BARRA Project (Spain)

Description: The BARRA project is devoted to the study of the long-term effect of some specific processes for the performance of the bentonite barrier in a deep geologic repository of nuclear waste. For this reason several bentonite outcrops from Cabo de Gata (SE Spain) have been investigated in the frame of the natural analogue program of ENRESA and SKB. Three different geologic conditions have been identified in the bentonite deposits from Cabo de Gata that could represent analogies of some of the potential evolutionary processes expected in the buffer of a deep underground repository (Bruno et al., 2002):

– the effect induced by an increase of temperature due to the intrusion of a volcanic dome intersecting the bentonite mass (thermal effect);
– the effect of seawater diffusion through the bentonite due to a marine transgression after the bentonite formation (saline effect); and
– the effect of the interaction with very high salinity water due to seawater aerosol (brine effect).

The first process can be considered as an analogy to the heating of the bentonite barrier by heat generating wastes, whereas the other two processes can be considered as analogies of high salinity groundwaters (or brines) interacting with the bentonite barrier.

For the thermal effect two different bentonite outcrops were selected as potentially affected by the heating (contact metamorphism) associated with volcanic intrusions: Morrón de Mateo and Cala de Tomate. Whereas, for the salinity and brine effects the outcrops from Cortijo de Archidona and San José were selected (Figure 1).

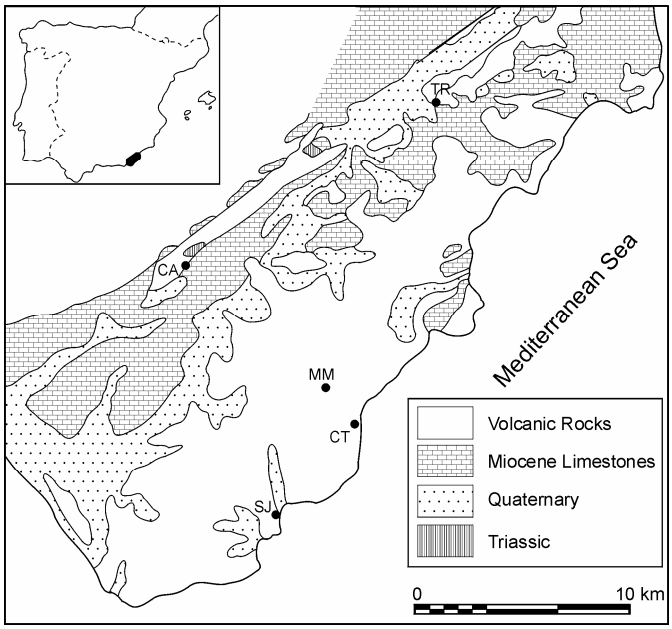

Figure 1. Geological map of the Cabo de Gata region (Caballero et al., 1992) with location of the main bentonite outcrops considered in the BARRA project: CA: Cortijo de Archidona; MM: Morrón de Mateo; CT: Cala de Tomate; SJ: San José.

The Morrón de Mateo outcrop (Figure 2) has been extensively studied in order to detect alteration to the bentonites as a function to the distance to the volcanic dome (Pérez del Villar et al., 2003), as well as to obtain information on the thermal gradient imposed by the intrusive dome on the surrounding rocks (bentonite and limestones). The results of the studies conducted in this outcrop showed that distal smectites are aluminium-rich, whereas those smectites close to the volcanic dome are Fe and Mg-rich. The same effect was detected on the limestones overlaying the bentonite, where calcite was replaced by Fe-rich dolomite close to the dome. The studies on stable isotopes from the smectites and carbonates (Pérez del Villar et al., 2002 and 2003), as well as the

fluid inclusion study in carbonates (Grandia et al., 2002) point to a very steep thermal gradient, with values ranging from 105 to 75ºC close to the intrusive dome and decreasing very fast to 25ºC in less than 20 m.

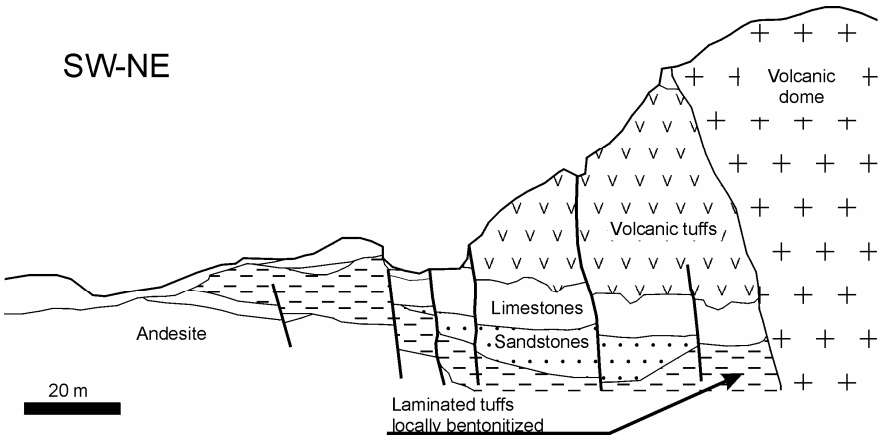

Figure 2. Geologic cross-section of the Morrón de Mateo outcrop (Fernández Soler, 2003).

