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FIELD GEOLOGY CLUB OF
SOUTH AUSTRALIA INC.
EXCURSION NOTES
MUSGRAVE BLOCK
25 August - 15 September 1984

GEOLOGICAL SURVEY

by

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FIELD GEOLOGY CLUB OF SOUTH AUSTRALIA INC.

EXCURSION NOTES

MUSGRAVE BLOCK

25 August - 15 September 1984

These notes have been compiled by the Musgrave Block Excursion Guide Sub Committee viz.

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MUSGRAVE BLOCK GEOLOGY

Introduction

The excursion provides a rare opportunity to study some of the outcrops of the Musgrave Block of the Australian Shield, where Precambrian crystalline basement rocks and their younger Precambrian to Mesozoic sedimentary cover rocks protrude through the desert plains of Central Australia. The crystalline rocks are the deep core of former mountain ranges which have become exposed due to uplift and erosion during and since the Precambrian.

Some of the outcrops such as the Cambrian age conglomerates of the Olgas and arkose of Ayers Rock, are spectacular residuals and familiar because of their tourist interest. The Precambrian basement rocks are less well known although they outcrop extensively from Western Australia to the Musgrave Ranges. A number of the features of the area are of global dimensions and can be readily seen on satellite photographs. These include the great Woodroffe Thrust fault and associated faults and also massive joint patterns which are oriented in E-W, NW-SE and NE-SW directions. To the east of the Musgrave Block sediments of the Great Artesian Basin outcrop as mesas. To the south and north sand dune systems are the result of previous more arid climates and past wind directions. Stream patterns show the drainage channels of rivers from earlier wetter climates and those of the present day ephemeral flows.

Geological and Tectonic Evolution of the Area

1. The Precambrian metamorphic and igneous rocks

Originally in Early Proterozoic times about 1700-1800 million years ago an elongated trough of sediments was deposited on an older crystalline basement which has not been exposed by erosion at present. These sediments were deeply buried and became metamorphosed and folded around 1650 my during a major mountain building (orogenic) period. This produced granulite-facies rocks and amphibolite-facies gneisses of high metamorphic grade. These rocks are products of extreme conditions of heat and pressure - temperatures of 600-800 degrees centigrade and pressures consistent with depths of 15-40 kilometres below the surface. These rocks outcrop only south of the Woodroffe Thrust.

Other amphibolite-facies gneisses were formed (650°C, 15 km) at about 1120 my ago and those north of the Thrust will be examined. (Locality 10, 12).

Although originally the amphibolite facies probably overlaid the granulites, they are now in juxtaposition across some present fault planes, and, across the low angle Woodroffe Thrust the granulites now overlie the amphibolite facies gneisses.

The most common granulites have a "granitic" composition and are termed acid granulites. Interlayered in these are granulites of dioritic and "gabbroic" composition which are termed intermediate and basic granulites respectively.

Acid granulites are light coloured and consist mainly of quartz and potassium-feldspars. They represent metamorphosed feldspathic sandstones and arkoses. The quartz grains are typically flattened due to the high pressured (Localities 13, 16, 19, 20, 21). Basic granulites are dark coloured and consist mainly of calcium (plagioclase) feldspar and iron-magnesium silicates principally pyroxene (usually hypersthene ± diopside) ± hornblende. They represent metamorphosed limey claystones (marls) and basalts. Garnet is a common mineral in many granulites. Other sedimentary rocks are represented by sillimanite and garnet-bearing quartzites, rare lenses of dolomitic marble with forsterite (magnesium olivine) (Locality 23), and, iron formations.

The amphibolite facies gneisses likewise are mainly of granitic composition (quartz, potassium feldspar, biotite and hornblende) with interlayered basic rock (calcium feldspar, hornblende and biotite) and represent similar types of sediments and igneous rocks as do granulites (Localities 10, 12).

Because the granulites were buried deeper and subject to higher temperatures (950-1000°C) and pressure (30-40 km), they have had most of their original water removed from them. Therefore their minerals are "drier" ie. pyroxenes instead of hornblende and biotite. The amphibolite facies rocks were subject to lower temperatures and pressures and therefore contain more water. Consequently they become plastic and melt at lower temperatures and so they exhibit better gneissic texture, more fold structures, more pegmatites and more granitic intrusions than do the deeper granulites.

The layering of these metamorphic rocks generally trends northeasterly in the southern portion of the Block, but near the Northern Territory border it changes to and east-west or a west-northwest direction. The zone of trend change is associated with the great shear systems of the Hinkley, Mann, Davenport and Ferdinand Faults and the Woodroffe Thrust.

During a deformational period about 1150 - 1050 my the amphibolite facies were intruded by hornblende and biotite-bearing granites (Localities 5, 8). The granulite facies were intruded by pyroxene-bearing granites (charnockite) (Locality 6) and also norite and gabbro (Giles Complex) (Localities 9, 23, 26). All were intruded by dolerite dykes (Localities 4, 5, 19, 20, 21).

At the end of the activity the whole region became a stable crystalline area (craton) part of which has been exposed since Precambrian times. As the craton has become uplifted it has shed its erosional products northerly into the Amadeus Basin and southerly into the Officer Basin.

2. Giles Complex

At about 1050 my ago enormous volumes of basic magma were intruded as many separate bodies into the granulite facies rocks (which were still deeply buried) of various depths and at various places along the present line of the Jameson and Blackstone Ranges in Western Australia eastwards to the Musgrave Ranges at Mount Woodroffe. The resulting rocks are composed of varying amounts of plagioclase feldspar, pyroxene and olivine. They are mainly norites and gabbro with lesser amounts of anorthosite, pyroxenite and peridotite. These rocks are collectively termed the Giles Complex (Localities 9, 22, 23, 26). The original temperatures of intrusion were about 1000°C and depths ranged from 30-45 km.

As the magma cooled the dark minerals (pyroxenes and olivine) and light minerals (plagioclase) crystallised and settled out at different rates in the magma chambers. This has resulted in the different rock types and in darker and lighter coloured layering. This layering looks like a sedimentary layering and, in addition, the movement of magma and crystals during cooling have resulted in graded bedding, cross-bedding, slump structures, cut-and-fill structures and possible ripple marks.

Uplift and erosion has exposed these formerly deeply buried rocks. They and their host granulites have been tilted during uplift and faulting so that the layering is well exposed. It generally strikes east-west.

Most masses of the Giles Complex are the correct way up but the Mount Davies massif has been overturned. The top of the body is to the south and the base is to the north where it is cut off by a fault.

The Giles Complex is one of the most outstanding physical and petrological features of the Musgrave Block. It forms dark coloured masses for 400 km along the centre of the Musgrave Block. It occupies 25 000 km^2 and the intrusions range in thickness from 6400 m at the Michael Hills in W.A. to over 4000 m at Mount Davies and 3650 m at Mount Woodroffe. Two well known mountains are composed of the Complex viz Mount Woodroffe in the Musgrave Ranges is the highest mountain in South Australia at 1434.6 m, and, Mount Davies at 1957.7 m in the Tomkinson Range is well known for the chrysoprase found in the area.

Similar layered basic-ultramafic igneous complexes have been described in other parts of the world. This is one of the largest, but lacks some of the rich economic elements, such as nickel, chromium and platinum that characterise some of the others. Many of the complexes are of Pre-Cambrian or early Palaeozoic age, but not exclusively so. The best known examples are: Stillwater in Montana USA (PrecC); Bushveld in South Africa (PreC); Bay of Islands in Newfoundland (Ord); Skaergaard in Greenland (Tertiary) and Dun Mt. in N.Z. (Eocene).

Nickel-bearing laterite (uneconomic) occurs at Wingellina and Claude Hills in the North Hinkley intrusion. It is associated with magnesite, jasper and serpentine in a weathered picrite (olivine, plagioclase, pyroxene) that crosscuts the igneous layering. The semi-precious chrysoprase is sporadically mined by the aboriginal owners in the Mount Davies and Wingellina areas. Vanadium-rich magnetite occurs in the Jameson Range in West Australia.

3. Woodroffe Thrust Zone (Localities 9, 15)

The Woodroffe Thrust Zone, named after Mount Woodroffe, (highest point in S.A. at 1434.6 m), is one of the most important structural and topographic features in the Musgrave Ranges. The thrust plane of mylonites, dipping at about 30 degrees south, strikes east-west, and varies from 6 m to perhaps 100 m thick in outcrop. Above and below the mylonites are varying thicknesses of sheared rocks and in some places, muscovite schists.

Norites and granulite-grade metamorphic rocks have been thrust northward for at least 24 km over granites and amphibolite-grade metamorphic rocks.

The Thrust zones at Ayliffe Hill, and, Kelly Hills and east of Feltham Hill in the N.T., are northern outliers of the thrust. The distance of 24 km is obtained by assuming that the norite and underlying mylonite at Ayliffe Hill is the most northerly extension of a former continuous sheet of norite which once extended from the present position of Mount Woodroffe.

The Woodroffe Thrust Zone is younger than the Mount Woodroffe Norite (Giles Complex, approx. 1050 my) and older than the Levenger Formation (south of Mount Woodroffe) which may by of Torrensian age (900 my±), ie. the Woodroffe Thrust is about 1000 my old.

North of the Woodroffe Thrust a complex of granite, granitic gneiss and mica schists extends northwest to the Petermann Ranges. This complex includes layers of highly sheared sericitic quartzite in which occasional sedimentary structures, such as pebble beds and cross bedding, are preserved. The quartzite is interlayered with bands of biotite-hornblende-granite-gneiss.

To the south the Woodroffe Thrust is cut off by the Davenport, Mann and Ferdinand Faults. These are steeply dipping structures in contrast to the low angle dip of the Thrust. They trend west-east and are subparallel to the Thrust.

The Davenport Shear Zone has a centre zone of very fine grained garnet-bearing basic rock flanked by sheared acid rocks. The regionally important Mann Fault (to the west) is continuous with the Ferdinand Fault (to the east). They are composed of mylonite and sheared acid rock.

4. Adelaidean Sediments

Erosion from the uplifting Musgrave Block resulted in sediments of Adelaidean age. The oldest are of the Burra Group and will be seen near the Indulkana Range at Localities 2 and 3. Burra Group sediments outcrop along the southern margin of the Musgrave Block. The Levenger Arkose (south of Mount Woodroffe) and Moorilyanna Conglomerate (north of the Indulkana Range) were deposited in fault bounded troughs and are probably Burra Group sediments.

Excellent examples of Umberatana Group sediments and volcanics can be seen just southwest and south of the Indulkana Range which is in the southeast margin of the Block. In the Chambers Bluff area (Locality 3) at the southwest end of the

Range are Burra Group sandstones and siltstones. These are unconformably overlain by the Chambers Bluff Tillite (equivalenbt to the Sturt Tillite). This is overlain by altered basalt (Wantapella Volcanics). The volcanics are unconformably overlain by a dark ferruginous pebbly quartzite. This is succeeded by laminated siltstones which are equivalent to the Tapley Hill Formation and, lastly, by calcareous siltstones, limestones and pebble conglomerates. These rocks have been folded along northeast trending axes and faulted. These Tapley Hill and overlying rocks occupy a wide expanse of lowlying outcrop between the Indulkana Range and the Mount John Range.

