COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Record No. 1969 / 85

Geology of the Napperby Sheet Area, Northern Territory

by

T.G. Evans and A.Y. Glikson

GEOLOGY OF THE NAPPERBY SHEET AREA, NORTHERN TERRITORY.

by

T.G. Evans and A.Y. Glikson

RECORDS 1969/85

GEOLOGY OF THE NAPPERBY SHEET AREA, NORTHERN TERRITORY.

by

T.G. Evans and A.Y. Glikson

RECORDS 1969/85

Contents

Contents

ILLUSTRATIONS

FIGURES

ILLUSTRATIONS

SUMMARY

This record describes the geology of the Napperby Sheet area in the southern part of the Northern Territory. Brief reconnaissance traverses and air photo-interpretation together with petrographic study of rock sections have made possible a broad identification of the major rock types.

The area can be divided into two geological parts: the Precambrian igneous and metamorphic basement rocks and the Ngalia Basin sedimentary rocks.

The Precambrian basement rocks crop out mainly in the northern half of the Sheet area and form rough mountainous terrain trending in a north-west direction. The metamorphic rocks have been divided into metamorphic belts - the greenschist facies metamorphic rocks of the Reynolds Range and the granulite-amphibolite facies rocks of the northern range. These belts are separated from one another by a major shear zone and a zone of intrusive granites. Retrograde metamorphic effects are widespread in the high grade belt, but their significance could not be determined by this survey. Granite intrusions are but weakly metamorphosed except where faults and shear zones cut the granite and result in pronounced dynamic metamorphic effects. Granitic gneiss, metamorphosed acid porphyries and doleritic and basaltic dykes were identified in the Sheet area. The emplacement of these igneous rocks occurred before or during the regional metamorphism of the area. All show traces of metamorphism.

Three sedimentary formations are exposed in the Ngalia Basin on the Napperby Sheet area. They are the Proterozoic Vaughan Springs Quartzite, the Ordovician Kerridy Sandstone and the Carboniferous Mount Eclipse Sandstone. The sediments are, for the most part, poorly exposed, and no formation contacts are visible. Their relationships and ages were previously determined from the adjacent Mount Doreen Sheet area. No identifiable fossils have been found in the sediments in this Sheet area. Geophysical evidence indicates a total thickness of at least 10,000 feet in the deepest part of the Ngalia Basin in this Sheet area.

The structural deformation which resulted in the present shape of the basin was caused by a number of earth movements, the most important two of which are believed to be post Ordovician - pre Carboniferous, and post Carboniferous in age.

Thin deposits of Tertiary and Quaternary sediments cover a large part of the Sheet area. These are important as water reservoirs and attain a thickness of up to 800 feet in some areas. Thin lignite deposits were identified from a shallow stratigraphic hole drilled into these Tertiary sediments and several other minor mineral occurrences are described. The oil and mineral potential of the area is considered to be low.

INTRODUCTION

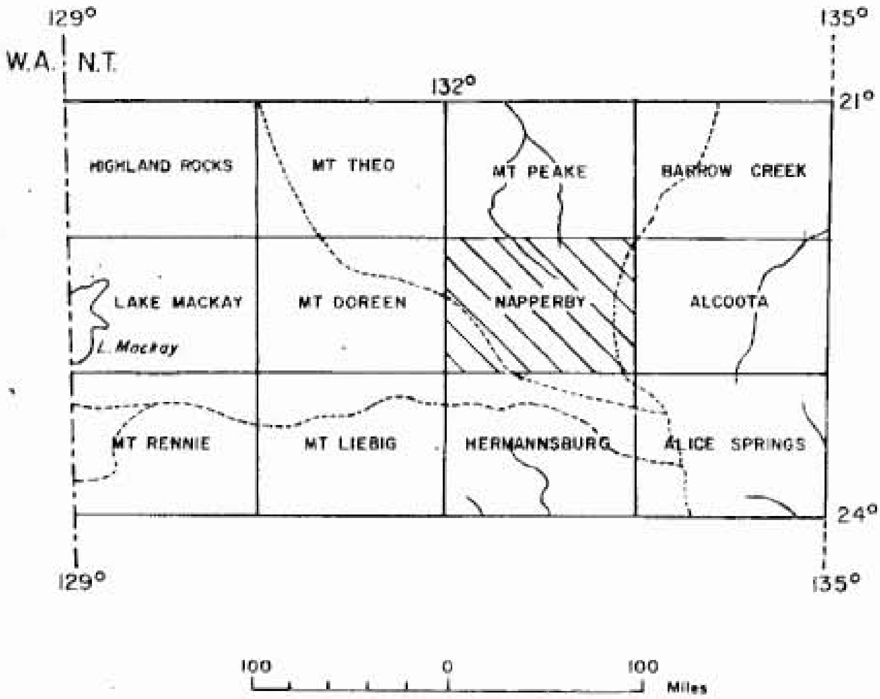
GENERAL

Reconnaissance geological mapping of the Napperby 1:250,000 Sheet area by a Bureau of Mineral Resources geological field party was completed in October 1968. The field party consisted of four geologists: A.T. Wells, T.G. Evans, T. Nicholas and A.Y. Glikson, and this report and accompanying map is the result of the field mapping and air photo-interpretation made by them. The map was compiled and drawn by Miss D.M. Pillinger, the field party draughtswoman.

Greater emphasis was placed, in the field, on the mapping of the sedimentary rocks which form part of the Ngalia Basin.than on the igneous and metamorphic rocks of the surrounding basement which were for the most part only briefly examined. Petrological descriptions of numerous thin sections and air-photo interpretation compiled with the assistance of Colin Simpson, Bureau of Mineral Resources photogeologist, have enabled us to delineate on the map most of the major rock types in the basement complex.

Fig. I

POSITION OF AREA MAPPED AND REFERENCE TO AUSTRALIAN 1:250,000 MAP SERIES



LOCALITY MAP

To accompany Record 1969/85

F 53/A9/15

Geophysical investigation of the Ngalia Basin by a Bureau of Mineral Resources geophysical party continued in the winter of 1968.

Both geological and geophysical parties are working on a project which aims to elucidate the structure and geological history of the Ngalia Basin.

LOCATION AND ACCESS

The Napperby 1:250,000 Sheet covers the area in the Northern Territory which lies between latitudes 22°00' to 23°00' south and longitudes 132°00' to 133°30' east. A locality map (Fig. 1) shows its position.

The Reynolds Range, the Giles Range and the Ennugan Mountains form a natural topographic barrier running in a north-west direction across the north-eastern part of the Sheet area, while the Stuart Bluff and the Hann Ranges run east-west across the southern part of the Sheet area and delineate the southern margin of the Ngalia Basin.

The Stuart Highway, from Alice Springs to Darwin, passes through the eastern part of the Sheet area. Graded earth roads link all the cattle stations with the Stuart Highway and with the beef road from Alice Springs to Yuendumu Native Settlement.

The field party was camped on Day Creek, 10 miles east of Napperby Homestead. Drinking water was obtained from the nearby homestead and also from Malcolm Bore, sited on the banks of Day Creek.

Regular mail deliveries were made by plane from Alice Springs to Napperby Station. This mail service covers most of the cattle stations in the area.

Telegraphic services and medical advice were received by transceiver radio from the Royal Flying Doctor Service base at Alice Springs.

Bush tracks provide reasonably good access to most areas covered by the Sheet. Only the Reynolds Range and Ennugan Mountains were inaccessible to 4-wheel drive Land Rovers.

CLIMATE

Many of the cattle stations on the Sheet area send daily weather reports to the Bureau of Meteorology in Darwin. Only the rainfall average for Tea-Tree Well is available, as other stations have only a few years of records. The average annual rainfall for Tea-Tree Well is 10.97 inches. In contrast with this figure is the total rainfall figure for 1968 for Tea-Tree Well which is 21.42 inches; of which 10.77 inches fell in the months of April and May (Fig. 2).

Temperature data is not available for the cattle stations on the area. Alice Springs temperature data are included as these would be representative of the area.

For a more detailed analysis of the climatic data of the Alice Springs area refer to Slatyer (in Perry et al. 1962).

DEVELOPMENT

The Stuart Highway from Alice Springs to Darwin carries sufficient traffic to support hotels at Aileron and Tea-Tree.

All settlements on the Sheet area rely exclusively on the cattle industry for their existence. With average climatic conditions and good management most stations appear to prosper.

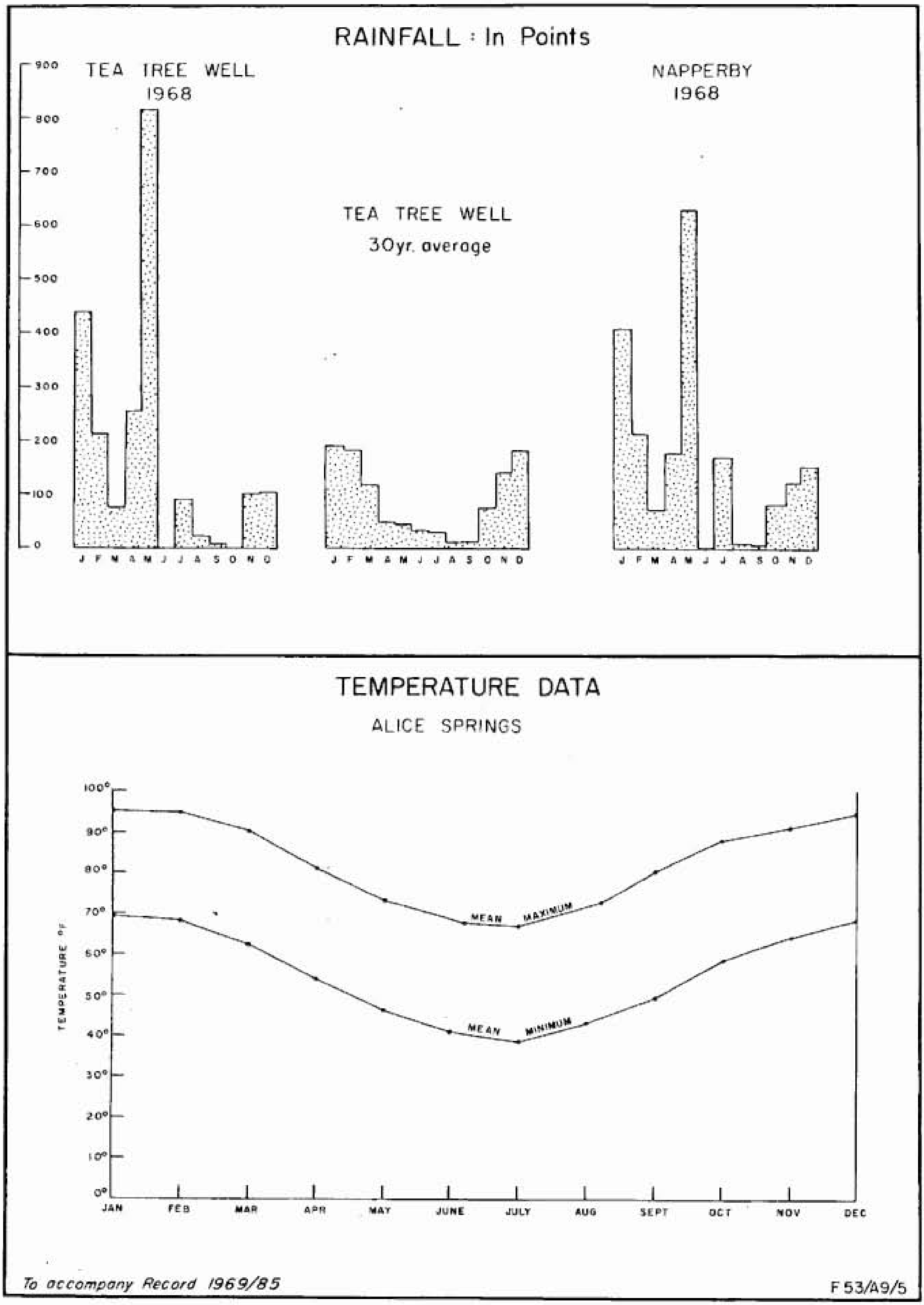


Fig. 2 METEOROGICAL DATA

SURVEY METHOD

Each geologist and his assistant normally made 5-day reconnaissance traverses away from the base camp using 4-wheel drive Land Rovers.

Vertical air photographs of the area were taken by the R.A.A.F. in 1950 and the geological information was plotted on transparent overlays prepared for each photograph. The scale of these photographs is 1:46,500. The geological data were transferred from the transparent overlays to controlled photoscale overlay sheets which were then photographically reduced to 1:250,000 scale and the map redrawn at that scale.

Photo-interpretation of the Ngalia Basin sediments had previously been completed by J. Rivereau (1965), and this proved an invaluable guide to the field geologists.

Sections were measured through the Ngalia Basin formation at selected localities using tape, compass and abney level.

PHYSIOGRAPHY

Six broad physiographic divisions are recognised on the Napperby Sheet area. They are: mountain ranges, sand plains, alluvial fans and plains, salt and clay pans, travertine plains, flood plains (Fig. 3).

The Mountain Ranges occupy a large part of the Napperby Sheet area and include the Reynolds Range, the Giles Range, Ennugan Mountains, the Stuart Bluff Range and the Hann Range. Included in this division are numerous smaller hills such as Mount Treachery, Quartz Hill, Uldirra Hill, Mount Stafford, Mount Finniss, Mount Weldon and Patty Hill.

The ranges are for the most part, composed of granite, gneiss and folded meta-sedimentary rocks with the exception of the Stuart Bluff Range, the Hann Range and Patty Hill all of which consist of the Vaughan Springs Quartzite. Mount Thomas in the Reynolds Range is the highest peak on the Sheet area. The ranges normally have a very shallow soil cover which supports sparse low trees, short grass and spinifex. The drainage pattern is controlled by the distribution of the Mountain Ranges, the differing rock types and their structural trends.

The Sand Plains cover most of the central part of the Sheet area. The average height of the sand plains is about 1900 feet above sea level. A few sporadic sand dunes are present in the southern part of the Sheet area. The dunes are normally less than 20 feet high, up to one mile in length and are mostly covered by spinifex.

Alluvial Fans and Plains are found at the foot of the mountain ranges where the rapid change in gradient causes the deposition of much of the water borne material. The alluvial soil supports a vegetation of sparse shrubs, low trees and short grass.

Clay and Salt Pans are present south of the Stuart Bluff Range. One of the earliest descriptions of a clay pan is that of Ernest Giles, the explorer, who wrote "A clay pan is a small area of ground whose top soil has been washed or blown away, leaving a hard clay exposed and upon this surface water may remain for some days after rain".

The clay pans normally hold water only after rain. The salt pans differ from clay pans in that the water is primarily surface water which has migrated into the area. It quickly evaporates leaving a thin crust of white salt on the surface. The clay and salt pans are commonly surrounded by numerous small sandridges. Napperby Creek drains into the large area of salt lakes south of the Stuart Bluff Range. No vegetation grows on these clay and salt pans but the fringing dunes have a cover of spinifex, samphire and salt bush.

Travertine Plains are found along the north-west margin of the Stuart Bluff Range and surrounding the salt pans south of the range. They commonly form a lightly dissected plain with a low relief, rarely rising over 10 feet above the level of the sand plain. They have a soil cover of shallow, sandy calcareous earths with short grasses and spinifex.

Flood Plains are characterised by alluvial clayey sands and sandy red earths with sparse low trees over short grass. The Woodforde, the Lander, the Hansen, Gidyea, Napperby and Day Creeks have large flood plains.

The drainage pattern of the area is complex with most of the river headwaters in the Reynolds Range. Much of the drainage has been superimposed on the present day landscape. This is particularly well demonstrated by Napperby Creek which has its headwaters in the Reynolds Range and flows south across the Uldirra Hill to Mount Freeling Divide and cuts through the Stuart Bluff Range to flood out into a salt lake. The watercourses are dry for most of the year but have a few permanent waterholes. The largest are South 20 mile water hole on Napperby Creek and Annas Reservoir on Wickstead Creek.

PREVIOUS INVESTIGATIONS

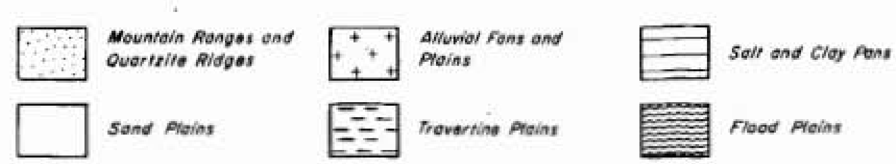
John McDouall Stuart (1861), during his hourney across Australia, was the first explorer to cross the Napperby Sheet area. His geological observations were few but he named the Reynolds Range, Mount Freeling, Mount Harris, Mount Finniss, Reaphook Hills and Bluff Ranges (later recognised by Gosse (1873) as Stuart's Bluff Ranges), the Hanson and Woodforde Rivers, Wickstead Creek and Annas Reservoir. It was in the Reynolds Range that Stuart found traces of copper, near Mount Freeling; the occurrence proved to be the only signs of mineralisation found on this exploratory journey.

Fig. 3

PHYSIOGRAPHIC DIVISIONS

MAIN TOPOGRAPHIC FEATURES AND ACCESS ROUTES

NAPPERBY SHEET AREA



To accompany Record 1969/85

F 53/A9/6

The Overland Telegraph was completed by 1872 and crosses the eastern part of the Napperby Sheet area. The telegraph line closely followed Stuart's exploratory track and it was from a point on this telegraph line, about 120 miles north of Alice Springs, that W.C. Gosse (1873) set out on his exploratory journey west of the telegraph line. Gosse named several topographic features on this journey notably Lander River, Mount Thomas, Mount Gardiner, the Giles Range, Warburton and Cockatoo Creeks, Quartz Hill and Crown Hill. Gosse mentioned "mica slate" in the Reynolds Range near Mount Gardiner and also occurring in the Giles Range, whilst he mistakenly identified "coarse granite" at the top of Crown Hill, observed quartz and gneiss at Quartz Hill and believed West Bluff in the Stuart Bluff Range to be composed of gneiss.

Winnecke (1882) built trig. points at Mount Ewart and Mount Boothby, camped on the Lander and Woodforde Rivers and saw Gosse's tracks. His only geological observation concerning this area was to state that Tea Tree Well was 20 feet deep 'through Limestone rock'.

Threadgill (1922) wrote a comprehensive account of all exploration in South Australia and the Northern Territory between the years 1856-1880.

In 1906, W.R. Murray (1907) in his prospecting operations south-west from Barrows Creek and the Davenport Ranges visited the Reynolds Range, which he called the Buxton Range. He described quartz reefs in mica schists north-east of Mount Freeling and decided that the Range was mostly barren quartzite. His map is of interest in that it shows 'Old 30 mile station' at the site of the present day Napperby Homestead and his 20 and 30 mile creeks are now known as Day and Napperby Creeks. Murray mentions a small vein of galena occurring north-east from Old 30 mile station and ironstone reefs, which did not produce gold, in the Reynolds Range (these may be Barneys ironstone deposits, discussed by Ryan, 1958).

Chewings (1928) studied the quartzites and slates in the Hann and Stuart Bluff Ranges. He correlated these rocks with the 'Heavitree Gap Quartzite' and other similar quartzites in the northern part of the Amadeus Basin.

Tindale (1933) published geological notes on his journey from the Hann Range to Cockatoo Creek. He divided the rocks seen into five divisions:

" A. Metamorphic series of Archaean age

B. Granites intruded into the Archaean rocks

C. Giles Range Series. These are tentatively considered to be of older Proterozoic age and may represent the northern equivalents of the Pertaknurra Series as defined by Mawson and Madigan

D. Hann Range - Uldirra Hill - Crown Hill series of unmetamorphosed quartzites, arkose grits and conglomerate

E. Consolidated grits and recent deposits of the Mamba Plain, Ngalia Plain and the Lander Valley. "

Tindale recognised that the Hann Range - Stuart Bluff Range formed the 'southern marginal beds which form a shallow synclinal fold, the Ngalia Syncline.' This is the first known use of the name - Ngalia Syncline. It has been subsequently revised by Wells et al. (1968) and called the Ngalia Basin.

The Aerial, Geological and Geophysical Survey of North Australia (1941) published brief descriptions of mineral deposits at Brooks Soak (wolfram), Mount Stafford (tin), and Aileron (gold). Of these only the Mount Stafford tin deposit has been exploited.

Private companies have maintained a sporadic interest in the mineral deposits and mineral potential of the Napperby Sheet area. Thomson (1948) made a reconnaissance for Zinc Corporation of the area surrounding the Reward Copper Mine (Davies and Southion's Prospect) and briefly mentioned a few other minor mineral occurrences.

Pacific American Oil Company took out an Oil Permit over the Ngalia Basin and commissioned Fitzpatrick and Webb (1963) to report on the geology of the Basin. This report was based on photo-interpretation by Fitzpatrick (1963).

Geophysical work was undertaken for Pacific American Oil Company by Geophysical Associates Pty Ltd who carried out a gravity survey (Nettleton 1965) and seismic survey (Hudson and Campbell 1965). An airborne magnetometer survey of the Napperby area by Aeroservices Ltd was interpreted by Hartman (1963) for Pacific American Oil Company.

The quartz-hematite veins occurring south of the Stuart Bluff Range and Reaphook Hills have aroused company interest. Layton (1965) wrote a report for Geolsite Associates on Prospecting Authority 1378 which covered the quartz hematite veins south of the Stuart Bluff Range near Mount Hammond.

A detailed regional investigation of the mineral potential of the rocks north of the Ngalia Basin was carried out by Australian Geophysical Pty Ltd (1967) who mapped a large area in the northern Reynolds Range, sampled stream sediments and drilled four diamond drill holes in the Pine Hill area. The results were disappointing and the Company relinquished their Authorities to Prospect.

The Bureau of Mineral Resources has been actively engaged in the geological exploration of small parts of the Napperby Sheet area for several years. Since 1953 the Resident Geologists Staff at Alice Springs have made brief visits to localities on the Sheet area.

Jones (1954) visited the quartz hematite veins near Patty Well but the first detailed work on the geology of the area was carried out by Ryan (1958) who commented on the geology and mineral deposits of the Reynolds Range area. Quinlan (1962) gave a brief outline of the geology of the Ngalia Basin and Milligan (1964) examined the rocks exposed in the Hann Range. A photogeological map was prepared by J. Rivereau (1965) at the start of a joint programme of geological mapping and geophysical investigation of the Ngalia Basin by the Bureau of Mineral Resources. In 1962 P.J. Cook briefly examined some of the sediments exposed on the Napperby Sheet area and revisited the area in 1964. Petrographic descriptions of the rock samples were carried out by I.F. Scott of the Australian Mineral Development Laboratories and the results of the field and petrographic work were the subject of an unpublished record (Cook and Scott, 1966) and a published report (Cook and Scott, 1967).

Geophysical work by exploration companies was supplemented by the Bureau of Mineral Resources work; Flavelle (1965) commented on the gravity data obtained from the Napperby Sheet area. This data is also discussed by Whitworth (1969, in prep.). A seismic survey across the Ngalia Basin near Napperby Creek is reported by Tucker (1969, in prep.) and discussed by Smith (1968). Detailed geological mapping of the adjacent Mount Doreen Sheet area by Wells et al. (1968) began in 1967 and this work greatly assisted the interpretation of the geological and structural history of the Ngalia Basin on the Napperby Sheet area.

The water resources of the Napperby Sheet area have been discussed by Jones and Quinlan (1962) in their report on the water resources of the Alice Springs area. Edworthy has written an unpublished report on the groundwater resources of the Lander River area (Edworthy, 1968) and has carried out a preliminary appraisal of the groundwater resources of the Tea Tree groundwater basin (Edworthy, 1966). A record of most water bore locations on the Sheet area is available in Kingdom, Woolley and Faulks (1967).

The geomorphology of the Alice Springs area, which includes the Napperby Sheet area was discussed by Mabbutt (1962) and a comprehensive account of the land systems of the area is given by Perry, Mabbutt, Litchfield and Quinlan (1962).

STRATIGRAPHY

GENERAL

The sedimentary formations mapped on the Napperby Sheet area are continuous with those previously recognised and described in the adjacent Mount Doreen Sheet area to the west.

The three formations which crop out in the eastern part of the Ngalia Basin on this Sheet area are the Vaughan Springs Quartzite, the Kerridy Sandstone and the Mount Eclipse Sandstone.

The Vaughan Springs Quartzite rests unconformably on Pre-Cambrian crystalline basement and is believed to be Proterozoic in age. The Kerridy Sandstone is only exposed in one small area in the western part of the Sheet area. It is probably Ordovician in age. The poorly exposed Mount Eclipse Sandstone contains Carboniferous fossils and is the youngest sedimentary formation in the Ngalia Basin. Many of the formations forming the Ngalia Basin sequence are either not exposed or not present on this Sheet area.

Cainozoic sediments cover a large area and from shallow drilling evidence are in places over 800 feet thick. Isolated outliers of sediment are present at Crown Hill, Nancy Hill and near Tea Tree. They are believed to be Proterozoic in age.

The Pre-Cambrian igneous and metamorphic basement is best exposed on the northern part of the Sheet area and many rock types are present. A few outcrops of granite crop out to the south of the Ngalia Basin.

Sections were measured through the Vaughan Springs Quartzite in the Stuart Bluff Range and in the ranges south-west of Napperby Homestead. These are shown in Plate 1.

PRECAMBRIAN BASEMENT

Geological outline of the basement

The eastern part of the Ngalia Basin is bound to the north by a series of northwest- to west-northwest-trending ranges which consist of igneous and metamorphic Precambrian rocks. Reconnaissance observations in this area were conducted by Ryan (1958). Three important ranges can be defined, the central and the highest one being the Reynolds Range. In this report, the two other ranges are designated as the southern range and the northern range respectively. The southern range branches off the Reynolds Range in the Mount Dunkin area. Extensive basement outcrops also occur north of the northern range, and south of the Stuart Bluff Range and the Hann Range.

The Reynolds Range extends between an area approximately 10 miles east of Aileron, and the Coniston area, where it is replaced by the Giles Range. The highest point within the range is Mount Thomas. The Reynolds Range consists of a low-grade metamorphic sequence, comprising mainly schists and quartzites which occur as prominent ridges, separated from one another by valleys entrenched in the softer schists and gneisses.

The southern range consists mainly of granitic gneiss. From east to west it becomes morphologically less continuous, grading into a series of low hills and domes, displaying the morphology characteristic of granite and gneiss outcrops. The northern range runs northwest of the Hanson River, and continues into the adjoining Mount Peake Sheet to the north. It is separated from the Reynolds Range by the Lander River valley which in the area near Pine Hill homestead is surrounded by granites and granitic gneisses. The northern range consists of high-grade metamorphic rocks and associated granitic gneiss.

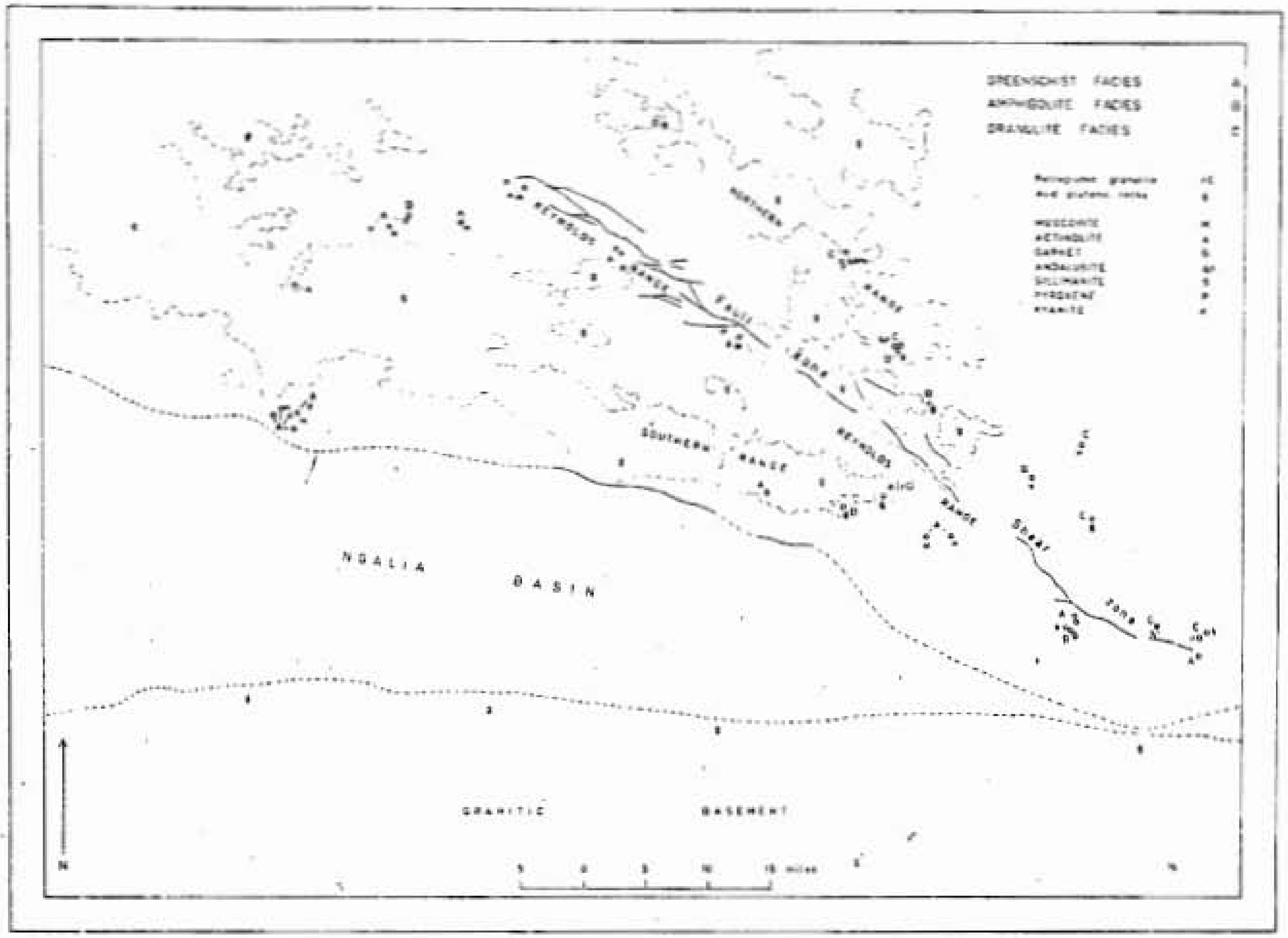


Fig. 4 METAMORPHIC ZONATION MAP-NAPPERBY SHEET AREA

To accompany Record 1969/85

F 53/A9/7

Geologically it may be considered a part of the high-grade metamorphic belt east and north of Aileron.

The morphological division expressed by the ranges thus broadly corresponds to the geological division of the basement with a southern zone of granitic-gneiss, a central low-grade metamorphic zone, and a northern high-grade metamorphic zones (Fig. 4). The central and northern zones are separated from one another by a zone of granites, as well as by a major shear zone, which runs in a northwesterly direction between Pretty Camp Dam (east of Aileron) and Nolens Dam (northwest of Aileron). Possible extensions of this shear zone may be represented by faults in the area south of Pine Hill. In the field, the shear zone may be over one mile wide and consists of numerous narrow parallel shears heavily intruded by quartz veins, and unsheared zones of gneissic granite. The shear zone constitutes a boundary between low-grade metamorphics and high-grade metamorphics on the south and on the north respectively. Granitic gneisses may occur on either side. The significance of this structural feature, considered to be a major line of displacement, will be discussed in the concluding section.

Petrography of major rock types*

Acid igneous and meta-igneous rocks

Granites and altered granites. Little-altered granites are common in the Napperby Sheet area, and were recorded from the Mount Denison - Coniston area, from an area northwest of Pine Hill, and from several other areas in the Reynolds Range and south of the Stuart Bluff Range. The granites consist of fine- to coarse-grained aggregates of microcline, plagioclase (mostly oligoclase), and quartz, in approximately equal proportions, with biotite, sericite, and muscovite occurring as major accessories, and zircon, tourmaline, calcite, apatite, sphene, metamict allanite, chlorite and iron ores as possible minor constituents. Hypidiomorphic-granular textures are commonly retained, and the textural relationships suggest an early crystallisation

* For individual specimen descriptions, refer to Appendix I

of plagioclase, and a late crystallisation of potash feldspar and quartz. The widespread sericitisation of the plagioclase and the occurrence of epidote in association with biotite, testify to deuteric or weak metamorphic effects. The microcline is usually slightly clouded. Dynamic metamorphism of granites is common along faults and shear zones, where development of mortar textures and cataclastic fabrics may be well pronounced. Cataclastic and mylonitic granites are displayed by specimens 68.66.0031 B, and 68.66.0020C. Alteration and weathering processes are represented by development of sericite and clay veinlets, by hematite impregnations, and by exsolution of iron ore from biotite.

