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238U-230Th disequilibrium in fossil hydrothermally altered material: a tool for dating volcano flank-collapse events.

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Flank instability has been recognized as a very common and often recurrent process in the evolution of volcanoes. Prolonged and extensive hydrothermal system activity is a major cause of volcano instability in promoting conditions of mechanical weakness of the edifice that have led to numerous partial edifice-collapses with emplacement of debris avalanche deposits (DAD). The purpose of this study is to evaluate potential applications of U-series disequilibrium analysis of altered material collected in active hydrothermal systems and in DADs that have sampled different regions of the paleo-hydrothermal systems developed prior to collapse on La Soufrière of Guadeloupe and Soufriere Hills (Montserrat) volcanoes. Significant redistribution of chemical elements occurs during hydrothermal alteration with a large fractionation between elements of the U-decay series. Indeed, samples of active hydrothermal systems show large variations in U/Th ratio at generally constant (^{230}Th/^{232}Th). This chemical fractionation between U and Th offers the opportunity to date hydrothermal alteration and to constrain the age of the active hydrothermal system involved in edifice collapses. The evolution of trace element compositions (REE, U, Th) are documented throughout the successive stages of andesite alteration and discussed in terms of relative element mobility and associated mineralogical assemblages. A progressive HREE depletion occurs together with significant U enrichment at low alteration degrees, followed by a final U depletion. Glass alteration in smectite is accompanied by large U depletions relative to Th. On the contrary, U enrichment is associated with silica polymorphs. All these processes are discussed in terms of relative U behaviours during leaching, incorporation and adsorption processes. Andesitic products that have been affected by hydrothermal alteration are complex assemblages of glass, phenocrysts, xenocrysts with complex magmatic histories, as a well as country rock lithologies and hydrothermal minerals. The detailed analytical procedure that we have developed allows to precisely correlate U-Th mobility and ^{238}U-^{230}Th disequilibrium to specific geochemical processes regardless of the initial material heterogeneity. We can therefore date the formation of smectite, a typical product of glass alteration. This work has important implications for improving hazard assessment from potentially unstable andesitic volcanoes hosting an active hydrothermal system.