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Editorial

The present Volume is after the 2015 EGU General Assembly, held in Vienna (Austria), where we convened a session entitled "The role of fluids in faulting and fracturing in carbonates and other upper crustal rocks". In that occasion, more than forty contributions were illustrated as oral and poster presentations. The invitation to contribute to this Volume was extended not only to the session participants, but also to a wider spectrum of researchers working on related topics. As a result, a group of Earth scientists encompassing geologists, geophysicists, geochemists and petrologists contributed to this Volume, providing a sampling of the state-of-the-science on fluids and faulting in carbonate, crystalline and siliciclastic rocks from studies that combine and integrate different methods, including rock mechanics, petrophysics, structural diagenesis and crustal permeability.

The present Volume, which includes sixteen scientific articles, greatly benefited from the help of the Elsevier editorial assistant Iswarya Samikannu, who has shown a great efficiency and dedication during the whole editing process. Without her enormous help, this would have been a much more difficult job. As guest editors, we also thank prof. Jean-Phillipe Avouac for his great support and patience, and acknowledge the work done by the numerous referees, who profoundly improved the quality of the present Volume.

We open this special issue of Tectonophysics with the studies from the perspective of experimental deformation, beginning with the contribution of Baud et al. (2016), who perform uniaxial compression tests on samples of microporous carbonate rocks crosscut by pervasive stylolites. The authors show an increase of porosity in the vicinity of the stylolites relative to the host rock and, in turn, that samples with stylolites are mechanically weaker with respect to those stylolite-free. Results of this work are therefore consistent with the stylolites acting as planes of weakness due to their higher amount of porosity, and shed new lights on the petrophysical and mechanical properties of pressure-solution features, which are quite common in fractured carbonate reservoirs. Delle Piane et al. (2016) test the hydro-mechanical behavior of artificial, travertine-derived fault rocks and surrounding fractured materials. Results of triaxial experiments, carried out under water-saturated conditions, are consistent with an initial fast hardening followed by apparent yield, with a friction coefficient of about 0.6. Permeability values show a higher exponential decay with increasing mean effective stress in fault rocks than in the fractured carbonates, highlighting the sealing behavior of carbonate-hosted fault zones comprised of continuous fault rock domains.

Fault/fracture analysis and the measurement or calculation of porosity and permeability are the focus of a second subset of the contributions. Sagi et al. (2016) study small-displacement, sub-seismic normal faults in chalk rocks occasionally interlayered with cm-thick marl horizons. Although cm-throw faults always display ramp-flat geometries, the architecture of larger displacement faults is strongly dependent upon marl horizons. Hydraulically-brecciated rocks are present only in the marl-free chalk rocks, whereas clay smears is documented along slip planes and associated open fractures in the marl-rich chalks. These observations point out to a localized fluid conduit behavior for fault zones that include brecciated fault rocks, and to a localized fluid barrier behavior for those with clay smears. The authors conclude that both dimension and geometry of the fault damage zones profoundly affect the overall fluid flow behavior of normal faults with throws up to a few a 10's of meters. Korneva et al. (2016) examine the structural architecture and fluid flow properties of faults in basinal limestone rocks with chert interlayers. Results are consistent with the overall fault architecture and permeability structure being profoundly affected by the timing of deformation. Faults that formed prior to the complete lithification of the host rock include smears of the not-completely lithified chert within the fault rocks. On the contrary, faults that developed after chert lithification are made up of carbonate fault rocks. Furthermore, the authors documented that latter rocks have lower values of permeability than the cherty fault rock, due to a lower amount of connected pores and smaller pore sizes. Bisdom et al. (2016) investigate the control exerted by fracture aperture on both porosity and permeability. By mean of finite element modeling of a discrete fracture network exposed in a large outcropping pavement, the authors show that the maximum amount of hydraulic aperture is obtained for fracture forming an angle of 15° to $\sigma1$. At this angle, fractures experience a minor amount of shear displacement, which allows them to remain open even when fluid pressure is lower than the local normal stress. Authors thus recommend to incorporate full aperture distributions, rather than simplified aperture models, in reservoir-scale flow computations. Mattos et al. (2016) use seismic reflection data to assess the geometry and kinematics of faults that crosscut the Samson Dome, offshore Norway. Results of displacement-length and throw-depth computations show the presence of a coherent fault system. Based on present-day stress distribution, the fault analysis carried out by the authors provides a scarce evidence for the escape of hydrocarbons at depth, which conversely likely occurs close to the Earth surface. Ward et al. (2016) use seismic and borehole data from the Southern North Sea, Netherlands, to compute the throw-depth and throw-distance plots of concentric faults that crosscut salt-withdrawal basins. Faults are highly segmented, and form localized fluid conduits mainly at the linkage zones; slip tendency analysis shows that fluid flow features preferentially occur in the vicinity of the fault segments close to failure. The results of this work therefore highlight the importance of fault analysis in projects dealing with carbon capture and storage, enhanced oil recovery, and overall development of fractured reservoirs. Felici et al. (2016) present a simplified methodology for fractured reservoir characterization based on the distribution of fracture intensity as a continuous property. By taking advantage of available data from the Illizi Basin, Southern Algeria, the authors

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built up a fracture intensity model by implementing a workflow commonly used in commercial geomodeling software by calibrating it with the outputs of well test data analysis. Such a methodology can be a useful tool for large fractured reservoir characterization, when discrete fracture network modeling is hardly applicable for computational reasons.

