

Detailed investigation of fracturing at the boundary of rock salt and anhydrite using engineering geology methods and ultrasonic measurements

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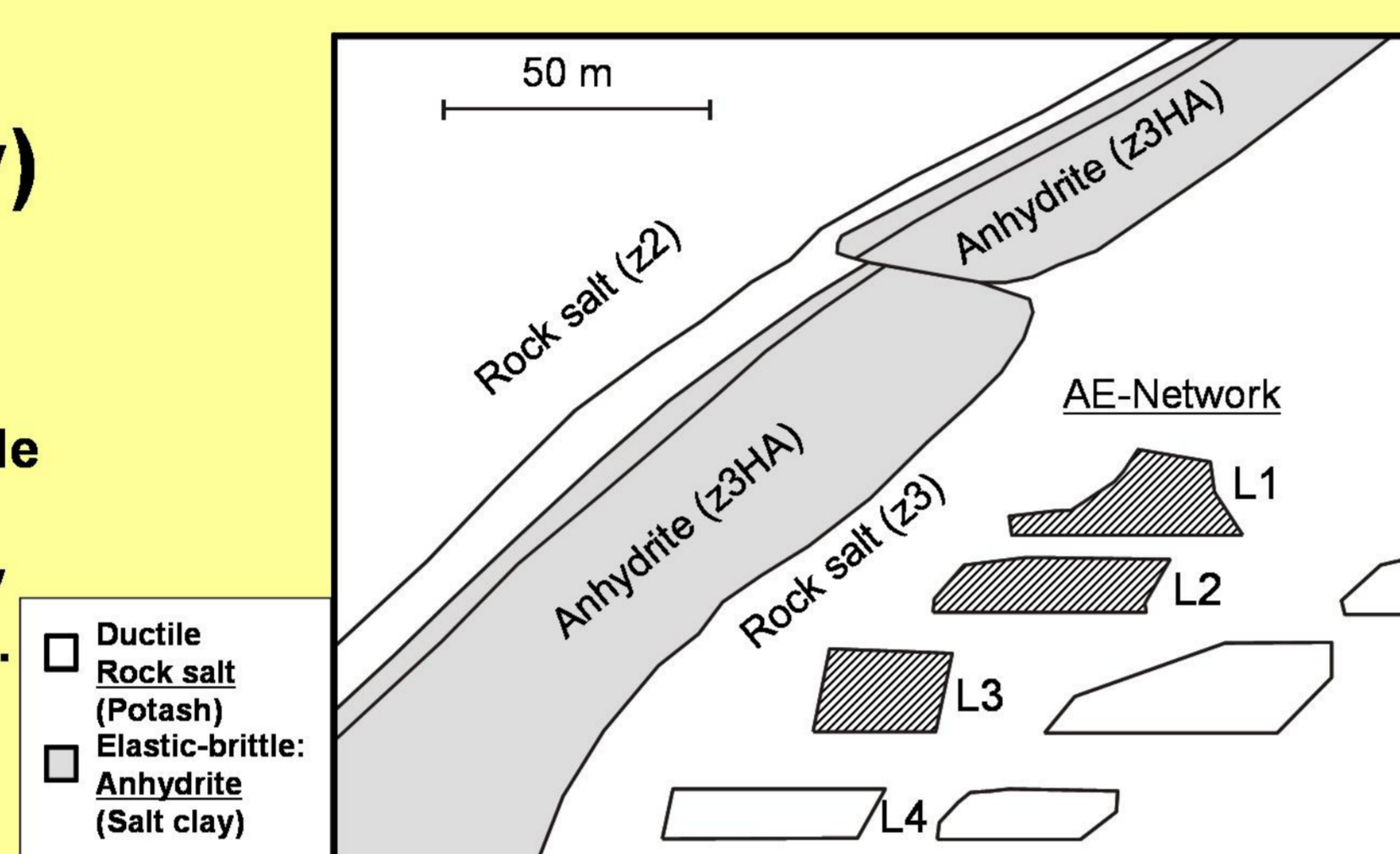
Introduction

Deformation of large rock salt formations occurs for the most part without the formation of fractures. Fracturing can occur, however, near cavities and at boundaries of ductile rock salt and stiff anhydrite. Acoustic emission (AE) measurements providing the locations of microcracks were performed in a mine segment near anhydrite beds. Often clustering of AE events was found in the rock but could not be attributed to certain geological features as the locations of geological boundaries were not known precisely. So the AE results were verified by drilling of two boreholes into a region of the rock in which a prominent cluster of events was observed.

