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Petrophysical rock data from the Schleswig, Fehmarn, Oldenbüttel Glückstadt and Lingen drillings

Georg Nover, Michael Poelchau, Dirk Schönbohm
Mineralogisches Institut, Universität Bonn, Poppelsdorfer Schloss, 53115 Bonn
(g.nover@uni-bonn.de / Phone: +49-228-732732)

The transport capacity of a porous network depends on the geometry of the pores, petrological parameters like grain size distribution, rock fabric and texture, metamorphic overprint, as well as on external parameters like pressure or stress and finally on the pressure gradient acting as a driving force. Percolation theory requires that a certain threshhold value for the degree of interconnection must be exceeded before flow starts. Inceasing confining pressures reduce permeability, while stress will enhance the transport capacity by formation of new microcracks. Consequently, pressure induced changes in pore geometry were studied on plug samples of 30 mm in diameter and 30 mm in height in different pressure regimes. In total 50 drill cores from the Schleswig Z1, Glückstadt T1, Oldenbüttel and Fehmarn Z1 drilling and 51 core samples from the Lingen area were studied. The core samples covered the lithologies Keuper, Upper Devonian, Stassfurt Karbonate (Ca2), Werra Anhydrite (Z1), Rotliegendes and Vise. The extraction depth ranged roughly from 2400 m down to more than 5300 m. Plug samples were drilled with respect to foliation and lineation to get an estimate for the anisotropy. Results of rock fabric analysis together with mineralogical composition, grain size distribution and density measurements were used to find correlations between the quantities porosity, permeability and electrical conductivity.

Matrix *densities* were measured on vacuum dry plug samples using a gas-pycnometer. Density data range from 2.6 up to 2.95 g/cm^3. High values indicate volcanic intrusions, a fact that was independently confirmed by optical microscopy and X-Ray analysis. Porosities range from 0.5 % for dense volcanic samples up to 10.6 % for porous sandstones. An instationary pressure gradient technique (range: 10^{-16} m^2 down to 10^{-22} m^2) and flow meters (range: 10^{-17} up to 10^{-12} m^2) were used to measure permeability. Its pressure dependence was measured by application of a confining pres-

sures of up to 300 MPa. Permeabilities ranged from 10^{-12} m^2 for weakly consolidated samples down to less than 10^{-21} m^{2}for dense rocks. Differences in permeabilities in axial and radial directions exceeded more than one order in magnitude.

Electrical properties of the samples were measured on fully saturated plugs (1M NaCl) up to confining pressures of up to 160 MPa. Drained conditions were established using porous electrodes in combination with a two electrode arrangement. This limited the low frequency range to 1 kHz due to electrode polarisations, the high frequency limit was about 1 MHz due to coupling effects. The complex electrical response reflects both, changes in pore geometry that mainly control variations of bulk properties and contributions of surface conductivity which is caused by the mineralogical composition of the rocks causing electrochemical interactions between the pore electrolyte and the solid mineral matrix. The pressure dependencies of permeability and complex electrical conductivity were correlated using model parameters of equivalent circuits that were fitted by a least squares refinement procedure to the measured data. This gave a rough picture of pressure induced fracture closing. For a more detailed correlation of electrical properties and permeability low frequency electrical properties were measured in a newly designed 4-electrode cell in the frequency range 1 kHz down to mHz.

The observed anisotropies in permeability and bulk electrical properties and the decrease of these two quantities as a function of pressure were correlated and allowed to derive a relation between the changes of electrical model parameters and BET-surface, thus opening a more detailed view on those parameters that are responsible for transport properties in porous and less porous rocks.