Structure, Sedimentology and Detrital Zircon U-Pb Analysis of Burra Group Rocks in the Southern Willouran Ranges

Thesis submitted in accordance with the requirements of the University of Adelaide for an Honours Degree in Geology.

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TITLE

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ABSTRACT

Neoproterozoic geology of the Adelaide rift complex is comprised of extremely thick sedimentation of deep subsidence; with very few breaks in sedimentation. In this respect the Adelaide rift complex becomes an ideal place to study this passive margin type setting and to study arrangement of continents. This study will use field mapping to determine paleo-stresses by measuring strain through field mapping. Furthermore, analysing U/Pb geochronology on detrital zircons through LA-ICP-MS to determine provenance and perhaps narrow down age of deposition. The area hosts a broad syncline anticline pair with maximum principle stresses of 60NE 240SW which matches up with shortening direction in the area for Delamarian orogeny. For the Copley Quartzite Formation, the primary sediment input was 1690-1750Ma which correlated with the Gawler Craton's Kimban orogeny and secondary peak at 2250-2500Ma which matched the Gawler craton's Sleaford orogeny. The Skillogallee Dolomite Formation had its major peak at 1020Ma which didn't correlate with any known local sources and warrants speculation on exotic source terrains such as the Ottowan orogeny and the Sunsas province of North and South American continents which were juxtaposed against Australia at the time. The Skillogallee Dolomite still has a major peak at 1660Ma which can be attributed to both the Upper Willyama supergroup of the Curnamona Province and the Kimban orogeny of the Gawler Craton. Structurally the region likely experienced only one deformational event due to its simplistic strain history observed; although nearby areas such as the Peake and Denison ranges have a more pronounced Alice Springs orogeny strain history. The provenance of the Copley Quartzite formation is dominated by Gawler craton sourced sediments. The primary peak of the Skillogallee formation does seem to have a source that cannot be explained by currently known Australian sources and more likely is from the Ottawan orogeny or Sunsas province.

KEYWORDS (LEVEL 1 HEADING)

Provenance, Structure, Skillogallee Dolomite, Copley Quartzite, Sunsas Province, Gawler Craton, Musgraves Province, Ottawan Orogeny

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INTRODUCTION

Work into understanding the structure of the region is extensive but perhaps non-specific and can be useful for surface lithological boundary relationships, subsurface interpretations were influenced by the theory of Earth expansion and as such are unreliable (Mawson & Sprigg, 1950; Murrell, 1977; Preiss, 1987). Sprigg (1984) mapped out the uranium field nearby and recalled the history of the nearby Arkaroola and Mt painter inlier in the northern flinders ranges area (Sprigg, 1984). Mawson 1949 defined the Elatina glaciation period in the flinders (Mawson, 1949). Preiss (2000) defined the Adelaide geosyncline and discussed the tectonism associated with the lithostratigraphic units being deposited at the time (Preiss, 2000). Modern studies interpret the structure of the Willouran Ranges to include three deformational fabrics for the Burra group: D1, D2 and D3. D1 for the Burra group is inclined folds with moderate to steep dip verging South-East. D2 was supposedly attributed to the Delamarian orogeny with N-S shortening with left lateral directed transpression. This event inverted the formerly extensional Norwest fault causing basin inversion and cessation of sedimentation (Mackay, 2011). Large variations in formation thickness across the Willouran are associated with ancient paleogeography of the depocentres and their proximity to basin edges (Murrell, 1977). As a result, rheology, chemistry and geometry of Burra group rocks are heterogeneous across the Adelaide Rift Complex (ARC) and preserve varied deformational histories. For example, Mackay's (2011) interpretations may not be precisely reflected at Termination Hill but can still serve as a foundation for initial interpretations.

Work done on the Burra group to determine age and source in the Willouran have yielded an age of initial maximum deposition of 777±7 Ma, based on penecontemporaneous intercalated Boucat volcanics (Preiss & Cowley, 1999). The upper limit is poorly constrained and based on a shallow intrusion in a Curdimurka unit thought to be correlative with the Skillogallee dolomite. The Rook Tuff, interlayered in the Curdimurka Subgroup dated at 802±10 Ma(Fanning, Ludwig, Forbes, & Preiss, 1986); however Mackay (2011) puts this data down as being spurious. Nowhere in Mackay's (2011) was mapping of the Curdimurka magnesite noted. Furthermore, they do not note the same amount of carbonates mapped by Belperio (1990). Mackay notes how characteristic of a feature the magnesite beds are in the Skillogallee and the amount of carbonates and says that as such the Curdimurka Subgroup cannot be considered correlative.

Until now this area has never been field mapped in as much detail, as previous studies have only relied on aerial photographic interpretation and gravity data (Mackay, 2011). This study aims to improve on current structural model of Termination Hill. Specifically, it will better constrain time of deposition and the source region of sediment input that formed the Burra group. Additionally, my work is going to prove that the fold orientation in the area correlates with the stress field in the Delamarian orogeny, which will contribute to the deformational model of the ARC.

To identify the structure, I undertook a field mapping exercise and produced multiple stereo nets to understand regional stress regimes. To better constrain age, Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS) on detrital zircons found in Burra group rocks to constrain maximum age of deposition. Using the zircon data and analysing other zircon data sets in the region will identify possible source regions for the sediments.

GEOLOGICAL SETTING/BACKGROUND

Introduction

Australia hosts one of the best preserved records of the Neoproterozoic period in the Adelaide rift complex. The Adelaide rift complex has been grouped into the Adelaidean System which has four chronostratigraphic subdivisions set by Preiss (1987) these are the Willouran, Torrensian, Sturtian and Marinoan the Warrina Supergroup, particularly the Burra group, is composed of shales, magnesite containing carbonates (Skillogallee dolomite) and sandstones. These were deposited during the Tonian to Cryogenian 1000-720Ma period. However, the Burra group is poorly constrained in this time period. The focus area will be the Adelaide Rift Complex's' Torrens hinge zone in the South-Western section of the Willouran ranges a locality known as Termination Hill.

Body

Palaeogeography and Depositional environment

The Burra group has an approximate time of deposition of middle Tonian. At which time Australia was part of Western Laurentia in close proximity to East Antarctica (Li et al., 2000). Using the *South Western America next to East Antarctica* hypothesised arrangement, put forward by Dalziel (1991) and Moores (1999), Australia was in the northern hemisphere with East Antarctica (Z.-X. Li, Li, Zhou, & Kinny, 2002; Z. X. Li, Linghua, & Powell, 1995) to its south, South China to its immediate northwest. Laurentia – encompassing Australia- lies east-south east (Z. X. Li et al., 2008) on top of the predicted super plume, where it is modelled that Australia separates westwards away from Laurentia towards India. Preiss (2000) suggests that this superplume became a spreading centre and that the ARC was the aulacogen. Mackay (2011) mentions a number of other possible configurations such as AUSWUS (Australia – Western United States), where the Willouran Trough is adjacent to southern California (Burrett & Berry, 2000) (Karlstrom et al., 1999; Burrett and Berry, 2000)(Figure 9).

The Burra group depositional environment was an inland sea setting consisting of a number of interconnected, linear basins where there was active down warping or block faulting (Murrell, 1977). This setting led to a marginal marine to lagoonal depositional centre that is evidenced by shallow marine facies sandstones and sandy siltstones. Then marine inundation due to thermal sag allowed deposition of intertidal magnesite bearing carbonates such as the Skillogallee dolomite (Preiss & Forbes, 1981). As a result, what we see, according to Preiss et al., (1981) is a number of West-derived deltaic cycles and magnesite bearing platform carbonates in the Burra group, which alludes to the Gawler Craton as a potential source region for sediments. The Adelaide Rift Complex is split into two supergroups; the lower one (Warrina Supergroup) is split into two Groups; the Callana group (including the Arkaroola sub-group and the Curdimurka sub-group) and the Burra Group (including the Emeroo, Mundallio subgroups and the overlying Myrtle Springs Formation in the northern Flinders)(Preiss, 2000). The Heysen Supergroup overlies the Burra Group and includes the Umberatana and Wilpena Groups. The overall tectonics of the Warrina Supergroup, which contains the Burra Group reflects the initial intracontinental rift development in the Adelaide Rift Complex; Furthermore, the Heysen Group, which contains the Umberatana Group, (overlies Burra group) reflects the break-up of Rodinia, demonstrating the transition to a passive margin (Mackay, 2011; Preiss, 2000).

Deformational history

After the deposition of the Burra Group and its deltaic type sandstone, siltstone and carbonate cycles, came a number of deformational events which is today evident in altered geometries and structures of the Burra Group rock beds. These changes can be seen throughout the Adelaide Rift Complex with minor locally restricted events such as salt diapirism associated with certain evaporite beds in the North-West of Termination Hill.

There has been extensive work done on structural deformation and identifying deformational fabrics of areas surrounding Termination Hill. Work done by Mackay (2011) has given the best general interpretation on deformational events: one prior to or during the deposition of the lower Burra group and the main one being the Delamarian orogeny which led to basin inversion.

An essential part of the area was the Torrens hinge zone; which acted as a platform area in the basin development and began to subside as the Burra group began to deposit as a result of the developing intracontinental rift (Mackay, 2011; Preiss, 1987).The 3 pervasive deformational fabrics Mackay (2011) suggests are D1 D2 and D3. The D1 folds are inclined with moderate to steep verging as you approach the south east (Mackay, 2011). Murrell (1977) interprets that the Burra group Umberatana group contact rocks are of different deformational fabrics due to their different styles of deformation. Later interpretation by Mackay (2011) interprets this to be more likely a result of the rheological difference over the area from western and northwest Willouran and draws his conclusion from the similar plunge and plunge direction between the contact rocks. Evidence for fluctuations and alternations in fault activity resulting from the movement of Australia breaking away from Rodinia varied stresses from extensional in the intracontinental rift setting, transpressional during the Delamarian orogeny. Not all the events are known however, and there are likely to be more less obvious changes in between events.

D2 was an activation of north-south shortening with a left lateral transpressional regime inverting the formerly extensional Norwest fault to a reverse fault, resulting in basin inversion of the Willouran trough; this phenomenon inverted the north west trending folds, F2, with upright inclined steep angled folds towards the north east and possibly axial planar cleavage(Mackay, 2011). D2 was likely due to the Delamarian orogeny, evidenced by refolding of Burra group rocks. The Delamarian Orogeny began when the paleo-Pacific margin of Australia changed from a passive to a convergent margin, with western directed subduction and accretion at the continental margin (Mackay, 2011). Another point of contention regarding deformation in the Willouran range is thin-skinned vs thick skinned deformation. However, most authors, such as Backé et al., (2010) favour thick skinned deformation. Backé et al., (2010) modelled potential fields in the area and favoured thick skinned deformation with diapirs being associated with basement penetrating normal faults.

Provenance

The geochronology of the Burra group shows that it commenced at approximately 777Ma, however the upper limit is not precisely known (Mackay, 2011). There is 'spurious' data on an intrusion in the Skillogallee dolomite dating it at 797 ± 5 Ma, this shallow intrusion is supposedly thought to be from clasts of the oodla wirra volcanics which implicates the Curnamona province. According to Preiss et al., Most of the clastic sediment, especially in the Burra and Wilpena Groups, had a westerly provenance (Preiss & Forbes, 1981) This would allude to the source being erosion from the Gawler Craton. Other likely sources based on proximity and timing could be the Curnamona Province or the Musgrave Province.

METHODS

Mapping

Detailed Mapping was undertaken on 1:10000 scale traverses across the Termination Hill area. Allowing for detailed measurements around key features using aerial map photographs.

Sedimentary logs were taken on 4 well exposed areas on the contact between lithological boundaries with ~100m transects 90^{o} to strike.

Stereonets were made with structural data gathered in the field and plotted up using the program Stereonet 9(Cardozo & Allmendinger, 2013).

Provenance

Zircons were separated from five samples by standard density separation and Frantz magnetic techniques, then mounted on epoxy discs, polished with lathe and then imaged using a Gatan cathodoluminescence analyser attached to a Phillips XL20 scanning electron microscope. U–Pb zircon geochronology was undertaken using LA-ICP-MS at Adelaide Microscopy following the methods of (Payne, Ferris, Barovich, & Hand, 2010). Zircons were ablated with a New Wave Research UP-213 laser using a spot size of 30 μm, frequency of 7 Hz and intensity at 75%. Isotopes (^{206}Pb/^{238}U, ^{207}Pb/^{235}U, 207Pb/206Pb and 208Pb/232Th) were measured with the attached Agilent 7500ccx series Inductively Coupled Plasma Mass Spectrometer. Information was processed using iolite (Hellstrom, Paton, Woodhead, & Hergt, 2008; Ludwig, 2003) and R (Vermeesch, Resentini, & Garzanti, 2016).

OBSERVATIONS AND RESULTS

SEDIMENTOLOGY

The map fig 12 shows the arrangement of units in our area and the paths taken for each sedimentary log. The oldest unit in the mapping area is the Copley Quartzite Formation which is overlain by the Skillogallee Dolomite Formation. The two other units are the Bolla Bollana Tillite and the youngest unit the Tapley Hill Shale. With the aim of better understanding the depositional environment of the Burra Group, sedimentary logging was undertaken in key areas fig 13 shows localities and chosen paths of logs. In the mapping phase 4 distinct mappable units were chosen the Copley Quartzite, Skillogallee Dolomite, Bolla Bollana Tillite and the Tapley Hill Shale with vastly different depositional environments. This text will focus on the Copley Quartzite and the Skillogallee Dolomite as a companion Honours thesis focuses on the upper formations (Shahin 2016). In the interest of having a brief description of all units in mapping area; the Bolla Bollana Tillite consists of poorly sorted diamictites with interbedded silts and shales. Complex sorting and morphology within diamicts occurs throughout the successions, commonly containing dolomite, sandstone and quartzite clasts. Tapley Hill Shale is made up of a thick shale bed of metre scale size with a small conglomerate band running through its base.

Table 1 Sedimentary interpretation table

Lithofacies	Characteristics	Interpretations	Association
Skillogallee Dolomite Formation: Crystalgal dolomites Shale Siltstone Grainstone	Clay to grainstone sized grains Chert pseudomorphed Stromatolites Thinly interbedded sandy shales and Dolomite Chert nodules Magnesite beds	Intertidal to Playa lake	Shallow water to emergent.
Copley Quartzite Formation: Sandstones Quartzites	Fine to coarse grained Low-angle cross beds Parallel laminations Minor siltstone interbeds Rip up clasts	Braided stream	Fluvial

COPLEY QUARTZITE FORMATION FACIES ANALYSIS

The Copley Quartzite Formation in the Termination Hill region underlies the Skillogallee Dolomite Formation and is thought to overly the Callana Group. It is a fine to coarse grained sandstone dominated facies with minor siltstone in the form of rip up clasts and very fine inter-beds (figures 4, 5). A few beds have silty matrix but are generally well sorted. Colour is usually yellow to pale grey in outcrop, in some cases weathered surfaces are reddish. The main feature is the low angle cross beds and parallel laminations. The selected section had minimal breaks in exposure relative to the region. Lateral extent in the Termination hill locality is one to four thousand metres

(Figure 12) and the true thickness of the unit was approximately just over one thousand metres (Figure 11). This unit has a sharp contact between it and the Skillogallee Dolomite unit.

