EXPLANATORY

FOR THE MAP OF GEOMAGNETIC INTERPRETATION

OF THE TANAMI AND NORTHERN ARUNTA REGIONS

IN WESTERN AUSTRALIA AND NORTHERN TERRITORY

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TABLE OF CONTENT

SUMMARY

The geology of the map area includes four major stages: 1) Archaean gneisses form the basement of, 2) Paleoproterozoic orogenic provinces, 3) Mesoproterozoic to Neoproterozoic deformed basins and 4) Paleozoic platform cover sequences.

The Archaean basement, which consists of banded granitic gneisses, paragneisses, amphibolites and possible granulites, has been observed in the southern and eastern areas of the Tanami region, and in cores of structural domes. The main blocks of Archaean gneisses appear to separate Tanami region from the Arunta region to the south and east. Archaean ages of ~2500 and 2540 Ma have been obtained from two areas: the first was from banded granitic gneiss sample collected from one outcrop in the area to the southwest of Mount Davidson; the second was from banded grey gneiss in the basement core of the Mesoproterozoic Browns Range Dome.

The Paleoproterozoic orogenic provinces include ten Paleoproterozoic tectonic cycles in the whole Tanami –Arunta region, but the map area includes only strata of the earlier five cycles. The strata of each tectonic cycles are the cycle 1 Tanami Group in the Tanami Orogen and cycle 1 Yundurbulu Group in the Arunta Orogen, the cycle 2 Pargee Sandstone in the Tanami region and the cycle 2 Woodforde River Group in the northern Arunta region, the cycle 3 Tanami Mine succession the Tanami region and cycle 3 Lander River Group in the Arunta region, the cycle 4 Nanny Goat Creek beds, and the cycle 5 Mount Winnecke Formation and Supplejack Downs Sandstone. The stratigraphic units of Mesoproterozoic to Paleozoic are adopted from Survey maps.

Each tectonic cycle includes deposition of strata, magmatism, deformation and mineralisation. Stratigraphic groups deposited during different cycles are separated by angular unconformities. Events of later cycles usually have given influences to the geological bodies formed in the earlier cycles. Strata formed in the later cycle obviously cannot record the earlier events. Each tectonic cycle started from deposition of sediments (may include volcanic rocks) within a subsiding basin which was largely caused by extension of the lower crust, and ended by compression which was caused by shortening of the lower crust.

The cycle 1 Tanami Group recorded six ductile deformation events, which caused ductile deformation and thermodynamic metamorphism. In addition to D1 to D5, a pre-D1 deformational event was recognised by the author since 1990. D1 was the orogenic deformation of cycle 1 Tanami Group. D2 to D5 were the influence from later sequential orogenic events.

Pre-orogenic deformation was labelled ED1, which was a long lived bedding parallel or subhorizontal shearing, which caused bedding parallel schistosity (ES1), recumbent folds (EF1), mineral and stretching lineation (EL1) and features caused by bedding parallel elongation (e.g. boudinage of competent layers or bands, sheathing of EF1 folds). During prolonged ED1, multiphase hydrothermal activities, sequential intrusion of granite sills and dolerite, and a progressive development of ES1 within the pre-D1 granite and

dolerite provide marks for further subdividing of the ED1 event into ED1a, ED1b, ED1c and ED1d.

D1 was a NW-SE oriented compressional event, which caused NE trending (F1) fold belt, or orogenic belt. Thermodynamic metamorphism caused new mineral growth and formed pervasive S1 schistosity and was probably responsible for the progressed metamorphism in one zone and retrogressed metamorphism in the next zone. Syn-orogenic magmatism occurred as syn-D1 gneissic granite. Post-orogenic acid magma intruded into the region and formed large plutons and plugs. These granitoid plutons partially cratonised the crust of the region.

D2 was a NE-SW oriented compressional event and caused refolding of F1 folds. Thermodynamic metamorphism also caused new mineral grow and formed pervasive S2 schistosity. Syn-D2 magma intruded into the strata along or cross cut S2 schistosity and formed foliated syn-tectonic tonalite dykes, which have been further metamorphosed and boudinaged during D2. D2 was the first deformation affected the Pargee Sandstone and caused NW trending tight folds and low grade metamorphism (see section.

D3 was a NW-SE oriented compressional event, similar to that of D1, and caused refolding or kinking of F3 folds. S3 is mainly a crenulations of earlier formed schistosity. A possible example of syn-D3 magmatism is a NE trending foliated andesite dyke which cross cut S2. D3 was the first deformation affected the Tanami Volcanics and caused NE trending folds without metamorphism.

D4 was a N-S oriented compressional event and caused large-scale E-W trending shear zones, faults and small-scale F4 folds. Syn-D4 magma intruded into the region and formed E-W trending foliation, which parallel to S4 in country rocks. No correlation has been made between the D4 and stratigraphic group in our ELs, but it is possible that an unrecognised stratigraphic group was deposited after D3 and deformed by D4.

D5 was an ENE-WSW oriented compressional event and caused large-scale NNW trending faults and small scale F5 folds in the Tanami Group. D5 was the first deformation affected the Mt Winnecke Formation and caused northerly trending folds without metamorphism. Post-D5 extensive acid magmatism formed many plutons and largely cratonised the region.

Mesoproterozoic strata include the Mesoproterozoic (Carpentarian) Birrindudu Group (Pd) in Birrindudu Basin; the Carpentarian Pindar Beds (Pc), the Carpentarian Baines Beds (Pup) and the Carpentarian Ima Ima Beds (Pum) in western Birrindudu Basin; the Carpentarian Bungle Bungle Dolomite (Ps-Pa) to Albert Edward Group in unnamed basin in northwest. They are all platform-like cover type strata. However deformation events occurred before the deposition of Neoproterozoic strata. The structural domes and basins within the Birrindudu Group are the results of interference between at least two events of deformation.

Neoproterozoic strata include the Neoproterozoic (Adelaidean) Red Cliff Pound Group (Pr, including Lewis Range Sandstone, Muriel Range Sandstone etc.), the (Adelaidean) Hidden Basin Beds (Pui), the (Adelaidean) Boee Beds, Jawilga Beds and Denison Beds (Pu). They are all platform cover type strata, but all deformed and developed folds and faults.

This region was finally cratonised before Cambrian and overlain by flat lying Antrim Plateau Volcanic sequence, which signalled the very end of multiphase tectonic cycles. The structures of the Paleozoic sequences in the Wiso Basin and Canning Basin have not been actually studied.