5. Cambrian rocks and the Peterman Ranges Orogeny

Cambrian rocks are seen off the southeast part of the Musgrave Block and to the north. In the southeast around the Mount John Range is an arkose and conglomerate (Mount Johns Conglomerate) which interfinger with siltstones and sandstone. The conglomerate has pebbles which shows that it was derived by uplift and erosion of the crystalline basement and Adelaidean rocks to the north.

To the north of the Musgrave Block Cambrian sedimentation is represented by the boulder conglomerate at Mount Olga (Mount Currie Conglomerate) and the arkose at Ayers Rock (Localities 31, 32).

This sedimentation resulted from erosion initiated by folding, thrust faulting and uplift of the Musgrave Block during the Peterman Ranges Orogeny about 600 my ago. The boulders at the Olgas (and the Ayers Rock arkose) were eroded from the crystalline basement to the south and are of rock types which were probably higher in the crystalline basement than the rocks currently exposed there.

Sedimentation during the Ordovician - Devonian - Carboniferous

Sediments of these ages were unconformably laid upon the Cambrian sediments, Adelaidean sediments and the crystalline basement. They were subsequently folded and uplifted probably during the Palaeozoic resulting in the large shallow synclines of the Mount Johns Range and the Indulkana Range. The sediments are dominantly sandstones. The Mount Chandler Sandstone (with worm burrows), the Indulkana Shale, the Blue Hills sandstone (Localities 2, 3) and the Cartu Beds (sandstone, shale) are Ordovician. These are unconformably overlain by the Devonian Mintabie Beds (arkose, sandstone, siltstone) which contain opal at the Mintabie Opal Field (Locality 34). The feldspathic sandstone and Carboniferous Waitoona Beds unconformably overlie the Mintabie Beds.

Mesozoic

Sedimentation to the east of the Musgrave Block continued from time to time from the Cambrian to the Mesozoic. During the Jurassic and Cretaceous widespread downwarping of the crust from S.A. up through the N.T. and Qld resulted in a very large shallow sedimentary basin called the Great Artesian Basin. These sediments are conglomerates, sandstone and shale and those abutting the Musgrave Block mark the western extension of the

Basin in that area. Sedimentation was stopped at the end of the Cretaceous by uplift which involved virtually no folding and so the sediments which will be seen west of Oodnadatta in the Arckaringa Hills (Locality 1) are flat lying.

Tertiary

Deep weathering of the Great Artesian Basin sediments (and older rocks around the margins of the Basin) occurred at several periods during the late Cretaceous and the Tertiary. This weathering oxidised iron-bearing minerals in the sediments resulting in the red, brown and yellow colours at the Arkaringa Hills (Locality 1). During the Tertiary these weathered rocks were capped by hard silcrete layers which protect the underlying soft shale and form the resistant tops to the mesas which are commonly seen across much of central northern South Australia. Silcrete breaks down to form gibber pebbles and cobbles which cover plains and rises across vast areas of the silcrete country.

DESCRIPTION OF LOCALITIES TO BE VISITED

Locality 1 - Arckaringa Hills

The Arckaringa Hills are an area of spectacularly coloured mesas formed by the dissection of a plateau which resulted from the uplift of Great Artesian Basin sediments towards the end of Cretaceous period.

The flat-lying sedimentary rocks are Early Cretaceous marine mudstones of dark-grey colour. They are capped by hard silcrete which protects the underlying soft mudstones from erosion. This silcrete formed after periods of deep weathering during the Tertiary. The deeply weathered Cretaceous mudstones and sandstones show ferruginous and pallid zones. Red, brown and yellow colours mark the precipitation of iron oxides and hydroxides, and, whitish colours where iron has been leached out. Interleaved silcrete layers indicate that there have been many cycles of weathering. The uppermost layer is a silicified soil/breccia cemented by red jasper. Fossil termite burrows are associated with this.

The whole is a remarkable profile showing deposition, weathering and erosion extending over about 120 million years.

The Arckaringa Hills are listed on the Register of the National Estate for their oustanding geological, physiographical, botanical and scenic interest. To prevent prospecting and mining for opal from defacing the Hills, a portion of the area, 300 sq. km, in size, was reserved from Part VII of the Mining Act in 1982. However, exploration for coal in the Wintinna deposit, which overlaps this reserved area, is being carried out by the Meekatharra Minerals Pty. Ltd. This is being monitored by the Department of Mines and Energy.

Locality 2 - on the northern flank of the Indulkana Range and 4 km SW of the Indulkana Settlement. It is at the mouth of the creek which drains northwards from the centre of the Range and in which is the Indulkana Well.

From the Settlement on crystalline basement we go southwest across Adelaidean (Burra Group) sediments to Ordovician sediments. The unconformities are not exposed and only the Ordovician outcrops well i.e. as the Indulkana Range.

The Indulkana Settlement is on a rise of dark ferruginous gravels overlying weathered crystalline basement. From there we travel southwest over poorly outcropping granitic gneisses.

At about 2.5 km SW of the Settlement is the unconformity (not exposed) between the gneisses and the Burra Group quartzites, red micaceous siltstones and kaolinised feldspathic sandstones. These sediments unconformably underlie the Sturtian Chambers Bluff Tillite at Locality 3.

At Locality 2 the Burra Group is unconformably overlain by the Ordovician Mount Chandler Sandstone of the Indulkana Range but the contact is not well exposed.

The Mount Chandler Sandstone forms a ridge and dips 40°S. Just above the base are breccia layers with clasts from the underlying Burra Group quartzites. The sandstone has fossil worm burrows, both straight and U-shaped, which are characteristic of some lower Palaeozoic sandstones in Central Australia.

To the south of the ridge is a valley occupied by limestone interbeds in the Indulkana Shale which overlies the Mount Chandler Sandstone.

Further south are ridges of the Blue Hills Sandstone which occupy the centre of the Indulkana Range.

Ref.: ALBERGA 1 inch = 4 miles geol. map.
Coats, 1963 : p.4, 5
Krieg, 1973 : p.14, 16, 17

<u>Locality 3</u> - southwest of Chambers Bluff which is at the western end of the Indulkana Range.

Here are exposed from north to south granitic gneisses, unconformably overlain by Adelaidean (Burra Group) sediments unconformably overlain by the Adelaidean (Sturtian) Chambers Bluff Tillite which is ?conformably overlain by ?Sturtian Wantapella Volcanics. The Volcanics are unconformably overlain by dark ferruginous siltstone and quartzite which are succeeded by Tapley Hill Formation siltstone.

The Burra Group sediments have a pebble conglomerate at their contact with the gneisses. Above this are mainly siltstones and shales with interbedded hard quartzites which form ridges. They were folded uplifted, partly eroded and then submerged again prior to the deposition of the Chambers Bluff Tillite but the contact is not seen.

The Tillite is yellow, pale brown and reddish coloured siltstones, with clasts, and, interbedded white feldspathic quartzites (with no clasts) which form ridges. The clasts are rounded and comprise pebbles and cobbles from the crystalline basement, middle Proterozoic and early Adelaidean rocks. They were carried to the present position by ice moving over the then exposed land at about 850 my ago. Some clasts have been facetted and striated by the ice.

The Wantapella Volcanics are mainly an altered grey-green vesicular basalt with a contorted laminated sandy dolomite at the base and minor interbeds of gritty limestone.

Erosion of the volcanics occurred prior to the deposition of the overlying ferruginous siltstone and quartzite as evidenced by a basal conglomerate composed of pebbles of volcanics.

The contact with the overlying Tapley Hill Formation is not seen and the grey, brown and purple micaceous siltstones outcrop poorly.

Ref.: EVERARD 1:250 000 geol map
Krieg, 1973 : p.10, 12, 13, 14
Bog Major field notes.

Locality 4 - 300 metres north of Mimili Homestead in the Everard Ranges.

This is a gneissic granite which has xenoliths of biotite and feldspar oriented parallel to the layering.

It has been intruded by a dolerite dyke with a NW orientation.

Ref.: EVERARD 1:250 000 geol. map
Bob Major field notes

Locality 5 - 2 km west of Victory Well in the Everard Ranges.

The Illbillie Adamellite is intruded by a gabbro dyke.

The Illbillie Adamellite is a massive, reddish weathering porphyritic hornblende adamellite with phenocrysts of potassium feldspar. It crystallised approx. 1140 my ago.

It forms the main mass of the Everard Range with the highest point Mount Illbillie 917 metres above sea level but about 420 metres above the surrounding plains.

The widely spaced blocky joint pattern has eroded resulting in huge rounded tor shapes.

The wide gabbro dyke has a northwest orientation. It is finer grained along the contact with the Adamellite where it cooled quickly but the remainder is coarse grained due to slow cooling. Towards the centre it has been altered with the development of epidote (deuteric alteration) from the traces of water which was concentrated in the final liquid prior to complete solidification.

The gabbro and dolerite dykes on the Musgrave Block are younger than about 1050 my because they are known to intrude the Giles Complex rocks which are thought to have that age.

Ref.: EVERARD 1:250 000 geol. map
Krieg, 1973 : p.8, 9, 10
Bob Major : field notes

Locality 6 - 2 km north of Ernabella in the Musgrave Ranges.

Isolated outcrops of the Ernabella Adamellite Age approx. 1150 my.

This is a charnockite i.e. a granite which has pyroxene (mainly hypersthene) instead of biotite and hornblende as in most granites (e.g. the Illbillie Adamellite at Locality 5). Pyroxenes do not contain water in their crystal structure but biotite and hornblende do.

The reason for this difference in mineralogy is that the charnockite was a "dry" magma which was probably formed by the melting of granulite grade metamorphic rocks with granitic composition. This magma intruded the granulites and cooled under similar high temperatures (±800°C) and high press (±30 km deep). Consequently the charnockite has a similar mineralogy to granulites of granitic composition i.e. orthoclase, plagioclase, quartz, hypersthene.

If the magma had been generated at higher levels (10-12 km) in the crust by the melting of "wetter" rocks and then cooled then it would have had a mineralogy similar to the Illbillie Adamellite viz microcline, plagioclase, quartz, hornblende.

At Locality 6 there is no evidence for the intrusive nature of the charnockite. However, west of Ernabella, where the contact between the charnockite and granulites is exposed, there are xenoliths of granulite in the charnockite.

Ref.: ALBERGA 1 inch = 4 miles geol. map
Coats, 1963 : p.12
Wilson, 1960 : p.39, 43-45.
Webb, 1984.

