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Ordinary Portland Cement Degradation in Seawater

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Ordinary Portland cement (OPC) based materials will be used extensively in the construction of an engineered repository for the geological disposal of radioactive wastes in Japan. Invasive groundwaters will cause OPC degradation by a sequence of dissolution/precipitation reactions that could have detrimental effects on the long-term safety and performance of the bentonite buffer used to encapsulate radioactive wastes. Being able to identify and predict the sequence of dissolution/precipitation reactions that control OPC degradation is therefore important.

In the present study, experiments were conducted to investigate changes in the OPC mineral assemblage and leachate compositions during their degradation in increasingly larger liquid/solid mass ratios of commercially available synthetic seawater (SW). SW was used as a saline groundwater analogue. Geochemical modeling of the experiments was performed using the computer program PHREEQC (v3.7.3) with the JAEA TDB (v2018) for geochemical reactions (https://migrationdb.jaea.go.jp/). The model included distribution coefficients to account for the uptake of alkali metals and the development of three binary solid solutions to describe the different solubility behaviors of calcium silicate hydrate (C-S-H) gel, magnesium silicate hydrate (M-S-H) gel and hibschite.

OPC degradation in SW was characterized by the rapid dissolution and loss of the hydrated OPC mineral assemblage and the precipitation, dissolution and loss of (i) Friedel's salt, (ii) secondary ettringite, (iii) secondary brucite, M-S-H gel & hydrotalcite, and (iv) calcite. These sequential changes (i-iv) are consistent with the known chloride, sulfate, magnesium, and carbonate forms of chemical attack. Geochemical modeling was able to provide a satisfactory match to these sequential changes (Figure 1), and also to the corresponding changes in the leachate compositions.

Similar experiments are being planned to underpin the ongoing development of geochemical models to describe the degradation of OPC and high content fly ash silica fume cement (HFSC) in other invasive groundwaters relevant to the geological disposal of radioactive wastes in Japan.

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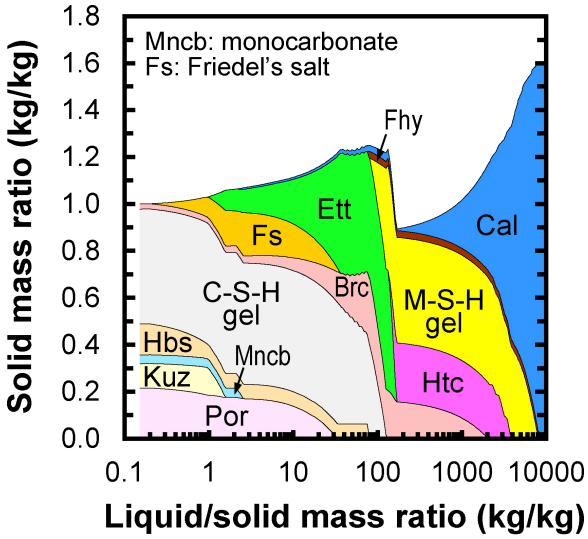

Figure 1: Predicted mineralogical changes associated with OPC degradation in SW.