Evidence of the geological conditions and of discontinuities as fractures or joints should be found by careful inspection of the rock cores in the laboratory and of the borehole walls in situ using a video camera. Active ultrasonic measurements were conducted in the boreholes in order to characterize discontinuities like fractures and to determine whether single fractures are persistent features between the boreholes.

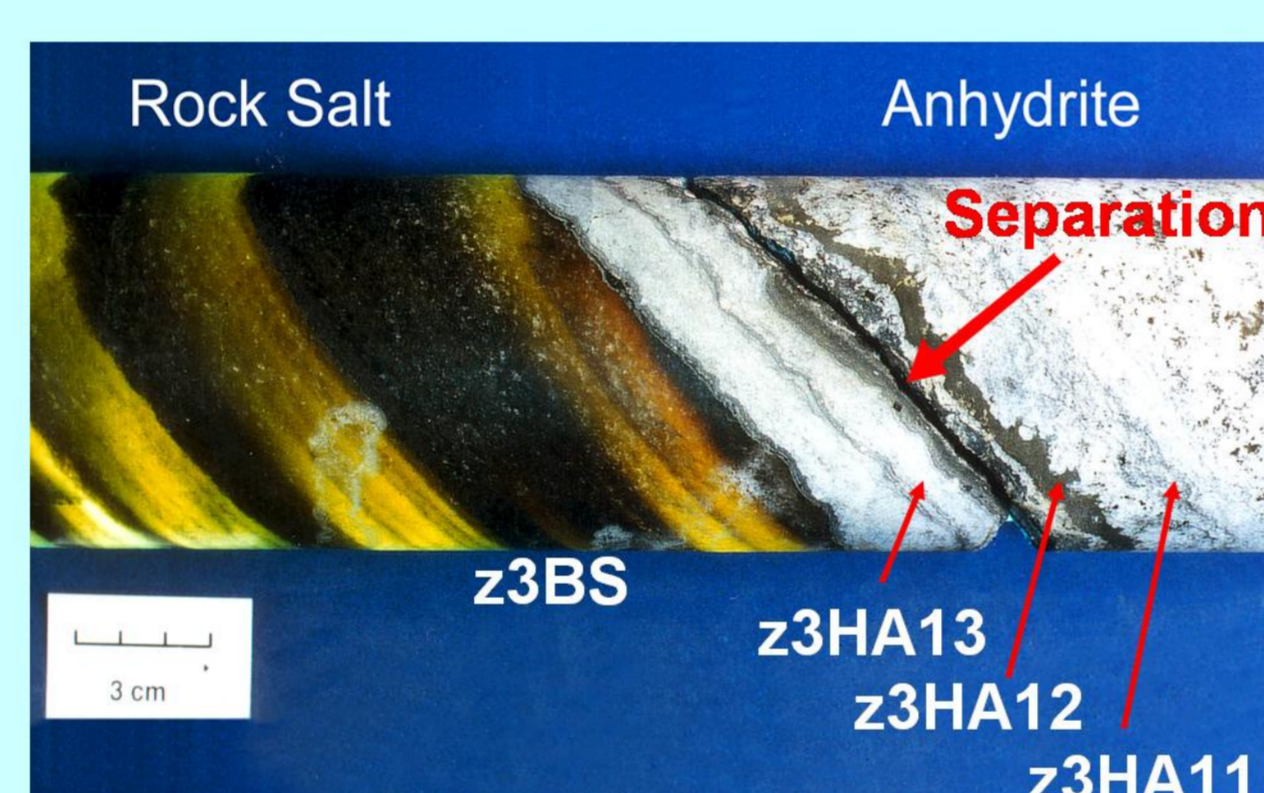
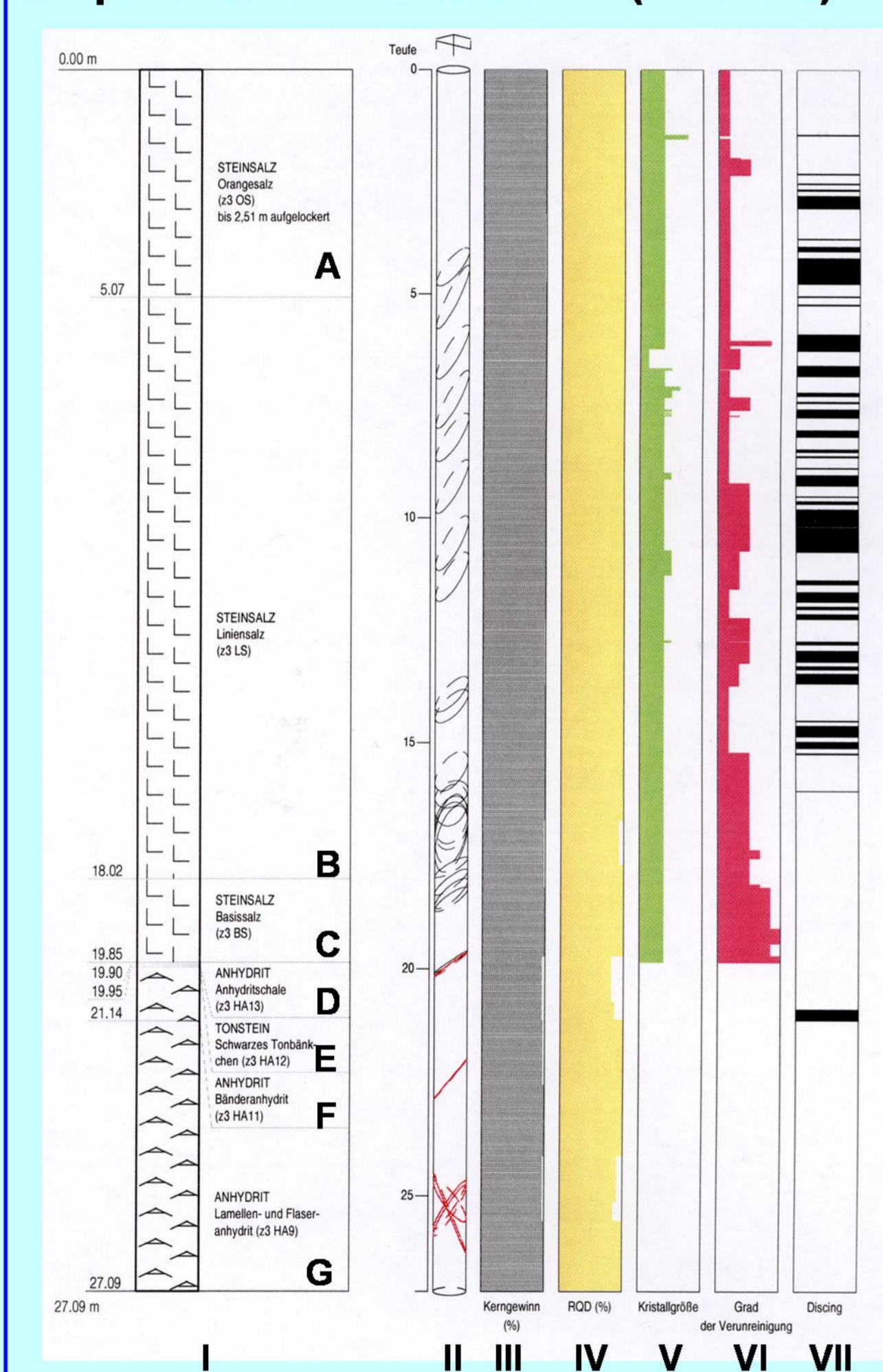
Sketch of geology (Zechstein NW Germany)

