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Montmorillonite under high H_2O pressures: Stability of hydrate phases, rehydration hysteresis, and the effect of interlayer cations

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ABSTRACT

Dehydration of Ca- and Mg-exchanged montmorillonite was studied along H_2O isochores in the hydrothermal diamond-anvil cell by in situ X-ray diffraction using a synchrotron radiation source. At pressures between the H_2O liquid-vapor (L-V) boundary and ~10 kbar, the dehydration temperature for the conversion from the 19 Å hydration state to the 15 Å hydration state occurred over the temperature range 260–350 °C for Ca-exchanged montmorillonite and 200–250 °C for Mg-exchanged montmorillonite, with a slight increase with increasing pressure. For both materials, the rehydration from the 15 Å to 19 Å states occurred at the same temperature as dehydration at pressures along the H_2O L-V boundary, thus showing no hysteresis. The rehydration hysteresis increased to nearly 75 °C at 6 kbar for Ca-exchanged montmorillonite and to the same amount at 2.5 kbar for Mg-exchanged montmorillonite. Dehydration experiments on Mg-exchanged montmorillonite along the isochores of 1.024 and 0.75 g/cm^3 showed conversion from the 15 Å hydrate to the 12.5 Å hydrate at 590–605 °C. The 12.5 Å hydrate only partially rehydrated after cooling to room temperature along those two isochores. In an experiment started from the 15 Å state, in which the pressure was below the H_2O L-V curve, dehydration occurred at 400–500 °C and rehydration at 430–350 °C. When our previous results on Na-exchanged montmorillonite are combined with the current experimental data, systematic trends can be found in the effect of pressure and interlayer-cation species on the dehydration temperature and rehydration hysteresis.