Iron mineral transformations in clay-rich sediments accompanying the progression of an oxidation front

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Clay-rich sedimentary formations are considered as host rocks for the disposal of radioactive waste. Often, the clay-rich layers have been exposed to reducing conditions during (early) diagenesis and contain redox sensitive Fe minerals which might become oxidized during construction and operation of the disposal facility. Oxidation of Fe minerals, in turn, can alter the properties of the host rock concerning its capacity to retard radionuclide transport. Here, we investigated Fe mineral transformations in an Early Pleistocene fluvial clay, which were initiated by the progression of a redox front. Samples were collected from a vertical transect perpendicular to an oxidation front at the Maalbeek quarry (Tegelen, the Netherlands). The samples were subjected to a combination of techniques to characterize and quantify the iron minerals. Techniques included XRD, sequential extractions, X-ray absorption spectroscopy but emphasis will be put on the collection of acquisition curves of isothermal remanent magnetization (IRM) and applying a magnetic property measurement system (MPMS). In general, acquisition of remanent magnetization in samples from below the oxidation front was higher than in samples above the oxidation front. Deconvolution of the acquisition curves indicates that a ferrimagnetic phase, with a coercivity that is unusually high for magnetite, accounts for the majority of the obtained magnetization in un-oxidized samples. Presence of authigenic, acicular magnetite might explain this observation. Changes in magnetic properties at low temperature with the MPMS turned out to be a valuable indicator for detecting and quantifying siderite, which has a Néel temperature of around 35 K. The applied magnetic methods were particularly useful for measuring magnetite and siderite. These minerals were difficult to be detected with the other applied techniques but are of particular interest in the context of radioactive waste disposal due to their reactivity towards radionuclides.