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Experimental investigation of laumontite → wairakite + H_2O: A model diagenetic reaction

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ABSTRACT

The rate and mechanism of a key diagenetic reaction, laumontite → wairakite + H_2O, have been determined in experiments with durations as long as three months at P_{H_2O} = 100 MPa and temperatures of 350–450 °C. In the lower temperature range, 350–400 °C, nucleation of wairakite occurred on the smallest laumontite fragments in the starting material. Growth then proceeded by the dissolution of large laumontite grains, transport within the fluid, and precipitation of euhedral to subhedral wairakite. At higher temperatures, 425 and 450 °C, each sample contains two product phases: wairakite and an unidentified plagioclase-like phase. The plagioclase-like silicate was stabilized by the uptake of Na and formed early as ~10 μm wide skeletal grains along laumontite grain boundaries. The wairakite grains subsequently nucleated on and grew into the interiors of large laumontite grains.

Nucleation rates at 425–450 °C were 10–100 wairakite grains per square meter of laumontite surface per second. Growth rates varied from 1.5×10^{-11} m/s at 350 °C to 2.1×10^{-10} m/s at 450 °C; the low-temperature data can be fit with an apparent activation energy of 72 ± 13 kJ/mol and a pre-exponential ‘‘interface jump distance’’ of $\sim 1 \times 10^{-18}$ m. This activation energy and these growth rates are comparable to those calculated by Walther and Wood (1984) to characterize interface-controlled reactions in silicates under H_2O-saturated conditions. Our data predict transformation rates for geologic conditions that are too fast to account for the commonly observed incomplete natural reaction of laumontite → wairakite, indicating that transformation in nature must be limited by slower nucleation rates or by slower intergranular diffusion—perhaps as a result of lower H_2O activity or slower heating rates.