The defining characteristics of the Copley Quartzite unit are parallel laminations near the base with finer grains coarsening upwards. Further up in stratigraphy you encounter more quartzite's (Figure 2f, 2g) and low angle cross beds with symmetric ripple features (Figure 2f, 2g). Towards the base of our log there is a rare example of rip up clasts of siltstone 2-5cm in size (Figure 2c). The Copley Quartzite Formation is very quartz rich with very little lithic material.

Interpretation

The parallel lamination facies would indicate anoxic or high sedimentation rate type conditions, so high that bioturbation was unable to occur. Seeing as Ripples are also present, this could indicate a lacustrine shallow environment or a river bar in a braided stream. Rip up clasts could be either related to lag deposits or more likely the subaqueous dunes and bars which would benefit the idea of braided stream setting. The low-angle cross-beds topped by symmetric ripples observed in fig 6G on the top quartzite indicates a decrease in flow regime. Low angle cross-beds are indicative of fast currents carrying large amounts of suspended sediments this would make a lot of sense in a braided stream setting.

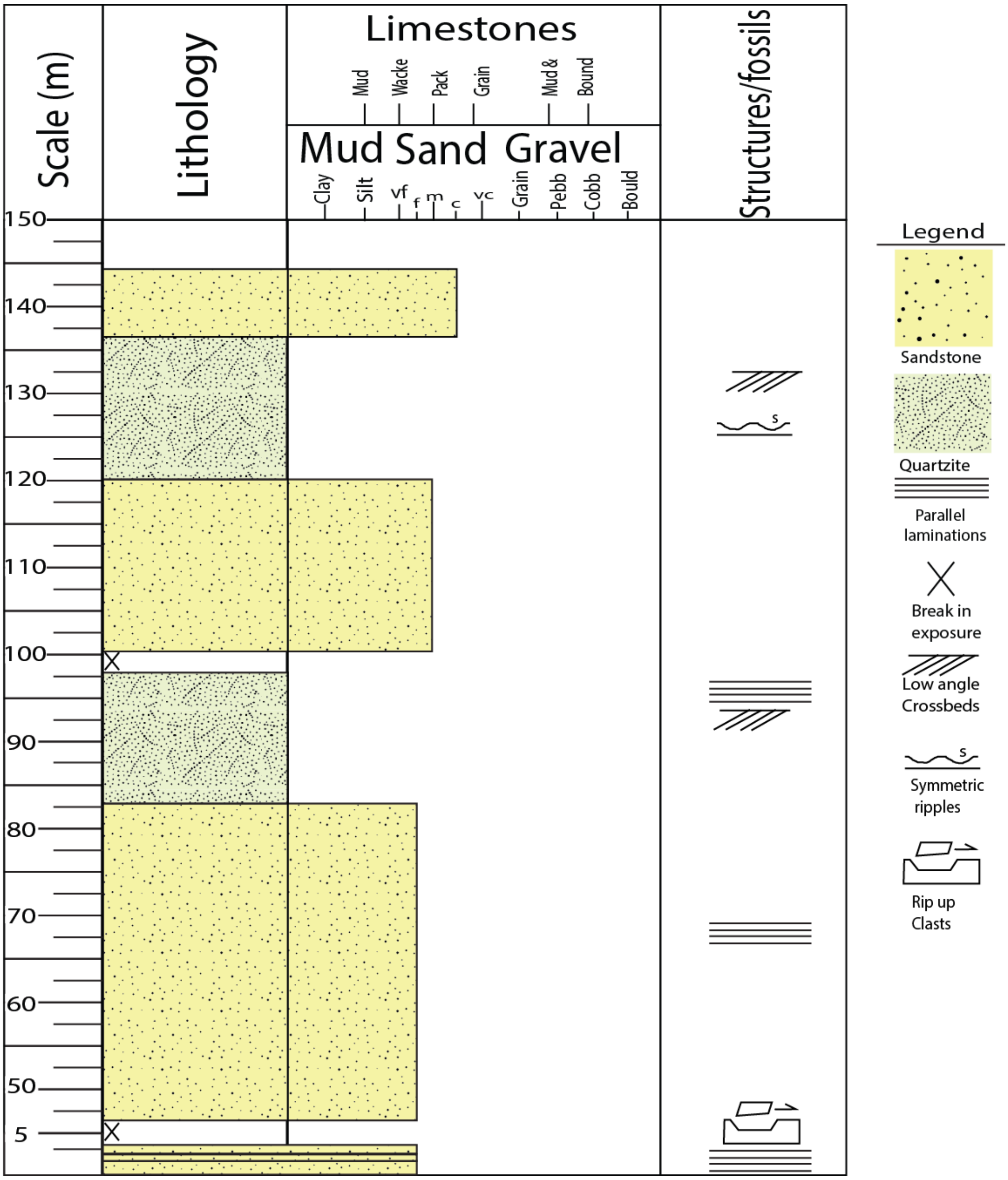

Figure 1 Sedimentary log of the Copley Quartzite Formation

Figure 2 Pictures of Copley Quartzite Formation in Sedimentary log a) fine grained sandstone with parallel laminations b) fine grained sandstone with minor shale interbeds c) fine grained sandstone with rip up clasts d) fine grained sandstone thick unit with parallel laminations e) quartzite with low angle cross-beds f) and g) same unit quartzite with symmetric ripples and low angle cross-beds h) coarse grained sandstone interbedded with a medium grained sandstone

SKILLOGALLE DOLOMITE FORMATION FACIES ANALYSIS

The Skillogallee Dolomite Formation in the Termination Hill region overlies the Copley Quartzite Formation and underlies the Bolla Bollana Tillite. It is a carbonate dominated sequence of dolomites, magnesites and arenaceous sediments. It is a carbonate dominated facies with shale and minor sandstone. Dolomites occur as crystalgal dolomites with stromatolites (Figure 4a, 4d), pure dolomites (Figure 4f), dolomitic shales (Figure 4b) and dolomites finely interbedded with shale (Figure 4h, 4g). Colour ranges from green grey (Figure 4a, 4d) to yellow grey (Figure 4e, 4i) on the weathered surfaces; on the fresh surfaces the dolomites are a darker green grey. The main features of this group are magnesite beds (Figure 4c) and chert nodules (Figure 4e) and chert pseudomorphing stromatolites (Figure 4a, 4d). The chosen section is well exposed with very minimal breaks in exposure. Lateral extent in the Termination Hill area is one to two thousand metres (Figure 12) and the true thickness of the unit was approximately just under two thousand metres thick (Figure 11). The Skillogallee has a fairly covered poorly defined contact with the overlying Bolla Bollana Tillite unit. Stromatolites and a magnesite (Figure 4a, 4d, 4c) bed occur towards the base. Up stratigraphy in the middle section of the sedimentary log (Figure 3) there is an increase in shale (Figure 4g, 4h) input and minor sandstone. The youngest top of the sedimentary log shows a change back to more dolomite (Figure 4i). The Skillogallee dolomite is barely reactive to acid and only fizzes slightly on fresh surfaces.

Interpretation

Stromatolites form in very shallow super saline type water, this justifies the idea that the environment for this unit was a shallow super saline lake. The presence of magnesite requires an influx of magnesium saturated waters so either groundwater input or occasional flooding into this lake would cause this to occur. The Coorong would be a modern analogue of this environment exemplifying the formation of magnesite beds in this fashion (Borch & Lock, 1979). Perhaps this magnesite bed is representative of a mini cycle of transgression-regression into the lake (Borch & Lock, 1979). The reason for evaporates not forming could have been due to a more humid climate at the time or a more thorough flushing of the hydrological system (Borch & Lock, 1979).

Chert occurs as a replacement reaction on algal structures, in this case on the stromatolites. Chert nodules can occur in lacustrine deposits of rift valleys associated with alteration of volcanoclastic material (Belperio, 1990). However, record of penecontemporaneous volcanism at the time of the Skillogallee Dolomite formation is lacking. An alternate way of explaining chert could be silica life like diatoms or radiolarians die their skeletons dissolve and recrystallise to form chert. The preservation of fine algal structures indicates that deposition of the dolomite and magnesite were formed penecotemporaneously with deposition as opposed to late stage diagenesis (Belperio, 1990). Tucker (1982) and Belperio (1990) have suggested that primary precipitation was most likely the norm due to the composition of seawater to modern day.

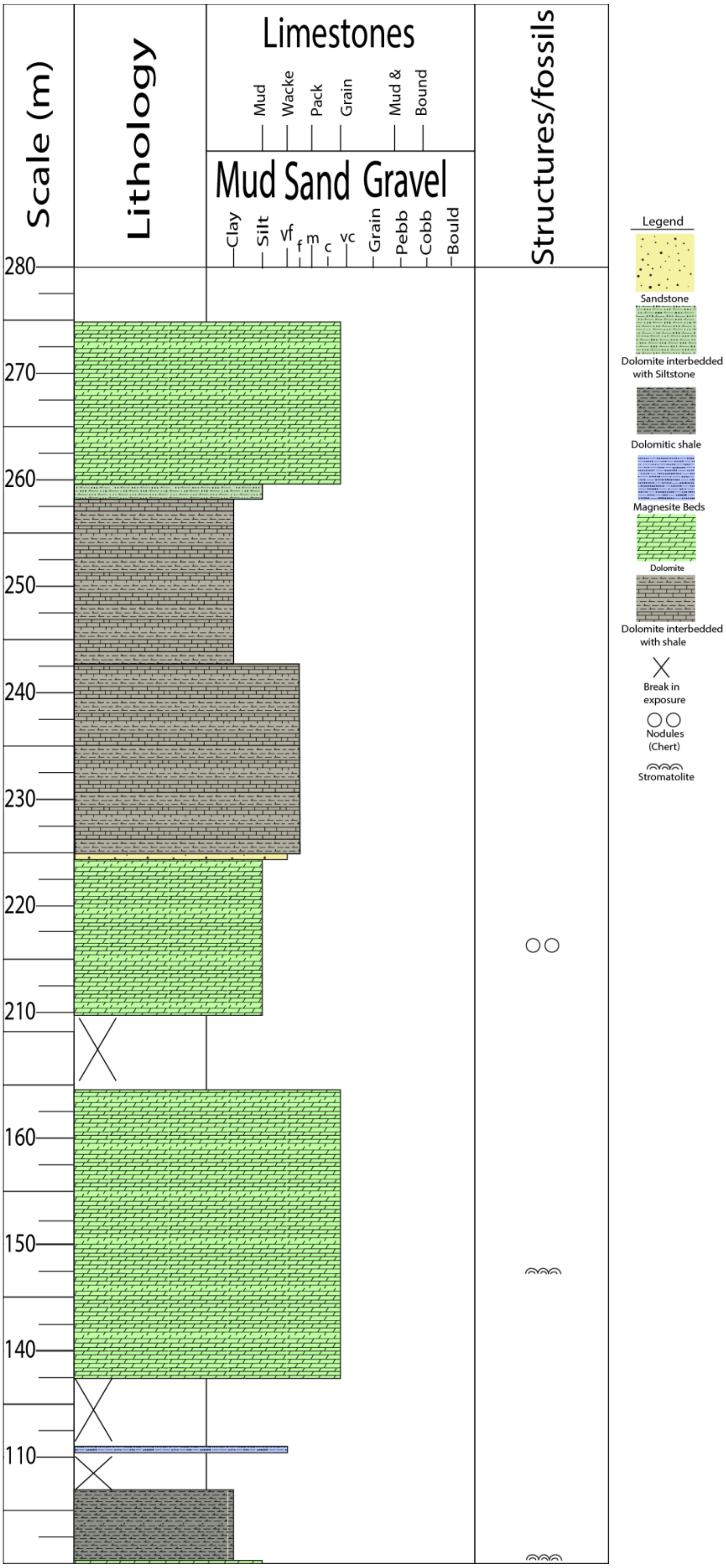
Scale (m)
Lithology
Limestones
Mud
Wacke
Pack
Grain
Mud &
Bound
Mud Sand Gravel
Clay
Silt
vf
f
m
c
vc
Grain
Pebb
Cobb
Bould
Structures/fossils
280
270
260
250
240
230
220
210
160
150
140
110
Legend
Sandstone
Dolomite interbedded with Siltstone
Dolomitic shale
Magnesite Beds
Dolomite
Dolomite interbedded with shale
Break in exposure
Nodules (Chert)
Stromatolite

Figure 3 Sedimentary log of the Skillogallee Dolomite Formation

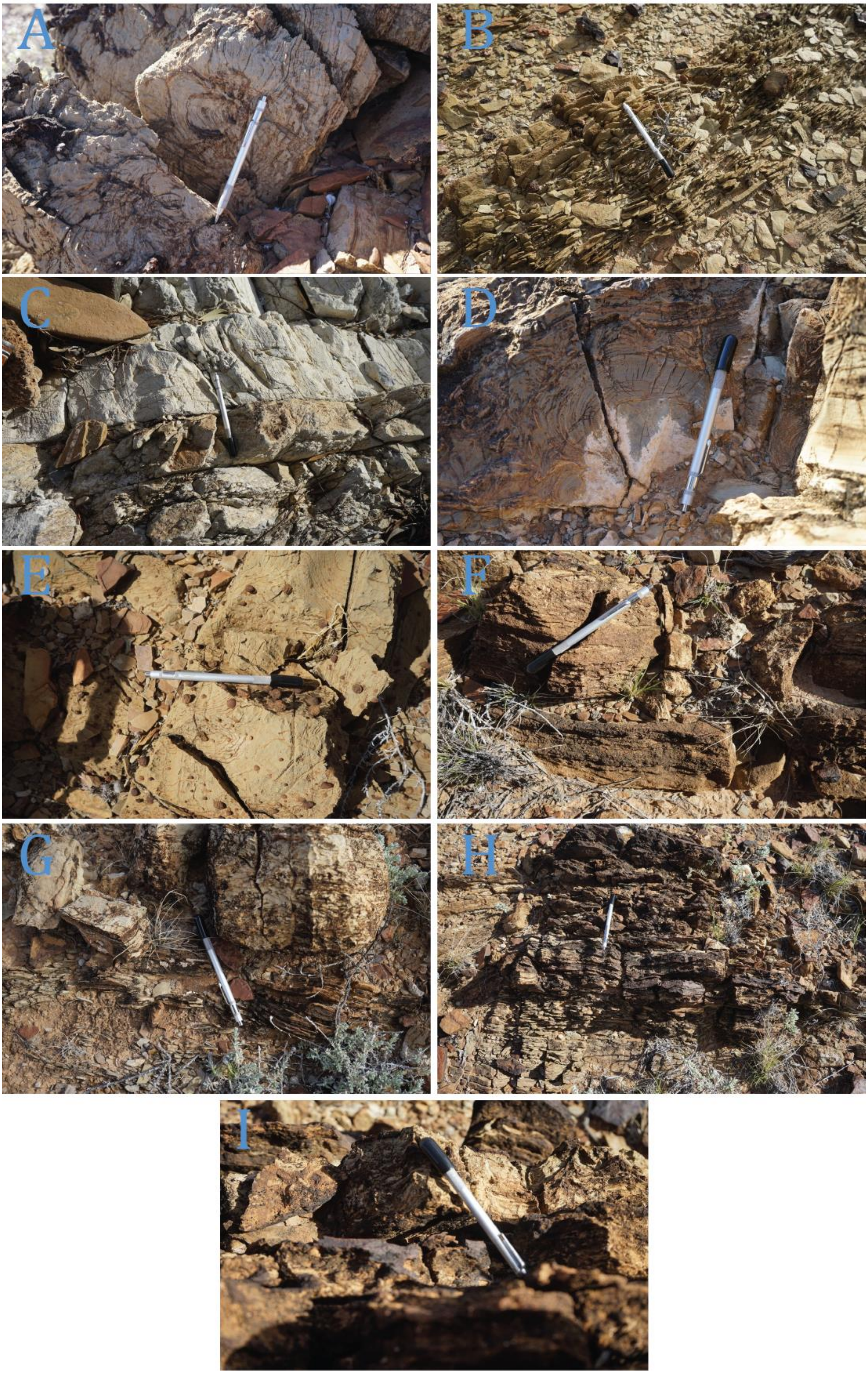
A
B
C
D
E
F
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Figure 4 Pictures of Skillogallee Dolomite Formation a) stromatolite in dolomite b) dolomitic shale c) Magnesite bed made up of intraclasts d) another stromatolite in crystalgal dolomite e) chert nodules on dolomite f) Dolomite g) dolomite interbedded with shale h) dolomite interbedded with shale i) dolomite