Next, we present contributions that emphasize geophysical analyses aimed at assessing the connections between fluids and faulting in the upper crust. Mahesh and Gupta (2016) investigate the earthquake distribution pattern and the crustal Vp and Vp/Vs variations of the Talala region, India, to understand the processes of earthquake generation in intraplate settings. The authors show that swarm-type seismicity takes place in the zone of lower Vp and lower Vp/Vs, whereas moderate magnitude earthquakes occur in a sector with higher Vp and higher Vp/Vs characterized by crystallized mafic magma. The latter zone hence represents a pronounced heterogeneity, which determines stress accumulation and stronger seismicity. Rossi et al. (2016) document, for the first time, a transient deformation event in the continental collision area of the North-Adria microplate, southern Europe. By analyzing Global Navigation Satellite System data, the authors provide evidences for vertical crustal movements, which are both spatially and temporally related to the Ravne Fault, the loci of the 2004 $Mw = 5.2$ event that occurred in Bovec, Slovenia. The transient crustal rises are interpreted by the authors as the expression of a porosity wave due to the fault valve behavior of the north-western termination of the Ravne Fault.

Finally, we consider mineralogical and geochemical approaches that document the mutual evolution of fluids and brittle structures in crystalline and carbonate rocks or via carbonate cements. Lawther et al. (2016) analyze strike-slip faults crosscutting the granitic gneiss of Monte Rosa, Italy, to decipher the evolving permeability and water/rock reactions. Oxygen and hydrogen isotope analyses, coupled to microstructural investigation, show that the fault zones were infiltrated by an original meteoric fluid. The different permeability structure associated to the evolving fault zones likely exerted a control on such a fluid, determining the growth of either K-feldspar or muscovite in the fault cores. The authors therefore suggest that modalities of fault growth in basement rocks may be dependent upon the initial hydrological properties of the host rock. Luetkemeyer et al. (2016) use clumped-isotope thermometry and $\delta^{18}O$- $\delta^{13}C$ compositions of calcite in veins to investigate the origin of paleofluids in two active fault zones pertaining to the San Andreas Fault, California, USA. Results are consistent with the flow of meteoric-derived fluids into the fault zone, which favored the formation of phyllosilicates within the evolving fault cores, and hence contributed to the present day weakness of the study fault zones. Furthermore, the authors document paleo-temperatures similar to the now days condition, and very little amounts of cross-fault fluid flow. Ukar and Laubach (2016) investigate the texture of syn- and post-kynematic carbonate cements by performing cathodoluminescence analysis. The authors document crack-seal and cement growth textures in previously assessed massive mineral deposits, and show that advances in delineating textures within carbonate infills may provide new insights into the growth and occlusion of fracture porosity. Sinisi et al. (2016) present the results of a multidisciplinary work aimed at assessing the origin and paths of the fluids that mineralized travertine deposits at the front of the Southern Apennines fold-and-thrust belt, Italy. Results are consistent with a mantle-derived CO_2 migrating upward through deep-seated extensional faults, whereas both biogenic- and mantle-derived CO_2 circulating through shallow-seated faults, which form tear faults associated to the frontal thrusts. Focusing on the latter type of faults, the authors show that the mixed fluids mainly circulated in the fault damage zones, which acted as a distributed conduit for both fault-parallel and cross-fault fluid flow. Berardi et al. (2016) analyze a several 10's of m-thick vein pertaining to fissure ridge travertines exposed in southern Tuscany, Italy, by mean of an integrated field and laboratory investigation. The work is aimed at assessing the modalities of growth of the giant vein and the implications in terms of the CO_2 leakage, has also a special emphasis on Quaternary paleoclimate and hydrology. We conclude this issue with the contribution of Hodson et al. (2016), who investigate the cementation history of a fault-intersection zone on the Moab Fault, Utah, USA, by using ^{13}C and ^{18}O geochemistry, clumped isotope thermometry, and cathodoluminescence. The authors are able to decipher multiple sources of the mineralizing fault fluids, each one of them associated with different carbonate precipitation temperatures, luminescence characteristics, and modalities of deformation. Luminescent, meteoric-derived cements have warm precipitation temperatures associated with jointing. On the contrary, earlier-formed, non-luminescent cements formed by marine-derived fluids at low precipitation temperatures, and are closely associated with deformation banding.

It is our hope that the present Volume will be of interest not only to the structural geologists, petrophysicists and geochemists dealing with upper crustal fault and fluids, but also be of use to the wider geoscience community.

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