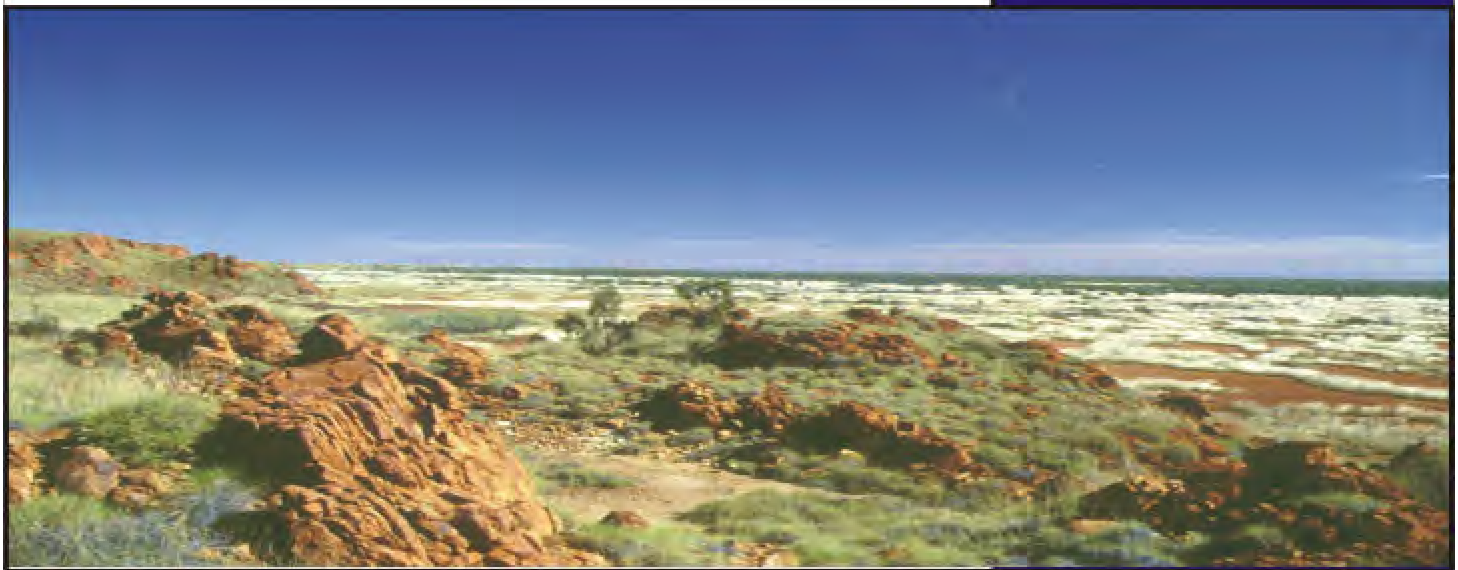
Palaeoproterozoic stratigraphy of the Tanami Region: regional correlations and relation to mineralisation-preliminary results.



Marc Hendrickx
Kerry Slater
Andrew Crispe
Alison Dean
Leon Vandenberg
Julie Smith

Northern Territory Geological Survey
Geological Survey Record GS 2000-13

Department of Mines & Energy Northern Territory

NORTHERN TERRITORY GEOLOGICAL SURVEY

Geological Survey Record
GS 2000-13

Palaeoproterozoic stratigraphy of the Tanami Region: regional correlations and relation to mineralisation - preliminary results

Marc A Hendrickx, Kerry R Slater, Andrew J Crispe, Alison A Dean,
Leon C Vandenberg and Julie B Smith

Alice Springs, June 2000

NORTHERN TERRITORY DEPARTMENT OF MINES AND ENERGY

MINISTER: Hon. Daryl Manzie, M.L.A.

SECRETARY: Peter Blake

NORTHERN TERRITORY GEOLOGICAL SURVEY

DIRECTOR: Dr R Dennis Gee

Marc A Hendrickx, Kerry R Slater, Andrew J Crispe, Alison A Dean, Leon C Vandenberg and Julie B Smith

Palaeoproterozoic stratigraphy of the Tanami Region: regional correlations and relation to mineralisation - preliminary results

ISSN 1443-1149; Geological Survey Record GS 2000-0013

ISBN 0 7245 3429 6

This report may be obtained in digital form from:
Northern Territory Geological Survey
Department of Mines and Energy (DME)
3rd Floor, Centrepoint Building
Smith Street Mall
DARWIN NT 0800

Or from the DME web site: http://www.dme.nt.gov.au

For further information contact:
Reference Geologist
Northern Territory Geological Survey
GPO Box 2901
Darwin NT 0801
Phone: +61 8 8999 5281

Cover Photo
Outcrop of Killi Killi Formation, McFarlane, AMG 523934-7786440.

Printed and published by the Northern Territory Geological Survey

CONTENTS

TABLES

FIGURES

MAPS (in back of report)

ABSTRACT

The oldest rocks of the Tanami Region are Archaean gneiss and schist of the “Billabong complex” and Browns Range Metamorphics. The basal Palaeoproterozoic sequence (MacFarlane Peak Group) is dominated by mafic volcanic and volcaniclastic rocks with minor clastic sediments and calcsilicates. It is interpreted to have formed during an early rift stage. MacFarlane Peak Group is overlain by a thick succession of clastic sediments (Tanami Group) representative of a passive margin sequence. The lower Tanami Group is characterised by carbonaceous siltstone with minor banded iron formation and calcsilicate rocks (Dead Bullock Formation), characteristic of deposition in deep water in an oxygen starved basin. The upper Tanami Group is a thick monotonous sequence of turbiditic sediments (Killi Killi Formation). Twigg Formation, comprising interbedded purple siltstone, greywacke and chert, may be a lateral equivalent of either Dead Bullock Formation or Killi Killi Formation. Dolerite sills intrude both MacFarlane Peak Group and Tanami Group and predate the first deformation event in the Tanami Region.

Major deformation between 1845-1840 Ma (Barramundi Orogeny) was accompanied by greenschist to amphibolite grade metamorphism and granite intrusion (Inningarra Suite) and followed by localised extension, forming small narrow basins which were filled with shallow marine sediments in the west (Pargee Sandstone) and pillow basalt and turbiditic sediments in the east (Mount Charles Formation). Widespread granite intrusion and volcanism followed between 1830-1810 Ma. This is represented in the Tanami Region by at least three granite suites (Coomarie, Winnecke and Frederick suites) and two volcanic complexes (Mount Winnecke Group and Nanny Goat Volcanics). These rocks were deformed prior to intrusion of the Granites Suite at 1800-1795 Ma.

The Birrindudu Group, a 2 km thick sedimentary platform sequence dominated by quartz arenite with minor carbonate, was deposited onto a subdued landscape sometime after intrusion of the Granites Suite (~1790-1700 Ma?).

KEY WORDS

Gold, Tanami SE52-15, The Granites SF52-03, Archaean, Proterozoic stratigraphy, Palaeoproterozoic, geophysics, “Billabong complex”, Browns Range Metamorphics, MacFarlane Peak Group, Tanami Group, Barramundi Orogeny, Pargee Sandstone, Mount Charles Formation, Coomarie Suite, Winnecke Suite, Frederick Suite, Mount Winnecke Group, Nanny Goat Volcanics, Birrindudu Group.

INTRODUCTION

Data releases

This publication represents the first of a series of preliminary reports on the Tanami Region by the Northern Territory Geological Survey (NTGS). Two more preliminary reports are intended for publication. These will focus on the results of structural mapping and granite petrology and geochemistry. Our intention is to disseminate new information and ideas as quickly as possible to help stimulate the generation of new exploration models which will result in a rapid increase in the number of substantial mineral discoveries. As a result readers are cautioned that interpretations may change as new information becomes available.

Forthcoming product releases will include:

- Two additional preliminary reports for release in August 2000:
  - Structural geology of the Tanami Region and relation to mineralisation (Vandenberg *et al* 2000)
  - Igneous rocks of the Tanami Region: petrology, geochemistry and relation to mineralisation (Dean *et al* 2000);
- Release of 1:250 000 basement geology interpretation maps for TANAMI and THE GRANITES (September 2000)
- Release of 1:100 000 basement and surface geology maps for McFarlane, Ptilotus, Granites, Frankenia, Inningarra, Tanami, Pargee and Wilson Creek (available from September 2000)
- Release of Frankenia 1:50 000 special map – basement geology interpretation (September 2000)
- Tanami – Granites GIS (December 2000).

The current study

This report describes a new preliminary interpretation of Archaean and Palaeoproterozoic stratigraphy of the Tanami Region and is the result of integrated geological, geophysical and geochronological studies by NTGS during 1999-2000. Field work concentrated on detailed and reconnaissance mapping of exposures of Archaean and Palaeoproterozoic rocks. The geophysical interpretation was greatly improved by detailed (line spacing of 200 m or less) geophysical and drill hole data made available by exploration companies (Otter Gold, Normandy NFM and Anglo Gold). Radiometric U-Pb in zircon ages have been obtained for samples in this project utilising the SHRIMP at The Australian National University, Canberra. A complete report of this new data will appear in the near future. SHRIMP (U-Pb in zircon) ages quoted from the AGSO Ozchron database identify the relevant sample number and geochronologist. The methods used for other age determinations are quoted in the text.

The report is accompanied by a new generalised 1:500 000 basement interpretation map and 1:500 000 geophysical images (Maps 1-3). References to individual 1:100 000 maps are in small capitals, 1:250 000 maps are in large capitals. All AMG references are correct to approximately 50 m for AGD 66 zone 52. To convert to approximate MGA 94 coordinates add 131 m to the easting and 164 m to the northing.

The Tanami Region lies 600 km northwest of Alice Springs. Its relationship with surrounding tectonic units is poorly known. The contacts with the Arunta Province to the south and Tennant Inlier to the east are not exposed but appear to be major shear zones in the magnetic data and will be the subject of continuing NTGS work. The Tanami Region is probably continuous with the eastern part of the Halls Creek Orogen in Western Australia and underlies much of the Victoria River Basin to the north (**Figure 1**).

The proposed stratigraphy and distribution of Archaean and Palaeoproterozoic rocks is substantially different from the earlier, first edition TANAMI and THE GRANITES geological maps (Blake *et al* 1972, 1973). Archaean and Palaeoproterozoic rocks in the Tanami Region form widely separated, discontinuous, deeply weathered or silicified outcrops which complicate the task of understanding the stratigraphy of the region. However, with the provision of detailed geophysical data, detailed mapping and drilling by exploration companies over the past two decades and more recently by NTGS, coupled with an increase in radiometric age determinations, sufficient information is now available to more accurately define the stratigraphy in the Tanami Region.

Previous work

The region was first mapped by the BMR (Bureau of Mineral Resources) between 1971 and 1974 (Blake *et al* 1972, 1972a, 1973, 1979). They recognised four units in the Palaeoproterozoic: Tanami Complex (with five constituent units) overlain with an angular unconformity by Pargee Sandstone, Mount Winnecke Formation, Supplejack Downs Sandstone and Birrindudu Group.

Tanami Complex comprised metasediments and volcanics that were divided into five separate units based on composition and location (Blake *et al* 1979). These units: Killi Killi beds, Mount Charles beds, Nanny Goat Creek beds, Nongra beds and Helena Creek beds, were thought to be lateral equivalents. Mapping by NTGS, exploration companies and university researchers has highlighted a number of problems and inconsistencies with the existing stratigraphy. Mount Charles beds were a mix of three different lithological associations (turbiditic sandstone; siltstone and chert, and mafic volcanics) with different ages and structural histories. In THE GRANITES the unit includes many outcrops of turbidites which were part of Killi Killi beds. The Nanny Goat Creek beds were a mixed unit comprising deep marine turbidites, and younger, less deformed subaerial felsic volcanic rocks. In the same area the Supplejack Downs Sandstone is now deemed to be equivalent to the Birrindudu Group. Nongra beds in northern TANAMI are similar to redefined and newly defined units described below and have been reassigned accordingly. Helena Creek beds crop out in BIRRINDUDU and were not part of this study. The stratigraphic position of Pargee Sandstone and Mount Winnecke Formation is unchanged from previous interpretations (**Table 1**).

Table 1 Comparison of stratigraphic nomenclature between Blake *et al* (1979) and this report

<table>
<tr><td colspan="6">Blake et al (1979)</td><td colspan="3">This report</td></tr>
<tr><td rowspan="3">Birrindudu Group</td><td colspan="5">Coomarie Sandstone</td><td rowspan="3">Birrindudu Group</td><td>Coomarie Sandstone</td><td rowspan="3">Supplejack Downs Sandstone</td></tr>
<tr><td colspan="5">Talbot Well Formation</td><td>Talbot Well Formation</td></tr>
<tr><td colspan="5">Gardiner Sandstone</td><td>Gardiner Sandstone</td></tr>
<tr><td colspan="6">Supplejack Downs Sandstone</td><td rowspan="3">Pargee Sandstone</td><td colspan="2">Nanny Goat Volcanics</td></tr>
<tr><td colspan="6">Mount Winnecke Formation</td><td colspan="2">Mount Winnecke Group</td></tr>
<tr><td colspan="6">Pargee Sandstone</td><td colspan="2">Mount Charles Formation</td></tr>
<tr><td rowspan="2">Tanami Complex</td><td rowspan="2">Mount Charles beds</td><td rowspan="2">Killi Killi beds</td><td rowspan="2">Nanny Goat Creek beds</td><td rowspan="2">Nongra beds</td><td rowspan="2">Helena Creek beds</td><td>Tanami Group</td><td>Killi Killi Formation
Dead Bullock Formation</td><td>Twigg Formation</td></tr>
<tr><td colspan="3">MacFarlane Peak Group</td></tr>
<tr><td colspan="6">Archaean</td><td colspan="3">Browns Range Metamorphics
“Billabong complex”</td></tr>
</table>

Tunks (1996) divided the Tanami Complex into two domains: the “ Ditjiedoonkuna suite” (Domain 1) and the younger “Black Peak formation” (Domain 2), based on metamorphic and structural differences. Tunks’ Domain 1 corresponds in part with the redefined Tanami Group. New structural evidence confirms the view of Tunks and Marsh (1998) that the Tanami Mine sequence (Mount Charles Formation) is younger than the rocks at the Granites and Dead Bullock (ie younger than the redefined Tanami Group). Current NTGS mapping and interpretation of detailed company geophysical data indicates that the distribution of Tunks’ “Black Peak formation” (Domain 2) has been exaggerated with much of this domain incorporating mapped Killi Killi Formation, Dead Bullock Formation and MacFarlane Peak Group. The “Black Peak formation” (Tunks 1996) is limited to the Tanami Mine corridor only, where it has been redefined as Mount Charles Formation.

Cooper and Ding (1997) briefly described Tanami Group in MOUNT SOLITAIRE as a conformable sequence with quartzite at the base, overlain by pelitic to semi pelitic schist with a metamorphosed turbidite sequence at the top. The top two units are equal to Dead Bullock Formation and Killi Killi Formation respectively. The basal quartzite has not been observed in TANAMI or THE GRANITES.

STRATIGRAPHY

The stratigraphic succession outlined in **Figure 2** shows similarities with other Palaeoproterozoic successions in northern Australia (Pine Creek and Halls Creek orogens) and in Canada (Wopmay Orogen – see Hoffman and Bowring 1984). In the Tanami Region MacFarlane Peak Group is interpreted to be the basal unit of the Palaeoproterozoic sequence. It is inferred to represent an early basin rift stage formed on extended Archaean basement and is dominated by volcanic and volcaniclastic rocks along with clastic and calc-silicate sedimentary rocks. This basal rift sequence is overlain by a succession dominated by siltstone with carbonaceous shale, calc-silicates and banded iron formation (Dead Bullock Formation). This in turn is overlain by a thick sequence of turbidites (Killi Killi Formation). Interbedded siltstone, greywacke and chert west of Tanami are included in the newly defined Twigg Formation. The later three units are grouped together in the Tanami Group and together represent a transgressive passive margin sequence. A number of outcrops show affinities with both MacFarlane Peak and Tanami groups, and in the absence of more detailed information these have been left undifferentiated.

Pargee Sandstone and the redefined Mount Charles Formation were deposited in small extensional basins on top of deformed MacFarlane Peak and Tanami groups. A period of wider extension followed and was accompanied by felsic volcanism (Mount Winnecke Group and Nanny Goat Volcanics).

Siliciclastic sediments of the Birrindudu Group were deposited onto a subdued landscape following deformation of Mount Winnecke Group and Nanny Goat Volcanics and underlying rocks.

Five main granite suites have been recognised in the Tanami Region. These and other intrusive and volcanic igneous rocks will be described in detail in a later report (Dean *et al* 2000). They fall into three main age groups. The oldest granites (Inningarra Suite) comprise foliated moderately magnetic I-type biotite granodiorite dated at 1840 ± 11 Ma (Cooper and Ding 1997 – conventional U-Pb). No radiometric ages are yet available for the Coomarie and Frederick suites but an age of 1830-1810 Ma is inferred from intrusive relationships. The Coomarie Suite dominates magnetic images, forming large diameter I-type plutons with non- to weak magnetic responses (Coomarie, Frankenia and Browns Range domes).

Smaller diameter ovoid, I-type plutons with high magnetic responses characterise the Frederick Suite close to the WA border. Large irregular I-type plutons in northeast TANAMI belong to the Winnecke Suite and are temporally and spatially associated with Mount Winnecke Group volcanics. The granites have variable magnetic responses and mainly outcrop in BIRRINDUDU. Zircon dating indicates an age of 1825-1815 Ma[1] for Mount Winnecke Suite.

The youngest granites in the area belong to the Granites Suite. These have variable magnetic signatures and consist of porphyritic biotite-hornblende granite dated at 1800-1795 Ma[2] and have a widespread distribution in the Tanami Region. An isolated composite intrusive complex of more mafic character has been identified from drill core northeast of The Granites (Borefield Road Igneous Complex). A similar intrusive body is inferred from magnetic data to the east.

Neoproterozoic and younger sequences include the Redcliff Pound Group, Antrim Plateau Volcanics, Lucas Formation, Pedestal beds and Larranganni Beds. These are not included in the current regional studies. In THE GRANITES the Redcliff Pound Group is represented by quartz arenite of the Muriel Range Sandstone, loosely correlated with the Heavitree Quartzite of the basal Amadeus Basin (Blake *et al* 1979). Neoproterozoic-Cambrian Antrim Plateau Volcanics consist of extensive tholeiitic basalt lava flows with minor sedimentary rocks. Flat lying siliciclastic rocks of the Devonian Lucas Formation and Pedestal Beds

---

[1] Sample IDs 87495026 and 87495029 SHRIMP (U-Pb in zircon) in Ozchron database, AGSO, age calculated by R. Page.
[2] Sample IDs 88495007 and 87495004 SHRIMP (U-Pb in zircon) in Ozchron database, AGSO, age calculated byR.Page.

and Cretaceous Larranganni Beds overlie Antrim Plateau Volcanics and older rocks. For more detailed descriptions of younger sedimentary sequences readers are referred to Blake *et al* (1979).
Most of the region is covered by Cainozoic deposits of laterite and calcrete and more recent fluvial and aeolian unconsolidated sand and gravel.

ARCHAEAN

In TANAMI and THE GRANITES Archaean rocks are known from drill core and small isolated outcrops in two areas: Browns Range Dome in TANAMI and the informally named "Billabong complex" in THE GRANITES. The distribution shown on the geology maps is largely inferred from geophysical interpretation.

Browns Range Metamorphics (Ab)

This new name is applied to Archaean high grade metamorphics that are confined to a narrow fault bound slice with high magnetic responses on the southern margin of Browns Range Dome. Interpretation of magnetic data indicate this package of rocks is 1-3 km thick and is cut by a number of east-west trending faults, part of the Browns Range Shear Zone.

Previous interpretations (eg Ahmad *et al* 1999) show the whole Browns Range Dome to be Archaean, this is clearly not the case. The regional magnetic and gravity data indicate most of the dome is a non-magnetic, low density body (Bouguer gravity response of -475 mms^{-2}) inferred to represent a large granite pluton. This has been included in the Coomarie Suite which shows a similar geophysical response. The magnetic data also outlines an irregular body with a moderately magnetic response and low Bouguer gravity response (-475 mms^{-2}) in the southern part of the dome. This corresponds to outcrop of porphyritic granite which has yielded 1800 Ma zircons (Smith 2000; SHRIMP) and is included in the Granites Suite.

Archaean ages (2505 ± 4 Ma[3]) come from biotite rich enclaves in granitic gneiss with a supracrustal age of 2510 ± 22 Ma[4]. The age of metamorphism of the gneiss is given as 1882 ± 14 Ma[5]. Archaean rocks are faulted to the south against a volcano-sedimentary package which consists of lithic fine grained sediments and meta-basalt interpreted to be part of MacFarlane Peak Group.

Browns Range Metamorphics include granitic gneiss and muscovite schist intruded by fine grained granite, thin granitic sills, aplite and pegmatite (**Figure 3a**). The gneiss precursor is inferred to have been igneous and the muscovite schist precursor to have been a sedimentary package. In places the muscovite schist contains a fabric interpreted to represent relic low angle crossbedding (**Figure 3b**).

Rocks north of the major east-west trending Browns Range Shear Zone have been intruded by pegmatite which shows evidence for minor buckling due to late stage fault reactivation. This structure divides the Browns Range Metamorphics to the north from MacFarlane Peak Group to the south.

Rocks previously assigned to Nongra beds in BREADEN by Blake *et al* (1979) contain a mix of lithologies assigned to Browns Range Metamorphics and MacFarlane Peak Group. Deeply weathered and silicified sedimentary rocks at AMG 559867-7884422 are included in Browns Range Metamorphics. Outcrop is dominated by foliated fine to medium grained biotite granodiorite (**Figure 4**), possibly part of the Inningarra Suite. This has intruded chloritised laminated siltstone and fine sandstone which occur as rafts in the granite outcrop or as in situ ferruginous saprolite.

---

[3] Sample ID 88495021 SHRIMP (U-Pb in zircon) in Ozchron database, AGSO, age calculated by R.Page.
[4] Sample ID 88495008 SHRIMP (U-Pb in zircon) in Ozchron database, AGSO, age calculated by R.Page.
[5] Sample ID 88495008 SHRIMP (U-Pb in zircon) in Ozchron database, AGSO, age calculated by R.Page.

Billabong complex (A)

"Billabong complex" is an informal name (Page 1995) for an Archaean terrane east of The Granites mine which displays a distinctive high magnetic response and is associated with high Bouguer gravity responses (up to -135 mms^{-2}). In THE GRANITES the complex is known from drill core only but outcrop has been noted in MOUNT SOLITAIRE (Cooper and Ding 1997). The rocks comprise mainly banded granitic gneiss, with an igneous age 2514 ± 3 Ma (Page 1995; SHRIMP). Two main populations of inherited zircon were evident, one at 2550 Ma and the other at 2530 ± 4 Ma (Page 1995; SHRIMP). In MOUNT SOLITAIRE the "Billabong complex" is overlain by Tanami Group (Cooper and Ding 1997).

The magnetic character is unlike the younger less deformed granites in the region. Gneisses have variable (moderate to intense) magnetic responses and are associated with high (up to –135 mms^{-2}) Bouguer gravity responses. The bodies tend to be elongate and fault bounded.

PALAEOPROTEROZOIC

MACFARLANE PEAK GROUP (Pm)

MacFarlane Peak Group is a new name for a thick sequence of mafic volcanic, volcaniclastic and clastic sedimentary rocks that outcrop poorly in TANAMI and THE GRANITES. These rocks were previously assigned to Mount Charles beds by Blake *et al* (1979).