Granitic gneiss (orthogneiss) - Granitic gneisses constitute the most widespread intrusive bodies in the Napperby Sheet area, and occur both as extensive batholiths and as small-scale intrusions, the long axes of which are broadly sub-parallel to the strike of adjacent metamorphic rocks. The most extensive orthogneiss bodies in the area occur in the southern range, whereas numerous smaller bodies are widespread both north and south of the Ngalia Basin.

The granitic gneisses are difficult to discern from unmetamorphosed granites on the air photos. In outcrop, they display weakly-developed to well developed segregation banding, with biotite-rich lamina alternating with quartzo-feldspathic bands. Augen orthogneisses are rare. Undulating gneissosity is not uncommon (Fig. 5), and is caused by drag folding of the gneisses along parallel shear planes. The time relationships between the granitic gneisses and the metamorphism may be indicated by the deflection of the bedding and foliation of meta-sedimentary units around intruded granitic gneisses, which appears to favour syn-metamorphic intrusion. This conclusion is supported by the development of andalusite at the expense of biotite in schists adjacent to orthogneiss contacts, with the biotite probably representing a regional metamorphic growth which preceded the contact metamorphism. The mineral assemblages of the granitic gneisses differ little from those of the granites described in the earlier section, and are considered their metamorphosed equivalents.

A continuous transition from orthogneisses with relict hypidiomorphic-granular textures to gneisses with mortar textures and granoblastic textures associated with a high degree of metamorphic differentiation, can be demonstrated. The biotite is crudely aligned, and the feldspar and quartz may show various degrees of recrystallisation. Other metamorphic effects are the development of muscovite at the expense of sericite, and possibly the crystallisation of epidote at the expense of biotite.

Some gneisses have plagioclase-microcline-quartz ratios deviating from those of normal granites (cf. 68.66.0066). This feature may be representative of either metasomatic changes of the original composition, or of a sedimentary parenthood of the gneiss. Contamination of the original granite by sedimentary material is another possibility.

Garnet- and sillimanite-bearing orthogneisses - Granitic gneisses cropping out in the vicinity of granulites commonly include garnet as a minor constituent. The mineral assemblages of these rocks are otherwise compatible with those of garnet-free orthogneisses. The garnet is usually, but not necessarily, developed at the expense of biotite, and commonly occurs as xenoblastic poikiloblasts enclosing quartz and biotite. In one specimen (68.66.0092) the garnet is partly replaced by chlorite along cracks. The plagioclase composition of garnet-bearing granitic gneisses ranges between oligoclase and andesine. The potash feldspar may be microperthitic. These characteristics are consistent with a definition of these rocks as medium- to high-grade metamorphosed granites.

Some gneisses with a generally granitic composition, contain minor amounts of sillimanite and andalusite, which point to a high-grade origin of these rocks. (cf. 68.66.0068c, 68.66.0058A). The sillimanite is commonly developed at the expense of the mica, and to a lesser extent of the feldspar.

Meta-granodiorites - Meta-granodiorites are comparatively rare in the Napperby Sheet area, and were observed near Tea Tree (on the Stuart Highway), and south of the Stuart Bluff Range. In outcrop, these rocks can be distinguished from granitic gneisses by their higher biotite content, which is approximately 20 percent. The mineral assemblages of the granodiorites consist of plagioclase (oligoclase-andesine), quartz, biotite, and minor potash feldspar. The plagioclase is usually sericitised to varying degrees. Epidote, apatite, chlorite, amphibole, zircon and iron ores are common accessories. The rocks are metamorphosed to varying degrees, as represented by the transition from hypidiomorphic-granular to gneissose textures, and by the development of garnet in some meta-granodiorites (cf. 68.66.0061).

Porphyries

A conformable body of porphyry was mapped east of Mount Thomas, and two isolated occurrences observed eight miles south of Uldirra Hill, and two miles northeast of Crown Hill. The porphyries consist of phenocrysts and clusters of phenocrysts of plagioclase (albite-oligoclase), microcline and quartz. The feldspar is usually idiomorphic to hypidiomorphic, whereas the quartz crystals are deeply embayed, presumably through magmatic resorption. Biotite is usually present, and may occur as aggregates pseudomorphic after (?) primary biotite. The phenocrysts are set in equigranular microcrystalline matrices of feldspar, quartz, sericite and biotite, with iron ores, tourmaline and chlorite forming common minor constituents. The varying degrees of shearing indicate the porphyries have been affected by the regional metamorphism, mainly represented by alignment of the biotite and sericite (cf. 68.66.0624B). Basic porphyries (porphyrites) are also present and are characterised by actinolite and biotite-rich matrices, with the latter mineral being the younger phase.

The metamorphosed porphyries represent hypabyssal intrusions, which may have been genetically related to the orthogneiss. The resorption of the quartz phenocrysts reflects a reduction in stability of this mineral upon magma ascent from high- to low-pressure crustal levels.

Basic meta-igneous rocks

Low-grade basic meta-igneous rocks - Amphibolites, epidosites, tremolite schists, actinolite schists, and prehnite-chlorite-calcite schists, occur within the basement of the Napperby Sheet area as conformable bodies and as dykes. The retention of relict sub-ophitic and basaltic textures by some of these rocks, as well as the magnesia- and iron-rich compositions of the basic schists, indicate an igneous origin. It is possible, however, that some of the basic schists have originated through the metamorphism of calcareous-magnesian shales. The presence of actinolite-tremolite, epidote, and chlorite in these rocks, indicate lower to middle greenschist metamorphic facies. Quartz is a common constituent. Accessory minerals include sphene, clinozoisite, apatite, calcite, biotite, ilmenite and magnetite. Where calcic plagioclase has been preserved, it is usually highly saussuritised, and/or recrystallised to albite. Veinlets of epidote, carbonate minerals, prehnite and quartz testify to the importance of metasomatic processes in the metabasites. Where biotite is present, it occurs as a relatively younger phase developed at the expense of amphibole, probably as a result of metasomatic introduction of potash (cf. 68.66.0611). Introduction of lime is represented by replacements of chlorite by prehnite, as well as by veinlets of calcite (cf. 68.66.0609). Introduction of iron may be deduced from replacements of tremolite by epidote (cf. 68.66.0608).

Some low-grade metabasites occur within high-grade metamorphic belts, which suggests their intrusion at a late-metamorphic stage. Alternatively, a second stage of regional metamorphism postdating the stage at which the granulites have formed is indicated by the low-grade metabasites. In any case, the basic metamorphic rocks cannot be used as facies indicators with respect to the major phase of regional metamorphism.

Hornblende-labradorite amphibolites - Amphibolite-grade hornblende-labradorite assemblages are associated with two pyroxene granulites along the northern range. A complete transition between pyroxene-free amphibolites and pyroxene granulites can be demonstrated, the variations are probably a result of differences in water pressure rather than of different temperature and pressure.

The major constituents of the amphibolites are green hornblende, brown hornblende, and labradorite. Quartz, epidote, magnetite, pyrite, apatite, sphene, clinozoiste and albite may occur as minor primary constituents and as alteration products. Prograde metamorphism reached the amphibolite facies, and was accompanied by retrograde effects, responsible for marginal replacement of hornblende by rims of actinolite, for the development of biotite at the expense of amphibole, and for the saussuritisation of labradorite and growth of clinozoisite.

Basic granulites - Pyroxene-labradorite granulites and hornblende-pyroxene-labradorite granulites occur either as continuous bodies or are interbanded with acid granulites in the northern range, and east of Aileron (Fig. 6). A complete transition from amphibolites to amphibole-free pyroxene granulites takes place over short distances. Thus, amphibolites with rims of granular pyroxene around hornblende (cf. 68.88.0052A, 68.66.0053A) grade into pyroxene granulites with inclusions of hornblende within pyroxene (cf. 68.66.0052B, 68.66.0068A). Most basic granulites comprise both hypersthene and diopside, but rocks consisting only of orthopyroxene or clinopyroxene occur. The labradorite is usually relatively free of clouding, except in granulites showing effects of retrogressive metamorphism. Quartz may constitute an important minor constituent, and magnetite, sphene, biotite and tourmaline are common accessory minerals. The mineral composition is suggestive of an origin from metamorphosed basic igneous rocks.

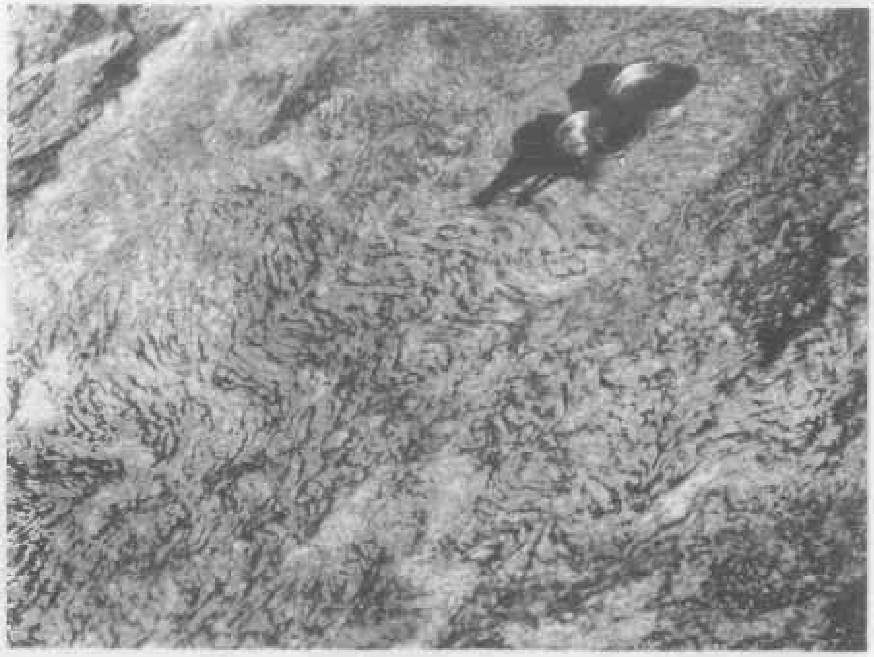


Figure 5 - Undulatory banding in granitic gneiss near Mount Freeling, Reynolds Range. The structure resulted from drag-folding along a parallel set of shear planes oriented parallel to the axis of the Brunton compass. (GA/1587)

Figure 6 - Interbanded and intertonguing horizons and lenses of acid and basic granulite, intruded by granite pegmatite, north of Pine Hill, northern range. (GA/1579)

The basic granulites may display varying degrees of retrogressive metamorphism. Thus, the pyroxene may be rimmed by tremolite, the hornblende may be rimmed by actinolite (cf. 68.66.0070), and the plagioclase may be rimmed by epidote (cf. 68.66.0055A). Clinozoisite, epidote, tremolite and actinolite are common minor constituents of retrograded granulites.

Meta-sediments and acid metamorphics of uncertain origin

Relict primary features - The low-grade metamorphic series of the Reynolds Range include a wide variety of micaceous and quartzo-feldspathic schists, with which metamorphosed quartzite beds are commonly intercalated. With the exception of some meta-conglomerate schist occurrences (Fig. 7), the schists display little or no primary structural or textural features. Associated meta-siltstones, on the other hand, usually show relic primary lamination and fine-scale grading features. Likewise, finely banded and cross-bedded quartzites were observed in the basement (Fig. 8), and are useful for the determination of facing orientation. The occurrence of cross-bedded quartzites and meta-conglomerates suggests a shallow-water littoral environment of deposition. While some metamorphosed basic igneous rocks are incorporated in the sequence, it is quite possible that some of the quartzo-feldspathic schists represent metamorphosed acid volcanics. In the absence of primary volcanic features, however, this possibility cannot be proved.

Acid schists - The Reynolds Range consists mainly of alternating zones of low-grade schists and meta-quartzites. The acid schists consist of assemblages of muscovite, sericite, biotite, quartz, sodic plagioclase and potash feldspar, accompanied by iron ores, tourmaline, rutile, epidote, apatite, chlorite and zircon. The proportion of the major constituents, the grain size, and the texture of the schists vary over a wide range and a transition from phyllites to coarse-grained schists and porphyroblastic schists is present. Some meta-siltstones have retained primary sedimentary structure, such as lamination and grading, in spite of a complete recrystallisation of the main constituents (cf. 68.66.0037A). The quartz and feldspar grains are commonly elongated with the foliation, defined by the alignment of the mica. Porphyroblastic and glomeroporphyroblastic growth of quartz (cf. 68.88.0034B), and of quartz and feldspar (cf. 68.66.0091), are common. Metamorphic segregation is common in schists occurring in the proximity of high-grade metamorphic belts (cf. 68.66.0057B, 68.66.0091). Tourmalinised schists were observed in association with pegmatitic intrusions, with the tourmaline being clearly younger than the mica (cf. 68.66.0055B). Folding of the metamorphic foliation on a small-scale is represented by the lineation of many schists, whereas folding of the schistosity on a mesoscopic scale is less common (cf. 68.66.0091). Boudinage structure is well developed in an interbedded quartzite schist sequence near Mount Freeling in the Reynolds Range (Fig. 9).

The sequence of crystallisation as suggested by the textural relationships indicates an early crystallisation of sericite and chlorite, and a late crystallisation of muscovite and biotite, pointing to a transition from the lower greenschist facies to the middle greenschist facies. An origin of some low grade metamorphic rocks through the retrogressive metamorphism of higher-grade rocks is indicated by the occurrence of relict sillimanite (cf. 68.66.0102) and pseudomorphs of biotite after prismatic crystals of unknown origin (cf. 68.66.0112).

Garnet- and andalusite-bearing schists - Garnet- and andalusite-bearing schists occur in the proximity of granulitic belts and adjacent to contacts of low-grade schists with granites and orthogneisses. These schists are typically coarser-grained than lower-grade schists, and usually display a development of coarse-grained porphyroblasts of feldspar, of segregation banding, and of quartzo-feldspathic augen with micaceous bands. The plagioclase composition ranges between oligoclase and andesine, and the potash feldspar may display microperthitic structure. The mineralogy of these rocks suggests upper greenschist to lower amphibolite metamorphic facies. In the case of an andalusite schist occurrence near an orthogneiss contact (68.66.0106), a hornblende hornfels contact metamorphic facies

Figure 7 - Metamorphosed conglomerate, showing flattened quartzite pebbles embedded in mica schist. Northern end of the Reynolds Range. (GA/1578)

Figure 8 - Cross-bedding in metamorphosed quartzite, Mount Singleton, Mount Doreen Sheet area. (GA/1539)

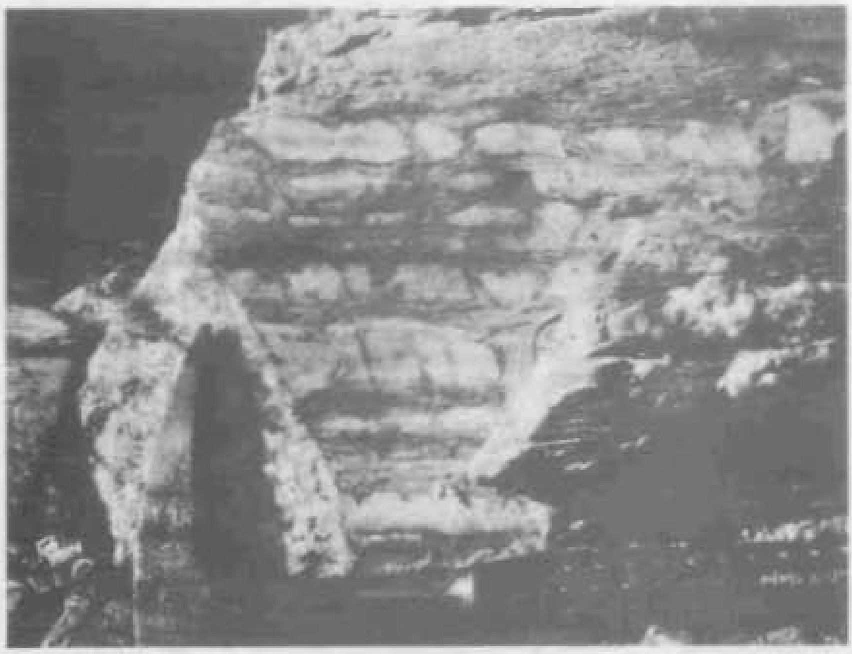


Figure 9 - Boudinage structure developed in an interbedded quartzite-schist sequence, near Mount Freeling, Reynolds Range. The schist is pressed into gaps between adjacent boudins. (GA/1581)

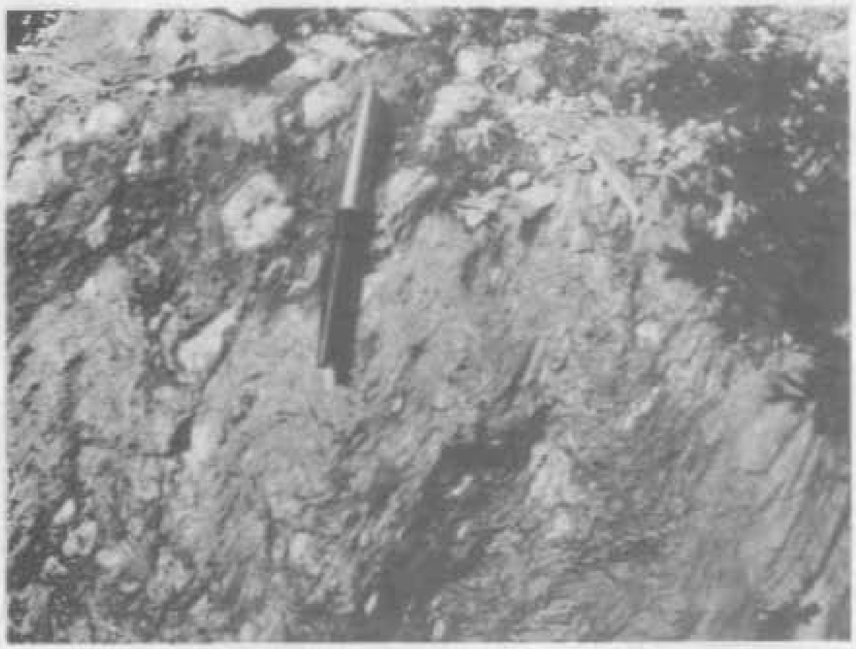


Figure 10 - Folded porphyroblastic schist, north of Pine Hill, northern range. Coarse-grained porphyroblasts of feldspar and lenses of quartz, are set in a biotite-rich matrix accompanied by minor garnet. (GA/1617)

is indicated. The accessory constituents of these schists include zircon, apatite, epidote, chlorite, rutile and magnetite. The sequence of crystallisation indicated by the textural relationships of garnet-andalusite assemblages, suggests that andalusite is the younger phase. Both garnet and andalusite tend to develop at the expense of biotite, and to retain quartz inclusions. Mesoscopic folding of the foliation is more common in garnet- and andalusite-bearing schists than in lower-grade schists (Fig. 10).

Granulites - Paragneisses, banded granulites, and basic granulites occur in a northwest-striking belt which includes the northern range and areas north and east of Aileron. The granulites are commonly intruded by granitic gneisses. They occur as banded fine- to medium-grained quartzo-feldspathic rocks, showing various degrees of metamorphic segregation. Fine-grained quartz-rich granulites can be easily mistaken for quartzites in hand-specimen. Folding on a mesoscopic scale is very common. In thin-section, the granulites consist of varying proportions of the following constituents: orthoclase (usually perthite), plagioclase (oligoclase-andesine), quartz, cordierite, sillimanite, garnet and biotite. Epidote, zircon, rutile, spinel, magnetite, andalusite, chlorite, pinite and sericite, may occur as minor components. Compositional segregation usually involves the development of quartz-feldspar-cordierite bands and biotite-sillimanite-garnet bands. Gneissosity and schistosity are invariably developed where biotite and sillimanite are present, whereas quartzo-feldspathic granulites tend to display xenoblastic equigranular textures. The sequence of crystallisation indicated by the textural relationships suggests an early crystallisation of biotite, and a late crystallisation of sillimanite, which may replace cordierite and garnet. Andalusite and sillimanite are commonly developed at the expense of biotite. The co-existence of biotite with sillimanite and spinel (68.66.0052D), points to disequilibrium of some of the high-grade assemblages, probably due to retardation of the metamorphic reactions. The co-existence of andalusite and sillimanite may support this conclusion, although this association is not uncommon in high-grade terrains (Pitcher, 1965). The occurrence of sillimanite and spinel indicates the acid granulites lie within the upper amphibolite facies-granulite facies interval. A more precise definition of the metamorphic facies is suggested by the pyroxene granulites, which are closely associated in space with the acid granulites, and which indicate the hornblende granulite facies. The presence of andalusite and absence of kyanite indicate that the rocks correspond to the low-pressure facies series of Miyashiro (Zwart et al., 1967). Slight retrogressive metamorphic effects are indicated by a partial replacement of cordierite by pinite, clouding of the plagioclase, and alteration of biotite to chlorite.

The acid granulite may have originated from sandstones, argillites, and acid to intermediate volcanic rocks. High-alumina and high-magnesia compositions of cordierite- and sillimanite-rich granulites, indicate their derivation from magnesian shales. The presence of alumino-silicates implies high alumina to potash ratios of the original rocks.

Structural, igneous and metamorphic evolution of the Reynolds Ranges

Structure

The metamorphic belts of the Reynolds Range and the northern range display a relatively simple structural pattern, with northwest and west-northwest-trending isoclinal folds predominating. The trend of the fold axes is relatively consistent, but may be locally deflected around granitic intrusions. The plunge of the major folds must be near horizontal or of low angles, for only in a few places have large-scale fold closures been observed. Small-scale folds with steeply plunging axes have been observed in several localities. (Figs 11, 12, 13). The discrimination of anticlines from synclines is usually hampered by the scarcity of facing data. The principal structural guide horizons in the Reynolds Range are furnished by quartzite beds, which are particularly well developed in the northwest, where they afford the delineation in detail of the folding and faulting pattern. The faults in this area have considerable strike-slip

Figure 11 - Ptygmatically folded quartzitic bands in a quartzite-meta-siltstone sequence, near Mount Freeling, Reynolds Range. (GA/1596)

Figure 12 - Folded banded quartzite, west of Mount Dunkin, southern range. (GA/1585)

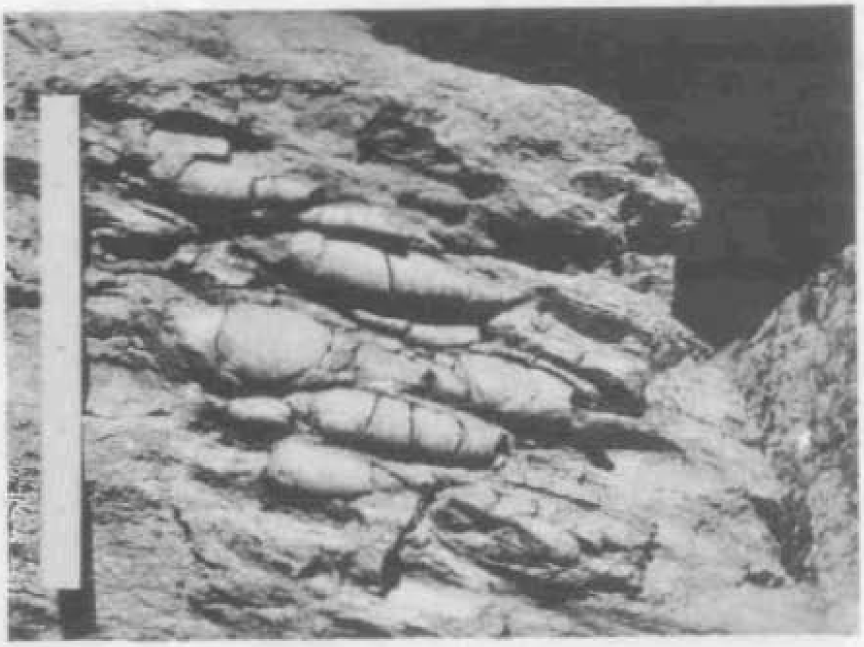


Figure 13 - Small-scale folding in schist, viewed on the foliation planes. Near Mount Singleton, Mount Doreen Sheet. (GA/1618)

components. Faulting is of relatively minor importance in the central part of the Reynolds Range, where quartzite ridges extend undisturbed over considerable distances along the strike. A major shear zone which separates the low-grade from the high-grade metamorphic zones, was described earlier.

The folding has been followed by the development of a regional flow-cleavage system. Wherever the relationships could be assessed, the foliation and the bedding were observed to strike at parallel orientation or at low angles to one another. The foliation is only weakly developed in the quartzites, and is usually parallel to the gneissosity of the associated gneisses. Where the foliated metamorphic rocks are deflected around intrusive orthogneiss, the foliation is deflected with the bedding, whereas the gneissosity remains parallel to the regional trend. These conclusions are based on only a few observations and must be considered as tentative.

The schistosity planes of pelitic schists commonly display a well developed lineation set, pitching with varying angles. Pitch angles up to 50° were measured. The problem as to whether the lineation is parallel to the axes of the folds, or is a reflection of a fracture cleavage set, is unclear at present, and its elucidation would require detailed structural mapping. The variations in the orientation and degree of pitch of the lineation may be interpreted in terms of cross-folding of an originally consistent lineation set.

Igenous Activity:

With the exception of the syn-depositional volcanic activity, which is represented by basic metamorphic rocks and possibly by acid schists and granulites which could be derived from volcanic rocks, the following groups of igneous and meta-igneous rocks were observed:

Granitic and granodioritic orthogneiss.
Acid porphyries (metamorphosed)
Doleritic and basaltic sills and dykes (metamorphosed).

The earliest and by far most extensive intrusive phase is represented by the granitic gneisses which constitute large-scale batholiths, and by smaller discordant to sub-concordant bodies intruded into both the low-grade and the high-grade metamorphic belts. The emplacement of these rocks probably took place during regional metamorphism, as suggested by the deflection of the foliation of associated schists, coupled with the metamorphosed state of the gneisses.

The time relationships of the porphyries are suggested by their metamorphic state. The porphyries occur as conformable bodies incorporated in the metamorphic sequence. It is likely these rocks represent volcanic or hypabyssal bodies emplaced contemporaneously with geosynclinal deposition. Alternatively, these rocks could be genetically related to the granitic gneisses.

The emplacement of the doleritic and basaltic dykes must have postdated the major phase of regional metamorphism, since low-grade metamorphosed dolerite dykes were observed near granulites in the northern range. The low-grade metamorphism of the dykes implies either emplacement during the waning stages of regional metamorphism or a second phase of greenschist facies metamorphism. The basic intrusions postdated the emplacement of the granitic gneisses, as is demonstrated by their occurrence within gneissic terrains (Figs. 14, 15). No unmetamorphosed basic igneous rocks were encountered in the Napperby Sheet area, although fresh olivine dolerires and basalts are known from dykes in the adjacent Mount Doreen Sheet area.

Metamorphism:

The metamorphic assemblages observed in the Precambrian basement display a wide petrographical variety, corresponding to metamorphism of the lower greenschist facies-hornblende granulite facies range. The variations in the metamorphic facies afford a division of the metamorphic terrain into two major belts, as follows:

> Greenschist-facies metamorphic rocks of the Reynolds Range.
> Granulite-and amphibolite-facies rocks of the Northern Range, extending southeastward to the Aileron area.

Figure 14: A metamorphosed basic dyke intruded into banded granitic gneiss in Day Creek, southern range. The basic dyke consists of a sheared biotite-albite-quartz metabasite, and is intruded by quartz veins. The foliation of the metabasite is parallel to the dyke walls, implying its origin due to wall pressures, rather than from the regional stress field. GA/1612.

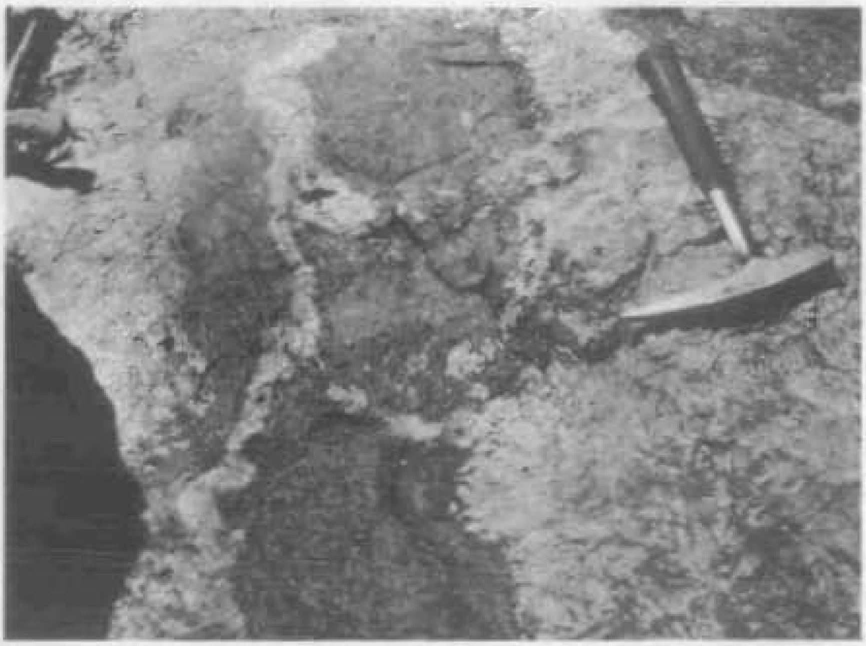


Figure 15: Remnants of a metamorphosed basic igneous rock engulfed by granitic gneiss at Day Creek, southern range. GA/1613

These zones are separated from one another by the intrusive granites of the Lander River Valley and by a major shear zone. Assuming an originally gradual transition between metamorphic zones of different grade, the occurrence of low-grade schists and granulites to the south and north of the shear zone respectively may signify a major displacement along this line. Since the high-grade rocks can be assumed to have been originally derived from lower structural levels than the low-grade rocks, an upward movement of the northern block is implied. The picture is complicated by the discovery of a retrograded granulite in the Reynolds Range, which could be interpreted in terms of a retrogressive origin of at least certain segments of the low-grade zone. The retrograde metamorphism could be associated with thrusting of basement sheets over the Ngalia Basin sediments. Such inferences, however, will have to be assessed by more detailed investigations in the area.

The presence in the metamorphic assemblage of andalusite and cordierite, and the absence of staurolite and kyanite (which has been encountered only in quartz-kyanite veins), implies a classification of the metamorphic terrain in the low to intermediate-pressure facies series type of Miyashiro (1961). The presence of andalusite, cordierite and garnet in the regionally metamorphosed assemblages, renders a distinction of the latter from andalusite-bearing contact metamorphic rocks rather difficult, particularly where the gneisses are associated with metamorphic rocks of the upper greenschist or lower amphibolite facies.

The close association in space of pyroxene-labradorite granulites, hornblende-pyroxene-granulites, amphibolites, and garnet schists, observed north of Pine Hill and east of Aileron, points to variations in the physical conditions within the high-grade belt. These variations may well have issued from differences in water pressure within this zone, with the sections with higher water pressure being characterised by wider stability fields of micas and amphiboles. An alternative explanation is a disequilibrium metamorphic condition resulting in a retardation of the metamorphic reactions. Metamorphic terrains with mixed amphibolite-facies and granulite facies assemblages are not uncommon, and have been reported by many workers (cf. Williams et al., 1954, p. 237).

Retrogressive metamorphic effects are widespread in the high-grade belt, and include chloritisation of garnet and biotite, marginal replacement of pyroxene by tremolite and of hornblende by actinolite, and development of epidote at the expense of calcic plagioclase. Whether these effects reflect changes during the waning stages of regional metamorphism, or a second stage of low-grade regional metamorphism, is uncertain. The occurrence of low-grade metamorphosed dolerite dykes in the high-grade zone appears to support the latter possibility.

Sequence of events:

The information discussed above, affords a tentative delineation of the sequence of tectonic, igneous and metamorphic events, as follows:

1. Sedimentation and volcanic activity. The abundance of cross-bedded orthoquartzites and occurrence of conglomerates, suggests a shallow-water environment. Volcanic activity was relatively of minor importance, and included minor basic volcanism, and possibly some acid volcanism.
2. Isoclinal folding on northwest-trending, horizontal to mildly plunging fold axes.
3. Regional metamorphism varying from low greenschist to hornblende granulite facies, development of foliation. Local folding of the foliation, and development of lineation.
4. Syn-metamorphic emplacement of extensive granites, resulting in local flexuring of the metamorphic series and in contact metamorphic effects.
5. Waning of the regional metamorphism.
6. Intrusion of doleritic dykes.
7. Greenschist-facies metamorphism, resulting in retrograde metamorphism of the granulites. This event may have been associated with orogenic movements including thrusting of basement segments over the Ngalia Basin sediments.

