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Relative timing of cementation and deformation band formation in Miocene calcareous sands (Eisenstadt Basin, Austria)

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In this study we investigated deformation bands in unconsolidated, arkosic sands and calcareous sands of Miocene age (Vienna Basin, Austria) by using sedimentological, geochemical and spectroscopic techniques. Deformation bands are tabular fault zones in high porosity rocks and sediments characterized by small displacements caused by reduction of porosity through grain rotation, translation and/or fracturing. We performed XRD, SEM, EPMA, grain size analyses and light-microscopy measurements to quantify the influence of sedimentological properties, chemical composition and alterations on the petrophysical properties and deformation mechanisms. The timing of deformation bands relative to cementation may be relevant in relation to the quality and connectivity of hydrocarbon or groundwater reservoirs.

The investigated outcrop in a sand pit near Eisenstadt, eastern Austria, exposes numerous conjugated deformation bands, some of which are formed in uncemented, coarse sands, while others occur in the overlying carbonate-bearing, cemented sands. These deformation bands formed at low burial depth and are related to the nearby Eisenstadt Fault. With regard to the mineral content and cementation the deformation bands differs in shape, displacement, mean grain size und porosity. To determine the deformation mechanisms and the resulting microstructures and porosity distribution of the deformation bands we observed the microstructures by using SEM and light-microscopy. We used grain size and XRD analyses to estimate the influence of mean grain size and mineral content on the displacement, thickness and porosity variations on deformation bands in the different lithologies.

The coarse host sediment mainly consists of detrital quartz, biotite, albite, sericite, chlorite, muscovite grains and metamorphic lithoclasts. The calcareous sands additionally contain calcitic bioclasts, and the pore space is cemented by a blocky, fine grained cement coating the individual grains. Previous studies of the uncemented sands revealed that the deformation bands have the same mineral content as the adjacent host sediment, but show an enrichment of phyllosilicates in the pore space. The microstructures indicate a grain size reduction by grain flaking and rotation in deformation bands with small offsets (0.5 - 8 cm), and an increasing grain fracturing and disaggregation of clasts at larger displacements (up to 60 cm). At the unconsolidated, arkosic sands the porosity reduction in deformation bands is dominated by a cataclasis of sericitised albite grains and the smearing of mica schists into the pore space. The measured reduction in porosity of up to 40% is associated with a permeability reduction. In order to constrain the influence of cementation on the mechanical properties, we collected samples from the carbonate-bearing, cemented lithologies. We identified two types of deformation bands, which can be distinguished by the timing of cementation relative to the deformation band formation. One type of deformation bands shows fractured cement coatings, indicating a deformation event postdating the cementation. In contrast, a second type of deformation bands shows a cementation of the previously fractured detrital siliciclastic grains. Notably, the porosity is significantly lower in the second type, while the first type shows increased porosity relative to the cemented host sediment.