Distribution and outcrop

The distinctive magnetic and gravity responses of this unit have been used to map its distribution in TANAMI and THE GRANITES. It occurs around the southern, eastern and western margin of the Frankenia Dome, along the southern margin of the Coomarie Dome (where it is informally referred to as "Flores complex") and at MacFarlanes Peak Range. It is interpreted to underlie Birrindudu Group south of the Browns Range Dome, extend into Western Australia in BILLILUNA and to be present beneath younger rocks in BIRRINDUDU and LIMBUNYA. Outcrops previously assigned to Nongra beds in northern TANAMI are tentatively included in the group. The most representative exposed section (proposed as the type locality) is located north of MacFarlanes Peak Range between AMG 538150-7751680 and 537100-7751325.

Relationships

Contacts with overlying units are not exposed. From the limited outcrop information and regional magnetic data it is inferred that the group has a complicated structural history and is probably in faulted contact with the overlying Tanami Group. An unconformable contact between moderately magnetic MacFarlane Peak Group and redefined Mount Charles Formation is inferred from detailed magnetic data between the Tanami Mine Corridor and the buried edge of the Frankenia granite. MacFarlane Peak Group is intruded by various granites dated at between 1840 and 1800 Ma. It is unconformably overlain by Pargee Sandstone, Birrindudu Group, Muriel Range Sandstone, Lucas Formation and Pedestal Beds.

Lithology and thickness

In TANAMI and THE GRANITES MacFarlane Peak Group outcrops in four areas: north of MacFarlanes Peak Range in MCFARLANE, between Rabbit Flat and Farrands Hills in PTILOTUS; at Cave Hill in FRANKENIA and in BREADEN in northern TANAMI. In areas of no outcrop rock type has been determined from drill hole data where available and descriptions are based on geophysical character.

MacFarlanes Peak Range: Outcrop here includes the type section. The section includes a number of faults and minor shear zones and is complicated by a numerous small scale folds. Despite this the rocks are structurally concordant and bedding shows a consistent west dip. A 200 m wide section of black graphitic phyllite and minor thin bedded calc-silicates rocks are structurally overlain to the west by 600 m of medium to thick bedded cordierite-garnet-magnetite schist interpreted to represent metamorphosed turbidites. The meta-turbidite package is overlain by 200 m of porphyroblastic amphibolite which passes into 550 m of intercalated meta-basalt and biotite schist inferred to be derived from volcanogenic sediments (**Figure 5**).

The magnetic data indicates MacFarlane Peak Group in this area is a complex body, 21 km long and 10 km wide, elongate in a north-south direction. The rocks are intensely magnetic and have an associated high Bouguer gravity anomaly of -175 mms^{-2}. The various rock types cannot be distinguished from the regional magnetic data. Magnetic susceptibilities of outcrops and RAB chips range from low to very high (**Figure 6**). The rocks are intruded by two non-magnetic granite plutons (2-3 km in diameter) with circular geophysical expressions that have been tentatively assigned to the Granites Suite.

Rabbit Flat and Farrands Hills: Aphyric and porphyritic meta-basalt and basaltic andesite form scattered subcrop around AMG 612030-7771380, northeast of Rabbit Flat. The well developed jigsaw fit texture of some volcanic rocks maybe the result of autobrecciation or due to subsequent alteration. Also present is scattered float of medium grained quartz-magnetite rock. To the northeast outcrop improves and includes intercalated meta-basalt, meta-dolerite, siltstone, magnetite quartzite and turbiditic greywacke. Metamorphic grade is middle to upper greenschist facies.

Magnetic data shows that outcrops of MacFarlane Peak Group in this area are part of a larger structurally complex body along the eastern margin of the Frankenia Dome. The magnetic data indicates the body is approximately 30 km long and 8 km wide. The rocks are intensely magnetic and have an associated high Bouguer gravity anomaly of –50 mms^{-2}.

Outcropping basalt has moderate magnetic susceptibilities ranging from 4-127 x 10^{-5} SI (average 20 x 10^{-5} SI). Siltstone and chert have low magnetic susceptibilities (0-90 x 10^{-5} SI – average 20 x 10^{-5} SI), whereas contact metamorphosed sediments have high magnetic susceptibilities (75-1400 x 10^{-5} SI). The unusual quartz-magnetite rock has extremely high magnetic susceptibilities (10-2500 x 10^{-5} SI) as does an outcrop of siltstone at AMG 611986-7771493 with readings up to 60000 x 10^{-5} SI and an average of 15000 x 10^{-5} SI (**Figure 6**).

Interpretation of detailed company magnetic data show three intercalated lithological units that are fault bounded (**Figure 7**). The magnetic units are 300-500 m wide and are interpreted to represent units dominated by meta-basalt, meta-dolerite and magnetite-rich hornfels. The non- to weakly magnetic units are interpreted to represent siltstone and chert. A broad north plunging antiform is interpreted in the western part of the area overprinting earlier fold structures (**Figure 7**).

Cave Hill: At AMG 597259-7759750 rocks are strongly silicified and record at least two generations of folding. The dominant rock type is purple siltstone and chert intercalated with weathered meta-dolerite or basalt (eg at AMG 596000-7760700).

In this area the rocks are intensely magnetic and have an associated high Bouguer gravity anomaly of -50 mms^{-2}. The magnetic data show that outcrops are continuous with those northeast of Rabbit Flat. MacFarlane Peak Group has been intruded by a non-magnetic granite pluton circular in shape with a diameter of approximately 4 km. The intrusion is surrounded by an intercalated rock package up to 2.5 km thick. Detailed company magnetic data show intensely magnetic bands which are 100-500 m wide. Thin weakly magnetic units are 150-500 m wide. The magnetic units are interpreted to represent meta-dolerite or basalt; weakly magnetic units represent siltstone. Late dextral strike slip faults are prominent.

North TANAMI: Rocks in this area have been tentatively assigned to MacFarlane Peak Group based on similarities in the range of lithologies and the style of deformation. Metamorphosed interbedded sedimentary chert, fine lithic arenite and phyllite outcrop at AMG 556564-7882668 and include minor ferruginised rocks of unknown origin. Bedding parallel and poddy quartz veins and haematitic breccia are well developed. The sediments show evidence for polydeformation (**Figure 8**) at amphibolite facies overprinted by later deformation at greenschist facies. Other more weathered lithologies intercalated with the sedimentary sequence include basalt, dolerite and suspected felsic volcanics (**Figure 9**).

The area in north TANAMI has a low Bouguer gravity response (-275 mms^{-2}), unlike MacFarlane Peak Group in other parts of the Tanami Region that displays a high gravity response. The magnetic data shows signatures uncharacteristic of other MacFarlane Peak Group rocks in TANAMI and THE GRANITES. Based on the magnetic data the rocks have been divided into four groups[6]: Pmdf (dolerites and felsic volcanics), Pmd (dolerite and minor felsic volcanics), Pms (phyllite) and Pmb (basalts that do not outcrop).

Units dominated by dolerite are moderately magnetic and comprise linear magnetic trends. Magnetic susceptibility values of the dolomites ranges from 8-202 x 10^{-5} SI with an average of 66 x 10^{-5} SI. Units comprising a mix of dolerites and felsic volcanics have variable magnetic responses. Phyllitic units are easily distinguishable by their non-magnetic response. Magnetic susceptibility values of the sedimentary rocks range from 10-50 x 10^{5} SI with an average of 12 x 10^{-5} SI (**Figure 6**). Intensely magnetic responses are interpreted to represent basalts. These linear units are 150-1100 m wide and trend northnorthwest. In the east the rocks have been intruded by granite plutons with variable magnetic responses.

Browns Range: Lithologies noted in this area and mapped as MacFarlane Peak Group are foliated dolerite, fine grained lithic arenite and siltstone. These outcrop to the south of the major shear zone bounding the Browns Range Metamorphics to the north and have a distinctive intensely magnetic response and a high Bouguer gravity response.

The following areas of non-poorly outcropping MacFarlane Peak Group are also noted.

BUCK, 12 km northeast of Farrands Hills: Beneath a shallow cover of Cainozoic sediments, MacFarlane Peak Group have been intruded by a moderately magnetic granite pluton. The granite is elliptical in shape (10 km long and 7 km wide). Almost fully surrounding the granite is an intensely magnetic unit (up to 900 m wide) assigned to MacFarlane Peak Group . The western margin of the granite and MacFarlane Peak Group is truncated by a fault. East of this fault, except for the intensely magnetic unit, the group is weak-moderately magnetic. The group is associated with a high Bouguer gravity response, not as pronounced as in other areas. Possibly due to the presence of granite nearby or a thinner sedimentary package.

East of Tanami Mine: On the northwest margin of the Frankenia Dome is a 5 km wide package of rocks that have high to intensely magnetic responses. Rock types and structures are difficult to distinguish in the regional data. Bouguer gravity responses for the group are not as high here as elsewhere, possibly due to the negative effect of the granite intrusives of the Frankenia Dome

"Flores complex", west of Tanami mine: MacFarlane Peak Group in this area is intensely magnetic and has high Bouguer gravity responses (-100 to -50 mms^{-2}). The magnetic data show the complex to be an unusual shape that appears folded around the southern margin of the Coomarie Dome. An extensive non-magnetic zone separates the northern part of the complex from the southern part. The zone is 250-300 m wide and is interpreted to represent a major shear zone (Flores Shear Zone). The non-magnetic character is probably due to magnetite destruction along the fault.

The northern part of the complex comprises a series of alternating magnetic and non-magnetic bands that are 200-500 m wide. The units are folded and faulted and represent a structurally complicated package of rocks. Interpretation of magnetic data shows a number of interfering fold structures and several generations of faulting. A magnetic unit at AMG 551200-7801000 drilled by the BMR (Blake 1974) intersected amphibolite. Non-magnetic bands at AMG 548000-779200 and AMG 543200-7798300 were also drilled by the BMR and intersected phyllite (Blake 1974).

Outcrops are confined to the western part of the complex and correspond to non- to weakly magnetic units. Chert is the most magnetic susceptible rock in outcrop (108-264 x 10^{5} SI). Siltstone and sandstone have low magnetic susceptibilities (0-82 x 10^{-5} SI). Meta-basalt also has low readings (15 x 10^{-5} SI) and small intrusions of felsic porphyries have low magnetic susceptibilities (15-34 x 10^{5} SI; **Figure 6**).

---

[6] These units are shown on the TANAMI 1:250 000 basement interpretation and are not depicted on the 1:500 000 basement map that accompanies this report.

Breaden, Supplejack Station: A large moderate to high magnetic body interpreted to represent MacFarlane Peak Group underlies Killi Killi Formation and Gardiner Sandstone in northeast Breaden. It is narrowest 4 km southeast of Supplejack station and reaches a maximum width of 16 km as it extends in a northwest direction for 60 km into BIRRINDUDU. It has high Bouguer gravity responses (-125 to 0 mms^{-2}).

Mallee, south of Browns Range Dome: MacFarlane Peak Group extends west of the Coomarie Dome beneath the rocks of the Birrindudu Group. Here MacFarlane Peak Group is highly magnetic and is associated with high Bouguer gravity responses (-200 to -125 mms^{-2}).

Initial thickness of the unit is difficult to establish due to complex folding and faulting. From the magnetic data the estimated minimum thickness of the most structurally simple part of MacFarlane Peak Group is in the order of 2.5 km.

Age and regional correlations

MacFarlane Peak Group shows lithological similarities to parts of Ding Dong Downs Volcanics, dated at 1910 Ma (Blake *et al* 1998) and Biscay Formation, dated at 1880 Ma (Blake *et al* 1998) in the eastern zone of the Halls Creek Orogen (**Figure 2)**. From this correlation an age of 1910-1880 Ma is inferred for MacFarlane Peak Group. Current understanding of the relationships with Dead Bullock Formation does not preclude the possibility that these units are in part contiguous (ie laterally equivalent).

Depositional environment

The association of mafic volcanic with turbiditic sandstone, laminated siltstone and calc-silicate rocks, indicates deposition in a subaqueous environment. Metamorphism has largely destroyed original fabrics aside from bedding. Based on similar lithological associations in the Ding Dong Downs Volcanics and the Akaitcho Group in the Wopmay Orogen in Canada (Hoffman and Bowring 1984) a rift setting is inferred (**Figure 10**). Rifting may have occurred in a transtensional setting in a failed rift arm associated with ocean basin formation west of the eastern part of the Halls Creek Orogen. The absence of ophiolites suggests rifting did not extend to the formation of an ocean basin in the Tanami area. (Note: the integration of petrological and geochemical data may modify this interpretation of the tectonic environment.)

TANAMI GROUP (Pt)

In TANAMI and THE GRANITES the Tanami Group comprises three main lithological associations: a lower package dominated by siltstone, mudstone, chert and banded iron formation (Dead Bullock Formation); an upper package dominated by turbiditic sandstone (Killi Killi Formation) and a package of purple siltstone with minor sandstone and chert (Twigg Formation) which may be a lateral equivalent to either Killi Killi Formation or Dead Bullock Formation.

A fourth lithological association has been noted by Cooper and Ding (1997) stratigraphically below Dead Bullock Formation and is characterised by quartzic sandstone. This unit was not observed in TANAMI or THE GRANITES and will be described and named at a later stage.

The name Tanami Group was first used by Blake *et al* (1973) but was changed to "Tanami complex" because there was insufficient data available to determine the constituent units at the time. It has also been used by Cooper and Ding (1997) who described the group as a conformable sequence with a basal quartzite overlain by pelitic to semi pelitic schist and an upper sequence of metamorphosed turbidites. The two later units are equal to Dead Bullock Formation and Killi Killi Formation respectively. Undifferentiated Tanami Group rocks have been metamorphosed to upper amphibolite facies and undergone partial melting in the southeast corner of THE GRANITES.

Depositional environment

In TANAMI and THE GRANITES the Tanami Group is characterised by two main portions: a lower portion dominated by siltstone, mudstone, chert and banded iron formation (Dead Bullock Formation), and an upper portion dominated by turbiditic sandstone (Killi Killi Formation). The sediments were derived from a continental metamorphic, granitic and volcanic source area.

The Dead Bullock Formation was deposited in quiet marine conditions below storm wave base. The presence of black graphitic mudstones and banded iron formation suggests that the basin periodically became cut off from external sources and became euxinic. The well-developed laminated mudstone was probably produced by gentle bottom currents. The association of variable sandstone and mudstone dominated facies of the Killi Killi Formation indicates deposition in a deep marine proximal to mid fan setting. The influx of sediment into the basin represented by Killi Killi Formation indicates uplift in the source area and the onset of orogeny.

The siltstone dominated Twigg Formation is interpreted as a lateral equivalent of Killi Killi or Dead Bullock formations and may have been deposited in a more distal marine environment. The absence of mapped carbonaceous siltstone indicates deposition in more oxygenated waters.

Tanami Group is inferred to have been deposited in a passive margin environment following cessation of major extension and normal faulting associated with rifting (**Figure 10**).

Dead Bullock Formation (Ptd)

This is a new name to describe a package of fine grained sedimentary rocks with minor sandstone named after Dead Bullock Soak in THE GRANITES. The rocks were previously included in the Mount Charles Beds of Blake *et al* (1973) and incorporate the informally named “Blake beds” and “Davidson beds” described by Smith *et al* (1998). Dead Bullock Formation is host to significant gold mineralisation at The Granites and Dead Bullock Soak in the Northern Territory.

Distribution and outcrop

In TANAMI and THE GRANITES Dead Bullock Formation forms a number of small isolated silicified outcrops. The best exposures are at Dead Bullock Soak and these were described in detail by Smith *et al* (1998). The exposures in the currently operating mines at Dead Bullock Soak, at the informally named “Lightning Ridge” in TANAMI (between AMG 531900-7810300 and 530850-7804200) and those at Officer Hill in INNINGARRA (between AMG 566680-7710200 and 570281-7710222) are proposed as reference localities. Similar lithologies are reported in BILLILUNA in Western Australia (Waddell 1999).The formation is associated with a strong magnetic response and the boundaries shown on the geology maps have been interpreted from magnetic and drill hole data.

At The Granites the formation has undergone shearing, at the contact with the overlying Killi Killi Formation, and metamorphism to amphibolite faces to form andalusite, garnet and hornblende bearing schists.

Relationships

The base of the formation has not been observed. The top of the formation is dominated by thin bedded laminated siltstone, and iron rich chert which is transitional over a short interval into interbedded greywacke and siltstone of Killi Killi Formation. This contact marks a strong rheological change and is typically multiply folded and sheared, hosting gold mineralisation at The Granites. The formation is intruded by numerous dolerite dykes and sills which are well exposed in currently operating mines in the Dead Bullock Soak area. Dead Bullock Formation is intruded by numerous granite bodies. It is unconformably overlain by Pargee Sandstone, Birrindudu Group, Muriel Range Sandstone, Pedestal Beds and Antrim Plateau Volcanics.

Lithology and thickness

Dead Bullock Formation is dominated by fine grained sedimentary rocks. Fresh outcrops at Dead Bullock Soak are buff to grey, massive to thin bedded laminated siltstone with interbedded black carbonaceous siltstone, thin bedded chert, banded iron formation and minor thin bedded quartz rich sandstone (**Figure 11**). Bands of chert nodules up to 5 cm across are common through the sequence (eg "Callie boudin chert"; Smith *et al* 1998) and have been interpreted in places as early, boudinaged, bedding parallel quartz veins. The sedimentary rocks have magnetic susceptibilities ranging from 0-60 x 10^{-5} SI. Interpretation of magnetic data at Dead Bullock Soak show thin (400-600 m wide) folded magnetic units that probably represent chert or siltstone rich in magnetite. The area has a high gravity response of -225 mms^{-2}.

Interbedded purple siltstone and thin bedded contorted chert form a small area of outcrop and subcrop 200 m across at AMG 532200-7766445 in MCFARLANE. There is a change to sandstone subcrop exposed on an exploration track at AMG 532050-7766485 which could represent Killi Killi Formation. Better outcrop of dark and pale silicified, iron and manganese stained banded chert (**Figure 12**) occurs further north at AMG 531134-7769678. The beds are typically 3-10 cm across and include bands with chert nodules similar to those in the Dead Bullock Soak area.

At "Lightning Ridge" in PARGEE the formation is exposed on either side of a north plunging synform. The hinge zone of the fold is complicated by disharmonic folding and fold and fault accommodation structures and fold interference structures but the limbs appear structurally simpler on a regional scale. On the west limb there are 400 m of alternating jasperlitic, manganiferous and banded dark brown and white chert with occasional chert nodules (**Figure 13**). In the "Lightning Ridge" area the magnetic data show linear moderately magnetic units under cover that are truncated by a northeast trending fault that splays off the Bluebush Fault and joins the Coomarie Fault. The formation is also faulted to the east. The magnetic bands are 450-1500 m wide. Outcropping chert have magnetic susceptibilities ranging from 0-230 x 10^{-5} SI (**Figure 6**). A higher reading of 900-2850 x 10^{-5} SI was recorded at one outcrop at AMG 531862-7810308.

At Apertawonga Ridge, close to the contact with the Apertawonga granite in FRANKENIA, are outcrops of strongly silicified interbedded dark grey chert, purple siltstone and fine grained sandstone. These are faulted against andalusite hornfels in the contact aureole of the Apertawonga granite. An unusual silicified stretched pebble conglomerate at AMG 557393-7762103 forms a useful marker bed at Apertawonga but has not been noted elsewhere (**Figure 14**). Similar lithologies outcrop along strike to the northwest and at AMG 552640-7765680 and include a rare outcrop of graphitic siltstone. Magnetic susceptibilities of chert range from 0-2100 x 10^{-5} SI and 0-300 x 10^{-5} SI for siltstones. The formation is intensely magnetic and has an associated high Bouguer gravity response (-185 mms^{-2}). Interpretation of detailed magnetic data show a series of fault duplexes trending northwest. On the western margin of this interpreted thrust package is a thin arcuate magnetic unit (100-450 m wide) that trends dominantly north-south. This unit is intensely magnetic and fault bounded.

In INNINGARRA interbedded ferruginous chert, siltstone and minor fine grained quartz sandstone mapped as Dead Bullock Formation forms Officer Hill (**Figure 15a**). This is a resistant ridge between a large irregular shaped granite intrusive identified from sparse outcrop and drill core to the south (AMG 566680-7710200) and a coarse grained foliated amphibolite (**Figure 15b**) of indeterminable thickness to the north (AMG 570281-7710222).

Dead Bullock Formation in this area exhibits evidence for at least two phases of folding. Isolated outcrops to the south are interpreted as roof pendants or large (>20 m diameter) meta-sedimentary rafts suspended in the intrusive body (**Figure 15c**). To the north (at AMG 624225-7710281) fault bounded slivers of interbedded dark ferruginous and pelitic mudstones and siltstones also occur.

The exposure at "Lightning Ridge" indicates a minimum thickness of at least 400 m. Thickness estimates from Dead Bullock Soak suggest a minimum thickness in the order of 1000 m but this is complicated by folding and faulting.

Age and regional correlations

No radiometric age determinations are available for Dead Bullock Formation. The unit must be older than the overlying Killi Killi Formation and is intruded by 1840-1800 Ma granites. Lithologically it is similar to the Koolpin Formation of the South Alligator Group in the Pine Creek Orogen and also with parts of the Biscay Formation in the Halls Creek Orogen (**Figure 2**). On the basis of these correlations the age is inferred to range from 1880 to 1850 Ma.

Killi Killi Formation (Ptk, Ptkj)

Blake *et al* (1972) applied the name Killi Killi Beds to the thick sequence of monotonous turbidites which extend from Western Australia into the Tanami Region. The formation, as redefined here, incorporates the informally named Madigan beds described from the Dead Bullock Soak area by Smith *et al* (1998). Killi Killi Formation is the youngest formation in the Tanami Group and it includes the informally named jasper chert member (Ptkj).

Distribution and outcrop

This is the most widespread formation in the Tanami Group. It outcrops sparsely in eastern Western Australia in BILLILUNA and LUCAS and extends east into TANAMI, THE GRANITES and MOUNT SOLITAIRE in the Northern Territory. The rocks are typically deeply weathered and outcrop poorly as low sand covered rises and breakaways. In a number of areas of thin surficial cover (eg north of Apertawonga Ridge) vegetation closely mimics the trend of bedding.

Blake *et al* (1979) nominated outcrops south of Mount Stubbins (AMG 491000-7873500) in BILLILUNA as a reference area for Killi Killi Beds. Northwest of Apertawonga Ridge in FRANKENIA a 2 .5 km wide section with continuous northwest younging is displayed in excellent outcrops between AMG 554450-7769135 and 555523-7768248. Outcrops in MCFARLANE at AMG 518770-7780990 contain a high proportion of thick bedded gritty sandstone with a significant felsic volcanic component. These localities are proposed as reference areas.

Relationships

Relationships with the underlying Dead Bullock Formation are described above. The unit is faulted against Twigg Formation along the Bluebush Fault. The nature of the contact with the jasper chert member is not known, it is marked by a rapid change in float from micaceous greywacke to banded jasper chert at AMG 551657-7782835. Structurally the member sits within the core of a tight northnorthwest plunging syncline in Killi Killi Formation. From this relationship it is inferred to lie near the top or overlie Killi Killi Formation. The formation is intruded by all major granite suites and is unconformably overlain by Pargee Sandstone, Birrindudu Group and Muriel Range Sandstone.

Lithology and thickness

Killi Killi Formation includes a variety of lithologies ranging from micaceous greywacke, quartzwacke, and lithic greywacke to quartz arenite and lithic arenite, interbedded with siltstone and mudstone and occasional thin chert beds. Most of the sandstone is medium grained but " gritstones" (coarse sandstone to granulestone) are prominent in places. The poorly sorted sandstone component typically contains a small but obvious component of detrital mica. A well developed penetrative structural fabric which refracts strongly when passing from mudstone to sandstone (**Figure 16**) is present in most outcrops. The rocks are generally metamorphosed to lower greenschist facies except within the contact aureoles of granites. There is a general increase in metamorphic grade east of The Granites goldfield where the rocks are metamorphosed to amphibolite grade and have a strong schistose fabric.