Locality 7 - a stoney rise on the track 20 km NNW of Ernabella, Musgrave Ranges.

The track crosses the Woodroofe Thrust and the rise is composed of black mylonite. Granulites have been very sheared by movements of the Thrust to produce mylonite and small veins of pseudotachylite (melted rock) can be seen intruding the granulites.

The rise gives a good view to the west over plains and towards Michell Nob in the direction in which the excursion will travel.

Ref.: ALBERGA 1 inch = 4 miles geol. map.

Locality 8 - on the track 27 km NNE of Mount Woodroffe, Musgrave Ranges.

Here a massive coarse grained porphyritic granite intrudes a medium grained-equigranular lineated granite.

Ref.: WOODROFFE 1:250 000 geol. map
Major, 1973a.
Bob Major : field notes.

Locality 9 - Mount Woodroffe and the area to the north, Musgrave Ranges.

Here we will walk from south to north up to the summit of Mount Woodroffe (1434.6 m) which is the highest point in S. Aust. Mount Woodroffe is composed of Giles Complex norite (approx. 1050 my) which has intruded granulite facies metamorphic rocks (1650 my). These rocks were then thrust northwards (possibly about 1000 my ago) over amphibolite - facies metamorphic rocks and granites (1120 my) which were originally overlying the granulites deep in the crust.

Most of this movement occurred along a plane about 100 m thick and dipping 30° south where the intense shearing changed granulites into mylonite. Some rocks melted to form pseudotachylite. This plane is now called the Woodroffe Thrust zone. However, some shearing took place in the amphibolite facies rocks below and to the north of the Thrust as will be seen on the flat area there. As shown on the diagrammatic cross-section the traverse will commence on these sheared gneisses and then climb up hill to the cliff formed by the breaking away of the flinty mylonite. Above this are granulites which have been stressed by the Thrust but not sheared.

Well exposed contacts between the granulites and the overlying, intrusive norite are difficult to find. However, where seen, the contact is sharp.

The norite is grey when fresh but weathers to various shades of brown depending on its content of pyroxene and magnetite. It is layered due to varying amounts of pyroxene in the dominate plagioclase, and graded layering may be seen. The rock has been stressed by the Thrust (evidenced by veins of pseudotachylite) but not sheared here.

There is a cairn at the summit of Mount Woodruffe from which good views of the surrounding country are seen, including Ayers Rock and the Olgas.

Ref.: WOODROFFE 1:250 000 geol. map.
Major, 1973a.
Major, 1970.
Nesbitt et al., 1970.

Locality 10 - Cave Hill 25 km NE of Amata, Musgrave Ranges.

This cave in granitic gneiss has the best paintings in the area. It is associated with the aboriginal ledgend of how the Seven Sisters (the Pleiades) went into the sky.

Ref.: WOODROFFE 1:250 000 geol. map.
Tindale, 1959.

Locality 11 - Wilunya Soak on the old road 19 km NE of Amata, Musgrave Ranges.

Here is a good outcrop of the Mangatitja Limestone which was deposited in lakes in a former drainage system which existed on the Musgrave Block in the late Tertiary to early Quaternary during a wetter climate. The traces of these drainage channels can be seen on the geological maps but are now clogged by sand and spinifex.

Ref.: WOODROFFE 1:250 000 geol. map.
Major, 1973a.
Major, 1973b.

Locality 12 - outcrop on the road 11 km NE of Amata, Musgrave Ranges.

Here are fresh exposures (due to explosives) of granitic gneisses which are metamorphic rocks of the amphibolite facies (1120 my).

Ref.: WOODROFFE 1:250 000 geol. map.
Major, 1973a
Webb, 1984

Locality 13 - 1.5 km west of Amata airstrip - Musgrave Range.

Here are granulites with garnet and platy quartz. They are mainly of granitic composition and the platy quartz is due to the flattening of the quartz grains due to the high pressures involved in such high grade metamorphism. These are excellent examples of granulites and platy quartz is characteristic of "classic" granulites.

Ref.: WOODROFFE 1:250 000 geol. map
Major, 1973a.
Bob Major : field notes.

Locality 14 - on the road 12 km SW of Amata is an astrofix marker placed by Len Beadell whose team made the roads which were are using.

Ref.: WOODROFFE 1:250 000 geol. map.
Beadell, 1965.

Locality 15 - Anpirnga Rockhole and Katjiwalanya 25 km west of Amata. Musgrave Range.

The granites at the Rockhole and at the base of Katjiwalanya are unsheared but towards the top of the latter is an excellent exposure of mylonite of the Woodroffe Thrust. Here the mylonite has been folded and lineations in it has also been folded.

The top and southern part of Katjiwalanya is slightly stressed granitic gneiss.

Ref.: WOODROFFE 1:250 000 geol. map
Major, 1973a.
Major, 1970.

Locality 16 - just north of the road at the SE corner of the Mann Range.

Here are granulite facies rocks.

Ref.: MANN 1 inch = 4 mile geol. map.
Mirams, 1964 : p.11-13.

Locality 17 - on the road at "Putungapa" south of the Mann Range.

The road crosses mylonite of the Mann Fault.

Ref.: MANN 1 inch = 4 miles geol. map.
Mirams, 1964 : p.16.

Locality 18 - on the road south of "Ngaltadjara" in the Mann Range is Len Beadell's astrofix AF32.

Ref.: MANN 1 inch = 4 miles geol. map.

Locality 19 - on the road SSW of Mount Edwin in the Mann Range are granulites intruded by a dolerite dyke.

Ref.: MANN 1 inch = 4 miles geol. map.
Mirams, 1964 : p.11-16.

Locality 20 - on the road 31 km ENE of Mount Davies, Tomkinson Ranges are granulites of granitic and noritic composition which have been intruded by dolerite dykes.

Ref.: MANN 1 inch = 4 miles geol. map.
Mirams, 1964 : p.11-16.

Locality 21 - on the road 26 km ENE of Mount Davies, Tomkinson Range, are granulites of dioritic and noritic composition which have been intruded by a dolerite dyke.

Ref.: MANN 1 inch = 4 miles geol. map.
Mirams, 1964 : p.11-16.

Locality 22 - just north of the road 20 km NE of Mount Davies, Tomkinson Ranges.

This is an anorthosite (the Teizi anorthosite) which is a massive plagioclase rock containing some orthopyroxene. It intrudes the granulites but its origin is not certain - it is probably related to the intrusion of the Giles Complex.

Ref.: MANN 1:250 000 geol. map.
Gray, 1967.
Mirams, 1964 : p.13, 29.

Locality 23 - south of the old road 6 km NE of Mount Davies and on the northern side of Gosses Pile, Tomkinson Ranges.

Here is a forsterite-bearing marble interlayered in granulites of dioritic composition. Just south are Giles Complex norite and pyroxenite of Gosses Pile.

The marble was originally a siliceous, dolomitic limestone which has recrystallised under granulite grade conditions to give a calcite marble with forsterite (magnesium olivine), diopside (calcium magnesium pyroxene), spinel (magnesium aluminium oxide) and phlogopite (magnesium mica).

Ref.: MANN 1:250 000 geol. map.
Mirams, 1964 : p.12, 13, 30.
Moore and Goode, 1978.

Locality 24 - on the new road at the eastern end of Scarface, Tomkinson Ranges.

The road cross jasper which has resulted from the weathering of pyroxene - and olivine-rich rocks during the Tertiary. Chrysoprase forms as veins in this type of rock.

Ref.: MANN 1 inch = 4 miles geol. map.
Mirams, 1964 : p.10, 11.

Locality 25 - the Pipalyatjara Community, 10 km NW of Mount Davies, Tomkinson Ranges.

In this area we may visit chrysoprase workings if this can be arranged. Chrysoprase is chalcedony which is coloured green by nickel silicate. It was formed in the Tertiary by deep weathering of pyroxene - and olivine-rich rock (Giles Complex) and is found as veins in jasper and ochre rock.

Ref.: MANN 1 inch = 4 miles geol. map.
Barnes et al., 1980 : p.101-109.

Locality 26 - just west of the road 5 km NW of Mount Davies camp, Tomkinson Ranges.

Here is a mass of magnetite in Giles Complex norite. This magnetite has precipitated from the norite magma.

Ref.: MANN 1 inch = 4 miles geol. map.

Locality 27 - Near the road NE and N of Mount Fanny, north of the Tomkinson Ranges in Western Australia.

Mount Fanny is composed of granite and to the east are migmatites and granite. North of Mount Fanny is a small outcrop just west of the road which is marked on the SCOTT geol. map as migmatite and granite. However, Bob Major remembers a rock in this area as being a fine grained, glassy granulite.

Ref.: SCOTT 1:250 000 geol. map.
Daniels, 1972.
Daniels, 1974.

Locality 28 - Giles Meteorological Station, in the Rawlinson Range, Western Australia.

The rock of the area was a quartz-feldspar porphyry which has been sheared to quartz-sericite schist and platy quartz.

This shearing may have occurred during the Peterman Ranges Orogeny at about 600 my.

An inspection of the Station will be requested.

Ref.: SCOTT 1:250 000 geol. map.
Daniels, 1972.

Locality 29 - on the road 13 km east of Docker River, Peterman Ranges, Northern Territory.

From the road we will look at the Ruined Rampart of the Peterman Range to the south where a recumbent fold in the Dean Quartzite has a core of crystalline basement rock (porphyroblastic schist). This structure is a result of folding during the Peterman Ranges Orogeny at about 600 my. The schist was folded with the overlying quartzite but then became detached from the main mass of schist to the south as the recumbent fold developed.

Ref.: BLOODS RANGE 1:250 000 geol. map.
Forman, 1966.
Wells et al., 1970 : p.129-133.

Locality 30 - Lasseter's Cave just south of the road where the Hull River cuts the Peterman Ranges.

This cave is in Dean Quartzite. Lasseter lived there for some time in 1930 before moving east where he died.

Ref.: PETERMAN RANGES 1:250 000 geol. map.

Localities 31, 32 - Mount Olga and Ayers Rock
Introduction

The rock unit to which the conglomerate at the Olgas and the arkose at Ayers Rock belong is called the Mount Currie Conglomerate. This appears to be a molasse sediment which was deposited in a non-marine environment to the north (i.e. in front) of the rising Peterman Ranges which were formed by folding, thrusting, uplift and erosion of crystalline basement and Proterozoic sediments during the Peterman Ranges Orogeny about 600 my ago.

That is the Mount Currie Conglomerate is thought to be Late Proterozoic or early Cambrian in age. It may have a maximum thickness of about 6000 m. Clasts near the bottom of this unit are largely sandstone, with felsic and mafic volcanic clasts in the middle, and, granite and gneiss towards the top. This variation in the lithology of the clasts represents the order of erosion of the rocks which comprised the rising mountain ranges to the south i.e. the sedimentary rocks overlying the crystalline basement are eroded first, then acid and basic volcanic rocks and eventually the granite and gneiss are exposed and eroded.

