Government of **Western Australia**
Department of **Mines and Petroleum**

**RECORD 2016/11**

# STRATIGRAPHIC EVOLUTION OF THE SOUTHERN AUSTRALIAN ONSHORE BIGHT BASIN: A RECORD FOR THE BREAKUP OF GONDWANA DURING THE CRETACEOUS

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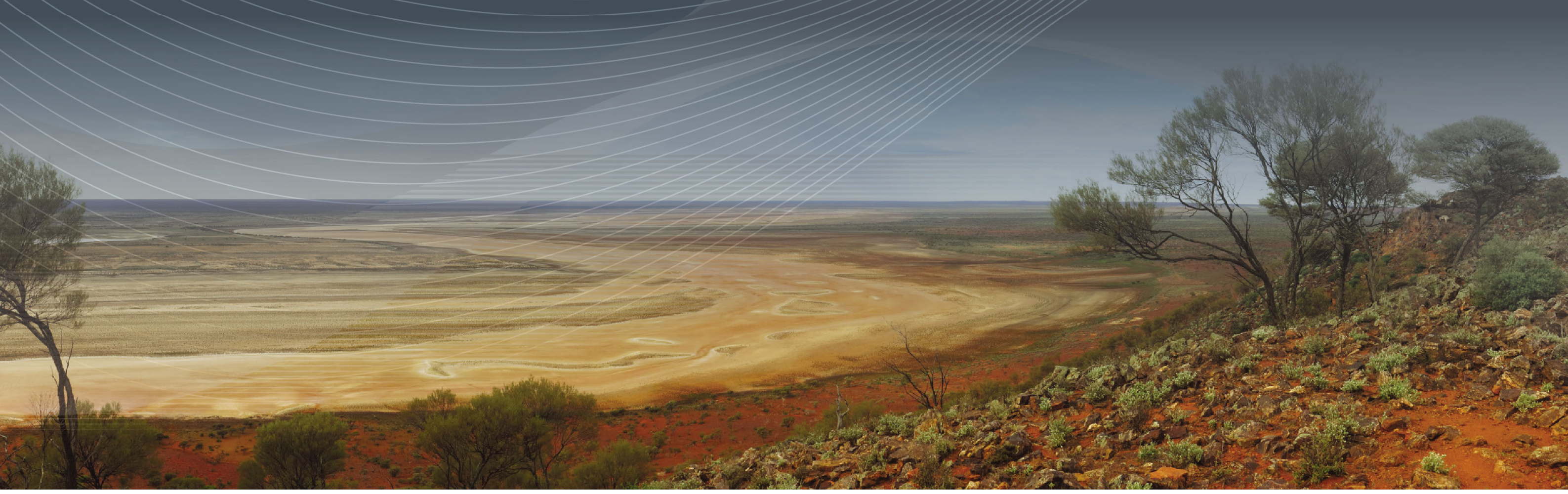

**Geological Survey of Western Australia**

Curtin University

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**Perth 2016**

**Geological Survey of Western Australia**

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**Cover image:** Elongate salt lake on the Yilgarn Craton — part of the Moore–Monger paleovalley — here viewed from the top of Wownaminya Hill, 20 km southeast of Yalgoo, Murchison Goldfields. Photograph taken by I Zibra for the Geological Survey of Western Australia

# Stratigraphic evolution of the southern Australian onshore Bight Basin: a record for the breakup of Gondwana during the Cretaceous

**Shane Reynolds**

**2014**

Supervised and edited by Dr. Milo Barham (Department of Applied Geology) and Dr. Michael O'Leary (Department of Environment and Agriculture)

*A thesis submitted to the Department of Applied Geology in part fulfilment of the requirements for the degree - Bachelor of Science (Honours), Curtin University*

**Affirmation of Research**

I hereby declare this thesis to be a reflection of my own work and capabilities. The following list provides details of the tasks that I personally undertook and completed during the course of this honours project.

- I logged a total of 1226 m of diamond core and 1266 m of core chips from 17 boreholes (Table 1) at the Geological Survey of Western Australia (GSWA) core library, Carlisle Western Australia.
- I sourced supplementary stratigraphic data for a further 13 wells from various online geoservers and reports (Table 1)
- I collected and systematically described 49 sediment samples under a binocular microscope, completed at Curtin University.
- I created digital summary logs for diamond cored intervals of five boreholes using Adobe Illustrator (Appendix 1).
- I picked an average of between 100 - 150 detrital zircons from seven processed sediment samples using a binocular microscope. I assisted in Cathodoluminescence (CL) mapping of detrital zircon grains and sample point selection for LA-ICPMS analysis.
- I created and managed databases of the logged and supplementary data, which was then used to create and analyse 2D and 3D models using Esri ArcMAP and Golden Software's Strater 4.
- I analysed and interpreted detrital zircon, palynology and lithology data to constrain the timing of key basinal events. Including basin subsidence and constraining the spatial and temporal extent of the Madura Formation's marine deposition during the Albian.

***Shane Reynolds***

## Table of Contents

## List of Figures



## List of Tables

**Abstract**

The Bight Basin, on the southern margin of Australia, was formed during the breakup of Gondwana and rifting of Australia and Antarctica. The sediment sequences preserved in the Mesozoic and Cenozoic basins along Australia's southern margin preserve a record of this breakup and transition to the present-day passive margin. However, many parts of the expansive Bight Basin, and in particular the onshore portion (the Madura Shelf), remain poorly understood and understudied. An updated geological history for the Madura Shelf in Western Australia is presented herein. This study describes the sedimentology, acquires palynology data and carries out U/Pb dating of detrital zircon populations from recently drilled boreholes from the Madura Shelf and associated sediments in Western Australia. The results presented here show that deposition of the Madura Shelf commenced during the Early Cretaceous, initial sedimentation was characterised by non-marine sands and silts before widespread marine conditions became established by the mid-Albian. Deposition continued until the end of the Cretaceous, by which time the sediment of the Madura Formation had completely blanketed the irregular basement topography. Detrital zircon U/Pb age populations from the Madura Shelf sediments are consistent with the expected detrital zircon signatures of the Musgrave Province and Albany-Fraser Orogen, suggesting these basement blocks are the likely primary sediment source or have been recycled via older sedimentary basins. This study also describes two previously unknown sedimentary units, the Decoration Sandstone and Shanes Dam Conglomerate. Detrital zircon U/Pb age populations for the Decoration Sandstone are similar to that of the Madura Shelf sediments, while the U/Pb ages for Shanes Dam Conglomerate indicate it was sourced locally. The study also reveals the possible existence of several previously unknown geological events, namely a record of mid-Cretaceous syn-depositional volcanism and late-Albian fault reactivation in a small near-shore half graben. Furthermore, the flat surface elevations for Madura Shelf identified in this study help constrain the position of the dynamic topographic low associated with the late Cenozoic uplift of the southern margin of Australia, as being located to the north of the Madura Shelf at the end of the Cretaceous.

**Keywords**

Bight Basin; Madura Formation; Loongana Formation; Stratigraphy; Detrital Zircon

## 1.0 Introduction

The Madura Shelf is the only onshore component of the expansive Bight Basin, which extends along western portions of the southern margin of Australia (Figure 1). The clastic sediments of the Madura Shelf were deposited during the Gondwanan breakup of southern Australia and Antarctica (Blevin and Cathro 2008; Bradshaw et al. 2003). These sediments record paleoenvironmental conditions and the timing of key basinal events, such as the initiation of basin subsidence and the timing of widespread marine conditions along the proto southern continental margin during the Cretaceous. Despite its potential to inform understanding of the geological evolution of the region, the Madura Shelf has been largely overlooked by recent studies in the area that have focussed on the more accessible Eucla Group carbonates (e.g. Feary and James 1995, 1998; O'Connell 2011) and the highly prospective frontier hydrocarbon exploration sub-basins of the offshore Bight Basin (e.g. Blevin and Cathro 2008; Bradshaw 2005; Totterdell et al. 2000). The reason for the limited studies is partly due to the fact that the Madura Shelf is completely obscured onshore by the Cenozoic sediments of the Eucla Basin and only known from a small number of exploration drill holes (Lowry 1970). This has resulted in a fragmentary record and understanding of the Madura Shelf, in particular for Western Australia, with the last major study of the Mesozoic sediments underlying the Eucla Basin in the state being conducted by Lowry (1970).

New borehole data has recently become available for the Madura Shelf in Western Australia, via the Geological Survey of Western Australia (GSWA) 2013/14 Eucla Basin basement drilling program and several mineral exploration holes which have also recently become open file. This study describes the sedimentology, stratigraphy, palynology, and acquires the first detrital zircon U/Pb ages of the Madura Shelf and related sediments from the sequences of the new boreholes. This study also analyses the new data, incorporates the findings of previous studies (e.g. Lowry 1970; Totterdell and Krassay 2003), and includes supplementary stratigraphic data from online government geoservers to develop an updated model for the geological history of the Cretaceous Madura Shelf for Western Australia with a focus on evolving paleoenvironments, sediment sourcing and basin subsidence. The results of this study will aid our fundamental understanding of the development of the southern continental margin during the separation of Australia and Antarctica during the Cretaceous.

## 2.0 Regional Setting

The Mesozoic Bight Basin is partly overlain by the Cenozoic Eucla Basin (Figure 1; Blevin and Cathro 2008). The Bight Basin encompasses a series of offshore half graben structures as well as the continental platform of the Madura Shelf (Figure 1; Bradshaw et al. 2003). The initial rifting of Australia and Antarctica was characterised by a period of upper crustal extension that progressed from west to east from the Late Jurassic to the Early Cretaceous. Deposition in the proto Bight Basin was restricted to a series of syn-rift half graben that developed in response to the crustal extension (Totterdell et al. 2000). Following the initial mechanical extensional period, thermal subsidence began towards the start of the Early Cretaceous. Subsidence resulted in wide-spread deposition throughout the Bight Basin, accumulating as post-rift fill in the half graben depocentres, and also forming a thin sediment veneer over the Madura Shelf (Figure 1; Bradshaw et al. 2003). A period of accelerated subsidence was initiated in the Bight Basin towards the end of the Early Cretaceous that coincided with a major mid-Cretaceous highstand that inundated much of central eastern Australia, and saw marine conditions become established throughout the Bight Basin (Blevin and Cathro 2008; Bradshaw et al. 2003; Totterdell et al. 2000). Sedimentation continued in the Bight Basin until the end of the Cretaceous, but was followed by a 25 – 60 Ma hiatus, which ended when sedimentation recommenced in the Eocene with the deposition of the Hampton Sandstone and Eucla Group carbonates of the Eucla Basin (Lowry 1970; Totterdell et al. 2000).

The Cretaceous Madura Shelf is flanked by four major basement blocks (Figure 1). The Archean Yilgarn Craton and the Paleo – Mesoproterozoic Albany-Fraser Orogen lie to the west, with the latter partly underlying the western portions of the Madura Shelf (Spaggiari 2012). The Mesoproterozoic Musgrave Province is situated to the north and it is separated from the Madura Shelf by the Neoproterozoic – Paleozoic sediments of the Officer Basin that continue under the northern and eastern Madura Shelf (Hou et al. 2011). The Neoarchean to early Paleoproterozoic Gawler Craton lies to the east of the Madura Shelf (Reid et al. 2013).

In Western Australia the Madura Shelf typically consists of the Madura Formation and the Loongana Formation (Figure 2). The generalised stratigraphy in the west (Figure 2) consists of an irregular distribution of the coarse, basal Loongana Formation overlying crystalline basement. The basal sands are conformably overlain by silts and fine sands of the Madura Formation, which continued to be deposited through to the Late Cretaceous (Lowry 1970). A hiatus of 25-60 Ma occurred from the Late Cretaceous, lasting until sedimentation recommenced in the mid - Eocene with the deposition of the Hampton Sandstone and the Eucla Group carbonates (O'Connell 2011; Lowry 1970; Feary and James 1998).

## 3.0 Materials and Methods

### 3.1 Acquisition and Processing of Stratigraphic Data

All core data used in this study came from archived drill core housed at the GSWA Carlisle Core Library in Perth, Western Australia. A total of seven diamond core wells were logged. Three wells were made available by GSWA via their recent 2013/14 Eucla Basin basement drilling program, and a further four open file mineral holes that cored the Madura Shelf have also recently become open file (Table 1). Additionally, chip trays and ditch cuttings were described for 10 wells, including one GSWA borehole and nine oil shale exploration wells (Table 1). A total of 49 representative samples were collected from the cored wells, which were then systematically described under a binocular reflected light microscope. A Hitachi TM3030 desktop SEM with Oxford Swift ED 3000 EDX capabilities was used to assist in mineral identification. Digitised summary log sheets were created for five wells that represent the logged sections (Appendix 1). Logged data were supplemented by reports and online well data for a further 13 wells (Table 1). Supplementary wells from South Australia have been included in this study to assist in extrapolating the stratigraphy to the Western Australian border. The meter values quoted in this study for specific features are actual drilling depths in meters, or where elevations have been quoted they are given relative to the Australian Height Datum (AHD) in meters and “AHD” will be written. Raw stratigraphic contact elevation data is presented in Appendix 2.

### 3.2 U/Pb Detrital Zircon Age Acquisition and Analysis

A total of eight sediment samples were submitted for detrital mineral processing, with a focus on the mineral zircon. Of these, six samples had a high zircon yield, one sample had minimal return and one sample was barren (Table 2; Figure 3). Samples were separated through SelFrag disaggregation (where required), and heavy mineral phases were concentrated via panning, heavy liquid floatation and Frantz magnetic separation. Care was taken to pick all zircon populations. The zircons were arranged and set in standard 25 mm diameter resin mounts that were later polished with a surface finish to 1 µm. Cathodoluminescence (CL) imaging of the zircon mounts was completed at the John De Laeter Centre at Curtin University using the Tescan Mira3 FESEM. CL images show that most zircons have oscillatory cores, which have been targeted, deriving ages from the magmatic sections of the grains. Zircon grains were analysed via LA-ICPMS also at the John de Laeter Centre, Curtin University. Individual zircon grains were ablated using a Resonetics M-50 193 nm ArF excimer laser ablation system. Isotopic intensities were measured using an Agilent 7700s quadrupole ICP-MS, with high purity Ar as the plasma gas. For this work, the following elements were monitored for 0.03 seconds each: $^{28}Si$, $^{29}Si$, $^{204}Pb$, $^{206}Pb$, $^{207}Pb$, $^{208}Pb$, $^{232}Th$, and $^{238}U$. Following an integration time of 10 s periods for background analysis, samples were spot ablated for 30 s at a 7Hz repetition rate in an ultrahigh purity $He\text{-}N_2$

atmosphere using a 33 µm beam and laser energy of 2.5 J/cm$^2$. International glass standard NIST 610 was used as the primary standard to calculate elemental concentrations (using $^{28}Si$ as the internal standard element) and to correct for instrument drift. Natural lead concentration was monitored throughout the analysis, however, no $^{204}Pb$ was detected thus no natural lead correction has been applied. The primary age standard used in this study was Plesovice (337.13±0.37 Ma; Sláma et al. 2008) with 91500 (1062.4±0.4 Ma; Wiedenbeck et al. 1995) and GJ-1 (608.5±1.5 Ma; Jackson et al. 2004) used as a secondary age standards. $^{206}Pb/^{238}U$ ages calculated for all secondary zircon standards were treated as unknowns and found to be within 3% of the accepted value. The isotope data was processed and displayed using the isoplot 4.1 software. Raw detrital zircon isotopic and age data is shown in appendix 3.

### 3.3 Palynology

Seven samples were submitted to Morgan Goodall Paleo Pty. Ltd. for palynology analysis (Figure 3). Sample locations likely to yield palynolomorphs were selected to give representative ages for the stratigraphy. Of the seven samples, one sample was barren, and six yielded palynomorph assemblages. For palynology, 100 specimens were counted for each sample and assigned to the Cretaceous zones of the Great Australian Bight (Morgan, Rowett and White). In addition, palynology, and other biostratigraphic data has been taken from Totterdell and Krassay (2003) and summarised in Figure 4.

## 4.0 Geological Descriptions

### 4.1 Precambrian Basement

Precambrian crystalline basement underlies the majority of the Madura Shelf. It largely comprises granitic gneiss. In some wells e.g. HDDH001 (Appendix 1) development of up to 20 m of regolith immediately overlying the basement was observed. The weathering horizon consisted of quartz rich, mottled saprolite.

### 4.2 Pre-Rift Sediments

Ages for the sediments described in this section have not been determined. However, stratigraphically they underlie the Loongana Formation and Madura Formation of the Madura Shelf. The sediments from the Madura Shelf were deposited during the Australia/Antarctic breakup (Bradshaw et al. 2003). The pre-rift units identified in this study have not been previously described. They have been subsequently named as the Decoration Sandstone (claystone overlying sandstone) and Shanes Dam Conglomerate.

***The Decoration Sandstone*** has only been identified in FOR010 to date. It is 109 m thick and is intersected between -67 m and -176 m (AHD) and depths of 249 m to 358 m. The unit nonconformably overlies crystalline basement and is disconformably overlain by the Loongana Formation, as evidenced by a sharp contact (Figure 5d).

Overall the unit has a conglomeritic base, and consists of alternating sections of irregular bedded sandstone, planar laminated sandstone and massive fining up sandstone. It can also be divided into three sections based on the degree of oxidation (Appendix 1). A basal hematite rich, oxidised zone from 312 m to 358 m, an upper section which is reduced and creamy white from 255 m to 295 m. And a transition zone from 295 m to 312 m.

The lower section consists of a basal pebbly conglomerate with several pebbly horizons and alternating >1 m beds of planar (Figure 5c) and irregular bedded sands. The irregular bedded sands have a distinctive wavy/irregular texture (Figure 5a), and are also bioturbated, with a distinctive burrow occurring at 308 m (Figure 5c). The sand is quartz dominated with minor hematite and lithics. Grain sizes range from<0.1 mm to 0.5 mm and average 0.3 mm. Sand is moderately to poorly sorted with finer silty grains tending to have low sphericity and be angular, with the coarser grains being highly spherical and well rounded .

The upper sandstone section is lithologically and texturally similar to the basal section. However, the pebble conglomerate and hematite staining are absent, and pyrite nodules are common. The interval also has fine green muddy laminations with similar texture to the wavy bedding in the lower section. There is also evidence for soft sediment deformation (Figure 5d).

The uppermost six metres of the Decoration Sandstone unit comprises claystone. The unit is mottled green and red, consisting of very fine grained mudstone to claystone (Figure 5d). It is faintly laminated in places with some pyrite present. The contact between the sandstone and claystone is sharp, indicating erosion, however green silts similar to the claystone are found in other sections of the Decoration Sandstone suggesting the lithologies are of a similar age and thus mapped together.

***Shanes Dam Conglomerate*** is localised to four wells; HDDH001, HDDH002, SDDH001 and SDDH002 where the unit achieves thicknesses of 25 m, >1 m, 24 m and 4 m respectively (Figure 6). In all cases the conglomerate nonconformably overlies crystalline basement and is disconformably overlain by the Madura Formation. The disconformity is most prevalent in SDDH002, where at 413 m depth, a sharp contact exists between a section of highly ferrugenised conglomerate and unaltered (lacking significant oxidation or mineral replacement) Madura Fm. (Figure 5g).

The conglomerate is variable in colour. Clasts range from light green, creamy white to grey, and consist of sandstone, soft green and white claystone, vein quartz, mafic and granitic clasts (Figure 5f). The conglomerate is clast supported and generally well indurated. Carbonate cementation is variable throughout the unit. Clasts are commonly between 1 mm and 20 mm in size, with occasional clasts up to 40 mm to 60 mm. Clasts are typically well rounded, but less common angular clasts are also present. The unit is highly magnetic, and in SDDH002 is highly ferrugenised (Figure 5g).

### 4.3 Cretaceous Sediment Descriptions

***The Loongana Formation*** is intersected in nine of the wells studied. It is most prevalent in the east of the study area where it achieves a thickness of between 20 m and 43 m (Figure 6). It nonconformably overlies crystalline basement in most wells except in FOR010 where it disconformably overlies the Decoration Sandstone (Figure 5e), and in KN 1 where it overlies Permian sands in South Australia.

The Loongana Formation typically comprises very poorly consolidated quartz dominated, felspathic sand (Figure 7a,b) with minor mica. Grain sizes average 0.5 mm to 1 mm with coarser grains up to 5 mm common. The sediment is grain supported, angular, low sphericity, and poorly sorted.

***The Madura Formation*** is by far the most laterally extensive and thickest unit of the Bight Basin encountered onshore. It is intersected in all wells included in this study. The Madura Formation achieves a maximum thickness of at least 355 m in Madura 1, where it is intersected between -180 m and -535 m (AHD) and depths of 285 m to 640 m. The unit thins in the west and east of the basin but remains relatively thick in the central region of the basin, achieving a thickness of 256 m in SDDH001. Two wells; Eucla 1 and BN 1 preserve anomalously thin sections of the Madura Formation, achieving thicknesses of just 30 m and 21 m respectively (Figure 8).

Where the base of the Madura Formation is penetrated it has been variously observed to overlie either the Loongana Formation conformably; or Shanes Dam Conglomerate disconformably; or in NDDH002 and Eucla 1, crystalline basement nonconformably. The Madura Formation is disconformably overlain by the Eucla Group carbonates or the Hampton Sandstone.

FOR011 (summary log in appendix 1) contains a sequence typical for the Madura Formation observed in the wells studied. It consists of a fine sandy micaceous base (248 m to 258 m) with occasional charcoal rich horizons (Figure 7f). The sequence grades into glauconitic medium to coarse sand from 245 m to 248 m. Homogenous light grey siltstone and minor beds of fine sands prevail from 182 m to 245 m. The interval contains faint planar bedding in places, and is notably barren of bioclasts and contains minimal charcoal (Figure 7g). The section from 110 m to 182 m consists of very similar siltstone and fine sands, but is weakly glauconitic (Figure 7e), with occasional small charcoal clasts.

Bioclasts are also common with the first being observed at 182 m. Most bioclasts are only fragments though some more complete brachiopods have been identified from the better preserved specimens (Figure 7c). Also, one coiled cephalopod has been identified in SDDH001 at 270.1 m (Figure 7d). This section also contains three distinct carbonate cemented horizons; they occur from 155 m to 165 m and are between 10 cm and 20 cm thick. The carbonate beds appear to be common, and have been observed in the Madura Formation in most of the wells (Appendix 1). The uppermost section grades from siltstone into fine sand from 88 m to 110 m. The section is oxidized, mostly consisting of fine angular quartz and glauconite that has been weathered to limonite. The section is overlain by the Hampton Sandstone, however the contact was not recovered in the core.

### 4.4 Cenozoic Sediment Descriptions

The Cretaceous sediments of the Madura Shelf are disconformably overlain by the sediments of the Eucla Group and the Hampton Sandstone (Lowry 1970; Bradshaw et al. 2003). Many authors have described the development of the Eucla Group in detail (e.g. Feary and James 1998; Lowry 1970; O'Connell 2011). However, the Cenozoic sediments are not the focus of this study, thus they are only briefly mentioned here for context. One find worth noting however, is the presence of possible micro-tektites in the Hampton Sandstone. The inferred micro-tektites range in size from 1 mm to 3 mm long, and their dumbbell shape is typical of melt ejecta being cooled in flight. To date they have only been located in FOR011 at a depth of ~88 m. Unsuccessful attempts were made to locate the micro-tektites in the nearby wells of FOR010, MAD014 and the 82NUR series (Figure 8). The micro-tektites have most likely come from the Hampton Sandstone, though ambiguity remains as the core return was poor from the sample interval. It is possible that the host sand is a coarse interval at the top of the Madura Formation, or indeed near surface contamination, though the latter seems unlikely given the partially cemented nature of some of the sediment bearing the micro-tektites.

## 5.0 Palynology and Age Constraints

***Decoration Sandstone*** - An age for the unit was not able to be determined as few sections were deemed likely to yield palynomorphs, and there were no observable macro fossils. One sample from the uppermost claystone section of the unit was submitted for palynology. However, the sample was barren of palynomorphs. The upper age range can be placed as Early Cretaceous (lower *Foraminisporis wonthaggiensis*), which is constrained stratigraphically by the overlying Loongana Formation. The presence of bioturbation pins the lowest age of the unit to somewhere within the Paleozoic.

***Shanes Dam Conglomerate*** - An age was not determined for Shanes Dam Conglomerate as there were no organic rich horizons favourable for palynology. Both Shanes Dam Conglomerate and the Loongana

Formation underlie the Madura Formation. The stratigraphic relationship between the two units is not directly observed. However the sharp disconformity between the conglomerate and the Madura Formation in SDDH002 suggests that the conglomerate is likely older than the Loongana Formation, which is conformable with the overlying Madura Formation. The upper age limit of Shanes Dam Conglomerate is therefore constrained stratigraphically as Early Cretaceous, with the oldest age limit restricted to the age of the basement that is c. 1400 Ma (Kirkland et al. 2013).

***Loongana Formation*** - In FOR010 two samples from depths of 236 m and 244 m were submitted for palynology (Figure 3). The samples yielded an age of Valanginian to Hauterivian (Early Cretaceous), and were assigned to the lower *Foraminisporis wonthaggiensis* pollen zone (Goodall 2014a).

***Madura Formation*** – Three samples from the Madura Formation were submitted for palynology (Figure 3). Two samples are from near the base of the Formation; FOR011 at 257 m and HDDH001 at 398 m. Both samples yielded an age of Valanginian to Barremian (Early Cretaceous), and were assigned to the *Foraminisporis wonthaggiensis* spore pollen zone (Goodall 2014b). One sample was collected from the upper section of FOR011 from 104 m. The sample yielded a mid-Albian age (mid-Cretaceous), and was assigned to the *Pseudoceratium [Endoceratium] ludbrookiae* dinocyst zone (Goodall 2014b).

## 6.0 U/ Pb Detrital Zircon Age Data and Results

Of the 749 detrital zircons analysed, 622 had a discordance of less than ±10%. Individual sample concordance and the number of zircons analysed for each sample is shown in Table 2. All samples taken from the Decoration Sandstone, the Madura Formation and the Loongana Formation recorded major age peaks at c. 1150 Ma and at c. 1600 Ma. One sample from the upper Madura Formation in FOR011 also recorded an age peak of c. 105 Ma. The sample taken from the Shanes Dam Conglomerate recorded a single age peak of c. 1410 Ma. Stacked relative probability plots for all samples are shown in Figure 9.

### 6.1 Provenance Discussion

***c. 105 Ma Zircons -*** Sample 199453 yielded 12 zircons with c. 105 Ma ages (Figure 9). This sample was taken from the upper part of the Madura Formation in FOR011 (Figure 3). Palynology taken near the sample in FOR011 (Figure 3) yields an Albian age for the upper Madura Formation. CL images show that a large proportion of zircons have oscillatory zoning and euhedral crystal faces. The matching palynology and zircon ages, and euhedral crystal shape of the zircons suggest near syn-depositional volcanism. The early age was unexpected and has not been recognised in recent provenance studies of the heavy mineral sand deposits in the Eucla Basin (e.g. Hou et al. 2011; Reid et al. 2013). A similar

83 to 200 Ma age zircon population has been identified in the Gnarlyknots well, which penetrated the upper lobe of the Ceduna Delta (MacDonald et al. 2013). The youngest ages for these zircons are thought to be very close to the depositional age for the sediment (MacDonald et al. 2013). The provenance for the Ceduna Delta zircons of this age was interpreted to be from eroded volcanagenic sediments that were widely developed across eastern and south eastern Australia during the Early Cretaceous (MacDonald et al. 2013). Two likely possibilities exist for the c. 105 Ma zircons. Either they are from the eastern Australian Early Cretaceous magmatic event recorded by the Ceduna Delta zircons, if so then they have been transported further west than previously recognised with very little modification. Alternatively, they may suggest that volcanism was active further west then has previously been recognised.

***c. 1410 Ma Zircons -*** Sample 199456 was taken from the Shanes Dam Conglomerate in HDDH001 (Figure 3). The sample yielded an age of c 1410 Ma (Figure 9). The age distribution is unimodal suggesting a single source is likely for the Shanes Dam Conglomerate. The basement in the area has been dated at 1411 ± 6 Ma, in the nearby LNGD002 well which is adjacent to LNGD001 (Figure 11; Kirkland et al. 2013). The large pebbles and cobbles present in Shanes Dam Conglomerate suggest that extensive transport is unlikely. Thus the Shanes Dam Conglomerate is likely locally derived.

***c. 1150 Ma and c. 1600 Ma Zircons -*** Samples 199443, 199444, 199453, 199454 and 19455, span the Decoration Sandstone, Loongana Formation and the Madura Formation (Figure3). All samples have two major peaks of c. 1150 Ma and c. 1600 Ma (Figure 9). These two age peaks are very similar to that of the Jacinth deposit (Figure 9), a world class heavy mineral sand deposit that formed as strandlines along the eastern margin of the Eucla Basin during the Eocene (Hou et al. 2011). The Gawler Craton, Yilgarn Craton, Albany-Fraser Orogen and the Musgrave Province (Figure 10) all lie within the Paleodrainage system for the Eocene Eucla Basin, thus are potential source regions for the Jacinth Deposit (Hou et al. 2011). Expected detrital zircon signatures for the two Grenvillian belts of southern Australia, the Musgrave Province and the Albany-Fraser Orogen show peaks similar to that of the 1172 Ma peak from the Jacinth deposit and of the c. 1150 Ma zircons recovered herein (Figure 9). Hou et al. (2011) interprets the Musgrave Province and Albany-Fraser Orogen as the most likely source for the 1172 Ma Jacinth deposit zircons.

The source of the c. 1600 Ma and 1662 Ma Jacinth deposit zircons is less clear. The Gawler Craton, Albany-Fraser Orogen and the Musgrave Province all have zircons with a corresponding age (Figure 9). However, Hou et al. (2011) argues that the Musgrave Province and Albany-Fraser Orogen are the most likely candidates for the Jacinth deposit zircons, given the relative abundances of c. 1150 Ma and 1172

Ma zircons. It should be noted that this does not rule out the possibility of some input from the Gawler Craton.

Given the very similar age profiles for the Jacinth deposit and the sampled zircons it is likely that they all share similar primary sources. This interpretation suggests that the paleodrainage systems for the area remained relatively stable from at least the Early Cretaceous though to the Eocene.

***Older than 2400 Ma Zircons -*** There are minor populations of >2400 Ma zircons in samples 199443, 199444 and in the Jacinth Deposit. The Yilgarn Craton, The Gawler Craton, and the Albany-Fraser Orogen are all candidates to be the primary zircon source as they all contain zircons of >2400 Ma (Figure 9).

## 7.0 Pre Rift Development and Setting

***Crystalline Basement*** - Lowry (1970), describes the crystalline basement underlying the Nullarbor Plain in Western Australia as a very irregular surface of granitic composition that is overlain by flat lying Mesozoic beds. The development of a regolith profile suggests that at some point the basement was exposed at the surface for a prolonged period. Overall the basement gently dips from the interior margins of the basin southwards, towards the central wells of Eyre 1 and Madura 1 (Figure 11). The deepest recorded part of the basin is around Madura 1, where the well was drilled to -535 m (AHD) and failed to reach crystalline basement (Figure 12). Regionally the trend of the basement slope is small. Between MAD014 and Madura 1 the basement dip is 0.19˚ dropping just 500 m over 150 km (Figure 12). However, there are instances where rugged local topography can be inferred. Between SDDH002 and SDDH001 there is an average dip of 1.9˚ dropping 60 m in 1.8 km (Figure 12), a full order of magnitude greater than the regional trend. There are also anomalous basement highs in the basin. The basement elevation in Eucla 1 is just -201 m (AHD). This is shallow compared with the other coastal wells that lie to the west, and is up slope from wells to the north, against the regional dip trend (Figure11; 12). Offshore, seismic data shows a rugged basement topography (Lowry 1970). The seismic study by JNOC (1992) interprets that incised canyons and small half graben exist in the most northern seismic lines that parallel the coast. These features likely exist onshore as well. However, the large distance between onshore wells makes it impossible to distinguish such localised topographic variations.

***Decoration Sandstone*** - The Decoration Sandstone is of indeterminate age and was deposited in the north east of the basin sometime before the Early Cretaceous (Figure 2). The depositional environment was likely fluvial to intertidal or paralic with an aeolian source, and periods of aeolian dunes (Table 3). This is evidenced by the cyclical nature of the sandstone, which switched from periods of deposition in a wet environment, characterised by the wavy bioturbated beds, transitioning to sections of planar laminated sandstones with well rounded, highly spherical quartz that are characteristic of aeolian sands (Nichols 2011). The unit is capped by a claystone, which was deposited in a low energy environment, and possibly represents a rise is relative sea level. The structure and oxidation state of the irregular bedded wavy sandstone section resembles that of the Silurian Tumblagooda Sandstone that outcrops around Kalbarri in Western Australia. The Tumblagooda Sandstone was deposited in a coastal fluvial type setting (Hocking 1991). Facies types included partially bioturbated, inter-bedded sandstone and siltstone, and sections of coarse sand and conglomerate (Hocking 1991). The Decoration Sandstone has only been encountered in FOR010 to date, thus it is not possible to constrain the lateral extent of the unit. It was speculated that the unit may be a lateral equivalent of the Ordovician Lennis and Wanna Formations of the adjacent Officer Basin, as they are lithologically similar to the Decoration Sandstone. However this possibility was ruled out as the Lennis and Wanna Formations have a main detrital zircon age of c. 520 Ma to 650 Ma (Haines et al. 2013). This peak is very different from the bimodal c. 1100 – 1200 Ma and c. 1600-1700 Ma peaks recorded for the Decoration Sandstone here (Figure 9).

***Shanes Dam Conglomerate*** - The Shanes Dam Conglomerate is of indeterminate age, and was deposited further west in the basin, around the vicinity of the SDDH and HDDH wells (Figure 6). The Shanes Dam Conglomerate was potentially deposited any time from the Mesoproterozoic basement age, to the Early Cretaceous age of the Madura Formation. However, the sharp erosional feature described between the Madura Formation and the Shanes Dam Conglomerate suggests a significant hiatus. The depositional environment of the Shanes Dam Conglomerate was high energy, alluvial-fluvial type setting (Table 3) with localised steep topography (Figure 12) that was able to transport and round cobbles and pebbles. As mentioned in the provenance section, detrital zircon ages and clast size indicate a local primary source. Lower Permian tillites correlated to the Wilkinson Range beds of the Officer Basin outcrop adjacent to, and underlie, the northern Eucla Basin, and Permian tillites are also known to underlie the basin in South Australia (Lowry 1970). However a possible tillite origin for the Shanes Dam Conglomerate is unlikely as there is no evidence of polished or striated faces on any of the cobbles and pebbles and the zircon population indicates a very local source. The Loongana Formation was also considered to be potentially lateral equivalent as it is conglomeritic in places (Appendix 1). This was ruled out as the Loongana Formation exhibits very different bimodal zircon ages compared to the unimodal c. 1410 Ma age of the Shanes Dam Conglomerate zircons (Figure 9). Also the Loongana Formation is conformable with the Madura Formation, which is likely separated from the Shanes Dam Conglomerate by a significant depositional hiatus.