Sedimentary structures are typical of turbidites and include amalgamated sandstone beds, graded bedding and crossbedding forming incomplete bouma sequences (**Figure 17**). The thicker sandstones are massive to graded, poorly sorted and medium to coarse grained with some beds containing scattered granule sized particles and larger rip-up clasts of mudstone close to the base. Thick bedded, poorly sorted massive and graded granulestones in McFARLANE are interpreted as channel deposits. The thinner sandstones are fine to medium grained and are either massive, crossbedded or graded. Siltstone and mudstone beds are generally medium bedded, massive, plane laminated or have fine unidirectional cross laminations. Pale chert is occasionally interbedded with sandstone and siltstone (**Figure 18**) forming discrete packages of several thin beds (<10 cm thick).

Sandstones are mostly greywacke but include quartzwacke and minor quartz arenite. They are dominated by angular to subrounded grains of igneous and vein quartz with varying amounts of plagioclase, K-feldspar, muscovite, tourmaline and lithic clasts. The presence of these minerals suggests derivation from a predominantly granitic source terrain. Mudstone and chert are the main lithic component. The matrix is a mix of fine quartz, sericite, clay and iron oxide. Several granulestone outcrops (eg AMG 519827-7780847) contain a high proportion of angular volcanic quartz grains and felsic volcanic lithics indicating derivation from a nearby felsic volcanic source.

Outcrops in WILSON CREEK were previously included in Nanny Goat Creek beds by Blake *et al* (1979). Current mapping demonstrates that these are lithologically and structurally similar to Killi Kill Formation elsewhere in the region (**Figure 19**). Good outcrop south of Wilsons Creek, east of the Crusade Prospect includes interbedded greywacke and siltstone. Siltstone packages are well developed at AMG 617315-7885056 and are thicker than those in McFARLANE and FRANKENIA. At AMG 615240-7883900 contact relationships between lithic, micaceous greywacke and intruding dolerite sills are well exposed (**Figure 20**).

As the top of the formation is not exposed the thickness cannot be calculated. The thickest sections, based on interpretation of aerial photographs, are up to 4 km thick. This does not take into account the possibility of structural thickening or loss of section due to faulting.

Killi Killi Formation is intruded in a number of places by basaltic-doleritic sills, similar to those intruding Dead Bullock Formation. Outcrop in the reference section northwest of Apertawonga contains numerous cross-cutting feldspar porphyry dykes.

Killi Killi Formation is non- to weakly magnetic and has a low Bouguer gravity response.

Age and regional correlations

Detrital zircons from two turbidite samples have been isotopically dated (AGSO OZCHRON database). The youngest detrital zircon populations for Killi Killi Formation are 1848 ± 22 Ma[7] and 1843 ± 68 Ma[8]. The age is further constrained by a 1840 ± 11 Ma zircon age for granite intruding Killi Killi Formation east of The Granites (Cooper and Ding 1997 – conventional U-Pb).

The unit is similar to the upper portion of the Olympio Formation in the eastern zone of the Halls Creek Orogen (Blake *et al* 1998). Killi Killi Formation also has a similar lithology to the Finniss River Group in the Pine Creek Orogen (**Figure 2**) dated at 1880-1850 Ma (Needham *et al* 1988).

Jasper chert member (Ptkj)

Jasper chert forms subcrop over several square kilometers around AMG 551650-7781900, which is proposed as the reference area. This new, informal unit consists of highly contorted thin bedded jasper chert (**Figure 21**). The siliceous and iron rich nature of the chert is probably a result of alteration and surface weathering of an original fine grained sediment. The unit outcrops in the core of a north plunging syncline and hence is assumed to lie either near or at the top of Killi Killi Formation. The member may

---

[7] Sample ID 88495006 SHRIMP (U-Pb in zircon) in Ozchron database, AGSO, age calculated by R.Page.
[8] Sample ID 88495005 SHRIMP (U-Pb in zircon) in Ozchron database, AGSO, age calculated by R.Page.

represent a separate formation overlying Killi Killi Formation at the top of the Tanami Group. It is non-magnetic and has a low Bouguer gravity response.

Twigg Formation (Ptt)

Twigg Formation (new name) is a sequence of purple siltstone with minor sandstone and chert of unknown thickness west of the Tanami mine corridor. The unit has been informally referred to as “Camp siltstone” and was previously assigned to the Mount Charles beds by Blake *et al* (1979).

Distribution and outcrop

Twigg Formation is confined to a triangular zone between the Frankenia and Coomarie domes and the Bluebush Fault where outcrops are typically strongly silicified and the rocks multiply deformed. A road cutting along the Tanami Joint Venture haul road at AMG 565100-7773000 is proposed as the reference area. The unit is also well exposed along a low rounded ridge north of the Otter Gold exploration camp between AMG 571920-7792400 and 571920-7791770.

Relationships

The formation is fault bound to the east against younger Mount Charles Formation along the Black Peak Fault (eg at Black Peak AMG 569800-7771060) and to the west with Killi Killi Formation, Dead Bullock Formation and MacFarlane Peak Group along the Bluebush Fault. Further work is required to establish stratigraphic relationships with other units.

Lithology and thickness

The unit comprises interbedded purple siltstone with thin bedded chert and minor medium bedded greywacke. Purple siltstone is dominant and is typically finely laminated in fresher outcrops. Chert beds are thin bedded or banded, white or red and occasionally contain nodules similar in form to those in Dead Bullock Formation (eg at AMG 571920-7792400; see also **Figure 22**). Sandstone beds of greywacke and quartzwacke composition are medium grained and thin to medium bedded. A strong cleavage is usually present and in places is overprinted by second generation fabrics. Interpretation of detailed magnetic data shows overprinting oblique fold interference patterns around AMG 565000-7780000. The formation is non- to weakly magnetic and has a low Bouguer gravity response.

Age and regional correlations

Structurally, the rocks of Twigg Formation have a similar deformation history to Killi Killi Formation and Dead Bullock Formation and hence it is included in the Tanami Group. It may be a lateral or distal equivalent of these formations.

Dolerite sills (Ptdd)

Dolerite sills intrude the Killi Killi and Dead Bullock formations. Individual sills of fine to coarse meta-dolerite and amphibolite are up to 200 m thick and are affected by the main deformation and metamorphic events that affect the Tanami Group. At Dead Bullock Soak they are informally named “End it all dolerite” and “Coora dolerite” (Smith *et al* 1998) and magnetic susceptibilities range from 2-52x 10^{-5} SI. At Bunkers Hill Pit at The Granites dolerite dykes cross-cut major fold structures but are deformed by later shearing and faulting. Magnetic susceptibility readings for dolerite outcrops in The Granites area range from 6-90 x 10^{-5} SI. The relationships observed at Bunker Hill Pit and elsewhere in the region (eg in WILSON CREEK and MCFARLANE) indicate there are multiple generations of dolerite sills and dykes in the Tanami Region.

No radiometric age determinations are currently available. Some sills predate the first deformation event to affect the Tanami Group which in turn predates intrusion of 1840 Ma granite. However the age relations of most dykes are difficult to establish. Many dolerite and basalt sills and dykes may be associated with younger mafic volcanic events such as those represented by the Mount Charles Formation, Nanny Goat

Volcanics and/or Antrim Plateau Volcanics. Older sills are correlated with the Woodward Dolerite in the Halls Creek Orogen and the Zamu Dolerite in the Pine Creek Orogen (**Figure 2**).

Undifferentiated lower Palaeoproterozoic (P-a, P-b)

P-a

The magnetic data shows an area of moderate to high magnetic responses corresponding to mapped Killi Killi Formation in northeast McFARLANE which is atypical for Killi Killi Formation elsewhere in the region. Outcrop is confined to the eastern edge and a small area over the central part of the anomaly and consists of interbedded greywacke and siltstone identical to Killi Killi Formation elsewhere. Structural trends derived from surface mapping do not correlate well with trends interpreted from detailed magnetic data, however this may merely be a reflection of poor outcrop. Magnetic susceptibilities of Killi Killi Formation above the anomaly are low (1-7 x 10^{-5} SI) and also do not reconcile with the high magnetic nature of the body, but this may be due to surface weathering. The body has a high Bouguer gravity response (-220 mms^{-2}). and shows complex folding and dextral offset of at least 6 km along the Tanami Fault.

In the absence of subsurface information from drill core or evidence of a magnetic source from surface mapping the source of the elevated magnetic response cannot be precisely determined. It could represent:

1. a magnetic sediment package within Killi Killi Formation;
2. a package of volcanics intercalated with Killi Killi Formation;
3. a deformed intrusive complex;
4. deformed dolerite sills;
5. an older Palaeoproterozoic volcano-sedimentary complex;
6. a fault bound block of Archaean metamorphics or
7. a combination of the above.

P-b

A complex highly magnetic signature in the western part of the Coomarie Dome is overlain by thin Cainozoic sand deposits. Drill hole data (NTGS TAN99DDH3, AMG 544939-7817879) shows a complex interfingering of meta-basalt with sediment and granite. The anomaly is interpreted to represent a contact metamorphosed sedimentary package near the margin of the several intrusive bodies that comprise the Coomarie Dome. The rocks may belong to either the MacFarlane Peak Group, Tanami Group or Mount Charles Formation and in the absence of further information have not been differentiated.

Pargee Sandstone (Plg)

Pargee Sandstone, first described by Blake *et al* (1972), consists of a thick sequence of interbedded conglomerate, quartz arenite and minor siltstone. It unconformably overlies the Tanami Group.

Distribution and outcrop

Pargee Sandstone forms a narrow north trending belt of separate outcrops, 8 km wide and 70 km long on the west side of the Coomarie Dome extending into BILLILUNA in Western Australia. Outcrops form smooth rounded hills up to 40 m above the surrounding sand plain. The rocks are generally steeply dipping with tight to open folds plunging northnorthwest cut by northnortheast trending shear zones. The type section nominated by Blake *et al* (1979) is along a gully approximately between AMG 520200-7827600 and 521100-7827800 in TANAMI. Excellent outcrops at AMG 524700-7779970 are nominated as a reference locality for the upper part of the formation.

Relationships

Pargee Sandstone unconformably overlies cleaved siltstone of KilliKilli Formation south of the Pingidijara Hills region in PARGEE, and is unconformably overlain by the Gardiner Sandstone, the basal unit of the Birrindudu Group. South of Mount Frederick the unconformable contact has been folded and is well exposed. The angular difference between the two formations is in the order of 30° (**Figure 23**). Where the unit is flat lying it can easily be mistaken for Gardiner Sandstone. The main difference being the more angular nature of clasts, the presence of jasper as a significant lithic component and poorer sorting in Pargee Sandstone. Pargee Sandstone often has a pinkish appearance while Gardiner Sandstone is mostly white or grey. A rhyolite sill intrudes the formation at AMG 523085-7782195. This has been folded and contains a well developed cleavage. To the north at AMG 523050-7782440 it becomes dyke like and broadly cuts through stratigraphy. The relationship of the rhyolite dyke/sill with a small felsic intrusive body at AMG 524665-7779010 is not known.

Lithology and thickness

The formation is dominated by interbedded thick bedded quartz arenite, lithic arenite and conglomerate. Pebbly sandstone and conglomerate are prominent at the base of the formation. Individual beds are up to 1 m thick and crossbedded. Most clasts are subangular to subrounded and comprise vein quartz, greywacke and siltstone derived from Killi Killi Formation and jasper from the jasper chert member. Granite clasts have not been noted.

Conglomerate horizons dominate outcrop west of Mount Frederick. Rocks here consist of 1090 m of interbedded, subrounded vein quartz and jasper pebble conglomerate and coarse sublithic arenite (**Figure 24**). Bedding thickness varies from thin to thick and crossbedding is common. A section traverse from the west to describe the lower part of the formation is illustrated in **Figure 25**.

Near the Tanami Highway to the south, Pargee Sandstone is a coarse grained, crossbedded, lithic clast bearing quartz arenite and sublithic arenite (**Figure 26**). The outcrops are pink or red, silicified and generally have moderate to steep dips.

Finer grained beds towards the top of the formation include siltstone and medium to fine greywacke. An excellent section between AMG 525070-7779780 and 524700-7779970 shows a progression from coarse grained quartz arenite to fine grained greywacke and cleaved siltstone (**Figure 27**).

Pargee Sandstone is non- to weakly magnetic. Thin, linear, weak magnetic responses may represent more silty lithologies or heavy mineral concentrations in the sequence. Magnetic susceptibility values are low, ranging from 0-60 x 10^{-5} SI and averaging 26 x 10^{-5} SI. The radiometric response is that of a mature sandstone of variable composition. The radiometric data shows the lower beds to be high in potassium, possibly reflecting higher clay and lithic content. Overlying these are more quartz rich lithologies that have low potassium and thorium concentrations. A ferruginous capping has developed on some outcrops and is reflected in the higher thorium response in the radiometric data.

In the Pargee Range area the unit attains a maximum thickness of 1300 m, although this may be complicated by repetition or loss of section due to faulting.

Age and regional correlations

Deposition of Pargee sandstone post dates folding and metamorphism of the Tanami Group and hence it must be younger than 1845-1840 Ma. Similar rock types are found in the Moola Bulla Formation in the Halls Creek Orogen to which Pargee Sandstone is tentatively correlated (**Figure 2**). Based on this correlation an age of 1835 Ma is inferred. A sample of the rhyolite sill (from AMG 523050-7782440) described above was collected for SHRIMP (zircon) dating and the result should help to further constrain the age of the formation.

Depositional environment

Siliciclastic sediments of Pargee Sandstone were deposited in a shallow marine environment initially under high energy conditions. Some of the lower parts of the formation may be fluvial. The sequence fines upwards overall, indicating a gradual decrease in sediment supply in the source area. The formation is inferred to represent a restricted molasse type basin which formed after major orogeny in the underlying Tanami Group (**Figure 28**).

Mount Charles Formation (Pc, Pcb)

The name Mount Charles Formation is here defined as a sequence of intercalated extrusive basalt and fine to coarse grained turbiditic sediment outcropping poorly along the western margin of the Frankenia Granite Dome where it is host to significant gold mineralisation. The unit was previously incorporated into Mount Charles beds (Blake *et al* 1972) and into the informally named "Black Peak formation" by Tunks (1996).

Distribution and outcrop

Like other units in the Tanami Region, Mount Charles Formation outcrops poorly, typically as low rounded hills with minor silicified outcrop and subcrop. The distribution of Mount Charles Formation depicted on the maps is based on lithological and structural data and interpretation of regional and detailed company magnetic data. In addition to the main belt between Black Peak and Tanami on the western margin of the Frankenia Dome a second belt of Mount Charles Formation is interpreted under cover east of Mount Charles. The formation is well exposed in open pits north and south of the Tanami Joint Venture treatment plant. The detailed section of Tunks (1996) across the Hurricane-Repulse and Bumper and Bouncer open pits is nominated as the type section.

Relationships

Neither the top or base of Mount Charles Formation is exposed. It is inferred from detailed magnetic data that the main belt between Tanami and Black Peak rests unconformably on undifferentiated MacFarlane Peak Group to the east. This contact appears faulted further south. Its contact with Twigg Formation to the west is marked by the Black Peak Fault exposed south of Black Peak. To the north the fault becomes difficult to distinguish in the magnetic data and its position is inferred. This fault marks a significant change in structural style between Twigg Formation and Mount Charles Formation, with the more complicated structures in Twigg Formation. The main belt hosts all known gold mineralisation and is truncated by a major eastsoutheast trending fault at AMG 581800-7799000. The belt east of Mount Charles is inferred to have a faulted contact with Twigg Formation to the southwest and is intruded by the Frankenia Granite Complex to the northeast. Mount Charles Formation is unconformably overlain by Birrindudu Group and Antrim Plateau Volcanics.

Lithology and thickness

Mount Charles Formation comprises intercalated extrusive basalt and fine to coarse grained turbiditic sediment. On the maps, where possible, basalt dominated (Pcb – basalt) and sediment dominated packages (Pc – undifferentiated Mount Charles Formation) have been distinguished. Based on magnetic data the Mount Charles Formation is between 1.75 and 2.1 km thick. The lithological descriptions below are based on Tunks (1996).

Undifferentiated Mount Charles Formation (Pc)

This unit is dominated by sedimentary packages with minor thin basalt flows. Tunks (1996) recognised four main lithofacies: sandstone, mudstone, carbonaceous mudstones and intraclast conglomerate. The sandstone lithofacies is characterised by thin to thick bedded lithic greywacke and pebbly greywacke. Sedimentary structures include sharp bases with load casts and flame structures, crossbedding, parallel lamination and grading typical of turbidites (**Figure 29**). Sandstone is composed of quartz, tabular feldspar laths, mafic volcanic lithics, metamorphic lithics, detrital muscovite and biotite. The matrix is dominated by fine clay. Laminated purple mudstone with thin beds of siltstone form most of the mudstone lithofacies. Carbonaceous mudstone lithofacies is locally developed and has been informally referred to as the "pale sediment". This facies forms up to five separate units that vary from 1 to 5 m in thickness interbedded with mudstone lithofacies immediately above major basalt-sediment contacts. The facies comprises finely interbedded light grey siltstone and black carbonaceous shale. Intraclast conglomerate facies form horizons of variable thickness (10 cm to 1 m) throughout the sequence. Conglomerates are predominantly matrix supported, massive or graded. Most clasts are up to 5 cm in diameter but occasionally clasts are up to 20 cm across. Clasts are composed of medium to fine grained massive to laminated siltstone and are typically rounded and imbricated.

Basalt (Pcb)

Tunks (1996) recognised three distinct basaltic lithofacies in the main belt between Black Peak and Tanami: massive basalt, brecciated basalt and pillow basalt. Massive basalts dominate the sequence and form 20 m thick massive units that have sharp contacts with adjacent sediments. Basaltic breccias are generally at the top of massive basalt units. The breccias are monomictic with angular clasts and are interpreted to be the product of autobrecciation. Pillow basalts form spectacular exposures in the Southern Pit (**Figure 30**) forming distinctive zones within the massive basalts. The composition of the basalts is similar for each lithofacies. It is fine to very fine grained with an equigranular or more rarely a weak porphyritic texture consisting of albitised plagioclase laths with interstitial clinopyroxene and fine grained magnetite. Larger plagioclase and chloritised olivine or pyroxene phenocrysts are occasionally present. The groundmass consists of fine grained chlorite and epidote probably the result of propylitic alteration. Away from faults basalts do not show signs of significant ductile deformation.

The belt east of Mount Charles does not outcrop well. Basalt chips from a drill pad at AMG 590979-7806245 are similar in appearance to those sampled from the Tanami mine area. Mount Charles formation in this area is intensely magnetic and has an associated high Bouguer gravity response (0 mms^{-2}). Thin linear units of alternating intensely magnetic and non- to weakly magnetic responses are 100-200 m wide. Magnetic bands are interpreted to represent basalt and non- to weakly magnetic bands interpreted to represent turbiditic sediment. The eastern magnetic bands are thicker and more magnetic and could be due to higher basalt to sediment ratios.

In the Tanami mine area Mount Charles Formation is high to intensely magnetic and has an associated high Bouguer gravity response. The package is an arcuate shape as it bounds the western margin of the Frankenia Dome. In the north the package trends northeast and has an average width of 3 km. In the south the package trends northwest and narrows to 500 m at the most southern point. The individual basalt horizons can be traced for up to 10 km but are truncated by numerous faults. The reconstructed length of the longest horizon in the Tanami Mine area is about 40 km.

Age and regional correlations

The maximum depositional age of 1916 ± 8 Ma[9] is given by detrital zircons. Aplite dykes which post date Mount Charles Formation and both predate and post date mineralisation are dated at 1824 ± 12 Ma[10]. Based on significant differences in structural style and metamorphic grade between the Mount Charles Formation and the Tanami Group it is inferred that the Mount Charles Formation is younger and was probably deposited between 1840 and 1810 Ma.

Depositional environment

The association of pillow basalt and turbiditic sediments indicates subaqueous deposition. Tunks (1996) proposed local shallowing of water depth due to the influx of thick basalt flows to account for carbonaceous shale in the sequence. The rocks are inferred to have been deposited in a narrow continental

[9] Sample ID 94495025 SHRIMP (U-Pb in zircon) in Ozchron database, AGSO, age calculated by R.Page.
[10] Sample ID 94495027 SHRIMP (U-Pb in zircon) in Ozchron database, AGSO, age calculated by R.Page.

rift setting (**Figure 28**). Note that geochemical data has not been scrutinised in detail and this may have an impact on the interpretation of the tectonic environment.

MOUNT WINNECKE GROUP (Plw, Plwa)

Mount Winnecke Group, first described and mapped by Blake *et al* (1979) as the Mount Winnecke Formation, crops out extensively in southeast BIRRINDUDU. A few outcrops extend into northeast TANAMI. Blake et al (1979) mapped three constituent lithological units but did not name them. Interpretation of geophysical data, in particular the radiometrics in BIRRINDUDU indicates these units are extensive enough to warrant formation status, hence the Mount Winnecke Formation is raised to group status. In TANAMI there are two constituent units (felsic volcanics – Plwa and clastic sediments – Plw); these correspond to the same units described by Blake *et al* (1979). The better outcrops in BIRRINDUDU were not part of this study and therefore have not been formally named.

Distribution and outcrop

In TANAMI Mount Winnecke Group forms a number of small outcrops, typically deeply weathered and covered by a thin veneer of sand and laterite. The distribution of units is largely unchanged from the first edition 1:250 000 maps except for the following: outcrop eastnortheast of Supplejack Downs homestead is assigned to Nanny Goat Volcanics and outcrops of Mount Winnecke Formation north of the Tanami mine are interpreted to be dykes or small intrusions related to the Coomarie Granite Suite.

Relationships

The relationship between Mount Winnecke Group and Tanami Group is not exposed. An unconformity is inferred based on structural differences between the units. The group is intruded by granites of the Winnecke Suite and unconformably overlain by Cambrian rocks of the Wiso Basin. Sedimentary and felsic volcanic units in the group are intercalated (Blake *et al* 1979).

Lithology

In TANAMI there are two units: siliciclastic sediments (Plw), and felsic volcanics (Plwa).

Siliciclastic sediments (Plw)

Clastic sediments are characterised by coarse grained, poorly sorted quartz sandstone and gritstone. Beds are generally up to 1 m thick and show well developed planar crossbedding. Pebble horizons are common and the main lithic component is felsic volcanic material probably derived from Plwa or possibly Nanny Goat Volcanics. The sediments are non- to weakly magnetic. Magnetic susceptibility values range from 0-10 x 10^{-5} SI.

Felsic volcanics (Plwa)

Felsic volcanic rocks form a large area of outcrop around AMG 638420-7897880 where they consist of purple, weathered feldspar-quartz porphyry. Feldspar, quartz and mafic phenocrysts comprise 10-20 % of the rock. Euhedral feldspar phenocrysts up to 6 mm across are conspicuous and nearly all completely replaced by sericite. Minor quartz phenocrysts are anhedral, rounded crystals up to 1.5 mm across with embayments. Mafic phenocrysts up to 1.5 mm across are now entirely replaced by a mosaic of fine grained chlorite but relict prismatic outlines indicate clinopyroxene pseudomorphs. Fine grained randomly aligned plagioclase needles 0 .25 mm long make up the groundmass. These sit in a devitrified mosaic of iron stained, fine grained feldspar and quartz. Felsic volcanic rocks are weakly magnetic. Magnetic susceptibility values range from 52-61 x 10^{-5} SI.