References to Localities 31 and 32.
AYERS ROCK 1:250 000 geol. map.
Forman, 1965.
Wells et al., 1970 : p.45-47, 129-133.

Locality 31 - The Olgas 30 km west of Ayers Rock.

Mount Olga is 1069 m asl and about 455 m above the surrounding sand plain. It is the highest one of about 30 domes which comprise the Olgas. They are composed of cobble and boulder conglomerate about 620 m thick from the middle and upper parts of the Mount Currie Conglomerate. The clasts are granite, gneiss, acid porphyry and basalt.

The matrix of the conglomerate is a granular arkose which has been cemented by epidote due to regional metamorphism or hydrothermal activity. In many areas it has firmly bound the clasts to the matrix so that the rock behaves as a massive body. This is reflected on the large scale by its joint pattern which on erosion has resulted in the domes of the Olgas. On a smaller scale in many outcrops the rock breaks straight across both clasts and matrix. This strong cementation results in small sheets of rock spalling from the steep faces.

Despite the large size of many boulders the bedding is well defined and dips about 15° SSW.

Locality 32 - Ayers Rock.

The top of the Rock is estimated to be 348 m above the sand plain and in places it has near vertical rock faces of 300 m. It has a basal circumference of about 9 km.

Ayers Rock is an inselberg and its rock is thought to be part of the Mount Currie Conglomerate and a lateral equivalent of the conglomerate at the Olgas. It is composed of coarse grained arkose which weathers to a reddish colour but when fresh it is pale to dark grey, pink grey or green grey. It is cross-bedded which is more easily seen by the presence of grains of dark iron oxide minerals. The arkose is poorly sorted with a wide range of grain sizes (some feldspar grains are up to 2.5 cm long) and grains are subangular. The presence of some clay pellets suggests that muddy sediments were deposited upstream but were ripped up by later stronger currents to be deposited downstream at the site of the future Ayers Rock.

The bedding is not as easily seen as that at the Olgas but it is picked out by differential erosion. It dips 80° SW.

There are few joint planes and this combined with case hardening of the outer skin of rock have resulted in erosion by spalling to create the rounded smooth shape. Some very large sheets of case hardened rock have flaked off and slipped down the rock face. The Kangaroo Tail is a spall sheet which has not yet fallen off but, except at the top and bottom, has become detached from the main rock mass.

Ayers Rock can be climbed at one point on the western end where a hand chain has been erected to aid climbers - the return walk takes approximately two hours.

Water bores to supply the settlement have shown that there are more than 60 m Tertiary sand and clay surrounding the Rock.

Locality 33 - 9 km west of Mount Conner

To the east of the road is an extensive outcrop of the Late Proterozoic Inindia Beds. This unit is mainly sandstone, siltstone, some limestone and a boulder clay horizon which is interpreted to be tillite. However, there is disagreement as to whether it is equivalent to the upper Marinoan tillite (pers. comm. Ron Coats SADME) or the lower Sturtian tillite (BMR).

However, the reason for this stop is to examine the extensive south dipping cross-beds in the unit here.

Mount Conner itself is composed of a sandstone unit within the Late Proterozoic Winnall Beds which unconformably overlie the Inindia Beds.

Ref.: AYERS ROCK 1:250 000 geol. map.
Forman, 1965.
Wells et al., 1970 : p.31, 37, 38.

Locality 34 - Mintabie Opal Field, 35 km west of Marla.

Opal was discovered here in 1921 or 1922 but was mined only intermittently until 1976. Since then up to 250 people have lived on the field and mined the opal by open cut using bulldozers or by conventional underground mines.

The opal is found down to 20 m depth in the Mintabie Beds which are a sequence of well sorted, kaolinitic white sandstones, with minor claystone interbeds. These dip 5°-10° south or southwest. Large scale cross-bedding is seen in outcrop.

The beds are of Ordovician or Devonian in age and they occupy the centre of the Mount Johns syncline in the northwest part of the Officer Basin.

Ref.: EVERARD 1:250 000 geol. map.
Barnes and Townsend, 1982 : p.123-136.
Krieg, 1973.

GEOMORPHOLOGY

Oodnadatta Area:

On this western margin of the Great Artesian Basin the topography consists of sporadic low hills of crystalline basement in a generally flat landscape created by the flat lying sandstones and shales originally laid down as sediments by the marine incursions from the north during the Cretaceous period. Remnants of silcreted surfaces can be seen east of Oodnadatta where extensive weathering has created 'breakaway' country. To the west of Oodnadatta lies the Stuart Range - a low, fragmented tableland less than 800 m above sea leve.

The Mt. John and Indulkanna Ranges consist of Ordovician sandstones of shallow water origin deposited unconformably on Adelaidean and Cambrian sediments. Both Ranges are shallow synclines formed by gentle folding probably during the Palaeozoic.

The Everard Ranges lie on the south eastern corner of the Musgrave Block and consist of two main ranges, several minor ranges and isolated hills rising to over 400 m above the surrounding alluvial plains. The ranges trend ENE. Each ridge is subdivided into massive blocks, some up to 1.6 km in diameter, by a series of joints which run predominantly northwest to southeast and northeast to southwest. The joint blocks form massive domes which are characteristic of the Everards. Features of weathering granite such as gnamma holes and surficial flaking are also present. The highest dome, Mt. Illbilie, rises just over 917 m above sea level. The northwest to southwest joint systems have been intruded by gabbroic dykes.

The Musgrave Block

A block of crystalline basement 480 km long and 160 km wide lying in the far northwest of the State has been called 'the topographic backbone of the Australian continent'. The Proterozoic rocks are exposed as a series of east-west trending ranges-the Musgrave, Mann, Tomkinson, Birksgate and Everard Ranges, or as inselbergs arising from the surrounding sand and alluvial plains. The east-west trend of the ranges follows that of the major structural features viz the Davenport Shear Zone, the Woodroffe Thrust Zone and the Mann Fault. These were formed during the later stages of the Musgravian Orogeny, when the southern part of the Block was elevated and thrust over the northern portion over a horizontal distance of at least 24 km.

Mt. Woodroffe, South Australia's highest mountain at 1 434.6 m, consists of norite rocks uplifted by the Woddroffe thrust.

In the Musgrave Ranges the drainage patterns are controlled by jointing and the macroscopic layering of the rocks. It is dendritic over most of the Range. Strong layering in the norites east of Brown's Pass, however, gives rise to trellis drainage. Creeks are youthful and ephemeral, with narrow channels, often blocked with boulders, and steep banks. The Officer River, rising near Brown's Pass, east of Mt. Woodroffe, and its tributary, the Currie are the only rivers. Both are usually dry. The Officer extends 150 km south south into the sandplain incising the Quaternary sediments in a series of well developed meanders.

South of the ranges is the Great Victoria Desert with east-west trending longitudinal dunes up to 14 km long, 6 m high and 1.75 km apart. These form part of an anticlockwise arc of stable dune systems which runs through the Simpson and Great Sandy Deserts. The configuration of these dunefields is controlled by former dominant winds associated with cells of high atmospheric pressure in the southern hemisphere. The dunes were formed between 25 000 and 13 000 years ago. They have a stable base, a clay-rich core and vegetated flanks. Only the crestal sand is live.

The Serpentine lakes along the SA/WA border and other former drainage systems (as seen on the geological maps). are all that remain of the southerly drainage system established in the Miocene age.

The Petermann Ranges occupy the south west corner of the Northern Territory.

They protrude through the sandy desert as resistant quartzite. Residuals to the east form the Olia Chain. To the south gneiss and granite form low ridges of the Pottoyu Hills, and beyond the ranges to the east are longitudinal braided sand dunes, up to 12 m high, with a few claypans.

Dip slopes and scarps are common features of weathering in these ranges. Incised drainage is to the north where it floods over the sand plains.

Mt Olga - The Olgas stand about 455 m above the surrounding plains. Mt Olga is 1069 m above sea level. They occupy an area of 15 km^2. The Olgas are composed of Mt Currie Conglomerate with clasts ranging from pebbles to massive boulders. The rounded shapes have evolved from a well developed rectangular jointing pattern of the mass, followed by differential weathering.

The Mt Currie Conglomerate and the arkose at Ayer's Rock were deposited during the Cambrian from sediments eroded from the mountain chain in the south west which was raised by the Petermann Ranges orogeny about 600 my ago. They are thought to be continental deposits.

Concentric sheets or shells, following the surface outlines of the domes have developed in some places. These can vary in thickness from about 30 cm to many metres. Sheeting is though to occur when rock masses, buried under pressure, eventually have that pressure relieved by the removal of the overload by erosion. The release of pressure allows the upward expansion of the rock, and fractures result, parallel to the surface of the rock.

Erosional offloading is apparent also at Ayer's Rock in the "Kangaroo Tail". These structures may occur in any massive rock mainly in arid areas.

Ayer's Rock, a massive dome shaped inselberg is formed from an arkose and is a finer grained variant of the Mt Currie Conglomerate. Ayer's Rock strata have been uptilted to about 80°. Differential weathering of the bedding is responsible for the prominence of the ridges.

Most minor erosional features associated with inselbergs in arid climates are present at Ayer's Rock and the Olgas. They include flared slopes, gnammas holes (weather pits), sheeting already mentioned, tafoni or cavernous weathering and honeycomb weathering (Ayer's Rock). In tafoni, the weathering out of large grains allows penetration of the hardened crust. Shade and shelter preserve moisture and encourage the upward and inward granular disintegration of the weaker inside rock forming a spherical or ellipsoidal hollow.

Mount Conner, 85 km ESE of Ayer's Rock is a mesa composed of flat dipping sandstone of the Late Proterozoic Winnall Beds. It has steep sandstone bluffs and well developed debris slopes.

SOILS OF SA-NT-WA BORDER AREA

Introduction

The term soil is used in the agricultural sense (ie. the surface layers which are genetically related). Three main groups of soil occur:

- transported soils, such as alluvium or dunes which have been moved by water or wind from their original position
- residual soils which have been formed by in-situ weathering of rocks or sediments
- unconsolidated sediments

The surface layers called horizons are grouped into a soil profile. In well developed profiles 3 horizons can be distinguished.

- A horizon: surface layer of mineral soil usually darkened by organic matter and usually less clayey (ie. less sticky when wet) than the B horizon
- B horizon: subsoil layer having concentration of clay, and/or sesquioxides (iron, aluminium oxides), and/or stronger colours than A or B horizons
- C horizon: deep subsoil layer of fragmented weathered parent material which is often difficult to distinguish from parent material

Soil mapping

The soils of the whole area have been mapped by Stace et al. (1968) and Northcote et al. (1960, 1968) and part of the area in Laut et al. (1977) and Perry et al. (1962). The detail of the mapping is limited due to the poor agricultural potential. Most of the mapping has been done from air photos and geological maps before 1960 with limited field verification. The proposed excursion may provide some surprises and even new data.