## 8.0 Development of the Madura Shelf

***Late Jurassic to Early Cretaceous*** - During the Late Jurassic, Australia began to separate from Antarctica (Blevin and Cathro 2008). Rifting progressed from west to east and a series of extensional half graben began developing offshore (Blevin and Cathro 2008). This period of upper crustal extension lasted until the start of the Early Cretaceous (Figure 4). Sedimentation during this period was restricted to the offshore half graben of the Eyre Sub-Basin and is characterised by syn-rift sedimentation in a lacustrine setting (Totterdell et al. 2000).

***Berriasian to mid-Albian*** - At the start of the Early Cretaceous, upper crustal extension gave way to thermal subsidence (Figure 4). By this stage offshore rifting had progressed east, forming half graben in the Ceduna and Duntroon Sub-Basins (Bradshaw et al. 2003). Sedimentation style offshore switched from syn-rift to post-rift and the lacustrine depositional setting prevailed (Totterdell et al. 2000).

By the start of the Valanginian (Early Cretaceous) thermal subsidence was also evident onshore, and is marked by the deposition of the Loongana Formation in Gambanga 1 (Figure 4). Thermal subsidence appears to have been relatively consistent basin wide. Penecontemporaneous sedimentation began in low lying areas, which include the central SDDH/HDDH, Madura 1 wells, and further east in FOR010/011/014 and Albala-Karoo wells (Figure 4). Initial sedimentation was characterised by the lenticular Loongana Formation, which has a discontinuous lateral distribution (Figure 6; Lowry 1970). The Loongana Formation was deposited in a high energy fluvial/lacustrine type environment (Table 3). Poor sorting and textural immaturity suggest deposition was rapid and that reworking was minimal. Palynology analysis identified the presence of low salinity/freshwater algae indicating a freshwater/brackish type setting (Goodall 2014a). Detrital zircon analysis indicates the Musgrave Province or the Albany-Fraser Orogen as likely primary sources, but the zircons may have been recycled from older sediments e.g. the Officer Basin that also likely drained these areas (Reid et al. 2013). This would suggest significant transport distances, with a river being a likely conduit. The river systems that transported the Loongana Formation were likely driven by topography generated by the thermal subsidence being experienced in the region at the time (Figure 4).

Thermal subsidence continued through the Early Cretaceous until the mid-Albian (Figure 4). The high energy fluvial regime that deposited the Loongana Formation gave way to a widespread low lying, low energy lacustrine environment, where the Madura Formation started to accumulate conformably over the Loongana Formation. Palynology analysis from the basal Madura Formation (Figure 3) identified the presence of low salinity/freshwater algae indicating a freshwater lacustrine environment (Goodall 2014b). Total organic carbon samples taken near the base of the Madura Formation in Gambanga 1 also show a strong non-marine influence (Totterdell and Krassay 2003). The age of the basal Madura

Formation suggests that the low energy lacustrine regime had become established sometime between the late Valanginian to Barremian (Figure 4). The common charcoal rich beds identified at the base of the Madura Formation (Figure 7f; Appendix 1) indicate that the land in the area was vegetated during the Early Cretaceous and subject to occasionally significant forest fire events. The vegetation may have occupied localised topographic highs that would later become blanketed with sediment (Figure 8).

Although the Madura Formation appears to have been initially deposited under non-marine conditions, there is evidence in some wells that sedimentation switched to at least intermittent marine conditions quite early. This interpretation is based on the presence of a glauconitic siltstone that occurs at or near the base of the Madura Formation in FOR011, HDDH002 and SDDH002 wells (Appendix 1). In all cases the glauconitic siltstone is overlain by a thick section of monotonous siltstone lacking any definitive marine indicators, thus there may have been a return to non-marine conditions. The brief marine incursion may have been the result of a short-term relative rise in sea level.

***Mid-Albian to Maastrichtian*** - During the mid-Albian a major rise in eustatic sea level (Haq, et al. 1988) coincided with a period of accelerated subsidence in the Bight Basin (Figure 4). At this time, the first major marine transgression of the Bight Basin occurred, depositing widespread marine siltstones offshore (Totterdell et al. 2000). On the onshore Madura Shelf, marine conditions had also become established. Palynology analysis from the upper Madura Formation (Figure 3) shows an assemblage dominated by marine dinocysts indicating deposition in an open marine environment (Goodall 2014b). The timing of the marine incursion onshore is unconstrained, and may have occurred significantly earlier than the mid-Albian (Figure 4)since the palynology sample from the upper Madura Formation overlies approximately 80 m of glauconitic siltstone containing common brachiopod shells (Figure 7c; Appendix 1). A dominantly marine upper section for the Madura Formation is a common feature in all wells studied, indicating relatively stable marine conditions were established basin wide by the mid-Albian (Figure 4).

In most wells, deposition of Cretaceous sediments commenced in the Valanginian to Barremian (Early Cretaceous), however in Eyre 1 and Eucla 1 deposition did not commence until the late-Albian (mid-Cretaceous) (Figure 4). The Madura Formation is relatively thin in Eucla 1 (Figure 8, 12), and it lies just inboard of a large offshore region that Bradshaw et al. (2003) interprets as lacking significant Mesozoic cover (Figure 8). As discussed previously, Eucla 1 is located on a basement high, and the well also lacks non-marine basal sediments that are common in the older wells (Figure 12). These factors lead to the interpretation that the basement high in Eucla 1 was not inundated until a marine transgression sometime during the late-Albian. Unlike Eucla 1, the Madura Formation is relatively thick in Eyre 1 (Figure 8; 12). It also has one of the deepest basement contacts, second only to nearby Madura 1

(Figure 12). Thus the same simple marine transgression model applied to Eucla 1 cannot explain why deposition did not commence until the late-Albian in Eyre 1. Instead, it is proposed that during the late-Albian, Eyre 1 was situated on a basement high similar to that preserved in Eucla 1. Later subsidence was initiated around Eyre 1 and Madura 1 during the late-Albian, creating accommodation space allowing for prolonged accumulation of the Madura Formation in that area. It appears that the subsidence continued around Eyre 1 and Madura 1 until the Campanian to Maastrichtian as sedimentation also continued until that time (Figure 4). In the wells east of Eyre 1 it appears that subsidence ceased earlier, as deposition had also ceased in these wells by the Cenomanian (Figure 4).

By the end of its deposition, the Madura Formation had in-filled topographic low lying areas creating a remarkably flat surface. The north-south dip of the horizon is relatively consistent basin wide. Between MAD014 and Madura 1 the surface of the Madura Formation dips 0.11˚ south, dropping just 300 m over 150 km (Figure 8, 12), this seaward slope is consistent with the typical slope on a continental shelf of <2˚ (Nichols 2011). From west to east, the surface of the Madura Formation has negligible dip, exhibiting near shore-parallel contour lines (Figure 8). The only surface anomaly is encountered in well BN 1, which exhibits a surface depression of nearly 100 m compared to nearby wells (Figure 8). The origin of this depression is likely from erosion. This interpretation is based on the fact that the basement depth in the area is of a consistent depth in nearby wells and the Madura Formation is relatively thin in BN 1, largely accounting for the difference in surface elevation (Figure 8, 11).

## 9.0 Cenozoic Development

At the end of the Cretaceous, the Bight Basin experienced a period of regional uplift (Figure 4). This effectively marked the depositional end of the Madura Shelf. Subsequently the onshore portion of the basin experienced a prolonged period of non-deposition of between 25-60 Ma duration (Figure 4; Hou et al. 2011; Lowry 1970; Totterdell and Krassay 2003). Despite the significant hiatus there is little evidence of widespread erosion. Offshore seismic data shows minimal incision (Lowry 1970), and borehole data show a relatively flat surface with only one instance of a possible paleovalley (Figure 8). Sedimentation recommenced in the mid Eocene with the deposition of the Hampton Sandstone and the Eucla Group carbonates (Figure 2) described by Lowry (1970) and Feary and James (1998).

## 10.0 Regional Implications

***Dynamic Topography*** – It has been proposed that the continent of Australia is tilting (e.g. Czarnota et al. 2013; Sandiford 2007). The nature and elevations of Cenozoic shorelines from the northern and southern Australian margins indicate some 250 m – 300 m north down, south-southwest up vertical motion since the mid Miocene, 90% of which has been assigned to dynamic topography, essentially differential crustal support from the underlying mantle (Sandiford 2007). The down warping of the northern coastline is thought to be associated with subduction along the Indo-Pacific plate margin (Quigley et al. 2010). It has been proposed that uplift along the southern Australian margin was caused by the northward movement of Australia away from a dynamic topography low associated with the remnants of a subducted slab that was located around central Australia c. 40 Ma (e.g. Barnett-Moore et al. 2014). Evidence for the existence of dynamic topography along the south coast is preserved in the Eucla Basin Neogene shorelines, which show a c. 150m elevation differential from the west to the east of the basin (Sandiford 2007; Quigleyet al. 2010). Barnett-Moore et al. (2014) used river profiles to further demonstrate that uplift has occurred along southwestern Australia from the Eocene to the mid to late Neogene. Given the building body of evidence for dynamic topography along the south coast of Australia during the Cenozoic, it would be reasonable to assume that topographic movements would also be recorded in the underlying Cretaceous Madura Shelf. Superficially, the flatness and low slope angle of the Madura Shelf (~0.1˚) resembles hypothetical original depositional conditions (Figure 8). This would imply that the Madura Shelf has remained relatively stable since the Cretaceous and argues against regional dynamic topographic effects. However, it is also plausible that the onshore Madura Shelf rode over the remnant slab, post deposition, and has subsequently rebounded back to the original deposition elevation following the complete migration of the Australian Plate northward over the mantle anomaly. If this interpretation is correct then it would constrain the position of the remnant slab to the north of the Madura Shelf at the end of the Cretaceous.

***Madura Shelf/Ceduna Delta Provenance Comparison*** – The Ceduna Delta is Australia's largest offshore delta and was deposited in the Ceduna Sub-basin (in the eastern Bight Basin) during the Late Cretaceous (Blevin and Cathro 2008). Recently the first detrital zircon provenance study was completed on the Ceduna Delta by MacDonald et al. (2013) who argued that the main sediment input was from eroded Permian and Early Cretaceous sediments deposited along the south coast, with minor inputs from the Gawler Craton and Musgrave Province. A comparison between the detrital zircon ages from the onshore Madura Shelf and Santonian to Maastrichtian delta lobe penetrated by the Gnarlyknots well on the Ceduna Delta (MacDonald et al. 2013), reveals very different age populations (Figure 9). The comparison shows that the main c. 1150 Ma and c. 1600 Ma age peaks from the Madura Shelf samples are negligible in the Ceduna Delta, and the main Ceduna Delta lobe age peaks of c. 200 – 300 Ma and c. 500 – 700 Ma are entirely absent in the Madura Shelf samples. The implications of the age differences are that erosion of the Madura Shelf was unlikely to have been a major sediment source for the Ceduna Delta. Likewise, the absence of c. 200 – 300 Ma and c. 500 –

700 Ma zircons in the Madura Formation makes long distance sediment transport from the east unlikely for the sediments of the Madura Shelf. Hence distinct sedimentary systems were likely operating in the east and west of the Madura Shelf/Bight Basin. This would therefore suggest that the Southern Magmatic Province across south eastern Australia is an unlikely source for the c. 105 Ma zircon population identified herein in the upper Madura Formation (Figure 3) and hints at the possibility of mid-Cretaceous volcanism further west then has been previously reported or an unknown routing system for eastern Australian volcanic products to the Madura Shelf.

***Regional Basin Correlation*** – The depositional environments suggested in this study for the Cretaceous Madura Shelf in Western Australia broadly correlate to the major depositional environments that have been described for the offshore Bight Basin during the Cretaceous (e.g. Blevin and Cathro 2008; Bradshaw et al. 2003; Totterdell and Krassay 2003). The basal non-marine Loongana Formation and Madura Formation sections are of similar ages to the Valanginian to mid-Albian fluvial lacustrine sediments of the Bronze Whaler supersequence (Totterdell et al. 2000). The widespread marine deposition of the Madura Formation that was established onshore by the mid-Albian (Figure 4) correlates with the mid-Albian to Cenomanian Blue Whale supersequence that records the first major marine transgression of the offshore Bight Basin (Totterdell et al. 2000). This period also coincides with a mid-Cretaceous highstand, which inundated much of central eastern Australia creating the Toolebuc seaway (Figure 10); Blevin and Cathro 2008). This study shows that the marine highstand recorded across much of Australia during the Albian also inundated the inland sections of the Madura Shelf (Figure 4).

***Albian Fault Re-activation*** – Many authors have inferred the presence of small half graben from the northern offshore Bight Basin seismic lines (e.g. JNOC 1992; Totterdell and Krassay 2003). The half graben are interpreted to have a rift fill character, and have thus been equated to the syn-rift Late Jurassic – Early Cretaceous sediments in the Eyre Sub-basin (Totterdell and Krassay 2003). These half graben trend towards the Madura 1 and Eyre 1 wells that lie to the northeast (JNOC 1992). Totterdell and Krassay (2003) speculated that Madura 1 and Eyre 1 may have been drilled in a similar half graben trend, and as basement was not reached in Madura 1 it may well contain Late Jurassic, Early Cretaceous sediment at depth. If this is the case then this study shows that there has likely been fault re activation in these half graben during the late-Albian, indicated from the localised late-Albian subsidence interpreted herein in Eyre 1 (Figure 4, 12). It is therefore possible that some of the rift fill sediment identified in the offshore half graben, may indeed be of mid to Late Cretaceous age, and not entirely from the Jurassic to Early Cretaceous as originally proposed by Totterdell and Krassay (2003).

## 11.0 Conclusions

In summary of the above, the following conclusions are draw from this study. Deposition of the Madura Shelf commenced at the start of the Early Cretaceous and was initially characterised by fluvial/lacustrine sedimentation before widespread marine conditions became established by the mid-Albian. Deposition continued until the end of the Cretaceous, by which time the sediment of the Madura Formation had completely blanketed the irregular basement topography. These findings largely support those of previous workers (e.g. Lowry 1970; Totterdell and Krassay 2003).

This study also describes new sedimentary units indicating a more complex depositional history along the southern margin than appreciated - the Decoration Sandstone and Shanes Dam Conglomerate. Furthermore, the identification of probable micro tektites indicates that there may have been an extra-terrestrial impact during the Eocene that has not been previously reported. These unexpected finds highlight the fact that the sediments obscured by the Cenozoic Eucla Basin in Western Australia still remain relatively poorly understood.

Results presented herein indicate that the Madura Shelf has made a complete northwards transit over the mantle anomaly thought to be responsible for the late Cenozoic uplift of the southern margin of Australia, with the mantle anomaly being located to the north of the Madura Shelf at the end of the Cretaceous.

Half graben fault systems are likely responsible for the relatively large depths to basement reported for Eyre 1 and Madura 1. Results of this study show that localised late-Albian subsidence occurred in these wells indicating that the half graben faults were active during the mid to Late Cretaceous. These findings question the previous interpretation by Totterdell and Krassay (2003) for Late Jurassic – Early Cretaceous age sediment fill for similar near shore half graben.

The first detrital zircon U/Pb study of the Madura Shelf yielded similar ages for the Loongana Formation and Madura Formation that are consistent with the expected detrital zircon signatures of the Musgrave Province and Albany-Fraser Orogen, suggesting these basement blocks are the likely primary sediment source, with possible sediment recycling via older sedimentary basins. Furthermore, U/Pb detrital zircon age populations show that the Cretaceous paleodrainage systems feeding the Madura Shelf in Western Australia and the Ceduna Delta were distinct, this offers an intriguing possibility that syn-depositional volcanism existed somewhere to the west of the Gawler Craton during the Cretaceous, accounting for the anomalous c. 105 Ma age zircons recorded for the upper Madura Formation.

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# 14.0 Figures

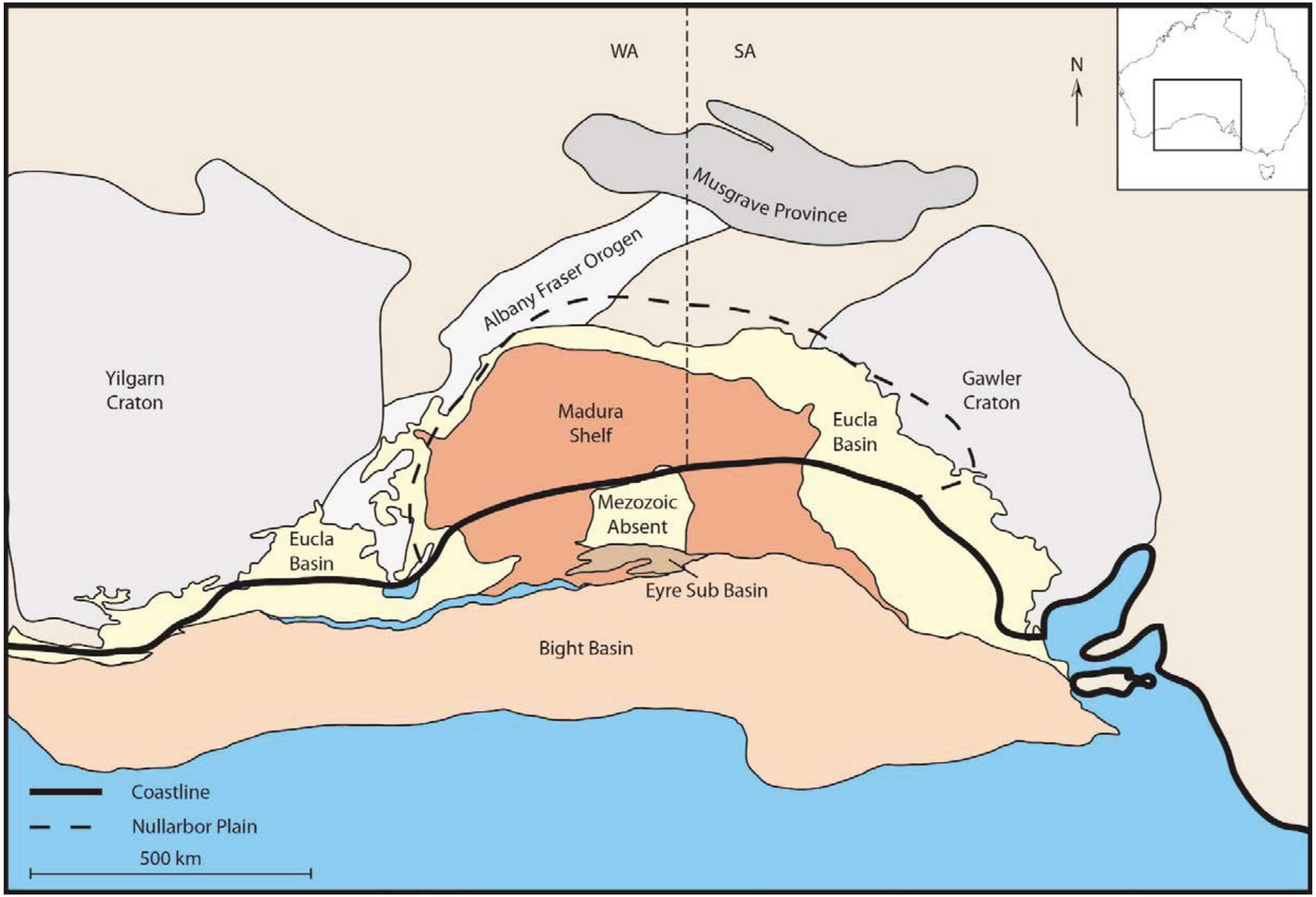
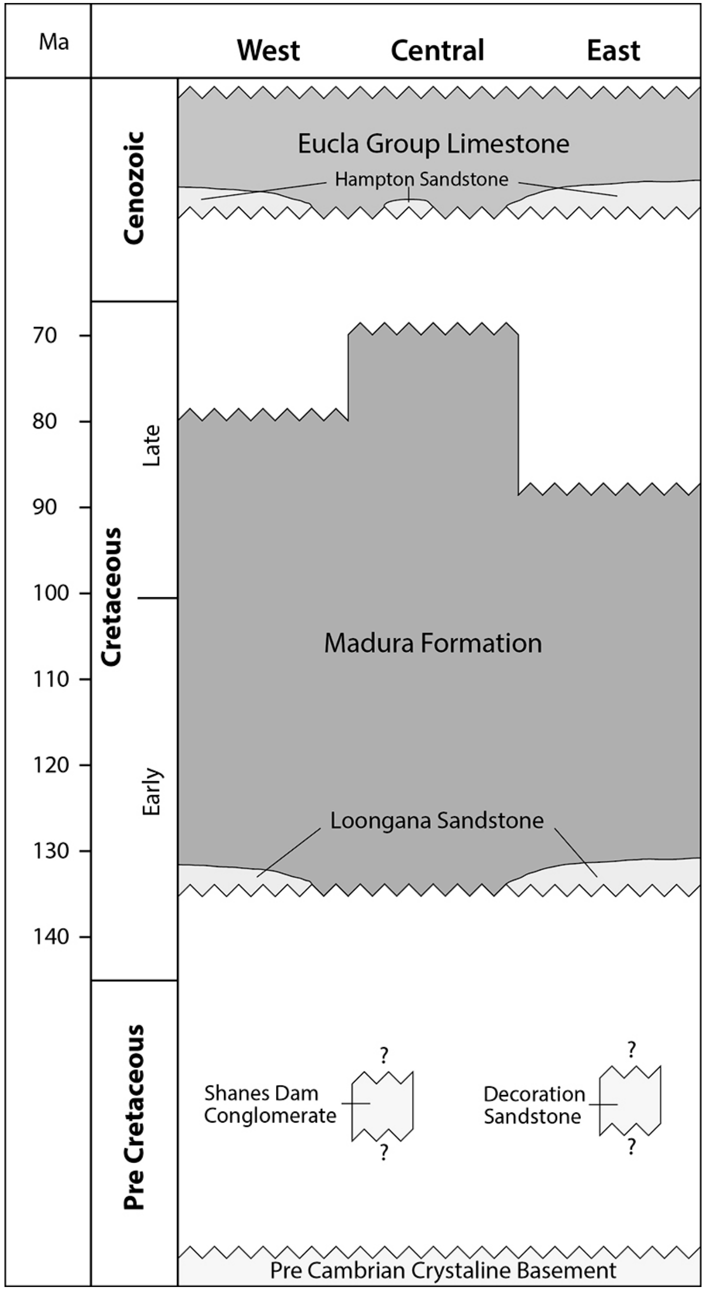
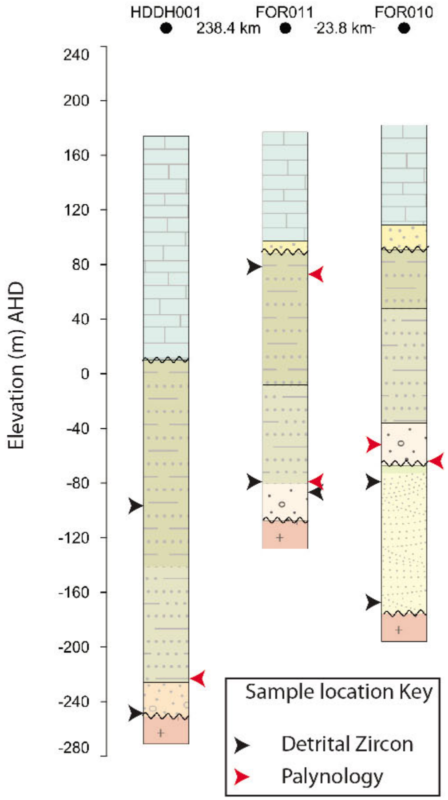
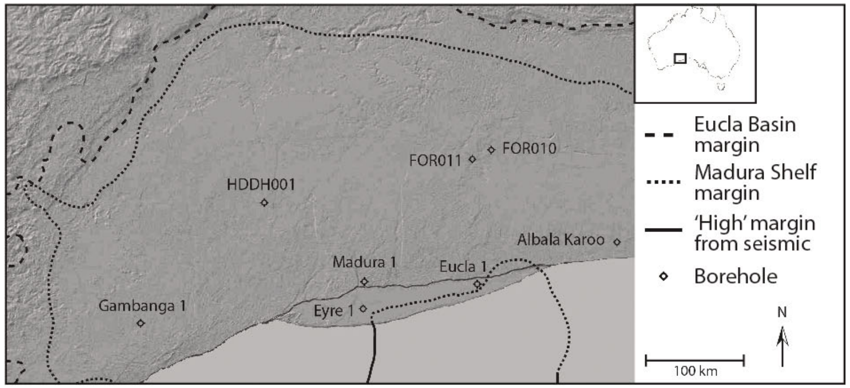
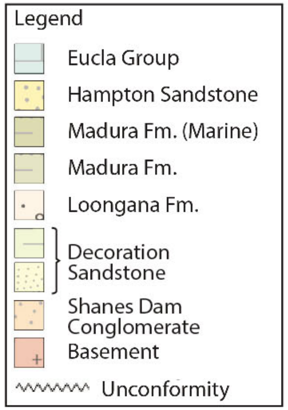



Figure 1: Regional map of southern Australia, showing major basement blocks in grey, and major sedimentary basins of Australia's southern Margin. Basins are shown with the Late Jurassic-Cretaceous Bight Basin and its components (Madura Shelf, Eyre Sub-basin) layered above the Cenozoic Eucla Basin. Basin outlines adapted from Bradshaw et al. (2003), basement blocks adapted from Hou et al. (2011), Nullarbor Plain outline adapted from O'Connell (2011). Note – The Bremer, Denmark, Ceduna and Duntroon Sub-basins of the Bight Basin are not distinguished here.




| Hole ID | Elv. (m) | Depth (m) | Type | GSWA # |
|---|---|---|---|---|
| HDDH001 | -95 | 269 | Detrital zircon | 199458 |
| HDDH001 | -249 | 423 | Detrital zircon | 199456 |
| HDDH001 | -224 | 398 | Palynology | |
| FOR011 | 79 | 98 | Detrital zircon | 199453 |
| FOR011 | -80 | 257 | Detrital zircon | 199454 |
| FOR011 | -90 | 267 | Detrital zircon | 199455 |
| FOR011 | 73 | 104 | Palynology | |
| FOR011 | -80 | 257 | Palynology | |
| FOR010 | -80 | 262 | Detrital zircon | 199443 |
| FOR010 | -169 | 351 | Detrital zircon | 199444 |
| FOR010 | -54 | 236 | Palynology | |
| FOR010 | -62 | 244 | Palynology | |

Figure 2: (left) Generalised stratigraphy of the onshore Cenozoic Eucla Basin and the Cretaceous Madura Shelf for Western Australia. Adapted from Lowry (1970); Totterdell and Krassay (2003); Hou et al. (2011).

Figure 3: (top) Detrital zircon and palynology sample locations, depths and elevations (AHD).

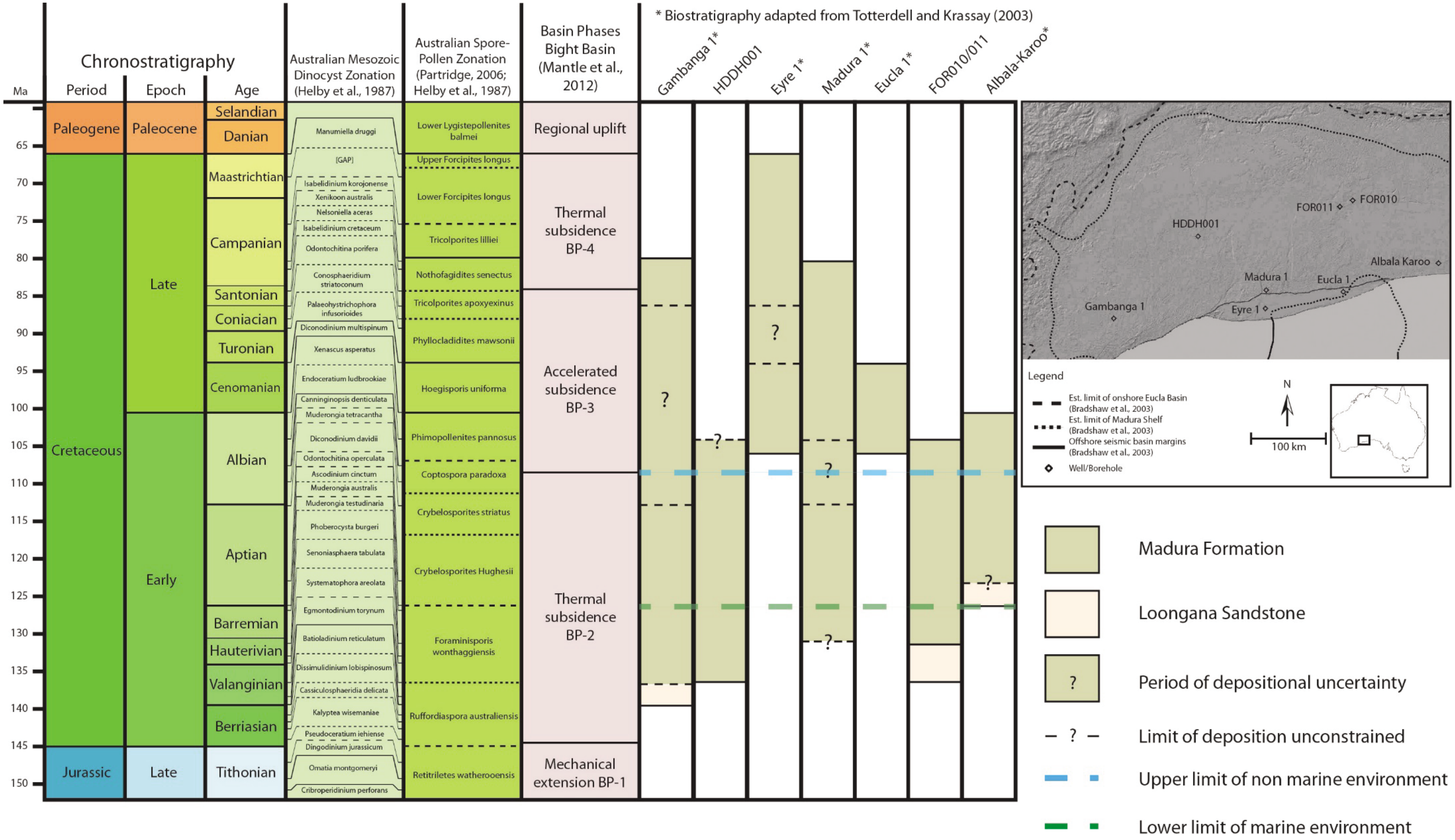



Figure 4: Timing constraints for the deposition for the Madura Formation and Loongana Formation, largely from Western Australia. Timing constraints adapted from Totterdell and Krassay (2003) and from palynology (Goodall 2014a, 2014b).

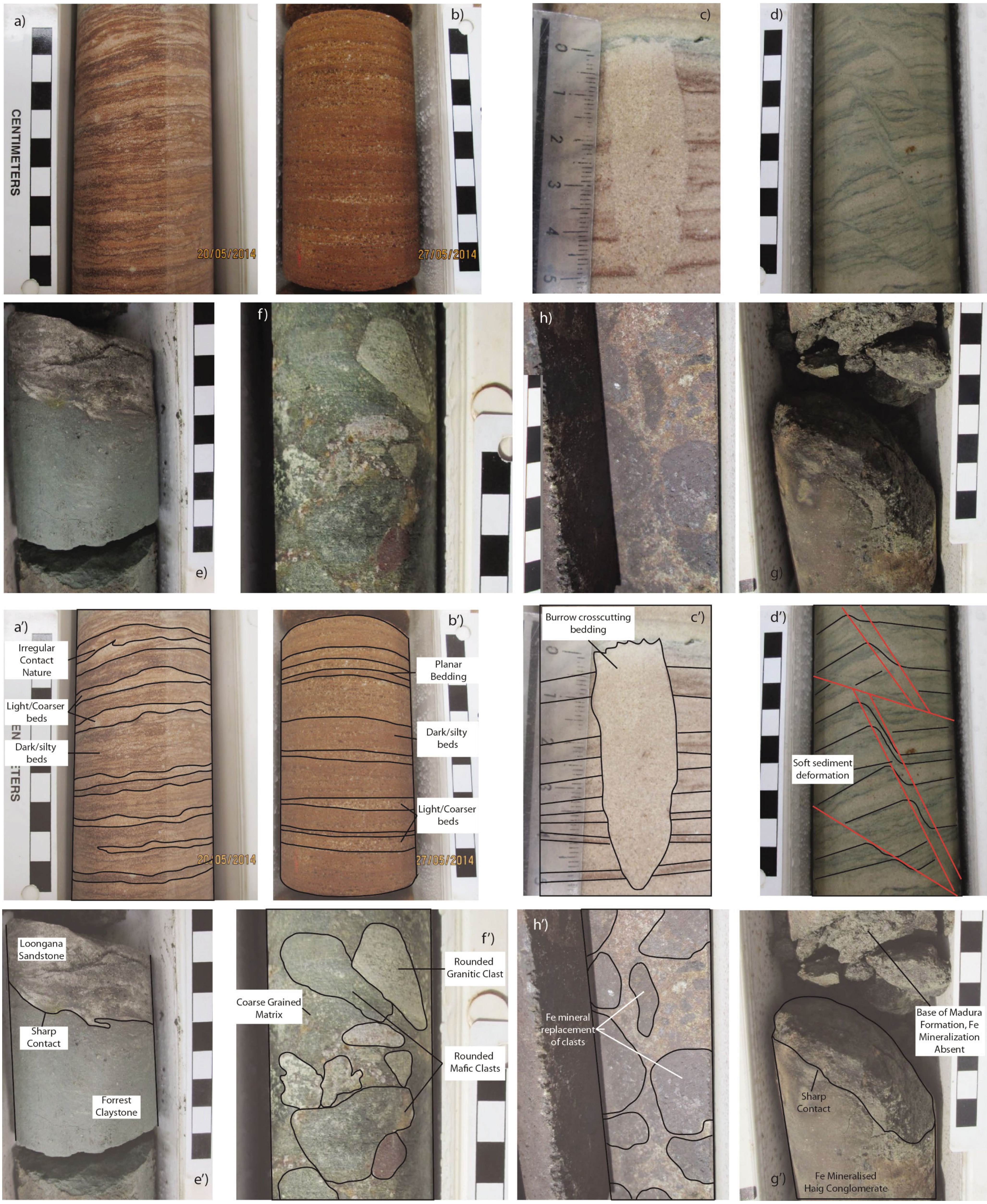



Figure 5: Pre-rift sediment core images and interpretations, depths quoted are actual drilling depths. a)a') FOR010 (341.5 m), hematite rich irregular/wavy bedding from the basal section of the Decoration Sandstone. b)b') FOR010 (316.5 m), hematite rich planar bedding from the basal section of the Decoration Sandstone. c)c') FOR010 (309 m), burrow crosscutting bedding from the oxidized/reduced transition zone of the Decoration Sandstone. d)d') FOR010 (284.5 m), soft sediment deformation, with faults (red) crosscutting bedding (black) in the upper reduced section of the Decoration Sandstone. e)e') FOR010 (249 m), sharp contact between the claystone at the top of the Decoration Sandstone and the overlying Loongana Formation. f)f') HDDH001 (421 m), rounded mafic and granitic clasts from the Shanes Dam Conglomerate. h)h') SDDH002 (416.5 m), Fe mineral replacement of clasts in a highly magnetic section of the Shanes Dam Conglomerate. g)g') SDDH002 (413 m), sharp contact between the Fe mineralised Shanes Dam Conglomerate and the overlying Madura Formation, which lacks Fe mineral replacement.

