



Comparison of provenance of northern- and southern-sourced Scamander Formation in Eastern Tasmania

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Geological Survey Technical Report 39:

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Cover: Author at the MM006 collection site, a coarse-grained sandstone of the Scamander Formation.

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Comparison of provenance of northern- and southern-sourced Scamander Formation in Eastern Tasmania

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1.0 INTRODUCTION

This project, which has generated new U-Pb radiometric ages of detrital zircon within the upper Mathinna Supergroup near Scamander on the east coast of Tasmania, was a collaborative effort between the University of Tasmania and Mineral Resources Tasmania. It comprised two components. Firstly, the crystallisation age of the date the Scamander Tier dyke was determined using U/Pb zircon analysis. A second component aimed to further elucidate the provenance to the Devonian sandstones in the Scamander area east of Catos Creek dyke.

Radiometric dating of detrital zircon grains in sandstones across the Lachlan Orogen can provide key insight into their provenance (e.g. Squire et al., 2006; Glen et al., 2017). While there are a number of analyses reported from across the Lachlan Orogen including Tasmania (Black et al., 2005; Habib et al., 2022) there is very little information available from the Devonian sandstones of NE Tasmania. The aim here is to add to data reported by Knight et al. (2022) so as to provide a representative suite of analyses from the Scamander Formation and link that to the other evidence of a changing depositional environment near the end of the Mathinna

Supergroup cycle of deposition (Powell et al., 1993; McClenaghan et al., 1992; Worthing and Woolward 2010).

2.0 REGIONAL GEOLOGY

The Mathinna Supergroup (Figure 1) is a 7 km-thick succession of a turbiditic sandstone and mudstone deposited from the Ordovician to the Devonian (Powell et al., 1993; Reed, 2001). It is divided into two main units (Calver et al., 2014), the Tippogoree Group and the younger Panama Group (Seymour et al., 2011). The youngest (Lower Devonian) section of the Panama Group is the Sideling Formation in the west and the Scamander Formation in the east (Calver et al., 2014).

Here we concentrate on the Scamander Formation and other siliciclastic rocks east of Catos Creek dyke (Figure 2) which are also probably Devonian in age (Turner and Calver, 1987). The Scamander Formation is a turbidite package with thick quartz sandstone beds, fault bounded in the west and extending east to the Scamander coastline (Worthing and Woolward, 2010). The thick sandstone units are overlain unconformably by the St. Marys Porphyry (Turner et al., 1986) in the south, and intruded by the Scamander Tier dyke.

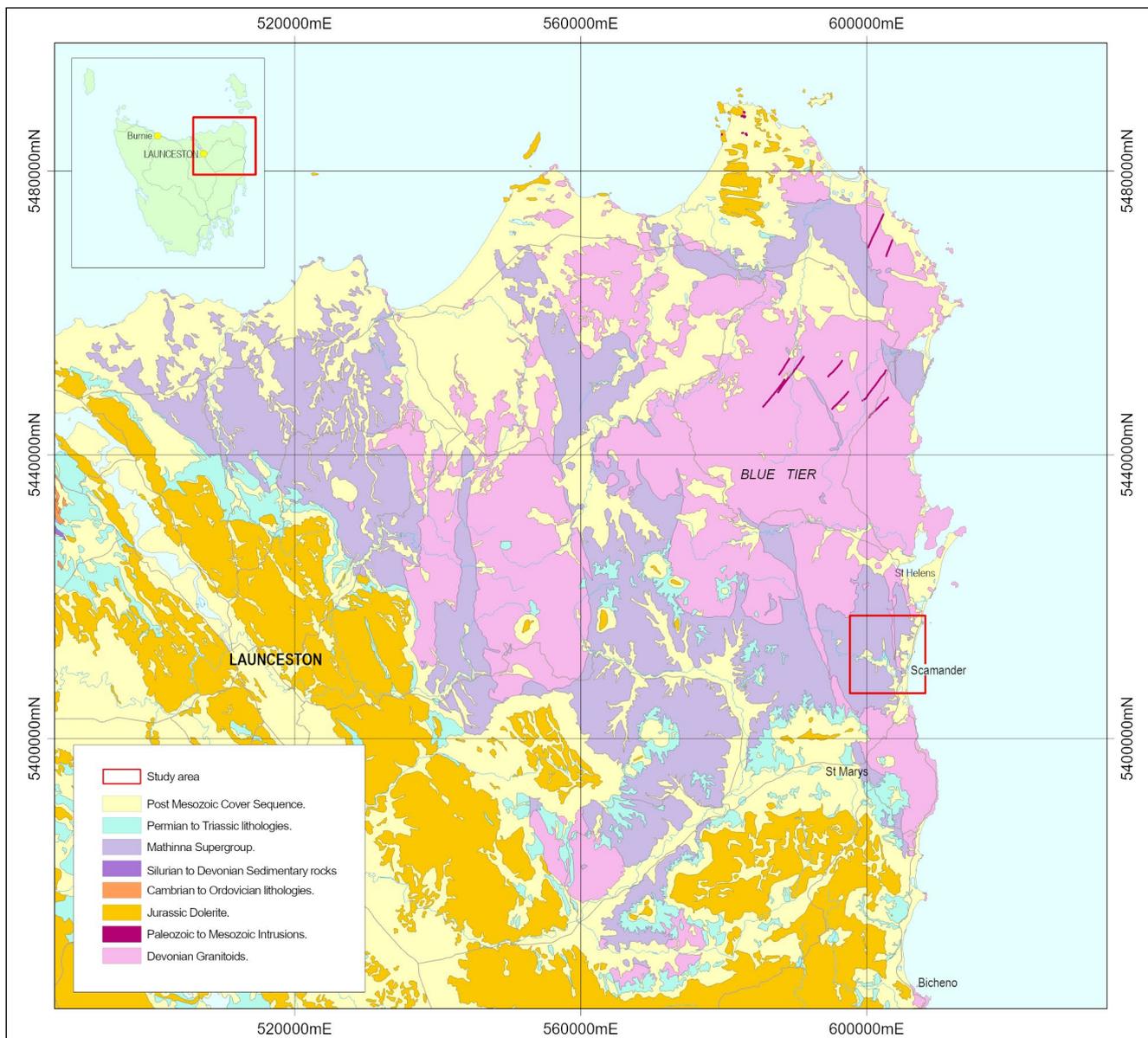


Figure 1. Geology of NE Tasmania (From 1:500 000 Map Brown et al., 2021). Purple = Mathinna Supergroup; Pink=intruding granitoids; Blue, green and orange = overlying Tasmania Basin; Yellow = younger sediment and basalt. Red box refers to sample area detailed in Figure 2.