- AE network of 24 sensors at Levels L1 to L3 (depth -280 m NN to -305 m NN).
- Boundary of ductile rock salt and brittle anhydrite near cavities.
- Stress concentrations at the boundary can cause micro- and macrofracturing.



Engineering geology methods

Inspection of rock cores (RB 971)



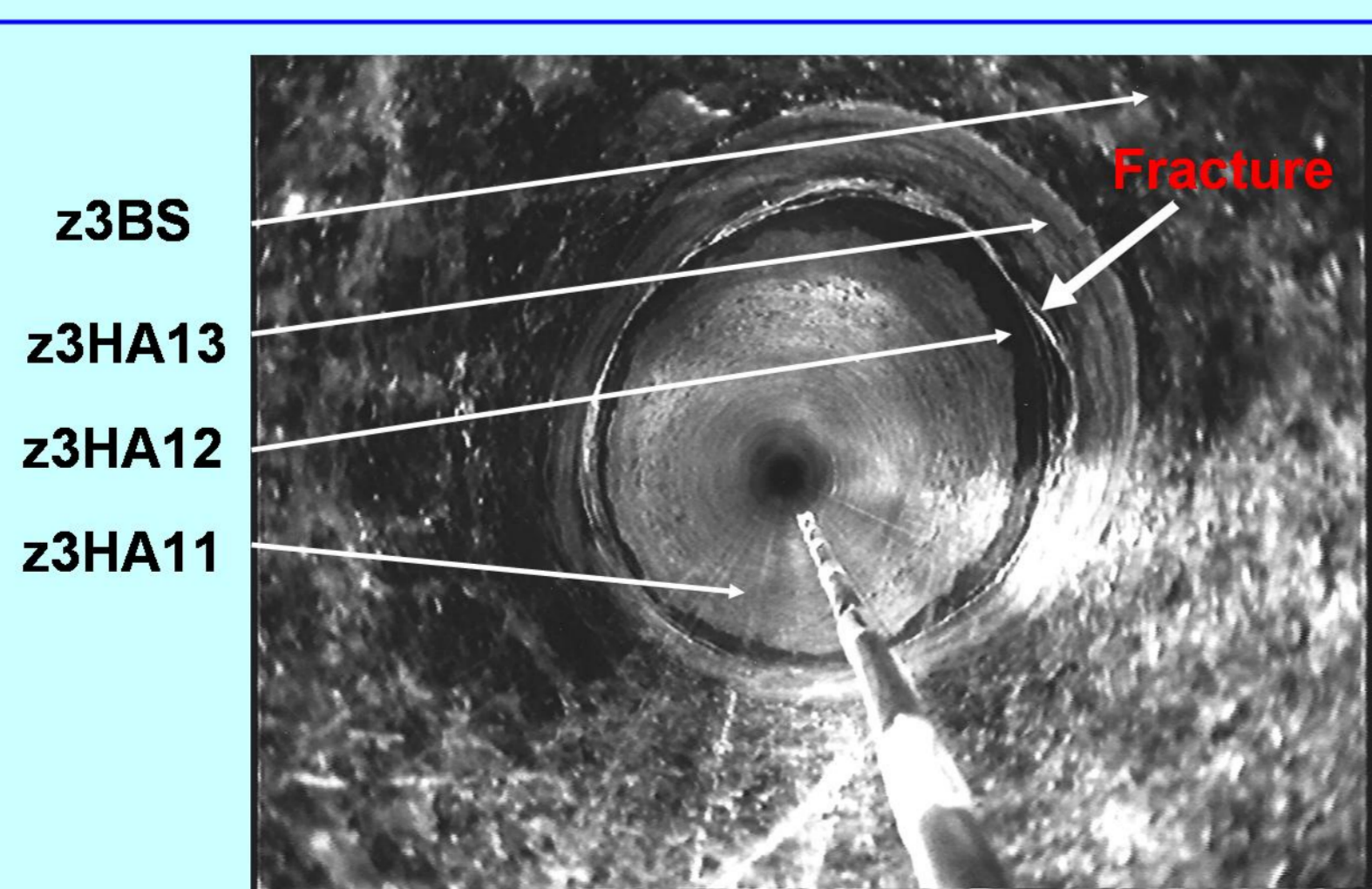
Near boundary rock salt – anhydrite: separation of core in thin layer of clay.

- I: Lithology:
 A: Rock salt z3OS (EDZ up to 2.5 m)
 B: Rock salt z3 LS
 C: Rock salt z3 BS
 D: Anhydrite z3HA13
 E: Clay z3HA12
 F: Anhydrite z3HA11
 G: Anhydrite z3HA9
- II: Bedding (black), separation of cores (red)
 III: Amount of gain
 IV: Rock Quality Designation (RQD)
 V: Size of rock salt grains (4 classes)
 VI: Impurities in rock salt (3 classes)
 VII: Discing

