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Advancements in Magnetite (U-Th)/He Geochronology: Incorporation of High Resolution X-ray Computed Tomography Imaging

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Magnetite is an excellent candidate for (U-Th)/He geochronology because it forms as a common mineral phase in felsic, mafic and hydrated ultramafic igneous and metamorphic rocks, has measurable amounts of U-Th, and grains can be separated by hand magnet. Magnetite (U-Th)/He dating has been proven as a viable geochronometer in basaltic to intermediate volcanic rocks and has the potential to extend to rocks that do not commonly contain mineral phases that are datable by traditional geochronometry. The present study is specifically interested in the ability to temporally constrain serpentinization by dating the formation of magnetites resulting from the reaction of olivine with water. Magnetite formation has been shown to be favored at temperatures lower than 250°C, which is promising for magnetite (U-Th)/He geochronology, which has a closure temperature of 250°C in basaltic rocks. Application of magnetite (U-Th)/He dating should provide critical temporal insights into continental rifting and serpentinization during break-up along magma-poor continental margins.

As attractive and powerful as magnetite (U-Th)/He dating is, refinement of the technique has highlighted the importance of screening grains to ensure suitability for dating in light of skeletal grain morphology and He implantation, as matrix [U] is commonly up to one order of magnitude greater than magnetite. While air-abrasion tends to correct for outer matrix and alpha implantation in large magnetite, irregular and complexly intergrown magnetite require further pre-analysis screening. SEM backscatter imaging is useful to determine the presence of skeletal or impure magnetite within a sample, but is destructive to the grain and unable to resolve heterogeneities in 3D. To overcome these challenges, this research incorporates high-resolution X-ray computed tomography (CT) as a powerful and non-destructive method to effectively screen the entire grain volume. Once magnetite grains are scanned with the CT, Avizo software is used to compile a 3D image of the magnetite grains and map the location of any matrix or inclusions present. Blob3D software is used to quantify volume and surface area measurements to monitor air-abrasion progress and high [U] matrix removal.

Keywords: (U-Th)/He geochronology, magnetite, high resolution x-ray computed tomography, serpentinization