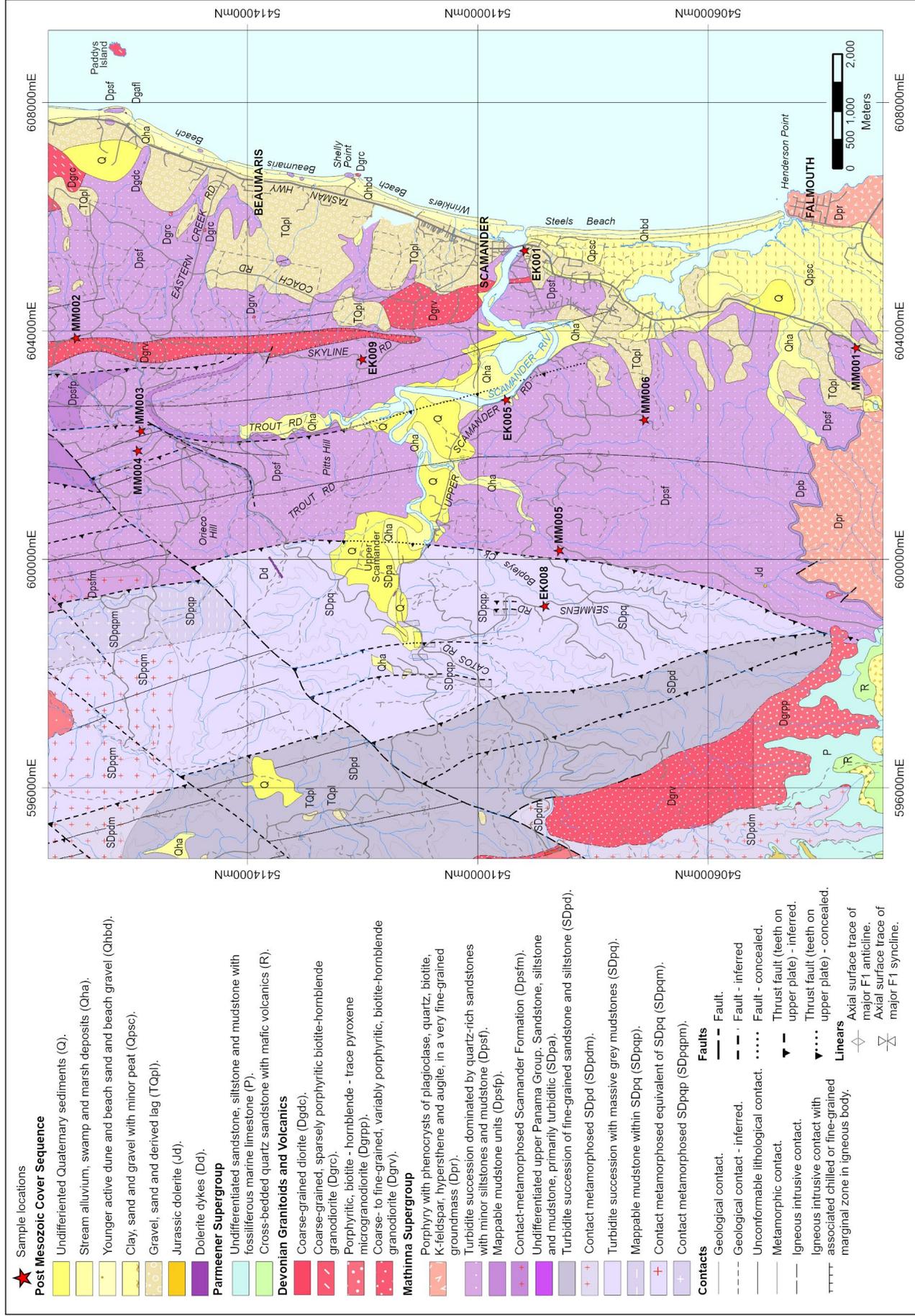


Figure 2. A map of the geology of Scamander area showing the main units and the sample locations inclusive of those reported in Knight et al., (2022) (accurate). Scale is 1:7500. Created by MRT (Simard, 2022).

Paleocurrent measurements from the Scamander Formation (McClenaghan et al., 1992; Powell et al., 1993) indicate transport from two directions within the Scamander Formation. Paleocurrents reported from the north of the study area suggest water movement towards the south (Figure 3) and in the south are towards the NNW. A divide of the paleocurrent directions with a NW-SE orientation, was inferred south and west of Scamander (McClenaghan et al., 1992). Worthing and Woolward (2010) also measured paleocurrent direction from cross bedding, slump folds, flute casts, tool marks, ripple marks and convolute lamination reporting broad orientations consistent with these findings.

Powell et al. (1993) reported the Scamander Formation as a sand-rich succession of sublitharenite and litharenite with variable feldspar content. They recognised the two distinct palaeocurrent domains. The domain dominated by south directed currents contain double the feldspar content of sandstones in the domain dominated by NNW directed currents. They concluded that the new source of feldspar was probably the Late Silurian-lowermost Devonian silicic igneous rocks in eastern Victoria. Worthing and Woolward (2010) recognised the domain of south directed currents also contained sandstone with a distinctive very low Na₂O content (red spots on Figure 3).

U/Pb detrital zircon analyses have previously been reported from the Stony Head Sandstone and the Silurian section of the Panama Group (Black et al., 2004, Habib

et al., 2022). These samples have features typical of the Gondwana signature but a small component of a West Tasmanian source was also detected (Habib et al., 2023).

More significantly, Knight et al. (2022) analysed three sandstone samples from the Scamander area: two from the Scamander Formation; and one from further west, but still in the presumed Devonian sandstones east of Catos Creek dyke. The maximum ages of deposition were 408.2 ± 6.6 Ma (EK008), 404.9 ± 5.4 Ma (EK009) and 397.2 ± 8.8 Ma (EK001). Detrital zircons older than 500 Ma have the typical Gondwana signature found in the older samples of the Mathinna Supergroup.

The Scamander Tier dyke is exposed almost continuously from the Blue Tier Batholith to the Scamander River (Figures 1 and 2). Worthing and Woolward (2010) describe the Scamander Tier dyke as a porphyritic I-type microgranodiorite. Turner et al. (1986) concluded this dyke is the intrusive equivalent of the succession of dacitic, ash-flow tuffs, the St Marys Porphyry. Geochemical analysis by Worthing and Woolward (2010) and Turner et al. (1986) convincingly supports a comagmatic relationship between the Scamander Tier dyke, Catos Creek dyke and the St Marys Porphyry. They are also closely linked to magmatism of the Blue Tier Batholith (McClenaghan et al., 1992).

Turner et al. (1986) determined the crystallisation age of the Scamander Tier dyke at 386 ± 5 Ma and St Marys Porphyry at 388 ± 1 Ma using Rb-Sr and K-Ar methods.

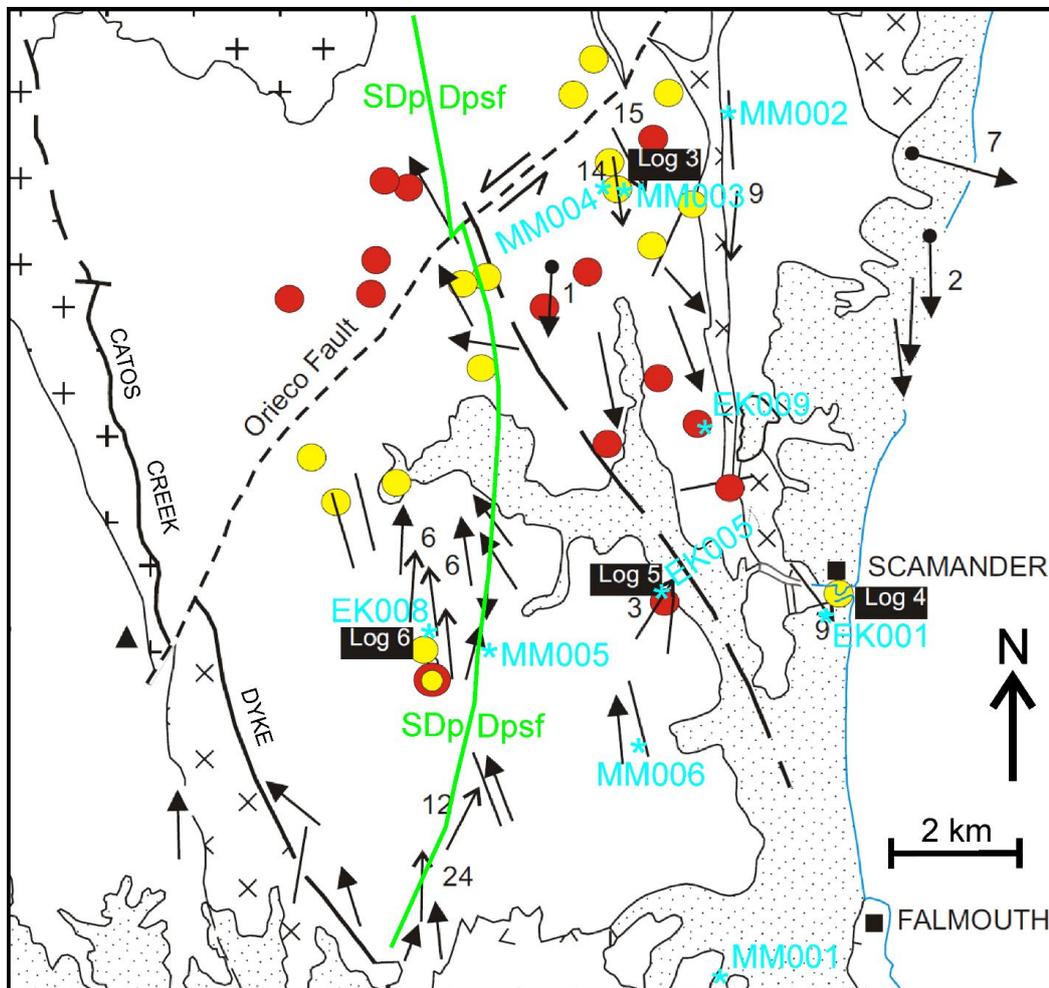


Figure 3. Map showing current direction data from Worthing and Woolward (2010). Geochemical samples shown in yellow for normal Na₂O and red for low Na₂O. Boundary of Scamander Formation shown in green. Sample locations from this paper and Knight et al. (2022) in pale blue.

3.0 METHODS

Five samples were collected from the Scamander area (Table 1; Appendix 1). Four of the samples were from coarse sandstone beds in the Scamander Formation. These samples were chosen for their locations close to paleocurrent direction measurements. MM001 was not analysed and paleocurrent measurements are not known for this sample. MM003 and MM004 are from the south directed paleocurrent domain. Samples EK005, MM005 and MM006 are from the NNW current directed domain. One sample (MM002) was taken from a porphyritic outcrop of the Scamander Tier dyke.

Four collected sandstone samples MM002, MM004, MM005 and MM006 were chosen for dating. The rock samples were crushed and milled. Zircon grains were separated using a panning technique. The pan concentrates were mounted in 25 mm round epoxy blocks. EK005 zircons were separated and mounted by Knight et al. (2022). The mounts were photographed using an optical microscope and by cathodoluminescence using a SEM at the Central Science Laboratories, University of Tasmania. These images were used in selecting zircon grains suitable for laser ablation. From each sample (MM002, MM004, MM005, MM006, EK005), 70 – 90 zircons were chosen for U-Pb isotope analysis. The analyses were conducted at CODES, University of Tasmania, using LA-ICPMS on polished mounts. De-

tails of the methods used can be found in Appendix 2. Images of sampled zircons are available in Appendix 3. Appendix 4 includes analytical results in full.

