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Experimental investigation of smectite interaction with metal iron at 80 °C: Structural characterization of newly formed Fe-rich phyllosilicates

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Abstract

Interactions between metallic iron and clay minerals have been extensively studied under low-temperature anoxic conditions owing to their potential impact on the long-term safety of high-level nuclear waste disposal in deep geological repositories. To complement the studies investigating the destabilization mechanisms and rates of various initial clay minerals, the prediction of the storage long-term performance requires a comprehensive characterization of the reaction products. The Fe-rich 1:1 phyllosilicates resulting from interactions at 80 °C and in the absence of O_2 between metallic iron and smectites with contrasting compositions are thus characterized chemically and structurally using various experimental techniques (X-ray and electron diffractions, infrared, energy-dispersive, and electron energy loss spectroscopies, and high-resolution electron microscopy). Cronstedtite and odinite are the two Fe-rich 1:1 phyllosilicates formed under the experimental conditions investigated, both species differing from their relative contents and the average valence state of structural Fe. No parental link has been evidenced between the two minerals despite their contrasting crystal morphologies and thermodynamical predictions. The formation of the 1:1 phyllosilicates apparently results from the destabilization of the initial smectite through the formation of an intermediate gel.

Keywords: Iron-clay, nuclear waste, smectite, serpentine, berthierine, cronstedtite, odinite