Fractionation behavior of ^{238}U-series nuclides during acid leaching of basaltic samples

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Measurement of ^{238}U–^{230}Th radioactive disequilibria shows potential for determining eruption ages younger than ca. 0.4 Ma. For the determination, it requires analyses of multiple phases by isochron methods, of which samples are assumed to have been homogeneous in ^{230}Th/^{232}Th at the time of eruption. Acid-leaching treatment can be useful for obtaining a wide range of (^{238}U/^{232}Th) from groundmass if no preferential fractionation among ^{238}U, ^{232}Th, and ^{230}Th occurs during leaching. In this study, we assessed the presence and extent of preferential fractionation between ^{238}U, ^{232}Th, and ^{230}Th by acid leaching for various types of basaltic samples (basanite, alkaline basalt, olivine tholeiite, and quartz tholeiite) with eruption ages sufficiently old (>0.5 Ma) to achieve ^{230}Th–^{238}U secular equilibria.

Acid leaching of these samples results in ^{230}Th–^{238}U and ^{234}U–^{238}U radioactive disequilibria for both leachates and residues. These radioactive disequilibria can be explained by redistribution of ^{234}Th (parent of ^{234}U) and ^{230}Th between acid-soluble and acid-resistant phases due to α-recoil. The number of ^{230}Th atoms redistributed by α-recoil can be calculated by using a mass conservation equation for ^{234}U atoms and by the relative amount of recoiled ^{230}Th and ^{234}Th, the latter proportional to the kinetic energy of the recoiled nuclide. When the fraction of daughter nuclide ^{234}U remaining in either the residue or leachate, after α-recoil redistribution of ^{238}U, is large enough (>95%), the corrected (^{230}Th/^{238}U) values of leachate and residue show radioactive equilibria.

This result demonstrates that preferential fractionation between U and Th does not occur during acid leaching for basaltic samples if there is no selective etching of the α-recoil track. It implies that acid-leaching can be used in conjunction with the ^{238}U–^{230}Th internal isochron method for dating young volcanic rocks by evaluating the degree of the α-recoil redistribution of ^{234}U.