereas such relations are common in the granulites, no increase in the abundance of dehydration phenomena towards their contacts with granite was noted, although more detailed studies are warranted in this regard. Also, dehydration reactions are common in granulites elsewhere in AILERON and TEA TREE, and so are not necessarily diagnostic in relation to granite palingenesis. Possibly, trace element fractionation patterns and isotopic ratios would shed light on the possible genetic relations between the granites and the granulites. The S.I. index of the single analysed sample suggests an origin by melting of igneous rock.

Samples (73921020) of the Boothby Orthogneiss have given an imprecise Rb-Sr whole-rock date of about 900 $\pm$ 150 Ma with an initial $^{87}Sr/^{86}Sr$ ratio of 0.764.

Mount Airy Orthogneiss (Egr) (A.J.S.)

The Mount Airy Orthogneiss is the body of coarse-grained granitic augen gneiss grading to massive porphyritic granite that crops out in the northeast of REYNOLDS RANGE and southwest of TEA TREE, between the Reynolds and Anmatjira Ranges. The name is derived from Mount Airy (GR5353-018122) in the southwest of TEA TREE. The unit forms low bouldery hills.

The Mount Airy Orthogneiss intrudes the Lander Rock beds to the north and south, and adjoins but does not breach the Mount Thomas Quartzite. Folds in the Quartzite adjacent to the Orthogneiss are of the spruce-tree type found on the flanks of gneiss domes (Skehan, 1961), and are attributed to intrusion of the Orthogneiss. Hence, the Mount Thomas Quartzite is regarded as older than the Mount Airy Orthogneiss, not a younger unit lying non-conformably on the Orthogneiss. The Orthogneiss is intruded by dykes of amphibolitised basic rock, micro-

Fig. 76: Interlayered porphyritic granite of Boothby Orthogneiss, and felsic to mafic granulite of Aileron metamorphics. GR5552-260975, 5 km northwest of Aileron. Notebook is 15 cm long. Neg. GA/9661.

Fig. 77: Porphyritic flow-structured granite of Boothby Orthogneiss intruding mafic granulite of Aileron metamorphics. Same locality as above. Neg. GA/9660.

Table 9: Results of chemical analysis of one sample of Boothby Orthogneiss. Major oxides in percent; trace elements in ppm.

| Sample no. | 73921020 |
|---|---|
| Locality | 5552-263975 |
| $SiO_2$ | 73.1 |
| $TiO_2$ | 0.28 |
| $Al_2O_3$ | 13.9 |
| $Fe_2O_3$ | 0.70 |
| FeO | 1.40 |
| MnO | 0.01 |
| MgO | 0.56 |
| CaO | 1.39 |
| $Na_2O$ | 2.93 |
| $K_2O$ | 6.20 |
| $P_2O_5$ | 0.34 |
| $H_2O^+$ | 0.52 |
| $H_2O^-$ | 0.06 |
| $CO_2$ | 0.25 |
| $SO_3$ | <0.01 |
| Total | 99.9 |
| S.I. index | 1.05 |
| Li | 8 |
| Be | 1 |
| B | 5 |
| F | 820 |
| Co | 72 |
| Ni | 4 |
| Zn | 30 |
| Rb | 310 |
| Sr | 180 |
| Y | 55 |
| Sn | 4 |
| Ba | 700 |
| W | <10 |
| Th | 60 |
| U | 14 |

Analysis by Amdel Rept AN3095/77

granite, aplite, and quartz veins. To the west, it adjoins and is probably intruded by the Harverson Granite, as the latter is not intruded by the amphibolitised dykes of basic rock. The unit is faulted against the Weldon metamorphics to the north, and against the Yaningidjara Orthogneiss to the east.

The type locality for the Mount Airy Orthogneiss is at GR5453-920210, 7.5 km west-southwest of Pine Hill homestead, in the Warimbi Hills. The locality is a hilly terrain of coarse granitic augen gneiss cut by dykes of microgranite.

The Mount Airy Orthogneiss in the eastern (type locality) and northern parts of its outcrop is a weakly foliated, coarse-grained granitic augen gneiss. Characteristically, biotite forms fine-grained ovoid to lenticular clots up to 1 cm long. Garnet was nowhere observed. In the east at the type locality, the rock is cut by irregular dykes of leucocratic microgranite, and by zones enriched in biotite, limonite, and silica. In the north, near the major fault on the south side of the Anmatjira Range, the gneiss is cut by chloritic films and gash veins of quartz + chlorite. The gneiss in this area also contains cuspate xenoliths of biotite schist, and cubes of limonite in its more strongly sheared portions. In the east of the outcrop, the Orthogneiss is very weakly foliated, and approaches a massive coarse-grained granite. Clots of biotite are fewer and smaller than in the east, and tourmaline clots up to 5 cm across are also present. In places the rock is porphyritic, with euhedral phenocrysts of potassium feldspar. Microgranite forms discrete masses several metres across, but whether they are intrusions or rafts could not be determined.

Porphyritic microgranite ($Bgr_1$) forms an extensive elongate body along the southwestern side of the Mount Airy Orthogneiss, between the coarse augen gneiss and the Lander Rock beds or Mount Thomas Quartzite. It consists of strained phenocrysts of quartz and orthoclase, sericitised oligoclase, muscovite, biotite clots, and tourmaline, in a subordinate fine-grained groundmass of sericite, quartz, and potassium feldspar (71920422). The rock contains xenoliths and one raft (shown on the map at sample locality 421) of pebbly meta-arkose, conglomerate (71920421), phyllitic schist, and green metasediment, derived from the nearby Lander Rock beds and/or Mount Thomas Quartzite to the south.

The Mount Airy Orthogneiss is a granite batholith that was intruded during or shortly before regional metamorphism to low amphibolite facies. It is presumably the same age as the other granitic masses of the area, i.e. Middle Proterozoic or older. The unit has not been isotopically dated.

Yaningidjara Orthogneiss (Bgy) (A.J.S. and A.Y.G.)

The Yaningidjara Orthogneiss is the body of coarse-grained garnetiferous granitic augen gneiss that crops out in the Yaningidjara Hills in the south of TEA TREE. The Orthogneiss forms prominent inselberg-like ranges covered by large boulders (Fig. 78). The type locality of the Orthogneiss is a prominent steepsided bare hill (Fig. 79), or inselberg, at GR5553-065154, on the southwestern side of the Yaningidjara Hills. The hill shows a large clean exposure of the augen gneiss cut by foliated microgranite dykes about 1 m wide. The Orthogneiss intrudes the Lander Rock beds to the south, and is faulted against the Mount Airy Orthogneiss to the east and the Weldon metamorphics to the north.

The Yaningidjara Orthogneiss consists of large microcline augen which weather white, orange-weathering plagioclase, quartz, biotite as thin films curved around the augen, abundant garnet, sillimanite, and opaque grains. The garnet and sillimanite have grown at the expense of biotite and feldspar (68660059, 73922060, -2061, -2092). Garnet is partly replaced by chlorite and/or sericite, and iron oxide. The gneiss is strongly foliated, but generally not layered; at the type locality, however, a few dark fine-grained schlieren a metre or so long are present.

The Orthogneiss is cut in many places by dykes of foliated microgranite up to 3 m wide. The foliation in the dykes parallels that in the Orthogneiss, and is oblique to the walls of the dykes. The dykes commonly contain fine-grained dark xenoliths, and some also contain xenoliths of the Orthogneiss. Aplite and pegmatite veins also cut the Orthogneiss in places.

The abundance of garnet and sillimanite after biotite, and the strong gneissic foliation which cuts through dyke rocks and the

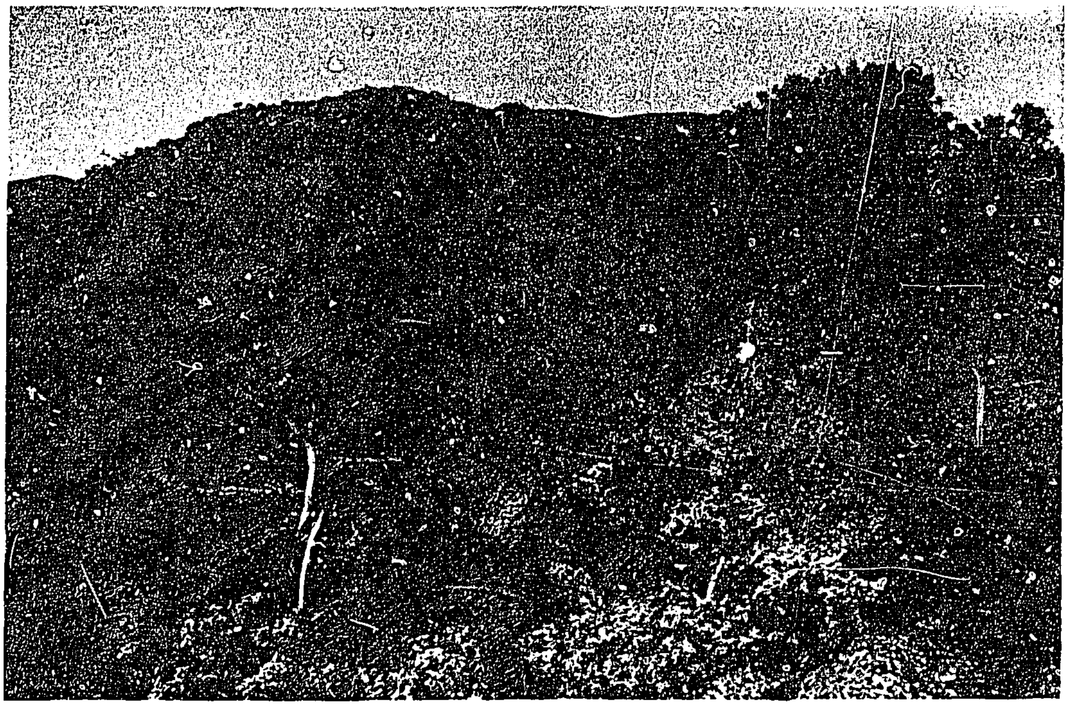


Fig. 78: Inselbergs of Yaningidjara Orthogneiss. GR5553-045195, 6 km southeast of Pine Hill homestead.

Neg. GA/5334.

Fig. 79: Type locality of Yaningidjara Orthogneiss. Microgranite dyke cuts Orthogneiss in centre of photograph. GR5553-065154, southwest side of Yaningidjara Hills.

Neg. GA/9662.

enclosing gneiss alike, indicate that the Yaningidjara Orthogneiss is a granite batholith that was subsequently deformed and metamorphosed to amphibolite facies. Neither the time of intrusion or metamorphism are known, but are probably Middle Proterozoic or earlier, as for the other granitic gneisses in the area. The unit is correlated with the Anmatjira Orthogneiss.

Ngalurbindi Orthogneiss (Egg) (L.A.O.)

The Ngalurbindi Orthogneiss is a distinctive body of gneissic granite which forms an east-west trending belt of low rounded hills and scattered tors in the southern part of DENISON and the central western part of REYNOLDS RANGE. The name is derived from the Ngalurbindi Hills, in DENISON, which are largely composed of the unit. Good exposures of coarse-grained gneissic granite containing xenoliths of biotite gneiss crop out at the type locality at GR5353-068309, 7 km southwest of Mount Allan homestead in DENISON.

Ngalurbindi Orthogneiss intrudes quartzose metasediment of the Lander Rock beds near Brookes Well in DENISON. Half a kilometre west of Yippi Dam in DENISON, the Orthogneiss intrudes an evenly medium-grained strongly foliated granite which in places contains abundant small black xenoliths. The foliation of the granite and host Orthogneiss is concordant. The Wangala Granite intrudes the Ngalurbindi Orthogneiss; an easily accessible example of this intrusive contact is situated 4 km southeast of Mount Allan homestead. Because of the poor exposure between the Ngaburlindi Orthogneiss and the Wangala Granite, and their similarity on aerial photographs, there is some uncertainty as to which unit the scattered granitic outcrops between the main masses of Ngalurbindi Orthogneiss and Wangala Granite should be assigned.

In the western part of the Ngalurbindi Orthogneiss, the unit is intruded by leucocratic microdiorite, microgranite, and partly retrograded dolerite dykes. Elsewhere, the Orthogneiss is intruded by roughly east-west-striking pegmatite dykes up to 3 m thick, feldspar porphyry, and a small number of aplite, quartz-tourmaline and porphyry dykes. In REYNOLDS RANGE, medium-grained biotite granitic gneiss, typical of the Napperby Gneiss, occurs in contact with and as xenoliths in the Ngalurbindi Orthogneiss. Also along the southern side of the

Ngalurbindi Hills, the coarse gneissic granite grades eastwards to medium-grained granitic gneiss similar to the Napperby Gneiss farther east.

The Ngalurbindi Orthogneiss consists of potash feldspar megacrysts and augen up to 3.5 cm long (but commonly in the range 1-1.5 cm) in a finer-grained schistose matrix composed of anastomosing films of quartz, feldspar, and biotite (Fig. 80). Xenoliths throughout the unit are commonly small, elongate to rounded, dark, fine-grained, and consist of quartz, feldspar, and biotite; xenoliths of biotite-feldspar porphyry containing feldspar megacrysts up to 2 mm across are rare. About 8 km northeast of Dingo Dam, the Orthogneiss is strongly deformed and consists of quartz-veined schistose muscovite-biotite granite and biotite-muscovite-quartz-feldspar schist. Near Mica Dam in the southwest of REYNOLDS RANGE, the Ngalurbindi Orthogneiss is commonly cut by pegmatite dykes, and includes lenticular aggregates of feldspar up to 6 cm long by 1 cm thick, quartz, and biotite. The Orthogneiss is porphyritic in places and locally contains muscovite. Other parts of the Orthogneiss near Mica Dam are migmatitic and agmatitic, consisting of banded gneiss, fragments of medium-grained granitic gneiss, and large masses of coarse-grained very micaceous quartzofeldspathic rock. Partly porphyroblastic grey xenoliths are enclosed in strongly lineated, weakly foliated gneissic granite in nearby Tower Creek (Fig. 81). In the vicinity of Ngamadingi Hill in the western part of REYNOLDS RANGE, and also about 5 km northeast of Brookes Well in DENISON, the Ngalurbindi Orthogneiss forms scattered exposures of banded gneiss composed of quartz-feldspar layers from 5 to 10 mm wide separated by biotite-rich zones. The gneiss is cut by granite, pegmatite, quartzofeldspathic veins (Fig. 82), and the Wangala Granite, and contains xenoliths composed of biotite, quartz, and feldspar. Near Ngamadingi Hill the Orthogneiss contains muscovite, and is irregularly flow-folded. Northeast of Brookes Well, the Orthogneiss is typically a muscovite-biotite or biotite-quartz-plagioclase-microcline gneiss (sample localities E844, 846).

Results of chemical analysis of two samples of Ngalurbindi Orthogneiss are presented in Table 10. The difference between the two S.I. indices suggest heterogeneities in the source material of the Orthogneiss.

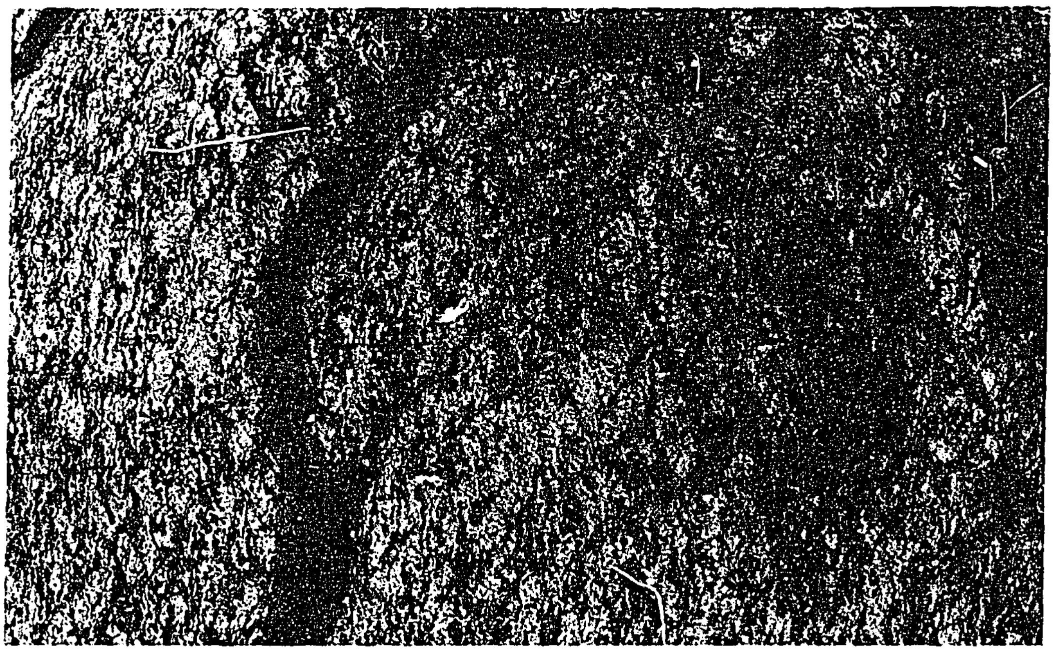


Fig. 80: Typical granitic augen gneiss of Ngalurbindi Orthogneiss at type locality, GR5353-066308, 7 km southwest of Mount Allan homestead. Neg. M/1805/26

Fig. 81: Elongate xenolith in strongly foliated Ngalurbindi Orthogneiss. GR5453-612334, 12 km west of Mount Thomas. Scale is 15 cm long. Neg. M/1803/56.

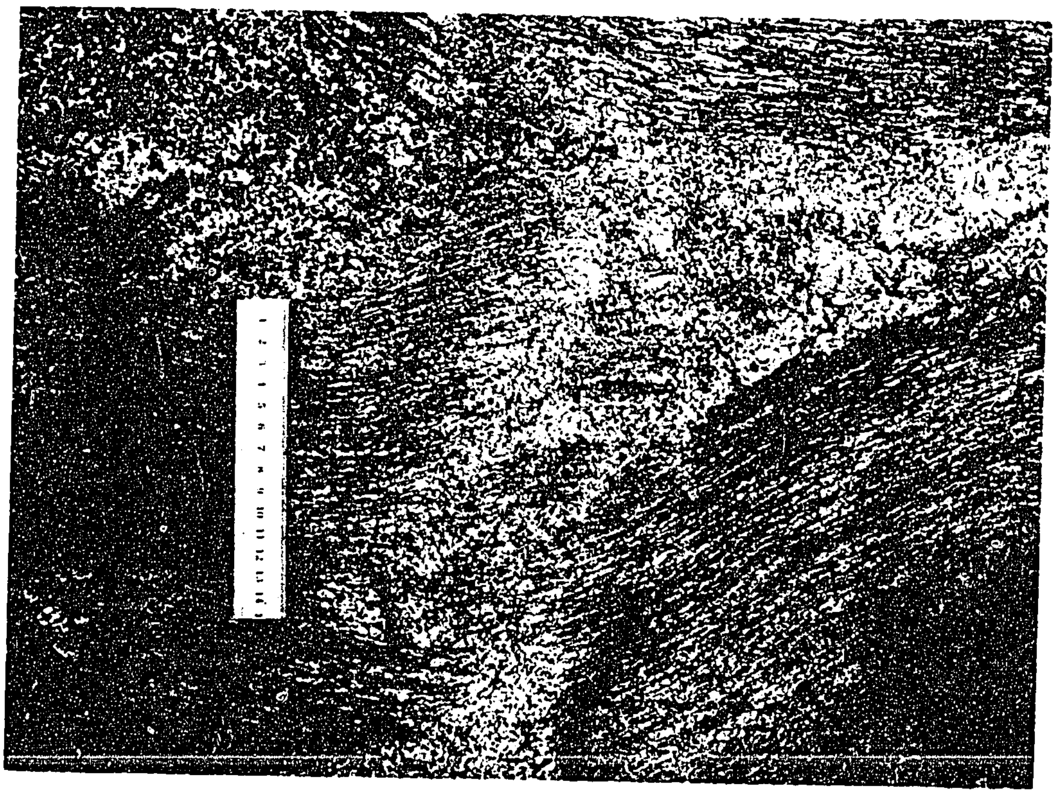


Fig. 82: Banded variant of the Ngalurbindi Orthogneiss veined by locally derived quartzofeldspathic material, GR5353-304353, 6 km south-southwest of Crown Hill.

Neg. GB/266.

Deeply weathered rock (Tla) caps some of the higher hills of Orthogneiss, and consists of cavernous decomposed gneissic granite composed of yellow, white, red, and bright green clays containing angular quartz. A complete weathering profile is exposed about 2 km northeast of Yaluma Dam in DENISON, and comprises, from bottom to top, leached, mottled, and silcrete zones. Decomposed gneissic granite forms an orange capping 15 m thick about 6 km northeast of Dingo Dam in DENISON.

Although the Ngalurbindi Orthogneiss is intrusive into granite near Yippi Dam, the intrusive contact is overprinted by a strongly penetrative foliation. This relationship suggests that deformation post-dates the emplacement of the Ngalurbindi Orthogneiss.

The Ngalurbindi Orthogneiss has not been isotopically dated, but the nearby Napperby Gneiss, which in the western part of REYNOLDS RANGE appears to be in contact with and forms xenoliths in the Orthogneiss, has given an imprecise Rb-Sr whole-rock date of 1600-1500 Ma. The Ngalurbindi Orthogneiss is intruded by the Wangala Granite, which is imprecisely dated at 1500 Ma. Thus the Ngalurbindi Orthogneiss is Middle Proterozoic.

Aloolya Gneiss (Ɓgo) (A.J.S.)

The Aloolya Gneiss is the medium even-grained granitic gneiss which crops out as two separate bodies on the northern flank of the southeastern part of the Anmatjira Range, in TEA TREE. The larger body of Gneiss measures 8 km by 2 km, and is located at the extreme south-eastern end of the Anmatjira Range, 11 km west of Aloolya Bore (GR5553-183304), whence the name is derived. The smaller body is about 3 km across, and is located 3 km southwest of Bluebush Bore and about 5 km northwest of the larger body. The Gneiss gives rise to a typical granitic terrain of tor-covered hills.

The smaller (northwestern) body of Aloolya Gneiss intrudes, and is therefore younger than, the Tyson Creek granulite (Fig. 83) and the Anmatjira Orthogneiss (Figs. 84, 85,86); it appears to have thermally metamorphosed and is therefore younger than the Possum Creek Charnockite. The larger (southeastern) body of Aloolya Gneiss adjoins, and probably

Table 10: Results of chemical analysis of two samples of Ngalurbindi Orthogneiss. Major oxides in percent; trace elements in ppm

| Sample no. | 74920897 | 72921015 |
|---|---|---|
| Locality | 5353-066308 | -120310 |
| $SiO_2$ | 72.2 | 72.2 |
| $TiO_2$ | 0.49 | 0.47 |
| $Al_2O_3$ | 13.4 | 13.0 |
| $Fe_2O_3$ | 0.89 | 0.58 |
| FeO | 2.55 | 2.55 |
| MnO | 0.04 | 0.04 |
| MgO | 0.63 | 0.61 |
| CaO | 1.62 | 1.70 |
| $Na_2O$ | 2.37 | 2.33 |
| $K_2O$ | 4.94 | 5.28 |
| $P_2O_5$ | 0.13 | 0.13 |
| $H_2O^+$ | 0.67 | 0.58 |
| $H_2O^-$ | 0.05 | 0.06 |
| $CO_2$ | 0.05 | 0.05 |
| $SO_3$ | 0.01 | 0.01 |
| Total | 100.0 | 99.6 |
| S.I. index | 1.13 | 1.06 |
| Li | 30 | 35 |
| Be | 4 | 4 |
| B | 5 | <5 |
| F | 1180 | 1620 |
| Co | 48 | 66 |
| Ni | 12 | 8 |
| Zn | 52 | 57 |
| Rb | 350 | 380 |
| Sr | 70 | 60 |
| Y | 46 | 46 |
| Sn | 10 | 14 |
| Ba | 580 | 500 |
| W | < 10 | < 10 |
| Th | 36 | 36 |
| U | 8 | 10 |

Analysis by Amdel Rept AN3095/77

intrudes the pelitic variant (Ben) of the Weldon metamorphics, but no actual relationship was observed. At its northwestern end (sample locality C645), the larger body intrudes a small outcrop of biotite gneiss which is too small to show on the map; the identity of this gneiss is unknown. The Aloolya Gneiss is intruded by veins of quartz, and by dykes of aplite, pegmatite, and amphibolite (Fig. 87).

The type locality of the Aloolya Gneiss is situated in the smaller body, at GR5553-992354, 3.5 km southwest of Bluebush Bore, where a large clean nearly vertical rock face provides an outstanding exposure of the Aloolya Gneiss intruding the Anmatjira Orthogneiss (Figs 84, 85). The Aloolya Gneiss contains pale grey elongate xenoliths up to 7 m long of Anmatjira Orthogneiss which have been made almost indistinguishable from the host Aloolya Gneiss by hybridisation. Right at the contact, elongate slivers of strongly foliated Anmatjira Orthogneiss are frozen in place after being prised loose by dykes of the Aloolya Gneiss. In one place, the contact of the two granites is cuspate; round lobes about 30 cm across of Aloolya Gneiss project into and are separated from each other by pointed cusps of Anmatjira Orthogneiss (Fig. 85). About 25 m northwest of the main rock-face, block stoping of the Anmatjira Orthogneiss at this locality contains large disrupted xenoliths of mafic Tyson Creek granulite (Fig. 88).

The Aloolya Gneiss is a leucocratic evenly medium-grained pale granitic gneiss and at the type locality contains conspicuous dark clots up to 2 cm across composed of tourmaline and garnet. At locality 635 in the smaller body the rock contains biotite and garnet but no tourmaline; neither garnet nor tourmaline were observed in the large body. No thin section of the Aloolya Gneiss has been cut. Results of chemical analysis of one sample of the Gneiss are presented in Table 11. The S.I. index (1.13) and presence of garnet and tourmaline indicate derivation of the Gneiss from sedimentary parent rock.

At sample locality C635, the smaller body of Aloolya Gneiss intrudes an outcrop of mafic Tyson Creek granulite, and two subsidiary rock-types are also present along the contact zone of the two main units. The first is an intermediate granulite adjoining the Tyson Creek granulite, and consists of fine-grained closely packed dark clots about

Fig. 83: Xenoliths of mafic Tyson Creek granulite in Aloolya Gneiss, GR 5553-978349, 5 km southwest of Bluebush Bore. Scale is 15 cm long.

Neg. M/1376/34.

Fig. 84: Type locality of Aloolya Gneiss, showing Aloolya Gneiss (top) intruding Anmatjira Orthogneiss (bottom). Note pale grey xenolith about 1 m long of Anmatjira Orthogneiss in slightly paler grey Aloolya Gneiss. Scale is 15 cm long. GR5553-992354, 3.5 km southwest of Bluebush Bore.

Neg. M/1386/8

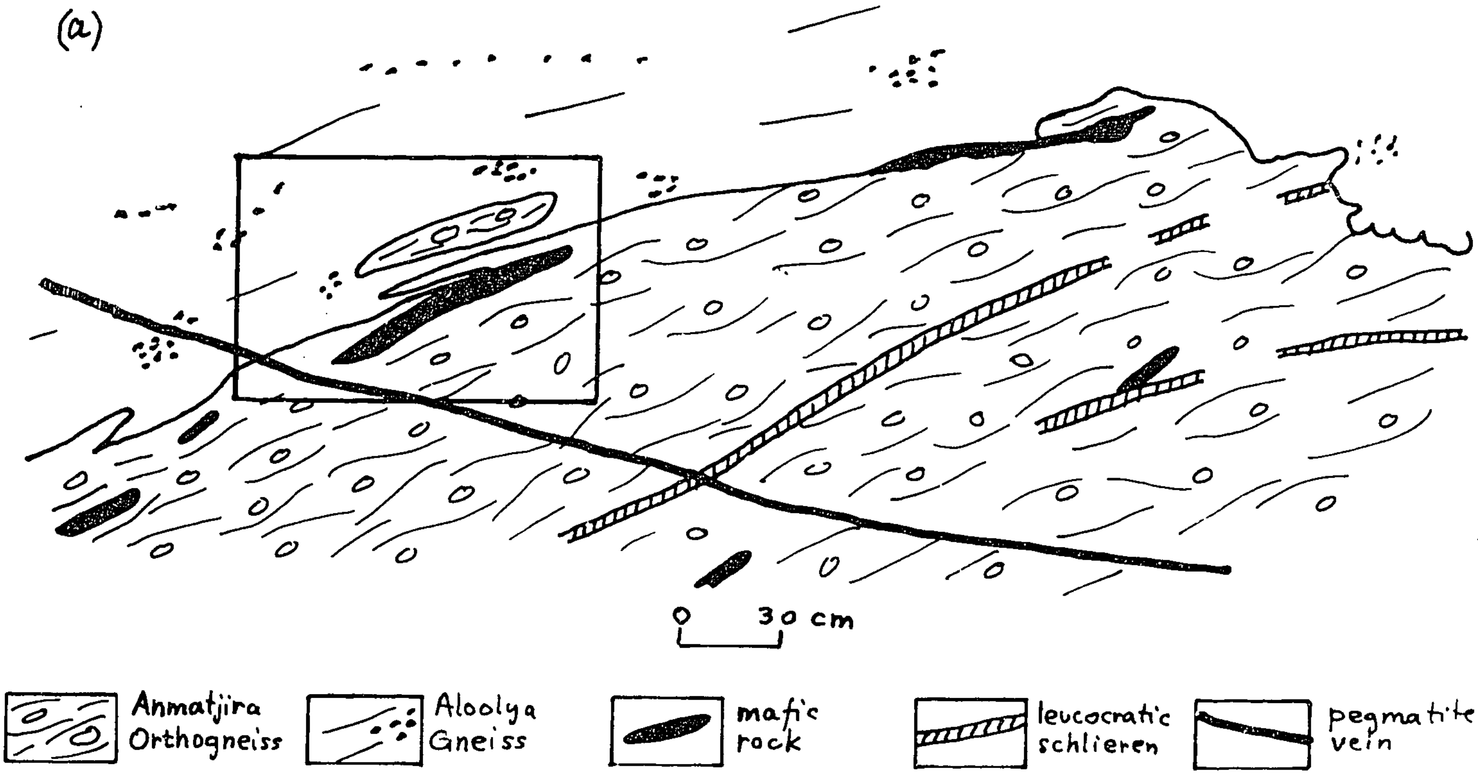



Fig. 85 : Sketch, from photograph, of type locality of Aloolya Gneiss, which here intrudes Anmatjira Orthogneiss. Note cuspate form of contact in upper right corner. Black dots in Aloolya Gneiss are clots of tourmaline and garnet. Rectangle shows position of Fig. 84.

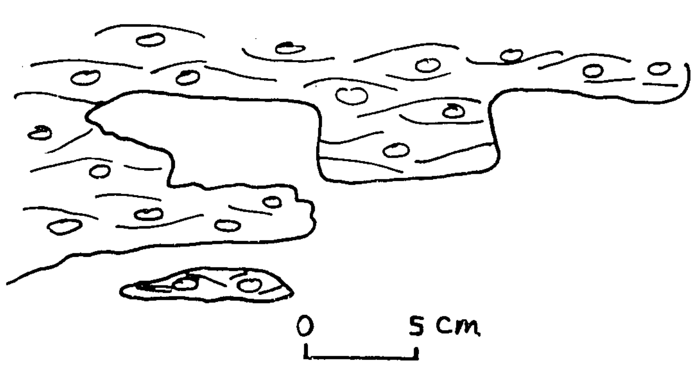



Fig. 86 : Block stoping of Anmatjira Orthogneiss (ellipses) by Aloolya Gneiss (blank); same locality as (a), 25 m to north of (a).

16/NT/10

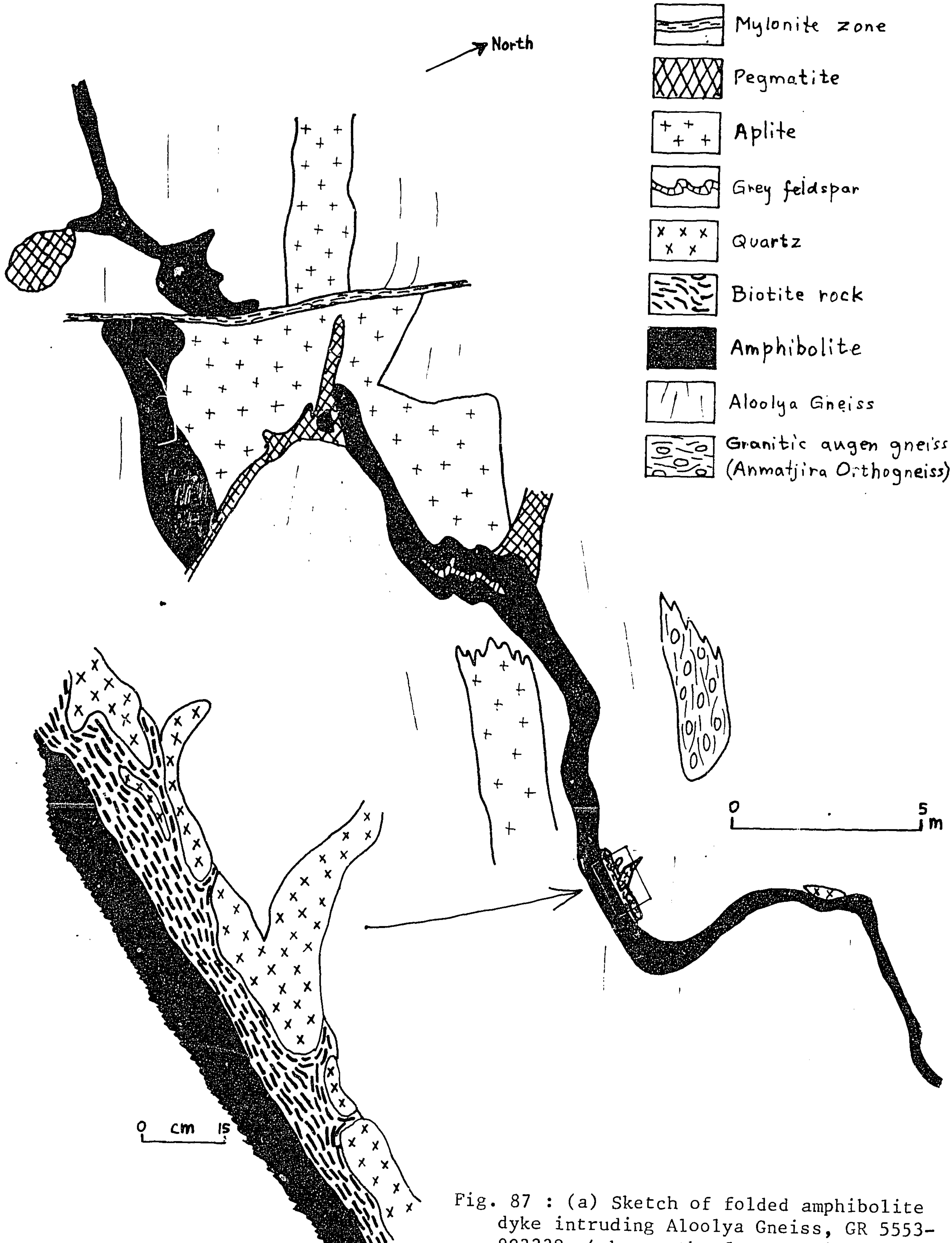



Fig. 87 : (a) Sketch of folded amphibolite dyke intruding Aloolya Gneiss, GR 5553-993338, 4 km north of Mount Finnis, TEA TREE. (b) Enlargement (sketched from a photograph) of biotite-quartz selvedge at margin of amphibolite dyke.

16/NT/11

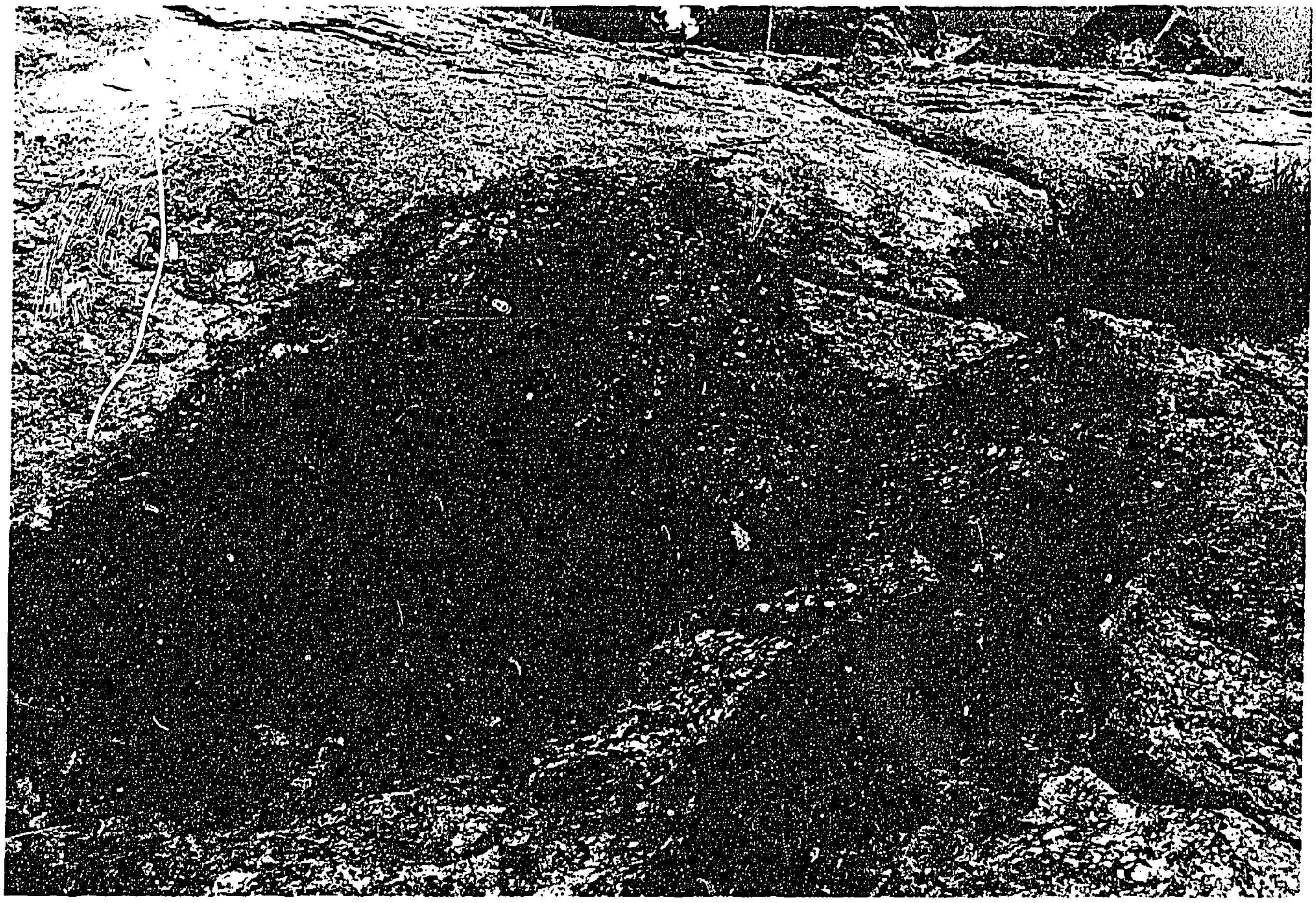


Fig. 88: Xenoliths of mafic granulite in granitic augen gneiss of Anmatjira Orthogneiss, the two forming a composite xenolith in Aloolya Gneiss (top of photo), at type locality of Aloolya Gneiss, GR5553-993354, 3.5 km southwest of Bluebush Bore.

Neg. M/1386/10.

Table 11: Results of chemical analysis of one sample of Aloolya Gneiss. Major oxides in percent; trace elements in ppm.

| | |
|---|---|
| Sample no. | 72920635 |
| Locality | 5553-978348 |
| $SiO_2$ | 77.1 |
| $TiO_2$ | 0.16 |
| $Al_2O_3$ | 11.7 |
| $Fe_2O_3$ | 0.19 |
| FeO | 1.65 |
| MnO | 0.03 |
| MgO | 0.27 |
| CaO | 0.76 |
| $Na_2O$ | 1.95 |
| $K_2O$ | 5.56 |
| $P_2O_5$ | 0.09 |
| $H_2O^+$ | 0.29 |
| $H_2O^-$ | 0.03 |
| $CO_2$ | 0.05 |
| $SO_3$ | <0.01 |
| Total | 99.8 |
| S.I. index | 1.13 |
| Li | 27 |
| Be | 1 |
| B | 5 |
| F | 400 |
| Co | 68 |
| Ni | 6 |
| Zn | 52 |
| Rb | 340 |
| Sr | 34 |
| Y | 48 |
| Sn | <4 |
| Ba | 140 |
| W | <10 |
| Th | 28 |
| U | 4 |

Analysis by Amdel Rept AN3095/77

7 mm across of mafic minerals, and a few bluish-grey feldspar crystals up to 5 mm across, in a pale greenish-grey fine-grained feldspathic matrix. The second subsidiary rock-type is a darker porphyritic variant of the Aloolya Gneiss, consisting of subhedral to euhedral megacrysts up to 5 cm long of potassium feldspar in a gneissic granite groundmass. Both variants contain xenoliths of mafic Tyson Creek granulite, and the porphyritic variant contains large partly assimilated xenoliths of regular Aloolya Gneiss. The two subsidiary rock-types may be hybrids resulting from reaction of the mafic Tyson Creek granulite with the Aloolya Gneiss.

The age of the Aloolya Gneiss is not known exactly, but the cuspate contact with the Anmatjira Orthogneiss at the type locality indicates that the Aloolya Gneiss was intruded only a very short time after emplacement of the Anmatjira Orthogneiss, when the latter was still hot and, moreover, less viscous (because it was hotter or wetter, or both) than the Aloolya Gneiss, perhaps even still partly liquid.

Napperby Gneiss (Egn) (A.J.S. and A.Y.G.)

Cook & Scott (1967) used the name Napperby Granite in their report of a reconnaissance study of the Ngalia Basin and its environs, and gave a petrographic description of one sample. The Napperby Gneiss is here defined as the body of strongly foliated granitic gneiss which crops out along the entire length of the Yalyirimbi Range, in the southern parts of REYNOLDS RANGE and TEA TREE, and northern parts of NAPPERBY and AILERON. The name is derived from Napperby homestead (GR59895089), on the southern side of the Yalyirimbi Range in NAPPERBY. The Gneiss forms rough rocky hills rising to about 150 m above the surrounding alluvial plains. In contrast to the various bodies of orthogneiss in the area, tors and domal surfaces are in general not prominent, an exception being the large dome which forms a prominent landmark 2.5 km north of Napperby homestead.

The Napperby Gneiss intrudes the Pine Hill Formation in the southeastern corner of REYNOLDS RANGE, the Mount Dunkin and Mount Freeling schists and the Aileron metamorphics in the northwest of AILERON, and the Wickstead Creek beds in the northwest of AILERON and northeast of

TEA TREE. East of Wickstead Creek in AILERON, the boundary between the Napperby Gneiss and the Mount Freeling schist is a major shear zone, and the granite displays nearly complete retrogression to muscovite-quartz schist copiously veined by quartz. In these areas sheared gneiss and sheared metamorphic rock cannot be readily distinguished from one another. In the northern part of AILERON, the Napperby Gneiss merges with outcrops of unnamed granite along the upper tributaries of Kerosene Camp Creek. Between Wickstead Creek and Wallaby Creek, the Gneiss commonly includes roof pendants of calc-silicate rock of the Wickstead Creek beds. These pendants are abundantly intruded by tourmaline-bearing coarse-grained porphyritic microcline pegmatites emanating from the granite. The Gneiss is intruded by dykes of pegmatite, feldspar porphyry, aplite, microgranite, and vein quartz. The Gneiss is thrust over the Vaughan Springs Quartzite along the northern margin of the Ngalia Basin.

The type locality of the Napperby Gneiss is at South 20 Mile Waterhole (GR28345069), on the southern side of the Yalyirimbi Range. Here, layered granitic gneiss cut by mylonite zones and kink bands is well exposed in the rocky creek bed.

The Napperby Gneiss is a medium-grained equigranular grey <u>granitic gneiss</u> which is everywhere strongly foliated; in places, especially at the type locality, the rock is discontinuously layered (Fig. 89). The Gneiss is commonly heterogeneous, and comprises a mixture of medium to coarse-grained granitic gneiss, irregular lenses and swirls of fine-grained granite, and irregular masses of pegmatitic granite. At the large dome north of Napperby homestead, granitic gneiss is intruded by dykes of leucocratic granite, leucocratic microgranite, pegmatite, and aplite. At locality C558, 4 km east of South 20 Mile Waterhole, granitic gneiss is intruded by cross-cutting dykes of grey porphyritic granite. At the western end of the Napperby Gneiss two varieties of microgranite are present: an earlier strongly foliated porphyritic microgranite containing numerous flattened xenoliths, intruded by a later weakly foliated very tough equigranular microgranite containing a few ovoid xenoliths and some leucocratic schlieren.

The dominant medium-grained granitic gneiss of the Napperby Gneiss has an allotrimorphic texture, and consists essentially of strained

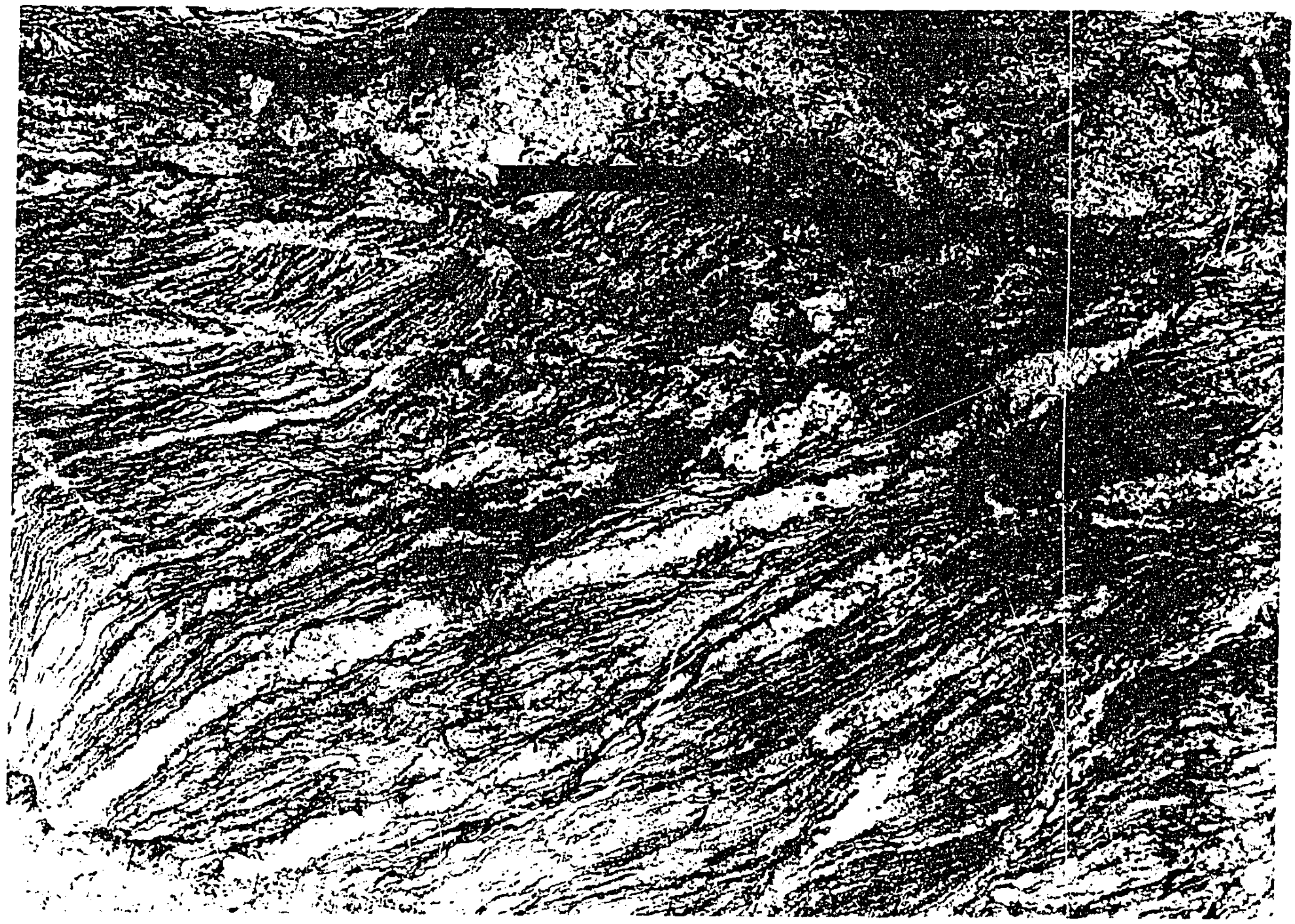


Fig. 89: Layered granitic gneiss of Napperby Gneiss at type locality, South 20 Mile Waterhole, GR5452-834073. Scale 15 cm long. Neg. M/1409/15.