Gold mineralisation occurred during ED1, D1, D2, D3, D4 and post D5. The ED1 mineralisation caused banded metasomatic lithologies, known as host units within the Davidson Beds. They are thin banded lithologies contain various amphibole, biotite, garnet, quartz and sulphides in amphibolite facies area or contain various chlorite, cummingtonite, actinolite, biotite, quartz and sulphides in greenschist facies area. Both the schists and quartz veins can carry economic grade of gold. The Granites deposit and the Dead Bullock Soak deposit are mainly contributed by the ED1 mineralisation. The D1 mineralisation is mainly quartz and calc-silicate quartz vein type controlled by F1 folds and S1 schistosity. The pre-D1 dolerite was not mineralised during ED1, but can be the host rock of D1 mineralisation. The D2 mineralisation is mainly quartz - calcite vein type controlled by D2 shear zones and fault zones. The D1 and D2 mineralisations also occurred within the Madigan Beds. The D2 and D3 mineralisation also made contribution to the Granites deposit and the Dead Bullock Soak deposit. The D3 mineralisation is quartz - chlorite vein type controlled by D3 faults and fractures. Its best known example is the mineralisation within the Tanami Volcanics at the Tanami Gold Mine. The D4 mineralisation is quartz - chlorite - calcite vein type controlled by D4 structures, i.e. large D4 fault zone, F4 folds, S4 schistosity and fractures. The Callie deposit and Titania deposit were mainly contributed by D4 mineralisation. Post-D5 mineralisation is found in the 1785 Ma small intrusive bodies, e.g. the Twin Bonanza prospect.. Later mineralisations could be certainly hosted by older lithologies, but the early mineralisations cannot be found within the younger lithologies. There could be more unknown types of mineralisation waiting for us to discover.

1. INTRODUCTION

The Map of Geomagnetic Interpretation of the Tanami and Northern Arunta regions was requested by Martin Kavanagh, the Exploration Director of Tanami Gold N.L.. A 1:500 000 magnetic image was provided as the base of the interpretation. I visited the tenements of Tanami Gold in the Tanami region during 17 September to 6 October 1999. The fact geology observed by myself was used as first priority of guidelines for the geological interpretation from magnetic image. In the areas out of the tenements of Tanami Gold, published information have been carefully read and selectively used as evidence of fact geology. Survey maps have also been referred and selectively compiled into this map. The main map available in WA side is the **Geology of The Granites – Tanami Region (1:500 000)**, which was published in 1979 by BMR and GSWA. In the Northern Territory area, published 1: 250 000 regional geological maps were used as references, however my own work in the region during 1990 to 1999 over rides the survey map. I did consulting work in the Tanami region for North Flinders Mines Limited in 1990 –1992 while I was based in the University of Adelaide. I continued my study in the region during 1992 – 1999, when I was a full time stuff member of the Company. The main result of my study has been presented to several conferences and published in the forms of Abstracts (see references).

The Interpretive Geomagnetic Map takes off the cover sequences, which include all sequence from recent sands, soil to Mesozoic strata. The youngest Stratigraphic unit on the Map is Paleozoic (Pz).

2.TECTONIC ELEMENTS

The geology of the map area includes four major stages: 1) Archaean gneisses form the basement of, 2) Paleoproterozoic orogenic provinces, 3) Mesoproterozoic to Neoproterozoic deformed basins and 4) Paleozoic platform cover sequences. The earlier two stages can be generally called the basement, while the later two stages the cover sequences.

The map area can also be tectonically divided into three main regions: the Tanami Orogen in the north, the Arunta Orogen in the south and the Archaean land in between.

3. ARCHAEAN BASEMENT

3.1. LITHOLOGY

The Archaean (Ar) basement, which consists of banded granitic gneisses, paragneisses, amphibolites and possible granulites, has been observed in the southern and eastern areas of the Tanami region, and in cores of structural domes. The main blocks of Archaean gneisses appear to separate Tanami region from the Arunta region to the south and east. An age of ~2500 Ma was obtained from banded granitic gneiss sample, which was collected from one outcrop in the Billabong area to the southwest of Mount Davidson.

Another age of ~2540 Ma was obtained from banded grey gneiss in the basement core of the Mesoproterozoic Browns Range Dome. In both the Billabong area and the Browns Range area younger granites are dominant.

Sillimanite grade gneiss complex was recognised in the field by myself at the southern part (Schultz Cairn E80/1513) and the northern part (Slatey Creek E80/1735) of the Tanami region in WA. The gneiss complex includes mainly paragneisses, migmatite and pegmatite veins. The paragneisses are interlayered pelitic gneisses and semi-pelitic gneisses. The gneisses comprise essential quartz, feldspar biotite and various amount of sillimanite. The pelitic gneisses are thin layered, whereas the semi-pelitic gneisses are thick layered and often boudinaged. The sillimanite grade gneiss complex was correlated to the Archaean Billabong Complex in Arunta Block by myself on the bases of regional setting, metamorphic grade, and spacial relationship with the Paleoproterozoic Tanami Group. However the complex has not been dated.

Archaean sillimanite grade gneiss complex was also recognised in the Mount Davidson and Mount Solitaire area. The gneiss consists of coarse-grained sillimanite, mica and two feldspars. The gneiss makes great contrast to the Tanami Group, which consists of amphibolite phases schists only. The Archaean gneiss in the eastern area was mapped as Lander Rock beds by survey geologists. In fact the type Lander Rock beds were much younger than the Tanami Group and the evidence will be discussed later.

Archaean (Ar) on my map may include some Proterozoic granites, which could not be interpreted from the magnetic image. Many outcrops of sillimanite gneiss in the Mount Solitaire area have been wrongly mapped as granite by BMR geologists.

The Archaean basement are largely unexposed. It is possible that some of the Archaean gneiss complex are covered by small blocks of Proterozoic.

3.2. STRUCTURE

Very limited outcrops of Archaean were observed in the region. Very ductile, tight to isoclinal folds in the gneiss complex have been observed in the field. The earlier formed isoclinal folds are interfered by later folds and crenulations. The details of the ductile deformation in Archaean complex have not been studied. Thrusts and retrogressed shear zones usually form the boundary between the Archaean and Proterozoic. Many faults has been interpreted within the Archaean basement on the bases of magnetic image. Some of the faults may represent retrogressed shear zones and related to gold mineralisation.

4. PALEOPROTEROZOIC OROGENIC PROVINCES

The Paleoproterozoic orogenic provinces include ten Paleoproterozoic tectonic cycles in the whole Tanami –Arunta region, but the map area includes only strata of the earlier five cycles. The strata of each tectonic cycles are the cycle 1 Tanami Group in the Tanami Orogen and cycle 1 Yundurbulu Group in the Arunta Orogen, the cycle 2 Pargee Sandstone in the Tanami region and the cycle 2 Woodforde River Group in the northern Arunta region, the cycle 3 Tanami Mine succession the Tanami region and cycle 3 Lander River Group in the Arunta region, the cycle 4 Nanny Goat Creek beds, and the cycle 5 Mount Winnecke Formation and Supplejack Downs Sandstone.