Soil types

The soils consist mainly of:

- uniform texture sands (ie. with no soil profile developed)
- more clayey soils with a soil profile
- shallow stony soils on the steeper slopes
- soils developed by deep weathering (laterite, silcrete, and mottled and pallid zones)

BOTANY

Vegetation

The Arid Zone of Australia can be defined as an environment enormously variable in terms of key features of water, radiation and nutrient availability - in general it is well vegetated and the term 'desert' is inappropriate. The average rainfall annually is from 100 mm in the Simpson Desert to 200 mm for most of the Arid Zone.

The major vegetation formations on our journey through low-rainfall arid and semi-arid land of South Australia and Northern Territory will be acacia shrubland, low shrubland and hummock or tussock grassland.

Acacia aneura (the Mulga) dominates in the most widespread acacia shrubland. Through the homeward part of the trip near the Gawler Ranges Acacia sowdenii (the Myall) becomes dominant.

The low shrubland, generally called Chenepodiaceous, consists of saltbush and bluebush species. This will be seen mainly from Marree to Oodnadatta on the east sloping stony plains and stony tablelands draining to Lake Eyre.

Hummock grasslands, generally on the poorest nutrient and water-holding soil, consist mainly of Triodia species, the porcupine grasses, commonly erroneously called spinifex. Zygochloa paradoxa, the sandhill cane-grass, as its name implies occupies the sandhill niche in this arid zone in the North East of S.A. Perhaps the dunes west of Lake Eyre may be closest to our route. Patches of Casuarina, Cassia, Dodonea (Native Hops) and Eremophila can occur in association with this plant community mainly on the rocky slopes of hills and ridges.

Where the dry creeks and rivers intersect these plant communities Eucalypts are found, where from flash floods moisture sinks deep into the channels. Eucalyptus cameldulensis is the River Red Gum and occasional other gums appear rarely on flood plains.

After rain which falls haphazardly, all the bare spaces between the permanent vegetation become filled with a mass of ephemeral plants, whose seed has lain dormant often for long periods. The seeds of these plants, germinate rapidly, grow and produce colourful flowers and prolific seeds while the moisture is there.

Plant Species

The main genera to look out for are:

1. Trees

Acacia	Codonocarpus	Hakea
Brachychiton	Eucalyptus	Heterodendrum
Callitris	Grevillea	Melaleuca
Casuarina	Gyrostemon	Pittosporum
Ficus	Capparis	Santalum

Of these the main species we might see are:

1. Acacias

1. A. aneura (mulga) - small tree (5-10 m) umbrella-like crown - foliage usually silvery grey - very widespread - soils sandy, rocky, stony, clay.
2. A. brachystachya (umbrella mulga)
3. A. cambagei (gidgee - also known as stinking wattle) - Dense tree up to 10 m. Widespreading drooping crown - usually associated with A. aneura and Capparis mitchelli. Foliage greyish and emits offensive smell in damp conditions - can be dominant tree, especially along watercourses and where water collects in clay depressions.
4. A. estrophiolata (ironwood) - young plant is prickly, unattractive, shrub, later becomes small dense tree and in maturity is graceful, weeping tree, about 10 m high, light grey-green foliage, favours heavy clay soils.
5. A. salicina (native willow or cooba) - drooping, willowy habit about 14 m, mainly found along watercourses and clay depressions.
6. A. sowdenii (Western myall) - silvery-green foliage, umbrella-like shape, 5-8 m high - very alkaline or limey soils - dominant tree west of Port Augusta.

2. Capparis mitchelli (native orange) - compact, dense habit, 7-8 m high very wide girth - showy white flowers from September - clay or loamy soils.

3. Casuarina decaisneana (desert oak) - graceful weeping habit, dull green foliage, straight dark trunk deeply furrowed - up to 10 m grows on red sand dunes.

4. Codonocarpus cotinifolius (native poplar) - slender, graceful tree leaves very narrow - 7-14 m high - often forms pure white stands (one near Curtin Springs)

5. Eucalyptus

1. E. camaldulensis (river red gum) - in Central Australia trunk is slender, smooth and white and is often confused with ghost gum. Mainly found along watercourses.
2. E. dichromophloia (bloodwood) - varies from 2 m shrub to spreading 10 m tree - usually asociated with mulga, desert kurrajong and Pittosporum philliraeoides.
3. E. intertexta (gum barked coolibah) - grows along creeks 5-20 m high - rather similar to river red gum but rough bark on lower trunk.

4. E. microtheca (coolibah) - spreading tree 14-20 m. - thick trunk, 120 cm diameter - grows along watercourses and depressions with clay subsoil.

5. E. papuana (ghost gum) - found in N.T. mainly on river flats subject to periodic flooding - grows up to 25 m, spreading branches and lustrous, smooth, white bark.

6. Hakea
1. H. suberea (cork bark tree) - small twisted and contorted tree 5-8 m long needle-like leaves, large spikes of cream fragrant flowers.
2. H. divaricata (small leaved cork-bark) - often found in association with H. suberea, similar in appearance, but denser foliage, leaves short and flowers greenish.

7. Callitris columellaris (native pine) - neat tree about 14 m high - likes rocky slopes.

8 Brachychiton gregorii (desert kurrajong) - erect tree up to 8 m with compact shady crown - likes elevated sandhills.

9. Ficus platypoda (native fig) - small tree - grows in clusters round springs.

10. Grevillea
1. G. nematophylla (silver-leaved water bush) small to medium shrub when young, but it often develops a single erect trunk to 6 m high - grows mostly on interdune flats and terraces or along waterways.
2. G. striata (beefwood) - produces a dark red resin which sets hard - grows up to 10 m on a variety of soils often along waterways or on flood plains.

11. Gyrostemon ramulosus (Chinese pine) - handsome when young but grows straggly later - persistent corky bark and clusters of slender leaves near ends of branchlets - up to 7 m high.

12. Heterodendrum oleaefolium (bullock bush) - small tree up to 5 m rounded crown of numerous branches and dense dull greyish-green foliage - widespread as clumps.

13. Melaleuca corrugata - small tree or shrub, pink flowers, found in small pockets in Everard Range.

14. Pittosporum phylliraeoides (native apricot) - small graceful tree 5-7 m high, weeping habit - bright apricot coloured seed capsule with sticky seeds.

15. Santalum
1. S. acuminatum (quandong) - a root parasite which grows into a small tree up to 4 m high - widespread on well-drained often calcareous soils - scarlet coloured edible fruit.
S. lanceolatum (plum bush) similar to S. acuminatum but the edible fruit is dark blue and plum-like.

These are only a few of the trees we may see. Among the shrubs are several more acacias, cassias, dodoneas, eremophilas (the name means desert loving), the large yellow Guinea Flower (Hibbertia glaberrima, Rulingia magniflora), Spearwood (Pandorea doratoxylon, Eriostemon linearis, Olearia ferresii (a large white flowered daisy) indigofera, prostanthera (mint bush) some solanums, a species of Native Bell (a calostemma), more grevilleas, thryptomene, Nicotiana excelsior (tobacco bush) some senecios, several members of the Malvaceae Family, including Lavateria (native hollyhock), Hibiscus Gossipium and rose mallow, and Gastrolobium graniflorum (Poison Pea.).

Among the smaller plants are numerous ephemeral composites (helipterums, helichrysums, waitzia and others) several Ptilotus (pussy tails) a blue borage, Trichodesma zeylanicum, a yellow legume Crotolaria eremaea, Ulcardo Melon (Cucumis melo), purple Stemmodia viscosa and a rare hand flower, Scaevola laciniata.

The chief grass to be seen is Triodia basedowii (Porcupine Grass, Spinifex) which grows in humped clumps. Chenopods such as atriplex (saltbush) and kochia (blue bush) will also be seen.

One of the Yaccas, Xanthorrhea thorntonii, only occurs in Central Australia. It is found in the North West of S.A. in the Musgrave and Mann Ranges.

The Caustic Vine, Sarcostemma australe, is a trailing fleshy grey-green plant found mainly on stony soils on rocky hills. The leaves are reduced to scales.

An interesting parasite is the mistletoe. Species are found on Mulgas and Myalls and on the Corkwood Tree (among others). The foliage can resemble closely that of the host tree in a remarkable way.

BIRDS

This list was compiled from the references given.

Some distribution information is necessarily very broad. Abundances are not shown, and many species are not likely to be seen on our trip.

The letters beside each name indicate distribution as follows:

A: Oodnadatta to Stuart Highway

B: North-western ranges

C: Giles to Ayers Rock

D: Macdonnell Ranges

EMU	ABCD	DABBLING DUCKS:	
GREBES:		Pacific Black	ABCD
Hoary-headed	ABCD	Mallard	D
Australasian	ABCD	Grey Teal	ABCD
AUSTRALIAN PELICAN	ABCD	Chestnut Teal	D
DARTER	ABCD	Australasian Shoveller	D
CORMORANTS:		Pink-eared	ABCD
Great	AD	HARDHEAD	ABCD
Pied	ABD	MANED DUCK	ABCD
Little Black	AD	MUSK DUCK	D
Little Pied	ABCD	SMALL KITES:	
HERONS:		Black-shouldered	ABCD
Pacific	ABCD	Letter-winged	AD
White-faced	ABCD	TRUE KITES:	
Pied	D	Black	ABCD
Great Egret	ABCD	Square-tailed	ABCD
Intermediate Egret	BD	Black-breasted	ABCD
Cattle Egret	D	Whistling	ABCD
RUFOUS NIGHT HERON	ABCD	GOSHAWKS:	
BLACK BITTERN	C	Brown	ABCD
IBISES:		Collared Sparrowhawk	ABCD
Glossy	D	HARRIERS:	
Sacred	AD	Spotted	ABCD
Straw-necked	ABCD	Marsh	D
SPOONBILLS		FALCONS	
Royal	ABCD	Black	ABCD
Yellow-billed	AD	Peregrine	ABCD
MAGPIE-GOOSE	D	Australian Hobby	ABCD
PLUMED WHISTLING-DUCK	D	Grey	ABCD
BLACK SWAN	AD	Brown	ABCD
FRECKLED DUCK	BD	Australian Kestrel	ABCD
BUTTON QUAILS:		MALLEE FOWL	ABCD
Little	AD	STUBBLE QUAIL	AD
Red-chested	A	PIGEONS:	
RAILS:		Peaceful Dove	AD
Buff-banded	D	Diamond Dove	ABCD
Baillon's Crake	D	Common Bronzewing	ABCD
Australian Crake	D	Flock Bronzewing	AD
Black-tailed Nativehen	ABCD	Crested	ABCD
Dusky Moorhen	A	Plumed	BCD

