Investigating a Mantle Source for Central Australian High Heat Producing Granites

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

James Alexander Hopkinson

November 2015

THE UNIVERSITY of ADELAIDE

ABSTRACT

The Arunta Region of Australia is a region of high heat flow, largely attributed to an abundance of heat producing elements. High heat producing Proterozoic granites found in the Anmatjira Range in Central Australia have close spatial relationships with mafic rock units. This paper uses field relations, geochemistry, geochronology and isotopic nature of mafic rocks observed in the Range, as well as the Arunta Region, to investigate a possible mantle source for the generation of a fractionation series including the high heat producing granites. Using U–Pb zircon geochronology the Possum Creek Charnockite and Tyson Creek Granulite were dated at 1795.4 ± 4.9 Ma and 1779.9 ± 4.9 Ma respectively. These data as well as field relationships are used to infer that the mafic rock units were interacting coevally with the granites and were intruded during the same tectonic events, the 1820-1795 Ma Stafford and 1790-1770 Ma Yambah Events. Geochemical results of high Cr and Ni concentrations with low SiO_2 contents characterised the rocks as mafic and ratios of LILE and HFSE suggests some form of enrichment of the source. Geochemistry implicates a subduction tectonic setting that produced dehydration metasomatism of the overlying mantle wedge. εNd values of -1.8 to -4.7 infer crustal contamination but coupled with the mafic nature of the units further implies a modified and enriched mantle source. It has been interpreted that a subduction related dehydration metasomatism event occurred to enrich the mantle source region which then interacted with crustally derived melts to form a fractionation series including both mafic rock units sampled in this work as well as the high heat producing granites of interest.

KEYWORDS

Heat production, Central Australia, Anmatjira Range, mantle enrichment, geochemistry, isotope geochemistry

TABLE OF CONTENTS

Abstract i
Keywords i
List of Figures and Tables 2
Introduction 3
Background 5
Methods 10
Results 12
Field Relationships & Petrography 12
U–Pb Zircon Geochronology 15
Geochemistry 17
Major Elements 17
Trace & Rare earth elements 17
Radiogenic Isotopes 23
Radiogenic Heat Production 25
Discussion 26
Field Observations on Coeval Magmatism and Magma Mixing 26
Geochronology 27
Geochemical Evidence of Source Region 28
Nd Isotope Constraints on Source 30
Petrogenetic & Tectonic Implications 30
Conclusions 33
Acknowledgments 33
References 34
Appendix A: Sample Locations and methods used 37
Appendix B: U–Pb Zircon Geochronology data 38
Appendix C: Geochemistry of pers. Comms. sources 49
Appendix D: Heat production data 51

LIST OF FIGURES AND TABLES

Figure 1: Location map of the Arunta Region 5
Figure 2: Field area showing rock units of the Anmatjira Range and sample locations 6
Figure 3: Field photographs taken in the Anmatjira Range 13
Figure 4: Total Alkali Silica diagram after Middlemost (1994) 14
Figure 5: Concordia plots, weighted averages plots and CL images 16
Figure 6: Harker Plots of SiO_2 vs major elements 20
Figure 7: Harker Plots of Mg# vs major elements 21
Figure 8: Spiderplots of trace and rare earth elements. 22
Figure 9: Epsilon-Neodymium vs time diagram 24
Figure 10: Heat production graph 25

Table 1:Geochronology zircon data. 15
Table 2: Major Element geochemical data 18
Table 3: Trace Element geochemical data 19
Table 4: Radiogenic Isotopic data 24
Table 5: Average heat production data 25
Table 6: Elemental ratiodata. 29