

APATITE U-PB THERMOCHRONOLOGY: AN ID-TIMS AND LA-ICP-MS STUDY FROM SOUTHERN ECUADOR

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Introduction

A combination of U-Pb LA-ICP-MS and ID-TIMS analyses of apatite has been used to investigate the high temperature (>450°C) thermal history of the Ecuadorian Andean margin. The rocks of the Eastern Cordillera of Ecuador evolved via Mesozoic terrane collision and accretion events, and intermittent active margin magmatism since the Early Ordovician. Our approach is novel because i) previous U-Pb thermochronological studies [1, 2] focused on the construction and stabilization of Precambrian cratons, whereas our study tests the applicability of U-Pb apatite thermochronology to relatively young rocks, and ii) we apply an inverse modeling technique to search for thermal history solutions to the data.

Apatite LA-ICP-MS and ID-TIMS U-Pb data have been acquired from a Triassic (247.2±4.3 Ma; U-Pb zircon) rift-related granite from southern Ecuador. ID-TIMS data were obtained from fifteen, euhedral apatite size-fractions, with grain radii ranging between 45–175 µm, representing a theoretical T_c range of 450–510 °C at cooling rates of 10°C/my. Concordant ²³⁸U/²⁰⁶Pb dates range between 81.9±0.21 and 137.87±0.27 Ma, and positively correlate with grain size, supporting our hypothesis that Pb loss has occurred via volume diffusion. LA-ICP-MS ²⁰⁷Pb corrected dates have been obtained from apatite size fractions that were fixed to a single epoxy mount. Primary and secondary standard apatites were: i) 92.5 Ma Emerald Lake with a measured weighted mean age of 91.5 ± 1.3 Ma, 2σ (N = 12), and ii) ~523 Ma McClure Mountain Syenite, with a measured weighted mean age of 519.9 ± 4.4 Ma, 2σ (N = 47). The apatite ²⁰⁷Pb corrected dates range from 196.9 ± 11.4 to 69.1 ± 12.1, 2σ (N = 43), with a majority of ages that cluster between 90–100 Ma.

Time (t)-temperature (T) solutions for the data have been generated using a controlled random search procedure provided by the HeFTy software (version 1.7.0; Ketcham, 2011), using the diffusion parameters of Cherniak et al. (1991) [3]. The thermal history solutions simultaneously satisfy apatite ID-TIMS U-Pb ages obtained from six size aliquots. The best fit t-T solutions (Kolmogorov-Smirnov goodness of fit >0.5) reveal periods of: i) rapid cooling (~240–220 Ma) through the Pb Partial Retention Zone (PRZ) shortly after crystallization, ii) residence at temperatures lower than the PRZ throughout the Jurassic, iii) reheating during 140–90 Ma, and iv) rapid cooling starting at 80–70 Ma. These solutions corroborate conclusions based on geochronological and sedimentological data. Additional in-situ age transects of apatite are scheduled to further determine the concentration and mechanisms for the distribution of radiogenic lead in the apatites.

[1] Blackburn *et al.* (2012) *Science* **335**, 73.

[2] Schoene & Bowring (2007) *GCA* **71**, 165–185.

[3] Cherniak *et al.* (1991) *GCA* **55**, 1663–1673.

A Plausible relationship between D/H in primitive Solar System organic solids, their origin, and their associated water

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Primitive extraterrestrial organic solids such as are present in type 1 and 2 chondrites (Insoluble Organic Matter, IOM, and Interplanetary Dust Particles (IDPs) are typically enriched in deuterium relative to terrestrial water, in some cases as much as 4 or more times so. The origin of such enrichment has predominantly been accepted to be a signature of a very low temperature origin of organic solids and/or their lower molecular weight precursors. Analyses of a wide range of pure IOM isolated from many different meteorites reveals no systematic relationship between IOM structure and D/H. Whether one plots D/H against H/C or the fraction of aromatic carbon, no obvious trends emerge [1]. A recent exception to this is observed with the Tagish Lake Clasts that reveal a very systematic variation in D/H with H/C [2]. We have been integrating materials characterization and laboratory based experimentation to address both the origins of primitive organic solids and gain improved understanding of the molecular nature of D/H abundances in context with gaining insight on fate of volatiles during early Solar System evolution. Towards this end we have proposed and demonstrated a likely route from interstellar formaldehyde to organic solids in comets, IDPs, and primitive chondrites [3]. We have also developed the capacity to detect deuterium speciation amongst different organic functional groups within organic solids. We find that comparison of D speciation with H speciation reveals a characteristic (apparent) intra-molecular fractionation that informs us how initial D/H enrichment reflects the environment of formation of organic solids. Finally, laboratory experiments investigating D-H exchange kinetics provide an essential understanding of why D/H in organic solids is what it is and may explain D/H variation in cometary water. It is clear that the early evolution of IOM sets the initial D/H, whereas subsequent evolution during hydrothermal processing in the parent body may affect a secondary evolution in D/H.

[1] Alexander C. M. O'D. et al. (2010) *GCA* **74**, 4417–4437. [2] Herd et al. (2011) *Science* **332**, 1304–1307. [3] Cody G. D. et al. (2011) *PNAS* **108**, 19171–19176.