Purple Swamphen	AD
COMMON COOT	D
BROLGA	AD
AUSTRALIAN BUSTARD	ABCD
BUSH THICKNEE (Stone-Curlew)	ABCD
PAINTED SNIPE	D
LAPWINGS:	
Masked	ABD
Banded	ABCD
PLOVERS:	
Red-kneed	ABCD
Oriental	A
Red-capped	D
Black-fronted	ABCD
INLAND DOTTEREL	ACD
STILTS:	
Black-winged	ABCD
Banded	AD
Red-necked Avocet	AD
SANDPIPERS:	
Little Whimbrel	D
Wood	BD
Wandering Tattler	D
Common	D
Greenshank	ABD
Marsh	D
Sharp-tailed	D
Pectoral	D
Red-necked Stint	D
AUSTRALIAN PRATINCOLE	ACD
SILVER GULL	D
TERNS:	
Whisked	AD
Gull-billed	AD
Caspian	D
SWALLOWS:	
White-backed	ABCD
Welcome	ABCD
Tree Martin	ABCD
Fairy Martin	ABCD
RICHARD'S PIPIT	ABCD
CUCKOO-SHRIKES:	
Black-faced	ABCD
Ground	ABCD
White-winged Triller	ABCD
ROBINS:	
Red-capped	ABCD
Hooded	ABCD
Jacky Winter	ABCD
WHISTLERS:	
Rufous	ABCD
Grey Shrike-thrush	ABCD
Crested Bellbird	ABCD
FANTAILS:	
Grey	ABCD
Willie Wagtail	ABCD
WEDGEBILLS:	
Chirruping	A
Chiming	ABCD

COCKATOOS:	
Red-tailed Black-	BCD
Galah	ABCD
Little Corella	ABCD
Pink	ABCD
PARROTS:	
Princess	BCD
Cockatiel	ABCD
Night	AD
Budgerigar	ABCD
Port Lincoln Ringneck	ABCD
Mulga	ABCD
Blue-Bonnet	AB
Bourke	ABCD
Scarlet-chested	ABD
CUCKOOS:	
Pallid	ABCD
Black-eared	ABCD
Horsfield's Bronze-	ABCD
Koel	D
OWLS:	
Southern Boobook	ABCD
Barn	ABCD
Masked	A
TAWNY FROGMOUTH	ABCD
OWLET-NIGHTJAR	ABCD
SPOTTED NIGHTJAR	ABCD
SWIFTS:	
White throated Needletail	CD
Fork-tailed	D
KINGFISHERS:	
Red-backed	ABCD
Sacred	D
RAINBOW BEE-EATER	ABCD
DOLLARBIRD	D
SINGING BUSHLARK	A
GROSS-WRENS:	
Striated	BCD
Thick-billed	AD
Dusky	BCD
AUSTRALIAN WARBLERS:	
Redthroat	ABCD
Calamanthus	ABCD
Weebill	ABCD
Western Gerygone (White-tailed Warbler)	BCD
THORNBILLS:	
Inland	ABCD
Chestnut-rumped	ABCD
Slate-backed	BCD
Slender-billed	A
Yellow-rumped	ABCD
WHITEFACES:	
Southern	ABCD
Chestnut-breasted	A
Banded	ABCD
VARIED SITTELLA	ABCD
TREECREEPERS:	
White-browed	ABCD
Black-tailed	D

QUAIL-THRUSHES:	
Chestnut	BCD
Cinnamon	ACD
BABBLERS:	
Grey-crowned	D
White-browed	ABCD
WARBLERS:	
Clamorous Reed	AD
Little Grassbird	AD
Spinifexbird	CD
Golden-headed Cisticola	D
SONGLARKS:	
Rufous	ABCD
Brown	ABCD
FAIRY-WRENS:	
Splendid	ABCD
Variegated	ABCD
White-winged	ABCD
RUFOUS-CROWNED EMU-WREN	CD
CHATS:	
Crimson	ABCD
Orange	ABCD
Yellow	D
White-fronted	A
Gibberbird	A
MISTLETOEBIRD	ABCD
PARDALOTES:	
Red-browed	ABCD
Striated	ABCD
MAGPIE-LARK	ABCD
WOODSWALLOWS:	
White-breasted	ABCD
Masked	ABCD
White-browed	ABCD
Black-faced	ABCD
Little	ABCD
HONEYEATERS:	
Spiny-cheeked	ABCD
Yellow-throated Miner	ABCD
Singing	ABCD
Grey-headed	BCD
Grey-fronted	ABCD
White-plumed	ABCD
Black-chinned (Golden-backed)	ACD
Brown	BCD
White-fronted	ABCD
Grey	ACD
Black	ABCD
Pied	ABCD
BUTCHERBIRDS:	
Grey	ABCD
Pied	ABCD
Australian Magpie	ABCD
Grey Currawong	ABC
CROWS:	
Australian Raven	A
Little	ABCD
Torresian	ABCD
HOUSE SPARROW	D
AUSTRALIAN FINCHES:	
Painted Firetail	ABCD
Zebra	ABCD
COMMON STARLING	A
SPOTTED BOWERBIRD	BCD

MAMMALS

Two animals we are certain to see on the trip are the Dingo and the Red Kangaroo. We will probably see a Euro, possibly a Brushtail Possum and, if we are lucky, a Black-footed Rock Wallaby. The Australian Museum Complete Book of Australian Mammals (Strathan, 1983) lists 28 species that live in this area; 11 of these are bats, which will be heared but probably not seen and certainly not close enough to be identifed. The remaining 12 are either rare, nocturnal or live in burrows.

DINGO Canis familiaris dingo	The usual colour of a dingo is sandy to reddish brown but black and brindles do occur. Dingoes breed only once a year, mostly in Autumn, unlike domestic dogs which have a second season in Spring.
RED KANGAROO Macropus rufus	Males are usually red and females blue-grey, but red females and blue males do occur. Their habitat is the open plain country. Top speed for a large male 'roo is 60 k.p.m., but a more normal fast hop is around 20 k.p.m. Troughton has reported a 'roo under pressure hopping 27 feet (8.2 m.) in one bound and clearing a heap of timber 10 feet (3 m.) high. The normal length of hop at slow speed is 1 m. and at high speed 4 m. Once a kangaroo gets into the swing of his hop he uses very little energy. The muscles and tendons of his legs work like a pogo stick and store energy on the down beat to use on the up beat, so he can go further and faster than if he used four feet.
EURO Macropus robustus	These kangaroos live in rocky country and use caves and rock crevasses for warmth in the winter and coolness in the summer. Their coat is longer and shaggier than that of the Red Kangaroo and the soles of their feet are rough, giving a good grip on rocks.
BLACK-FOOTED ROCK WALLABY Petrogale lateralis	These wallabies are about half the size of the kangaroos and are much harder to see. They also have rough soles in their feet which are surrounded by stiff hairs enabling them to hop up almost vertical rock falls. They live among the rocks and can exist without water by sheltering during the day in caves where the humdity is high and the temperature 10-15°C cooler than that of the outside air.

REPTILES

SNAKES

Worm Snakes	Often called blind snakes because of their rudimentary eyes. They live underground and beneath logs and stones. They have highly polished scales which help them to push their way through the earth. At night they may be found on the ground surface. Non-venomous and do not bite.

Pythons	They crush their prey and are not venomous, but have sharp teeth and can bite. E.g. The Woma and Children's Python.
Front Fanged Snakes	These are the venomous ones. E.g. Brown, King Brown, Desert Banded, Bandy Bandy and Desert Death Adder.

LIZARDS

Skinks	Overlapping smooth or glossy scales. Enlarged symmetrical shields on head. Broad flat tongue. Moveable eyelids. Fragile tails. eg. Blue Tongue, Stumpytail (which is an aberrant form of skink).
Geckos	Soft dull skin. Large unblinking eyes. Expanded adhesive tips of digits. Some geckos have voices and may squeak when handled roughly or frightened. Some can climb on walls and ceilings hunting insects around the lights. eg. Dtella and Prickly Gecko.
Legless Lizard	Fore limbs are absent. Hind limbs are rudimentary structures with no visible digits. Can vocalise. eg. Burton's Legless Lizard.
Dragon	Well developed movable eyelids. Distinct mobile heads.
Lizards	Well developed 5-clawed limbs. Slender non-fragile tails. Skin dull and rough, or spinose. Tongue broad and flat. eg. Painted Dragon, Moloch or Thorny Devil (aberrant form of dragon).
Goannas	Elongated head and neck. Tail is slender, powerful and non-fragile. Limbs strong and 5-clawed. Skin dull with granular scales. Moveable eyelids. Deeply forked tongue like a snake. eg. Goulds Goanna and Perentie (which can grow up to 2.4 m in length).

HISTORY

It is now over 100 years since the first links between this isolated area of nomadic hunter-gatherer and the outside world. Events over these years have left indelible marks on both the land and its people, the Pitjantjatjara and Yangkuntjatjara.

White Australians have believed ... 'that history began with the growth of colonies at the beginning of the 19th century'. It is now evident that Aborigines preceded European settlement by at least 40 000 years and life continued from that time, with little to alter the evolved pattern of living.

A hint pointing to that great antiquity lies in the fact that stones and rocky hills are known by a collective noun "apu" with few exceptions. Dolerite dykes are distinguished as alkara maru (chop black), tektites are ku:ti, or in the neighbourhood of Mt Davies, 'black hail'. Quartzite is also distinguished from other rocks.

These people traditionally spun hair and fur into yarn. Their technique of spinning with crossed sticks precedes the oldest known method using a weighted spindle, which dates back more than 10 000 years.

The Aboriginal people maintained a spiritually centred culture. The Dreamtime stories shaped their lives and gave both an explanation of how their world came to be and how to conduct their behaviour and social relationships. They were members of an ordered society, living within prescribed boundaries. Each locality had its own totem and links with the land were strengthened by this affiliation - man was an integral part of nature and shared the same life essence.

Gradual change came through ceremonial getherings and via the great trade routes which criss-crossed the continent. However traditional life bound people to the past and what had always been. Mobility kept possessions to a minimum - spear, woomera, wooden dish, digging stick. (Giles and others noted the absence of boomerangs in this area.)

Pitjantjatjara lands had been centred in the Mann, Blackstone, Rawlinson and Petermann Ranges. With the worsening of drought in 1915 they moved eastwards into the Musgrave Ranges and forced the Yangkuntjatjara, the original occupiers, east and south as far as Ooldea.

European explorers came and pastoralists, prospectors and others followed, assuming that the land was 'terra nullius' - wasteland for the taking. The Aboriginal owners were not consulted, just expected to move on and make available any land chosen to be occupied and any spiritual affinity with their land was disregarded. It was assumed that they were dying out - extinction seemed inevitable. The sudden impact of European materialistic outlook, the idea of racial superiority and white man diseases caused rapid decline among the Aborigines. They were expected and encouraged to shed their own ways and traditions. At best they were seen as primitive race and useful subjects of scientific research - seldom were they considered as people. The newcomers perceived view, with its omissions and distortions excluded the Aboriginal people from the pages of history. The forces that shaped the Australian experience have been told from one side of the frontier and we are left with only half a history.