Each tectonic cycle includes deposition of strata, magmatism, deformation and mineralisation. Stratigraphic groups deposited during different cycles are separated by angular unconformities. Events of later cycles usually have given influences to the geological bodies formed in the earlier cycles. Strata formed in the later cycle obviously cannot record the earlier events. Each tectonic cycle started from deposition of sediments (may include volcanic rocks) within a subsiding basin, which was largely caused by extension of the lower crust, and ended by compression, which was caused by shortening of the lower crust.

4.1. CYCLE 1 TANAMI OROGEN

4.1.1. STRATIGRAPHY

4.1.1.1. INTRODUCTION

The Early Proterozoic Barramundi Orogeny was used by BKR geologists to described the tectonic event which caused the angular unconformity between the Tanami Complex and its cover sequences, i.e. the Mt Winnecke Formation (1808 +/- 15ma) (Blake et al. 1975). They correlated Pargee Sandstone and Supplejack Downs Sandstone with the Mt Winnecke Formation, because these formations are all cover type strata. In fact, they did not have any direct age evidence. The term "Tanami Complex" of BMR means the stratigraphy in the Tanami region was too complex that they could not work out clear sequential relationships between different lithological units. Their mapping units, e.g. the Mt. Charles Beds, the Kili Kili Beds and the Nanny Goat Creek Beds, are lateral equivalents in different geographic areas. They did not make any real stratigraphic subdivisions within the whole "complex".

The first stratigraphic subdivisions were established by geologists of North Flinders Exploration, and the term **Tanami Group** ($\underline{P}$t) was introduced to replace the “Tanami Complex”. Unfortunately the depositional age of the Tanami Group has not been successfully dated. It is inferred that the Tanami Group unconformably overlies the Archaean basement.

4.1.1.2. STRATIGRAPHIC SUBDIVISION OF THE TANAMI GROUP

The Tanami Group in the type area includes four conformable subdivisions, from lower to upper, the Thomson Beds (Ptt), the Blake Beds (Ptb), the Davidson Beds (Ptd) and the Madigan Beds (Ptm). In terms of lithology, the basal unit, Thomson Beds, consists of coarse-grained quartzite and muscovite quartz schists. The middle units, Blake Beds and Davidson Beds, consist of fine-grained silty to pelitic schists. The upper unit, Madigan Beds, is a flysch-type, turbidite sequence. They represent a full cycle of sedimentation.

Thomson Beds (Ptt).

The Thomson Beds were recognised in 1993. They are well exposed in the Mt Davidson area, and a very wide area to the west of De Bavay Hills. Isolated quartzite within Archaean gneiss complex at the Mount Solitaire may also be Thomson Beds. The main lithologies of Thomson Beds are monotonous quartz rich metamorphic rocks, containing 90 to 95 % of quartz and minor muscovite which was very likely produced by breaking down of feldspar sands during the metamorphism. Foliation and lineation are obvious on the rock surfaces, however due to recrystallisation no optical fabrics remain in quartz grains. Thin interbeds of fine-grained lithologies have also found within the unit. The total thickness of the unit is difficult to measure due to discrete exposure and complex folding. It occupies a zone as wide as 10 to 15 km and implies a possible thickness of several thousand meters.

Blake Beds (Ptb)

The Blake Beds are mainly silty to semi-pelitic metamorphic rocks, consisting dominant quartz and plagioclase with variable amount of biotite, sericite, carbonate and chlorite in some areas (e.g. the DBS area), but with dominant biotite in higher grade areas. The Blake Beds are poorly exposed in the region except in a few areas, e.g. the western DBS area and the MacFarlanes area. Outcrops of Blake Beds are rather massive with some layers of banded schists, some of which contain abundant boudinaged quartz. Detailed stratigraphic subdivisions of Blake Beds have been made by NFM from drill cores and the open cut pit at Callie. Some carbonate and calcareous thin layers have been encountered by deep drill in Callie deposit. These detailed subdivisions may be difficult to apply to the deeply weathered and poorly exposed Blake Beds at a regional scale and will not be further discussed in this report. The intersected thickness of Blake Beds in the DBS area is about 400-500 metres. As the basal boundary of the Blake Beds has not been penetrated, the precise thickness of the Blake Beds is unknown. A conformable contact between the Thomson Beds and Blake Beds is exposed in the area to the southwest of Mount Davidson.

Davidson Beds (Ptd)

The Davidson Beds always form ridges and highs in the region due to the characteristic cherty layers in the middle of the pile. The Davidson Beds can be divided into two sub-units, which can be roughly applied to regional geology. The lower sub-unit is pelitic schists, often with intercalated thin layers or bands of ferruginous schists, ferruginous chert and quartz-rich lithologies, but no intercalated graphitic schists. This lower sub-unit is represented by the ORAC Formation in DBS, and the Main Host Unit in the MLS8 area. The upper sub-unit is very similar to the lower sub-unit except for that it often contains well banded or laminated graphitic schist, and thin layers or bands of boudinaged manganeferous chert. More boudinaged chert bands appear in the upper sub-unit. This upper sub-unit is represented by the Schist Hill Formation (including SHIM) in the DBS area, and the Hangingwall Schist Unit (including the HW host Unit) in The Granites area. For small exposures of Davidson Beds, it was often difficult to decided whether they are of the upper or lower stratigraphic position within the unit. Detailed stratigraphic subdivisions of Davidson Beds have been made by NFM project geologists. Similar to that of Blake Beds, it has been difficult to identify these subtle subdivisions through the whole region, because the lithological markers do not occur continuously and they appear at different levels with different amount of intercalated other lithologies. The thickness of Davidson Beds in the DBS area can be measured as about 500 metres excluding dolerite sills. The Davidson Beds and Blake Beds are conformable, and the boundary between them are somewhat arbitrary.

The Blake Beds and Davidson Beds represent a rather quiet environment, low relief of the source land and deeper water in the depositional basin. Although the two units are relatively thin, they are likely to represent a much longer period than that of Thomson Beds.

Madigan Beds (Ptm)

The Madigan Beds are usually poorly exposed at sides of the ridges which were caused by erosion resistant Davidson Beds in the major part of our EL areas, however they are well exposed in the western area of the Tanami Block, where little Davidson Beds are exposed at the surface. Isolated patches of low outcrops of Madigan Beds are mapped throughout the whole region. The Madigan beds are a typical deep-water turbiditic sedimentary sequence. It consists of schistose greywacke, lithic arenite, siltstone and mudstone, or the phyllite. The thickness of each bed varies from centimetres to over a metre. Graded bedding was well developed in each bed with the coarse gritty sands deposited at the bottom with the silts or clays at the top. The detailed stratigraphy within the Madigan Beds has not been studied.

