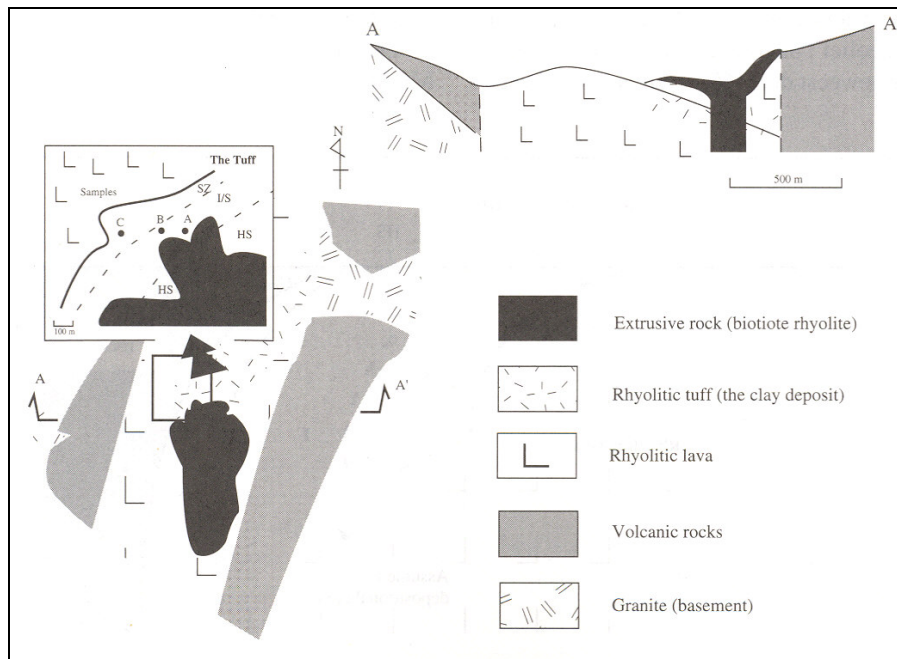


## Murakami (Japan)

**Description:** About 7 million years ago (Pliocene), a rhyolitic (volcanic) layer with a thickness of 80 m was formed in a marine environment. After its deposition, the rhyolite was transformed into a bentonite (smectite and zeolite) by diagenesis. One million years later, this subhorizontal bentonitic layer was cut through by a biotitic-rhyolitic extrusion. The small magmatic body has the form of a funnel between 150 m and 500 m wide (Figures 1 and 2). The original temperature of the magma is estimated at 350°C and decreased with 70°C each million year.