PROTEROZOIC

VAUGHAN SPRINGS QUARTZITE

The Vaughan Springs Quartzite is defined (Wells et. al. 1968) as a tough, pink, white and grey massive to thick bedded ortho-quartzite and in places a white, friable sandstone which weathers pink to red-brown. At the base of the section there is commonly a local basal conglomerate and pebbly hematitic conglomerate. On the Napperby Sheet area an arkose is locally present at the base of the formation in the Stuart Bluff Range. The formation derives its name from Vaughan Springs in the north-west quadrant of the Mount Doreen Sheet area. The type section is EX-11 in the Vaughan Springs Syncline on the Mount Doreen Sheet area.

Many of the early explorers and geologists who visited central Australia and travelled north from Alice Springs crossed the eastern part of the Ngalia Basin and saw outcrops of sediments but did not describe them. Tindale (1933)first described the rocks cropping out in the eastern part of the Basin; he referred to the "Hann Range - Uldirra Hill - Crown Hill series of unmetamorphosed quartzites, arkose grits and conglomerates". These have now been mapped in the Hann Range as the Vaughan Springs Quartzite. Ryan (1958) in his notes on the geology and mineral deposits of the Reynolds Range briefly referred to "Sandstone" south of Napperby Homestead and in the Hann and Stuart Bluff Ranges. This is now mapped as Vaughan Springs Quartzite. Cook (1963) described the sediments exposed on the Yuendumu Native Reserve and determined the stratigraphic position of the Quartzite. In 1963 Fitzpatrick and Webb (1963) carried out a geological reconnaissance of the southern margin of the Ngalia Basin for Pacific American Oil Company. This work was based on photointerpretation of the area by Fitzpatrick (1963). J. Rivereau (1965) photointerpreted the entire Ngalia Basin and this work delineated the areal extent of the Vaughan Springs Quartzite. Cook and Scott (1968) described the geology and petrography of the Ngalia Basin sediments. They informally named the quartzite "Unit A". Systematic geological mapping by Wells et. al. (1968) led to the revision of all earlier work and the formation was formally defined and named the Vaughan Springs Quartzite.

The type section, E11, is two miles west of Vaughan Springs and forms part of the western limb of the Vaughan Springs Syncline on the Mount Doreen Sheet area. In the type section the contact of the quartzite with the underlying Precambrian granite is not visible. The contact between the quartzite and the overlying Mount Doreen Formation in the syncline appears to be conformable. In other areas on the Mount Doreen Sheet area (e.g. the Naburula Hills) there is an unconformity between the two units.

The Vaughan Springs Quartzite is the base of the Ngalia Basin sequence and outcrops on the northern and southern margins of the Basin on the Napperby Sheet area. It extends as a long cuesta from the Stuart Bluff Range through the Reaphook Hills to the Hann Range and rests unconformably on Precambrian granite and metamorphics. These hills mark the southern limit of the Basin. The quartzite crops out sporadically along the northern margin of the Basin; the largest single exposure is three miles south-west of Napperby Homestead. (Fig. 16, 16A).

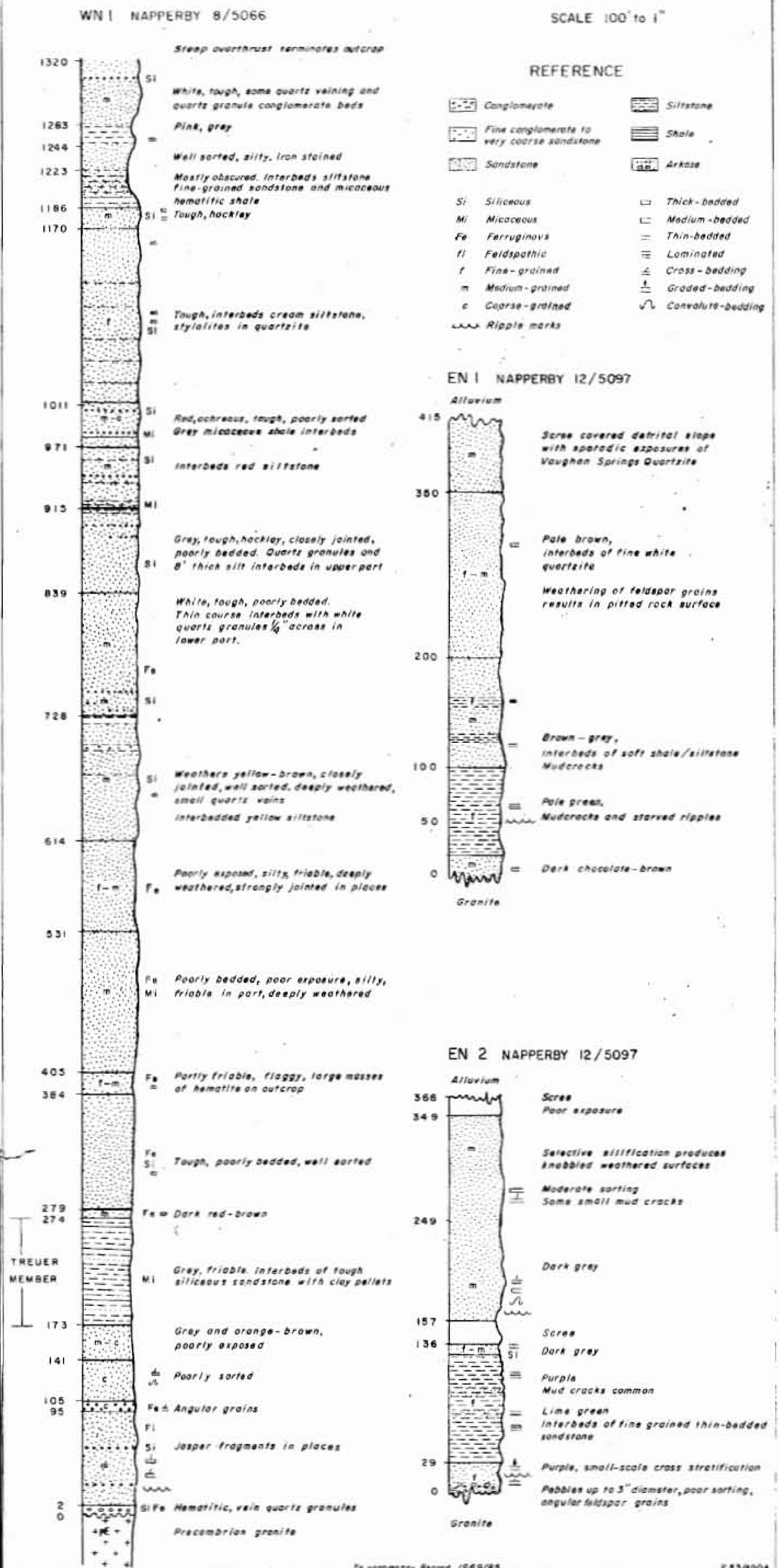
No sedimentary formation is in contact with the Vaughan Springs Quartzite on the Napperby Sheet area although two other formations are exposed.

Sections were measured through the Vaughan Springs Quartzite on the Napperby Sheet area at three localities. Sections EN-1 and EN-2 were measured in the Stuart Bluff Range near Mount Wedge Station, whilst section WN-1 was measured in the outcrops of quartzite approximately three miles south-west of Napperby homestead. All three measured sections are incomplete as the quartzite dips under alluvium at all three localities and the top of the formation is not exposed.

At section EN-1 the formation rests unconformably on porphyritic granite and is 415 feet thick. At the base of the formation there is an arkose with a few pebbly interbeds; within a few feet of the base interbeds of siltstone and shale about 75 feet thick are present. They are laminated to thin bedded, fine-grained, blue, green and red. The lower half of the formation exposed at this locality has more siltstone than quartzite. Mud cracks are well developed in the siltstone which grade upwards into typical quartz sandstone. The formation dips at 25° to the north and the top of the unit is covered by alluvium.

PLATE I

MEASURED SECTIONS IN THE VAUGHAN SPRINGS QUARTZITE NAPPERBY SHEET AREA



To accompany Record 1969/85

Figure 16: Aerial view of Vaughan Springs Quartzite and Treuer Member in the Ranges south west of Napperby Homestead.

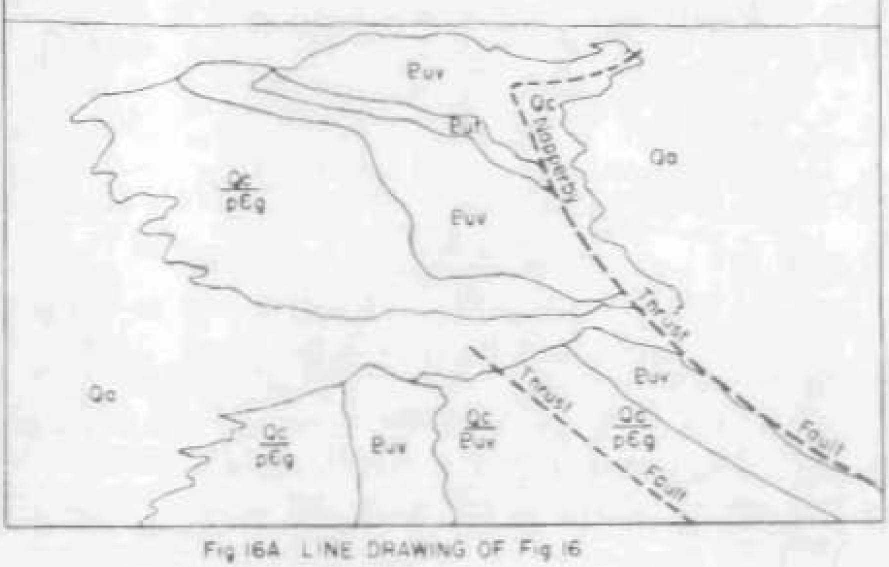


Fig 16A LINE DRAWING OF Fig 16

To accompany Record 1969/85 F 53/A9/8

Figure 16A: Line drawing of Figure 16. Ꞓuv - Vaughan Springs Quartzite, Ꞓut - Treuer Member. pꞒg - Granite, Qc - Colluvium, Qa - Alluvium.

Section EN-2 is almost identical in lithology to section En-1 and is 350 feet thick. This is also incomplete thickness due to the cover of alluvium obscuring the top of the formation.

Section WN-1, 1320 feet thick, was measured in the Vaughan Springs Quartzite about three miles south-west of Napperby Homestead. The Treuer Member of the formation is 100 feet thick in this section. A two-foot bed of hematitic, poorly sorted, siliceous conglomerate at the base of the formation is followed by a medium grained, siliceous sandstone with coarse angular sandy interbeds. Cross-bedding is common with variable size sets from 1 inch to 3 feet thick. Ferruginisation occurs at sporadic intervals throughout the formation which has a variable dip to the north from 24° up to 65°.

Lithological differences in the formation are noticeable between the eastern and western extremities of the southern ranges; there is a variable percentage of siltstone present in the formation and thick conglomerate beds occur at some localities.

The siltstone interbeds are best exposed and thickest near Mount Wedge Station, in the Stuart Bluff Range. They are finely laminated, micaceous with well developed mud cracks. Unidentifiable trace fossils were collected from these siltstones.

A conglomerate bed is well exposed near Cabbage Tree Gap. The bed may be up to 8 feet thick with the individual well rounded clasts ranging up to 5 inches in diameter. (Fig.17). The conglomerate is about 50 feet above the base of the formation. East of Cabbage Tree Gap the individual clasts decrease in size and the bed is closer to the base of the formation. West of Cabbage Tree Gap the conglomerate thins and eventually disappears.

Variations in the amount of iron present in the formation are noticeable. The quartzite is very ferruginous in places and there is a tendency in the ranges south-west of Napperby, for ferruginisation to be concentrated along joint planes (Fig.18) mainly in quartz sandstone immediately above the Treuer Member. Minor amounts of hematite are found in the quartzite in the Stuart Bluff Range.

Petrological study of the formation shows that it is mainly a fine to medium-grained orthoquartzite. The grains are sub-rounded to sub-angular and secondary silica overgrowths are common. The porosity of the rock is variable depending on the degree of silicification. The contact between the sand grains is in places sutured and occasionally the grains have a coating of iron oxide.

The outcrop of Vaughan Springs Quartzite, three miles south-west of Napperby homestead, is closely jointed with the larger joints parallel to the strike of the bedding; however, the joint pattern here is complex as a result of the tight folding and faulting of the formation. Where the quartzite is less deformed, along the southern margin of the basin, the joint pattern is less complex and is strikingly shown on the aerial photographs.

Sedimentary structures in the Vaughan Springs Quartzite are limited to cross stratification and current ripple marks whilst mud cracks are well developed in the siltstone interbeds seen in the Stuart Bluff Range. Stylolites are seen in the Vaughan Springs Quartzite at two localities; 15 miles west-south-west of Napperby Homestead at sample locality N203 and near sample locality N206, three miles west of the homestead. The stylolitic surface is marked by a thin deposit of iron oxide and has a relief of up to ¾" (Figs. 19, 20). Stylolites are formed in consolidated rock by pressure solution (Pettijohn, 1957), but they are not common in quartzite.

The Vaughan Springs Quartzite was deposited over a vast area extending from close to the Northern Territory - Western Australia border to approximately six miles east of the Stuart Highway on the Alcoota Sheet area. The environment of depositions was uniform over a vast area. The almost monomineralic nature of the formation suggests that the less stable minerals were broken up whilst in transit from a distant source area. Alternatively the absence of other minerals could have been caused by winnowing or may indicate that the formation was derived from the weathering and erosion of a sedimentary rock which had previously been sorted.

Figure 17: Conglomerate bed in the Vaughan Springs Quartzite near Cabbage Tree Gap. Neg. GA/1560

Figure 18: Vaughan Springs Quartzite replaced by hematite. Three miles south west of Napperby Homestead. Neg. GA/1568.

Figure 19: Styolites in the Vaughan Springs Quartzite 15 miles west south-west of Napperby Homestead. Neg.GA/1593.

Figure 20: Stylolites in the Vaughan Springs Quartzite. Three miles west of Napperby Homestead. Neg. GA/1586.

The cross stratification and current ripple marks indicate deposition under shallow water conditions. The basal sun cracked siltstones exposed in the Stuart Bluff Ranges suggest sub-aerial exposure of the formation for some time. The red colour of some of the siltstones may be due to the oxidation of iron during the dry sub-aerial period. The basal conglomerate and local arkose seen in the Stuart Bluff Range indicate that deposition was at first rapid but later deposition continued at a much slower rate.

The provenance of the formation is not known. It is the oldest formation in the Ngalia Basin sequence and it rests unconformably on Precambrian igneous and metamorphic rocks. No fossils have been found but identifiable tracks and trails occur in siltstones in the Stuart Bluff Range and Ryan (1958) reported worm trails in the quartzite south-east of Napperby homestead. The Vaughan Springs Quartzite lies unconformably below Lower Cambrian formations in the Mount Doreen Sheet area. This suggests that the formation is Proterozoic in age.

The Vaughan Springs Quartzite is correlated on lithological similarity and stratigraphic position with the Heavitree Quartzite in the Amadeus Basin.

TREUER MEMBER.

The Treuer Member has been defined by Wells et al. (1968) as a unit of laminated to thin bedded, white to grey sandstone; it is cross stratified in places, micaceous in part and has minor occurrences of small clay pellets. White, yellow and red siltstones are interbedded with the sandstone and several beds of glauconitic sandstone are known to occur within the sequence at the type locality. In places siltstone is predominant in the member. The member may contain interbedded evaporites; gypsum was found in the Hann Range associated with the Treuer Member siltstones and a powdery efflorescence is commonly present on the siltstones at several localities in the Ngalia Basin.

The Treuer Member was named after the Treuer Range on the Mount Doreen Sheet area. The type section (NX-5) lies about $12\frac{1}{2}$ miles on a bearing of 238° from Mount Davenport on the Mount Doreen Sheet area.

On the Napperby Sheet area the Treuer Member is well exposed in the Hann Range and in the ranges 3½ miles west-south-west of Napperby homestead. At the latter locality the Treuer Member is 100 feet thick. (WN-1). Here the member is mostly finely micaceous, friable shale with interbeds of tough, siliceous, pale green and grey thin bedded sandstone which has abundant clay pellets. The shales are well exposed on the hill slopes and show a variety of sedimentary structures including lamination, small scale cross stratification and possible slump structures. The shales are incompetently folded in places (Fig. 21) and are stained red by hematite in many places. At sample locality N201, 10 miles south-west of Napperby homestead, concretions of specular hematite occur in the green shales. (Fig.22). They have not been found elsewhere in the Treuer Member. The hematite concretions are randomly distributed throughout the rock and do not have any obvious relationship with the fractures in the shale. Chert concretions were observed in the Hann Range at sample locality N227. The nodules and masses of grey, black and white chert appear to replace the white claystone at this locality. In thin section this chert showed fragments of chert, veined by biotite - chlorite veins, and including biotite-chlorite aggregates set in a base of microcrystalline quartz and clay with some pockets of clay. This may be a metasomatised recrystallised chert. (B.M.R. Reg. No. 68.66.0047).

One outcrop of the Treuer Member is present in the Stuart Bluff Range, seven miles east of Mount Wedge Homestead. The exposure is poor and consists of thin bedded, mud pelleted, pale grey sandstone.

In the Hann Range the Treuer Member is a white, finely micaceous siltstone and fine-grained clayey sandstone interbedded with tough, siliceous, fine to medium grained sandstone and clay pelleted, thin bedded sandstone. Near the base there is a medium grained, well sorted sandstone with some silty matrix with very well rounded quartz grains. Encrustations of gypsum are present near the top of the exposed beds which consist of grey shales, silts and interbedded fine, white, siliceous, tough, thin bedded sandstone. Clay pellets are not uncommon in the Treuer Member at this locality.

Figure 21: Incompetent folding in the Treuer Member of the Vaughan Springs Quartzite. Three miles south west of Napperby homestead. Neg. GA/1553

Figure 22: Hematite pods in the Treuer Member of the Vaughan Springs Quartzite. Ten miles south west of Napperby homestead. Neg. GA/1557.

A shallow stratigraphic hole (B.M.R. Napperby No.3 - Grid Ref. 534'196) encountered the Treuer Member in a core taken at a depth of about 510 feet. Only 3 feet of core was recovered from the interval 503-513 feet. The core consisted of soft grey-green clay and several inches of laminated, thin-bedded, in part silicified shale. The last few inches of core is a grey green clay with black chert fragments. The clay is believed to belong to the Treuer Member.

Section WN-1, in the ranges south-west of Napperby homestead where the member is 100 feet thick, is the only measured thickness of the member on the Napperby Sheet area. The extensive folding of the rocks in the ranges south of Napperby homestead has caused a marked variation in the thickness of the member.

No fossils have been discovered in the Treuer Member. The evaporitic material and the glauconite suggest deposition in a shallow water marine environment in a partially restricted basin.

SEDIMENTARY OUTLIERS AT CROWN HILL, NANCY HILL AND TEA-TREE.

Small outliers of sedimentary rocks crop out at Crown Hill, Nancy Hill and Tea Tree on the Napperby Sheet area outside the margin of the Ngalia Basin.

At Crown Hill about 460 feet of gently dipping sediments rest unconformably on Precambrian schists. A purple brown siltstone, with large boulders up to 8 feet across of granite, quartzite and many other rock types, occurs at the base of the sequence. Some of the boulders are faceted and a few have indistinct striae. The thickness of the siltstone varies from 50 to 100 feet. The abundance of large erratics, the poor sorting and lack of any obvious bedding surfaces suggest that this is a glacial deposit (Fig. 23). Above this basal horizon several hundred feet of interbedded siltstones, sandstones and coarse arkosic conglomerate occur. The sequence is shown in Fig.24.

The sequence appears to be conformable, but only the basal, poorly sorted siltstone with erratics can be correlated with the Ngalia Basin sequence with any certainty. The glacial deposit is similar to the Mount Doreen Formation which crops out on the Mount Doreen Sheet area (Wells et al, 1968).

A large fault along the northern edge of the outcrop in the Crown Hill area has downthrown the sediments against the Precambrian basement and has probably been mainly responsible for their preservation.

Nancy Hill, in the northeastern quadrant of the Napperby Sheet area, is an outlier of sediments unconformably overlying deeply weathered basement rocks. The sediments dip westwards and basement rocks are exposed on the eastern slopes of the hill. The sedimentary sequence is shown in Fig.24.

At Nancy Hill there are three glacial beds separated by massive quartz sandstone. The lowermost tillite unconformably overlies basement rocks. The glacial deposits consist of non-bedded, poorly sorted, purple siltstone with pebbles of quarrzite up to 5 inches in diameter. Striated surfaces were noted on one of the quartzite pebbles. The three glacial beds vary in thickness with the lowest being the thinnest and the middle the thickest. Above the middle glacial horizon there are thick siltstone beds that are probably varied and in places contain medium grained, well rounded quartz grains.

The interbedded sandstones are mostly medium grained, well sorted with a few pebble beds and thin finer streaks. The sandstone is mostly thick bedded and silicified, commonly contains limonite pseudomorphs after pyrite and has rounded quartz grains. Sedimentary structures in the sandstone included cross stratification in the lowermost beds and interference ripple marks in the upper sandstone.

North-east of Tea-Tree on the Stuart Highway, outcrops of sedimentary rocks are preserved resting unconformably on Precambrian crystalline basement. The sediments are mostly medium grained, tough, thick bedded, well sorted quartzite with some pebbles. Interbeds of fine, poorly sorted granule conglomerate and fine to coarse grained, thin bedded silicified sandstone occur within the sequence. Ripple marks were noticed and, as at Nancy Hill, limonite casts after pyrite are common.

Figure 23. Probable tillite at Crown Hill. Neg. GA/1554.

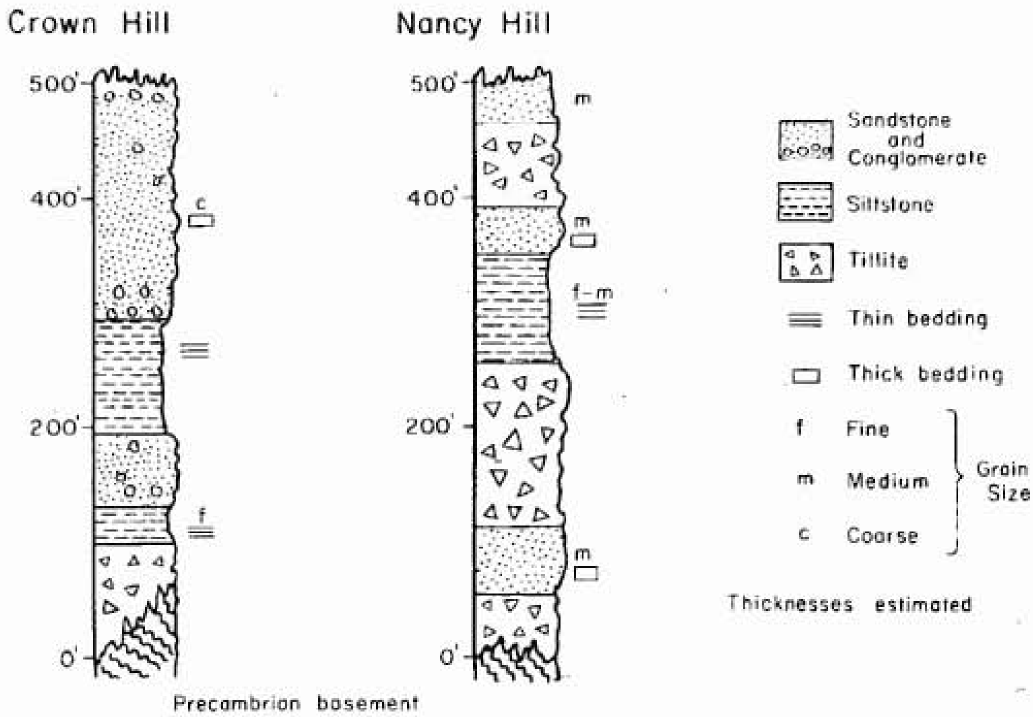


Fig. 24 SEQUENCE AT CROWN HILL AND NANCY HILL

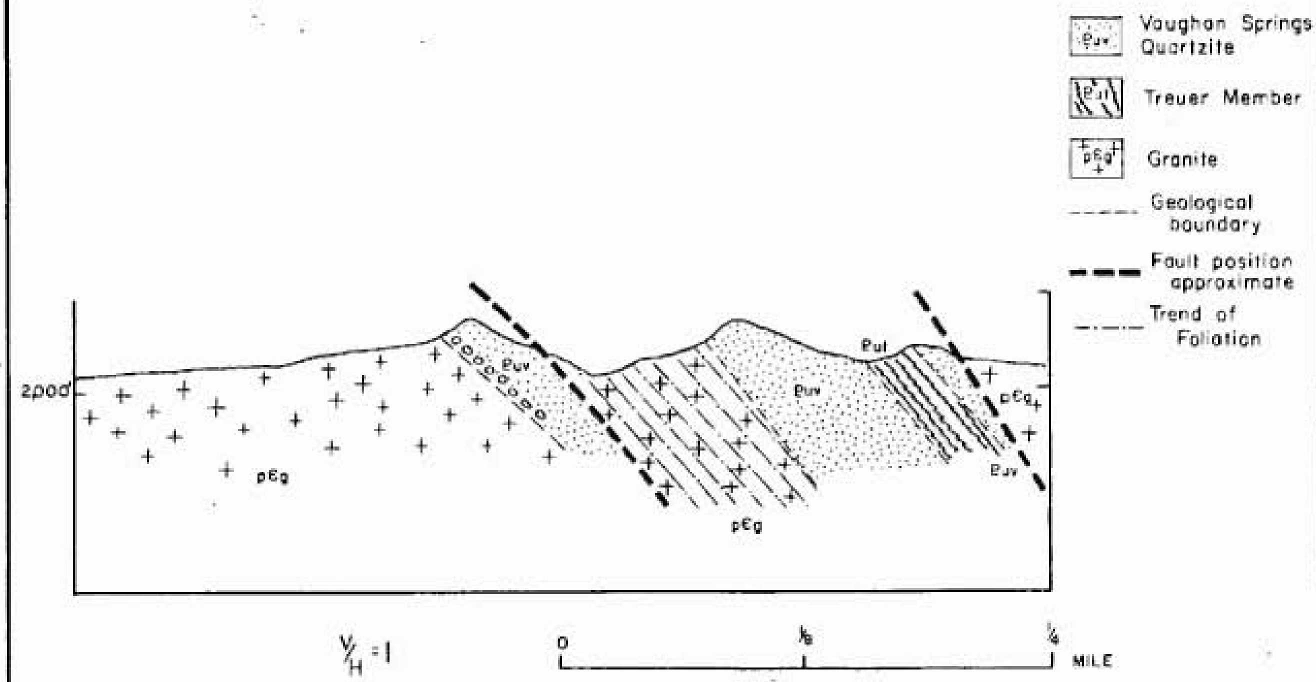


Fig 25 SKETCH CROSS SECTION OF STRUCTURE 1¼ MILES SOUTH-WEST OF NAPPERBY HOMESTEAD

At sample locality N258, north east of Tea-Tree, the following sequence was noted in steeply north-east dipping sediments - on the south side of the ridge the lowermost beds are interbedded, grey, micaceous siltstones, shale and sandstones. The shale is friable, very fine grained, microlaminated, powdery and in places varved, Slumps and microslumps are present in the shale and flame structures are common where sandstone interbeds rest on the shale. The thin siltstone interbeds are in places richly micaceous. The sequence continues with beds of moderately sorted, moderate to well rounded, medium to coarse grained granule conglomerate mostly friable with a silty-matrix and micaceous in places. The conglomerate is overlain by poorly exposed beds of medium grained, silicified sandstone with some pink and purplish gritty, silty, fine sandstone similar to that present at Nancy Hill.

Correlation of these sediments occurring at Crown Hill, Nancy Hill and near Tea-Tree with named formations in the Ngalia and Georgina Basins can only be based on lithological similarities. The glacigene beds at each locality suggests that the sediments should be correlated with the Mount Doreen formation in the Ngalia Basin and with the Central Mount Stuart Beds in the Georgina Basin. The Central Mount Stuart Beds are probably time-equivalents of the Mount Cornish Formation and Elyuah Formation, and also of the upper part of the Field River Beds (Smith 1966). The Field River Beds and the Mount Cornish Formation are correlated by Smith (1966) with the two Adelaidean glacial horizons in the Amadeus Basin - the Areyonga Formation (Pritchard and Quinlan, 1962) and the Olympio Member of the Pertatataka Formation (Wells, et al, 1967). Therefore the sediments occurring at Crown Hill, Nancy Hill and near Tea-Tree are probably Adelaidean in age.

ORDOVICIAN

KERRIDY SANDSTONE

The Kerridy Sandstone is a purple and red brown, medium to coarse grained, moderately sorted, sitly and in part arkosic sandstone with minor interbedded siltstones. It was first informally named 'Unit E' by Cook and Scott (1968). Wells et al (1968) described, defined and formally named the unit-- the Kerridy Sandstone.

The type section is Ex 1 at the type locality approximately ½ mile south east of White Point on the Mount Doreen Sheet area. There the unit appears to lie conformably on the Djagamarra Formation and lies with an angular unconformity below the Mount Eclipse Sandstone.

The name is derived from Kerridy Waterhole, 10 miles south of Yuendumu Native Settlement on the Mount Doreen Sheet area.

The Kerridy Sandstone crops out at one locality only on the Napperby Sheet area. It forms a small ridge north of the Yuendumu - Alice Springs beef road on the western part of the Sheet area. At this locality the formation is a red brown, weathering to dark chocolate btown, medium grained, mostly well sorted sandstone with clay pellets common on some bedding planes.

The sandstone is very micaceous in places and is for the most part silty with some white clay. The formation is thin bedded and dips to the southwest at 21^{o}. Current lineation, slump structures and small scale cross-stratification are present; skeletal weathering is common in the formation and is well developed at this locality.

It is not known whether the unit continues in the sub-surface for any great distance on the Napperby Sheet area. Seismic evidence suggests that it is not present in the Basin south of Napperby homestead. Aeromagnetic interpretation indicates a total sedimentary thickness of 10,000 feet in the western part of the Napperby Sheet area and it is therefore possible that the Kerridy Sandstone and other units persist below the western half of the Sheet area.

No fossils have been found in the Kerridy Sandstone but Wells et al. (1968) believes its age to be middle Palaeozoic, possibly Ordovician. It is tentatively correlated with the Stairway sandstone and/or the Carmichael Sandstone in the Amadeus Basin.

CARBONIFEROUS

THE MOUNT ECLIPSE SANDSTONE.

The Mount Eclipse Sandstone is defined by Wells et al.(1968) as a pale brown, coarse-grained, poorly sorted sandstone; it is micaceous in part, thin to massively bedded, cross-bedded, arkosic with cobble and boulder beds and a few siltstone interbeds, and it unconformably overlies most of the older formations of the Ngalia Basin sequence.

Cook (1963) first referred to the unit in his record on the geology of the Yuendumu Native Reserve and Rivereau (1965) recognised and described the distinctive photogeological characteristics. Cook and Scott (1968) described some of the sediments and informally named the formation 'Unit P'.

Wells et al (1968) defined, described and named the Mount Eclipse Sandstone. The type locality is in the Mount Eclipse Syncline on the Mount Doreen Sheet area. The name is derived from Mount Eclipse, 21 miles south-west of Yuendumu Native Settlement. It is the youngest sedimentary formation in the Ngalia Basin. Two identifiable plant fossils found at locality MD 135A, eight miles south of Vaughan Springs Homestead, and locality MD 43, seven miles west-southwest of Djagamara Peak on the Mount Doreen Sheet area, prove the age of the formation to be Carboniferous.

The formation is only exposed at two localities on the Napperby Sheet area south of Smiths Gift Bore on the western part of the Sheet area and in an isolated outcrop in the centre of the Basin, southwest of Patty Hill. South of Smiths Gift Bore the formation forms low rubble covered rises less than 10 feet above the sand plain whilst southwest of Patty Hill it forms a low isolated hill in the centre of the sand plain. At none of these localities is the Mount Eclipse Sandstone in contact with any other sedimentary formation. The stratigraphic position and its relationship to the other sediments of the Ngalia Basin has been determined from the adjacent Mount Doreen Sheet area.

No sections have been measured through the Mount Eclipse Sandstone. In the type locality it is estimated to be over 8,000 feet thick.

The outcrop six miles south of Patty Hill is the best exposure of Mount Eclipse Sandstone on the Napperby Sheet area. It is poorly sorted, medium to coarse-grained sandstone with pebble and cobble beds. The phenoclasts are dominantly quartzite derived from the Vaughan Springs Quartzite; these attain a maximum diameter of 18 inches and all are well rounded. The sandstone is fawn coloured when fresh but weathers to an orange-brown. It is for the most part poorly exposed with a rubble covered surface and appears to be thick bedded with pebble bands paralleling the bedding plane. The sandstone dips to the west with a variable dip between 8° and 14°. Sedimentary structures are not common, curent lineation and cross stratification were seen close to the foot of the outcrop. Some fragments of ferruginous shale were found on the surface but no shale beds crop out at this locality.