Outcrops are massive except for pervasive jointing and the rock is inferred to represent a subvolcanic or hypabyssal intrusion. Relationships with Plw are not exposed. The unit is faulted to the west against Winnecke Suite granite, the fault marked by a 2-10 m thick quartz vein which forms a prominent ridge.

Age and regional correlations

A SHRIMP zircon date of 1824 ± 5 Ma [11] from unit Plwa is interpreted as the crystallisation age of the volcanics. The group is intruded by the Winnecke Suite dated at 1815 ± 5 Ma[12]. While there are no direct regional equivalents, the group formed during a period of widespread felsic volcanism and granite intrusion across the north Australian craton between 1830 and 1800 Ma (**Figure 2**).

Depositional environment

Blake *et al* (1975) suggest a subaqueous deposition environment based on the intimate association of acid lava and subaqueous sedimentary rocks and the absence of subaerial pyroclastics in BIRRINDUDU. The presence of volcanic lithics in unit Plw indicates that felsic volcanics were exposed in the region. It is not possible to ascertain whether these clasts were derived from subaerial volcanics or from an uplifted subaqueous volcanic source. The close spatial and temporal association with the high level Winnecke Suite suggests to us the possibility that the volcanics and sediments may have been deposited in a large caldera type structure (**Figure 31**).

Nanny Goat Volcanics (Pn1-5, Pnm, Pnn)

The name Nanny Goat Creek beds was used by Blake *et al* (1979) to describe a mixed volcano-sedimentary package east and northeast of Supplejack Downs in TANAMI. Mapping by NTGS demonstrates that the unit described by Blake *et al* (1979) is a composite one, comprising an older more deformed package of marine turbidites and a less deformed package of subaerial felsic volcanics. Hence Nanny Goat Creek beds are divided into two separate units. The older turbidite package is included in Killi Killi Formation and the younger volcanic component is redefined as Nanny Goat Volcanics. Five lithological associations have been recognised (Pn1-5). Units Pnn (weakly magnetic) and Pnm (magnetic) are interpreted from magnetic data and are probably intrusives.

Distribution and outcrop

Nanny Goat Volcanics form a number of separate weathered outcrops near the junction of Nanny Goat Creek and the Lajumanu Road and east of Supplejack Downs in WILSON CREEK. Additional outcrops may occur in BIRRINDUDU where they are mapped as Nongra beds. The formation probably underlies Gardiner Sandstone in the Ware Range, perhaps extending as far west as the Ware Range Fault. A number of drill holes in WILSON CREEK have intersected "dacite" interpreted to be high level porphyries associated with the formation.

Relationships

Contact relationships with the surrounding and probably underlying Killi Killi Formation are not exposed. An unconformity is inferred based on differences in the structural histories of the two formations (ie the Nanny Goat Volcanics are less deformed). An unconformable relationship between Nanny Goat Volcanics and Supplejack Downs Sandstone is preserved at AMG 613176-7870440 where purple feldspar-quartz porphyry (or ignimbrite) with a strong vertical foliation is overlain by quartz arenite that dips gently north. The sandstone contains small clasts of feldspar-quartz ignimbrite just above the base. The Nanny Goat Fault marks the contact between Supplejack Downs Sandstone to the south and Pn1 and Pn3 to the north around AMG 612540-7881250. Relationships within the formation are difficult to interpret due to limited outcrop.

---

[11] Sample ID 87495029 SHRIMP (U-Pb in zircon) in Ozchron database, AGSO, age calculated by R.Page.
[12] Sample ID 87495026 SHRIMP (U-Pb in zircon) in Ozchron database, AGSO, age calculated by R.Page.

Lithology

Nanny Goat Volcanics are characterised by extrusive volcanic rocks. Rock types include quartz-feldspar ignimbrite (Pn1), feldspar ignimbrite (Pn2), rhyolite lava (Pn3), basalt (Pn4) and minor siliciclastic sediments (Pn5) described separately below.

Units Pn1-3 and 5 cannot be differentiated from the magnetic data. Continuous moderately magnetic units 300-800 m wide correspond to outcropping basalt (Pn4). Units labeled Pnn and Pnm could also be part of the Winnecke Suite.

Feldspar-quartz ignimbrite (Pn1)

Feldspar-quartz ignimbrite outcrops well around in northeast WILSON CREEK between AMG 612100-7882360 and 612540-7882310. It also crops out 12 km to the south (**Figure 32**) where it is unconformably overlain by Supplejack Downs Sandstone and west of the Lajumanu Road at AMG 610860-7887330 where it abuts feldspar ignimbrite (Pn2). In the Crusade prospect area the rocks are intruded by basalt (Pn4) and faulted against Supplejack Downs Sandstone along the Nanny Goat Fault to the south.

The unit is fairly homogenous throughout its outcrop area. It is a fine grained pale green and purple quartz-feldspar ignimbrite with a moderate phenocryst content and quartz:feldspar ratio of 3-5:1. Quartz forms small embayed, bipyramidal phenocrysts and broken crystals up to 2 mm across. Feldspar crystals, replaced by fine grained sericite, are mostly anhedral and are of similar size. The rock contains few lithics. Those present are generally less than 1 cm across and consist of volcanic material now completely replaced by fine grained sericite, quartz and feldspar. The groundmass is composed of fine grained quartz, feldspar and amorphous material and has a well developed eutaxitic foliation that wraps around phenocrysts, indicative of welding and compaction.

Feldspar-ignimbrite (Pn2)

This unit has only been noted west of the Lajumanu Road between AMG 612420-7887125 and 610785-7887400. The contact with Pn1 is obscured by thin cover at AMG 610850-7887330. Purple feldspar rich ignimbrite has a moderate phenocryst component dominated by sericitised feldspar phenocrysts up to 2 mm across. Quartz forms occasional small phenocrysts typically < 1 mm across. The low quartz-feldspar ratio (1:10 or more) serves to distinguish it from Pn1.

Rhyolite lava (Pn3)

Small hills of weathered felsic volcanic rock east of the Lajumanu Road between AMG 612910-7887330 and 613400-7887215 consist of fine grained rhyolite lava which occasionally shows flow banding (**Figure 33a**). A zone of angular fist sized blocks of rhyolite in a volcanic matrix (**Figure 33b**) near flow banded rhyolite at AMG 613300-7887450 probably represents the products of autobrecciation. Volcaniclastic sediment forms a narrow band of subcrop at AMG 613150-7887360. The rocks are a mix of sericite altered felsic volcanic lithics up to 2 mm across and small quartz phenocrysts to 0.5 mm in a fine grained weathered matrix.

Basalt (Pn4)

Basalt outcrops along a low north south trending ridge either side of Nanny Goat Creek. On the east side it is probably faulted against Killi Killi Formation. Its western contact is with Pn3 north of Nanny Goat Creek and Pn1 to the south. It is faulted against Supplejack Downs Sandstone along the Nanny Goat Fault.

Massive purple basalt is the dominant rock type. A well developed foliation and fracture cleavage is developed near the contact with Killi Killi Formation and Supplejack Downs Sandstone. Drill chips from holes around Crusade indicate the rock is a typical basalt with fine plagioclase microlites, magnetite and occasional small relic phenocrysts which may have been clinopyroxene but are now replaced by fine chlorite.

The contact with Pn3 is not exposed and the relationship with Pn1 (feldspar-quartz ignimbrite) is difficult to interpret. The contact is exposed at Crusade Hill (AMG 612975-7883170) and also to the south at AMG 612630-7882190. The former outcrop shows a complex relationship with a brecciated basalt dyke with a jig saw fit texture intermingled with felsic volcanic material (**Figure 34a**). In the latter outcrop narrow dykes of basalt intrude feldspar-quartz ignimbrite (**Figure 34b**). The basalt is interpreted to be a late dyke or sill that broadly cuts across felsic volcanic lithologies. The contact between Pn1 and the basalt is the host to gold mineralisation at Crusade.

Siliciclastic sediments (Pn5)

A number of isolated outcrops of siliciclastic sediments are included in the unit. These are similar to quartz arenites in the overlying Birrindudu Group and also to those in Mount Winnecke Group (Plw). On lithological grounds they are difficult to distinguish from either of these units but their more complicated structural history indicates the possibility that they are part of the Nanny Goat Volcanics or Mount Winnecke Group.

Volcanogenic sandstone outcrops at AMG 609738-7865550 and is interbedded with lithic quartz arenite. Bedding is overturned, younging to the east. Volcanic lithics are strongly sericitised and may be derived from either Mount Winnecke Group or Nanny Goat Volcanics. The matrix includes a large proportion of volcanic quartz. A faulted contact is inferred to the east with Killi Killi Formation and to the west with Supplejack Downs Sandstone.

Isolated outcrops of quartz arenite north of the Nanny Goat Fault and east of the Crusade prospect are included in Nanny Goat Volcanics. They are inferred to be faulted against Killi Killi Formation to the east and against basalt (Pn4) to the west. Individual outcrops show steeply plunging folds with steep to overturned bedding.

Age and regional correlations

A SHRIMP zircon date of 1816 ± 7 Ma (SHRIMP, Smith 2000a) from feldspar-quartz ignimbrite (Pn1) at the Crusade Prospect is interpreted as the volcanic crystallisation age of the unit. Rhyolite lava (Pn3) at AMG 613514 -7886736 was dated at 1800 ± 13 Ma[13].

Depositional environment

The lithological association of densely welded ignimbrite, flow banded, autoclastic rhyolite with only a small proportion of clastic sediments suggests that the Nanny Goat Volcanics were deposited in predominantly subaerial conditions. They may represent the subaerial equivalents of felsic volcanics in the Mount Winnecke Group (**Figure 31**). Analysis of whole rock geochemical data should show if the two groups are related (Dean *et al* 2000).

BIRRINDUDU GROUP (Pd)

Birrindudu Group was mapped and described in detail by Blake *et al* (1979) who recognised three constituent units comprising, from the base, Gardiner Sandstone, Talbot Wells Formation and Coomarie Sandstone. Based on lithological and structural similarities Supplejack Downs Sandstone is now included in the group.

Distribution and outcrop

Birrindudu Group crops out extensively in TANAMI and BIRRINDUDU in the Northern Territory and in GORDON DOWNS, BILLILUNA and LUCAS in Western Australia. Large outliers of the group occur in

[13] Sample ID 87495001 SHRIMP (U-Pb in zircon) in Ozchron database, AGSO, age calculated by R.Page.

THE GRANITES at Farrands Hills, Davidson Tablelands and the Nora Range. Both the Gardiner and Coomarie sandstones form most of the prominent ridges in the area. Outcrop of Talbot Wells Formation is subdued forming low mounds partly covered subcropping rubble.

Relationships

Birrindudu Group rests unconformably on Browns Range Metamorphics, MacFarlane Peak Group, Tanami Group, Pargee Sandstone, Nanny Goat Volcanics and Mount Winnecke Group. It unconformably overlies intrusives of the Coomarie Dome which shows signs of ongoing uplift after deposition of the Birrindudu Group. The group is overlain by Antrim Plateau Volcanics and Redcliff Pound Group and by younger Mesozoic rocks. Supplejack Downs Sandstone unconformably overlies foliated Nanny Goat Volcanics east of Supplejack Downs homestead at AMG 613175-7870440. This contact was previously described (Blake *et al* 1979) as being a possible conformable contact between Mount Winnecke Formation and Supplejack Downs Sandstone but current mapping indicates this is not the case. The underlying volcanics are clearly foliated and are lithological identical to Nanny Goat Volcanics (Pn1). Volcanic clasts derived from Nanny Goat Volcanics are common in Supplejack Downs Sandstone.

Lithology

The descriptions below are based on Blake *et al* (1979) with some additional information from current mapping. Readers are referred to Blake *et al* (1979) for a more detailed account of the lithology. All formations in the group have non- to weakly magnetic responses and low Bouguer gravity responses. Bedding is clearly visible in the magnetic data, particularly in the area south of Browns Range Dome.

Thickness

Blake *et al* (1979) indicated a maximum thickness of 6000 m for the Birrindudu Group east of the Gardiner Range in BILLILUNA. Outcrops south of Browns Range show duplication of stratigraphy due to shallow dipping thrust faults which appear to be rooted in Talbot Wells Formation or involve a major basement detachment at the base of the Gardiner Sandstone which has propagated through the sequence. Duplication of stratigraphy through faulting is inferred to be a common feature of the unit. This will be better resolved when the group is mapped in more detail in the next few years. A section through the group on the northern margin of the Coomarie Dome (between AMG 556000-7835000 and 551000-7846000) appears to be structurally simple and reveals the total thickness of the group to be 1900 m comprising 1000 m of Gardiner Sandstone, 500 m of Talbot Wells Formation and 400 m of Coomarie Sandstone.

Age and regional correlations

The age of the Birrindudu Group is not well constrained. It probably postdates intrusion of the Granites Suite and hence is younger than 1800 Ma. The lower age limit is constrained by the overlying Redcliff Pound Group which is probably Neoproterozoic. Deposition of Birrindudu Group predates movement on the Tanami Fault and the group shows evidence of significant deformation particularly in the area south of Browns Range Dome. K- Ar and Rb-Sr dating of glauconite from the Gardiner Sandstone gave ages of 1560 ± 20 Ma and 1560 ± 120 Ma respectively (Blake *et al* 1979). These ages are considered to be unreliable and grossly underestimate the age of the group.

Birrindudu Group is correlated with the Bastion Group in Halls Creek in Western Australia and with the Tomkinson Creek Group and upper Wauchope Subgroup in the Tennant Inlier (**Figure 2**). The basalt horizon inferred near the top of Coomarie Sandstone may correlate with the Kudinga Basalt in the Wauchope Subgroup. The age is estimated to be between 1790 and 1700 Ma based on regional correlations with units elsewhere in the region.

Depositional environment

Sedimentary structures, the presence of stromatolites and dolomite indicate Birrindudu Group was deposited in shallow marine conditions. The extent of the group suggests deposition on an large, shallow marine shelf (**Figure 35**). The low proportion of dolomite in the sequence supports a high rate of sediment supply.

Gardiner Sandstone (Pdg)

Gardiner Sandstone (Blake *et al* 1979) is characterised by medium to thick bedded sublithic to lithic arenite and quartz arenite. Shale and siltstone are subordinate and conglomerate is common at the base. Sandstones are mostly medium grained. Crossbedding and ripple marks are common throughout and mudcracks and synaeresis cracks are locally developed (eg at AMG 570258-7794733).

At Nora Range (AMG 509475-7756590) a spectacular basal conglomerate overlies foliated Nora Range Granite. It is 2 m thick with rounded boulders and cobbles of Nora Range granite and greywacke, siltstone and vein quartz from Killi Killi Formation at the base overlain by poorly sorted, coarse grained lithic arenite (**Figure 36**) at the top of the outcrop.

An unusual section several kilometers south of the Killi Killi Hills in west Tanami includes thick bedded conglomerate interbedded with purple micaceous sandstone and siltstone (**Figure 37a,b**). The cliffs forming the Killi Killi Hills to the north are composed of quartz arenite typical of the rest of the formation. Micaceous sandstones were noted (Blake *et al* 1979) near the base of the formation in the type section at Larranganni Bluff.

Talbot Wells Formation (Pdt)

Talbot Wells Formation (Blake *et al* 1979) is a recessive unit characterised by chert. The formation also includes sublithic arenite, quartz arenite and laminated siltstone, shale and minor limestone. Chert is commonly stromatolitic indicating it is silicified limestone or dolomite.

Coomarie Sandstone (Pdc)

This is the youngest unit in the Birrindudu Group. The formation is characterised by sublithic arenite and minor quartz arenite, similar to Gardiner Sandstone (Blake *et al* 1979).

A thin basalt horizon is interpreted in the magnetic data within Coomarie Sandstone south of Browns Range Dome. The unit has an inferred thickness of about 200 m. The first edition TANAMI map shows the presence of laterite capped Antrim Plateau Volcanics overlying Coomarie Sandstone in this area, however the magnetic data clearly shows a highly magnetic horizon folded with the rest of the stratigraphy. This laterite capped basalt is inferred to be part of the Birrindudu Group.

Supplejack Downs Sandstone (Pdc)

Supplejack Downs Sandstone (Blake *et al* 1979) outcrops in northeast TANAMI. Previous interpretations (Blake *et al* 1979) place the unit below the Birrindudu Group, however current mapping clearly shows the unit is younger than Nanny Goat Volcanics. It is faulted against Nanny Goat Volcanics along the Nanny Goat Fault. Isolated outcrops of quartz arenite north of the Nanny Goat Fault and east of the Crusade prospect are included in Nanny Goat Volcanics.

The unit is lithologically identical to Gardiner Sandstone, comprising thick bedded medium to coarse grained quartz arenite and sublithic arenite. Crossbedding is locally well developed. It is uncertain at this stage how the unit correlates to the rest of the Birrindudu Group – further mapping may even rename these outcrops as Gardiner Sandstone or Coomarie Sandstone.

GOLD MINERALISATION

In the Tanami region significant gold prospects and operating gold mines are hosted by McFarlane Peak Group, Tanami Group, Mount Charles Formation, and Nanny Goat Volcanics as well as the Winnecke and

Granites Suites. Recent drilling results by NTGS indicate the Coomarie Suite is also anomalous in gold with several 6-7 ppb anomalies reported in samples sent for whole rock analysis and assay. Hence it would appear that stratigraphy is not the main controlling factor on the distribution of gold mineralisation in the Tanami Region. However it plays a significant role in producing economic deposits.

The most significant control on the localisation of gold in the Tanami area are structures, typically late brittle faults, formed during regional transpression (at ~1810-1800 Ma) after the intrusion of the Coomarie, Winnecke and Frederick Suite granites. Detailed mapping by NTGS at Bunkers Hill Pit, Dead Bullock Soak and in the Tanami Mine Corridor indicates that gold mineralisation is associated with late shear zones and brittle faults with the richest grades occurring where suitable lithological horizons are intersected (**Figure 38 a-c**).

In most cases lithology has played a somewhat passive role and mineralisation has been localised in particular lithologies (eg “Callie host unit”, Tanami Mine basalts) or contacts (eg basalt-sediment contact at Tanami, reactivated early faulted contacts at The Granites) that have a higher propensity to respond to deformation in a brittle fashion (**Figure 38a-c**). This results in localised sites of increased porosity which are subsequently mineralised probably due to a sudden drop in the pressure of mineralised fluids. There is, however, a close spatial association between mineralisation and carbonaceous shales in all three currently operated mines (The Granites, Dead Bullock Soak and the Tanami corridor). Iron rich lithologies (BIFs) are also an important control on mineralisation at Dead Bullock Soak and The Granites. Both the shales and BIFs provide a chemical control for gold deposition. In the case of the carbonaceous shales oxidising fluids reacted with reducing shales, altering the fluid chemistry and allowing gold to precipitate in favourable low pressure sites. These sites must lie structurally above the reducing horizons (**Figure 38 a-c**), however they may also be intimately associated with carbonaceous material.

At Dead Bullock Soak gold mineralisation is also localised in iron rich units near the top of Dead Bullock Formation (**Figure 38a**). These thin horizons are interbedded with shales which are inferred to have behaved as an impermeable cap causing mineralising fluids to pond and spread out laterally along iron rich zones creating large areas of diffuse moderate grade stratabound mineralisation (**Figure 38a**). Gold mineralisation at The Granites is hosted by a system of brittle faults that are localised in an early ductile shear zone at the contact between Dead Bullock Formation and Killi Killi Formation (**Figure 38c**). The shear zone (“host unit” of Mayer 1990) is dominated by metamorphosed iron rich, carbonaceous and calcareous lithologies in Dead Bullock Formation and the best grades are associated with iron rich lithologies. These units are inferred to have behaved in a more brittle manner than carbonaceous and calcareous lithologies, have increased porosity and hence are more likely to host mineralisation.

Gold exploration models

The regional magnetic dataset combined with detailed (line spacing of 200 m or less) magnetic data remains the best method for identifying potential target areas. Focus should be directed to identifying areas where late faults intersect favourable stratigraphic packages identified on the ground or inferred from geophysical interpretation. Coupled with sensible geochemical sampling programs aimed at targeting in-situ regolith material, this should result in rapid identification of anomalous zones which then merit higher intensity exploration. Second phases of exploration should target intersections with suitable horizons structurally above carbonaceous or other reducing lithologies or should focus on intersections with Fe rich units. One or two diamond holes early at this stage may provide a better understanding of the underlying geology. This should also allow for more rapid identification of suitable host horizons which can be traced along strike into cross-cutting structures.

Units with the highest potential for large deposits are those which contain a significant proportion of carbonaceous or other reactive material (egBIFs, mafic volcanics and calc-silicate). Therefore MacFarlane Peak Group and Dead Bullock Formation should be considered as having a high potential for hosting large gold deposits where these units or contacts intersect suitable structures (eg Bluebush, Callie, Davidson, Mount Charles, MacFarlane, Black Peak and Coomarie faults or preferably extensional splays off these structures like those at Dead Bullock Soak). The potential for localised development of carbonaceous units in Killi Killi and Twigg formations is high and hence both units are regarded as having significant gold potential. Coarse grained lithologies in the Killi Killi and Twigg formations may also form the host to mineralisation close to the contact with Dead Bullock Formation (**Figure 38a,c**) or in the hanging wall of major faults (**Figure 38b**).

Pargee Sandstone should be considered a favourable target where it overlies suitable units in McFarlane Peak and Tanami Group, with gold possibly having been deposited in coarse grained rocks (conglomerate and sandstone) at the unconformity, or in porous horizons higher in the sequence (**Figure 38a**). Likewise the competency contrast between dolerite sills and sedimentary packages has significant potential for creating open space which could have been the locus for mineralising fluids (**Figure 38c**). Contact metamorphic affects may also have lead to rheological changes in rocks surrounding granite intrusions. These changes are likely to have lead to an increase in brittle fracturing and hence provide suitable sites for gold mineralisation.

Target selection should also take into account a potential heat source to drive fluids and ground selected should be in the proximity of intrusives related to the Coomarie, Frederick, Winnecke and Granites suites. Intrusions may be in the form of narrow felsic/mafic dyke swarms and need not necessarily be large plutons.

Late structures that cut granite bodies are also considered to have high potential for gold mineralisation (eg Coomarie Fault, late faults/joints in plutons of the Frederick Suite). Fluid chemistry may be different to deposits hosted by sedimentary rocks but the presence of late brittle structures creating space is still inferred to be the main factor controlling gold mineralisation (**Figure 38c**).

Other minerals

The range of lithologies and depositional environments described above suggest the Tanami Region is prospective also for other metals. Little exploration for base metals has been conducted in the area. MacFarlane Peak Group may contain volcanic hosted massive sulphide or volcanic associated massive sulphide. The siltstone dominated Dead Bullock Formation may hold significant shale hosted (SEDEX) stratiform base metal and silver deposits. These types of deposits may be missed if the suite of elements in geochemical sample programs is too narrowly focussed. The Mount Winnecke Group and associated Winnecke Suite granites may be prospective for porphyry style Cu-Au deposits. The composite mafic intrusive subvolcanic complexes identified in drill core and by geophysics (eg Borefield Complex) may be potential sources of base metals and platinum group elements. Unconformity related uranium deposits at the base of the Birrindudu Group have only drawn minor attention to date.

ACKNOWLEDGEMENTS

The authors thank Chris Field, Max Heckenberg and Liam McNally for their assistance and company during fieldwork. We thank the staff of Normandy NFM, Otter Gold, Anglo Gold, Tanami Gold and Glengarry Resources for their generous, on going support of the Tanami Project.

M. Hendrickx wrote most of the text for this Record and K. Slater contributed the geophysical descriptions. Zircon ages for this project were obtained by J.B. Smith, AGSO. The report was edited by David Young and Barry Pietsch. All authors are employed by NTGS except for J.B. Smith who is employed by AGSO.