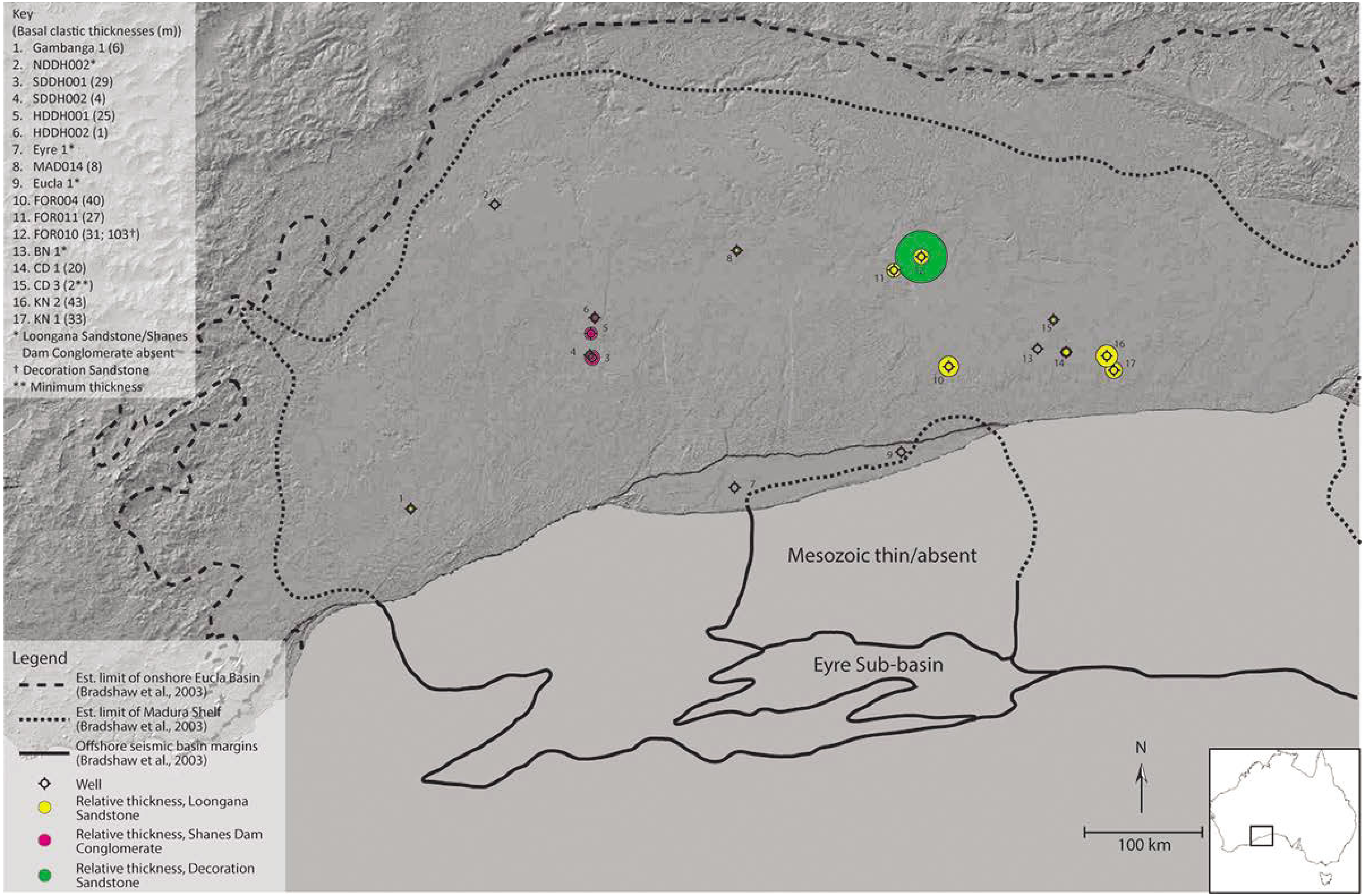



Figure 6: Relative thickness and distribution of the Loongana Formation and Shanes Dam Conglomerate.

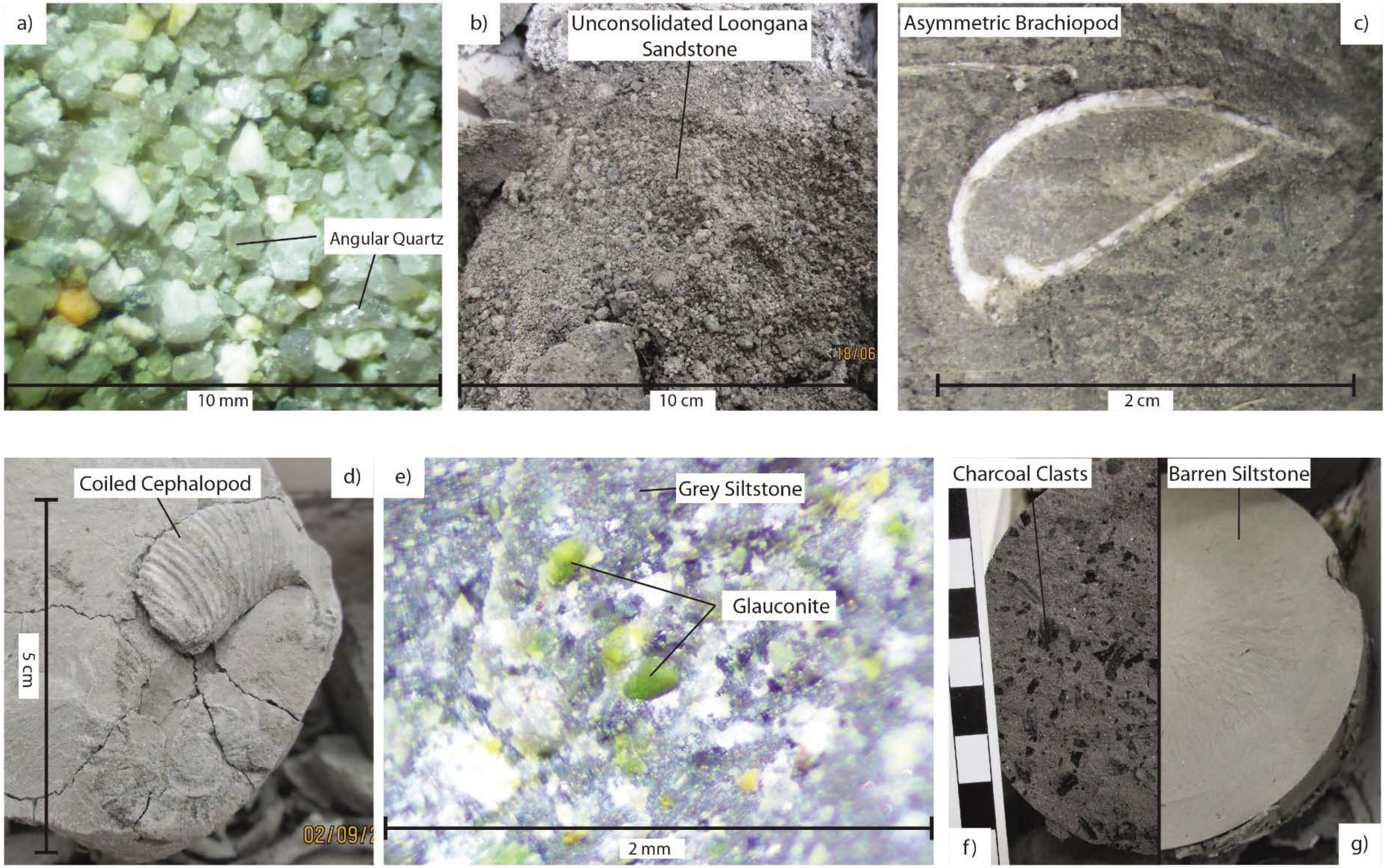



Figure 7: Core and microscope images of the Loongana Formation and Madura Formation, depths quoted are actual drilling depths. a) FOR004 (367 m) Microscope image of the Loongana Formation showing the typical unconsolidated coarse, angular quartz. b) FOR011 (~266 m) Unconsolidated core from the Loongana Formation. c) FOR001 (167 m) Well preserved brachiopod shell from the marine section of the Madura Formation. d) SDDH001 (271 m) Coiled cephalopod mould from the marine section of the Madura Formation. e) HDDH001 (298 m) Microscope image of glauconitic siltstone from the marine Madura Formation. f) FOR011 (256 m) Micaceous charcoal rich horizon from the non-marine section of the Madura Formation. g) FOR011 (~239 m) Barren siltstone that is a staple of the Madura Formation

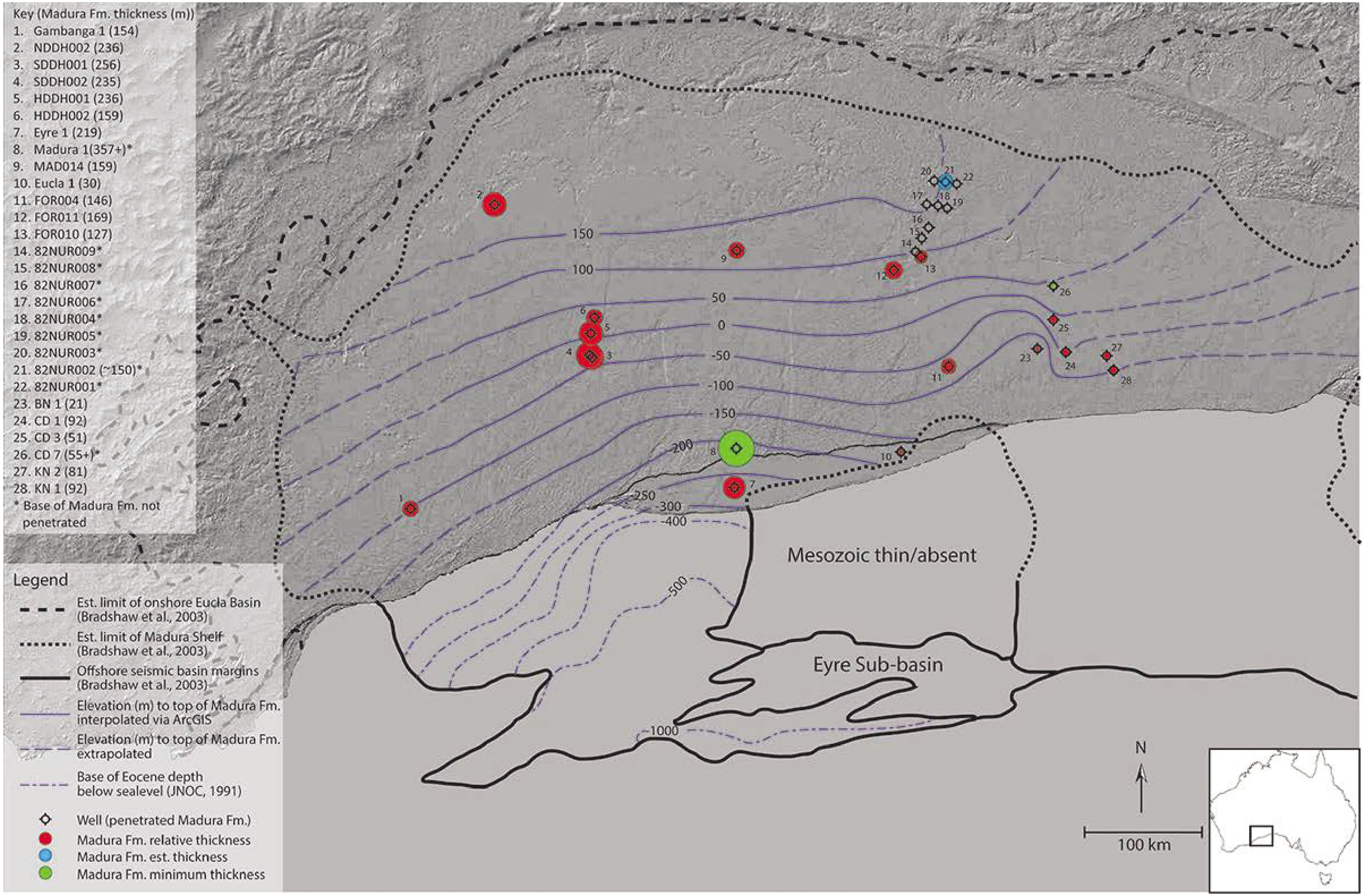



Figure 8: Relative thickness of the Madura Formation, contours show elevation (AHD) in meters to the top of the Madura Formation.

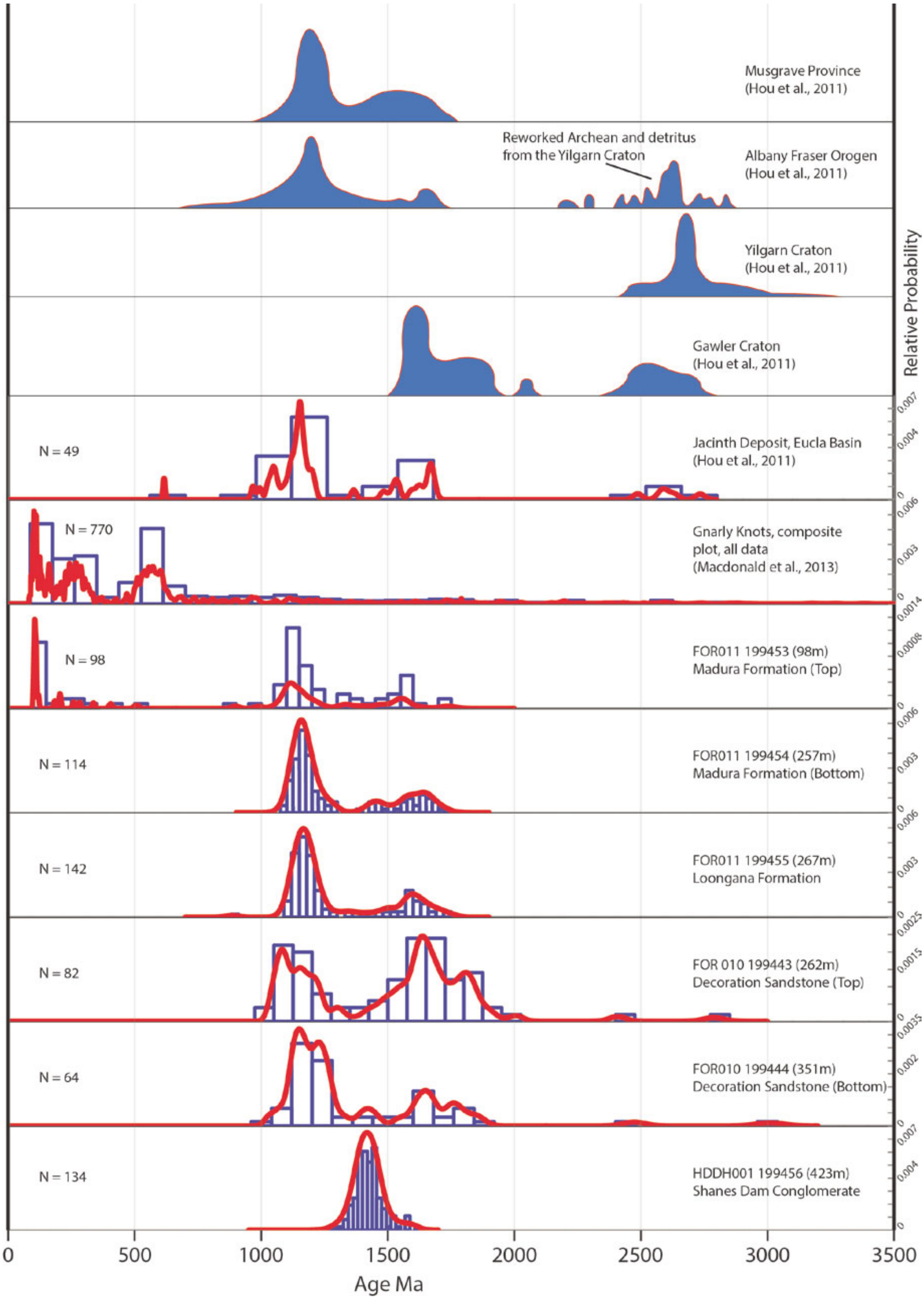



Figure 9: Stacked detrital zircon relative probability plots. Graphs for the Shanes Dam Conglomerate, Decoration Sandstone, Loongana Formation, Madura Formation and Jacinth deposit show detrital zircons < ± 10%. Graph for the Gnarly Knots well shows concordant and discordant data. Graphs for the Gawler Craton, Yilgarn Craton, Albany-Fraser Orogen and the Musgrave Province show expected detrital zircon signature for each basement block.

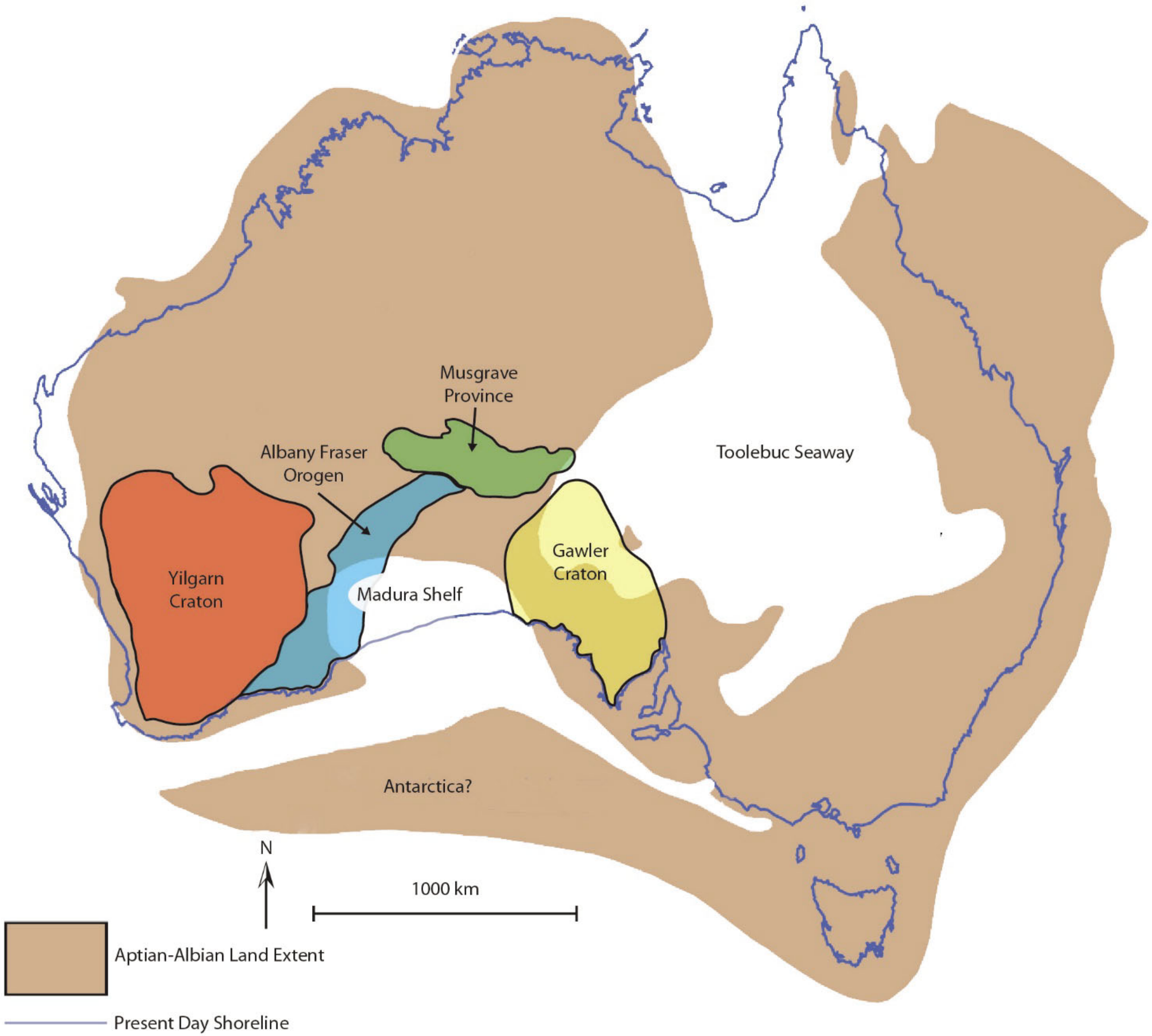



Figure 10: Positions of the major basement blocks of southern Australia, adapted from Hou et al. (2011), Estimated major epeiric seaways of the Aptian-Albian, and location of Antarctica (Totterdell and Krassay 2003).

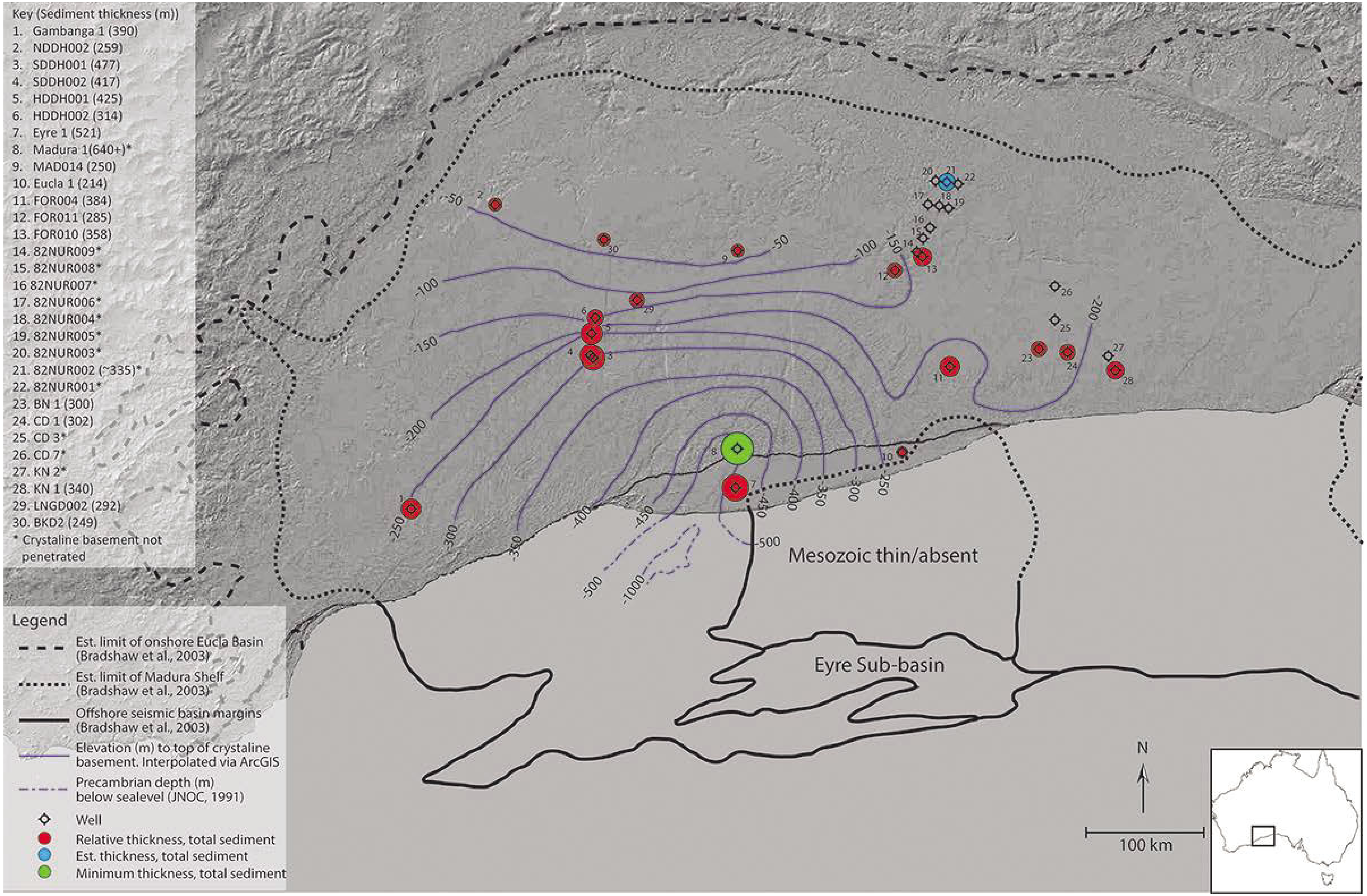



Figure 11: Relative total sediment thickness, contour lines are in meters showing depth to basement relative to AHD.

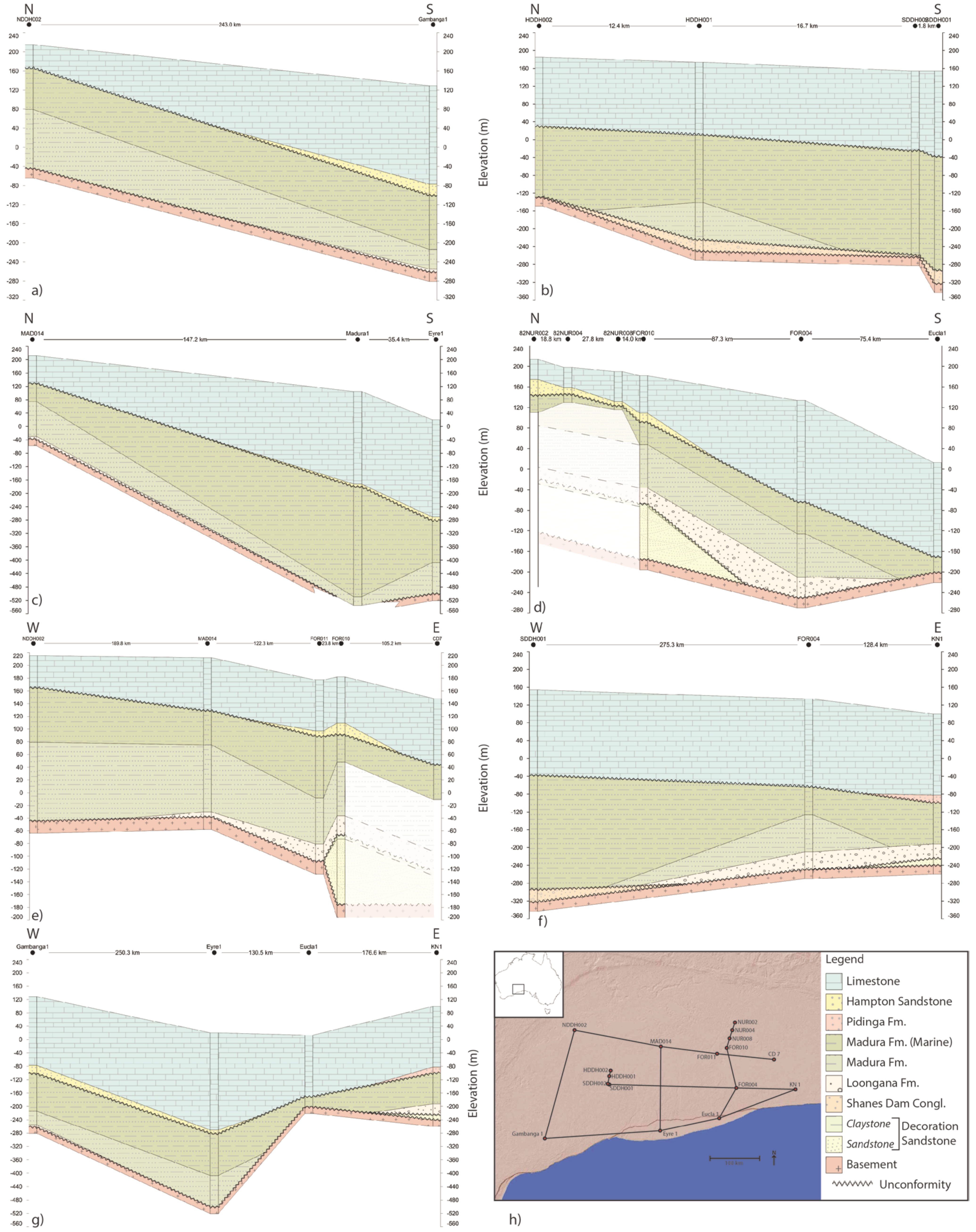



Figure 12: Cross sections showing the major stratigraphic units of the Madura Shelf and Eucla Basin from Western Australia. Madura Fm. indicates undifferentiated or non-marine conditions, whereas Madura Fm. (Marine) indicates well established marine conditions. a) Western, north-south cross section. b) Central western, north-south cross section. c) Central north-south cross section. d) Eastern north-south cross section. e) Northern west-east cross section. f) Central west-east cross section. g) Southern west-east cross section. h) Cross section locations and lithology legend.

## 15.0 Tables

Table 1: Showing the various sources of stratigraphic data, indicating if intervals were logged via diamond core, chips or sourced from supplementary data such as online government geoservers, or reports.

| Well ID | Core Interval Logged (m) | Chip Interval Logged (m) | Supplementary Interval | Logged Sample Source | Sup. Source | Reference |
|---|---|---|---|---|---|---|
| FOR004 | 138 - 389 | 0 - 138 | | GSWA | | |
| FOR010 | 227 - 358 | 0 - 227 | | GSWA | | |
| FOR011 | 89 - 285 | 0 - 89 | | GSWA | | |
| MAD014 | | 0 - 250 | | GSWA | | |
| HDDH001 | 225 - 425 | | 0 - 225 | Mineral Expl. | WAMEX | (WAMEX 2014) |
| HDDH002 | 207 - 314 | | 0 - 207 | Mineral Expl. | WAMEX | (WAMEX 2014) |
| SDDH001 | 270 - 477 | | 0 - 270 | Mineral Expl. | WAMEX | (WAMEX 2014) |
| SDDH002 | 283 - 417 | | 0 - 283 | Mineral Expl. | WAMEX | (WAMEX 2014) |
| 82NUR001 | | 0 - 92 | | Oil Shale Expl | | |
| 82NUR002 | | 0 - 104 | | Oil Shale Expl | | |
| 82NUR003 | | 0 - 62 | | Oil Shale Expl | | |
| 82NUR004 | | 0 - 68 | | Oil Shale Expl | | |
| 82NUR005 | | 0 - 62 | | Oil Shale Expl | | |
| 82NUR006 | | 0 - 68 | | Oil Shale Expl | | |
| 82NUR007 | | 0 - 74 | | Oil Shale Expl | | |
| 82NUR008 | | 0 - 74 | | Oil Shale Expl | | |
| 82NUR009 | | 0 - 88 | | Oil Shale Expl | | |
| Eyre1 | | | 0 - 521 | | WCR | (Shiels 1960a) |
| Gambanga1 | | | 0 - 390 | | WCR | (Shiels 1960b) |
| Eucla1 | | | 0 - 214 | | WCR | (Stach 1964) |
| BN1 | | | 0 - 300 | | SARIG | (SARIG 2014) |
| CD3 | | | 0 - 206 | | SARIG | (SARIG 2014) |
| CD7 | | | 0 - 159 | | SARIG | (SARIG 2014) |
| CD1 | | | 0 - 362 | | SARIG | (SARIG 2014) |
| KN1 | | | 0 - 340 | | SARIG | (SARIG 2014) |
| KN2 | | | 0 - 436 | | SARIG | (SARIG 2014) |
| NDDH002 | | | 0 - 279 | | WAMEX | (WAMEX 2014) |
| Madura1 | | | 0 - 640 | | Report | (Lowry 1970) |
| LNGD002 | | | 0 - 292 | | WAMEX | (WAMEX 2014) |
| BKD2 | | | 0 - 249 | | WAMEX | (WAMEX 2014) |

Table 2: Data for detrital zircon samples showing number of zircons analysed, number of ± 10% concordant zircons and the percentage of concordant zircons.

| GSWA Sample # | Well ID | Depth (m) | Formation | # Zircons | # Concordant ± 10% | %Concordant |
|---|---|---|---|---|---|---|
| **199443** | FOR010 | 262 | Forrest Sst. | 124 | 82 | 66 |
| **199444** | FOR010 | 351 | Forrest Sst. | 86 | 64 | 75 |
| **199453** | FOR011 | 98 | Madura Fm. | 94 | 81 | 86 |
| **199454** | FOR011 | 257 | Madura Fm. | 140 | 114 | 81 |
| **199455** | FOR011 | 267 | Loongana Sst. | 158 | 142 | 90 |
| **199458** | HDDH001 | 269 | Madura Fm. | 12 | 5 | 42 |
| **199459** | HDDH001 | 241 | Madura Fm. | Barren | - | - |
| **199456** | HDDH001 | 423 | Haig Cglm. | 136 | 134 | 99 |

Table 3: Summary of key rock units, key environmental indicators, and depositional environment interpretations.

| Rock Unit | Key Sedimentary Structures/Lithology | Biota | Gross Depositional Environment |
|---|---|---|---|
| ***Marine Madura*** | Faint planar laminated siltstone and fine sands. Moderately glauconitic. | Brachiopods, coiled cephalopod, shell fragments, charcoal clasts.<br>Abundant dinocysts. | Low energy, marine |
| ***Non-marine Madura*** | Faint planar laminated siltstone and fine sands. | No macro fossils observed.<br>Charcoal clasts.<br>Low salinity/fresh water algae. | Low energy, lacustrine |
| ***Loongana Formation*** | Poorly consolidated quartz dominated felspathic sand. Medium-coarse grained, angular, poorly sorted. | No macro fossils observed.<br>Low salinity/fresh water algae. | High energy, fluvial/lacustrine |
| ***Shanes Dam Conglomerate*** | Rounded quartz, sandstone, mafic and granitic, pebbles-cobbles. Clast supported, moderate to well consolidated, variable carbonate cement. Highly magnetic + ferrugenised in places. | No macro fossils observed. | High energy, alluvial/fluvial |
| ***Decoration Sandstone – claystone facies*** | Red/green claystone to mudstone.<br>Minor pyrite. | No macro fossils observed.<br>Barren of palynomorphs | Low energy non-marine/marine? |
| ***Decoration Sandstone – sandstone facies*** | >1m, Interbedded planar sandstone, massive fining up sandstone and wavy/irregular bedded bioturbated sandstone, with a conglomeritic base. Quartz dominated, medium to coarse grained moderately sorted well rounded. Minor fine angular quartz fraction. Hematite rich lower half | No macro fossils observed. | Aeolian to paralic |

## 16.0 Appendices

### 16.1 Appendix 1

Appendix 1 contains five summary logs for the diamond cored section of boreholes FOR004, FOR010, FOR011, HDDH001 and HDDH002. Data sources for the summary logs include: Core logs completed at the Geological Survey of Western Australia (GSWA) core library; Sediment description completed under a binocular microscope with mineral identification aided using A Hitachi TM3030 desktop SEM with Oxford Swift ED 3000 EDX capabilities.