Inspection of borehole walls using a video camera

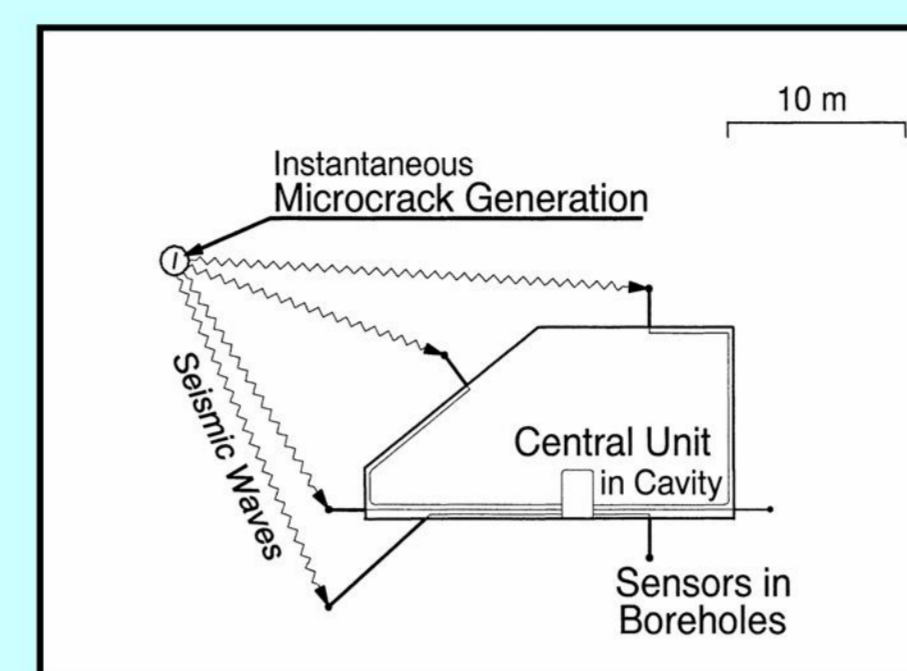
Wide angle view of the boundary of rock salt and anhydrite with identification of a fracture directly behind the boundary (whitish line).

In anhydrite section of borehole 3 fractures were identified in RB971 and 5 in RB972.



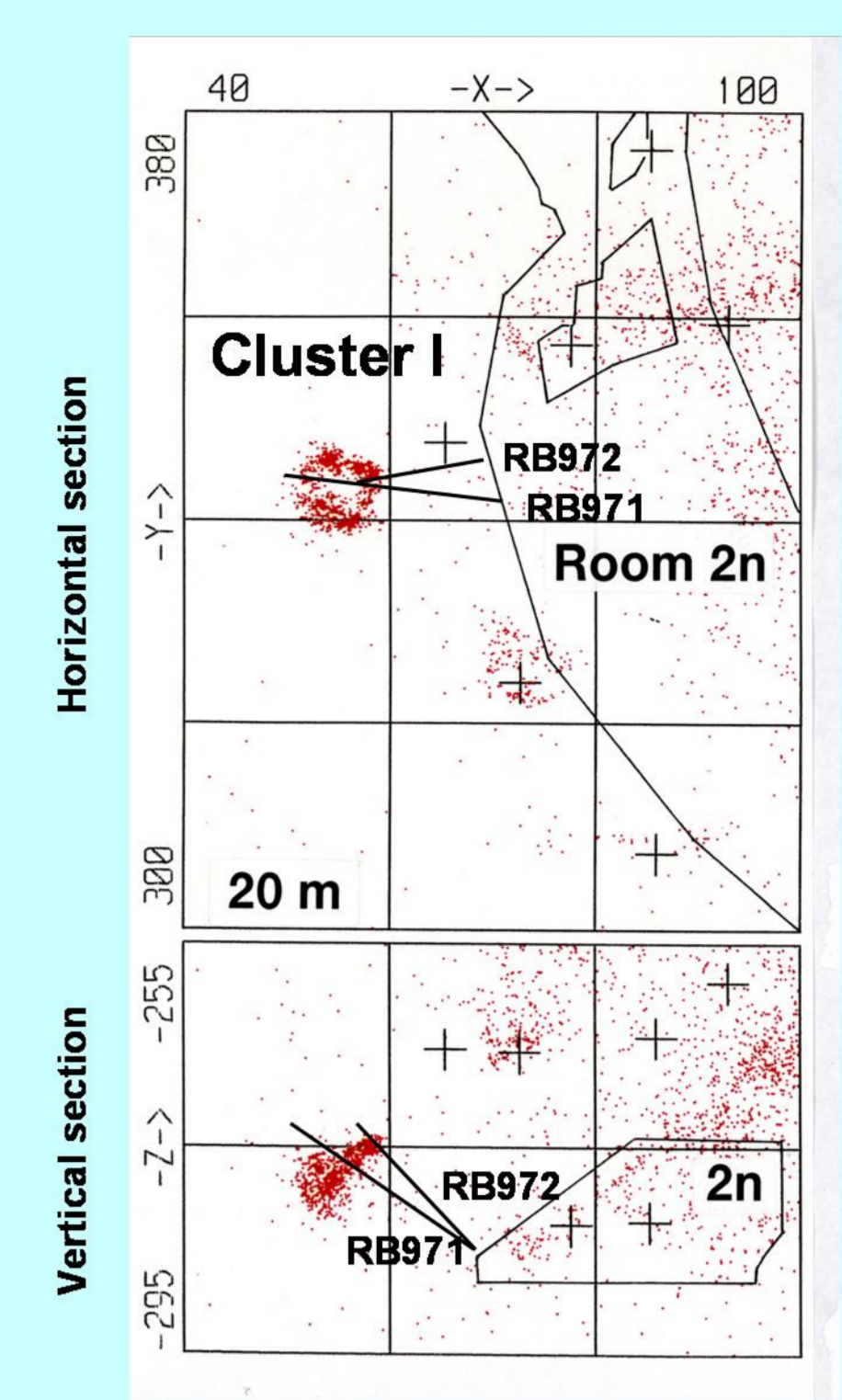
Passive ultrasonic measurements (AE)