4.0 RESULTS

4.1 Detrital zircons in the Scamander Formation

4.1.1 Sample MM004

Zircons in this sample included a few zircons with euhedral magmatic shapes but most are fractured or rounded. The metamict zircons (black in CL) were not analysed (Figure 4a). Overall, zircons were up to 150 μm in diameter (Figure 4a).

Of the 79 analyses conducted on MM004, 14 were excluded due to Pb loss, high common Pb, or failing the concordance criteria. From the concordant grains the spectrum has peaks at 500 to 600 Ma and at about 1000 Ma typical of Tasman Fold Belt samples (Figure 5). There is also a peak at 410 Ma, 470 Ma and 500 Ma. The 500 Ma has been reported from Victorian sandstones. Habib et al. (2023) showed that 470 Ma zircons in the Stony Head Sandstone came from the Macquarie Arc. The 410 Ma peak in this sample is consistent with volcanic rocks common in eastern Victoria such as the Snowy River Volcanics. The three youngest zircons were used to calculate a maximum depositional age of 409.0 ± 5.6 Ma (Table 2) for this sample. MM004 contained the highest proportion of Archean zircons of all the samples analysed (Figure 5).

Table 1. Outcrop descriptions and sample locations.

| Field No. | MRT No.? | General Location | Mathinna Supergroup Formation | Lithology | Zone | Easting | Northing | Comments |
|-----------|----------|------------------------|-------------------------------|--|------|---------|----------|--|
| MM001 | | Roses Creek Quarry | Scamander Formation | Fine to medium grained sandstone | 55G | 603700 | 5403437 | Base of 40cm amalgamated sandstone bed. Convolute bedding, slumping and loading found in sandstone beds |
| MM002 | | Loila Tier Road Quarry | Scamander Tier dyke | Igneous porphyritic rock | 55G | 603871 | 5416987 | Alignment of feldspars or increased biotite in some portions of the outcrop. Prominent (1-4cm) K-feldspar phenocrysts. |
| MM003 | | Arm Creek | Scamander Formation | Fine to medium grained sandstone (SSE cd*) | 55G | 602241 | 5415912 | Carbonaceous spots and possible plant fossils. Sample take from the base of a 20cm thick bed. |
| MM004 | | Arm Creek | Scamander Formation | Coarse grained sandstone (SSE cd*) | 55G | 601898 | 5415912 | Base of a 20cm bed. Some parts of the outcrop were slightly altered. |
| MM005 | | Workers Creek | Scamander Formation | Medium to coarse grained sandstone (NNW cd*) | 55G | 600152 | 5408594 | Sample taken from a weathered outcrop with some quartz veins. |
| MM006 | | Lower Scamander | Scamander Formation | Partly silicified coarse grained sandstone (NNW cd*) | 55G | 602436 | 5407114 | Sample was taken from the base of a 50cm thick amalgamated sandstone bed. |
| EK005 | | Lower Scamander Road | Scamander Formation | Medium to coarse sand (NNW cd*) | 55G | 602789 | 5409518 | Sample from thick sandstone (Knight et al., 2022). |

*cd= current direction

Table 2. Key features of zircon analyses.

| Field Sample No. | Youngest Zircon Age (Ma) | Total No. of Zircons | No. Rejected | No. Used in Max Dep Age | Weighted Mean of Max Dep Age (Ma) |
|------------------|--------------------------|----------------------|--------------|-------------------------|-----------------------------------|
| MM002 | 368.17 +3.9 - 4.2 | 68 | 21 | 23 | 391.5 ± 1.6 |
| MM004 | 407 +6.6 -8.3 | 79 | 14 | 3 | 409.0 ± 5.6 |
| MM005 | 407 +4.4 -4.5 | 90 | 12 | | |
| MM006 | 488.33 +4 -4.9 | 95 | 16 | | |
| EK005 | 352 | 76 | 13 | 2 | 412.4 ± 3.0 |

4.1.2 Sample MM005

The CL imaging showed zircons similar to MM004 (Figure 4b) but in general larger crystals. Overall, there were less zircons that had clear euhedral shapes and more that were black in CL than in MM004. Zircons were variable in size but some were up to 200 µm long.

In total, 12 of the 90 analyses were rejected for Pb loss, high common Pb, or failing the concordance criteria. The older zircon grains define peaks in Cambrian and Proterozoic zircons of 650 – 520 Ma, and 1250 – 1000 Ma typical of the Tasman Fold Belt Gondwana signature (Figure 6). There is a large peak at 480 Ma typical of a source in the Macquarie Arc. There were two detrital zircon grains at 430 – 410 Ma, however, these were not sufficient to define a maximum depositional age for this sample (Figure 6).

4.1.3 Sample MM006

Zircon crystals in this sample were more rounded than in the other two samples. The CL imaging showed zircons are often fragmented and many display zoning. A few grains are euhedral. The grain size was typically 80 µm diameter (Figure 4c).

Sixteen zircon analyses were rejected from the 95 analyses as they failed to meet the concordance criteria. Most either contained inclusions, showed evidence of Pb loss or had high levels of common Pb. All the zircons in this sample were older than 488 Ma. The largest peak in the age spectra is at 620 to 520 Ma with a secondary peak at 1300 – 800 Ma. The spectra is typical for the Tasman Fold Belt (Squire et al., 2006; Berry et al., 2019; Habib et al., 2022), with only one grain from younger sources (Figure 7).

4.1.4 Sample EK005

CL Imaging for this sample was completed by Knight et al. (2022) (Figure 4d). Out of the 75 zircons picked for analysis for EK005, 13 were rejected as they failed to meet the concordance criteria. Most either contained inclusions, showed evidence of Pb loss or had increased levels of common Pb. The sample is dominated by a Lower Devonian peak at 412.4 ± 3.0 (Figure 8). There is a secondary peak at 430 Ma and the remaining older

grains scatter from 450 Ma to the Archean. There are small peaks around 550 Ma and 1000 Ma suggesting that the background Gondwana source is contributing to this sample. The dominance of younger zircons in this sample is consistent with the recognition of volcanic lithic fragments in the petrography.

4.2 Zircon from the Scamander Tier dyke sample MM002

The zircons in MM002 have a variety of morphologies with magmatic euhedral shapes, broken grains and some that were black in CL (metamict). Fractured and metamict zircons were not analysed. Some are large, although most are around 1-2 mm long (Figure 4e).

Out of the 68 zircons selected for analysis 21 were rejected as they failed to meet the concordance criteria. Most contain inclusions, show evidence of Pb loss or had high levels of common Pb. A preferred age of crystallisation was calculated from 23 zircons in the dominant peak in the zircon spectra. The age of the Scamander Tier dyke sample MM002 was determined to be 391.5 ± 1.6 Ma (Figure 9, Table 2).

There was a scatter of zircon ages back to 500 Ma reflecting partly reset inherited grains. Four concordant grains had apparent ages younger than the preferred crystallisation age of the granite (Figure 9).

5.0 IMPLICATIONS OF AGE DATING

5.1 Comparison to one another

The detrital zircon spectra all show and range of older grains typical of the ‘Gondwana signature’ probably reflecting reworking of older Tasman Fold Belt rocks. However, samples MM005 and MM006 do not contain any Devonian zircons that could be dated (Figure 10). They are also from the domain dominated by NNW directed currents (Figure 3). For samples collected in the domain dominated by south directed currents such as sample MM004 the spectra include significant peaks at 410 Ma and 470 Ma. Sample EK005 is dominated by the 410 Ma peak. All the samples from the Scamander Formation (Figure 2) suggest the maximum depositional age is best defined by the zircons in sample MM004