The Madigan Beds has been correlated to the major part of the KIlli Killi Beds, which was defined by Blake & others (1975), and are best exposed in the foot hills flanking parts of the Gardiner Range. The maximum thickness of the unit is unknown, but a minimum thickness of several thousand metres was estimated from aerial photographs.

"The greywacke is mainly medium to fine-grained, but is locally coarse and gritty. It is grey to greenish where unweathered, and generally forms beds about 1 m thick, some of which are graded. It is composed of sub-angular clasts, mostly of quartz, but also of quartzite, schist, tourmaline, zircon and feldspar, set in recrystallised fine matrix of quartz and sericite. With decreasing amount of matrix, the greywacke grades into lithic arenite, which is mostly coarse grained, containing rounder clasts and commonly shows cross-bedding. Siltstone forms beds generally less than 1 m thick interbedded with greywacke; some is laminated and shows small-scale low-angle cross-bedding." (quoted from Blake et al., 1979).

The Madigan Beds represent a more active subsiding geosynclinal phase of the basin. The source land around the basin must have been rapidly uplifted and eroded to supply detritus for the formation of greywacke - turbidite sequences. The wide spread distribution of the turbidite sequences implies a large source land of Archaean basement known in the south and east side of the orogen. The other possible palaeolands in the north and west side may be the basements of the Kimberley Basin, the Canning Basin and the Wiso Basin.

The Ptm in WA part of the Orogen is a thick sequence of metamorphosed turbidite sequence. The metamorphic grades vary from low green schist to low amphibolite facies at its lowest position. The strata are subdivided into three mapping units in the southern area, the lower (Ptm^a), middle (Ptm^b) and upper (Ptm^c), although the subdivisions within the Madigan beds are somewhat arbitrary.

The lower unit (Ptm^a) is poorly exposed only in the core of an anticline, which is mainly located in the northern part of Schultz Cairn (E80/1513). It consists of more fine-grained meta-sediments, i.e., meta-pelite and meta-siltstone with metamorphosed quartz veins, which has been folded and boudinaged with chert-like appearance on the surface. The diamond drill cores from Hatches Find intersected fresh Lithologies of Ptm^a , which sometimes show convincing graded bedding.

The middle unit (Ptm^b) forms the major part of the Billiluna area, and is conformably overlying the Ptm^a. The Ptm^b consists of mainly thick-bedded turbidite sequence. Each bed may show clear graded bedding with curved cleavage. This unit contains abundant dolerite sills, which provide magnetic markers for structural interpretation.

The upper unit (Ptm^c) exposes mainly in the middle part of the Billiluna Central (E80/1514). It is not remarkably different from the Ptm^b. It was mapped as different unit to show its relative upper position within the Madigan beds. It has a few characters: the first, it forms outstanding hills; the second, it has quartz-rich sandstone beds at its lower position; the third, it contains less dolerite sills and less magnetic lithologies. Unfortunately this subdivision can not be interpreted for the whole region from the magnetic image, so all Madigan beds are shown on the map as Ptm.

The contact between the Davidson Beds and Madigan Beds was largely a shear zone, however their original relationship was conformable. I did not see any evidence of unconformity relationship between the two units. Geologists of GSNT recently interpreted an unconformity between the two units without evidence.

4.1.2. DEFORMATION

The cycle 1 Tanami Group recorded six ductile deformation events, which caused ductile deformation and thermodynamic metamorphism. In addition to D1 to D5, a pre-D1 deformational event was recognised by the author since 1990. D1 was the orogenic deformation of cycle 1 Tanami Group. D2 to D5 were the influence from later sequential orogenic events.

Pre-orogenic deformation was labelled ED1, which was a long lived bedding parallel or subhorizontal shearing, which caused bedding parallel schistosity (ES1), recumbent folds (EF1), mineral and stretching lineation (EL1) and features caused by bedding parallel elongation (e.g. boudinage of competent layers or bands, sheathing of EF1 folds). During prolonged ED1, multiphase hydrothermal activities, sequential intrusion of granite sills and dolerite, and a progressive development of ES1 within the pre-D1 granite and dolerite provide marks for further subdividing of the ED1 event into ED1a, ED1b, ED1c and ED1d. ED1 were rather pervasive in Davidson Beds, Blake Beds and Thomson Beds, but discrete within the Madigan Beds.

D1 was a NW-SE oriented compressional event, which caused NE trending (F1) fold belt, or orogenic belt. Thermodynamic metamorphism caused new mineral growth and formed pervasive S1 schistosity and was probably responsible for the progressed metamorphism in one zone and retrogressed metamorphism in the next zone. Syn-orogenic magmatism occurred as syn-D1 gneissic granite. Post-orogenic acid magma intruded into the region and formed large plutons and plugs. These granitoid plutons partially cratonised the crust of the region.

D2 was a NE-SW oriented compressional event and caused refolding of F1 folds. Thermodynamic metamorphism also caused new mineral grow and formed pervasive S2 schistosity. Syn-D2 magma intruded into the strata along or cross cut S2 schistosity and formed foliated syn-tectonic tonalite dykes, which have been further metamorphosed and boudinaged during D2. D2 was the first deformation affected the Pargee Sandstone and caused NW trending tight folds and very low-grade metamorphism (see section 4.3.).

D3 was a NW-SE oriented compressional event, similar to that of D1, and caused refolding or kinking of F3 folds. S3 is mainly a crenulations of earlier formed schistosity. Examples of syn-D3 magmatism are NE trending foliated tonalite dykes which cross cut S2 but developed foliation, which parallel S3 in the Tanami Group. D3 was the first deformation affected the Tanami Mine Succession and caused NE trending folds in the Tanami Mine Succession without metamorphism.

D4 was a N-S oriented compressional event and caused large-scale E-W trending shear zones, faults and small-scale F4 folds. Syn-D4 magma intruded into the region and formed E-W trending foliation, which parallel to S4 in country rocks. D4 was the first deformation affected the Nanny Goat Creek Beds.

D5 was an ENE-WSW oriented compressional event and caused large-scale NNW trending faults and small scale F5 folds in the Tanami Group. D5 was the first deformation affected the Mt Winnecke Formation and caused northerly trending folds without metamorphism.

Structures related to D1, D2, D3, D4 and D5 can be identified in the field or on a map of much larger scale, however the structures in the Tanami Group are not shown on this 1: 500 000 map. The folds in the Tanami Group are shown by trend of layering.

4.2. CYCLE 1 ARUNTA OROGEN

4.2.1.INTRODUCTION

The Cycle 1 stratigraphic sequence in the Arunta Orogen is named the Yundurbulu Range Group (Py), which is mainly a high-grade metamorphic complex including the Mount Stafford beds (Pys), Weldon Metamorphics (Pye) in the Yundurbulu Range to Anmatjira Range area, the Yuendumu Metamorphics (Pyy) in the Mount Doreen area, and major part of the Division One of BMR in other areas. Only small outcrops of the Yuendumu Metamorphics (Pyy) are exposed in the southern area of the map, which I have not had a chance to study. With cautious I use Arunta Complex (Pa) to label the cycle 1 Yundurbulu Range Group (Py) plus possible cycle 2 Woodforde River Group (Pw) (see section 4.4.).

