Orciatico Intrusion (Italy)

Description: About 4 million years ago, a small (some millions m³) magmatic body (intrusion) was formed in the Pliocene clays of Orciatico, Italy (Benvegnù et al., 1988; De Putter and Charlet, 1994) (Figure 1). Several characteristics of the alkali trachites of the intrusion seem to indicate that the magma was crystallized under clayey sediments with a relatively limited thickness (a maximum of several hundred metres). The initial temperature of the magma is estimated at more than 800°C.

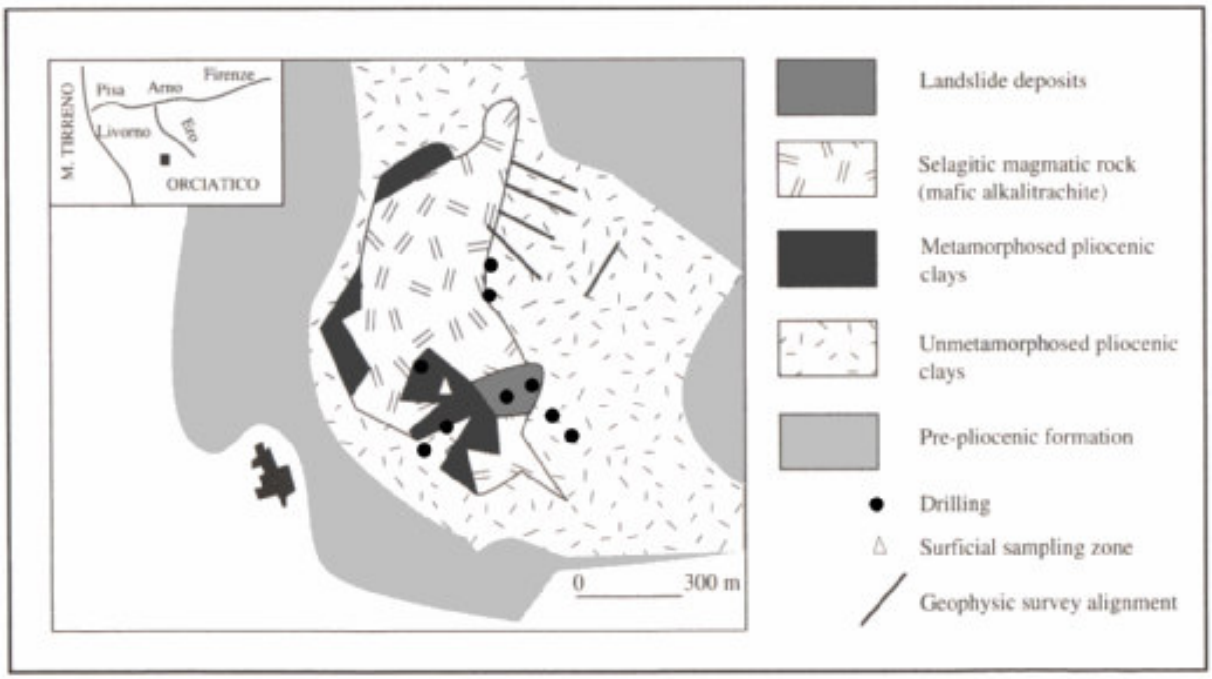

Figure 1: Location of Orciatico and geological map showing the intrusion and the metamorphic halo (the term "Selagitic" in the legend is obsolete).

The formation of the trachite intrusion in the clay caused contact metamorphism. These transformations are observable over a thickness of about 2 to 3 metres around the intrusion and 6 to 15 metres (maximum) above the intrusion (Figure 2). The intensity of the transformations to which the clays were subjected, rapidly diminishes when moving away from the intrusion.

A first zone with variable thickness (0.5 to 3 m) is characterized by an extremely compact texture, a very rare fracturation and a very low permeability: the newly formed minerals are pyroxene, plagioclase and biotite (horn rock facies, with moderate temperature and low pressure).

A second zone, thicker than the first (2 to 10 m), presents important micro-fracturing, probably caused by the loss of plasticity of the rock under the influence of heat and recrystallization: the newly formed minerals are mainly k-feldspar, illite and smectites. The rock is hardened and schaly, and its permeability is greater than that of the initial clay.

In a third, more diffuse and manifestly thinner zone (about 1.5 m), the texture of the initial clay did not change but the clay minerals (illite, vermiculite and interstratified illite/smectite) underwent destabilization and important smectitization.

Past this metamorphic "halo" of variable thickness, no mineralogical, chemical or physical transformation whatsoever is observed in the initial clay.

The neoformation of smectites in the second and third zones is particularly important, since it is supposed to have contributed to the significant increase of the clay's capacity to fix the cations that are supposed to have circulated in it. This means that the clay of the metamorphic halo would be more capable of adsorbing the radionuclides migrating in the vicinity of a possible disposal site for high-level waste, than the original rock that remained intact under the intrusion.