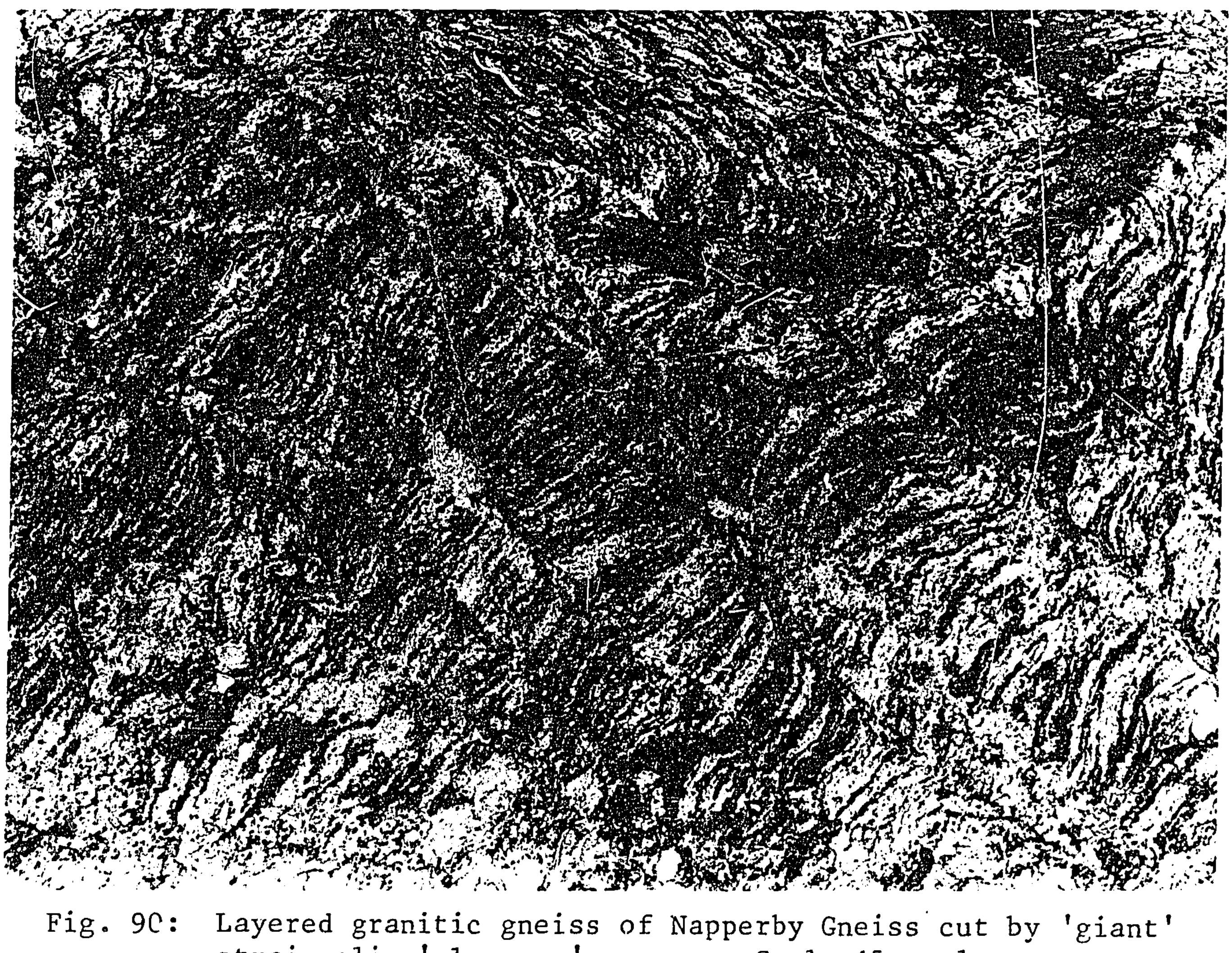


Fig. 90: Layered granitic gneiss of Napperby Gneiss cut by 'giant' strain-slip 'cleavage' zones. Scale 15 cm long. At South 20 Mile Waterhole. Neg. M/1409/4

microcline (50-65%), strained and partly recrystallised quartz (20-30%), sericitised plagioclase (10-15%), and greenish-brown oriented biotite (5%) intergrown with muscovite. Apatite, pink zircon, and ilmenite are accessory, and sericite, epidote, clinozoisite, and sphene are secondary (72921017, -1019). In sample -1018, the Gneiss consists of coarsely sericitised andesine (65%), recrystallised quartz (20%), and epidote (15%) in aggregates and veinlets throughout the rock; clinozoisite also forms monomineralic veinlets. The porphyritic granite dykes at sample locality C558 consist of closely packed euhedral prisms up to 1.5 cm long of microcline with Carlsbad twinning, in a medium-grained matrix of quartz, plagioclase, and biotite; apatite, and metamict zircon are accessory.

Results of chemical analysis of two samples of the Napperby Gneiss are presented in Table 12. The S.I. indices are inconclusive as to the parent material of the Gneiss.

In AILERON, most specimens collected from the Napperby Gneiss show some degree of mechanical deformation e.g., mylonitisation, fracturing, annealed textures, and alteration. The mylonitisation involves extensive recrystallisation of quartz into polygonal mosaics, and fracturing, shearing, and sericitisation of feldspar (73922015A, 72921206B). Plagioclase is heavily sericitised, whereas the microcline is relatively clear and remains as relics even where the rest of the rock is completely altered to a quartz-sericite aggregate (73922003). Metamorphic differentiation associated with shearing results in the segregation of sericite and quartz in separate bands.

The foliation and layering in the Napperby Gneiss are cut at high angles by thin zones up to 5 cm wide in which the foliation is completely re-oriented, as in 'strain-slip cleavage' (Fig. 90). In a few places, the 'strain-slip cleavage' grades into kink bands, including conjugate sets (Fig. 91), and elsewhere, the strain-slip cleavage grades along strike into pegmatite bodies, some of which are irregular lenticular masses and stringers, others are more regular dykes. South of Mount Dunkin and Mount Freeling in AILERON, the foliation is conspicuously folded and crenulated. The banding of the gneiss in this area is particularly well developed, with biotite-rich bands alternating with quartzofeldspathic bands.

Table 12: Results of chemical analysis of two samples of Napperby Gneiss. Major oxides in percent; trace elements in ppm

| Sample nos. | 72921017 | 72921019 |
|---|---|---|
| Localities | 5453-616110 | 5452-938055 |
| $SiO_2$ | 71.5 | 73.6 |
| $TiO_2$ | 0.41 | 0.40 |
| $Al_2O_3$ | 13.9 | 13.3 |
| $Fe_2O_3$ | 0.61 | 0.65 |
| FeO | 2.85 | 1.80 |
| MnO | 0.03 | 0.01 |
| MgO | 0.67 | 0.50 |
| CaO | 1.91 | 1.76 |
| $Na_2O$ | 2.55 | 2.97 |
| $K_2O$ | 4.89 | 4.07 |
| $P_2O_5$ | 0.16 | 0.16 |
| $H_2O^+$ | 0.59 | 0.54 |
| $H_2O^-$ | 0.03 | 0.04 |
| $CO_2$ | 0.10 | 0.05 |
| $SO_3$ | <0.01 | <0.01 |
| Total | 100.2 | 99.9 |
| S.I. index | 1.104 | 1.099 |
| Li | 37 | 8 |
| Be | 3 | 3 |
| B | 10 | 10 |
| F | 1180 | 700 |
| Co | 54 | 82 |
| Ni | 6 | 12 |
| Zn | 73 | 27 |
| Rb | 350 | 210 |
| Sr | 70 | 85 |
| Y | 28 | 40 |
| Sn | 10 | 4 |
| Ba | 580 | 720 |
| W | <10 | <10 |
| Th | 65 | 26 |
| U | 30 | 8 |

Analyses by Amdel Rept AN3095/77

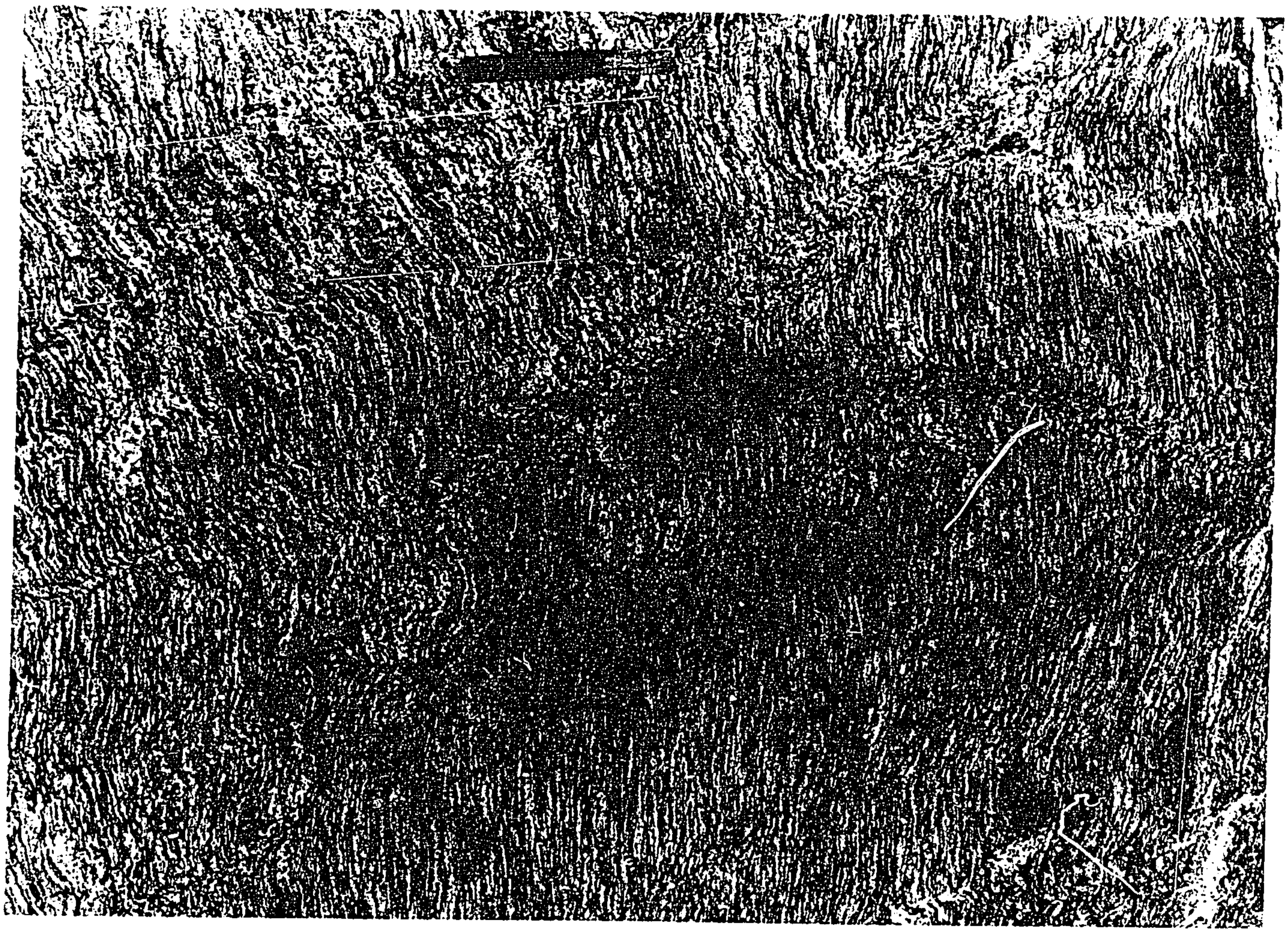


Fig. 91: Conjugate kink bands in layered granitic gneiss of Napperby Gneiss, South 20 Mile Waterhole.
Neg. M/1409/5.

Fig. 92: Two mylonite zones, accompanied by quartz lenses and strongly sheared gneiss, cutting layering of Napperby Gneiss at large angle. South 20 Mile Waterhole.
Neg. M/1409/11.

Xenoliths in the Napperby Gneiss are rare except along the northern margin, where rafts of calc-silicate rock of the Wickstead Creek beds are present; the area is depicted as igneous breccia on the Preliminary Edition of AILERON.

The Napperby Gneiss is cut by numerous faults and fault zones filled with mylonite, flaser granite, and vein quartz (Fig. 92). Heavily mylonitised, brecciated, and sheared granite is exposed in the southern-most outcrops between Wickstead and Wallaby Creeks, in AILERON.

The Napperby Gneiss appears to be a syntectonic batholith intruded concurrently with orogenic deformation of the region. Its medium grain, and the common occurrence of fine-grained hypabyssal variants, some with euhedral feldspar phenocrysts, suggest faster cooling and hence a higher crustal level of emplacement than the Anmatjira Orthogneiss.

Rb-Sr analyses of samples of whole rock and muscovite of the Napperby Gneiss from localities 72921017, -1019 have given an imprecise date of 1600-1500 Ma. Small intrusions of unnamed granite emplaced in the Mount Freeling schist and Woodforde River beds in the northwest of AILERON may be offshoots of the Napperby Gneiss.

<u>Unnamed granite</u> (Egp) (L.A.O. and A.J.S.)

Unnamed porphyritic and even-grained granite crop out mainly in the Ennugan Mountains, which straddle the junction of REYNOLDS RANGE, TEA TREE, and MOUNT PEAKE; it also occurs in the southeast of the Mount Peake 1:250 000 Sheet area, and 4 km southeast of Mount Stafford, in REYNOLDS RANGE. The granite of the Ennugan Mountains intrudes three separate outcrops of biotite schist and gneiss of the Lander Rock beds in the northwest of TEA TREE, and is intruded by acid igneous dykes. An amphibolite body of unknown relationships (intrusive plug or xenolithic raft) crops out within the granite in the southern part of the Mountains, in TEA TREE (locality C762). To the east, well exposed, folded, cross-bedded quartzite crops out, and is mapped as Vaughan Springs Quartzite. The granites are not seen to intrude the quartzite and thus may unconformably underlie it.

The porphyritic granite consists of laths, stubby prisms, and ovoids of potash feldspar, commonly up to 5 cm across and containing quartz and biotite inclusions, in a biotite-feldspar-quartz matrix. Fluorite is a common accessory. Flow alignment of the feldspars is common. The feldspar phenocrysts commonly have a clear translucent core and a white opaque mantle.

Poorly foliated even-grained granite is confined to the north-eastern side of the major northwest-trending fault zone in the northeast corner of REYNOLDS RANGE. It consists primarily of biotite, quartz, and feldspar with minor fluorite, and is intruded by granophyric quartz-microcline porphyritic microgranite (72110158 and 72920768), aplite dykes, and quartz veins.

Results of chemical analysis of four samples (72110149, 72920763, -0766, -0773) of the granite of the Ennugan Mountains are set out in Table 13. The granite is rich in silica, beryllium, fluorine, rubidium, tin, thorium, and uranium; the last ranges up to five times the average uranium content in granite. The S.I. indices indicate an origin by melting of igneous rock.

Faults and minor shear zones cut the granites, and produce granitic orthoschist. The orthoschist characteristically consists of quartz grains in a muscovite-chlorite matrix. The large northwest-trending fault zone in the northeast of REYNOLDS RANGE consists of about 35 m of laminated quartz flanked on each side by orthoschist. In some shears the feldspar has altered to kaolin.

Xenoliths and rafts of metasediment have equilibrated with the enveloping granite, and consist of biotite, quartz, and feldspar of medium-grained granitic texture. Feldspar porphyroblasts occur in some xenoliths.

Porphyritic granite of the Ennugan Mountains type also crops out in the southeast of the Mount Peake Sheet area, south of the Anningie Tin Field. Here, the microcline phenocrysts reach 12 x 3 x 1.5 cm, and are strongly aligned in a steeply dipping platy flow structure (Fig. 93). At GR308459 4 1, the phenocrysts are gathered together in a magmatic 'eddy'

Table 13: Results of chemical analysis of eight samples of Unnamed granite (porphyritic). Major oxides in percent, trace elements in ppm.

| Sample no. | *0149 | **0763 | **0766 | **0773 | ***0341 | ***0348 | ***0349 | ***0030 |
|---|---|---|---|---|---|---|---|---|
| Locality | 5454-613880 | 5453-908509 | 5453-866652 | 5553-954612 | 30706027 | 30715951 | 30845941 | 33335745 |
| $SiO_2$ | 75.00 | 76.14 | 75.95 | 77.66 | 71.7 | 72.6 | 70.2 | 64.5 |
| $TiO_2$ | 0.20 | 0.05 | 0.04 | 0.09 | 0.17 | 0.21 | 0.33 | 0.74 |
| $Al_2O_3$ | 12.51 | 12.79 | 12.56 | 11.47 | 14.4 | 14.0 | 14.9 | 15.5 |
| $Fe_2O_3$ | 0.55 | 0.13 | 0.13 | 0.15 | 0.32 | 0.59 | 0.54 | 2.44 |
| FeO | 1.55 | 0.90 | 0.90 | 1.15 | 1.50 | 1.30 | 2.45 | 2.55 |
| MnO | 0.04 | 0.03 | 0.05 | 0.02 | 0.03 | 0.03 | 0.04 | 0.05 |
| MgO | 0.08 | 0.06 | 0.02 | 0.02 | 0.41 | 0.51 | 0.75 | 1.59 |
| CaO | 0.95 | 0.72 | 0.61 | 0.20 | 1.01 | 0.97 | 1.44 | 2.17 |
| $Na_2O$ | 2.70 | 2.30 | 3.64 | 3.34 | 2.87 | 2.60 | 2.53 | 2.56 |
| $K_2O$ | 5.64 | 6.44 | 4.72 | 4.70 | 6.52 | 5.82 | 5.30 | 4.90 |
| $P_2O_5$ | 0.03 | 0.03 | 0.03 | 0.01 | 0.14 | 0.19 | 0.18 | 0.28 |
| $H_2O^+$ | 0.70 | 0.54 | 0.85 | 0.41 | 0.68 | 0.84 | 0.93 | 1.78 |
| $H_2O^-$ | 0.04 | 0.02 | 0.13 | 0.19 | 0.04 | 0.08 | 0.05 | 0.02 |
| $CO_2$ | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.50 |
| $SO_3$ | 0.01 | <0.01 | <0.01 | <0.01 | <0.01 | 0.04 | <0.01 | 0.02 |
| Total | 100.05 | 100.20 | 99.67 | 99.46 | 99.9 | 99.8 | 99.7 | 99.6 |
| S.I. index | 1.02 | 1.07 | 1.03 | 1.05 | 1.09 | 1.18 | 1.23 | 1.21 |
| Li | 32 | 18 | 160 | 70 | 65 | 25 | 100 | 34 |
| Be | 6 | 2 | 6 | 8 | 2 | 1 | 4 | 5 |
| B | 10 | 5 | 10 | 5 | 10 | 15 | 20 | 20 |
| F | 2800 | 360 | 7900 | 2950 | 320 | 660 | 1200 | 1520 |
| Co | <1 | <1 | <1 | <1 | 44 | 60 | 44 | 38 |
| Ni | <2 | <2 | <2 | <2 | 8 | 6 | 12 | 14 |
| Zn | 76 | 52 | 64 | 58 | 53 | 57 | 72 | 82 |
| Rb | 410 | 390 | 960 | 680 | 310 | 330 | 320 | 280 |
| Sr | 48 | 17 | 16 | 7 | 80 | 75 | 85 | 230 |
| Y | 95 | 70 | 160 | 50 | 24 | 18 | 20 | 22 |
| Sn | 14 | 12 | 50 | 20 | <4 | 18 | 6 | <4 |
| Ba | 250 | 60 | <20 | 40 | 350 | 340 | 380 | 720 |
| W | 15 | <10 | 25 | 10 | <10 | <10 | <10 | <10 |
| Th | 48 | 16 | 46 | 38 | 22 | 14 | 22 | 44 |
| U | 10 | 10 | 20 | 14 | 12 | <4 | 6 | 12 |

*Preceded by 7211; **7292: ***7411

Analyses by Amdel Repts AN3095/77 (-0341, -0348, -0349, -0030)
AN3805/77 (-0149, -0763, -0766, -0773).

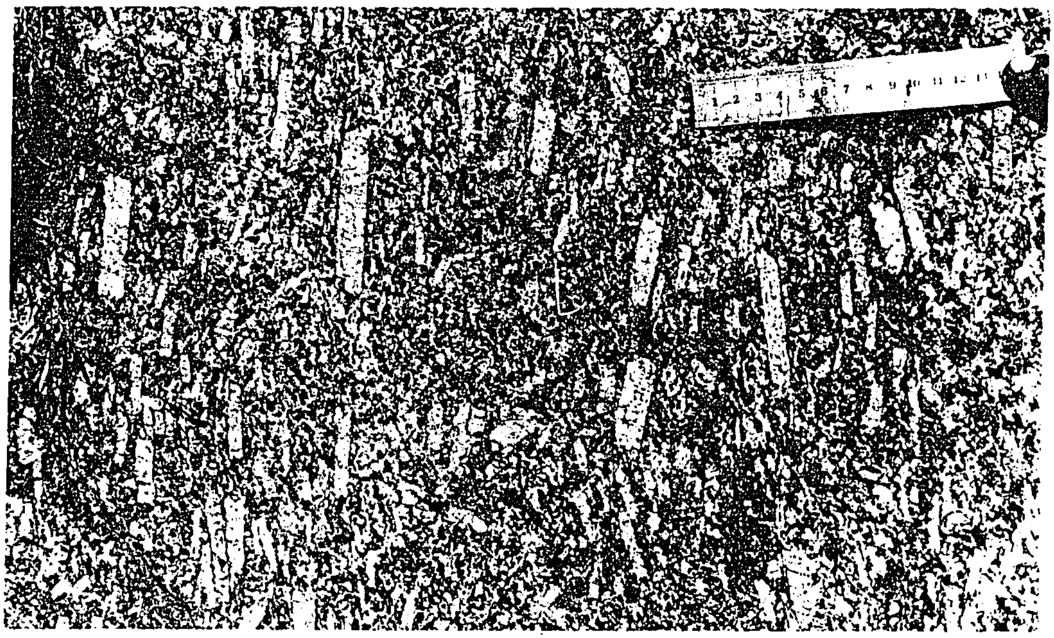


Fig. 93: Unnamed porphvritic granite showing strong platy parallelism of microcline tablets. GR30845942, 12 km north-northeast of Anningie homesteac, Mount Peake 1:250 000 Sheet area.
Neg. M/1724/51.

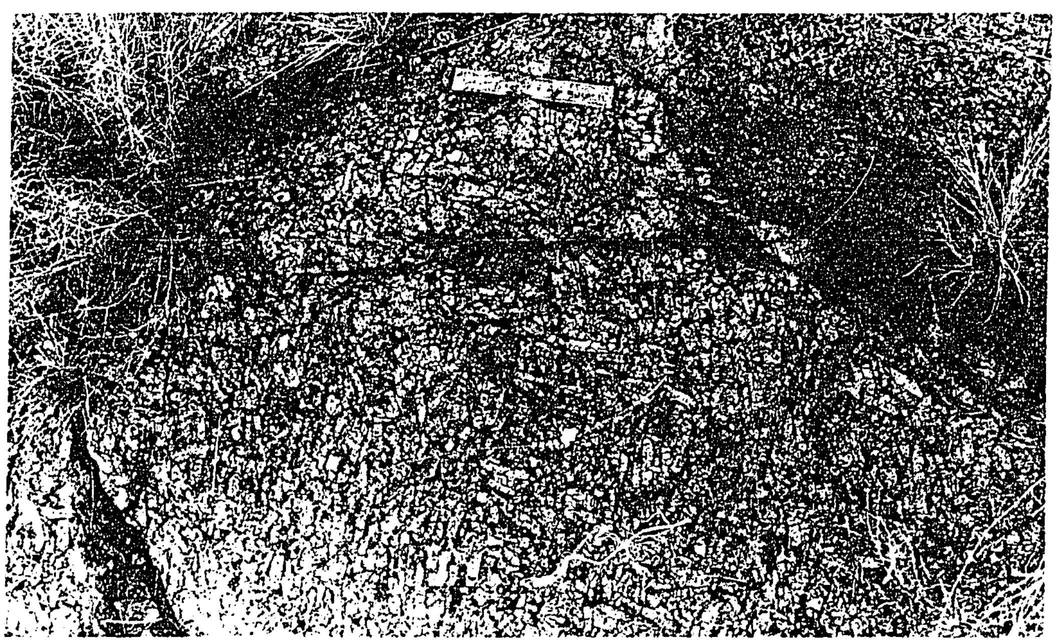


Fig. 94: Orthophyric segregation of microcline tablets in unnamed porphyritic granite, same locality as Fig. 93.
Neg. M/1724/41.

and form an orthophyric syenite segregation (Fig. 94). Results of chemical analysis of three samples of this granite (74110341, -0348, -0349) are set out in Table 13. In contrast to the granite of the Ennugan Mountains, the S.I. indices indicate a largely sedimentary parentage.

Porphyritic granite of a different type crops out immediately east and south of Mount Esther homestead, and at Mount Chisholm in the southeast corner of the Mount Peake Sheet area. This variety comprises equant euhedral phenocrysts of microcline up to 5 cm across, in a coarse to very coarse-grained green groundmass of plagioclase, quartz, and biotite (74110030). An analysis of one sample (74110030) of this granite is set out in Table 13.

Unnamed granite 4 km southeast of Mount Stafford in REYNOLDS RANGE intrudes the Mount Stafford beds, and is intruded by a porphyritic border phase of the Anmatjira Orthogneiss. It is a fairly even-medium-grained rock consiscing of poorly aligned sericitised feldspar, quartz, and clots of chloritised biotite (72920756 and -0759) and contains rare green fine-grained xenoliths. Pegmatite, aplite, and quartz veins cut the granite.

The age of these granites is not known exactly. They intrude and are therefore younger than the Middle Proterozoic or older Lander Rock beds, and appear to be unconformably overlain by the Late Proterozoic Vaughan Springs Quartzite. Hence the granites of the Ennugan Mountains are Middle Proterozoic or older. The granite 4 km southeast of Mount Stafford is older than the Anmatjira Orthogneiss, which is dated at 1600 $\pm$ 100 Ma.

Wangala Granite (Egx) (A.J.S.)

The Wangala Granite is the composite body of various types of granite that crops out mainly in the northern part of DENISON, and extends east into the western part of REYNOLDS RANGE. The Granite erodes to rocky and bouldery hills rising sharply from the surrounding alluvial plains to a height of about 150 m. The name is derived from the Wangala Hills (GR5353-000430) in the northwest of DENISON: the Hills are composed almost wholly of the Granite. The type locality is located at GR5353-018453, 5 km south-southeast of Mount Denison homestead; here a rock face on the side of the Wangala Hills has been dynamited for fresh samples; the blast site displays coarse-grained granite (type 1; see below) with aligned tabular phenocrysts of potassium feldspar, intruded by medium-grained porphyritic granite (type 4) (Fig. 96).

The Wangala Granite intrudes the Ngalurbindi Orthogneiss, the Wickstead Creek beds, the unnamed quartzofeldspathic gneiss pЄf, and surrounds rafts of and presumably intrudes the unnamed schist pЄs$_2$. It is faulted against the Mount Stafford beds, the unnamed granitic gneiss pЄg, and the unnamed granite Єg, and is unconformably overlain by the Central Mount Stuart Formation. It is intruded by a plug of diorite 13 km west-northwest of Mount Allan homestead, and by dykes of amphibolite, porphyry, pegmatite, quartz + chlorite, and vein quartz.

The Wangala Granite is a composite fault-bounded batholith comprising at least eight different types of granite. Figure 95 shows the known distribution of the eight types. Contacts have been observed between six of the varieties, enabling an order of intrusion to be established.

1. The earliest intrusion is a <u>coarse-grained porphyritic granite</u> characterised by euhedral tabular phenocrysts of microcline. It crops out extensively in the west of the Wangala Granite, and to a lesser extent in the northern portion (Fig. 95). The microcline phenocrysts are up to 6 m long, spaced several centimetres apart, and aligned in a steeply dipping platy flow structure. The rock is a two-mica granite, and consists of quartz, oligoclase, microcline which contains blebs of sericitised plagioclase rimmed with unaltered more sodic plagioclase, biotite, muscovite, and apatite (72921012). It contains xenoliths of metapelitic rock, composed of quartz, feldspar, biotite, muscovite, and, in some samples, sillimanite. The granite is cut by numerous veins and dykes of pegmatite, some of which are folded and fracture cleaved. In the northern part of the Wangala Hills, the coarse porphyritic granite is intruded at many places by the fourth variety, medium-grained porphyritic granite (Fig. 96). In the northeastern part of the Wangala Hills, and in the Mau Hills, it is associated with, and at two localities intruded by the second variety. Chemical analyses of two samples of the granite (72920563, -1012) are set out in Table 14.

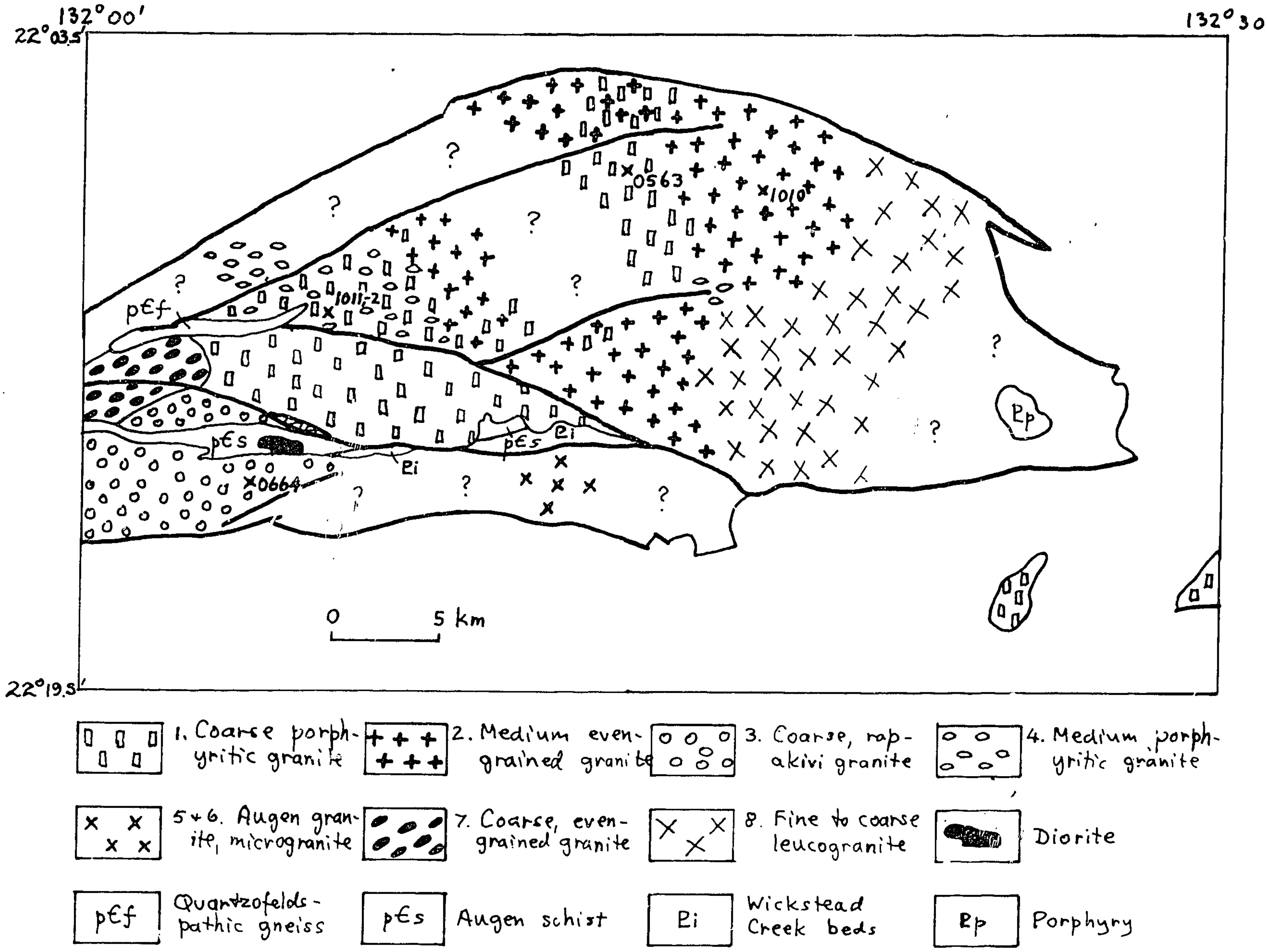



Fig. 95 : Map of Wangala Granite, showing known distribution of eight granitic rock-types, and locations (marked by x) of four of the five chemically analysed samples (Table 14); sample 0838 is located outside area of figure, in southeast of DENISON. Queries indicate areas of non-exposure.

16/NT/12

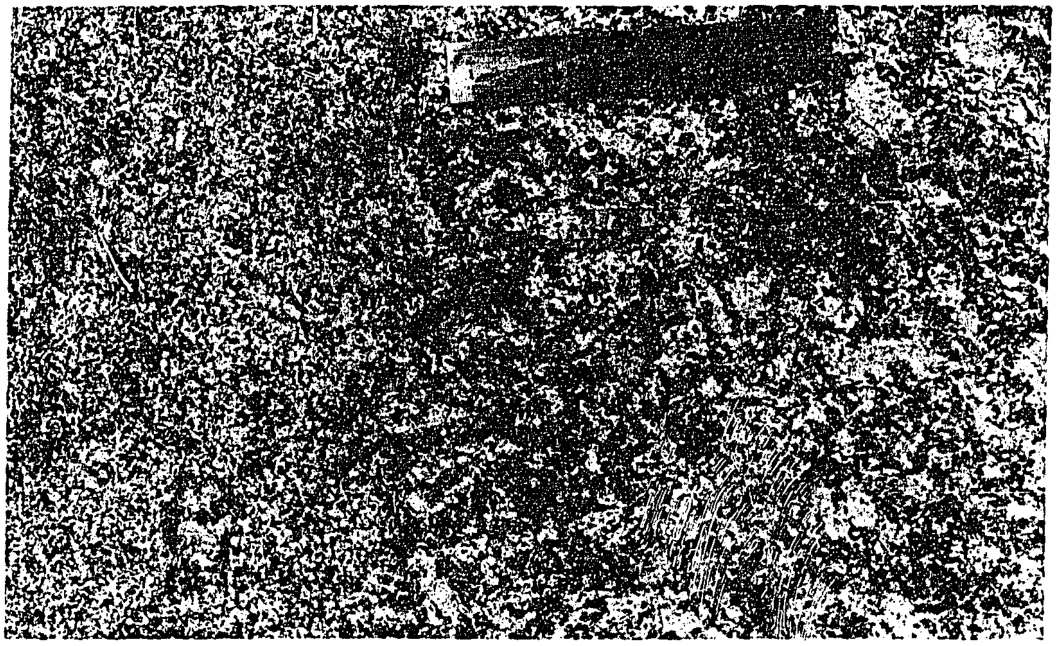


Fig. 96: Type locality of Wangala Granite, showing coarse-grained porphyritic granite (type 1) (right) cut by medium-grained porphyritic granite (type 4, left). GR5353-018453, 5 km south-southeast of Mount Denison homestead.
Neg. M/1729/14.

Fig. 97: Coarse-grained rapakivi granite (type 3) of Wangala Granite, showing two mantled feldspars (grey kernels, black shells) near centre of photo. GR5353-941377, 13 km south-southwest of Mount Denison homestead.
Neg. M/1729/38.

Table 14: Results of chemical analysis of six samples of Wangala Granite. Major oxides in percent; trace elements in ppm.

| Sample nos | *0563 | *1012 | *1010 | **0664 | *1011 | **0838 |
|---|---|---|---|---|---|---|
| Locality | 5353-152521 | -018453 | -213512 | -983376 | -018453 | -407216 |
| Wangala Granite type | 1 | 1 | 2 | 3 | 4 | unassigned |
| $SiO_2$ | 75.9 | 71.4 | 72.7 | 73.0 | 73.3 | 72.3 |
| $TiO_2$ | 0.13 | 0.25 | 0.15 | 0.38 | 0.17 | 0.46 |
| $Al_2O_3$ | 13.9 | 14.5 | 14.3 | 13.2 | 14.2 | 12.5 |
| $Fe_2O_3$ | 0.26 | 0.27 | 0.58 | 0.76 | 0.28 | 0.96 |
| FeO | 0.95 | 2.05 | 1.00 | 1.90 | 1.30 | 2.45 |
| MnO | 0.02 | 0.03 | 0.03 | 0.03 | 0.02 | 0.05 |
| MgO | 0.19 | 0.49 | 0.28 | 0.40 | 0.33 | 0.52 |
| CaO | 0.82 | 0.92 | 0.58 | 1.36 | 1.07 | 1.67 |
| $Na_2O$ | 2.80 | 2.70 | 2.98 | 2.39 | 2.93 | 2.21 |
| $K_2O$ | 3.47 | 5.42 | 5.52 | 5.67 | 5.42 | 5.14 |
| $P_2O_5$ | 0.15 | 0.21 | 0.23 | 0.10 | 0.15 | 0.11 |
| $H_2O^+$ | 1.03 | 0.94 | 1.00 | 0.57 | 0.69 | 0.84 |
| $H_2O^-$ | 0.03 | 0.06 | 0.08 | 0.07 | 0.07 | 0.06 |
| $CO_2$ | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 |
| $SO_3$ | <0.01 | <0.01 | <0.01 | 0.02 | <0.01 | 0.01 |
| Total | 99.7 | 99.3 | 99.5 | 99.9 | 100.0 | 99.3 |
| S.I. index | 1.45 | 1.23 | 1.25 | 1.07 | 1.15 | 1.03 |
| Li | 70 | 110 | 85 | 48 | 70 | 42 |
| Be | 12 | 7 | 8 | 5 | 6 | 4 |
| B | 30 | 50 | 315 | 15 | 10 | 25 |
| F | 680 | 1320 | 1160 | 1280 | 860 | 1640 |
| Co | 58 | 50 | 52 | 74 | 74 | 72 |
| Ni | 2 | 6 | 6 | 6 | 4 | 2 |
| Zn | 61 | 70 | 66 | 72 | 44 | 64 |
| Rb | 270 | 440 | 500 | 430 | 430 | 360 |
| Sr | 22 | 44 | 28 | 55 | 50 | 60 |
| Y | 8 | 16 | 8 | 36 | 30 | 60 |
| Sn | 8 | 16 | 12 | 14 | 10 | 10 |
| Ba | <20 | 180 | 120 | 520 | 230 | 580 |
| W | 1100 | 10 | 10 | <10 | 10 | 10 |
| Th | 6 | 28 | 10 | 55 | 28 | 36 |
| U | 24 | 10 | 14 | 12 | 12 | 14 |

*Preceded by 7292; **7492

Analyses by Amdel Rept AN3095/77

2. The second variant of the Wangala Granite is a medium even-grained granite, which crops out in the central part of the batholith (Fig. 95). The rock ranges from massive, to weakly foliated, to strongly foliated, and consists generally of microcline, sodic andesine ($An_{32}$), quartz, muscovite in large clear flakes, and biotite (74920678). A leucocratic variety in the western part of the batholith contains topaz as an abundant accessary, but lacks biotite (-0680). The rock is cut by numerous large pegmatite dykes, but contains very few xenoliths. It is intruded by the fourth variety of the Wangala Granite in the northern part of the Wangala Hills. A chemical analysis of one sample of the granite (72921010) is set out in Table 14.

3. The third variety of Wangala Granite is a coarse to very coarse-grained rapakivi granite that crops out in the southwestern part of the batholith (Fig. 95). The rock ranges from massive, containing nearly circular megacrysts of microcline up to 3 cm across, rare euhedral mantled feldspars 1 cm long, and small euhedral grains of plagioclase 0.3 cm across (Fig. 97), to foliated, in which the microcline megacrysts are augen-shaped or lenticular. The rock is adamellitic in composition; the plagiocase is oligoclase, and a small amount of muscovite is intergrown with the biotite. The granite contains abundant xenoliths, and these contain mantled feldspars also. The rapakivi granite is intruded by the fourth variety of Wangala granite, and the contact of the two is well exposed at GR5353-941377, 13 km south-southwest of Mount Denison homestead. The rapakivi granite forms a large xenolith in the medium-grained porphyritic granite (Fig. 98), and is surrounded by a shell a few centimetres thick of chilled medium-rained granite without phenocrysts. A large pegmatite dyke occurs between the two granite varieties, and has a core of porphyritic aplite containing phenocrysts of microcline up to 28 cm across (Fig. 99). A chemical analysis of one sample (74920664) of this granite is set out in Table 14.

4. The fourth variety is a medium-grained porphyritic granite containing phenocrysts of microcline up to 1.5 cm long, and crops out in the northwestern part of the batholith. It is intimately associated with and intrusive into the coarse porphyritic granite of the first variety. A small amount is also associated with the second variety in the Mau Hills. Two small isolated exposures of porphyritic fine-grained

granite, respectively 1.5 km south and 3 km southwest of Mount Denison homestead, are also assigned to the fourth variety. The phenocrysts in the medium-grained porphyritic granite are aligned in a platy flow structure parallel to the contacts with adjoining coarse-grained porphyritic granite, and at GR5353-060467, 8 km east-southeast of Mount Denison homestead, the medium-grained porphyritic granite shows dark schlieren parallel to the contact with the second variety (medium even-grained granite). The rock is a two-mica granite (72921011), and is lithologically identical to the first variety. A chemical analysis of sample -1011 is set out in Table 14.

The two isolated exposures of porphyritic fine-grained granite are adamellitic in composition, and contain no muscovite. Biotite forms 8 to 10 percent of the rock, quartz makes up only 15 percent, and allanite and sphene are abundant accessories (74920648, -0685). The westerly exposure (-0685) contains 1 percent blue-green hornblende as well.

5. The fifth variant of the Wangala Granite is represented by a small exposure of granitic augen gneiss at GR5353-139375, 3 km northeast of Mount Allan homestead. The rock is coarse-grained, strongly foliated, and the microcline augen are up to 2 cm long. Plagioclase ($An_{41}$) is generally sericitised and saussuritised, but blebs of plagioclase in the microcline augen are surrounded by a clear unaltered rim of sodic plagioclase, which probably formed by late-stage unmixing from the microcline (Tuttle & Bowen, 1958) (74920671B). No contacts with the previous four varieties are exposed, and so the place of the fifth variety in the order of emplacement is unknown. It is, however, intruded by the sixth variety.

6. The sixth variety is an even-grained microgranite that crops out with the fifth variety, 3 km northeast of Mount Allan Homestead. It resembles the two isolated exposures of porphyritic fine-grained granite of variety 4, except for its lack of phenocrysts. Like them, it contains only 15 percent quartz, and allanite and sphene are abundant; unlike them, however, it contains accessory muscovite, and biotite forms only 5 percent of the rock (74920671A). The rock is weakly foliated, and contains sparse leucocratic schlieren.

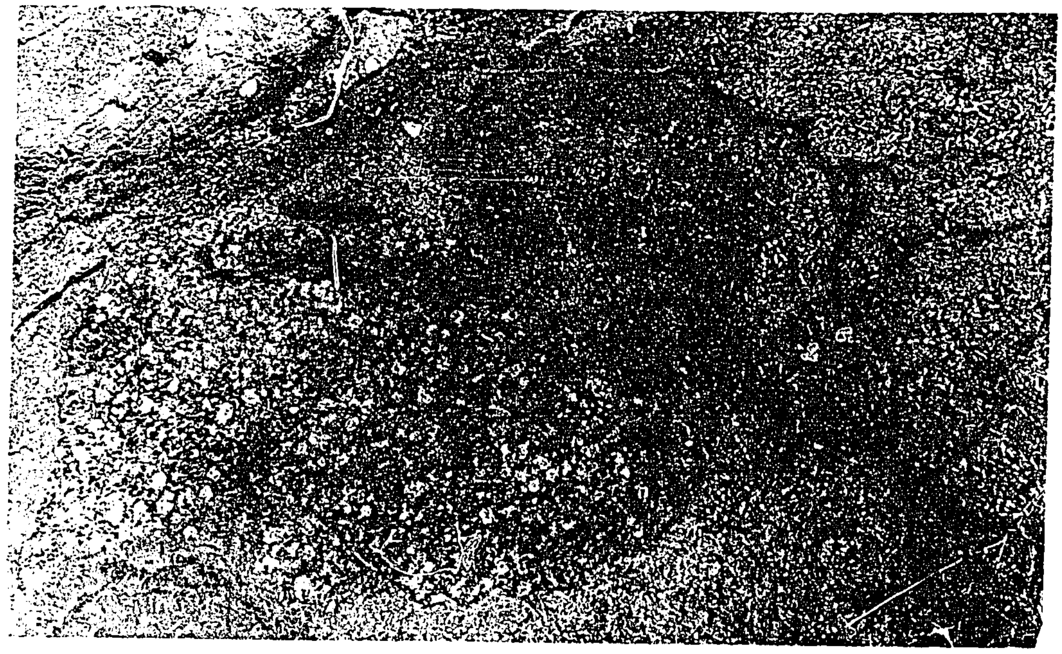


Fig. 98: Wangala Granite; xenolith of coarse-grained rapakivi granite (type 3) in medium-grained porphyritic granite (type 4), showing zone relatively free of small phenocrysts around xenolith. GR5353-941377, 13 km south-southwest of Mount Denison homestead.

Neg. M/1729/24.

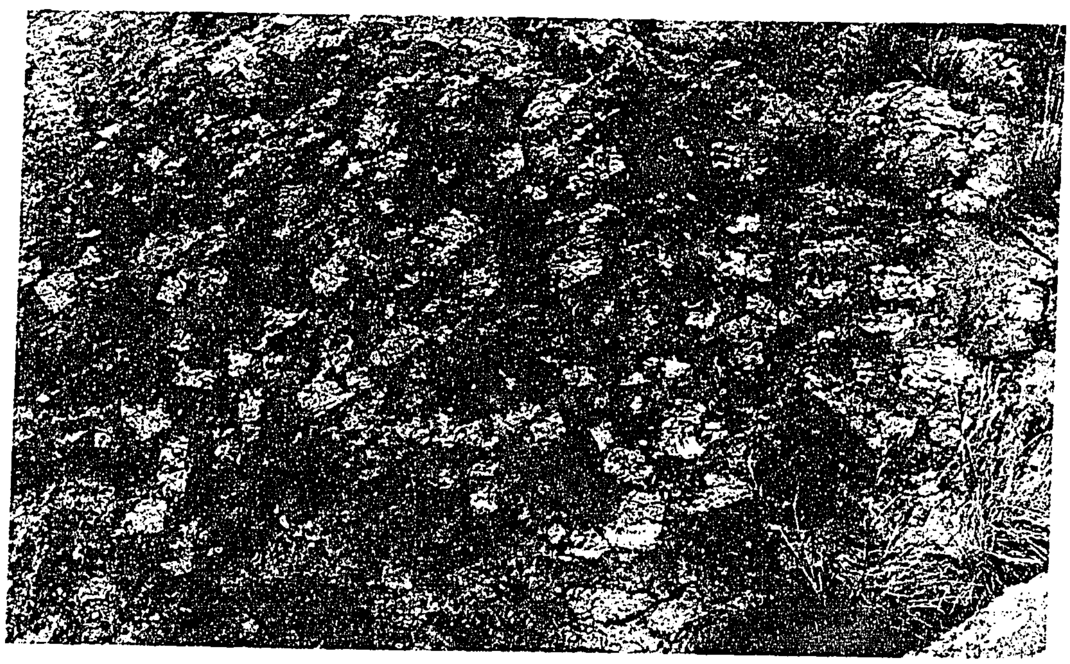


Fig. 99: Porphyritic aplite containing microcline phenocrysts up to 28 cm across, Wangala Granite. Same locality as Fig. 98.

Neg. M/1729/26.