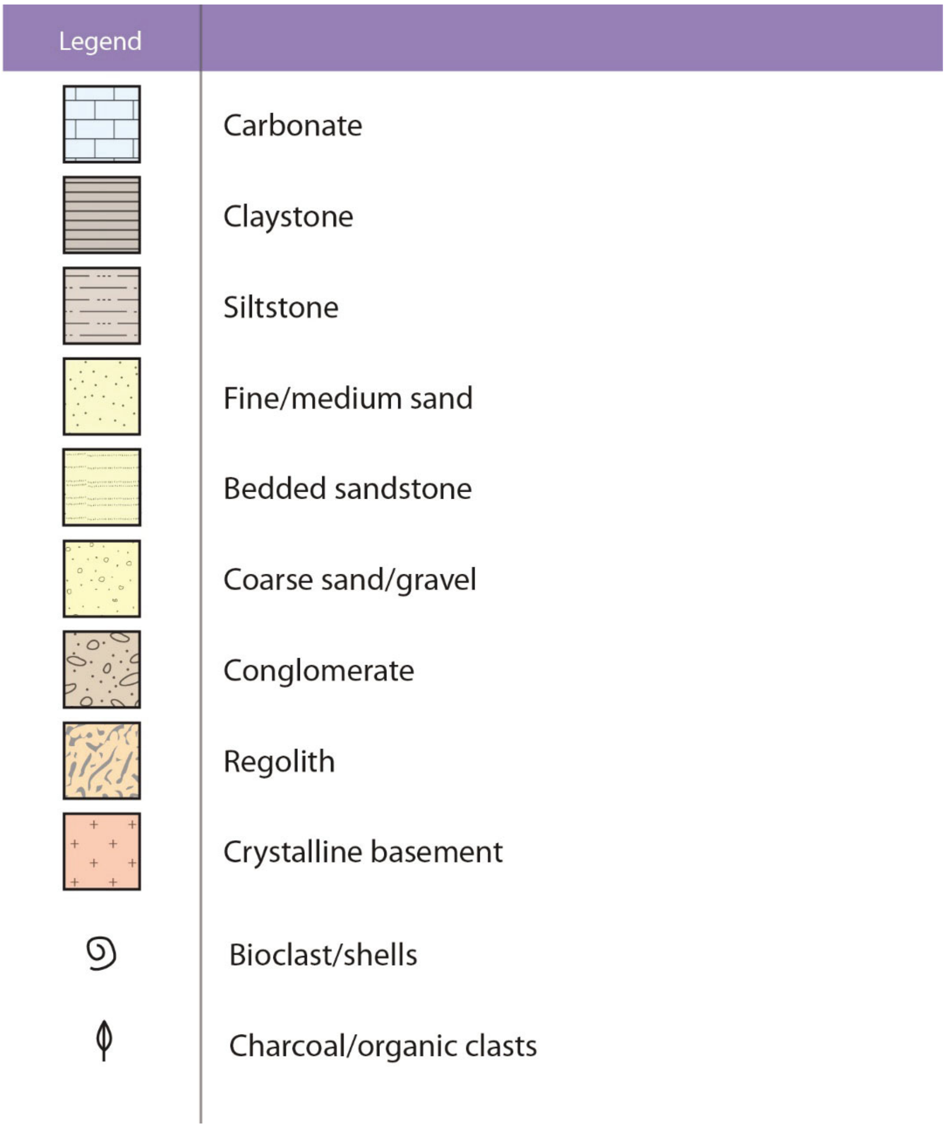



Figure 1: Legend for summary logs showing lithologies and various clast types.

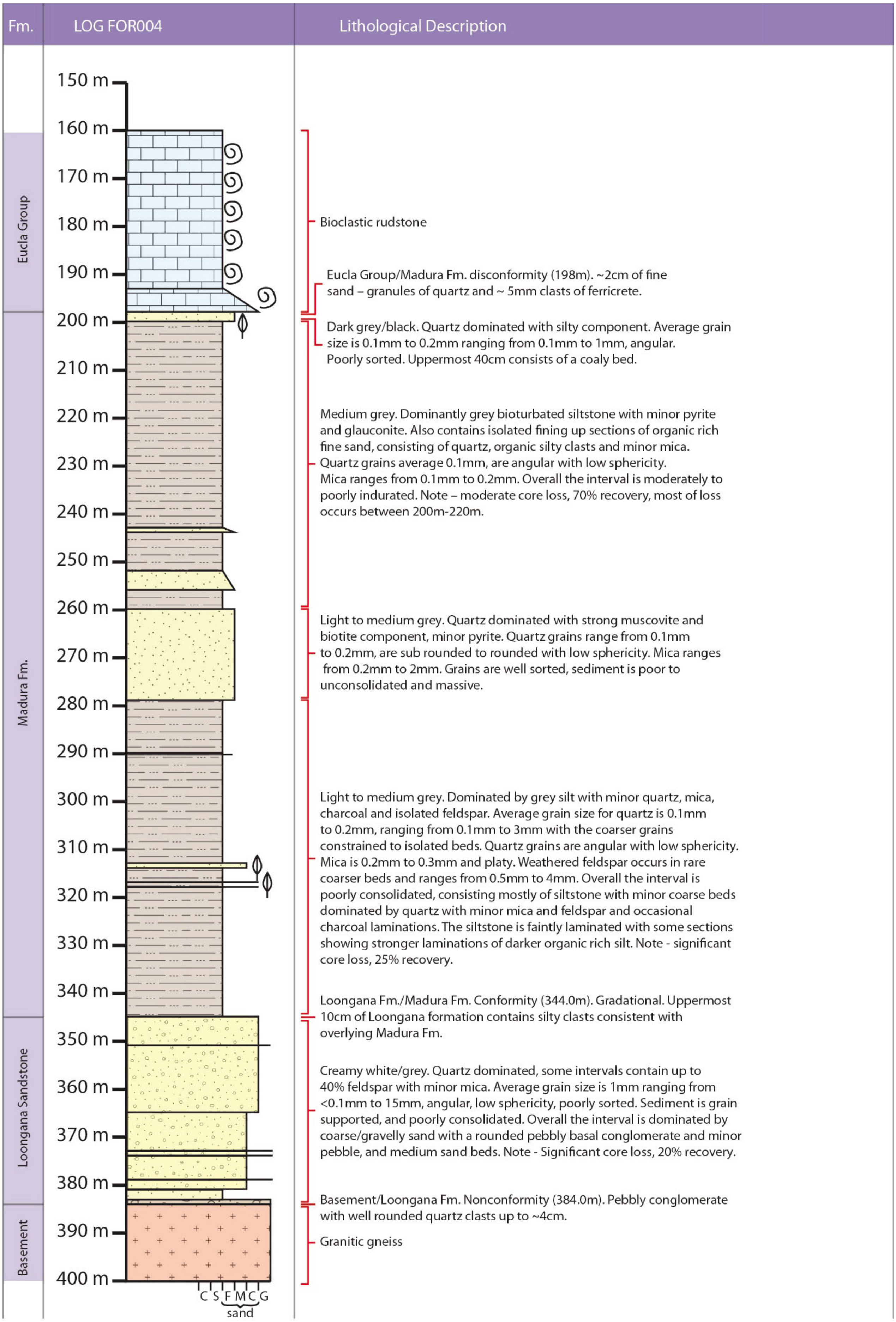



Figure 2: Summary log of FOR004 showing grain size variations, distribution of bioclasts, organic/charcoal clasts and brief descriptions of lithological units.

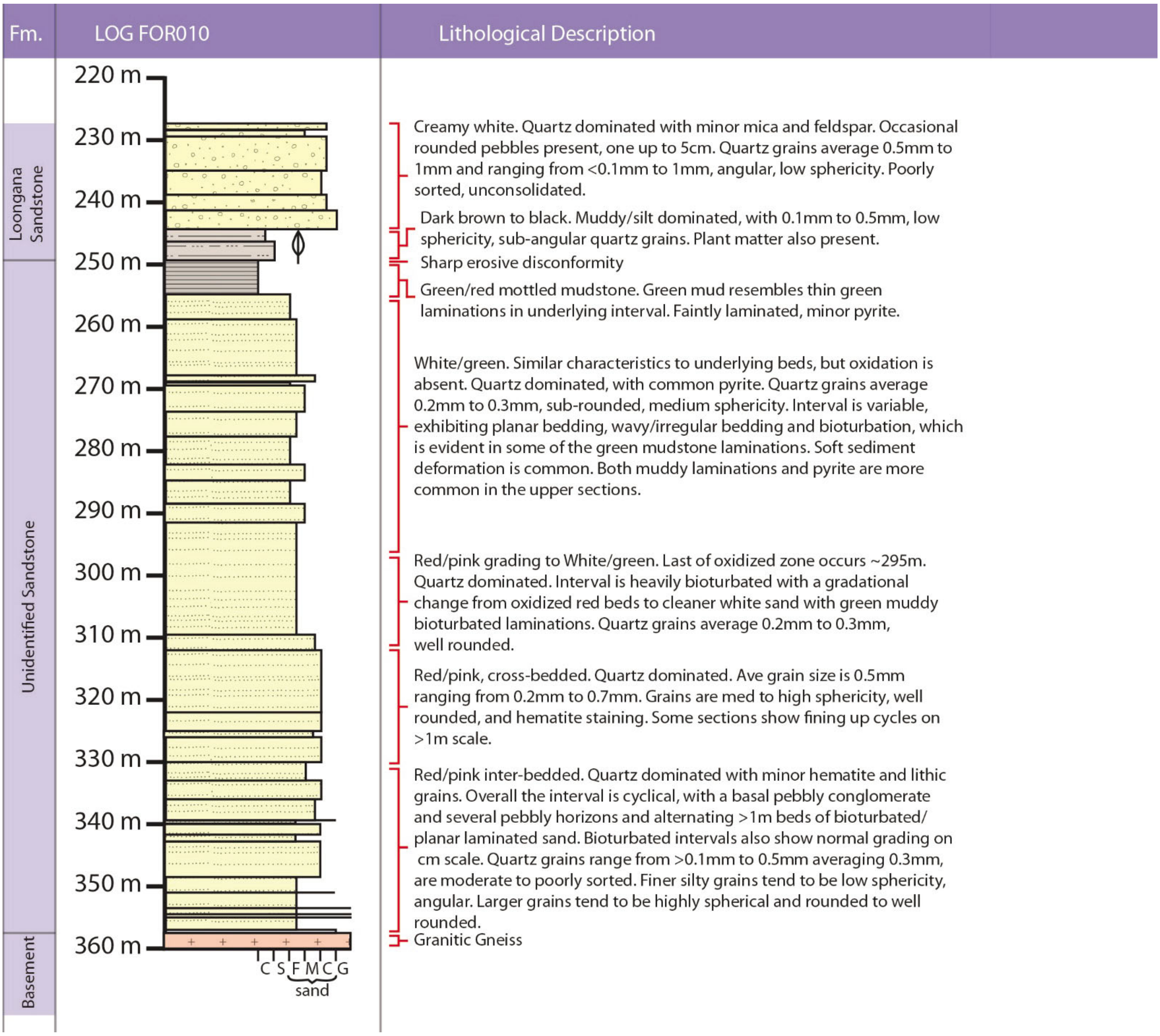



Figure 3: Summary log of FOR010 showing grain size variations, distribution of bioclasts, organic/charcoal clasts and brief descriptions of lithological units. *Note the "unidentified sandstone" represents the Decoration Sandstone.*

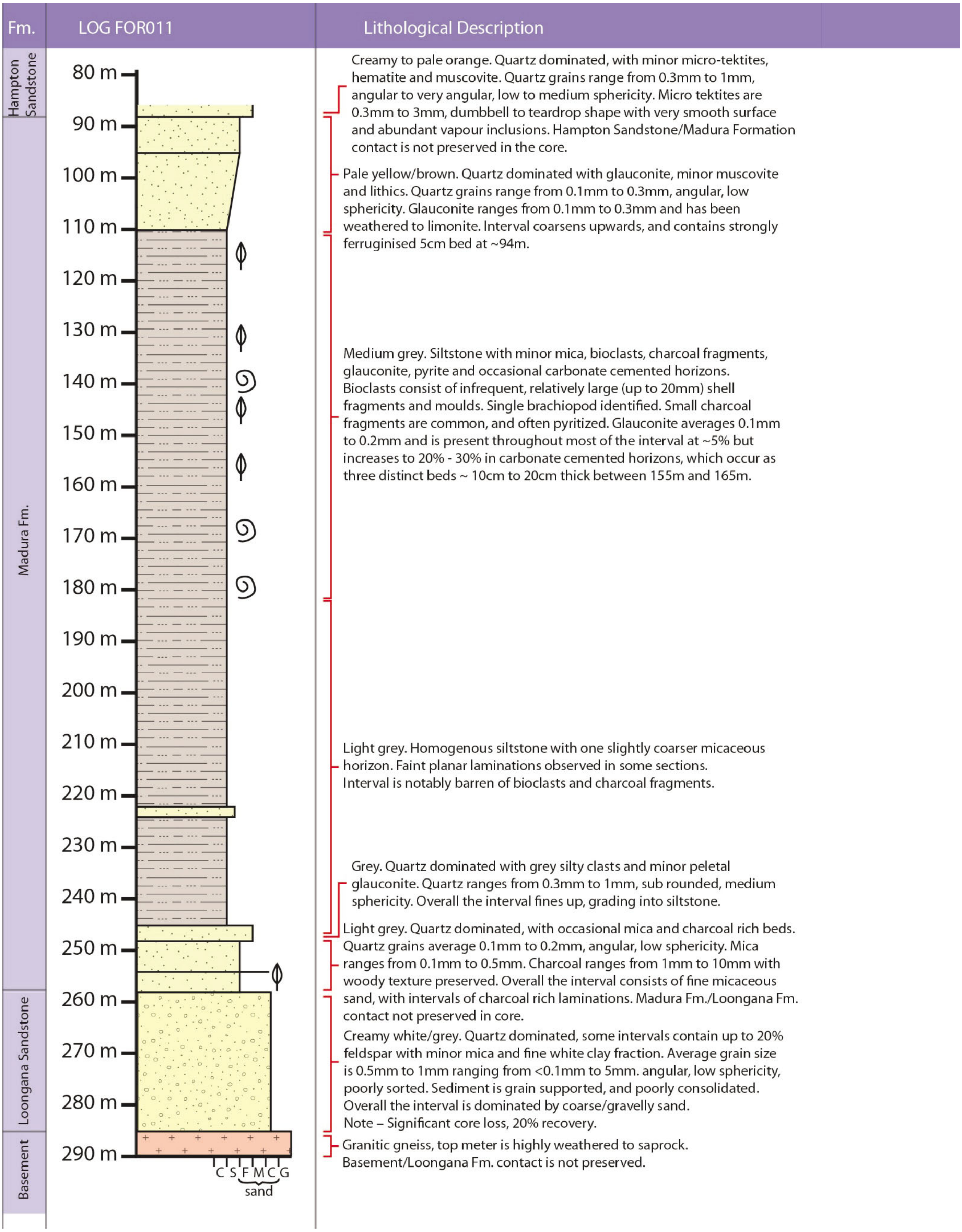



Figure 4: Summary log of FOR011 showing grain size variations, distribution of bioclasts, organic/charcoal clasts and brief descriptions of lithological units.

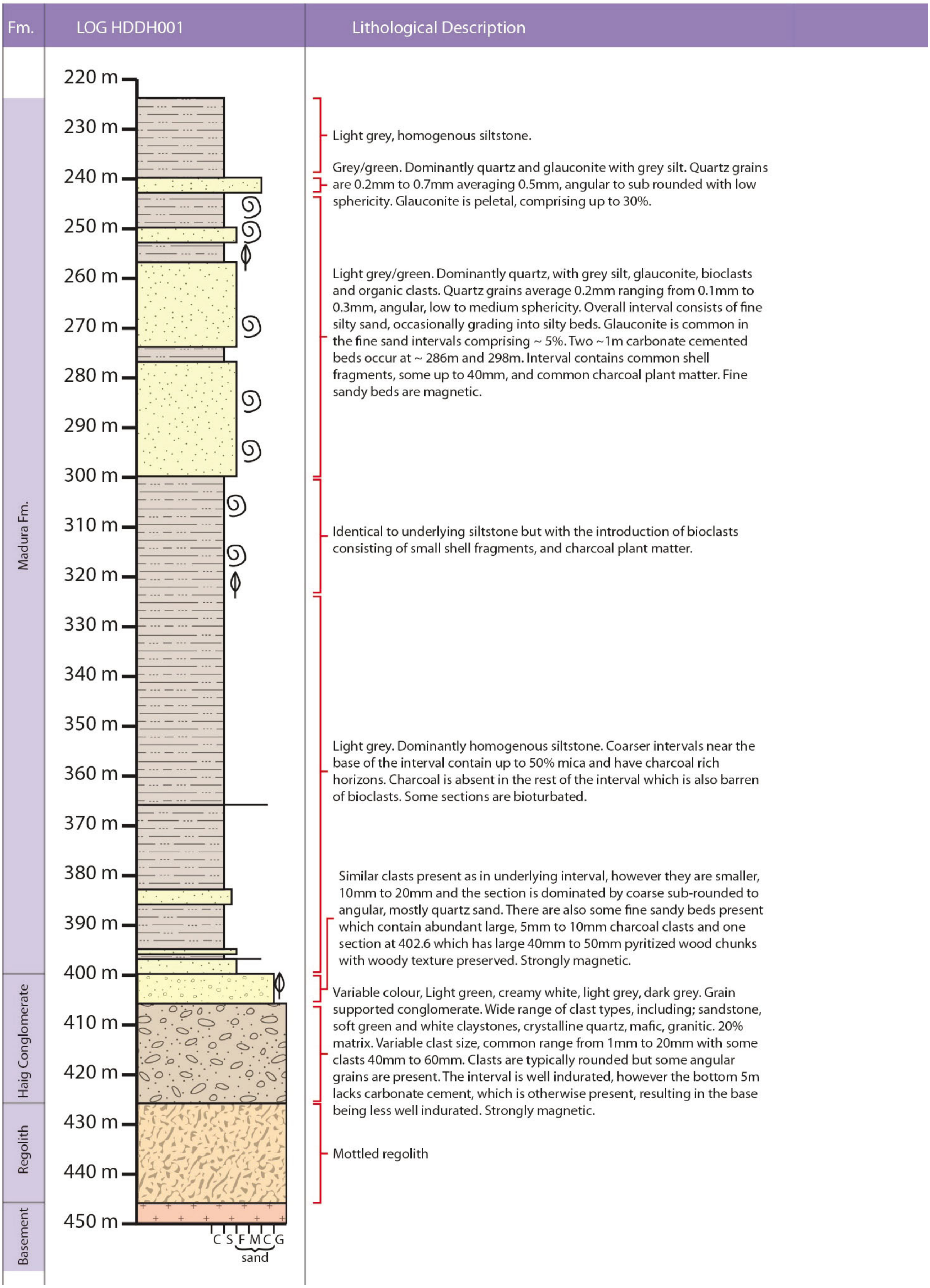



Figure 5: Summary log of HDDH001 showing grain size variations, distribution of bioclasts, organic/charcoal clasts and brief descriptions of lithological units. *Note "Haig conglomerate" represents the "Shanes Dam Conglomerate"*.

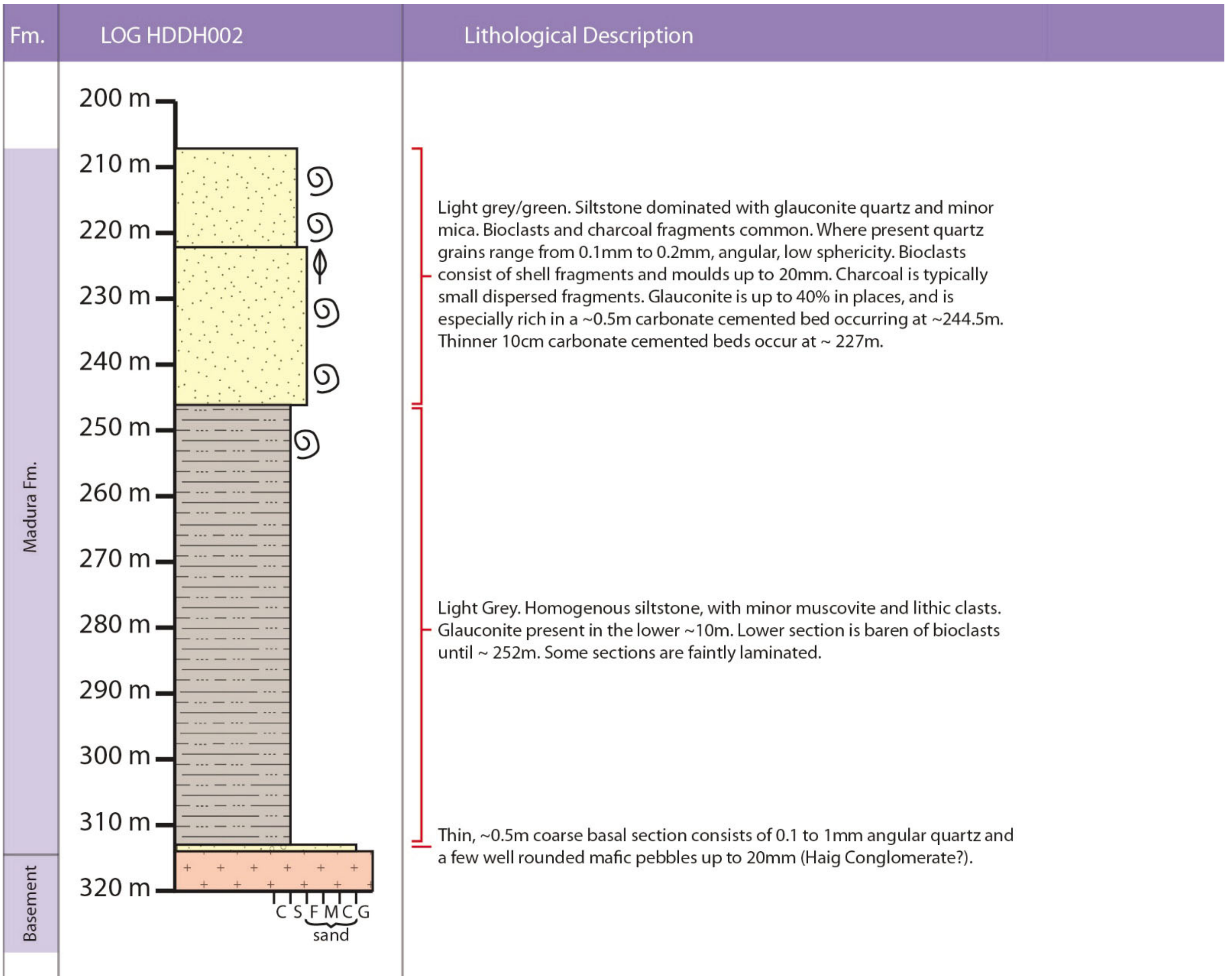



Figure 6: Summary log of HDDH002 showing grain size variations, distribution of bioclasts, organic/charcoal clasts and brief descriptions of lithological units.

## 16.2 Appendix 2

Raw contact data for major lithology units, from all wells included in this study. All elevations are in meters and Australian Height Datum (AHD). Lithology codes are as follows: Lst = Eucla Group carbonates; Hst = Hampton Sandstone; Mad = Madura Formation; Lng = Loongana Formation; Hcg = Shanes Dam Conglomerate; Fcl = Decoration Sandstone - claystone facies; Fst = Decoration Sandstone - sandstone facies; Bsm = Crystalline basement; Pdg = Pidinga Sandstone. Abbreviations; Long = Longitude; Lat = Latitude; Thk = unit thickness in meters. Latitude and longitude coordinate system is GDA 94.

| Hole ID | LONG | LAT | Base Lst | Top Lst | Thk Lst | Base Hst | Top Hst | Thk Hst | Base Mad | Top Mad | Thk Mad | Base Lng | Top Lng | Thk Lng | Base Hcg | Top Hcg | Thk Hcg | Base Fcl | Top Fcl | Thk Fcl | Base Fst | Top Fst | Thk Fst | Top Bsm | Base Pdg | Top Pdg | Thk Pdg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **FOR004** | 128.554 | -31.280 | -64 | 134 | 198 | | | | -210 | -64 | 146 | -250 | -210 | 40 | | | | | | | | | | -250 | | | |
| **FOR010** | 128.366 | -30.519 | 109 | 182 | 73 | 91 | 109 | 18 | -36 | 91 | 127 | -67 | -36 | 31 | | | | -73 | -67 | 6 | -176 | -73 | 103 | -176 | | | |
| **FOR011** | 128.176 | -30.617 | 97 | 177 | 80 | 88 | 97 | 9 | -81 | 88 | 169 | -108 | -81 | 27 | | | | | | | | | | -108 | | | |
| **MAD014** | 127.086 | -30.479 | 129 | 212 | 83 | | | | -30 | 129 | 159 | -38 | -30 | 8 | | | | | | | | | | -38 | | | |
| **HDDH001** | 126.079 | -31.053 | 10 | 174 | 164 | | | | -226 | 10 | 236 | | | | -251 | -226 | 25 | | | | | | | -251 | | | |
| **HDDH002** | 126.104 | -30.945 | 30 | 185 | 155 | | | | -128 | 30 | 158 | | | | -129 | -128 | 1 | | | | | | | -129 | | | |
| **SDDH001** | 126.082 | -31.215 | -38 | 154 | 192 | | | | -294 | -38 | 256 | | | | -323 | -294 | 29 | | | | | | | -323 | | | |
| **SDDH002** | 126.071 | -31.203 | -24 | 154 | 178 | | | | -259 | -24 | 235 | | | | -263 | -259 | 4 | | | | | | | -263 | | | |
| **82NUR001** | 128.612 | -30.020 | 172 | 208 | 36 | 143 | 172 | 30 | | 143 | | | | | | | | | | | | | | | | | |
| **82NUR002** | 128.534 | -30.009 | 175 | 214 | 40 | 144 | 175 | 31 | | 144 | | | | | | | | | | | | | | | | | |
| **82NUR003** | 128.456 | -29.998 | 154 | 208 | 55 | 153 | 154 | 1 | | 153 | | | | | | | | | | | | | | | | | |
| **82NUR004** | 128.482 | -30.170 | 159 | 198 | 39 | 146 | 159 | 13 | | 146 | | | | | | | | | | | | | | | | | |
| **82NUR005** | 128.547 | -30.187 | 166 | 200 | 35 | 145 | 166 | 21 | | 145 | | | | | | | | | | | | | | | | | |
| **82NUR006** | 128.404 | -30.164 | 155 | 202 | 47 | | | | | 155 | | | | | | | | | | | | | | | | | |
| **82NUR007** | 128.417 | -30.320 | 130 | 189 | 59 | 128 | 130 | 2 | | 128 | | | | | | | | | | | | | | | | | |
| **82NUR008** | 128.370 | -30.393 | 132 | 190 | 58 | 123 | 132 | 9 | | 123 | | | | | | | | | | | | | | | | | |
| **82NUR009** | 128.326 | -30.486 | 120 | 184 | 64 | 100 | 120 | 20 | | 100 | | | | | | | | | | | | | | | | | |
| **Eyre1** | 127.077 | -32.117 | -282 | 20 | 302 | | | | -501 | -282 | 219 | | | | | | | | | | | | | -501 | | | |
| **Gambanga1** | 124.833 | -32.267 | -77 | 129 | 206 | -101 | -77 | 24 | -255 | -101 | 154 | -261 | -255 | 6 | | | | | | | | | | -261 | | | |
| **Eucla1** | 128.223 | -31.871 | -171 | 13 | 184 | | | | -201 | -171 | 30 | | | | | | | | | | | | | -201 | | | |
| **BN1** | 129.167 | -31.156 | -38 | 132 | 170 | -147 | -97 | 50 | -168 | -147 | 21 | | | | | | | | | | | | | -168 | -97 | -38 | 59 |
| **CD3** | 129.279 | -30.959 | -5 | 146 | 151 | -7 | -5 | 2 | -58 | -7 | 51 | | -58 | | | | | | | | | | | | | | |
| **CD7** | 129.287 | -30.728 | 44 | 148 | 104 | | | | | 44 | | | | | | | | | | | | | | | | | |
| **CD1** | 129.351 | -31.187 | -44 | 128 | 172 | | | | -136 | -44 | 92 | -156 | -136 | 20 | | | | | | | | | | -174 | | | |
| **KN1** | 129.707 | -31.311 | -82 | 100 | 182 | | | | -192 | -100 | 92 | -225 | -192 | 33 | | | | | | | | | | -240 | -100 | -82 | 18 |
| **KN2** | 129.653 | -31.215 | -52 | 114 | 166 | | | | -165 | -84 | 81 | -208 | -165 | 43 | | | | | | | | | | | -84 | -52 | 32 |
| **NDDH002** | 125.410 | -30.162 | 192 | 215 | 23 | | | | -44 | 192 | 236 | | | | | | | | | | | | | -44 | | | |
| **Madura1** | 127.050 | -31.800 | -180 | 105 | 285 | | | | | -180 | | | | | | | | | | | | | | -535 | | | |
| **LNGD002** | 126.420 | -30.800 | | | | | | | | | | | | | | | | | | | | | | -105 | | | |
| **BKD2** | 126.190 | -30.380 | | | | | | | | | | | | | | | | | | | | | | -28 | | | |

## 16.3 Appendix 3

Appendix 3 contains raw detrital raw detrital zircon age data from LA-ICPMS analysis. % discordance shown is $^{238}$U/$^{206}$Pb.

