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Fault zones and fault domain characterisation along boreholes – using geophysical well logging and packer tests

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Faults are rarely single discontinuities but are developed as zones which can be built up by different domains. Caine et al. (1996) distinguished between the protolith and the fault domains damage and core zone. Based on the tectonic evolution and the petrophysical properties of the protolith a fault zone can be developed as one fault domain (damage zone or core zone) or with a complex architecture including different domains with varying hydraulic and petrophysical properties. Boreholes provide the possibility to get information about faults and their architecture as a function of depth. Based on geophysical well logging fault zones and their domains can be detected and distinguished providing to determine and quantify petrophysical and hydraulic properties.
Eight boreholes were drilled down to depths between 40 m and 330 m below surface exposing different lithological and tectonic units in the Semmering Area (Lower Austro Alpine) and were used for well logging and hydraulic tests. The standard well logs Gamma Ray Log (GR-Log) and resistivity logs (Short and Long Normal Log R16, R64, Focusing Log LL3) were applied to characterize fault zones and their architecture. Porosity logs were calculated from the resistivity logs using Archie′s Law. In combination with the lithological profile of the drill cores the protolith, the damage zone and the core zones could be determined and distinguished nearly for all lithologies.
From the porosity logs it could be shown that core zones are characterized by higher porosities than the two other domains. The porosity medians range from $\sim$ 1% for the protoliths with over $\sim$ 2% for the damage zones to $\sim$ 5% for the core zones. The differentiation between the domains by the porosities corresponds well with the lithological profile of the drill cores. The sections with highly deformed cataclasites or fault gouges result the highest porosities with varying absolute values depending on the different host rocks. The analyses including all data of the eight drill holes result an increase of the porosity from protolith to core zone that means that increasing tectonic deformation increase the porosity.
In the developed wells packer tests were applied and in a further step the log results were combined with hydraulic packer test results. Hydraulic packer tests hardly provide the possibility to differentiate the individual test sections by varying hydraulic properties. Thus, the porosity logs were used to develop hydraulic profiles along the packer test sections considering the differences between fracture porosity and matrix porosity, where the fracture porosity controls hydraulic permeability and matrix porosity fluid storage capacity.

Caine, S. J., Evans, J.P., Forster, C. B: Fault zone architecture and permeability structure; Geology, v. 24, no. 11, p. 1025-1028 (1996)