Sodic Clay-Zeolite Assemblage in Basalt at Boron, California[1]

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Abstract: An assemblage of clay minerals, Na-zeolites, Fe- and Sb-sulfides, and borates occurs in cavities in the basalt flow that underlies the main borax ore body exposed by the U.S. Borax open pit at Boron, Kern County, California. Analcime and saponite are widespread in cavities and fractures near the top of the basalt. Part of the basalt recently exposed, although restricted in distribution, contains a much more diverse assemblage of diagenetic minerals. Although only a few different minerals occur in each cavity, the composite order of deposition is: ferroan saponite, pyrrhotite, saponite, phillipsite, gmelinite, clinoptilolite, herschelite, analcime, greigite, rhodochrosite, searlesite, borax, calcite, and colemanite. In some cavities early-formed zeolites appear to have dissolved as later ones crystallized.

Microprobe analyses of the zeolites yielded the following compositions: phillipsite, $Na_{4.28}K_{0.08}(Al_{4.36}\text{-}Si_{11.64}O_{32}) \cdot xH_2O$ (Si/Al = 2.67); gmelinite, $Na_{6.64}K_{0.10}(Al_{6.80}Si_{17.22}O_{48} \cdot xH_2O$ (Si/Al = 2.53); herschelite, $Na_{2.96}K_{0.24}(Al_{3.21}Si_{8.79}O_{24}) \cdot xH_2O$ (Si/Al = 2.75); clinoptilolite, $Na_{6.48}K_{0.56}(Al_{7.15}Si_{28.77}O_{72}) \cdot xH_2O$ (Si/Al = 4.02); analcime, $Na_{14.02}K_{0.09}(Al_{13.33}Si_{34.44}O_{96}) \cdot xH_2O$ (Si/Al = 2.58).

These zeolites formed by reactions between the basalt and evolving fluids, which were controlled by the development of an overlying, Na-borate lake. The wide distribution of saponite, analcime, and searlesite suggests that these minerals formed by the diagenetic reaction between basaltic glass and Naborate water. The localized occurrence of the complex mineral assemblage, including some of the saponitic clay and the zeolites, phillipsite, gmelinite, and clinoptilolite, formed through a different process, perhaps deuteric or hydrothermal alteration of the basalt, before the lake developed. Because these zeolites are extraordinarily rich in Na, cation exchange may have taken place as the pore fluids became increasingly Na rich. In the latest stages of mineral growth, each of these zeolites was apparently partially dissolved and epitaxially overgrown by a second generation crystal, phillipsite on phillipsite, herschelite on gmelinite, and sodian heulandite on clinoptilolite.

Key Words: Analcime • Boron • Cation exchange • Clinoptilolite • Gmelinite • Heulandite • Phillipsite, Saponite • Sodium • Zeolite

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