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Petrophysical and sedimentological characterization of fault rocks from the Vienna Basin: Implications for induced seismicity and fault reactivation

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The use of geothermal energy bears a great potential to reduce greenhouse gas emissions and consequently to reach the set climate goals. To further establish geothermal energy production and other geoenergy-related applications (e.g., geological storage of carbon dioxide) in our society and increase public acceptance, however, a more profound understanding of induced seismicity associated with such operations is essential. Thereby the reactivation behaviour of (sub-seismic) faults plays a crucial role. This contribution aims for a detailed petrophysical and sedimentological characterization of faulted mudstones, a common seal lithology in sedimentary basins. Core samples from mudstone fault zones in the Vienna Basin (near Bockfließ) have been investigated. The sample set consists of 10 mudstones of Badenian age, all originating from a depth of approximately 1650 m. Observations from thin sections and handsamples suggest an early syn-sedimentary and a later deformation phase. The mineral assemblages (authigenic glauconite, early diagenetic framboidal and later diagenetic euhedral pyrite) document the evolution of increasingly anoxic conditions in the sediment column. Biogenic quartz (e.g., siliceous sponge spicules) provided silica for both the diagenetic formation of clay minerals and of microcrystalline quartz cement. Cation exchange capacity measurements as well as clay mineralogy determined by X-ray diffraction indicate that a higher degree of deformation leads to a better crystal order (illitization) of illite/smectite mixed layer minerals which is related to fluid and heat flow. In general, the microscale observations point to low grade deformation under relatively low p/T conditions. Porosity measurements (broad ion beam – scanning electron microscopy, mercury intrusion capillary pressure, helium pycnometry) reveal systematically lower porosity values for the fault rocks compared to the un-faulted mudstone "host rocks" from a similar depth range. Despite the lower porosity of the fault rocks they show larger capillary displacement radii in relation to the median pore diameter. This suggests that the fluid displacement pressure into these fault zones can eventually be lower compared to the surrounding un-faulted mudstones, which may increase the risk of fault reactivation by higher pore pressure or other fluid injection-related alteration (e.g., mineral dissolution).

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