Comparative Study of the Mobility of Major and Trace Elements During Alteration of an Andesite and a Rhyolite to Bentonite, in the Islands of Milos and Kimolos, Aegean, Greece

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Abstract: Progressive alteration by seawater of an andesite in the Aegean Island of Milos and an ignimbrite in the Aegean Island of Kimolos, Greece, formed bentonites with or without zeolites. Both profiles are dominated by migration of alkalis and uptake of Mg, Fe and H_2O, while Al and Ti are immobile. The relative removal of alkalis controls the formation of either smectite or zeolites. The behavior of Ca and Si depends on the chemistry of the parent rock. In the rhyolitic profile, alteration is controlled by gain of Mg, Fe^{2+} and Ca and loss of Na, K and Si, while in the andesitic profile by gain of Mg and Fe^{2+} and loss of Na, K and Ca. In both profiles, significant uptake of $SO_4^{=}$ was not observed. Moreover Zr, Nb, V and Ni are immobile and have been enriched residually, while Sr, Rb and Y are lost in both profiles. Thorium is immobile in the rhyolitic profile but is leached in the andesitic profile. Also, the rare earth elements (REE) display fractionation in both profiles; the degree of fractionation increases with the degree of alteration to bentonite. Fractionation of the REE in both profiles and mobility of Th in the andesitic profile are related to the existence of monazite (rhyolitic profile) and apatite (andesite profile). The REE and Th appear to partition into phosphates rather than smectite.

The mobility of Y coupled with the immobility of Nb increases the Nb:Y ratio with advancing alteration, rendering discrimination diagrams that use this ratio to determine the nature of the protoliths misleading. Mass balance calculations showed that in the smectite-rich zones the water:rock (WR) ratio might be as high as 13:1 in both profiles, while in the zeolite-bearing zones it is about 5.5:1. Such WR ratios explain the observed extensive mass transfer and suggest that the pore fluid chemistry might overprint the chemical characteristics of the parent rocks controlling smectite and bentonite chemistry.

Key Words: Alteration • Andesite • Bentonite • Element Mobilization • Mordenite • Phosphates • REE Fractionation • Residual Enrichment • Rhyolite • Smectite • Water:Rock Ratio

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