According to the information obtained from the Morrón de Mateo outcrop, the observed processes could represent an analogy, not only of the heating effect due to high-level waste, but also of the interaction between bentonite and the iron corrosion products.

The Cala de Tomate outcrop, initially selected as another natural analogue of the thermal effect, was discarded because the geologic contact between the volcanic dome and the bentonite occurs through a fault. However, the features of this outcrop showed that it can be considered as a natural analogue of the saline effect (Pérez del Villar et al., 2004 a; b).

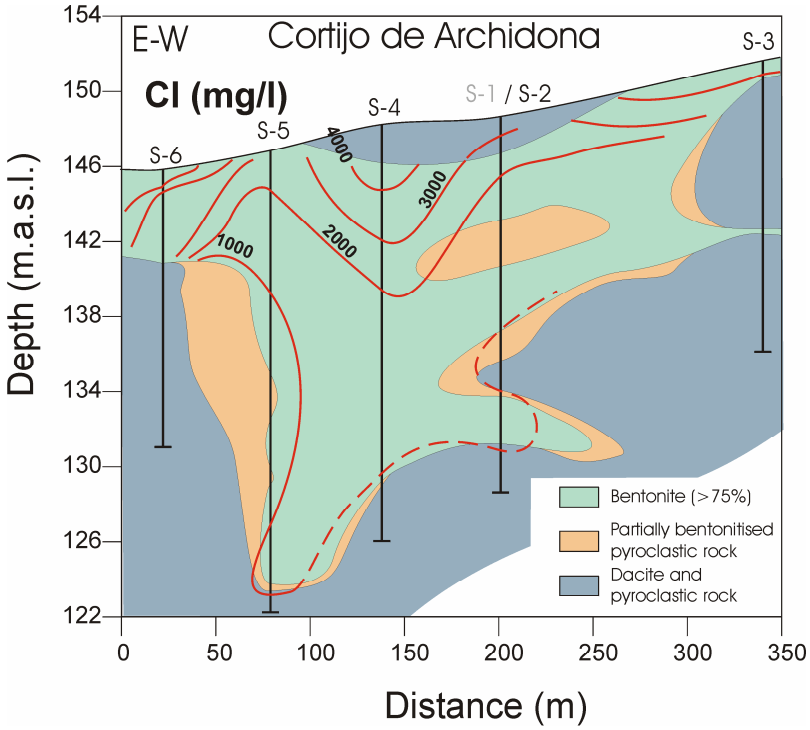

Figure 3. Geologic cross-section of the Cortijo de Archidona deposit using data from surface geology and borehole information (Fernández et al., 2001). The chloride contours correspond to the composition of porewater obtained by squeezing.

For the study of the Cortijo de Archidona deposit (saline effect) a complete sampling campaign was conducted in both surface and borehole samples (Fernández et al., 2001). The selected samples were analysed for mineral composition, bentonite porewater, cation exchange capacity

(CEC) and other parameters as porosity, water content and swelling capacity. The results showed the existence of a salinity gradient with depth, with higher chloride concentrations (5,000 mg/L) in the upper part of the deposit (Figure 3). A higher Na occupancy in the CEC was found to be associated to high salinity porewater in the upper part of the deposit. However, no major changes have been observed in the bentonite in terms of its behaviour as potential barrier in a deep spent fuel repository.

The San José outcrop has been studied to obtain information on the long-term performance of bentonite as a potential barrier due to its interaction with very high salinity water (Karnland et al., 2004). Despite the interaction with very high salinity water, the favourable physical properties of the bentonite as a barrier have not been altered.

Relevance: The BARRA project provides comprehensive information on the long-term effect of some processes expected in the near field of a deep spent fuel repository. This is especially significant for the performance of the bentonite barrier.

Position(s) in the matrix tables: Near field, behaviour of the bentonite barrier. Chemical and mechanical properties.

Limitations: The obtained results can only be applied qualitatively for the long-term evolution of the bentonite barrier. Some limitations concern the uncertainties associated to the duration of the processes and bentonite density (which is below the one expected in the repository).

Quantitative information: The obtained information has to be used in order to corroborate the extrapolation of laboratory experiments to longer time periods. For this reason quantitative information is restricted to the experimental data obtained with samples from the natural analogue.

Uncertainties: Duration of some of the processes (i.e. the time-length of the thermal regime in Morrón de Mateo).

Time-scale: Most of the processes have been acting for more than a few million years. However, the duration of the thermal event due to the volcanic dome intrusion in Morrón de Mateo, could be less than the time-length of the thermal stage expected in a repository.

PA/safety case applications: The information obtained can be very useful to validate long-term PA models on the performance of the bentonite barrier.

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Added value comments: This particular analogue has the added value of being placed close to the bentonite reserves that could potentially be used in the Spanish deep geological repository.

Potential follow-up work: Detailed analysis of bentonite samples is still needed to better understand the potential changes induced on the bentonite by some of the studied processes.

Keywords: Near field, bentonite, thermal stage, iron/bentonite interaction, brine/bentonite interaction.

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