U-Th/He Geochronology of Young Volcanic Rocks

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RESEARCH OBJECTIVES

Constraining time scales for Quaternary (<1.8 my) events remains a challenge. Despite considerable progress in C-14 and Ar-Ar dating, no single method with wide applicability has emerged. This project investigates the use of the U-Th/He system for dating young volcanic rocks, which is based on the accumulation and retention of ^{4}He from decay of U and Th in mineral grains.

APPROACH

The first step was to assess technique viability by analyzing young samples of known age: garnets from the 79 AD eruption of Mt Vesuvius. The second was application to a system that could benefit from direct age measurements, but for which only cursory knowledge of age is known: olivine phenocrysts from a suite of Hawaiian basalts.

Inherent in the application of the U-Th/He technique are several sources of error that must be addressed. First, typical minerals (garnet, olivine) have low and heterogeneous U,Th concentrations, making measurement of U,Th, and He concentrations difficult and necessitating measurement on the same aliquot. A furnace was designed capable of melting 1–2 g samples in platinum containers from which the melted sample can be retrieved for U,Th determination. Second, basalt matrix often has more U and Th than the embedded phenocrysts, leading to additional helium accumulation in the phenocryts by alpha recoil implantation. Modeling indicates that for a given matrix/phenocrysts (U,Th) concentration ratio, the magnitude of the age correction is strongly dependent on grain size (Figure 1). Furthermore, the correction assumes perfect extraction of unbroken phenocrysts from the matrix. The range of recoiled alpha particles is on the order of 10's of microns. Therefore, to overcome alpha recoil effects, we abrade samples, removing the exterior portions that are most effected. Since the matrix/phenocryst U,Th concentration ratio in the Vesuvian garnets is close to one, the correction is negligible. However, the high ratio in Hawaiian lavas is more problematic. To assess our abrasion technique, we analyzed abraded and nonabraded olivine aliquots to compare alpha recoil model ages with those determined directly from the abraded samples.

ACCOMPLISHMENTS

We successfully determined the age of the 79 AD eruption of Mt Vesuvius within analytical error. Analyses of abraded and nonabraded samples indicated that the alpha recoil model overcorrects for injection of radiogenic helium. Detailed analysis of the accuracy of abrasion is still required, but this initial investigation indicates that it is possible to date young olivine samples with low U,Th concentrations, despite high concentrations in the matrix. For two Hawaiian samples, the calculated ages of 329 kyr and 189 kyr fall within the age range constrained by previous methods.

SIGNIFICANCE OF FINDINGS

We have demonstrated the ability to date Quaternary volcanic samples, indicating that the U-Th/He method can be used as a reliable geochronological tool. Extension of the technique will vastly improve constraints on time scales for Quaternary events.

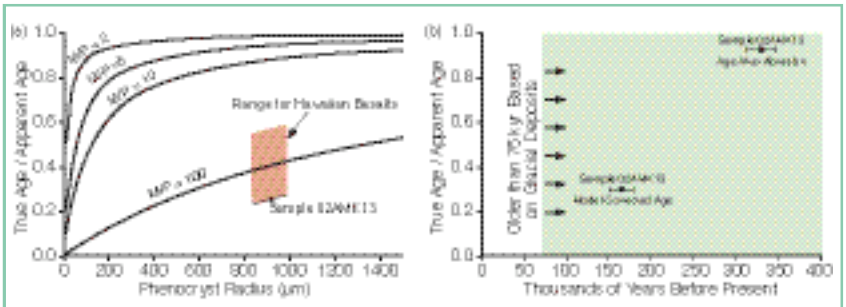

Figure 1. (a) Contours of age correction factors as a function of grain size, using varying matrix/phenocryst (M/P) concentrations of U and Th. Also plotted are the range of correction factors for Hawaiian samples using measured [U,Th] and U-series isotopes. Sample 02AMK13 has a M/P ratio of 145 and a 800–1,000 µm grain size, which corresponds to a correction factor of 0.32. (b) Comparison of ages for sample 02AMK13 constrained by glacial deposits—shown are calculated ages plotted against the correction for alpha recoil; the unabraided sample has a model correction factor of 0.32, while the abraded sample requires no alpha recoil correction and thus has a correction factor of 1.

RELATED PUBLICATION

Aciego, S.M., B.M. Kennedy, D.J. DePaolo, J.N. Christensen, and I. Hutcheon, U-Th/He age of phenocrystic garnet from the 79 AD eruption of Mt. Vesuvius. Earth and Planetary Science Letters, 216, 209–219, 2003. Berkeley Lab Report LBNL-53622.

ACKNOWLEDGMENTS

This research was supported by the Director, Office of Energy Research, Basic Energy Sciences, Chemical Sciences, Biosciences, and Geosciences Division of the U.S. Department of Energy under Contract No. DOE-AC03-76SF00098.