Table 1: GSWA sample #199443

| Spot ID | $^{238}$U (ppm) | $^{232}$Th (ppm) | $^{232}$Th/$^{238}$U | $^{238}$U/$^{206}$Pb | ± 2σ | $^{207}$Pb/$^{206}$Pb | ± 2σ | $^{206}$PB/$^{238}$U date (Ma) | ± 2σ | $^{206}$Pb/$^{207}$Pb date (Ma) | ± 2σ | Disc. (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| X443_1 | 266 | 314 | 1.180451 | 4.653327 | 0.199212 | 0.1142 | 0.0049 | 1254 | 49 | 1883 | 79 | 16.95364 |
| X443_2 | 131 | 130 | 0.992366 | 3.649635 | 0.133198 | 0.0945 | 0.0038 | 1563 | 51 | 1503 | 76 | -0.57915 |
| X443_3 | 414 | 319 | 0.770531 | 6.518905 | 0.288974 | 0.1401 | 0.0054 | 924 | 37 | 2225 | 65 | 33.66834 |
| X443_4 | 257 | 137 | 0.533074 | 3.205128 | 0.113001 | 0.1074 | 0.0031 | 1751 | 53 | 1751 | 52 | 0.567859 |
| X443_5 | 17 | 27 | 1.588235 | 3.367003 | 0.192724 | 0.155 | 0.02 | 1670 | 85 | 2320 | 220 | 16.0804 |
| X443_6 | 152 | 128 | 0.842105 | 3.508772 | 0.135426 | 0.0994 | 0.0041 | 1615 | 55 | 1608 | 72 | -0.87445 |
| X443_7 | 232 | 128 | 0.551724 | 3.401361 | 0.127262 | 0.1294 | 0.0048 | 1663 | 53 | 2079 | 65 | 10.5914 |
| X443_8 | 13 | 9 | 0.692308 | 4.1841 | 0.2626 | 0.114 | 0.018 | 1379 | 79 | 1690 | 310 | 9.869281 |
| X443_9 | 122 | 115 | 0.942623 | 3.663004 | 0.134176 | 0.0931 | 0.0042 | 1557 | 53 | 1470 | 84 | -1.1039 |
| X443_10 | 286 | 128 | 0.447552 | 4.043672 | 0.150432 | 0.0919 | 0.0035 | 1424 | 48 | 1452 | 73 | 0.69735 |
| X443_11 | 162 | 86 | 0.530864 | 4.132231 | 0.170753 | 0.114 | 0.0078 | 1397 | 53 | 1810 | 120 | 11.30159 |
| X443_12 | 148 | 181 | 1.222973 | 4.752852 | 0.187494 | 0.0775 | 0.0034 | 1230 | 44 | 1114 | 88 | -2.67112 |
| X443_13 | 497 | 448 | 0.901408 | 7.369197 | 0.309539 | 0.1208 | 0.004 | 820 | 32 | 1981 | 57 | 32.2314 |
| X443_14 | 69 | 84 | 1.217391 | 3.787879 | 0.157828 | 0.0912 | 0.0056 | 1507 | 58 | 1430 | 110 | -2.93716 |
| X443_15 | 299 | 200 | 0.668896 | 6.83527 | 0.31303 | 0.0866 | 0.0043 | 879 | 38 | 1324 | 97 | 12.9703 |
| X443_16 | 85 | 78 | 0.917647 | 3.816794 | 0.145679 | 0.0867 | 0.0035 | 1497 | 52 | 1350 | 77 | -3.24138 |
| X443_17 | 69 | 45 | 0.652174 | 5.452563 | 0.246763 | 0.0716 | 0.0047 | 1085 | 45 | 950 | 130 | -5.23763 |
| X443_18 | 66 | 58 | 0.878788 | 5.002501 | 0.232733 | 0.0751 | 0.0045 | 1174 | 50 | 1040 | 130 | -3.71025 |
| X443_19 | 294 | 496 | 1.687075 | 5.94884 | 0.21941 | 0.1976 | 0.007 | 1001 | 34 | 2804 | 61 | 42.40506 |
| X443_21 | 126 | 96 | 0.761905 | 4.780115 | 0.201076 | 0.0801 | 0.0035 | 1229 | 45 | 1208 | 97 | -0.7377 |
| X443_22 | 988 | 1690 | 1.710526 | 15.87302 | 0.831444 | 0.224 | 0.011 | 394 | 20 | 3003 | 76 | 63.48471 |
| X443_23 | 1180 | 13035 | 11.04661 | 25 | 3.3125 | 0.726 | 0.021 | 252 | 33 | 4796 | 48 | 84.25 |
| X443_24 | 220 | 183 | 0.831818 | 2.754821 | 0.106247 | 0.1239 | 0.0042 | 2006 | 60 | 2005 | 60 | 0.199005 |
| X443_25 | 1100 | 1898 | 1.725455 | 15.72327 | 0.914719 | 0.341 | 0.013 | 397 | 22 | 3657 | 56 | 71.92362 |
| X443_26 | 48 | 55 | 1.145833 | 4.854369 | 0.235649 | 0.0765 | 0.0066 | 1207 | 53 | 1030 | 170 | -4.50216 |
| X443_28 | 283 | 575 | 2.031802 | 5.662514 | 0.224449 | 0.1669 | 0.0065 | 1048 | 38 | 2516 | 66 | 35.54736 |
| X443_29 | 149 | 154 | 1.033557 | 3.424658 | 0.129011 | 0.0967 | 0.0042 | 1650 | 54 | 1565 | 80 | -2.29386 |
| X443_30 | 1281 | 1329 | 1.037471 | 8.741259 | 0.336202 | 0.45 | 0.013 | 698 | 25 | 4081 | 42 | 67.122 |
| X443_31 | 132 | 87 | 0.659091 | 5.552471 | 0.21581 | 0.0765 | 0.0043 | 1067 | 38 | 1090 | 110 | 0.55918 |
| X443_32 | 531 | 656 | 1.235405 | 6.418485 | 0.362533 | 0.1528 | 0.0069 | 932 | 49 | 2360 | 76 | 36.3388 |
| X443_33 | 1232 | 2965 | 2.406656 | 13.83126 | 0.765215 | 0.434 | 0.014 | 449 | 24 | 4027 | 49 | 73.35312 |
| X443_34 | 202 | 300 | 1.485149 | 4.288165 | 0.174689 | 0.1142 | 0.0044 | 1350 | 49 | 1885 | 74 | 14.55696 |
| X443_35 | 142 | 118 | 0.830986 | 5.482456 | 0.219419 | 0.0781 | 0.0046 | 1079 | 40 | 1150 | 120 | 1.280878 |
| X443_36 | 91 | 108 | 1.186813 | 3.205128 | 0.133547 | 0.1051 | 0.0048 | 1750 | 65 | 1706 | 84 | -1.03926 |
| X443_37 | 396 | 281 | 0.709596 | 5.437738 | 0.218811 | 0.16 | 0.014 | 1088 | 40 | 2410 | 140 | 32.16958 |
| X443_38 | 122 | 81 | 0.663934 | 3.412969 | 0.128132 | 0.0989 | 0.0041 | 1653 | 57 | 1622 | 87 | -1.66052 |
| X443_39 | 1497 | 1143 | 0.763527 | 17.85714 | 0.797194 | 0.401 | 0.012 | 351 | 15 | 3909 | 44 | 75.40294 |
| X443_40 | 55 | 79 | 1.436364 | 5.205622 | 0.238467 | 0.0804 | 0.005 | 1138 | 47 | 1180 | 120 | 2.065404 |
| X443_41 | 237 | 440 | 1.85654 | 5.75374 | 0.304571 | 0.1059 | 0.0043 | 1031 | 51 | 1715 | 74 | 19.82893 |
| X443_42 | 132 | 74 | 0.560606 | 2.906977 | 0.118307 | 0.1122 | 0.004 | 1905 | 68 | 1826 | 66 | -1.76282 |
| X443_43 | 333 | 192 | 0.576577 | 5.387931 | 0.209015 | 0.0786 | 0.003 | 1101 | 39 | 1168 | 77 | 2.046263 |
| X443_44 | 435 | 1016 | 2.335632 | 6.480881 | 0.352815 | 0.2198 | 0.0074 | 924 | 47 | 2973 | 55 | 46.92705 |
| X443_45 | 66 | 54 | 0.818182 | 1.845018 | 0.071486 | 0.205 | 0.0072 | 2788 | 88 | 2865 | 56 | 1.90007 |
| X443_46 | 231 | 227 | 0.982684 | 3.496503 | 0.134481 | 0.0989 | 0.0035 | 1619 | 53 | 1602 | 69 | 0.430504 |
| X443_47 | 319 | 17 | 0.053292 | 3.174603 | 0.110859 | 0.1078 | 0.0031 | 1762 | 56 | 1759 | 53 | -0.39886 |
| X443_48 | 183 | 120 | 0.655738 | 2.207506 | 0.077969 | 0.1574 | 0.0046 | 2407 | 70 | 2424 | 50 | 0.496073 |
| X443_49 | 129 | 165 | 1.27907 | 5.524862 | 0.280822 | 0.0803 | 0.0043 | 1071 | 50 | 1190 | 100 | 2.636364 |
| X443_50 | 198 | 173 | 0.873737 | 4.512635 | 0.16902 | 0.079 | 0.0036 | 1290 | 44 | 1161 | 89 | -4.03226 |
| X443_51 | 200 | 278 | 1.39 | 3.875969 | 0.180278 | 0.1029 | 0.0044 | 1477 | 62 | 1669 | 81 | 6.043257 |
| X443_52 | 202 | 132 | 0.653465 | 3.322259 | 0.121412 | 0.103 | 0.0032 | 1696 | 56 | 1673 | 57 | -0.11806 |
| X443_53 | 204 | 325 | 1.593137 | 5.09684 | 0.189638 | 0.0783 | 0.0031 | 1155 | 39 | 1160 | 83 | 0.345125 |
| X443_54 | 145 | 741 | 5.110345 | 9.009009 | 1.136271 | 0.1073 | 0.0096 | 686 | 85 | 1750 | 170 | 27.78947 |
| X443_55 | 104 | 75 | 0.721154 | 3.533569 | 0.137347 | 0.0998 | 0.0048 | 1603 | 55 | 1608 | 91 | 0.988264 |
| X443_56 | 634 | 837 | 1.320189 | 8.467401 | 0.329806 | 0.2772 | 0.0089 | 719 | 27 | 3354 | 50 | 58.82016 |
| X443_57 | 90 | 64 | 0.711111 | 5.476451 | 0.230935 | 0.077 | 0.0045 | 1080 | 42 | 1110 | 120 | 0.917431 |
| X443_58 | 123 | 102 | 0.829268 | 3.030303 | 0.110193 | 0.1054 | 0.0045 | 1835 | 60 | 1715 | 82 | -2.2854 |
| X443_59 | 147 | 188 | 1.278912 | 5.178664 | 0.222594 | 0.0803 | 0.0033 | 1137 | 45 | 1186 | 83 | 1.728608 |
| X443_60 | 58 | 51 | 0.87931 | 5.30504 | 0.272991 | 0.082 | 0.006 | 1111 | 52 | 1220 | 140 | 3.307224 |
| X443_61 | 90 | 123 | 1.366667 | 4.426737 | 0.176364 | 0.0869 | 0.0043 | 1312 | 47 | 1343 | 99 | 1.649175 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **X443_62** | 93 | 106 | 1.139785 | 3.448276 | 0.130797 | 0.0977 | 0.0044 | 1641 | 56 | 1573 | 81 | -0.36697 |
| **X443_63** | 38 | 98 | 2.578947 | 3.289474 | 0.16231 | 0.0927 | 0.0052 | 1718 | 71 | 1480 | 120 | -5.52826 |
| **X443_64** | 40 | 35 | 0.875 | 4.878049 | 0.261749 | 0.0719 | 0.0055 | 1198 | 59 | 950 | 170 | -6.48889 |
| **X443_65** | 148 | 99 | 0.668919 | 3.378378 | 0.125548 | 0.097 | 0.0035 | 1668 | 55 | 1567 | 63 | -1.8315 |
| **X443_66** | 252 | 86 | 0.34127 | 5.580357 | 0.255351 | 0.0883 | 0.0038 | 1061 | 45 | 1397 | 83 | 9.625213 |
| **X443_67** | 795 | 967 | 1.216352 | 10.01001 | 0.410821 | 0.1596 | 0.0054 | 614 | 24 | 2451 | 58 | 48.61925 |
| **X443_68** | 36 | 43 | 1.194444 | 3.125 | 0.15625 | 0.1058 | 0.0069 | 1785 | 76 | 1720 | 130 | -1.7094 |
| **X443_69** | 817 | 1642 | 2.009792 | 9.07441 | 0.395256 | 0.34 | 0.01 | 674 | 28 | 3657 | 46 | 63.54786 |
| **X443_70** | 539 | 463 | 0.858998 | 7.309942 | 0.347329 | 0.204 | 0.011 | 826 | 37 | 2836 | 86 | 48.31039 |
| **X443_71** | 268 | 175 | 0.652985 | 3.436426 | 0.129899 | 0.1004 | 0.0032 | 1645 | 54 | 1632 | 61 | -0.61162 |
| **X443_72** | 132 | 97 | 0.734848 | 3.076923 | 0.132544 | 0.101 | 0.0038 | 1819 | 65 | 1660 | 67 | -4.00229 |
| **X443_73** | 589 | 664 | 1.127334 | 11.02536 | 0.449767 | 0.1312 | 0.0044 | 559 | 22 | 2121 | 62 | 43.42105 |
| **X443_74** | 473 | 632 | 1.336152 | 6.55308 | 0.257657 | 0.1524 | 0.0056 | 922 | 32 | 2371 | 65 | 36.9357 |
| **X443_75** | 941 | 2777 | 2.951116 | 6.702413 | 0.274026 | 0.585 | 0.017 | 896 | 34 | 4468 | 41 | 65.72303 |
| **X443_76** | 67 | 102 | 1.522388 | 3.508772 | 0.147738 | 0.094 | 0.0054 | 1622 | 59 | 1500 | 110 | -1.75659 |
| **X443_77** | 92 | 102 | 1.108696 | 3.448276 | 0.142687 | 0.0976 | 0.0057 | 1638 | 60 | 1590 | 110 | -0.67609 |
| **X443_78** | 1783 | 2402 | 1.347168 | 23.14815 | 1.071674 | 0.535 | 0.017 | 273 | 12 | 4341 | 44 | 81.30137 |
| **X443_79** | 774 | 718 | 0.927649 | 7.183908 | 0.325134 | 0.231 | 0.015 | 840 | 36 | 3020 | 100 | 50.53004 |
| **X443_80** | 58 | 106 | 1.827586 | 3.355705 | 0.14639 | 0.1009 | 0.0065 | 1678 | 66 | 1610 | 130 | -1.02348 |
| **X443_81** | 100 | 213 | 2.13 | 3.717472 | 0.165835 | 0.1005 | 0.0051 | 1536 | 60 | 1649 | 93 | 3.578154 |
| **X443_82** | 145 | 129 | 0.889655 | 3.937008 | 0.1705 | 0.1049 | 0.0047 | 1463 | 54 | 1703 | 84 | 7.170051 |
| **X443_83** | 771 | 851 | 1.103761 | 9.433962 | 0.889996 | 0.447 | 0.033 | 648 | 58 | 4020 | 120 | 67.92079 |
| **X443_84** | 987 | 1508 | 1.527862 | 13.96648 | 0.643707 | 0.1897 | 0.008 | 445 | 20 | 2756 | 67 | 57.89972 |
| **X443_85** | 100 | 93 | 0.93 | 5.733945 | 0.24001 | 0.0788 | 0.0055 | 1040 | 40 | 1120 | 150 | 3.970452 |
| **X443_86** | 253 | 124 | 0.490119 | 3.058104 | 0.112224 | 0.1067 | 0.0033 | 1835 | 58 | 1745 | 55 | -2.62864 |
| **X443_87** | 194 | 66 | 0.340206 | 5.175983 | 0.187536 | 0.0767 | 0.0036 | 1138 | 38 | 1089 | 94 | -0.44131 |
| **X443_88** | 155 | 101 | 0.651613 | 3.663004 | 0.147594 | 0.0917 | 0.0038 | 1553 | 54 | 1457 | 76 | -2.50825 |
| **X443_89** | 64 | 71 | 1.109375 | 3.322259 | 0.132449 | 0.0999 | 0.005 | 1703 | 59 | 1595 | 96 | -2.96252 |
| **X443_90** | 75 | 115 | 1.533333 | 3.08642 | 0.133364 | 0.1029 | 0.0046 | 1805 | 68 | 1666 | 87 | -2.44041 |
| **X443_91** | 84 | 51 | 0.607143 | 5.67215 | 0.212344 | 0.0739 | 0.0058 | 1046 | 36 | 990 | 170 | -1.25847 |
| **X443_92** | 714 | 745 | 1.043417 | 11.21076 | 0.477589 | 0.1468 | 0.0053 | 551 | 23 | 2299 | 62 | 47.22222 |
| **X443_93** | 178 | 169 | 0.949438 | 2.941176 | 0.103806 | 0.1171 | 0.0042 | 1891 | 59 | 1902 | 65 | 0.734908 |
| **X443_94** | 132 | 87 | 0.659091 | 3.333333 | 0.122222 | 0.1042 | 0.004 | 1692 | 55 | 1688 | 71 | -0.59453 |
| **X443_95** | 1183 | 1527 | 1.290786 | 11.16071 | 0.411053 | 0.384 | 0.011 | 553 | 20 | 3849 | 46 | 68.82751 |
| **X443_96** | 110 | 71 | 0.645455 | 3.521127 | 0.136382 | 0.0968 | 0.004 | 1609 | 55 | 1568 | 76 | -0.75141 |
| **X443_97** | 180 | 142 | 0.788889 | 3.115265 | 0.126163 | 0.1089 | 0.0036 | 1791 | 62 | 1774 | 60 | 0.33389 |
| **X443_98** | 46 | 58 | 1.26087 | 4.975124 | 0.247519 | 0.0686 | 0.005 | 1180 | 54 | 870 | 150 | -7.07804 |
| **X443_99** | 61 | 56 | 0.918033 | 5.015045 | 0.246477 | 0.0752 | 0.0052 | 1171 | 52 | 1030 | 150 | -3.62832 |
| **X443_100** | 178 | 157 | 0.882022 | 3.367003 | 0.147377 | 0.1021 | 0.0041 | 1674 | 63 | 1657 | 78 | -0.11962 |
| **X443_101** | 57 | 69 | 1.210526 | 3.496503 | 0.171158 | 0.1214 | 0.0076 | 1629 | 68 | 1950 | 110 | 7.914076 |
| **X443_102** | 851 | 1364 | 1.60282 | 9.319664 | 0.373481 | 0.2623 | 0.0086 | 657 | 25 | 3255 | 51 | 58.96315 |
| **X443_103** | 96 | 78 | 0.8125 | 4.887586 | 0.198275 | 0.0803 | 0.0055 | 1199 | 44 | 1230 | 130 | 0.497925 |
| **X443_104** | 1197 | 4252 | 3.552214 | 16.86341 | 0.739374 | 0.35 | 0.015 | 372 | 16 | 3714 | 69 | 72.78713 |
| **X443_105** | 119 | 123 | 1.033613 | 3.533569 | 0.149833 | 0.0937 | 0.0036 | 1613 | 60 | 1489 | 73 | -2.93555 |
| **X443_106** | 557 | 884 | 1.587074 | 10.42753 | 0.500173 | 0.1799 | 0.0069 | 590 | 27 | 2658 | 66 | 52.64848 |
| **X443_107** | 889 | 1086 | 1.221597 | 15.79779 | 0.648882 | 0.2436 | 0.0082 | 396 | 16 | 3149 | 54 | 65.89147 |
| **X443_108** | 140 | 167 | 1.192857 | 3.267974 | 0.128156 | 0.0989 | 0.0036 | 1719 | 59 | 1592 | 69 | -2.93413 |
| **X443_109** | 108 | 73 | 0.675926 | 5.488474 | 0.204839 | 0.0739 | 0.0043 | 1078 | 37 | 1040 | 120 | 0.185185 |
| **X443_110** | 89 | 128 | 1.438202 | 3.401361 | 0.1504 | 0.0952 | 0.0041 | 1660 | 65 | 1526 | 90 | -3.23383 |
| **X443_111** | 93 | 50 | 0.537634 | 5.376344 | 0.231241 | 0.0774 | 0.004 | 1099 | 43 | 1110 | 110 | 2.049911 |
| **X443_112** | 481 | 211 | 0.438669 | 8.764242 | 0.361016 | 0.1086 | 0.0045 | 696 | 27 | 1770 | 74 | 30.4 |
| **X443_113** | 294 | 213 | 0.72449 | 3.10559 | 0.115736 | 0.1161 | 0.0036 | 1797 | 57 | 1898 | 53 | 2.548807 |
| **X443_114** | 184 | 113 | 0.61413 | 3.717472 | 0.152016 | 0.0922 | 0.0039 | 1535 | 56 | 1453 | 79 | -1.65563 |
| **X443_115** | 127 | 99 | 0.779528 | 3.496503 | 0.146706 | 0.0983 | 0.0039 | 1618 | 58 | 1577 | 75 | -1.44201 |
| **X443_116** | 172 | 187 | 1.087209 | 3.484321 | 0.133545 | 0.1011 | 0.0035 | 1623 | 57 | 1636 | 66 | -0.30902 |
| **X443_117** | 239 | 127 | 0.531381 | 3.058104 | 0.112224 | 0.1237 | 0.0056 | 1824 | 60 | 1993 | 75 | 4 |
| **X443_118** | 179 | 159 | 0.888268 | 3.095975 | 0.115021 | 0.1074 | 0.0046 | 1802 | 57 | 1738 | 77 | -1.80791 |
| **X443_119** | 402 | 402 | 1 | 6.053269 | 0.282144 | 0.1219 | 0.0044 | 985 | 43 | 1982 | 65 | 26.98295 |
| **X443_120** | 321 | 226 | 0.70405 | 4.444444 | 0.237037 | 0.1059 | 0.0036 | 1304 | 62 | 1723 | 60 | 10.50103 |
| **X443_121** | 198 | 188 | 0.949495 | 3.355705 | 0.157651 | 0.1134 | 0.0036 | 1681 | 69 | 1848 | 57 | 4.434338 |
| **X443_122** | 125 | 276 | 2.208 | 4.786979 | 0.197071 | 0.0773 | 0.0042 | 1222 | 46 | 1130 | 100 | -2.34506 |
| **X443_123** | 95 | 80 | 0.842105 | 5.336179 | 0.216409 | 0.0804 | 0.005 | 1106 | 41 | 1210 | 120 | 2.210433 |
| **X443_124** | 445 | 381 | 0.85618 | 8.787346 | 0.409253 | 0.1117 | 0.0056 | 694 | 31 | 1843 | 91 | 31.49062 |
| **X443_125** | 138 | 128 | 0.927536 | 3.030303 | 0.119376 | 0.1033 | 0.0049 | 1838 | 62 | 1698 | 92 | -4.19501 |
| **X443_126** | 171 | 73 | 0.426901 | 5.047956 | 0.214048 | 0.0844 | 0.0057 | 1164 | 45 | 1330 | 130 | 6.355591 |

Table 2: GSWA sample #199444

| Spot ID | $^{238}U$ (ppm) | $^{232}Th$ (ppm) | $^{232}Th/^{238}U$ | $^{238}U/^{206}Pb$ | ± 2σ | $^{207}Pb/^{206}Pb$ | ± 2σ | $^{206}PB/^{238}U$ date (Ma) | ± 2σ | $^{206}Pb/^{207}Pb$ date (Ma) | ± 2σ | Disc. (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **X444_1** | 152 | 58 | 0.381579 | 5.040323 | 0.198158 | 0.0763 | 0.0036 | 1166 | 42 | 1077 | 95 | -1.30321 |
| **X444_2** | 254 | 171 | 0.673228 | 4.833253 | 0.189219 | 0.102 | 0.004 | 1216 | 45 | 1647 | 75 | 12.64368 |
| **X444_3** | 283 | 262 | 0.925795 | 4.892368 | 0.177121 | 0.0801 | 0.0027 | 1199 | 39 | 1216 | 66 | 0.332502 |
| **X444_4** | 125 | 184 | 1.472 | 4.975124 | 0.180689 | 0.0735 | 0.0038 | 1181 | 39 | 1020 | 110 | -6.30063 |
| **X444_5** | 142 | 168 | 1.183099 | 5.344735 | 0.239956 | 0.0998 | 0.0055 | 1104 | 45 | 1620 | 100 | 14.4186 |
| **X444_6** | 227 | 168 | 0.740088 | 3.215434 | 0.124068 | 0.108 | 0.0034 | 1742 | 57 | 1767 | 56 | 0.966458 |
| **X444_7** | 108 | 180 | 1.666667 | 3.389831 | 0.137891 | 0.0995 | 0.0043 | 1664 | 56 | 1597 | 81 | -2.52619 |
| **X444_8** | 602 | 200 | 0.332226 | 8.389262 | 0.492658 | 0.1761 | 0.0085 | 725 | 40 | 2628 | 82 | 47.46377 |
| **X444_9** | 74 | 80 | 1.081081 | 5.055612 | 0.230033 | 0.0744 | 0.0042 | 1162 | 49 | 1030 | 110 | -3.84272 |
| **X444_10** | 80 | 49 | 0.6125 | 5.497526 | 0.281072 | 0.084 | 0.0067 | 1076 | 51 | 1240 | 160 | 7.560137 |
| **X444_11** | 255 | 206 | 0.807843 | 4.640371 | 0.174418 | 0.0813 | 0.0033 | 1258 | 43 | 1223 | 80 | -1.69766 |
| **X444_12** | 2698 | 1194 | 0.44255 | 46.3392 | 1.889643 | 0.592 | 0.016 | 137.7 | 5.6 | 4486 | 39 | 86.53959 |
| **X444_13** | 175 | 95 | 0.542857 | 3.389831 | 0.126401 | 0.0999 | 0.004 | 1666 | 57 | 1650 | 75 | -0.66465 |
| **X444_14** | 45 | 59 | 1.311111 | 5.017561 | 0.244207 | 0.0837 | 0.0062 | 1170 | 52 | 1250 | 160 | 2.418682 |
| **X444_15** | 79 | 40 | 0.506329 | 1.689189 | 0.074187 | 0.2235 | 0.0065 | 3010 | 110 | 3008 | 45 | -0.33333 |
| **X444_16** | 128 | 87 | 0.679688 | 3.389831 | 0.137891 | 0.0975 | 0.0046 | 1663 | 60 | 1569 | 86 | -2.08717 |
| **X444_17** | 356 | 289 | 0.811798 | 5.611672 | 0.217287 | 0.0936 | 0.0032 | 1057 | 38 | 1490 | 68 | 12.64463 |
| **X444_18** | 72 | 39 | 0.541667 | 5.567929 | 0.223213 | 0.072 | 0.0046 | 1069 | 40 | 1020 | 120 | 0.279851 |
| **X444_19** | 297 | 353 | 1.188552 | 5.757052 | 0.28835 | 0.1614 | 0.0084 | 1031 | 48 | 2470 | 89 | 35.11643 |
| **X444_20** | 195 | 208 | 1.066667 | 4.589261 | 0.166384 | 0.0807 | 0.0034 | 1270 | 42 | 1195 | 83 | -1.92616 |
| **X444_21** | 170 | 152 | 0.894118 | 4.078303 | 0.159673 | 0.0987 | 0.0038 | 1413 | 50 | 1598 | 67 | 6.050532 |
| **X444_22** | 557 | 312 | 0.560144 | 5.434783 | 0.203804 | 0.2386 | 0.0064 | 1092 | 39 | 3108 | 43 | 44.62475 |
| **X444_23** | 225 | 148 | 0.657778 | 4.728132 | 0.174371 | 0.0767 | 0.0036 | 1236 | 43 | 1100 | 97 | -3.9529 |
| **X444_24** | 184 | 217 | 1.179348 | 5.279831 | 0.197924 | 0.084 | 0.0043 | 1118 | 39 | 1300 | 100 | 4.851064 |
| **X444_25** | 57 | 77 | 1.350877 | 3.546099 | 0.163473 | 0.102 | 0.0056 | 1598 | 64 | 1640 | 100 | 2.023299 |
| **X444_26** | 129 | 76 | 0.589147 | 2.985075 | 0.115839 | 0.1091 | 0.004 | 1862 | 62 | 1800 | 69 | -1.08578 |
| **X444_27** | 208 | 125 | 0.600962 | 3.030303 | 0.119376 | 0.1093 | 0.0041 | 1837 | 62 | 1793 | 70 | -1.32377 |
| **X444_28** | 1905 | 7319 | 3.841995 | 35.71429 | 1.530612 | 0.646 | 0.018 | 178 | 7.4 | 4618 | 39 | 86.01728 |
| **X444_29** | 111 | 78 | 0.702703 | 5.257624 | 0.20732 | 0.0716 | 0.004 | 1122 | 41 | 970 | 110 | -5.55033 |
| **X444_30** | 255 | 202 | 0.792157 | 4.748338 | 0.182628 | 0.079 | 0.0032 | 1231 | 43 | 1166 | 83 | -2.24252 |
| **X444_31** | 136 | 116 | 0.852941 | 3.194888 | 0.11228 | 0.1041 | 0.0042 | 1760 | 59 | 1683 | 75 | -1.49942 |
| **X444_32** | 219 | 158 | 0.721461 | 4.830918 | 0.196037 | 0.0773 | 0.0034 | 1212 | 45 | 1142 | 92 | -2.79898 |
| **X444_33** | 128 | 91 | 0.710938 | 3.703704 | 0.137174 | 0.0948 | 0.0037 | 1544 | 50 | 1510 | 72 | -0.06481 |
| **X444_34** | 125 | 114 | 0.912 | 5.537099 | 0.233012 | 0.1014 | 0.0072 | 1069 | 42 | 1650 | 130 | 16.48438 |
| **X444_35** | 193 | 148 | 0.766839 | 3.10559 | 0.115736 | 0.1096 | 0.0036 | 1797 | 57 | 1785 | 60 | -0.33501 |
| **X444_36** | 99 | 132 | 1.333333 | 4.48833 | 0.193393 | 0.0833 | 0.0044 | 1296 | 50 | 1260 | 110 | 0.38432 |
| **X444_37** | 61 | 87 | 1.42623 | 4.901961 | 0.237889 | 0.0775 | 0.0058 | 1195 | 53 | 1140 | 130 | -1.78876 |
| **X444_38** | 105 | 141 | 1.342857 | 4.149378 | 0.172173 | 0.0912 | 0.0049 | 1390 | 54 | 1430 | 110 | 1.974612 |
| **X444_39** | 162 | 135 | 0.833333 | 4.732608 | 0.192619 | 0.0796 | 0.0035 | 1235 | 46 | 1166 | 87 | -2.40464 |
| **X444_40** | 91 | 78 | 0.857143 | 5.211047 | 0.222671 | 0.0804 | 0.0041 | 1131 | 45 | 1190 | 100 | 1.993068 |
| **X444_41** | 89 | 79 | 0.88764 | 4.732608 | 0.18814 | 0.0818 | 0.0048 | 1235 | 45 | 1270 | 100 | 0.483481 |
| **X444_42** | 271 | 213 | 0.785978 | 5.08647 | 0.183693 | 0.0748 | 0.0028 | 1156 | 38 | 1050 | 74 | -1.67106 |
| **X444_43** | 194 | 99 | 0.510309 | 5.767013 | 0.236135 | 0.0705 | 0.0036 | 1030 | 38 | 990 | 110 | -2.38569 |
| **X444_44** | 221 | 180 | 0.81448 | 4.775549 | 0.180166 | 0.0765 | 0.003 | 1225 | 42 | 1095 | 77 | -3.90161 |
| **X444_45** | 309 | 209 | 0.676375 | 4.653327 | 0.160236 | 0.08 | 0.0026 | 1258 | 39 | 1188 | 66 | -1.77994 |
| **X444_46** | 759 | 742 | 0.977602 | 11.84834 | 0.729993 | 0.23 | 0.011 | 522 | 31 | 3027 | 80 | 59.75328 |
| **X444_47** | 112 | 100 | 0.892857 | 3.205128 | 0.14382 | 0.1068 | 0.0043 | 1747 | 66 | 1742 | 75 | -0.05727 |
| **X444_48** | 214 | 128 | 0.598131 | 4.81232 | 0.17832 | 0.0793 | 0.0029 | 1216 | 41 | 1178 | 74 | -0.66225 |
| **X444_49** | 224 | 210 | 0.9375 | 3.164557 | 0.120173 | 0.1006 | 0.0037 | 1768 | 60 | 1641 | 68 | -3.21074 |
| **X444_50** | 964 | 410 | 0.425311 | 8.810573 | 0.395894 | 0.1526 | 0.0058 | 693 | 29 | 2364 | 65 | 44.2926 |
| **X444_51** | 64 | 81 | 1.265625 | 5.157298 | 0.250019 | 0.0832 | 0.0057 | 1141 | 51 | 1260 | 130 | 2.97619 |
| **X444_52** | 343 | 283 | 0.825073 | 4.591368 | 0.179186 | 0.0778 | 0.0027 | 1269 | 45 | 1157 | 72 | -3.76124 |
| **X444_53** | 79 | 47 | 0.594937 | 3.984064 | 0.1746 | 0.0916 | 0.0056 | 1445 | 53 | 1470 | 120 | -0.06925 |
| **X444_54** | 52 | 98 | 1.884615 | 5.125577 | 0.212799 | 0.0878 | 0.0078 | 1148 | 44 | 1320 | 170 | 6.590724 |
| **X444_55** | 42 | 59 | 1.404762 | 5.291005 | 0.307942 | 0.093 | 0.016 | 1115 | 58 | 1200 | 270 | 3.87931 |
| **X444_56** | 212 | 145 | 0.683962 | 5.005005 | 0.185371 | 0.0796 | 0.0032 | 1174 | 40 | 1193 | 77 | 0 |
| **X444_57** | 298 | 141 | 0.473154 | 4.99002 | 0.189242 | 0.1139 | 0.0055 | 1177 | 41 | 1861 | 91 | 19.38356 |
| **X444_58** | 191 | 163 | 0.853403 | 3.472222 | 0.13262 | 0.1007 | 0.0033 | 1633 | 53 | 1629 | 61 | 0.244349 |
| **X444_59** | 80 | 70 | 0.875 | 5.122951 | 0.215206 | 0.0809 | 0.005 | 1148 | 44 | 1210 | 130 | -1.14537 |
| **X444_60** | 248 | 201 | 0.810484 | 4.690432 | 0.200201 | 0.0995 | 0.004 | 1245 | 48 | 1630 | 77 | 9.057706 |
| **X444_61** | 95 | 218 | 2.294737 | 2.136752 | 0.091314 | 0.1665 | 0.0059 | 2473 | 87 | 2514 | 60 | 0.76244 |
| **X444_62** | 367 | 737 | 2.008174 | 7.496252 | 0.387737 | 0.1463 | 0.0058 | 806 | 39 | 2301 | 72 | 38.98562 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **X444_63** | 230 | 353 | 1.534783 | 5.417118 | 0.246499 | 0.1004 | 0.0049 | 1096 | 46 | 1649 | 93 | 14.84071 |
| **X444_64** | 214 | 170 | 0.794393 | 3.508772 | 0.135426 | 0.0966 | 0.003 | 1613 | 56 | 1553 | 57 | -1.19197 |
| **X444_65** | 485 | 363 | 0.748454 | 9.009009 | 0.373346 | 0.1998 | 0.007 | 681 | 26 | 2823 | 58 | 52.24404 |
| **X444_66** | 57 | 74 | 1.298246 | 3.496503 | 0.134481 | 0.1007 | 0.0057 | 1619 | 57 | 1600 | 110 | 0.061728 |
| **X444_67** | 77 | 67 | 0.87013 | 5.022602 | 0.221993 | 0.0743 | 0.0045 | 1169 | 48 | 1040 | 120 | -3.08642 |
| **X444_69** | 233 | 175 | 0.751073 | 4.364906 | 0.179093 | 0.1042 | 0.0042 | 1329 | 49 | 1686 | 73 | 9.653297 |
| **X444_70** | 225 | 290 | 1.288889 | 5.621135 | 0.233819 | 0.0907 | 0.0043 | 1055 | 40 | 1428 | 90 | 10.97046 |
| **X444_71** | 126 | 169 | 1.34127 | 4.987531 | 0.206466 | 0.0777 | 0.0043 | 1177 | 45 | 1150 | 100 | -1.64076 |
| **X444_72** | 129 | 66 | 0.511628 | 5.216484 | 0.217694 | 0.0804 | 0.0042 | 1130 | 43 | 1170 | 100 | 1.137358 |
| **X444_73** | 87 | 55 | 0.632184 | 5.167959 | 0.208321 | 0.0776 | 0.0041 | 1139 | 42 | 1100 | 110 | -0.52957 |
| **X444_74** | 169 | 181 | 1.071006 | 3.436426 | 0.165326 | 0.115 | 0.0045 | 1655 | 68 | 1876 | 69 | 6.072645 |
| **X444_75** | 190 | 90 | 0.473684 | 4.608295 | 0.18688 | 0.0808 | 0.0036 | 1265 | 47 | 1221 | 88 | -0.87719 |
| **X444_76** | 1393 | 950 | 0.681981 | 14.14427 | 0.920278 | 0.327 | 0.012 | 440 | 28 | 3608 | 57 | 69.69697 |
| **X444_77** | 889 | 771 | 0.867267 | 10.06036 | 0.404844 | 0.2728 | 0.0073 | 611 | 24 | 3320 | 42 | 61.25555 |
| **X444_78** | 173 | 84 | 0.485549 | 4.816956 | 0.208828 | 0.083 | 0.0037 | 1215 | 48 | 1259 | 91 | 0.654129 |
| **X444_79** | 71 | 92 | 1.295775 | 3.355705 | 0.135129 | 0.1012 | 0.0051 | 1678 | 61 | 1658 | 96 | 0.119048 |
| **X444_80** | 203 | 228 | 1.123153 | 5.186722 | 0.209836 | 0.0829 | 0.0037 | 1136 | 42 | 1257 | 89 | 3.483432 |
| **X444_81** | 167 | 123 | 0.736527 | 6.485084 | 0.315422 | 0.0881 | 0.0041 | 924 | 42 | 1386 | 95 | 12.25071 |
| **X444_82** | 306 | 174 | 0.568627 | 3.04878 | 0.120836 | 0.2443 | 0.0066 | 1825 | 65 | 3146 | 43 | 27.80854 |
| **X444_83** | 95 | 136 | 1.431579 | 4.016064 | 0.225803 | 0.111 | 0.0051 | 1441 | 70 | 1830 | 80 | 9.199748 |
| **X444_84** | 102 | 53 | 0.519608 | 5.243838 | 0.236481 | 0.0789 | 0.0047 | 1124 | 47 | 1160 | 120 | 1.316945 |
| **X444_85** | 460 | 525 | 1.141304 | 7.087172 | 0.316437 | 0.1509 | 0.0058 | 850 | 36 | 2345 | 65 | 38.36113 |
| **X444_86** | 285 | 93 | 0.326316 | 4.807692 | 0.184911 | 0.0796 | 0.0027 | 1217 | 43 | 1203 | 68 | -0.91211 |
| **X444_87** | 137 | 165 | 1.20438 | 6.067961 | 0.272469 | 0.0887 | 0.0053 | 983 | 41 | 1390 | 110 | 12.23214 |