REFERENCES

Ahmad M, Wygralak AS and Ferenczi PA, 1999. Gold deposits of the Northern Territory. *Northern Territory Geological Survey, Report* 11.

Blake DH, 1974. Shallow stratigraphic drilling in The Granites-Tanami region, Northern Territory and Western Australia, 1971-1973. *Bureau of Mineral Resources, Australia, Record* 1974/104.

Blake DH, Hodgson IM and Smith PA, 1972. Geology of the Birrindudu and Tanami 1:250 000 sheet areas, Northern Territory. Report on the 1971 field season.*Bureau of Mineral Resources, Australia, Record* 1972/92.

Blake DH, Hodgson IM and Smith PA, 1972a. Geology of the Birrindudu and Tanami 1:250 000 sheet areas, Northern Territory. *Bureau of Mineral Resources, Australia, Report* 174.

Blake DH, Hodgson IM and Muhling PC, 1973. Geology of The Granites and Precambrian parts of Billiluna, Lucas and Stansmore 1:250 000 sheet areas, Northern Territory and Western Australia. *Bureau of Mineral Resources, Australia, Record* 1973/171.

Blake DH, Hodgson IM and Muhling PC, 1979. Geology of The Granites-Tanami region. *Bureau of Mineral Resources, Australia, Bulletin* 197.

Blake DH, Tyler IM, Griffin TJ, Sheppard S, Thorne AM and Warren RG, 1998. Geology of the Halls Creek 1:100 000 sheet area (4461), Western Australia. *Australian Geological Survey Organisation, Canberra.*

Cooper JA and Ding PQ, 1997. Zircon ages constrain the timing of deformation events in The Granites - Tanami region, northwest Australia. *Australian Journal of Earth Sciences* 44, 777-787.

Dean AA, Hendrickx MA, Slater KR, Crispe AJ, Vandenberg LC and Smith JB, 2000. Igneous rocks of the Tanami Region: petrology, geochemistry and relation to mineralisation – preliminary results. *Northern Territory Geological Survey Record* (in prep).

Hoffman PF and Bowring SA, 1984. Short lived 1.9 Ga continental margin and its destruction, Wopmay orogen, northwest Canada. *Geology* 12, 68-72.

Mayer TE, 1990. The Granites goldfield. In Hughes FE (editor) Geology of the mineral deposits of Australia and Papua New Guinea. *The Australasian Institute of Mining and Metallurgy, Melbourne. Monograph* 14, 719-724.

Needham RS, Stuart-Smith PG and Page RW, 1988. Tectonic evolution of the Pine Creek Inlier, Northern Territory. *Precambrian Research* 40/41, 543-564.

Page R, 1995. Geochronology of an exposed late Archaean basement terrane in The Granites - Tanami region. *Australian Geological Survey Organisation, Research Newsletter* 22, 19-20.

Slater KR, 1999. Northern Territory airborne geophysical survey specifications. *Northern Territory Geological Survey Record* GS1999-0003.

Smith JB, 2000. NTGS-AGSO Geochronology Project Report 2. *Australian Geological Survey Organisation Professional Opinion* 2000/15.

Smith JB, 2000a. NTGS-AGSO Geochronology Project Report 1. *Australian Geological Survey Organisation Professional Opinion* 2000/17.

Smith MEH, Lovett DR, Pring PI and Sando BG, 1998. Dead Bullock Soak gold deposits. In Berkman DA and Mackenzie DH (editors) Geology of Australian and Papua New Guinean mineral deposits. *The Australasian Institute of Mining and Metallurgy, Melbourne. Monograph* 22, 449-460.

Tunks AJ, 1996. Structure and origin of gold mineralization, Tanami Mine, Northern Territory. *PhD thesis, University of Tasmania, Hobart.*

Tunks A and Marsh S, 1998. Gold deposits of the Tanami Corridor. In Berkman DA and Mackenzie DH (editors) Geology of Australian and Papua New Guinean mineral deposits. *The Australasian Institute of Mining and Metallurgy, Melbourne. Monograph* 22, 443-448.

Vandenberg LC, Hendrickx MH, Dean AA, Crispe AJ, Slater KR and Smith JB, 2000. Structural geology of the Tanami Region and relation to mineralisation – preliminary results. *Northern Territory Geological Survey Record* (in prep).

Waddell DP, 1999. Quarterly report for the period ending 30 September, 1999. Tanami Gold N.L. Subiaco, Western Australia.

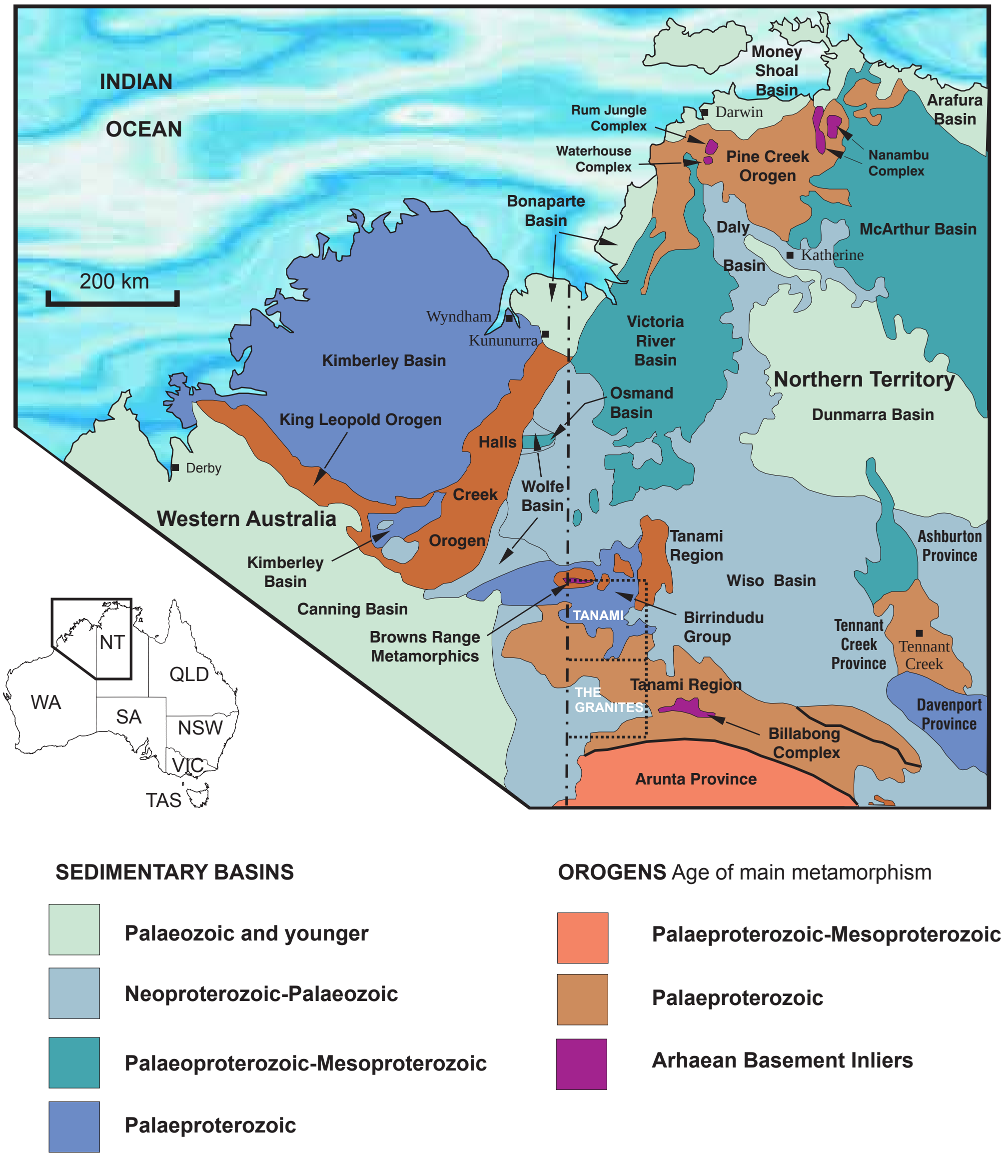


Figure 1 Regional geological setting of the Tanami Region

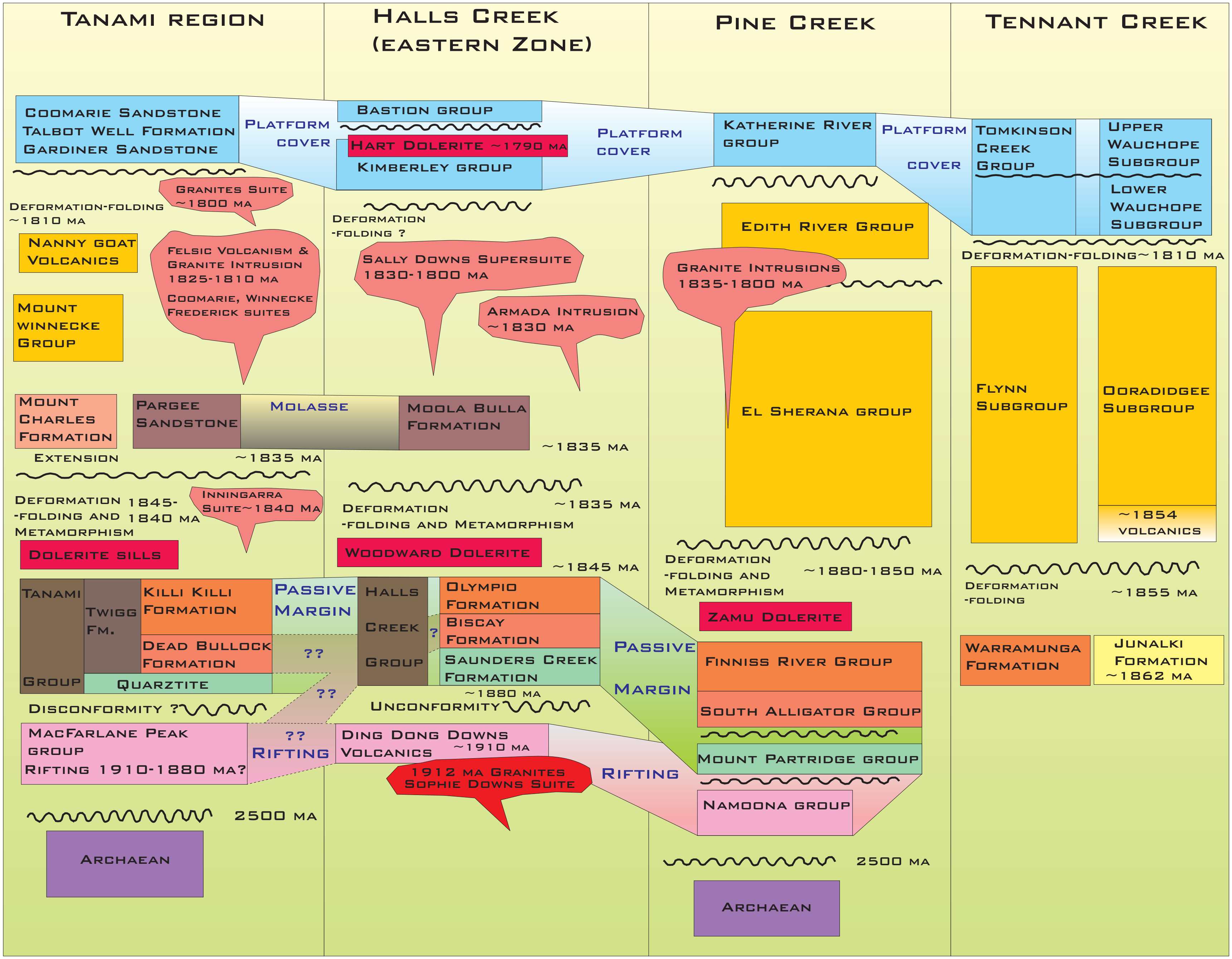
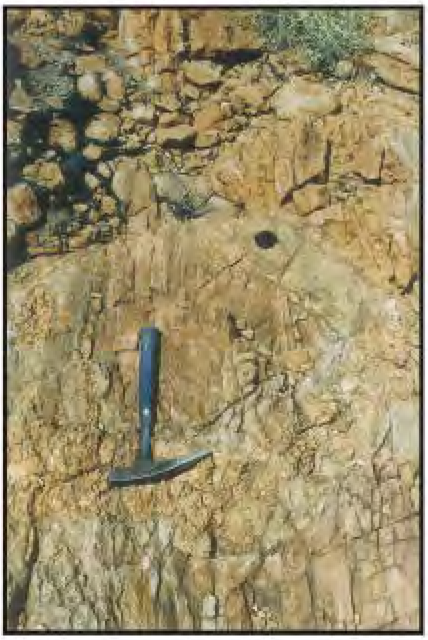


Figure 2 Archaean and Palaeoproterozoic stratigraphy of the Tanami Region and regional correlations

A



B

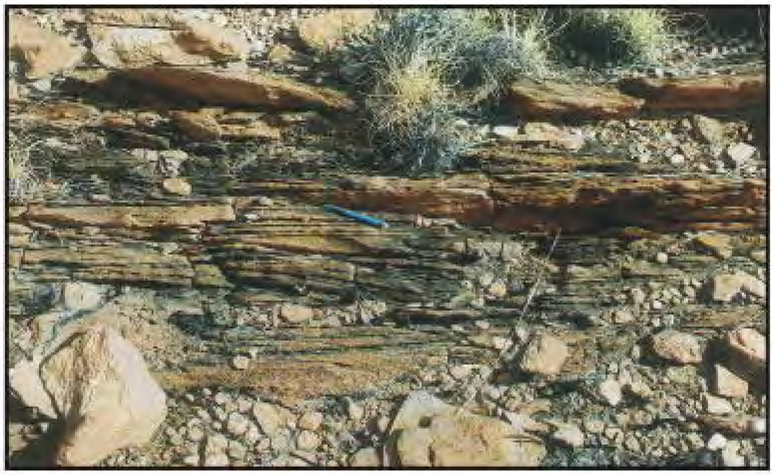


Figure 3 A. Layered granitic gneiss of the Browns Range Metamorphics (parallel to hammer handle) intruded by fine grained granite (under the lens cap) and pegmatite (under hammer head), MALLEE (AMG 514984-7896279)
B. Possible low angle cross bedding in S0 (parallel to pencil) in quartz-muscovite schist of the Browns Range Metamorphics, MALLEE (AMG 500970-7897089)

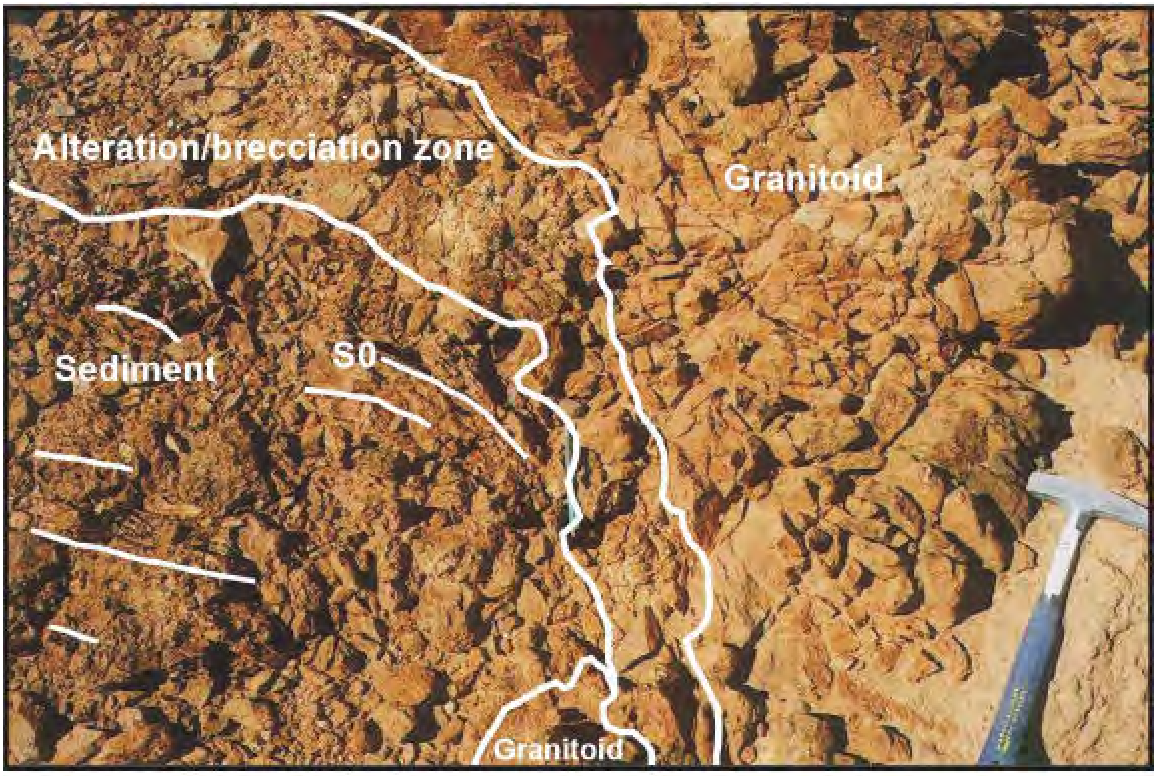


Figure 4 Sediment raft of altered Browns Range Metamorphics in possible Inningarra Suite granite, north of Coomarie Dome, BREADEN (AMG 559867-7884422)

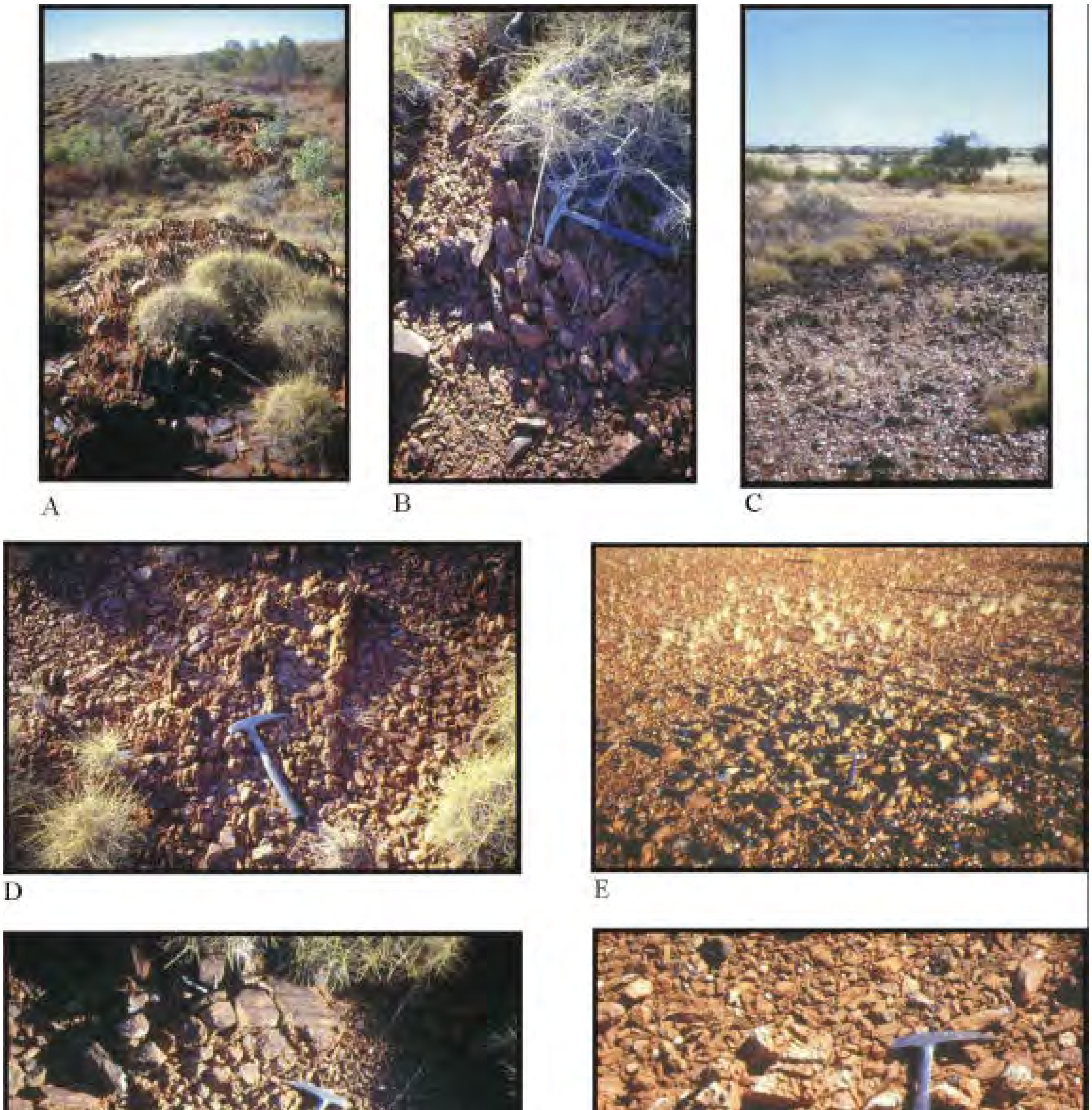


Figure 5 Lithologies in MacFarlane Peak Group at MacFarlanes Peak Range, MCFARLANE.
A. Cleaved graphitic phyllite (AMG 537995-7752466); B. Purple cleaved meta-basalt (AMG 537100-7751325); C. Amphibolite subcrop (AMG 536660-7753018); D. Intercalated biotite schist and lithic meta-greywacke (AMG 537110-7751320); E. Amphibolite subcrop (AMG 537180-7751279); F. Fine grained amphibolite (AMG 537345-7751253); G. Calc-silicate horizon (AMG 538197-7752035).

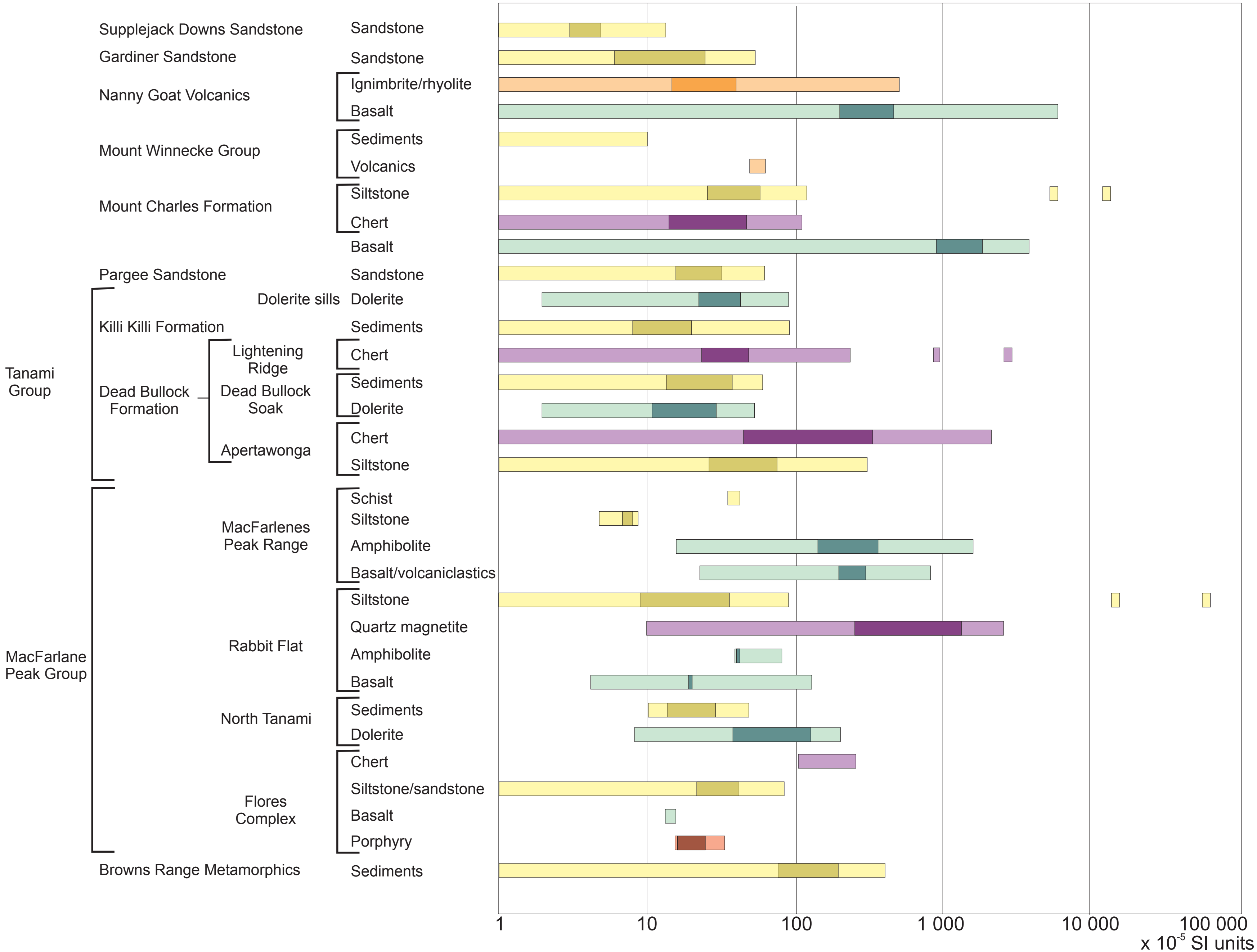


Figure 6 Measured magnetic susceptibilities for various rock types in the Tanami Region. Light fill represents the total measured range, heavy fill represents the range of averaged low and high values. Measured values may be affected by surface weathering and probably underestimate the true readings.

