Geochronological and Geochemical Constraints on the Lithospheric Evolution of the Arabian Shield, Saudi Arabia: Understanding Plutonic Rock Petrogenesis in an Accretionary Orogen.

A thesis submitted for the
degree of Doctor of Philosophy

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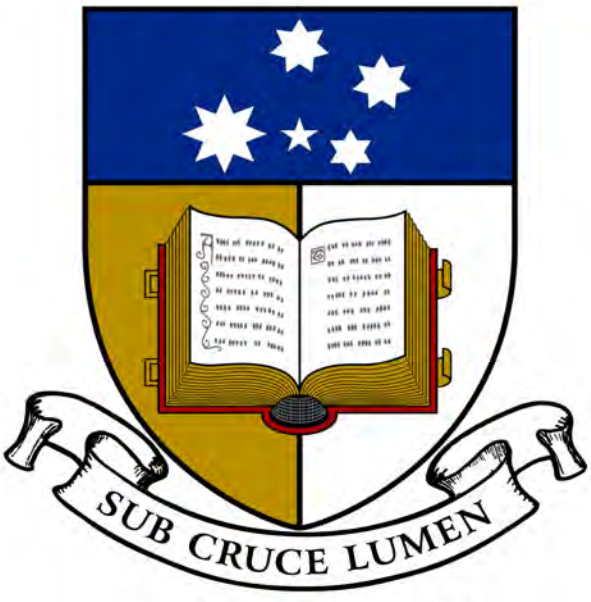
B.Sc. (Hons)



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Abstract

The Arabian-Nubian shield reflects the complex interplay between juvenile oceanic and continental arc fragments accreted during the final stages of Gondwanian super continental assembly. To date, much of the geochronological and geochemical data from the Arabian Shield, Saudi Arabia, is absent or poorly constrained and extrapolated from neighbouring Middle Eastern and African countries. Little attention has been paid to the petrogenesis and tectonic significance of the plutonic rocks pursuant to lithospheric orogenesis.

A total of 137 samples from 26 geological units were collected from the Midyan, Hijaz, Asir, Tathlith, Afif, Ad Dawadimi and Ha'il terranes with particular emphasis on accretionary suture zone and within plate setting relationships. Extensive data bases are constructed using zircon U-Pb geochronology and Hf isotopes to evaluate Gondwanian significance and whole rock major and trace element geochemistry, Nd, Sm, Sr isotopes and zircon geochemistry to determine their petrogenetic properties. These parameters provide new insight into changing mantle conditions beneath collisional sutures (Yanbu, Nabitah and Halaban) and within plate asthenospheric upwelling.

19 granitic units are subdivided into metaluminous, peraluminous and peralkaline groups that possess distinguished island arc (~950-730Ma), syncollisional (~<730-636Ma), post tectonic (~<636-600Ma) and anorogenic (<600Ma) U-Pb geochronology. These magmatic phases represent accretionary cycles initiating from the dismantlement of Rodinia, closure of the Mozambique Ocean and final Gondwana amalgamation. Evidence for final assembly is recorded at ~525Ma (Najd fault reactivation) which is now the youngest dated magmatism in the Arabian-Nubian Shield and warrants repositioning of the regional unconformity at ~542Ma.

Emplacement of sampled Arabian Shield classic A-type post-tectonic and anorogenic granitoids falls into three categories: **1)** Intrude sutures immediately following collision which contain extensive mafic cumulate fractionation and N-MORB affiliation. **2)** Plate boundary juxtaposed suites without obvious mafic cumulates, but

posses contaminated N-MORB geochemistry. **3)** Within plate granitoids isolated from plate boundaries and also without obvious mafic cumulates, but with a distinctive enriched (OIB) like asthenospheric mantle source. All categories produce similar felsic endmembers, but contain isotopically distinct mantle source. These are differentiated using a newly developed geochemical scheme (contaminated and enriched mantle granitoids) that is successfully applied to regional Arabian-Nubian examples.

The diachronous Nabitah Orogenic Belt symbolises collision and subduction between western oceanic and eastern continental terranes that was terminated by the appearance of category **1** post-tectonic granitoids. This long lived (~50Ma) granitic magmatism contains mingling textures, discrete crystallisation ages, distinguished zircon morphologies and isotopically less juvenile mafics that geochronologically and geochemically reflect magmatic pulsing from a contaminated lower crustal MASH zone. The transition from N-MORB like mafics to isotopically enriched granitoids (isotopically similar to category **3** suites) reflects subduction magmatism followed by slab tear and asthenospheric influx.

Conversely, the appearance of category **3** anorogenic plutons is characterised by widespread, tightly constrained (<10Ma) magmatism that is geochemically enriched, economic and symbolic of lithospheric delamination and asthenospheric (OIB like) upwelling. Differences between category **1**, **2** and **3** zircon geochemistry constrain further contaminated and enriched mantle source behaviour that produces similar felsic products from distinguished petrogenetic processes.

In summary, the work presented in this thesis establishes clear distinctions between accretionary syncollisional suites and anorogenic suites, but more significantly, post-orogenic plutons confined to suture zones from those confined to within plate settings. This allows new petrogenetic insights into changing juvenile mantle beneath the Arabian Shield.

Declaration

I certify that this work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution in my name and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. In addition, I certify that no part of this work will, in the future, be used in a submission in my name, for any other degree or diploma in any university or other tertiary institution without the prior approval of the University of Adelaide and where applicable, any partner institution responsible for the joint-award of this degree.

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