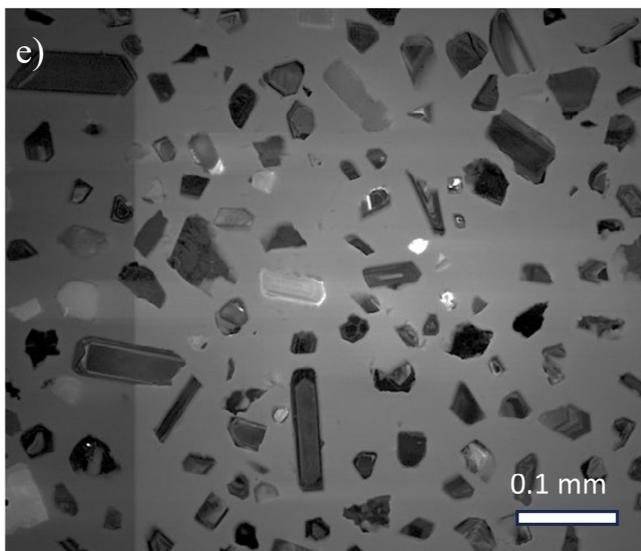
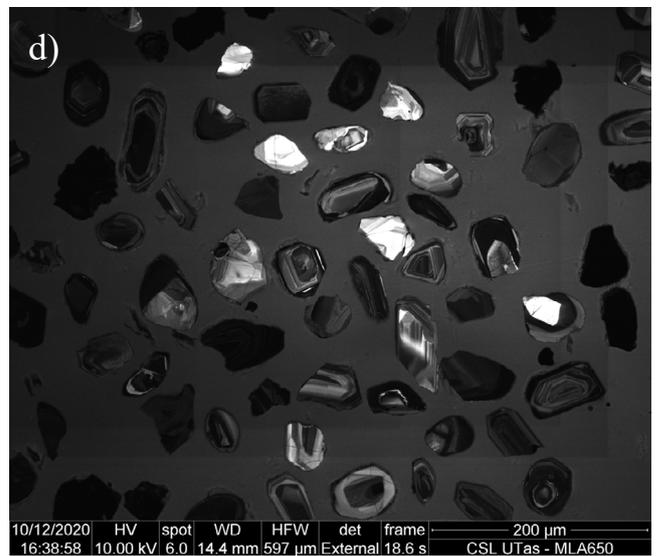
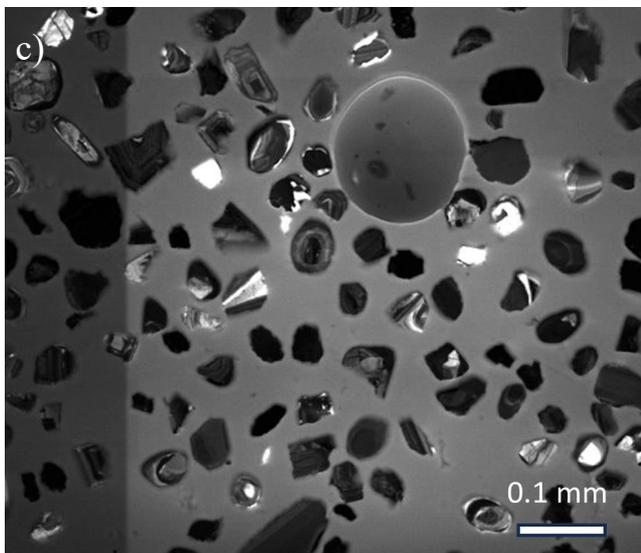
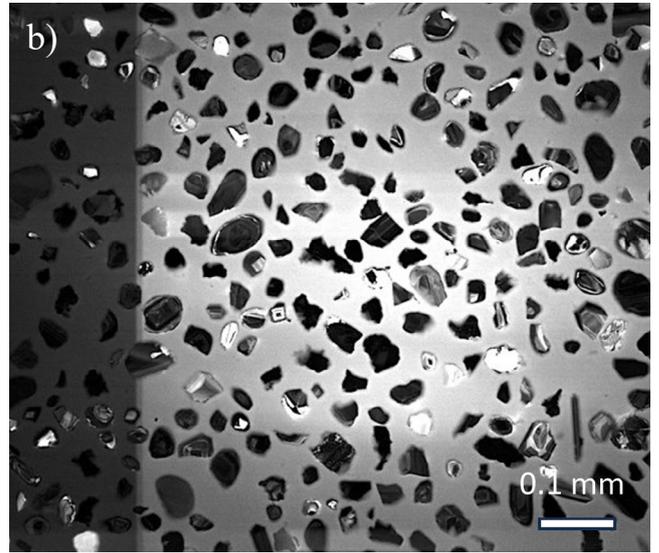
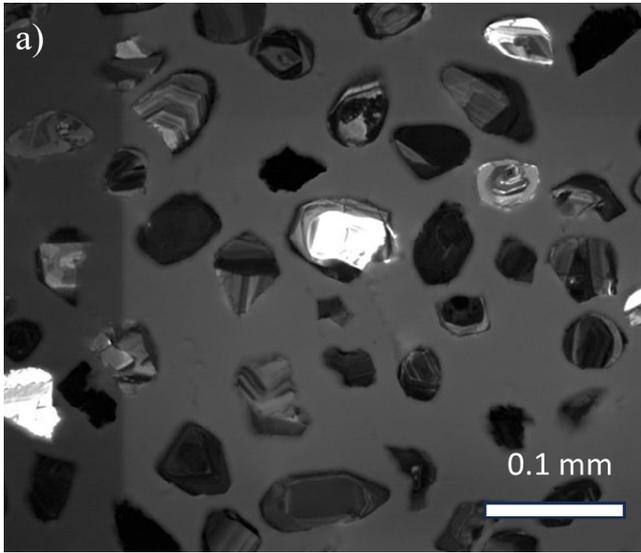


Figure 4. CL image of zircons in:

- a) sample MM004;
- b) sample MM005;
- c) sample MM006;
- d) sample EK005;
- e) sample MM002.

Age and Concordance of Zircons from Sample MM004

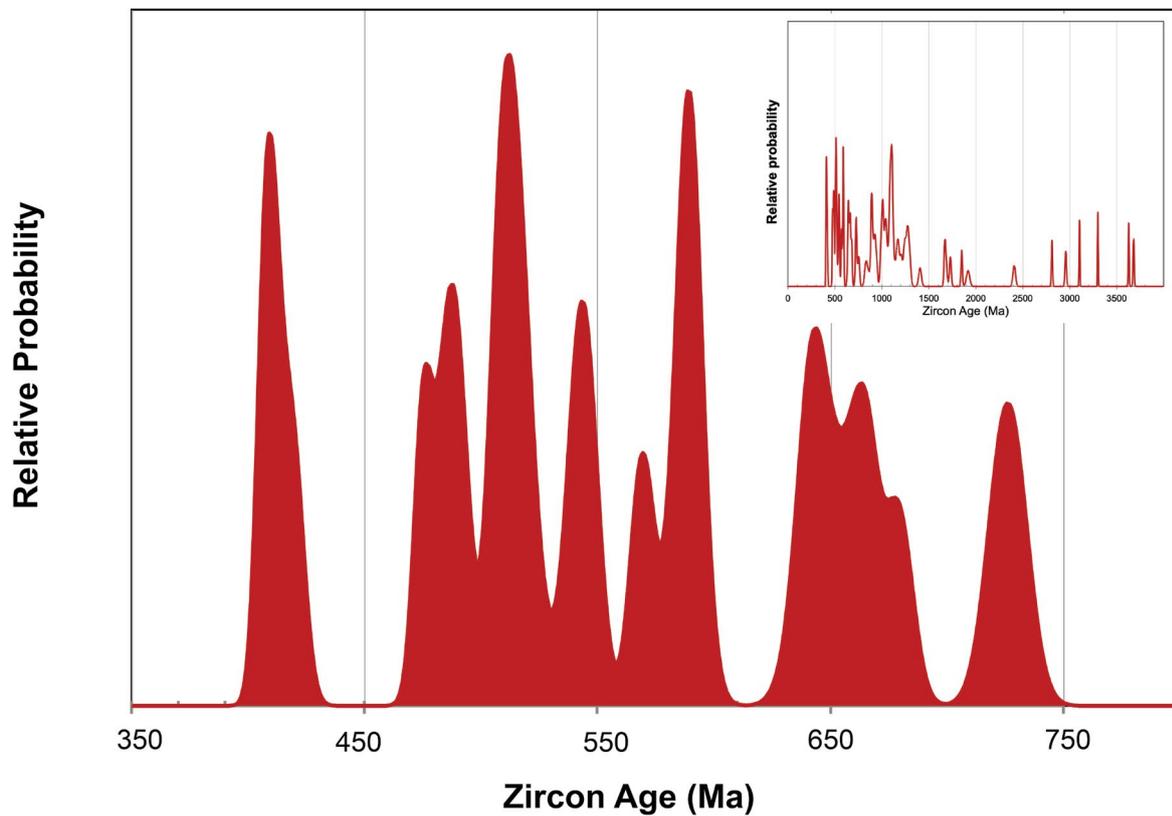
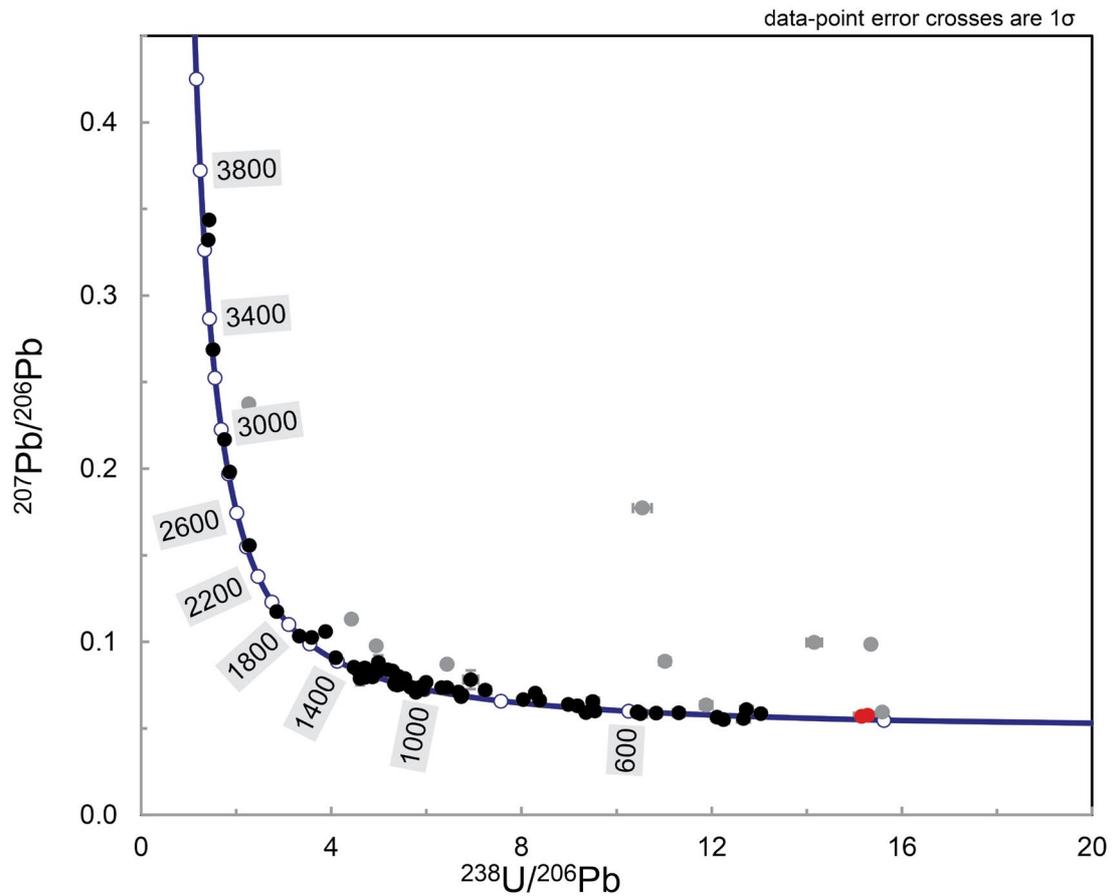


