Reaction Mechanisms of Smectite Illitization Associated with Hydrothermal Alteration from Ponza Island, Italy

Robert F. Ylagan[1,†], Stephen P. Altaner[1] and Antonio Pozzuoli[2]

[1] University of Illinois, Department of Geology, 1301 W. Green, Urbana, Illinois 61801 USA
[2] Università degli Studi di Napoli ‘ Federico II ’ , Dipartimento di Geofisica e Vulcanologia, Largo S. Marcellino 10 80138, Napoli, Italy

[†] Present address: ExxonMobil Upstream Research Co., P.O. Box 2189, Houston, Texas 77252-2189 USA. E-mail of corresponding author: bob.f.ylagan@exxon.sprint.com

Abstract: A hydrothermally altered rhyolitic hyaloclastite from Ponza island, Italy, has four alteration zones with unique clay assemblages: (1) a non-pervasive argillic zone characterized by smectite; (2) a propylitic zone with interstratified illite-smectite (I-S) containing 10 – 85% illite (I); (3) a silicic zone composed of I-S with ⩾90% I and pure illite; and (4) a sericitic zone with I-S ranging from 66% I to pure illite. Atomic force microscopy reveals abrupt changes in particle morphology with illitization, including initial changes from anhedral plates to laths and then to euhedral plates and hexagonal plates. I-S particles progressively thicken with illitization and mean particle area (basal plane) remains constant from pure smectite to I-S with 80% I. However, particle area increases from 90 to 100% illite. Computer modeling of I-S structural forms indicates octahedral cation ordering progressively changes from *cis*-vacant smectite to interstratified *cis*- and *trans*-vacant I-S, and then to *trans*-vacant illite. In addition, polytypes progressively change from $1M_d$ to $1M$, and then to $2M_1$ illite. Electron-microprobe and X-ray fluoresence analyses show that I-S chemistry progressively changes during illitization, evolving toward a phengitic composition with ~0.89 fixed interlayer K^+ per $O_{10}(OH)_2$. Octahedral Mg^{2+} shows little change with illitization, varying from 0.3 to 0.5 cations per $O_{10}(OH)_2$. The layer charge of smectite is ~0.38 equivalents per $O_{10}(OH)_2$.

On the basis of abrupt changes in morphology and progressive changes in polytype and chemistry, smectite illitization on Ponza involved a dissolution and recrystallization mechanism with multiple stages of nucleation and crystal growth. In this multi-step model, temperature of alteration provided the major control for the layer composition, polytype, and morphology of I-S crystallites. Other factors that may play a secondary role include: K^+ availability, water-rock ratio, and permeability. Alternatively, the mechanism of I-S and illite formation at Ponza and other hydrothermal environments may occur by direct precipitation of I-S crystallites from rhyolite glass and may not involve progressive reactions of smectite precursors.

Key Words: Atomic Force Microscopy • Chemical Analysis • Illite • Polytype • Smectite • XRD

Clays and Clay Minerals; December 2000 v. 48; no. 6; p. 610-631; DOI: 10.1346/CCMN.2000.0480603
© 2000, The Clay Minerals Society
Clay Minerals Society (www.clays.org)