7. The seventh variety of granite is a coarse even-grained granite that crops out in the western part of the batholith, north of the rapakivi granite of variety (3). The grains are generally about 5 mm across or slightly larger. The rock is weakly to strongly foliated, and contains numerous pegmatite and aplite veins, and a few dark xenoliths. Microcline forms euhedral grains, and as a result the rock appears like a transition phase between the second and fourth varieties. No intrusive contacts are exposed, and its position in the emplacement sequence is unknown.

8. The eighth variety of Wangala Granite is a fine to medium to coarse grained leucogranite that crops out in the eastern part of the batholith. The rock contains abundant tourmaline and muscovite, but biotite is rare or absent. The rock is copiously intruded by large pegmatites. No intrusive contacts are exposed, but the mineral assemblage suggests that the variety came late in the emplacement sequence.

The Wangala Granite is a composite intrusive batholith of magmatic origin. Excluding the small body of rapakivi granite (sample 74110664), and the small body (74110838) in the southeast of DENISON, the S.I. indices (Table 14) of the major part of the batholith are markedly greater than 1.1, indicating an origin by melting of sediments. This is supported by the abundance of muscovite, and rarity of hornblende. The body of rapakivi granite, and its associated diorite mass, are apparently derived from igneous source rocks. Plots (not figured) of Differentiation Index (D.I.) against $K_2O$, CaO, and F contents show no discernible linear trends; the data points are scattered, suggesting that the different granite varieties are not differentiates of a single magma, but are of separate origins.

Whole-rock samples of Wangala Granite (72921010) from near Brookes Soak have given an imprecise Rb-Sr age of about 1500 $\pm$ 100 Ma, with an initial $^{87}Sr/^{86}Sr$ ratio of 0.756. The Wangala Granite is lithologically correlated with the unnamed granite (Egp) of the Ennugan Mountains in REYNOLDS RANGE, TEA TREE, and MOUNT PEAKE, and with the coarse porphyritic granite (Egp) in the southeast of the Mount Peake 1:250 000 Sheet area.

The Granites Granite (Ꞓgg) (L.A.O.)

The Granites Granite, defined by Blake & others (in press), crops out in the southeastern part of The Granites-Tanami Block and extends into the western part of the Mount Solitaire 1:250 000 Sheet area at East Granites and Thomson's Rockhole. It intrudes and thermally metamorphoses the Mount Charles Beds in The Granites 1:250 000 Sheet area (Kleeman, 1934; Hossfeld, 1940; Blake & others, op. cit.), and at East Granites, in the west of the Mount Solitaire Sheet area, it intrudes a xenolith-bearing porphyritic granite assigned to the unnamed granite unit Ꞓg. At the type area, 1 km south of the abandoned gold mining centre of The Granites, The Granites Granite is a biotite adamellite. In the Mount Solitaire Sheet area, the unit is a medium-grained, speckled pink and white granite, and consists of recrystallised polygonal quartz, microcline, sericitised and saussuritised plagioclase, and chloritised biotite. At locality 430 the granite is porphyritic. Page & others (1976) determined an age of 1742 ± 23 Ma (i.e. early Middle Proterozoic) on The Granites Granite.

Harverson Granite (Ꞓgh) (A.J.S.)

The Harverson Granite is the massive very coarse-grained grey porphyritic granite which crops out between Lander Rock and Harverson Pass, in the southeast of REYNOLDS RANGE. The name is derived from Harverson Pass (GR5453-765289) which is the lowest point in the Reynolds Range and is located 2.5 km west of the nearest exposure of the Granite. The Pass is named in memory of Mr Ian Harverson, a field assistant with the BMR 1972 survey party, who was killed the following year while climbing in the Colombian Andes. Mr Harverson was the first person ever to negotiate the Pass in a motorised vehicle. The Granite is poorly exposed, and erodes to a distinctive pattern of very low elongate stony rises with a few isolated tors separated by broad alluviated flats and stream courses, which are the headwaters of the Lander River.

The Harverson Granite intrudes and metamorphoses, and is therefore younger than, the Lander Rock beds; a raft 1.5 by 1 km of Lander Rock beds has been mapped in the northeastern corner of the Granite mass. The Granite is intruded by a large number of quartz veins (48 are shown on the map), and by a few dykes of aplite and tourmaline-bearing pegmatite; no mafic dykes are known to intrude the Granite.

The contact of the Harverson Granite with the adjoining Mount Airy Orthogneiss to the east is obscured by superficial Cainozoic deposits, but because the Mount Airy Orthogneiss is intruded by numerous mafic dykes, where the Harverson Granite is not, and in fact creates a bight in the area intruded by mafic dykes in the Mount Airy Orthogneiss, the Harverson Granite is probably younger than the Mount Airy Orthogneiss.

The type locality of the Harverson Granite is a group of large tors located at GR5453-806328, 4.5 km south-southwest of Lander Rock.

The Harverson Granite is a very coarse-grained leucocratic porphyritic grey granite, containing white to pale grey phenocrysts of microcline perthite up to 7 cm long and commonly Carlsbad twinned; some are ovoid, some euhedral. In addition to microcline, the granite consists of yellowish-green plagioclase, grey translucent quartz, and small fine-grained aggregates of biotite, muscovite, and biotite and muscovite together (72921005). The rock is slightly deformed and markedly deuterically altered; plagioclase is strongly altered to coarse sericite, or to massive aggregates of clinozoisite, quartz is strained and polygonised, biotite is altered to chlorite and sphene, and is in places intergrown with epidote.

A chemical analysis of the Harverson Granite is set out in Table 15.

Xenoliths in the Harverson Granite are of two types. The first are up to 5 cm long, dark, very fine-grained, and composed of biotite and felsic minerals. Xenoliths of the second type are up to 2.5 m long, light-coloured, rounded, and have the appearance and composition of microgranodiorite. These xenoliths generally have sharp contacts with the host granite, but intermingling of the two rock-types was seen in one exposure at the type locality (Fig. 100), and another xenolith at the type locality is intruded by a cuspate mass of host granite (Fig. 101). The microgranodiorite xenoliths contain ovoid to euhedral megacrysts up to 5 cm long of microcline; some of these are jacketed with plagioclase, and plagioclase also forms a few anhedral megacrysts of its own, up to 2 cm across. The groundmass of the microgranodiorite between the megacrysts consist of plagioclase (54%) much altered to sericite,

Table 15: Results of chemical analysis of one sample of Harverson Granite. Major oxides in percent; trace elements in ppm.

| | |
|---|---|
| Sample no. | 72921005 |
| Locality | 5453-806328 |
| $SiO_2$ | 73.5 |
| $TiO_2$ | 0.26 |
| $Al_2O_3$ | 14.0 |
| $Fe_2O_3$ | 0.39 |
| FeO | 1.65 |
| MnO | 0.03 |
| MgO | 0.42 |
| CaO | 1.18 |
| $Na_2O$ | 1.46 |
| $K_2O$ | 6.10 |
| $P_2O_5$ | 0.14 |
| $H_2O^+$ | 0.67 |
| $H_2O^-$ | 0.05 |
| $CO_2$ | 0.05 |
| $SO_3$ | <0.01 |
| Total | 99.9 |
| S.I. index | 1.28 |
| Li | 50 |
| Be | 3 |
| B | 10 |
| F | 1020 |
| Co | 68 |
| Ni | 12 |
| Zn | 56 |
| Rb | 380 |
| Sr | 75 |
| Y | 26 |
| Sn | 8 |
| Ba | 430 |
| W | <10 |
| Th | 22 |
| U | 4 |

Analysis by Amdel, Rept AN3095/77

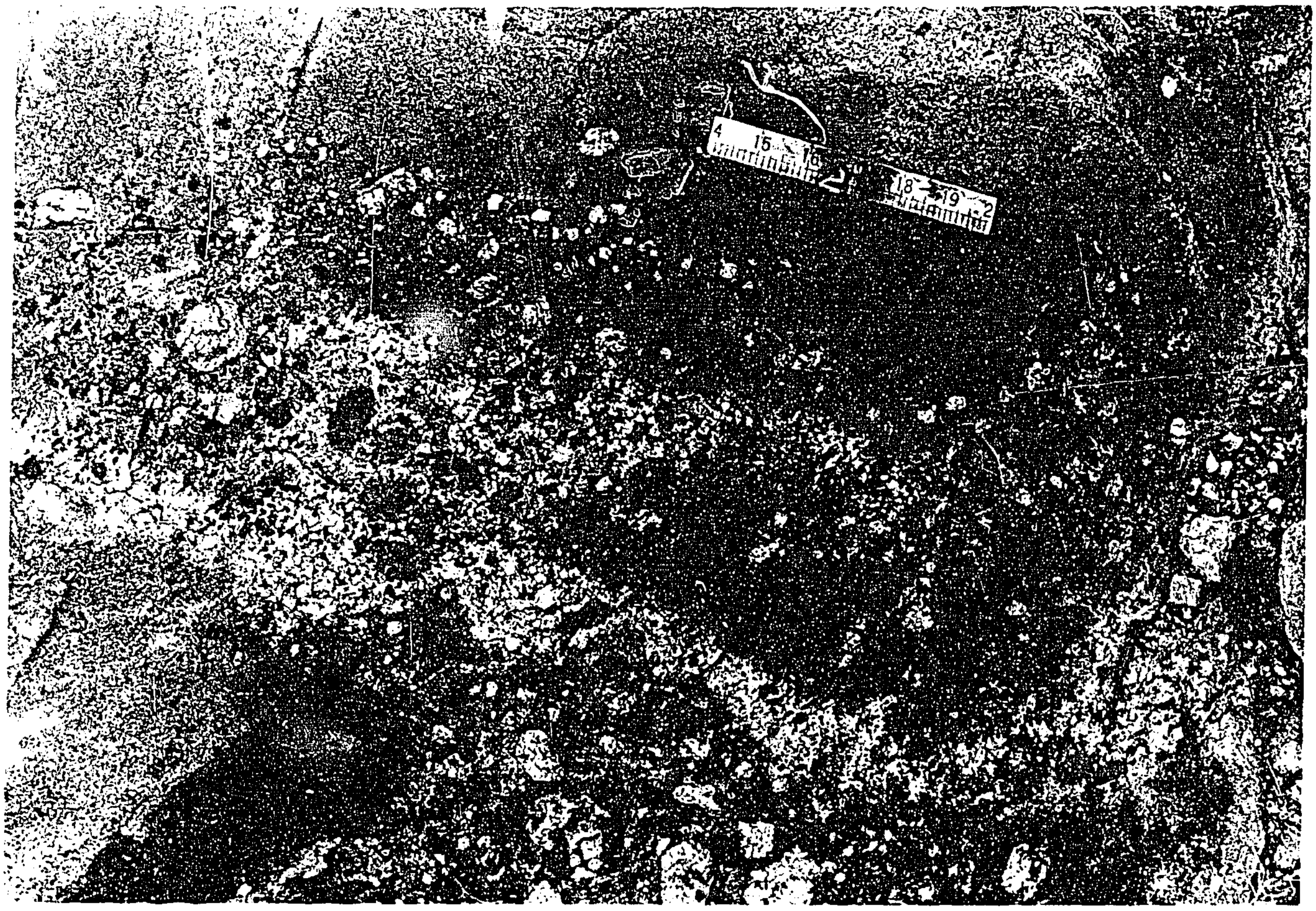




Fig. 100: Mixture of xenolith of microgranodiorite and intrusive Harverson Granite at type locality, GR5453-806328, 6 km northeast of Harverson Pass. Scale is 15 cm long.
Neg. M/1342/56.

Fig. 101: Coarse porphyritic granite of Harverson Grenite intruding xenolith of microgranodiorite; same locality as Fig.100. Width of field of view is 1.5 m.
Neg. M/1246/3.

anhedral quartz (20%), microcline (18%), red-brown to dark brown biotite (5%) accompanied by clinozoisite, muscovite (3%), and accessory zircon, apatite, and an opaque mineral (72921006).

The light-coloured microgranodiorite xenoliths themselves contain small dark xenoliths of the first type; the latter are surrounded by a sharply defined shell about 1 mm thick of fine-grained yellowish-green plagioclase, and this in turn by a less regular zone about 5 mm thick of coarse crystalline biotite. The small dark xenoliths are considered to be metasedimentary in origin, and presumably are stoped pieces of Lander Rock beds. The microgranodiorite xenoliths are interpreted as an early chilled border phase that preceded, and was itself later engulfed by, the main mass of the Harverson Granite.

The equant shape of the outcrop of the Harverson Granite, the absence of foliation and lineation in the rock, the large size of the microcline phenocrysts, the abundance of muscovite, the high S.I. index, the marked deuteric alteration, the large number of quartz veins, and the absence of intrusive mafic dykes, all indicate that the Harverson Granite is a typical late, post-orogenic, 'wet' granite, derived by melting of sedimentary rocks. Hence it is probably the youngest granite in the area. Samples (72921005) of the Granite gave an imprecise Rb-Sr whole-rock age of about 900 $\pm$ 200 Ma, with an initial $^{87}Sr/^{86}Sr$ ratio of 0.915. Samples of the light-coloured microgranodiorite xenoliths gave an imprecise Rb-Sr whole-rock age of 1500 $\pm$ 150 Ma (initial $^{87}Sr/^{86}Sr$ ratio = 0.817).

Unnamed porphyry (Ep) (L.A.O.)

Isolated low rises of unnamed porphyry crop out in the west of REYNOLDS RANGE and the east of DENISON.

The unit is best exposed at the reference locality about 1 km north-northwest of Crown Hill, in the east of DENISON (Fig. 103).

One and a half kilometres northeast of Crown Hill, biotite augen gneiss probably equivalent to the porphyry unit, is unconformably overlain by the Central Mount Stuart Formation. At the same locality the unit is intruded by an altered mafic dyke. In the north-central

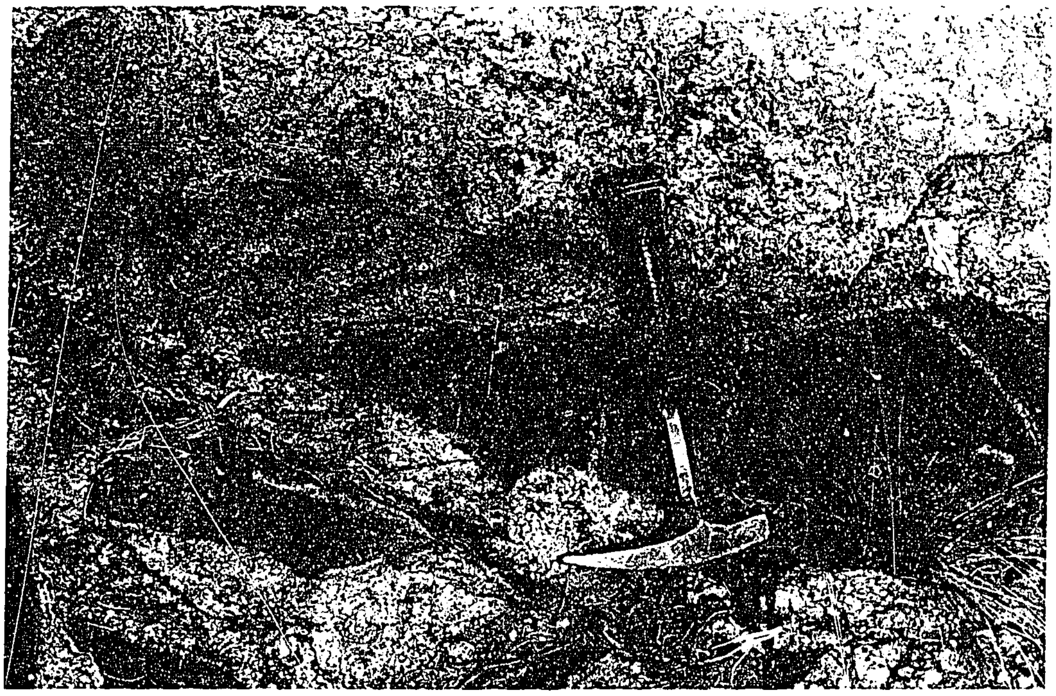


Fig. 102: Angular xenoliths of metaporphyry in Wangala Granite, GR5353-186507, 5 km south of Mount Treachery.

Neg. M/1730.

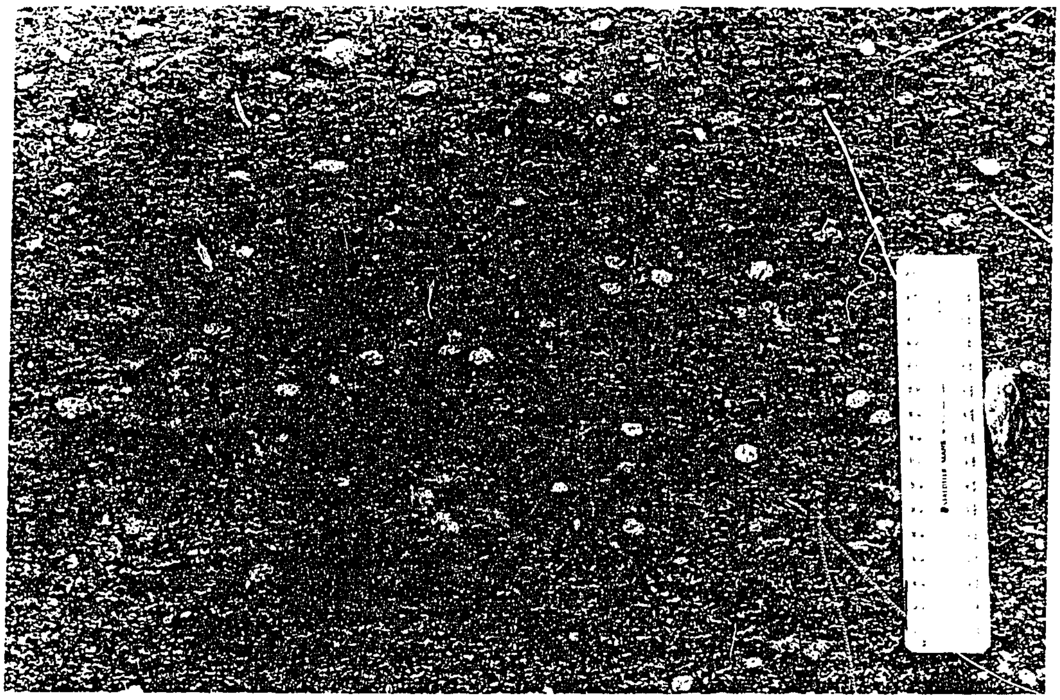


Fig. 103: Unnamed porphyry at reference locality GR5353-331417, 1 km north of Crown Hill.

Neg. M/1730

part of DENISON, about 5 km north of Pinnacle Yard, meta-porphyry crops out within and is intruded by the Wangala Granite (Fig. 102) and resembles the porphyry north-northwest of Crown Hill.

At the reference locality, the porphyry is deformed and weakly metamorphosed, and consists of oval feldspar grains up to 2 cm long in a fine-grained matrix of microcline, altered plagioclase, quartz, partly chloritised biotite, and minor muscovite and opaque grains (72920806). Foliation is defined by oriented biotite clots and quartz aggregates, and lineation by biotite streaking. In places the unit contains lenses several centimetres long of fine-grained biotite-rich rock. At one locality the porphyry is folded, and the lineation is parallel to the axes of the folds. Quartz veins occur in places and parallel the foliation.

In the north-central part of DENISON, the porphyry consists of megacrysts of feldspar and quartz aggregates up to 1 cm long in a fine-grained matrix of altered feldspar, quartz, chlorite, biotite, sphene, and opaque grains (74920800, -0804).

If the meta-porphyry and highly deformed augen gneiss are related, then the unit is older than the Late Proterozoic Central Mount Stuart Formation. The meta-porphyry north of Pinnacle Yard is older than the Wangala Granite, i.e., Middle Proterozoic or older.

Uldirra Porphyry (Epu) (A.J.S.)

The Uldirra Porphyry is the body of porphyritic microgranite, even-grained leucogranite, and porphyritic microgranodiorite that crops out in the centre of the southern part of DENISON. The Porphyry forms low rocky hills which in the south are deeply weathered and characteristically flat-topped (Fig. 104). The name is derived from Uldirra Hill (GR5353-182290), a prominent quartz-filled fault in the northern part of the Porphyry (Fig. 106). The unit is readily distinguished by its porphyritic texture and fine-grained groundmass from adjoining masses of coarse granitic augen gneiss of the Ngalurbindi Orthogneiss to the north and east, and from unnamed medium-grained granite and granodiorite to the west. The Porphyry both adjoins and is faulted against the Ngalurbindi Orthogneiss in the north, but the age relation-

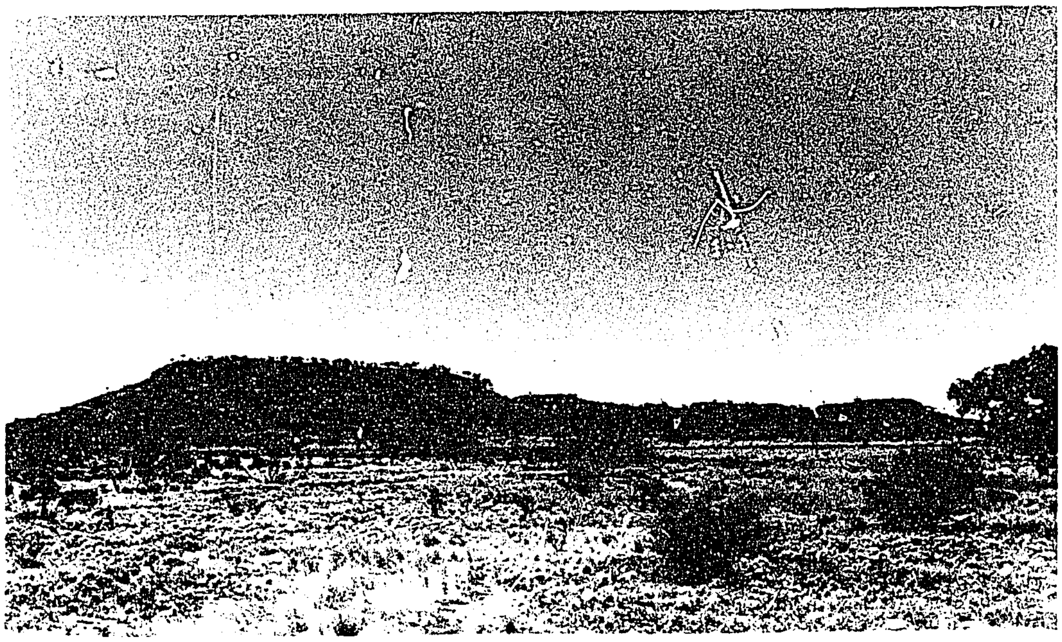


Fig. 104: Typical exposure in southern part of Uldirra Porphyry, showing flat-topped deeply weathered cappings above pediment of unweathered rock. GR5353-226184, 12 km south-southeast of Uldirra Hill.
Neg. M/1803/10.

Fig. 105: Foliated weathered porphyritic microgranite of Uldirra Porphyry, showing flattened quartz phenocrysts and elongated xenolith (top left) weathered out in relief from softer crumbly groundmass. GR5353-226200, 10 km south-southeast of Uldirra Hill.
Neg. M/1803/18.

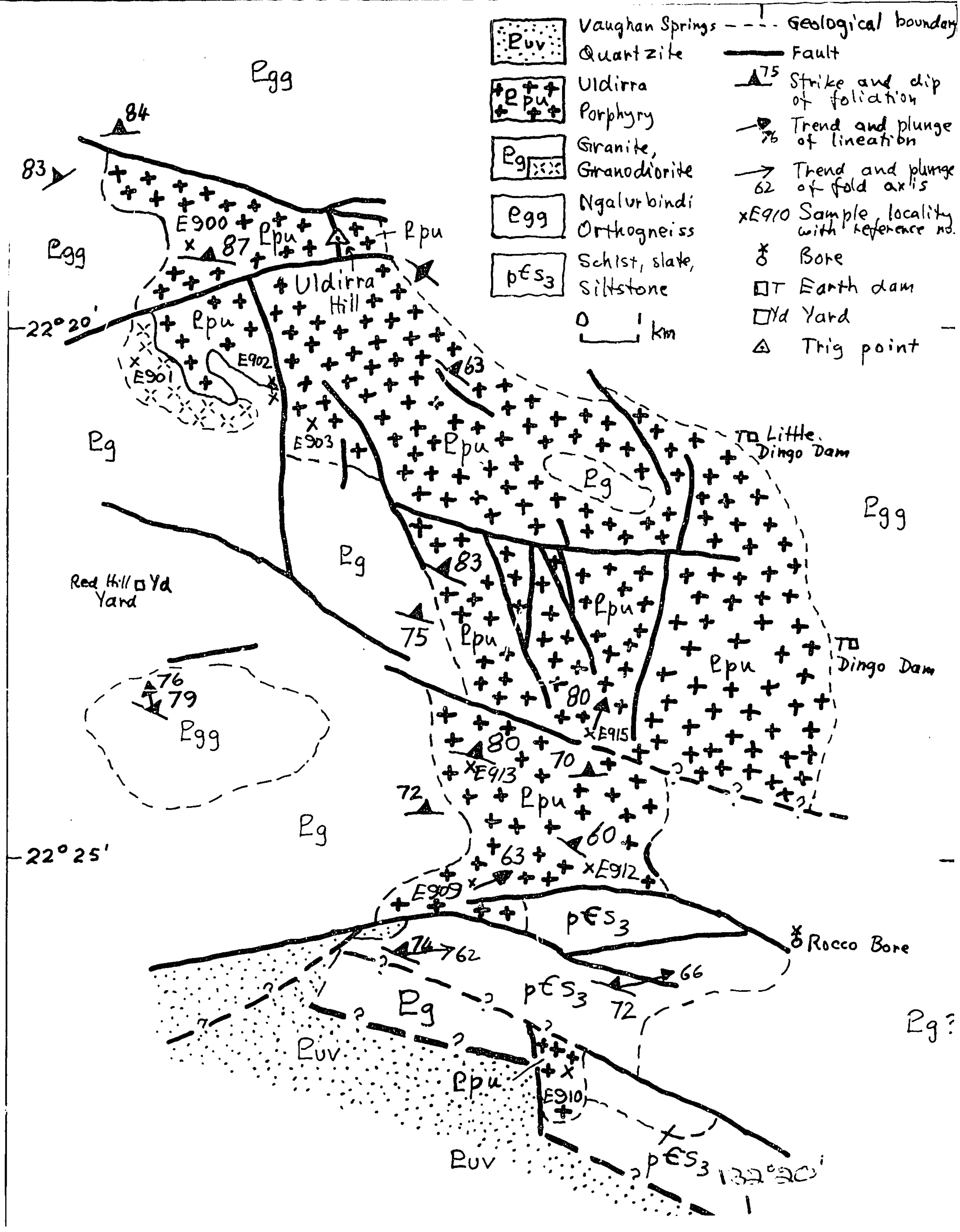



Fig. 106 : Geological sketch map of Uldirra Porphyry and surrounding units

16/NT/13

ship of the two units is not known. Similarly, the relationship with the unnamed granite and granodiorite masses to the west is also unknown.

Porphyritic microgranite makes up almost the whole of the Uldirra Porphyry. The rock is closely jointed, and comprises phenocrysts up to 5 mm across in a yellow-brown, grey, or white, weakly to moderately foliated fine-grained groundmass. In the northern part of the unit, white massive porphyritic microgranite is also abundant; it passes without break into the first type, e.g., at sample localities E900 (GR5353-155290) and E903 (GR5353-175261) on the western margin of the body, and is not a separate intrusion. There is considerable variation throughout the Porphyry in the types and proportions of mineral constituents. In general, phenocrysts in the rock are composed of quartz as embayed single crystals or elongated and lenticular glomerophenocrysts, microcline, and plagioclase which is generally sericitised and saussuritised oligoclase-andesine ($An_{30}$) (74920900, -0903, -0909, -0910, -0913, -0915). The groundmass in all samples is composed largely of quartz and microcline forming a recrystallised polygonal mosaic. Other micro-phenocrysts, found in many but not all samples, are composed of dark yellow sphene (-0903, -0910, -0913, -0915), muscovite (-0900, -0903, -0915), chlorite after biotite (-0903), or biotite itself (-0900). Allanite forms small phenocrysts in sample -0903. The sphene is a particularly conspicuous component in the samples from the southern and western regions of the Porphyry. Other constituents of the groundmass in some samples include andesine (-0900, -0903, -0913), muscovite (-0903, -0909, -0913), biotite or chlorite (-0900, -0903, -0913), hematite (-0909), epidote (-0913), and zircon (-0903).

Muscovite leucogranite is a variant of the microgranite at sample locality E902 (GR5353-170265), and 4 km to the southeast at GR5353-198236, both on the western margin of the unit. The rock is white, massive to weakly foliated, medium-grained, and composed of feldspar, quartz and muscovite.

Porphyritic microgranodiorite is exposed at sample locality E912 (GR5353-226184), in the southern part of the unit. It differs from the porphyritic microgranite only in the absence of microcline from the groundmass, which instead is composed of a polygonal mosaic of quartz and andesine ($An_{33}$). Sphene is abundant as small phenocrysts, as in the microgranite.

Table 16: Results of chemical analysis of one sample of Uldirra Porphyry. Major oxides in percent; trace elements in ppm.

| Sample no. | 74920903B |
|---|---|
| Locality | 5353-175261 |
| $SiO_2$ | 73.1 |
| $TiO_2$ | 0.35 |
| $Al_2O_3$ | 13.4 |
| $Fe_2O_3$ | 0.46 |
| FeO | 1.10 |
| MnO | 0.01 |
| MgO | 0.56 |
| CaO | 1.30 |
| $Na_2O$ | 2.89 |
| $K_2O$ | 5.63 |
| $P_2O_5$ | 0.13 |
| $H_2O+$ | 0.93 |
| $H_2O^-$ | 0.09 |
| $CO_2$ | 0.10 |
| $SO_3$ | <0.01 |
| Total | 100.1 |
| S.I. index | 1.03 |
| Li | 5 |
| Be | 3 |
| B | 15 |
| F | 1080 |
| Co | 76 |
| Ni | 6 |
| Zn | 23 |
| Rb | 230 |
| Sr | 85 |
| Y | 38 |
| Sn | 4 |
| Ba | 780 |
| W | <10 |
| Th | 26 |
| U | 4 |

Analysis by Amdel, Rept. AN3095/77.

A chemical analysis of one sample of the Uldirra Porphyry is set out in Table 16. The S.I. index indicates derivation from igneous parent material.

Deep weathering has affected much of the southern part of the Uldirra Porphyry. In this area, many exposures are capped with a flat-topped mottled zone a few metres thick which passes down into a white pallid zone. Porphyritic microgranodiorite in the mottled zone is a strikingly coloured rock (74920912B) composed of a groundmass of bright orange spongy kaolin after plagioclase, enclosing creamy-white angular phenocrysts of partly kaolinised microcline, brown glassy grains of unaltered quartz, and black streaks of ferruginised biotite. The rock (-0912A) in the underlying pallid zone appears in thin section to be virtually unaltered. At specimen locality E910 (GR5353-222149), at the southern end of the Porphyry (Fig. 106), porphyritic microgranite is strongly silicified along an irregular network of curved grey zones several centimetres thick containing small cavities. The rock in these silicified zones is composed of masses of needles and prisms of tourmaline, large fragments of kaolin after feldspar phenocrysts, and pale brown isotropic masses of opal (74920910). Sphene is unusually abundant, and forms yellow isotropic masses associated with the opal. Quartz forms the usual embayed phenocrysts and small polygonal grains of the groundmass, and is unweathered. The small cavities are lined with yellow brown chalcedony.

Most of the Uldirra Porphyry is foliated, the foliation being imparted by the preferred orientation of biotite or chlorite flakes, and the flattening and elongation of quartz phenocrysts (Fig. 105). The foliation strikes uniformly west-northwest and has a steep northerly dip; it parallels that in the adjoining rock units (Fig. 106), and is clearly tectonic, not a magmatic flow structure. The Porphyry is cut by two sets of steeply dipping faults. One set - the 'north-south set' - comprises faults striking a few degrees east or west of north, and the other - the 'east-west set' - comprises faults striking west-northwest or east-northeast (Fig. 106). As far as can be judged from apparent offsets of geological boundaries, or of the faults themselves, the 'north-south set' appears to be the older, and the 'east-west set' the younger. The latter also affect the Vaughan Springs Quartzite, and so are probably late

Palaeozoic in age. The small north-south fault separating the southernmost outcrop of Porphyry (F910) from Vaughan Springs Quartzite is inferred only, and there is no visible evidence of its existence. Offsets on both sets of faults indicate that the maximum compressive stress was directed north-south, and the minimum stress east-west.

All unweathered samples of Uldirra Porphyry show sericitisation and saussuritisation of plagioclase, chloritisation of biotite, recrystallisation of some quartz phenocrysts to polygonal mosaics, and two samples contain epidote as small megacrysts (74920915) or in the groundmass (-0913). Some microcline phenocrysts in sample -0909 are fractured, others are flattened and recrystallised to lenticular aggregates of small crystals. Plagioclase phenocrysts in -0915 are similarly deformed and recrystallised. Hence, the Porphyry has undergone slight retrogressive metamorphism of the greenschist facies at the same time that the penetrative foliation was imparted to the rock. Before metamorphism,the Porphyry was a massive acid igneous body presumably intruded to a high crustal level.

No isotopic dates have been determined on the Uldirra Prophyry. It is older than late Palaeozoic, and by analogy with the Coniston and Warimbi Schists in REYNOLDS RANGE to the east, it is probably mid-Proterozoic in age.

Dykes, sills, veins, and plugs (A.J.S. and L.A.O.)

Amphibolite (a, amph) forms numerous discordant dykes in the northeastern half of REYNOLDS RANGE; it is also present, though less abundantly, in the northern half of DENISON, and forms isolated dykes and plugs in TEA TREE, AILERON, and the Mount Peake and Lander River 1:250 000 Sheet areas. Only the Denison outcrops have been thin-sectioned; they consist of laths of plagioclase forming between 35 and 70 percent of the rock and ranging from calcic to sodic andesine ($An_{48}$ to $An_{32}$), hornblende (12 to 60%) showing marked pleochroism in shades of blue-green, emerald green, or dark green (Z), through green (Y), to yellow-green (X), biotite (0 to 17%), quartz (0 to 5%), and opaque grains (1 to 3%); epidote, sphene, and apatite are accessory in some rocks (74920663, -0665B, -0681A, -0865). Where retrogressively metamorphosed, e.g. in a fault zone at GR5353-139609, 3 km southwest of Claypan Dam, hornblende has altered to epidote + chlorite + quartz, and plagioclase to clinozoisite (-0871).

In TEA TREE, a folded and disrupted amphobolite dyke is well exposed on a clean rock face of Aloolya Gneiss at GR5553-994338 (Fig. 87); a selvedge of biotite + quartz about 20 cm thick has formed between the amphibolite and gneiss.

Aplite (apl) is a common vein rock in most of the granitic bodies of the area. It forms dykes large enough to show on the maps in REYNOLDS RANGE, where they are localised in the border phase of the Mount Airy Orthogneiss, and in DENISON, where they intrude the Ngalurbindi Orthogneiss at GR5353-015328, and the unnamed granite Eg at GR5353-348587.

Diorite (dr) forms a plug intruding the unnamed schist pЄs$_2$ and the Wangala Granite in DENISON, and a dyke intruding the western part of the Ngalurbindi Orthogneiss, also in DENISON. Sills of diorite shown in unit Ell$_{1a}$ of the Lander Rock beds in REYNOLDS RANGE were misidentified; the rock is actually a melatonalite (Streckeisen, 1976). The diorite plug 13 km west-northwest of Mount Allan homestead is about 2 km long, and is closely associated with, and intruded by dykes and plugs of amphibolite. The rock is medium-grained, foliated, and composed of zoned oligoclase ($An_{23}$, 75%), chloritised biotite (15%), microcline (7%), quartz (3%), and accessory epidote, zircon, apatite, and tourmaline (74920665A). A similar but slightly more calcareous quartz diorite forms a dyke striking northwest for 5 km in the western part of the Ngalurbindi Hills. The rock is laminated pale green and grey, and consists of andesine ($An_{39}$, 75%), quartz (10%), diopside (7%), tremolite (6%), and sphene (2%) (74920886). The melatonalite intruding the Lander Rock beds is medium-grained and tough, and composed of hornblende (35 to 43%), quartz (35 to 40%), plagioclase (?oligoclase; 10 to 20 %), biotite (5%), ilmenite (2 to 5%), epidote, apatite, and sphene (72920506).

Dolerite (do, dl) is known in the unmetamorphosed state in only one area, at GR5553-989277, 4.5 km north of Pine Hill homestead, in TEA TREE. The rock forms a small plug intrusive into pelitic gneiss of the Weldon metamorphics; three dykes of the same rock-type have been identified by airphoto interpretation 1 km north and 1 km southeast of the plug. The rock is a very tough 'clinkstone', and forms large smooth boulders like cannon balls about 1 m in diameter (Fig. 107). The rock

Fig. 107: Spheroidal boulders of dolerite, GR5553-989277, 4 km north of Pine Hill homestead.

Neg. M/1376/6.

consists of clinopyroxene (?titanaugite) with bright pink cores grading to colourless rims, olivine mantled with thin rims of colourless pyroxene, labradorite, opaque grains, and biotite as a reaction rim between opaque grains and labradorite (72920593). The rock was sampled and analysed for isotopic dating in 1973, but contains insufficient radiogenic strontium to yield a meaningful date.

Retrogressively metamorphosed dolerite intrudes the Ngalurbindi Orthogneiss at two localities in DENISON. The less retrograded rock forms a dyke several metres thick at GR5353-059349, 6 km west of Mount Allan Homestead, and consists of sodic labradorite ($An_{52}$), greenish-yellow clinopyroxene, hornblende as rims around the clinopyroxene grains and also around opaque grains, interstitial recrystallised quartz, and apatite (74920885). There is some mingling of the metadolerite and adjoining granitic gneiss host rock, with production of coarse-grained biotite rock. Completely retrograded and closely fractured dolerite forms a dyke at GR5353-144308, 4 km northwest of Uldirra Hill,and consists of epidote (40%), actinolite + chlorite (together 38%), quartz (20%), and ilmenite (2%) encrusted with sphene (-0899).

Numerous metadolerite dykes, plugs, and sills intrude the Mount Stafford beds in REYNOLDS RANGE and MOUNT PEAKE, and form prominent black ridges and peaks. In MOUNT PEAKE the rocks consist of hornblende partly altered to tremolite which itself is rimmed by actinolite (total amphibole about 65%), labradorite partly altered to epidote and clinozoisite (30%), opaque minerals (3%), small amounts of reddish-brown biotite partly altered to chlorite, and minor hypersthene enclosed in amphibole (72110126). At specimen locality C749, the rock is strongly foliated, equigranular and contains hypersthene (40%), hornblende (30%), labradorite (30%) and minor opaque minerals. In contrast the specimen from locality C136 in MOUNT PEAKE contains two pyroxenes, viz., hypersthene and augite (total 38%), brown and green hornblende (32%), labradorite (30%) and accessory apatite and opaque minerals (72110136). The clinopyroxene appears to be more abundant than the hypersthene. The proxenes in this sample enclose amphibole and plagioclase grains, thus implying metamorphic growth after intrusion and consolidation of the mafic body; the pyroxenes possibly grew during contact metamorphism by the Anmatjira Orthogneiss.

Granite dykes (gr) in MOUNT PEAKE and REYNOLDS RANGE are hypabyssal offshoots of the Anmatjira Orthogneiss intrusive into the Mount Stafford beds and Lander Rock beds (GR5453-717551), respectively. In DENISON, micro-adamellite forms a large dyke intruding the Ngalurbindi Orthogneiss at GR5353-940344, parallel to a large nearby dyke of diorite. The micro-adamellite is partly retrogressively metamorphosed (74920887).

Pegmatite dykes and masses (peg) are common throughout the area, and are particularly abundant in the southeast of the Ngalurbindi Orthogneiss, and in the east of the Wangala Granite, in DENISON. In REYNOLDS RANGE, masses of pegmatite occur in the Lander Rock beds 4 km east of Lander Rock, and a swarm of pegmatite dykes cuts the Weldon metamorphics 7 km east of Mount Stafford.

Porphyry (po) forms a large dyke in the porphyritic granite (Ēgp) in the southeast of MOUNT PEAKE, and consists of phenocrysts of quartz, microcline, and plagioclase, in a granophyric groundmass of epidote, chlorite, apatite, biotite, calcite, fluorite, and opaque grains (72110158). A plug (74920924) and several dykes of porphyry have also been mapped in the western part of the Napperby Gneiss, in REYNOLDS RANGE. In DENISON, a porphyry dyke is associated with aplite at GR5353-015328, and several plugs intrude the Wangala Granite 5 km south of Mount Treachery. A mass of porphyry has been tentatively identified by airphoto interpretation at GR5353-373253 in the southeast of the Ngalurbindi Orthogneiss, in DENISON, and a porphyry dyke disrupted by faults has been similarly identified in the Napperby Gneiss 5 km northwest of Aileron.

Quartz veins (q) intrude and fill faults in all the metamorphic and igneous rocks of the northern Arunta area, and also fill joints and faults in the Central Mount Stuart Formation and Kerridy Sandstone. The quartz in the faults is brecciated and recemented, and thin-section examination shows that this has happened several times. Most of the fault-filling quartz is accompanied by hematite or limonite; pyrolusite is present in some faults in the Mount Peake 1:250 000 Sheet area, and pyrite accompanies quartz veins in the south of AILERON (O'Sullivan, 1972). Tourmaline accompanies some quartz veins in the north of the Mount Solitaire Sheet area, and a large mass of quartz + tourmaline makes up Yalbadjandi Hill at GR5453-750560, REYNOLDS RANGE. Chlorite-quartz rock in the

Wangala Granite 4 km south of Mount Treachery has probably formed by alteration of amphibolite, which crops out in the same area.

Troctolite (tr) crops out in DENISON, 12.5 km east of Mount Allan homestead. The rock is exposed as a group of large black boulders resting in a topographic hollow. A crude, steeply dipping magmatic layering is visible in some boulders. The rock is medium-grained, and composed of laths of labradorite ($An_{66}$, 60%), subhedral olivine (30%), clinopyroxene (5%) as large ophitic poikiliths and as reaction rims where olivine touches labradorite, red-brown biotite (3%), and magnetite (2%) (74920675A). The troctolite body is intruded by two intersecting dykes about 2 m wide of medium-grained granite (-0675C). Between the dykes and the troctolite, a hybrid rock of meladioritic composition has formed, and is composed of saussuritised plagioclase (55%), actinolite with cores of tremolite (together 40%), and chlorite + sphene (together 5%) (-0675E).

Ultramafic rock (u, un) crops out in the western part of DENISON and eastern part of AILERON. Serpentinite forms two dykes 20 km southwest of Mount Allan homestead. The larger is about 1 km long and 3 m wide, and strikes subparallel to a quartz-breccia filled fault. The serpentinite consists of antigorite, hematite, spherulites of chalcedony in the hematite, and a few large grains of quartz. Three costeans have been cut through the serpentinite; they may be the 'Uldirra Uranium Claims' once held by Central Pacific Minerals (Schindlmayr, 1973). Ultramafic rock forms an exposure about 300 m across 3 km east of Native Gap, on the southern side of the Hann Range in AILERON. The rock is a massive medium to coarse-grained amphibolite with some chlorite-tremolite schist. Aeromagnetic data indicate that the body is of considerable subsurface extent (Fig. 141).

A small dyke incorrectly labelled dolerite at GR30515886, 6 km north of Anningie homestead in the Mount Peake Sheet area, is in fact a serpentinite composed of antigorite, talc, colourless chlorite, anthophyllite, and opaque grains (74110352).

Vaughan Springs Quartzite (Ɛuv) (L.A.O.)

The Vaughan Springs Quartzite was first described and defined in the Mount Doreen 1:250 000 Sheet area by Wells & others (1968). It consists of tough, massive to thick-bedded orthoquartzite and sandstone with local basal conglomerate and pebbly hematitic conglomerate. In the Yuendumu area the quartzite unconformably overlies basement granite, and is itself unconformably overlain by the Yuendumu Sandstone.

The Vaughan Springs Quartzite north of the Reynolds Range forms isolated resistant ridges and hills rising above the sand plain (Fig. 108). The largest outcrops of quartzite, the Nanga, Yindjirbi and Bau Ranges, are located in the southwest of the Mount Peake 1:250 000 Sheet area. Smaller exposures crop out southeast of the main quartzite ranges as far as the Ennugan Mountains in TEA TREE.

The identification of the quartzite outcrops as Vaughan Springs Quartzite is based essentially on the lithological similarity and the apparent unconformable underlying basement relationship. On the southern flank of the Nanga range, the basal conglomerate unit of the quartzite is well exposed (Fig. 109) and lies unconformably on strongly foliated granite. The basal conglomerate, consisting of closely packed boulders and cobbles of rounded undeformed quartzite (Fig. 110), crops out along most of the length of the range (20 km) and varies slightly in thickness from 10 to 15 m. Beds of quartzite, higher in the sequence, contain sparse quartzite, chert,and siltstone pebbles. The thickest section of quartzite is in the Nanga Range, and is estimated to be at least 700 m thick, and consists of ripple-marked cross-bedded purple, white, and pinkish orthoquartzite with minor grey laminated quartz sandstone (Fig. 111). Scour and fill structures are also present.

The Yindjirbi Range consists of white cross-bedded orthoquartzite, purple micaceous, ferruginous and feldspathic quartz sandstone, red and purple shale, and minor coarse-grained sandstone containing chert and siltstone pebbles. No contact between the lithified sediments and basement is exposed.

The Bau Range is composed of clear quartzite and friable silicified quartz sandstone. Bedding and cross-bedding are common. No contact between the lithified sediments and basement is exposed.

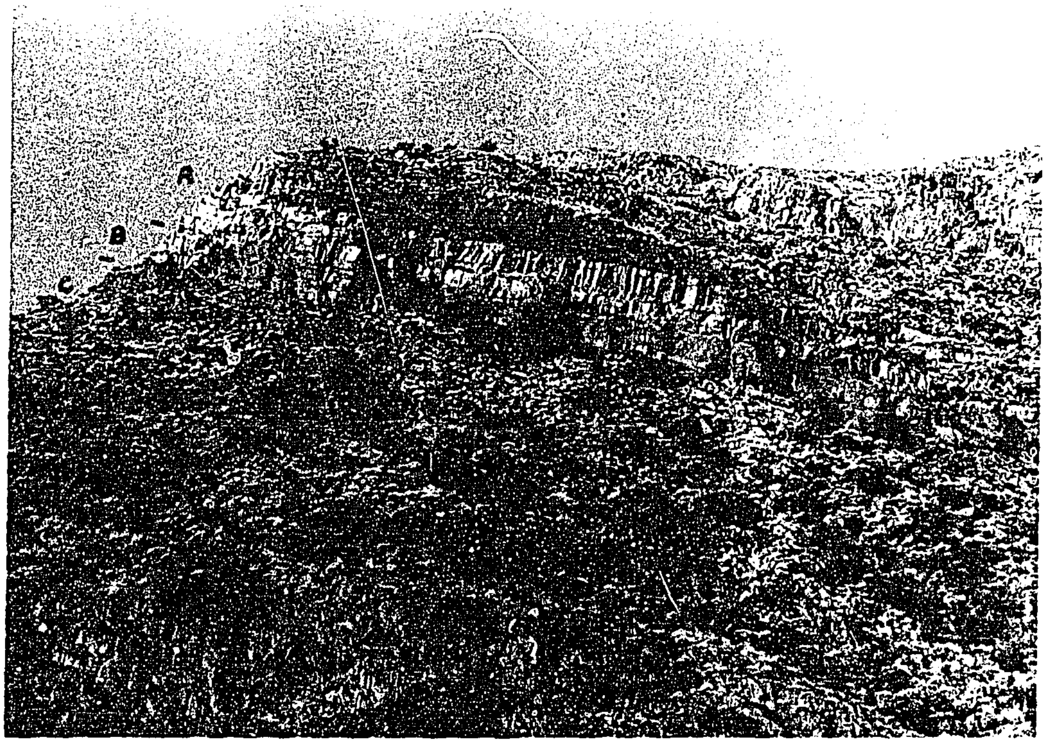


Fig. 108: Vaughan Springs Quartzite unconformably overlying foliated granite; looking west along southern flank of Nanga Range, GR5454-520855 A-white, bedded quartzite; B-Basal conglomerate; C-foliated granite.

Neg. M/1662.