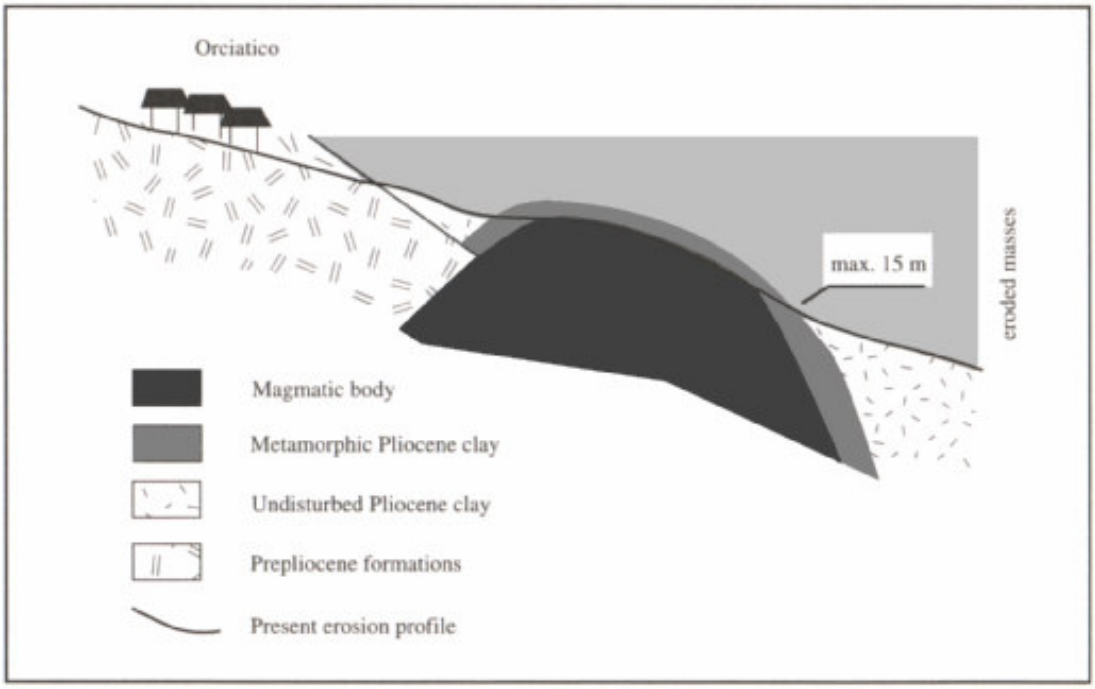

Figure 2: Simplified geological cross-section of the Orciatico trachite intrusion, the metamorphic halo and the regional surrounding rock

Relevance: A magmatic intrusion formed in the Pliocene clays of Orciatico in Tuscany. The transformations that took place in the clay as a result of the crystallization of magma with a temperature of more than 800°C, particularly consist in a neoformation of smectites of variable thickness, from about 3 to 12 metres around the circumference of the intrusion.

The results of the study seem to indicate that the thermal effect expected in the vicinity of a repository for high-level waste would contribute to reinforcing the adsorption capacity of clay for radionuclides, by causing an important neoformation of smectites. This shows that the choice of clay as a host formation for high-level waste, but also of bentonite as a filling material, would be particularly appropriate. The sorption property of the clay is only one important property of the clay barrier as the hydraulic properties of the clay are also important. However, micro-fracturing exists in the vicinity of the intrusion in zone 2. This might increase the permeability of the clay and therefore could reduce its hydraulic barrier effect.

Position(s) in the matrix tables: Near-field, Mechanical integrity of barriers (Mechanical failure), Buffer/Backfill (Bentonite).

Limitations: This analogue has three main limitations. Firstly, the absence of radionuclides in the Orciatico intrusion does not allow verification in-situ of the retention capacity of heated clay for these elements. Secondly, the volume of the intrusion and the thermal effect caused by this intrusion in the clay is considerably higher than the volume anticipated within the scope of the disposal projects.

The volume of the intrusion, in the order of several millions of m^3, is 1000 times higher than the volume of the waste destined for geological disposal; the thermal effect of an intrusion of 800°C (or more) is much higher than the temperature rise expected in the vicinity of the waste drums (about 100°C). It should be underlined that these limitations of the Orciatico analogue fall away when one assumes that conclusions that are valid under extreme circumstances are probably valid in less serious circumstances. Finally the presence of micro-fracturing in the vicinity of the intrusion in zone 2 is important to note, although as it is suggested to be associated with the thermal regime and recrystalization it is considered less probable in the vicinity of a repository for high-level waste (due to the lower temperature).

Quantitative information: None identified.

Uncertainties: Uncertainties in the estimation of the timing and temperature of the intrusion and also the importance of the microfracturing and its mechanism of occurrence.

Time-scale: The time-scale of the analogue is geological (4 Ma).

PA/safety case applications: None identified.

Communication applications: None identified.

References:

De Putter Th and Charlet J-M (1994) Analogues Naturelles en Milieu Argileux : Essai de synthèse bibliographique. NIROND -94-13 (ONDRAF/NIRAS publication), 183 p.

Benvegnù F, Brondi A and Polizzano C (1988) Natural analogues and evidence of long-term isolation capacity of clays occurring in Italy. CEC-EUR 11896 EN, pp. 26-32.

Added value comments: None identified.

Potential follow-up work: None identified.

Keywords: contact metamorphism, clay, neoformation, intrusion, adsorption capacity

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