Principle of measurements



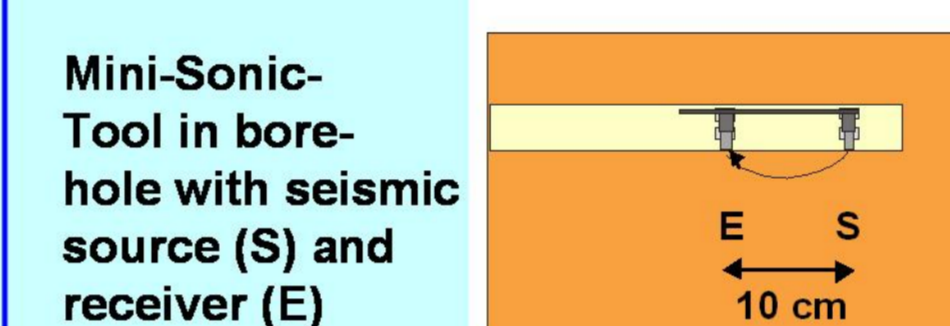
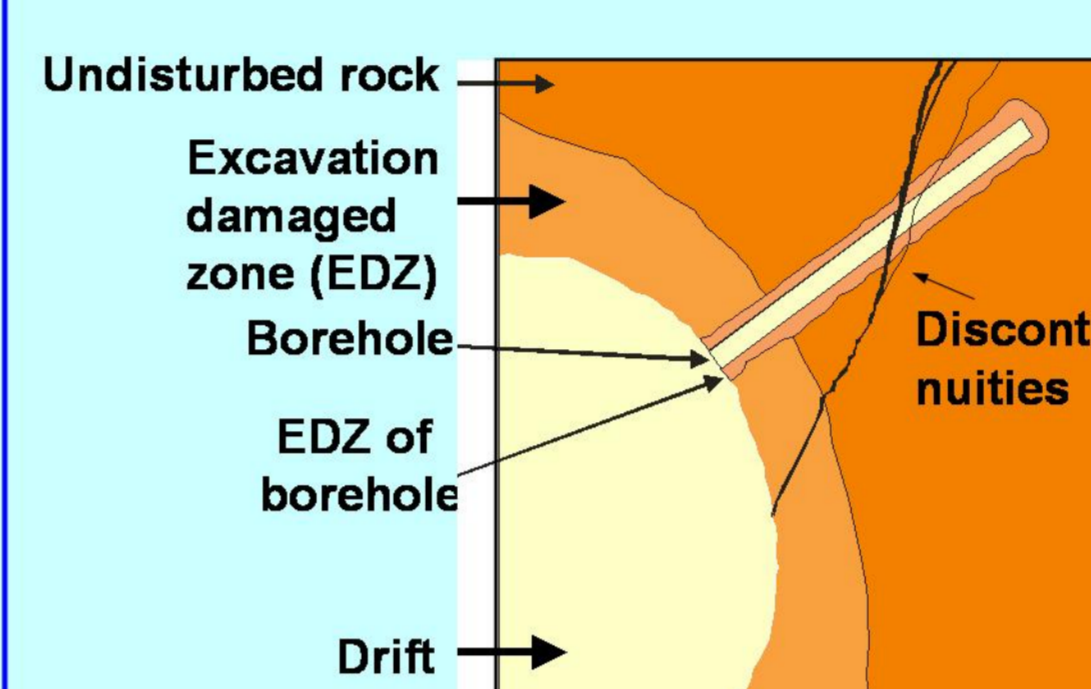
Location of AE events (right figure):

- Data from Jan 97 to Jun 97: Cluster I activity emerged during 2 days near Room 2n.
- Verification of AE results by drilling of two boreholes in center of ring-shaped structure (RB971) and in outer part (RB972).