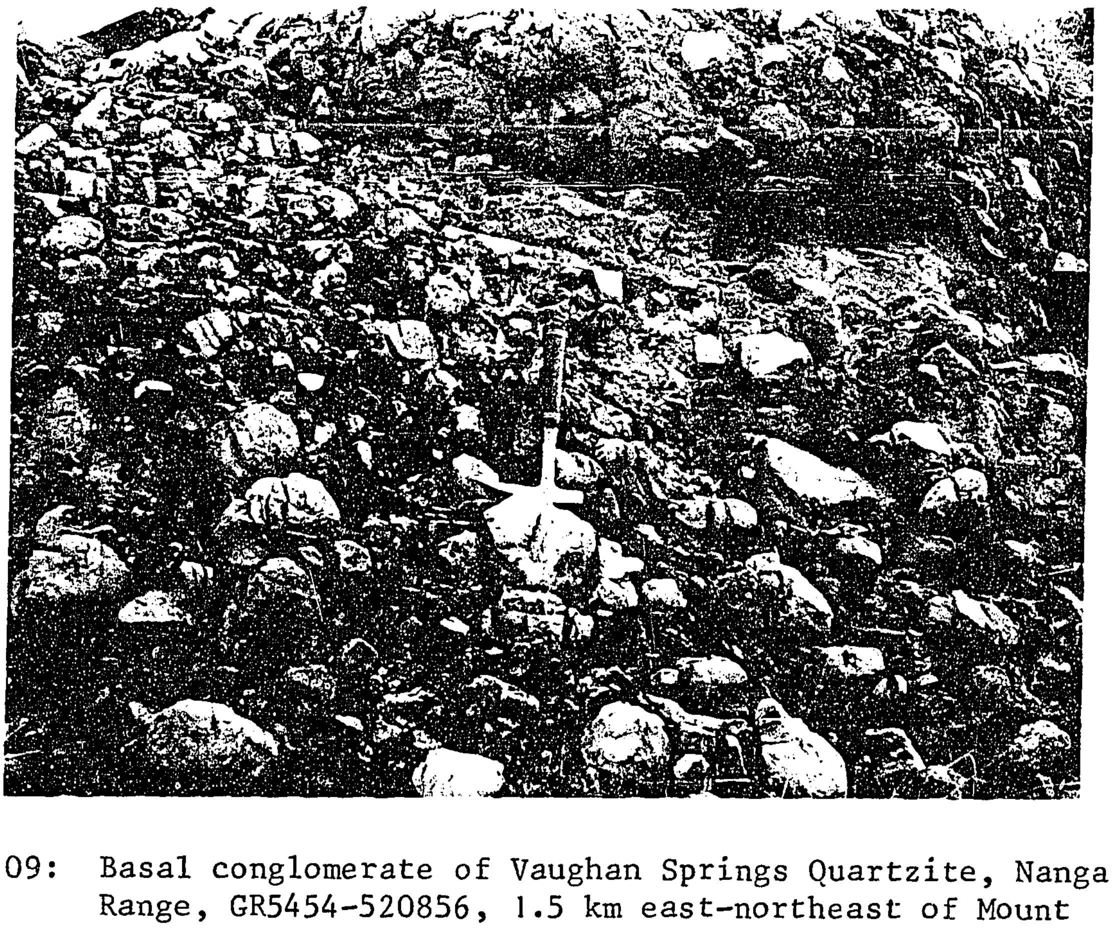


Fig. 109: Basal conglomerate of Vaughan Springs Quartzite, Nanga Range, GR5454-520856, 1.5 km east-northeast of Mount Leichhardt.

Neg. M/1662.

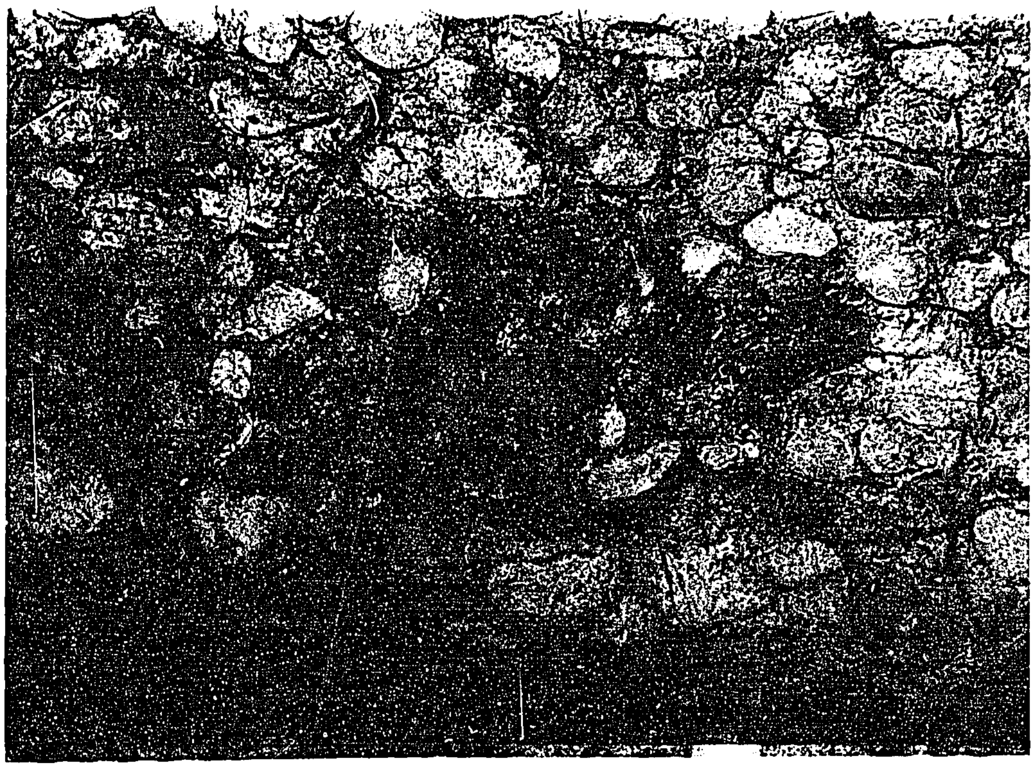


Fig. 110: Rounded quartzite pebbles in basal conglomerate, Vaughan Springs Quartzite. GR5454-505855, 0.5 km north of Mount Leichhardt.
Neg. GB/262.

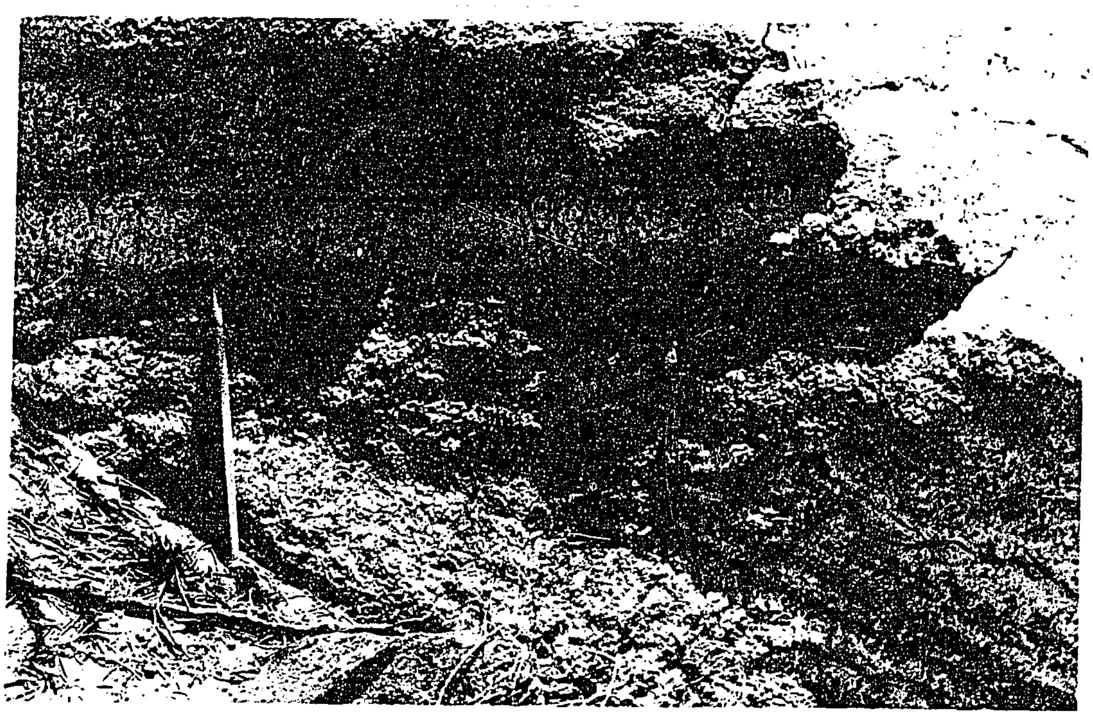


Fig. 111: Medium-scale cross-bedding in coarse-grained quartzite of Vaughan Springs Quartzite, GR5553-989591, 3 km south-southwest of Anningie Bore. Pen is 15 cm long.
Neg. M/1662.

East of these ranges, cross-bedded milk-white quartzite forms a small northwest plunging syncline. Strongly foliated basement granite is poorly exposed in the vicinity of the syncline, but no visible contact between the two exposures exists. Another hill of bedded milk-white quartzite crops out about 12 km farther east.

On the eastern side of the Ennugan Mountains in TEA TREE white medium-grained silicified sandstone with medium-scale cross-bedding (Conybeare & Crook 1968) is exposed (Fig. 111). Ferruginous spots and spherical siliceous concretions are present in places (Figs 112, 113). On the slope of one ridge, conglomerate (sample 74920784) is poorly exposed and consists of angular to subrounded cobbles of vein quartz, quartzite, and gneiss in a sandy matrix of quartz, clay, and weathered feldspar. The granite of the Ennugan Mountains crops out nearby and may be basement to the quartzite, although no contact is visible.

The quartzite is folded about near northwest-plunging axes except at one outcrop in the Ennugan Mountains where a fold plunges to the southeast. The folding is generally open concentric, but locally tightens close to faults.

Low, north-dipping ridges of Vaughan Springs Quartzite in the south of DENISON consist of thick-bedded pebbly cross-bedded orthoquartzite at the base, with round siliceous concretions, overlain by thin to medium-bedded quartzite which is blocky to flaggy, and fine to medium-grained.

The presence of rounded quartzite phenoclasts in the basal conglomerate of the Nanga Range indicates that deposition occurred in the abrasive near-shore environment. The thick sequence of bedded and cross-bedded quartzite which follows is typical of shallow marine deposition. From the regular thickness of the conglomerate it appears that deposition occurred on a featureless basement. The nature of the phenoclasts in the basal conglomerate and the abundance of quartzite strongly indicates that the source area included quartz-rich sandstone. In the Ennugan Mountains area the conglomerate at the base of the quartzite outcrop contains fragments of angular to subrounded gneiss as well as quartzite, and is probably locally derived. The Vaughan Springs

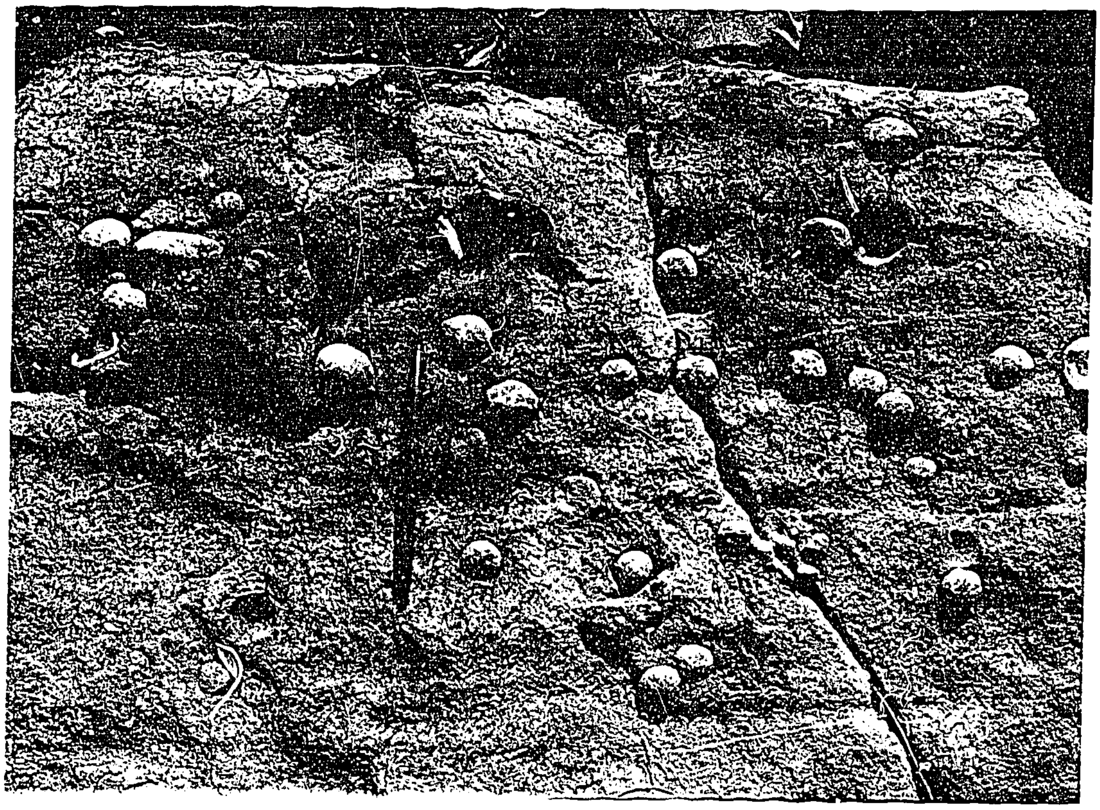


Fig. 112: Spheroidal siliceous concretions (about 3.5 cm across) in Vaughan Springs Quartzite, GR5553-016577, 4.5 km south-southeast of Anningie Bore. Pen is 15 cm long.

Neg. M/1662.

Fig. 113: Spheroidal ferruginous spots, probably formed by weathering of pyrite, in Vaughan Springs Quartzite, GR5553-963617, 3.5 km west of Anningie Bore.

Neg. M/1662.

Quartzite north and northeast of the Reynolds Range resulted from lithification of beach gravel and a thick sequence of near-shore quartz sand.

The Vaughan Springs Quartzite is correlated with the Heavitree Quartzite (Wells, Evans & Nicholas, 1968; Wells, Moss & Sabitay, 1972). Dolerite dykes in the Arunta Block unconformably overlain by the Heavitree Quartzite are dated at 897 ± 7 Ma (Black & others, 1980) and thus deposition of the Heavitree Quartzite started after that time. The Bitter Springs Formation conformably overlies the Heavitree Quartzite and is thought to have a 900-650 Ma age of deposition (Glaessner, Priess & Walter, 1969; Priess, 1972). Thus the Vaughan Springs Quartzite is probably of Late Proterozoic age.

Treuer Member (Ꞓut) (A.J.S.)

The Treuer Member crops out near the middle of the Vaughan Springs Quartzite, and was defined by Wells & others (1968) in the Treuer Range of the Mount Doreen 1:250 000 Sheet area. The Member is exposed in the Hann Range in the south of AILERON, and comprises white micaceous siltstone and fine-grained clayey sandstone, interbedded with tough siliceous fine to medium-grained sandstone and clay-pelleted, thin-bedded sandstone (Evans & Glikson, 1969). Gypsum forms encrustations near the top of the exposed beds, which include grey shale, siltstone, and fine-grained sandstone. The Member is thought to have been deposited in a shallow-marine, partly evaporitic environment.

Central Mount Stuart Formation (ꞒЄs) (A.J.S. and L.A.O.)

The Central Mount Stuart Formation consists of red-brown sandstone and siltstone with subordinate limestone, diamictite, and arkose, in the southeastern part of the Mount Peake 1:250 000 Sheet area. Outliers of the Formation crop out in the northern part of TEA TREE, the western part of REYNOLDS RANGE, and the eastern part of DENISON. The name is derived from Central Mount Stuart (GR340576), the highest point in Johns Range in the southeastern part of the Mount Peake 1:250 000 Sheet area, and the geographical 'centre' of Australia. The unit was originally named the Central Mount Stuart Beds by Smith & Milligan (1964). However several exposures of the lower boundary of the Beds are now known, and the upper boundary coincides with the base of the overlying Donkey

Creek beds, shown as Grant Bluff Formation on the Barrow Creek 1:250 000 Sheet (First Edition), but now redefined by Walter (in press). Regional correlations indicate that the contact of the Central Mount Stuart Beds and Donkey Creek beds is a paraconformity (Walter, in press). Hence, the Central Mount Stuart Beds were upgraded to Formation by Offe (1978). The unit crops out as rather rounded hills and ranges flanked by poorly consolidated and partly dissected Cainozoic colluvial fans. In the Mount Peake and Napperby 1:250 000 Sheet areas it rests conformably on granite, gneiss, and amphibolite of the Arunta Block. No unit overlies the Formation in these Sheet areas, and the top of the Formation is eroded. The Formation may underlie the sediments of the Wiso Basin in the Lander River 1:250 000 Sheet area (Kennewell & Offe, 1979).

The type section of the Central Mount Stuart Formation is located on the southern side of Central Mount Stuart. The section was measured in two parts because the basal unconformity is exposed at one locality in the Johns Range, whereas the top of the sequence is situated at another locality 4 km from the first and separated by a northwest-trending fault. The topmost bed of the lower part of the section was traced by airphoto interpretation along strike from the southwestern block across the fault into the northeastern block, and the upper part of the section measured from there to the summit of Central Mount Stuart. The type section is illustrated in Figure 114. The thickness measured in the type section totals 800 m.

In the Mount Peake 1:250 000 Sheet area, the basal part of the Central Mount Stuart Formation varies markedly in composition, whereas the upper part is more uniform, generally consisting of feldspathic sandstone. At Central Mount Stuart (Fig. 114), the basal part is about 100 m thick, and consists of bouldery diamictite (Fig. 115) overlain by interbedded limestone (Fig. 116), pebble conglomerate, shale, and fine to very coarse sandstone. The upper part of the Formation, above 100 m, comprises about 350 m of interbedded shale and sandstone, overlain by another 350 m of monotonous, cross-bedded red and purple feldspathic sandstone which contains minor granule beds and flattened clay pellets. Some exposures of the feldspathic sandstone display graded bedding, ripple marks, and current scours.

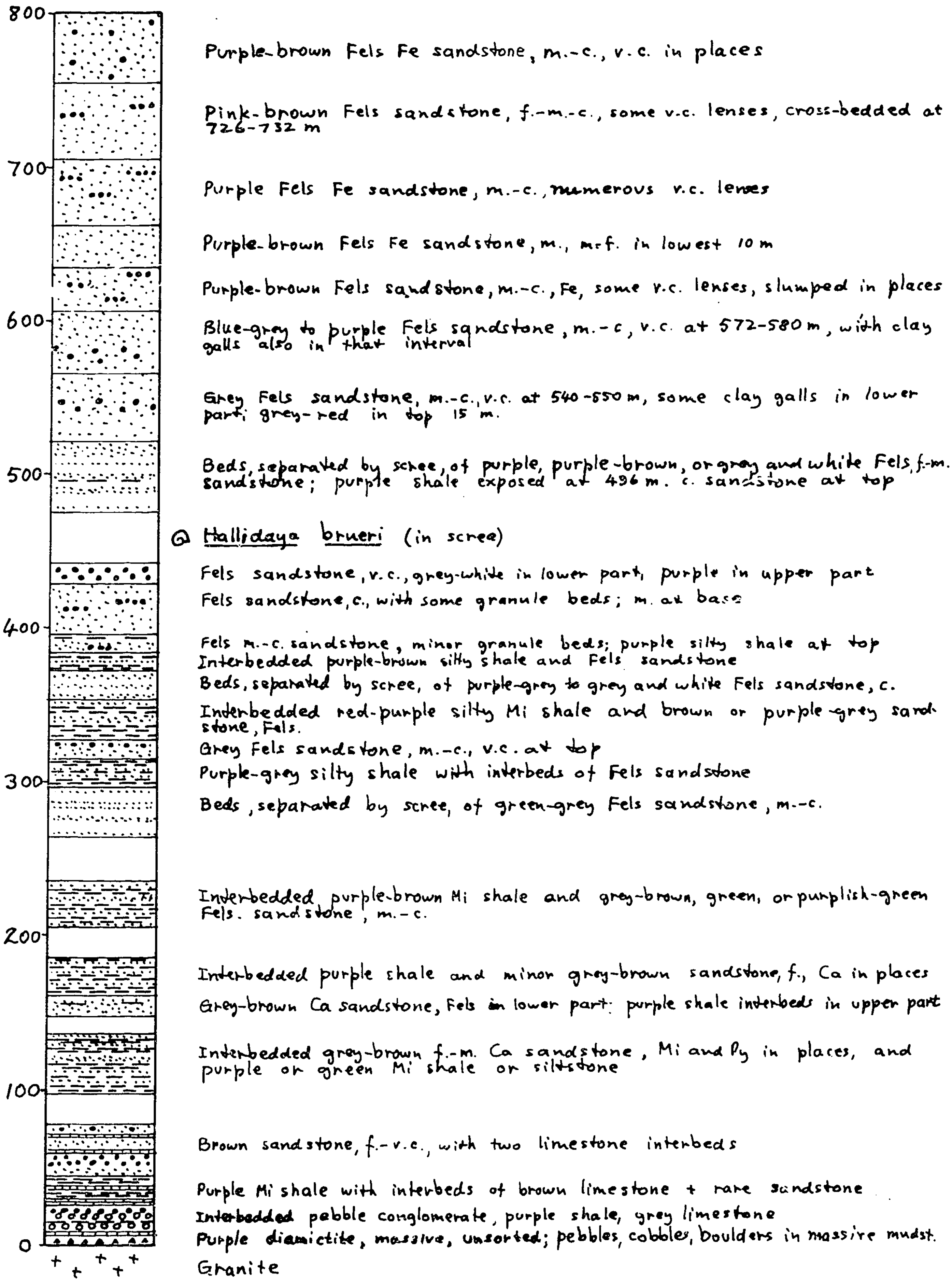



Fig. 114 : Type section of Central Mount Stuart Formation at Central Mount Stuart. f - fine-grained; m - medium-grained; c - coarse-grained; v.c. - very coarse-grained; Ca - calcareous; Fe - ferruginous; Fels - feldspathic; Mi - micaceous; Py - pyritic

16/NT/114

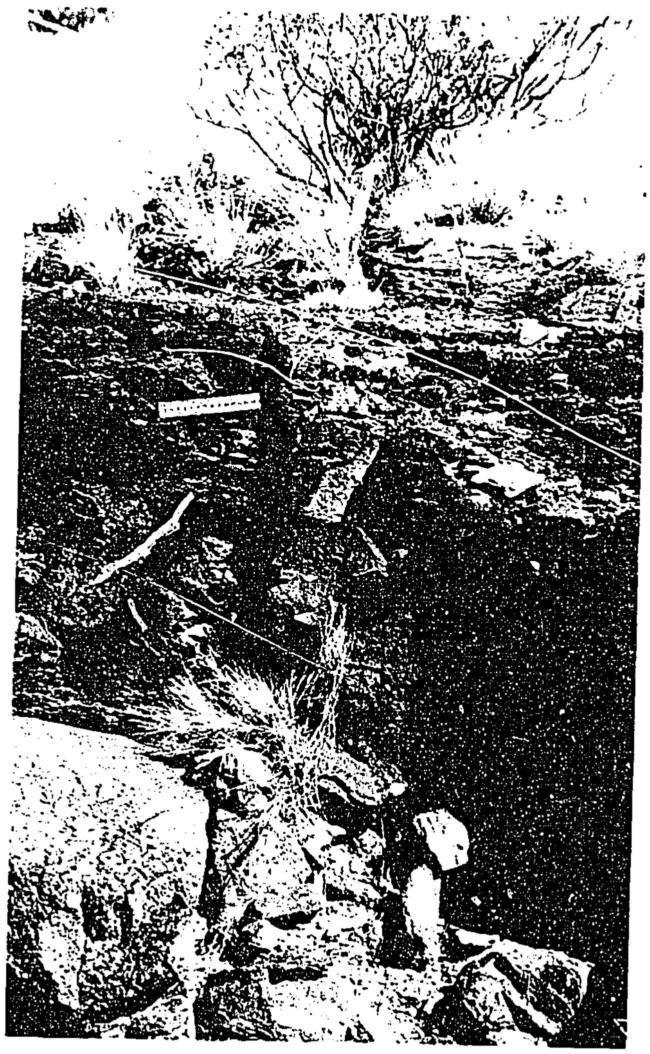


Fig. 115: Basal diamictite of Central Mount Stuart Formation at base of type section GR33845725. Boulders of granite in non-bedded matrix, overlain by 8 cm limestone bed (at base of bush).

Neg. M/1724/69.

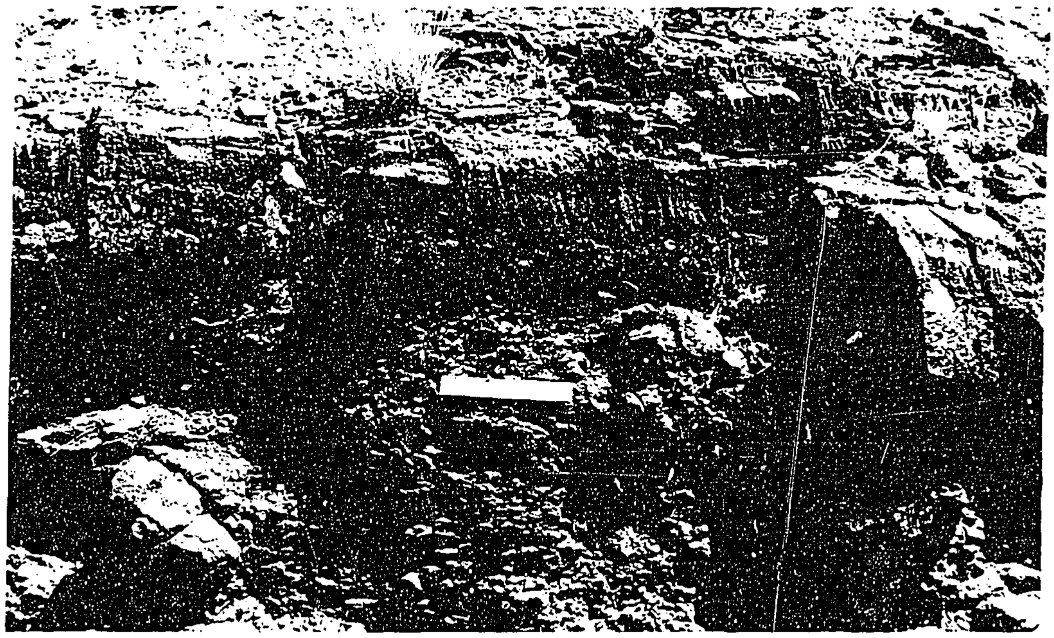


Fig. 116: Limestone bed (top), overlying pebble conglomerate with limestone matrix, overlying pebbly diamictite near base of type section of Central Mount Stuart Formation. Same locality as Fig. 115.

Neg. M/1724/71.

Fig. 117a: Diamictite of Central Mount Stuart Formation, GR33355745, 1 km east of abandoned Mount Esther homestead, Mount Peake 1:250 000 Sheet area.
Neg. M/1716/8.

Fig. 117b: As for Fig. 117a. Neg. 1716/58.

A small outcrop of diamictite and varved siltstone is well exposed at a small prominent hill at GR33405745, 1.5 km east of the abandoned Mount Esther homestead, in the Mount Peake Sheet area (Figs 117a, b). The diamictite comprises angular to subrounded pebbles, cobbles, and boulders up to 1.5 m across, composed of granite, amphibolite, quartzite, and shale, and a matrix which in places is highly indurated and very tough. The matrix consists of angular fragments of quartz, quartzite, granite, microcline, and plagioclase, aggregates of green biotite, aggregates of sericite after feldspar, and idioblastic grains of opaque oxide, in a very fine-grained groundmass of sericite, quartz, a zeolite, and opaque grains (74110031A). The biotite replaces microcline, presumably by reaction with iron oxide, the excess of which crystallised as the idioblastic opaque mineral. The varved silstone overlying the diamictite is about 3 m thick, and consists of alternating coarse yellow laminae and fine grey laminae. The coarse laminae are composed of detrital grains of angular quartz, muscovite, kaolin, limonite, and tourmaline, and authigenic biotite, and euhedral opaque grains (74110031B). The fine laminae are similar, but lack the limonite component. The varved siltstone is overlain by white micaceous claystone and shale to the top of the hill.

Another small occurrence of indurated diamictite is located at GR33455705, 4 km southeast of Mount Esther homestead; it includes clasts of calcite and retrogressively metamorphosed amphibolite, and the matrix contains chlorite and biotite as well as quartz and sericite (74110057A). Indurated laminated siltstone and slate about 80 m thick overlie the diamictite. The siltstone is pale greenish-yellow, has a weak cleavage, and consists essentially of quartz, detrital flakes of muscovite, and a fine-grained groundmass of scaly muscovite (-0057B). Small veinlets are filled with epidote and quartz. X-ray diffraction analysis by Amdel confirmed the groundmass muscovite as a well crystallised $2M_1$ form, and also found traces of alunite, jarosite, and gypsum in the rock (Brown, 1978). The slate (Fig. 119) comprises alternating red laminae composed of hematite, quartz, and sericite, and grey quartz-sericite laminae without hematite (74110057C). The siltstone and slate are capped by a bed of grey silicified sandstone. At GR33405734, siltstone and claystone resting unconformably on granite are coated with white efflorescent salts, including halite, hexahydrite, kieserite, and thenardite (74110054B, -0058; G.W.R. Barnes, BMR, pers. comm., 1975).

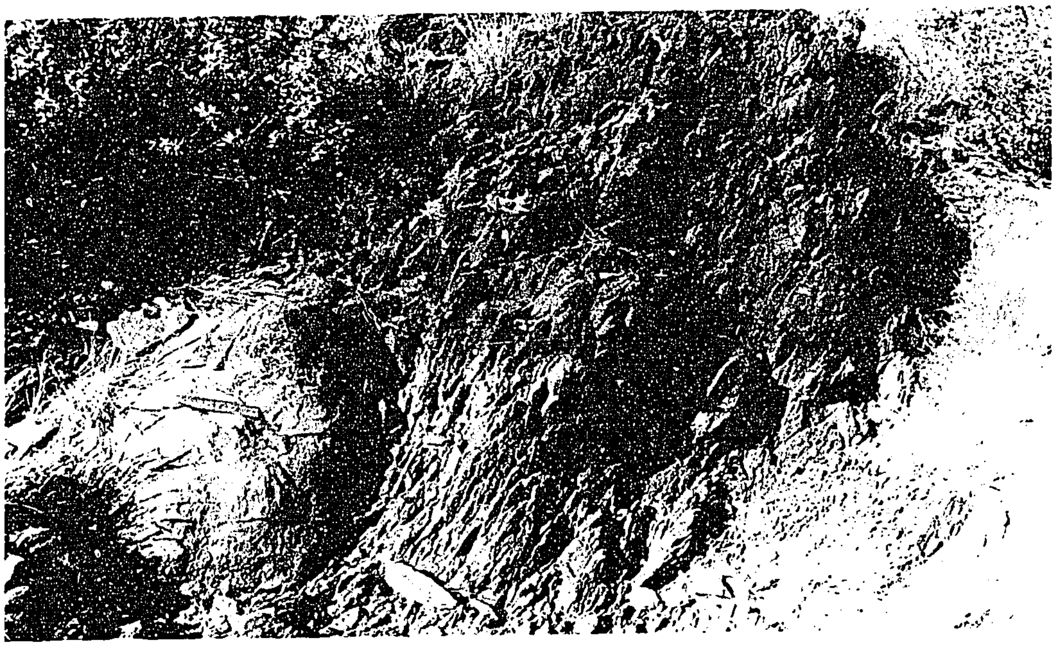


Fig. 118: Cleaved diamictite of Central Mount Stuart Formation, GR33005778, 1 km southwest of Mount Chisholm, Mount Peake 1:250 000 Sheet area.

Neg. M/1719/33.

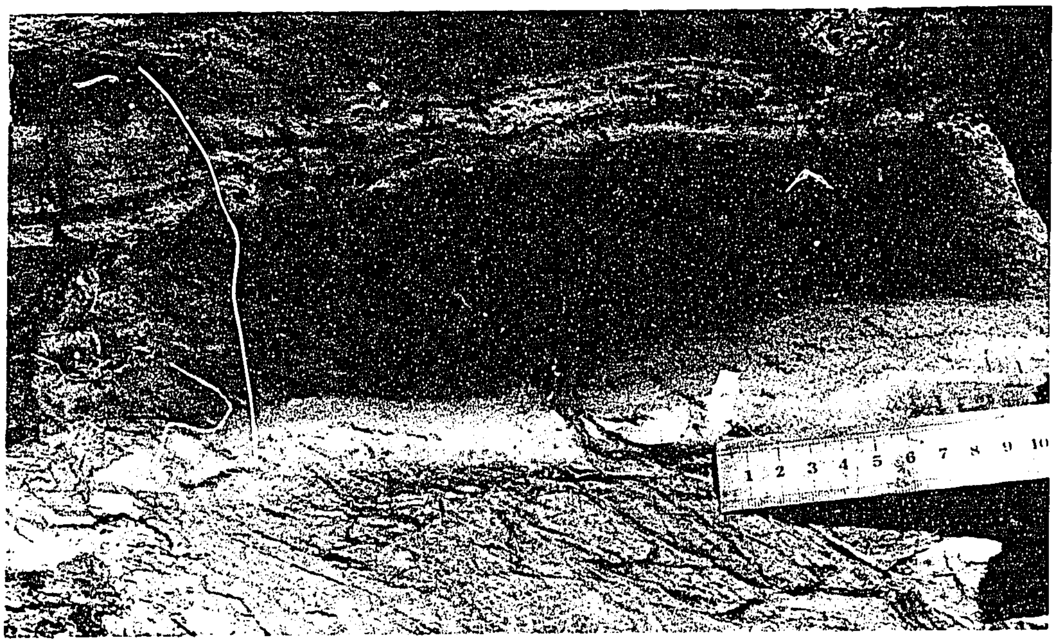


Fig. 119: Laminated and thin bedded claystone of Central Mount Stuart Formation, showing cleavage (top left to bottom right) oblique to bedding. GR33455706, 4 km south-southwest of Mount Esther homestead (aband.).

Neg. M/1719/39

Indurated closely packed diamictite about 2 m thick is exposed at GR32015785, 13 km northwest of Mount Esther homestead, and consists of fragments of muscovite quartzite, muscovite granite, sericite schist, biotite-muscovite schist, subangular quartz, microcline, plagioclase, calcite, opaque grains, and tourmaline, in a fine-grained matrix of authigenic biotite and sericite (74110048B). The diamictite is overlain by 5 m of bouldery arkose, then by several tens of metres of coarse friable arkose, following by weakly cleaved feldspathic sandstone at the top.

Poorly sorted diamictite containing cobbles of granite and quartzite is exposed at GR318581, 15 km northwest of Mount Esther homestead. The cobbles are microfaulted, and their surfaces are striated in places. The striations trend in only one direction on each cobble, and resemble a tectonic lineation rather than glacial scratches.

Grey arkose is an abundant component of several hills from Mount Chisholm to Murray Creek Dam, and at Mount Brown, in the southeast of the Mount Peake Sheet area. The arkose is coarse-grained, thick-bedded to massive, cross-bedded, pebbly, and up to 30 m thick. It is generally overlain by feldspathic sandstone (Fig. 120) which is micaceous and in places pyritic, and then by interbedded grey shale or siltstone (Fig. 121), arkose, conglomerate, and feldspathic sandstone. X-ray diffraction of the phyllosilicate groundmass of samples of the silstone (74110055B) and shale (-0050) shows that it is well crystallised $2M_1$ muscovite (Brown, 1978). Cleaved diamictite crops out along the faulted southern side of Mount Chisholm (Fig. 118).

The northern exposures of the unit in the Mount Peake 1:250 000 Sheet area consist of a basal orthoquartzite (Amesbury Quartzite Member, described separately) about 20 m thick, overlain by feldspathic quartz sandstone.

In the northern part of TEA TREE, the Central Mount Stuart Formation consists of orthoquartzite, diamictite, varved shale, and conglomerate (A.T. Wells, BMR, personal communication, 1978). At some localities siltstone and feldspathic sandstone are also present. In the western part of REYNOLDS RANGE and eastern part of DENISON, several

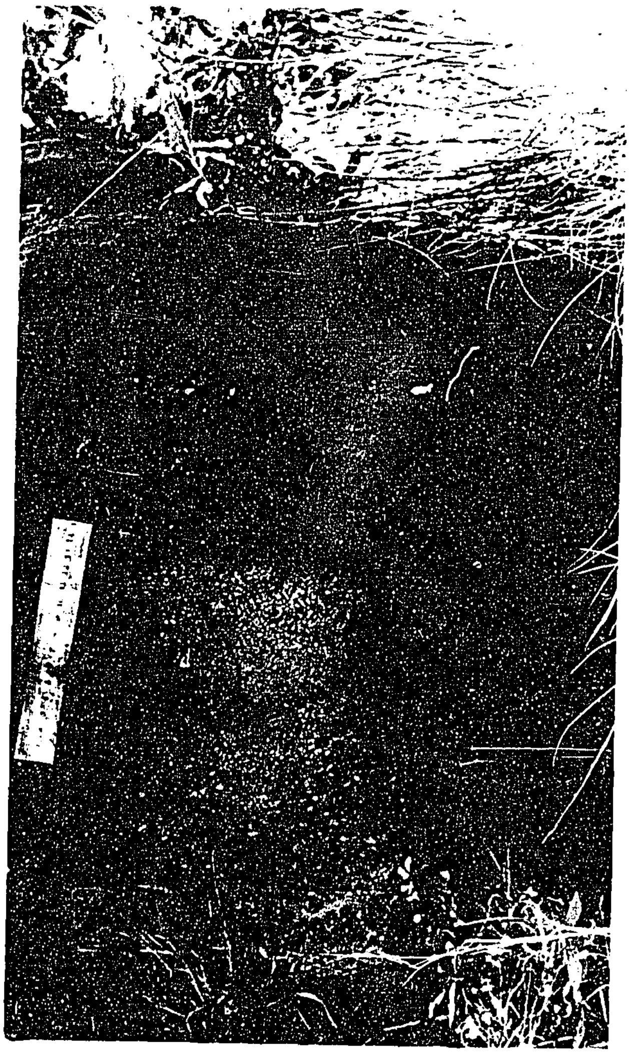


Fig. 120: Thick, graded bed in Central Mount Stuart Formation, with very coarse pebbly arkose in lower part, grading up to feldspathic sandstone. GR33295805, on west side of Mount Browne.

Neg. M/1716/46.

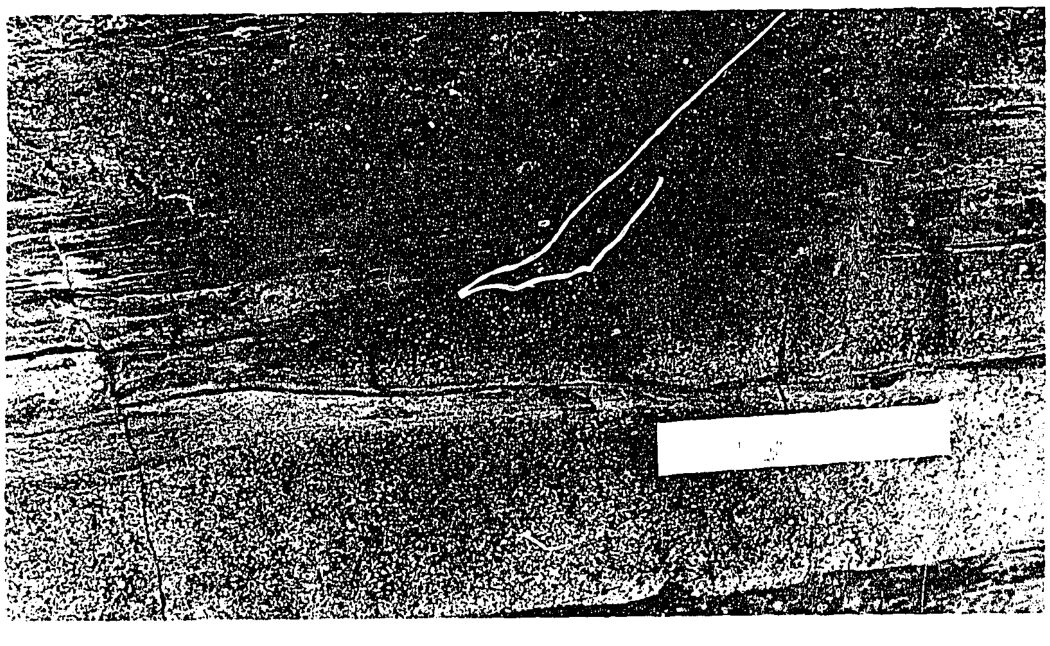


Fig. 121: Intertonguing beds of shale and arkose, same locality as Fig. 120.

Neg. M/1716/50.

gently dipping sedimentary outliers of Central Mount Stuart Formation crop out. At Crown Hill the base of the Formation is marked by a pocket of diamictite which is exposed on the southwestern side of the hill and consists of about 20 m of poorly sorted, non-bedded siltstone containing pebbles, cobbles, and boulders up to 2 m across of granite and quartzite (Fig. 122). Some of the erratics are faceted and striated. The diamictite is overlain by about 4 m of purple shale containing minor interbeds of granulose and pebbly siltstone. Orange coarse-grained feldspathic sandstone containing rounded quartz and quartzite pebbles overlies the shale with a sharp contact. One kilometre east-northeast of Crown Hill,grey mottled feldspathic sandstone containing pebbles of quartz and quartzite unconformably overlies augen gneiss, and is succeeded to the east by at least 15 m of weathered orange granule beds (Fig. 123). The granule beds consist of closely packed subrounded quartz, feldspar, and chert grains and form an isolated outcrop overlain by dark purplish feldspathic sandstone containing rounded cobbles of quartz, and purple and white quartzite. A ridge of Central Mount Stuart Formation about 2 km east of Crown Hill consists of red and green shale overlain by light brown quartz sandstone. The sandstone is crossbedded, contains some feldspar, and grains are subrounded. The sandstone appears to be overlain along parts of this ridge by fine-grained silty sandstone. About 6 km east of Crown Hill, a ridge of shale of the Central Mount Stuart Formation is overlain by well-bedded light brown coarse-grained feldspathic sandstone, overlain by partly folded and fractured shale which in turn is overlain by speckled white partly feldspathic quartz sandstone. This latter unit is overlain by whitish-pink medium-grained feldspathic sandstone which is locally veined by limonite and contains in places granule beds and flattened clay pellets. Evans & Glikson (1969) noted the similarity between the diamictite at Crown Hill and the Mount Doreen Formation (which crops out in the Mount Doreen Sheet area; Wells & others, 1968) and the Central Mount Stuart Formation in the Georgina Basin. Except for calcareous beds, the lithified sediments exposed in the Crown Hill area are very similar to the sediments in the lower part of the Central Mount Stuart Formation at the type locality, and thus are considered to be Central Mount Stuart Formation.

Mount Treachery in the northern part of DENISON is capped by an outlier of north-dipping Central Mount Stuart Formation, consisting of a

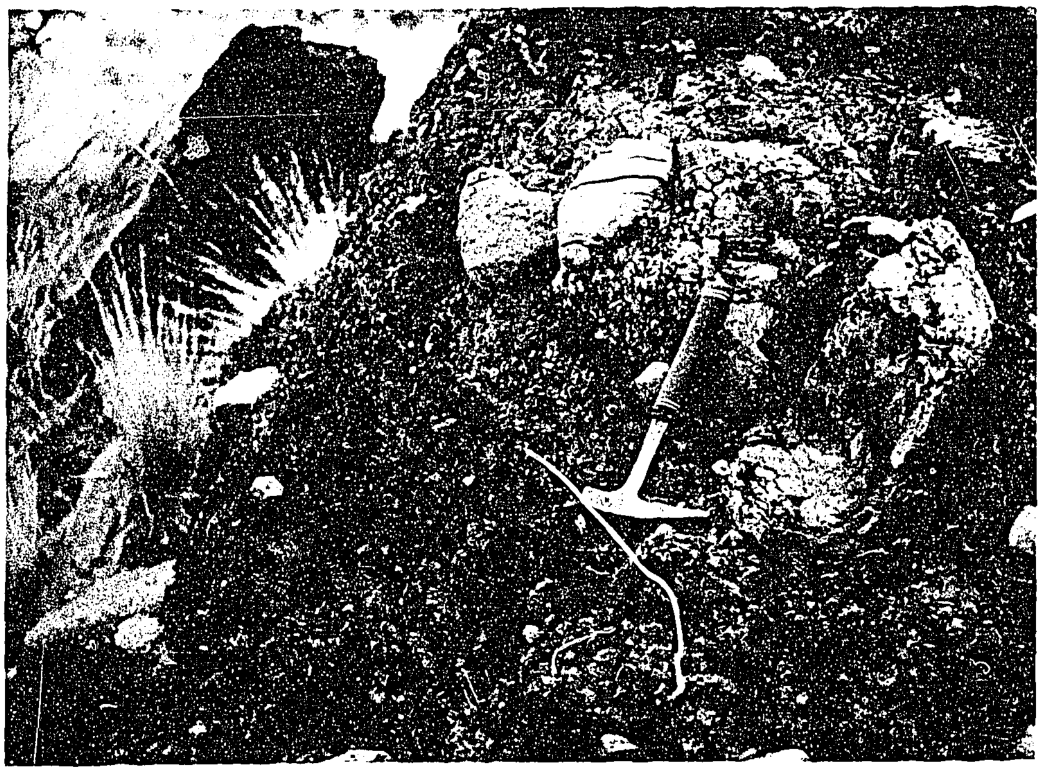


Fig. 122: Faceted and fractured cobbles, Central Mount Stuart Formation, Crown Hill, GR5353-332408.

Neg. GB/273.

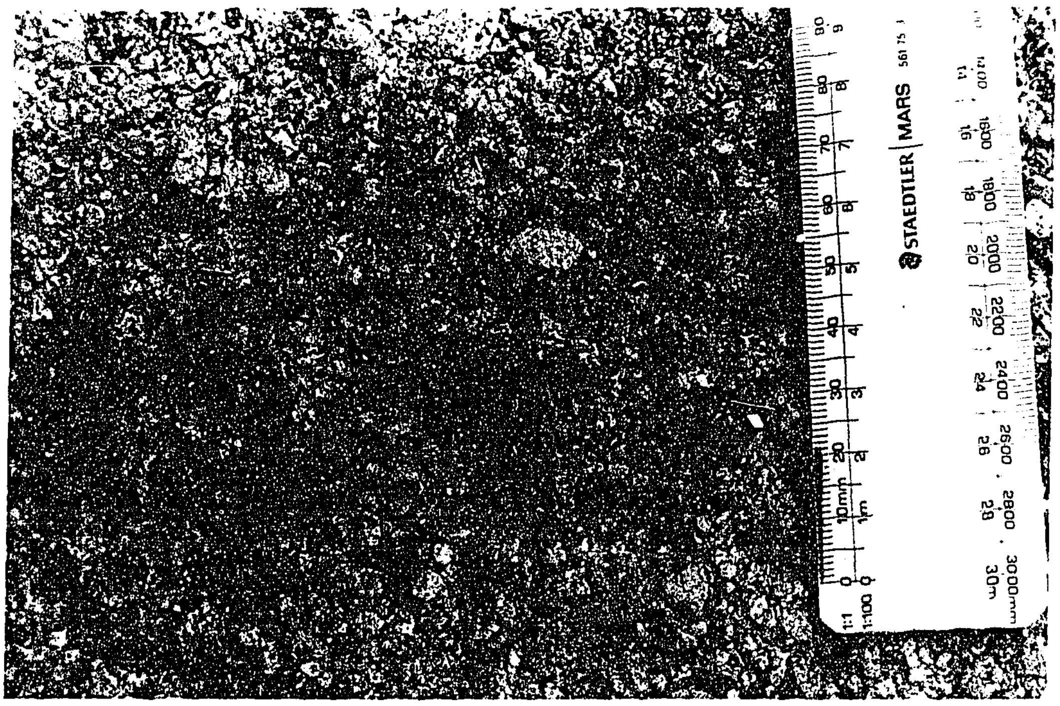



Fig. 123: Granule bed in Central Mount Stuart Formation. GR5353-347416, 1.5 km northeast of Crown Hill.