Eight miles to the west of the outcrop there is a low cobble covered rise which has no outcrops, but the abundance of phenoclasts of quartzite on the surface suggest that this low rise is a weathered remnant of Mount Eclipse Sandstone.

Two miles south of Smiths Gift Bore, the Mount Eclipse Sandstone crops out as low ridges of conglomerate beds, 6 to 8 feet thick, interbedded with coarse sandstone. The cobbles in the conglomerate attain a maximum diameter of 12 inches and are composed of vein quartz and silicified sandstone. The matrix is a poorly sorted sandstone. A specimen of the sandstone from this locality has been described by Scott (Cook and Scott, 1968) as a porous protoquartzite approaching the purity of an orthoquartzite with angular to subrounded, fine quartz grains which are welded together by pressure solution. Another sandstone specimen from the same locality described by Scott (Cook and Scott, 1968) differed in that the cementing material was opal. This is a surface phenomenon, the rock being friable beneath the surface opalised crust. At this locality, two miles south of Smiths Gift Bore, the bedding is thick and dips 48° south.

Little can be deduced concerning the environment of deposition and provenance of the Mount Eclipse Sandstone from the exposures on the Napperby Sheet area. The better exposures on the adjacent Mount Doreen Sheet area enabled a better assessment to be made of the environment of deposition. The poorly sorted conglomeratic nature of the sandstone and the absence of marine organisms, the well developed cross-stratification, the sedimentary structures and the remains of plant fossils suggest that the deposit is continental and probably formed in a fluvial and piedmont environment.

The Mount Eclipse Sandstone has been tentatively correlated with the Pertnjara Group in the Amadeus Basin whilst in the Georgina Basin the only formation with comparable lithology is the Dulcie Sandstone which is Upper Devonian in age and may be the time equivalent of the lower part of the Mount Eclipse Sandstone.

CAINOZOIC

The Quaternary deposits of sand, alluvium, evaporites and travertine are widely distributed over the Ngalia Basin and Precambrian basement and successfully hide the older Tertiary sediments which are believed to occupy depressions in the pre-Tertiary land surface.

Tertiary sediments have been encountered in several water bores in the Tea Tree area and in the shallow stratigraphic holes drilled into the Ngalia Basin by the Bureau of Mineral Resources in 1968. Dating of these sediments has been possible in one of these stratigraphic holes (B.M.R. Napperby No.1 - Grid Reference 587.180) where Nothafagus pollen obtained from lignitic clay at a depth of 455 feet indicates an age which is post-Eocene and pre-Pliocene (pers. comm. D. Burger, B.M.R.). The lignitic clay found in B.M.R. Napperby No.1 stratigraphic hole is similar to that reported in water bore cuttings gathered from bores drilled in the Tea Tree ground water basin, for example; in W.R.B. 130/62.5 Bore (1966) No. 198 black and very dark brown soft argillaceous coal fragments with associated minor grey clay are present in the interval 340' - 350'. Similarly carbonaceous clays and lignite fragments are found in W.R.B. 130/57.5 Bore No. 214 at depths between 340' and 400'. In many of the water bores around Tea Tree the depth to pre-Tertiary basement is up to 800 feet.

In the Ngalia Basin 1968 shallow drilling three stratigraphic bores failed to reach pre-Tertiary basement whilst the fourth (B.M.R. Napperby No.3 - Grid Reference 534.196) bottomed in Treuer Member at 513 feet.

On the adjacent Alcoota Sheet area, Tertiary limestone crops out. This limestone and associated sandstone and siltstone (Aeltunga Beds; Smith 1964) is not exposed on the Napperby Sheet area.

Undifferentiated Cainozoic silcrete and ferricrete have been mapped resting on weathered basement south of Hann Range. Photo-interpretation suggests that similar Cainozoic deposits are present in the central part of the Reynolds Range, 5 miles southeast of Mount Thomas, and also 2 to 3 miles east of Nancy Hill. Smaller outcrops of Cainozoic deposits occur as a capping on pre-Cambrian crystalline rocks at several localities on the northern half of the Sheet area.

The Quaternary deposits include alluvium, colluvium, sand and sand dunes, red soil alluvial plains, evaporites and travertine.

The alluvium is found along the valley floors and flood-outs of the rivers and creeks. There the soils are normally brown sands and red clayey sands and they support a plant community of sparse low trees over short grasses.

The colluvium which surrounds the mountain ridges into the alluvium on the valley floors and the red earths which surround drainage heads. The red earths support a dense cover of mulga trees over short grasses. The largest area of Quaternary deposition is occupied by sand and sand dunes. Most of the Ngalia Basin is covered by sand with sporadic sand dunes. The sand plain has an average height above sea level of 1900 feet. Evaporites are found in the salt lakes and salt pans which occur south of the Stuart Bluff Range, they commonly form a surface encrustation. Travertine forms low hummocky terrain surrounding the salt lakes and is also found near White Bull yard on Crown Creek.

STRUCTURE

Only three sedimentary formations of the Ngalia Basin crop out on this Sheet area and of these only the Vaughan Springs Quartzite provides information which can be used to elucidate the structural history. Most of the central part of the Ngalia Basin on the Napperby Sheet area is covered by Quaternary deposits.

The Ngalia Basin occupies the south-central part of the Napperby Sheet area and is 27 miles wide in the west. It extends to both east and west onto the adjacent 1:250,000 Sheet areas of Alcoota and Mount Doreen. The southern margin is clearly delineated by the Vaughan Springs Quartzite cropping out in a long ridge striking east and named, at various places, the Stuart Bluff Range, the Reaphook Hills, and the Hann Range. The quartzite rests unconformably on Precambrian granite and metamorphics and dips at between 20° and 25° to the north.

Strong folding and faulting is present in the few exposures of the sediments at the northern margin of the basin.

Most evidence relating to the structural history of the Ngalia Basin has been obtained from the adjacent Mount Doreen Sheet area where the sediments have been affected by two major periods of diastrophism and several smaller epeirogenic movements. The tentative ages given to the major periods of diastrophism are post Ordovician and post Carboniferous. There are unconformities between most of the formations in the Basin and each represents a period of uplift and erosion.

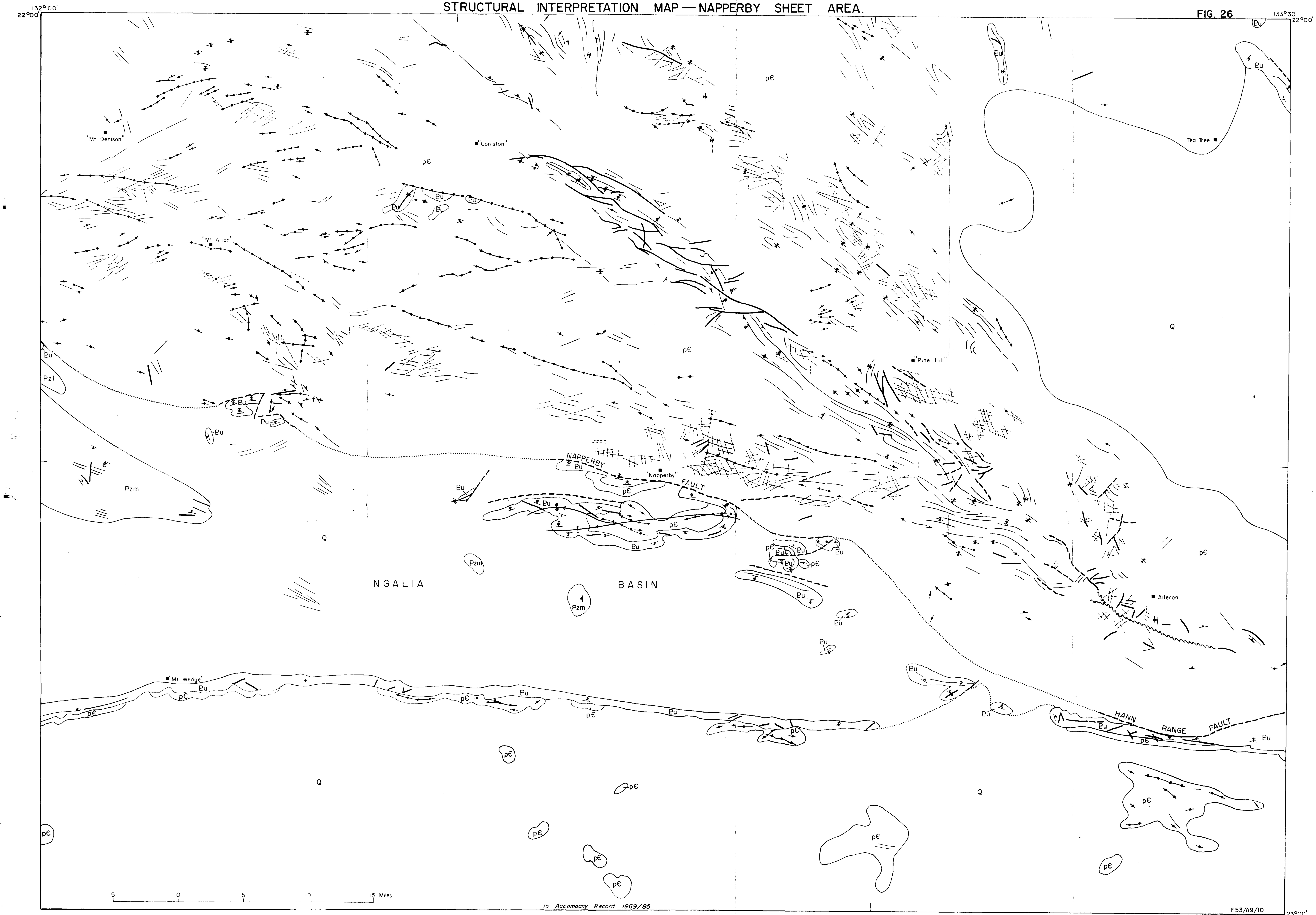
Aeromagnetic interpretation indicates 10,000 feet of sediment in the western part of the Basin on the Napperby Sheet area and 8,000 feet of sediments in the central region of the basin near Napperby Creek. Surface geology tend to confirm this eastward shallowing of the Basin as the basal formation of the Ngalia Basin sequence, the Vaughan Springs Quartzite, is exposed in the eastern part of the Napperby Sheet area.

The structure seen in the Vaughan Springs Quartzite three miles west of Napperby homestead is complex. A large thrust fault is postulated where the quartzite dips northward beneath Pre-canbrian granite. It is apparent that one major fault and several minor faults have affected the sediments and basement in this area. For example, in the same range of hills 1¼ miles west-southwest of Napperby homestead two northerly dipping quartzite ridges are separated by a valley underlain by sheared granite (Fig.25). The southern quartzite ridge has a basal pebble conglomerate, rests unconformably on weathered granite and dips 37° to the north. The cross-strata present show that the beds are not inverted. Poorly exposed, sheared granite crops out north of this quartzite ridge in the creek beds in the valley floor. The shearing trends at 85° and dips to the north at 70°. This granite is very much more foliated than the granite underlying the southern ridge. The northernmost quartzite ridge is tough, silicified. closely jointed and thick-bedded, dips north at 55° and rests directly on the sheared granite. The facing could not be determined. It differs from the southern ridge of quartzite in that it has no basal pebble conglomerate and is more highly silicified. The two quartzite ridges are less than 400 yards apart and both are Vaughan Springs Quartzite. Slight variation in the lithology of the quartzite in the two ridges is noticeable but as they both rest unconformably on granite they may be the same beds. The repetition of the quartzite and the presence of sheared granite between the two ridges indicates the presence of a thrust fault parallel to the major thrust along the north side of the basin.

The basement is believed to have been uplifted and eroded prior to the deposition of the Carboniferous Mount Eclipse Sandstone as phenoclasts of Pre-cambrian crystalline rock are present within the formation. The basement rocks have been thrust over the Ngalia Basin sediments along the northern margin of the basin after the deposition of the Mount Eclipse Sandstone and it is likely that the quartzite which marks the southern limit of the basin has gently tilted to the north as a result of upwarping of the basement to the south. The structure of the southern margin of the basin is not entirely a simple tilting; between the Reaphook Hills and the Hann Ridge folding and faulting have occurred. However, the faulting along the northern margin of the basin is the only structural feature which can be seen to affect both the Ngalia Basin and the Pre-cambrian basement. A structural interpretation of the Napperby Sheet area is shown in Fig.26.

STRUCTURAL INTERPRETATION MAP — NAPPERBY SHEET AREA.

FIG. 26



AGE	SYMBOL	ROCK UNIT
CAINOZOIC	Q	Sand, alluvium, dunes, salt lakes.
CARBONIFEROUS	Pzm	Mount Eclipse Sandstone
ORDOVICIAN	Pzl	Kerridy Sandstone
PROTEROZOIC	Pu	Vaughan Springs Quartzite. Unnamed glacial deposits
PRECAMBRIAN	pЄ	Metamorphic and igneous rocks.

- *Geological boundary*
- *Shear zone*
- *Fault or thrust*
- *Fault or thrust inferred*
- *Anticline showing plunge*
- *Syncline showing plunge*
- *Trend lines*
- *Trend of foliation with prevailing dip*
- *Vertical foliation*
- *Foliation trend, dip indeterminate*
- *Dip < 15°*
- *Dip 15°–45°*
- *Dip > 45°*
- *Overturned dip*
- *Horizontal strata*
- *Vertical strata*
- *Dyke or vein*
- *Concealed margin of basin, position approximate*
- *Joint pattern*

GEOPHYSICAL INVESTIGATIONS

Aeromagnetic Survey:

The prime purpose of the aeromagnetic survey and interpretation (Hartman, 1963) was to define geological information as it is reflected in the aeromagnetic records. The results were plotted as total magnetic intensity maps with the interpretation superimposed on the isomagnetic contours.

The results indicate that the Ngalia Basin on this sheet area is a narrow trough which has interpreted fault boundaries along its northern and southern margins (Fig. 27). Depth estimates are considered to be "somewhat tenuous". The deepest part of the Basin on this Sheet area is interpreted as being 10,000 feet in the west. This depth occurs in an area where, according to Hartman "structural complexities are likely to occur and hence of interest in exploring for structural and stratigraphic traps". The central part of Basin on this Sheet area, as defined by the aeromagnetics, is characterised by a relatively featureless magnetic gradient from which rather deep depth estimates can be obtained. At Napperby Creek an interpreted depth of 8,000 feet to basement correlates very well with the 8,000 feet depth estimate obtained from a seismic survey over the same area (Tucker 1969 in prep).

The aeromagnetic survey did not cover the entire Sheet area and surface outcrop of sediments indicate that the areal extent of the Ngalia Basin is greater than that indicated by the aeromagnetic work, which suggests that the basin closes to the east at approximately i. the position of a line drawn perpendicular to the Reaphook Hills. The shallowing of the basin at this locality is coincidental with the structural distortion of the southern ranges between the Reaphook Hills and Hann Range and may be due to structural control of basin deposition by the configuration of the basement. Features 2-A and 2-B (Fig.27) are delineated from minor magnetic anomalies of only a few gammas, suggesting the possibility of basement relief.

Gravity Surveys:

The regional gravity pattern over the Napperby Sheet area has been the subject of two Bureau of Mineral Resources records. Flavelle (1965) commented briefly on the gravity pattern which emerged as a result of a helicopter gravity survey in the Northern Territory and Queensland (Fig. 28). Flavelle named the Napperby Regional Gravity Low (the name is now discarded - the gravity feature corresponds to the eastern end of the Yuendumu Regional Gravity Low) and the Papunya Regional Gravity Ridge both of which are on the Napperby Sheet area. The Napperby Regional Gravity Low has a maximum width of 80 miles. The lowest bouguer anomaly value recorded over the low is - 105 mgals. It is bordered to the north and south by regional gravity ridges - the Willowra Regional Gravity Ridge and the Papunya Regional Gravity Ridge. Flavelle postulated that the gravity low was caused by emplacement of low density granite. This was based on the fact that two culmunations within the province correlate with granite outcrop. The Papunya Regional Gravity Ridge, which has a maximum bouguer anomaly value of +50 mgals, is separated from the Napperby Regional Gravity Low by a steep gravity gradient which Flavelle (1965) considered to be caused by a fundamental density change within the crust.

Whitworth (1969,in prep.) re-interpreted and re-defined the gravity provinces occurring on the Napperby Sheet area as a result of the more recent helicopter gravity survey over the adjacent Sheet areas west of Napperby. Whitworth re-defined Flavelle's Napperby Regional Gravity Low and included the feature in the Yuendumu Regional Gravity Low.

Whitworth has suggested four explanations for the Yuendumu Regional Gravity Low:

1. Density variations within the basement
2. Variation in the crustal thickness.
3. The Ngalia Basin is the outcrop of a much larger basin over which Archaean rocks have been overthrust by several tens of miles.
4. A faulted Palaeozoic-Proterozoic basin to the north of the Ngalia Basin, with its northern half overthrust southwards, and Palaeozoic sediments preserved mainly on the downthrown block.

Gravity Surveys:

The regional gravity pattern over the Napperby Sheet area has been the subject of two Bureau of Mineral Resources records. Flavelle (1965) commented briefly on the gravity pattern which emerged as a result of a helicopter gravity survey in the Northern Territory and Queensland (Fig. 28). Flavelle named the Napperby Regional Gravity Low (the name is now discarded - the gravity feature corresponds to the eastern end of the Yuendumu Regional Gravity Low) and the Papunya Regional Gravity Ridge both of which are on the Napperby Sheet area. The Napperby Regional Gravity Low has a maximum width of 80 miles. The lowest bouguer anomaly value recorded over the low is - 105 mgals. It is bordered to the north and south by regional gravity ridges - the Willowra Regional Gravity Ridge and the Papunya Regional Gravity Ridge. Flavelle postulated that the gravity low was caused by emplacement of low density granite. This was based on the fact that two culmunations within the province correlate with granite outcrop. The Papunya Regional Gravity Ridge, which has a maximum bouguer anomaly value of +50 mgals, is separated from the Napperby Regional Gravity Low by a steep gravity gradient which Flavelle (1965) considered to be caused by a fundamental density change within the crust.

Whitworth (1969, in prep.) re-interpreted and re-defined the gravity provinces occurring on the Napperby Sheet area as a result of the more recent helicopter gravity survey over the adjacent Sheet areas west of Napperby. Whitworth re-defined Flavelle's Napperby Regional Gravity Low and included the feature in the Yuendumu Regional Gravity Low.

Whitworth has suggested four explanations for the Yuendumu Regional Gravity Low:

1. Density variations within the basement
2. Variation in the crustal thickness.
3. The Ngalia Basin is the outcrop of a much larger basin over which Archaean rocks have been overthrust by several tens of miles.
4. A faulted Palaeozoic-Proterozoic basin to the north of the Ngalia Basin, with its northern half overthrust southwards, and Palaeozoic sediments preserved mainly on the downthrown block.

GEOPHYSICAL INVESTIGATIONS

Aeromagnetic Survey:

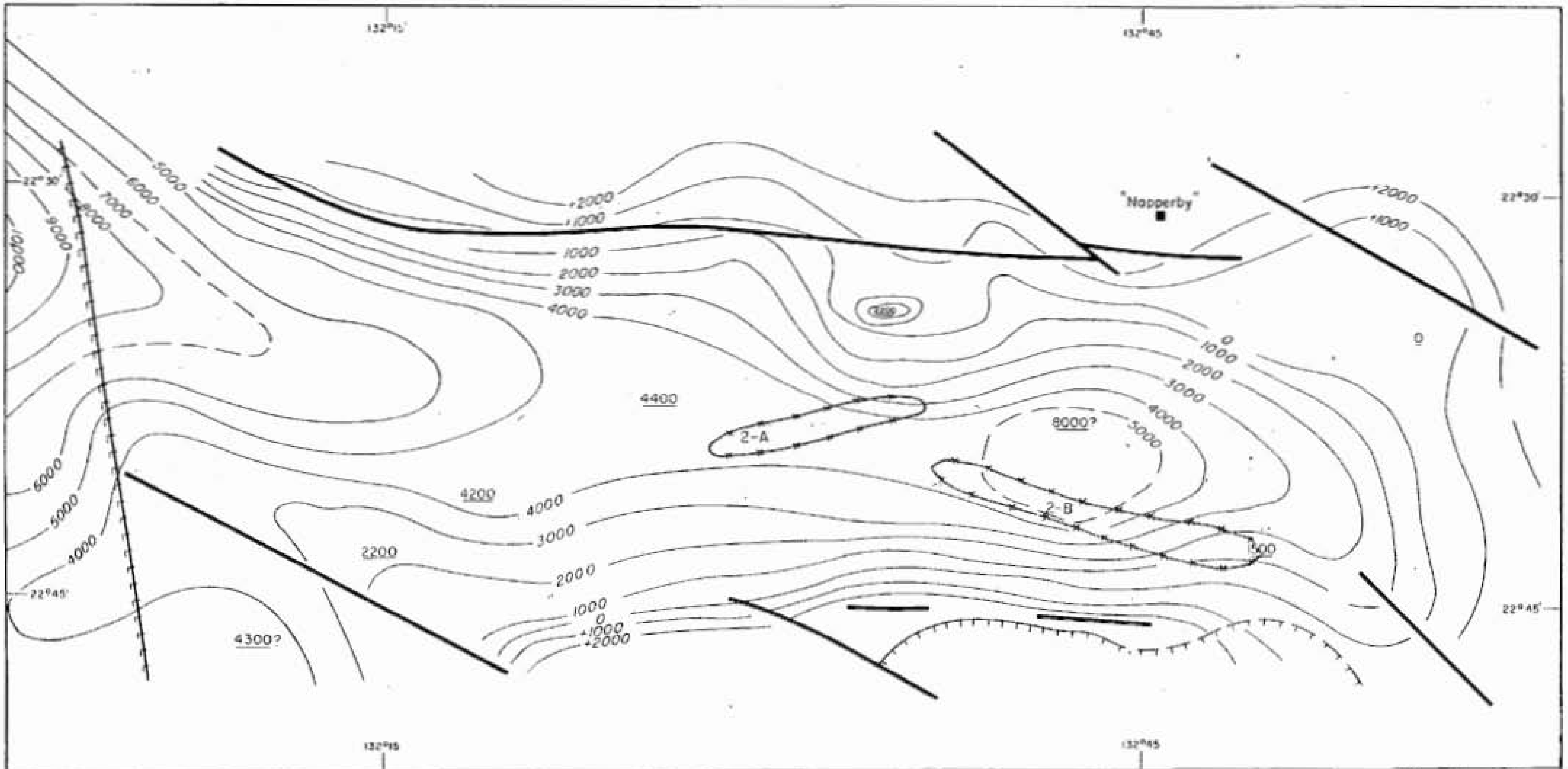
The prime purpose of the aeromagnetic survey and interpretation (Hartman, 1963) was to define geological information as it is reflected in the aeromagnetic records. The results were plotted as total magnetic intensity maps with the interpretation superimposed on the isomagnetic contours.

The results indicate that the Ngalia Basin on this sheet area is a narrow trough which has interpreted fault boundaries along its northern and southern margins (Fig. 27). Depth estimates are considered to be "somewhat tenuous". The deepest part of the Basin on this Sheet area is interpreted as being 10,000 feet in the west. This depth occurs in an area where, according to Hartman "structural complexities are likely to occur and hence of interest in exploring for structural and stratigraphic traps". The central part of Basin on this Sheet area, as defined by the aeromagnetics, is characterised by a relatively featureless magnetic gradient from which rather deep depth estimates can be obtained. At Napperby Creek an interpreted depth of 8,000 feet to basement correlates very well with the 8,000 feet depth estimate obtained from a seismic survey over the same area (Tucker 1969 in prep).

The aeromagnetic survey did not cover the entire Sheet area and surface outcrop of sediments indicate that the areal extent of the Ngalia Basin is greater than that indicated by the aeromagnetic work, which suggests that the basin closes to the east at approximately i. the position of a line drawn perpendicular to the Reaphook Hills. The shallowing of the basin at this locality is coincidental with the structural distortion of the southern ranges between the Reaphook Hills and Hann Range and may be due to structural control of basin deposition by the configuration of the basement. Features 2-A and 2-B (Fig.27) are delineated from minor magnetic anomalies of only a few gammas, suggesting the possibility of basement relief.

MAGNETIC BASEMENT CONTOURS FROM AEROMAGNETIC SURVEY
NAPPERBY AREA

Fig. 27



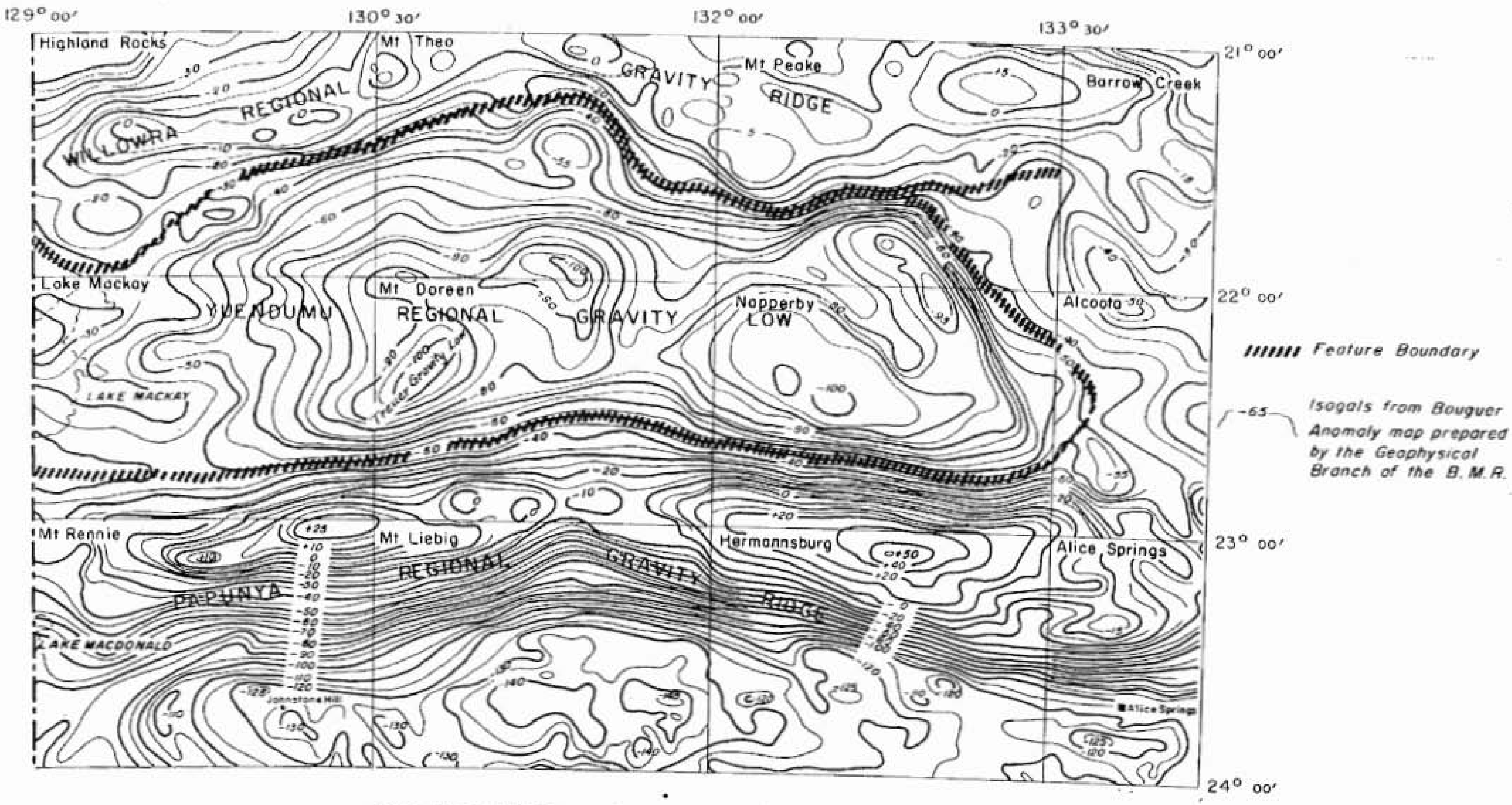
After Hartman 1963

4 0 4 8 12 Miles

2000	Depth to basement contour, where inferred line dashed		Lineament resulting from fault or contact in the basement
	Interpreted fault		Approximate northern limit of top of highly magnetic steeply dipping rocks at southern edge of survey
	Zone of possible minor structural significance affecting the section	8000	Depth estimate to magnetic basement (Feet below sea level)

To accompany Record 1969/85

F 53/A9/11



BOUGUER ANOMALIES AND GRAVITY FEATURES

Fig 28

40 0 40 80 Miles

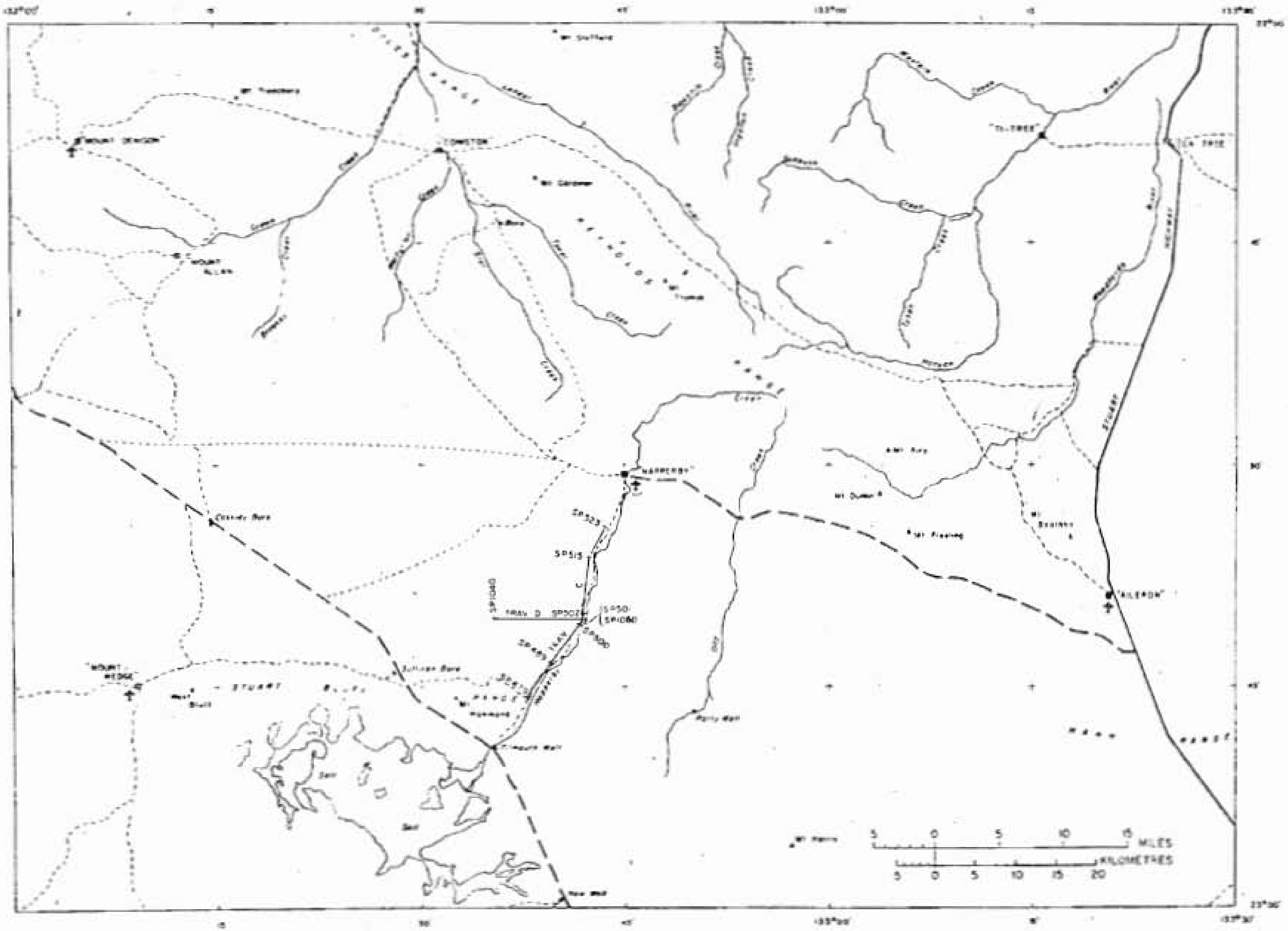
To accompany Record 1969/89

NT/A 192

NGALIA BASIN SEISMIC SURVEY 1968

Location of Traverses

Fig 29



To accompany Record 1969/65

F53/B6/2

Mission
homestead
River or creek } intermittent
Lake
Highway
Road
Track
BMR Seismic traverse and shot point numbers
SP104

Several explanations of the Papunya Regional Gravity Ridge have been put forward. Flavelle (1965) suggested a fundamental horizontal density change within the crust. Wells et al (1967) advocate crustal warping whilst Langron (1962) postulated either overfolding of Archaean rocks over the northern edge of the Amadeus Basin or faulting bringing ultrabasic rocks close to the surface. Whitworth (1969, in prep.) favours a combination of Langron and Flavelle's interpretation.

