Reaction of bentonite in low-alkali cement leachates: an overview of the Cyprus Natural Analogue Project

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Bentonite is a key component in many designs for radioactive waste repositories. The plasticity, swelling capacity, colloid filtration, low hydraulic conductivity, high retardation of key radionuclides and stability in relevant geological environments all make bentonite an ideal barrier/buffer material. However, as noted in Fujii et al, (this session), bentonite is unstable at higher pH levels and this is a potential problem for repository designs which mix cement and concrete barriers with bentonite barriers. The hyperalkaline (pH~13) leachates from the cement are expected to cause rapid alteration of the bentonite. This explains the recent interest in low-alkali cements, because they will produce a lower pH (around 10-11) leachate. It is expected that this lower pH will slow bentonite reaction (or even stop it altogether) over the timespan of relevance to repository safety.

These reactions are currently being tested in the laboratory, but the very slow rates means that such studies require support from longer-term datasets, such as those obtained in natural analogue studies. Here, an overview of investigation of long-term bentonite reaction in the natural hyperalkaline groundwaters of the Troodos ophiolite in Cyprus are presented. Serpentinisation of the ultramafic rocks present in ophiolites results in naturally hyperalkaline groundwaters and these have previously been studied at several sites around the world (eg

Papau New Guinea, Japan, China, Bosnia, USA etc). In Cyprus, ophiolitic groundwater pH values up to 12.0 have been measured recently by the authors (Alexander et al, 2011) but values of between 10.0 and 11.0 are more usual (cf. Alexander & Milodowski, 2011), falling into the range typical of low-alkali cements that are presently being developed for use in radioactive waste disposal.

As with most ophiolites worldwide, bentonites are an integral part of the Troodos Massif and many other parts of Cyprus, so presenting an ideal opportunity to examine long-term bentonite reaction in groundwaters of a relevant pH range. Bentonite samples analysed from several sites around the island show evidence of limited hyperalkaline reaction and these data will be presented here and compared with data from other bentonite NA studies and relevant laboratory work. The relevance of this work to the likely long-term performance of repository engineered barriers will be discussed and the potential impact on repository design explored.

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