Neg. M/1730.

metamorphosed thin basal pebble conglomerate, overlain by medium-grained metaquartzite. The conglomerate is strongly deformed, and comprises small sub-angular to rounded pebbles of quartz and feldspar in a clear recrystallised quartz matrix. The metaquartzite contains about 10 percent feldspar, muscovite, and opaque material (74920792).

The vertical gradation from basal beds of various rock types upwards to feldspathic sandstone suggests rapid deposition under transitional marine and terrestrial or deltaic conditions, near a land mass that separated the Ngalia and Georgina Basins (Shaw & others, 1975). In the pockets of diamictite at the base of the Formation, the pebbles and cobbles are commonly faceted, and in some cases striated. The rock is poorly sorted, and obvious bedding is lacking. Hence, the diamictite may be a tillite.

The presence of authigenic biotite, a zeolite, chlorite, epidote, well crystallised groundmass muscovite, and sericitic slate in the lower part of the Central Mount Stuart Formation indicate that it has undergone low-grade metamorphism to zeolite and possibly greenschist facies.

A trace fossil found in scree in the interval from 300 to 500 m above the base of the type section of the Formation was identified as *Hallidaya brueri* by M.R. Walter (BMR, personal communication, 1975). The same fossil occurs in the lower part of the Arumbera Sandstone of the Amadeus Basin (Wade, 1969), well below the Precambrian/Cambrian boundary (Glaessner, 1969). Furthermore, the existence of diamictite at the base of the Central Mount Stuart Formation, and the lithological similarity of the lower part of the unit to the upper part of the Late Precambrian Grant Bluff formation in the Elyuah Range of the Huckitta 1:250 000 Sheet area (Smith, 1972) and to certain members of the Pertatataka Formation in the Amadeus Basin to the south (Wells & others, 1970), also indicate that the lower part of the Central Mount Stuart Formation is Adelaidean in age. Hence most of the Central Mount Stuart Formation is late Proterozoic. When the Preliminary editions of REYNOLDS RANGE, TEA TREE, and the First Edition of Mount Peake 1:250 000 Sheet were prepared, the upper boundary of the Central Mount Stuart Formation was thought to be conformable with the overlying unit shown as Grant

Bluff Formation on the Barrow Creek 1:250 000 Sheet area, but known to contain Cambrian fossils (and now mapped as Donkey Creek beds). Hence, the upper part of the Central Mount Stuart Formation was thought to be Cambrian. Subsequent work by Walter (in press) indicates that the contact of the Central Mount Stuart Formation and Donkey Creek beds is a paraconformity, and that all the Central Mount Stuart Formation is Late Proterozoic. Shaw & others, (1975) correlated the basal diamictite of the Central Mount Stuart Formation with the Mount Doreen Formation of the Ngalia Basin, and with the Olympic Formation of the Amadeus Basin, which are correlatives of the upper tillite of the Adelaide Geosyncline. Smith (1972) and Walter (in press), however, correlate the basal diamictite of the Central Mount Stuart Formation with the Mount Cornish Formation and Yardida Tillite of the Georgina Basin, and with the Areyonga Formation of the Amadeus Basin. These units are correlatives of the lower tillite of the Adelaide Geosyncline. Walter correlates the overlying 400 m of the Central Mount Stuart Formation with the upper part of the Elkera Formation in the Georgina Basin, and with the Julie Formation of the Amadeus Basin; the uppermost 400 m is correlated with Arumbera Sandstone 1 of the Amadeus Basin. If these correlations are correct, the contact of the basal diamictite and overlying sediments is a paraconformity, and represents a time gap of about 300 Ma. Erosion during this interval could explain the very limited and sporadic distribution of the basal diamictite.

Amesbury Quartzite Member (Eusq) (L.A.O. and A.J.S.)

The Amesbury Quartzite Member, defined by Offe (1978), crops out in the southeastern part of the Mount Peake 1:250 000 Sheet area. The unit forms isolated cuestas (Fig. 124) from 7 km northeast of Amesbury Bore (GR31835938), after which the name of the unit is derived, to 29 km farther northwards. The type section is situated at GR33345990, 16 km east-northeast of Amesbury Bore.

Granite of the Arunta Block unconformably underlies the Amesbury Quartzite Member at the type section. The Member is conformably overlain by reddish-purple feldspathic quartz sandstone typical of the Central Mount Stuart Formation. Four kilometres north-northwest of Boko Bore (GR33266125) in the eastern part of the Mount Peake 1:250 000 Sheet area, the Amesbury Quartzite Member is conformably overlain by laminated siltstone and fine-grained micaceous sandstone, followed by feldspathic quartz sandstone with clay galls. This is succeeded by a covered interval, and then by purple-brown to white feldspathic quartz sandstone, medium to coarse-grained. If it is valid to relate the Amesbury Quartzite Member to the type section of the Central Mount Stuart formation, then upper and lower stratigraphic limits of the Quartzite can be interpolated into the type section on the following grounds:

1) There are no calcareous beds in or above the Amesbury Quartzite Member, therefore it must lie above the uppermost level of calcareous rocks in the type section of the Central Mount Stuart Formation, i.e., above 183 m.

2) The Amesbury Quartzite Member is overlain by laminated siltstone at the locality 4 km north-northwest of Boko Bore, therefore it must be below the uppermost level of pelite in the type section of the Central Mount Stuart Formation, i.e., below 395 m.

If these limits are accepted, the Amesbury Quartzite Member lies stratigraphically well above the basal diamictite of the Central Mount Stuart Formation, by at least 179 m.

The sequence at the type section begins with 0.5 m of poorly sorted conglomerate consisting of subrounded pebbles of white quartz, claystone, and shale, in a quartz sandstone matrix (Fig. 125). This is overlain by about 20 m of coarse-grained colourless orthoquartzite, feldspathic in the lower part but clean above, medium-bedded, moderately rounded, and blocky. The quartzite is succeeded by superficial Cainozoic deposits. The unconformity between the basal conglomerate and underlying weathered granite is very well exposed. The thickness at the type section is estimated at 20m; away from there the thickness is rather less than this.

The Member typically consists of cross-bedded and locally ripple marked, medium to coarse-grained orthoquartzite commonly with a pebble or granule conglomerate at the base. The phenoclasts in the conglomerate are composed of white quartz and pelitic rocks. In places the Member consists of white quartz sandstone containing flattened clay galls.

Fig. 124: Cuestas of gently dipping Amesbury Quartzite Member (left), and pillar of blocky Amesbury Quartzite (right). Looking north from type locality (GR33345992).

Neg. M/1718/17.

Fig. 125: Base of type section of Amesbury Quartzite Member, showing pebble conglomerate overlying granite (top of 15 cm scale coincides with unconformity), and overlain by blocky quartzite. GR33345992, 16 km east-northeast of Amesbury Bore, Mount Peake 1:250 000 Sheet area.

Neg. M/1718/5.

The Amesbury Quartzite Member and the overlying feldspathic quartz sandstone of the Central Mount Stuart Formation were gently folded and subsequently faulted. About 11 km north-northwest of Boko Bore, feldspathic quartz sandstone appears to be down-faulted against the Amesbury Quartzite Member.

Deposition of the Member may have been under shallow-marine or fluviatile conditions.

If the Amesbury Quartzite Member is correctly interpolated into the type section of the Central Mount Stuart Formation (Fig. 114), it lies below the level of occurrence of the Late Proterozoic trace fossil *Hallidaya brueri*, and above the level of the diamictite, which is correlated with the Late Proterozoic Areyonga Formation of the Amadeus Basin in Walter (in press); hence, the Amesbury Quartzite Member is regarded as Late Proterozoic.

Kerridy Sandstone (Pzy) (A.J.S.)

The Kerridy Sandstone of the Ngalia Basin sequence is exposed only in the west of DENISON, and forms a single south-dipping ridge. The unit consists mostly of red-brown cross-laminated sandstone which is generally fine to medium-grained, silty and clayey, and contains abundant flat clay pellets. Slumps and sole markings are common, and skeletal weathering is well developed in the lower beds. The unit is considered to be early Palaeozoic in age, and is correlated with the Stairway Sandstone and Carmichael Sandstone of the Amadeus Basin (Evans & Glikson, 1969).

Mount Eclipse Sandstone (Pzt) (A.J.S.)

The Mount Eclipse Sandstone of the Ngalia Basin sequence is exposed only in the south of DENISON. It forms very low rises covered with *Acacia neura* (mulga), or low ridges about 3 m high rising out of the sand plain. The unit comprises thick beds of conglomerate inter-bedded with coarse-grained sandstone. The conglomerate is poorly bedded and poorly sorted; the clasts range up to 30 cm across, are subangular to well rounded, and composed of quartzite, silicified sandstone, or hematite-quartz breccia. They are commonly packed together in irregular pockets and lenses; elsewhere, they are spread out in layers one pebble thick. The sandstone is red-brown to yellow-brown, laminated to thick-bedded, cross-bedded with curved trough-like cross-beds, micaceous and kaolinitic, poorly sorted, and pebbly. The unit was deposited in a continental, fluvial piedmont environment. Plant fossils from the Mount Doreen Sheet area have established the age as Early Carboniferous (White, in Wells & others, 1968). The unit is lithologically correlated with the Devonian Pertnjara Group of the Amadeus Basin, and with the Dulcie sandstone (also Devonian) of the Georgina Basin (Evans & Glikson, 1969).

Palaeozoic Faults and Fault Zones (A.J.S.)

All the rocks in the area are cut by steeply dipping faults marked by zones of orthoschist, vein quartz, or brecciated rock.

Orthoschist is a greyish-green medium to coarse-grained quartz-muscovite schist (Fig. 126), which forms zones up to 1.5 km wide. The rock is flaky and phyllonitic and commonly includes lenses of white quartz (Fig. 127). The orthoschist is composed of coarse-grained aggregates of strained quartz which is partly recrystallised to fine-grained polygonal mosaic quartz, and a streaky groundmass of strongly oriented muscovite, quartz, and rare biotite (72920539, -0549). In some specimens the quartz aggregates are wholly recrystallised to fine-grained polygonal quartz. Feldspar is completely lacking. The lenticular masses of white quartz which accompany the orthoschist consist of fine-grained recrystallised polygonal quartz which has undergone mild post-recrystallisation strain (72920539). The orthoschists are clearly zones of intense retrogressive metamorphism where feldspar has altered to muscovite and quartz, and biotite has largely disappeared, possibly to form additional muscovite; the general absence of chlorite and epidote from the orthoschists suggests that iron, calcium, and magnesium have moved away. The quartz originating from the alteration of feldspar forms the lenses of finer-grained recrystallised quartz in the orthoschist.

The orthoschists could have formed at any time after consolidation and cooling of the rocks which they cut. Many of the orthoschist zones in the Napperby Gneiss are parallel to the major fault along its southern margin, where the Arunta Block is thrust over

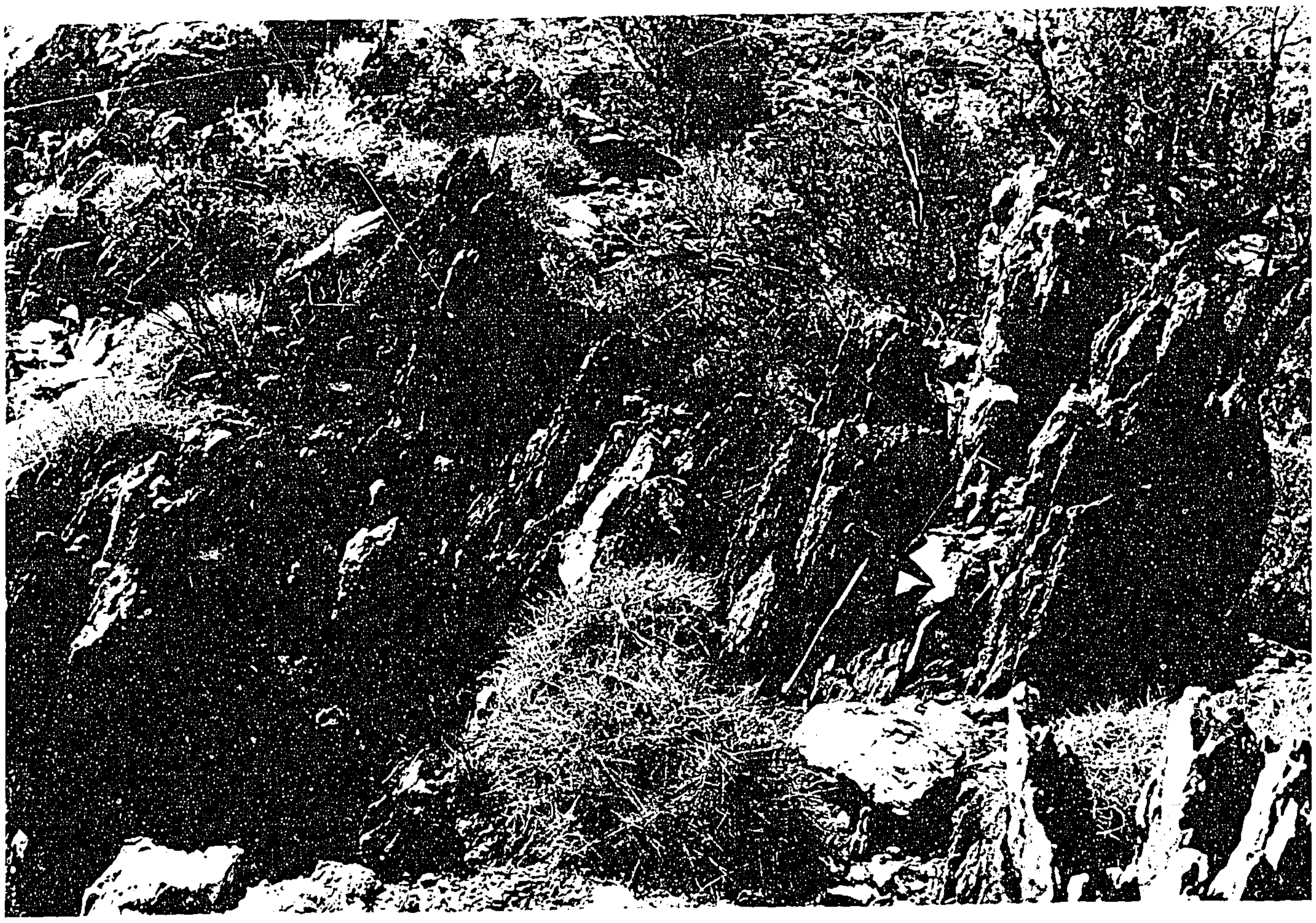


Fig. 126: Orthoschist in shear zone of foliated and retrogressively metamorphosed Mount Airy Orthogneiss, GR5453-904303, 14 km east of Harverson Pass. Neg. M/1376/19.

Fig. 127: Orthoschist with quartz lenticles, some folded (right). Scale is 15 cm long. Same locality as Fig. 126.

Neg. M/1376/18.

the Ngalia Basin, and two samples of biotite from the southern edge of the Napperby Gneiss have given Rb-Sr isotopic dates of 390 and 685 Ma. Similarly, the northern edge of the Anmatjira Orthogneiss in the Yundurbulu Range may be a fault line scarp, because it is parallel to several of the major faults in the area, and the Orthogneiss itself is strained and shows retrogressive alteration. Muscovite from this area has given a K-Ar date of 615 Ma (Lowder & Webb, 1972). The isotopic dates almost certainly result from partial resetting during the Devonian-Carboniferous Alice Springs Orogeny, and hence the major zones of orthoschist throughout the Reynolds Range area probably formed at that time also.

Many faults are filled with elongate masses of white vein quartz several kilometres long. In some cases, the quartz is foliated and lineated (Fig. 128), and interlayered with very fine-grained quartz-muscovite schist (Fig. 129), and in others is brecciated and accompanied by kaolin (Fig. 130). Many of the quartz veins carry minor hematite, and are generally bordered by orthoschist. They are probably larger versions of the lenticular masses of white quartz in the orthoschist zones, i.e., they are metamorphic segregations, not igneous intrusions.

Fanglomerate (Czc, Qlc) (L.A.O.)

Cainozoic fanglomerate occurs as dissected remnants of colluvial fans flanking the Reynolds Range, Giles Range, Yindjirbi Range, Nanga Range, Bau Range, Johns Range, and Djilbari Hills. At the south base of Mt Leichhardt in the Nanga Range (Mount Peake Sheet area), the unit is composed of subrounded to rounded flaser granite and quartz cobbles cemented in a gritty matrix of granular weathered granitic detritus (Fig. 131). Elsewhere it consists of unconsolidated cobbles and less commonly boulders mainly of quartzite and sandstone in a matrix of coarse silty quartz sand. This unit was regarded as early Quaternary on MOUNT PEAKE, and designated Qlc; we now consider a Cainozoic age more appropriate.

Sand, Silt, Clay (Czs) (L.A.O. and A.J.S.)

Unconsolidated sand, silt, and clay occur in basement depressions e.g., the Yaloogarrie, Willowra, and Tea Tree Basins, and are overlain by Quaternary sediments.

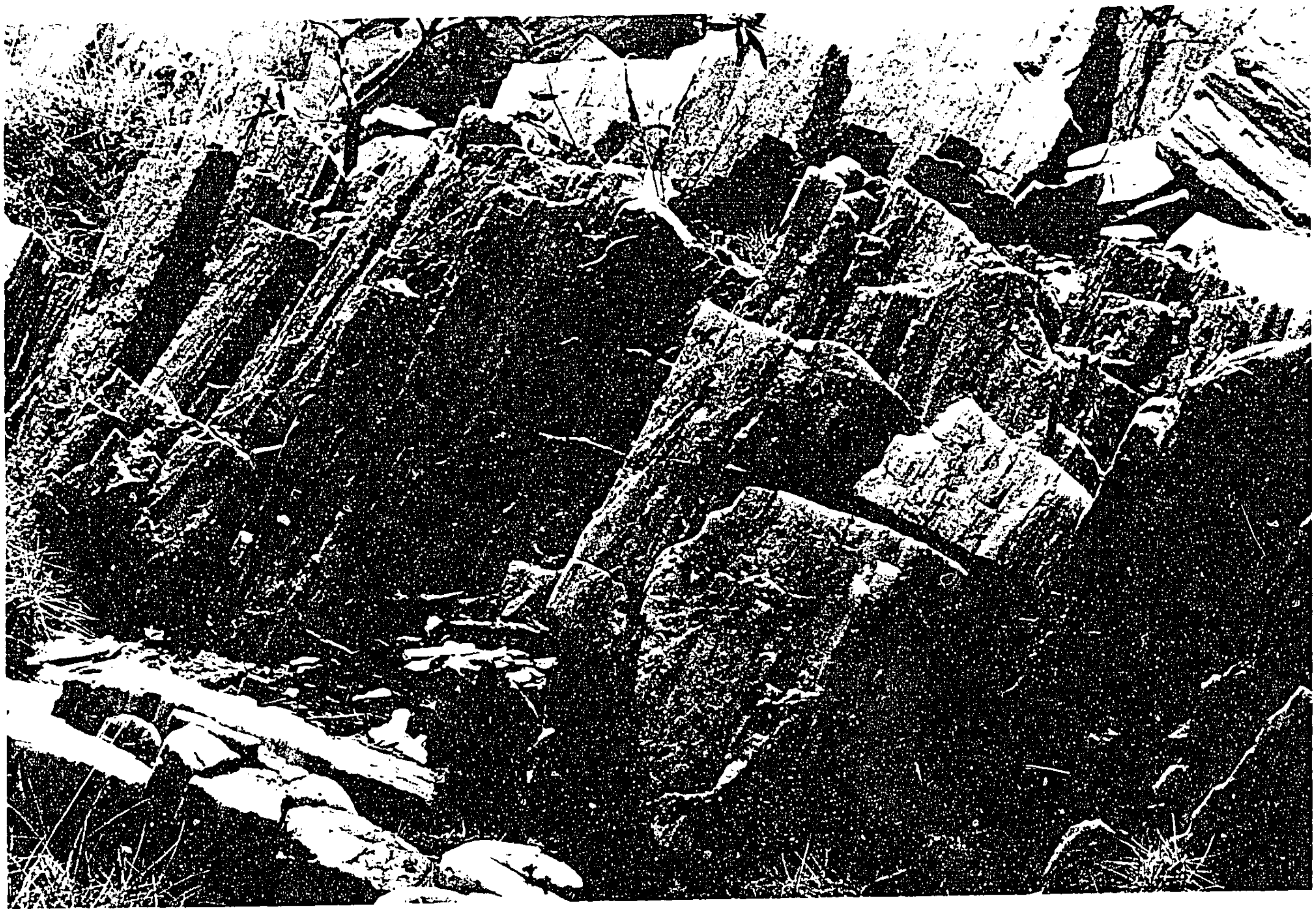


Fig. 128: Vein quartz in fault zone, showing strong down-dip lineation. Scale 15 cm. GR5553-944410, 8 km west-northwest of Bluebush Bore. Neg. M/1376/22.

Fig. 129: Vein quartz and sericite-quartz schist in fault zone, same locality as Fig. 128. Neg. M/1376/21.

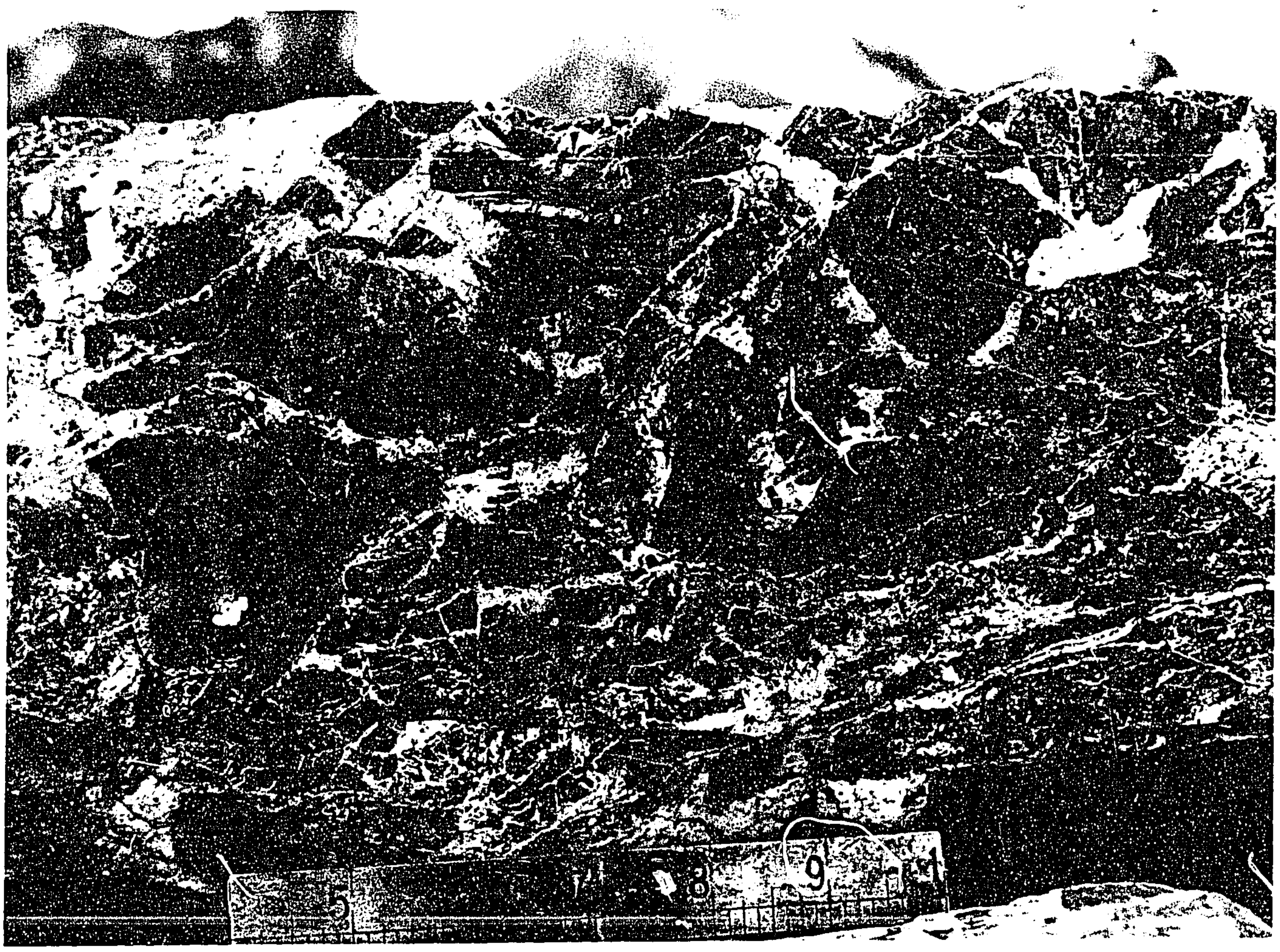


Fig. 130: Kaolinic quartz breccia in fault cutting Anmatjira Orthogneiss, GR5453-782524, 3 km north-northwest of Ingallan Spring. Scale is 15 cm long.
Neg. M/1412/43.

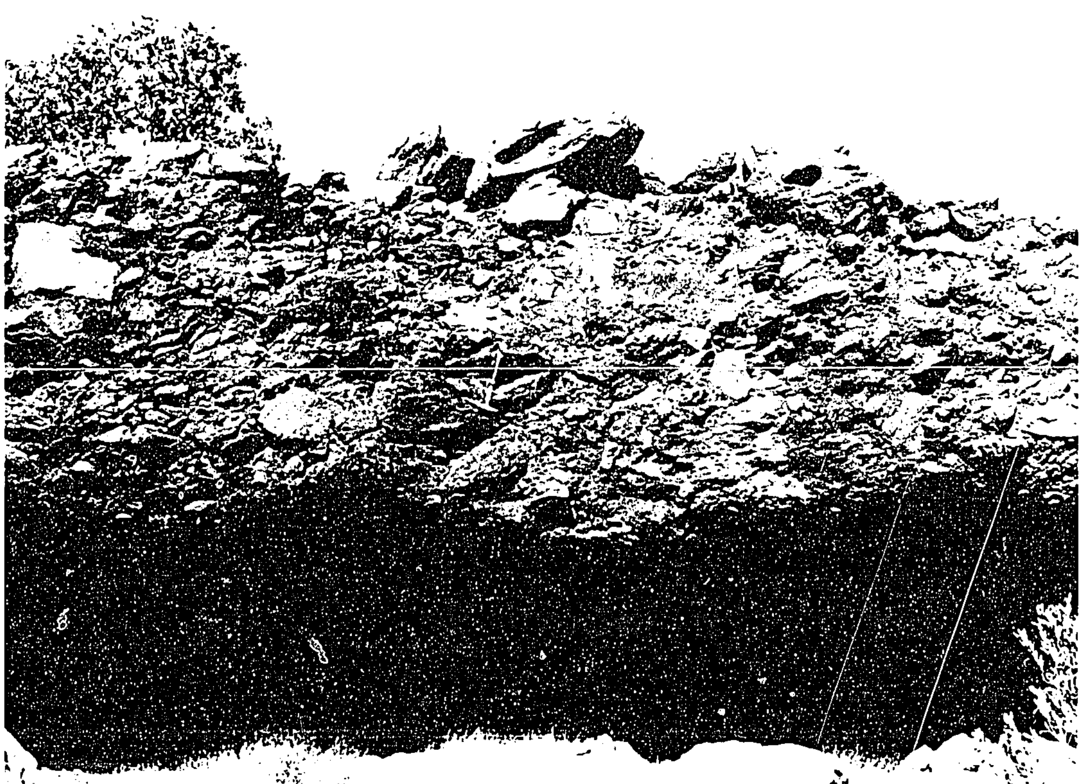


Fig. 131: Indurated colluvium (fanglomerate) at southern foot of Nanga Range, GR5454-502836, 1 km south of Mount Leichhardt.
Neg. M/1662.

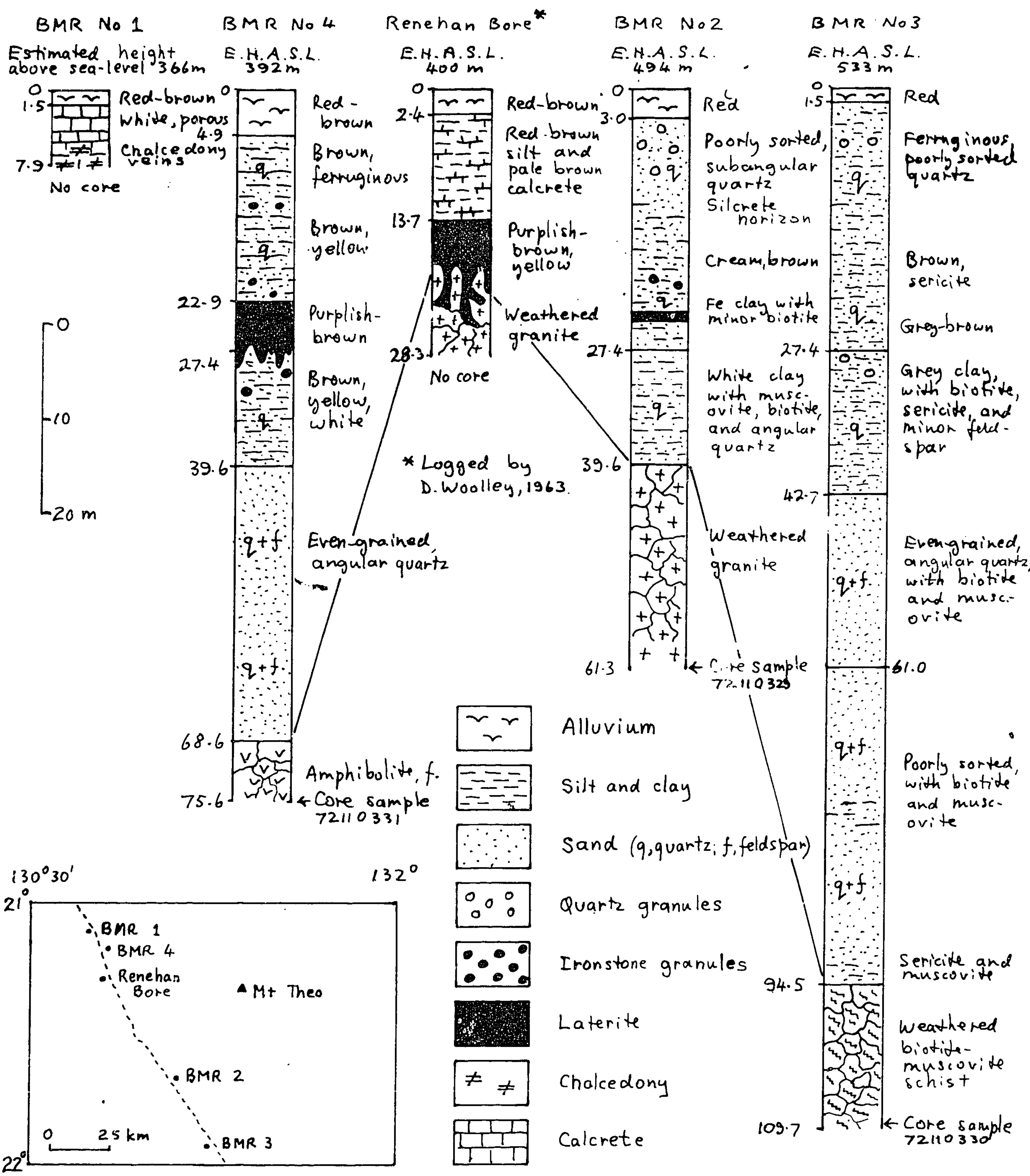



Fig. 132 : Generalised lithological logs of BMR Mount Theo Stratigraphic Holes Nos 1-4 and Renehan Bore. Inset map (lower left) shows locations of bores on Alice Springs-Tanami road, Mount Theo 1:250 000 Sheet area

16/NT/15

In 1972, BMR drilled four holes to basement along the Alice Springs-Tanami road in the Mount Theo Sheet area. The generalised lithological logs of these holes together with that for Renehan Bore (on the same road) are shown in Figure 132. From the information gained from these holes and from earlier water bores in the area, Stewart (1976) outlined several Cainozoic basins in the Sheet area. The deepest of them, the Yaloogarrie Basin, is up to 100 m deep and contains unconsolidated sand-sized angular grains of quartz and feldspar. In BMR Nos. 2 and 4, Tertiary ferricrete is interbedded near the middle of the section. Hence, the Czs unit is probably Tertiary also, and originated as alluvial river channel deposits.

Two areas in the Mount Peake Sheet area also contain subsurface sediments of Cainozoic age. Morton (1965) defined the Willowra Basin as a basement depression, at least 35 m thick, composed of late Tertiary and Quaternary sediments including river channel sand. Between the Bau and Nanga Ranges, water bores intersected up to 95 m of alluvium.

CRA Exploration drilled six holes to basement across the Tea Tree Basin, in the east of TEA TREE (O'Sullivan, 1973, Fig. 133). Depth to basement ranged from 145.8 m to 318.8 m. Laterite, 13 to 26 m thick, covered the basement in the shallower holes, and was overlain by soft buff and pink sands. These were intercalated with white kaolinitic silt and clay (20 to 30 m). In the deeper holes, white silt and clay rest on basement, and are overlain by lenticular units of lignite or carbonaceous clay (20 to 30 m). The carbonaceous beds, or where they are absent, the white beds, are overlain by greenish-grey silt and silty sand (27 to 160 m); and these pass up into their weathered and oxidised equivalents (65 to 100 m thick). Two laterite horizons are present in one hole, one overlying basement, the other higher up, in the greenish-grey silt. The carbonaceous clay is under examination for microfossils by E.M. Truswell (BMR). Similar carbonaceous sediment at a depth of 136-139 m in BMR Napperby No. 1, 13.5 km southwest of Napperby homestead, contains a middle Eocene microflora (Kemp, 1976), but this age may yet be revised (E. Truswell, personal communication, 1980).

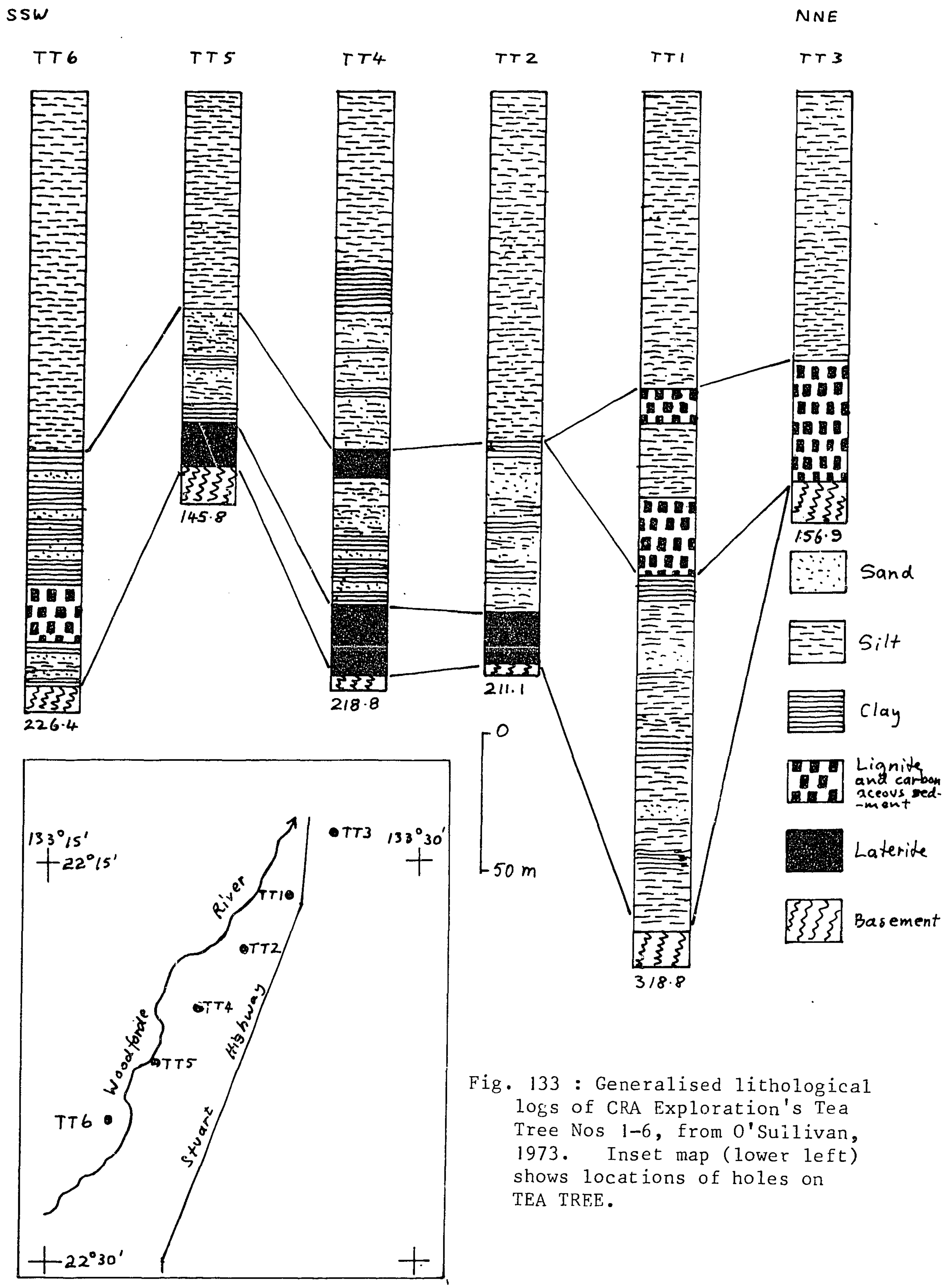



Fig. 133 : Generalised lithological logs of CRA Exploration's Tea Tree Nos 1-6, from O'Sullivan, 1973. Inset map (lower left) shows locations of holes on TEA TREE.

16/NT/16

Lag Gravel (Czg) (L.A.O.)

Lag gravel flanks gentle red soil rises and also forms low rises and outwash fans from ferricrete mounds. It commonly consists of angular to rounded, locally polished, ironstone fragments and minor quartz scree in a matrix of sand, silt and clay. In the area between the Yalyirimbi Range and Reynolds Range (in REYNOLDS RANGE), the gravel consists of angular granules and pebbles of milky-white quartz derived from nearby quartz veins and fault fills.

Calcrete (Czt, Ql) (L.A.O.)

Calcrete up to 15 m thick crops out along the margins of water courses in hilly areas of REYNOLDS RANGE, TEA TREE, AILERON, and MOUNT PEAKE, and larger outcrops occupy broad gentle depressions in the sand plain to the north, mainly in the Mount Peake and Mount Theo 1:250 000 Sheet areas. A single sample has been analysed, from north of Mount Davidson in the Mount Solitaire 1:250 000 Sheet area, and is composed of finely crystalline calcite and dolomite containing chalcedony concretions and minor quartz grains. Rare fragments of recrystallised dolomite may be derived from underlying Palaeozoic dolomite, possibly Undivided Montejinni Limestone or Hooker Creek Formation (Offe & Kennewell, 1978). The lower part of the calcrete in the Ajax-Sandford Bore area of the Mount Peake Sheet is nearly completely converted to chalcedony and opaline silica (Scott, 1973 a, b). The calcrete forms by concentration and precipitation of calcium carbonate during evaporation of water from a shallow-water-table. Although much of the calcrete is a recent Quaternary product, Morton (1965) has recorded Tertiary calcrete from boreholes drilled in the Willowra Homestead area in the central part of the Mount Peake 1:250 000 Sheet area, and so the symbol Czt is used in the Mount Solitaire and Lander River Sheet areas; Ql is used elsewhere.

Sediments below silcrete (Ts) (A.J.S.)

Sediments older than silcrete are exposed only in the southeast of the Mount Peake 1:250 000 Sheet area, at GR33855875, on the eastern side of the Djilbari Hills. The sediments form a low flat-topped hill, with the best exposure on the western side. The sequence begins with a few metres of white, micaceous, medium to coarse-grained sandstone, overlain by a few metres of white to purple laminated claystone. These beds dip north at 15 to 20 degrees, and are unconformably overlain by about 6 m of gently north-dipping poorly sorted, poorly cemented conglomerate, containing pebbles, cobbles, and boulders of quartzite from the Central Mount Stuart Formation. The lower part of the conglomerate is finer-grained and shows a sharp, rather uneven unconformable contact with the underlying sandstone, with a difference in dip of about 10 degrees, (Fig. 134). The conglomerate is lateritised and strongly jointed at the top.

Silcrete (Tls) (L.A.O., A.J.S.)

Silcrete has been mapped only in the east of the Mount Peake and the north of the Mount Solitaire 1:250 000 Sheet areas. In Mount Peake the silcrete forms small gently dipping mesas a few metres high on the northeastern side of the Djilbari Hills. The tops of the mesas are covered with boulders (Fig. 135) and chips of silcrete. The rock is white, and consists of angular to subangular sand-sized grains of quartz in a matrix of very fine-grained nearly crypocrystalline quartz mixed with tiny opaque particles. Isolated patches of brown isotropic opaline silica showing concentric rings of opaque particles are also present, and cross-cut and separate the large quartz grains into smaller fragments (74110073). Tourmaline and zircon are accessory. At GR33425986 in Mount Peake, the silcrete is transitional into and has formed by silicification of fanglomerate.

In Mount Solitaire, the silcrete is similar, but lacks the patches of opaline silica (Offe & Kennewell, 1978).

Deeply weathered rock (Tld, Tla) (L.A.O.)

This unit is mainly confined to parts of the southwestern side of the Reynolds Range, the central parts of the Mount Peake and Mount Solitaire Sheet areas, and the southern part of DENISON. It consists of a deeply weathered profile, generally ferruginous and clayey, and it appears to be older than the Cainozoic fanglomerate since it commonly forms the dissected slopes underneath the fanglomerate on the southwest side of the Reynolds Range.

Ferricrete (Tla, Tlf) (L.A.O.)

This unit applies to ferruginised basement rocks and laterite. Ferricrete was originally symbolised as Tla (on MOUNT PEAKE), but during later mapping the symbol was changed to Tlf.

The ferruginous-capped sediments of the Reynolds Range consist of accumulations of exotic earthy limonite and ironstone. The carbonate beds of the Algamba Dolomite Member in particular appear to have neutralised and precipitated iron minerals from acidic iron solution, possibly derived from hematite lodes associated with the Mount Thomas Quartzite.

On the northern side of the Nanga Range (Mount Peake Sheet area), three dissected remnants of laterite abut the quartzite of the range. A laterite hill away from the quartzite range is about 15 to 20 m high and consists of horizontally parted, porous, earthy limonite containing cemented quartz gravel and pebbles and cobbles of quartzite. Crumbly ferruginous coarse-grained quartz sandstone crops out on the northern side of the Bau Range (MOUNT PEAKE), and appears to be the remnants of an earlier lithified conglomeratic outwash fan.

Narrow arcuate bands of laterite and lateritic gravel cap gentle rises in the plain to the north, northwest and west away from the main ranges.

Red soil (Qr), alluvium (Qa), and aeolian sand (Qs) (L.A.O.)

Red soil commonly forms low mounds which are on-lapped by Quaternary alluvium, colluvium,and aeolian sand, and hence is considered to be older than these sediments. It consists of poorly sorted gravel, sand, silt, and clay and may be a regolith no more than several metres thick. Soil creep probably causes the deposit to move slowly downhill giving rise to arcuate mulga groves which characterise and outline the surface extent of the unit.

Alluvium forms superficial cover on the lower slopes of the ranges and in alluvial fans and floodouts. Alluvial soil flanking the ranges is generally coarse-textured. Outwash plains and larger creek

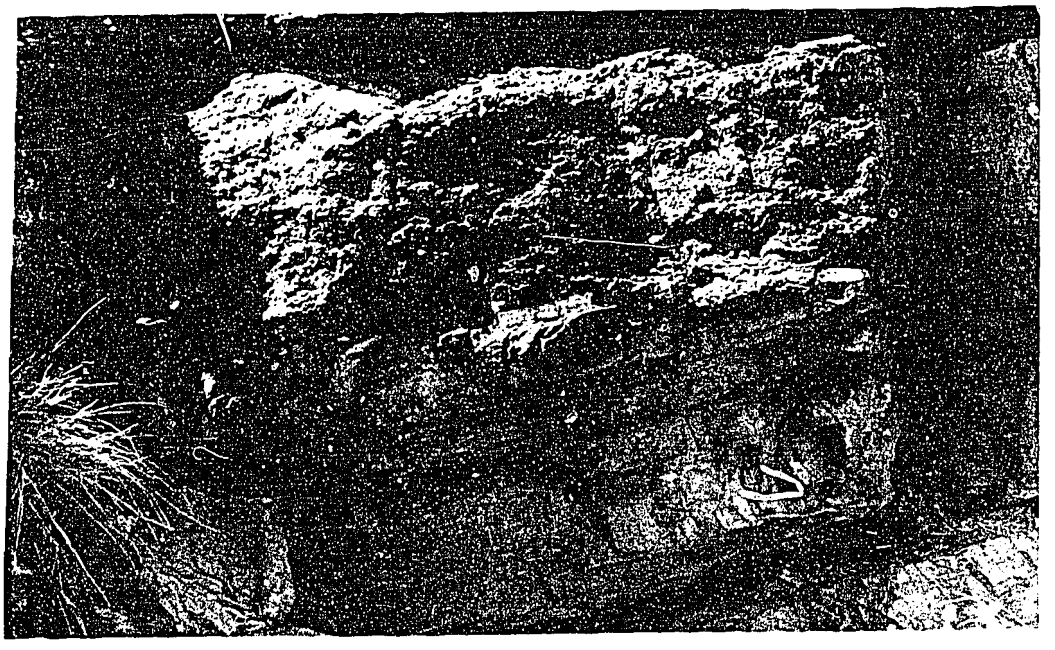


Fig. 134: Unconformity between gently dipping well bedded sandstone (lower), and subhorizontal poorly bedded conglomerate (above), in Tertiary sediments below silcrete. GR33805872, 10 km south of Mistake Bore, Mount Peake 1:250 000 Sheet area.

Neg. M/1718/61

Fig. 135: Cabbage-like boulders of silcrete, GR33455985, 4 km west of Mistake Bore, Mount Peake 1:250 000 Sheet area.

Neg. M/1718/31

channels consist of finer-textured soil brought down from the source area or reworked from the sand and red soil plains through which they pass. The unit is generally poorly sorted, and is known to underlie Quaternary aeolian sand in places (Stewart, 1976; Kennewell & Offe, 1979).

Aeolian sand is found in the north and northwest plains, the eastern part of TEA TREE, and southern part of AILERON. It forms an extensive veneer several metres thick, and is typically quartzose and fine to coarse-grained. The grains are sub-rounded, and stained reddish-brown by iron oxide. Spinifex and low shrubs generally prevent sand drifts and dunes forming. West-northwest dunes up to 15 m high cover the southern part of the Wiso Basin in the north of the Mount Solitaire and Lander River Sheet areas.