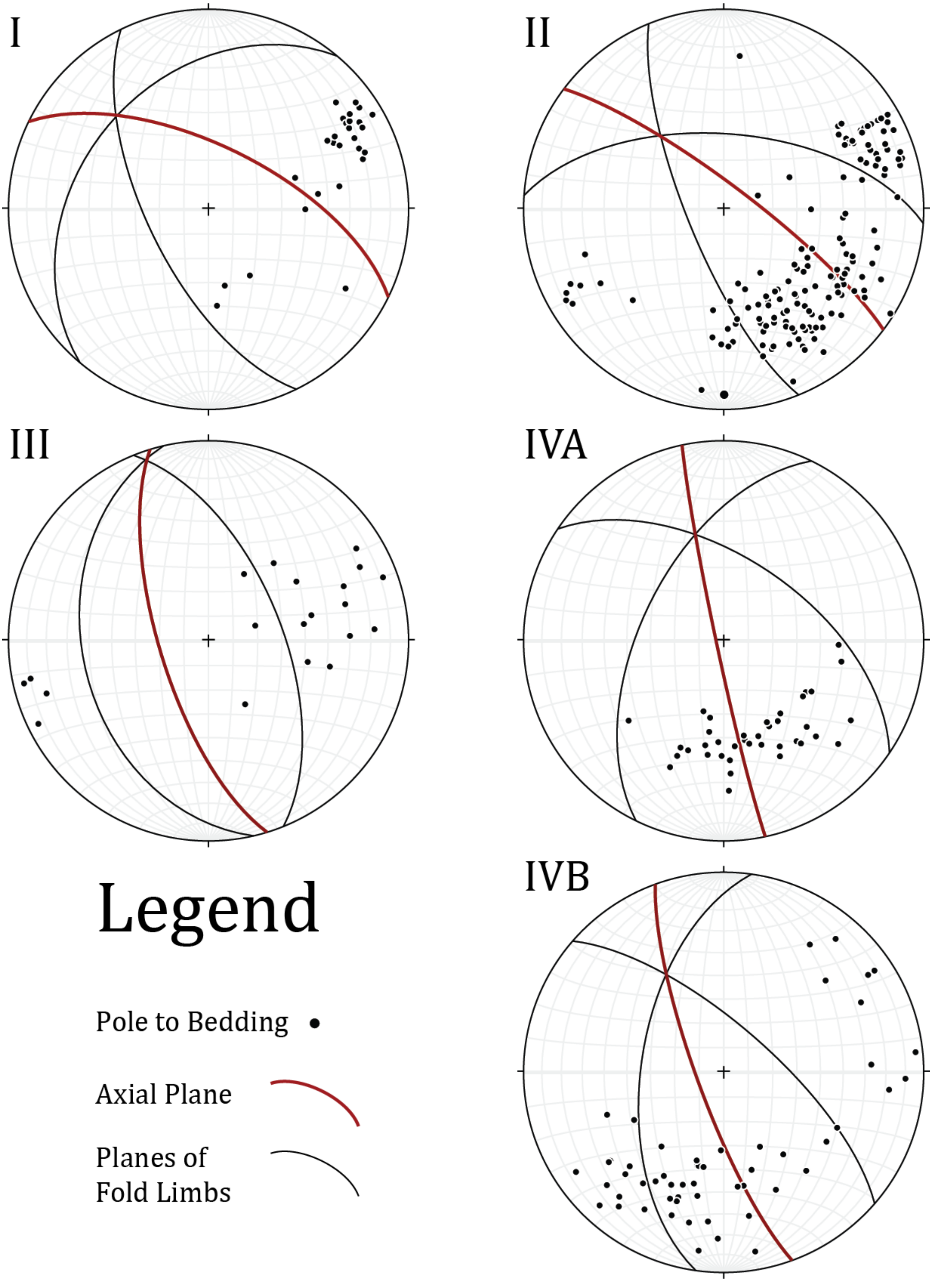

Figure 5 Stereonet Subarea analysis (sub area locations shown on figure 12)

SUBAREA STEREONET ANALYSIS

FOLDS CLASSIFIED BASED ON (FLEUTY, 1964)

SUB AREA I

Sub area I is made up of the north western most readings along the syncline the stereo net displays two fold limbs at 220/35W and 154/65W, which makes the fold axis 36->314 and the axial plane 296/54N. The maximum principal stress to this fold is 224 and 044. Sub area I has an inter-limb angle of 80. From Fleuty (1964) the fold would be classified as a moderately inclined gently plunging fold. (Figure 5)

SUB AREA II

Sub area II is made up of the middle section of the map containing the bulk of the readings of the map; containing both the syncline and anticline structures. Shows two average fold limbs at 158/75W and 274/59N, which makes the fold axis 51->319 and the axial plane 307/80N. The maximum principal stress to this fold is 229 and 049. Sub area II has an inter-limb angle of 46. From Fleuty (1964) the fold would be classified as an upright moderately plunging fold. (Figure 5)

SUB AREA III

Sub area III located on the easternmost side of the map contains on syncline readings has part of the overturned syncline in there. Shows two average fold limbs at 167/36W and 338/60E, which makes the fold axis intersecting at 5->341 and the axial plane 163/70W. The maximum principal stress to this fold is 251 and 071. Sub area III has an inter-limb angle of 84. From Fleuty (1964) the fold would be classified as an upright steeply plunging fold. (Figure 5)

SUB AREA IVA

Sub area IVA located on the top part of the anticline fig 12. Shows two average fold limbs at 206/55W and 304/56N, which makes the fold axis intersection at 43->343 and the axial plane 168/87W. The maximum principal stress to this fold is 253 and 073. Sub area IVA has an inter-limb angle of 69. From Fleuty (1964) the fold would be classified as an upright moderately plunging fold. (Figure 5)

SUB AREA IVB

Sub area IVB located on the bottom part of the anticline fig 12. Shows two average fold limbs at 188/56W and 311/71N, which makes the fold axis intersection at 43->330 and the axial plane 160/79W. The maximum principal stress to this fold is 240 and 060. Sub area IVB has an inter-limb angle of 53. From Fleuty (1964) the fold would be classified as steeply inclined moderately plunging fold. (Figure 5)

OVERALLL

The area overall structure in the Termination Hill locality shows a broad syncline anticline pair which is generally upright moderately plunging on the footwall of an inverted normal fault. The mean principal stress of the area across all sub areas is directed 60 and 240 meaning the area underwent SW NE directed shortening. With one observable deformational fabric. (Figure 5)

GEOCHRONOLOGY

Copley Quartzite Formation - W11

The sandstone dominated Copley Quartzite Formation conformably underlies the Skillogallee Dolomite formation. It contains predominantly sandstone and quartzite's with minor shales and has a range of sedimentary structures; including ripples, rain imprints and low angle cross-beds. From the stratigraphically lowest sample W11 of the Copley Quartzite formation had one hundred thirty-one grains analysed; the sample was taken from 1.8km SE of Skillogallee dolomite formation contact (Figure 12). One hundred and two yielded ages that were <10% discordant data with $^{207}Pb/^{206}Pb$ ages ranging from ~1105 Ma to ~3172Ma, with the youngest analysis at 1105±49 Ma (Figure 6 and 7). The data has one major peak at ~1690Ma, two secondary peaks at ~1490Ma and ~2400Ma and 3 minor peaks at 1130Ma, 2500Ma and 3050Ma (Figure 6 and 7).

Copley Quartzite Formation - W4

Sample W4 of the Copley Quartzite Formation fifty-eight detrital zircon grains were analysed the sample was taken 900m from the base of the Copley Quartzite (Figure 12). Thirty-three yielded ages that were <10% discordant data with $^{207}Pb/^{206}Pb$ ages ranging from ~1450Ma to ~2831Ma, with the youngest analysis at 1456 ±62 Ma (Figure 6 and 7). The data has a major peak at ~1710Ma, a secondary peak at ~2400Ma and 3 minor peaks at 2500Ma, 2250Ma and 2800Ma (Figure 6 and 7).

Copley Quartzite Formation - W5

Sample W5 of the Copley Quartzite Formation forty detrital zircon grains were analysed the sample was taken 700m from the Skillogallee Dolomite (Figure 12). Thirty-three yielded ages that were <10% discordant data with $^{207}Pb/^{206}Pb$ ages ranging from ~1534Ma to ~2557Ma, with the youngest analysis at 1534±36 Ma (Figure 6 and 7). The data has major peak at ~1750Ma with a secondary peak at ~2400Ma (Figure 6 and 7).

Copley Quartzite Formation - W2

Sample W2 of the Copley Quartzite Formation Forty detrital zircon grains were analysed for U-Pb geochronology from a sandstone located ~150m from the Copley Quartzite Skillogallee Dolomite contact (Figure 12). Twenty-nine of these yielded ages that were <10% discordant data with $^{207}Pb/^{206}Pb$ ages ranging from ~1020Ma to ~2540Ma, with the youngest analysis at 1027 ±87 Ma (Figure 6 and 7). The data has a major peak at ~1700Ma and a secondary peak at ~2350Ma with a minor peak at 1050Ma (Figure 6 and 7).

Skillogallee Dolomite Formation - Sample W1

The dolomite shale dominated Skillogallee Dolomite Formation disconformably underlies the Bolla Bollana Tillite. It contains shales and wackestones passing up to dolomites with abundant stromatolites pseudomorphed by chert. From the stratigraphically youngest unit of the Burra Group sample W1 had one hundred and sixty-one detrital zircon grains analysed for U-Pb geochronology from a medium grained sandstone horizon 1km into the Mundallio subgroup from the base (Figure 12). One hundred and twelve of these yielded ages that were <10%

discordant data with $^{207}Pb/^{206}Pb$ ages ranging from ~900 to 3800Ma, with youngest analysis at 903 ±26 Ma (Figure 6 and 7). More erratic results stretch out to ~3825Ma (Figure 6 and 7). The most prominent peak occurs at ~1020Ma with a second major peak at ~17—00Ma and two less prominent peaks at ~1200Ma and ~2350Ma (Figure 6 and 7).

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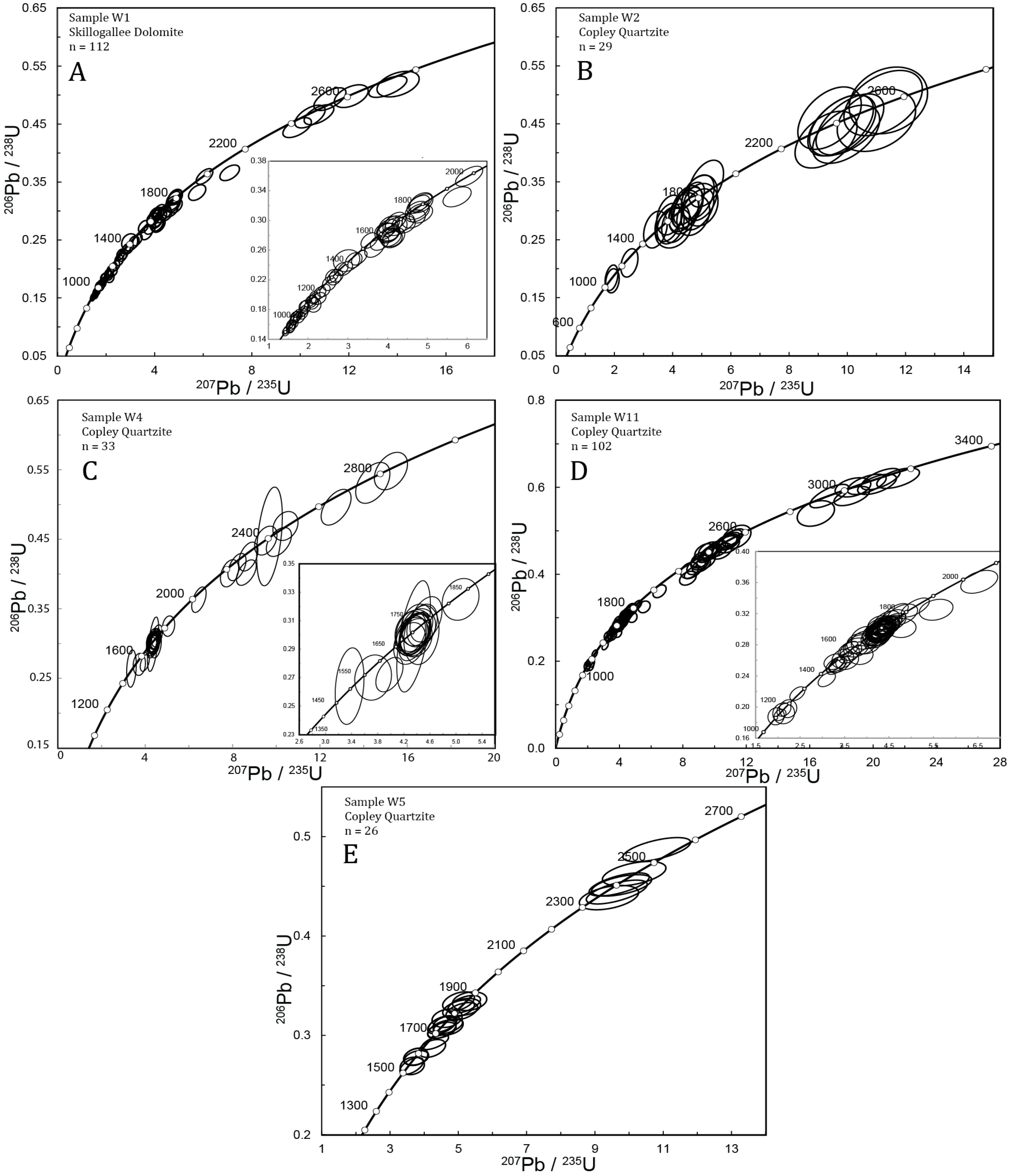