**Figure 1:** Location map of Murakami

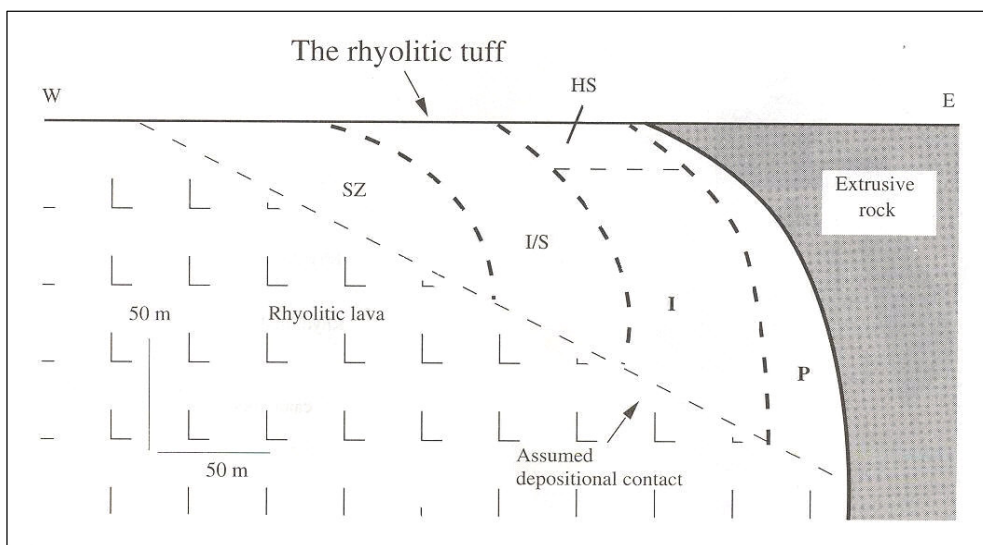


**Figure 2:** Geological map and profile of the environment of Murakami

The intrusion of the magmatic body has caused mineralogical transformations (contact metamorphism). With increasing distance of the intrusion, several concentric zones are distinguished

(Figure 3). At the contact with the rhyolitic pipe, the high temperature (350°C) has created a zone build up predominantly by pyrophyllite (a mineral belonging to the talc group). The deeper part of the second zone consists entirely of illite.

Near the surface, smectite with a high cristallynity is encountered. In a third zone, the newly formed minerals are made up by interstratified illite/smectite in a proportion of 80/20. The zone near to the magmatic body illustrates that the temperature decreased in the past 3.5 million years from 340°C to 100°C. Further away, at a distance of about 30 m, the maximum temperature did not exceeded 240°C and after 3 million years, the temperature also reduced to 100°C. In this zone the interstratified layers are composed of 40% of illite. A fourth and last zone is characterized by smectite and zeolite. The temperature here remained below 161°C and decreased to 100°C in 2 million years. Newly formed illite crystals are not found and the originally mineral association doesn't seem to have changed.



**Figure 3:** Schematic profile of the bentonite, with the different zones of newly formed minerals (P= pyrophyllite; I= illite; HS: high crystallinity smectites; I/S: interstratified illite/smectite; SZ community of smectite - zeolite)

This study confirms that a transformation of bentonite to illite needs a sustained temperature increase above a threshold value before illite can be formed. The threshold temperature is, in this region, estimated at 105°C. The supply of K, Mg, Ca and Na, which is indispensable for the transformation, is produced by the sea.

**Relevance:** The intrusion of a magmatic body into bentonite, provides an analogue for the increased temperatures expected in the neighborhood of heat-emitting HLW in a clay formation and/or with bentonite buffer or back-fill.

The results of the study seem to indicate that bentonite which is heated to a temperature of 240°C and cooled down to 100°C in a period of 3 million years, can be transformed in an interstratified illite/smectite, if sufficient ions required for this transformation are available. The illitic part in this transformed zone does not reach more than 40%. If the maximum temperature doesn't exceed 160°C, and decreases in 2 million years to 100°C, no newly formed illite is found and the original smectites are not changed. In a repository for heat-emitting HLW the temperature increase is not expected to be higher than 100°C and so no transformation to illitic minerals is expected to occur.

**Position (s) in the matrix tables:** Near-field matrix, mechanical integrity of barriers (corrosion – chemical alteration), Buffer/Backfill (Bentonite).

**Limitations:** The following points are noted:

1. Due to the absence of nuclides in the magmatic body, the long term effect of a temperature increase for the clay retention capacity is not known.
2. The temperature of intrusion is above that expected near the waste in a repository.

**Quantitative information:** Summary of any particular quantitative information from the study.

**Uncertainties:** Estimations of the intrusion temperature and cooling profile have some uncertainties associated with them.

**Time-scale:** The time-scale of the analogue is geological (2-3 million years).

**PA/safety case applications:** None identified.

**Communication applications:** None identified.

**References:**

De Putter TH and Charlet J-M. 1994. Natuurlijke analogieën in klei: een bibliografische synthese. NIROND 94-14. p.183.

**Added value comments:** None identified.

**Potential follow-up work:** None identified.

**Keywords:** bentonite, illite, Japan, metamorphism, Pliocene, rhyolite, smectite.

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