An Insight into the Low-Temperature Thermal Evolution of the covered eastern Gawler Craton margin: the Stuart Shelf Basement

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

Christopher Wayne Trenouth

November 2015

THE UNIVERSITY of ADELAIDE

AN INSIGHT INTO THE LOW-TEMPERATURE THERMAL EVOLUTION OF THE COVERED EASTERN GAWLER CRATON MARGIN: THE STUART SHELF BASEMENT

ABSTRACT

Multi-method thermochronology applied to the eastern Gawler Craton, beneath the Stuart Shelf cover (Olympic Dam Domain, South Australia), reveal multiple episodes of exhumation. Modelled data from Apatite Fission Track (AFT) analysis identifies four time periods where the eastern Gawler Craton basement experienced cooling into AFT closure temperatures (~60-120°C); at1050 ± 55 Ma (Mesoproterozoic), 439 ± 14 Ma (late Ordovician-Silurian), 304 ±36 Ma (mid-Carboniferous-mid Permian) and 245 ± 52 Ma (late Permian-early Jurassic). In addition, the Carboniferous and Jurassic peaks are supported by zircon (ZHe) and apatite (AHe) (U-Th-Sm)/ He results. The Ordovician peak is interpreted as resulting from the final pulses of the Delamerian Orogeny partially, mixed with the first pulses of the Alice Springs Orogeny. The Carboniferous-Permian event is linked with widespread exhumation likely due to the final pulses of the Alice Springs Orogeny (~300Ma). The preserved Mesoproterozoic event presents new AFT data in the area and coincides with some recent studies. However, it occurs only in samples obtained from the Gawler Range Volcanics and more prominent in core depth shallower than 500m. The late Permian-early Jurassic event is comparable to events believed have to stemmed from hydrothermal events. This event compliments AFT studies in the northern Flinders Ranges. The Late Ordovician-Silurian and Carboniferous-early Permian AFT pulses confirm events seen in studies of surrounding regions. Other geochronological studies around the Olympic dam area indicate that this pulse, either results from a localised hydrothermal event or distal effects of the Musgravian Orogeny. The Jurassic event suggests that the hydrothermal effect on AFT ages may be more widespread event and not just localised to the northern Flinders Ranges as previously thought. The Ordovician event represents mixing between Delamerian and Alice Springs Orogenies. The Carboniferous-Permian event represents late distal effects of the Alice Springs Orogeny. These events match those of surrounding regions.

KEYWORDS

Exhumation, eastern Gawler Craton, Stuart Shelf, Olympic Dam Domain, Low-Temperature Thermochronology, Apatite Fission Track, Apatite Helium, Zircon Helium, South Australia

TABLE OF CONTENTS

LIST OF FIGURES AND TABLES

points have the same error bar indicated by the axis about the origin on the left showing ± 2σ. The closer an individual data point is to the age axis (right side), the more precise the measurement is, as seen by the horizontal precision axis directly below the plot (Boone *et al*., .2013). The colour assigned to each individual point indicates the uranium concentration in ppm of that particular grain, which corresponds to the colour scheme illustrated at the bottom of the figure. The units for the uranium scale are ppm. This plot was constructed using Radial plotter (Vermeesch *et al*., 2009).

Figure 8: Radial plots of single grain apatite fission track ages for samples pooled by depth and corresponding length distribution histograms for pooled sets. A) shallow samples (<500m) B) shows intermediate samples (500-800m) and C) shows pooled data for samples below 800mThe age for each point on the diagram is obtained by projecting a line from the origin onto the right curved axis in Ma. The central age for the sample is given at the top of the figure. A key feature of the radial plot is that all points have the same error bar indicated by the axis about the origin on the left showing ± 2σ. The closer an individual data point is to the age axis (right side), the more precise the measurement is, as seen by the horizontal precision axis directly below the plot (Boone *et al*., .2013). The colour assigned to each individual point indicates the uranium concentration in ppm of that particular grain, which corresponds to the colour scheme illustrated at the bottom of the figure. The units for the uranium scale are ppm. This plot was constructed using Radial plotter (Vermeesch *et al*., 2009).

Figure 9: Radial plots of single grain apatite fission track ages for all samples. AFT peaks are in purple, AHe peaks are in green and ZHe peaks are in blue. The age for each point on the diagram is obtained by projecting a line from the origin onto the right curved axis in Ma. The central age for the sample is given at the top of the figure. A key feature of the radial plot is that all points have the same error bar indicated by the axis about the origin on the left showing ± 2σ. The closer an individual data point is to the age axis (right side), the more precise the measurement is, as seen by the horizontal precision axis directly below the plot (Boone *et al*., .2013). The colour assigned to each individual point indicates the uranium concentration in ppm of that particular grain, which corresponds to the colour scheme illustrated at the bottom of the figure. The units for the uranium scale are ppm. This plot was constructed using Radial plotter (Vermeesch *et al*., 2009). The histogram shows the length distribution of measured confined tracks from all samples.

Figure 10: A TMI image indicating the gap is the regional low temperature exhumation of Australia (South Australia in particular) is seen in figure 10, which shows comparison between the central ages obtained by this study for the buried eastern Gawler Craton with all AFT central ages obtained by studies in the surrounding regions mentioned in this study.

Table 1; Sampled drill core names, number (DH#), sample location (Latitude/Longitude; Easting/Northings), Sample Depth, sampled unit and overlying unit. Sampled units in grey represent Hutchinson Granite, yellow = Hiltaba Suite Granites, light orange= Donnington Suite, light purple= Gawler Range Volcanics (GRV), olive green= Un-named granitic gneiss, kingfisher blue= Gabbro. Overlying stratigraphic unit are identified as follows light blue= Dolomitic Tapley Hill Formation, light grey = Unnamed GIS Unit, dark orange/red= Pandurra Formation (Adelaidean basement), dark purple= Apilla Tillite, bottle green= Gairdner Dyke Swarm.