Figure 6 Concordia plots of all samples with zoomed pictures on significant areas

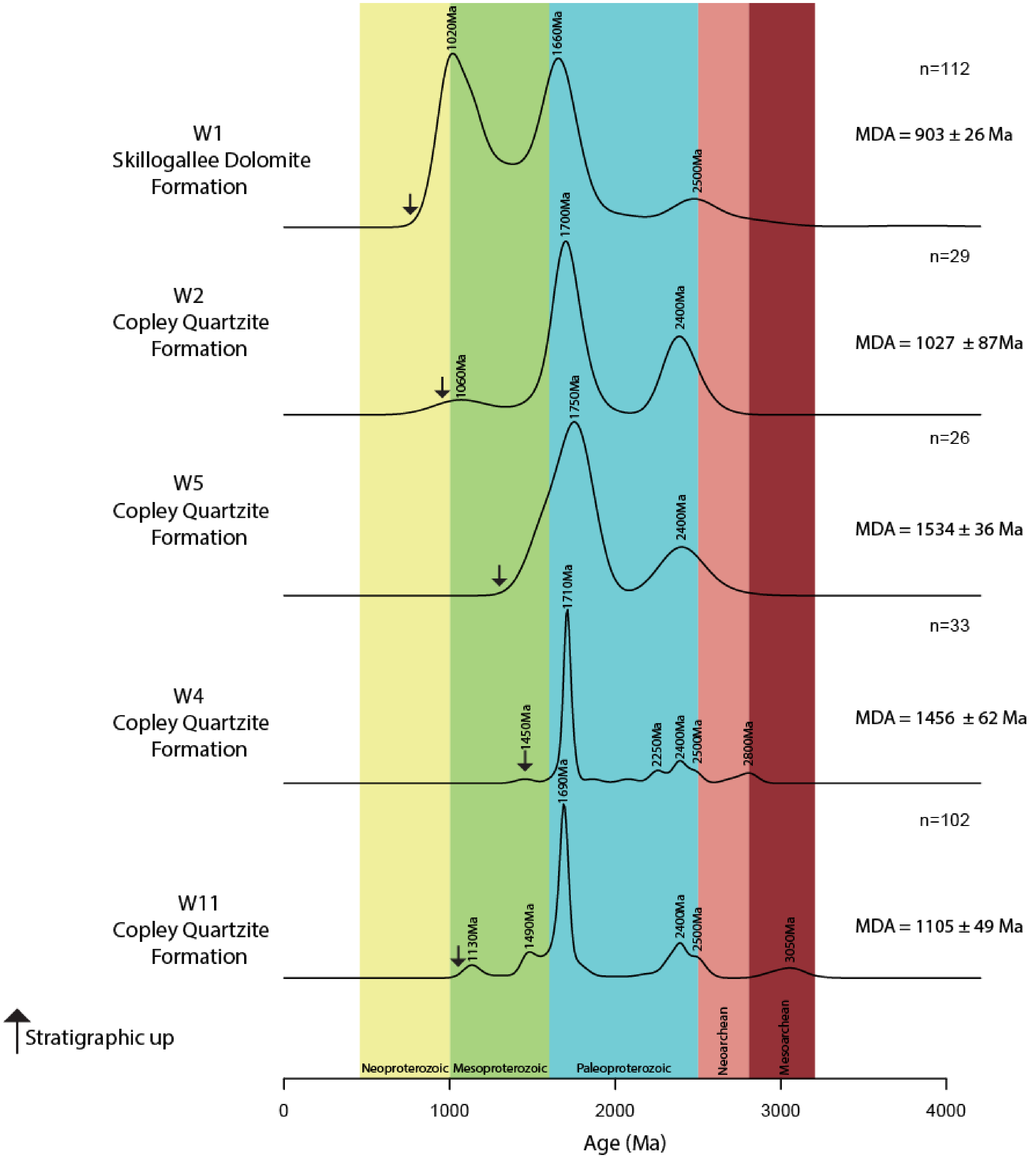


Figure 7 Kernel density plot of all samples ordered stratigraphically outlining detrital zircon peaks

DISCUSSION

STRUCTURE

The Termination Hill area is a broad syncline anticline pair on the footwall of the Norwest fault (Figure 12). Mean shortening direction are 60 degrees NW and 240 degrees SE and this direction of shortening is in agreement with (Preiss, 2000). Moreover this shortening direction matches up with the proposed principal stress in the Northern flinders ranges area during the Delamarian orogeny which occurred 500-514Ma~(Foden, Elburg, Dougherty-Page, & Burtt, 2006). Mackay (2011) has argued through U/Pb monazite data suggested fault activity during the Delamarian orogeny although his data was reasonably all over the place. The Delamarian orogeny is said to have caused basin inversion (Mackay, 2011) for the Burra group which is the reason it is so well preserved in this area. The Skillogallee Dolomite Formation is mapped as ~2250m thick to the east of the Norwest Fault (T.Baker, 2012), whereas the thickness of the Skillogallee Dolomite Formation to the west of the same fault is mapped here as 1000m. This suggests that the Norwest Fault was active during deposition of the Skillogallee Dolomite Formation and that the east side was downthrown. This difference in thickness would make sense for synrift deposition into grabens. Following this interpretation, it could be said that the Skillogallee in our area was deposited on a horst or a less declined graben relative to the outcropping Skillogallee seen east of the Norwest fault. Preiss (2009) suggests a sequence of rifting events over the course of the ARC's history firstly intracratonic rifting for the Copley Quartzite and a stage of thermal sag for the Skillogallee During the Delamarian orogeny the Norwest fault underwent thrust sense movement (Mackay, 2011) producing the folds seen in (Figure 12). However, the fault did not fully invert (Figure 11) today's Norwest fault records a normal sense of movement due to the cessation of stress after the Delamarian orogeny, which is why the Norwest fault is classified as an inverted normal fault (Figure 12). Research by Hall et al (in review) casts doubt on the timing of deformation for a nearby locality along strike from the Willouran Ranges; the Peake and Denison Ranges are said by Hall et al (in review) to show parts in the area to be exhumed during the Delamarian orogeny and part being exhumed during the Alice Springs orogeny. This casts doubt on the timing of movement of the Norwest fault or could suggest multiple phases of movement. However, in the Termination Hill locality the strain history observed is extremely simple which would suggest a single phase of movement.

AGE OF DEPOSITION OF THE BURRA

The youngest <10% discordant detrital zircon (2σerror) analysis recovered from the respective subgroups here has been interpreted as the maximum age of constraint on age of deposition fig kernel. The detritus is exclusively sourced from older terranes, so the maximum depositional age for the formations produced here is not close to their true depositional age. In the interest of constraining the depositional age of the Burra groups' subgroups as much as possible we will discuss new and published data from all mapped units in the termination hill area. The stratigraphically lowest data unit was the Copley Quartzite formation which underlies Skillogallee Dolomite Formation the maximum age of deposition calculated from this study was 1027 ± 87Ma. However, through further reading the base of the Emeroo Subgroup is defined by the Boucaut volacnics intercalated in the basal formation the Rhynie Sandstone making the age of deposition 777±7 (Parker, Cowley, & Thomson, 1990; Preiss, 1987, 1997).

The overlying Skillogallee dolomite formation has been dated as young as 797±5Ma from a cross-cutting porphyritic intrusion in the thought to be correlate-able Curdimurka subgroup (Preiss, Drexel, & Reid, 2009). However, Mackay (2011) describes this date to be “spurious” as he writes that the dated unit cannot be considered correlate-able with the Skillogallee due to its lack of characteristic magnesite beds of the Skillogallee Dolomite formation; additionally, the overlying Skillogallee Dolomite formation cannot possibly have an older maximum age of deposition then the underlying Copley Quartzite formation. The youngest zircon <10% discordant this study yielded was in the Skillogallee Dolomite dated at 903±26Ma. This date also cannot constrain the maximum age of deposition of the Skillogallee due to the basal Emeroo Subgroups Rhynie sandstone being constrained to 777±7 Ma. The minimum age constraint on the age of deposition of the Copley Quartzite formation is dependent on the overlying Skillogallee Dolomite which we do not have a better maximum age of deposition on due to an already so well constrained basal unit (Preiss et al., 2009). The Minimum age of constraint for the Skillogallee Dolomite is dependent on the maximum age of deposition for the Bolla Bollana Tillite which Shahin (in review) has dated a <10% discordant detrital zircon $^{207}Pb/Pb^{206}$ age of 673±19Ma. Therefore, the Burra group has been interpreted to have been deposited between 777±7Ma and 673±19Ma (Shahin, 2016). However Preiss (2009) interprets there to have been a regional erosional event that effected the base of the Sturtian glacials meaning this minimum age of constraint may be younger than the actual age of constraint (Preiss, 2000). Thus the true minimum age of constraint for the Skillogallee is not known. Although this papers zircon analyses have not yielded any constraining dates; it can be said that the Skillogallee must have been deposited between 777±7Ma and 673±19Ma.

PROVENANCE

190 detrital zircon grains analysed with <10% discordance have been analysed from the Copley Quartzite formation; from samples W2, W4, W5, W11 all contain a late Paleoproterozoic peak ranging from 1690-1750Ma, this age range is consistent with the Kimban Orogeny 1690-1730Ma (Fanning, Reid, & Teale, 2007; Hand, Reid, & Jagodzinski, 2007) of the Gawler Craton. However, this major peak could also have a less distinctive mixing with the upper 1670-1640Ma and lower 1715-1640Ma Willyama supergroup (Barovich & Hand, 2008) less distinctive because on the multi-dimensional scaling plot the Copley Quartzite samples are all at quite a distance from the Curnamona province (Figure 8). The secondary peak in the early Paleoproterozoic which all Copley samples share ranges from 2400-2500Ma, which is consistent with the Sleaford orogeny of the Gawler Craton. There are latest to middle Mesoarchean peaks however these are minor peaks effecting the Copley such as 2800Ma, which could be attributed to the Sleaford Complex 2510-2850Ma (Hand et al., 2007) of the Gawler craton and the 3050Ma peak which could be associated with the Cooyerdoo Granite ca.3150Ma of the Gawler craton (Fraser, McAvaney, Neumann, Szpunar, & Reid, 2010). These peaks would suggest the primary source input was shedding of proximal material from the Gawler Craton into the Willouran Trough. The Copley Quartzite has some minor peaks at 1060Ma and 1130Ma these peaks are very distinctively Musgravian matching up with the Giles event at 1070-1080Ma and the Pitjantjatjara Supersuite at 1120-1190Ma (Edgoose, Close, & Scrimgeour, 2004). This indicates a distal minor material input from erosion of the Giles event and Pitjantjatjara Supersuite of the Musgrave province NW of the Willouran Trough.

The 112 analysed zircons with <10% discordance from the Skillogallee Dolomite Formation have a late Paleoproterozoic peak that is far younger than the Copley Quartzite Paleoproterozoic peaks. This peak is at 1660Ma this peak could easily link up with the Upper Willyama Supergroup ~1670-1640 (Barovich & Hand, 2008) of the Curnamona province or the Kimban orogeny of the Gawler Craton 1730-1690Ma (Hand et al., 2007). The Skillogallee Dolomite Formation has a late Mesoproterozoic peak which is considerably younger than the other similar age peaks from the Copley Quartzite. Especially the 1020Ma peak maxima (Figure 7) it is hard to find a source close to this age in Australia. In the Musgraves Orogeny the main granite producing period is 1.1-1.2 Ga Pitjantjatjara Supersuite; the 1070-1080 Giles event (Edgoose et al., 2004) is dominated by mafic rocks which are poor producers of zircons. This lack of Australian sources for this major peak warrants an investigation of other sources. From AUSWUS reconstruction Karlstrom (1999) it can be seen that the Grenville belt (Ca. 980-1250Ma) of North America and South America was very close to the Willouran rift in reconstruction (Figure 9) in this belt there are late Mesozoic source rocks. Such as the Ottawan orogeny was 1035-1090Ma (McLelland et al., 2001) shedding material into the basin from the east south east along the rift axis rather than from the Gawler Craton. The Sunsas Orogeny of the Amazonian craton in South America is also consistent with this age where peak orogenesis occurred 1120-1000Ma (Chew, Cardona, & Mišković, 2011). Skillogallee Dolomite exhibits dramatic thickness change across the Norwest fault, which was interpreted as a rift fault at the time (Mackay, 2011). This change in thickness and evidence for this being a rift fault can be seen by change in thickness shown on Leigh Creek map sheet by Baker (2012). The Skillogallee Dolomite formation has an early Paleoproterozoic peak at 2500 Ma which is older than the majority of Copley Quartzite's early Paleoproterozoic peaks; this peak can still be explained by the Sleaford orogeny 2480-2420Ma (Hand et al., 2007) of the Gawler Craton. The fact that there are still these Gawler signatures abundant in the Skillogallee Dolomite formation tells us that the source doesn't get covered but becomes secondary to new sediment pathways.