Figure 5. Radiometric age and concordance data for the zircons from sample MM004, from Upper Scamander. a) The Tera-Wasserburg plot. b) The probability density plot for the zircon ages for sample MM004.

Age and Concordance of Zircons from Sample MM005

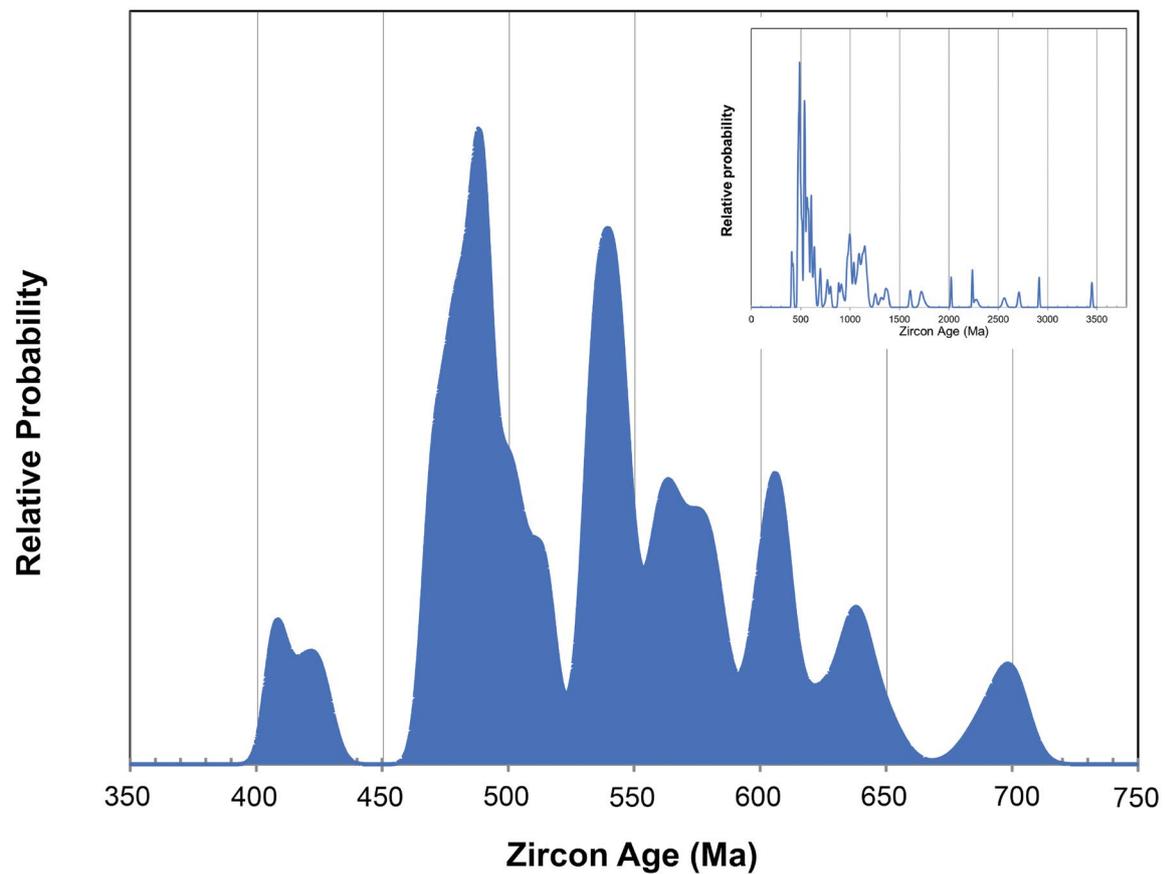
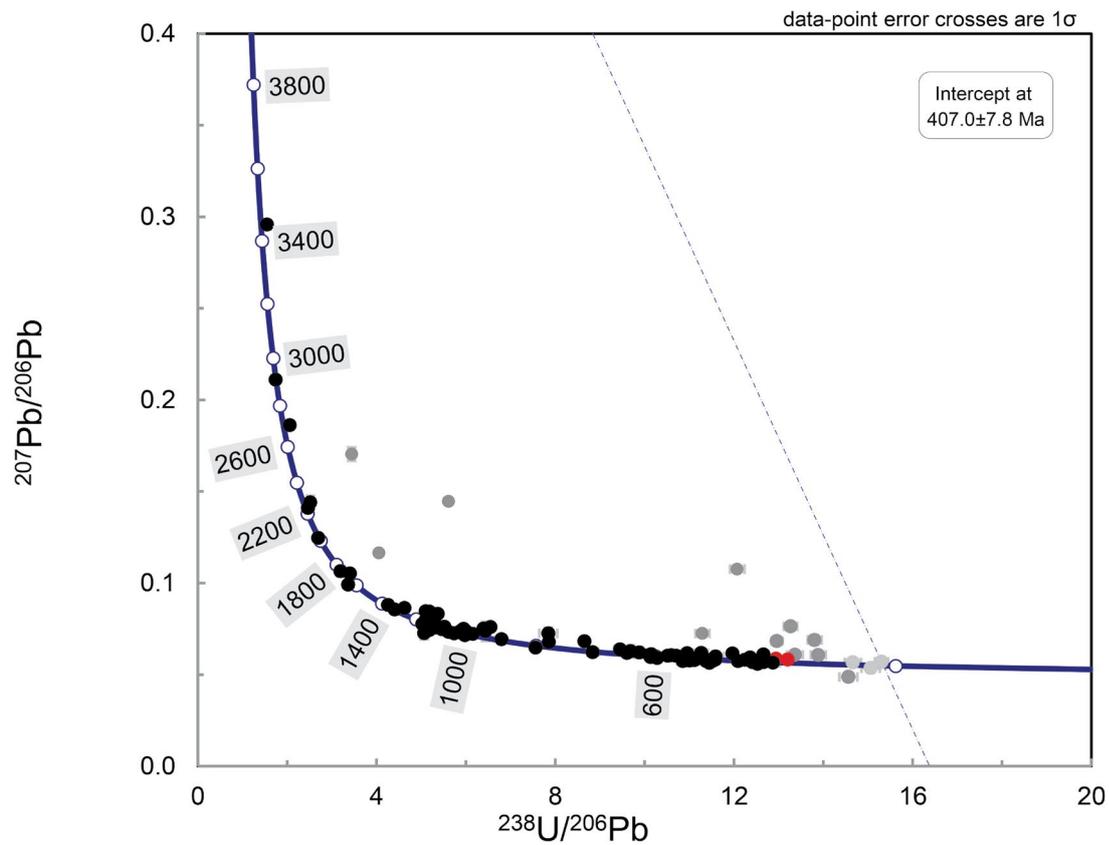


Figure 6. Radiometric age and concordance data for the zircons from sample MM005, from Lower Scamander. a) The Tera-Wasserburg plot b) The probability density plot for the zircon ages in sample MM005.