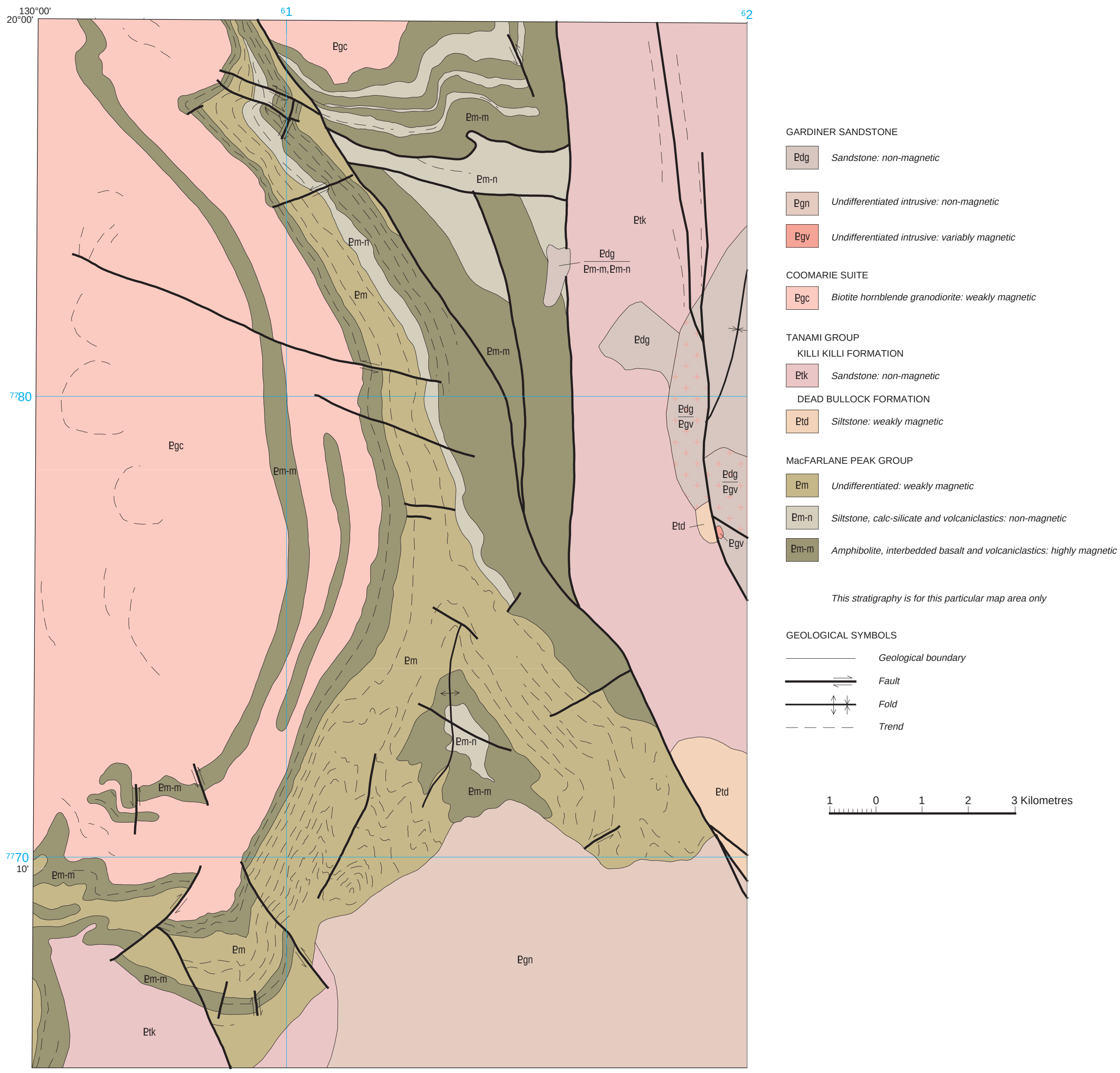


Figure 7 Basement geology interpretation of the area northeast of Rabbit Flat

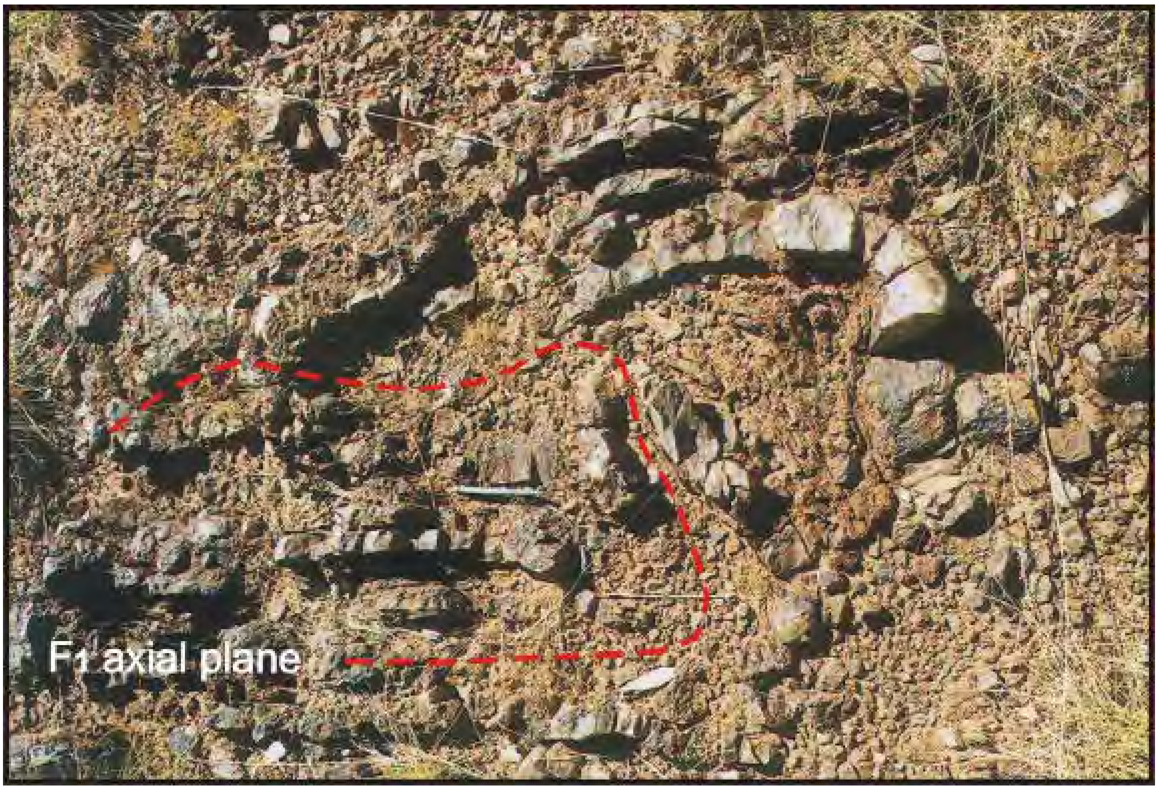


Figure 8 Refolded isoclinal folds in MacFarlane Peak Group siltstone and chert, north of Coomarie Dome, BREADEN (AMG 556564-7882668)

Figure 9 Weathered layered mafic rock (probably metadolerite) intruding poorly outcropping felsic volcanic rock included in MacFarlane Peak Group, BREADEN (AMG 551439-7883368)

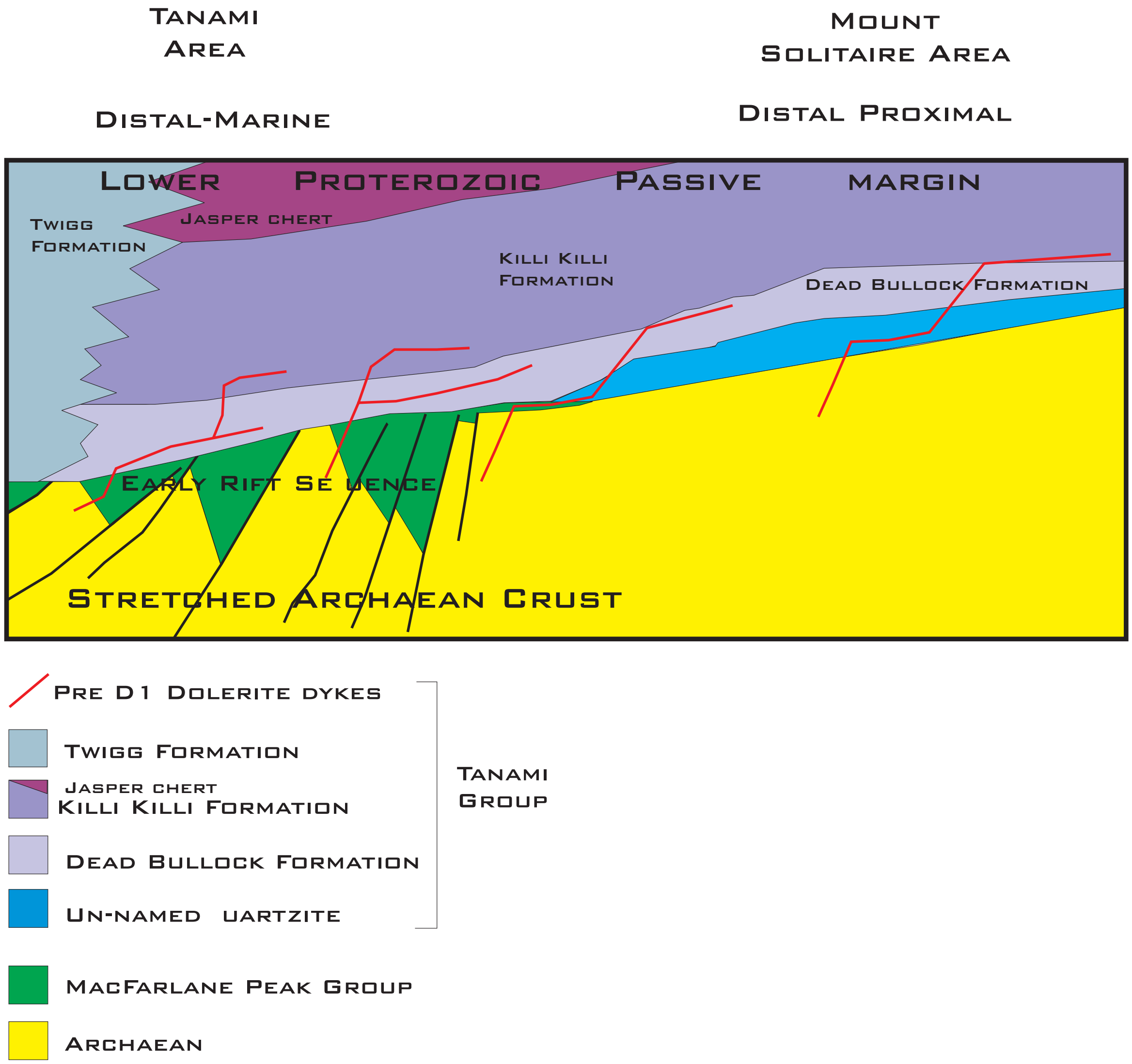


Figure 10 Inferred deposition setting for MacFarlane Peak and Tanami groups. The presence of quartzite at the base of the Tanami Group in MOUNT SOLITAIRE implies a more proximal environment.

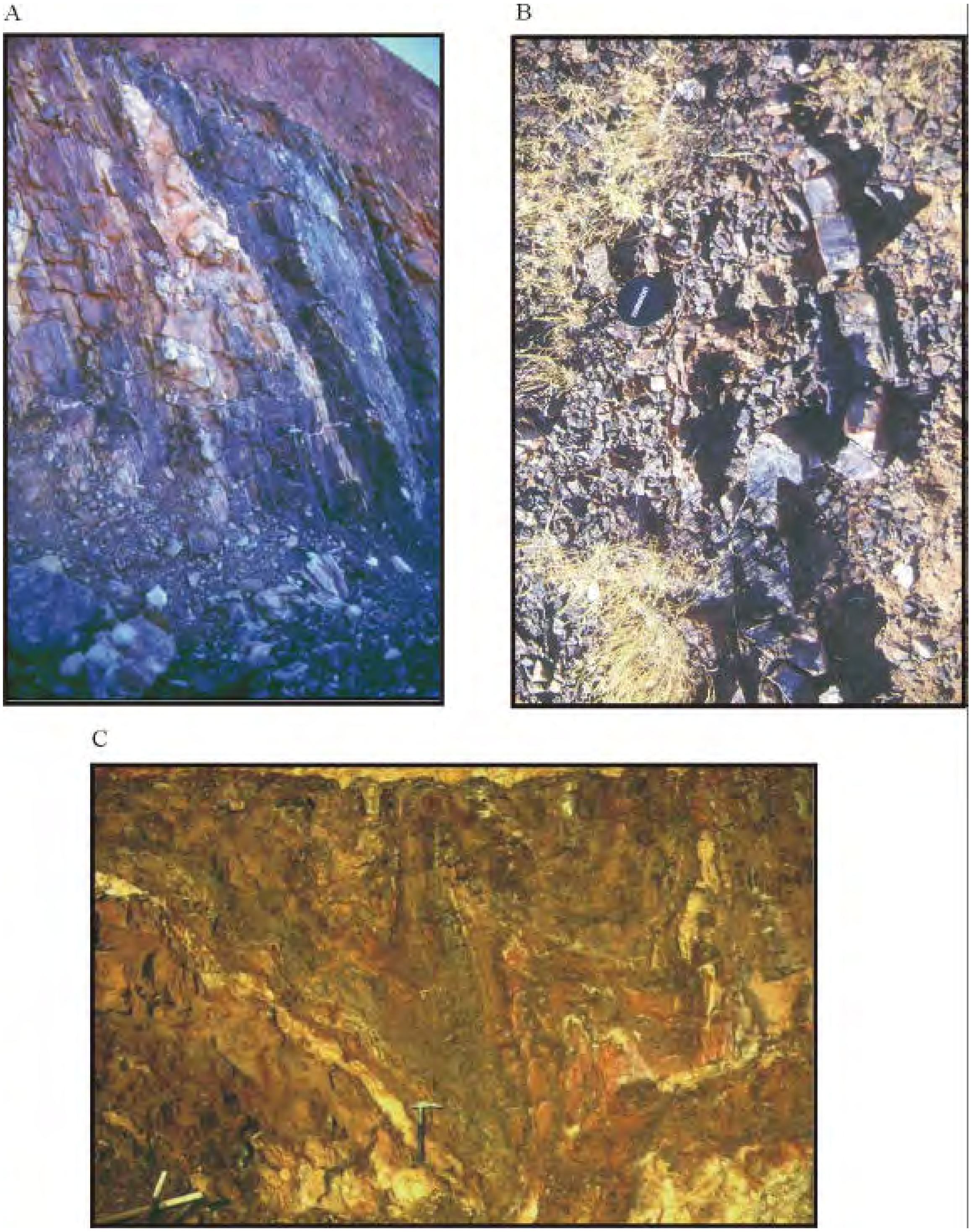


Figure 11
A. Steeply dipping black carbonaceous siltstone intruded by a narrow fine grained felsic dyke.
Dead Bullock Formation, Dead Bullock Ridge (DBR) pit, INNINGARRA (AMG 597645-7730236).
B. Dead Bullock Formation outcrop south of Dead Bullock Soak showing overprinting fold generations; probably F1\F2, INNINGARRA (AMG 592292-7720725).
C. Folds in Dead Bullock Formation, DBR pit, INNINGARRA (AMG 598259-7730252).

Figure 12 Silicified thin bedded chert in Dead Bullock Formation, north of MacFarlanes Peak Range, MCFARLANE (AMG 531134-7769678)

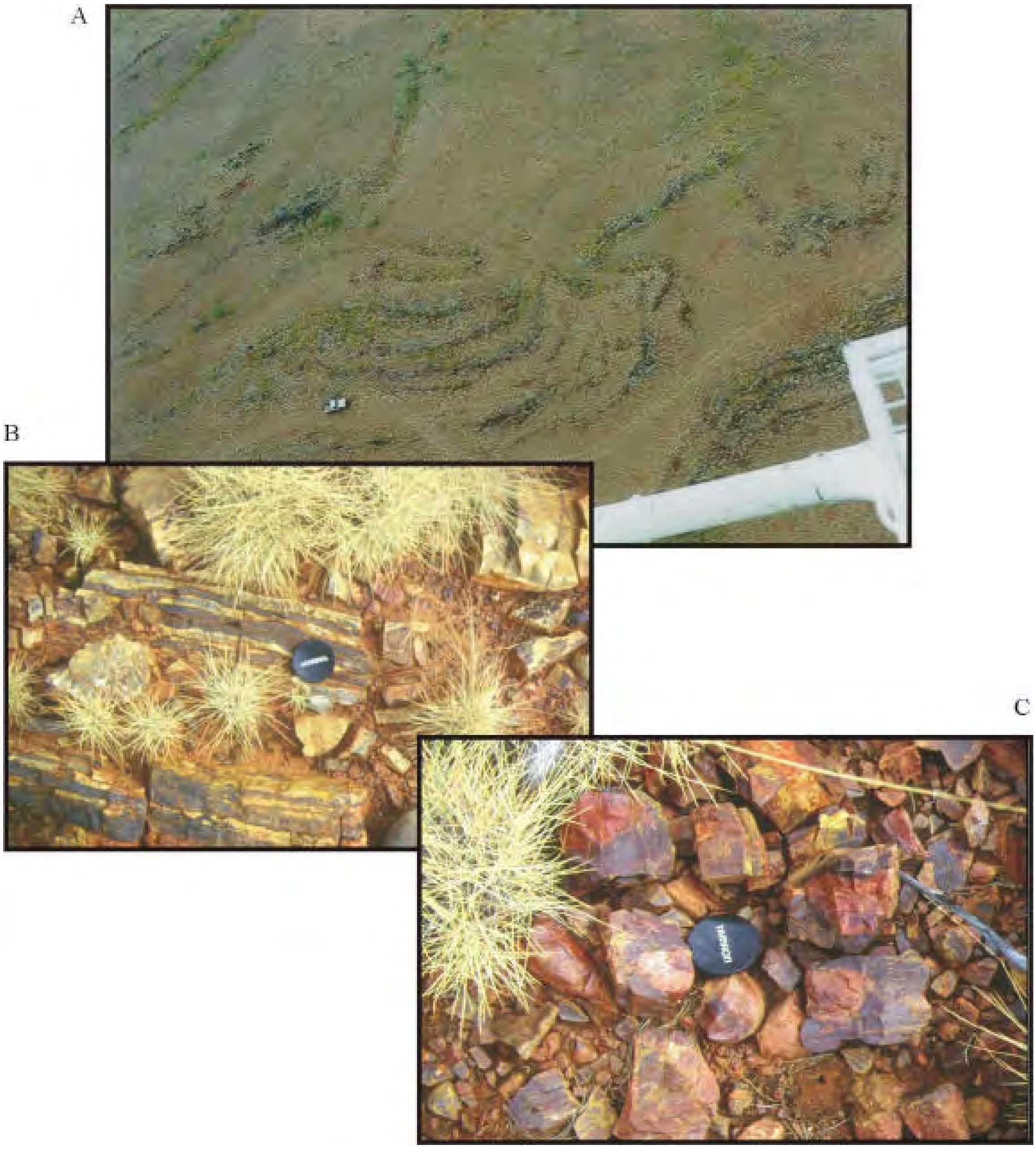
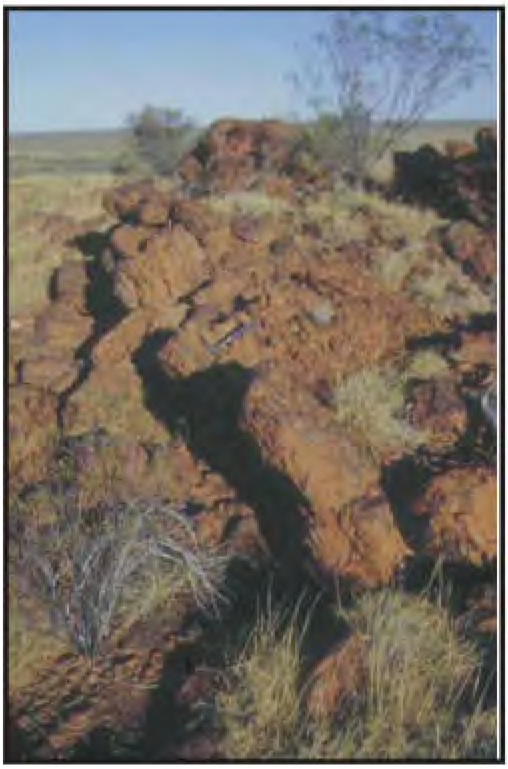


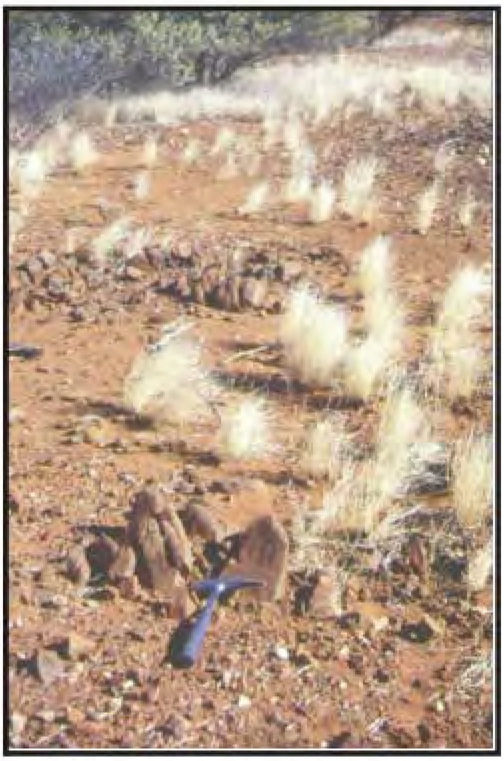
Figure 13 Dead Bullock Formation outcrop at “Lightning Ridge” in PARGEE.
A. Aerial view showing highly contorted bedding trends; B. Silicified outcrop of thin bedded chert (originally siltstone?) (AMG 531553-7809790); C. Broken subcrop of iron rich jasper chert showing development of chert nodules (replacing carbonate?) (AMG 531631-7809208).