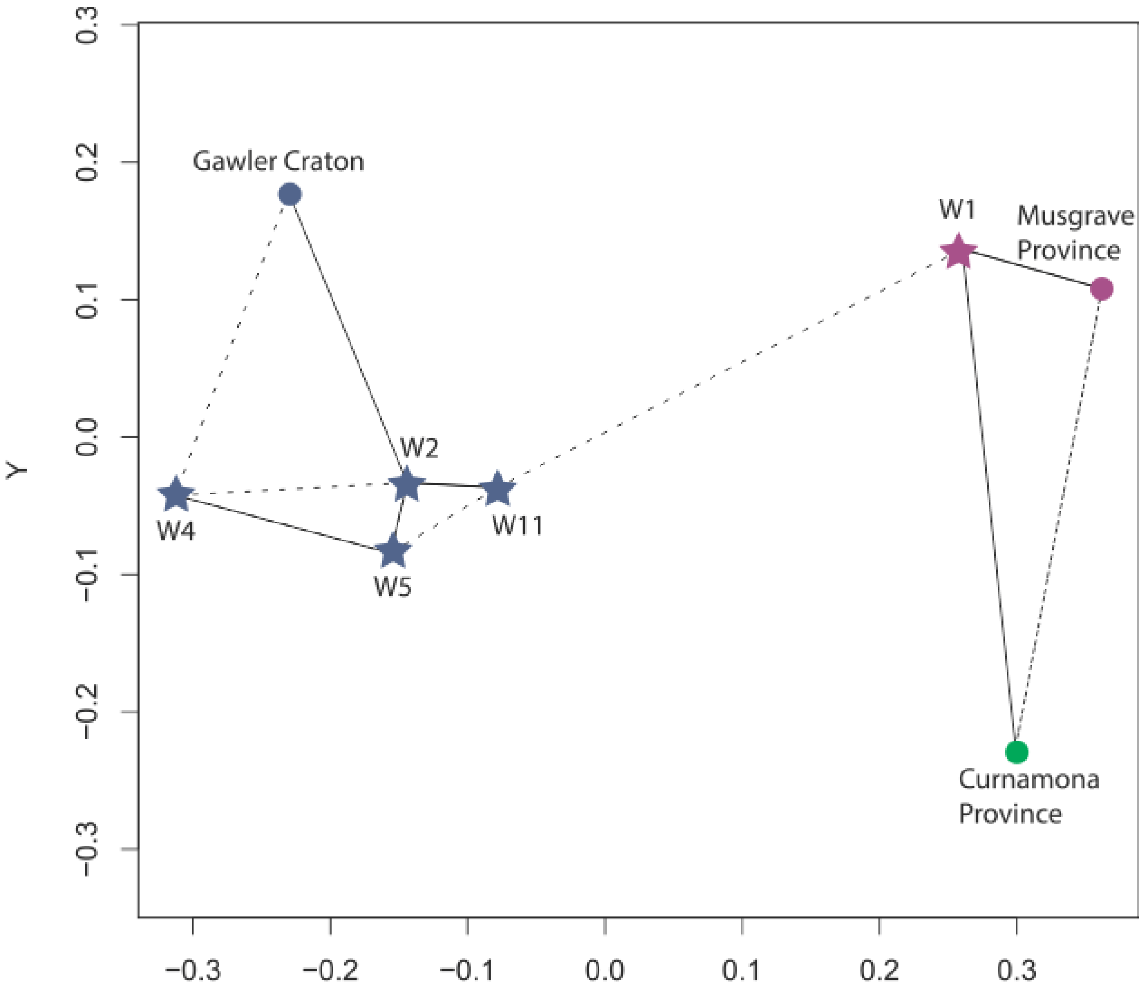


Figure 8 MDS plots of all samples against Curnamona Province, Musgrave province and then Gawler Craton nearest neighbour solid line dotted line second nearest

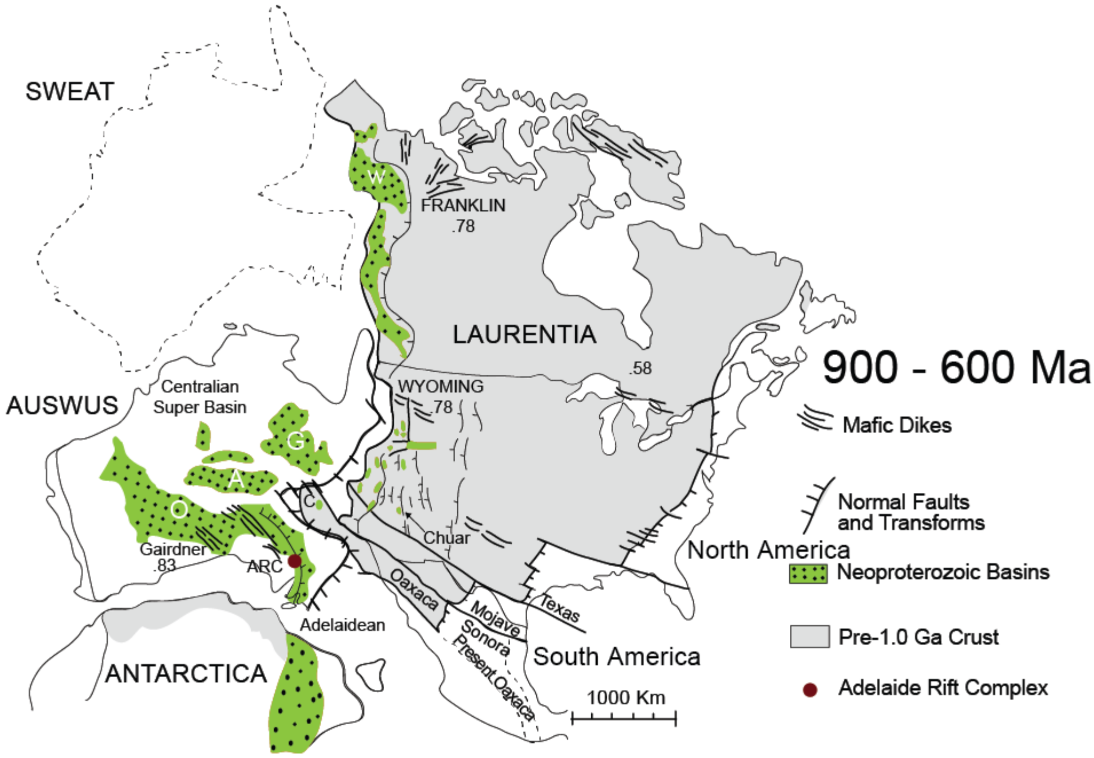


Figure 9 Figure of SWEAT and AUSWUS arrangement hypotheses for Rodinia during 900-600Ma modified diagram from (Karlstrom et al., 1999) showing ARC arrangement relative to Antarctica, South America and North America. (O) Officer Basin and ARC (A) Musgraves (G) Georgina Basin

TECTONIC IMPLICATIONS

Copley Quartzite was deposited in the initial rift stage

Change in zircon age spectra from Copley Quartzite formation samples W2, W4, W5, W11 to Skillogallee Dolomite formation W1 shows an increase in complexity. Sample W1 has a small proportion of zircons from likely proximal sources which would suggest that the basin was in sag phase during this deposition combined with the fact that there are thicker packets of this Skillogallee dolomite that crop out further west of the Norwest fault suggesting that this was deposited in syn rift setting with axial drainage down the rift axis from east south east shedding material off of the Ottowan orogeny and Sunsas orogeny. The Copley Quartzite was deposited in the initial rift stage with transverse drainage of proximal sources shedding material off of the Kimban Orogeny and the Sleaford orogeny from the West with minor input from the Musgrave province's Giles event and Pitjantjatjara super suite from the north west.

CONCLUSION

To conclude the Burra group in our area underwent rifting in the ARC ~780Ma with deposition of Burra group into grabens. The major source of sediments at this time was westerly derived sediments from the Gawler craton. As rifting progressed further and relative sea level reached a low-stand depositing the Skillogallee Dolomite formation evidenced by stromatolites and magnesite beds and the primary source of sediment became the distal Ottowan orogeny and the Sunsas Province input from the SE along the rift axis. Proximal transgressive drainage was still a major input but was secondary to the distal Sunsas Province and Ottowan orogeny. The rocks in the Termination area evidence rifting and transpression with the inverted normal fault and the broad syncline anticline pair. The Norwest fault was initially a normal fault during rifting then during Delamarian orogeny became a thrust which inverted the basin and preserved the basin stratigraphy and folded the rocks to what we see them as today. However, it didn't fully invert and today shows normal sense of movement.

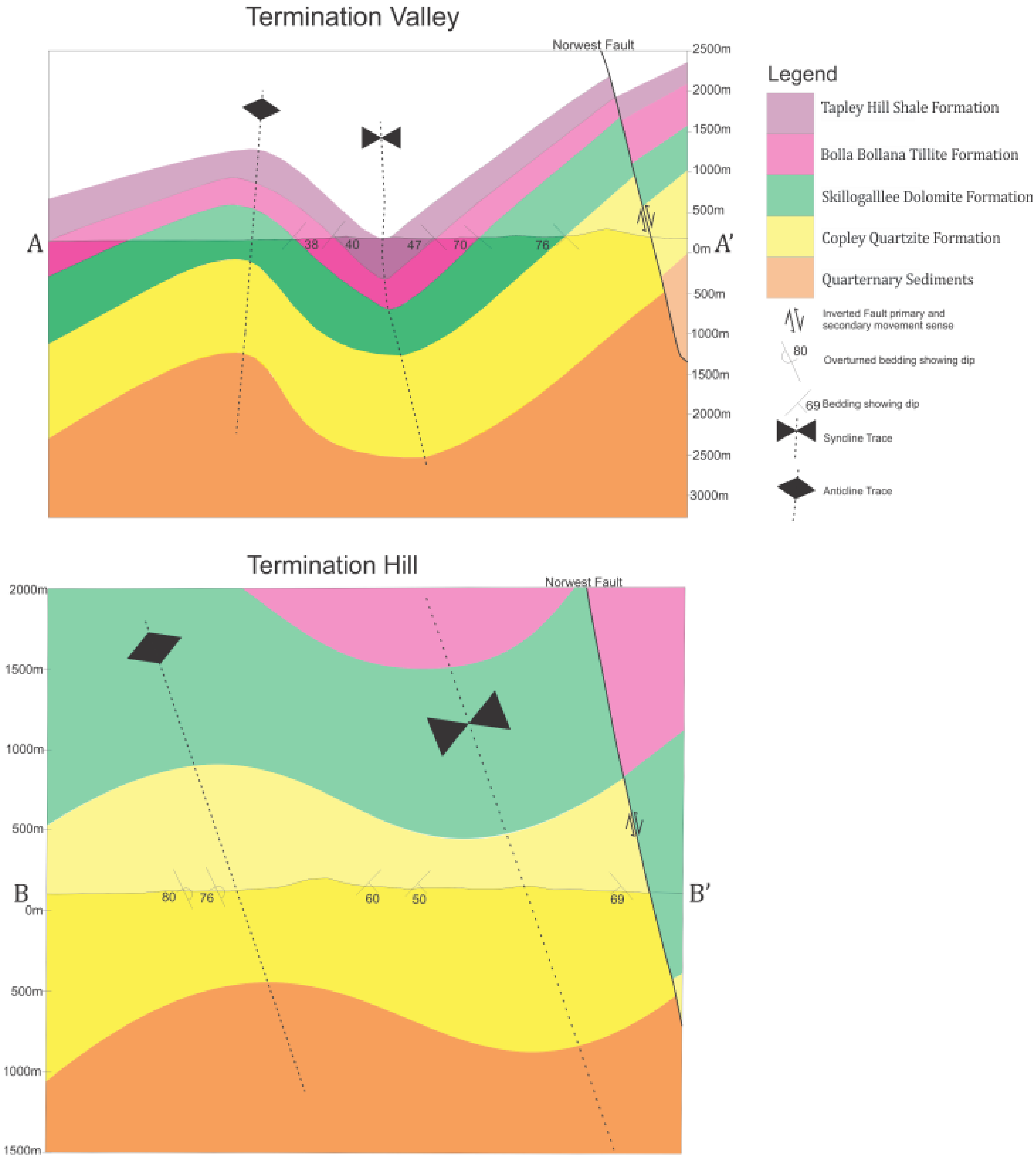
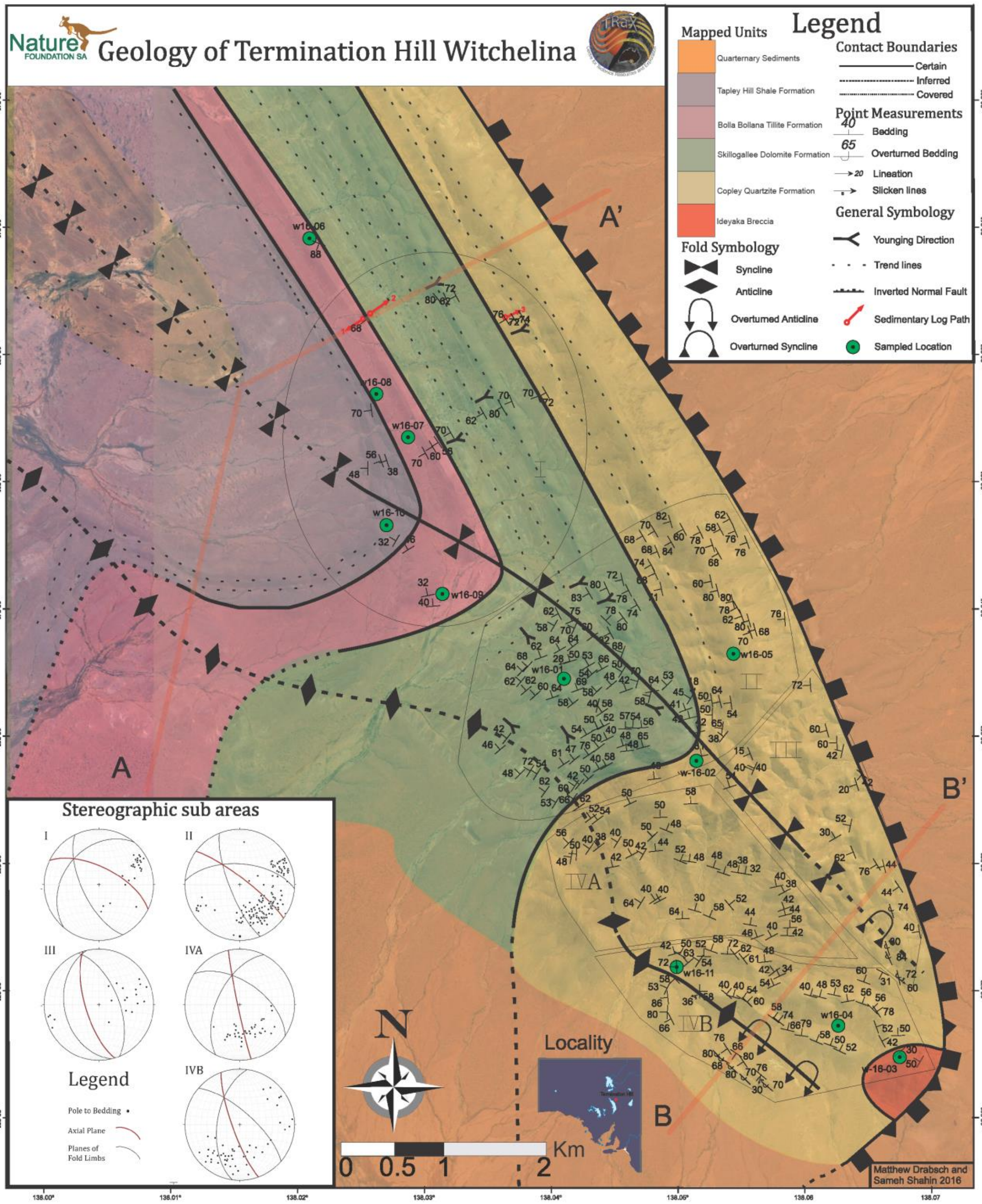


Figure 10 Cross-sections of Termination Hill and Termination Valley line shown on Termination Map

Figure 11 Map of Termination Hill in Witchelina Showing lithological boundaries, Sampling locations, locations of sedimentary logs and locations of cross sections for fig 11



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APPENDIX A ALL STRUCTURAL READINGS PLOTTED ON MAP AND THEIR WAYPOINTS

id no.	latitude	longitude	dip	dip direction
31	-30.242112	138.035354	63	341
35	-30.243632	138.037945	68	325
38	-30.245237	138.039126	69	345
39	-30.245729	138.040439	52	283