Age and Concordance of Zircons from Sample MM006

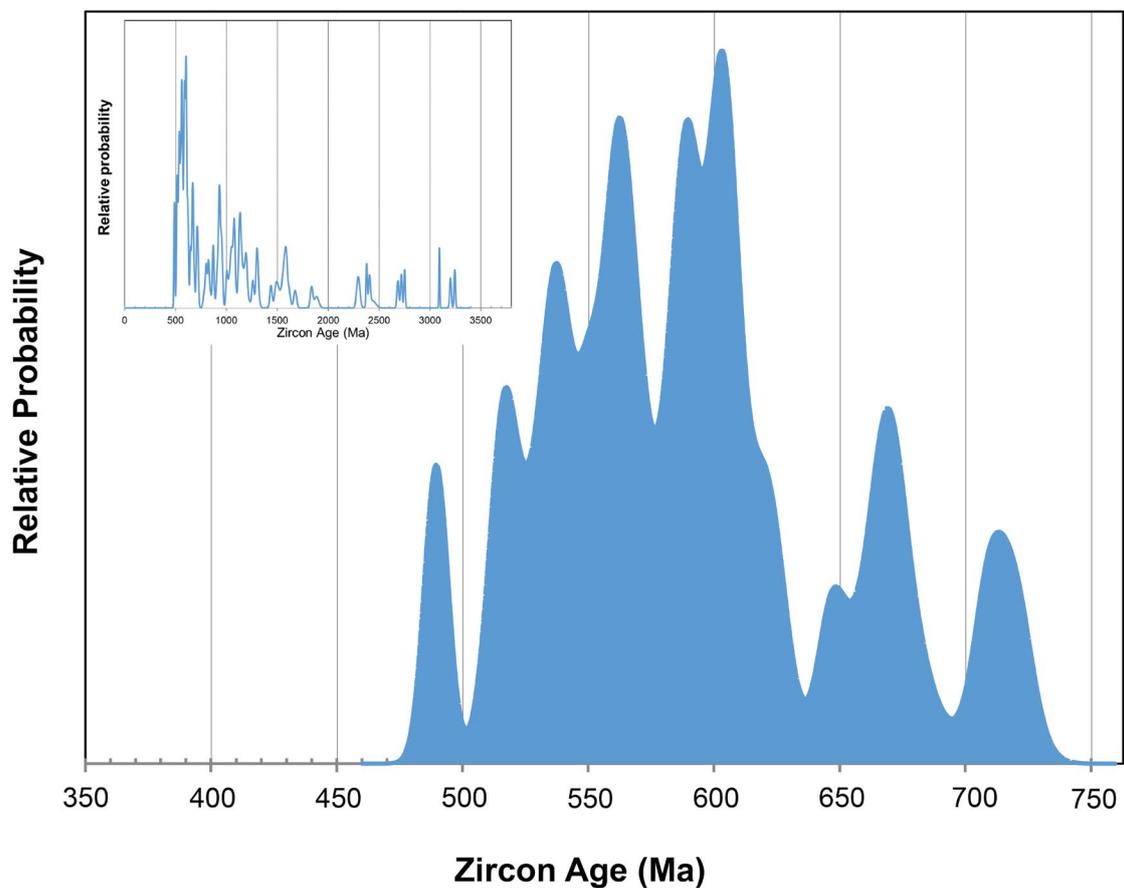
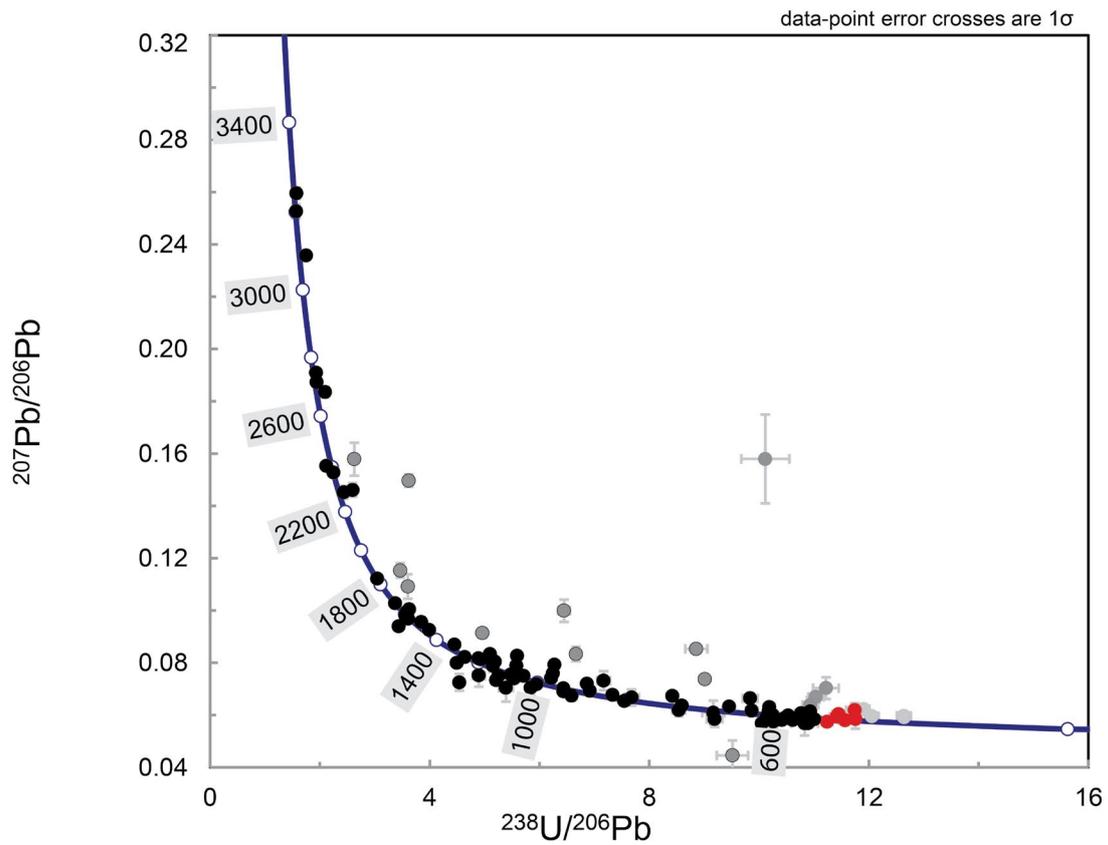


Figure 7. Radiometric age and concordance data for the zircons from sample MM006, from Lower Scamander. a) The concordance graph. b) The probability density plot for the zircon ages for sample MM006.

Age and Concordance of Zircons from Sample EK005

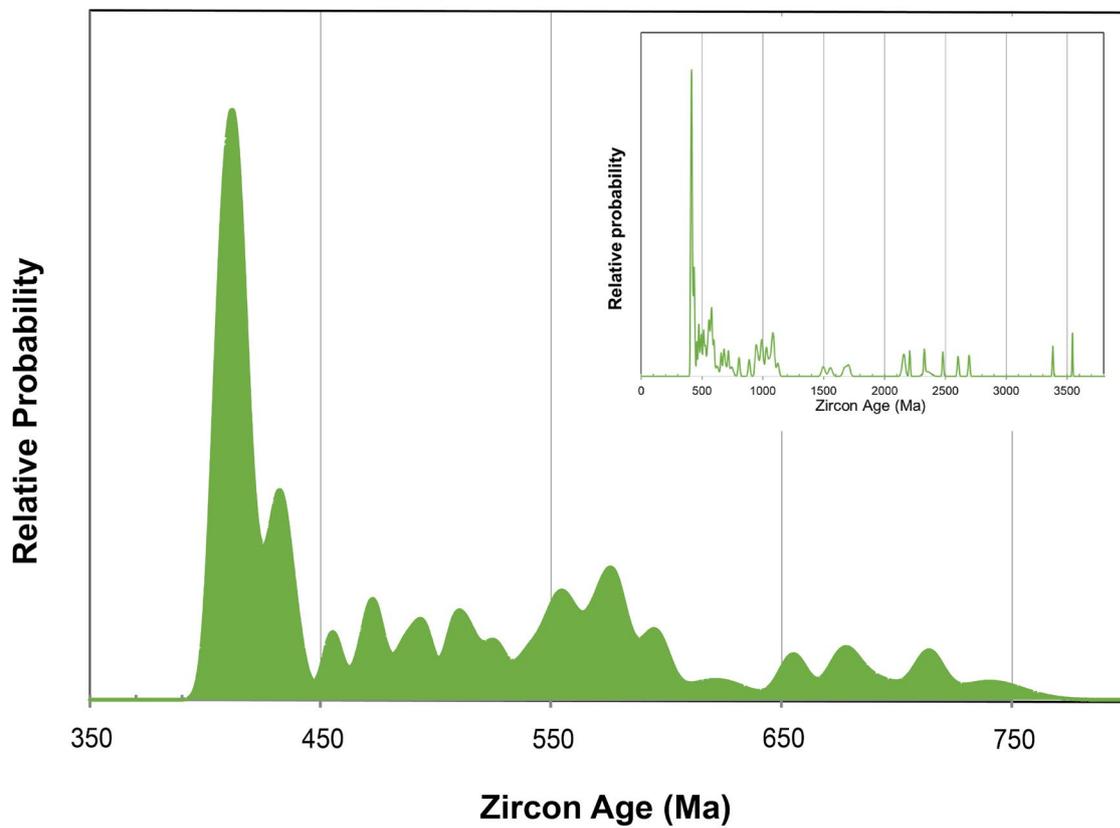
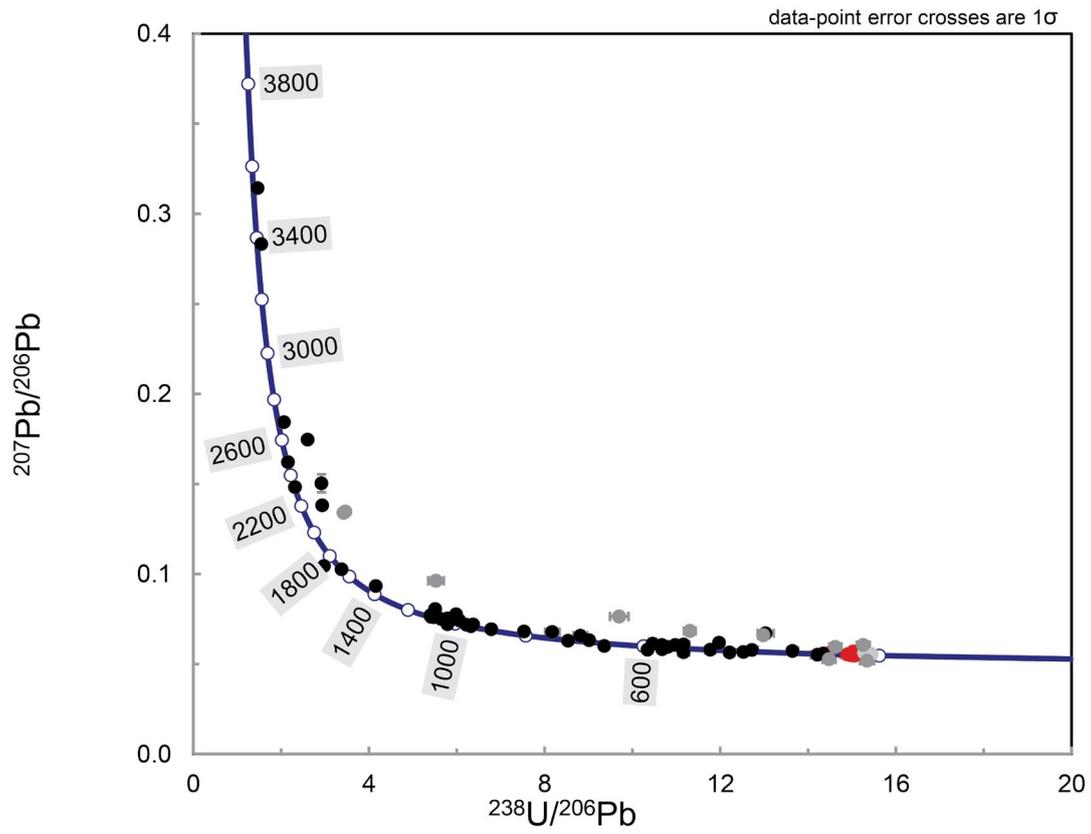