Seismic Surveys:

A seismic survey of the Ngalia Basin, including this Sheet area, was carried out by the Bureau of Mineral Resources in 1968. The results have been briefly described by Tucker(1969 in prep.) and discussed by Smith (1968). A more detailed analysis is being prepared by Jones (1969 in prep). Both reflection and refraction techniques were used. The reflection shooting on both Traverses C and D (Fig. 29) indicated that there is about 8,000 feet of sedimentary section in the central region of the basin near Napperby Creek. The sediments dip northwards at about 10°. Refraction data from Traverse D indicated the presence of three refracting horizons at depths of 800, 2,000 and 3,500 feet.

GEOLOGICAL HISTORY

Analysis of the Precambrian basement rocks suggests the following sequence of events.

1. Sedimentation and volcanic activity. The abundance of cross-bedded orthoquartzite and occurrence of conglomerate, suggest a shallow water environment. Volcanic activity was of minor importance and included minor basic volcanism and possibly some acid volcanism.

2. Isoclinal folding on north-west trending, horizontal to mildly plunging, fold axes.

3. Regional metamorphism varying from low greenschist to hornblende granulite facies, development of foliation. Local folding of the foliation and development of lineation.

4. Syn-metamorphic emplacement of extensive granites resulting in local flexuring of the metamorphic series and in contact metamorphic effects.

5. Waning of regional metamorphism.
6. Hypabyssal intrusion of doleritic dykes.
7. Greenschist facies metamorphism resulting in retrograde metamorphism of the granulites.

The sedimentary history of the Ngalia Basin began in the Proterozoic with the deposition of the Vaughan Springs Quartzite, which was deposited unconformably on eroded igneous and metamorphic rocks. This orthoquartzite is believed to be a shallow marine deposit. It crops out over a wide area. Cross bedding and current ripple marks together with mud cracks,which are well developed in interbedded shales and siltstone in the Stuart Bluff Range, indicate a shallow sea with sporadic sub-aerial exposure. The Treuer Member of the Vaughan Springs Quartzite has associated evaporites and these, together with the glauconite found within the Member, indicate a shallow water, partially restricted marine environment.

Isolated outliers of sediments of glacial origin at Crown Hill are correlated with the Mount Doreen Formation in the Ngalia Basin. Thus there was a period of uplift and erosion of the Vaughan Springs Quartzite prior to the deposition of these glacial sediments. This is named the Vaughan Springs Movement.

The Ngalia Basin sedimentary sequence is not complete on this Sheet area. Knowledge of the sequence from the adjacent Mount Doreen Sheet area indicates that there were several marine transgressions into the Ngalia Basin during Cambrian and Ordovician times. Whether all of these continued onto the Napperby Sheet area is not known. One Ordovician marine transgression did reach the Napperby Sheet area where a medium grained well sorted sandstone - the Kerridy Sandstone, was deposited.

Post Ordovivician earth movements, the Kerridy Movement, caused uplift, tilting and erosion of the sediments prior to the deposition of the continental Mount Eclipse Sandstone. This continental deposit is Carboniferous in age.

Post Carboniferous earth movements culminating in the Mount Eclipse Orogeny caused considerable folding and faulting of all the sediments of the Ngalia Basin and caused the thrusting of basement rocks over the Basin sediments along the northern margin of the Basin. This orogeny raised the land above sea level where it has remained to the present day.

Silcrete cappings are found on sediments and basement rocks of all ages. The silcrete is believed to have formed during a period of weathering in the Tertiary. Tertiary deposits mainly lacustrine sandstone but with some claystone and thin lignite were deposited over a considerable area. Quaternary sand covers a large part of the Ngalia Basin and is indicative of an arid climatic phase. This sand is now stabilised by spinifex as a result of recent amelioration of the climate.

ECONOMIC GEOLOGY

The Vaughan Springs Quartzite and the Mount Eclipse Sandstone are non-prospective as petroleum source rocks due to age and environment of deposition. The Kerridy Sandstone is the only formation cropping out on the Napperby Sheet area which could possibly have source beds. It is very poorly exposed and occurs at only one locality - on the northern margin of the Ngalia Basin at the western edge of the Sheet area.

The Kerridy Sandstone is a purple, red-brown, medium to coarse grained, unfossiliferous, moderately sorted, silty and in part arkosic sandstone with minor interbedded siltstones. It is unlikely that this formation is a source rock whilst the poor to moderate sorting and silty matrix suggest that it would also be a poor reservoir rock. Potential source rocks of Cambrian age are found in the eastern part of the adjacent Mount Doreen Sheet area and may be present sub-surface on the Napperby Sheet area.

The Mount Eclipse Sandstone, which is a continental deposit, may act as a reservoir rock. However, the poor sorting and lack of a suitable cap rock above or within the formation suggest that this is not likely. Aeromagnetic interpretation (Hartman, 1963) suggests that there may be up to 10,000 feet of sediment present sub-surface in the Ngalia Basin on the western part of the Napperby Sheet area, and a seismic survey (Tucker,1969) indicates that there is about 8,000 feet of sedimentary section in the central region of the Basin near Napperby Creek. It is suggested that most of the sedimentary thickness indicated by aeromagnetic and seismic work can be accounted for by the Vaughan Springs Quartzite, Kerridy Sandstone and Mount Eclipse Sandstone.

Late Palaeozoic diastrophism caused folding and faulting of the Ngalia Basin sediments and this structural deformation is well shown on the adjacent Mount Doreen Sheet area and on the northern margin of the Basin on the Napperby Sheet area. Such deformation may have formed structures in reservoir rocks in which petroleum may be trapped.

The long time break represented by the unconformity separating the potential source rocks of Cambrian age and the Ordovician(?) Kerridy Sandstone indicates that the Cambrian source rocks were subjected to a considerable period of erosion during which time any entrapped oil could have been released. Thus the importance of unconformities in the sedimentary section is a debatable value as it is a factor which on the one hand increases the petroleum potential of the area by providing potential zones of porosity and permeability in which petroleum may be held whilst on the other hand it decreases the petroleum potential by indicating a period of uplift and erosion during which the petroleum may be released. The importance of the numerous unconformities in the Ngalia Basin aequence cannot be accurately assessed without additional sub-surface geological information.

The non-prospective nature of the exposed formations and the lack of any known thicknesses of source beds are the main reason for assessing the petroleum potential of the Ngalia Basin on the Napperby Sheet area as low.

WATER SUPPLY

The area covered by the Napperby Sheet has about a 10-inch annual rainfall and due to high summer temperatures has a high evapotranspiration loss. The whole area falls into the arid climate classification of Meigs (1953).

The rivers which drain the area are dry for most of the year, only during summer storms does enough rain fall to flood the creeks and replenish the water hooes. Five permanent water holes occur on this Sheet area. These are named Long, Walker, North 20 mile, South 20 mile and Anna's Reservoir. They are of limited use due to their inaccessibility. One natural spring, Ingallan Spring, occurs on this Sheet area.

Eight cattle stations operate on the Napperby Sheet area and they rely on homestead water bores for their domestic supplies. Up to October, 1968, 260 water bores had been drilled on the Sheet area. These were drilled mainly to assist station owners who require abundant water for their stock. Many water bores proved to be dry whilst in others the water proved to be too saline for either human or agricultural use. Information on these water bores is obtainable from the Resident Geologists Office at Alice Springs and duplicate copies of all water bore logs are held in the Bureau of Mineral Resources technical files in Canberra.

This information is reproduced in a condensed form in Fig. 30. The ground water resources of the area were first discussed by Jones and Quinlan (in Perry et al., 1962). They delineated three groundwater provinces, the Lander, the Hann and Conniston groundwater provinces. They concluded that the grounwater resources of the area are more than adequate for likely pastoral development although locally it may not be possible to obtain a suitable or a sufficient supply. In addition Jones and Quinlan recognised that catchment areas surrounding Tea Tree and the Lander River had sufficient groundwater for irrigation projects to be theoretically viable.

In 1966 Edworthy made an appraisal of the groundwater resources of the Lander River area (Edworthy, 1968) and recommended that further drilling be done to assess the potential of the area.

The availability of water for stock is of prime importance, for the prosperity of the region is dependant upon it. For continued growth the area will undoubtedly need more water which can only be obtained economically from water bores. Development, other than pastoral, is likely to be restricted to projects along the Stuart Highway. Two centres at Tea Tree and Aileron are expanding as a result of the increase in tourist traffic along the Highway. These centres rely on bores for their water supply.

Edworthy (1966) made a preliminary assessment of the Tea Tree groundwater basin. As a result many water bores have been drilled at, or near to, the site of the township. Not all have proved to be successful.

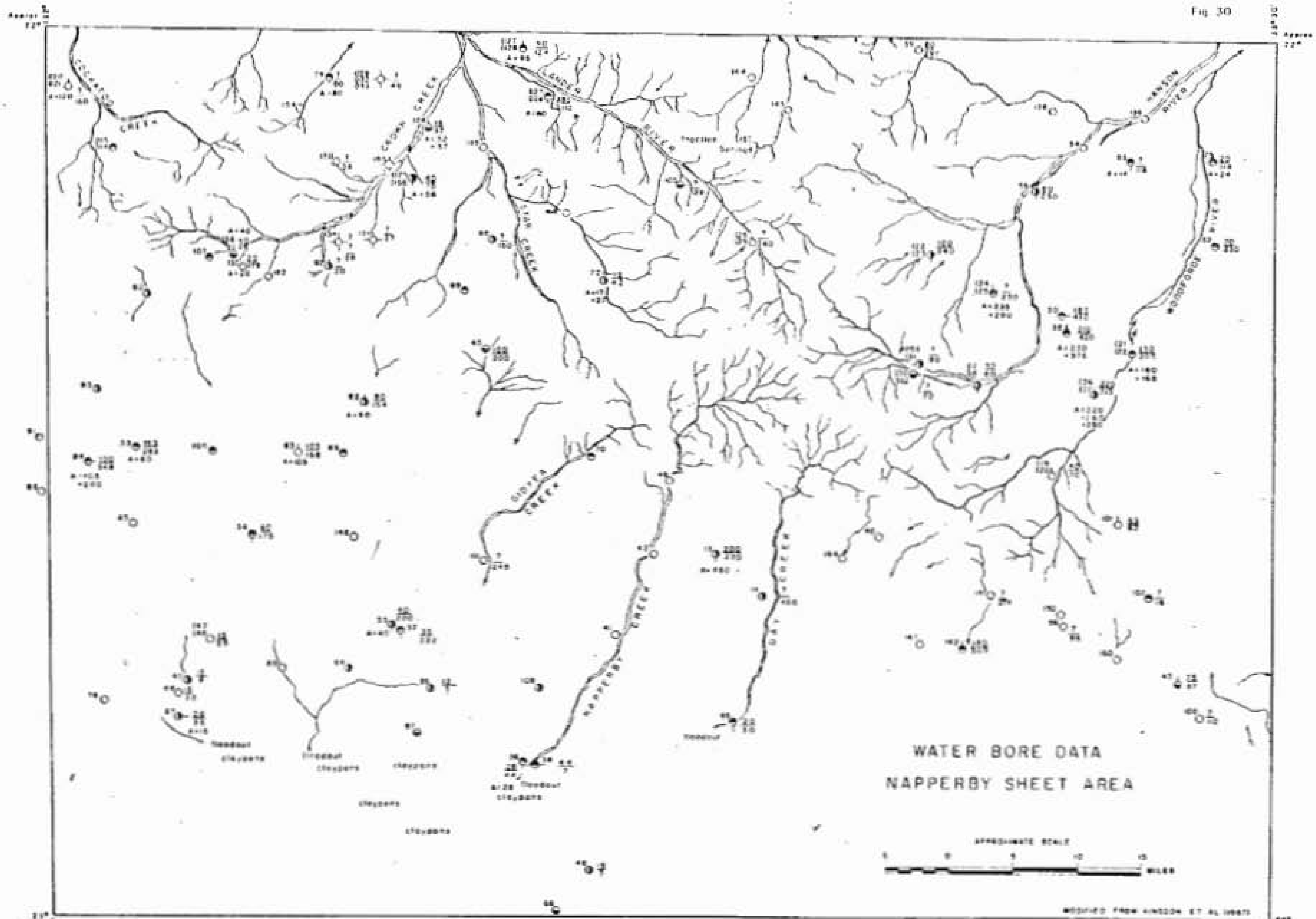
Water supply will continue to be a problem on the Napperby Sheet area and will only be overcome by the drilling of many more water bores. Due to the lack of geological information the siting of successful water bores is difficult but with the increase in knowledge of the geology future attempts should be more successful.

MINOR MINERAL DEPOSITS:

Minor mineral occurrences on the Napperby Sheet area include copper, tin, wolfram, gold, lead, ironstone, hematite, kyanite and lignite. With the exception of lignite and some of the hematite all are found in the Pre-cambrian basement rocks to the north of the Ngalia Basin (Fig. 31).

Officers of the Aerial, Geological and Geophysical Survey of Northern Australia in 1940 visited many of the mineral occurrences and described them in their annual report. (A.G.G.S.N.A. 1941).

Fig. 30



- Bore Number
- Dry Bore
- 1–500 gallons per hour
- 500–1000 gallons per hour
- 1000–2000 gallons per hour
- 3000+ gallons per hour
- Spring

SALINITY

- < 2500 ppm
- 2500–10000 ppm
- > 10000 ppm
- Standing water level in feet / Total depth in feet
- A:63 Depth to aquifer in feet

To accompany Record 1969/85

F 53/A9/13

TABLE 1

WATER BORES - NAPPERBY SHEET AREA

F53/9

Bore No.	Lease	Name
F53/9-1	North South Stock Route	Tea Tree Well
2	Ti Tree Township	Block 533 Old Store Well
3	" " "	Block 534 Heffermans Well
4	" " "	Block 536 Haines Well
5	" " "	Block 470 Store Bore
6	" " "	Block 470 Store Well
7	North South Stock Route	Ti Tree Bore
8	Napperby	1952 D.R. No.1 Dud
9	"	1952 D.R. No.2 Dud
10	"	Dud 17 mile W of Homestead
11	"	Dud 17 mile W of Homestead
12	"	Dud 17 mile W of Homestead
13	"	Dunja Bore
14	"	Haraji Bore
15	"	Dud 16 mile NW of Homestead
16	"	1958 D.R. No.1 Dud
17	Pine Hill	Sandy Creek Bore
18	" "	Sandy Creek Well
19	" "	Kerosene Bore
20	" "	Kerosene Well
21	North South Stock Route	Arden Soak Bore
22	Pine Hill	Bluebush No.1 Bore
23	" "	Bluebush No.2 Bore
24	" "	Hawks Nest No.1 Bore
25	" "	Hawks Nest No.2 Bore
26	" "	Tinakie No.1 Bore
27	" "	Tinakie No.2 Bore
28	" "	Algamba No.1 Bore

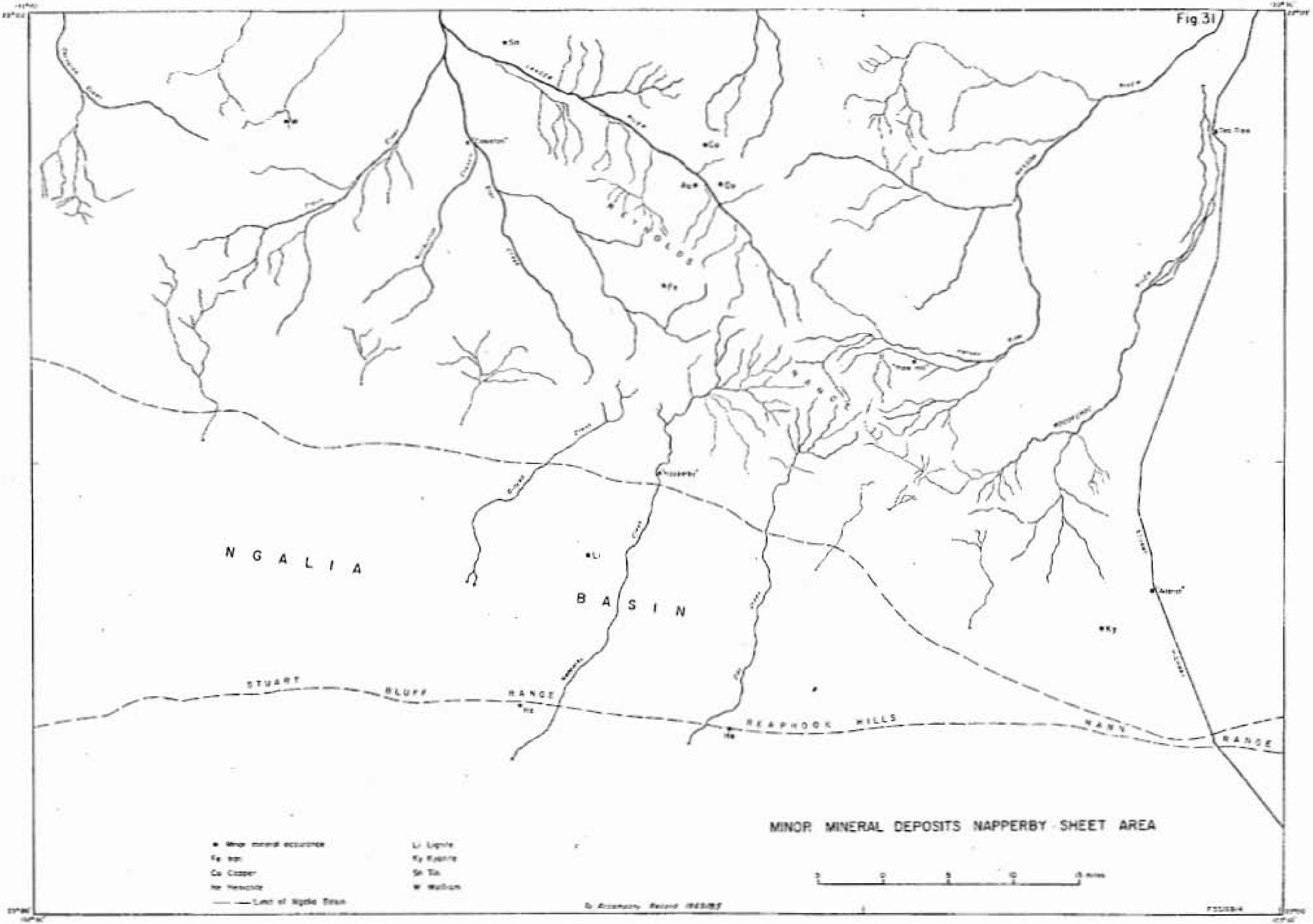
29	" "	Algamba No.2 Bore
30	" "	Station Well
31	" "	Station Bore
32	" "	D.R. No.1 Try Dud
33	North West Stock Route	Smiths Gift Bore
34	" " " "	Cassidy Bore
35	" " " "	Witchety Replacement Bore
36	" " " "	Sandy's Bore
37	" " " "	Witchety Original Bore
38	Napperby	Tilmouth Well
39	"	Sullivan's Well
40	"	Boundary Bore
41	"	No.2 Bore
42	"	8 Mile Soak Well
43	North South Stock Route	Ryans Well
44	Mt. Wedge	Homestead Well
45	" "	Yungarra Well
46	Napperby	Abandoned Well
47	Mt. Wedge	Rinkabeena Well
48	" "	Rinkabeena Bore
49	Napperby	Homestead Well
50	Pine Hill	D.R. No.2 Try Bore
51	Ti Tree Township	Block 472 Police Station Bore
52	Ti Tree	Goreys Bore
53	Ti Tree	Anullicha Bore
54	Ti Tree	Homestead Well
55	Ti Tree	Waterloo Bore
56	Aileron	Dud Bore 7 miles W. of Homestead
57	Mt. Wedge	Coppock Bore
58	Ti Tree	Pound Well
59	" "	Anningie Bore

60	Ti Tree	Ridge Hole Bore
61	Gibeanie	Sandys Bore (Wooraka)
62	"	Dud Bore 8 miles SW of Homestead
63	Napperby	1958 D.R. No.2 Dud
64	"	1958 D.R. No.3
65	"	Salt Bush Bore
66	"	Gift Bore
67	"	Sandy's Bore
68	"	Limestone Bore
69	"	Sugarbag Bore
70	"	Gidyea Bore
71	Pine Hill	Weldon Well
72	Napperby	Murray Bore
73	Ti Tree Reserve	Hart No.1 Bore
74	" " "	Liddles Citrus
75	" " "	Hart No.2 Bore
76	Napperby	Dud 32 miles SSE of Homestead
77	"	New Bore
78	Mt. Wedge	Yarragan Bore
79	Mt. Denison	Naval Action Bore
80	Mt. Wedge	Rabbit Hole Bore
81	Aileron	Dud
82	Mt. Allan	A41/1 No.1 Try Dud
83	" "	A41/2 No.1 Try Dud
84	" "	A41/5 Midway Bore
85	" "	A41/ Site
86	" "	A41/ Site
87	" "	A41/2 No.2 Try, Ferdies Bore
88	" "	A41/1 No.2 Try, Rochow Bore
89	" "	10 Mile Bore
90	" "	Salty Bore
91	" "	Bloodwood Bore
92	" "	Brookes Well

93	Mt. Allan	Direct Action Bore
94	Napperby	Wallaby Bore
95	"	Paddy (Patty) Well
96	"	Bloodwood Bore
97	"	Supplejack Bore
98	"	Herberts Well
99	"	Corroborree Bore
100	North South Stock Route	Native Gap Bore
101	" " " "	Prowse Gap Well
102	" " " "	Aileron Dam
103	Gibeanie	Homestead Bore
104	North West Stock Route	Tilmouth Creek Bore
105	Coniston	Lander Bore
106	Mt. Allan	No.1 Bore
107	" "	Homestead Dam
108	Napperby	Bore
109	"	Clay Pan Bore
110	"	Tinkle Bore
111	"	No.1 Bore
112	"	Gimcrack Bore
113	Mt. Denison	Homestead Well
114	" "	Homestead Bore
115	" "	No.1 Bore
116	North West Stock Route	Witchetty Dud Bore
117	Mt. Allan	Dud Bore
118	" "	Dud Bore
119	Mt. Denison	Failure Well
120	" "	7(8) Mile Bore No.1
121	" "	7(8(Mile Bore No.2
122	North South Stock Route	Arden Soak Well
123	Coniston	Block Hill No.2 Bore
124	"	New Homestead No.1 Try Dud
125	"	New Homestead No.2 Try Dud
126	"	Block Hill No.1 Bore

127	Coniston	Tin Field Bore
128	"	Tin Field Replacement Bore
129	Mt. Denison	A34/8 No.1 Try Dud
130	" "	A34/9 No.1 Try Dud
131	Mt. Allan	A41/4 No.1 Try Dud
132	Mt. Denison	A34/8 No.2 Try Dud
133	" "	A34/8 No.3 Try Dud
134	Mt. Allan	A41/4 No.2 Try Dud
135	" "	Carters Yard Dud
136	" "	A41/6 Dud
F53/9 -		
137	Aileron	Birthday Bore
138	Ti Tree	Western Bore
139	" "	Ken's Soak
140	Ti Tree Reserve	Liddles Abandoned Well
141	Aileron	Mt. Freeling Bore
142	"	Pridmores Bore
143	"	Sheppards Bore
144	Coniston	Nintabrinna Bore
145	"	White Tree Bore
146	Mt. Allan	Desert Bore
147	Aileron	Advice Site A87/2
148	"	Advice Site A87/1
149	"	Homestead Bore and Duds
150	"	Dud 7 Miles W of Homestead
151	"	Dud 9 Miles W of Homestead
152	Pine Hill	Homestead (Harrys) Bore
153	Mt. Denison	A34/5 No.1 Try Dud
154	" "	Brookes Soak Well
155	Coniston	Old Homestead Bore
156	"	Crown Well
157	"	Ingallana Spring
158	Ti Tree	Salt Bush Bore

159	Pine Hill	Station No.2 Bore
160	Aileron	Rabbit Flat Well
161	"	Max's Bore
162	Mt. Allan	Centipede Dam
163	Napperby	Malcolm Soak Bore
164	"	Wallaby Well
165	"	Spinifex Bore
166	"	Cabbage Tree Bore
167	"	Long Hole Bore
168	"	Walker Hole Well
169	Ti Tree Township	Block 535 Site
170	" " "	Block 470 store Bore



MINOR MINERAL DEPOSITS NAPPERBY SHEET AREA

B.P. Thomson (1948) wrote a short report for Zinc Corporation Limited which was concerned mainly with Davies and Southion's Prospect, Lander River. The company drilled three diamond drill holes but the results were disappointing and no further work was done by this company. However, the area of Davies and Southion's lease was re-examined and a small copper mine established on the lease. This was named the Reward Copper Mine and was worked until 1956. In the same report Thomson (1948) commented on an old gold prospect, 1¾ miles west of Davies and Southion's Prospect. A shaft 80 feet deep was dug at the site of the gold prospecr but the effort proved unrewarding. Thomson collected chip samples over a width of 24 inches from a pit near the shaft and this sample assayed 4.0 dwt. Au. A grab sample from a small dump at the shaft assayed 3.2 dwt. Au.

Thomson also believed wolfram had been obtained from alluvium three miles west of Ingallan Spring. Ryan (1958) wrote a record on the geology and mineral deposits of the Reynolds Range area and visited he following mineral deposits; the Mount Stafford tin lodes, the Lander copper deposits, the Reward copper mine and Barneys ironstone deposits. Of these only two, the Mount Stafford tin Lodes and the Reward copper mine, have been worked but are now abandoned.

The Mount Stafford tin lodes are about 40 miles north of Coniston Homestead on the north side of the Lander River. The tin is present as large isolated crystals of cassiterite which are found in two pegmatite dykes which intrude Precambrian metamorphics. A small crystal of piedmontite (manganese epidote) was found in the vicinity of the mine during the 1968 regional mapping.

The Lander copper deposits are described by Ryan as 'four small concentrations of secondary copper minerals". No work has been done on them. They lie 3½ miles west southwest of Ingallan Spring close to the site of the alluvial wolfram reported by Thomson (1948).

The Reward copper mine has previously been mentioned. The copper occurs mainly as malachite associated with a quartz vein emplaced in metamorphics.

Barnys ironstone deposits lie in quartz schists three miles south-west of Mount Thomas in the Reynolds Range. They are composed almost entirely of earthly brown limonite.

Ryan mentioned several other minor occurrences notably wolfram bearing pegmatites south of Brooks Soak, 15 miles west of Coniston Homestead, mica and gold which were reported from the Pine Hill locality, and a small deposit of lead reported from a few miles west of Coniston.

Since 1958 few new mineral localities have been reported and little prospecting has been attempted. Ryan (1958) claimed that "most of the known mineral deposits of the area were originally reported by aboriginals who have indicated the presence of many small mineral deposits, but refuse to divulge their whereabouts, principally for tribal reasons".

Australian Geophysical Pty Limited carried out geological mapping, stream sediment sampling, costeaning and diamond drilling over specific areas of the Napperby Sheet and produced a final report (Australian Geophysical, 1967) on the Reynolds Range and Pine Hill areas. This report indicated that mineralisation in the Pine Hill area is uneconomic. No new mineral deposits were located and the potential of the area was considered low.

Lignite was found at a depth of 455 feet in a stratigraphic drill hole (B.M.R. Napperby No.1 - Grid Reference 587.180) drilled by the Bureau of Mineral Resources in 1968. This lignite is believed to be Tertiary in age. (Nothofagus pollen indicates a post Eocene- pre Pliocene age). Similar lignite has been encountered in water bores drilled into the Tea Tree groundwater basin (e.g. W.R.B. 130/62.5 Bore No.198, 1966). The B.M.R. stratigraphic hole Napperby No.1 encountered only a few inches of lignite in a bottom hole core.

Kyanite was discovered in quartz veins intruding schist in the southern part of the Reynolds Range near to the Stuart Highway. This is only a very minor occurrence and was discovered during the regional mapping of the Napperby Sheet area.

Hematite occurs in quartz dykes which intrude the basement rocks immediately south of the Reaphook Hills and south of the Stuart Bluff Range near Mount Hammond. These quartz hematite dykes were once believed to be potential gold prospects (Jones, 1954). An Authority to Prospect was taken out in 1955 by Geolsite Associates on these dykes and a progress report written by Layton (1965). Samples were collected by Layton and assayed but the results were disappointing. Recent geochemical surveys and diamond drilling by Central Pacific Minerals Pty have also proved these quartz hematite dykes to have no economic mineralisation.

ACKNOWLEDGEMENTS

The authors wish to acknowledge assistance from the following persons during the field season.

The Resident Geologist and Staff of Alice Springs, Mr. and Mrs. R. Shepard from Napperby Cattle Station, Mr. L. Martin from Mount Denison Cattle Station, and the Staff at the Royal Flying Doctor Control Station at Alice Springs.

REFERENCES

Most unpublished references can be consulted at the Bureau of Mineral Resources, Parkes, Camberra, A.C.T.

UNPUBLISHED

AUSTRALIAN GEOPHYSICAL, 1967 - Report No.12. Final Report on the Reynolds Range and Pine Hill areas, N.T.

COOK, P.J., and SCOTT, I.F., 1966 - Reconnaissance geology and petrology, Ngalia Basin, Northern Territory. Bur. Miner. Resour. Aust. Rec. 1966/73.

EDWORTHY, K.J., 1966 - Preliminary appraisal of the Tea-Tree groundwater basin, Northern Territory. Unpubl. Report Alice Springs Resident Geologists Office, N.T.A.

EDWORTHY, K.J., 1968 - Apprisal of the rgoundwater resources of Lander River area, Northern Territory, 1966. Bur. Miner. Resour. Aust. Rec. 1968/73.

FITZPATRICK, B.F., and WEBB, E.A., 1963 - Report on field reconnaissance - O.P.81, Report by Fitzpatrick and Webb for Pacific American Oil Co.

FITZPATRICK, B.F., 1963 - Photogeological map (1:250,000) of Permit 81 (Ngalia Basin). Unpubl. map for Pacific American Oil Co.

FLAVELLE, A., 1965 - Helicopter gravity survey by contract, Northern Territory and Queensland 1965. Bur. Miner. Resour. Aust. Rec. 1965/212.

HARTMAN, R.F., 1963 - Interpretation report of airborne magnetometer survey over portion of Oil Permit No.81, Ngalia Trough, N.T. Report by Aeroservices Ltd for Pacific American Oil Co.

HUDSON, H.B., and CAMPBELL, J.H.B., 1965 - Napperby seismic survey, Oil Permit 81 Northern Territory of Australia. Report by Geophysical Associated Pty Ltd for Pacific American Oil Company.

JONES, N.O., 1954 - Gold prospect near Patty Well, Napperby Station. Preliminary Report. Unpubl. Report Alice Springs Resident Geologist Office, N.T.A.

JONES, P., 1969 - Ngalia Basin seismic survey 1967-68. Bur. Miner. Resour. Aust. Rec. (in prep.)

KINGDOM, E., WOOLLEY, D., and FAULKS, I., 1957 - Water bore locations in central Australia. Bur. Miner. Resour. Aust. Rec. 1967/83.

LANGRON, W.J., 1962 - Amadeus basin reconnaissance gravity survey using helicopters N.T. 1961. Bur. Miner. Resour. Aust. Rec. 1962/24.

LAYTON, N., 1965 - Quartz-hematite veins south of the Stuart Bluff Ranges, Napperby Sheet area. N.T. Reports by Geolsite Associates on Prospecting Authority 1378.

MILLIGAN, E.N., 1964 - The regional geology of the northern half of the Alcoota 1:250,000 Sheet area, N.T. Bur. Miner Resour. Aust. 1964/43.

NETTLETON, L.L., 1965 - Report on interpretation of gravity results, Napperby area. Oil Permit 81, Northern Territory of Australia. Report by Geophysical Associates Pty Ltd for Pacific American Oil Company.

RIVEREAU, J.,1965 - The photogeology of the Ngalia Basin, Northern Territory. Bur. Miner. Resour. Aust. Rec. 1965/255.

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.

SCOTT, I.F., 1966 - A series of rocks from the Ngalia Basin, N.T., Australian Mineral Development Laboratories, Rep. MP 1595 - 66.

SMITH, K.G., 1966 - The geology of the Georgina Basin. Bur. Miner. Resour. Aust. Rec. 1966/71

SMITH, E.R., 1968 - Discussion on seismic record sections, Ngalia Basin seismic survey Northern Territory, 1967-68. Bur. Miner. Resour. Aust. Rec. 1968/136.