4.2.2. YUNDURBULU RANGE GROUP

The Yundurbulu Range Group (Py) consists of mainly granulite to upper amphibolite facies meta-sediments, meta-gabbro and meta-dolerite. Some of the meta-sediments have been migmatised by quartzo-feldspathic melts. The characteristic metamorphic mineral assemblages in meta-sediments are cordierite-biotite-sillimanite-andalusite-garnet-hypersthene-quartz and K-feldspar. The main metamorphic minerals in mafic rocks are two pyroxenes, hornblende and plagioclase.

The Mount Stafford beds (Pys)

This unit exposes mainly in the Yundurbulu Range area. It was assigned into Division 2 by BMR and correlated to their "Lander Rock beds". The Mount Stafford beds can be divided into three parts. The lower part is mainly granulite facies migmatite, layered migmatitic granulite and well bedded granulite with abundant mafic granulite. The middle part is banded migmatitic granulite and well layered granulite but lack of mafic granulite. The top part is mainly non-migmatitic amphibolite to transition granulite facies metasediments with graded texture which reflects graded sedimentary bedding. However the cordierite of high-grade metamorphic rocks have been partially replaced by biotite and muscovite during later retrogressive metamorphism.

The precursor of Mount Stafford beds can be interpreted as a clay-rich turbidite sequence. I correlated the higher-grade Mount Stafford beds of the Yundurbulu Group with the lower-grade Madigan Beds of the Tanami Group. Both are of the oldest Paleoproterozoic stratigraphic Group.

Weldon Metamorphics (Pye)

The Weldon Metamorphics (Pye) exposes mainly in the Anmatjira Range and comprises granulite to amphibolite facies gneisses and schists.

Yuendumu Metamorphics (Pyy)

The granulite to upper amphibolite facies rocks in the 1: 250 000 Mount Doreen Sheet and Mount Theo Sheet area were temporarily named the Yuendumu Metamorphics (Pyy), which includes K-feldspar-andalusite-sillimanite-cordierite felsic granulite, cordierite-biotite (-sillimanite) felsic gneiss, and K-feldspar-biotite-garnet-sillimanite gneiss. The texture of the Yuendumu Metamorphics (Pyy) is very alike to that of the Mount Stafford beds (Pys). The Yuendumu Metamorphics was intruded by the ~1880 Ma Ngadarunga Granite, which is not metamorphosed.

4.2.3. STRUCTURE

The Cycle 1 strata are interpreted to have been originally deformed by NW-SE oriented compression and formed a NE trending fold belt, which can be seen in the Yundurbulu Range area, the Anmatjira Range area and in the southeast part of the Reynolds Range area. The high-grade metamorphic rocks developed intense northeast trending lineation, which remains predominant even after the interference of northwest trending D2 structures. Isoclinal F1 folds are often seen at the outcrop scale. The NE trending D1 structures have been further deformed and interfered during D2 and formed northwest trending F2 folds, which can be seen in the Yundurbulu Range, the Anmatjira Range and the southeast part of the Reynolds Range. In the Yundurbulu Range area the F1 folds became recumbent before D2 reworking. It was further reworked during D3 and developed NE trending shear zones and F3 folds. It was uplifted and sheared during D4 before the intrusion of 1820 Ma Anmatjira Granite and Mount Stafford Granite, which were sheared by D6, folded by D7 and faulted by D8.

4.3. CYCLE 2 PARGEE OROGEN

4.3.1. INTRODUCTION

A second phase of extension occurred along NNE-SSW direction, perpendicular to the G3 Corridor, and two new orogens formed over the WNW trending extensional zone. The Pargee Orogen was formed in the Tanami region and the Napperby Orogen was formed in the Arunta region (see section 4.4).

4.3.2. PARGEE SANDSTONE

The sediments in the Pargee Orogen were deposited unconformably over the folded and eroded surface of the Tanami Group. The remaining Pargee Sandstone now occupies an area of about 20 km wide and 60 km long after folding and erosion. It must have been deposited in a much wider basin, as isolated outcrops of Pargee Sandstone spread in a zone as wide as 50 Km. The most extensive exposures of Pargee Sandstone are situated at the west and south of the Pargee Range, where 1500 meters strata can be measured. The Pargee Sandstone consists of interbedded sublithic, lithic and quartz arenite, and minor conglomerate and siltstone. The arenites are mainly poorly sorted and medium to coarse grained. Individual beds are generally about 1 metre thick. They commonly show cross-bedding, and some beds preserved ripple mark at bedding surfaces. Pebbly beds and conglomerate are present mainly near the base of the formation. Most clasts are subangular, and pebbles in the arenite and conglomerate can be matched with lithologies of the underlying Tanami Group. No granite pebbles has been seen within the formation, but many of the sands are probably derived from granite. Cleavages developed in the siltstone and indicate a very low-grade greenschist metamorphism

A break of metamorphic grade exists across the angular unconformity boundary. It is interpreted that the Tanami Group had been uplifted and eroded to certain degree to allow the exposure of metamorphosed Tanami Group and post-D2 granite plutons before the deposition of the Pargee Sandstone. No suitable rocks of the Pargee Sandstone can be dated, so the actual age of this unit is unknown. On the basis of regional consideration, the Pargee Sandstone should be younger than the post-D2 plutons but older than the Tanami Volcanics.

4.3.3. DEFORMATION

The Pargee Sandstone has been deformed by NNE-SSW trending orogenic compression and formed WNW trending fold belt. The folds in the Pargee Sandstone have wide closures but quite steep limbs, locally vertical or overturned.

The orogenic deformation affected the Pargee Sandstone was in fact the major D2 deformation affected the Tanami Group. The major fold belt of Pargee Sandstone has been refolded by regional D3, D4 and D5 and developed cleavages in siltstone.

4.4. CYCLE 2 NAPPERBY OROGEN

4.4.1. STRATIGRAPHY AND LITHOLOGY

The cycle 2 Napperby Orogen was recognised by the author at the first time in the Reynolds Range area. The stratigraphic sequence of the Napperby Orogen is named the Woodforde River Group (Pw). This Group is well exposed in the middle and southeastern part of the Reynolds Range, to the southeast of Algamba Bore. The BMR’s Wickstead

Creek beds to the southwest of Reynolds Range is correlated with this Group without direct evidence.

The Woodforde River Group is unconformably overlying the Yundurbulu Range Group, which was greatly uplifted and eroded before the deposition of Woodforde River Group to allow the typical granulite facies rocks exposed to the surface.

