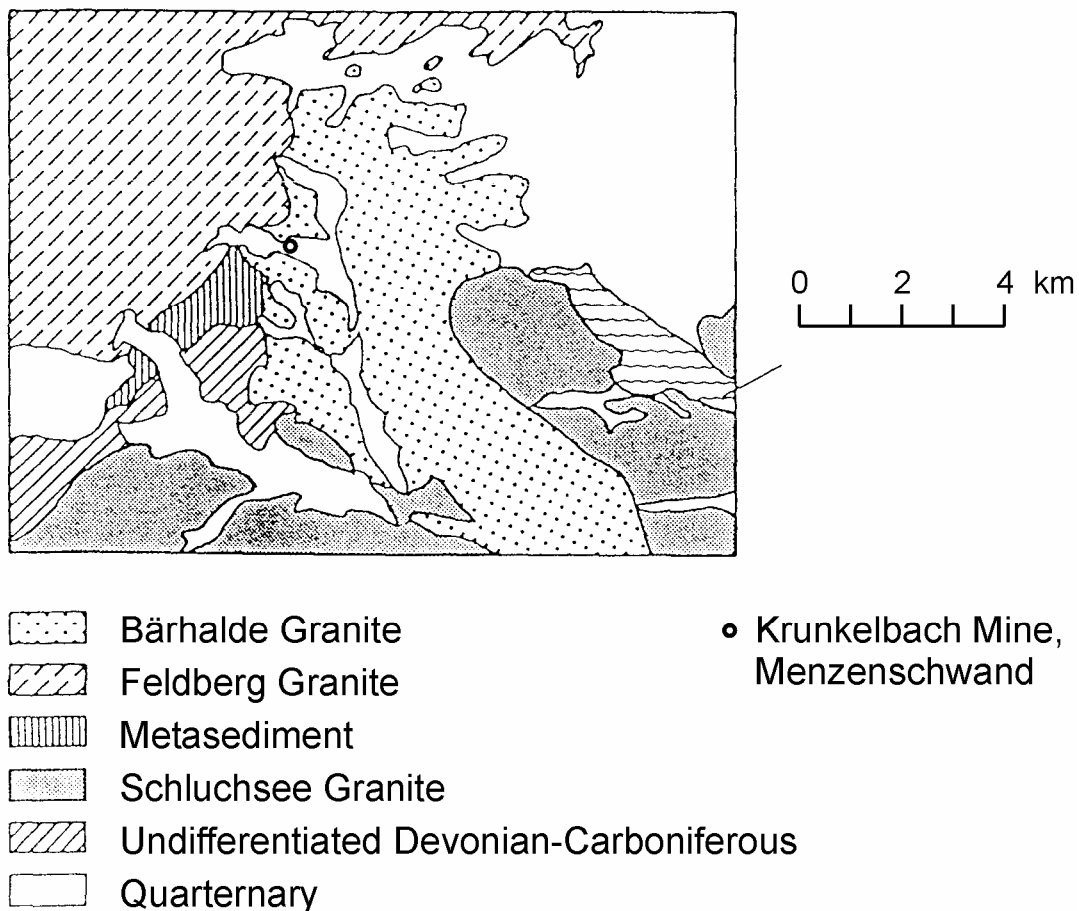


## **Menzenschwand (Germany)**

**Description:** The Krunkelbach mine near Menzenschwand is located in Southern Germany in the crystalline basement complex in the Black Forest. The host rock of the Krunkelbach uranium mine is a highly differentiated, so-called, Bärhalde granite. The uranium mineralization is bound to hydrothermal quartz-(barite-fluorite)-veins, which have a vertical extent of at least 400 m. The uranium ore veins show a width of several cm to a few m.

The formation of the uranium mineralization took place at  $310 \pm 3$  Ma. In the late Tertiary or in the Quaternary the basement of the Black Forest was uplifted and the prevailing hydrological conditions were installed. As a consequence oxidising conditions in the area of uranium mineralization have been formed.



**Figure 1:** Geological sketch map of the Menzenschwand area

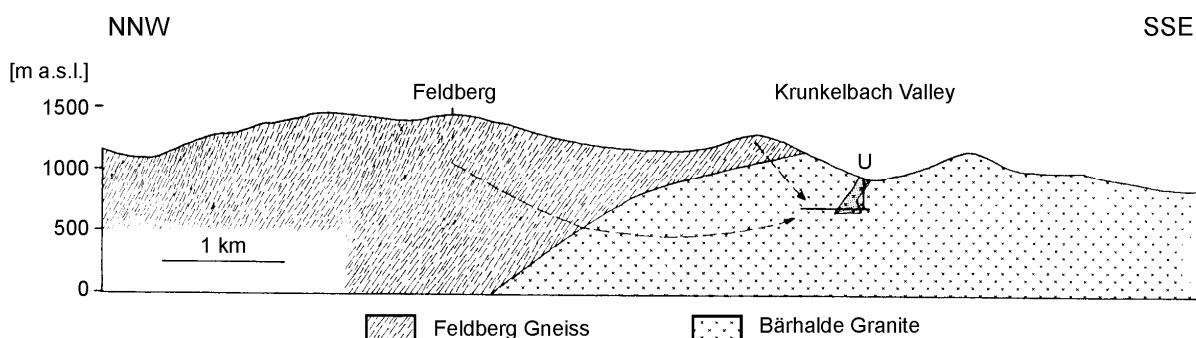
Under the near surface weathering conditions a number of secondary uranium minerals have been formed in the ore, mainly uranites (uranium mica) and secondary uranyl silicates. The age of the secondary uranium minerals has been determined by  $^{234}\text{U}/^{230}\text{Th}$ -analysis in a range between 250 000 to 340 000 years. Oxidation of the pitchblende and of iron sulphides is observed down to a depth of at least 240 m. The formation of the uranium peroxide mineral studtit ( $\text{UO}_4 \cdot 4\text{H}_2\text{O}$ ) indicate the existence of highly oxidising conditions and could be an indicator for radiolysis. This mineral is also found in Shinkolobwe (Zaire), where similar near surface weathering conditions occur and also association with primary pitchblende and uranyl silicates is found. Radiolysis is supposed to be responsible for peroxide formation. Uranium oxidation is most likely caused by atmospheric oxygen.