Figure 14 Close up of chert pebble conglomerate in Dead Bullock Formation, Apertawonga Ridge, FRANKENIA (AMG 557393-7762103)

A



B



C

Figure 15 Outcrops at Officer Hill, INNINGARRA.
A. Outcrop of gently dipping ferruginised Dead Bullock Formation at AMG 566495-7710177
B. Amphibolite subcrop at AMG 566669-7710248
C. Outcrop of contact metamorphosed, silicified Dead Bullock Formation at AMG 566809-7706735. This outcrop forms a large metasedimentary raft in poorly outcropping granite (not shown).

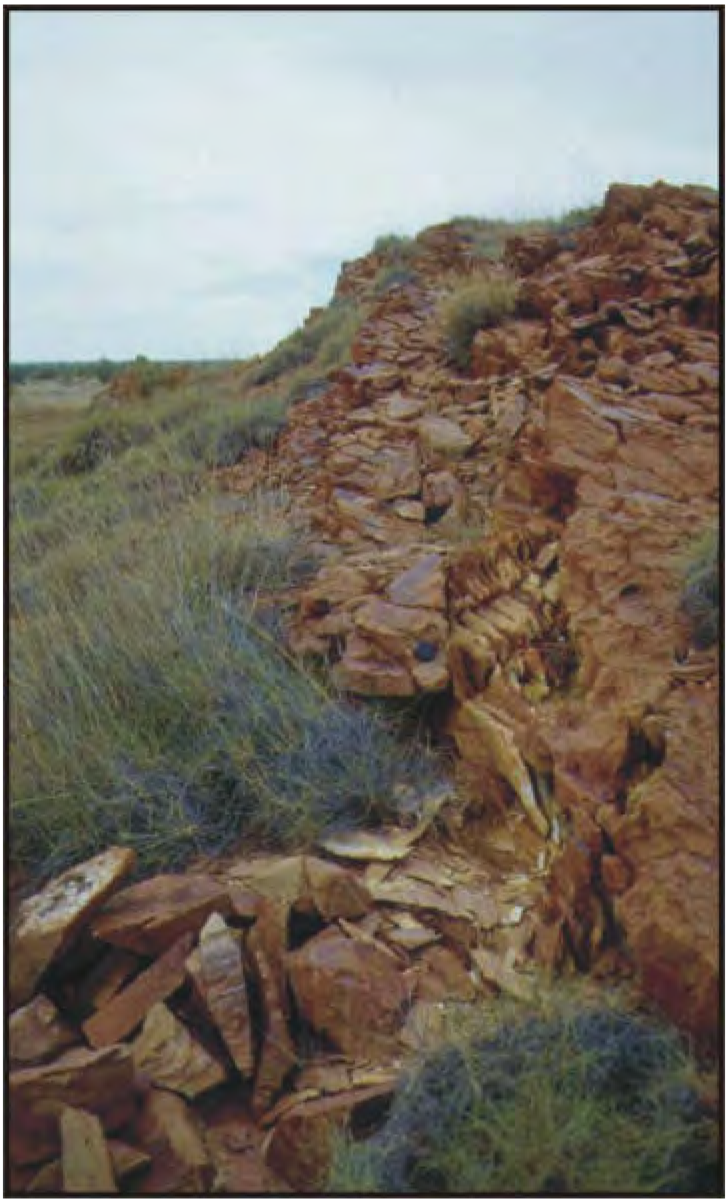


Figure 16 Interbedded greywacke and siltstone (note the well developed refracting cleavage), Killi Killi Formation, MCFARLANE (AMG 518772-7780993)

Figure 17 Bleached graded turbiditic sandstones in Killi Killi Formation, northwest of Apertawonga Ridge, FRANKENIA (AMG 554450-7769135)

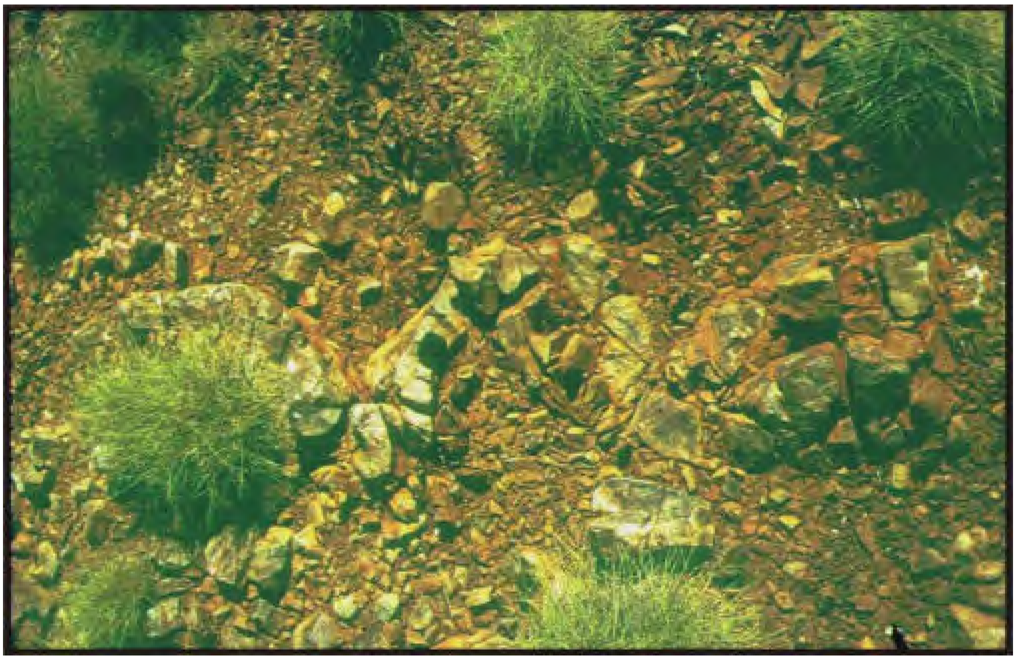


Figure 18 Steeply plunging fold in thin bedded chert, Killi Killi Formation, MCFARLANE (AMG 524158-7786028)

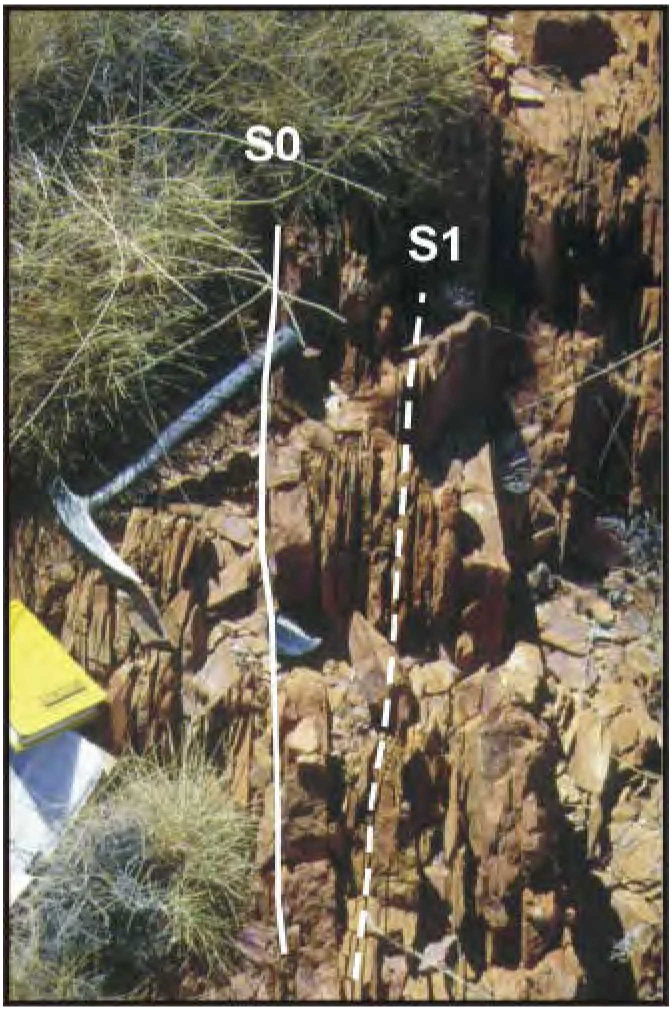


Figure 19 Well developed S1 slaty cleavage in interbedded siltstone and thin bedded greywacke in Killi Killi Formation, WILSON CREEK (AMG 615829-7884152)

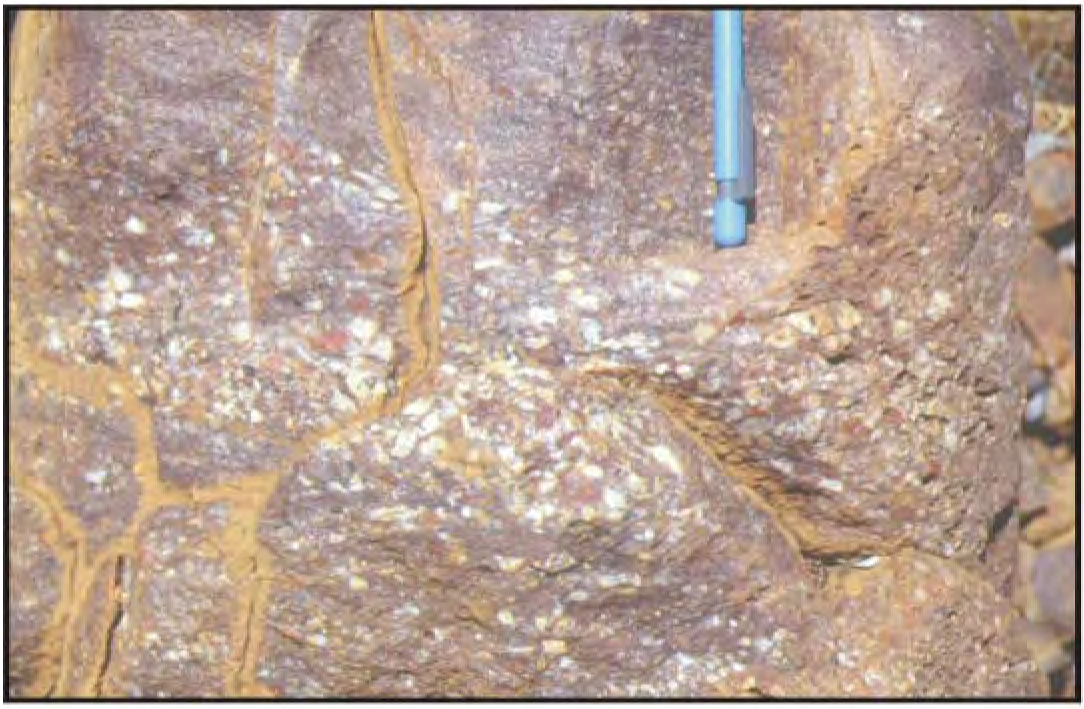
Figure 20 Intrusive contact between fine grained weathered maroon mafic sill (lower half of photo) and medium grained, poorly sorted greywacke. The photo shows a lobe of basalt truncating bedding in the sandstones , Killi Killi Formation, WILSON CREEK (AMG 615240-7883900).

Figure 21 Contorted thin bedded jasper chert. Jasper chert member, Killi Killi Formation, MCFARLANE (AMG 551647-7781892).

Figure 22 Thin bedded chert in weathered siltstone, Twigg Formation, FRANKENIA (AMG 565393-7772332)

Figure 23 Unconformable contact between Pargee Sandstone (cleaved rocks in middle to lower left) and Gardiner Sandstone (pale quartz arenite on right), PARGEE (AMG 524913-7827261)

A



B

Figure 24 Pargee Sandstone, west of Mount Frederick, PARGEE (AMG 521083-7826602).
A. Angular clasts of jasper and vein quartz in poorly sorted conglomerate.
B. Coarse sublithic arenite showing well developed cross bedding.

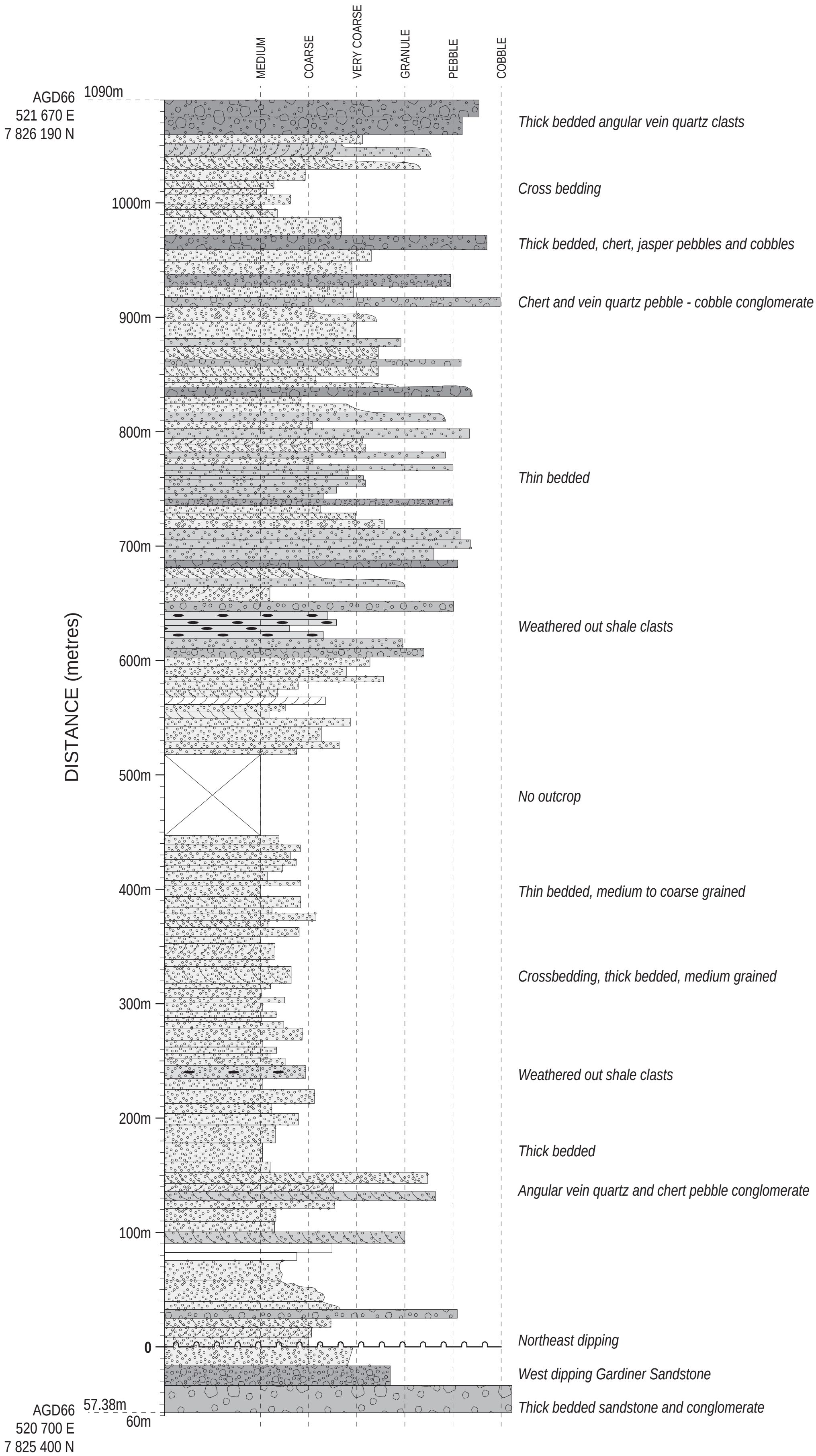


Figure 25 Measured stratigraphic section through Pargee Sandstone, PARGEE AMG 521670-7826190 to 520700-7825400. Note unconformable contact with Gardiner Sandstone at west end of section.

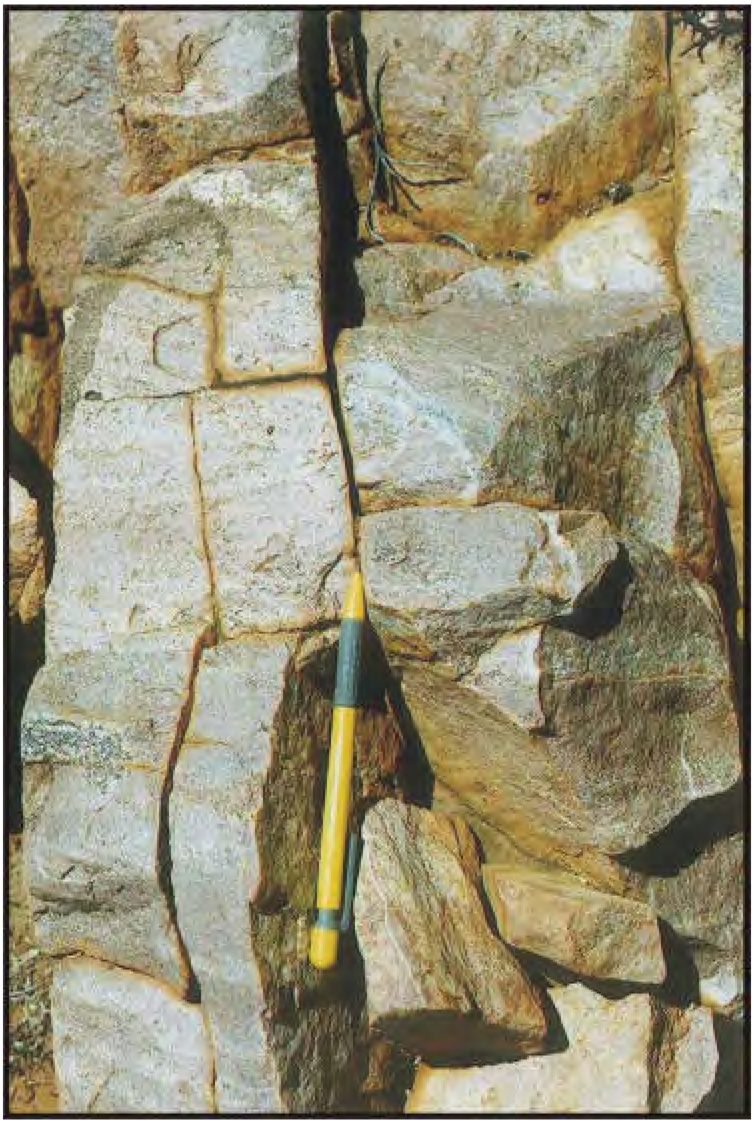


Figure 26 Crossbedded, coarse grained quartz arenite in Pargee Sandstone, PARGEE (AMG 524982-7798828)

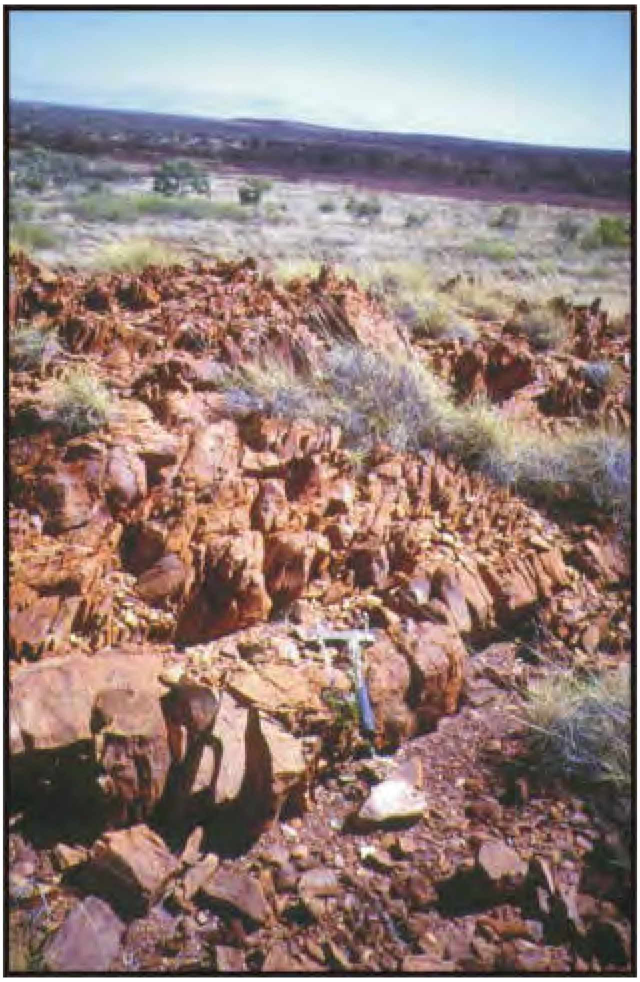


Figure 27 Interbedded medium grained greywacke and siltstone near the top of Pargee Sandstone. Note the well developed cleavage in finer grained lithologies, MCFARLANE (AMG 554450-7769135).