Table 3: GSWA sample #199453

| Spot ID | $^{238}U$ (ppm) | $^{232}Th$ (ppm) | $^{232}Th/^{238}U$ | $^{238}U/^{206}Pb$ | ± 2σ | $^{207}Pb/^{206}Pb$ | ± 2σ | $^{206}PB/^{238}U$ date (Ma) | ± 2σ | $^{206}Pb/^{207}Pb$ date (Ma) | ± 2σ | Disc. (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **X453_1** | 471 | 143 | 0.303609 | 12.22494 | 0.493182 | 0.0571 | 0.0027 | 507 | 20 | 480 | 110 | 0.19685 |
| **X453_2** | 227 | 157 | 0.69163 | 49.26108 | 2.66932 | 0.0551 | 0.0074 | 129.7 | 6.7 | 470 | 250 | 13.53333 |
| **X453_3** | 542 | 190 | 0.350554 | 15.40832 | 0.569799 | 0.0559 | 0.0026 | 405 | 14 | 440 | 110 | 2.877698 |
| **X453_4** | 133 | 104 | 0.781955 | 59.41771 | 3.42455 | 0.043 | 0.01 | 107.5 | 6.1 | -30 | 380 | -6.43564 |
| **X453_5** | 138 | 303 | 2.195652 | 5.390836 | 0.235395 | 0.0781 | 0.0041 | 1096 | 44 | 1170 | 110 | 2.922941 |
| **X453_6** | 182 | 244 | 1.340659 | 3.802281 | 0.231318 | 0.0977 | 0.0059 | 1502 | 80 | 1560 | 110 | 2.149837 |
| **X453_7** | 193 | 352 | 1.823834 | 5.29661 | 0.193573 | 0.0806 | 0.0031 | 1114 | 38 | 1196 | 78 | 3.046127 |
| **X453_8** | 393 | 248 | 0.631043 | 57.50431 | 2.34779 | 0.0457 | 0.0055 | 111.2 | 4.5 | 60 | 220 | -0.18018 |
| **X453_9** | 371 | 277 | 0.746631 | 62.89308 | 3.085321 | 0.0439 | 0.0059 | 101.7 | 4.9 | 0 | 240 | -4.84536 |
| **X453_10** | 277 | 239 | 0.862816 | 22.37136 | 0.90086 | 0.0508 | 0.0044 | 282 | 11 | 200 | 170 | -1.43885 |
| **X453_11** | 122 | 127 | 1.040984 | 3.215434 | 0.134407 | 0.1084 | 0.0049 | 1746 | 63 | 1776 | 78 | 1.522843 |
| **X453_12** | 243 | 134 | 0.55144 | 3.690037 | 0.136164 | 0.0942 | 0.0034 | 1546 | 53 | 1511 | 64 | 0.064641 |
| **X453_13** | 473 | 400 | 0.845666 | 53.27651 | 2.242325 | 0.0524 | 0.004 | 119.9 | 5 | 270 | 160 | 7.484568 |
| **X453_14** | 163 | 301 | 1.846626 | 4.933399 | 0.228781 | 0.0784 | 0.0038 | 1188 | 50 | 1160 | 110 | -0.16863 |
| **X453_15** | 212 | 178 | 0.839623 | 59.8444 | 3.04415 | 0.0472 | 0.0072 | 106.8 | 5.4 | 80 | 260 | 2.018349 |
| **X453_16** | 92 | 271 | 2.945652 | 4.714757 | 0.197838 | 0.079 | 0.004 | 1239 | 47 | 1140 | 100 | -2.90698 |
| **X453_17** | 345 | 466 | 1.350725 | 6.688963 | 0.250557 | 0.0695 | 0.0029 | 898 | 32 | 904 | 88 | -0.3352 |
| **X453_18** | 361 | 523 | 1.448753 | 5.291005 | 0.307942 | 0.0827 | 0.0039 | 1115 | 61 | 1238 | 91 | 4.619333 |
| **X453_19** | 168 | 142 | 0.845238 | 57.80347 | 3.675365 | 0.0536 | 0.0068 | 110.8 | 7.1 | 260 | 240 | 6.101695 |
| **X453_20** | 384 | 276 | 0.71875 | 63.41154 | 2.814716 | 0.0482 | 0.0059 | 100.9 | 4.5 | 90 | 220 | -0.9 |
| **X453_21** | 329 | 493 | 1.49848 | 5.274262 | 0.219761 | 0.0778 | 0.0028 | 1118 | 43 | 1131 | 71 | 0.356506 |
| **X453_22** | 335 | 227 | 0.677612 | 7.067138 | 0.329633 | 0.1112 | 0.0047 | 852 | 37 | 1833 | 72 | 27.24167 |
| **X453_23** | 104 | 94 | 0.903846 | 5.479452 | 0.249203 | 0.0752 | 0.0049 | 1079 | 45 | 1070 | 130 | 1.099908 |
| **X453_24** | 276 | 210 | 0.76087 | 24.39024 | 1.011303 | 0.0579 | 0.0049 | 259 | 10 | 450 | 180 | 7.829181 |
| **X453_25** | 53 | 93 | 1.754717 | 5.213764 | 0.214748 | 0.0778 | 0.0053 | 1130 | 43 | 1100 | 140 | 1.653612 |
| **X453_26** | 310 | 119 | 0.383871 | 3.875969 | 0.180278 | 0.0956 | 0.0055 | 1479 | 58 | 1534 | 97 | 1.727575 |
| **X453_27** | 333 | 145 | 0.435435 | 4.1841 | 0.227587 | 0.1001 | 0.005 | 1377 | 69 | 1628 | 96 | 5.813953 |
| **X453_28** | 81 | 128 | 1.580247 | 4.863813 | 0.191619 | 0.0782 | 0.0046 | 1205 | 43 | 1190 | 110 | -1.34567 |
| **X453_29** | 177 | 144 | 0.813559 | 14.9925 | 0.606893 | 0.0639 | 0.0046 | 416 | 17 | 720 | 170 | 11.48936 |
| **X453_30** | 104 | 82 | 0.788462 | 58.47953 | 3.761841 | 0.05 | 0.012 | 109.3 | 7.1 | 150 | 410 | 3.274336 |
| **X453_31** | 202 | 376 | 1.861386 | 34.48276 | 1.664685 | 0.051 | 0.0059 | 184.1 | 8.5 | 210 | 220 | -1.15385 |
| **X453_32** | 491 | 733 | 1.492872 | 6.161429 | 0.246761 | 0.1 | 0.0037 | 969 | 36 | 1621 | 68 | 19.31724 |
| **X453_33** | 426 | 1448 | 3.399061 | 7.352941 | 0.356834 | 0.086 | 0.0031 | 821 | 37 | 1326 | 71 | 15.62179 |
| **X453_34** | 117 | 173 | 1.478632 | 5.063291 | 0.240987 | 0.0811 | 0.0042 | 1161 | 51 | 1200 | 110 | 0.769231 |
| **X453_35** | 419 | 745 | 1.778043 | 5.279831 | 0.267616 | 0.0794 | 0.003 | 1117 | 52 | 1169 | 75 | 0.534283 |
| **X453_36** | 340 | 117 | 0.344118 | 6.027728 | 0.228901 | 0.0718 | 0.0033 | 989 | 35 | 977 | 95 | -1.22825 |
| **X453_37** | 99 | 97 | 0.979798 | 62.22775 | 3.639956 | 0.108 | 0.021 | 102.8 | 6 | 1550 | 390 | 49.10891 |
| **X453_38** | 90 | 180 | 2 | 5.045409 | 0.216377 | 0.0768 | 0.0045 | 1165 | 46 | 1130 | 120 | -0.77855 |
| **X453_39** | 78 | 175 | 2.24359 | 5.083884 | 0.224859 | 0.0861 | 0.0055 | 1156 | 45 | 1310 | 130 | 4.383788 |
| **X453_40** | 183 | 127 | 0.693989 | 14.40922 | 0.602115 | 0.064 | 0.0047 | 432 | 18 | 750 | 170 | 12.55061 |
| **X453_41** | 120 | 160 | 1.333333 | 3.690037 | 0.14978 | 0.096 | 0.0042 | 1551 | 57 | 1555 | 82 | 0.385356 |
| **X453_42** | 30 | 54 | 1.8 | 5.128205 | 0.315582 | 0.0846 | 0.0087 | 1146 | 62 | 1300 | 200 | 3.778338 |
| **X453_43** | 199 | 217 | 1.090452 | 3.891051 | 0.166543 | 0.0982 | 0.0035 | 1471 | 55 | 1598 | 67 | 3.604194 |
| **X453_44** | 94 | 81 | 0.861702 | 3.676471 | 0.148681 | 0.0962 | 0.0047 | 1552 | 56 | 1540 | 90 | 0.32113 |
| **X453_45** | 147 | 319 | 2.170068 | 5.29661 | 0.201989 | 0.0782 | 0.0038 | 1114 | 39 | 1153 | 89 | 1.676964 |
| **X453_46** | 98 | 114 | 1.163265 | 5.506608 | 0.215291 | 0.0784 | 0.0041 | 1075 | 39 | 1160 | 110 | 1.916058 |
| **X453_47** | 37 | 88 | 2.378378 | 5.167959 | 0.245712 | 0.0804 | 0.0063 | 1139 | 50 | 1180 | 160 | 3.228547 |
| **X453_48** | 141 | 212 | 1.503546 | 5.324814 | 0.206982 | 0.079 | 0.0041 | 1109 | 40 | 1210 | 100 | 2.974628 |
| **X453_49** | 29 | 65 | 2.241379 | 5.076142 | 0.283439 | 0.0725 | 0.0074 | 1157 | 58 | 1030 | 210 | -2.48007 |
| **X453_50** | 124 | 133 | 1.072581 | 5.359057 | 0.246988 | 0.0828 | 0.0041 | 1102 | 47 | 1270 | 100 | 5.32646 |
| **X453_51** | 168 | 63 | 0.375 | 4.363002 | 0.169419 | 0.0899 | 0.0035 | 1329 | 47 | 1420 | 73 | 3.555878 |
| **X453_52** | 361 | 167 | 0.462604 | 5.34188 | 0.188336 | 0.0751 | 0.0027 | 1106 | 36 | 1060 | 73 | -1.00457 |
| **X453_53** | 107 | 213 | 1.990654 | 5.333333 | 0.238933 | 0.0778 | 0.0047 | 1107 | 45 | 1190 | 120 | 3.318777 |
| **X453_54** | 55 | 99 | 1.8 | 5.157298 | 0.220761 | 0.0764 | 0.0048 | 1141 | 45 | 1120 | 120 | -0.3518 |
| **X453_55** | 29 | 54 | 1.862069 | 4.310345 | 0.278686 | 0.118 | 0.019 | 1343 | 77 | 1720 | 300 | 12.22222 |
| **X453_56** | 151 | 141 | 0.933775 | 5.249344 | 0.1984 | 0.0793 | 0.0033 | 1123 | 42 | 1185 | 77 | 3.022453 |
| **X453_57** | 169 | 252 | 1.491124 | 4.887586 | 0.183941 | 0.0817 | 0.0038 | 1199 | 41 | 1228 | 88 | 2.042484 |
| **X453_58** | 248 | 96 | 0.387097 | 4.385965 | 0.23084 | 0.0912 | 0.0041 | 1324 | 61 | 1427 | 90 | 4.196816 |
| **X453_59** | 158 | 444 | 2.810127 | 3.472222 | 0.13262 | 0.0953 | 0.0034 | 1630 | 57 | 1532 | 63 | -1.17939 |
| **X453_61** | 313 | 267 | 0.853035 | 5.260389 | 0.204771 | 0.0748 | 0.0028 | 1121 | 40 | 1050 | 77 | 0.266904 |
| **X453_62** | 132 | 234 | 1.772727 | 5.037783 | 0.19542 | 0.0784 | 0.0038 | 1167 | 41 | 1142 | 96 | 0.596252 |
| **X453_63** | 65 | 109 | 1.676923 | 5.29661 | 0.2076 | 0.0926 | 0.0058 | 1114 | 40 | 1450 | 120 | 11.23506 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **X453_64** | 274 | 250 | 0.912409 | 3.636364 | 0.158678 | 0.1024 | 0.0052 | 1566 | 59 | 1658 | 87 | 3.690037 |
| **X453_65** | 370 | 158 | 0.427027 | 31.34796 | 1.277503 | 0.0472 | 0.0045 | 202.4 | 8.1 | 50 | 170 | -8.8172 |
| **X453_66** | 705 | 1942 | 2.75461 | 6.830601 | 0.303271 | 0.164 | 0.01 | 880 | 37 | 2480 | 110 | 40.58069 |
| **X453_67** | 535 | 294 | 0.549533 | 30.76923 | 1.136095 | 0.0565 | 0.0038 | 206.2 | 7.6 | 450 | 150 | 8.761062 |
| **X453_68** | 385 | 828 | 2.150649 | 7.55287 | 0.54764 | 0.107 | 0.0047 | 799 | 54 | 1754 | 80 | 27.165 |
| **X453_69** | 168 | 190 | 1.130952 | 4.132231 | 0.170753 | 0.0996 | 0.0044 | 1395 | 54 | 1619 | 83 | 6.875834 |
| **X453_70** | 143 | 53 | 0.370629 | 60.82725 | 3.070962 | 0.05 | 0.0087 | 105.1 | 5.3 | 150 | 310 | 3.577982 |
| **X453_71** | 58 | 46 | 0.793103 | 3.649635 | 0.173158 | 0.0928 | 0.0052 | 1557 | 66 | 1490 | 110 | -1.96464 |
| **X453_72** | 166 | 170 | 1.024096 | 4.662005 | 0.189088 | 0.1067 | 0.004 | 1252 | 46 | 1758 | 67 | 12.99514 |
| **X453_73** | 190 | 404 | 2.126316 | 5.359057 | 0.229756 | 0.0853 | 0.0034 | 1102 | 44 | 1320 | 81 | 8.090075 |
| **X453_75** | 357 | 329 | 0.921569 | 63.49206 | 2.902494 | 0.0453 | 0.0069 | 100.7 | 4.6 | 80 | 260 | -1.71717 |
| **X453_76** | 332 | 238 | 0.716867 | 60.64281 | 2.831714 | 0.0473 | 0.006 | 105.4 | 4.9 | 50 | 220 | -3.33333 |
| **X453_77** | 449 | 234 | 0.521158 | 4.347826 | 0.226843 | 0.1015 | 0.0035 | 1332 | 60 | 1643 | 64 | 8.954204 |
| **X453_78** | 197 | 254 | 1.28934 | 3.624502 | 0.130056 | 0.1006 | 0.0034 | 1575 | 52 | 1634 | 65 | 1.623985 |
| **X453_79** | 170 | 157 | 0.923529 | 3.246753 | 0.126497 | 0.1009 | 0.0042 | 1728 | 61 | 1624 | 78 | -1.88679 |
| **X453_80** | 259 | 195 | 0.752896 | 59.73716 | 2.854822 | 0.0448 | 0.0069 | 107 | 5.1 | -10 | 260 | -8.08081 |
| **X453_82** | 113 | 83 | 0.734513 | 3.968254 | 0.188965 | 0.0989 | 0.0044 | 1447 | 61 | 1610 | 84 | 4.927727 |
| **X453_83** | 371 | 215 | 0.579515 | 18.62197 | 0.658878 | 0.0549 | 0.0034 | 337 | 12 | 390 | 130 | 0.589971 |
| **X453_84** | 640 | 688 | 1.075 | 61.16208 | 2.581152 | 0.0481 | 0.0045 | 104.5 | 4.4 | 130 | 180 | -2.45098 |
| **X453_85** | 396 | 282 | 0.712121 | 57.57052 | 2.518918 | 0.0442 | 0.006 | 111 | 4.8 | 10 | 240 | -4.71698 |
| **X453_86** | 164 | 143 | 0.871951 | 4.854369 | 0.179093 | 0.0778 | 0.0034 | 1207 | 41 | 1148 | 85 | -1.94257 |
| **X453_87** | 1003 | 1257 | 1.25324 | 61.23699 | 2.212481 | 0.0493 | 0.0035 | 104.4 | 3.7 | 170 | 140 | 1.229896 |
| **X453_88** | 328 | 322 | 0.981707 | 4.746084 | 0.19597 | 0.078 | 0.0038 | 1232 | 46 | 1130 | 97 | -1.39918 |
| **X453_89** | 323 | 405 | 1.25387 | 5.07872 | 0.188292 | 0.0793 | 0.0032 | 1162 | 41 | 1176 | 78 | 0.171821 |
| **X453_90** | 91 | 87 | 0.956044 | 3.676471 | 0.148681 | 0.0985 | 0.0039 | 1550 | 57 | 1581 | 75 | 2.022756 |
| **X453_91** | 113 | 223 | 1.973451 | 5.11509 | 0.188382 | 0.0749 | 0.0043 | 1154 | 39 | 1090 | 110 | -2.57778 |
| **X453_92** | 85 | 170 | 2 | 1.162791 | 0.189292 | 0.681 | 0.043 | 3790 | 480 | 4640 | 140 | 12.06497 |
| **X453_93** | 140 | 321 | 2.292857 | 5.414185 | 0.199331 | 0.0807 | 0.0047 | 1096 | 37 | 1240 | 120 | 4.861111 |
| **X453_94** | 135 | 293 | 2.17037 | 5.649718 | 0.252163 | 0.0752 | 0.0039 | 1054 | 43 | 1079 | 94 | -0.66858 |
| **X453_95** | 337 | 458 | 1.35905 | 3.703704 | 0.150892 | 0.0973 | 0.0032 | 1539 | 56 | 1579 | 62 | 1.092545 |
| **X453_96** | 122 | 859 | 7.040984 | 5.154639 | 0.249761 | 0.0801 | 0.0042 | 1142 | 51 | 1200 | 110 | 1.296456 |
| **X453_97** | 93 | 100 | 1.075269 | 3.663004 | 0.147594 | 0.0998 | 0.0044 | 1561 | 58 | 1628 | 75 | 0.699746 |

Table 4: GSWA sample #199454

| Spot ID | $^{238}$U (ppm) | $^{232}$Th (ppm) | $^{232}$Th/$^{238}$U | $^{238}$U/$^{206}$Pb | ± 2σ | $^{207}$Pb/$^{206}$Pb | ± 2σ | $^{206}$PB/$^{238}$U date (Ma) | ± 2σ | $^{206}$Pb/$^{207}$Pb date (Ma) | ± 2σ | Disc. (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **X454_1** | 35 | 53 | 1.514286 | 5.050505 | 0.280584 | 0.079 | 0.0081 | 1161 | 57 | 1080 | 220 | -1.66375 |
| **X454_2** | 43 | 66 | 1.534884 | 5.494505 | 0.268687 | 0.079 | 0.0059 | 1077 | 48 | 1150 | 150 | -0.56022 |
| **X454_3** | 42 | 69 | 1.642857 | 5.050505 | 0.255076 | 0.0741 | 0.0059 | 1163 | 54 | 1050 | 170 | -3.46975 |
| **X454_4** | 32 | 43 | 1.34375 | 4.975124 | 0.247519 | 0.08 | 0.0068 | 1181 | 55 | 1170 | 180 | 1.665279 |
| **X454_5** | 30 | 43 | 1.433333 | 5 | 0.325 | 0.0655 | 0.0066 | 1174 | 70 | 840 | 220 | -12.9933 |
| **X454_6** | 74 | 116 | 1.567568 | 3.937008 | 0.310001 | 0.21 | 0.04 | 1450 | 100 | 2430 | 350 | 27.5 |
| **X454_7** | 518 | 806 | 1.555985 | 7.092199 | 0.502993 | 0.1173 | 0.0054 | 857 | 58 | 1907 | 83 | 28.93864 |
| **X454_8** | 45 | 59 | 1.311111 | 4.89716 | 0.227831 | 0.0764 | 0.0071 | 1196 | 51 | 1080 | 190 | -0.84317 |
| **X454_9** | 85 | 156 | 1.835294 | 3.597122 | 0.155272 | 0.0973 | 0.0044 | 1586 | 60 | 1564 | 91 | -0.25284 |
| **X454_10** | 53 | 82 | 1.54717 | 5.165289 | 0.250794 | 0.0837 | 0.0053 | 1140 | 51 | 1270 | 130 | 5.472637 |
| **X454_11** | 45 | 63 | 1.4 | 5 | 0.275 | 0.0807 | 0.0062 | 1180 | 55 | 1210 | 150 | 1.420217 |
| **X454_12** | 27 | 47 | 1.740741 | 5.076142 | 0.283439 | 0.078 | 0.0087 | 1155 | 58 | 1120 | 230 | -1.04987 |
| **X454_13** | 58 | 97 | 1.672414 | 5.252101 | 0.228952 | 0.0825 | 0.0065 | 1123 | 45 | 1190 | 150 | 2.432667 |
| **X454_14** | 36 | 57 | 1.583333 | 5.159959 | 0.247614 | 0.0737 | 0.0067 | 1140 | 54 | 1040 | 180 | -1.42349 |
| **X454_15** | 41 | 59 | 1.439024 | 4.716981 | 0.222499 | 0.0744 | 0.0066 | 1240 | 53 | 1010 | 170 | -5.26316 |
| **X454_16** | 251 | 262 | 1.043825 | 4.761905 | 0.226757 | 0.1022 | 0.0041 | 1225 | 54 | 1659 | 73 | 12.5 |
| **X454_17** | 226 | 356 | 1.575221 | 4.025765 | 0.157206 | 0.1046 | 0.0041 | 1429 | 50 | 1722 | 72 | 7.268008 |
| **X454_18** | 79 | 101 | 1.278481 | 5.065856 | 0.251496 | 0.113 | 0.017 | 1160 | 53 | 1680 | 240 | 15.32847 |
| **X454_19** | 70 | 79 | 1.128571 | 3.333333 | 0.155556 | 0.1 | 0.0038 | 1689 | 68 | 1611 | 72 | -1.13772 |
| **X454_20** | 36 | 64 | 1.777778 | 5.405405 | 0.292184 | 0.0805 | 0.0068 | 1092 | 57 | 1230 | 150 | 4.042179 |
| **X454_21** | 200 | 225 | 1.125 | 3.921569 | 0.169166 | 0.0978 | 0.0044 | 1464 | 59 | 1596 | 82 | 3.810775 |
| **X454_22** | 205 | 121 | 0.590244 | 4.032258 | 0.17885 | 0.0919 | 0.0034 | 1426 | 56 | 1463 | 73 | 1.655172 |
| **X454_23** | 94 | 123 | 1.308511 | 4.819277 | 0.183481 | 0.0764 | 0.0045 | 1215 | 42 | 1090 | 120 | -3.66894 |
| **X454_24** | 70 | 89 | 1.271429 | 5.09165 | 0.207399 | 0.0795 | 0.0049 | 1155 | 43 | 1190 | 120 | 0.858369 |
| **X454_25** | 86 | 85 | 0.988372 | 4.291845 | 0.221039 | 0.164 | 0.018 | 1347 | 63 | 2360 | 220 | 24.83259 |
| **X454_26** | 389 | 290 | 0.745501 | 7.374631 | 0.309996 | 0.1258 | 0.005 | 819 | 32 | 2066 | 66 | 33.84491 |
| **X454_27** | 112 | 156 | 1.392857 | 3.895598 | 0.148722 | 0.091 | 0.0043 | 1477 | 54 | 1435 | 92 | -0.33967 |
| **X454_28** | 101 | 138 | 1.366337 | 5.221932 | 0.223602 | 0.0746 | 0.004 | 1129 | 44 | 1040 | 110 | -2.54314 |
| **X454_29** | 57 | 78 | 1.368421 | 4.90918 | 0.20485 | 0.0806 | 0.0057 | 1199 | 46 | 1210 | 140 | -1.09612 |
| **X454_30** | 75 | 132 | 1.76 | 5.076142 | 0.198408 | 0.0872 | 0.0051 | 1159 | 42 | 1360 | 110 | 6.45682 |
| **X454_31** | 42 | 89 | 2.119048 | 5.235602 | 0.301527 | 0.0772 | 0.0068 | 1124 | 58 | 1060 | 180 | -1.62749 |
| **X454_32** | 41 | 58 | 1.414634 | 4.854369 | 0.259214 | 0.0775 | 0.0084 | 1204 | 59 | 1090 | 220 | -5.61404 |
| **X454_33** | 121 | 168 | 1.38843 | 5.109862 | 0.227163 | 0.0792 | 0.0043 | 1151 | 47 | 1180 | 110 | 0.432526 |
| **X454_34** | 76 | 92 | 1.210526 | 5.324814 | 0.221158 | 0.08 | 0.0048 | 1109 | 42 | 1160 | 130 | 3.565217 |
| **X454_35** | 60 | 88 | 1.466667 | 5.221932 | 0.269959 | 0.0797 | 0.0062 | 1134 | 54 | 1150 | 150 | 0.176056 |
| **X454_36** | 47 | 37 | 0.787234 | 4.504505 | 0.304358 | 0.1 | 0.0057 | 1288 | 79 | 1620 | 110 | 8.262108 |
| **X454_37** | 178 | 151 | 0.848315 | 3.597122 | 0.142332 | 0.0975 | 0.0037 | 1581 | 54 | 1593 | 67 | 1.372427 |
| **X454_38** | 175 | 176 | 1.005714 | 3.508772 | 0.135426 | 0.1023 | 0.0041 | 1616 | 57 | 1683 | 71 | 1.703163 |
| **X454_39** | 257 | 394 | 1.533074 | 4.273504 | 0.182628 | 0.1055 | 0.0037 | 1355 | 54 | 1712 | 66 | 10.67897 |
| **X454_40** | 50 | 75 | 1.5 | 4.166667 | 0.190972 | 0.1054 | 0.0088 | 1383 | 56 | 1700 | 160 | 10.60116 |
| **X454_41** | 251 | 190 | 0.756972 | 5.28262 | 0.195343 | 0.0765 | 0.003 | 1117 | 38 | 1093 | 78 | 0.089445 |
| **X454_42** | 34 | 67 | 1.970588 | 4.901961 | 0.264321 | 0.11 | 0.013 | 1196 | 58 | 1660 | 200 | 13.83285 |
| **X454_43** | 169 | 160 | 0.946746 | 3.401361 | 0.127262 | 0.1007 | 0.0037 | 1662 | 54 | 1626 | 69 | -0.72727 |
| **X454_44** | 133 | 189 | 1.421053 | 3.773585 | 0.156639 | 0.0957 | 0.0044 | 1522 | 58 | 1560 | 78 | 0.911458 |
| **X454_45** | 51 | 67 | 1.313725 | 5.271481 | 0.233424 | 0.0741 | 0.0052 | 1119 | 45 | 1050 | 150 | -1.81984 |
| **X454_46** | 39 | 79 | 2.025641 | 5.076142 | 0.231905 | 0.0877 | 0.0087 | 1165 | 51 | 1260 | 200 | 5.284553 |
| **X454_47** | 48 | 98 | 2.041667 | 5.102041 | 0.286339 | 0.0777 | 0.0056 | 1152 | 57 | 1110 | 150 | 2.620456 |
| **X454_48** | 34 | 137 | 4.029412 | 4.950495 | 0.269581 | 0.0863 | 0.0073 | 1182 | 56 | 1350 | 160 | 4.058442 |
| **X454_49** | 144 | 241 | 1.673611 | 3.257329 | 0.137933 | 0.1018 | 0.0034 | 1725 | 65 | 1648 | 63 | -1.95035 |
| **X454_50** | 292 | 116 | 0.39726 | 4.115226 | 0.237091 | 0.0932 | 0.003 | 1399 | 75 | 1493 | 62 | 2.576602 |
| **X454_51** | 1143 | 102 | 0.089239 | 6.978367 | 0.287316 | 0.0978 | 0.0028 | 863 | 33 | 1583 | 56 | 20.9707 |
| **X454_52** | 50 | 108 | 2.16 | 5.208333 | 0.298394 | 0.0915 | 0.0084 | 1128 | 60 | 1370 | 180 | 6.234414 |
| **X454_53** | 233 | 369 | 1.583691 | 4.694836 | 0.242456 | 0.136 | 0.014 | 1250 | 62 | 2180 | 180 | 23.78049 |
| **X454_54** | 53 | 55 | 1.037736 | 4.945598 | 0.239698 | 0.0719 | 0.0057 | 1185 | 53 | 950 | 170 | -8.61595 |
| **X454_55** | 94 | 63 | 0.670213 | 3.424658 | 0.152468 | 0.0919 | 0.0042 | 1651 | 63 | 1481 | 89 | -3.51097 |
| **X454_56** | 198 | 172 | 0.868687 | 3.460208 | 0.143676 | 0.0942 | 0.0037 | 1637 | 60 | 1525 | 77 | -3.67321 |
| **X454_57** | 74 | 30 | 0.405405 | 5.310674 | 0.248189 | 0.0823 | 0.0052 | 1111 | 48 | 1200 | 130 | 5.527211 |
| **X454_58** | 39 | 53 | 1.358974 | 5.200208 | 0.254196 | 0.0743 | 0.007 | 1132 | 51 | 1090 | 200 | -2.25836 |
| **X454_59** | 48 | 95 | 1.979167 | 4.965243 | 0.244071 | 0.079 | 0.0063 | 1181 | 55 | 1170 | 160 | -0.94017 |
| **X454_60** | 28 | 32 | 1.142857 | 4.975124 | 0.297022 | 0.0821 | 0.0077 | 1178 | 63 | 1140 | 190 | 1.669449 |
| **X454_61** | 163 | 172 | 1.055215 | 5.058169 | 0.197005 | 0.0809 | 0.0039 | 1162 | 42 | 1204 | 92 | 0.257511 |
| **X454_62** | 38 | 72 | 1.894737 | 5.022602 | 0.242175 | 0.0868 | 0.0075 | 1169 | 51 | 1280 | 180 | 4.80456 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **X454_63** | 297 | 323 | 1.087542 | 4.237288 | 0.179546 | 0.1081 | 0.0036 | 1367 | 51 | 1778 | 59 | 11.23377 |
| **X454_64** | 59 | 96 | 1.627119 | 4.997501 | 0.227273 | 0.0815 | 0.0065 | 1175 | 49 | 1180 | 160 | -0.77187 |
| **X454_65** | 137 | 145 | 1.058394 | 3.401361 | 0.1504 | 0.0986 | 0.0035 | 1657 | 65 | 1610 | 67 | -0.36342 |
| **X454_66** | 137 | 218 | 1.591241 | 4.694836 | 0.187353 | 0.1022 | 0.0066 | 1244 | 45 | 1660 | 110 | 11.58493 |
| **X454_67** | 205 | 229 | 1.117073 | 3.623188 | 0.144402 | 0.0996 | 0.004 | 1571 | 55 | 1601 | 76 | 0.632511 |
| **X454_68** | 419 | 1403 | 3.348449 | 13.15789 | 0.640582 | 0.1014 | 0.0044 | 472 | 22 | 1656 | 83 | 35.43092 |
| **X454_69** | 243 | 271 | 1.115226 | 5.094244 | 0.207611 | 0.1508 | 0.0071 | 1154 | 43 | 2344 | 83 | 30.10297 |
| **X454_70** | 153 | 141 | 0.921569 | 3.367003 | 0.147377 | 0.0956 | 0.0042 | 1676 | 66 | 1519 | 85 | -4.16408 |
| **X454_71** | 154 | 139 | 0.902597 | 3.424658 | 0.129011 | 0.0956 | 0.0037 | 1651 | 53 | 1536 | 71 | -1.97653 |
| **X454_72** | 39 | 80 | 2.051282 | 5.047956 | 0.244626 | 0.0806 | 0.0074 | 1164 | 52 | 1210 | 180 | 1.439458 |
| **X454_73** | 239 | 189 | 0.790795 | 3.472222 | 0.120563 | 0.0943 | 0.0031 | 1631 | 52 | 1521 | 63 | -2.44975 |
| **X454_74** | 86 | 72 | 0.837209 | 3.484321 | 0.157826 | 0.1046 | 0.0063 | 1625 | 68 | 1680 | 110 | 1.455428 |
| **X454_75** | 34 | 61 | 1.794118 | 4.926108 | 0.266932 | 0.0849 | 0.0071 | 1188 | 57 | 1260 | 190 | 4.807692 |
| **X454_76** | 72 | 112 | 1.555556 | 5.359057 | 0.241244 | 0.0777 | 0.0053 | 1102 | 46 | 1140 | 140 | 2.044444 |
| **X454_77** | 77 | 205 | 2.662338 | 5.083884 | 0.214521 | 0.083 | 0.005 | 1156 | 45 | 1250 | 120 | 1.027397 |
| **X454_78** | 107 | 115 | 1.074766 | 5.005005 | 0.217936 | 0.0806 | 0.0042 | 1174 | 47 | 1210 | 110 | 2.41064 |
| **X454_79** | 42 | 68 | 1.619048 | 4.807692 | 0.277367 | 0.144 | 0.023 | 1217 | 63 | 2080 | 270 | 24.87654 |
| **X454_80** | 240 | 447 | 1.8625 | 3.571429 | 0.127551 | 0.0994 | 0.0034 | 1588 | 52 | 1604 | 65 | 0.68793 |
| **X454_81** | 46 | 75 | 1.630435 | 3.787879 | 0.416093 | 0.201 | 0.049 | 1470 | 130 | 2190 | 430 | 24.61538 |
| **X454_82** | 150 | 155 | 1.033333 | 3.289474 | 0.140668 | 0.0971 | 0.0037 | 1710 | 62 | 1567 | 74 | -3.01205 |
| **X454_83** | 292 | 420 | 1.438356 | 4.201681 | 0.176541 | 0.1079 | 0.0037 | 1377 | 52 | 1763 | 62 | 10.35156 |
| **X454_84** | 95 | 158 | 1.663158 | 4.962779 | 0.206885 | 0.0732 | 0.0046 | 1182 | 45 | 1060 | 130 | -3.95778 |
| **X454_85** | 34 | 55 | 1.617647 | 3.773585 | 0.284799 | 0.178 | 0.024 | 1510 | 100 | 2610 | 220 | 25.61576 |
| **X454_86** | 181 | 177 | 0.977901 | 3.623188 | 0.144402 | 0.1034 | 0.004 | 1569 | 57 | 1683 | 72 | 3.088326 |
| **X454_87** | 94 | 130 | 1.382979 | 5.015045 | 0.201205 | 0.077 | 0.0039 | 1171 | 43 | 1090 | 100 | -1.12263 |
| **X454_88** | 192 | 82 | 0.427083 | 4.547522 | 0.198528 | 0.0939 | 0.0034 | 1280 | 50 | 1494 | 69 | 6.569343 |
| **X454_89** | 322 | 245 | 0.76087 | 3.921569 | 0.184544 | 0.0979 | 0.0031 | 1461 | 59 | 1576 | 61 | 2.794411 |
| **X454_90** | 409 | 525 | 1.283619 | 5.263158 | 0.443213 | 0.1269 | 0.0061 | 1129 | 87 | 2036 | 82 | 24.27901 |
| **X454_91** | 195 | 120 | 0.615385 | 4.708098 | 0.179546 | 0.0908 | 0.0036 | 1241 | 43 | 1439 | 78 | 5.483625 |
| **X454_92** | 116 | 113 | 0.974138 | 3.690037 | 0.14978 | 0.0993 | 0.0043 | 1547 | 56 | 1644 | 86 | 4.151177 |
| **X454_93** | 437 | 53 | 0.121281 | 3.93391 | 0.145471 | 0.0963 | 0.0031 | 1460 | 48 | 1561 | 61 | 3.054449 |
| **X454_94** | 28 | 40 | 1.428571 | 5.184033 | 0.255305 | 0.0765 | 0.0073 | 1135 | 52 | 1110 | 200 | 0.438596 |
| **X454_95** | 44 | 75 | 1.704545 | 5.14668 | 0.254288 | 0.0718 | 0.0056 | 1143 | 52 | 970 | 150 | -5.05515 |
| **X454_96** | 165 | 163 | 0.987879 | 4.514673 | 0.165096 | 0.0752 | 0.0031 | 1289 | 43 | 1092 | 85 | -4.96743 |
| **X454_97** | 48 | 54 | 1.125 | 5.128205 | 0.289283 | 0.0776 | 0.0051 | 1151 | 56 | 1120 | 130 | -2.58467 |
| **X454_98** | 60 | 102 | 1.7 | 4.975124 | 0.237618 | 0.0783 | 0.0053 | 1186 | 51 | 1160 | 150 | 0.336134 |
| **X454_99** | 162 | 93 | 0.574074 | 3.780718 | 0.14008 | 0.0911 | 0.0034 | 1512 | 50 | 1446 | 69 | -1.13712 |
| **X454_100** | 100 | 126 | 1.26 | 4.770992 | 0.188928 | 0.0788 | 0.0044 | 1226 | 44 | 1130 | 110 | -1.57415 |
| **X454_101** | 41 | 53 | 1.292683 | 5.128205 | 0.315582 | 0.0733 | 0.0052 | 1144 | 64 | 1020 | 180 | -4.47489 |
| **X454_102** | 45 | 61 | 1.355556 | 5.154639 | 0.265703 | 0.0734 | 0.0057 | 1140 | 55 | 1050 | 150 | -3.26087 |
| **X454_103** | 49 | 63 | 1.285714 | 4.955401 | 0.230826 | 0.0793 | 0.0061 | 1184 | 50 | 1150 | 160 | -0.33898 |
| **X454_104** | 31 | 52 | 1.677419 | 5.076142 | 0.309207 | 0.0862 | 0.0083 | 1156 | 65 | 1280 | 180 | 8.399366 |
| **X454_105** | 79 | 132 | 1.670886 | 5.265929 | 0.22184 | 0.0772 | 0.0054 | 1120 | 43 | 1060 | 150 | 0.972591 |
| **X454_106** | 60 | 123 | 2.05 | 4.92126 | 0.208282 | 0.0767 | 0.0052 | 1192 | 46 | 1110 | 150 | -3.74238 |
| **X454_107** | 33 | 55 | 1.666667 | 5.050505 | 0.306091 | 0.0805 | 0.0072 | 1163 | 65 | 1170 | 180 | 2.104377 |
| **X454_108** | 98 | 127 | 1.295918 | 5.09165 | 0.197029 | 0.0741 | 0.0039 | 1155 | 42 | 1030 | 100 | -4.43038 |
| **X454_109** | 369 | 331 | 0.897019 | 6.17284 | 0.281969 | 0.1139 | 0.0044 | 967 | 41 | 1860 | 74 | 25.27048 |
| **X454_110** | 82 | 106 | 1.292683 | 5.157298 | 0.204802 | 0.0781 | 0.0055 | 1142 | 41 | 1160 | 160 | -0.08764 |
| **X454_111** | 41 | 58 | 1.414634 | 3.968254 | 0.283447 | 0.179 | 0.029 | 1445 | 91 | 2350 | 300 | 24.73958 |
| **X454_112** | 49 | 87 | 1.77551 | 5.200208 | 0.259605 | 0.079 | 0.0059 | 1132 | 52 | 1170 | 140 | 1.821336 |
| **X454_113** | 135 | 113 | 0.837037 | 3.448276 | 0.142687 | 0.094 | 0.0034 | 1638 | 61 | 1518 | 68 | -3.60531 |
| **X454_114** | 66 | 82 | 1.242424 | 5.065856 | 0.241231 | 0.0853 | 0.006 | 1160 | 50 | 1300 | 150 | 4.290429 |
| **X454_115** | 483 | 328 | 0.679089 | 6.090134 | 0.344935 | 0.0862 | 0.0031 | 986 | 51 | 1340 | 70 | 10.93044 |
| **X454_117** | 39 | 87 | 2.230769 | 5.050505 | 0.255076 | 0.0769 | 0.006 | 1165 | 54 | 1160 | 170 | 1.019541 |
| **X454_118** | 171 | 359 | 2.099415 | 4.62963 | 0.180041 | 0.0762 | 0.0033 | 1260 | 45 | 1080 | 89 | -3.61842 |
| **X454_119** | 57 | 77 | 1.350877 | 5.162623 | 0.245205 | 0.0805 | 0.0056 | 1147 | 48 | 1240 | 130 | 0.864304 |
| **X454_120** | 286 | 236 | 0.825175 | 3.623188 | 0.131275 | 0.0977 | 0.0037 | 1576 | 52 | 1569 | 70 | -0.25445 |
| **X454_121** | 122 | 182 | 1.491803 | 4.962779 | 0.211811 | 0.0832 | 0.0035 | 1183 | 49 | 1255 | 85 | 2.633745 |
| **X454_122** | 151 | 187 | 1.238411 | 3.355705 | 0.135129 | 0.0965 | 0.0038 | 1679 | 59 | 1553 | 77 | -4.09175 |
| **X454_123** | 111 | 164 | 1.477477 | 4.655493 | 0.205899 | 0.0755 | 0.0034 | 1253 | 51 | 1072 | 97 | -4.59098 |
| **X454_124** | 55 | 86 | 1.563636 | 4.854369 | 0.235649 | 0.0751 | 0.0051 | 1207 | 54 | 1030 | 130 | -4.95652 |
| **X454_125** | 58 | 80 | 1.37931 | 4.878049 | 0.30934 | 0.082 | 0.013 | 1201 | 71 | 1190 | 270 | -4.98252 |
| **X454_126** | 244 | 295 | 1.209016 | 3.636364 | 0.145455 | 0.0923 | 0.0036 | 1563 | 57 | 1469 | 73 | -2.35756 |
| **X454_127** | 123 | 138 | 1.121951 | 4.807692 | 0.231139 | 0.0821 | 0.0066 | 1216 | 53 | 1220 | 150 | -0.66225 |
| **X454_128** | 82 | 97 | 1.182927 | 4.878049 | 0.214158 | 0.0737 | 0.0051 | 1206 | 47 | 1030 | 150 | -6.5371 |
| **X454_129** | 49 | 87 | 1.77551 | 5.076142 | 0.224175 | 0.0787 | 0.0066 | 1158 | 47 | 1150 | 170 | 0.429923 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **X454_130** | 233 | 197 | 0.845494 | 3.460208 | 0.143676 | 0.1002 | 0.0035 | 1642 | 61 | 1639 | 63 | -0.30544 |
| **X454_132** | 54 | 66 | 1.222222 | 4.716981 | 0.266999 | 0.0869 | 0.007 | 1239 | 62 | 1360 | 150 | 1.666667 |
| **X454_133** | 53 | 76 | 1.433962 | 5.081301 | 0.222049 | 0.0837 | 0.0074 | 1157 | 46 | 1290 | 160 | 3.017603 |
| **X454_134** | 84 | 123 | 1.464286 | 5.144033 | 0.211689 | 0.0785 | 0.0042 | 1145 | 43 | 1170 | 110 | 0.865801 |
| **X454_135** | 45 | 46 | 1.022222 | 5.076142 | 0.283439 | 0.0795 | 0.0093 | 1159 | 60 | 1190 | 260 | 0.940171 |
| **X454_136** | 274 | 218 | 0.79562 | 6.123699 | 0.326247 | 0.126 | 0.0062 | 980 | 47 | 2059 | 85 | 27.02904 |
| **X454_137** | 53 | 66 | 1.245283 | 5.128205 | 0.262985 | 0.0819 | 0.0063 | 1147 | 56 | 1240 | 140 | 1.965812 |
| **X454_138** | 312 | 596 | 1.910256 | 5.293806 | 0.201776 | 0.0823 | 0.0032 | 1115 | 39 | 1249 | 73 | 4.944587 |
| **X454_139** | 149 | 303 | 2.033557 | 4.892368 | 0.234566 | 0.0841 | 0.0065 | 1198 | 53 | 1290 | 170 | 2.995951 |
| **X454_140** | 162 | 266 | 1.641975 | 6.557377 | 0.399893 | 0.0852 | 0.0062 | 913 | 52 | 1290 | 130 | 12.63158 |
| **X454_141** | 127 | 60 | 0.472441 | 3.968254 | 0.188965 | 0.0886 | 0.0049 | 1447 | 60 | 1350 | 120 | -2.91607 |
| **X454_142** | 150 | 140 | 0.933333 | 3.508772 | 0.135426 | 0.1022 | 0.0053 | 1615 | 56 | 1676 | 87 | 0.431566 |