The most important role of the Menzenschwand analogue study lies in the transport of inorganic colloids in granite. Therefore, the review is focussed on this topic. The Bärhalde granite of the Black Forest shows similar properties as the granites in Northern Switzerland, i.e. the overall

lithology and mineralogy of the Bärhalde granite fractures is representative of some of the fractures in the north Switzerland basement. Inorganic colloids, mostly made up of clay minerals, have been observed in the Bärhalde granite groundwater with concentrations in the range of 400 µg/l.

The chemical composition of the colloids was measured in groundwater sampled in the deepest (240 m) level of the Krunkelbach mine. The groundwater system is characterized by oxygenated low saline Ca-Na-bicarbonate water.

In a preliminary study it was recognized that the Mg:Ti ratio of the colloids differs significantly from the host granite (Hoffmann 1989a). Comparison with Mg:Ti ratios of other material from the surrounding rocks indicates that the colloids could stem from the Feldberg Gneiss. In this case transport distance of the colloids through the granite is approximately 1 (nearest distance) to 5 kilometres as can be seen in a simplified picture with the main flow paths in Figure 2. The recharge of the water, sampled at Krunkelbach mine, from the topographic high Feldberg in the Gneiss formation is supported by signatures of N<sub>2</sub> and Ar.



**Figure 2:** NNW-SSE profile through Feldberg and Krunkelbach mine with assumed main flow paths of the groundwater

Based on the preliminary results a more detailed study has been performed (Alexander et al. 1990). From a limited number of water samples taken in the Krunkelbach mine colloids in different size fractions of 1000 nm, 100 nm, 30 nm and 15 nm were isolated and chemically analysed. The major effort of the investigation was put on the characteristic elemental composition of colloids and different rock types of the area, i.e. contents of Mg, Ti, Zr and REE, since it was known, that the granite has particularly low concentrations and the Feldberg Gneiss has high concentrations of these elements.

The concentration ratios of Mg, Ti, Zr and REE in the different colloid fractions were analysed and compared to the ratios in the rock of Gneiss and the Bärhalde granite. The results of the analysis show an equivocal picture. Comparing the ratios of the elements by plots of concentration of two elements against each other it is difficult to clearly decide whether the colloids stem from the Feldberg Gneiss. This is especially due to a large scatter in the element composition of the colloids of different size.

As a more sophisticated method the REE data of the >100 nm and > 1000 nm colloid fractions have been presented as chondrite-normalized plot and compared with the granite and Gneiss signatures. This comparison suggests that the origin of the granite water colloids from the gneisses is not unreasonable and that the Bärhalde granite itself contributes not or only minor to the colloid formation. It becomes clear that the hydrothermal clays present in the granite fracture system are not involved in the formation of colloids.

**Relevance:** This study is relevant for the transport of colloids in granitic formations. Colloids could enhance the pollutant transport by sorbing radionuclides released from a repository and travelling long distances with the same velocity as the groundwater, i.e. they might act as a carrier for the radionuclides.

To judge the impact of colloids on the radionuclide transport, one important question is whether colloids are stable enough to be transported over long distances. This study gives indication that inorganic colloids are transported in fractures of granite over distances of kilometres.

**Position(s) in the matrix tables:** Near-field, RN migration in barriers, colloidal transport.

**Limitations:** The study gives indication for long distance transport of colloids. However, the hydraulic conditions at Menzenschwand are different to conditions expected in low permeable domains in granite host rock, i.e. the water flow rate is about 4 – 6 orders of magnitude higher. This will probably influence colloid concentrations. No information is derived on the stability of the colloids over long time frames.

The study addresses only transport of the colloids. No detailed analyses on interaction of natural radionuclides (U, Th) with colloids and on colloid facilitated transport was performed because of the low concentrations of both elements.

**Quantitative information:** Quantitative information is given for the transport distance of colloids which is at least one km and could be more than five kilometres. Furthermore data for colloid concentrations and element contents of the colloids from four size fractions are given.

**Uncertainties:** The main uncertainty arises from the limited number of colloid measurements. Only four samples were investigated, which do not allow to derive statistically sound results, especially because a large spread in element contents in colloids of different size is observed.

**Time-scale:** The time-scale addressed by the study is geological. The current hydrological conditions were established in the late Tertiary/Quaternary. Concerning the transport time of the groundwater colloids from the gneiss to the granite time scale is only in the range of years or less.

**PA/safety case applications:** Put into general context with other sites with different groundwater and flow properties (Degueldre, 1996). From this study maximum colloid concentrations for granitic site in Switzerland have been derived. In SR-97 the Menzenschwand study is mentioned as one of few analogues, where colloid transport over distances of several 100 metres was observed. It shows that impact of colloids needs to be addressed in PA. Nevertheless, colloid transport was discussed to play no role in Swedish repository concept mainly due to very low concentrations of colloids in water of Swedish granite.

**Communication applications:** None identified

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**Added value comments:** None identified

**Potential follow-up work:** Most important would have been analyses of additional samples to receive statistically more meaningful results. But the mine has been closed so there is no follow up work possible.

**Keywords:** inorganic colloids, granite, groundwater, transport

**Reviewers and dates:** Ulrich Noseck, GRS; (October, 2004)