1862 John McDouall Stuart led the way overland from Adelaide to Darwin in response to a 2000 pound reward offered by the S.A. Government.

1872 Overland Telegraph linked Adelaide and Pt Darwin and made a starting point for further journeys seeking new stock routes, new pastoral country and mineral wealth.

1872 Ernest Giles mapped between the MacDonnell Ranges and Lake Amadeus in N.T.

1873 W.C. Gosse named the Musgrave Ranges and Mt Woodroofe. Visited Ayers Rock, seen in the distance the previous year by Giles. Travelled through Mann and Tomkinson Ranges into W.A. and returned east via the Tomkinson, Mann and Musgrave Ranges.

1873 Giles - travelled west from Overland Telegraph Line, via Musgrave Ranges - the first white men to visit the Musgraves. Sighted and named Everard Ranges from Sentinel Hill then on to Mann and Tomkinson Ranges. Returned to Charlotte Waters via Rawlinson and Petermann Ranges, Mt Olga, Ayers Rock and George Gills Range. Attacked by Aborigines at the Officer Creek and at Sladden Waters (9 km from present Giles Weather Station). Forced to spend the summer at Fort Mueller in the Cavanagh Ranges. Giles 'the last of the great explorers' discovered no new pastures, no major stock routes and no waterholes. No great feature bears his name - his only reward a gold medal. Endured hardship, privation and tragedy - a companion Gibson disappeared into the desert which now bears his name.

1874 John Forrest from W.A. through the Tomkinson, Mann and Musgrave Ranges to Peake Telegraph Station, aided by the tracks of Gosse and Giles. Earlier reports of explorers did not inspire settlement of the region and years passed before others followed.

1888-92 John Carruthers - Government Surveyor, undertook a Trigonometrical survey from Oodnadatta to the border of W.A. and noted herbage, rocks and soil.

1903 H. Basedow - S.A. Government N.W. Prospecting Expedition. Sufferings of the early explorers dispelled illusions of those who dreamed of rich pastures and fresh opportunities. Gold had been discovered at Kalgoorlie and Coolgardie and the hope of discovering minerals in commercial quantities was regarded as the most promising way of opening up the land. Prospecting parties covered the area.

1929 Rail terminus taken through from Oodnadatta to Alice Springs.

1930 Michael Terry covered the area extensively and introduced the first motor vehicle to the country. Still little to show for the effort and privations suffered by explorers and prospectors - drought and distance remained major stumbling blocks. Whole aim and object of exploration - to sound its possibilities for future development for the benefit of white society.

1932 First pastoral lease taken up near Everard Ranges, most of the surrounding country leased during the next few years. Primarily 'dogging camps' - dingo scalps exchanged for Government bounty. Dogging period coincided with other big changes - Aborigines came into settlements because life seemed easier there. White man's food in exchange for dingo scalps proved a strong attraction. It became increasingly obvious to the Aboriginal people that the white man was no longer a mere traveller passing through - he was here to stay.

1930s Cattle stations established west of railway line eg. Lambina, Kulgera, de Rose Hill, Kenmore Park.

1936 Ernabella Mission established by the Presbyterian Church. Dr Charles Duguid saw that the Aborigines needed time to absorb new ways and to assess new values of the encroaching culture.

1953-63 Len Beadell, Department of Supply surveyor, led a roadmaking team putting in roads. Initial purpose was for a geodetic link, prior to the establishment of weapon testing at Woomera, Maralinga and Emu Junction. Also chose the site of Giles Weather Station.

1957 Musgrave Park established, S.A. Government administrative centre for the N.W. Reserve - renamed Amata 1968.

1970 Homeland Movement - initiated by Aboriginal people to re-establish their communities along more traditional social lines and under traditional leadership away from the European influence of missions, settlements etc.

1981 Pitjantjatjara gained freehold title to about 100 000 sq km and the right to negotiate with people wanting to use their land.

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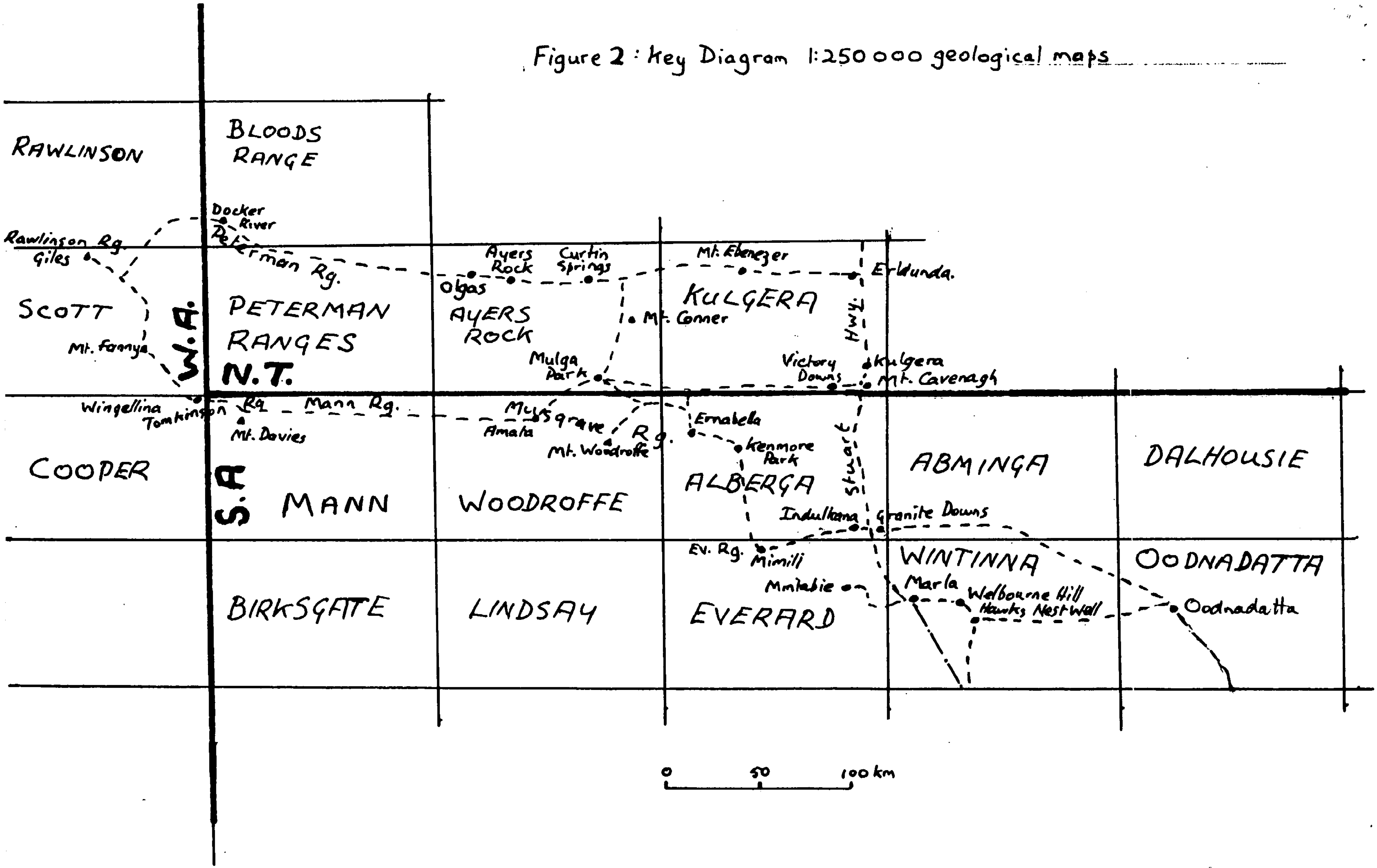
Figure 2: Key Diagram 1:250 000 geological maps



