(U-Th)/He Dating of Magnetites in Serpentinites

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While numerous studies exist on the petrology, structure and geochemistry of serpentinites, geochronological analysis remains elusive because they lack minerals with well-established dating techniques. With technological advances in radiogenic isotope analysis in the past decade, it is now possible address the timing of serpentinization by dating the growth of magnetite that forms as a direct result of the breakdown of olivine and pyroxene in the presence of water. This study presents a (U-Th)/He-based method that is tailored for analyzing magnetite formation in serpentinites.

Although magnetite (U-Th)/He dating has been proven as a viable geochronometer in basaltic to intermediate volcanic rocks [1], refinement of the technique has highlighted the importance of screening magnetite to ensure suitability for dating in light of skeletal or complexly intergrown magnetite. The application of High Resolution X-Ray Computed Tomography (CT) provides a non-destructive method to visualize the internal structure of a sample in 3D. Internal visualization is critical for opaque minerals to screen for inclusions or intergrowths that can affect parent and daughter nuclide distribution, and diffusion domain size. CT scanning of individual grains and whole-rock specimens was coupled with thin section and Scanning Electron Microscope (SEM) Energy Dispersive Spectroscopy (EDS) analyses in order to fully characterize the petrographic context of magnetie in 3D and assess their suitability for (U-Th)/He dating. Refined laboratory techniques for He extraction, grain dissolution and U, Th measurement greatly improve the recovery of low [U], [Th] and [He] in ultramafic samples. This method is piloted with a case study using magnetites from serpentinites in an exhumed high-pressure, low-temperature metamorphic terrane on Syros Island, Greece. Magnetites from this unit reveal reproducible middle Miocene ages in agreement with zircon (U-Th)/He cooling ages. The ability to temporally constrain serpentinization with magnetite (U-Th)/He has the potential to not only provide an additional t-T constraint on the exhumation of HP-LT terannes, but to address a critical gap in the current understanding of the role of serpentinization as a thermal, mechanical and chemical process that progressively modifies the mechanical nature of plate boundaries.

[1] Blackburn (2007) *EPSL* **259,** 360-371.