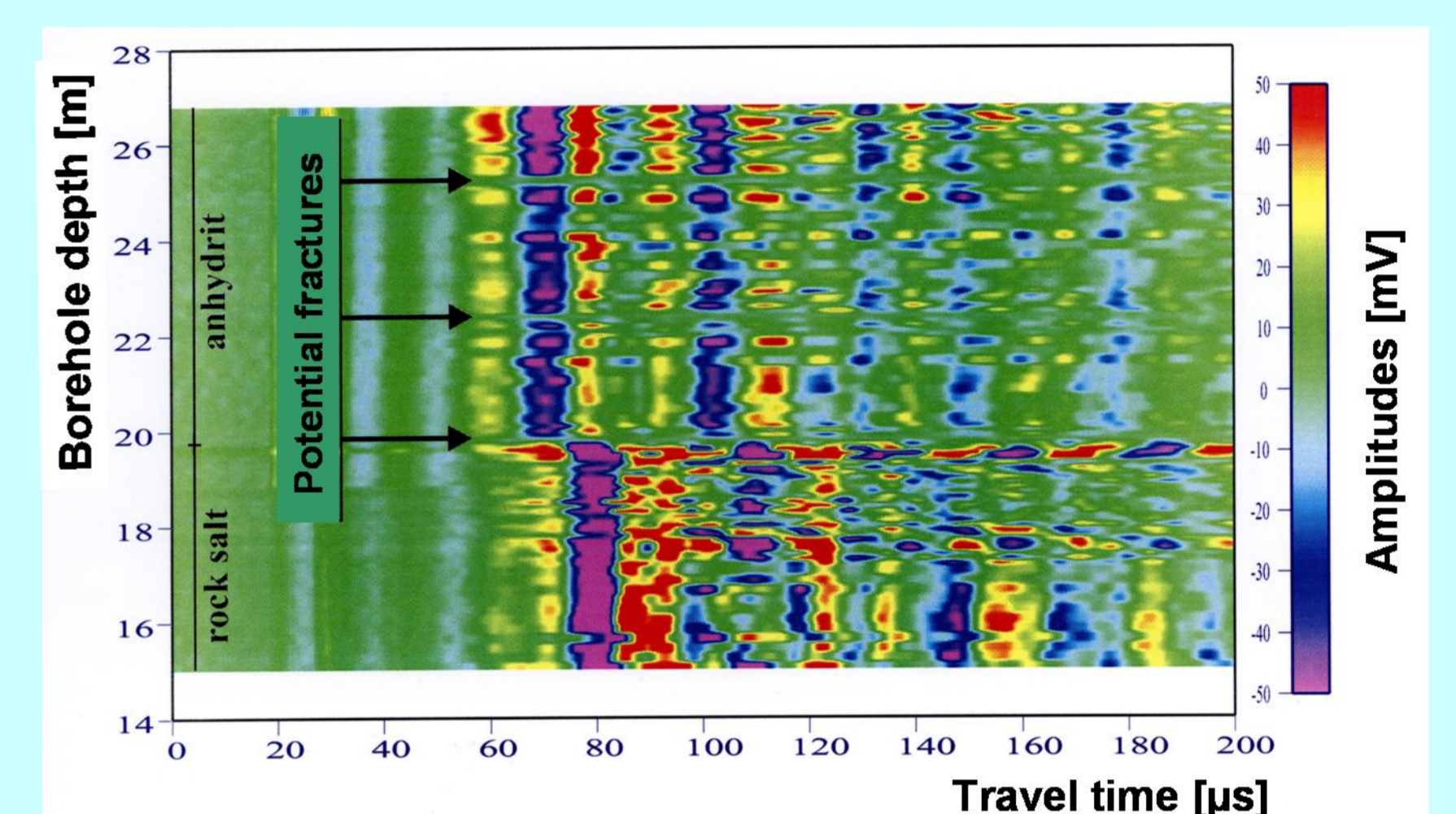
Active ultrasonic Measurements

Principle of measurements

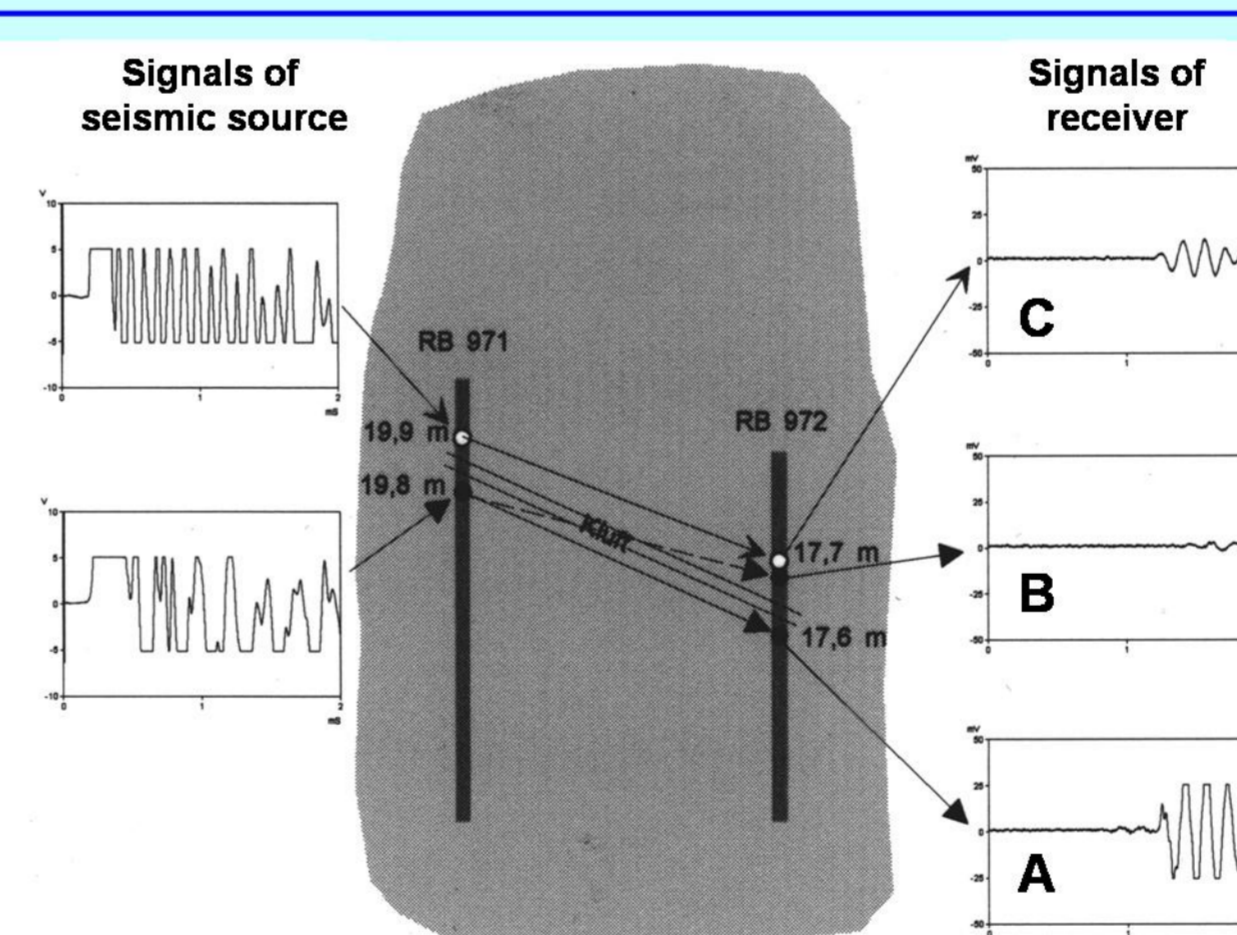


- Interval measurements in one borehole by movement of one tool along borehole.
- Crosshole measurements between two boreholes by movement of two tools.

Interval measurements along borehole RB971: Color-coded seismogram section



- Lower part: signals in rock salt.
- Upper part: signals in anhydrite with 3 potential fractures indicated by low signal amplitudes in RB971.
- Potential fracture directly behind boundary of rock salt and anhydrite.



Crosshole measurements at boundary of rock salt and anhydrite

- Large signal amplitudes when seismic source and receiver both were located before fracture and behind fracture (see signals A and C in right part of figure).
- No signal detected when source was before fracture and receiver behind (see signal B).
- Conclusion: Fracture behind boundary is persistent between boreholes.

Conclusions

The cluster of AE events emerged at the boundary of rock salt and anhydrite. The refined geology is displayed in a vertical section in the lower figure with the cluster, here called No. I. A fracture was found in a thin clay layer at the boundary being a zone of weakness. The AE events of the cluster marked the growth of the fracture zone of about 8 m diameter.

The results of the engineering geology methods and the ultrasonic methods completed each other in the identification and characterization of discontinuities. So fractures could be determined reliably and the question of persistency of single fractures between boreholes could be answered.

Refined geology and Cluster I