40	-30.246339	138.041141	40	326
45	-30.249268	138.045149	65	345
46	-30.250971	138.049475	60	344
48	-30.249932	138.050562	31	349
49	-30.24992	138.050566	44	328
50	-30.24904	138.051016	38	356
53	-30.246953	138.051414	34	345
54	-30.246953	138.051416	36	297
55	-30.24649	138.051325	50	284
56	-30.246593	138.049853	41	309
59	-30.244079	138.047252	53	316
68	-30.275306	138.068917	32	91
69	-30.275305	138.068916	30	140
75	-30.273073	138.069361	50	358
79	-30.268005	138.069027	73	244
80	-30.267953	138.067342	31	208
81	-30.268736	138.066323	60	20
82	-30.270345	138.06569	80	350
83	-30.26993	138.065664	80	350
85	-30.272698	138.063061	64	24
87	-30.27255	138.063379	70	219
90	-30.208105	138.012674	88	200
96	-30.242791	138.041169	54	331
97	-30.242255	138.041486	55	290
98	-30.240599	138.042301	80	7
99	-30.239904	138.041407	82	242
100	-30.239552	138.041192	61	59
101	-30.239207	138.041654	54	45
102	-30.238875	138.04223	80	60
104	-30.238699	138.042618	60	234
105	-30.23825	138.043456	74	64
106	-30.237612	138.043948	60	240
191	-30.23623	138.046344	71	258
192	-30.23433	138.045275	74	240
193	-30.235462	138.042611	72	256
194	-30.235998	138.041051	64	252
195	-30.23631	138.040039	70	62
197	-30.237017	138.039548	83	245
198	-30.239487	138.04082	78	62
199	-30.240139	138.040207	64	324
200	-30.240637	138.039894	60	302
204	-30.241387	138.042865	68	290

206	-30.241836	138.043021	59	292
207	-30.242107	138.042989	66	296
208	-30.242968	138.042888	88	302
209	-30.243664	138.042509	58	304
210	-30.244084	138.041996	48	320
211	-30.244617	138.040587	58	316
212	-30.245191	138.039256	58	326
213	-30.245613	138.03834	58	322
214	-30.245711	138.037306	32	338
235	-30.245187	138.036527	64	342
236	-30.245193	138.036484	52	316
279	-30.244934	138.034739	60	318
280	-30.244664	138.034201	64	326
281	-30.244306	138.03373	62	320
284	-30.243776	138.033334	58	310
285	-30.243389	138.033808	62	324
286	-30.242912	138.033477	64	314
287	-30.242559	138.033962	68	312
288	-30.241902	138.035395	62	340
289	-30.241563	138.036006	62	318
290	-30.241247	138.037145	64	330
291	-30.240473	138.037649	68	330
292	-30.239981	138.038212	70	330
293	-30.23938	138.0383	75	294
294	-30.239068	138.038506	64	334
295	-30.2389	138.03836	82	338
296	-30.238324	138.03647	62	243
297	-30.239178	138.036422	58	300
305	-30.23196	138.044475	68	240
306	-30.231841	138.045052	70	240
307	-30.231339	138.045659	58	237
309	-30.230717	138.047185	82	254
310	-30.23141	138.048338	60	242
311	-30.231634	138.049969	30	244
312	-30.231385	138.050357	78	58
313	-30.230928	138.049772	62	72
315	-30.232033	138.050859	58	242
316	-30.232654	138.051182	70	252
317	-30.233388	138.05169	68	241
318	-30.235603	138.05108	60	258
322	-30.236355	138.05167	80	256
323	-30.237253	138.053125	80	256

325	-30.237813	138.053453	78	240
328	-30.238494	138.053951	62	250
329	-30.238849	138.054658	80	254
330	-30.239812	138.054746	70	250
332	-30.239588	138.055251	68	254
333	-30.238673	138.058134	76	266
341	-30.238237	138.060035	82	252
347	-30.233358	138.063109	86	244
437	-30.23168	138.058193	62	234
438	-30.232435	138.054462	76	250
439	-30.231621	138.053666	66	186
442	-30.231507	138.053311	76	248
443	-30.23149	138.052636	70	252
444	-30.2314	138.051872	62	242
445	-30.232461	138.047185	84	240
446	-30.233204	138.0459	68	248
447	-30.235001	138.045678	68	246
448	-30.236409	138.04315	78	244
449	-30.236201	138.041083	68	246
450	-30.236274	138.040225	80	240
451	-30.236658	138.039371	72	240
468	-30.242427	138.039064	60	330
469	-30.242532	138.039909	50	330
471	-30.241934	138.039356	42	334
472	-30.243174	138.040156	66	320
473	-30.244078	138.041932	40	334
474	-30.24344	138.0427	58	320
475	-30.243213	138.043064	50	274
476	-30.243129	138.043344	58	296
477	-30.244179	138.043406	42	340
478	-30.244679	138.045239	62	272
479	-30.244983	138.04542	62	284
484	-30.247708	138.045042	56	356
485	-30.247781	138.044223	54	5
486	-30.247848	138.043513	57	1
487	-30.248207	138.042595	56	332
488	-30.247492	138.041313	58	332
489	-30.247691	138.040783	52	336
490	-30.247773	138.039891	54	342
491	-30.249223	138.040825	50	322
492	-30.249814	138.039852	76	325
493	-30.2502	138.038482	47	320

494	-30.250603	138.037501	61	326
495	-30.251332	138.034799	54	302
496	-30.251098	138.034153	72	302
498	-30.252807	138.035596	62	306
499	-30.25347	138.036138	54	298
500	-30.253678	138.036587	53	302
501	-30.253734	138.037735	66	302
502	-30.25411	138.038935	62	326
503	-30.255022	138.04007	52	324
504	-30.255145	138.040697	54	323
505	-30.25385	138.043856	50	335
506	-30.255079	138.046831	50	357
507	-30.256294	138.047442	48	22
508	-30.256499	138.045888	50	316
509	-30.258056	138.043986	50	332
511	-30.259102	138.042271	42	348
512	-30.256929	138.042458	40	302
513	-30.257387	138.040795	38	322
514	-30.257475	138.039819	40	305
515	-30.257908	138.038347	48	272
516	-30.25817	138.037906	50	280
517	-30.257398	138.038063	66	312
518	-30.257051	138.037899	56	316
519	-30.253978	138.038052	56	320
520	-30.253173	138.038266	60	306
521	-30.252604	138.038248	60	326
523	-30.252333	138.038404	42	304
524	-30.252198	138.038895	50	310
525	-30.251774	138.039797	40	318
526	-30.251593	138.040416	50	358
527	-30.250969	138.0409	40	330
528	-30.250748	138.041582	58	330
529	-30.250027	138.040245	40	328
530	-30.24803	138.0397	50	330
532	-30.24528	138.03908	52	330
533	-30.244561	138.038896	54	340
534	-30.243929	138.03847	60	346
536	-30.243205	138.037878	40	334
538	-30.226304	138.018489	40	270
539	-30.226308	138.018597	48	270
542	-30.2259	138.019168	40	260
545	-30.225808	138.019486	56	250

547	-30.225719	138.020186	38	252
556	-30.225169	138.023817	70	242
558	-30.224644	138.024492	60	240
559	-30.224418	138.024822	58	236
561	-30.223471	138.026202	70	240
566	-30.22188	138.02932	62	240
567	-30.221753	138.029774	76	236
571	-30.221374	138.031086	80	240
572	-30.221227	138.031573	84	238
573	-30.22088	138.032071	70	248
574	-30.220459	138.034572	70	250
576	-30.220378	138.0351	72	240
579	-30.24223	138.038185	50	342
580	-30.243468	138.038412	53	320
586	-30.244605	138.039264	44	330
587	-30.247797	138.039747	44	335
588	-30.247986	138.039765	50	328
590	-30.248554	138.041669	40	334
591	-30.249125	138.043255	48	342
592	-30.24961	138.043629	48	354
593	-30.25191	138.046245	46	353
594	-30.253961	138.049727	58	358
595	-30.252521	138.053381	54	342
596	-30.250612	138.055145	40	294
597	-30.250139	138.054748	15	248
598	-30.248286	138.05259	37	308
599	-30.246522	138.051275	51	272
600	-30.245156	138.049405	45	302
601	-30.245106	138.049542	68	257
602	-30.244092	138.047269	48	330
607	-30.221048	138.01883	70	262
609	-30.237286	138.025317	40	355
610	-30.236947	138.024839	32	348
611	-30.23301	138.0227	46	328
612	-30.232207	138.021365	32	300
614	-30.214908	138.01792	68	234
618	-30.212573	138.024707	80	244
619	-30.212529	138.024919	62	230
620	-30.212491	138.025808	72	244
621	-30.212253	138.026276	70	242
623	-30.214194	138.031458	76	238
624	-30.214194	138.032278	72	236

625	-30.213965	138.033021	74	242
629	-30.274966	138.071337	50	300
631	-30.269077	138.069745	60	270
632	-30.268659	138.069453	72	78
633	-30.266995	138.068605	84	64
634	-30.266268	138.068396	80	78
635	-30.263159	138.068737	74	72
636	-30.260751	138.068866	44	236
637	-30.25897	138.067522	44	256
638	-30.258906	138.066749	76	238
639	-30.257847	138.064552	62	248
640	-30.256663	138.063354	30	330
641	-30.255849	138.064375	82	250
642	-30.255582	138.06448	52	282
643	-30.25482	138.065522	84	77
644	-30.25227	138.064903	20	252
645	-30.2516	138.065307	42	220
646	-30.249445	138.063505	42	282
647	-30.248795	138.0631	60	268
648	-30.247844	138.062077	60	255
649	-30.24409	138.060572	72	266
650	-30.264335	138.071003	40	260
651	-30.273823	138.067982	42	62
653	-30.272968	138.067521	52	70
654	-30.272501	138.067174	40	16
655	-30.271373	138.067502	78	56
656	-30.27109	138.067115	56	45
657	-30.270514	138.066174	56	20
658	-30.270114	138.065505	64	6
659	-30.270157	138.064747	62	350
660	-30.270016	138.064046	65	20
661	-30.269762	138.063484	53	12
662	-30.26993	138.062116	48	15
663	-30.269852	138.061251	40	16
664	-30.26879	138.057653	54	336
665	-30.26839	138.057978	48	350
666	-30.268017	138.058186	34	334
667	-30.267612	138.05753	42	324
668	-30.266939	138.056872	48	353
669	-30.267012	138.054804	61	52
670	-30.266612	138.053897	62	52
671	-30.266337	138.053344	72	2

672	-30.266183	138.051785	58	20
673	-30.266539	138.051074	32	2
674	-30.26669	138.050246	52	304
675	-30.26678	138.04908	54	320
676	-30.266505	138.048708	50	30
677	-30.266235	138.048246	42	344
678	-30.267217	138.047859	63	267
679	-30.267923	138.047702	72	276
680	-30.268355	138.047614	58	228
681	-30.268944	138.047237	53	296
682	-30.269744	138.047089	86	264
683	-30.270929	138.04714	80	272
684	-30.27146	138.047204	66	243
686	-30.269859	138.053253	40	40
687	-30.269931	138.053894	40	15
688	-30.270212	138.054788	54	32
689	-30.270531	138.055219	60	44
690	-30.271832	138.057719	58	36
691	-30.27207	138.058203	74	38
693	-30.272637	138.059063	66	13
694	-30.273074	138.060365	79	8
695	-30.273184	138.060726	40	12
696	-30.273657	138.061799	58	23
697	-30.273799	138.062258	38	17
698	-30.27394	138.063142	50	20
699	-30.274438	138.06402	52	25
700	-30.276673	138.056339	70	40
701	-30.276257	138.05569	76	220
702	-30.275128	138.054154	80	236
703	-30.274568	138.053411	66	214
704	-30.27406	138.052626	76	236
705	-30.274872	138.052454	80	43
706	-30.27517	138.052916	68	30
707	-30.275924	138.053754	80	43
708	-30.276754	138.055148	70	46
709	-30.240936	138.038322	64	322
711	-30.244624	138.045241	64	276
712	-30.244984	138.045412	58	272
713	-30.245511	138.049815	26	287
714	-30.245222	138.050558	50	267
715	-30.245336	138.051139	62	260
716	-30.245481	138.051919	64	256

717	-30.245598	138.052646	54	262
718	-30.247311	138.052766	52	255
719	-30.247621	138.052274	65	278
720	-30.247731	138.052078	40	300
721	-30.248126	138.050974	52	340
722	-30.24804	138.050399	42	346
724	-30.247581	138.049793	30	330
725	-30.247363	138.049672	42	6
726	-30.246881	138.049577	46	346
727	-30.246186	138.049168	42	340
728	-30.244722	138.046038	54	350
729	-30.243766	138.044272	52	286
730	-30.243453	138.043665	70	300
731	-30.243308	138.04335	68	284
733	-30.242833	138.041997	36	270
734	-30.242269	138.041101	58	298
735	-30.241156	138.039855	58	290
736	-30.261901	138.0447	64	302
739	-30.261728	138.046193	40	326
740	-30.261798	138.046678	40	332
741	-30.263393	138.048939	64	358
742	-30.262828	138.05013	30	16
743	-30.263397	138.051554	58	23
744	-30.262559	138.053388	52	50
745	-30.263995	138.055506	44	10
746	-30.264784	138.055982	46	340
747	-30.264751	138.057298	40	332
748	-30.264802	138.058923	42	3
749	-30.264116	138.059183	56	357
751	-30.263035	138.05869	44	346
752	-30.262516	138.058561	42	340
753	-30.261295	138.058945	54	334
754	-30.261083	138.058532	38	332
761	-30.260704	138.057849	40	348
762	-30.259771	138.054926	32	10
763	-30.259685	138.054249	38	9
764	-30.259874	138.053586	48	0
765	-30.259802	138.052887	48	18
766	-30.259337	138.051945	48	18
767	-30.258757	138.049603	48	8
768	-30.258813	138.048784	52	22
769	-30.257827	138.046381	44	354

770	-30.257921	138.04489	42	300
771	-30.251369	138.033262	48	315
772	-30.24937	138.031402	46	320
773	-30.248436	138.031963	42	308
774	-30.021251	138.043188	40	302