Figure 8. Radiometric age and concordance data for the zircons from sample EK005, from Lower Scamander.

Age and Concordance of Zircons from Sample MM002

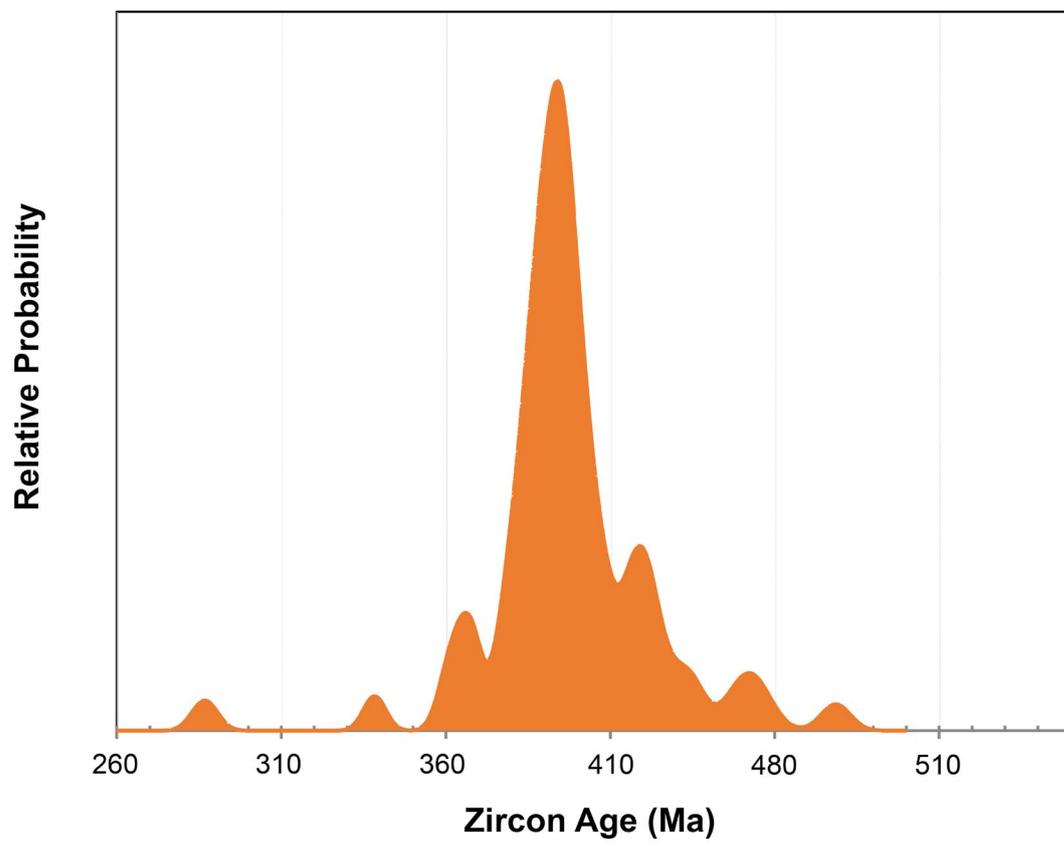
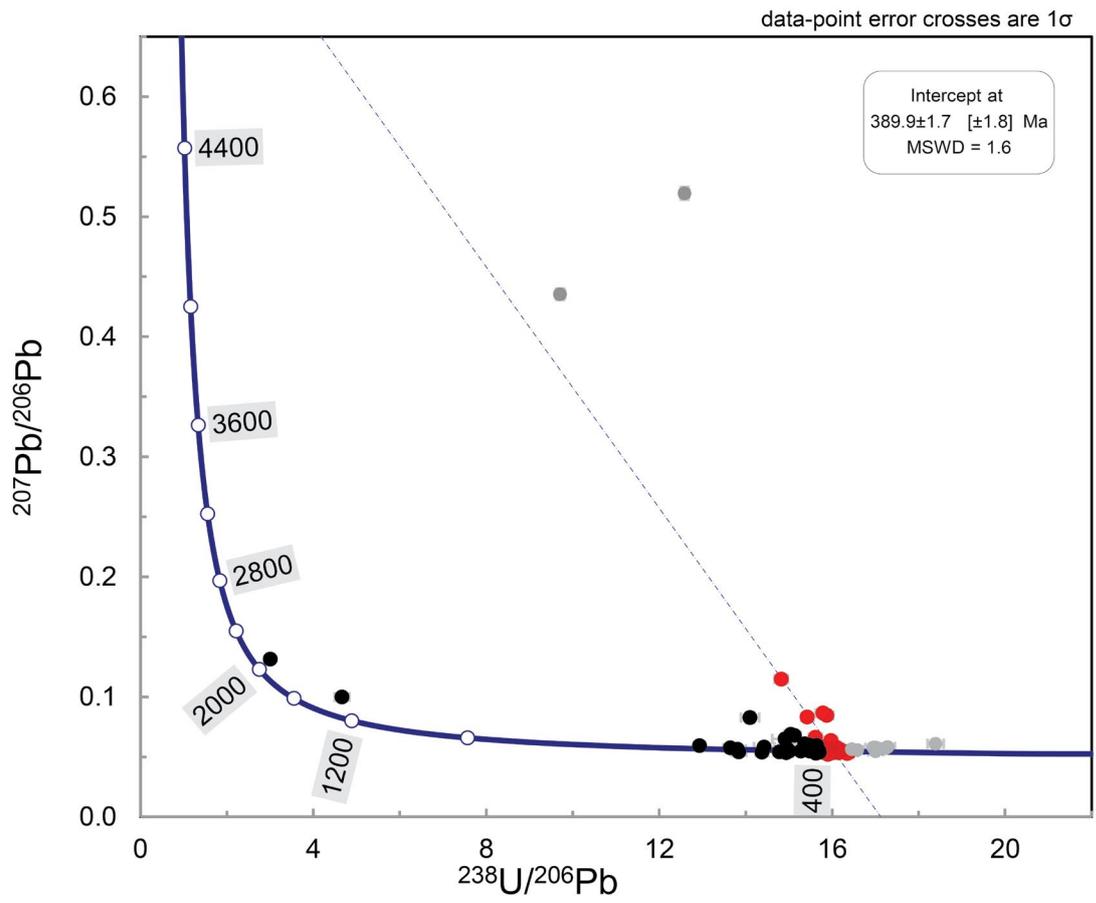


Figure 9. Radiometric age and concordance data for the zircons from sample MM002, from Upper Scamander. a) The Tera-Wasserburg plot. b) The probability density plot for the zircons for the igneous sample MM002.

which is 409 ± 6 Ma consistent with the Pragian (~411-407 Ma) age reported from this area by Rickards and Banks (1979). The young ages reported in EK005 are consistent with the influx of new volcanogenic material from the north in the Lower Devonian (Powell et al., 1993).