THOMPSON, B.P., 1948 - Report on geological reconnaissance, vicinity of Davies and Southion's Prospect, Lander River, N.T. Report for Zinc Corporation Ltd.

TUCKER, D.H., 1969 - Preliminary report Ngalia Basin (N.T.) seismic survey 1968. Bur. Miner. Resour. Aust. Rec. 1969/70.

WHITWORTH, R., 1969 - Reconnaissance gravity survey using helicopters of Arnhem Land, N.T., and the Kimberleys, W.A., Bur. Miner. Resour. Aust. Rec. (in prep.).

WELLS, A.T., EVANS, T.G., and NICHOLAS, T., 1968 - The geology of the central part of the Ngalia Basin, Northern Territory. Bur. Miner. Resour. Aust. Rec. 1968/38.

PUBLISHED REFERENCES

AERIAL GEOLOGICAL AND GEOPHYSICAL SURVEY OF NORTHERN AUSTRALIA.1941 - Annual Report for period ending 31st December, 1940.

CHEWINGS, C., 1928 - Further notes on the stratigraphy of central Australia. Trans. Roy. Soc. S. Aust., 52, 62-81.

COOK, P.J., and SCOTT, I.F., 1967 - Reconnaissance geology and petrography of the Ngalia Basin, N.T. Bur. Miner. Resour. Aust. Rep. 125.

GOSSE, W.C., 1874 - Report and diary of W.C. Gosse's central and western exploring expeditions 1873-74. S. Aust. Parl. Pap. 48, 1874.

JONES, N.O., and QUINLAN, T., 1962 - An outline of the water resources of the Alice Springs area. In Perry et al (1962) General report on lands of the Alice Springs, N.T., 1956-57. Sci. ind. Res. Org. Melb. Land. Res. Ser. 6.

MABBUTT, J.A., 1962 - Geomorphology of the Alice Springs area. In Perry et al (1962) General report on lands of the Alice Springs area, N.T. 1956-57. Sci. ind. Res. Org. Melb. Land. Res. Ser. 6, 163-184.

MEIGS, P., 1953 - World distribution of arid and semi-arid homoclimates.. In Reviews of Research on Arid Zone Hydrology. Unesco: Paris, 203-210.

MIYASHIRO, A., 1961 - Evolution of metamorphic belts. J. Petrol.2, 1961. 277-311.

MURRAY, W.R., 1907 - Record of prospecting operations in country south-west from Barrow Creek and Davenport Ranges, 1906. S. Aust. Parl. Pap. 50, 1907.

PERRY, R.A., MABBUTT, J.A., LITCHFIELD, W.H., and QUINLAN, T., 1962 - Land systems of the Alice Springs area In Perry et al (1962), General report on lands of the Alice Springs area, N.T. 1956-57. Sci. ind. Res. Org. Melb., Land Res. Ser. 6.

PETTIJOHN, F.J., 1957 - SEDIMENTARY ROCKS, 2nd Edition. Harper and Brothers New York.

PITCHER, W.S., 1965 - The aluminium silicate polymorphs. In Controls of metamorphism. J. Geol. Special Issue No.1.

POWERS, M.C., 1967 - Fluid release mechanisms in compacting marine mud-rocks and their importance in oil exploration. Bull. Amer. Assoc. Petroleum. Geologist. 51,7.

QUINLAN, T., 1962 - An outline of the geology of the Alice Springs area. In Perry et al (1962) General report on Lands of the Alice Springs area, N.T. 1956-57. Sci. ind. Res. Org. Melb. Land. Res. Ser. 6.

RYAN, G.R., 1962 - The mineral deposits of the Alice Springs area. In Perry et al. (1962) General report on lands of the Alice Springs area, N.T., 1956-57. Sci. ind. Res. Org. Melb. Land Res. Ser. 6.

STUART, J. McDOUALL, 1861 - Diary of explorations to the North West Coast from March 2nd to September 3rd, 1860. S. Aust. Parl Pap. 65, 1861.

STUART, J. McDOUALL, 1865 - Explorations in Australia; the journals of John McDouall Stuart during the years 1858-1862. W. HARDMAN EDITOR, LONDON : SAUNDERS, OTLEY AND CO. 2nd Ed.

THREADGILL, B., 1922 - South Australian Land Exploration, 1856-1880. Part I and II. Public Library, Museum and Art Gallery of South Australia, Historical compilations No.3, Adelaide.

TINDALE, N.B., 1933 - Geological notes on the Cockatoo Creek and Mount Leibig country, Central Australia. Trans. Roy. Soc. S.Aust. 57, 206-217.

WELLS, A.T., RANFORD, L.C., STEWART, A.J., COOK, P.J., and SHAW, R.D., 1967 - The geology of the north-eastern part of the Amadeus Basin, Northern Territory. Bur. Miner. Resour. Aust. Rep. 113.

WILLIAMS, H., TURNER, F.J., and GILBERT, C.M., 1954 - PETROLOGY. W.H. Freeman and Company, San Francisco.

WINNECKE, C., 1882 - Plan and report of Mr. Winnecke's explorations from Alice Springs to the Herbert River and Tennant Creek. S. Aust. Parl. Pap. 121, 1882.

ZWART, H.J., CORVALAN, J., JAMES, H.L., MIYASHIRO, A., SAGGERSON, E.P., SOBOLEV, V.S., SUBRAMANIAM, A.P., and VALLANCE, T.G., 1967 - A scheme of metamorphic facies for the cartographic representation of regional metamorphic belts. I.U.G.S. Geol. Newsletter, 57-72.

APPENDIX I.

PETROGRAPHY OF IGNEOUS AND METAMORPHIC ROCKS FROM THE NAPPERBY SHEET AREA

Contents

Abbreviations

crypt.	- cryptocrystalline	(< 0.01 mm.)
mic.	- microcrystalline	(0.01 - 0.05 mm.)
f.g.	- fine-grained	(0.05 - 0.3 mm.)
m.g.	- medium-grained	(0.3 - 3.0 mm.)
c.g.	- coarse-grained	(3.0 mm <)

the mineral modes are based on visual estimate; specimen number is the BMR serial number. The number in brackets is the field number, marked on the 1:250,000 geological map.

sp.	- specimen
tr.	- trace.

A. Basic metamorphic rocks

1. Low-grade basic meta-igneous rocks

sp. 68.66.0033 A (N212A) :- Tremolite-epidote-quartz schist.

Hand specimen :- Fine to medium-grained banded green and grey rock.

Mineralogy : -

Quartz	f.g. - m.g.	40 per cent
Epidote	f.g. - m.g.	} 40 " "
Clinozoisite	f.g.	}
Tremolite	f.g.	20 " "
Sphene, apatite, allanite metamict.		tr.

Microtexture :- Schistose. The quartz grains are elongated with the schistosity, and show strain shadows (undulating extinction). Bundles of fibrous tremolite are extensively replaced by granular epidote. Tremolite-rich and epidote-rich bands alternate with quartz-rich bands.

Petrogenesis :- The rock was originally either a basic igneous rock or a magnesian shale. Metamorphism according to the greenschist facies resulted in development of tremolite and in complete replacement of feldspar by epidote, accompanied by shearing.

sp. 68.66.0038 (N218) :- Fine-grained calcite-tremolite-albite-actinolite-epidote-quartz metabasite.

Hand-specimen :- Aphanitic, weakly foliated, grey to greenish rock.

Mineralogy :-

Quartz	mic. - f.g.	} 45 per cent
Albite	mic. - f.g.	}
Epidote	f.g.	40 " "
Actinolite	f.g. - m.g.	} 10 " "
Tremolite	mic. - f.g.	}
Calcite	f.g. - m.g.	5 " "

Microtexture :- Equigranular granoblastic aggregate of microcrystalline quartz, albite and epidote. The amphibole is weakly aligned. Calcite occurs mainly in veinlets parallel to the foliation. Micropoikiloblasts of actinolite carry inclusions of quartz.

Petrogenesis :- The rock is probably a metamorphosed basic igneous rock. The calcic plagioclase has been replaced by epidote and albite, whereas the pyroxene has been replaced by amphibole.

sp. 68.66.0049c. (N229c) :- Medium-grained actinolite schist.

Hand-specimen :- Dark green, medium-grained, uniformly-textured rock.

Mineralogy :-

Actinolite (z-bluish green)	f.g. m.g.	95 per cent
Plagioclase	f.g. m.g.	3 " "
Sericite	mic.	2 " "
Biotite, epidote, sphene, magnetite		tr.

Microtexture :- Weakly nematoblasic aggregate of xenoblastic actinolite, including minor highly sericitised grains of plagioclase.

Petrogenesis :- The rock is a metamorphosed ultramafic rock, probably a meta-pyroxenite.

sp. 68.66.0095 (N323):- Epidote-bearing quartz-plagioclase-actinolite metabasite schist.

Hand-specimen:- Aphanitic, dark green amphibolite

Mineralogy :-

Actinolite (z-blue green)	mic.-f.g.	50 per cent
Plagioclase (andesine)	f.g.	30 " "
Quartz	f.g.	20 " "
Epidote, chlorite, sphene, iron ore		tr.

Microtexture :- A nematoblastic aggregate of well aligned amphibole and granoblastic fine-grained quartz and feldspar. Edidote may occur as microporphyroblasts, and is younger than the amphibole. The lineation is micro-folded.

Petrogenesis :- The rock is a metamorphosed basic igneous rock. Metamorphism reached the upper greenschist or lower amphibolite facies. The specimen is derived from a dyke.

sp. 68.66.0096 (N323) :- Quartz-plagioclase-actinolite metabasite schist.

Hand specimen :- Fine to medium-grained, dark green amphibolite.

Mineralogy :-

Actinolite (z-blue green)	f.g. - m.g.	55 per cent
Plagioclase (andesine)	f.g.	35 " "
Quartz	mic. - f.g.	10 " "
Biotite, iron ore		tr.

Microtexture :- The columnar amphibole is well aligned in parallel orientation, with plagioclase and quartz forming elongated granoblastic pockets. Quartz also occurs as veinlets.

Petrogenesis :- The specimen is a metamorphosed basic igneous rock, derived from a dyke. Metamorphism reached upper greenschist or lower amphibolite facies.

sp. 68.66.0608 (N7) :- Tremolite-albite-quartz-epidote metabasite.

Hand specimen :- Banded, light green, aphanitic rock, with lenses and veins of quartz.

Mineralogy :-	Epidote	f.g. - m.g.	80 per cent
	Tremolite	f.g.	3 " "
	Quartz	mic.-f.g.	10 " "
	Albite	f.g.	7 " "
	Iron ore, sphene		tr.

Microtexture :- Equigranular aggregate of fine-to medium-grained epidote, with intergranular aggregates of quartz and feldspar. Quartzofeldspathic aggregates also occur as streaks and lenses in the rock. The tremolite is partly replaced by epidote.

Petrogenesis :- The specimen is a metamorphosed basic igneous rock. Metamorphism reached the middle greenschist facies.

sp. 68.66.0609 (N9) :- Prehnite-chlorite-calcite metabasite.

Hand specimen : - Light-green to off-white aphanitic rock.

Mineralogy :-	Chlorite	f.g.	30 per cent
	Prehnite	mic.	25 " "
	Calcite	f.g. - m.g.	45 " "
	Apatite	f.g.	tr.
	Tremolite	mic.	tr.

Microtexture :- An irregularly-textured aggregate of fibrous chlorite (usually with anomalous blue and brown birefringence), calcite mosaics occuring either as veinlets or disseminated through the rock, and prehnite granules, which are usually developed at the expense of chlorite. The chlorite appears to replace tremolite, relicts of which may be preserved at the centres of chlorite aggregates.

Petrogenesis :- The rock is a carbonated basic igneous rock. The primary ferromagnesian constituents were replaced by tremolite, subsequently replaced by chlorite. Introduction of lime is represented by the replacement of chlorite by prehnite, as well as by the abundance of calcite.

sp. 68.66.0611 (N46A) :- Porphyroblastic biotite - tremolite-quartz-actinolite-plagioclase meta-basalt.

Hand specimen :- Green aphanitic uniform rock with porphyroblasts of biotite.

Mineralogy :-	Actinolite	f.g.	35 per cent
	Tremolite	f.g.	5 " "
	Plagioclase (labradorite)	f.g.	40 " "
	Quartz	m.g.	15 " "
	Biotite	c.g.	5 " "
	Iron ore, sphene		

Microtexture :- The plagioclase occurs as clear, commonly twinned microlites, and as anhedral grains. The actinolite (z-green) may be partly rimmed or completely replaced by tremolite. Poikiloblasts of biotite with inclusions of plagioclase and actinolite are common. The quartz occurs as interstitial grains or as poikiloblasts. Pleochroic haloes in amphibole are developed around inclusions of rutile.

Petrogenesis :- The rock is a low-grade metamorphosed basalt, which underwent slight potash metasomatism, resulting in the growth of biotite at the expense of amphibole.

sp. 68.66.0614 (N31) : : Ilmenite-bearing quartz-plagioclase-actinolite meta-basalt.

Hand specimen :- Fine to medium-grained amphibolite.

Mineralogy :-	Actinolite -	f.g.-m.g.	60 per cent
	Plagioclase -	m.g.	20 " "
	Sassurite -	crypt.	15 " "
	Ilmenite -	F.g.	1 " "
	Quartz -	mic-F.g.	4 " "

Microtexture :- Sassuritised lath-like plagioclase crystals are intervened by fibrous to columnar actinolite. Ilmenite occurs as skeletal crystals and granular aggregates. Quartz mosaics occur in pockets and veinlets. The feldspar delineates a relict intergranular texture.

Petrogenesis :- The rock is a metamorphosed basalt in which the original outlines of the plagioclase and the ilmenite have been preserved.

2. Medium-grade basic meta-igneous rocks

sp. 68.66.0050B. (N230B):-

Pyrite-rich biotite-hornblende-labradorite amphibolite

Hand specimen :- Black, medium-grained, uniformly textured.

Mineralogy :-

Green hornblende.	f.g.-m.g.	30 per cent	
Labradorite	f.g.-m.g.	50 " "	
Biotite (z-reddish brown)	f.g.	10 " "	
Quartz	m.g.	10 " "	
Apatite, magnetite, pyrite		tr.	

Microtexture :- Medium-grained, xenoblastic-granular. Little or no preferred orientation.

Petrogenesis :- Metamorphosed basic igneous rock. Metamorphism reached the amphibolite facies. Late growth of biotite and development of rims of tremolite around hornblende indicate incipient retrogressive metamorphism accompanied by potash-metasomatism.

sp. 68.66.0051 (N231) :- Clinozoisite-bearing labradorite-hornblende amphibolite.

Hand specimen :- Medium-grained dark green amphibolite.

Mineralogy :-

Hornblende (z-greenish to light brown)	m.g. -	55 per cent
Labradorite	f.g.-m.g.-	40 " "
Clinozoisite, epidote, sphene, iron ore, albite, quartz.	-	5 " "

Microtexture :- Medium-grained, xenoblastic-granular assemblage of amphibole and plagioclase. The amphibole occurs as equant to short prismatic anhedral grains.

The plagioclase is relatively clear, and usually twinned. Granular aggregates of microcrystalline clinozoisite occur within slightly clouded grains of plagioclase, and are associated with albite and quartz. The sphene occurs as oval grains within amphibole, and is surrounded by opaque rims and pleochroic haloes.

Petrogenesis :- The rock is a metamorphosed basic igneous rock. Metamorphism reached the amphibolite facies. Weak retrograde metamorphism may be represented by the partial sassuritisation of the plagioclase, and by a development of green amphibole rims around cores of brown amphibole.

sp. 68.66.0054A (N234A) :- Andesine-actinolite-hornblende amphibolite.

Hand specimen :- Dark green, medium-grained, weakly banded amphibolite.

Mineralogy :-

Hornblende (z-brown)	m.g.	} 60 per cent
Actinolite (z-green)	mic.-m.g.	
Plagioclase (andesine)	f.g.-m.g.	30 " "
Epidote	m.g.	5 " "
Quartz	f.g.	5 " "

Microtexture :- Xenoblastic-granular. The actinolite is accicular, and commonly constitutes rims around the brown hornblende, or forms individual grains. The plagioclase may be sassuritised, and is accompanied by quartz grains. Epidote occurs as medium-grained idioblastic crystals in a vein.

Petrogenesis :- The rock is a metamorphosed basic igneous rock conforming to the amphibolite facies. Retrograde metamorphism is suggested by the occurrence of rims of blue-green amphibole (actinolite?) around the brown amphibole.

3. Basic granulites

sp. 68.66.0052A (N232A):- Hypersthene-diopside-hornblende-labradorite granulite.

Hand specimen:- Medium-grained dark green rock.

Mineralogy:-

Labradorite	f.g.-m.g.	50 per cent
Hornblende(z-green-brown)	m.g.	30 " "
Diopside	f.g.-m.g.	10 " "
Hypersthene	f.g.-m.g.	10 " "
Iron ore		tr.

Microtexture:- Medium-grained xenoblastic-granular, or granulitic. The pyroxene often occurs as small grains at the rims of the hornblende, and is therefore younger. The opaques are associated with the amphiboles, and may form rims around it.

Petrogenesis:- The rock is a metamorphosed basic igneous rock, showing a transition from the amphibolite facies to the granulite facies.

Sp. 68.66.0052 (N232B):- Porphyroblastic hornblende-diopside-labradorite granulite.

Hand specimen:- Porphyroblastic medium to coarse-grained mafic granulite.

Mineralogy:-

Diopside	m.g.-c.g.	30 per cent (Diopside + Hypersthene)
Hypersthene	m.g.-c.g.	
Hornblende(green)	f.g.-m.g.	10 " "
Labradorite	f.g.-m.g.	60 " "
Iron ore		tr.

Microtexture:- Coarse to very coarse-grained xenoblastic porphyroblasts of pyroxene are set in a medium-grained granoblastic aggregate of labradorite, pyroxene, and hornblende. The hornblende occurs mainly as inclusions in the pyroxene, and is clearly earlier than this mineral. Hypersthene may show multiple lamellar twinning. The opaques are associated with the ferromagnesian minerals, and may occur as veins in the pyroxene.

Petrogenesis:- The rock is a high-grade metamorphosed basic igneous rock, corresponding to the granulite facies.

sp. 68.66.0052C (N232C):- Biotite-bearing hornblende-diopside-labradorite granulite.

Hand specimen:- Medium-grained dark green granulite.

Mineralogy:-

Diopside	f.g.-m.g.	30 per cent
Hornblende(z-green)	f.g.-m.g.	30 " "
Labradorite	f.g.-m.g.	40 " "
Biotite	f.g.	tr.
Iron ore		tr.

Microtexture:- Granulitic, or xenoblastic-granular. The plagioclase is almost free of clouding and is multiply-twinned. The pyroxene is clearly developed at the expense of the hornblende. The biotite (z-red to brown) is associated with the hornblende.

Petrogenesis:- The rock is a metamorphosed basic igneous rock. Metamorphism reached the hornblende-granulite facies.

Sp. 68.66.0053A (N233A):- Diopside-hypersthene-hornblende-labradorite granulite.

Hand specimen:- Medium-grained dark-green rock.

Mineralogy:-

Diopside	f.g.	} 15 per cent
Hypersthene	f.g.	
Hornblende(z-green)	f.g.-m.g.	30 " "
Labradorite	f.g.-m.g.	55 " "
Sphene, iron ore, clinozoisite		tr.

Microtexture:- Granulitic, or xenoblastic-granular. The pyroxene forms fine-grained granular aggregates developed at the expense of amphibole.

Petrogenesis:- The specimen is a high-grade metamorphosed basic igneous rock, with metamorphism reaching the granulite facies.

Sp. 68.66.0055A (N2354):- Sphene-bearing quartz-epidote-labradorite-diopside granulite.

Hand specimen:- Banded, fine-grained light green rock.

Mineralogy:-

Diopside	f.g.-m.g.	40 per cent
Epidote	mic.-f.g.	15 " "
Plagioclase(labradorite)	f.g.-m.g.	30 " "
Quartz	f.g.	13 " "
Sphene	f.g.	2 " "
Iron ore	Mic.-f.g.	tr.

Microtexture:- Fine-grained granulitic. The plagioclase grains are usually twinned, and are conspicuously rimmed by epidote. The diopside is light green, and occurs as anhedral to short prismatic grains. The sphene is mostly associated with the pyroxene. Pyroxene-rich bands alternate with feldspathic bands.

Petrogenesis:- The rock is a metamorphosed basic igneous rock which reached the granulite facies. Retrograde metamorphic effects are represented by replacement of the plagioclase by epidote.

Sp. 68.66.0068A (N248A):- Fine-grained hornblende-quartz-hypersthene-labradorite granulite.

Hand specimen:- Fine-grained green weakly-banded granulite.

Mineralogy:-

Hypersthene	f.g.-m.g.	35 per cent
Labradorite	f.g.-m.g.	45 " "
Quartz	f.g.-m.g.	15 " "
Hornblende(z-green)	f.g.	5 " "
Iron-ore, tourmaline, biotite		tr.

Microtexture:- Xenoblastic-granular. Granular and irregularly-shaped grains of pyroxene are intergrown with feldspar and quartz. The plagioclase is twinned according to the albite law, and is relatively free of inclusions. The hornblende is texturally earlier than the pyroxene.

Petrogenesis:- The rock is a metamorphosed basic igneous rock, which reached the granulite facies.

Sp. 68.66.0070 (N250):- Tremolite-actinolite-hornblende-plagioclase-diopside granulite.

Hand specimen:- Medium-grained, banded dark green granulite.

Mineralogy:-

Diopside	f.g.-m.g.	40 per cent
Hornblende(z-brown)	f.g.-m.g.	20 " "
Actinolite(z-green)	mic.-f.g.	} 5 " "
Tremolite	mic.-f.g.	}
Plagioclase(andesine-labradorite)		35 " "
Iron ore, epidote, clinozoisite		tr.

Microtexture:- Granulitic, or xenoblastic-equigranular. The pyroxene is rimmed by thin veneers of actinolite and tremolite. The plagioclase may be heavily sassuritised by aggregates of clinozoisite, but is mostly free of clouding.

Petrogenesis:- The rock is a metamorphosed basic igneous rock. Metamorphism reached the granulite facies. Slight retrograde metamorphism is evident from the development of actinolite and tremolite rims around the pyroxene, as well as from the sassuritisation. The sequence of crystallisation is: hornblende, diopside, actinolite and tremolite.

Sp. 68.66.0072 (N252):- Actinolite-hypersthene-diopside-hornblende-plagioclase granulite.

Hand specimen:- Medium-grained, dark green, weakly banded granulite.

Mineralogy:-

Hypersthene	m.g.	20 per cent
Diopside	m.g.	
Hornblende(z-yellowish brown)	m.g.	30 " "
Actinolite(z-green)		tr.
Plagioclase(andesine)	f.g.-m.g.	50 " "
Iron ore, apatite		tr.

Microtexture:- Granulitic, or xenoblastic-equigranular. The pyroxene may carry inclusions of hornblende, and may be rimmed by actinolite. The hornblende may be rimmed by pyroxene, and by cryptocrystalline aggregates of an unknown mineral. The plagioclase shows cross-hatched and discon-uous lamellar twinning.

Petrogenesis:- The rock is a metamorphosed basic igneous rock. Metamorphism reached the granulite facies. Slight retrograde metamorphism is developed.

Sp. 68.66.0097 (N324):- Biotite-bearing hypersthene-quartz-plagioclase banded granulite.

Hand specimen:- Fine-grained to medium-grained granulite, banded in grey and white colours.

Mineralogy:-

Hypersthene	f.g.-m.g.	15 per cent
Biotite	mic.	4 " "
Plagioclase (labradorite)	f.g.-m.g.	45 " "
Quartz	mic.-m.g.	35 " "
Iron ore	mic.	1 " "
Diopside	f.g.	tr.

Microtexture:- Xenoblastic-equigranular. Bands rich in hypersthene and plagioclase alternate with plagioclase-quartz bands. The quartz shows strain and recrystallization features, and may occur as interstitial microcrystalline aggregates. The plagioclase is often cross-twinned.

Petrogenesis:- The rock is probably a metamorphically differentiated metabasite. The metamorphism reached the granulite facies.

B. Acid intrusive rocks,

1. Granites and altered granites.

Sp. 68.66.0026 (N204) :- Biotite-microline-oligoclase-quartz granite.

Hand specimen :- Medium-grained grey granite.

Mineralogy :-	Plagioclase (oligoclase-andesine)	f.g. - m.g.	- 40 per cent
	Microcline (slightly perthitic)	f.g. - m.g.	- 20 " "
	Quartz	f.g. - m.g.	- 30 " "
	Biotite	f.g.	- 5 " "
	Sericite	crypt.	- 5 " "
	Epidote, apatite, tourmaline, zircon, calcite, magnetite		tr.

Microtexture:- Medium-grained xenomorphic to hypidiomorphic-granular. The plagioclase is more heavily clouded than the microcline. Epidote is associated with biotite. Little or shearing is evident.

Petrogenesis:- Igneous intrusion in port-metamorphic times. Sequence of crystallization : Plagioclase, microline and quartz. Metamorphism is represented by growth of epidote.

Sp. 68.66.0028 (N207) :- Biotite-microline-oligoclase-quartz granite.

Hand specimen :- Medium grained, grey, weakly banded granite.

Mineralogy :-	Oligoclase	f.g. - m.g.	- 25 per cent
	Microcline	f.g. - m.g.	- 35 " "
	Quartz	f.g. - m.g.	- 30 " "
	Biotite	f.g. -	5 " "
	Sericite	mic.	5 " "

Metamict allanite, zircon, sphene, apatite, calcite, epidote and magnetite occur as accessories.

Microtecture:- Medium-grained xenomorphic granular. Incipient development of mortar structure. Quartz tends to occur in an interlobate texture. The plagioclase is sericitized. Epidote, biotite, iron ore,and allanite, tend to be associated with each other.

Petrogenesis:- Igneous crystallization under plutonic conditions, with plagioclase preceding microcline and quartz. Slight late - or post-magnetic clouding and carbonate introduction. Incipient granulation due to late-magmatic or tectonic stresses. The presence of epidote implies slight metamorphic effects.

Sp.68.66.0031A(N210A):- Coarse-grained chlorite-epidote-muscovite-quartz-plagioclase-microcline granite.

Hand specimen:- Pink to white medium- to coarse-grained granite.

Mineralogy:-

Microcline	m.g. - c.g. -	60 per cent
Plagioclase	m.g.	15 " "
Quartz	f.g. - m.g. -	10 " "
Muscovite + sericite	mic. - f.g. -	10 " "
Chlorite, epidote, zircon		5 " "

Microtexture:- Coarse-grained, porphyritic, hypidiomorphic-granular. Coarse-grained microcline grains are intervened by a fine- to medium-grained aggregate of highly sericitized plagioclase, quartz, finer-grained microcline, and interstitial clots of muscovite, chlorite and epidote. The microcline is partly perthitic, and carries inclusions of plagioclase and quartz. Grain boundaries may be recrystallized into a fine-grained aggregate. An incipient mortar structure is evident. The chlorite is ferruginous, and is partly replaced by epidote. Relict rutile included in the chlorite indicates an origin from alteration of biotite.

Petrogenesis:- The rocks is a potash-rice granite. Slight metamorphic alteration is represented by the development of epidote.

Sp.68.66.0031B(N210B):- Sheared medium-grained epidote-biotite-plagioclase microcline-muscovite-quartz meta-granite.

Mineralogy:-

Microcline	f.g.	- 20 per cent
Plagioclase	f.g.	- 10 " "
Quartz	f.g. - m.g.	- 30 " "
Muscovite + sericite	mic. - f.g.	- 30 " "
Epidote, biotite, chlorite, apatite, iron ore, zircon		- 10 per cent

Microtecture:- Cataclastic to schistose. Elongated anhedral quartz grains and ameboid-textured quartzo-feldspathic aggregates are sent in a microcrystalline matrix of sericite, muscovite, biotite, chlorite and epidote. The biotite is slightly altered. The coarser-grained muscovite is developed at the expense of sericite. Foliation is poorly developed.

Petrogenesis:- The rock is a sheared and metasomatized granite. Most of the feldspar has been altered to sericite and epidote. The biotite is altered, and the quartz is sheared and recrystallized.

Sp.68.66.0048(N228):- Biotite-plagioclase-quartz microcline-porphyroblastic cataclastic granite.

Hand specimen:- Weakly banded quartzose gneiss.

Mineralogy:-

Microcline	f.g. - m.g. -	45 per cent
Plagioclase	f.g.	10 " "
Quartz		40 " "
Biotite + sericite	mic. - f.g. -	5 " "
Apatite, zircon, iron ore	tr.	

Microtexture: Mortar structured. Fractured and corroded grains of feldspar are intervened by an intergranular, finely comminuted mosaic of microcrystalline quartz and feldspar, with accessory veins and clots of mica. Bands of fine-grained interlobate quartz are common.

Petrogenesis:- Originally a granite, which has been subject to shearing accompanied by little recrystallization.

Sp.68.66.0062(N242):- Porphyritic biotite-plagioclase-quartz microcline granite.

Hand specimen: Coarse-grained phenocrysts set in a fine-grained groundmass.

Mineralogy:

Microcline + perthite	f.g. - m.g. -	40 per cent
Plagioclase (andesine)	f.g. - m.g. -	20 " "
Quartz	f.g. - c.g. -	30 " "
Biotite	f.g.	10 " "
Sericite, epidote, zircon, iron ore	tr.	

Sp.68.66.0062(N242):- Porphyritic biotite-plagioclase-quartz microcline granite

Hand specimen:- Coarse-grained phenocrysts set in fine-grained groundmass.

Mineralogy:-

Microcline + perthite	f.g. - m.g. -	40 per cent
Plagioclase (andesine)	f.g. - m.g. -	20 per cent
Quartz	f.g. - c.g. -	30 per cent
Biotite	f.g.	10 per cent
Sericite, epidote, zircon, iron ore	tr.	

Microtexture :- Porphyritic. Xenomorphic to hypidiomorphic-granular. Phenocrysts of quartz and microcline are set in a fine-grained quartzo-feldspathic base. The biotite is weakly aligned. Some alteration of feldspar to clay takes place along cracks.

Petrogenesis:- Igneous crystallization, metamorphism, and slight weathering effects.

Sp.68.66.0069(N249):- Medium-grained plagioclase-microcline-quartz granite.

Hand specimen:- Medium-grained granite.

Minderalogy:-

Microcline	f.g. - m.g. -	30 per cent
Plagioclase	f.g. - m.g. -	30 per cent
Quartz	f.g. - m.g. -	30 per cent
Clay minerals	Crypt.	10 per cent

Microtexture:- Hypidiomorphic granular. Heavy clouding of the feldspar by submicroscopic inclusions, mainly distributed along cleavage planes.

Petrogenesis:- Igneous crystallization, weak weathering.

Sp.68.66.0628B(N105B):- Coarse-grained plagioclase-muscovite-quartz-microcline granite.

Hand specimen:- Coarse-grained granite

Mineralogy:-

Microcline	m.g. - c.g.	- 35 per cent
Plagioclase	f.g. -	- 10 " "
Quartz	m.g.	- 30 " "
Sericite + muscovite	mic. - m.g.	- 20 " "
Biotite, iron ore	f.g.	- 5 " "

Microtexture:- Coare-grained subhedral prisms of microcline with inclusions of plagioclase are intervened by quartz, sericite and muscovite, accompanied by altered biotite and rod-like hematite. The plagioclase inclusions are clouded, as contrasted with the clear microcline. The muscovite is developed at the expense of sericite.

Petrogenesis:- The rock is a porphyritic granite which has been partly altered, as reflected by the clouding and by the alteration of the biotite.

Sp.68.66.0629A(106A):- Poikiloblastic biotite-feldspar-quartz-muscovite meta-granite.

Hand specimen:- Porphyroblasts of muscovite are set in a medium-grained muscovite-quartz matrix.

Mineralogy:-

Quartz	f.g.	- 40 per cent
Muscovite, sericite	mic. - c.g.	- 50 " "
Feldspar	m.c.	7 " "
Biotite	f.g.	3 " "
Apatite, epidote	tr.	

Microtexture:- The rock consists mainly of fragments of quartz embedded in a groundmass of foliated microcrystalline sericite, and altered biotite. The sericite and biotite and replaced by coarse-grained poikiloblasts of muscovite, with quartz inclusions. The sericite is commonly pseudomorphic after feldspar, remnants of which are still present.

Petrogenesis:- The rock is an altered granite, with the feldspar almost completely altered to sericite. Metamorphism is reflected by the development of muscovite poikiloblasts.

Sp.68.66.0620C(N106C):- Medium- to coarse-grained muscovite-oligoclase-quartz-microcline granite

Hand specimen:- Medium-grained granite, with pegmatitic veins.