The metamorphic grades of Woodforde River Group vary from the upper greenschist facies around the Mount Thomas, to lower granulite facies towards the southeastern part of the Reynolds Range. The transition from higher grade to lower grade metamorphism has been observed through the continuously exposed lithological units. The high-grade metamorphism may be partially achieved by progressive metamorphism during later orogenic event. However, geological evidence shows that the Woodforde River Group reached sillimanite grade in many places before the deposition of Lander River Group

The Woodforde River Group formed the basement of Lander River Group and subjected to retrogressed metamorphism in positions adjacent to the basal Lander River Group.

The type Woodforde River Group can be divided into five sub-units. The basal sub-unit ($\underline{P}w^{a}$) is mainly a thick pile of quartz-sillimanite gneiss or sillimanite quartzite. This unit overlies the pelitic granulite of the Cycle 1 Weldon Metamorphics ($\underline{P}ye$) unconformably at the Woodforde Anticline. The second sub-unit ($\underline{P}w^{b}$) is mainly cordierite-andalusite-sillimanite-biotite gneiss and thin package of quartzite with mafic granulite in high-grade area. However the ($\underline{P}w^{b}$) is biotite spotted meta-siltstone/argillite and meta-quartz sandstone in the low-grade area. The third sub-unit ($\underline{P}w^{c}$) is an interbedded sequence of psammitic sillimanite-quartzite / felsic gneiss and pelitic cordierite-biotite-sillimanite quartzo-feldspathic gneisses in high-grade area, but interbedded meta-quartz wacke and quartz-mica schist (meta-pelite) in the low-grade area. Cross bedding and ripple mark are well preserved in meta-psammite, particularly in the low-grade meta-quartz wacke. The forth sub-unit ($\underline{P}w^{d}$) is a sequence of interbedded marble, dolomite, calc-silicate rocks, pelitic schist, gneiss and quartzite of various metamorphic grade. The fifth sub-unit ($\underline{P}w^{e}$) is mainly a thick pile of pelitic schist or gneiss and well exposed at the Mount Freeling.

The precursor of the Woodforde River Group was thinly bedded, well-sorted shallow water sediments, including mature quartz sandstone, siltstone, argillite, particularly carbonate-rich rocks. This character can be traced from the area to the west of Giles Range through whole Reynolds Range to the Strangways Range in the eastern Arunta Inlier.

4.4.2. STRUCTURE

The Woodforde River Group was originally deformed by NNE-SSW oriented compression and formed a WNW trending Cycle 2 fold belt, which parallels the G3 lineament. The cycle 2 folds are very tight to isoclinal. The layer parallel fabrics within the Woodforde River Group have been folded and refolded several times. The cycle 2 structures have been further deformed and interfered during later orogenic events, particularly during D6 and D8.

4.5. ARUNTA COMPLEX

The detailed information of the cycle 1 Yundurbulu Range Group and cycle 2 Woodforde River Group were originated in the area out of this map. It was impossible to differentiate Py from Pw in the map area by means of geomagnetic interpretation. So a temporal term, Arunta Complex (Pa) is used on the map to include both cycle 1 and cycle 2 strata and some granitoid bodies.

4.6. CYCLE 3 TANAMI MINE RIFT

4.6.1. INTRODUCTION

Deformed Pargee Sandstone and Woodforde River Group were uplifted and partially eroded in places, particularly at both limb areas of the cycle 2 fold belts. A third phase of extension occurred along the WNW-ESE direction. Localised rifting occurred along the Tanami Mine Lineament in the Tanami region, while large orogen developed in the Arunta region.

4.6.2. TANAMI MINE SUCCESSION

In the Tanami Mine Rift Basin shallow water detrital arenite and mudstone were deposited at the lower section of the strata, whereas pillow basalt flows and tuff beds were deposited at the upper section with interbedded sedimentary beds. The stratigraphic sequence in the rift is named the Tanami Mine Succession (Pm). This unit is poorly exposed and the main information was obtained from the open cut pits of the Tanami Gold Mine. The Tanami Mine succession is considered part of the Halls Creek Group to the northwest and is likely the stratigraphic equivalent of the Lander River Group to the southeast.

This unit was called Tanami Volcanics and interpreted as part of the Mount Charles beds by BMR workers (Blake et al. 1975). In my first regional report in 1991, it was concluded that the Tanami Volcanics do not show evidence of ductile deformation and metamorphic fabrics, and thus must be a unit of Cover sequences. The strata around Tanami Gold Mine was also recognised as cover sequence by Nicholson (1990). However, non of us have direct evidences. The evidence I used was the deformational relationships between the Pargee Sandstone, the Tanami Volcanics and the Tanami Group

4.6.3. STRUCTURE

The Tanami mine Succession have been deformed by a NW-SE directed compressional event and formed NE trending open fold without development of schistosity. The dips of fold limbs may vary from 20 to 40 degrees, however the dips could be steeper nearby faults. The cycle 1 Tanami Group and cycle 2 Pargee Sandstone were both refolded by cycle 3 deformation, however the cycle 3 folds is the second phase of fold in the Pargee Sandstone but the third phase of fold in the Tanami Group.

4.6.3. MINERALISATION

Gold mineralisation occurred in a northerly trending fracture system, which may be related to the northeast trending cycle 3 faults, which confine the extent of the Tanami Mine Succession.

4.7. CYCLE 3 LANDER RIVER OROGEN

4.7.1. STRATIGRAPHY AND LITHOLOGY

The stratigraphic sequence in the Lander River Orogen is named the Lander River Group (Pl). Evidence shows that the Lander River Group is unconformably overlying the Cycle 2 Woodforde River Group and the cycle 1 Yundurbulu Range Group. The lithology of this Group is mainly a low-grade metamorphosed turbidite sequence with few quartz-rich meta-sandstone or quartzite, but lack of shale and meta-carbonate rocks. The Lander River Group can be divided into two sub-units:

The main and upper part ($\underline{P}l^b$) is a greenschist facies thick-bedded turbidite sequence of interbedded greywacke, arenite, siltstone and shale. Cross bedding or cross lamellar were occasionally developed in typical low-grade meta-sedimentary rocks of Lander River Group or in high-grade hornfels of typical Lander River Group. It can reach to lower amphibolite facies in places, particularly at the bottom of this sub-unit.

The basal unit ($\underline{P}l^a$) is thinly bedded quartz-sandstone, pebbly sandstone and conglomerate, which often experienced lower amphibolite facies metamorphism. The metamorphic minerals occurred mainly in the matrix of psammite, whereas the detrital sands remain sedimentary characters.