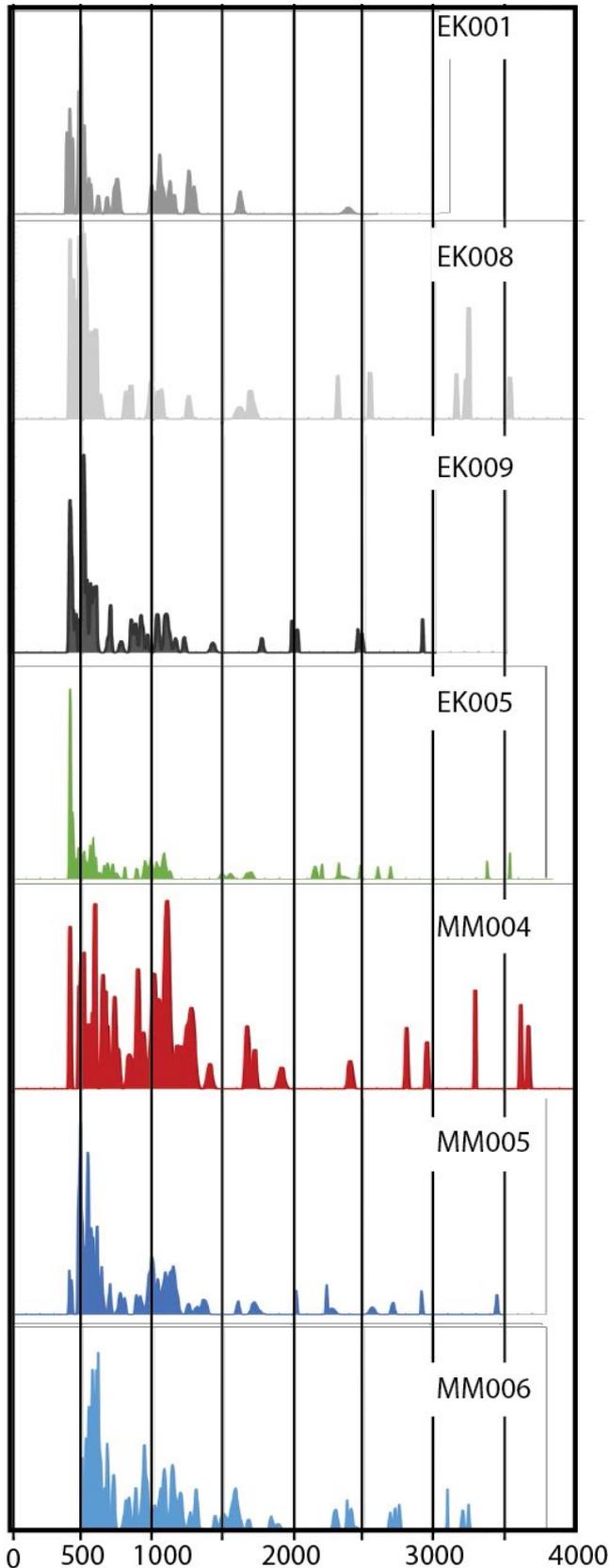


Figure 10. Data on zircon age populations for EK001 (light grey), EK008 (dark grey) and EK009 (black) from Knight et al. (2022) compared to EK005, MM004, MM005 and MM006 from this study.

The Scamander Tier dyke was dated at 391.5 ± 1.6 Ma. This provides a minimum age for the Scamander Formation. It is slightly older than the preferred age for the St Marys Porphyry (388 ± 1 Ma) but given the latter age was deduced using Rb-Sr and K-Ar methods, with a lower closure temperature, the suggestion they are comagmatic (Turner et al. 1986) cannot be excluded.

5.2 Comparison of zircon age data with other Scamander area sandstones

The three samples reported in Knight et al. (2022) all have a suite of older zircons typical of the ‘Gondwana signature’ (Figure 10). They calculated a maximum depositional age for all three samples that demonstrated the samples were no older than Pragian. This included sample EK008 which is west of the presently defined limit of the Scamander Formation (Figures 2, 3) and supports previous suggestions that all Mathinna Supergroup rocks east of Catos Creek dyke are Lower Devonian (Turner and Calver 1987).

The 410 Ma and 470 Ma zircon peaks in age spectra from the new samples are also seen in EK008 and EK009. EK008 also has a few zircons at 430 Ma and 450 Ma. Sample EK001 has a spread of U/Pb detrital zircon peaks from 440 – 395 Ma and a peak at 500 Ma. In general, all samples in the domain dominated by south directed paleocurrents have a large component of post Cambrian zircons but in the domain dominated by NNW directed paleocurrents only half of samples have post Cambrian detrital zircons. We conclude that the younger detrital zircons are introduced into the basin by the southward prograding sand wedge recognised by Powell et al (1993).

5.3 Comparison of zircon age data of local igneous rocks with the Scamander Tier dyke

The U-Pb zircon radiometric average age of crystallisation for the Scamander Tier dyke is 391.5 ± 1.6 Ma. The emplacement of the Blue Tier Batholith, of which the dyke is a part of, took place over approximately 22 million years with the oldest intrusion, the Garden Granite dated at 400 ± 2 Ma (Black et al., 2005, Kositsin and Everard, 2013; Figure 11). This places the Scamander Tier dyke mid to late in the emplacement history of the Blue Tier Batholith, as suggested by McClenaghan (2006).

The 391.5 ± 1.6 Ma of the dyke is similar to the 388 ± 1 Ma Rb-Sr and K-Ar age of the St. Marys Porphyry (Turner et al., 1986). This strengthens the theory that the Scamander Tier dyke was a feeder for the St. Marys Porphyry (Turner et al., 1986, Black et al., 2005; Worthing et al., 2010a, b).

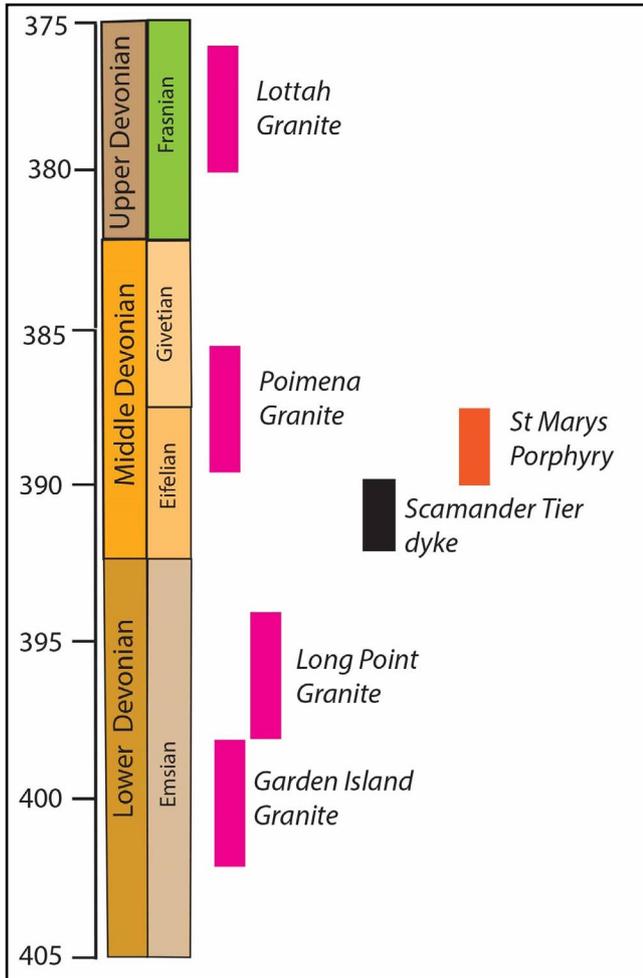


Figure 11. Comparison of age data for igneous rocks in the Scamander area. In pink are U-Pb zircon ages for granite bodies in the Blue Tier Batholith to the north and the Long Point Granite in the south. Data from Black et al., 2005, Kositsin and Everard, 2013 and McClenaghan, 2014. The orange is the Rb-Sr age range at 95% confidence level for St Marys Porphyry (Turner et al., 1986). In black is the U-Pb zircon age for the Scamander Tier dyke from this study sample MM002.

6.0 CONCLUSIONS

U-Pb detrital zircon age dating of sandstones from the Mathinna Supergroup at Upper and Lower Scamander confirm a Lower Devonian depositional age. Ordovician to Lower Devonian zircons in these sandstones probably come from volcanic rocks in eastern Victoria. The Cambrian and older detrital zircons are typical for Tasman Fold Belt Palaeozoic sandstone including Stony Head Sandstone and the Silurian sandstone from west of Catos Creek dyke.

The new data provides the first U-Pb date for the Scamander Tier dyke at 391.5 ± 1.6 Ma.

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APPENDICES

Located :

<https://www.mrt.tas.gov.au/mrtdoc/dominfo/download/TR39/>



Appendix 1 - Location and descriptions of samples
EK001-EK009
-Download-



Appendix 2 - Zircon sample preparation, analyses and data reduction methods
-Download-



Appendix 3 - Cathodoluminescence images of zircon mounts EK001, EK008 and EK009
-Download-



Appendix 4 - Zircon analyses and calculated ages
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