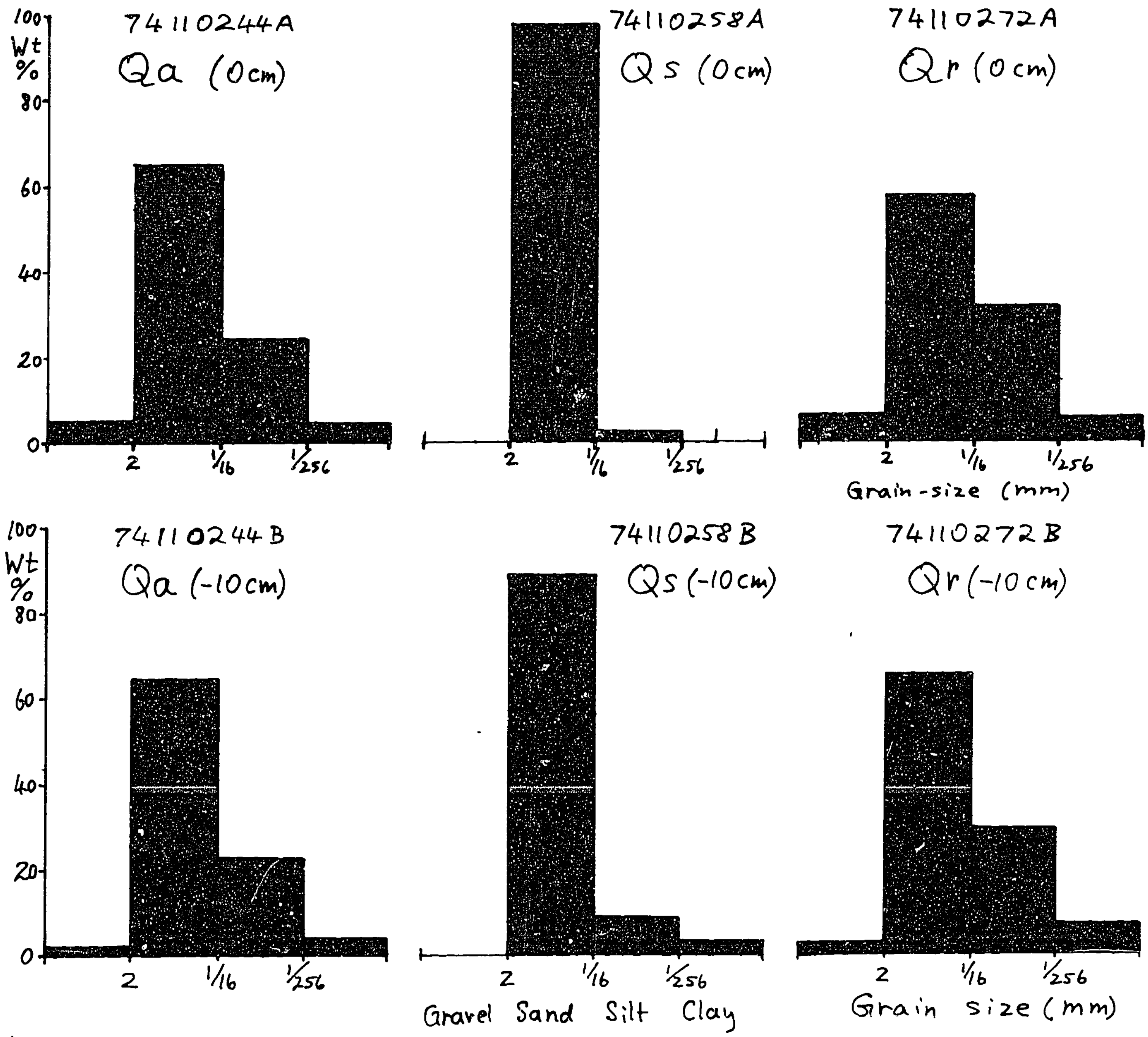
Samples of red soil, alluvium, and aeolian sand were collected and analysed for grain size (Table 17; Fig. 136). The red soil and alluvium are poorly sorted, and consist of angular to sub-rounded gravel, poorly sorted sand, silt, and clay. In the sand fraction the red soil (Fig. 139) tends to be fine to medium-grained, whereas the alluvium (Fig. 137) appears to have a bimodal grain-size distribition of fine and coarse. Seasonal weather variations do not appear to affect the top-soil composition because samples taken 10 cm below the surface reflect the same grain-size distribution shown by the respective surface samples. The aeolian sand (Fig. 138) is well sorted, generally medium-grained, and grains are sub-angular to sub-rounded with a reddish-brown iron oxide coating; silt and clay are minor.

Colluvium (Qc) (L.A.O.)

This unit consists of unconsolidated alluvium and scree, and is restricted almost entirely to outwash fans and the lower slops of ranges and quartz ridges.

## Table 17: Quaternary Sample Localities

| Sample no. | Sheet Area | Grid Reference | Map Symbol | Lithology | Remarks |
|---|---|---|---|---|---|
| 74110244A) | Mount | E 336 | Qa | Alluvium | Surface sample |
| ) | Peake | N 615 | | | |
| ) | | | | | |
| 74110244B) | 1:250 000 | | Qa | Alluvium | Sample 10 cm below 244A |
| 74110258A) | Mount | E 233 | Qs | Aeolian Sand | Surface sample |
| ) | Peake | N 586 | | | |
| ) | | | | | |
| 74110258B) | 1:250 000 | | Qs | Aeolian Sand | Sample 10 cm below 258A |
| 74110272A) | Mount | E 243 | Qr | Red Soil | Surface sample |
| ) | Peake | B 573 | | | |
| ) | | | | | |
| 74110272B) | 1:250 000 | | Qr | Red Soil | Sample 10 cm below 272B |
| 74920876 | Denison | E 223 | Qs | Aeolian Sand | Representative surface sample |
| | 1:100 000 | N 560 | | | |



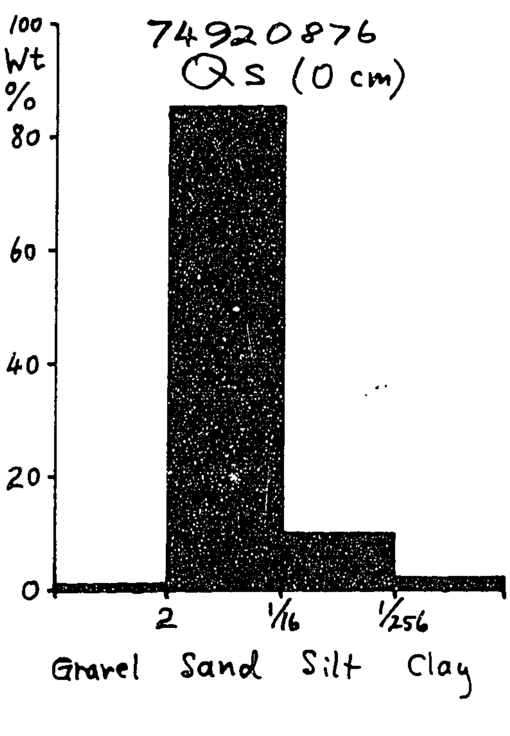




Fig. 136 : Histograms showing measured grain-size distributions of Quaternary alluvium (Qa), aeolian sand (Qs), and red earth (Qr), Mount Peake 1:250 000 Sheet area (samples prefixed by 7411) and Denison 1:100 000 Sheet area (7492). Figures in parenthesis indicate depth of sample below ground level. Settling tube.

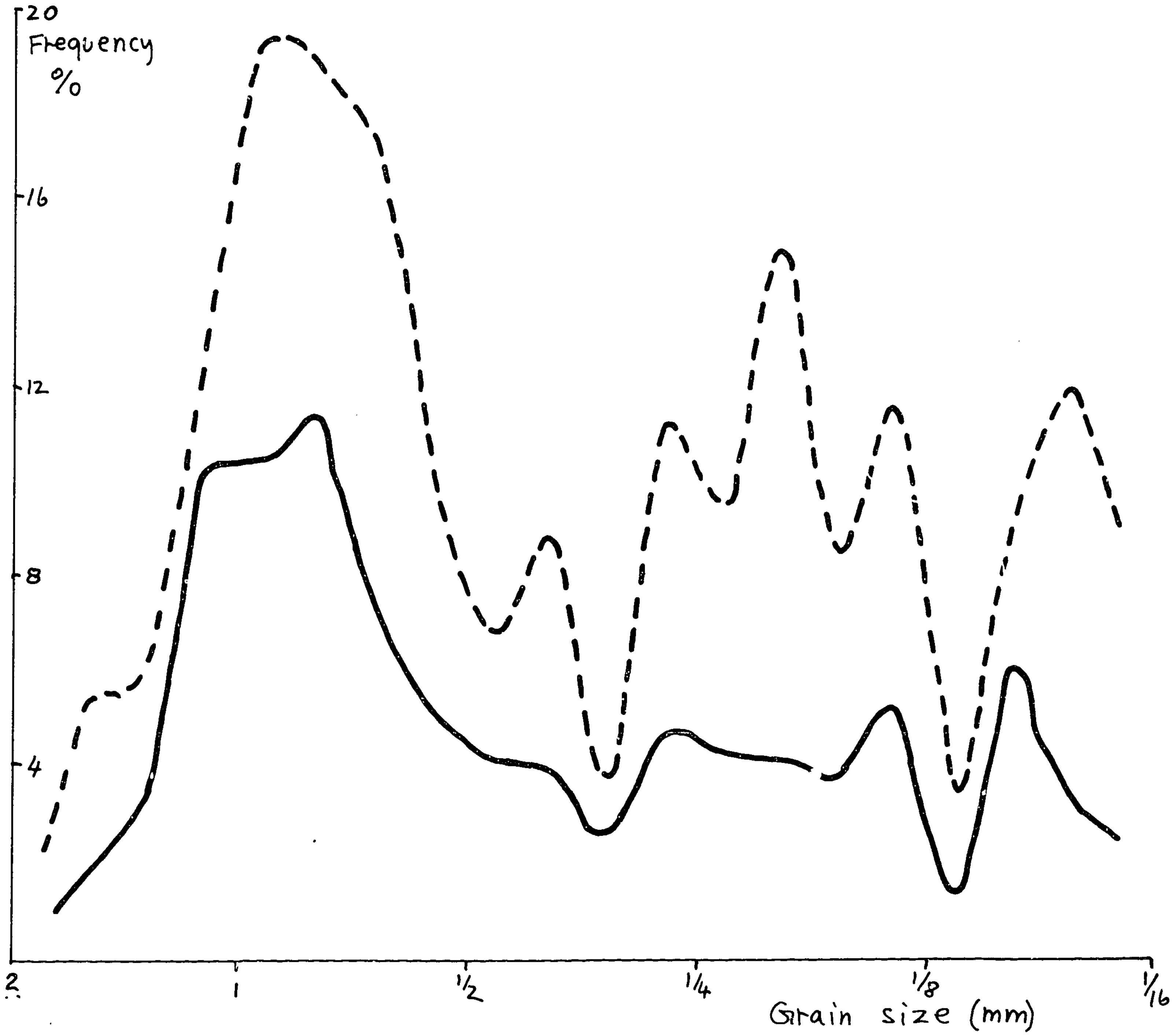



Fig. 137 : Grain-size distribution of sand fraction of sample 74110244 of Quaternary alluvium (Qa), Mount Peake 1:250 000 Sheet area. Solid line refers to sample from ground level (-0244A), dashed line to sample from 10 cm below ground level (-0244B)

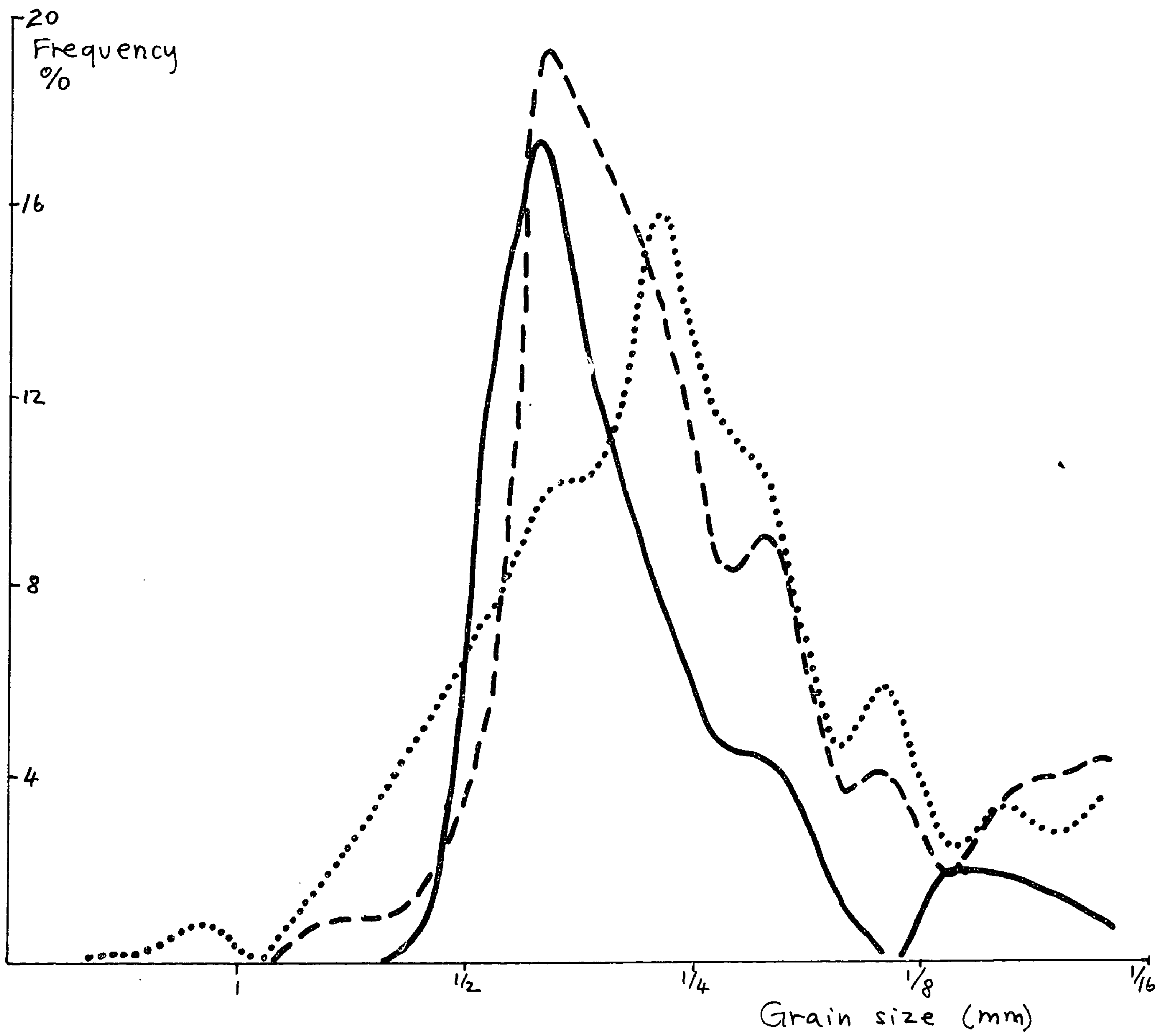



Fig. 138 : Grain-size distribution of sand fraction of sample 74110258 of Quaternary aeolian sand (Qs), Mount Peake 1:250 000 Sheet area, and sample 74920876, Denison 1:100 000 Sheet area. Solid line refers to sample from ground level (-0258A), dashed line to sample from 10 cm below ground level (-0258B), and dotted line to Denison sample (-0876), from ground level.

16/NT/19

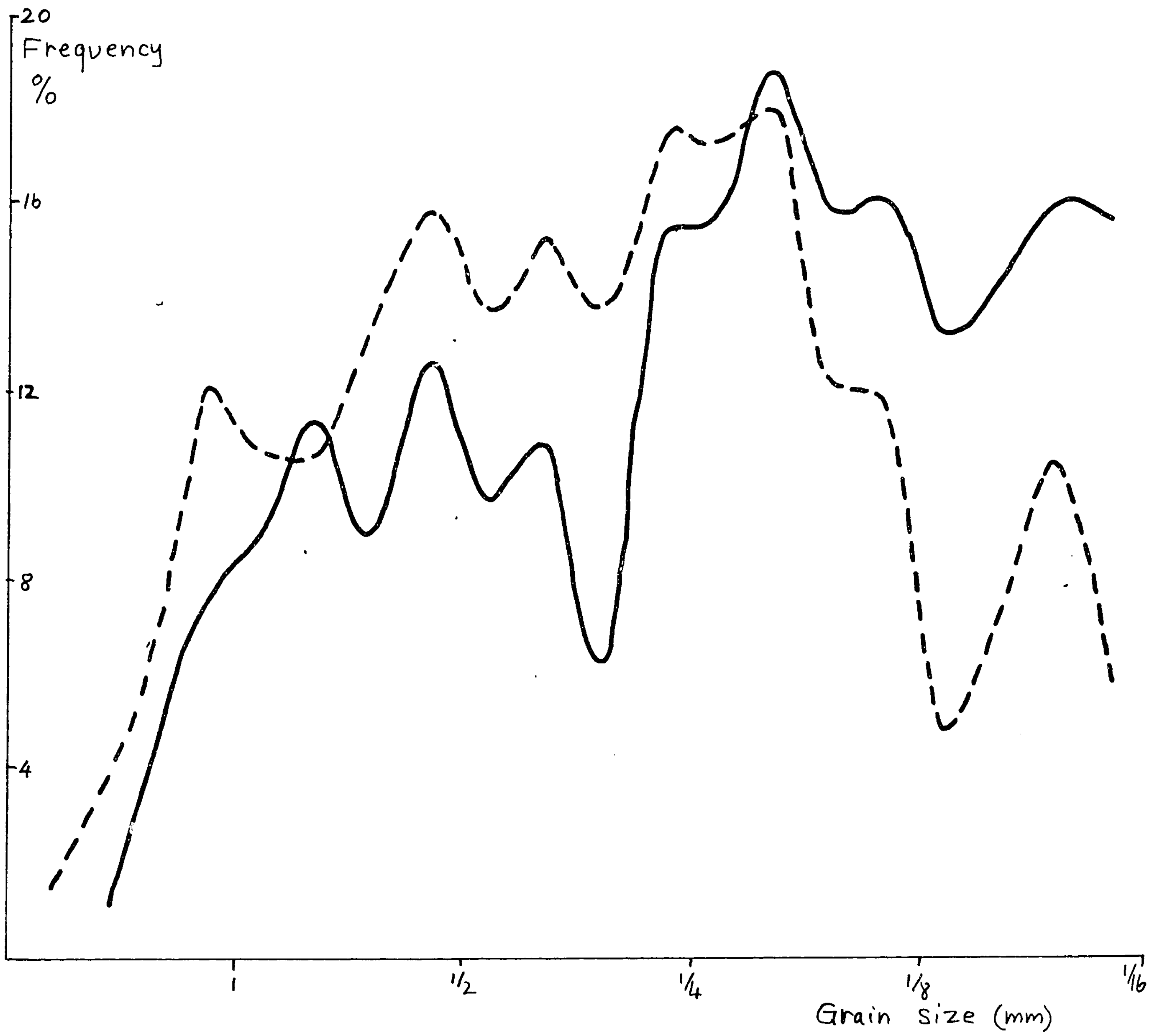



Fig. 139 : Grain-size distribution of sand fraction of sample 74110272 of Quaternary red earth (Qr), Mount Peake 1:250 000 Sheet area. Solid line refers to sample from ground level (-0272A), dashed line to sample from 10 cm below ground level (-0272B).

16/NT/20

## STRUCTURE (A.J.S.)

Following Shaw & Stewart (1975b) and Stewart & Warren (1977), the Arunta Block can be divided into three tectonic zones (Fig. 140), which show differences in rock-type, times and grade of metamorphism, internal structural style, abundance of granite, and metal content.

The Central (and possibly oldest) Zone is characterised by a high proportion of rocks of Division 1. The rocks are highly deformed, and double or triple folding is common. Faults are numerous and extensive, and include low-angle slides and steeper wrench faults (Shaw & others, 1979). Metamorphic grade is almost everywhere of granulite facies, but amphibolite facies is extensive in the eastern part of the zone. Metamorphism occurred at around 1760 and 1660 Ma, and at around 1400 Ma in part of the Strangways Range (Iyer, Woodforde & Wilson, 1976). Granites in this zone are few and small, generally gneissic and anatectic, and are dated at around 1760-1660 Ma. The characteristic metal occurrence is the metamorphosed stratabound Pb-Zn-Cu Oonagalabi type, of possible volcanic exhalative origin. The zone is brought up against the Southern Zone along a major high-angle reverse fault. The northern boundary of the Central Zone is exposed only in the east of the Arunta Block, and is also a mjor high-angle fault (Warren, 1978). Its sense of displacement is not known, but Shaw & others envisage it as south-block-up.

The Southern Zone is the smallest of the three tectonic zones. (Fig. 140), and is characterised by quartzofeldspathic gneisses of Division 2, unconformably overlain by pelitic schist and quartzite of Division 3. Division 1 rocks are absent. Folding is complex and multiple. The grade of the earliest regional metamorphism ranges from greenschist in the upper part of the sequence to amphibolite lower down; the metamorphism is dated at 1640 to 1570 Ma. Intrusive granites are more abundant than in the Central Zone, and are commonly deformed to orthogneiss. The Southern Zone was the site of two subsequent episodes of metamorphism. The first was of amphibolite facies at around 1050 Ma (Marjoribanks & Black, 1974), and produced abundant migmatite. The second was an episode of retrogressive metamorphism of greenschist facies, and was associated with extensive thrust-faulting

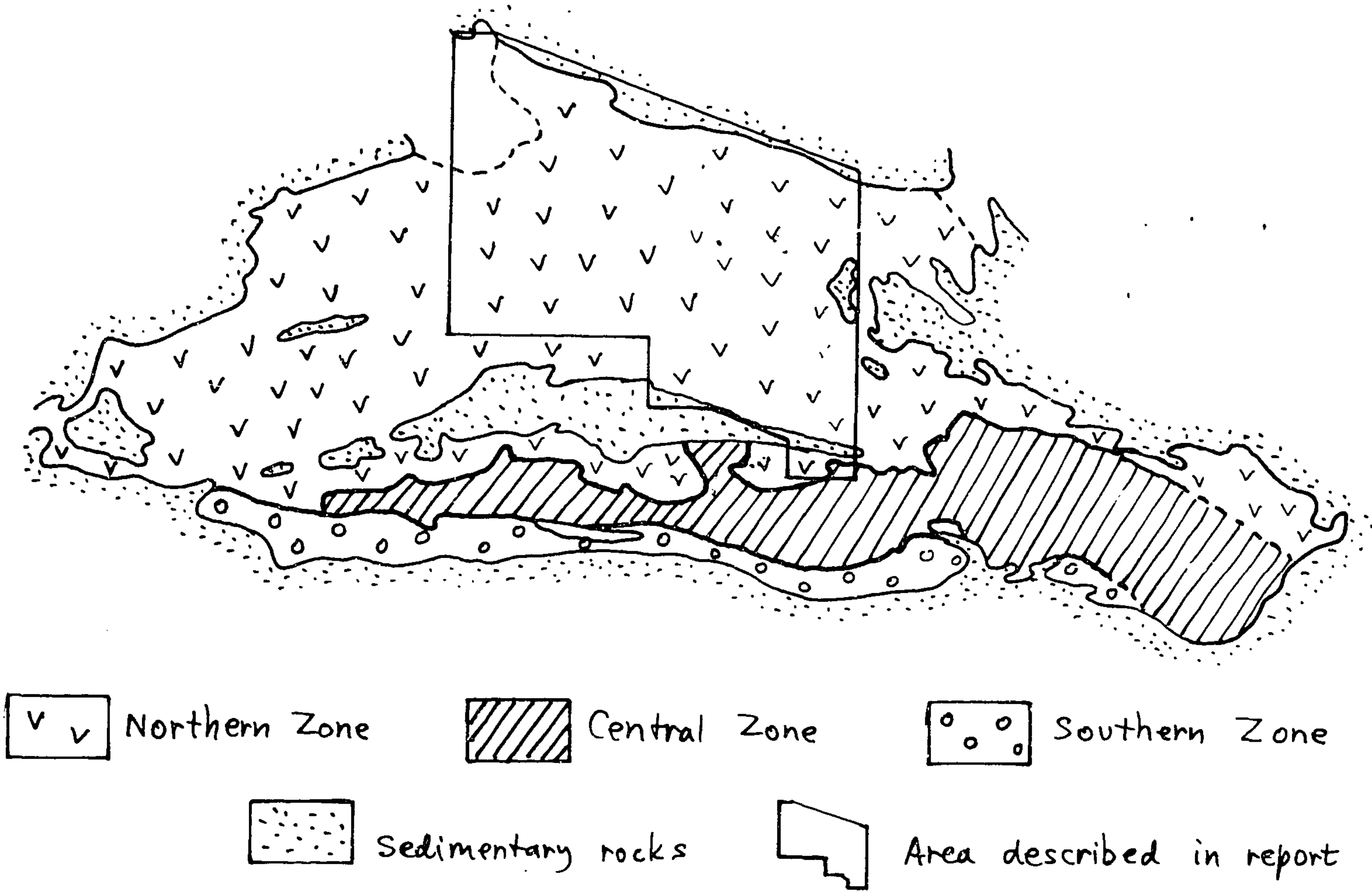



Fig. 140 : Tectonic zones of Arunta Block

16/NT/21

along the southern margin of the Arunta Block at around 335 Ma, i.e., in the mid-Palaeozoic. The faulting and metamorphism also affected the lower part of the Upper Proterozoic sediments of the Amadeus Basin, and produced the well known nappes in the Ormiston, Alice Springs, and Arltunga areas (Stewart, 1967; Shaw & others, 1971; Forman, 1971; Marjoribanks 1976; Clarke, 1976). The Palaeozoic metamorphism concentrated gold in the root zone of the Arltunga Nappe Complex, but apart from this metals in the Southern Zone are rare.

The Northern Zone, which includes the area described in this report, somewhat resembles the Southern Zone, in that rocks of Division 1 are scarce, whereas those of Divisions 2 and 3 are abundant. The metasediments of Division 2 are complexly folded pelitic schist, micaceous metasandstone, and calc-silicate rock, and these are unconformably overlain by macroscopic synforms of quartzite, shale and carbonate of Division 3. Metamorphic grade in both these Divisions is usually greenschist, but in places rises to low in the granulite facies, e.g., near Aileron. Isotopic dates on granulites of Division 1 are around 1650 Ma, and on schist of Division 2 about 1400 Ma. Like the Southern Zone, the Northern Zone contains extensive masses of granite. In the Napperby and Mount Peake 1:250 000 Sheet areas, granite makes up 70 percent of the country, and the metamorphic rocks form enclaves and rafts within and between them. The granites include older orthogneisses (dated at about 1600 Ma), and younger unmetamorphosed granites (1500-900 Ma), some of them coarsely porphyritic. Many are S-type granites in the terminology of Chappell & White (1974), and have brought in tungsten, tin, tantalum, molybdenum, copper, uranium, and thorium. Other metals in the northern zone include stratabound Cu-Pb-Zn in shale of Division 2, and hydrothermal fluorite and barite of late Proterozoic age around the margins of the Ngalia and Georgina Basins. As in the Southern Zone, mid-Palaeozoic thrusting considerably affected the Northern Zone. The movements were more brittle than in the Southern Zone, and extensive faulting was the rule, rather than nappe formation. Greenschist retrogression was also more limited in extent.

The large-scale geological structure of the northern Arunta Block (Fig. 141) is largely the result of granite intrusion and later major faulting. As shown in Fig. 141, and on the 1:500 000 scale Solid Geology

Maps which accompany the 1:100 000 scale Geological Sheets, much of the southeastern part of the region consists of granite in which there are irregular but dominantly northwest-trending enclaves of metamorphic rock, the whole cut by northwest to west-trending faults many kilometres in extent. In the southern part of Napperby 1:250 000 Sheet area, which is almost wholly concealed beneath Cainozoic cover, aeromagnetic data indicate the existence of (1) numerous masses of felsic and mafic granulite in the southeast, (2) a mafic granulite body of considerable size in the southwest, (3) considerable subsurface extent of quartz-hematite concentrations along a fault zone near the southern margin of the Ngalia Basin, and (4) considerable subsurface extent of the ultramafic body which is exposed 3 km east of Native Gap, at the southeast edge of the Sheet area. In the Mount Peake Sheet area, the data indicate that the Central Mount Stuart Formation below Cainozoic cover is much more extensive than is shown in the 1:440 000 scale sketch map of Pre-Cainozoic Geology on the Mount Peake First Edition Geological Map (Stewart & Offe, 1974).

In REYNOLDS RANGE and TEA TREE, the various types of granitic rock are distributed in three main areas which trend roughly northwest. These are a central area coinciding with the Anmatjira Range, consisting of older granites, the orthogneisses, which are S-type (Chappell & White, 1974), and two flanking areas of younger, mostly I-type granitic rocks, one in the south composed largely of Napperby Gneiss (and its extension, the Ngalurbindi Orthogneiss, into DENISON) the other in the northeast composed wholly of porphyritic granite of the Ennugan Mountains (Fig. 141). The metamorphic rocks show a somewhat similar distribution; Division 1 rocks (Tyson Creek granulite and Weldon metamorphics) are largely restricted to the central area of older granitic gneisses, whereas Division 2 and 3 rocks form enclaves in the flanking areas of younger granite and gneiss. Most of the rocks of Division 1 are in a single large enclave north of Pine Hill homestead. The distribution of the Tyson Creek granulite and Weldon metamorphics in this enclave indicate a complex (and as yet unsolved) structure. This is overprinted by a steeply north-dipping penetrative foliation, which also affects the adjacent orthogneisses. The metasediments of Division 2 form a sequence of complexly folded schist, metapsammite, and calc-silicate rock, and are concentrated in the region between the central and southern granitic zones. The metasedimentary enclaves are irregularly cuspate in shape, caused largely by the rather

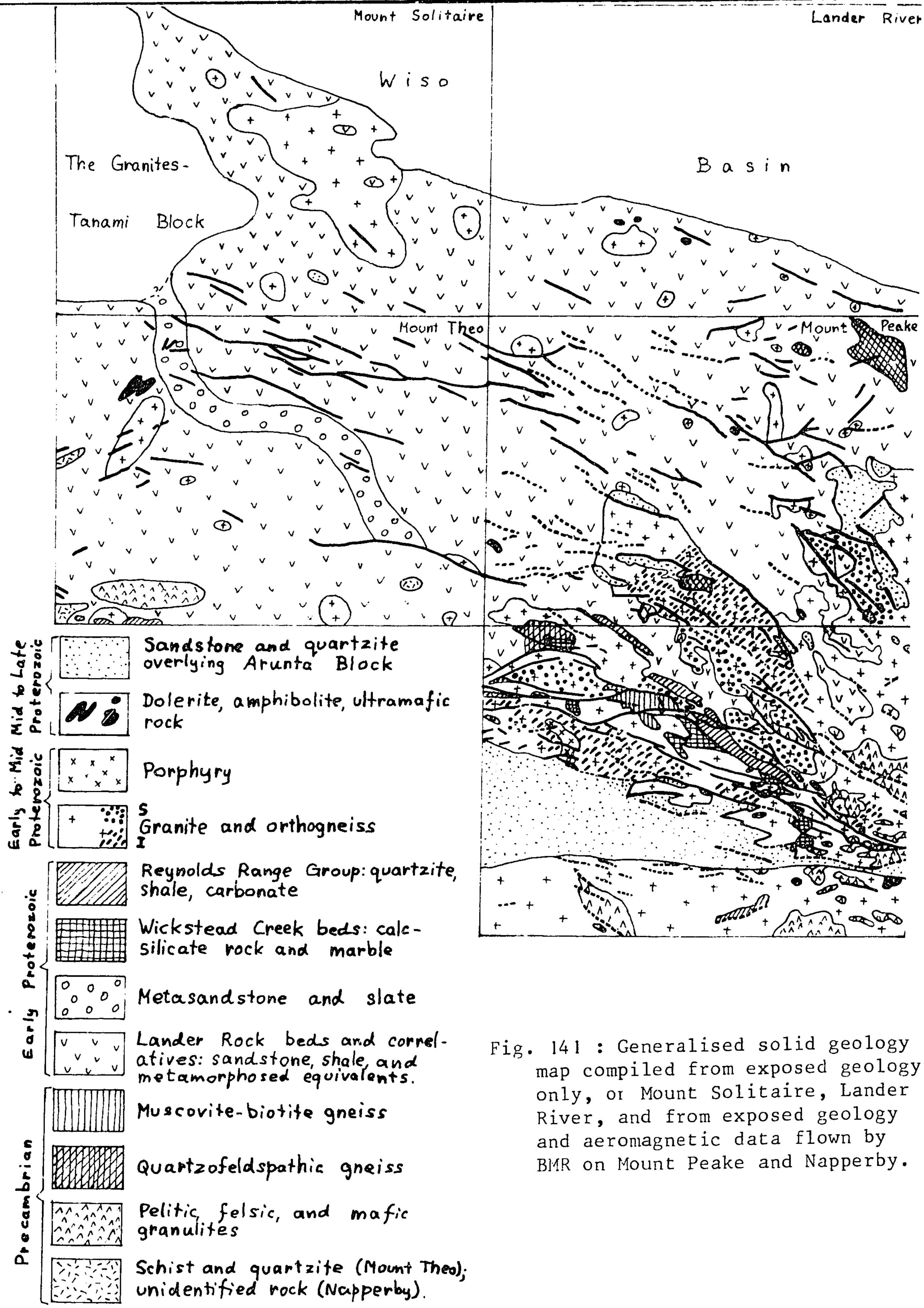



Fig. 141 : Generalised solid geology map compiled from exposed geology only, or Mount Solitaire, Lander River, and from exposed geology and aeromagnetic data flown by BMR on Mount Peake and Napperby.

rounded protuberant margins of the intruding granite masses. Four <u>en echelon</u> synforms of Division 3 metasediments belonging to the Reynolds Range Group occur within the area of Division 2 rocks. The four synforms have northwest-trending axial planes and steeply dipping limbs. Southeast of Mount Thomas the northern limb of the largest syncline is steeply overturned. Folding in the Reynolds Range Group can be divided into three episodes, accompanied by two of faulting.

The earliest folds (Fig. 142) are close or tight, and have steep axial planes trending northwest, and subhorizontal axes. They formed by flexural slip during buckling of the sediments into the macroscopic synforms (Fig. 144a); macroscopic folds belonging to this generation also can be seen in the trends of bedding in the Pine Hill Formation, 7 km southeast of Mount Gardiner.

The second set of folds in the Reynolds Range Group is located in the northern, overturned limb of the largest of the four synforms 20 km southeast of Mount Thomas. They are open mesoscopic 'drag' folds with steeply dipping axial planes and subhorizontal axes (Fig. 143) and are accompanied by a rough axial-plane fracture cleavage which cuts the earlier folds obliquely (Fig. 145). Their sense of 'drag' is south-verging (Fig. 144b), which is the opposite of what would be expected from normal flexural-slip 'drag' folds on the northern limb of a synform (Fig. 144a). The 'drag' folds indicate upward movement of the Mount Airy Orthogneiss on the northern side of the synform, and are interpreted as having been formed by intrusion of the Orthogneiss adjacent to the Reynolds Range Group, analogously to the 'spruce-tree' folds on the flanks of gneiss domes (Skehan, 1961).

Folds of the third episode are located chiefly in the Mount Thomas area. They have west-northwest-trending axial planes, steep to vertical axes (Fig. 146), and an axial-plane cleavage which cuts obliquely across both limbs of the major synform. An isoclinal macroscopic fold of Mount Thomas Quartzite at GR5453-720316 is an example of this episode.

Faults in the Reynolds Range Group include dip-slip strike faults and wrench faults. The strike faults parallel bedding, and repeat the northern limb of the largest synform, in the Mount Gardiner,

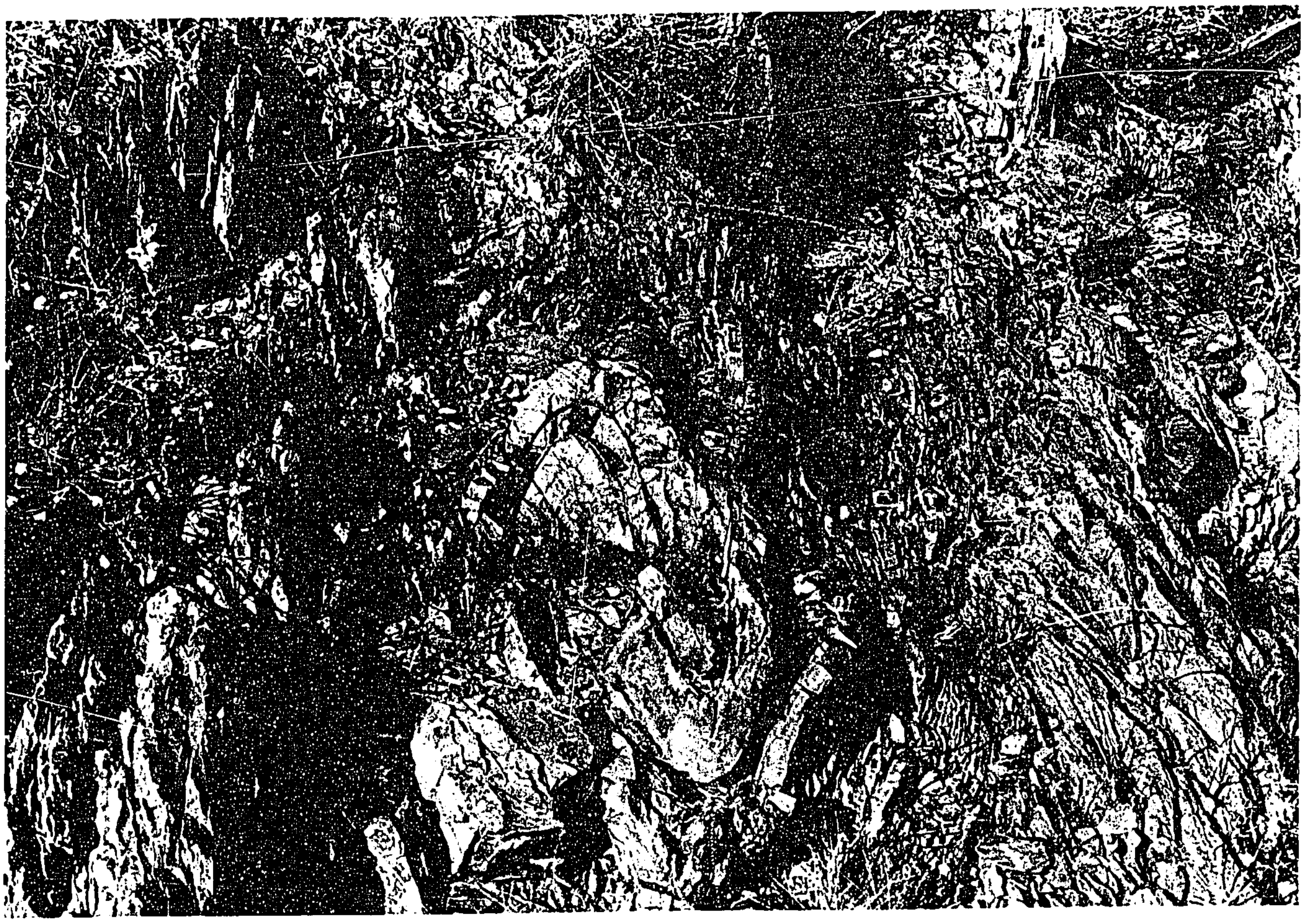


Fig. 142: Tight, upright, gently plunging, flexural-slip folds of earliest folding phase, in Pine Hill Formation at GR5453-581442, 2 km southwest of Mount Gardiner. Scale is 15 cm long.

Neg. M/1342/26

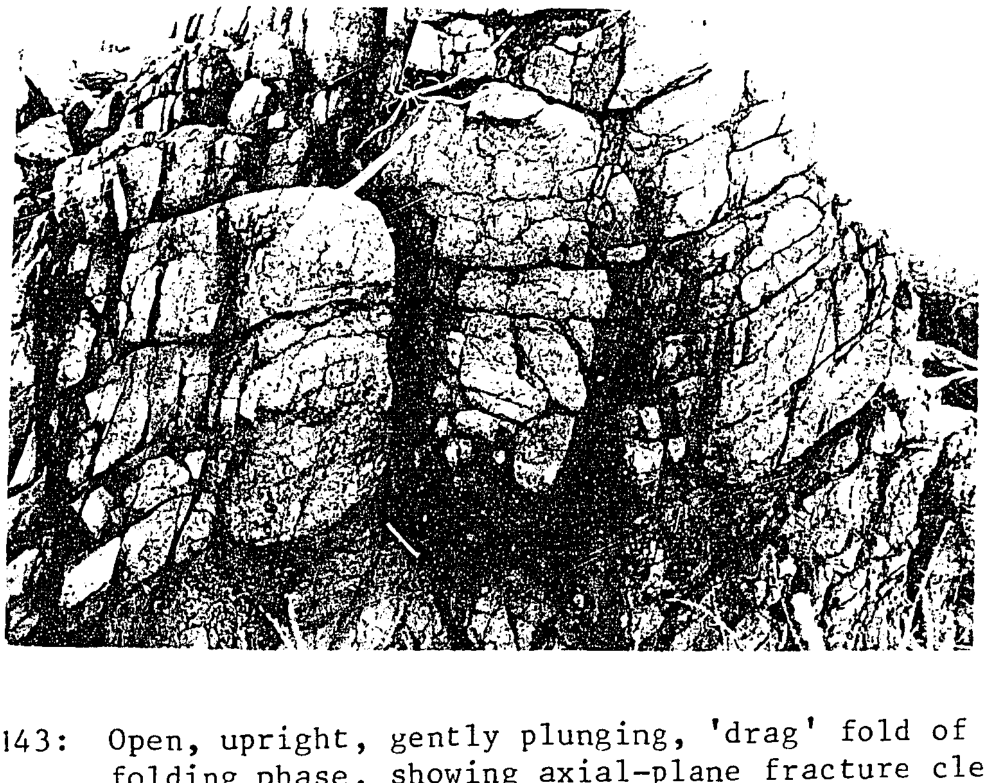


Fig. 143: Open, upright, gently plunging, 'drag' fold of second folding phase, showing axial-plane fracture cleavage, in Mount Thomas Quartzite at GR5453-917175, 19 km southeast of Harverson Pass. Width of field about 1 m.

Neg. M/1945/26A

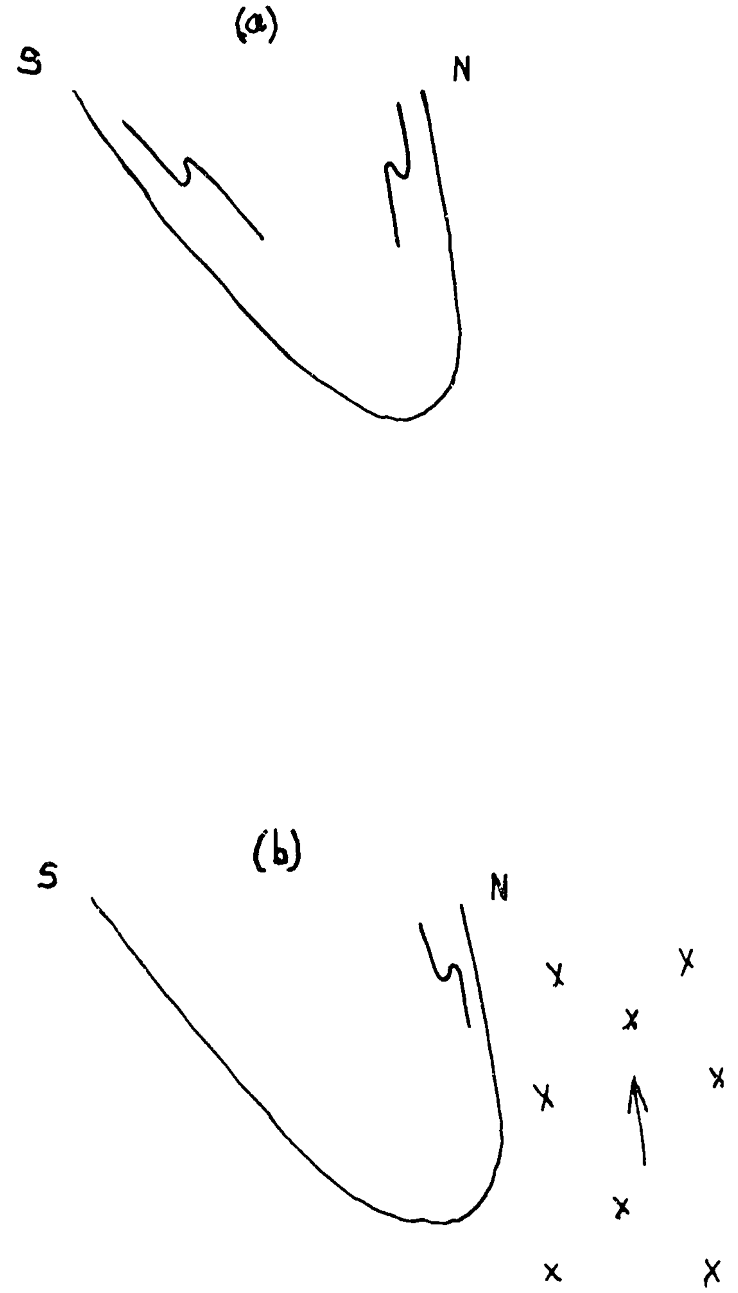



Fig. 144 : Sketches of parasitic or drag folds in Reynolds Range Group. (a) - normal drag folds formed by flexural slip of strata during buckling into macroscopic synform, Mount Gardiner area. (b) - Reversed drag folds formed by flexural slip of strata by drag of upward intruding Mount Airy Orthogneiss (crosses) north of macroscopic synform, southeast of Mount Thomas.

16/NT/23

Fig. 145: Close, upright, gently plunging fold of first folding phase, cut by non-axial-plane cleavage of second folding phase; cleavage is subparallel to left hand limb, and subperpendicular to right hand limb. In Mount Thomas Quartzite at GR5453-889186, 16 km SE of Harverson Pass. Neg. M/1413/5

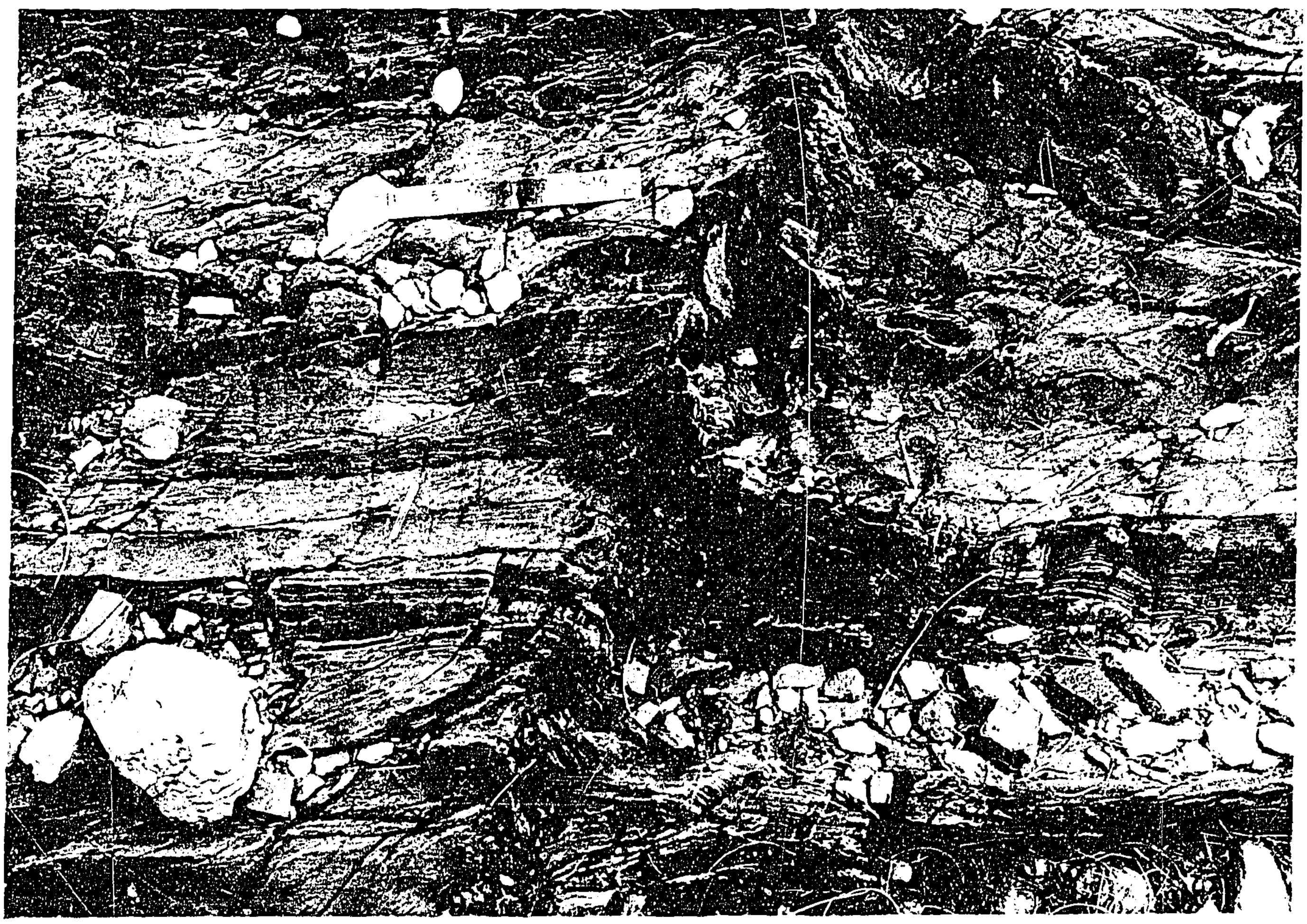


Fig. 146: Open, upright, steeply plunging kink-fold of third folding phase. In Pine Hill Formation, at GR5453-752318, 2.5 km south-east of Mount Thomas. Scale is 15 cm long. Neg. M/1247/3

Harverson Pass, and Mount Airy areas. At Mount Airy itself, the strike faults place Mount Thomas Quartzite against Mount Airy Orthogneiss, and hence are younger than the time of intrusion of the Orthogneiss, and by implication are younger than the 'spruce-tree' drag-folds in the Mount Thomas Quartzite.