APPENDIX B ALL GATHERED U/PB DATA AND SOME ACOMPANYING TABLES

CONCORDANT DATA TABLE
WITH PROPOGATED ERRORS
FOLLOWED BY
DISCORDANT DATA TABLE
WITH PROPOGATED ERRORS

Source file	FinalAge206_238	FinalAge206_238_Prop2SE	FinalAge207_206	FinalAge207_206_Prop2SE	concordance
112w1.D	1715	140	1602	81	107.0537
113w1.D	3879	280	3825	56	101.4118
115w1r.D	2246	180	2466	62	91.07867
116w1.D	2903	230	2865	71	101.3264
117w1.D	1499	130	1517	85	98.81345
118w1.D	1811	150	1750	82	103.4857
119w1.D	1583	140	1715	84	92.30321
120w1.D	972	88	895	100	108.6034
122w1.D	1547	130	1667	77	92.80144
122w1r.D	1688	140	1656	70	101.9324
123w1.D	1519	130	1452	86	104.6143
126w1.D	1701	140	1640	78	103.7195
127w1.D	1131	100	1142	82	99.03678
129w1.D	1553	130	1536	86	101.1068
130w1.D	1046	93	1156	85	90.48443
131w1.D	1105	98	1162	90	95.09466
133w1.D	1265	110	1274	79	99.29356
136w1.D	1739	150	1787	69	97.31393
138w1.D	1496	130	1440	87	103.8889
138w1r.D	1485	130	1475	73	100.678
139w1.D	1783	150	1707	71	104.4523
140w1.D	989	91	1043	110	94.82263
141w1.D	1796	150	1768	71	101.5837
142w1.D	1126	99	1140	110	98.77193
143w1.D	1056	94	1091	86	96.79193
145w1.D	1247	110	1245	94	100.1606
147w1.D	1329	110	1329	110	100
151w1.D	1953	160	2025	64	96.44444
153w1.D	998	87	959	88	104.0667
156w1.D	923	82	1015	78	90.93596
157w1.D	2386	190	2421	63	98.55432
158w1.D	1772	150	1732	78	102.3095
158w1r.D	1600	130	1720	70	93.02326
159w1.D	2003	170	2057	68	97.37482
160w1.D	925	85	870	130	106.3218
162w1r.D	976	86	1020	87	95.68627
162w1.D	979	86	1025	93	95.5122
163w1.D	1259	110	1244	88	101.2058
1w2.D	1723	150	1708	89	100.8782
3w2.D	1753	150	1695	70	103.4218
4w2.D	2445	190	2354	69	103.8658

5w2.D	1919	160	1810	75	106.0221
7w2.D	1524	130	1536	93	99.21875
7w2r.D	1593	140	1631	78	97.67014
8wr.D	1090	96	1027	87	106.1344
8w.D	1062	95	1097	97	96.80948
9w2.D	2399	190	2409	65	99.58489
9w2r.D	2382	190	2360	63	100.9322
10w2.D	1738	150	1731	98	100.4044
11w2.D	1227	110	1282	81	95.70983
12w2.D	1709	140	1877	74	91.04955
13w2b.D	2419	190	2544	63	95.08648
15w2.D	1562	130	1663	81	93.92664
16w2.D	1806	150	1789	74	100.9503
17w2r.D	2269	180	2322	65	97.71748
17w2rr.D	2382	190	2337	63	101.9255
18w2.D	2314	180	2395	64	96.61795
19w2.D	1688	140	1680	76	100.4762
20w2.D	1649	140	1796	80	91.81514
23w2.D	1551	140	1670	130	92.87425
24w2.D	1714	140	1706	69	100.4689
26w2.D	2576	200	2478	67	103.9548
28w2.D	2549	200	2464	62	103.4497
29w2.D	1798	150	1720	120	104.5349
30w2.D	1648	140	1594	76	103.3877
33w2.D	1676	140	1760	83	95.22727
34w2r.D	1580	130	1667	76	94.78104
1W11.D	1713	49	1699	68	100.824
2W11.D	1982	56	2068	67	95.84139
3W11.D	1478	42	1426	89	103.6466
4W11.D	2497	60	2463	62	101.3804
6W11.D	1685	45	1647	70	102.3072
7W11.D	2437	60	2398	58	101.6264
8W11.D	1722	47	1709	63	100.7607
9W11.D	2187	57	2366	58	92.43449
10W11.D	1813	55	1962	82	92.40571
11W11.D	3044	74	3010	58	101.1296
12W11.D	1712	43	1611	66	106.2694
13W11.D	1596	54	1570	120	101.6561
14W11.D	2402	61	2389	59	100.5442
15W11.D	3051	76	3060	55	99.70588
16W11.D	1717	46	1690	68	101.5976
17W11.D	1696	50	1830	75	92.6776

18W11.D	1686	44	1657	64	101.7502
20W11.D	2501	65	2472	62	101.1731
21W11.D	1758	47	1694	67	103.778
23W11.D	2292	61	2362	68	97.03641
24W11.D	1713	49	1689	69	101.421
25W11.D	1693	50	1687	68	100.3557
26W11.D	1675	46	1715	63	97.66764
27W11.D	1649	50	1667	78	98.92022
28W11.D	1667	57	1694	94	98.40614
29W11.D	2941	75	3026	58	97.19101
30W11.D	1573	53	1611	94	97.64122
32W11.D	2523	63	2478	58	101.816
33W11.D	1645	48	1713	74	96.03036
34W11.D	1714	50	1695	84	101.1209
36W11.D	1691	45	1713	64	98.7157
37W11.D	1105	49	1050	150	105.2381
39W11.D	1656	45	1679	61	98.63014
40W11.D	2382	66	2373	59	100.3793
41W11.D	3118	74	3172	56	98.2976
42W11.D	1731	48	1729	69	100.1157
44W11.D	1675	44	1680	66	99.70238
45W11.D	1121	32	1079	79	103.8925
46W11.D	1525	44	1564	71	97.50639
51W11.D	1154	37	1119	94	103.1278
52W11.D	1725	45	1710	64	100.8772
53W11.D	1687	46	1668	67	101.1391
54W11.D	1129	57	1110	190	101.7117
55W11.D	2777	97	2944	78	94.32745
57W11.D	1563	43	1506	71	103.7849
58W11.D	1459	37	1511	64	96.55857
59W11.D	1672	54	1686	98	99.16963
60W11.D	1675	45	1710	73	97.95322
62W11.D	2476	68	2547	67	97.21241
63W11.D	1714	51	1654	74	103.6276
64W11.D	1695	48	1682	73	100.7729
65W11.D	1779	55	1790	81	99.38547
67W11.D	2210	69	2286	74	96.67542
68W11.D	1696	54	1645	77	103.1003
69W11.D	1685	49	1712	76	98.4229
70W11.D	1692	55	1711	74	98.88954
71W11.D	1595	50	1568	88	101.7219
72W11.D	1791	49	1690	66	105.9763

73W11.D	1686	49	1690	75	99.76331
74W11.D	3051	77	3112	57	98.03985
76W11.D	1690	47	1689	78	100.0592
78W11.D	1660	47	1705	71	97.3607
79W11.D	1447	40	1491	67	97.04896
80W11.D	2443	67	2434	68	100.3698
81W11.D	1363	40	1507	73	90.44459
82W11.D	1703	53	1728	75	98.55324
86W11.D	1703	48	1697	73	100.3536
88W11.D	1663	47	1696	70	98.05425
89W11.D	2259	61	2407	60	93.85127
90W11.D	1625	45	1682	65	96.61118
92W11.D	2549	68	2503	60	101.8378
94W11.D	1746	48	1651	71	105.7541
95W11.D	2303	68	2439	63	94.42394
96W11.D	2409	65	2477	66	97.25474
97W11.D	3104	80	3098	55	100.1937
99W11.D	2373	63	2397	59	98.99875
101W11.D	1265	38	1213	79	104.2869
102W11.D	1630	62	1610	120	101.2422
103W11.D	1825	51	1815	63	100.551
105W11.D	1531	52	1653	99	92.61948
106W11.D	1158	50	1220	150	94.91803
107W11.D	1672	48	1696	68	98.58491
108W11.D	2317	69	2379	70	97.39386
109W11.D	1692	50	1655	74	102.2356
111W11.D	2537	94	2532	96	100.1975
112W11.D	2400	66	2311	66	103.8511
113W11.D	1461	44	1475	82	99.05085
114W11.D	1714	50	1692	76	101.3002
115W11.D	2948	91	2924	64	100.8208
116W11.D	2246	71	2352	70	95.4932
118W11.D	1547	49	1520	87	101.7763
119W11.D	1687	48	1662	69	101.5042
120W11.D	1488	46	1562	92	95.26248
121W11.D	1630	47	1724	71	94.54756
122W11.D	2416	66	2337	64	103.3804
123W11.D	2524	77	2514	66	100.3978
124W11.D	2397	67	2387	60	100.4189
125W11.D	2128	57	2338	56	91.01796
126W11.D	1462	41	1475	69	99.11864
128W11.D	1611	62	1630	130	98.83436

129W11.D	1649	49	1679	78	98.21322
130W11.D	1501	50	1499	92	100.1334
1w5.D	2557	43	2458	70	104.0277
3w5.D	1822	35	1801	78	101.166
4w5.D	1858	38	1770	82	104.9718
6w5.D	1718	37	1703	77	100.8808
6w5r.D	1776	37	1725	90	102.9565
7w5r.D	1829	34	1844	83	99.18655
9w5.D	2340	45	2388	76	97.98995
10w5.D	1534	36	1545	100	99.28803
12w5.D	1743	38	1746	92	99.82818
14w5.D	1850	36	1837	79	100.7077
15w5.D	1580	36	1574	92	100.3812
16w5.D	2372	44	2425	69	97.81443
17w5.D	1856	37	1886	83	98.40933
18w5.D	1581	36	1586	86	99.68474
19w5.D	1715	33	1730	80	99.13295
20w5.D	1810	35	1847	77	97.99675
21w5.D	2403	42	2405	68	99.91684
22w5r.D	2451	44	2405	71	101.9127
22w5rr.D	2397	39	2413	70	99.33692
23w5.D	1623	37	1746	86	92.95533
24w5.D	1745	35	1712	81	101.9276
25w5.D	1536	35	1595	83	96.30094
27w5.D	1655	30	1749	74	94.6255
30w5.D	1751	34	1720	80	101.8023
33w5.D	1736	30	1802	73	96.3374
34w5.D	1576	30	1564	86	100.7673
2w1.D	1071	27	1119	82	95.71046
3w1.D	1735	50	1861	76	93.22945
4w1.D	1664	46	1749	77	95.14008
5w1.D	987	30	983	91	100.4069
6w1.D	930	31	1005	95	92.53731
10w1.D	1254	41	1321	100	94.92808
17w1r.D	1013	33	975	95	103.8974
18w1.D	2675	65	2757	59	97.02575
19w1.D	1654	50	1668	88	99.16067
21w1.D	2364	60	2472	62	95.63107
22w1.D	1114	34	1202	100	92.67887
25w1.D	1309	37	1343	88	97.46835
27w1.D	1147	36	1259	92	91.10405
28w1.D	1294	38	1339	89	96.63928

29w1.D	962	28	1032	98	93.21705
30w1.D	949	29	964	100	98.44398
31w1.D	1547	43	1648	85	93.87136
32w1.D	1572	50	1702	100	92.36193
34w1r.D	903	26	884	86	102.1493
34w1rr.D	915	25	885	78	103.3898
35w1.D	1594	41	1703	70	93.59953
38w1.D	1158	36	1187	94	97.55687
39w1.D	1010	33	1042	110	96.92898
41w1.D	1574	55	1740	91	90.45977
44w1.D	1847	51	2027	73	91.11988
45w1.D	1677	49	1700	81	98.64706
46w1.D	1597	46	1667	79	95.80084
48w1.D	1362	39	1395	76	97.63441
49w1.D	1798	49	1729	70	103.9907
50w1.D	2013	51	2223	64	90.55331
51w1r.D	1088	34	1068	95	101.8727
52w1.D	1101	33	1087	87	101.2879
53w1.D	1977	54	1976	66	100.0506
54w1r.D	1623	46	1594	79	101.8193
55w1.D	2467	63	2509	63	98.32603
57w1.D	2591	67	2482	63	104.3916
59w1.D	1554	43	1487	76	104.5057
60w1.D	1362	39	1366	78	99.70717
61w1.D	1133	32	1161	80	97.58829
62w1.D	1661	48	1639	80	101.3423
62w1r.D	1666	45	1615	79	103.1579
63w1.D	1015	29	945	84	107.4074
67w1.D	2601	68	2596	65	100.1926
68w1.D	1126	37	1152	100	97.74306
69w1.D	1809	52	1782	77	101.5152
71w1.D	1756	49	1764	74	99.54649
73w1.D	1637	48	1597	85	102.5047
75w1.D	1414	63	1290	180	109.6124
77w1.D	1682	50	1629	77	103.2535
78w1.D	1742	52	1793	75	97.15561
79w1.D	1502	49	1595	81	94.16928
79w1r.D	1308	38	1286	83	101.7107
80w1.D	1573	44	1737	72	90.55843
83w1.D	1149	35	1196	84	96.07023
84w1.D	941	31	1004	92	93.7251
85w1.D	1806	48	1746	71	103.4364

87w1.D	994	32	987	95	100.7092
88w1.D	1611	51	1583	94	101.7688
89w1.D	2447	68	2474	64	98.90865
90w1.D	957	29	894	86	107.047
91w1.D	1702	50	1820	79	93.51648
92w1.D	1032	30	989	81	104.3478
96w1.D	1035	32	1127	86	91.83673
97w1.D	1105	43	1210	140	91.32231
98w1r.D	1054	33	1105	83	95.38462
99w1.D	1614	49	1712	89	94.2757
101w1.D	1419	43	1468	88	96.66213
102w1.D	1014	29	993	78	102.1148
104w1.D	2693	76	2779	71	96.90536
106w1.D	1435	41	1536	71	93.42448
109w1.D	1018	29	1004	82	101.3944
110w1.D	1206	37	1287	87	93.70629
111w1.D	1189	36	1245	87	95.50201
4w4.D	2477	77	2491	37	99.43798
6w4r.D	1811	59	1862	41	97.26101
7w4r.D	1553	51	1712	30	90.71262
8w4.D	1686	55	1682	41	100.2378
8w4r.D	1715	57	1711	44	100.2338
9w4.D	1680	56	1724	40	97.4478
10w4.D	1730	57	1697	42	101.9446
11w4.D	2374	76	2475	33	95.91919
12w4.D	1704	57	1690	64	100.8284
12w4r.D	1700	59	1663	48	102.2249
13w4.D	2384	75	2379	29	100.2102
14w4.D	2180	69	2411	25	90.41891
14w4r.D	1693	56	1690	29	100.1775
18w4.D	2744	99	2796	42	98.1402
19w4.D	2825	88	2831	30	99.78806
19w4r.D	1996	68	2079	31	96.0077
20w4.D	2216	75	2258	30	98.13995
22w4.D	1745	61	1704	44	102.4061
23w4.D	1698	59	1698	45	100
25w4.D	2172	72	2244	34	96.79144
27w4r.D	2592	88	2707	36	95.75175
28w4r.D	1689	59	1711	46	98.7142
29w4.D	1695	58	1721	36	98.48925
30w4.D	1723	60	1732	40	99.48037
30w4r.D	2283	76	2334	32	97.81491

31w4.D	1695	57	1709	35	99.18081
33w4.D	2420	160	2391	34	101.2129
44w4.D	1690	110	1714	31	98.59977
45w4.D	1506	94	1456	62	103.4341
47w4.D	1691	77	1757	47	96.2436
49w4.D	1690	67	1739	42	97.18229
50w4.D	1660	60	1743	48	95.2381
51w4.D	1534	63	1631	88	94.05273

