# DETAILED CHARACTERIZATION OF FRACTURES IN THE ROCK MASS USING ENGINEERING METHODS, ULTRASONIC AND PERMEABILITY MEASUREMENTS

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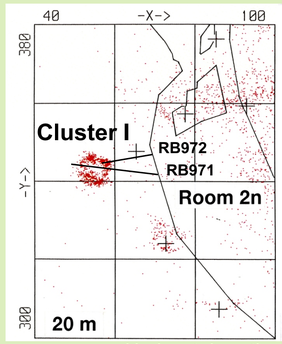
## Introduction

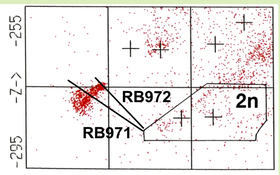
Due to their good barrier properties, salt deposits are very suitable as repositories for hazardous waste. However, even in rock salt fracturing can occur near cavities and at the boundary of rocks, e.g. of ductile rock salt and stiff anhydrite. Acoustic emission (AE) indicates microcrack processes in the rock. In this investigation, a ring-shaped cluster of AE events was analysed by a combination of geophysical, geotechnical and engineering geology methods.
Careful inspection of rock cores in the laboratory and investigations of borehole walls using a video camera were performed. Active ultrasonic measurements were conducted in boreholes in order to characterize discontinuities like fractures and to determine whether single fractures were persistent features between boreholes. Furthermore, permeability measurements were performed in and between boreholes.

## Detection of microcrack clusters




Horizontal section

### Location of AE events (prominent example)

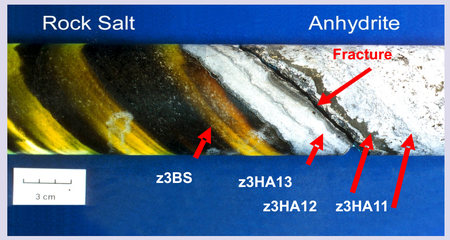



Vertical section

- Data from January - June 1997: Cluster I activity emerged during two days near Room 2n.
- Verification of AE results by drilling of two boreholes in the center (RB971) and the outer part of the ring-shaped cluster (RB972).

## Methods of engineering geology

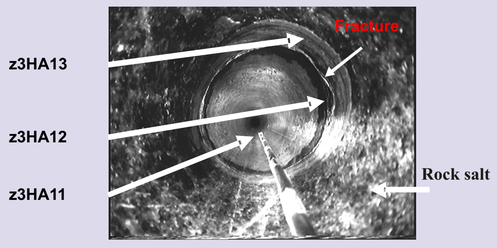
### Inspection of rock cores




*RB971 (19,9 m depth)*

Near boundary of rock salt and anhydrite: Separation of the core in a thin layer of clay.

### Inspection of corehole walls using a video camera




*RB972*

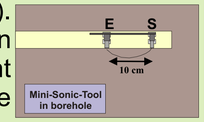
Wide angle view of the boundary of rock salt and anhydrite with identification of a fracture directly behind the boundary (whitish line).

***Engineering geology methods detected 3 fractures in borehole RB971 and 5 fractures in RB972.***

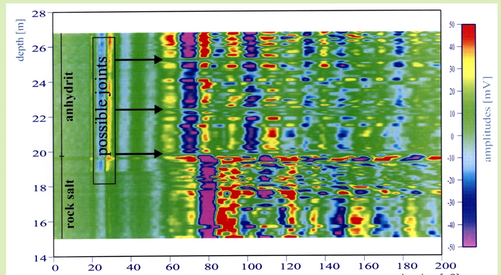
## Active ultrasonic measurements

### Principle of interval measurements

Mini-Sonic-Tool in the borehole with seismic source (S) and receiver (E). Interval measurements in one borehole by movement of one tool along the




### Color-coded seismogram section

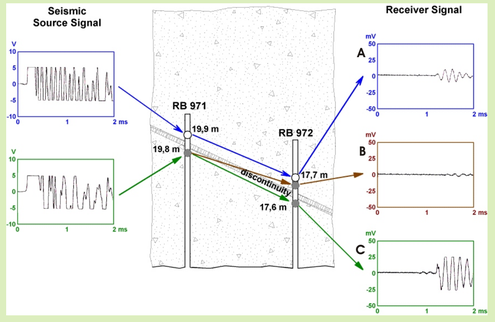



*RB971*

Potential fractures are marked by low signal amplitudes. 3 potential fractures directly behind the boundary of rock salt and anhydrite.

***Like video inspection, active ultrasonic measurements also detected 3 fractures in borehole RB971 and 5 fractures in RB972.***

### Crosshole measurements




Large signal amplitudes when seismic source and receiver both were located before or behind fracture (A and C).
No signal detected when source before and receiver behind fracture (B).
Conclusion: Fracture near boundary rock salt - anhydrite is persistent between boreholes.

## Permeability measurements

Tests between sections of 1.5 m length in boreholes RB971 and RB972 sealed by packers.
Classification of high, middle and low permeability in tested rock areas.
Conclusion: Fracture near boundary of rock salt and anhydrite is persistent, volume of the fracture (network) could be determined (around 50 litres).

## Conclusions

The results of the engineering geology methods and the ultrasonic methods completed each other in regard to the identification of discontinuities in the rock mass. Thus, the locations of fractures could be determined reliably and the persistency of fractures between boreholes could be stated. It was concluded that the investigated cluster of microcracks marked the shape of a roughly elliptical macroscopic fracture plane of about 10 m diameter at the boundary of rock salt and anhydrite. It had an opening width in the order of 1 mm.
The combination of methods proved to be very successful. The ultrasonic measurements provide a high spatial resolution and can be performed quickly and cost-effective so that the number of permeability measurements can be reduced significantly.

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