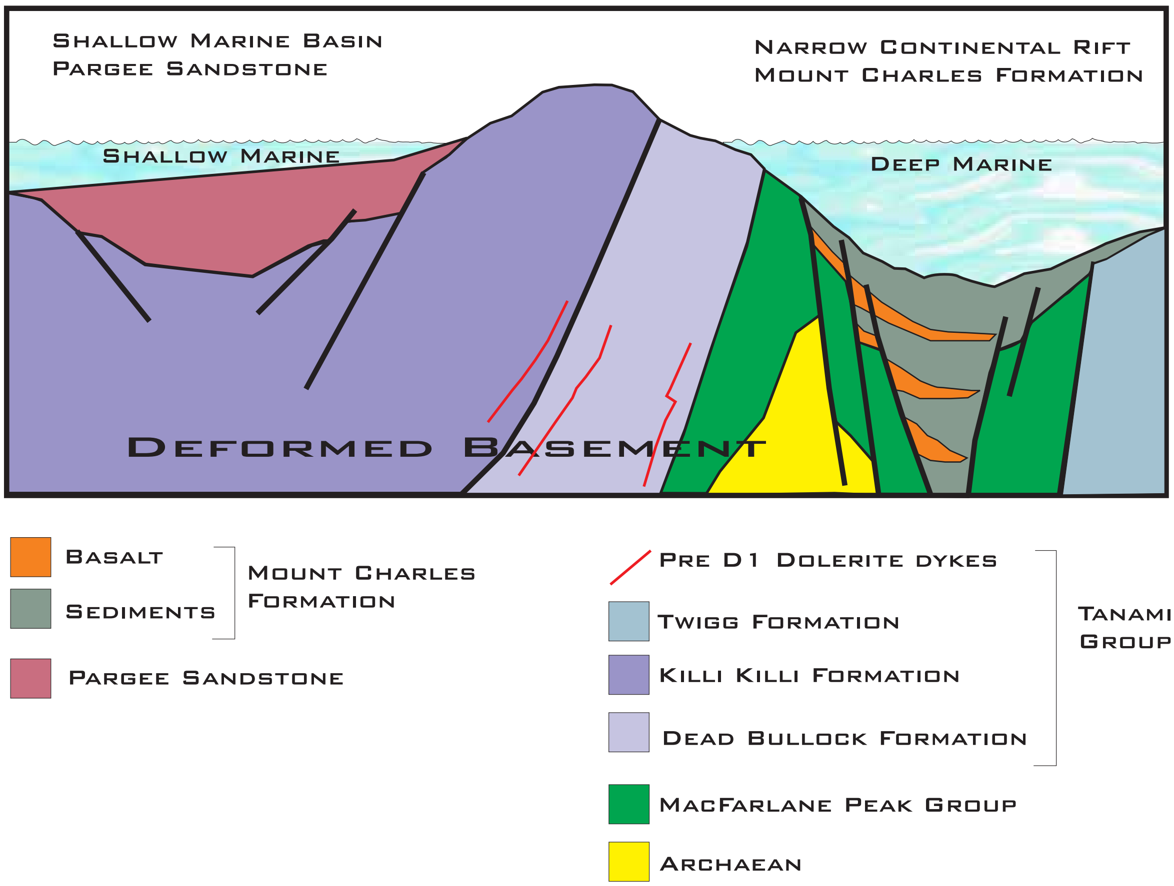


Figure 28 Inferred depositional setting for Pargee Sandstone and Mount Charles Formation

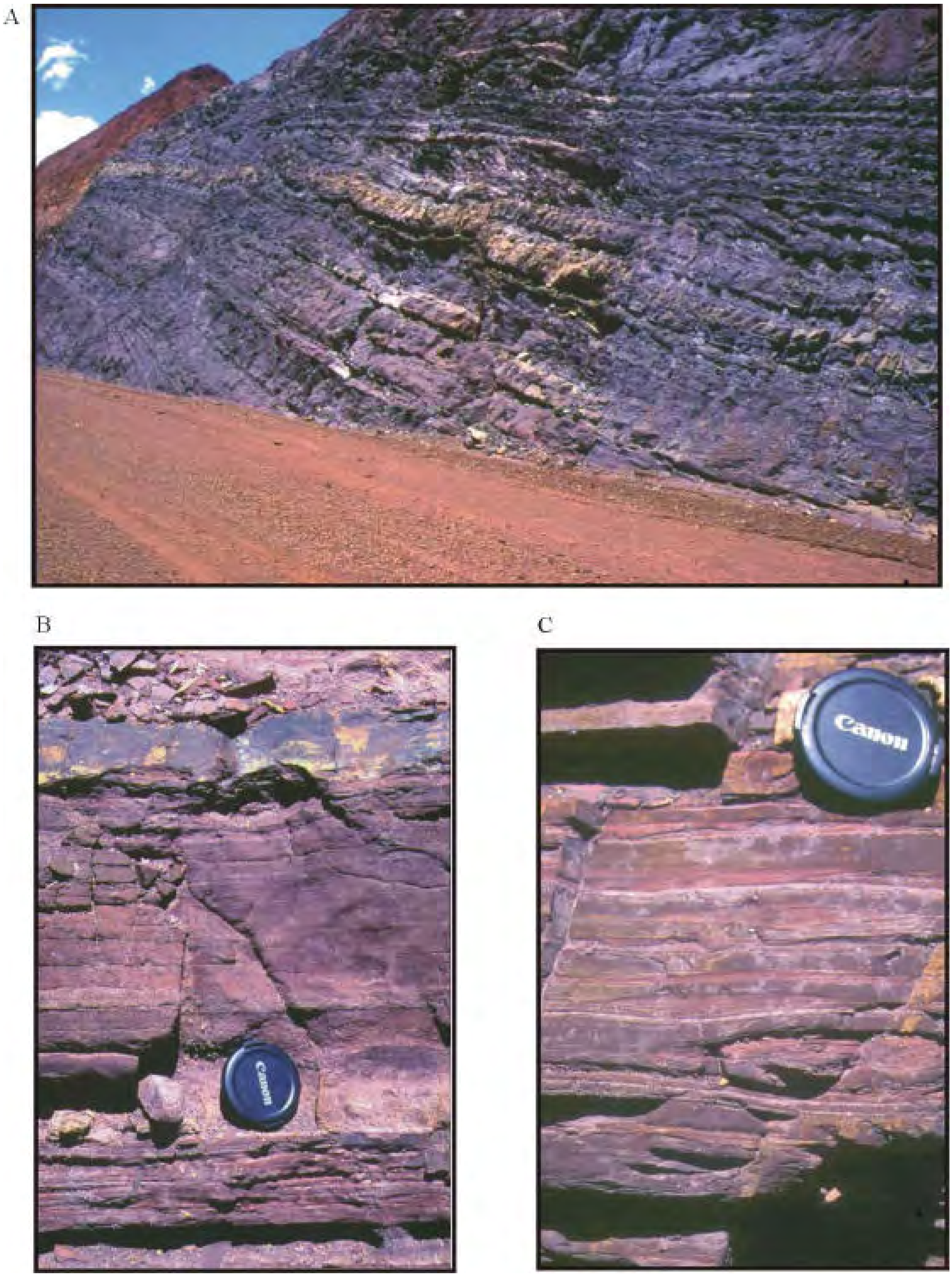


Figure 29 Mount Charles Formation sediments, Hurricane Pit, TANAMI (AMG 574825-7792725)
A. Interbedded purple sandstone and siltstone. Note the presence of a low angle fault truncating bedding through the center of the cutting.
B. Close up of graded lithic sandstone bed
C. Close up of interbedded fine grained sandstone and siltstone

A

B

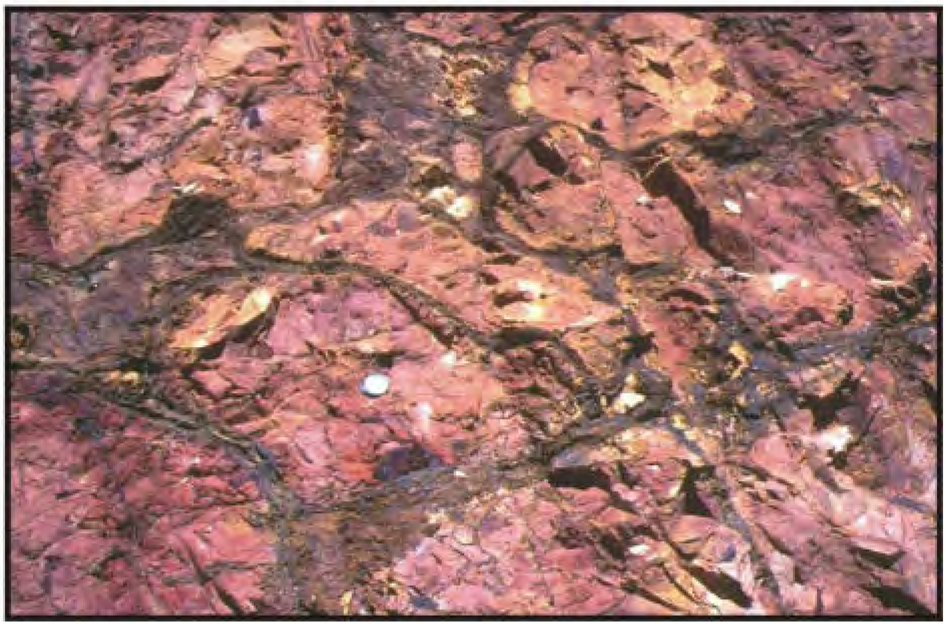


Figure 30 Pillow basalt in Mount Charles Formation exposed in the Southern Pit, TANAMI (AMG 573500-7790650)

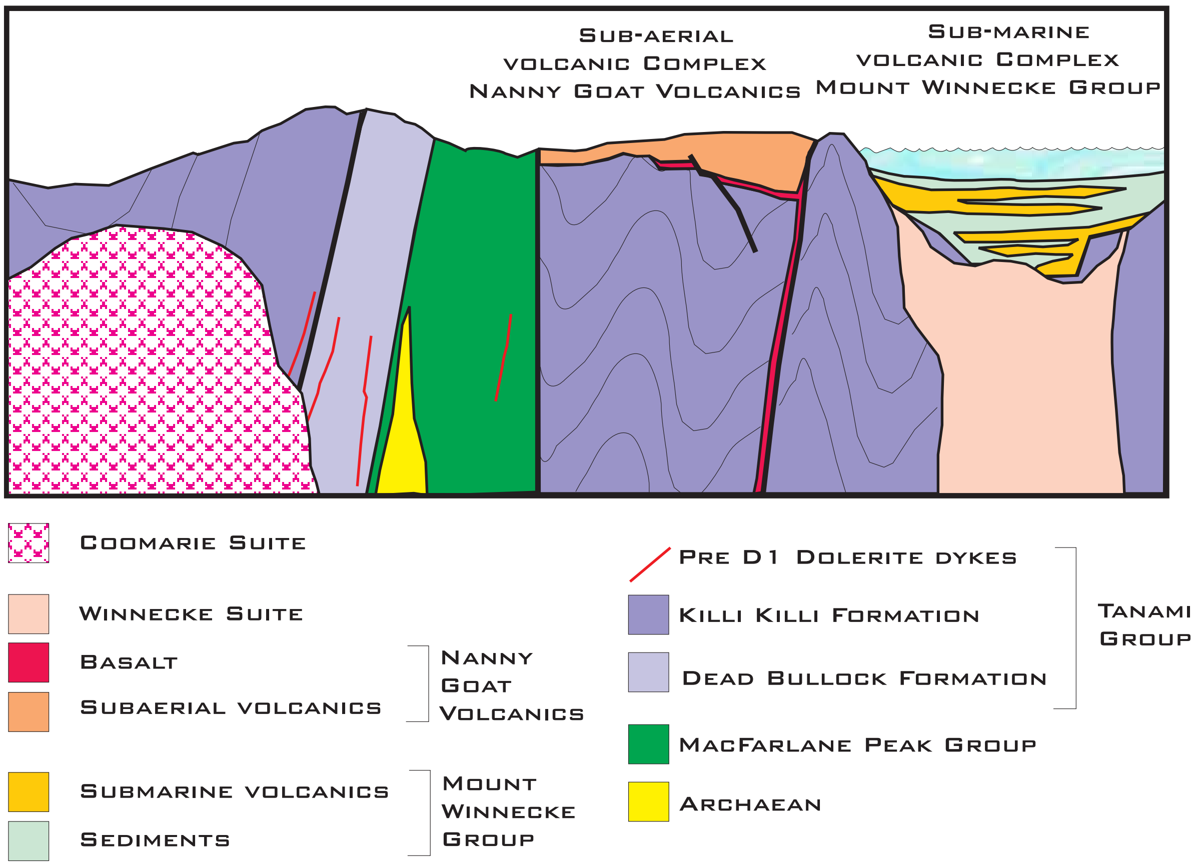


Figure 31 Inferred depositional setting for Mount Winnecke Group and Nanny Goat Volcanics

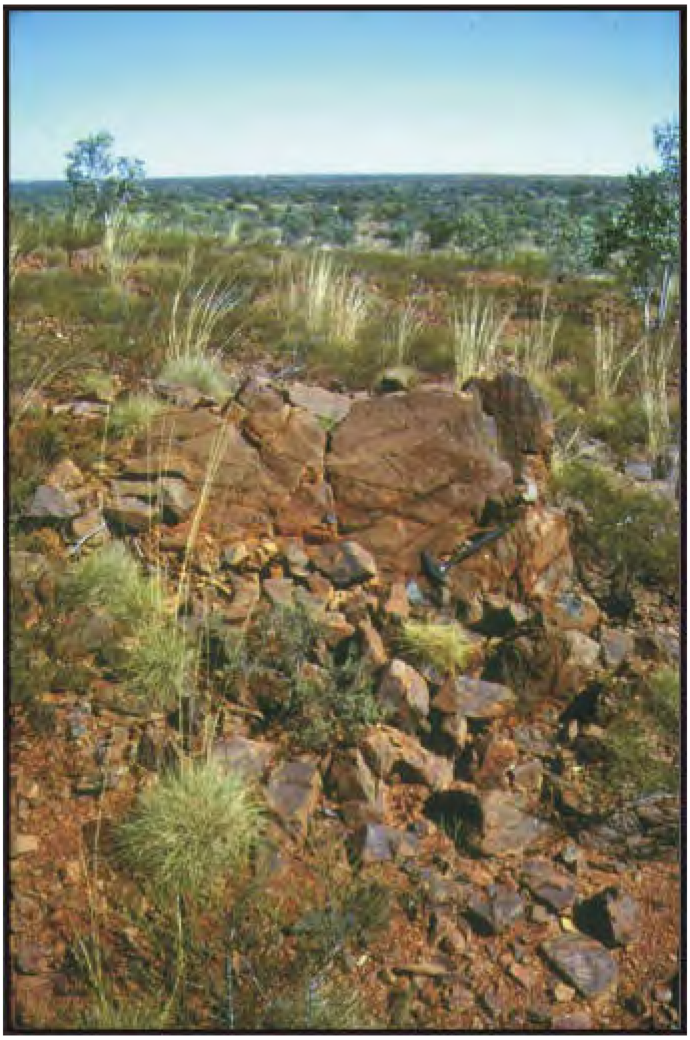
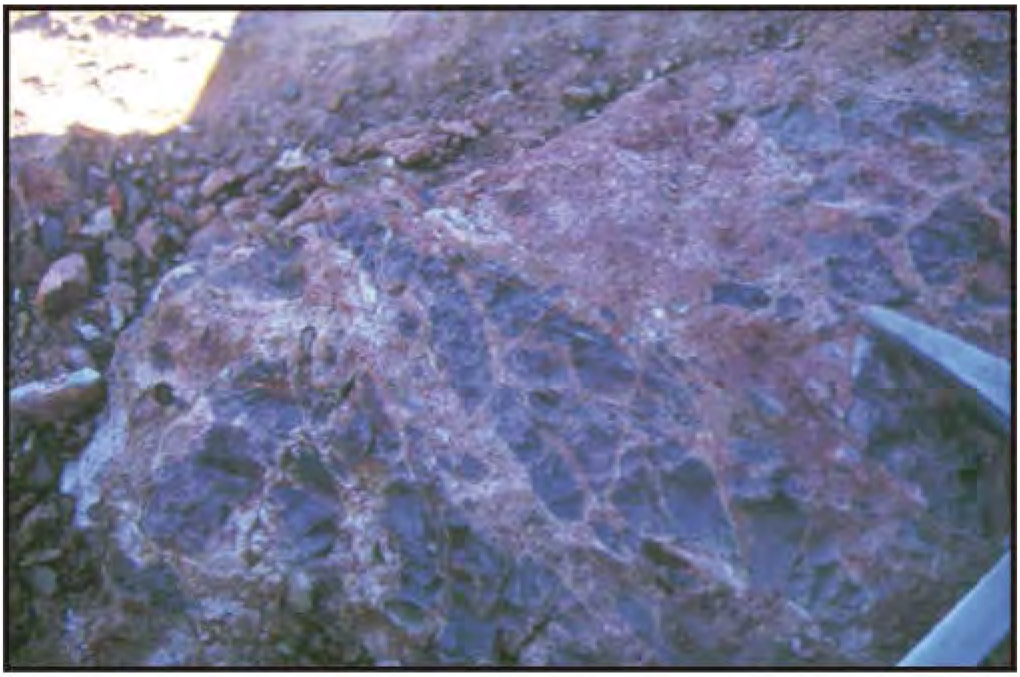


Figure 32 Quartz-feldspar ignimbrite in Nanny Goat Volcanics, eastnortheast of Supplejack Downs homestead, WILSON CREEK (AMG 612639-7870756)

Figure 33 Nanny Goat Volcanics, unit Pn3 (rhyolite), WILSON CREEK (AMG 613300-7887450).
A. Relict flow banding
B. Brecciated rhyolite, possibly representing autobrecciation

A



B

Figure 34 Contact relationships between quartz-feldspar ignimbrite (Pn1) and basalt (Pn4) in Nanny Goat Volcanics near Crusade Prospect, WILSON CREEK.

A. Complex break up of basalt dyke intruding Pn1 with well developed jig saw fit texture (AMG 612973-7883172)

B. Basalt lobe (to right of lens cap) intruding and truncating layering in Pn1 (AMG 612633-7882187)

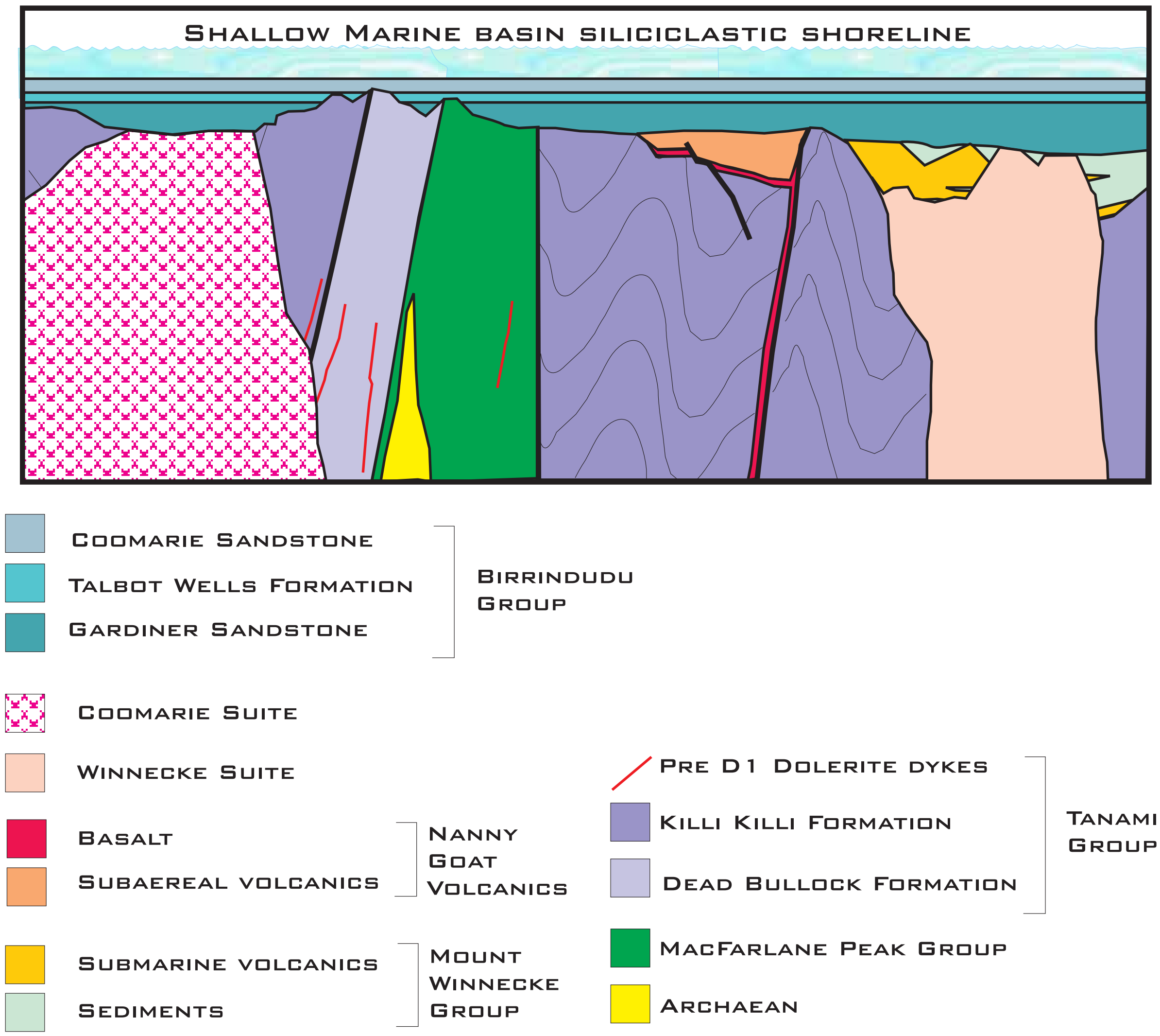


Figure 35 Inferred depositional setting for the Birrindudu Group

Figure 36 Cobble conglomerate at the base of Gardiner Sandstone. The unconformity with undifferentiated granite is exposed in the small hollow in front of Alison Dean. The conglomerate grades into coarse grained lithic arenite at the top of the outcrop, Nora Range, MCFARLANE (AMG 509439-7756593).

A

B

Figure 37 Gardiner Sandstone outcrops, south of the Killi Killi Hills, PARGEE.
A. Close up of cobble conglomerate. Clasts are vein quartz and greywacke (AMG 500102-7813109)
B. Siltstone interbedded with micaceous lithic arenite (AMG 500000-7812800)

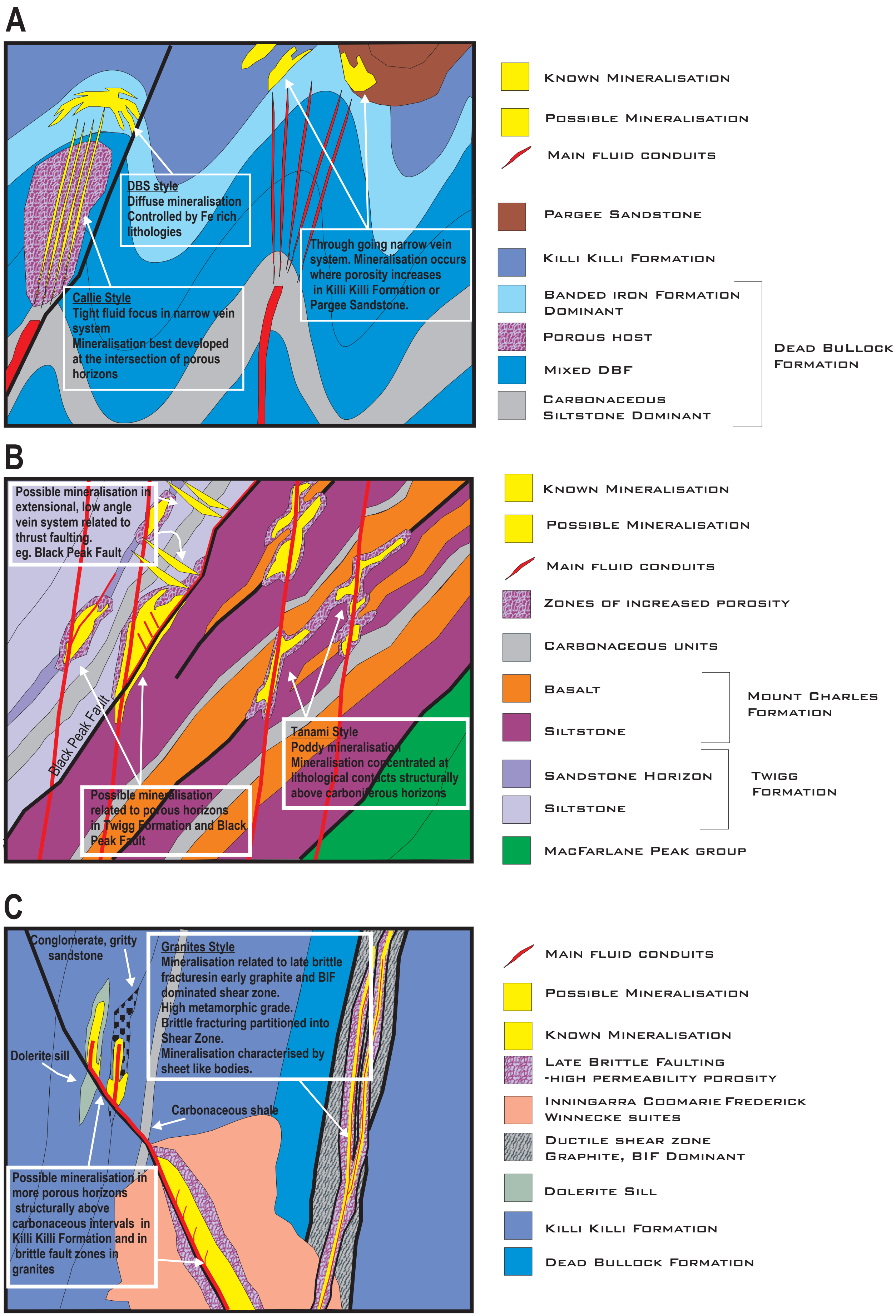


Figure 38 Gold mineralisation models for the Tanami Region