Table 5: GSWA sample #199455

| Spot ID | $^{238}U$ (ppm) | $^{232}Th$ (ppm) | $^{232}Th/^{238}U$ | $^{238}U/^{206}Pb$ | ± 2σ | $^{207}Pb/^{206}Pb$ | ± 2σ | $^{206}PB/^{238}U$ date (Ma) | ± 2σ | $^{206}Pb/^{207}Pb$ date (Ma) | ± 2σ | Disc. (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| X455_1 | 116 | 166 | 1.431034 | 4.997501 | 0.192308 | 0.0768 | 0.0045 | 1175 | 41 | 1090 | 120 | -2.70979 |
| X455_2 | 140 | 140 | 1 | 3.472222 | 0.144676 | 0.1013 | 0.0035 | 1628 | 60 | 1647 | 65 | 0.912964 |
| X455_3 | 143 | 363 | 2.538462 | 4.952947 | 0.210973 | 0.0835 | 0.0036 | 1185 | 46 | 1272 | 87 | 2.308326 |
| X455_4 | 112 | 163 | 1.455357 | 4.081633 | 0.159933 | 0.0934 | 0.0044 | 1412 | 50 | 1473 | 89 | 2.080444 |
| X455_5 | 91 | 198 | 2.175824 | 5.070994 | 0.210863 | 0.0775 | 0.0045 | 1159 | 44 | 1110 | 110 | -0.95819 |
| X455_6 | 64 | 104 | 1.625 | 5.24109 | 0.211512 | 0.0746 | 0.0052 | 1125 | 42 | 1130 | 140 | -0.7162 |
| X455_7 | 99 | 86 | 0.868687 | 3.597122 | 0.142332 | 0.1012 | 0.0042 | 1582 | 54 | 1639 | 77 | 1.063164 |
| X455_8 | 113 | 41 | 0.362832 | 3.802281 | 0.137345 | 0.0969 | 0.0052 | 1505 | 49 | 1560 | 100 | 2.525907 |
| X455_9 | 97 | 112 | 1.154639 | 5.094244 | 0.205015 | 0.0768 | 0.004 | 1155 | 42 | 1150 | 110 | -0.43478 |
| X455_10 | 138 | 189 | 1.369565 | 3.571429 | 0.140306 | 0.0951 | 0.0038 | 1593 | 55 | 1527 | 74 | -2.31214 |
| X455_11 | 85 | 151 | 1.776471 | 3.584229 | 0.141314 | 0.1013 | 0.0045 | 1589 | 59 | 1628 | 83 | 1.852996 |
| X455_12 | 85 | 131 | 1.541176 | 4.644682 | 0.211416 | 0.0775 | 0.0042 | 1256 | 52 | 1100 | 100 | -4.14594 |
| X455_13 | 39 | 57 | 1.461538 | 5.025126 | 0.252519 | 0.0795 | 0.0073 | 1168 | 56 | 1190 | 190 | 0.764656 |
| X455_14 | 21 | 36 | 1.714286 | 4.132231 | 0.307356 | 0.186 | 0.025 | 1392 | 93 | 2700 | 260 | 28.97959 |
| X455_15 | 79 | 111 | 1.405063 | 4.856727 | 0.209931 | 0.0855 | 0.0063 | 1206 | 48 | 1260 | 150 | 1.791531 |
| X455_16 | 16 | 27 | 1.6875 | 6.756757 | 0.456538 | 0.061 | 0.011 | 885 | 57 | 510 | 320 | -9.39431 |
| X455_17 | 59 | 86 | 1.457627 | 4.524887 | 0.188366 | 0.0693 | 0.0049 | 1292 | 50 | 860 | 150 | -11.7647 |
| X455_18 | 116 | 285 | 2.456897 | 3.225806 | 0.135276 | 0.1005 | 0.0034 | 1737 | 62 | 1636 | 59 | -2.53837 |
| X455_19 | 106 | 174 | 1.641509 | 3.496503 | 0.134481 | 0.1002 | 0.0046 | 1630 | 62 | 1621 | 85 | -0.4313 |
| X455_20 | 345 | 446 | 1.292754 | 4.504505 | 0.202906 | 0.0941 | 0.003 | 1292 | 53 | 1510 | 59 | 6.512301 |
| X455_21 | 63 | 75 | 1.190476 | 4.62963 | 0.235768 | 0.1047 | 0.0084 | 1260 | 58 | 1650 | 150 | 10.44776 |
| X455_22 | 35 | 64 | 1.828571 | 5.037783 | 0.233489 | 0.0942 | 0.0086 | 1178 | 50 | 1540 | 180 | 8.040593 |
| X455_23 | 203 | 302 | 1.487685 | 3.355705 | 0.135129 | 0.099 | 0.0036 | 1680 | 57 | 1594 | 69 | -1.38805 |
| X455_24 | 49 | 91 | 1.857143 | 5.350455 | 0.280548 | 0.0784 | 0.0067 | 1103 | 53 | 1130 | 180 | 1.780944 |
| X455_25 | 50 | 74 | 1.48 | 4.995005 | 0.222056 | 0.0803 | 0.0068 | 1175 | 48 | 1190 | 160 | 1.426174 |
| X455_26 | 85 | 138 | 1.623529 | 5.112474 | 0.209099 | 0.0736 | 0.0047 | 1156 | 41 | 1040 | 120 | -4.99546 |
| X455_27 | 261 | 316 | 1.210728 | 4 | 0.192 | 0.149 | 0.013 | 1444 | 60 | 2300 | 150 | 21.73442 |
| X455_28 | 101 | 69 | 0.683168 | 3.584229 | 0.15416 | 0.093 | 0.0046 | 1582 | 61 | 1475 | 97 | -4.14747 |
| X455_29 | 89 | 105 | 1.179775 | 4.712535 | 0.197651 | 0.0859 | 0.0039 | 1240 | 49 | 1313 | 89 | 2.362205 |
| X455_30 | 26 | 35 | 1.346154 | 4.784689 | 0.251826 | 0.0754 | 0.0086 | 1222 | 57 | 1010 | 230 | -4.17732 |
| X455_31 | 43 | 59 | 1.372093 | 5.268704 | 0.23873 | 0.0756 | 0.0063 | 1119 | 47 | 1070 | 170 | -2.47253 |
| X455_32 | 225 | 390 | 1.733333 | 4.732608 | 0.18366 | 0.0782 | 0.0025 | 1235 | 43 | 1153 | 68 | -2.2351 |
| X455_33 | 31 | 52 | 1.677419 | 4.854369 | 0.282779 | 0.0822 | 0.0063 | 1205 | 62 | 1170 | 160 | 1.712887 |
| X455_34 | 68 | 111 | 1.632353 | 5.219207 | 0.226093 | 0.0793 | 0.0067 | 1129 | 45 | 1170 | 160 | 1.39738 |
| X455_35 | 91 | 124 | 1.362637 | 5.213764 | 0.236495 | 0.0776 | 0.0041 | 1130 | 47 | 1169 | 99 | 0.352734 |
| X455_36 | 42 | 63 | 1.5 | 5.260389 | 0.232442 | 0.0741 | 0.0058 | 1121 | 46 | 990 | 160 | -3.70028 |
| X455_37 | 30 | 49 | 1.633333 | 5.050505 | 0.280584 | 0.093 | 0.012 | 1163 | 62 | 1470 | 250 | 6.661316 |
| X455_38 | 76 | 100 | 1.315789 | 5.073567 | 0.213651 | 0.0742 | 0.0056 | 1159 | 44 | 1010 | 160 | -5.17241 |
| X455_39 | 152 | 129 | 0.848684 | 3.401361 | 0.138831 | 0.0955 | 0.0037 | 1659 | 61 | 1533 | 74 | -2.85183 |
| X455_40 | 152 | 239 | 1.572368 | 3.773585 | 0.156639 | 0.0957 | 0.004 | 1513 | 54 | 1545 | 80 | 1.111111 |
| X455_41 | 64 | 40 | 0.625 | 3.968254 | 0.220459 | 0.0966 | 0.0062 | 1446 | 71 | 1510 | 120 | 1.364256 |
| X455_42 | 151 | 249 | 1.649007 | 3.663004 | 0.147594 | 0.0995 | 0.0049 | 1560 | 59 | 1599 | 92 | 0.446713 |
| X455_43 | 53 | 82 | 1.54717 | 5.050505 | 0.255076 | 0.0767 | 0.0058 | 1170 | 58 | 1050 | 170 | -2.09424 |
| X455_44 | 195 | 174 | 0.892308 | 4.201681 | 0.211849 | 0.1163 | 0.009 | 1375 | 64 | 1930 | 150 | 13.30391 |
| X455_45 | 28 | 38 | 1.357143 | 3.663004 | 0.161011 | 0.0953 | 0.0084 | 1556 | 63 | 1560 | 150 | -1.56658 |
| X455_46 | 39 | 58 | 1.487179 | 4.878049 | 0.261749 | 0.0791 | 0.006 | 1215 | 60 | 1230 | 150 | -1.50376 |
| X455_47 | 60 | 78 | 1.3 | 5.149331 | 0.23864 | 0.0791 | 0.0066 | 1143 | 50 | 1150 | 170 | -0.88261 |
| X455_48 | 36 | 77 | 2.138889 | 5.136107 | 0.253244 | 0.0838 | 0.0069 | 1145 | 52 | 1200 | 170 | 2.053037 |
| X455_49 | 26 | 52 | 2 | 4.99002 | 0.244023 | 0.0797 | 0.009 | 1176 | 55 | 1040 | 230 | -3.24846 |
| X455_50 | 80 | 99 | 1.2375 | 4.830918 | 0.221709 | 0.0814 | 0.0055 | 1212 | 51 | 1250 | 130 | -0.74813 |
| X455_51 | 167 | 213 | 1.275449 | 5.076142 | 0.334974 | 0.1087 | 0.0062 | 1178 | 74 | 1760 | 110 | 15.2518 |
| X455_52 | 128 | 133 | 1.039063 | 5.08647 | 0.212152 | 0.0752 | 0.004 | 1156 | 44 | 1100 | 100 | -3.21429 |
| X455_53 | 26 | 40 | 1.538462 | 5.102041 | 0.260308 | 0.096 | 0.011 | 1153 | 56 | 1520 | 230 | 11.64751 |
| X455_54 | 34 | 24 | 0.705882 | 4.878049 | 0.285544 | 0.0778 | 0.0071 | 1202 | 63 | 1080 | 190 | -2.99914 |
| X455_55 | 42 | 72 | 1.714286 | 5.107252 | 0.219106 | 0.076 | 0.0063 | 1152 | 46 | 1110 | 170 | -1.67696 |
| X455_56 | 34 | 68 | 2 | 4.995005 | 0.234531 | 0.0754 | 0.0071 | 1175 | 51 | 1020 | 190 | -5.09839 |
| X455_57 | 28 | 39 | 1.392857 | 4.878049 | 0.285544 | 0.0758 | 0.0082 | 1199 | 62 | 1050 | 220 | -5.17544 |
| X455_58 | 34 | 95 | 2.794118 | 5.102041 | 0.31237 | 0.0785 | 0.0088 | 1150 | 63 | 1130 | 230 | 2.459712 |
| X455_59 | 61 | 75 | 1.229508 | 5.01002 | 0.243473 | 0.0802 | 0.0057 | 1172 | 52 | 1210 | 130 | 0.255319 |
| X455_60 | 33 | 73 | 2.212121 | 5.076142 | 0.283439 | 0.117 | 0.011 | 1156 | 58 | 1870 | 180 | 18.76318 |
| X455_61 | 22 | 41 | 1.863636 | 5.181347 | 0.349003 | 0.081 | 0.011 | 1136 | 69 | 1080 | 280 | 0.525394 |
| X455_62 | 62 | 112 | 1.806452 | 5.007511 | 0.248244 | 0.0796 | 0.0059 | 1172 | 53 | 1160 | 150 | 0 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **X455_63** | 28 | 39 | 1.392857 | 5.025126 | 0.252519 | 0.0801 | 0.0065 | 1169 | 56 | 1190 | 170 | -2.90493 |
| **X455_64** | 269 | 217 | 0.806691 | 3.412969 | 0.151429 | 0.0978 | 0.0031 | 1662 | 61 | 1585 | 57 | -1.52718 |
| **X455_65** | 70 | 104 | 1.485714 | 4.894763 | 0.234795 | 0.0783 | 0.0041 | 1197 | 53 | 1120 | 100 | -0.67283 |
| **X455_66** | 22 | 35 | 1.590909 | 4.807692 | 0.277367 | 0.0773 | 0.0071 | 1215 | 64 | 1110 | 200 | -2.10084 |
| **X455_67** | 66 | 75 | 1.136364 | 5.035247 | 0.200294 | 0.0774 | 0.0052 | 1167 | 43 | 1090 | 150 | -1.30208 |
| **X455_68** | 302 | 319 | 1.056291 | 5.162623 | 0.242539 | 0.0805 | 0.0032 | 1140 | 49 | 1192 | 80 | 2.145923 |
| **X455_69** | 315 | 294 | 0.933333 | 4.338395 | 0.18257 | 0.0962 | 0.0034 | 1336 | 52 | 1576 | 65 | 5.716302 |
| **X455_70** | 60 | 109 | 1.816667 | 5.099439 | 0.257442 | 0.0782 | 0.0063 | 1152 | 53 | 1100 | 180 | -0.08688 |
| **X455_71** | 32 | 50 | 1.5625 | 5.14668 | 0.246341 | 0.0821 | 0.0081 | 1150 | 50 | 1210 | 200 | 4.246461 |
| **X455_72** | 29 | 46 | 1.586207 | 4.926108 | 0.266932 | 0.0792 | 0.0082 | 1191 | 57 | 1150 | 200 | -0.9322 |
| **X455_73** | 25 | 52 | 2.08 | 5.263158 | 0.33241 | 0.077 | 0.01 | 1127 | 65 | 1010 | 270 | 0 |
| **X455_74** | 35 | 72 | 2.057143 | 5.050505 | 0.306091 | 0.0819 | 0.0079 | 1164 | 62 | 1150 | 190 | 2.348993 |
| **X455_75** | 177 | 126 | 0.711864 | 3.533569 | 0.149833 | 0.0924 | 0.0038 | 1605 | 61 | 1459 | 77 | -4.69667 |
| **X455_76** | 338 | 113 | 0.33432 | 4.873294 | 0.175743 | 0.0818 | 0.0032 | 1203 | 40 | 1227 | 76 | -0.66946 |
| **X455_77** | 37 | 58 | 1.567568 | 4.901961 | 0.240292 | 0.0816 | 0.0077 | 1195 | 55 | 1170 | 180 | -0.25168 |
| **X455_78** | 214 | 305 | 1.425234 | 3.558719 | 0.139309 | 0.0951 | 0.0035 | 1597 | 57 | 1529 | 68 | -2.24072 |
| **X455_79** | 48 | 72 | 1.5 | 4.347826 | 0.189036 | 0.0944 | 0.0081 | 1335 | 53 | 1530 | 160 | 6.184118 |
| **X455_80** | 34 | 51 | 1.5 | 5.208333 | 0.271267 | 0.0883 | 0.008 | 1139 | 55 | 1360 | 190 | 6.944444 |
| **X455_81** | 127 | 145 | 1.141732 | 3.546099 | 0.150898 | 0.095 | 0.0042 | 1601 | 59 | 1522 | 79 | -2.16975 |
| **X455_82** | 36 | 66 | 1.833333 | 5.263158 | 0.304709 | 0.0829 | 0.0067 | 1118 | 58 | 1210 | 170 | 4.851064 |
| **X455_83** | 26 | 36 | 1.384615 | 5.102041 | 0.31237 | 0.0788 | 0.0073 | 1149 | 63 | 1240 | 200 | 3.364172 |
| **X455_84** | 270 | 183 | 0.677778 | 3.484321 | 0.145686 | 0.0941 | 0.0034 | 1634 | 58 | 1500 | 69 | -3.28698 |
| **X455_85** | 28 | 52 | 1.857143 | 4.739336 | 0.33692 | 0.122 | 0.018 | 1228 | 79 | 1870 | 270 | 17.02703 |
| **X455_86** | 86 | 101 | 1.174419 | 5.167959 | 0.208321 | 0.0792 | 0.0041 | 1139 | 42 | 1140 | 100 | 0.262697 |
| **X455_87** | 54 | 91 | 1.685185 | 4.995005 | 0.247006 | 0.0749 | 0.0053 | 1175 | 53 | 1020 | 140 | -3.70697 |
| **X455_88** | 224 | 1 | 0.004464 | 4.96771 | 0.197425 | 0.0803 | 0.0037 | 1182 | 43 | 1194 | 91 | 1.335559 |
| **X455_89** | 278 | 209 | 0.751799 | 3.90625 | 0.183106 | 0.0936 | 0.0038 | 1475 | 64 | 1497 | 73 | 1.337793 |
| **X455_90** | 27 | 48 | 1.777778 | 4.784689 | 0.274719 | 0.108 | 0.012 | 1230 | 61 | 1720 | 210 | 14.93776 |
| **X455_91** | 331 | 265 | 0.800604 | 4.2123 | 0.170337 | 0.0882 | 0.0031 | 1372 | 50 | 1385 | 66 | 0.363108 |
| **X455_92** | 23 | 37 | 1.608696 | 5 | 0.325 | 0.0723 | 0.0074 | 1174 | 71 | 1030 | 220 | -4.26288 |
| **X455_93** | 63 | 80 | 1.269841 | 4.882812 | 0.224114 | 0.0762 | 0.0053 | 1200 | 50 | 1130 | 140 | -2.12766 |
| **X455_94** | 43 | 71 | 1.651163 | 4.92126 | 0.234922 | 0.0816 | 0.0046 | 1191 | 52 | 1240 | 120 | 0.832639 |
| **X455_95** | 119 | 124 | 1.042017 | 3.278689 | 0.128998 | 0.0984 | 0.0035 | 1716 | 60 | 1584 | 66 | -3.81125 |
| **X455_96** | 26 | 56 | 2.153846 | 4.608295 | 0.318546 | 0.0735 | 0.0082 | 1263 | 80 | 1020 | 220 | -5.95638 |
| **X455_97** | 143 | 134 | 0.937063 | 3.333333 | 0.122222 | 0.0968 | 0.0037 | 1691 | 57 | 1550 | 73 | -4.77076 |
| **X455_98** | 157 | 203 | 1.292994 | 1.855288 | 0.192757 | 0.347 | 0.037 | 2770 | 230 | 3630 | 160 | 16.06061 |
| **X455_99** | 86 | 62 | 0.72093 | 3.225806 | 0.135276 | 0.1008 | 0.0038 | 1740 | 66 | 1626 | 71 | -2.83688 |
| **X455_100** | 83 | 141 | 1.698795 | 5.336179 | 0.210714 | 0.0769 | 0.0049 | 1106 | 40 | 1100 | 140 | -0.27199 |
| **X455_101** | 70 | 100 | 1.428571 | 3.597122 | 0.142332 | 0.1035 | 0.0059 | 1582 | 58 | 1720 | 110 | 2.466091 |
| **X455_102** | 27 | 37 | 1.37037 | 5 | 0.325 | 0.0714 | 0.008 | 1170 | 67 | 920 | 230 | -8.13309 |
| **X455_103** | 42 | 59 | 1.404762 | 5.230126 | 0.235246 | 0.0777 | 0.0055 | 1127 | 46 | 1090 | 160 | 1.486014 |
| **X455_104** | 41 | 52 | 1.268293 | 5.291005 | 0.279947 | 0.0793 | 0.0063 | 1124 | 56 | 1210 | 140 | 2.005231 |
| **X455_105** | 52 | 79 | 1.519231 | 4.933399 | 0.238517 | 0.0779 | 0.0063 | 1188 | 52 | 1110 | 150 | -0.8489 |
| **X455_106** | 66 | 105 | 1.590909 | 4.859086 | 0.229024 | 0.0877 | 0.0064 | 1205 | 52 | 1420 | 140 | 7.164869 |
| **X455_107** | 30 | 52 | 1.733333 | 5.33049 | 0.2813 | 0.0775 | 0.0088 | 1107 | 54 | 1110 | 200 | 2.46696 |
| **X455_108** | 25 | 39 | 1.56 | 5.136107 | 0.261158 | 0.0799 | 0.0085 | 1145 | 53 | 1210 | 240 | 4.662781 |
| **X455_109** | 36 | 64 | 1.777778 | 4.975124 | 0.272271 | 0.0833 | 0.0077 | 1181 | 57 | 1180 | 200 | -0.76792 |
| **X455_110** | 30 | 41 | 1.366667 | 4.901961 | 0.264321 | 0.0757 | 0.0069 | 1193 | 60 | 1000 | 210 | -5.48187 |
| **X455_111** | 234 | 234 | 1 | 3.802281 | 0.144573 | 0.0941 | 0.003 | 1502 | 52 | 1511 | 63 | -0.26702 |
| **X455_112** | 58 | 0 | 0 | 5.060729 | 0.215132 | 0.079 | 0.0056 | 1162 | 45 | 1130 | 140 | -2.28873 |
| **X455_113** | 24 | 39 | 1.625 | 4.694836 | 0.264498 | 0.0869 | 0.0078 | 1239 | 66 | 1340 | 180 | 2.59434 |
| **X455_114** | 34 | 57 | 1.676471 | 4.926108 | 0.266932 | 0.077 | 0.006 | 1189 | 58 | 1090 | 150 | -2.2356 |
| **X455_115** | 42 | 93 | 2.214286 | 5.184033 | 0.244555 | 0.0738 | 0.0056 | 1136 | 49 | 1070 | 150 | -1.70098 |
| **X455_116** | 25 | 38 | 1.52 | 5.208333 | 0.352648 | 0.076 | 0.0086 | 1130 | 67 | 1040 | 240 | -1.34529 |
| **X455_117** | 253 | 457 | 1.806324 | 4.219409 | 0.195838 | 0.1002 | 0.0041 | 1368 | 59 | 1611 | 76 | 7.065217 |
| **X455_118** | 162 | 132 | 0.814815 | 3.508772 | 0.172361 | 0.0979 | 0.0033 | 1614 | 69 | 1576 | 65 | -0.43559 |
| **X455_119** | 103 | 172 | 1.669903 | 4 | 0.192 | 0.0953 | 0.0046 | 1437 | 63 | 1538 | 94 | 4.136091 |
| **X455_120** | 89 | 126 | 1.41573 | 4.926108 | 0.218399 | 0.0806 | 0.0053 | 1190 | 48 | 1150 | 140 | 0 |
| **X455_121** | 96 | 106 | 1.104167 | 3.496503 | 0.158932 | 0.0976 | 0.0045 | 1618 | 64 | 1570 | 86 | -1.56937 |
| **X455_122** | 49 | 74 | 1.510204 | 4.716981 | 0.244749 | 0.0913 | 0.0093 | 1237 | 55 | 1440 | 180 | 4.256966 |
| **X455_123** | 85 | 128 | 1.505882 | 3.610108 | 0.169428 | 0.0992 | 0.0051 | 1574 | 68 | 1596 | 93 | 0.316656 |
| **X455_124** | 144 | 182 | 1.263889 | 4.863813 | 0.198716 | 0.0787 | 0.0045 | 1205 | 45 | 1120 | 110 | -2.20526 |
| **X455_125** | 277 | 209 | 0.754513 | 3.883495 | 0.13875 | 0.0897 | 0.0032 | 1477 | 47 | 1415 | 71 | -2.42718 |
| **X455_126** | 45 | 99 | 2.2 | 4.854369 | 0.259214 | 0.133 | 0.01 | 1206 | 56 | 2080 | 140 | 23.67089 |
| **X455_127** | 53 | 77 | 1.45283 | 3.676471 | 0.554174 | 0.254 | 0.064 | 1520 | 200 | 2430 | 440 | 27.27273 |
| **X455_128** | 68 | 100 | 1.470588 | 5.194805 | 0.226682 | 0.0807 | 0.0052 | 1134 | 45 | 1220 | 130 | 0.960699 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **X455_129** | 63 | 82 | 1.301587 | 4.992511 | 0.211864 | 0.0834 | 0.0062 | 1176 | 46 | 1260 | 140 | 1.093356 |
| **X455_130** | 36 | 88 | 2.444444 | 5.138746 | 0.245582 | 0.0774 | 0.0085 | 1168 | 51 | 1090 | 230 | -4.47227 |
| **X455_131** | 35 | 56 | 1.6 | 4.950495 | 0.269581 | 0.0842 | 0.0079 | 1184 | 61 | 1220 | 170 | 2.067825 |
| **X455_132** | 62 | 76 | 1.225806 | 5.025126 | 0.252519 | 0.0732 | 0.005 | 1169 | 55 | 1030 | 140 | -4.46828 |
| **X455_133** | 99 | 105 | 1.060606 | 3.448276 | 0.142687 | 0.0969 | 0.0049 | 1646 | 58 | 1564 | 97 | -2.10918 |
| **X455_134** | 89 | 106 | 1.191011 | 3.584229 | 0.141314 | 0.1015 | 0.0049 | 1586 | 57 | 1651 | 94 | 1.73482 |
| **X455_135** | 30 | 52 | 1.733333 | 5.208333 | 0.298394 | 0.0801 | 0.0091 | 1129 | 57 | 1130 | 240 | 1.138354 |
| **X455_136** | 130 | 111 | 0.853846 | 3.448276 | 0.154578 | 0.0959 | 0.0038 | 1648 | 66 | 1543 | 73 | -2.80724 |
| **X455_137** | 177 | 117 | 0.661017 | 3.623188 | 0.131275 | 0.0937 | 0.004 | 1571 | 51 | 1496 | 81 | -2.88147 |
| **X455_138** | 144 | 132 | 0.916667 | 4.784689 | 0.183146 | 0.0804 | 0.0039 | 1223 | 43 | 1179 | 95 | -2.51467 |
| **X455_139** | 99 | 109 | 1.10101 | 3.344482 | 0.145412 | 0.1004 | 0.0043 | 1694 | 62 | 1644 | 77 | -2.48034 |
| **X455_140** | 52 | 84 | 1.615385 | 5.263158 | 0.221607 | 0.0743 | 0.006 | 1121 | 43 | 1010 | 170 | -2.56176 |
| **X455_141** | 31 | 47 | 1.516129 | 4.545455 | 0.289256 | 0.0822 | 0.0074 | 1289 | 75 | 1260 | 160 | -3.36808 |
| **X455_142** | 187 | 282 | 1.508021 | 3.745318 | 0.154302 | 0.1001 | 0.004 | 1522 | 56 | 1621 | 77 | 2.310655 |
| **X455_143** | 36 | 79 | 2.194444 | 4.807692 | 0.254253 | 0.0955 | 0.0093 | 1215 | 59 | 1530 | 200 | 10.19956 |
| **X455_144** | 36 | 61 | 1.694444 | 5.128205 | 0.289283 | 0.0757 | 0.0076 | 1145 | 58 | 1040 | 200 | -2.23214 |
| **X455_145** | 86 | 85 | 0.988372 | 5.422993 | 0.238212 | 0.0794 | 0.0053 | 1090 | 44 | 1180 | 140 | 0.274474 |
| **X455_146** | 33 | 48 | 1.454545 | 4.761905 | 0.272109 | 0.08 | 0.0065 | 1228 | 64 | 1150 | 180 | -1.73985 |
| **X455_147** | 31 | 46 | 1.483871 | 5.184033 | 0.266055 | 0.0824 | 0.0087 | 1135 | 53 | 1290 | 190 | 4.861693 |
| **X455_148** | 38 | 67 | 1.763158 | 5 | 0.275 | 0.0785 | 0.0068 | 1175 | 62 | 1090 | 170 | -2.62009 |
| **X455_149** | 34 | 43 | 1.264706 | 4.777831 | 0.216863 | 0.114 | 0.014 | 1224 | 51 | 1840 | 240 | 16.73469 |
| **X455_150** | 119 | 121 | 1.016807 | 3.484321 | 0.133545 | 0.0958 | 0.0047 | 1626 | 55 | 1531 | 93 | -1.625 |
| **X455_151** | 72 | 134 | 1.861111 | 5.122951 | 0.236202 | 0.0803 | 0.0048 | 1148 | 48 | 1230 | 130 | 3.285594 |
| **X455_152** | 55 | 91 | 1.654545 | 4.930966 | 0.209104 | 0.0782 | 0.0062 | 1196 | 43 | 1150 | 170 | -0.84317 |
| **X455_153** | 26 | 47 | 1.807692 | 4.830918 | 0.303391 | 0.0795 | 0.0099 | 1212 | 67 | 1050 | 260 | -3.76712 |
| **X455_154** | 76 | 103 | 1.355263 | 4.935834 | 0.202208 | 0.0806 | 0.0047 | 1188 | 45 | 1170 | 120 | -1.27877 |
| **X455_155** | 43 | 54 | 1.255814 | 4.784689 | 0.228933 | 0.098 | 0.01 | 1222 | 53 | 1590 | 190 | 12.27566 |
| **X455_157** | 73 | 101 | 1.383562 | 5.173306 | 0.227486 | 0.0768 | 0.0055 | 1138 | 46 | 1100 | 140 | 1.386482 |
| **X455_158** | 75 | 46 | 0.613333 | 3.558719 | 0.164638 | 0.0933 | 0.0047 | 1595 | 63 | 1482 | 91 | -2.44059 |
| **X455_159** | 181 | 261 | 1.441989 | 4.957858 | 0.228597 | 0.082 | 0.0033 | 1183 | 50 | 1250 | 78 | 1.907131 |