Source file	FinalAge206_238	FinalAge206_238_Prop2SE	FinalAge207_206	FinalAge207_206_Prop2SE	concordance
121w1.D	919	83	1534	77	59.90874
124w1.D	1397	120	1644	75	84.97567
125w1.D	1139	92	2127	95	53.5496
128w1a.D	708	64	2829	65	25.02651
128w1.D	892	79	1031	81	86.51794
132w1.D	1263	110	2401	100	52.60308
134w1.D	1530	130	1745	83	87.67908
135w1.D	1153	100	1543	81	74.72456
137w1.D	877	79	1094	95	80.16453
139w1r.D	993	87	1324	73	75
144w1.D	1077	96	1261	84	85.40841
146w1.D	838	75	2383	65	35.16576
148w1.D	857	76	1786	74	47.98432
149w1r.D	1170	100	1925	67	60.77922
150w1.D	529	51	1762	93	30.0227
152w1.D	967	86	1450	85	66.68966
154w1.D	1971	160	2566	68	76.81216
155w1.D	972	87	1098	95	88.52459
159w1r.D	1508	130	1917	67	78.66458
2w2.D	2770	430	4300	260	64.4186
6w2.D	377	36	2028	66	18.58974
13w2.D	1354	130	2122	66	63.80773
14w2.D	545	50	2013	64	27.07402
21w2.D	1432	130	1595	110	89.78056
22w2.D	2324	190	2629	62	88.39863
25w2.D	no value		no value		#VALUE!
27w2.D	693	63	1865	67	37.15818
31w2.D	1084	97	1675	88	64.71642
32w2.D	2170	180	2522	79	86.04282
34w2.D	1493	130	1704	79	87.61737
5W11.D	1568	57	1850	120	84.75676
20W11R.D	1469	62	1719	84	85.45666
22W11.D	526	50	2549	70	20.63554
31W11.D	1759	52	2038	87	86.31011
35W11.D	1095	34	2260	65	48.45133
39W11R.D	1124	31	1779	62	63.18156
43W11.D	1458	67	2099	83	69.46165
47W11.D	1373	39	1667	65	82.36353
48W11.D	1114	50	1450	160	76.82759
49W11.D	1309	42	2372	59	55.1855
50W11.D	170	5.2	2801	56	6.069261
56W11.D	943	37	1781	93	52.94778
61W11.D	1375	41	2183	62	62.98672
66W11.D	563	20	1969	71	28.59319
75W11.D	1245	36	1674	64	74.37276
77W11.D	1016	29	2232	58	45.51971
83W11.D	1588	50	1771	70	89.66685

84W11.D	925	29	1953	61	47.36303
86W11R.D	1424	58	1873	110	76.02776
87W11.D	1031	38	1662	77	62.03369
91W11.D	1210	34	1510	68	80.13245
94W11R.D	1489	58	1759	76	84.65037
98W11.D	777	31	1855	89	41.88679
100W11.D	1106	35	1427	71	77.50526
104W11.D	1298	44	1718	89	75.55297
110W11.D	1126	33	1700	64	66.23529
117W11.D	1875	88	3212	110	58.37484
127W11.D	1444	41	1875	84	77.01333
2w5.D	819	16	1808	75	45.29867
5w5.D	1522	38	1710	100	89.00585
7w5.D	1677	43	1935	90	86.66667
8w5.D	1441	30	1791	77	80.45784
11w5.D	2116	47	2358	74	89.73707
13w5.D	549.4	12	2087	73	26.32487
26w5r.D	607	14	2036	77	29.81336
26w5rr.D	257.9	5.7	2590	71	9.957529
28w5.D	1614	30	1867	74	86.44885
29w5.D	1170	38	2299	72	50.89169
31w5.D	1086	33	3568	77	30.43722
32w5.D	1466	41	1812	87	80.90508
35w5.D	no value		no value		#VALUE!
36w5.D	1178	21	1828	76	64.44201
1w1.D	1962	47	2661	60	73.73168
7w1.D	1312	41	1458	83	89.98628
8w1.D	607	18	2768	60	21.92919
9w1.D	849	23	1389	73	61.12311
11w1.D	1174	30	1696	69	69.2217
12w1.D	1334	66	2060	140	64.75728
13w1r.D	1016	27	1156	80	87.88927
13w1.D	984	27	1175	81	83.74468
14w1.D	929	26	2501	62	37.14514
15w1.D	497	18	2981	62	16.67226
16w1.D	1789	49	2347	63	76.22497
23w1.D	1309	35	2483	64	52.71849
24w1.D	562	18	3325	58	16.90226
26w1.D	1042	31	2180	180	47.79817
33w1.D	876	27	1702	81	51.46886
33w1r.D	770	22	2408	63	31.97674
37w1.D	1685	52	2515	62	66.99801

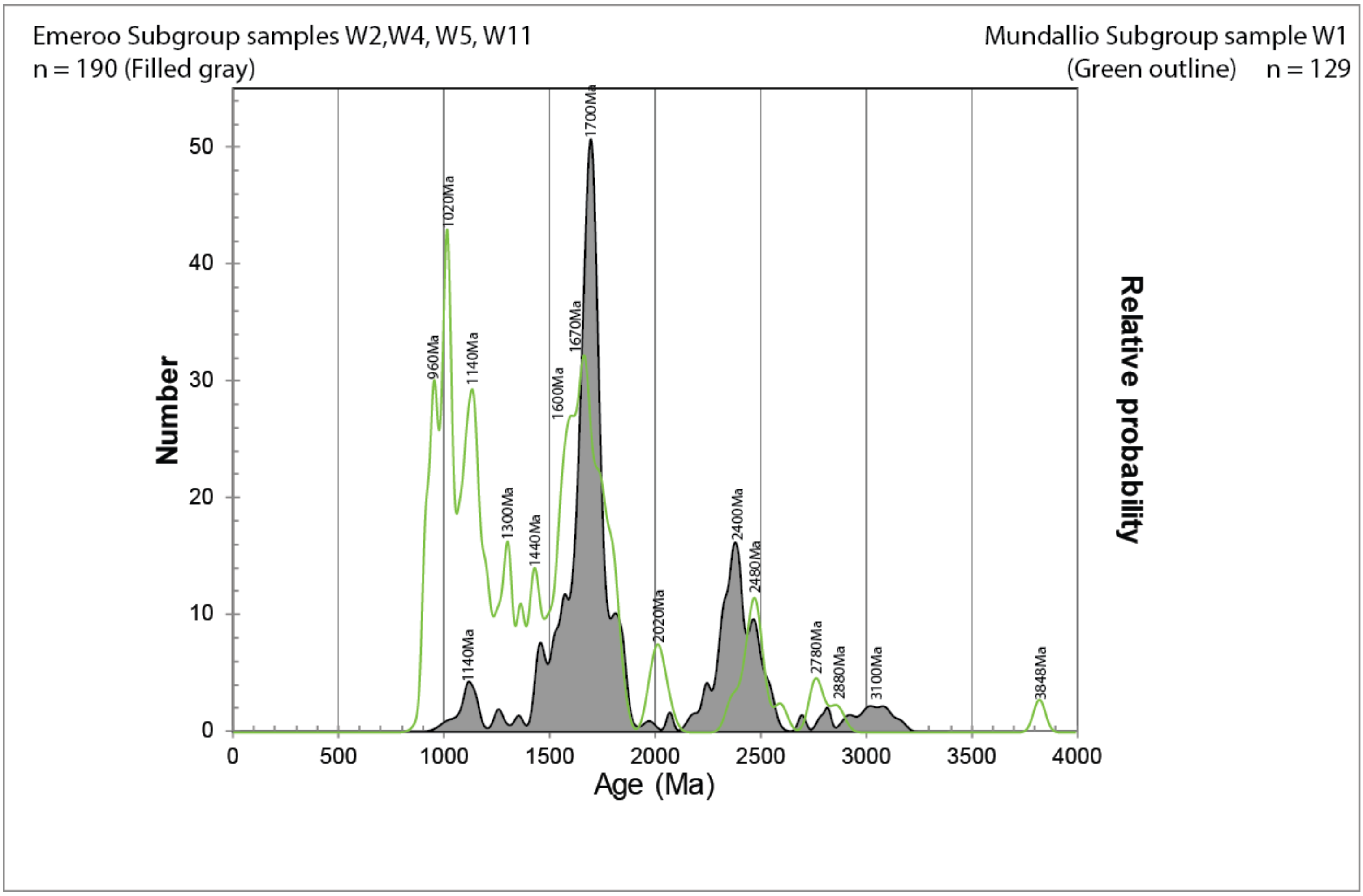
36w1.D	1509	49	2021	67	74.66601
40w1.D	1174	32	1523	75	77.0847
42w1.D	1018	34	1467	100	69.39332
43w1.D	967	27	1331	78	72.65214
44w1r.D	874	25	1436	72	60.86351
47w1.D	1614	44	2209	64	73.06474
51w1.D	1068	33	1197	100	89.22306
52w1r.D	970	28	1549	70	62.62105
54w1.D	1518	45	1717	76	88.41002
56w1.D	975	28	1143	71	85.30184
58w1.D	957	28	1266	78	75.59242
64w1.D	1572	53	2237	82	70.27269
66w1.D	388	12	2036	68	19.05697
70w1.D	1356	36	2553	61	53.11398
72w1.D	946	28	2263	72	41.80292
76w1.D	1040	35	1584	67	65.65657
74w1.D	1060	31	883	120	120.0453
65w1.D	1045	30	936	87	111.6453
77w1r.D	1303	36	1468	70	88.76022
81w1.D	901	27	1072	84	84.04851
82w1.D	1211	41	1827	66	66.28352
86w1.D	962	31	1258	87	76.47059
93w1.D	1163	34	1332	79	87.31231
94w1.D	1470	44	1811	80	81.17062
95w1.D	1425	45	1845	68	77.23577
100w1.D	792	28	2494	76	31.75621
103w1.D	646	25	1979	77	32.64275
105w1.D	931	27	1039	82	89.60539
107w1.D	1722	51	2351	76	73.24543
115w1.D	2294	180	2566	63	89.39984
20w1.D	1031	29	1272	73	81.05346
108w1.D	910	34	1740	100	52.29885
1W4.D	1222	43	1611	33	75.85351
1W4R.D	493	18	2203	29	22.37857
2W4R.D	511	19	2482	26	20.58824
3w4.D	1183	42	1881	33	62.89208
5w4r.D	1468	48	1724	30	85.15081
5w4.D	594	23	1670	45	35.56886
7w4rr.D	1056	39	1703	44	62.00822
16w4.D	2344	89	3896	42	60.16427
17w4.D	494	21	2603	32	18.9781
21w4.D	1170	49	2360	29	49.57627

24w4.D	414	18	2542	33	16.28639
26w4r.D	1236	46	1639	45	75.41184
32w4.D	373	14	2225	28	16.76404
42w4.D	1360	170	1643	44	82.77541
43w4.D	186	21	3450	32	5.391304
46w4.D	1650	100	3773	64	43.73178
48w4.D	1364	63	1692	56	80.61466

ACCOMPANYING PROBABILITY DENSITY CURVE AND TABLE OF POSSIBLE SOURCE REGIONS

Sampled Formations			Geological unit			
Emeroo Subgroup	Mundallio Subgroup	Known age determinations (Ma)	Gawler Craton	Curnamona Provicne	Musgrave Province	References
	3848Ma	???				
3110Ma		ca.3150	Cooyerdoo Granite			Fraser et al. (2010)
	2880Ma	???				
2836Ma	2780Ma					
2565Ma	2486Ma	2558±27	Mulgathing and Sleaford Complexes			Daly et al. (1998)
		2560-2500				
2480Ma	2480Ma					Fanning et al. (1988)
2400Ma	2020Ma	2015±28	Milatalie Gneiss			Belousova et al. (2009)
1844Ma		ca. 1850	Donington Suite			Myers et al. (1996)
		1760-1740	Wallaroo Group			Belousova et al. (2009)
		1763-1738	Moonta Porphyry			Dutch et al. (2008)
		ca. 1750	Moody Suite			
		1737±7	Middle Camp Granite			Reid et al. (2008)
1700 Ma		~1715-1670		lower Wilyama Supergroup		Barovich and Hand (2008)
		~1670-1640		upper Wilyama		
	1670Ma	~1670-1640	Tarcoola Formation	Supergroup		Barovich and Hand (2008)
		1656±7	St Peter Suite			Flint etal. (1990)
		1631-1627	Nuyts Volcanics			Flint et al. (1990)
	1600Ma					
1594Ma		1595-1575	Hiltaba Suite			Flint et al. (1993)
		ca.1590	Gawler Range Volcanics			Howard et al. (2011)
		ca1580	Munjeela granite			Ferris et al. (2004)
1473Ma	1440Ma	ca. 1500	Spilsby Suite			Howard et al. (2011)
	1300Ma	1200-1160			Musgrave Orogeny	Edgoose et al. 2004
1140Ma	1140Ma	1190-1120			Pitjantjatjara Supersuite	Edgoose et al. 2004
	1020Ma	1080-1040			Giles Event	Edgoose et al. 2004
	960Ma					

Table 2 Table of Gawler Curnamona and Musgrave igneous and metamorphic events against Emeroo and Mundallio sample age peaks from fig 11. Figure modified from (Job, 2011).



Mulgathing 2558±27 and Sleaford complexes 2560-2500Ma (Daly, Fanning, & Fairclough, 1998)

Cooyerdoo granite ~3150Ma (Fraser et al., 2010)

Milatalie Gneiss 2015±28Ma (Fanning, Flint, Parker, Ludwig, & Blissett, 1988)

Donington suite ~1850Ma (Belousova, Reid, Griffin, & O'Reilly, 2009)

Wallaroo group Gawler Craton 1760-1740Ma (Myers, Shaw, & Tyler, 1996)

Moonta Porphyry 1763-1738 (Belousova et al., 2009)

Moody Suite ~1750Ma (Dutch, Hand, & Kinny, 2008)

Middle Camp Granite 1737±7 (Reid, Hand, Jagodzinski, Kelsey, & Pearson, 2008)

Lower Willyama Supergroup Curnamona province ~1670-1715Ma (Barovich & Hand, 2008)

Upper Willyama super group ~1670-1640 (Barovich & Hand, 2008)

Tarcoola Formation Gawler craton~1670-1640 (Barovich & Hand, 2008)

St Peter Suite 1656±7 (Flint, Rankin, & Fanning, 1990)

Nuyts volcanics 1631-1627 (Flint et al., 1990)

Hiltaba suite 1595-1575 (M. P. Hand et al., 2008)

Gawler range volcanics ~1590 (Howard, Hand, Barovich, & Belousova, 2011)

~1580Ma Munjilla granite (Ferris & Schwarz, 2004)

Moolawtana Suite 1550-1560Ma (Robertson, Preiss, Crooks, Hill, & Sheard, 1998)

Curnamona province

Curnamona Granitoid gneiss (Raetz, Krabbendam, & Donaghy, 2002)