The Lander River Group is unconformably overlying the Cycle 2 Woodforde River Group within the Cycle 2 fold belt, but directly overlying the Cycle 1 Yundurbulu Group outside the Cycle 2 fold belt. This relationship implies that the Cycle 2 strata have been intensely eroded in the area to the northeast of Lander Fault and in the area to the southwest of Reynolds Range.

The Lander River Group was mapped as Lander Rock beds by BMR and other geologists, and was assigned into Division 2 of BMR without evidence of direct relationship with their Division 1. The "Lander Rock beds" was recently interpreted as the oldest strata in the region by GSNT in their new Geological Map series Mount Doreen sheet.

The Lander River Group was preserved in the NW Arunta to the south and southeast of Tanami Block. The Lander River Group and the Warramunga Group in the Tennant Creek Inlier are interpreted as the time equivalents.

4.7.2. STRUCTURE

The Lander River Group is interpreted to have been originally deposited in an NE trending orogen and deformed by NW-SE oriented compression during D3 and formed a gentle NE trending Cycle 3 fold belt. Its basal unconformity boundary has been observed in several places, although in most cases the boundary was poorly exposed or reworked as a shear zone. An excellent exposure of the unconformity has been observed in the location 3 km northeast of the Mount Thomas. The contact between the two groups are almost vertical and forms very steep slops of small cliffs without any cover of soil or scree. The basal conglomerate and pebbly sandstone of the Lander River Group have been strained but the sandstone retain cross bedding, which shows younging direction towards the northeast, in other words, towards the turbidite sequence of the typical Lander River Group. The sandstone or quartzite below the conglomerate is the sub-unit 3 ($\underline{P}w^{c}$) of the Woodforde River Group. The cross bedding in the strata below the unconformity shows consistent younging direction towards the southwest.

The cycle 3 structures have been clearly reworked by later events. The present trend of major folds in the Lander River Group is WNW. The evidence of fold interference is provided by the very steep (or vertical) plunges of the fold hinges. It means that before the WNW trending folds were developed, the Lander River Group had been tightly folded. The structure in the Lander River Group has not been studied in detail by myself.

4.8 CYCLE 4 OROGEN

The Nanny Goat Creek Beds was described as lateral equivalent of the Mount Charles beds by BMR. It is an acid volcanic sequence with intercalated sedimentary beds. Structural study shows that the Nanny Goat Creek beds were much younger than the Tanami Group, because the former developed two foliations only. The earlier metamorphic foliation in the acid volcanic rocks was reworked to form crenulations. This unit was reinterpreted as Paleoproterozoic cycle 4 Nanny Goat Creek Beds ($\underline{P}n$), which can be correlated with the Whitewater Volcanics (~1850 Ma) in the Kimberley region.

A few cycle 4 granitoids ($\underline{P}g^{4}$) intruded into the Tanami Group during cycle 4. A N-S oriented compression caused several regional scale E-W trending cycle 4 faults and shear zones in the Tanami Group. The Foliation in the tonalite also trends east-west with steep dips. One of the foliated tonalite gives zircon age of ~1845 Ma.

4.9. CYCLE 5 OROGEN

The Supplejack Downs Sandstone and the Mount Winnecke Formation were described as the post-orogenic cover sequences of the Tanami Complex and correlated to the Pargee Sandstone. An unconformity boundary has been observed between the Supplejack Downs Sandstone and the Nanny Creek beds. My own study recognised that the two formations are not post-orogenic cover sequences, but strata of another orogen, the cycle 5 orogen. So the Supplejack Downs Sandstone (Ps) and the Mount Winnecke Formation (Pw) are re-assigned into Paleoproterozoic cycle 5.

4.9.1. THE MOUNT WINNECKE FORMATION

The Mount Winnecke Formation consists of lithic quartz sandstone and minor acid lava flow. It remains 4800 m in thickness after deformation and erosion. The acid lava was dated as about 1815 Ma.

4.9.2. STRUCTURE

The Mt Winnecke Formation has been folded under the compression at the direction perpendicular to the G2 lineament and formed N to NNW trending moderate to tight folds The dips of fold limbs are usually 40 to 50 degrees, but steep or vertical near fault zones.

4.10. POST CYCLE 5 GRANITOIDS

Some undeformed granitoids have been dated and grouped into cycle 6 granitoid (Pg6). However most of the granetoids are poorly exposed and undifferentiated (Pg). In the Mt Winnecke area, large scale Winnecke Granophyre intruded after D5 and occupied an area over one thousand square kilometres. The Rb-Sr age of the Winnecke Granophyre is about 1800 Ma.

The famous The Granites granite is an undeformed magnetic potassium-rich porphyrytic biotite adamellite. Its size may be up to 10 square kilometres, although its outcrop area is much smaller. It is a post-orogenic intrusive body and cross cut all phases of fabrics within its country rocks of Tanami Group and thus provides evidence for its maximum age of post-D5. Its zircon U-Pb age is 1800 +/- 2 ma (Cooper 1994). The post-D5 The Granites Granite is magnetic. This character has caused confusion in interpretation.

The Lewis Range Granite is undeformed post-tectonic batholith (~1800 Ma), which usually exposed below the cliff of cover sandstone.

The undifferentiated granitoid (Pg) includes granites in all ages. In fact, most of the granites have not been studied by geochronologists. The outcrops of granitoids mapped by survey geologists have been compiled into this map, however the majority of the granite on this map are interpreted from the magnetic image.

5. MESOPROTEROZOIC

Mesoproterozoic Birrindudu Group (Pd)

This Group includes Coomarie Sandstone, Talbot Well Formation and Gardiner Sandstone. Lithologically it comprises sublithic arenite, quartz arenite, siltstone, shale, conglomerate and minor dolomitic sandstone. The Gardiner Sandstone includes a whole range of detrital sediments from conglomerate, pebbly sandstone to quartz sandstone. It is characterised by well rounded sand grains, thick beds, fluvial type cross bedding and ripple marks. Its thickness vary from 600 to 2250 metres.

The Mesoproterozoic to the west of Tanami region includes Carpentarian Ima Ima Beds (Pum), the Carpentarian Baines (Pup) and the Carpentarian Pindar Beds in western Birrindudu Basin (Pc), and the Carpentarian Bungle Bungle Dolomite to Albert Edward Group in unnamed basin to the northwest of the region (Ps-Pa).

The Mesoproterozoic cover sequence (Pd) has been moderately deformed to form upright folds and cut by faults. The structures affected the Gardiner Sandstone are usually wide open domes and basins, however on the basis of structural analysis, it is interpreted that the Gardiner Sandstone may have been firstly deformed by a gentle NW-SE compression and formed NE trending open folds, which usually dips 15 to 30 degrees at its limb area. The dome and basin shaped structures were attributed to the interference of later deformations.

The Mesoproterozoic deformational should have influence to the Paleoproterozoic sequences. For example the Tanami Mine Succession may have been further tilted when its cover sequence, the Gardiner Sandstone, was deformed to be a NE trending anticline. Tilting of other older sequences is also possible, but this gentle deformation has not been seriously studied.