Large-scale wrench faults are evident in the Mount Thomas-Harverson Pass area, and probably formed as a continuation of the third episode of folding, i.e, the vertically plunging folds. Four kilometres east, and 5 km southeast of Harverson Pass, the repeated northern limb of the major synform is folded by the vertically plunging folds, and faulted by the wrench faults. Hence, the wrench faults and associated vertical folds are younger than the strike faults.

It is therefore possible to deduce the following sequence of structural events in the Reynolds Range.

1. First episode of folding: formation of major synforms and mesoscopic flexural-slip folds with subhorizontal axes.
2. Second episode of folding: formation of 'spruce-tree' folds in response to intrusion of Mount Airy Orthogneiss.
3. First episode of faulting: strike faults causing repetition of northern limbs of major synforms.
4. Third episode of folding: vertically plunging folds, transitional into
5. Second episode of faulting: wrench-faulting.

Northwest to west-trending faults are a major element in the structure of the northern part of the Arunta Block. In places in the southeast of the area, e.g. in AILERON, they widen out to form shear zones of retrogressively metamorphosed rock. In DENISON, the faults curve around to a northeast trend, and form part of a zone of northeast-trending faults that cuts right through the Northern Tectonic Zone of the Arunta Block (Stewart & Warren, 1977). In the Mount Peake area, the faults displace the Central Mount Stuart Formation, and in the Lander River Sheet area they displace Cambrian to Ordovician sediments, but are onlapped by the Late Palaeozoic Lake Surprise Sandstone (Kennewell & Offe, 1979). Hence, movement along some of the faults took place in mid-

Palaeozoic time. When the Arunta Block is viewed as a whole, the trend of the major faults is seen to form an arc convex to the north, from northwest in the Reynolds Range region, to east-west in the Mount Theo Sheet area, to northeast in the Highland Rocks and Lake Mackay Sheet areas. The arc is parallel to the thrust-faulted northern margin of the Ngalia Basin. The thrust-faulting took place during the Carboniferous (Wells, Moss & Sabitay, 1972), and so the movements along the faults in the Arunta Block to the north probably took place at that time also. This supposition is supported by evidence of mid-Phanerozoic isotopic disturbance revealed by mineral dates ranging from 920 to 390 Ma (Table 18) in various parts of the Reynolds Range Region.

Table 18: Isotopic dates in Ma on minerals from the Reynolds Range region.

| Sample No. | Locality | Method | Material | Date | Reference 1, 2 |
|---|---|---|---|---|---|
| 71920402 | 5453-695360 | K-Ar | Biotite | 920 | L. & W. |
| 71921037 | 5553-070234 | K-Ar | Biotite | 777 | L. & W. |
| 72921017 | 5453-615110 | Rb-Sr | Biotite | 685 | L.P.B., 1975 |
| 71921059 | 5454-504686 | K-AR | Muscovite | 615 | L. & W. |
| 71920401 | 5552-957097 | K-Ar | Biotite | 534 | L. & W. |
| 72110206 | 5454-553700 | Rb-Sr | Biotite | 440 | L.P.B., 1974 |
| 71921078 | 5552-335921 | K-Ar | Biotite | 435 | L. & W. |
| 72921019 | 5452-939046 | Rb-Sr | Biotite | 390 | L.P.B., 1975 |

1. L. & W. = Lowder & Webb (1972). 2. L.P.B. = L.P. Black (BMR).

METAMORPHISM

A generalised metamorphic map of the Arunta Block is shown in Figure 147. The greater part of the area, including Mount Solitaire, Mount Theo, most of Mount Peake, and Lander River Sheet areas, is at greenschist facies, and comprises mostly slate, schist, and micaceous metasandstone of the Lander Rock beds and Mount Charles beds of Division 2. Typical assemblages are biotite-muscovite-quartz ± andalusite in pelites, and actinolite-chlorite-epidote in basic rocks. Grade rises through low amphibolite (sillimanite-biotite-muscovite-quartz; hornblende-andesine) to high amphibolite facies (sillimanite-cordierite-microcline-biotite-quartz ± garnet; diopside-hornblende-labradorite; chondrodite-forsterite-calcite) in the southeast of REYNOLDS RANGE and north of TEA TREE. These rocks are faulted against low granulite facies rocks (orthoclase-cordierite-sillimanite-biotite ± garnet; cordierite-phlogopite-orthopyroxene-spinel ± sapphirine; labradorite or bytownite-clinopyroxene-orthopyroxene-biotite; orthopyroxene-quartz-andesine ± garnet; bytownite-orthopyroxene-clinopyroxene-quartz; hornblende-orthopyroxene-clinopyroxene-andesine) of all three Divisions which occupy the southern part of TEA TREE and northern part of AILERON. Nowhere is there an uninterrupted progression from greenschist to granulite facies. Greenschist and low-amphibolite facies rocks of Division 2 form enclaves surrounded by granite in DENISON. An isolated area of metapelitic granulite in the southwest of the Mount Theo Sheet area is presumably surrounded by a region of amphibolite facies, but superficial Cainozoic cover conceals these postulated rocks. The amphibolite to granulite facies shown in the south of AILERON is based on interpretation of aeromagnetic data; the total magnetic intensity of this area suggests the existence of rocks similar to the Aileron metamorphics, which are exposed in the north of AILERON. In the northwest of REYNOLDS RANGE and southwest of MOUNT PEAKE, hornfelses form a contact aureole south of the Anmatjira Orthogneiss, and another area of hornfels crops out in the northwest of DENISON.

It is readily apparent that the batholithic orthogneisses and other large bodies of granite in the Napperby 1:250 000 Sheet area are associated with metamorphic rocks of the amphibolite and granulite facies, whereas the smaller bodies of granite in the remaining sheet areas are intruded into rocks of the greenschist facies. It may be legitimate to

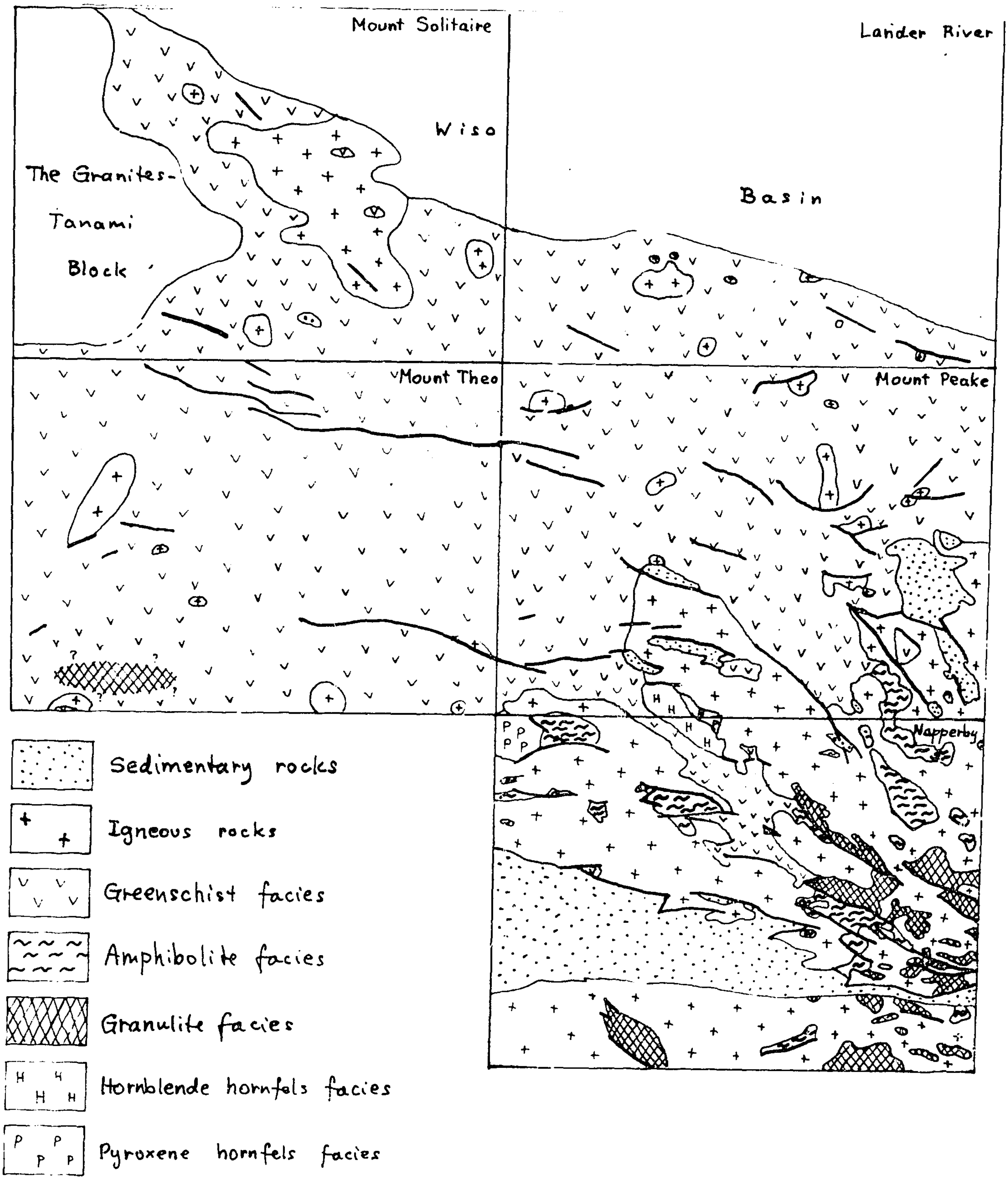



Fig. 147 : Distribution of metamorphic facies in northern Arunta Block. Generalised from Fig. 141.

16/NT/94

assume that the large granite masses are in equilibrium with and can be included in the amphibolite facies. If so, they appear to form two large thermal tongues which extend northwest from the even warmer region of granulite in the southeast of Napperby, and are separated by a narrow cooler septum of greenschist facies rocks forming the Reynolds Range.

Patchy retrogressive metamorphism to greenschist facies is widespread throughout the northern Arunta block, and is confined to the vicinity of faults and fault zones. It is particularly noticeable near and along the Napperby thrust, Aileron Shear, and the major fault through Quartz Hill, in DENISON, where zones of orthoschist up to 1.5 km wide have formed. The major fault along the southern flank of the Anmatjira Range is also marked by strong retrogression. As discussed above, the retrogressive metamorphism is probably Palaeozoic.

## MINERAL OCCURRENCES

A summary of recorded mineral finds is presented in Table 19. A fuller account of these occurrences is covered by Ryan (1958), Evans & Glikson (1969), Warren & others (1974), Stewart (1976), Offe (1978), Offe & Kennewell (1978), and Kennewell & Offe (1979).

### Aluminium silicates

Granulites and granofels in the southwestern part of TEA TREE contain sillimanite. In the northern part of AILERON, coarse kyanite blades are found with biotite in cross-cutting veins. Andalusite porphyroblasts occur in several areas in the Lander Rock beds and the Pine Hill Formation. They have formed by contact metamorphism characteristically as idioblastic crystals with rare chiastolites.

The aluminium silicates do not occur in sufficient concentrations to allow economic recovery.

### Base Metals

Australian Geophysical (Anon, 1965, 1967) reported on the mapping, stream sediment sampling, and drilling phases of their exploration

Table 19: Summary of recorded mineral occurrences in Northern Arunta Block

| Name | Sheet and Grid reference | Economic minerals | Associated rock ('gangue') | Host rock | Remarks |
|---|---|---|---|---|---|
| Aileron Gold Reefs | AILERON E246 N931 | Gold Arsenopyrite | Quartz | Schist in shear zone | Production 0.03 kg; aband. |
| Anningie Tin Field | Mount Peake E3025 N6008 | Cassiterite Tantalite Lithium minerals | Pegmatite | Hornfels, schist | Production ca. 27 t concentrate |
| | Mount Peake E3025 N6008 | Galena | Amphibolite | - | Along joints |
| Barney's Ironstone | REYNOLDS RANGE E688 N318 | Reputed malachite stains | Earthy brown limonite | Sericite-quartz schist; quartzite | No Cu stains found this survey |
| Brookes Soak Wolfram Lodes | DENISON E223 N510 | Wolframite | Segregations in gneissic granite | | Production ca. 0.5 t concentrate to 1976; aband. |
| Coniston Tin Prospect | REYNOLDS RANGE E485 N524 | Cassiterite | Greisen | Albite-quartz rock | Alluvial; aband. |
| Double Dams Tantalite Prospect | DENISON E170 N520 | Tantalite | Pegmatitic segregations | Granite | Small yield, alluvial workings |
| Double Dams Wolfram Prospect | DENISON E190 N517 | Wolframite | Pegmatite | Granite | Production 0.05 t W |
| Ingellina Gap Wolfram Show | REYNOLDS RANGE E745 N510 | Wolframite | Not known | Not known | Probably alluvial; aband. |

Table 19 (contd)

| Name | Sheet and Grid reference | Economic minerals | Associated rock ('gangue') | Host Rock | Remarks |
|---|---|---|---|---|---|
| Lander Copper Prospect | REYNOLDS RANGE E735 N487 | Malachite Cuprite | Meta-quartzite and brecciated dolerite | Psammitic schist | Not worked |
| Mount Allan Tin Mine | DENISON E098 N397 | Cassiterite Columbite | Kaolinised pegmatite | Calc-silicate rock, marble, quartzite | Estimated production 1 t Sn |
| Mount Boothby Tungsten Prospect | AILERON E283 N990 | Wolframite | Pegmatitic segregation | Between granitic gneiss, pelitic gneiss | Production ca. 0.4 t W (hand-picked) |
| Mount Peake Lead Show | Mount Peake E3008 N6190 | Galena | Quartz vein | Coarse-grained amphibolite | Not worked; galena assays 279 g/t Ag |
| Mount Stafford Tin Lodes | REYNOLDS RANGE 1)E492 N623 2)E520 N600 | Cassiterite | Pegmatite | Hornfels | Low-grade; abandoned |
| Pine Hill Gold-Copper Prospect | REYNOLDS RANGE E725 N444 | Gold Copper minerals | Quartz vein | Schist | Assays 6.14, 4.91 g/t Au; not worked |
| Reward Copper Mine | REYNOLDS RANGE E750 N450 | 1. Primary: Chalcopyrite, galena pyrite 2. Secondary: Chrysocolla, malachite, cerussite, azurite, covellite, native copper, cupriferous heulandite | Quartz vein in shear zone | Andalusite-mica schist and quartz-mica schist | Primary grade low (one assay 0.016% Cu). Production from secondary minerals; 8t Cu produced 1953-57. Abandoned. |

Table 19 (contd)

| Name | Sheet and Grid reference | Economic minerals | Associated rock ('gangue') | Host rock | Remarks |
|---|---|---|---|---|---|
| Waldron's Hill Gold Prospect | Lander River E2386 N7107 | Gold | Carbonate and quartz-veined shear zone | Meta-dolerite, granite, hornfels | Assays: 5 g/t Au, 0.4 g/t Au. |
| Wilson's Find (Mt Singleton Wolfram) | Mount Theo E6718 N5688 | Wolframite Chrysocolla | Quartz veins | Gneissic granite | Production 2 t concentrate; aband. |
| Woodforde River Ironstones | AILERON E016 N098 | - | Limonite | Marble and calc-silicate rock | Assays: see Table 20. |
| White Hill Yard Copper | TEA TREE E062 N126 | Malachite | Quartz in fault zone | Felsic gneiss and granulite | Assay: 5% Cu on grab sample |
| Unnamed occurrences of mineralogical interest | Mount Peake E3335 N5746 | Chromium | Dark green chalcedonic quartz vein | Granite | Occurs in spinel and fuchsite |
| | Mount Peake E3125 N5820 | Secondary copper minerals | - | Amphibolite | Not confirmed |
| | Mount Peake E3314 N5729 | Fluorite | Quartz vein | Granite | Others reported in nearby area |
| | Mount Peake E3330 N5805 | Galena Pyrite | Quartz scree from quartz-filled fault | Fault cuts granite and Central Mt Stuart Formation | - |
| | Mount Peake E3202 N5785 | Pyrolusite cementing quartz fragments | Quartz vein in fault | Fault brings granite against feldspathic sandstone of Central Mount Stuart Formation | |
| | Mount Peake E3042 N6188 | Leucophosphite; possible K, Al and Fe, Al phosphates. As pale green veins in amphibolite at peak of hill. Probably formed by reaction of bird guano on amphibolite | | | |

| Name | Sheet and Grid reference | Economic minerals | Associated rock ('gangue') | Host rock | Remarks |
| --- | --- | --- | --- | --- | --- |
| Unnamed occurrences of mineralogical interest | Mount Peake E3165 N5950 | Variscite | Coats fractures in vein quartz | Sillimanite mica schist | Possibly recent in origin. Minor |
| | Mount Peake E3330 N5805 | Malachite | Granite fragments | Not in situ. Piled near corner of old lease | |
| | Mount Theo E7630 N5655 | Reputed copper minerals | - | - | Not confirmed |
| | Mount Theo E6650 N6210 | Wolframite | Metasediment | - | - |

Table 20: Results of analyses of ironstones, in ppm except where otherwise stated.

| Sample number | 7292 0493A* | 7292 0647C* | 7292 0737* | 7292 1217** | 7492 0801 xxx | 7211 0307*** |
|---|---|---|---|---|---|---|
| Sheet | REYNOLDS RANGE | TEA TREE | REYNOLDS RANGE | AILERON | DENISON | Mount Theo |
| Grid ref. | E661 N416 | E958 N139 | E780 N251 | E016 N098 | E186 N512 | E6838 N6368 |
| Host Rock | Laterite capping dolomite | Ironstone capping marble | Ironstone capping dolomite | Ironstone capping marble and calc-silicate | Quartz-ironstone vein at contact of granite and mafic rock | Laterite |
| Cu | 730 | 340 | 140 | <10 | 1500 | 11 |
| Pb | 1200 | 30 | 75 | 65 | 40 | 29 |
| Zn | 1100 | 160 | 310 | 375 | 25 | 72 |
| Ni | 100 | 40 | 75 | - | 270 | 13 |
| Bi | 15 | 10 | 10 | - | 10 | ND |
| Ag | 1 | <1 | <1 | 5 | - | 1 |
| Au | - | - | - | - | 0.1 | - |
| Se | <5 | <5 | <5 | - | 80 | <2 |
| Hg | - | - | - | - | - | - |
| Mn | 58% | 10.5% | 8.2% | - | 150 | 763 |
| Fe | - | - | - | - | 39.1% | 8.9% |

ND = Not detected — = Not determined

* Analyst : A.M.D.L. (Report AN 2285/73)
** Analyst : A.M.D.L. (Report AN 1958/73)

Method : A.A.S. except for Se which was done by "special analysis".

*** Analyst : A.M.D.L. (Reports AN 2285/73 - Sample 0313C only; AN 1916/74 - all Se and Fe); B.I. Cruikshank & G.F. Sparksman (BMR Lab. Report No. 14, 6 March, 1974).

xxx Analyst : A.M.D.L. (Report AC 3941/80) Method : A.A.S. except for Se (XRF) and Au (fire assay)

Table 20 (contd)

| Sample number | 7211 0309A*** | 7211 0313C*** | 7211 0317*** | 7211 0322*** | 7211 0325 | 7411 0180[x] | 7411 0190[x] |
|---|---|---|---|---|---|---|---|
| Sheet | Mount Theo | Mount Theo | Mount Theo | Mount Theo | Mount Peake | Mount Peake | Mount Peake |
| Grid ref. | E7140 N6398 | E8055 N5843 | E7679 N6120 | E7390 N6495 | E2134 N6717 | E2739 N6749 | E2977 N6726 |
| Host rock | Laterite | Gossan | Laterite | Laterite | Laterite | Laterite | Laterite |
| Cu | 13 | 300 | 10 | 11 | 7900 | 180 | 30 |
| Pb | 16 | 540 | 41 | 38 | - | 42 | 20 |
| Zn | 9 | 30 | 13 | 8 | - | 130 | 18 |
| Ni | 6 | 10 | 6 | 6 | - | 18 | <5 |
| Bi | ND | 40 | ND | ND | - | <10 | <10 |
| Ag | 1 | <1 | 19 | 48 | - | <1 | <1 |
| Au | - | - | - | - | - | .05 | .05 |
| Se | <2 | 25 | 4 | 14 | - | 4 | 4 |
| Hg | - | - | - | - | - | <4 | <4 |
| Mn | 108 | 290 | 37 | 82 | - | 95 | 230 |
| Fe | 9.4% | - | 31.2% | 35.6% | - | 54.9% | 28.7% |

[x] Analyst : A.M.D.L. (Report AN 3566/76) - Method : A.A.S. except for Se and Hg (both XRF).

Table 20 (contd)

| Sample number | 7411 0191[x] | 7511 0402[xx] | 7511 0411[xx] | 7511 0416[xx] | 7511 0421A[xx] | 7511 0421B[xx] |
|---|---|---|---|---|---|---|
| Sheet | Mount Peake | Mount Solitaire | Mount Solitaire | Mount Solitaire | Mount Solitaire | Mount Solitaire |
| Grid ref. | E3126 N6757 | E7210 N7674 | E7048 N7145 | E7148 N7163 | E7044 N7192 | E7044 E7192 |
| Host rock | Laterite | Quartz-veined ironstone; possible gossan | Ironstone capping Mount Charles beds | Ironstone capping Mount Charles beds | Ironstone capping Mount Charles beds | Ironstone capping Mount Charles beds |
| Cu | 48 | 330 | 150 | 28 | 100 | 770 |
| Pb | 48 | 45 | 22 | 25 | 12 | 20 |
| Zn | 42 | 50 | 80 | 120 | 90 | 170 |
| Ni | 15 | 15 | 18 | 15 | <5 | 240 |
| Bi | <10 | 15 | <10 | <10 | <10 | <10 |
| Ag | <1 | <1 | <1 | <1 | <1 | <1 |
| Au | .10 | – | .10 | .05 | .05 | .05 |
| Se | 4 | <2 | 2 | 3 | 3 | <2 |
| Hg | <4 | – | <4 | <4 | <4 | <4 |
| Mn | 60 | 95 | 140 | 5400 | 130 | 29.4% |
| Fe | 32.3% | 14.0% | 53.3% | 37.9% | 43.1% | 12.3% |

xx Analyst : A.M.D.L. (Report AN 1624/76 - Sample 402 only; AN 3566/76) - Method : A.A.S. except for Se and Hg (both XRF)

Table 20 (contd)

| Sample number | 7511 0445 [xx] | 7511 0603 [x] | 7511 0623 [x] |
|---|---|---|---|
| Sheet | Mount Solitaire | Lander River | Lander River |
| Grid ref. | E7417 N7301 | E2489 N6830 | E2380 N7108 |
| Host rock | Ironstone | Ironstone capping granite and meta-sediments | Carbonate-veined quartz |
| Cu | 250 | 40 | 25 |
| Pb | 15 | 38 | <5 |
| Zn | 290 | 180 | 130 |
| Ni | 110 | 42 | 15 |
| Bi | <10 | <10 | <10 |
| Ag | <1 | <1 | <1 |
| Au | .10 | .10 | .40 |
| Se | <2 | 5 | <2 |
| Hg | <4 | 4 | <4 |
| Mn | 2340 | 440 | 1900 |
| Fe | 41.1% | 50.9% | 14.5% |

[xx] Analyst : A.M.D.L. (Report AN 1624/76 - Sample 402 only; AN 3566/76) - Method : A.A.S. except for Se and Hg (both XRF).

program which was designed to evaluate the mineralisation potential of the Reynolds Range and surrounding areas. The survey proved unrewarding.

Induced polarisation was completed in a lease area covering Lander Bore and the Reward Copper Mine, and provided a number of anomalous targets which were followed up by costeaning and drilling. The anomalies are generally related to carbonaceous beds and weakly pyritic black carbonaceous siltstones of the Lander Rock beds. Traces of chalcopyrite and sphalerite in the pyritic beds occur as films paralleling the schistosity of the country rock and to a lesser extent as fracture fills.

A stream-sediment survey by Central Pacific Minerals N.L. of the Woodforde River beds in the northwest of AILERON obtained a negative result (Green, 1977).

Pacminex Pty Ltd (Allen, 1978) found no anomalous amounts of base metals in stream-sediment samples from the Reynolds Range Group in REYNOLDS RANGE, and from part of the Napperby Gneiss north of Napperby homestead.

At a locality 6 km east of South 20 Mile Waterhole in NAPPERBY, marble in a raft of Wickstead Creek beds contains numerous tiny specks of cuprite rimmed with malachite, and an associated dark green cherty rock is cut by seams of malachite a fraction of a millimetre thick. The calc-silicate rocks of the same unit at the summit of Mount Dunkin in AILERON also contain secondary copper minerals.

## Brown Coal

Lenticular units of lignite or carbonaceous clay up to 30 m thick were intersected by CRA Exploration Pty Ltd in three holes drilled in the Tertiary Tea Tree Basin, in the northeast of the Sheet area (O'Sullivan, 1973); the shallowest intersection was at about 100 m depth. Tertiary lignite also occurs at about 140 m depth in BMR Napperby No.1, 13 km south-southwest of Napperby homestead. The occurrences have been recently evaluated by the Northern Territory Geological Survey.

## Chromium and Nickel

The Native Gap Prospect in the southern part of AILERON is a small ultramafic amphibolite body that contains up to 0.12% Cr and 0.16% Ni. No specific chromium or nickel mineral has been observed in hand specimen (Morlock, 1973). Small veins of green chromite-fuchsite-quartz rock cut granite 1 km east of the abandoned Mount Esther homestead, in the southwest of the Mount Peake Sheet area (Offe, 1978); the occurrence is chiefly of mineralogical interest.

## Crushed Rock Aggregate

Crushed rock aggregate for road surfacing has been obtained from small open cuts along the Stuart Highway in AILERON; material has come from the Boothby Orthogneiss, quartz veins in retrograde schist in the Aileron Shear Zone, the Vaughan Springs Quartzite, and Tertiary deeply weathered rock. Aggregate for the road from Alice Springs to Yuendumu has been obtained from an open cut in the Kerridy Sandstone in the west of DENISON.

## Fluorspar

A fluorite-quartz vein crops out in a fault zone in the Anmatjira Orthogneiss at GR5453-772517 in REYNOLDS RANGE, and another cuts granite 2 km southwest of the old Mount Esther homestead, in the Mount Peake Sheet area (Offe, 1978).

## Gemstones and Mineralogical Specimens

Anhedral dark green apatite and one euhedral pale green beryl crystal 3 cm across were found in a pegmatite 32 km northeast of Mount Solitaire in the central part of the Mount Solitaire Sheet area (Offe & Kennewell, 1978).

Fander (in Kojan, 1979) noted 'rough, poorly developed granular aggregates' of chrysoberyl in a xenolith of muscovite schist from the granite of the Ennugan Mountains (GR5453-924628). Irregular patches of topaz and fine-grained purplish fluorite are also present in the rock.

An idioblastic reddish-brown corundum crystal (1 cm long) was found in creek gravel about 4 km north of Mount Weldon. The corundum is thought to come from the surrounding sillimanite-garnet-biotite-cordierite-quartz gneiss.

Kornerupine prisms several centimetres long occur in cordierite granulite at GR5552-131068, in AILERON.

Tourmaline is a common constituent of pegmatites and quartz veins throughout the Yundurbulu and Anmatjira Ranges. The tourmaline is present as black, striated, commonly fractured prisms. In the Mount Stafford area of the Yundurbulu Range, one quartz vein contains tourmaline prisms up to 2 cm across. The tourmaline is not gem quality.

Smoky quartz suitable for cutting occurs about 2 km south of Aileron.

Gold

Traces of gold and pyrite in quartz and ironstone reefs were found by Davidson (1905) in the western part of the Mount Solitaire Sheet area. An analysis of carbonate-veined quartz from Waldron's Hill gold prospect, Lander River Sheet area, appears in Table 20. Small amounts of gold have been obtained from the Pine Hill Prospect in REYNOLDS RANGE, and the Aileron Gold Reefs in AILERON (Table 19).

Graphite

Black carbonaceous siltstone of the Lander Rock beds, exposed in a costean excavated by Australian Geophysical (Anon, 1967) in REYNOLDS RANGE, was analysed at 0.45% free carbon. The rock was partly bleached. Black graphitic siltstone was also encountered in a drill hole completed by this company.

Black slate cropping out 5.8 km north-northwest of North Bore, in MOUNT PEAKE contains about 45% opaque minerals (probably graphite; specimen 72110146). The slate occurs as a narrow sliver, about 40 m long, within flaser gneiss.

The Mount Charles beds (western part of the Mount Solitaire Sheet area) contain a small amount of grey slate. Farther west, in the Tanami 1:250 000 Sheet area, the Mount Charles beds contain black carbonaceous pyritic shale, capped in places by gossan (Phillips, 1962; Blake & others, in press).

Black siltstone was intersected beneath Cainozoic cover in drillhole BMR Napperby No.5, about 5 km east of Smiths Gift Bore, in the west of the Napperby Sheet area (Wells, 1974; Wells & Moss, in preparation). Analysed samples show no anomalous base-metal values (Wells, 1974). The siltstone may be part of the Naburula Formation of the Ngalia Basin (Wells & Moss, in preparation).

## Iron

A number of small hematite lodes were located in the Reynolds Range during the 1972 mapping survey. The lodes consist characteristically of massive to bladed steel-grey lustrous hematite containing veinlets of fine-grained quartz. The largest deposit located is in the type section of the Mount Thomas Quartzite (REYNOLDS RANGE), at the contact of the Warimbi Schist and the overlying Quartzite. The genesis of these iron lodes is uncertain, but may be related to the regional and contact metamorphic events which have affected the hematitic beds of the Mount Thomas Quartzite.

## Ironstones

These consist generally of dark brown to black earthy limonite, and most formed during the late Cretaceous or early Tertiary weathering of the area. During the survey, 21 ironstones were collected for analyses (Table 20). Of these, two (72110313C and 75110402) contain cellular structures interpreted as residual after pyrite and possibly chalcopyrite (Pontifex, 1973; Offe & Kennewell, 1978). From the cellular quartz-limonite gossan at Keyser Hill (313C), Pontifex also identified small unaltered blebs of pyrite and chalcopyrite within quartz. At sample locality 402, the earthy-brown quartz-veined ironstone crops out adjacent to a quartz reef. In the central Mau Hills in DENISON sample 74920801 comes from a northwest-trending four metre long quartz-hematite vein which lies along the contact between a mafic body and granite. The hematite contains cellular structures.

## Lead

Galena occurs in quartz veins cutting amphibolite 4 km south-southwest of Conical Hill, in the Mount Peake Sheet area (Offe, 1978).

## Limestone

Limestone occurs as calcrete in abundance in the Mount Theo and Mount Peake Sheet areas, and smaller amounts are present in Lander River and Mount Solitaire Sheet areas, and in REYNOLDS RANGE and DENISON. The calcrete is usually admixed with impurities such as sand grains, chalcedony, and evaporite salts. Recrystallised limestone is present in the Algamba Dolomite Member in REYNOLDS RANGE, and marble crops out in the Woodforde River beds in AILERON, but is not easily accessible. Marble interbedded with calc-silicate rock of the Wickstead Creek beds crops out adjacent to the disused road from the Stuart Highway to Napperby homestead. No samples have been analysed.

## Lithium

Lepidolite, elbaite, and spodumene occur in a small pegmatite body 4 km northeast of the Anningie Tin Field in the Mount Peake Sheet area (Pontifex, 1965; Offe, 1978).

## Manganese

Pyrolusite forms small earthy masses in a quartz-filled fault 1.5 km southeast of Murray Creek Dam, in the Mount Peake Sheet area (Offe, 1978). Manganiferous laterite containing up to 58 percent Mn overlies parts of the Algamba Dolomite Member in REYNOLDS RANGE, but the occurrences are too small to be economic. Manganese values in a stream-sediment survey of the northwest of AILERON ranged up to 1880 ppm in the Woodforde River; the values above 1000 ppm came from material weathering from cordierite granulite of the Pine Hill Formation adjacent to the Woodforde River beds (Green, 1977).

## Phosphate

Leucophosphite and variscite have been found as joint-fillings in the Mount Peake Sheet area (Offe, 1978), and triplite occurs at the western end of the Wabudali Range, in the Mount Theo Sheet area (Stewart, 1976). The occurrences are of mineralogical interest only.

Small masses of radioactive uranium-rich apatite-mica schist occur spasmodically over an area of about 2 $km^2$, centred about 1.5 km north of Quartz Hill, in DENISON (Davies, 1979). The belts of schist trend east-northeast through the Wangala Granite, and in places are boudinaged; one line of boudins extends for some hundreds of metres, and ranges in thickness from zero in the pinches to 5 m in the swells. Contacts between schist and granite are sharp. The schists pass along strike into quartz-feldspar-mica schist and quartz-tourmaline schist. Only the apatite schists carry uranium, together with anomalous amounts of trace elements (Table 21). Davies (op. cit.) believes that the schists are relict metasediments, but because of their unusual composition - biotite up to 55 percent, muscovite up to 25 percent, apatite up to 25 percent, and quartz up to 55 percent, in different samples - the possibility exists that they may be metasomatic concentrations of granitic minerals from the surrounding granite. Table 21 shows that compared to average shale, the apatite-mica schists are enriched in Li, Ti, Rb, Y, Zr, Nb, Sn, Cs, La, Ce, Th, and U, but these are exactly those elements which substitute in or accompany micas (Li, Rb, Sn, Cs) or apatite (Y, Zr, Nb, La, Ce, Th, U). The enclosing granite is enriched in Li, B, Co, Rb, Sn, Th, and U (it was not analysed for Y, Zr, Nb, Cs, La and Ce), but the schists would not be expected to take up much B or Co, because they do not contain suitable acceptor minerals. Hence, the trace-element data are consistent with either a purely metasomatic origin, or a metasomatised sedimentary origin for the schists. Solution of the problem may lie in trace-element analysis of the individual minerals of the schists and enclosing granite.

Pyrite

Limonite pseudomorphs after pyrite have been found in orthoschist of the Coniston Schist collected from creek scree about 10 km northwest of Mount Thomas. The orthoschist is pale green-grey, and consists of brown limonite cubes (up to 11 mm along the edge) after pyrite and glassy quartz eyes (up to 5 mm) in a fine-grained schistose biotite-chlorite-muscovite-quartz matrix (72920777).

The red beds of the Central Mount Stuart Formation locally contain cubes and pyrotohedra (up to 6 mm across) of limonite after pyrite.

Table 21: Trace-element abundances in two samples of apatite-mica schist from near Quartz Hill, average shale, Wangala Granite near Quartz Hill, and average low-Ca granite.

| | Apatite-mica schist[1] | Apatite-mica schist[2] | Average shale[3] | Wangala Granite[4] | Average low-Ca Granite[3] |
|---|---|---|---|---|---|
| Li | 100-1000 | 1000 | 66 | 90 | 40 |
| Be | 1-10 | 1-10 | 3 | 6.5 | 3 |
| B | 10 | not determ. | 100 | 30 | 10 |
| F | not determ. | not determ. | 740 | 1090 | 850 |
| Na | 1000 | 100-1000 | 9600 | 2.08% | 2.58% |
| Sc | 10-100 | 10-100 | 13 | not determ. | 7 |
| Ti | 1000-1% | 1% | 4600 | 1300 | 1200 |
| V | 10-100 | 100-1000 | 130 | not determ. | 44 |
| Cr | 10-100 | 100 | 90 | " " | 4 |
| Mn | 1000 | 1000 | 850 | " " | 390 |
| Co | 10-100 | 10-100 | 19 | 62 | 1 |
| Ni | 10-100 | 100 | 68 | 5 | 4.5 |
| Cu | 10-100 | 10 | 45 | not determ. | 10 |
| Zn | 100-1000 | 100 | 95 | 57 | 39 |
| Ga | not determ. | 10-100 | 19 | not determ. | 17 |
| Rb | 1000-1% | 1000-1% | 140 | 435 | 170 |
| Sr | not determ. | not determ. | 300 | 47 | 100 |
| Y | 1000 | 1000 | 26 | 23 | 40 |
| Zr | 1000 | 1000 | 160 | not determ. | 175 |
| Nb | 100 | 100-1000 | 11 | not determ. | 21 |
| Mo | 10 | not determ. | 2.6 | " " | 1.3 |
| Sn | 10-100 | 100 | 6 | 13 | 3 |
| Cs | 100-1000 | 1000-1% | 5 | not determ. | 4 |
| Ba | 100-1000 | 100-1000 | 580 | 205 | 840 |
| La | 100-1000 | 1000 | 92 | not determ. | 55 |
| Ce | 100-1000 | 1000-1% | 59 | " " | 92 |
| Pb | 100 | 10-100 | 20 | " " | 19 |
| Th | 120 | 420 | 12 | 28 | 17 |
| U | 360 | 85 | 3.7 | 11 | 3 |

1. Sample 3132 of Davies (1979) 2. Sample 3144 of Davies (1979)
3. Turekian & Wedepohl, 1961, Bull. geol. Soc. Amer. 72, 175-192.
4. Average of samples 74921011, -1012, Table 14 this report.

A brecciated quartz vein containing pyrite voids cuts the basal beds of the Central Mount Stuart Formation in the southeast of the Mount Peake 1:250 000 Sheet area (GR34 105667).

Pyrite and pyrrhotite occur in hornfels adjacent to the pegmatite veins in the Anningie Tin Field (Mount Peake 1:250 000 Sheet area; Fruzzetti & Morlock, 1974).

Rare Earths

Otter Exploration located an occurrence of garnet-monazite gneiss 6 km north of Pine Hill homestead (Kojan, 1979, 1980a). The rock forms a conformable lens about 2 m x 0.2 m in a unit of biotite gneiss up to 300 m wide in the Weldon metamorphics. The rock consists of monazite as mosaics of euhedral grains up to 0.6 mm across, garnet as poikiloblasts up to 10 mm enclosing monazite grains, quartz, ilmenite, goethite after ?pyrite, biotite, zircon, and green spinel. The rock appears to be of metasomatic origin. Grab samples of the rock gave the following assays (in ppm unless otherwise stated):

| Sample | N1-4A | N1-4B | N1-4C | N1-4 Composite |
|---|---|---|---|---|
| Ce | 10.1% | 6.9% | 4750 | 9.2% |
| La | 4.75% | 3.15% | 2050 | |
| Y | 2750 | 1900 | 500 | 3400 |
| Nd | | | | 3.98% |
| Gd | | | | 0.80% |
| Sm | | | | 0.34% |
| Dy | | | | 640 |
| Er | | | | 900 |
| Yb | | | | 110 |
| U | 1000 | 690 | 42 | |
| Th | 6.3% | 3.35% | 1950 | |

Talc

Talc 'of generally good quality' but veined with quartz forms a lode ranging in width from 60 cm to 30 m and extending for about 1 km at a locality about 0.7 km west of Mount Freeling, in AILERON. The lode is conformable with the schistosity in the surrounding Mount Freeling schist (McMahon & Partners, 1968).

Tantalum

Tantalite-columbite occurs in pegmatite cutting the Wangala Granite in DENISON, and is associated with cassiterite in the Anningie Tin Field in the Mount Peake Sheet area (Offe, 1978).

Tin

Tin prospects are located in the northwest of REYNOLDS RANGE (nos 6 and 14 in Table 19), at the Mount Allan Tin Mine in DENISON (Warren & others, 1974), and at the Anningie Tin Field in the Mount Peake Sheet area (Offe, 1978). In a survey of the granite of the Ennugan Mountains in the northeast of REYNOLDS RANGE and northwest of TEA TREE, Otter Exploration found several metasedimentary rafts of biotite schist, one of which assayed 0.15 percent Sn, at GR5453-920633 (Kojan, 1979). A reconnaissance stream sediment and grab sample survey of the Ennugan Mountains returned average values of 9 ppm Sn for the granite, and 5 ppm for the stream sediments (Kojan, 1979). An earlier stream-sediment survey of the same area by Tanganyika Holdings gave similar results (Paltridge, 1973; Davies, 1973).

Tungsten

Wolframite occurs in pegmatite at several localities in the northern Arunta block, including the Mount Boothby Prospect 3 km north of Aileron, the Ingellina Gap Prospect (GR5453-744509) in the Anmatjira Range, the Double Dams Prospect in the Wangala Hills in DENISON, and Wilson's Find at the western end of the Wabudali Range, in the Mount Theo Sheet area (Stewart, 1976). All the occurrences are very small. Stream-sediment sampling by Central Pacific Minerals N.L. of the Wickstead Creek beds in the Mount Dunkin-Mount Freeling area of AILERON gave discouraging results (Green, 1977).

Pacminex Pty Ltd recorded anomalously high tungsten in a heavy mineral stream concentrate from about 10 km southwest of Mount Thomas, which is an area of possible contact between the Wickstead beds and the Napperby Gneiss, in REYNOLDS RANGE (Allen, 1978). Heavy-mineral sampling by Australian and New Zealand Exploration Co in DENISON and the northwest of REYNOLDS RANGE found a high tungsten background, but no areas of economic mineralisation (Lockhart, 1979).

Coarse grains of Wolframite occur in the Wangala Granite at GR5353-151522 (74920563). Wolframite occurs sporadically over a 500 m strike length in poorly exposed metasediments about 37 km west-northwest of Sowden Hill in the Mount Theo Sheet area (F.Baarda, Yuendumu Mining Company N.L. personal communication, 1980).

Uranium

A radiometric survey by BMR (Carter, 1960) covered REYNOLDS RANGE, DENISON, the western edge of TEA TREE, and the southern edges of Mount Peake and Mount Theo. The survey showed that all major granites of the area were "hot", having radio-active intensities six times or more above the standard deviation recorded on the low side of the change.

Tanganyika Holdings completed initial exploration work in 1972-3 in areas to the north and northeast of the Reynolds Range. The results indicated that active leaching of uranium from the granites is occurring, but an oxidising-reducing interface may not be present. The subsurface groundwater is alkaline (pH usually greater than 8) and oxidising, and small concentrations of uranium are known in poorly sorted Cainozoic sands and siliceous calcrete. There appears to be no single concentrating mechanism. Davies (1973) found that most high radiometric ground readings (up to 600 ppm U) were located in shear zones between the Anmatjira Orthogneiss and the granite of the Ennugan Mountains in the headwater region of Ingallan Creek. Granitic rocks away from the shear zones contained up to 40 ppm U (Paltridge, 1973; Davies, 1973). In the same general area, Tanganyika found high levels of uranium in Nintabrinna Bore (800 ppb) and several other bores nearby (Paltridge, 1973).

CRA Exploration Pty Ltd found similarly high levels of uranium in these bores, but airborne radiometrics and rotary drilling of the downstream part of the Ingallan Creek drainage system found no significant uranium mineralisation (Scott, 1973a, b). Low levels of uranium in the downstream area indicated that uranium was being transported only for a short distance from the headwater region, before being precipitated or diluted before reaching the downstream area. CRA also drilled six holes across the Tea Tree Basin of Tertiary freshwater sediments, in the southwest of TEA TREE, and measured up to 40 ppm U in carbonaceous mudstone, and an average of 3.86 ppm U (1160 samples) in all sediments (O'Sullivan, 1973). The sediments were found to be characterised by poor permeability, fine grain size, and fair to good sorting, and were considered 'not generally favourable as hosts for uranium mineralisation'.

Central Pacific Minerals N.L. found up to 100 ppm U in quartz-hematite veins 8 km southeast of Limestone Bore, in the west of REYNOLDS RANGE (Schindlmayr, 1973). The Ngalurbindi Orthogneiss in DENISON and the southwest of REYNOLDS RANGE, and small stocks of granite intruding Lander Rock beds in the northwest of AILERON contain no radioactive mineralisation (Green, 1978a, b).

Pacminex Pty Ltd flew a low-level (80 m altitude) radiometric survey over the southeastern part of REYNOLDS RANGE. Follow-up work on the ground found no significant concentrations of uranium (Allen, 1978). Stream-sediment samples from the Napperby Gneiss north of Napperby homestead contain up to 22 ppm U.

Otter Exploration found three occurrences of uranium in small biotite-rich shear zones in the granite of the Ennugan Mountains, at GR5453-934517 and GR5553-975488, -984488. The uranium is contained in detrital xenotime grains up to 0.3 mm across, embedded in the biotite. The rocks assay up to 320 ppm U, 820 ppm Th, 1000 ppm Ta, and 500 ppm Nb (Kojan, 1979). The rare-earth prospect 6 km north of Pine Hill homestead contains up to 1000 ppm U. Kojan (1979) found high background levels of uranium (average 24 ppm) in 16 samples of granite from the Ennugan Mountains. Otter also investigated the Anningie tin field in the Mount Peake Sheet area for uranium, but found none (Kojan, 1980b).

Australia and New Zealand Exploration Co. (Davies, 1979) analysed 18 samples of various rock types (mostly granitic) from DENISON, and the results are set out in Table 22. Secondary autunite occurs in fractures over a few square metres in granite 5 km west of Quartz Hill and 1 km southwest of Quartz Hill, in DENISON; grab samples contained up to 560 ppm U (Davies, 1979). Grab samples of the uraniferous apatite-mica schist described in the section on Phosphate contain up to 820 ppm U.

Table 22: Uranium and thorium assays on 19 samples from the northern Arunta Block.

| Sample no. | Locality | Stratigraphic Unit | Rock-type | U | Th |
|---|---|---|---|---|---|
| 72921008 | 5353-213512 | Wangala Granite(2) | Granite | <4 | 4 |
| 1009 | " 213512 | " " (2) | Granite | 20 | 28 |
| 1011 | " 018453 | " " (4) | Granite | 8 | 34 |
| 74920660 | " 960440 | p€f | Biotite gneiss | 8 | 30 |
| 0667 | " 099401 | p€s$_2$ | Augen schist | 6 | 20 |
| 0676A | " 269414 | porphyry dyke | Hematitic porphyry | 10 | 55 |
| 0678 | " 163406 | Wangala Granite(2) | Gneissic granite | 14 | 42 |
| 0680 | " 071479 | Wangala Granite(2) | Greisen | 14 | 32 |
| 0681B | " 093480 | Wangala Granite(2) | Gneissic granite | 12 | 36 |
| 0686B | " 911451 | Fault | Mylonite | <4 | 20 |
| 0687 | " 907499 | p€g | Granitic gneiss | 6 | 38 |
| 0851B | " 006592 | Bg | Sericitised granite | 4 | 18 |
| 0856 | " 029621 | p€s$_1$ | Seric-qtz rock | <4 | 40 |
| 0858B | " 046579 | Wickstead Creek beds | Gar-musc-qtz rock | 8 | 8 |
| 0863 | " 032569 | Bg | Rapakivi granite | 6 | 32 |
| 0866 | " 106565 | p€f | Apat-biot-qtz rock | 26 | 310 |
| 0870 | " 125629 | p€f | Qtzo-fspathic gneiss | 10 | 22 |
| 0915 | " 225208 | Uldirra Porphyry | Porph. microgranite | 6 | 26 |
| 75920928C | 5453-909175 | Mt Thomas Qtzt | Qtz-lim-musc sch. | 4 | 28 |

Analysis by Amdel, Rept GS2782/79.

Metalliferous Potential

The most likely future prospects in the northern Arunta Block appear to be base metals, tungsten, tin, and uranium. Base metals are known in the Lander Rock beds at three localities (nos 1, 2, and 7 in Table 19) within 5 km of each other, and so a larger subsurface deposit is a possibility. The Wickstead Creek beds and Woodforde River beds are prospective for scheelite, especially near granite. Economic deposits of wolframite in the Boothby Orthogneiss and Wangala Granite are less likely, though still possible. Kojan (1979) considered the granite of the Ennugan Mountains to be prospective for tin. The so-called 'Tin-Zone' of Stewart & Warren (1977) crosses DENISON and the Mount Peake Sheet area, and so further occurrences may be present in those areas.

With regard to uranium, leaching from granites is an on-going process, but no environment suitable for uranium precipitation appears to be present in the area. Kojan (1979), however, thought the areas near Sandy Creek Bore and Nintabrinna Bore may be favourable for uranium precipitation.