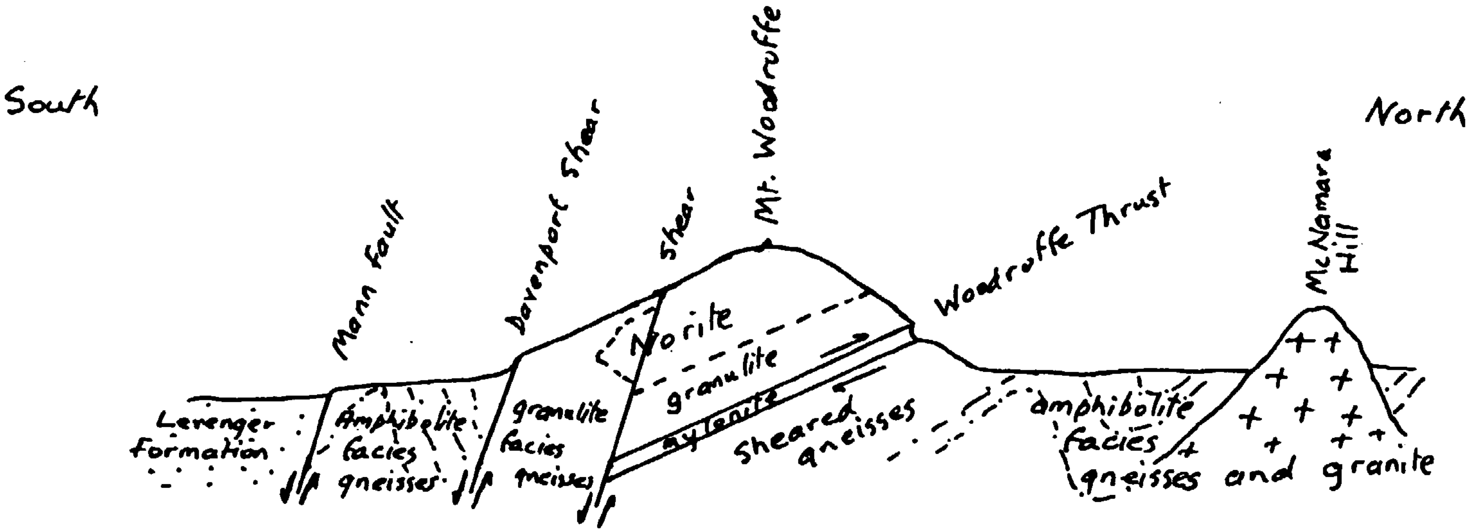


Figure 4: Diagrammatic cross-section Mount Woodroffe

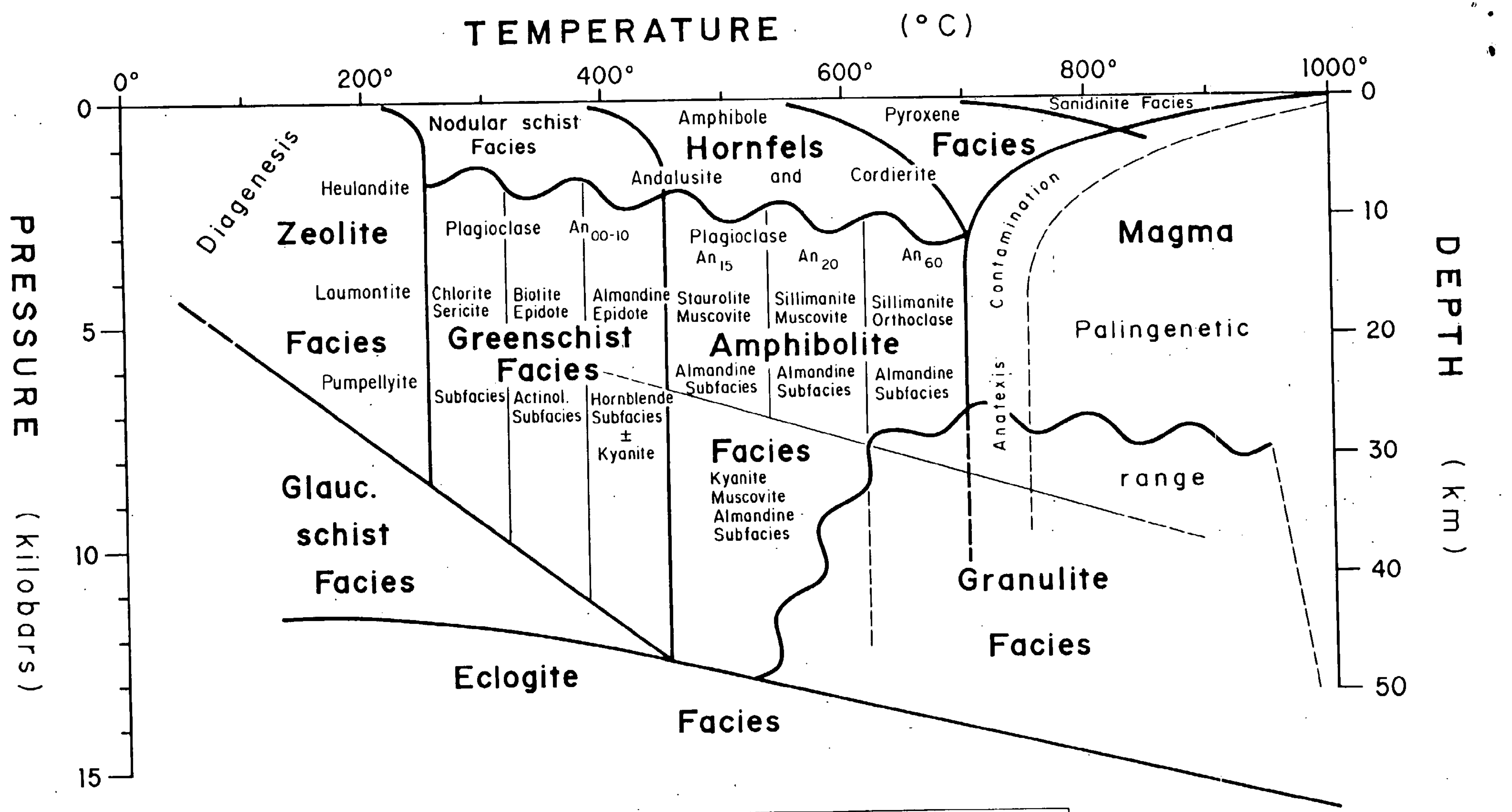


Figure 5 RELATION BETWEEN THE METAMORPHIC FACIES AND THE TEMPERATURES AND PRESSURES IN THE EARTH'S CRUST

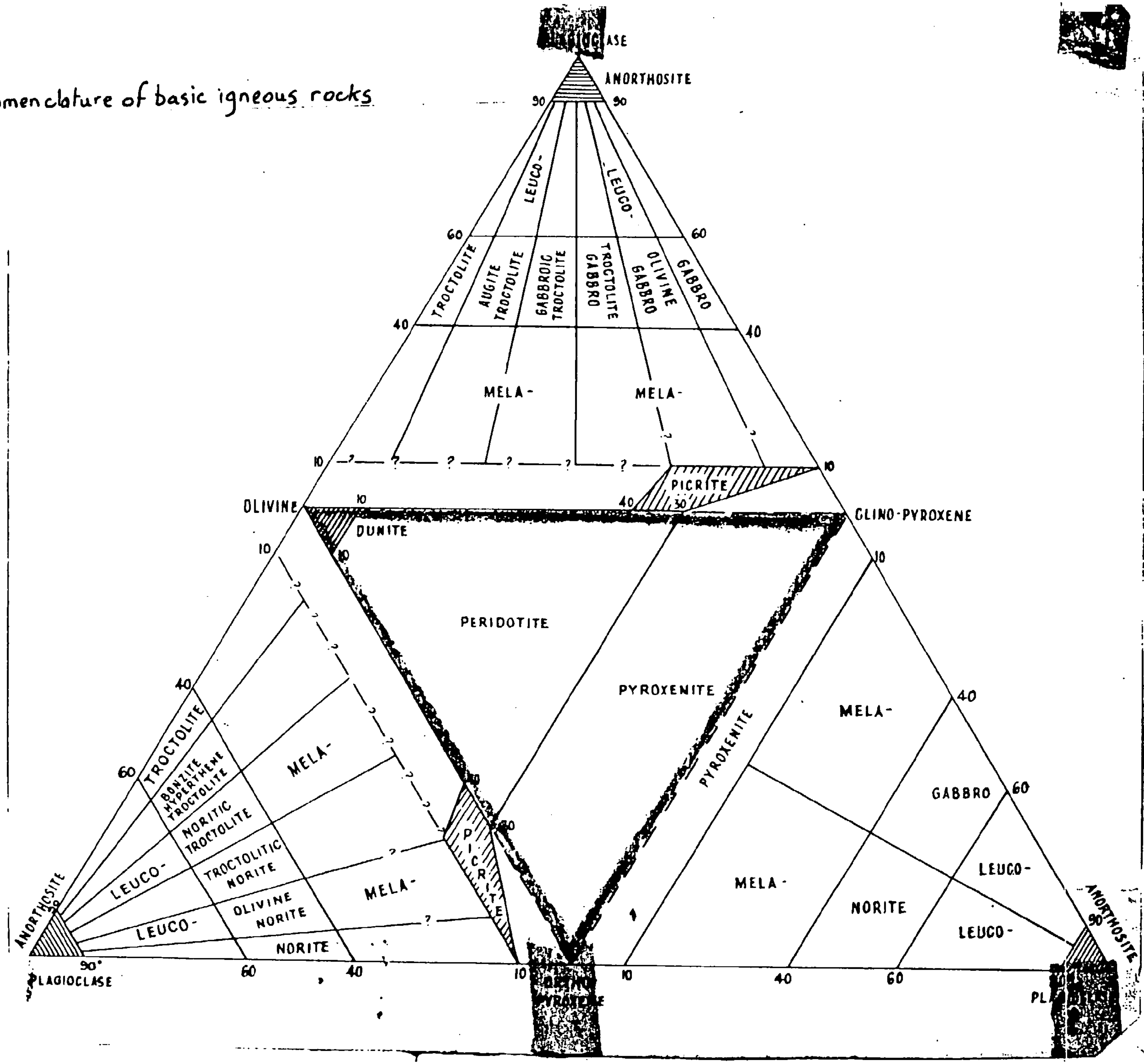
after TRÖGER, 1963

From 84-313

DEPARTMENT OF MINES AND ENERGY – SOUTH AUSTRALIA

S 17472

Figure 6: Nomenclature of basic igneous rocks



FIELD GEOLOGY CLUB OF SOUTH AUSTRALIA INC.

Excursion to Musgrave Ranges and Ayers Rock areas

Saturday 25 August - Saturday 15 September 1984

PROPOSED ITINERARY

Date	Locality
Sat 25 Aug.	Adelaide - Hawker - Copley
Sun 26 Aug.	Copley - Marree - Gregory River - William Creek
Mon 27 Aug.	William Creek - Oodnadatta - Arkaringa Hills.
Tues 28 Aug.	Arkaringa Hills - Hawkes Nest Well - Welbourn Hill - Marla - Indulkana
Wed 29 Aug.	Indulkana Range
Thurs 30 Aug.	Indulkana Range - Mimili - Everard Range
Fri 31 Aug.	Everard Range - Kenmore Park - Ernabella
Sat 1 Sept.	Ernabella - Mount Woodroffe
Sun 2 Sept.	Mount Woodroffe
Mon 3 Sept.	Mount Woodroffe - Mulga Park - Amata
Tues 4 Sept.	Amata - Katjiwalanya
Wed 5 Sept.	Katjiwalanya - Mann Range - Gosse Pile - Pipalyatjara (Mount Davies)
Thurs 6 Sept.	Pipalyatjara - Irrunytju - Giles Meteorological Stn.
Frid 7 Sept.	Giles Met. Station - Docker River - Lasseter's Cave - Mount Olga
Sat 8 Sept.	Mount Olga - Ayers Rock
Sun 9 Sept.	Ayers Rock
Mon 10 Sept.	Ayers Rock - Curtin Springs - Mulga Park - Victory Downs
Tues 11 Sept.	Victory Downs - Mount Cavenagh - Marla - Mintabie
Wed 12 Sept.	Mintabie - Marla - Coober Pedy
Thurs 13 Sept.	Coober Pedy - Woomera
Frid 14 Sept.	Woomera - Adelaide
Sat 15 Sept.	

FIELD GEOLOGY CLUB OF SOUTH AUSTARLIA

Field excursion to Musgrave Range - Ayers Rock area

25 August to 15 September, 1984

LIST OF PEOPLE ON EXCURSION

(20 August, 1984)

1. Total number of people is 62. (57 F.G.C., 5 Ansett-Briscoe)

2. Ansett - Briscoe staff:

   Drivers: Geoff Morphett, Doug Tennant

   Cooks: Janice Horton, Marion Brokken, Justin Morphett

3. Field Geology Club members:

   Dr. Jack Anderson
   Ken Archibald
   Mavis Boase
   Margaret Brown
   Harvey Burton
   Malcolm Campbell
   Dr. Peg Christian
   Joan Clark
   Ron Collins
   Brian Davenport
   Jean Fordham
   Nancy Friee
   Dr. Robin Giesecke
   Roger Giesecke
   Claire Gifford
   Dean Gillett
   Florence Gillett
   Lucy Giordano
   Pat Gluis
   Barbara Hardy
   Pam Hasenohr
   Rita Humphreys
   Gerhard Horr
   Irene Hunt
   Ray Hunt
   Ross Kennedy
   Wolfgang Kretci
   Nell Lowe