Mineralogy:-

Microcline	m.g. - c.g. - 40 per cent
Plagioclase (oligoclase)	f.g. - m.g. - 20 " "
Quartz	f.g. - c.g. - 30 " "
Muscovite + sericite	mic. - m.g. - 10 " "
Weathered biotite, iron ore	tr.

Microtexture:- Allotriomorphic granular. The plagioclase is relatively clouded, and is partly replace by sericite. Exsolved iron ore is interleaved with weathered biotite.The pegmatitic patches show a similar texture, but are coarse-grained.

Petrogenesis:- The rock is an altered granite.

2. Granitic gneisses

Sp.68.66.0029(N208):+ Porphyritic biotite-plagioclase-quartz-microcline granitic microgneiss.

Hand specimen:- Phenocrysts of feldspar and quartz in fine-grained sheared quartzo-feldspathic matrix.

Mineralogy:-

Plagioclase	f.g. - c.g. - 20 per cent
Microcline	f.g. - 35 " "
Quartz	f.g. - 35 " "
Biotite	f.g. - 5 " "
Sericite	mic. - f.g. - 5 " "
Apatite, epidote, magnetite and hematite (euhedral)	tr.

Microtexture:- Porphyroblasts and glomeroporphyroblasts of sericitized plagioclase, and cumuloblasts of quartz, are set in a granoblastic mosaic of fine-grained microcline and quartz. The biotite is well aligned. The plagioclase porphyroblasts may be recrystallized at their margins into finer grained aggregates.

Petrogenesis:- The rock is a sheared and recrystallized blastoporphyritic micro-granite. The metamorphism resulted in alignment of the biotite, marginal or complete break down of the plagioclase phenocrysts, and recrystallization of the matrix.

Sp.68.66.0030(N209):- Coarse-grained sphene-rich biotite-plagioclase-quartz-microcline granite gneiss

Hand specimen:- Porphyroblastic biotite gneiss.

Mineralogy:-

Microcline	f.g. - c.g. - 40 per cent
Plagioclase (oligoclase)	f.g. - c.g. - 20 " "
Quartz	f.g. - m.g. - 30 " "
Biotite	f.g. - m.g. - 5 " "
Chlorite, sericite, apatite, sphene, epidote and clinozoisite	5 " "

Microtexture:- Gneissose. Bands of crudely oriented biotite alternate with xenomorphic inequigranular aggregates of microcline, plagioclase and quartz. The biotite is accompanied by abundant sphene, accessory apatite, and epidote, and is marginally altered by chlorite. The plagioclase is abundantly clouded by clinozoisite epidote, sericite, and submicroscopic sassurite. Microcline is clouded to a lesser extent.

Petrogenesis:- The rock is probably a metamorphosed granite which underwent late-magmatic, hydrothermal, or retrogressive metamorphic alteration. High titania and lime contents are reflected by the abundance of sphene and epidote. The alteration included replacement of biotite by chlorite, and sassuritization and sericitization of the feldspar.

Sp.68.66.0034C(N214C):- Medium-grained muscovite-biotite-plagioclase-microcline-quartz granite augen gneiss

Hand specimen:- Grey, banded, medium-grained augen gneiss.

Mineralogy:-

Microcline	mic. - m.g. -	40 per cent
Plagioclase	f.g. - m.g. -	10 " "
Quartz	mic. - f.g. -	40 " "
Biotite (z-deep brown)	mic. - f.g. -	4 " "
Muscovite + sericite		4 " "
Apatite, zircon, iron ore		2 " "

Microtexture:- Porphyroblastic gneissose. Xenomorphic porphyroblasts and cumuloblasts of microcline and sericitized plagioclase, and lenses of medium-grained interlobate quartz, are set in a granoblastic groundmass of quartz, microcline, plagioclase and biotite. The biotite is well aligned. Films of foliated biotite and muscovite may form coats around quartzo-feldspathic augen.

Petrogenesis:- Metamorphosed granite. Early metamorphic stages involved complete granulation and development of schistosity, followed by porphyroblastic growth of augen of microcline, plagioclase and quartz, deflecting the mica along the boundaries. Muscovite is younger than the sericite and the biotite, and probably represents the latest stage of metamorphic growth.

Sp.68.66.0042(N222):- Medium-grained biotite-plagioclase-microcline-quartz granitic gneiss.

Hand specimen:- Medium-grained biotite-banded gneiss.

Mineralogy:-

Microcline	f.g. - c.g. -	40 per cent
Oligoclase-andesine	m.g.	20 " "
Quartz	f.g. - m.g.	25 " "
Biotite	m.g.	10 " "
Sericite, epidote, apatite, rutile, iron ore		5 " "

Microtexture:- Xenomorphic-granular quartzo-feldspathic bands alternate with crudely-foliated biotite-rich bands. The plagioclase is slightly sericitized. The potash feldspar may be perthitic. Epidote and apatite are developed in close association with biotite, which has inclusions of rutile. The rutile and epidote are surrounded by pleochroic haloes.

Petrogenesis:- Metamorphosed granite, displaying metamorphic segregation. The sequence of crystallization is: Plagioclase, microcline + quartz, biotite, epidote, muscovite + sericite.

Sp.68.66.0056B(N236B):- Medium-grained porphyroblastic biotite-microcline-plagioclase-quartz granite gneiss.

Hand specimen:- Medium- to coarse-grained porphyroblasts of feldspar, set in fine-grained matrix.

Mineralogy:-

Oligoclase	f.g. - c.g.	- 20 per cent
Microcline	f.g. - c.g.	- 20 " "
Quartz	f.g. - m.g.	- 40 " "
Biotite	f.g.	- 10 " "
Sericite	mic.	- 10 " "
Zircon, apatite, iron ores		tr.

Microtexture:- Porphyroblastic, gneissose. Porphyroblasts of feldspar are set in fine-grained interlobate aggregate of quartz, accompanied by moderately well-aligned biotite and by clots of microcrystalline sericite. Grains of myrmekite are present.

Petrogenesis:- Metamorphosed granite, with incipient mortar structure, and a moderate foliation of the matrix.

Sp.68.66.0060(N240):- Coarse-grained biotite-plagioclase-quartz microcline gneiss.

Hand specimen:- Coarse-grained gneiss with biotite bands.

Mineralogy:-

Microcline + orthoclase (perthitic)	m.g. - c.g.	- 50 per cent
Plagioclase (oligoclase)	m.g. - c.g.	- 20 " "
Quartz	f.g. - m.g.	- 20 " "
Biotite	f.g. - m.g.	- 5 " "
Sericite	mic.	- 5 " "
Apatite, epidote		tr.

Microtexture:- Coarse-grained xenomorphic-granular aggregate of partly sericitized feldspar and of quartz. Clots of biotite are accompanied by apatite and epidote. The feldspar may be heavily fractured.

Petrogenesis:- Metamorphosed granite, with mechanical strain effects shown by the feldspar.

Sp.68.66.0066(N246):- Biotite-muscovite-oligoclase-quartz-microcline gneiss.

Hand specimen:- Banded fine- to medium-grained gneiss.

Mineralogy:-

Microcline	f.g. - m.g.	- 40 per cent
Oligoclase	f.g.	- 10 " "
Quartz	f.g. - m.g.	- 30 " "
Muscovite	mic. - f.g.	- 10 " "
Biotite	mic. - f.g.	- tr.
Opaques	mic. - f.g.	- tr.

Microtexture:- Xenomorphic-granular to weakly gneissose. Slight segregation of quartzose bands and lenses. The microcline is usually cryptoperthitic. Muscovite and biotite are aligned in micaceous bands.

Petrogenesis:- The rock is probably a metamorphosed granite, though the low percentage of plagioclase does not conform to a normal granitic composition.

Sp.<u>68.66.0090</u>(N311):- Biotite-plagioclase-microcline-quartz granite gneiss.

Hand specimen: Banded gneiss, with slight development of augen.

Mineralogy:-

Microcline	f.g. - c.g.	- 30 per cent
Plagioclase (oligoclase)	m.g.	- 20 " "
Quartz	f.g. - m.g.	- 40 " "
Biotite	f.g.	- 10 " "
Muscovite	f.g.	- 10 " "
Apatite, chlorite, epidote, zircon.		tr.

Microtexture:- Medium-grained gneissose. Quartzo-feldspathic xenoblastic-granular bands alternate with films of foliated biotite and muscovite. The plagioclase is cloubed by cryptocrystalline sericite, and may occur as inclusions in the potash feldspar. Incipient mortar structure is suggested by the occurrence of interstitial aggregates of fine-grained quartz.

Petrogenesis:- Igneous crystallization, with plagioclase preceding microcline and quartz. Metamorphism involved recrystallization and compositional segregation.

Sp.<u>68.66.0054B</u>:- Garnet-biotite-plagioclase-orthoclase-quartz gneiss.

Mineralogy:-

Plagioclase (andesine)	f.g. - m.g. - 30 per cent
Orthoclase	f.g. - m.g. - 30 " "
Quartz	f.t. - m.g. - 30 " "
Biotite	f.g. - 8 " "
Garnet	m.g. - c.g. - 2. " "
Apatite, epidote, iron ore, zircon	m.g. - c.g. - tr.

Microtexture:- Allotriomorphic granular. The quartzo-feldspathic aggregate is fine- to medium-grained, and of granoblastic texture. The biotite is crudely foliated. The garnet is anhedral and poikiloblastic, and includes inclusions of biotite and quartz. The plagioclase shows fine lamellar twinning.

Petrogenesis:- The rock may be a metamorphosed granite, or a metamorphosed feldspathic to argillaceous sandstone.

Sp.68.66.0092(N315):- Porphyroblastic coarse-grained garnet-biotite-quartz plagioclase microcline granitic gneiss.

Hand specimen:- Porphyroblastic coarse-grained gneiss.

Mineralogy:-

Microcline (microperthite)	m.g. - very c.g.	- 40 per cent
Plagioclase (andesine)	f.g. - m.g.	- 20 " "
Quartz	f.g. - m.g.	- 20 " "
Garnet	m.g. - c.g.	- 3 " "
Biotite	f.g. - m.g.	- 7 " "
Sericite	mic.	- 5 " "
Chlorite	crypt.	- 5 " "
Apatite, zircon, epidote		- tr.

Microtexture:- Coarse- to very coarse-grained porphyroblastic to weakly gneissose. Very coarse-grained porphyroblasts of perthite and microcline are set in a medium-grained base of plagioclase, microcline and quartz. Some very-coarse quartz grains occur. The garnet is extensively altered to cryptocrystalline and microcrystalline aggregates of chlorite and sericite. These alteration products appear to be earlier than the biotite.

Petrogenesis:- The rock is a porphyritic granite which underwent regional metamorphism, involving the growth of garnet. Retrograde metamorphism is represented by alteration of the garnet to chlorite and sericite, and their partial replacement by biotite.

Sp.66.0058A(N238A):- Sillimanite-andalusite-biotite-orthoclase-plagioclase-quartz gneiss.

Hand specimen:- Grey, medium-grained, slightly prophyroblastic gneiss.

Mineralogy:-

Plagioclase (oligoclase)	f.g. - m.g. -	25 per cent
Orthoclase	f.g. - m.g. -	20 " "
Quartz	f.g. -	30 " "
Biotite	f.g. - m.g. -	15 " "
Sillimanite		5 " "
Andalusite	mic. - m.g. -	3 " "
Iron-ore, epidote, zircon, chlorite	-	2 " "

Microtexture:- Fine- to medium-grained xenoblastic-granular aggregate of quartz and feldspar, with interstitial little-foliated biotite. Andalusite occurs at the expense of biotite. Aggretates of cryptocrystalline accicular (?) sillimanite occur interstitially.

Petrogenesis:- The rock is probably a metamorphosed granite.

Sp.68.66.0059(N239):- Sillimanite-garnet-biotite-plagioclase-quartz-microcline gneiss.

Hand specimen:- Biotite-banded medium-grained gneiss with garnet porphyroblasts.

Mineralogy:-

Microcline + orthoclase	f.g. - m.g. -	30 per cent
Plagioclase (andesine)	f.g. - m.g. -	30 " "
Quartz	f.g. - m.g. -	30 " "
Biotite	f.g. - m.g. -	30 " "
Garnet, sillimanite, iron ore, epidote, zircon, chlorite		5 " "

Microtexture:- Xenomorphic granular medium-grained aggregate of quartz and feldspar, intervened by films of foliated biotite and microcrystalline needles of sillimanite. Anhedral skeletal grains of coarse-grained garnet are present, abounding in quartz and biotite inclusions.

Petrogenesis:- The rock is a granite metamorphosed under upper amphibolite or hornblende granulite facies conditions. The textural relationships suggest the following sequence of crystallisation: Biotite, epidote, garnet, sillimanite. The garnet is partly veined by chlorite, which may suggest slight retorgrade metamorphic effects.

Sp.68.66.0068C(N248C):- Sillimanite-garnet-biotite-orthoclase-plagioclase-sericite-quartz meta-granite.

Hand specimen:- Medium- to coarse-grained gneiss, with biotitic bands alternating with quartzo-feldspathic bands.

Mineralogy:-

Quartz	m.g. - c.g.	- 30 per cent
Plagioclase (oligoclase)	f.g. - m.g.	- 15 " "
Orthoclase	m.g. - c.g.	- 15 " "
Garnet		5 " "
Biotite		10 " "
Sillimanite		3 " "
Sericite	crypt- mic.	- 20 " "
Epidote, zircon, iron ore		2 " "

Microtexture:- Corroded grains of quartz and feldspar are set in a cryptocrystalline matrix of sericite, which also occurs as veinlets and in cracks developed in the quartz and the feldspar. The sericite is replaced by biotite, garnet and sillimanite. In some cases only remnants of pre-existing feldspar crystals occur within the sericite base.

Petrogenesis:- The rock was probably orginally a granite. Hydrothermal alteration represented by the sericite matrix has taken place before or during the onset of regional metamorphism, which is represented by the biotite, garnet and sillimanite.

Sp.68.66.0076(N256):- Medium-grained biotite-quartz-plagioclase meta-granodiorite gneiss.

Hand specimen:- Medium-grained biotite gneiss.

Mineralogy:-

Plagioclase (oligoclase)	m.g.	- 40 per cent
Quartz	f.g. - m.g.	- 30 " "
Biotite	m.g.	- 20 " "
Sericite	mic.	- 8 " "
Epidote, apatite, iron ore		- 2 " "

Microtexture:- Allotrimorphic-granular to weakly gneissose. The rock consists of a medium-grained aggregate of moderately sericitised plagioclase, anhedral quartz, are weakly foliated biotite (z-deep brown). Epidote and apatite and invariably associated with the biotite.

Petrogenesis:- The rock is probably a weakly metamorphosed granodiorite.

Sp.68.66.0079(MD413):- Sassuritised amphibole-microcline-biotite-quartz-plagioclase meta-granodiorite.

Hand specimen:- Medium-grained porphyroblastic biotite gneiss.

Mineralogy:-

Plagioclase (oligoclase-andesine)	f.g. - m.g.	- 30 per cent
Microcline	f.g.	- 10 " "
Quartz	f.g. - m.g.	- 25 " "
Biotite	m.g.	- 15 " "
Amphibole	m.g.	- 2 " "
Sericite	crypt. mic	- 8 " "
Epidote + sassurite	crypt. mic	- 10 " "
Chlorite, iron ore		tr.

Microtexture:- Hypidiomorphic-granular. Heavily sassuritised and sericitised medium-grained subhedral phenocrysts of oligoclase and andesine are set in an aggregate of quartz, microcline, and randomly-oriented biotite. Relic amphibole is replaced by biotite. Epidote crystals are developed at the expense of plagioclase.

Petrogenesis:- The rock is a metamorphosed granodiorite. Alteration is represented by the sassuritisation and sericitisation of plagioclase and by replacement of amphibole by biotite.

Sp.68.66.0061(N241):- Garnet-quartz-biotite-plagioclase meta-granodiorite gneiss.

Hand specimen: Garnetiferous, biotite-rich medium-grained gneiss.

Mineralogy:-

Garnet	m.g. - c.g.	- 10 per cent
Biotite (z-deep brown)	f.g. - m.g.	- 30 " "
Plagioclase (oligoclase-andesine)	m.g.	- 50 " "
Quartz	f.g. - m.g.	- 10 " "
Apatite, epidote, zircon		tr.

Microtexture:- Hypidiomorphic-granular to weakly gneissose. The plagioclase is weakly clouded. The biotite clots are accompanied by epidote and apatite grains. The porphyroblastic garnet carries abundant inclusions of biotite, quartz, epidote and iron ore.

Petrogenesis:- The rock appears to be a metamorphosed granodiorite, which reached the upper greenschist or lower amphibolite facies.

5. Porphyries

Sp.68.66.0040(N220):- Biotite-plagioclase-sericite-microcline-quarts porphyry.

Hand specimen - Fine- to medium-grained quartz-feldspar porphyry with dark spotting.

Mineralogy:- Microcline f.g. - m.g. - 20 per cent

Microcline	f.g. - m.g.	- 20 per cent
Plagioclase	f.g.	- 10 " "
Quartz	mic. - m.g.	- 0 " "
Sericite	mic.	- 20 " "
Biotite	mic.	- 10 " "

Microtexture:- Porphyritic and glomeroporphyritic anhedral to subhedral medium-grained phenocrysts of microcline and of plagioclase, polycrystalline grains of quartz, and pseudomorphs of microcrystalline biotite aggregates after (?) primary biotite, are set in microcrystalline base of quartz, feldspar, and sericite. The phenocrysts may be slightly resorbed. The plagioclase phenocrysts are clouded at their centres, and are rimmed by clear albite. Some of the biotite is replaced by muscovite.

Petrogenesis:- The rock is an igneous prophyry, probably of hypabyssal origin. Original phenocrysts of quartz have been recrystallised, and partial reorption of feldspar phenocrysts took place, probably in association with pressure reduction which lowered their stability. The crystallization of the matrix went along with the formation of albitic rims around the phenocrysts. Late alteration resulted in recrystallisation of biotite phenocrysts, as well as in sericitisation.

Sp.68.66.0620B(N158):- Microcline-quartz porphyry.

Hand specimen:- Medium- to coarse-grained prophyrobalsts of quartz and feldspar set in light coloured aphanitic matrix.

Mineralogy:-

Quartz	mic. - c.g.	- 90 per cent
Microcline	f.g. - m.g.	- 5 " "
Sericite	mic.	- 5 " "
Biotite, iron ore, chlorite		tr.

Microtexture:- Phenocrysts of quartz and microcline, and pseudomorphs of sericite after phenocrysts of (?) plagioclase, are set in a cryptocrystalline to microcrystalline matrix composed mainly of quartz. The phenocrysts are deeply embayed, and carry inclusions of the matrix. (which are probably cross sections of embayments oriented at an angle to the thin-section).

Petrogenesis:- The rock is a slightly altered igneous prophyry. The embayments in the phenocrysts probably represent resorption by the magma upon ascent to lower pressure levels. Little shearing is evident.

Sp.68.66.0624B is a highly sheared equivalent of the above-described rock. The feldspar phenocrysts are highly altered, and the sericite-rich microcrystalline matrix displays good foliation.

Sp.68.66.0613(N29):- Porphyritic biotite-albite-actinolite-quartz porphyrite.

Hand specimen:- Dark grey aphanitic schist, with medium-grained porphyroblasts of quartz.

Mineralogy:-

Actinolite	mic.	- 40 Per cent
Biotite	f.g. - m.g.	- 10 " "
Albite	mic.	- 10 " "
Quartz	mic. - m.g.	- 40 " "
Tourmaline	mic.	- tr.

Microtexture:- Medium-grained phenocrysts of quartz are set in a microcrystalline granoblastic aggregate of actinolite, quartz and albite. Shear planes are marked by concentration of amphibole. The matrix is partly replaced by biotite, well aligned parallel to the foliation. The tourmaline is associated with the biotite. The quartz phenocrysts are subhedral to euhedral, and are commonly embayed.

Petrognesis:- The rock is a sheared and metamorphosed igneous quartz porphyrite.

Sp.68.66.0621(N40):- Sericite-biotite-quartz meta-porphyry.

Hand specimen:- Dark green, slightly schistose, with medium-grained quartz phenocrysts set in an aphanitic matrix.

Mineralogy:-

Quartz	m.g.	- 50 per cent
Biotite	crypt.-mic.	- 30 " "
Sericite	crypt.-mic.	- 20 " "
Iron ore		tr.

Microtexture:- Fractured and fragmented phenocrysts of quartz are set in a foliated matrix of biotite and sericite. The fractures in the quartz are filled by sericite and biotite.

Petrogenesis:- The rock is a sheared and metamorphosed quartz porphyry.

C. Meta-sediments and Metamorphic Rocks of Uncertain Origin

1. Micaceous and Quartzo-feldspathic Schists

sp. 68.66.0037A (N217A): - Hematitic laminated sericite-quartz meta-siltstone.

Hand-specimen: - Laminated brown meta-siltstone.

Mineralogy: -

Quartz	mic.	40 per cent
Sericite	crypt.-mic.	20 " "
Hematite	crypt.-mic.	20 " "
Clouding	crypt.	20 " "

Microtexture: - Foliated microcrystalline aggregate of quartz, muscovite, hematite, and cryptocrystalline clouding. Primary lamination and fine-scale grading are well preserved.

Petrogenesis: - The rock is a metamorphosed laminated siltstone, impregnated by hematite due to weathering.

sp. 68.66.0037B (N217B): - Laminated sericite-quartz meta-siltstone.

The rock is similar to sp. 68.66.0037A, except for the development of lenticular augen of microcrystalline to to fine-grained quartz aggregates.

sp. 68.66.0034B (N214B): - Porphyroblastic biotite-sericite-quartz schist.

Hand specimen: - Red brown, aphanitic, schistose, with coarse-grained porphyroblasts of quartz.

Mineralogy: -

Quartz	mic. (matrix); m.g. -c.g. (Porphyroblasts)	50 per cent
Sericite	mic.	40 " "
Biotite	f.g.	10 " "
Iron ore (mainly hematite)		tr.

Microtexture: - Microcrystalline-schistose. The rock consists of a foliated aggregate of mic. quartz and sericite, accompanied by minor biotite (weathered) and exsolved iron ore associated with the biotite. The quartz porphyroblasts carry abundant inclusions of the matrix, and may be deeply embayed and re-crystallised along their margins and along cracks. Undulatory extinction is common.

Petrogenesis: - The rock is either an altered and metamorphosed porphyry, with relicts of resorbed quartz phenocrysts, or a mata-sediment with prophyroblastic growth of quartz.

sp. 68.66.0055B (N235B): - Medium-grained tourmaline-bearing muscovite-biotite schist.

Hand specimen: - Medium-grained, foliated muscovite-biotite schist, with green porphyroblasts of tourmaline.

Mineralogy: -	Biotite	m.g.	60 per cent
	Muscovite	F.g.-m.g.	38 " "
	Tourmaline		2 " "
	Iron Ore, rutile		tr.

Microtexture: - A well-foliated aggregate of muscovite and biotite flakes. The biotite carries inclusions of rutile surrounded by pleochroic haloes. Porphyroblasts of green tourmaline carry inclusions of biotite.

Petrogenesis: - The rock is a metamorphosed sediment. The tourmaline is younger than the mica, and may represent a late introduction of boron.

sp. 68.66.0057B (N237B): - Biotite-sericite-quartz schist.

Hand-specimen: - Banded, micro-folded medium-grained micaceous schist.

Mineralogy: -	Biotite	m.g.	20 per cent
	Muscovite	mic.-m.g.	45 " "
	Quartz	f.g.	35 " "

Microtexture: - Strongly schistose, and metamorphically segregated into bands of sericite and bands of quartz. Biotite and muscovite are developed at the expense of the sericite. The schistosity is tightly folded on a small scale.

Petrogenesis: - The rock is a metamorphosed sediment. Metamorphic segregation preceded the growth of biotite. The metamorphism reached the middle greenschist facies.

sp. 68.66.0089 (N303): - Augen-structured weathered sericite-biotite-quartz schist.

Hand-specimen: - Red-brown micaceous schist.

Mineralogy: -	Quartz	mid.-f.g.	50 per cent
	Sericite	mic.	45 " "
	Biotite	mic.-f.g.	
	Hematite	crypt.	5 " "
	Tourmaline		tr.

Microtexture: - Lenticular aggregates of microcrystalline quartz are separated by bands of cryptocrystalline to microcrystalline sericite and weathered biotite, impregnated by finely disseminated hematite dust.

Petrogenesis: - The rock is a metamorphosed sediment. The metamorphism involved compositional segregation.

sp. 68.66.0091 (N312): - Porphyroblastic, augen-structured muscovite-quartz-plagioclase-biotite schist.

Hand-specimen: - Porphyroblastic, augen-structured, medium-grained schist.

Mineralogy: -	Biotite	f.g.	40 per cent
	Muscovite	f.g.	10 " "
	Plagioclase (albite-oligoclase)	f.g.-m.g.	30 " "
	Quartz	f.g.-m.g.	20 " "
	Epidote, rutile, iron ore		tr.

Microtexture: - Porphyroblasts and glomeroporphyroblasts of plagioclase and quartz are set in a foliated matrix of mica, quartz and feldspar. The feldspar is usually sericitised. The biotite may be associated with exsolved iron ore. The porphyroblasts and glomeroporphyroblasts are sheared into lenticular form. The matrix is segregated into micaceous and quartzose bands.

Petrogenesis: - The rock is a metamorphosed and weakly segregated sediment, showing the development of porphyroblasts of quartz and feldspar. Metamorphism reached the upper greenschist facies.

sp. 68.66.0093 (N320): - Fine-grained biotite-albite-microline-quartz meta-siltstone.

Hand-specimen: - Finely laminated grey-white aphanitic rock.

Mineralogy: -	Quartz	f.g.	40 per cent
	Microcline	f.g.	40 " "
	Albite	f.g.	
	Biotite	f.g.	20 " "
	Apatite, zircon, iron ore		tr.

Microtexture: - Sheared granoblastic mosaic of fine-grained quartz and feldspar, with well aligned biotite flakes.

Petrogenesis: - The rock is a low-grade metamorphosed siltstone.

sp. 68.66.0099 (N326): - Chlorite-biotite-muscovite-quartz schist.

Hand-specimen: - Medium-grained, micaceous, light brown schist.

Mineralogy: -	Quartz	f.g.	55 per cent
	Muscovite	mic.-f.g.	20 " "
	Biotite	mic.-f.g.	15 " "
	Chlorite	mic.-f.g.	10 " "
	Zircon, iron ore		tr.

Microtexture: - Foliated aggregates of sericite, muscovite, biotite and chlorite, interchange with lenses of fine-grained quartz mosaics. Chlorite and muscovite, and chlorite and biotite may be interleaved in the same flakes.

Petrogenesis: - The rock is a metamorphosed sediment. Sequence of crystallisation: chlorite and sericite, biotite, muscovite. Metamorphism reached the middle greenschist facies.

sp. 68.66.0101 (N334): - Plagioclase-muscovite-quartz schist.

Hand-specimen: - light coloured, medium-grained, micaceous to quartzo-feldspathic schist.

Mineralogy: -	Quartz	mic.-f.g.	50 per cent
	Plagioclase (oligoclase)	mic.-f.g.	10 " "
	Muscovite	mic.	40 " "
	Biotite, apatite, iron ore		tr.

Microtexture: - Irregular bands of foliated muscovite, intervening and enclosing polycrystalline pockets of quartz mosaics. The plagioclase is often clouded.

Petrogenesis: - The rock is a metamorphosed quartzose sediment. Metamorphism reached the middle greenschist facies.

sp. 68.66.0103 (N309): - Fine-grained muscovite-chlorite-quartz slate.

Hand-specimen: - Grey, aphanitic, siliceous slate.

Mineralogy: -	Quartz	mic.-f.g.	65 per cent
	Chlorite	mic.	20 " "
	Muscovite	mic.	15 " "
	Biotite, tourmaline, zircon, iron ore		tr.

Microtexture: - The rock consists of sheared aggregates of quartz, with intervening bands of foliated microcrystalline chlorite muscovite and sericite, enclosing crudely defined lenses of quartz.

Petrogenesis: - The rock is a metamorphosed siltstone.

sp. 68.66.0105 (N314): - Fine-grained feldspar-quartz-sericite slate.

Hand-specimen: - Grey, fine-grained slate.

Mineralogy: -	Sericite	m.c.	40 per cent
	Quartz	f.g.	40 " "
	Feldspar	f.g.	20 " "
	Biotite, iron ore		tr.

Microtexture: - Bands of foliated mica separate lenses of quartzo-feldspathic aggregate.

Petrogenesis: - The rock is a low-grade metamorphosed shale.

sp. 68.66.0107 (N333): - Similar to 68.66.0105, but with a higher quartz/mica ratio, and a lack of feldspar.

sp. 68.66.0110 (N346): - Tourmaline-bearing sericite-biotite-quartz schist.

Hand-specimen: - fine-grained micaceous to quartzose schist.

Mineralogy: -	Quartz	mic.-m.g.	50 per cent
	Sericite	crypt.-mic.	25 " "
	Biotite (z-khaki colour)		20 " "
	Muscovite		5 " "
	Tourmaline, apatite, iron ore		tr

Microtexture: - Irregularly-shaped quartz grains are set in a cryptocrystalline matrix of sericite abundantly replaced by biotite, which is crudely aligned with the schistosity. The quartz grains are separated from each other by sericite, which also penetrates into cracks in the quartz.

Petrogenesis: - The rock is a metamorphosed sediment. The sericite may represent alteration products of unknown pre-existing aluminosilicates.

sp. 68.66.0112 (N351): - Blastoporphyroblastic muscovite-chlorite-quartz schist.

Hand-specimen: - Porphyroblastic schist, with very coarse-grained altered prismatic porphyroblasts set in a fine-grained micaceous matrix.

Mineralogy: -	Chlorite (ferruginous)	mic.-f.g.	30 per cent
	Muscovite	mic.	20 " "
	Quartz	f.g.	50 " "
	Tourmaline, iron ores		tr.

Microtexture: - Vaguely defined pseudomorphs of chlorite (altered biotite) after (?) andalusite, are set in a schistose matrix of microcrystalline muscovite and fine-grained quartz. The quartz grains are elongated with the foliation.

Petrogenesis: - The rock might have been an andalusite schist. The andalusite was replaced by biotite, which was in turn altered to chlorite.

sp. 68.55.0618 (N29A):- Sericite-biotite-quartz meta-conglomerate schist.

Hand-specimen: - Meta-conglomerate. Pebbles of quartzite are embedded in a schistose matrix.

Mineralogy: - (1) A quartzite pebble

Quartz	f.g.	85 per cent
Sericite	crypt.-mic.	7 " "
Biotite	f.g.	8 " "
Iron ore, tourmaline, zircon		tr.

(2) The schist

Biotite	f.g.-m.g.	25 per cent
Quartz	mic.-m.g.	55 " "
Sericite	crypt.-mic.	20 " "

Microtexture: - The pebble displays a uniformly textured mosaic of quartz, with interstitial patches of microcrystalline sericite, partly replaced by biotite. The matrix is strongly schistose and metamorphically segregated, with undulating bands of sericite, biotite and quartz alternating with each other. Clasts of quartz are common.

Petrogenesis: - The foliation if finely crenulated. The rock is a metamorphosed and metamorphically-segregated conglomerate. Metamorphism reached the biotite grade.

Retrograded Granulite

sp. 68.66.0102 (N346): - Sillimanite-chlorite biotite-sericite-quartz schist. (Retrograded granulite).

Hand-specimen: - Foliated fine-grained grey schist, with abundant coarse-grained fibrous white porphyroblasts of sillimanite.

Mineralogy: -

Sillimanite	f.g. remnants of c.g. crystals	5 per cent
Biotite	mic.-f.g.	25 " "
Sericite-chlorite aggregates	crypt.-mic.	40 " "
Quartz	f.g.	30 " "
Tourmaline, iron ore		tr.

Texture: - Relics of coarse-grained sillimanite are set in cryptocrystalline to microcrystalline aggregates of sericite and chlorite. Aggregates of cryptocrystalline chlorite may be alteration produced of (?) cordierite. The altered porphyroblasts are extensively replaced by biotite, and are set in a weakly foliated matrix of quartz, sericite, cryptocrystalline chlorite, and fine-grained biotite.

Petrogenesis: - The rock is a retrograded sillimanite-(?) cordierite granulite. The retrogressive effects took place before or during greenschist facies metamorphism, as indicated by the replacement of the alteration products by biotite.

2. Garnet and Andalusite-bearing Schists

sp. 68.66.0039 (N219): - Porphyroblastic garnet-muscovite-biotite-andalusite-quartz schist.

Hand-specimen: - porphyroblastic schist, with coarse-grained prismatic andalusite set in a fine-grained foliated biotite-rich matrix.

