Mineralogical and chemical characterization of various bentonite and smectite-rich clay materials

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Mineralogy is essential issue in understanding thermo-hydro-mechanical-chemical (THMC) behavior of buffer and backfill materials. Mineralogy affects, among others, on chemical composition of pore water, susceptibility for erosion, and transport of radionuclides. Consequently, mineralogy affects the designs of the buffer and backfill components.

Objective of this work was to implement and develop mineralogical and chemical methods for characterization of reference clays to be used as buffer and backfill materials in nuclear waste disposal. In this work, different methods were tested, compared, developed, and best available techniques selected. Additionally, the aim was to characterize reference materials that are used in various nuclear waste disposal supporting studies, such as in ABM project.

Materials studied included three different Wyoming-bentonites, two different bentonites from Milos, four different bentonites from Kutch district, and two Friedland clays.

First, minerals were identified using x-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR) and polarizing microscopy. Mineralogical composition was estimated using Rietveld-analysis. Chemical methods were used to support and validate mineralogical interpretation. Total chemical composition was determined from decomposed samples using spectrometry (ICP-AES), and by combustion (Leco-S, Leco-C). Ferric and ferrous iron was distinguished titrimetrically. In addition, the amount of soluble sulphate and poorly crystalline Fe-, Al- and Si-phases using selective extractions, cation exchange capacity and exchangeable cations were determined. Chemical composition of fine (<2µm) fraction was used for structural calculations.

The XRD is a basis method for all mineralogical characterization, but it is insensitive for detecting trace minerals, in identification of some clay minerals, such as kaolinite, and detecting variations in structural chemical composition of clay minerals. Polarizing microscopy proved to be useful in characterization of coarse fraction: identification of trace minerals, estimating the particle size distribution, and characterization of crystal morphology, possible alteration of minerals, as well as mineral assemblages. FTIR not only supported mineralogical observations from XRD, but it revealed variations in clay structural compositions, and the presence of mineral impurities in purified clay fractions that were used for the basis of structural calculations.

Studied Wyoming-type Na-bentonites were very similar with each other and contained approximately 80 wt. % of smectite. All Kutch bentonites were enriched with ferric iron. The smectites in Kutch bentonites were Al-rich, and their kaolinite content varied, up to 20 wt. %. Bentonites from Milos-area were Ca-rich and contained slightly more illite in fine fraction than bentonites from Wyoming or Kutch areas. Approximately 30 % of the clay fraction in Friedland clays consisted of illite.