Abstract

The reconstruction of continuous time-temperature paths using the parameters of Pb-in-apatite diffusion (Cherniak et al. 1991, Cherniak 2010) is a developing method in the field of high temperature (>350°C) thermochronology. Previous studies have been successful in this pursuit through inversion modeling of apatite U-Pb dates and grain sizes (Cochrane et al. (2014), Van der Lelij et al. (2016), and Paul et al. (2018, 2019). These studies have shown that the apatite U-Pb system is capable of distinguishing between slow cooling and re-heating t-T topologies within the Apatite Pb Partial Retention Zone (APbPRZ), which is generally defined between 360ºC and 550ºC (Paul et al., 2018).

The aim of this project was two part. One was to build upon previous work in apatite U-Pb thermochronology and attempt to establish high-temperature (>350°C) thermal histories of the Precambrian basement of Madagascar, which is composed of highly deformed orthogneisses, paragneisses, granites, mafics, and arc lithologies. Doing so would help to constrain the tectonic history of these juxtaposing basement sequences, which crystallized during 3.3 - 0.65 Ga and have been subsequently exhumed following Gondwana-building (i.e. Pan-African) tectonic events. The other aim of this study was to examine if Pb loss in apatite was driven by thermally activated diffusion, a necessary assumption of U-Pb apatite thermochronology, or if Pb loss was driven by fluid facilitated flow, a case that would challenge apatite U-Pb thermochronology.

In order to accomplish this goal, fieldwork was conducted in Madagascar, where a representative selection of igneous, metaigneous, and metasedimentary samples was taken from the Archean Antongil-Masora and Antananarivo domains, and the Proterozoic Ikalamavony Domain. Apatite was separated from these samples and dated with both bulk grain (ID-TIMS) and in-situ techniques (LA-MC-ICP-MS). Both bulk grain and in-situ data was collected to examine the influence of intra-grain spatial variations in U abundances on U-Pb dates. Additionally, elemental concentrations of Ca, Mn, Y, Sr, La, Pb, Th, and U in apatite were mapped in-situ in order to better understand the possible controls composition has on Pb diffusion through apatite

Suspect t-T solutions were generated through the inversion of the bulk grain and in-situ dates, grain sizes, and Pb-in-apatite diffusion parameters of Cherniak et al. (1991). Bulk grain and in-situ dates were corrected for common Pb with 3 methods: (i)207Pb correction (Chew et al., 2011) (ii) Co-genetic feldspar Pb composition correction, and (iii) Stacey and Kramers (1975) correction. Apatite U-Pb dates from in-situ data with both a 207Pb correction and a co-genetic feldspar correction yielded plausible t-T paths that agree with the tectonic history of post Pan-African Madagascar. This is taken as evidence for the validation of thermally driven volume diffusion in apatite and therefore a confirmation of U-Pb in apatite thermochronology. However, this study also finds evidence for fluid interaction in some of the sampled apatites, and therefore we say that fluid-facilitated Pb-loss in apatite is still a likelihood and further investigation needs to be done into distinguishing between protolithic apatite populations which would make good U-Pb thermochronometers, and metasomatised/neocrystalline apatites which would yield U-Pb dates irrelevant to the reconstruction of time-Temperature histories.
Keywords*: Apatite, High-temperature thermochronology, U-Pb, Element Mapping, Madagascar*