Geochemistry of Hydrothermal Chlorite Replacing Igneous Biotite

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Abstract: Hydrothermal chlorite replaces igneous biotite in the Gold Hill, Utah, quartz monzonite. Chemical compositions of coexisting biotite and chlorite determined by electron microprobe and wet chemical methods were used to evaluate chemical mass transfer during the alteration process. The mole ratio Mg/(Mg + Fe) varies from 0.52 to 0.65 in the chlorite and from 0.51 to 0.60 in the parent biotite. The Mg content of the chlorite decreases systematically with increase in the volume percent replacement of biotite. Homogenization temperatures of fluid inclusions in nearby quartz microveinlets indicate that the chloritic alteration took place at approximately 200 ° C.

Textural relationships suggest that the alteration of biotite to chlorite is isovolumetric, but a comparison of mineral compositions and mineral assemblages with phase diagrams in which Al or volume are conserved among solid phases suggests that the chlorite compositions are best explained as a function of reaction progress in an Al-conservative system. The chlorite composition changes in response to changes in solution composition produced by the dissolution of successive small amounts of biotite. Representative mass balance for the alteration of all of the biotite to chlorite in 1 m^3 of rock containing 336 moles of biotite indicates that 74 moles of Mg, 35 moles of Fe^{3+}, 420 moles of H^+, and 2 moles of Mn are added to the rock and that 311 moles of K, 54 moles of Fe^{2+}, 76 moles of Ti, 53 moles of F, and 6 moles of Cl are lost to solution. The mass transfer for partially altered biotite is 11 to 188 moles of K, 2 to 46 moles of Ti, 2 to 44 moles of F, and 0.3 to 6 moles of Cl removed per cubic meter of rock and 1 to 26 moles of Fe^{3+} and 20 to 347 moles of H^+ added. The mass transfer of Mg varies from 12 moles added to 32 moles removed per cubic meter of rock depending on mineral composition and extent of replacement.

Key Words: Aluminum conservative alteration • Biotite • Chlorite • Electron probe analysis • Fluid inclusions • Hydrothermal alteration • Isovolumetric alteration

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