Geophysical Research Abstracts
Vol. 15, EGU2013-10811, 2013
EGU General Assembly 2013

Structural investigation of brittle carbonate fault rocks at various scales: implications for fluid migration

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The EW-striking, sinistral Salzach-Ennstal-Mariazell-Puchberg fault system is a prominent feature in the Northern Calcareous Alps (NCA) in Austria. In particular, within the eastern part of the NCA, in Styria, it creates characteristic fault rocks in carbonates, comparable to fault rocks from similar tectonic regimes in other areas. Furthermore, faults and their characteristic fault rocks in this area play an important role in groundwater filtering, fluid pathways and in initiating karstification; this is of great social and economic importance since most of the drinking water for Vienna is obtained from that area. The fault zones are therefore ideal for investigating reservoir properties such as porosity and permeability evolution. Since detailed studies of such fault rocks on a micro scale are still rare, this work focuses on investigating structures and processes that create typical features in carbonate fault rocks from field- to nano-scale. Additionally, reservoir properties have been characterized. Apart from detailed structural field-work and porosity and permeability-measurements in the laboratory, thin-sections were analysed by optical microscopy, cathodoluminescence microscopy and electron microscopy using backscattered electron pictures and focused ion-beam techniques. The analytical methods provide an insight on processes and features such as grain size reduction, cementation and recrystallization, and point out porosity and permeability differences due to deformation mechanisms and cementation events. The results show that besides the common theory of grain interaction (rotation, gliding), in situ grain size reduction, predominantly controlled by pore fluid, plays an important role in creating cataclastic fabrics. Microscopic observations reveal a high amount of matrix porosity in dolomitic fault-core rocks, such as cataclasites and dilation breccias, which explains the high porosity values for those rocks measured in the laboratory; generally laboratory data revealed that fault cores in limestones seem to form fluid-barrier zones, while dolomitic fault cores, in contrast show conduit-character. Furthermore, field-based fault rock classification is challenged by microscopic data, calling for classification schemes that account for the different scales of observation.