Geophysical Research Abstracts
Vol. 18, EGU2016-5884-4, 2016
EGU General Assembly 2016

Control On Fluid Flow Properties In Sandstone: Interactions Between Diagenesis Processes And Fracture Corridors

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During the development of a fault zone, processes occur at different scales: secondary faults and fractures development in the damage zone while “diagenetic” processes, i.e: fluid rock interaction at the grains size scale, contribute to modify the matrix features. Spatial distribution of these processes is clearly controlled by microstructural transformations induced by fractured corridors and their location. Understanding flowing properties in the associated damage zone contributes to the better modeling of the fluid flow in faulted and fractured reservoirs which could be oil, gas or water bearing.

The Lower Triassic Buntsandstein sandstones outcrop of Cleebourg is located in the Hochwald Horst affected by a major NNE-SSW striking fault, and the structure globally dips with 30° toward Rhenish Fault (Upper Rhine Graben main western border fault). The study of the outcrop aims to decipher the fluid-flow scheme and interactions between fracture network and diagenetic features distribution in the damage zone of a fault, located close to major faulted areas, through field and laboratories petrophysical measurements (permeability, thermic conductivity), and samples microstructural and diagenetical descriptions.

The outcrop is structurally divided into a 14 meters thick fault core, surrounded by 5 meters thick transition zones, and damage zone of minimum thickness of 40 meters (total thickness unknown, due to the limits of the outcrop). Damage zone includes three fractured corridors, perpendicular to bedding and from 2 to 5 meters thick. Results presented here were acquired in 2 different layers with similar lithology but only on damage zone samples.

In entire damage zone, porosity results and thin section description allow to distinguish two different facies:

• Fa1 Intermediate porous (porosity of 12%) sandstone with major illite cement and clay content up to 20% (detrital and diagenetic);

• Fa2 High porous (porosity >15%) sandstone with quartz feeding.

Permeabilities measured both on field and in the laboratory show higher values in fractured corridors and close to the fault-core than in the host rock of the damage zone. Samples from both facies, collected close to macroscopic fractures present an increase of permeability (Fa1 permeability from 250 mD up to 1D, Fa2 from 100 mD up to 500mD) associated at microscopic scale with an increase of cracks and fracture density in detrital grains, grain chemical and mechanical compaction, and a decrease of quartz cementation in Fa1 (partly dissolved). Outside of corridors, permeability remains low for both facies (100-130 mD). Smaller contact surfaces between grains, low amounts of cracks and preservation of quartz cement were observed in Fa1 and Fa2. Fractures and cracks create trans-granular spaces and increase connectivity between intergranular spaces, which explains higher ranges of permeability for constant porosities. The increased dissolution of quartz cements observed in high permeable facies can be considered as a result of fluid/rock interaction on a zone restrained to the high permeability corridors.

The multiscale analysis of Cleebourg’s outcrop shows that sedimentary heritage and structural location seem to constraint and orient fluid-flows, impacting on dissolution and cementation, thus on porosity and permeability increase, and linked petrophysical properties.