Mineralogy: -	Andalusite	c.g.	30 per cent
	Garnet	m.g.	2 " "
	Biotite	mic.-f.g.	25 " "
	Muscovite	mic.-f.g.	3 " "
	Quartz	f.g.	40 " "
	Iron ore		tr.

Microtexture: - Sieve-structured porphyroblasts of andalusite, with inclusions of biotite and muscovite, are set in a moderately well foliated matrix of quartz, biotite, and minor muscovite. Subhedral porphyroblasts of garnet occur in the matrix or as inclusions in the andalusite, and are commonly rimmed by exsolved iron ore.

Petrogenesis: - The sequence of crystallisation as indicated by the textural relationships is: biotite, garnet, andalusite, muscovite. The rock is a contact metamorphosed meta-sediment. The contact metamorphism took place later than the regional metamorphism.

sp. 68.66.0050C (N230C): - Fine-grained garnet-bearing-muscovite-albite-biotite-microcline-quartz schist.

Hand-specimen: - Grey, aphanitic, weakly foliated rock.

Mineralogy: -	Quartz	mic.-f.g.	40 per cent
	Albite	mic.-f.g.	20 " "
	Microcline	f.g.	20 " "
	Biotite	mic.-f.g.	10 " "
	Sericite	mic.	10 " "
	Garnet, zircon, apatite		tr.

Microtexture: - A well-foliated microcrystalline aggregate of quartz, feldspar and mica. The plagioclase also occurs as medium-grained phenocrysts. Lenticular glomeroporphyroblasts of fine- to medium-grained microcline occur.

Petrogenesis: - The rock is either a metamorphosed sediment or a metamorphosed felsic volcanic rock. Metamorphism reached the upper greenschist or the lower amphibolite facies.

sp. 68.66.0108 (N338): - Coarse-grained, porphyroblastic garnet-bearing andesine-quartz-biotite schist.

Hand-specimen: - Porphyroblastic schist, with coarse-grained porphyroblasts of feldspar, and augen of quartz set in biotite-rich foliated matrix.

Mineralogy: -	Biotite	(1) crypt. (2) f.g.-m.g.	50 per cent
	Quartz	f.g.-m.g.	35 " "
	Andesine	f.g.-m.g.	10 " "
	Garnet	m.g.	3 " "
	Epidote	m.c.-f.g.	2 " "
	Apatite, iron ore		tr.

Microtexture: - Porphyroblasts and glomeroporphyroblasts of andesine, and lenses of interlobate quartz aggregates, are embedded in a well foliated base of biotite. Garnet, epidote apatite and iron ores are associated with the biotite. The biotite may be associated with exsolved interleaved quartz. The foliation is folded.

Petrogenesis: - The rock is a metamorphosed sediment, showing strong development of porphyroblasts, and metamorphic segregation. Metamorphism reached the amphibolite grade, and was followed by minor folding. The sequence of crystallisation is: Biotite, epidote, garnet.

sp. 68.66.0094 (N321): - Coarse-grained porphyroblastic garnet-bearing muscovite-microcline-biotite-plagioclase-quartz augen schist.

Hand-specimen: - Coarse-grained augen schist, with well developed lenses of quartz and feldspar set in a dark micaceous matrix.

Mineralogy: -	Plagioclase (oligoclase-andesine)	f.g.-c.g.	30 per cent
	Microcline	f.g.-c.g.	10 " "
	Quartz	mic.-f.g.	30 " "
	Biotite	f.g.-m.g.	20 " "
	Muscovite	f.g.-m.g.	10 " "
	Garnet, chlorite, apatite, epidote, rutile, iron ore		tr.

Microtexture: - Porphyroblasts of clouded (sericitised) plagioclase and of microcline occur as mica-coated lenses in a matrix of quartz feldspar and mica. The quartzose matrix around the augen may be highly sheared. Epidote is developed as clouding in the plagioclase, or is associated with biotite. The feldspar porphyroblasts are commonly recrystallised along their margins.

Petrogenesis: - The rock is a metamorphosed sediment or felsic volcanic rock. Metamorphism reached upper greenschist or lower amphibolite facies, and was associated with strong porphyroblastic growth.

sp. 68.66.0106 (N329): - Medium-grained andalusite-orthoclase-biotite-quartz segregated schist.

Hand-specimen: - Finely banded grey medium-grained schist.

Mineralogy: -	Quartz	f.g.-m.g.	30 per cent
	Biotite	f.g.-m.g.	30 " "
	Orthoclase (Perthitic)	f.g.	30 " "
	Chlorite + sericite	crypt.-mic.	8 " "
	Andalusite	f.g.	2 " "
	Iron ore		tr.

Microtexture: - Undulating bands of foliated biotite enclose lenses of granoblastic quartz and feldspar. Elongated aggregates of cryptocrystalline chlorite and sericite represent altered sillimanite. Andalusite grains are developed in association with biotite.

Petrogenesis: - The rock is a metamorphosed sediment, metamorphism reached the amphibolite facies. Retrograde metamorphism may be represented by alteration of (?) pre-existing sillimanite. The sequence of crystallisation: Chlorite + sericite, biotite, andalusite. The andalusite may be the consequence of contact metamorphism by nearby granites.

3. Granulites and Paragneisses

sp. 68.66.0049D (N229D): - Fine-grained banded sillimanite-garnet-quartz-biotite-orthoclase granulite.

Hand-specimen: - Finely-banded aphanitic rock.

Mineralogy: -	Orthoclase (microperthitic)	f.g.	40 per cent
	Quartz	f.g.	20 " "
	Biotite	mic.-f.g.	30 " "
	Sillimanite (?)	crypt.	5 " "
	Garnet	f.g.	5 " "
	Apatite, zircon, iron ore, chlorite		tr.

Microtexture: - Granoblastic to granulitic. Fine-grained equidimensional mosaic of quartz and feldspar, intergrown with fine scales of biotite, which are well aligned in parallel orientation. Garnet occurs as poikiloblastic xenoblastic grains. Cryptocrystalline accicular crystals are interpreted as sillimanite. Biotite-garnet rich bands alternate with quartzo-feldspathic bands.

Petrogenesis: - Origin through metamorphism of a siltstone, according to amphibolite or higher facies conditions. Sequence of crystallisation: Biotite, garnet, sillimanite.

sp. <u>68.66.0049A</u> (N229A): - Medium-grained quartz-sillimanite-biotite-cordierite-orthoclase granulite.

Hand-specimen: - Fine to medium-grained, uniform to weakly banded grey rock.

Mineralogy: -	Orthoclase (Partly perthitic)	f.g.-m.g.	30 per cent
	Cordierite	f.g.-m.g.	20 " "
	Quartz	f.g.	10 " "
	Biotite	f.g.	15 " "
	Garnet	f.g.-m.g.	15 " "
	Sillimanite	f.g.-m.g.	10 " "
	Magnetite, pinite		tr.

Microtexture: - Granulitic. Bands of biotite, garnet and sillimanite alternate with feldspathic granoblastic bands. The biotite and the sillimanite are fairly well aligned. The garnet occurs as xenoblastic grains. Quartz is common as inclusions in the feldspar. The orthoclase shows incipient perthitic structure, and may be partly twinned. The cordierite is discontinuously twinned, and shows slight marginal alteration to cryptocrystalline pinite.

Petrogenesis: - The rock is probably a metamorphosed potassic-magnesian shale. Metamorphism reached the sillimanite grade, on the boundary of the amphibolite and granulite facies. The sequence of crystallisation as suggested by the textural relationships is: biotite, garnet + orthoclase + cordierite, sillimanite.

sp. 68.66.0049B (N229B): - Medium-grained garnet-andalusite-cordierite-plagioclase-orthoclase-biotite granulite.

Hand-specimen: - Banded grey granular fine- to medium-grained rock.

Mineralogy: -

Orthoclase (partly perthitic)	f.g.-m.g.	20 per cent
Plagioclase (oligoclase-andesine)	f.g.-m.g.	20 " "
Cordierite	f.g.-m.g.	20 " "
Biotite	f.g.	25 " "
Andalusite	mic.-f.g.	3 " "
Garnet	f.g.	2 " "
Pinite	crypt.	10 " "
Epidote, apatite, quartz		tr.

Microtexture: - Granulitic. Fine- to medium-grained granoblastic aggregate of feldspar and cordierite, intergrown with thin flakes of biotite, which are moderately-well aligned in parallel orientation. Andalusite develops within clots of biotite. The biotite and the cordierite are extensively rimmed by cryptocrystalline pinite.

Petrogenesis: - The rock is probably a metamorphosed potassic-magnesian shale. Metamorphism reached the amphibolite facies. Sequence of crystallisation: Biotite, andalusite, cordierite and garnet, pinite.

sp. 68.66.0052D (232D): - Spinel-bearing andalusite-garnet-sillimanite-perthite-biotite-cordierite-plagioclase.

Hand-specimen: - Porphyroblastic, garnet-bearing medium-grained granulite.

Mineralogy: -

Garnet	f.g.-c.g.	- 5 per cent
Sillimanite	f.g.	- 10 " "
Cordierite	m.g.	- 20 " "
Biotite	f.g.-m.g.	- 20 " "
Andalusite	f.g.	- 1 " "
Perthite	f.g.-m.g.	- 10 " "
Plagioclase (andesine)	f.g.-m.g.	- 30 " "
Pinite	crypt.	- 4 " "
Chlorite, epidote, magnetite, green spinel		- tr.

Microtexture: - Granulitic. Porphyroblastic biotite-sillimanite-rich bands alternate with feldspar-cordierite bands. Xenoblastic garnet porphyroblasts carry inclusions of biotite, magnetite and spinel, and may be penetrated (replaced) by sillimanite. Sillimanite shows typical euhedral square sections. The andalusite grows at the expense of biotite as subhedral grains. Xenoblastic cordierite grains are recognised by marginal alteration into pinite, and by yellow pleochroic haloes. The spinel, magnetite, biotite, sillimanite and cordierite are rimmed by corona of crypto-crystalline pinite and by other alteration products.

Petrogenesis: - The rock is a metamorphosed potassic-magnesian shale, showing a transition from the upper amphibolite facies (andalusite, epidote, biotite) into the granulite facies (spinel, sillimanite). The sequence of crystallisation is: Biotite, andalusite + garnet + cordierite, sillimanite and spinel, pinite.

sp. 68.66.0053B (233B): - Banded garnet-cordierite-sillimanite-perthite-plagioclase-biotite-quartz granulite.

Hand-specimen: - Porphyroblastic, grey and white banded garnetiferous granulite.

Mineralogy: -	Garnet	f.g.-c.g.	4 per cent
	Perthite	f.g.-m.g.	10 " "
	Plagioclase	f.g.-m.g.	10 " "
	Sillimanite	f.g.	10 " "
	Andalusite	mic.-f.g.	1 " "
	Cordierite	f.g.-m.g.	10 " "
	Biotite	f.g.	15 " "
	Quartz	m.g.	40 " "
	Chlorite, epidote	mic.	tr.

Microtexture: - Porphyroblastic to medium-grained granulitic. Medium- to coarse-grained porphyroblasts of garnet and quartz, are set in a fine-grained to medium-grained base of quartz, cordierite, feldspar, sillimanite and biotite. The two latter constituents are moderately well foliated. The garnet carries inclusions of quartz and biotite. The cordierite is recognised by tiny inclusions. Andalusite is developed in association with biotite. Chlorite occurs as alteration product of biotite, cordierite and garnet. The rock is slightly weathered.

Petrogenesis: - Probably metamorphosed greywacke or argillaceous sandstone. Sequence of crystallisation: Biotite, andalusite, garnet and cordierite, sillimanite. Metamorphism reached the upper amphibolite-granulite facies boundary.

sp. 68.66.0067 (N247): - Sillimanite-muscovite-cordierite-perthite-quartz paragneiss.

Hand-specimen: - Medium-grained, white to yellow uniformly textured gneiss.

Mineralogy: -	Perthitic orthoclase	f.g.-m.g.	30 per cent
	Cordierite	f.g.-m.g.	20 " "
	Quartz	m.g.	40 " "
	Muscovite	mic.-f.g.	5 " "
	Sillimanite	mic.	5 " "
	Chlorite, iron ore, epidote		tr.

Microtexture: - Xenomorphic-granular, equigranular aggregate of quartz, perthite and cordierite. The latter mineral is recognised by rims of cryptocrystalline chlorite, (pinite) and by a small negative optic angle. Muscovite, in crudely-foliated bands, is heavily replaced by accicular aggregates of microcrystalline sillimanite, and by perthite.

Petrogenesis: - The rock has probably been originally a potassic-magnesian shale. Metamorphism on the greenschist facies, represented by relic muscovite, was followed by low-pressure metamorphism on the sillimanite grade. The elevation in metamorphic grade is represented by the replacement of muscovite by orthoclase and sillimanite. The cordierite probably developed at the expense of chlorite.

sp. 68.66.0068B (N248B): - Garnet-andalusite-sillimanite-oligoclase-biotite-orthoclase-cordierite-quartz paragneiss.

Hand-specimen: - Medium-grained banded gneiss with fibrous sillimanite and garnet porphyroblasts.

Mineralogy: -

Orthoclase (cryptoperthitic)	f.g.-m.g.	20 per cent
Oligoclase	f.g.-m.g.	5 " "
Quartz	f.g.-m.g.	30 " "
Cordierite	m.g.	20 " "
Biotite	f.g.	10 " "
Sillimanite	mic.-f.g.	10 " "
Garnet	c.g.	5 " "
Andalusite, magnetite, rutile, zircon, chlorite		tr.

Microtexture: - Granulitic. Bands of well aligned biotite and accicular sillimanite alternate with aggregates of xenoblastic cryptoperthitic orthoclase, plagioclase, cordierite and quartz. Anhedral porphyroblasts of garnet include inclusions of biotite and quartz. Andalusite develops within clots of biotite. The sillimanite constitutes accicular aggregates which may replace cordierite.

Petrogenesis: - Metamorphism of magnesian shale. The sequence of crystallisation appears to be as follows: Biotite, garnet + andalusite, cordierite, sillimanite + orthoclase.

sp. 68.66.0071 (N251): - Coarse-grained garnet-biotite-cordierite-plagioclase-microcline-quartz paragneiss.

Hand-specimen: - Coarse-grained gneiss with garnet porphyroblasts.

Mineralogy: -

Garnet	c.g.	5 per cent
Biotite	f.g.-m.g.	5 " "
Plagioclase (andesine)	m.g.-c.g.	10 " "
Cordierite	f.g.-m.g.	20 " "
Microcline	f.g.-m.g.	20 " "
Quartz	f.g.-m.g.	40 " "
Epidote, chlorite (pinite) iron ore		tr.

Microtexture: - Xenoblastic granular. Medium- to coarse-grained aggregate of feldspar, cordierite and quartz, with clots of biotite and porphyroblasts of garnet. The cordierite is recognised by rims of pinite and by interpenetrated twinning systems. The garnet carries inclusions of quartz, epidote is preferentially associated with biotite.

Petrogenesis: - The rock is probably a metamorphosed magnesian-potassic shale; metamorphism reached the almandine amphibolite facies. The sequence of crystallisation: Biotite, garnet + cordierite + microcline, pinite. The latter mineral presumably represents slight retrograde metamorphism.

sp. 68.66.0054C (N234C): - Medium-grained plagioclase-orthoclase-cordierite-garnet-sillimanite-biotite-quartz schist.

Hand-specimen: - Medium-grained schist displaying slight metamorphic differentiation.

Mineralogy: -	Sillimanite	mic.-m.g.	20 per cent
	Orthoclase (microperthitic)	f.g.-m.g.	10 " "
	Cordierite	f.g.-m.g.	10 " "
	Garnet	m.g.-c.g.	15 " "
	Plagioclase (labradorite)	m.g.	4 " "
	Biotite	f.g.-m.g.	20 " "
	Andalusite	f.g.	tr.
	Quartz	f.g.-m.g.	20 " "
	Iron ore, chlorite		tr.

Microtexture: - Strongly nematoblastic and schistose. Metamorphic segregation is well developed, with biotite-sillimanite-garnet bands alternating with quartz-feldspar bands. The sillimanite occurs as sheaf-like aggregates and accicular bundles, often replacing biotite, garnet, and cordierite. Biotite occurs as two phases; brown and green, with the green biotite presumably representing alteration of the brown biotite. Cordierite is discontinuously twinned, and is rimmed by pinite. Small crystals of andalusite are associated with biotite. Elongated patches of magnetite are characteristically associated with sillimanite.

Petrogenesis: - The rock is a sheared and differentiated metamorphosed shale. The sequence of crystallisation was as follows: Biotite, andalusite and cordierite and garnet, sillimanite, green biotite, and chlorite. The latter represent slight retrogressive effects. The replacement of biotite by sillimanite involved exsolution of iron ore.

sp. 68.66.0056A (N236A): - Porphyroblastic sillimanite-garnet-cordierite-orthoclase-plagioclase-quartz-biotite granulite.

Hand-specimen: - Banded fine-grained grey rock, with coarse-grained porphyroblasts of garnet.

Mineralogy: -

Garnet	m.g.-very c.g.	10 per cent
Biotite	f.g.	25 " "
Cordierite	f.g.-m.g.	10 " "
Sillimanite	f.g.	5 " "
Orthoclase (Perthitic)	f.g.-m.g.	15 " "
Plagioclase (andesine)	f.g.-m.g.	15 " "
Quartz	f.g.-m.g.	20 " "
Epidote, iron ore, chlorite		tr.

Microtexture: - Porphyroblasts of garnet and plagioclase are embedded in a fine- to medium-grained granulitic aggregate, showing a crude segregation into biotite-rich and garnet-rich bands. The biotite is aligned in parallel orientation. The cordierite and biotite are partly altered to chlorite.

Petrogenesis: - The rock is probably derived from an argillaceous sandstone. Metamorphism probably reached the upper amphibolite facies.

Sp. 68.66.0056C is similar to sp. 68.66.0056A.

sp. 68.66.0058B (N238B): - Sillimanite-muscovite-biotite-orthoclase-quartz-cordierite granulite.

Hand-specimen: - Light grey medium-grained rock with white patches.

Mineralogy: -

Quartz	f.g.-m.g.	30 per cent
Cordierite	mic.-m.g.	45 " "
Orthoclase (micro-perthitic)	f.g.-m.g.	10 " "
Biotite	mic.-f.g.	5 " "
Sillimanite	crypt.-f.g.	2 " "
Muscovite	mic.-f.g.	3 " "
Pinite	crypt.	5 " "

Microtexture: - Granoblastic to interlobate fine- to medium-grained aggregate of cordierite, quartz and orthoclase: The cordierite shows weak clouding, is rimmed by pinite, and has yellow pleochroic haloes. Sillimanite in sheaf-like aggregates is mostly developed at the expense of biotite.

Petrology: - The rock is probably a metamorphosed magnesian shale. Metamorphism reached the upper amphibolite facies. Biotite and muscovite are relics of lower-grade metamorphism.

sp. 68.66.0073 (N253): - Sillimanite-biotite-plagioclase-orthoclase-garnet-quartz paragneiss.

Hand-specimen: - Medium-grained light coloured garnetiferous granulite.

Mineralogy: -

Microperthitic orthoclase	f.g.-m.g.	20 per cent
Quartz	f.g.-m.g.	40 " "
Plagioclase	f.g.-m.g.	10 " "
Garnet	m.g.	25 " "
Biotite (green)	mic.-f.g.	5 " "
Biotite (brown)	f.g.	
Sillimanite, opaques		tr.

Microtexture: - Mortar structured to porphyroblastic. Anhedral poikiloblasts of garnet and porphyroblasts of microperthitic orthoclase are set in an interlobate aggregate of microcrystalline to fine-grained quartz. The garnet is associated with clots of biotite, and is partly replaced by sillimanite.

Petrogenesis: - The rock is a sheared granulite, which probably originated from a quartzose sediment. Sequence of crystallisation: Biotite, garnet, sillimanite.

sp. 68.66.0098 (N325): - Garnet-bearing quartz-orthoclase paragneiss.

Hand-specimen: - Medium-grained garnet-bearing gneiss.

Mineralogy: -

Orthoclase (cryptoperthitic)	f.g.-m.g.	73 per cent
Quartz	f.g.-m.g.	25 " "
Garnet	m.g.-c.g.	2 " "
Sericite, biotite, iron ore		tr.

Microtexture: - Weakly gneissose, with incipient mortar structure. Elongated and fractured anhedral feldspar grains are intergrown with irregularly shaped quartz, whereas aggregates of microcrystalline quartz occur at intergranular positions. The fractures in the feldspar are accentuated by clouding. The garnet forms poikiloblasts, carrying quartz inclusions.

Petrogenesis: - The rock is a metamorphosed potash-rich meta-sediment. Metamorphism reached the amphibolite facies, and was followed by shearing and granulation, accompanied by slight hydrothermal activity.

Additional references

Cook, P. J., 1963 - The geology of the Yuendumu Native Reserve, Northern Territory. <u>Bur. Miner. Resour. Aust. Rec.</u>, 1963/37 (unpubl.).

Prichard, C. E., and Quinlan, T., 1962 - The geology of the southern half of the Hermannsburg 1:250.000 Sheet. <u>Bur. Min. Resour. Aust. Rep. 61</u>

Errata

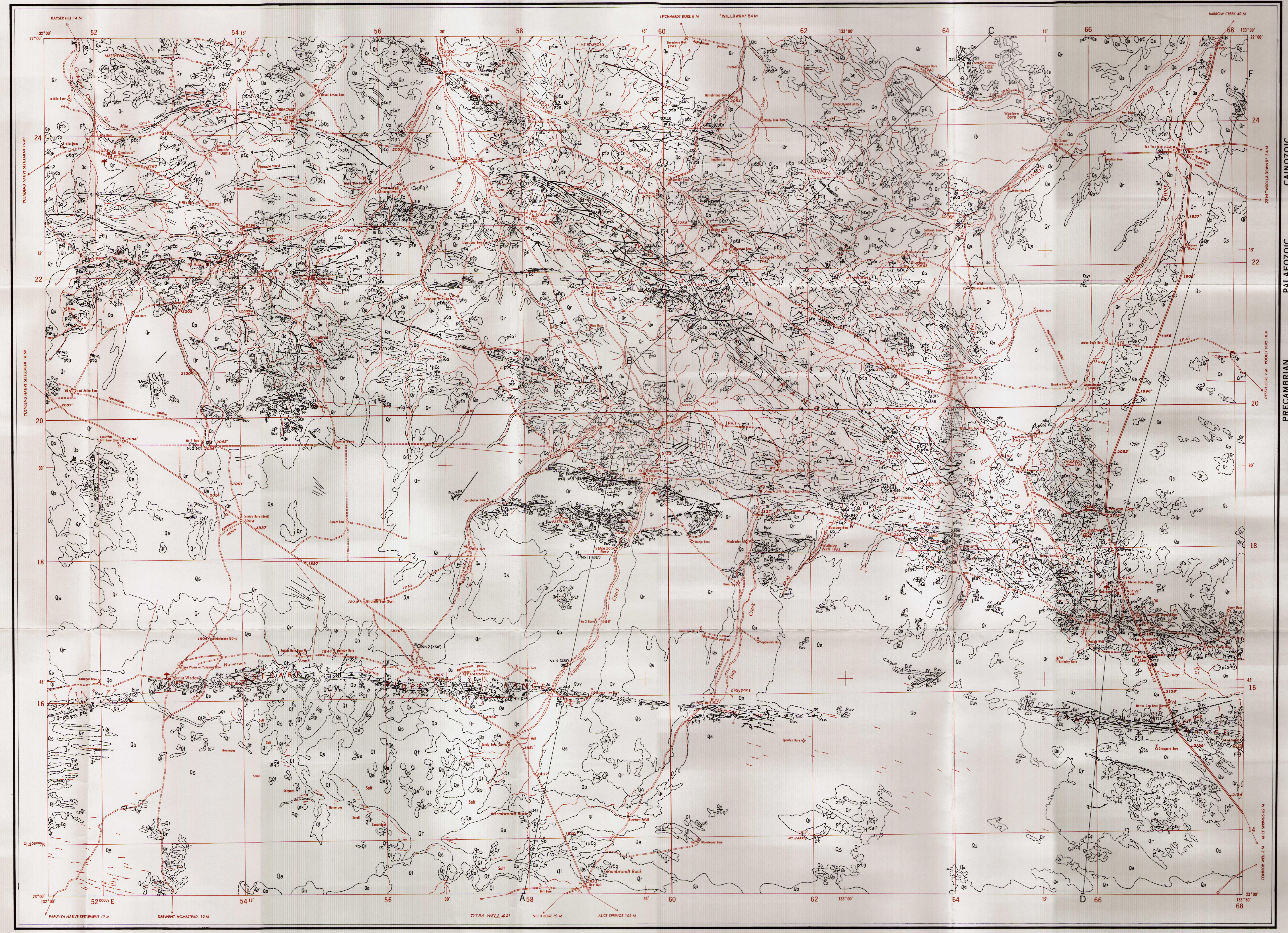
p. ii, line 23: divisions for division.
p. ii, line 34: Boudinage for boundinage.
p. 5, line 15: formations for formation.
p. 6a, line 21: journey for hourney.
p. 40, line 21: ridges grade into, for ridges into.
p. 49, line 8: bores for hooes.
p. 51, line 8: Thompson for Thomson.

AUSTRALIA 1:250,000 GEOLOGICAL SERIES

NAPPERBY

NORTHERN TERRITORY

SHEET SF 53-9



Reference

CAINOZOIC	QUATERNARY		Qa	Alluvium
			Qs	Sand, sand dunes
			Qr	Red soil, alluvium
			Qt	Evaporites
			Ql	Travertine
			Qc	Colluvium
		Undifferentiated	Cz	Silcrete and ferricrete
PALAEOZOIC	CARBONIFEROUS	Mount Eclipse Sandstone	Pzt	Coarse grained arkosic sandstone; conglomeratic sandstone, minor cobble conglomerate and red siltstone
	ORDOVICIAN?	Kerridy Sandstone	Pzy	Red-brown silty sandstone, siltstone and subgreywake
PRECAMBRIAN	PROTEROZOIC		Pu	Undifferentiated sandstone, subgreywacke, siltstone, tillitic siltstone
		Vaughan Springs Quartzite	Puv	Thick bedded quartzite, granule and pebble conglomerate
		Treuer Member	Put	White siltstone, thin bedded, fine grained sandstone. Possibly interbedded evaporites
			p€	Igneous and metamorphic rocks
			p€g	Granite
			p€a	Orthogneiss, gneissic granite
			p€o	Quartz-feldspar porphyry
			p€s	Schist
			p€q	Quartzite
			p€m	Schist, quartzite, dolomite and marble
			p€d	Amphibolite and basic igneous rocks
			p€n	Paragneiss, basic and acid granulites

Geological boundary
Anticline
Syncline
Fault, showing relative horizontal movement
Lineament
Shear zone

Where location of boundaries and faults is approximate, line is broken; where inferred, queried; where concealed, faults are shown by short dashes

15 Strike and dip of strata
65 Strike and dip of strata, facing not known
Vertical strata
Horizontal strata
75 Overturned strata
Dip < 15° (Air-photo interpretation)
Dip 15°-45° (Air-photo interpretation)
Dip < 45° (Air-photo interpretation)
Trend lines (Air-photo interpretation)
Joint pattern (Air-photo interpretation)
70 Strike and dip of foliation
Prevailing strike and dip of foliation
Vertical foliation
Strike and dip of foliation, dip indeterminable

x121 Specimen locality, text reference prefix N
WN-1 Measured section
Dyke; q - quartz, do - dolerite, gr - granite

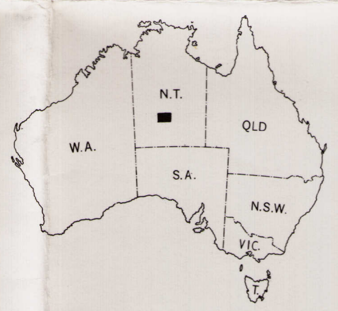
•Fe Minor mineral occurrence
Sn Mine not worked
Cu Copper
He Hematite
Fe Iron
Au Gold

Ky Kyanite
Sn Tin
W Wolfram
St(513') Stratigraphic hole showing depth, BMR Napperby

Bore
Bore with windpump
Abandoned bore
Well
E Earth dam
Dam on stream
WH Waterhole
Spring

Sand dunes
Highway
Road
Vehicle track
Landing ground
Homestead
Building
Yd Yard
Fence
Telephone line
2635' Trigonometrical station
Astronomical station
3300' Spot elevation - accurate
2134' Spot elevation - barometric
(PA) Position approximate
(PD) Position doubtful
Abd Abandoned

Compiled by the Bureau of Mineral Resources, Geology and Geophysics, Department of National Development. Issued under the authority of the Hon. David Fairbairn, Minister for National Development. Base map compiled by the Division of National Mapping from aerial photography at 1:46,500 scale
Transverse Mercator Projection



INDEX TO ADJOINING SHEETS

Showing Magnetic Declination 1965

THE GRANITES SF 52-3	MOUNT SOLITAIRE SF 52-4	LANDER RIVER SF 53-1	BONNEY WELL SF 53-2	FREW RIVER SF 53-3
HIGHLAND ROCKS SF 52-7	MOUNT THEO SF 52-8	MOUNT PEAKE SF 53-5	BARROW CREEK SF 53-6	ELKEDRA SF 53-7
LAKE MACKAY SF 52-11	MOUNT DOREEN SF 52-12	NAPPERBY SF 53-9	ALCOOTA SF 53-10	HUCKITTA SF 53-11
MOUNT RENNIE SF 52-15	MOUNT LIEBIG SF 52-16	HERMANNSBURG SF 53-13	ALICE SPRINGS SF 53-14	ILLOGWA CREEK SF 53-15
BLOODS RANGE SG 52-3	LAKE AMADEUS SG 52-4	HENBURY SG 53-1	RODINGA SG 53-2	HALE RIVER SG 53-3

5°E 4°30'E

ANNUAL CHANGE 1'00" E

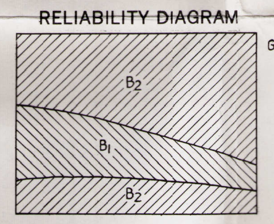
Scale 1:250,000

5 0 5 10 15 MILES

5 0 5 10 15 20 25 KILOMETRES

Geology, 1968, by: A.T. Wells, T.G. Evans, T. Nicholas and A.Y. Glikson
Compiled, 1969, by: A.T. Wells, T.G. Evans, T. Nicholas, A.Y. Glikson and Miss D.M. Pillinger
Cartography by: Geological Branch BMR
Drawn by: Miss D.M. Pillinger

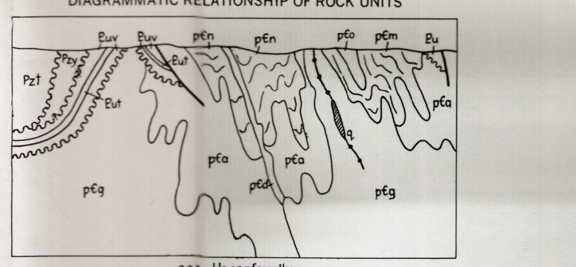
RELIABILITY DIAGRAM



Geology B1 Detailed reconnaissance and air-photo interpretation

B2 General reconnaissance, few traverses and air-photo interpretation

DIAGRAMMATIC RELATIONSHIP OF ROCK UNITS

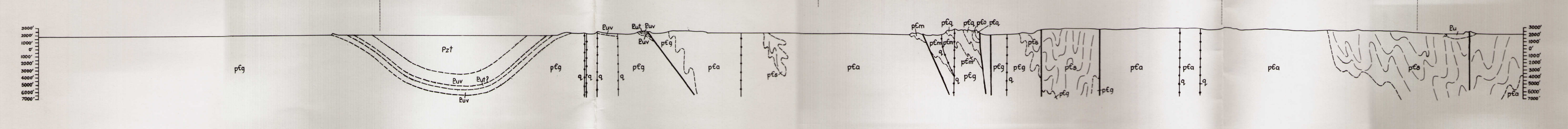


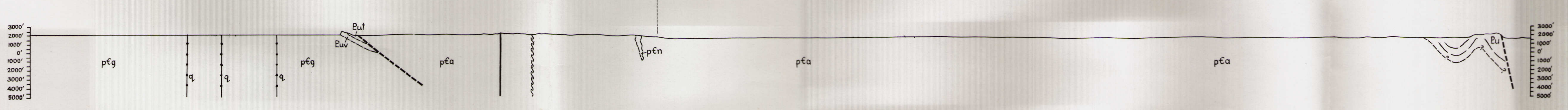
Unconformity

Sections

(Cainozoic sediments omitted. Folding in part schematic)

Scale: $\frac{V}{H} = 2$





PRELIMINARY EDITION, 1969

SUBJECT TO AMENDMENT

NAPPERBY

SHEET SF 53-9

Complimentary