Table 6: GSWA sample #199456

| Spot ID | $^{238}$U (ppm) | $^{232}$Th (ppm) | $^{232}$Th/$^{238}$U | $^{238}$U/$^{206}$Pb | ± 2σ | $^{207}$Pb/$^{206}$Pb | ± 2σ | $^{206}$PB/$^{238}$U date (Ma) | ± 2σ | $^{206}$Pb/$^{207}$Pb date (Ma) | ± 2σ | Disc. (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| X456_1 | 21 | 14 | 0.666667 | 3.731343 | 0.222767 | 0.0869 | 0.0087 | 1526 | 81 | 1290 | 200 | -6.11961 |
| X456_2 | 87 | 81 | 0.931034 | 3.984064 | 0.158728 | 0.0917 | 0.0047 | 1444 | 53 | 1457 | 99 | 0.276243 |
| X456_3 | 108 | 128 | 1.185185 | 3.636364 | 0.158678 | 0.0862 | 0.0045 | 1578 | 58 | 1340 | 100 | -7.71331 |
| X456_4 | 125 | 125 | 1 | 4.123711 | 0.161548 | 0.0914 | 0.0037 | 1399 | 49 | 1452 | 73 | 1.686578 |
| X456_5 | 17 | 8 | 0.470588 | 3.90625 | 0.244141 | 0.111 | 0.013 | 1463 | 82 | 1730 | 230 | 9.691358 |
| X456_6 | 58 | 40 | 0.689655 | 3.984064 | 0.190473 | 0.0951 | 0.0059 | 1443 | 61 | 1500 | 120 | 3.671562 |
| X456_7 | 34 | 22 | 0.647059 | 3.952569 | 0.187474 | 0.0814 | 0.0073 | 1451 | 62 | 1250 | 190 | -7.24316 |
| X456_8 | 163 | 96 | 0.588957 | 3.846154 | 0.177515 | 0.0886 | 0.0031 | 1486 | 59 | 1394 | 73 | -2.9799 |
| X456_9 | 115 | 120 | 1.043478 | 3.558719 | 0.139309 | 0.0906 | 0.0034 | 1608 | 54 | 1445 | 75 | -5.92885 |
| X456_10 | 129 | 84 | 0.651163 | 3.861004 | 0.149074 | 0.0903 | 0.004 | 1484 | 53 | 1412 | 85 | -1.50479 |
| X456_11 | 131 | 67 | 0.51145 | 3.745318 | 0.154302 | 0.0868 | 0.0041 | 1522 | 58 | 1369 | 92 | -4.03281 |
| X456_12 | 78 | 55 | 0.705128 | 4.016064 | 0.161288 | 0.0855 | 0.0048 | 1434 | 53 | 1320 | 100 | -4.36681 |
| X456_13 | 48 | 39 | 0.8125 | 4.201681 | 0.211849 | 0.0838 | 0.0055 | 1376 | 61 | 1300 | 130 | -3.22581 |
| X456_14 | 118 | 146 | 1.237288 | 4.242681 | 0.160203 | 0.0905 | 0.0047 | 1364 | 46 | 1423 | 96 | 0.944081 |
| X456_15 | 154 | 134 | 0.87013 | 3.984064 | 0.158728 | 0.0936 | 0.0043 | 1441 | 53 | 1503 | 80 | 1.368925 |
| X456_16 | 61 | 35 | 0.57377 | 4.291845 | 0.202619 | 0.0888 | 0.007 | 1347 | 58 | 1380 | 160 | 0.590406 |
| X456_17 | 187 | 216 | 1.15508 | 4.081633 | 0.166597 | 0.0899 | 0.0033 | 1411 | 53 | 1411 | 71 | 0.70373 |
| X456_18 | 146 | 133 | 0.910959 | 4.166667 | 0.173611 | 0.0905 | 0.0039 | 1384 | 54 | 1418 | 82 | 2.808989 |
| X456_19 | 207 | 142 | 0.68599 | 4.098361 | 0.167966 | 0.0884 | 0.004 | 1407 | 52 | 1367 | 89 | -0.78797 |
| X456_20 | 117 | 109 | 0.931624 | 3.969829 | 0.14814 | 0.0885 | 0.004 | 1447 | 48 | 1398 | 98 | -0.34674 |
| X456_21 | 170 | 100 | 0.588235 | 4.00641 | 0.141252 | 0.0905 | 0.0038 | 1440 | 45 | 1428 | 82 | -0.06949 |
| X456_22 | 195 | 136 | 0.697436 | 3.954132 | 0.145407 | 0.0884 | 0.0037 | 1453 | 48 | 1382 | 81 | -1.39567 |
| X456_23 | 217 | 152 | 0.700461 | 3.979308 | 0.145681 | 0.0916 | 0.0033 | 1445 | 48 | 1456 | 70 | -0.34722 |
| X456_24 | 93 | 72 | 0.774194 | 3.875969 | 0.165255 | 0.0893 | 0.004 | 1476 | 57 | 1404 | 83 | -0.75085 |
| X456_25 | 76 | 73 | 0.960526 | 4.194631 | 0.163633 | 0.0868 | 0.0038 | 1377 | 48 | 1348 | 89 | -0.21834 |
| X456_26 | 65 | 36 | 0.553846 | 4.310345 | 0.185791 | 0.0912 | 0.0053 | 1345 | 56 | 1460 | 120 | 3.8599 |
| X456_28 | 148 | 213 | 1.439189 | 4.149378 | 0.172173 | 0.0923 | 0.0044 | 1392 | 52 | 1448 | 94 | 2.040816 |
| X456_29 | 51 | 40 | 0.784314 | 4.115226 | 0.186286 | 0.0856 | 0.0051 | 1399 | 56 | 1340 | 120 | -0.71994 |
| X456_30 | 54 | 41 | 0.759259 | 3.952569 | 0.187474 | 0.0894 | 0.0063 | 1451 | 61 | 1410 | 140 | -1.32682 |
| X456_31 | 27 | 11 | 0.407407 | 4.237288 | 0.215455 | 0.0901 | 0.0089 | 1366 | 63 | 1350 | 200 | 0.654545 |
| X456_32 | 118 | 111 | 0.940678 | 4.196391 | 0.170814 | 0.0922 | 0.0046 | 1377 | 50 | 1458 | 95 | 2.478754 |
| X456_33 | 26 | 11 | 0.423077 | 4.048583 | 0.229474 | 0.0791 | 0.0086 | 1419 | 72 | 1110 | 230 | -9.65997 |
| X456_34 | 152 | 147 | 0.967105 | 4.159734 | 0.15227 | 0.09 | 0.0037 | 1388 | 46 | 1428 | 78 | 0.857143 |
| X456_35 | 244 | 176 | 0.721311 | 4.048583 | 0.144241 | 0.09 | 0.0035 | 1422 | 45 | 1411 | 75 | 0.698324 |
| X456_36 | 38 | 24 | 0.631579 | 4.149378 | 0.172173 | 0.0832 | 0.006 | 1389 | 55 | 1260 | 140 | -3.81166 |
| X456_37 | 14 | 6 | 0.428571 | 4.291845 | 0.257879 | 0.103 | 0.012 | 1354 | 72 | 1570 | 230 | 6.685045 |
| X456_38 | 141 | 73 | 0.51773 | 4.1511 | 0.160254 | 0.0878 | 0.0042 | 1391 | 48 | 1365 | 90 | 0.071839 |
| X456_39 | 79 | 71 | 0.898734 | 3.990423 | 0.154458 | 0.09 | 0.0046 | 1441 | 50 | 1425 | 97 | -0.48815 |
| X456_40 | 82 | 32 | 0.390244 | 4.115226 | 0.169351 | 0.0839 | 0.0054 | 1400 | 52 | 1300 | 120 | -3.16875 |
| X456_41 | 58 | 24 | 0.413793 | 4.1841 | 0.175067 | 0.0913 | 0.0062 | 1388 | 52 | 1430 | 130 | 1.977401 |
| X456_42 | 26 | 17 | 0.653846 | 3.984064 | 0.269837 | 0.0857 | 0.0093 | 1440 | 86 | 1230 | 220 | -4.65116 |
| X456_43 | 245 | 162 | 0.661224 | 4.545455 | 0.268595 | 0.0929 | 0.0031 | 1276 | 69 | 1477 | 63 | 6.038292 |
| X456_44 | 29 | 12 | 0.413793 | 4.065041 | 0.231344 | 0.0875 | 0.0073 | 1412 | 71 | 1410 | 160 | -2.69091 |
| X456_45 | 40 | 20 | 0.5 | 3.952569 | 0.203096 | 0.0893 | 0.0064 | 1448 | 69 | 1390 | 140 | -3.87374 |
| X456_46 | 254 | 338 | 1.330709 | 4.156276 | 0.150289 | 0.0866 | 0.0029 | 1389 | 45 | 1362 | 73 | 0 |
| X456_47 | 47 | 24 | 0.510638 | 4.065041 | 0.214819 | 0.0894 | 0.0072 | 1417 | 69 | 1400 | 150 | 0.770308 |
| X456_48 | 113 | 100 | 0.884956 | 4.120313 | 0.162979 | 0.0909 | 0.0043 | 1400 | 50 | 1432 | 92 | 1.477833 |
| X456_49 | 31 | 21 | 0.677419 | 4.1841 | 0.21008 | 0.081 | 0.0074 | 1389 | 59 | 1230 | 170 | -3.34821 |
| X456_50 | 99 | 54 | 0.545455 | 4.110152 | 0.157108 | 0.0901 | 0.0043 | 1403 | 48 | 1401 | 97 | 0.284293 |
| X456_51 | 87 | 50 | 0.574713 | 3.977725 | 0.153476 | 0.0864 | 0.0046 | 1445 | 50 | 1310 | 110 | -2.62784 |
| X456_52 | 346 | 180 | 0.520231 | 4.009623 | 0.139871 | 0.0886 | 0.0032 | 1435 | 45 | 1391 | 68 | -0.70175 |
| X456_53 | 82 | 27 | 0.329268 | 3.921569 | 0.169166 | 0.0881 | 0.0048 | 1461 | 57 | 1370 | 110 | -3.3239 |
| X456_54 | 178 | 119 | 0.668539 | 3.94011 | 0.149035 | 0.0885 | 0.0033 | 1457 | 49 | 1382 | 73 | -1.32128 |
| X456_55 | 21 | 12 | 0.571429 | 4.347826 | 0.245747 | 0.092 | 0.0099 | 1334 | 66 | 1410 | 210 | 4.441261 |
| X456_56 | 55 | 29 | 0.527273 | 4.132231 | 0.204904 | 0.0863 | 0.0056 | 1402 | 59 | 1310 | 120 | -2.78592 |
| X456_57 | 147 | 133 | 0.904762 | 4.111842 | 0.152165 | 0.0895 | 0.0041 | 1403 | 47 | 1392 | 88 | 0.071225 |
| X456_58 | 156 | 141 | 0.903846 | 4.065041 | 0.156983 | 0.0881 | 0.0039 | 1417 | 49 | 1388 | 85 | -1.86916 |
| X456_59 | 11 | 3 | 0.272727 | 4.081633 | 0.333195 | 0.09 | 0.013 | 1400 | 100 | 1290 | 310 | 0.70922 |
| X456_60 | 32 | 11 | 0.34375 | 4.132231 | 0.239055 | 0.0868 | 0.0073 | 1393 | 72 | 1320 | 170 | -1.30909 |
| X456_61 | 84 | 45 | 0.535714 | 3.584229 | 0.205547 | 0.0948 | 0.0081 | 1584 | 77 | 1500 | 170 | -1.34357 |
| X456_62 | 28 | 20 | 0.714286 | 4.366812 | 0.228829 | 0.0923 | 0.0085 | 1327 | 65 | 1420 | 180 | 1.921656 |
| X456_63 | 21 | 10 | 0.47619 | 4.098361 | 0.251948 | 0.0959 | 0.0095 | 1402 | 78 | 1460 | 200 | 3.376981 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **X456_64** | 28 | 8 | 0.285714 | 4.016064 | 0.241932 | 0.0976 | 0.0077 | 1427 | 77 | 1520 | 160 | 2.726653 |
| **X456_65** | 13 | 7 | 0.538462 | 4.149378 | 0.309912 | 0.081 | 0.013 | 1383 | 95 | 1170 | 330 | -3.98496 |
| **X456_66** | 55 | 89 | 1.618182 | 3.937008 | 0.1705 | 0.0946 | 0.0056 | 1458 | 58 | 1500 | 110 | -0.06863 |
| **X456_67** | 68 | 50 | 0.735294 | 3.984064 | 0.1746 | 0.0908 | 0.005 | 1444 | 54 | 1440 | 110 | -0.0693 |
| **X456_68** | 110 | 125 | 1.136364 | 4.122012 | 0.161414 | 0.0845 | 0.0036 | 1399 | 49 | 1318 | 82 | -3.32349 |
| **X456_69** | 92 | 77 | 0.836957 | 4.063389 | 0.155205 | 0.0882 | 0.0053 | 1418 | 48 | 1340 | 120 | -1.14123 |
| **X456_70** | 186 | 98 | 0.526882 | 4.053506 | 0.151164 | 0.0889 | 0.0038 | 1421 | 47 | 1406 | 81 | -0.28229 |
| **X456_71** | 139 | 93 | 0.669065 | 4.149378 | 0.167008 | 0.0888 | 0.0044 | 1391 | 50 | 1385 | 96 | -1.09012 |
| **X456_72** | 169 | 130 | 0.769231 | 4.180602 | 0.148558 | 0.0887 | 0.0034 | 1382 | 44 | 1395 | 72 | -0.43605 |
| **X456_73** | 134 | 109 | 0.813433 | 4 | 0.16 | 0.0871 | 0.0033 | 1436 | 53 | 1349 | 73 | -2.3521 |
| **X456_74** | 225 | 137 | 0.608889 | 3.759398 | 0.155464 | 0.089 | 0.0035 | 1520 | 57 | 1399 | 74 | -3.19077 |
| **X456_75** | 56 | 26 | 0.464286 | 4.048583 | 0.16391 | 0.0914 | 0.0063 | 1423 | 52 | 1390 | 140 | -0.42343 |
| **X456_76** | 178 | 164 | 0.921348 | 4 | 0.16 | 0.0905 | 0.0033 | 1438 | 53 | 1434 | 69 | -0.84151 |
| **X456_77** | 27 | 15 | 0.555556 | 4 | 0.224 | 0.0895 | 0.007 | 1434 | 71 | 1380 | 160 | -2.20955 |
| **X456_78** | 285 | 369 | 1.294737 | 5.235602 | 0.328938 | 0.0986 | 0.0035 | 1124 | 67 | 1588 | 66 | 13.86973 |
| **X456_79** | 64 | 27 | 0.421875 | 3.875969 | 0.165255 | 0.0914 | 0.0055 | 1476 | 55 | 1440 | 110 | -0.54496 |
| **X456_80** | 30 | 34 | 1.133333 | 4 | 0.192 | 0.0891 | 0.0077 | 1438 | 63 | 1380 | 160 | -2.13068 |
| **X456_81** | 64 | 51 | 0.796875 | 4.273504 | 0.200891 | 0.0964 | 0.006 | 1353 | 57 | 1530 | 120 | 5.318404 |
| **X456_82** | 39 | 19 | 0.487179 | 4.132231 | 0.204904 | 0.0872 | 0.0063 | 1397 | 64 | 1340 | 150 | -4.33159 |
| **X456_83** | 90 | 70 | 0.777778 | 4.115226 | 0.169351 | 0.0919 | 0.0045 | 1403 | 52 | 1439 | 96 | 0.355114 |
| **X456_84** | 46 | 31 | 0.673913 | 4.1841 | 0.192574 | 0.0859 | 0.0056 | 1385 | 56 | 1340 | 130 | -0.65407 |
| **X456_85** | 36 | 15 | 0.416667 | 4.132231 | 0.187829 | 0.087 | 0.0066 | 1405 | 59 | 1360 | 140 | -3.69004 |
| **X456_86** | 100 | 16 | 0.16 | 4.13736 | 0.167754 | 0.0882 | 0.0046 | 1394 | 51 | 1410 | 100 | -0.43228 |
| **X456_87** | 103 | 11 | 0.106796 | 4.484305 | 0.221199 | 0.0982 | 0.0049 | 1296 | 58 | 1560 | 100 | 8.280255 |
| **X456_88** | 113 | 75 | 0.663717 | 3.968254 | 0.15747 | 0.0871 | 0.0045 | 1447 | 52 | 1391 | 99 | -2.40623 |
| **X456_90** | 196 | 128 | 0.653061 | 4.1841 | 0.245094 | 0.0911 | 0.0036 | 1379 | 74 | 1468 | 71 | 0.933908 |
| **X456_91** | 68 | 52 | 0.764706 | 3.584229 | 0.15416 | 0.0924 | 0.005 | 1587 | 60 | 1470 | 110 | -2.25515 |
| **X456_92** | 112 | 86 | 0.767857 | 4.016064 | 0.161288 | 0.0864 | 0.0043 | 1434 | 53 | 1334 | 91 | -3.31412 |
| **X456_93** | 19 | 12 | 0.631579 | 4.016064 | 0.25806 | 0.0913 | 0.0084 | 1427 | 80 | 1400 | 170 | -1.4936 |
| **X456_94** | 226 | 204 | 0.902655 | 3.863988 | 0.134374 | 0.0891 | 0.0034 | 1483 | 46 | 1422 | 70 | -1.8544 |
| **X456_95** | 122 | 72 | 0.590164 | 3.992016 | 0.154581 | 0.0871 | 0.0033 | 1440 | 50 | 1370 | 75 | -2.4911 |
| **X456_96** | 158 | 116 | 0.734177 | 4.019293 | 0.159932 | 0.0895 | 0.004 | 1431 | 51 | 1434 | 89 | 0.139567 |
| **X456_97** | 79 | 27 | 0.341772 | 4.115226 | 0.169351 | 0.0947 | 0.0052 | 1402 | 54 | 1500 | 100 | 2.841303 |
| **X456_98** | 52 | 24 | 0.461538 | 4.149378 | 0.172173 | 0.0923 | 0.0054 | 1392 | 54 | 1430 | 110 | 1.55587 |
| **X456_99** | 9 | 4 | 0.444444 | 3.322259 | 0.353197 | 0.284 | 0.045 | 1680 | 160 | 3290 | 250 | 33.33333 |
| **X456_100** | 87 | 80 | 0.91954 | 3.610108 | 0.143362 | 0.0849 | 0.0041 | 1576 | 57 | 1314 | 88 | -6.77507 |
| **X456_101** | 138 | 78 | 0.565217 | 3.894081 | 0.145573 | 0.0837 | 0.0039 | 1473 | 50 | 1274 | 88 | -5.5914 |
| **X456_102** | 85 | 45 | 0.529412 | 4.301075 | 0.181293 | 0.0819 | 0.0053 | 1353 | 49 | 1230 | 120 | -3.8373 |
| **X456_103** | 302 | 330 | 1.092715 | 3.961965 | 0.138135 | 0.0883 | 0.0031 | 1450 | 43 | 1405 | 64 | -1.32774 |
| **X456_104** | 177 | 111 | 0.627119 | 4.020909 | 0.15521 | 0.0875 | 0.0031 | 1431 | 50 | 1378 | 72 | -0.70373 |
| **X456_105** | 205 | 146 | 0.712195 | 3.90625 | 0.144959 | 0.088 | 0.0034 | 1468 | 49 | 1387 | 79 | -2.01529 |
| **X456_106** | 103 | 41 | 0.398058 | 4.166667 | 0.190972 | 0.0861 | 0.0047 | 1386 | 57 | 1350 | 110 | -1.6129 |
| **X456_107** | 148 | 91 | 0.614865 | 4.130525 | 0.145021 | 0.0873 | 0.0041 | 1397 | 44 | 1343 | 91 | -1.08538 |
| **X456_108** | 257 | 207 | 0.805447 | 3.960396 | 0.149005 | 0.0908 | 0.0036 | 1450 | 47 | 1438 | 76 | -0.83449 |
| **X456_109** | 194 | 204 | 1.051546 | 3.846154 | 0.162722 | 0.0891 | 0.0034 | 1496 | 59 | 1426 | 68 | -1.63043 |
| **X456_110** | 125 | 52 | 0.416 | 3.897116 | 0.150356 | 0.0918 | 0.004 | 1472 | 50 | 1445 | 84 | -1.0989 |
| **X456_111** | 32 | 17 | 0.53125 | 4.048583 | 0.196692 | 0.0921 | 0.0075 | 1423 | 62 | 1400 | 160 | -0.70771 |
| **X456_112** | 37 | 18 | 0.486486 | 4.201681 | 0.211849 | 0.0959 | 0.007 | 1375 | 62 | 1550 | 140 | 4.975812 |
| **X456_113** | 213 | 161 | 0.755869 | 4.280822 | 0.152101 | 0.0883 | 0.0036 | 1353 | 43 | 1385 | 75 | 2.027516 |
| **X456_114** | 101 | 100 | 0.990099 | 4.048583 | 0.16391 | 0.0912 | 0.0043 | 1424 | 54 | 1438 | 95 | -0.63604 |
| **X456_115** | 164 | 120 | 0.731707 | 3.717472 | 0.152016 | 0.0898 | 0.0032 | 1533 | 56 | 1429 | 64 | -3.09348 |
| **X456_116** | 45 | 18 | 0.4 | 4.115226 | 0.203221 | 0.0897 | 0.0054 | 1414 | 62 | 1410 | 120 | 1.668985 |
| **X456_117** | 228 | 130 | 0.570175 | 4.111842 | 0.152165 | 0.0884 | 0.0029 | 1403 | 46 | 1382 | 65 | -0.64562 |
| **X456_118** | 55 | 30 | 0.545455 | 4 | 0.192 | 0.0893 | 0.0062 | 1445 | 59 | 1440 | 130 | -0.06925 |
| **X456_119** | 29 | 21 | 0.724138 | 4.385965 | 0.269314 | 0.0936 | 0.0077 | 1319 | 74 | 1460 | 170 | 5.244253 |
| **X456_120** | 83 | 66 | 0.795181 | 4.048583 | 0.16391 | 0.0887 | 0.0041 | 1420 | 52 | 1374 | 89 | -0.14104 |
| **X456_121** | 185 | 120 | 0.648649 | 3.90625 | 0.152588 | 0.1077 | 0.0048 | 1469 | 53 | 1751 | 84 | 7.610063 |
| **X456_122** | 235 | 105 | 0.446809 | 4.014452 | 0.138596 | 0.0894 | 0.0035 | 1434 | 44 | 1420 | 79 | -0.91485 |
| **X456_123** | 77 | 41 | 0.532468 | 4.208754 | 0.173593 | 0.0896 | 0.0052 | 1373 | 53 | 1430 | 110 | 2.830856 |
| **X456_124** | 110 | 73 | 0.663636 | 3.846154 | 0.162722 | 0.0945 | 0.0041 | 1491 | 56 | 1499 | 82 | -0.94787 |
| **X456_125** | 81 | 61 | 0.753086 | 4.149378 | 0.223825 | 0.0879 | 0.0047 | 1387 | 66 | 1350 | 110 | -0.50725 |
| **X456_126** | 18 | 9 | 0.5 | 4.255319 | 0.271616 | 0.083 | 0.0087 | 1368 | 78 | 1170 | 200 | -4.66718 |
| **X456_127** | 72 | 48 | 0.666667 | 3.773585 | 0.170879 | 0.0865 | 0.0042 | 1516 | 59 | 1350 | 99 | -4.47967 |
| **X456_128** | 225 | 191 | 0.848889 | 4.366812 | 0.20976 | 0.0917 | 0.0038 | 1326 | 60 | 1446 | 77 | 5.353319 |
| **X456_129** | 77 | 68 | 0.883117 | 4.065041 | 0.18177 | 0.0848 | 0.0041 | 1414 | 58 | 1296 | 98 | -4.27729 |
| **X456_130** | 159 | 102 | 0.641509 | 3.923107 | 0.15083 | 0.0872 | 0.003 | 1463 | 50 | 1373 | 72 | -2.2362 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **X456_131** | 23 | 11 | 0.478261 | 4.098361 | 0.218355 | 0.0961 | 0.0079 | 1415 | 66 | 1500 | 150 | 3.544649 |
| **X456_132** | 156 | 102 | 0.653846 | 4.095004 | 0.155952 | 0.09 | 0.0037 | 1408 | 48 | 1430 | 82 | 1.192982 |
| **X456_133** | 76 | 31 | 0.407895 | 4.255319 | 0.199185 | 0.0941 | 0.0046 | 1362 | 55 | 1530 | 110 | 3.813559 |
| **X456_134** | 68 | 41 | 0.602941 | 4.048583 | 0.213083 | 0.0924 | 0.0059 | 1419 | 66 | 1460 | 120 | 0.630252 |
| **X456_135** | 49 | 38 | 0.77551 | 4.065041 | 0.18177 | 0.0911 | 0.0061 | 1416 | 57 | 1440 | 130 | 0.561798 |
| **X456_136** | 121 | 70 | 0.578512 | 3.960396 | 0.145868 | 0.0842 | 0.0042 | 1450 | 48 | 1331 | 99 | -3.64546 |
| **X456_137** | 143 | 67 | 0.468531 | 3.952569 | 0.156228 | 0.0891 | 0.0037 | 1452 | 52 | 1409 | 77 | -0.48443 |
| **X456_138** | 190 | 129 | 0.678947 | 4.048583 | 0.16391 | 0.0878 | 0.0036 | 1430 | 51 | 1386 | 78 | -1.49042 |

Table 7: GSWA sample #199458

| Spot ID | $^{238}$U (ppm) | $^{232}$Th (ppm) | $^{232}$Th/$^{238}$U | $^{238}$U/$^{206}$Pb | ± 2σ | $^{207}$Pb/$^{206}$Pb | ± 2σ | $^{206}$PB/$^{238}$U date (Ma) | ± 2σ | $^{206}$Pb/$^{207}$Pb date (Ma) | ± 2σ | Disc. (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **X458_1** | 169 | 207 | 1.224852 | 3.436426 | 0.141708 | 0.0968 | 0.0037 | 1645 | 60 | 1560 | 74 | -2.62009 |
| **X458_2** | 609 | 813 | 1.334975 | 14.1844 | 0.563352 | 0.0869 | 0.0037 | 439 | 17 | 1339 | 82 | 29.07916 |
| **X458_3** | 984 | 1016 | 1.03252 | 16.92047 | 0.887538 | 0.112 | 0.012 | 370 | 19 | 1790 | 190 | 42.54658 |
| **X458_4** | 906 | 578 | 0.637969 | 15.2207 | 0.556007 | 0.0559 | 0.0022 | 410 | 15 | 457 | 94 | 1.204819 |
| **X458_5** | 1047 | 732 | 0.69914 | 26.59574 | 1.202467 | 0.1502 | 0.0065 | 238 | 10 | 2343 | 72 | 59.66102 |
| **X458_6** | 671 | 566 | 0.843517 | 36.63004 | 1.475936 | 0.0611 | 0.0052 | 173.6 | 7.2 | 610 | 170 | 18.8785 |
| **X458_7** | 450 | 372 | 0.826667 | 31.54574 | 1.393187 | 0.081 | 0.011 | 201.1 | 8.8 | 1090 | 280 | 33.84868 |
| **X458_8** | 295 | 257 | 0.871186 | 22.62443 | 1.02373 | 0.057 | 0.0051 | 279 | 12 | 440 | 190 | 7 |
| **X458_9** | 920 | 248 | 0.269565 | 12.04819 | 0.740311 | 0.0678 | 0.0036 | 514 | 30 | 850 | 110 | 12.28669 |
| **X458_10** | 159 | 122 | 0.767296 | 3.424658 | 0.187653 | 0.1009 | 0.0067 | 1652 | 81 | 1620 | 120 | 1.725164 |
| **X458_11** | 646 | 543 | 0.840557 | 11.01322 | 0.473035 | 0.089 | 0.0037 | 560 | 23 | 1397 | 83 | 26.41261 |
| **X458_12** | 660 | 293 | 0.443939 | 12.30012 | 0.453879 | 0.0584 | 0.0026 | 504 | 18 | 540 | 100 | 2.890173 |

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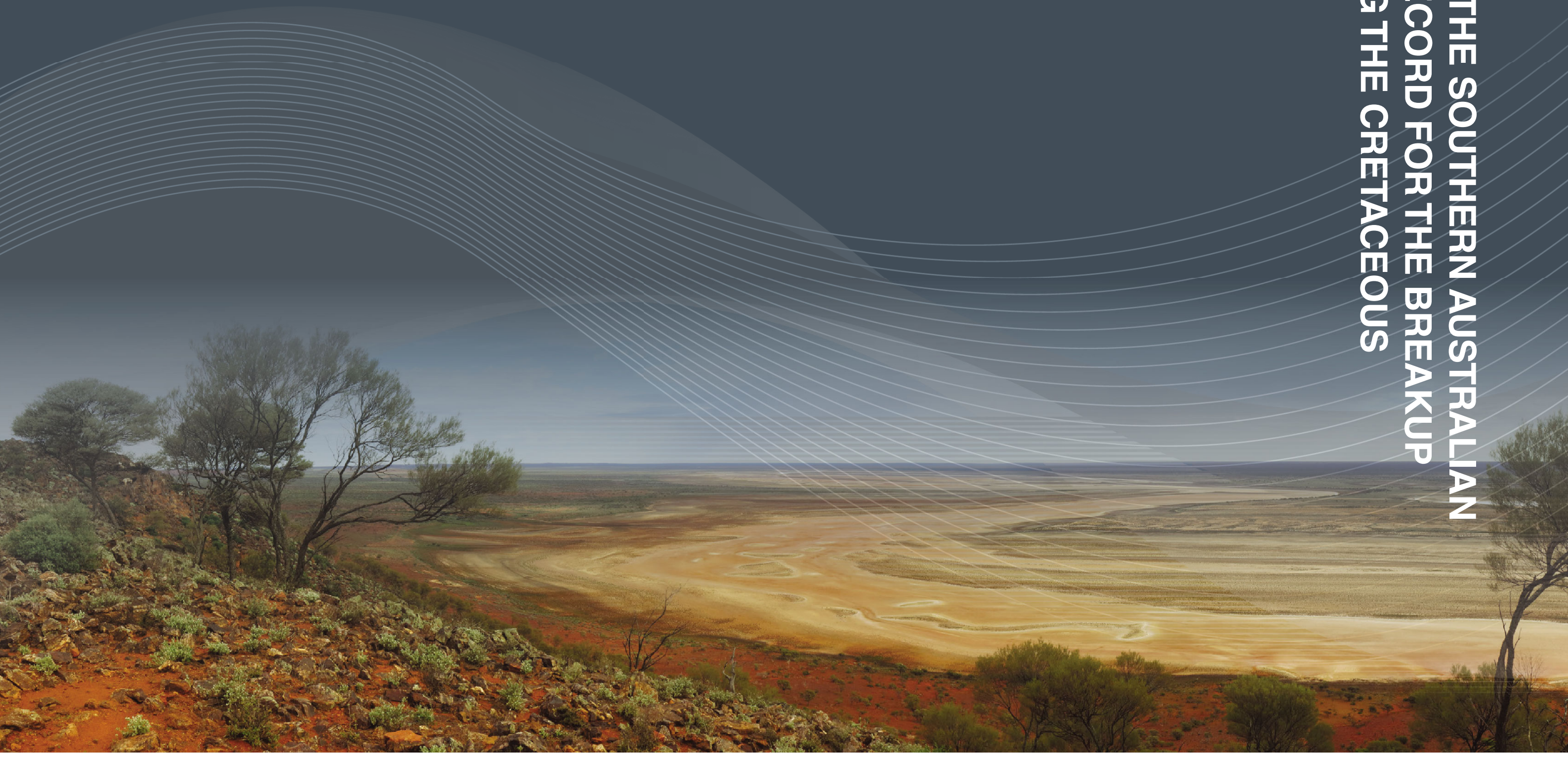
STRATIGRAPHIC EVOLUTION OF THE SOUTHERN AUSTRALIAN ONSHORE BIGHT BASIN: A RECORD FOR THE BREAKUP OF GONDWANA DURING THE CRETACEOUS



Reynolds