Water Resources

The groundwater resources of much of the northern Arunta Block have been outlined by Jones & Quinlan (1962). Edworthy studied the groundwater resources of the Lander River area and Tea Tree Basin, but only the evaluation of the Lander River area was completed (Edworthy, 1968). Stewart (1976), Offe (1978), Offe & Kennewell (1978), and Kennewell & Offe (1979) discuss the water resources of the Mount Theo, Mount Peake, Mount Solitaire, and Lander River 1:250 000 Sheet areas respectively.

The northern Arunta area lies largely within the 'Lander' and 'Coniston' groundwater provinces of Jones & Quinlan (Fig. 148). The main characteristics of these, and the adjoining 'Stirling' and 'Wycliffe' provinces, are set out in Table 23. It appears that most groundwater recharge is by rainfall channelled from ranges along major drainage systems. Aquifers about the ranges are likely to be local and have small supplies, whereas out into the plains, larger aquifers in buried Tertiary basins may be present.

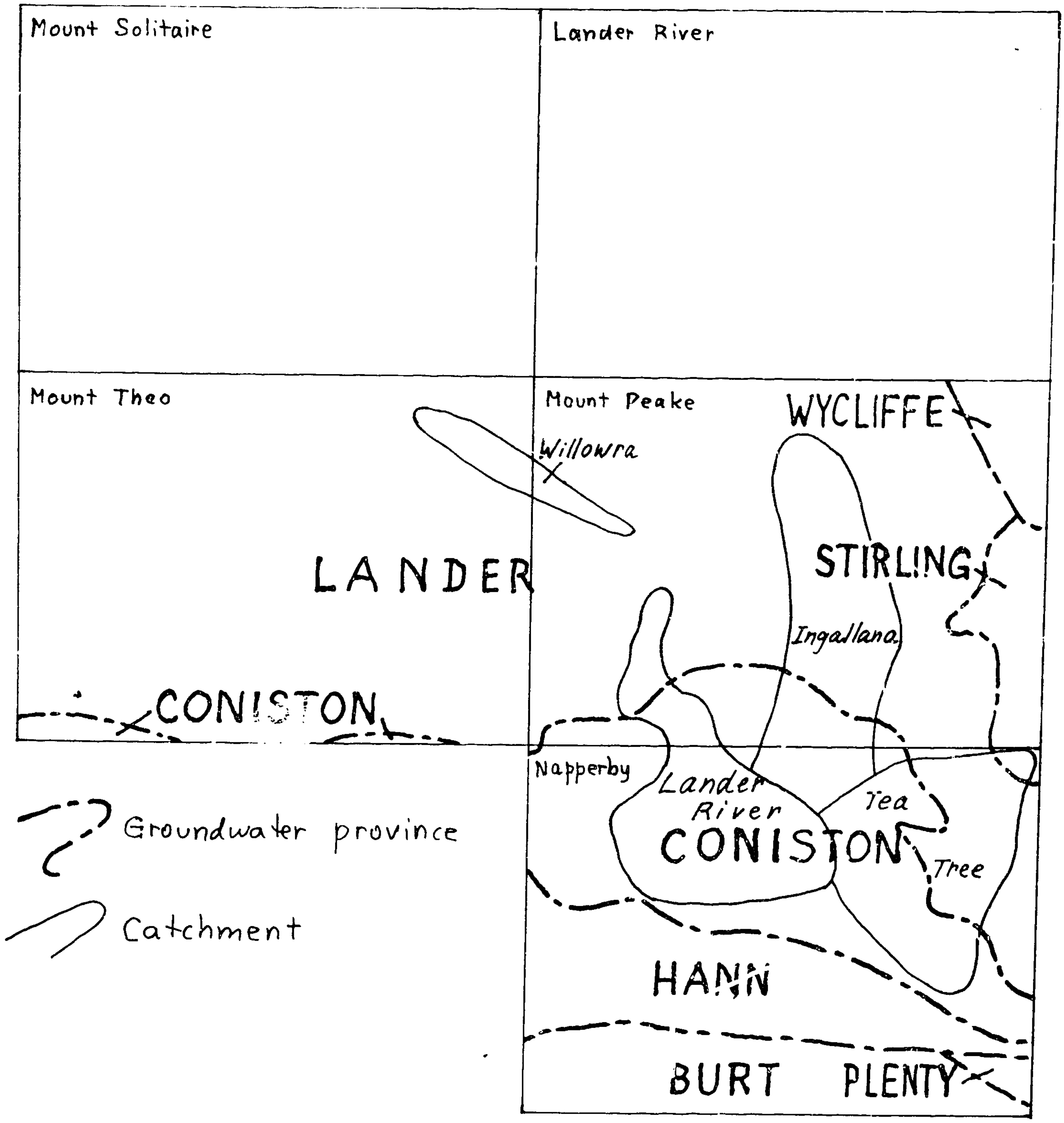



Fig. 148 : Groundwater provinces (large capitals) and catchments (italics), Napperby, Mount Peake, and Mount Theo 1:250 000 Sheet areas. Mount Solitaire and Lander River 1:250 000 Sheet areas are probably parts of LANDER and WYCLIFFE provinces. From Jones & Quinlan (1962).

16/NT/25

Table 23: Characteristics of groundwater provinces in Northern Arunta Block (from Jones & Quinlan, 1962).

| Province | Aquifers | Depth to Piezometric Surface* | Drilling Depth* | Quality** | Availability |
|---|---|---|---|---|---|
| Lander | Quaternary kunkar | Shallow | Shallow | Good to moderate | Good |
| | Minor basins and piedmonts | Shallow to moderate | Shallow to moderate | Good to moderate | Generally good |
| | Weathered and fractured metamorphic rocks | Shallow to moderate | Shallow to moderate | Moderate to saline | Poor |
| Coniston | Fractured and weathered zones in metamorphic rocks; sands in small pockets of creek alluvium | Commonly shallow | Shallow to moderate | Very variable, depending on local conditions of recharge | Poor; some areas of granite with almost no prospects |
| Stirling | Porous and fractured Palaeozoic sandstones | Moderate to deep | Moderate to deep | Good to saline | Good where sandstones extend below the piezometric surface |
| | Quaternary sands and kunkar | Shallow | Shallow | Good to moderate | Good in kunkar areas, variable in shallow alluvium |
| | Fractured and weathered zones in metamorphic rocks | Shallow | Shallow to moderate | Moderate or saline | Poor |
| Wycliffe | Unconsolidated sands in alluvium; and Quaternary kunkar | Shallow to moderate | Shallow to moderate | Mostly good to moderate; may be saline to the north-west | Good except near southern margin |

* Shallow = <30 m; moderate = 30-80 m; deep = >80 m.

** Good = <1500 ppm total dissolved solids; moderate = 1500-7000 ppm t.d.s.; saline = >7000 ppm t.d.s.

With regard to water for irrigation, Jones & Quinlan outlined four catchment zones: Willowra, Lander River, Ingallana, and Tea Tree (Fig. 148). From estimates of mean annual recharge and storage capacity, they considered Ingallana and Tea Tree to offer the most promise; Lander River was suspected of poor infiltration, and Willowra was largely unknown. Morton (1965) however, in a later study, estimated that the Lander River and Ingallan Creek could supply sufficient water to recharge the northern parts of Lander and Ingallana catchments, and also the area in between them, to warrant irrigated agriculture.

Surface water can be found at most, if not all times of the year at several soaks and waterholes along the main creeks and rivers. Waterholes and springs within the ranges are probably a more reliable source of water, but inaccessibility limits their use.

## CONCLUSION

The northern Arunta Block lacks the characteristics of an ensimatic depositional and tectonic environment, such as ophiolites, glaucophane schist, serpentinite sheets, chert, turbidite, argillite, volcanoclastic conglomerate, andesite, and paired metamorphic belts. Instead, it is characterised by mafic and felsic meta-igneous rocks, abundant quartzose and rather fine-grained metasediments, and low-pressure metamorphism. Hence, the northern Arunta Block is interpreted as part of an early Proterozoic ensialic geosyncline floored by continental crust of Archaean or Early Proterozoic age.

Deposition in the northern part of the Arunta Geosyncline began with eruption of mafic and silicic lavas of Division 1, implying extension and rifting of the underlying crust, but not oceanic splitting. These were overlain by pelitic sediments and some carbonate, following which the rocks were deformed and metamorphosed to granulite facies at about 1760 Ma. Metamorphism was sufficiently intense to cause partial melting, forming small charnockite plutons. This early tectonic episode suggests that compression and thickening of the previously extended sialic crust occurred, and coincided with a period of world-wide tectonism, all of which may be related to a hairpin bend in the global polar wandering curve at about that time (McElhinny & Embleton, 1976).

These events were followed by the laying down of a flood of fine to medium-grained terrigenous detritus - micaceous quartz sand, silt, clay, and impure limestone of Division 2. Eruption of mafic lavas was limited and spasmodic. The composition of the detritus indicates an ensialic source, possibly the Archaean or early Proterozoic basement marginal to the Arunta Geosyncline. These sediments were then folded, and may have been intruded by granite, before being eroded and then buried beneath the sediments of Division 3.

The quartzite, shale, and carbonate of Division 3 are compositionally the most highly differentiated sedimentary rocks in the northern Arunta block, and this suggests that they are cannibalised and reworked rocks of Division 2. The silicic igneous sills and lopolith which invaded the Division 3 sequence were the forerunners of later extensive granite emplacement in the area.

The region was then folded and metamorphosed at about 1350 Ma, generally only as far as the greenschist facies; in the southeast, however, the rocks reached granulite facies. Numerous and voluminous granites, some carrying tin, tungsten, and uranium, were emplaced during this generaly orogenic episode. The area was then faulted on a major scale, uplifting the dense meta-igneous rocks of Division 1 against the metasediments of Division 2. About 300 Ma of quiescence followed.

At around 1050 Ma, the southern part of the Arunta Block was tectonically reactivated, and underwent metamorphism, folding, migmatisation, and granite emplacement (Marjoribanks & Black, 1974; Shaw & others, 1979; Offe & Shaw, in prep). This event is represented in the northern Arunta Block by the Rb-Sr date of about 900 Ma on the Boothby Orthogneiss, implying either initial crystallisation or later recrystallisation of the Orthogneiss at that time. The reactivated part of the Arunta Block may be part of the belt of tectonism dated at about 1000 Ma that extended from the Albany-Fraser Range area of Western Australia, through the Musgrave Ranges and southern Arunta Block, to the Mount Painter area and Houghton Inlier of South Australia (Plumb, 1979).

The entire Arunta Block was tectonically disturbed yet again, in the Palaeozoic, when the northern margins of the Amadeus and Ngalia Basins were thrust-faulted and retrogressively metamorphosed in response to meridionally directed stress. In the northern Arunta, old faults were rejuvenated, and extended into the Proterozoic-Palaeozoic cover sediments. Mineral isotopes were again disturbed, and partly or wholly reset. The faulting can be viewed as a mildly plate-tectonic intra-cratonic jostling or adjustment across the Trans-Australia Zone of Austin & Williams (1978).

## ACKNOWLEDGEMENTS

We thank the staff of the Northern Territory Geological Survey at Alice Springs and Darwin, Mrs E. Wright (now deceased) and staff of the Aileron Hotel, Mrs Hughes of Tea Tree Hotel, Mr G. Bowman of 'Pine Hill', Mr and Mrs R. Shepherd of 'Napperby', Mr and Mrs A. Chisholm of 'Anningie' and 'Napperby', Mr and Mrs L. Martin of 'Mount Denison', and Mr and Mrs D. Smith of 'Mount Allan' homesteads for their assistance during the survey. We also thank CRA Exploration Pty Ltd, Central Pacific Minerals N.L., Otter Exploration, Pacminex Pty Ltd, Tanganyika Holdings, Australian and New Zealand Exploration Co. and Yuendumu Mining Company N.L. for permission to include their unpublished information. The maps were drawn by Miss D.M. Pillinger, BMR.

## APPENDIX 1

### Peraluminous sapphirine from near Aileron (R.G.W.)

A metamorphic rock, collected because of its unusual appearance, with pale blue porphyroblasts in a matrix of pale green mica, has been shown by petrographic work and microprobe analysis to have a very unusual chemistry and mineralogy. The rock (72921235) is very magnesian; the porphyroblasts are spinel ($\underline{Mg}$ = $^{100Mg}/Mg+Fe^{2+}$ = 96) with minor corundum and sapphirine (Mg = 98.2), and the matrix is phlogopite (Mg $\approx$ 99) (microprobe analyses are given in Table 24).

A second specimen (78921235) collected later from the same outcrops consists of white porphyroblasts in pale grey mica. The porphyroblasts in this specimen consist of sapphirine (Mg = 98.2-98.9) which is peraluminous in the sense of Schreyer & Abrahams (1975) in a matrix of phlogopite ($\underline{Mg}$ = 98.5-99) (microprobe analyses are given in Table 25).

Geological setting The outcrops from which the specimens were collected are about 6 km north of Aileron (GR5552-306006). Both specimens were collected from a lens of phlogopite rock about 5 m long by 1 m wide. The lens is surrounded by biotite-feldspar-quartz gneisses thought to be metasediments, and is within a roof pendant in porphyritic granite.

The regional metamorphic grade in this part of the Arunta Block is regarded as granulite as two-pyroxene mafic granulite and hypersthene-bearing quartzofeldspathic gneiss crop out in the district. Retrogressive metamorphism is most obvious close to the major faults, but hydration which produced partial retrogression of granulite assemblages is widespread.

Sapphirine In hand specimen the sapphirine in 78921235 is white and opalescent. In thin section it is colourless and non-pleochroic. (In 72921235 the sapphirine which occurs as minute grains at the edge of the spinel porphyroblasts cannot be distinguished optically from the more abundant corundum which also occurs at the edge of spinel grains.) The optic sign is negative and estimated to be in the range 40 to 50$^{\circ}$.

Table 24: Microprobe analyses 72921235 (Sapphirine-corundum-spinel-phlogopite assemblage)

| | Sapphirine | Sapphirine | Sapphirine | Spinel | Spinel | Phlogopite | Phlogopite |
|---|---|---|---|---|---|---|---|
| $SiO_2$ | 12.41 | 13.37 | 13.57 | | | 38.53 | 38.14 |
| $TiO_2$ | | | | | | .20 | .23 |
| $Al_2O_3$ | 66.63 | 64.88 | 64.87 | 70.94 | 71.19 | 18.68 | 18.79 |
| FeO* | .55 | .67 | .68 | 2.09 | 1.80 | .50 | .36 |
| MgO | 20.40 | 21.07 | 20.72 | 26.30 | 26.38 | 24.91 | 25.70 |
| ZnO | | | | .67 | .64 | | |
| $K_2O$ | | | | | | 9.70 | 9.62 |
| $Na_2O$ | | | .14 | | | | |
| Total | 99.99 | 99.99 | 99.98 | 100.00 | 100.01 | 92.52 | 92.86 |
| Si | 1.430 | 1.541 | 1.574 | | | 5.499 | 5.428 |
| $Al^{iv}$ | 4.570 | 4.459 | 4.426 | 2.004 | 2.007 | 2.501 | 2.572 |
| $Al^{vi}$ | 4.482 | 4.359 | 4.464 | | | .642) | .579) |
| Ti | | | | | | .021) | .025) |
| Fe | .053 | .064 | .066 | .042 | .036 | .059) 6.022 | .044) 6.099 |
| Mg | 3.509 | 3.626 | 3.596 | .941 | .942 | 5.300) | 5.451) |
| Zn | | | | .012 | .011 | | |
| K | | | | | | 1.766 | 1.746 |
| Na | | | .016 | | | | |
| Total | 14.044 | 14.049 | 14.104 | 2.999 | 2.996 | 15.790 | 15.845 |
| Oxygens | 20 | 20 | 20 | 4 | 4 | 22 | 22 |
| Mg/Mg+Fe | 98.5 | 98.2 | 98.2 | 95.7 | 96.3 | 98.9 | 99.2 |

*Total iron expressed as FeO

Table 25: Microprobe analyses 78921235 (Corundum-Sapphirine-Phlogopite assemblage)

| | Sapphirine | Sapphirine | Sapphirine | Sapphirine | Sapphirine | Sapphirine | Phlogopite | Phlogopite |
|---|---|---|---|---|---|---|---|---|
| $SiO_2$ | 11.74 | 11.36 | 11.08 | 10.70 | 10.33 | 10.07 | 37.94 | 38.48 |
| $TiO_2$ | | | | | | | .20 | .21 |
| $Al_2O_3$ | 68.47 | 68.88 | 69.47 | 69.58 | 70.34 | 70.91 | 20.27 | 20.15 |
| FeO* | .56 | .39 | .47 | .51 | .52 | .49 | .64 | .72 |
| MgO | 19.30 | 19.42 | 18.99 | 19.13 | 18.88 | 18.54 | 24.21 | 24.68 |
| $Na_2O$ | | | | | | | .16 | |
| $K_2O$ | | | | | | | 9.71 | 9.69 |
| Total | 100.07 | 100.05 | 100.00 | 99.92 | 100.07 | 100.00 | 93.13 | 93.94 |
| Si | 1.351 | 1.307 | 1.276 | 1.234 | 1.190 | 1.160 | 5.386) 8 | 5.410) 8 |
| $Al^{iv}$ | 4.649 | 4.693 | 4.734 | 4.766 | 4.810 | 4.840 | 2.614) | 2.590) |
| $Al^{vi}$ | 4.638 | 4.649 | 4.707 | 4.694 | 4.740 | 4.790 | .777) | .750) |
| Ti | | | | | | | .022) 5.997 | .022) 6.028 |
| Fe | .054 | .037 | .045 | .049 | .050 | .047 | .076) | .085) |
| Mg | 3.314 | 3.335 | 3.264 | 3.293 | 3.246 | 3.188 | 5.122) | 5.171) |
| Na | | | | | | | .043 | |
| K | | | | | | | 1.758 | 1.739 |
| Total | 14.006 | 14.021 | 14.016 | 14.036 | 14.035 | 14.025 | 15.797 | 15.767 |
| Oxygen | 20 | 20 | 20 | 20 | 20 | 20 | 22 | 22 |
| Mg/Mg+Fe | 98.4 | 98.9 | 98.6 | 98.5 | 98.5 | 98.5 | 98.5 | 98.4 |

*Total iron expressed as FeO

The sapphirines in both specimens are very magnesian. In 72921235 the sapphirine has Mg values ranging from 98.2 to 98.5 (average of 5 is 98.3), and in 78921235 the Mg value of the sapphirine is slightly higher, ranging from 98.2 to 98.9 (average of 26 is 98.6). When the analyses of the sapphirines are plotted in the $RO-R_2O_3-SiO_2$ triangle, all the samples show a slight excess of divariant cations (Fig. 149). Calculation of ferric iron by the method of Higgins & others (1979) shows that nearly all the iron must be ferric, and Mg is actually very close to 100. Though such highly magnesian sapphirine is unusual, it is by no means unique. Schreyer & Abrahams (1975) described sapphirines without iron. Sapphirine from the Mawson sapphirine lens (Antarctica) is also very magnesian, with Mg in the range 98.6-99.1; calculation of ferric iron for this sapphirine also shows that most of the iron must be ferric (J.W. Sheraton, BMR, personal communication).

The plot of the analyses in Figure 149 also shows that the sapphirine in 72921235 has compositions in the "normal" range of the sapphirine substitution series, though close to the 7:9:3 (aluminous) end of the series. However analyses of the sapphirines in 78921235 are more aluminous than the 7:9:3 end of the series. Analyses of the peraluminous sapphirines described by Schreyer & Abrahams (1975) and the very aluminous sapphirine analysed by Cameron (1976) are shown in Figure 149 for comparison.

The peraluminous sapphirines described by Schreyer & Abrahams (1975, 1976) were fine grained material interpreted as metastable, intermediate-stage products of reactions that did not go to completion. In both cases the sapphirine formed at moderate pressures and temperatures during hydration reactions. The very aluminous sapphirine described by Cameron (1976) formed at elevated temperatures and low pressures, which are the conditions which Higgins & others (1979) predicted from crystal chemistry where aluminous sapphirines should be more stable.

The very aluminous sapphirine in 78921235 is coarse-grained, and stable in an assemblage that formed under moderate pressures and temperatures. (Sillimanite and cordierite-garnet bearing assemblages are regionally stable.

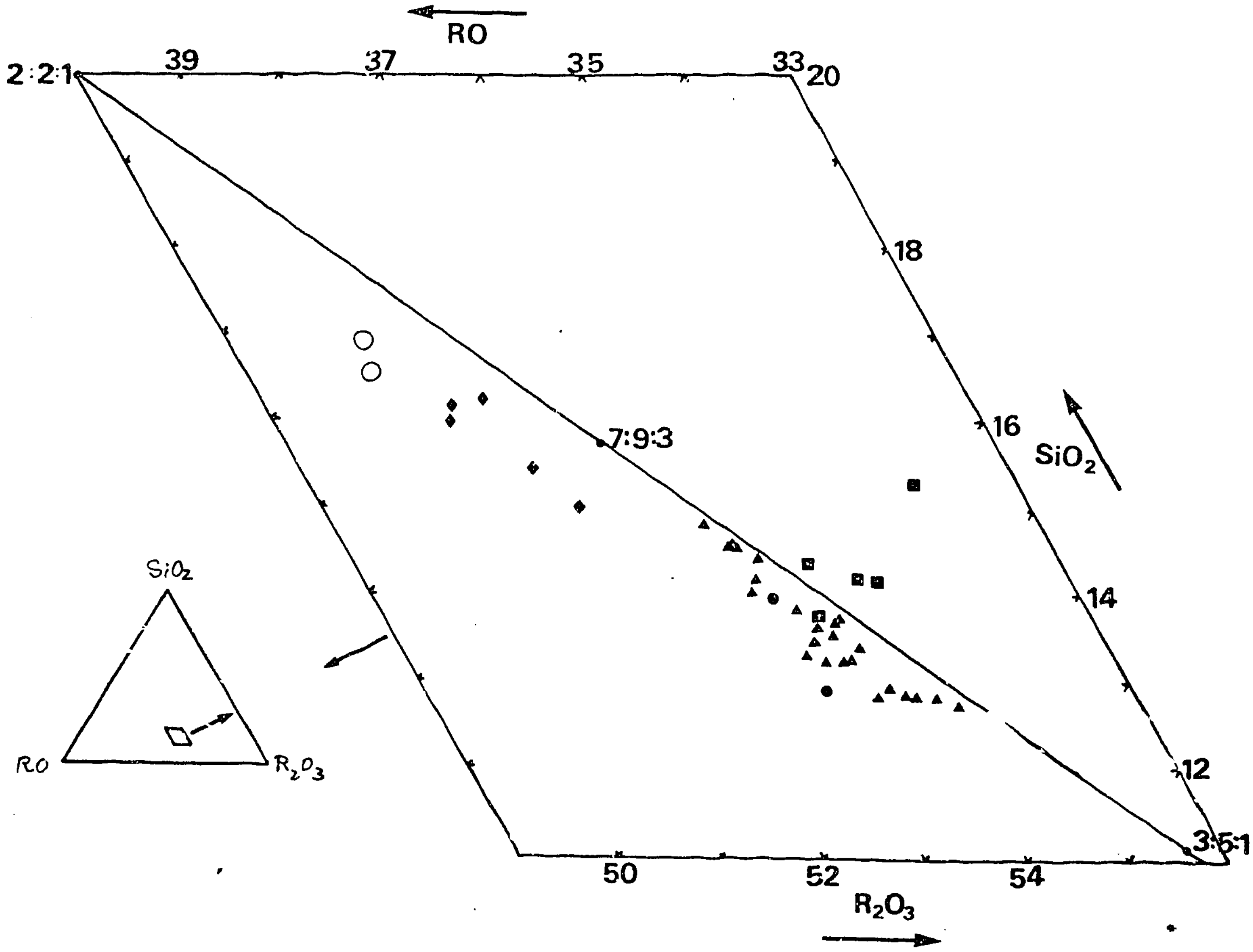



Fig. 149 : RO - $R_2O_3$ - $SiO_2$ plot

- ▲ Sapphirines in 78921235
- ◆ Sapphirines in 72921235
- O Highly magnesian sapphirine from Mawson
- ■ Peraluminous sapphirine from Sar el Sang
- ● Highly aluminous sapphirine from a xenolith in the Bushveld

16/NT/26

The nearby granite may have been comparatively dry so the temperature may have been higher than is common in regional metamorphism, but not excessively high.) Ellis & others (1980) have shown that the $Al_2O_3$ content of sapphirine is controlled by exchange reactions with co-existing minerals. Both the phlogopite and sapphirine are more aluminous in 78921235 than in 72921235, and the high $Al_2O_3$ content of the sapphirine may be buffered by exchange reactions with the eastonitic phlogopite.

## APPENDIX 2

### Occurrence of Wagnerite in Sapphirine-bearing granofels (R.G.W.)

The magnesium phosphate, wagnerite, is present in specimens collected from several of the lenses of sapphirine-bearing granofels in the eastern Reynolds Range. It has not been identified in hand specimens. In thin section it forms irregular grains to 2 mm across, with low relief, low birefringence, and a small, positive 2V. The grains are distinguished from adjacent cordierite by their slightly mottled appearance. (Cordierite in these specimens is rarely twinned, and has no marginal alteration.)

Microprobe analyses are given in Table 26 for wagnerite in 78921260A, collected at GR5552-137073 in AILERON. These analyses are consistent with the formula $Mg_4(PO_4)_3(OH)_2$, rather than the normal formula $Mg_4(PO_4)_3(F)_2$. No fluorine peak was present in the microprobe spectrum.

The whole-rock chemical analyses of 72921232 (collected at GR5552-083096), which also contains wagnerite, clearly shows an excess of phosphorous over the percentage needed to form apatite with available calcium.

Table 26: Microprobe Analyses of Wagnerite in 78921260A

| | | | | | | |
|---|---|---|---|---|---|---|
| $TiO_2$ | | .27 | .25 | .33 | .25 | .25 |
| FeO* | 1.31 | 1.42 | 1.28 | 1.33 | 1.25 | 1.20 |
| MgO | 49.29 | 48.75 | 48.95 | 48.82 | 48.73 | 48.95 |
| $Na_2O$ | .31 | .29 | .27 | .20 | .31 | . |
| $P_2O_5$ | 44.26 | 44.16 | 44.16 | 44.17 | 44.40 | 43.93 |
| Total | 95.17 | 94.89 | 94.91 | 94.91 | 94.94 | 94.33 |

FeO* Total iron expressed as FeO

## BIBLIOGRAPHY

Bureau of Mineral Resources unpublished material can be consulted at the Bureau of Mineral Resources, Parkes, Canberra, A.C.T.


ALLEN, J.H., 1978 - Annual report 1977/78 on geology and exploration, E.L. 1294 Napperby area, Northern Territory. Pacminex Pty Ltd Rept. PMR 94/78 (unpubl.).

ANON., 1965 - The results of prospecting operations in the Pine Hill area, N.T. Australian Geophysical Pty Ltd, Rept 4 (unpubl.).

ANON., 1967 - Final report on the Reynolds Range and Pine Hill areas. Australian Geophysical Pty Ltd, Report 12 (unpubl.).

AUSTIN, P.M., & WILLIAMS, G.E., 1978 - Tectonic development of Late Precambrian to Mesozoic Australia through plate motions possibly influenced by the earth's rotation. J. geol. Soc. Aust., 25, 1-21.

BLACK, L.P., SHAW, R.D., & OFFE, L.A., 1980 - The age of the Stuart Dyke Swarm and its bearing on the onset of Late Precambrian sedimentation in central Australia. Jour. geol. Soc. Aust., 27, 151-155.

BLAKE, D.H., HODGSON, I.M., & MUHLING, P.C., 1980 - Geology of The Granites-Tanami Region, Northern Territory and Western Australia. Bur. Miner. Resour. Aust. Bull. 197.

BLAKE, D.H., HODGSON, I.M., & SMITH, P.A., 1975 - Geology of the Birrindudu and Tanami 1:250 000 Sheet areas, Northern Territory. Bur. Miner. Resour. Aust. Rep. 174.

BROWN, B.D., 1972 - Final report AP 3376 - Windjajong Bore. Kewanee Australia Pty Ltd Rept. (unpubl.).

BROWN, R.N., 1978 - Aust. Miner. Dev. Labs. Rept. GS 2627/78 (unpubl.).

CAMERON, W.E., 1976 - Co-existing sillimanite and mullite. Geol. Mag. 113, 497-514.

CARTER, R.M., 1960 - Mt Hardy region magnetic and radiometric survey, N.T. 1958. Bur. Miner. Resour. Aust. Rec. 1960/117 (unpubl.).

CHAPPELL, B.W., & WHITE, A.J.R., 1974 - Two contrasting granite types. Pacif. Geol., 8, 173-174.

CHEWINGS, C., 1931 - A delineation of the Precambrian plateau in central and north Australia, with notes on the impingent sedimentary formations. Trans. Roy. Soc. S.A., 55, 1-11.

CLARKE, D., 1976 - Heavitree Quartzite. In: Excursion guide No. 48A : Geology of the Late Proterozoic-Palaeozoic Amadeus Basin (by A.T. Wells), 26-28. Guidebook for 25th Int. geol. Congr.

CONYBEARE, C.E.B., & CROOK, K.A.W., 1968 - Manual of sedimentary structures. Bur. Miner. Resour. Aust. Bull. 102.

COOK, P.J., & SCOTT, I.F., 1967 - Reconnaissance geology and petrography of the Ngalia Basin, N.T. Bur. Miner. Resour. Aust. Rept. 125.

DALY, J., 1955 - Examination of museum specimens for radioactivity. Bur. Miner. Resour. Aust. Rec., 1955/18 (unpubl.).

DALY, J., & DYSON, D.F., 1963 - Radiometric investigations at Anningie, Utopia, and Bundey River mineral fields, Northern Territory, 1949. Bur. Miner. Resour. Aust. Rec., 1963/45 (unpubl.).

DAILY, B., 1974 - The Precambrian-Cambrian boundary in Australia. Prog. and Abstr. for Symp. 'Precision in Correlation', Geol. Soc. Aust. Spec. Group in Biostrat. and Palaeont., Hobart, Feb. 1974, 4-8.

DAVIDSON, A.A., 1905 - Journal of explorations in Central Australia, 1898-1900. S. Aust. parl. Pap. 27.

DAVIES, E.R., 1979 - Report on uranium exploration on Exploration Licence 1317 Mount Denison area Northern Territory. In Annual Reports for Exploration Licences 1316 and 1317 for year ending 19th April 1979, Section 1. Rept. for Central Pacific Minerals N.L. and Yuendumu Mining Co. by Australian and New Zealand Exploration Co. (unpubl.).

DAVIES, H., 1973 - Report on reconnaissance exploration programme Arunta, Northern Territory. Tanganyika Holdings Ltd (unpubl.).

EDWARDS, A.B., 1932a - The geology and petrology of the Warburton area, Victoria. Proc. Roy. Soc. Vict., 44, 163-181.

EDWARDS, A.B., 1932b - On the dacite-granodiorite contact relations in the Warburton area. Proc. Roy. Soc. Vict., 44, 182-199.

EDWARDS, A.B., 1936 - On the occurrence of almandine garnets in some Devonian igneous rocks of Victoria. Proc. Roy. Soc. Vict., 49, 40-50.

EDWARDS, A.B., 1956 - The rhyolite-dacite-granodiorite association of the Dandenong Ranges. Proc. Roy. Soc. Vict., 68, 111-149.

EDWORTHY, K.J., 1968 - Appraisal of the groundwater resources of Lander River area, Northern Territory, 1966. Bur. Miner. Resour. Aust. Rec., 1968/73 (unpubl.).

ELLIS, D.J., SHERATON, J.W., ENGLAND, R.N., & DALLWITZ, W.B., 1980 - Osumilite-sapphirine-quartz granulites from Enderby Land, Antarctica - mineral assemblages and reactions. Contributions to Mineralogy and Petrology, 72, 123-143.

EVANS, T.G., 1972 - Napperby, N.T. - 1:250 000 Geological Series. Bur. Miner. Resour. Aust. explan. Notes, SF/53-9.

EVANS, T.G., & GLIKSON, A.Y., 1969 - Geology of the Napperby Sheet area, Northern Territory. Bur. Miner. Resour. Aust. Rec., 1969/85 (unpubl.).

FORMAN, D.J., 1971 - The Arltunga Nappe Complex, MacDonnell Ranges, Northern Territory, Australia. J. geol. Soc. Aust., 18, 173-182.

FRUZZETTI, O., 1969 - Notes on the Mount Allan tin mine, Napperby, N.T. Rep. Res. Geol. Office for Mines Branch, N. Terr. Admin., Alice Springs, N.T. (unpubl.).

FRUZZETTI, O., 1970 - The Mount Allan tin mine, Napperby 1:250 000 Sheet area SF53-9, Northern Territory. Rep. Res. Geol. Office for Mines Branch, N. Terr. Admin., Alice Springs, N.T. (unpubl.).

FRUZZETTI, O.G., & MORLOCK, J.S., 1974 - The Bismark's Tin Prospect, Anningie Tin Field, Mt Peake SF 53-5, 1:250 000 Sheet area, Northern Territory. N. Terr. Geol. Surv. Rec., 1974/10 (unpubl.).

GLAESSNER, M.F., 1969 - Trace fossils from the Precambrian and basal Cambrian. Lethaia, 2, 369-394.

GLAESSNER, M.F., PREISS, W.V., & WALTER, M.R., 1969 - Precambrian columnar stromatolites in Australia : morphological and stratigraphic analysis. Science, 164, 1056-1058.

GREEN, P.W., 1977 - Annual report for E.L. 1384 Scarborough. Central Pacific Minerals N.L., Report NT 178 (unpublished).

GREEN, P.W., 1978a - Annual and final report for E.L. 1411 Friendship. Central Pacific Minerals N.L., Report NT 183 (unpublished).

GREEN, P.W., 1978b - Final report for E.L. 1384 Scarborough. Central Pacific Minerals N.L., Report NT 185 (unpublished).

HIGGINS, J.B., RIBBE, P.H., & HERD, R.K., 1979 - Sapphirine I. Crystal chemical contributions. Contributions to Mineralogy and Petrology, 68, 349-356.

HOSSFELD, P.S., 1940 - The gold deposits of The Granites-Tanami district, central Australia. Aer. geol. geophys. Surv. N. Aust., N. Terr. Rept. 43.

HUGHES, F.E., & O'SULLIVAN, K.N., 1973 - E.L. 50, Willowra, N.T., report for 12 months ending 7th February 1973. CRA Exploration Pty Ltd. Rept. NT 275 (unpubl.).

HUGHES, F.E., & O'SULLIVAN, K.N., 1973 - E.L. 51 - Mount Rennie, N.T. report for 12 months ending 18th January 1973. CRA Exploration Pty Ltd Rept. (unpubl.).

JENSEN, H.I., 1945 - The geology of central Australia. Proc. Roy. Soc. Qld, 56, 85-94.

JONES, N.O., & QUINLAN, T., 1962 - An outline of the water resources of the Alice Springs area. In Perry, R.A. (Compiler), General report on lands of the Alice Springs area, Northern Territory, 1956-57. Comm. sci. ind. Res. Org. Aust. Land Res. Ser. 6, 150-162.

KEMP, E.M., 1976 - Early Tertiary pollen from Napperby, central Australia. BMR Journal of Australian Geology and Geophysics, 1, 109-114.

KENNEWELL, P.J., & OFFE, L.A., 1979 - Lander River, N.T. - 1:250 000 Geological Series. Bur. Miner. Resour. Aust. explan. Notes, SF/53-1.

KLEEMAN, A.W., 1934 - An adamellite from "The Granites", Northern Territory. Trans. Roy. Soc. S. Aust. 58, 234-236.

KNORRING, O.G., SAHAMA, Th. G., & LEHTINEN, M., 1960 - Kornerupine-bearing gneiss from Inanaky near Betroka, Madagascar. Bull. geol. soc. Finland, 41, 79-84.

KOJAN, C., 1979 - 1978 Report,Northern Territory, Part 2, Mount Peake/Napperby Report for Otter/CEGB (unpubl.).

KOJAN, C., 1980a - Final report E.L. 1444. Rept. for Otter Exploration N.L.(unpubl.)

KOJAN, C., 1980b - Final report E.L. 1448. Rept. for Otter Exploration N.L.(unpubl.)

LOCKHART, J.D., 1979 - Report on tungsten exploration on Exploration Licences 1316 and 1317 Northern Territory. In Annual Reports for Exploration Licences 1316 and 1317 for year ending 19th April 1979, section 2. Rept. for Central Pacific Minerals and Yuendumu Mining Co. by Australian and New Zealand Exploration Co. (unpubl.).

LOWDER, G.G., & WEBB, A.W., 1972 - Aust. Min. Devel. Labs. Rept. AN2968/ 72 (unpubl.).

McELHINNY, M.W., & EMBLETON, B.J.J., 1976 - Precambrian and early Palaeozoic palaeomagnetism in Australia. Phil. trans. Roy. Soc. Lond. A, 280, 417-431.

McMAHON, K., & PARTNERS, 1968 - Mount Freeling talc deposit, central Australia. Rept. for Minerals Pty Ltd (unpubl.).

MARJORIBANKS, R.W., 1976 - The relation between microfabric and strain in a progressively deformed quartzite sequence from central Australia. Tectonophysics, 32, 269-293.

MARJORIBANKS, R.W., & BLACK, L.P., 1974 - Geology and geochronology of the Arunta Complex, north of Ormiston Gorge, central Australia. J. geol. Soc. Aust., 21, 291-300.

MORLOCK, J.S., 1973 - Preliminary report on Native Gap Prospect. N. Terr. geol. Surv. Rept. GS 346 (unpubl.).

MORTON, W.H., 1965 - The occurrence of groundwater suitable for irrigation, Willowra Station, Northern Territory. Bur. Miner. Resour. Aust. Rec., 1965/146 (unpubl.).

NOCKOLDS, S.R., 1954 - Average chemical compositions of some igneous rocks. Geol. Soc. Amer. Bull., 65, 1007-1032.

OFFE, L.A., 1978 - Mount Peake, N.T. - 1:250 000 Geological Series. Bur. Miner. Resour. Aust. explan.Notes, SF/53-5.

OFFE, L.A., & KENNEWELL, P.J., 1978 - Mount Solitaire, N.T. - 1:250 000 Geological Series. Bur. Miner. Resour. Aust. explan. Notes, SF/52-4.

O'SULLIVAN, K.N., 1972 - Final report A. to P. 3447, 'Mt Harris', N.T. CRA Exploration Pty Ltd Rept. NT 168 (unpubl.).

O'SULLIVAN, K.N., 1973 - Stratigraphic drilling, Tea Tree area, N.T. CRA Exploration Pty Ltd Rept. NT 143 (unpubl.).

PAGE, R.W., BLAKE, D.H., & MAHON, M.W., 1976 - Geochronology and related aspects of acid volcanics, associated granites, and other Proterozoic rocks in The Granites-Tanami region, northwestern Australia. BMR J. Aust. Geol. Geophys., 1, 1-13.

PALTRIDGE, I.M., 1973 - Arunta Project - report on drilling during 1973. Tanganyika Holdings Ltd Rept. (unpubl.).

PERRY, R.A. (Compiler), 1962 - General report on lands of the Alice Springs area, Northern Territory, 1956-57. Comm. sci. ind. Res. Org. Land Res. Ser. 6.

PHILLIPS, K.M., 1962 - Tanami, Northern Territory. Report of activities on Authority to Prospect No. 845 from March 1961 to March 1962; and an assessment of the status of this prospect. Consolidated Zinc Pty Ltd, Report NT 171 (unpublished).

PLUMB, K.A., 1979 - The tectonic evolution of Australia. Earth Science Reviews, 14, 205-249.

PONTIFEX, I.R., 1965 - Mineralogical examination of a lithium-bearing pegmatite, Anningie Tin Field, N.T. Rept. 89 in Bur. Miner. Resour. Aust. Rec., 1965/209 (unpubl.).

PONTIFEX, I.R., 1973 - McPhar Geophysics mineral. Rept. 1362 (unpubl.).

PREISS, W.V., 1972 - Proterozoic stromatolites - succession, correlations and problems. In: Stratigraphic Problems of the Later Precambrian and Early Cambrian (Ed. by J.B. Jones & B. McGowran) Spec. Pap. Univ. Adelaide Centre Precamb. Resear., 1, 53-62.

RHEA, S., 1973 - E.L. 775 - Winjajong Bore Project 22 Final report. Kewanee Australia Pty Ltd Rept. (unpubl.).

RHEA, S., 1973 - E.L. 381 - Hanson River Prospect No. 29 Final report. Kewanee Australia Pty Ltd Rept. (unpubl.).

RIVEREAU, J.C., & PERRY, W.J., 1965 - Report on photo-interpretation in the Wiso Basin Northern Territory. Bur. Miner. Resour. Aust. Rec. 1965/115 (unpubl.).

RYAN, G.R., 1958 - Notes on the geology and mineral deposits of the Reynolds Range area, Northern Territory. Bur. Miner. Resour. Aust. Rec. 1958/107 (unpubl.).

SCHINDLMAYR, W.E., 1973 - Djamidjimba EL23 Final Report. Central Pacific Minerals N.L. Rept. NT 62 (unpubl.).

SCHREYER, W., & ABRAHAMS, K., 1975 - Peraluminous sapphirine as a metastable reaction product in kyanite-gedrite-talc schist from Sar e Sang, Afghanistan. Mineralogical Magazine 40, 171-180.

SCHREYER, W., & ABRAHAMS, K., 1976 - Natural boron-free kornerupine and its breakdown products in a sapphirine rock of the Limpopo Belt, southern Africa. Contributions to Mineralogy and Petrology 54, 109-126.

SCOTT, A.K., 1973a - Report on investigations in E.L. 50, Willowra, N.T. CRA Exploration Pty Ltd Rept. (unpubl.).

SCOTT, A.K., 1973b - Final report on investigations in E.L. 51 Mt Rennie, N.T. CRA Exploration Pty Ltd Rept. (unpubl.).

SEDERHOLM, J.J., 1923 - On migmatites and associate pre-Cambrian rocks of southwestern Finland. Comm. geol. Finlande Bull. 58, 75-95.

SHAW, R.D., LANGWORTHY, A.P., OFFE, L.A., STEWART, A.J., ALLEN, A.R., SENIOR, B.R., & CLARKE, D.B., 1979 - Geological report on 1:100 000 scale mapping of the southeastern Arunta Block, Northern Territory. Bur. Miner. Resour. Aust. Rec. 1979/47, BMR Microform MF 133 (unpubl.).

SHAW, R.D., & STEWART, A.J., 1975a - Towards a stratigraphy of the Arunta Block. First Aust. geol. Conv. 'Proterozoic Geology'. Geol. Soc. Aust., Adelaide, May 1975, Abstr., 35.

SHAW, R.D., & STEWART, A.J., 1975b - Arunta Block-regional geology. In, Knight, C.L. (Ed.) ECONOMIC GEOLOGY OF AUSTRALIA AND PAPUA NEW GUINEA: 1, METALS. Monogr. Ser. Aust. Inst. Min. Metall., 5, 437-442.

SHAW, R.D., STEWART, A.J., YAR KHAN, M., & FUNK, J.L., 1971 - Progess reports on detailed studies in the Arltunga Nappe Complex, N.T., 1971. Bur. Miner. Resour. Aust. Rec. 1971/66 (unpubl.).

SHAW, R.D., & WARREN, R.G., 1975 - Alcoota N.T. - 1:250 000 Geological Series. Bur. Miner. Resour. Aust. explan. Notes SF/53-10.

SHAW, R.D., WARREN, R.G., SENIOR, B.R., & YEATES, A.N., 1975 - Geology of the Alcoota 1:250 000 Sheet area. Bur. Miner. Resour. Aust. Rec. 1975/100, BMR Microform MF 107 (unpubl.).

SINGLETON, O.P., 1949 - The geology and petrology of the Tooborac district, Victoria. Proc. Roy. Soc. Vict.61, 75-104.

SKEHAN, J.W., 1961 - The Green Mountain anticlinorium in the vicinity of Wilmington and Woodford, Vermont. Vermont geol. Surv. Bull. 17.

SMITH, K.G., 1972 - Stratigraphy of the Georgina Basin. Bur. Miner. Resour. Aust. Bull. 111.

SMITH, K.G., & MILLIGAN, E.N., 1964 - Barrow Creek, N.T. - 1:250 000 Geological Series. Bur. Miner. Resour. Aust. explan. Notes, SF/53-6.

STEIGER, R.H., & HART, S.R., 1967 - The microcline-orthoclase transition within a contact aureole. Amer. Miner. 52, 87-116.

STEWART, A.J., 1967 - An interpretation of the structure of the Blatherskite Nappe, Alice Springs, Northern Territory. J. geol. Soc. Aust., 14, 175-184.

STEWART, A.J., 1976 - Mount Theo, N.T. - 1:250 000 Geological Series. Bur. Miner. Resour. Aust. explan. Notes SF/52-3.

STEWART, A.J., 1980 - Geology of the Reynolds Range Region, Northern Territory. Bur. Miner. Resour. Aust., 1:100 000 Map Commentary.

STEWART, A.J., SHAW, R.D., OFFE, L.A., LANGWORTHY, A.P., WARREN, R.G., ALLEN, A.R., & CLARKE, D.B., 1980 - Stratigraphic definitions of named units in the Arunta Block, Northern Territory. Bur. Miner. Resour. Aust. Rept. 216, BMR Microform MF 104.

STEWART, A.J., & WARREN, R.G., 1977 - The mineral potential of the Arunta Block, central Australia. BMR J. Aust. Geol. Geophys., 2, 21-34

STRECKEISEN, A., 1976 - To each plutonic rock its proper name. Earth-Sci. Rev., 12, 1-33.

TUTTLE, O.F., & BOWEN, N.L., 1958 - Origin of granite in the light of experimental studies in the system $NaAlSi_3O_8$-$KAlSi_3O_8$-$SiO_2$-$H_2O$. Geol. Soc. Amer. Mem. 74.

WADE, M., 1969 - Medusae from uppermost Precambrian or Cambrian sandstones, central Australia. Palaeontology, 12, 351-365.

WALTER, M.R., in press - Adelaidean and early Cambrian stratigraphy of the southwestern Georgina Basin: correlation chart and explanatory notes. Bur. Miner. Resour. Aust. Rept. 214, BMR Microform MF 92.

WARREN, R.G., 1978 - Delny-Mount Sainthill Fault System, eastern Arunta Block, central Australia. BMR J. Aust. Geol. Geophys., 3, 76-79.

WARREN, R.G., STEWART, A.J., & SHAW, R.D., 1974 - Summary of information on mineral deposits of the Arunta Complex, Alice Springs area, N.T. Bur. Miner. Resour. Aust. Rec. 1974/117 (unpubl.).

WELLS, A.T., 1974 - New stratigraphic information from shallow drilling in the central and eastern parts of the Ngalia Basin, Northern Territory. Bur. Miner. Resour. Aust. Rec. 1974/153 (unpubl.).

WELLS, A.T., EVANS, T.G., & NICHOLAS, T., 1968 - The geology of the central part of the Ngalia Basin, Northern Territory. Bur. Miner. Resour. Aust. Rec. 1968/38 (unpubl.).

WELLS, A.T., FORMAN, D.J., RANFORD, L.C., & COOK, P.J., 1970 - Geology of the Amadeus Basin, central Australia. Bur. Miner. Resour. Aust. Bull. 100.

WELLS, A.T., & MOSS, F.J., in preparation - The Ngalia Basin, Northern Territory. Stratigraphy and structure. Bur. Miner. Resour. Aust. Bull.

WELLS, A.T., MOSS, F.J., & SABITAY, A., 1972 - The Ngalia Basin, Northern Territory - Recent geological and geophysical information upgrades petroleum prospects. Aust. Petrol. Expl. J. 12, 144-151.

WHITWORTH, R., 1970 - Reconnaissance gravity survey of parts of Northern Territory and Western Australia, 1967. Bur. Miner. Resour. Aust. Rec., 1970/15 (unpubl.).

WOODFORD, P.J., & WILSON, A.F., 1976 - Kornerupine in metasomatic zones, Strangways Range, central Australia. Miner. Mag., 40, 589-594.

WRIGHT, T.L., 1967 - The microcline-orthoclase transformation in the contact aureole of the Eldorado stock, Colorado. Amer. Miner. 52, 117-136.

YOUNG, H., 1972 - Final report, Prospecting Authority 2854, Anningie Station. Le Nickel (Australia) Exploration Pty Ltd Rept. (unpubl.).