6. NEOPROTEROZOIC

The main Neoproterozoic strata are assigned into the Adelaidean Red Cliff Pound Group (Pr). According to BMR, the Red Cliff Pound Group includes three laterally equivalent formations, the Muriel Range Sandstone in the eastern region, the Lewis Range Sandstone in the northwestern region and the Munyu Sandstone in the southwestern region, and two sequencial formations, the overlying Murraba Formation and the youngest Erica Sandstone. The Muriel Range Sandstone was mainly mapped in The Granites Sheet and consists of 450 metres sublithic arenite, quartz arenite, minor siltstone, and shale, with conglomerate, arkose, and breccia at base of the Formation.

Different names were used for the Neoproterozoic (Pu) in the northwest corner of the map, including the Adelaidean Boee Beds, Jawilga Beds and Denison Beds. Lithologically they all comprises sublithic arenite, quartz arenite, siltstone, shale and conglomerate. Another name, Adelaidean Hidden Basin Beds (Pui), appears in the southwest corner of the map.

The Neoproterozoic cover sequence has also been generally deformed to form open folds and cut by faults. The dips of beds generally vary from 5^{o} to 10^{o}. However where a fault is nearby, the dips of the Neoproterozoic strata can be up to 50^{o}. Most of the faults are normal faults except in the southwest area, where curved shallow dipping thrusts may occurred after the development of a fold belt in Pr.

7. PALEOZOIC

The Paleozoic includes the Cambrian Antrim Plateau Volcanics (Cla) and undivided Paleozoic (Pz) from Cambrian to Permian in the Canning Basin Succession and Wiso Basin Succession on national maps.

The Cambrian Antrim Plateau Volcanics (Cla) are distributed between the Canning Basin and the Wiso Basin, along the northeast trending Tanami Lineament, and forms flat lying caps of the folded Proterozoic strata and granitoids. It consists of mainly tholeiite basalt with minor intercalated sediments. This unit is almost unfolded, but developed fractures and faults.

The details of each unit within the undivided Paleozoic (Pz) can be found from the map of BMR. The strata deposited since Cambrian were actually unfolded on the regional scale, although they could be significantly tilted against faults.

REFERENCES FROM AUTHOR'S WORK PAPERS

Cooper, J.A. and Ding, P, 1989. **Zircon ages constrain the timing of deformation events in The Granites-Tanami region, Northwest Australia.** *Australian Journal of Earth Sciences,* 44, 777-787.

Ding, P., James P.R. and Sandiford, M., 1992. **Late Proterozoic deformation in the Amadeus Basin, Central Australia.** *Australian Journal of Earth Sciences,* 39, 495-500.

Ding, P. and James, P.R., 1989. **Crustal-scale ductile systems in the Arunta Inlier, Central Australia – Discussion.** *Tectonophysics, Volume 158,* No.1-4, 67-69.

James, P.R. and Ding, P., 1988**. 'Caterpillar tectonics' in the Harts Range area: A kinship between two sequential Proterozoic extension-collision orogenic belts within the eastern Arunta Inlier of Central Australia.** *Precambrian Research, 40/41,* 199-216.

Oliver, R.L., Lawrence, R.W., Goscombe, B.D., Ding, P., Sivell, W.J. and Bowyer, D.G., 1988. **Metamorphism and crustal consideration in the Harts Range and neighbouring regions, Arunta Inlier, Central Australia.** *Precambrian Research, 40/41,* 277-295.

Ding, P. and James, P.R., 1985. **Structural evolution of the Harts Range area and its implication for the development of the Arunta Block, Central Australia.** *Precambrian Research, 27,* 251-276.

ABSTRACTS PRESENTED TO CONFERENCES

July 1999, “Orogenesis in the Outback”. Alice Springs, NT (GSA Abstracts No. 54).

- Field evidence for five palaeoproterozoic orogeniesin the Northern and Eastern Arunt orogenic province, central Australia.
- Cyclic orogenies in the Halls Creek Region, WA – Field evidence.

February 1999. “The Specialist Group in Tectonics and Structural Geology Field Conference”, Halls Gap, Vic. (GSA Abstracts No. 53).

- Palaeoproterozoic orogenies in Northern Australia and their Tectonic implication

December 1997. “Geological Structures and their Geophysical Signatures” Marysville, Vic.

- Geophysical Lineaments and their associated geological evolution in Northern Australia – The Lineaments Tectonism.

September 1997. “Palaeoproterozoic Tectonics and Metallogenesis”, Darwin NT.

- Palaeoproterozoic Geological Events and Gold Mineralisation in the Halls Creek-Granites-Tanami Orogenic Domain, Northern Australia, in AGSO Record 1997/44.

August 1996. “30th International Geological Congress”, Beijing, China.

- Early Proterozoic Orogenic Events in Northern Australia and their Tectonic Implications.
- Extensional Tectonism: Pre-Orogenic Deformational History and its Associated Metamorphism, Magmatism and Hydrothermal Activity within the Early Proterozoic Tanami Group in The Granites-Tanami Block, N.T. Australia.

February 1994. “The Specialist Group in Tectonics and Structural Geology Field Conference”, Jindabyne, NSW (GSA Abstracts No. 36).

- “Structural and Tectonic Evolution of the Northern Australian Orogenic Province in N.T. Australia.

June 1993. “International Symposium on Gold Mining Technology”, Beijing China.

- Geological Setting of Gold Mineralisation in the Tanami Region, Northern Territory, Australia (P. Ding and C. Giles)
- Timing of Deformational Events with Respect to Gold Mineralisation in the Tennant Creek Goldfield, Northern Territory, Australia.

February 1989. “Specialist Group in Tectonics and Structural Geology Conference”, Kangaroo Island, SA.

- Late proterozoic deformation and the evolution of the northern margin of the Amadeus Basin (P. Ding et al).

February 1987. “International Conference on Deformation of Crustal Rocks”, Mt Buffalo, Australia.

- The Harts Range Mobile Belt: A short-lived Proterozoic Intraplate Orogen from the Eastern Arunta Inlier of central Australia. (P. Ding & P.R. James).

February 1984. “Specialist Group in Tectonics & Structural Geology Conference”, Bermagui, NSW.

- Teclonic evolution and fabric development of the Arunta Complex in the Hart Range, Central Australia. (P.R. James et al)

August, 1983. “International Symposium on Crustal Evolution”, Beijing, China.

- Structural evolution of the Harts Range area and its implication for the development of the Arunta Block, central Australia.

February 1983. “Sixth Australian Geological Convention”, Canberra, Australia (GSA. Abstracts No.9).

- Structural Evolution of the Harts Range Group, central Australia (P. Ding et al).