Genesis of Dioctahedral Phyllosilicates During Hydrothermal Alteration of Volcanic Rocks: II. The Broadlands-Ohaaki Hydrothermal System, New Zealand

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Abstract: The clay mineral textures, assemblages, formation mechanisms, and controlling geological parameters relating to alteration of silicic volcanic rocks by hydrothermal solutions, in core samples from the Broadlands-Ohaaki hydrothermal system, New Zealand, were investigated using X-ray diffraction (XRD), scanning electron microscopy (SEM), and transmission and analytical electron microscopy (TEM/AEM). Mineralogical and textural relations of this active hydrothermal system, for which temperatures and fluid relations are well known, are equivalent to those in the Golden Cross hydrothermal gold deposit as described in Part 1.

XRD data show a sequence of clay minerals from smectite to a range of interstratified I-S to mica with increasing depth and temperature, on average. TEM observations are in general agreement with XRD data, especially with respect to relative proportions of illite (I)- and smectite (S)- like layers. TEM data also show that: (1) Smectite packets contain no discrete illite-like layers in samples identified as (Reichweite, R = 0) I-S by XRD. They coexist with separate packets of (R = 1) I-S. (2) A continuous range in I-S occurs from (R = 1) I-S with increasing proportion of illite-like layers, but at high illite-like layer contents there is a gap between I-S and illite. (3) 1*M* and $2M_1$ polytypes of mica coexist in separate packets, but the rare 1*M* polytype has a larger ^{VI}Mg content.

The data imply that clay minerals formed by dissolution and neocrystallization directly from volcanic phases, although multiple reaction events can not be ruled out. Such “ episodic ” alteration produces a sequence of clay minerals identical to those of prograde diagenesis of pelitic sediments. This result implies that the presence of a continuous sequence is not definitive proof of continuous sequences of transformation as a function of time and continuous burial. Reaction progress of the clay-mineral sequence is in general accord with the known temperature gradient, but with significant and common exceptions. High porosity and permeability, both inherent in rock texture and local structure, are inferred to foster local reaction progress, as consistent with metastability of phases and the Ostwald step rule.

Key Words: Crystallization • Dioctahedral Phyllosilicates • Hydrothermal System • Illite-Smectite (I-S) • Polytypism • Transmission Electron Microscopy

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