Geophysical Research Abstracts
Vol. 12, EGU2010-13320-1, 2010
EGU General Assembly 2010

Hydrothermal alteration in Lesser Antilles volcanoes: a study of trace element and U-Th isotope redistribution in active- and paleo-hydrothermal systems of Guadeloupe and Montserrat

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Hydrothermally altered material have been collected in active hydrothermal systems and in debris avalanche deposits (DAD) that have sampled different region of the paleo-hydrothermal system of La Soufrière of Guadeloupe and Soufriere Hills volcanoes. A detailed analysis of the mineralogy, the trace element (REE, U, Th, 1st transition series) composition and the U-Th isotopes disequilibrium of this altered material has been performed. These results are discussed in terms of relative element mobility and associated mineralogical assemblages in function of the progressive alteration stages of the andesitic material.

Andesitic products that have been affected by shallow hydrothermal alteration are complex assemblages of volcanic material (glass, phenocrysts and xenocrysts with complex magmatic histories) of different ages and lithologies. In DAD, this altered material has been more or less deeply reworked during transport. This material has eventually been exposed to later meteoritic or fumarollic alteration.

Since REE and other incompatible elements (Th, U, Hf, Zr) are mainly concentrated in the groundmass of andesitic magmas, composition variations of these elements in altered material mainly traces the transformation of volcanic glass into smectite. This transformation is accompanied during the first stages of hydrothermal alteration, (1) by a massive loss of alkaline and 1st transition series elements, (2) by a large REE fractionation, characterized by a low LREE mobility and a progressive HREE depletion with alteration degree, and (3) by a large U depletion relative to Th. LREE, Hf and Zr are not significantly modified by these alteration processes except that their absolute concentrations are generally increased in altered material by mass balance effects. U is generally redistributed over relatively short distances (maximum few centimetres) and is sometimes re-concentrated by adsorption on silica polymorphs or magnetites. Meteoric and low temperatures fumarollic activities do not significantly modify these elements redistributions.

The large variations in U/Th ratio during shallow hydrothermal alteration generally occurs at constant 230Th/232Th ratio. This offers the opportunity to date hydrothermal alteration breakdown and to reconstruct the evolution in space and time of hydrothermal activity in a volcanic edifice. It also allows to constrain the age of DAD emplacement by dating the breakdown of the hydrothermal system that was active at the time of the edifice collapse. U and Th isotope analyses of hydrothermally altered material contained in two distinct DADs of La Soufrière of Guadeloupe provides well-defined isochrones with ages of 8 900 and 56 100 yrs which are in agreement with 14C ages and the chronostratigraphy of these flank collapse events. This outcome extends the dating range for recent collapse events which are generally constrained by conventional radiocarbon dating. It extends the dating range to late Pleistocene (< 250-300 ky) and to arid environments where no organic C may be available.