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Preface

Rock Physics and Geomechanics see more and more applications nowadays, in particular because of environmental and energy policy issues related to natural hazard assessment, CO_2 sequestration, waste underground disposal and oil exploration/exploitation. In this context, many recent contributions stressed the importance of a better understanding of rock deformation, in particular the complex mechanical behaviours arising from thermo-hydro-mechanical (THM) couplings.

While field studies documented an ever larger spectrum of deformation mechanisms (Schoenherr et al., 2010) and strain localization features (Eichhubl et al., 2010), laboratory studies have emphasized the importance of THM couplings on several key questions, such as co-seismic thermo-chemical pressurization of fault gouges (Brantut et al., 2010; Han et al., 2010), time-dependent deformation in rocks (Heap et al., 2009), dehydration embrittlement (Rutter et al., 2009), acoustic signature of fluid movements in volcanic environments (Benson et al., 2008), rheology of polyphasic aggregates (Marques et al., 2010), or rock–CO_2 interactions (Angeli et al., 2009; Pini et al., 2009). Laboratory data are then commonly used to constrain theoretical models investigating the micromechanisms of deformation in porous rocks (Zhu et al., 2010), in-pore crystallization (Lecampion, 2010) or the constitutive behavior of oil relevant materials (Fredrich et al., 2007).

At the scale of the reservoir, geomechanical modeling for production enhancement requires the integration of information from the studies in rock mechanics and rock physics. Depending on the type of coupling, different levels of complexity exist, involving more or less time-consuming numerical codes (see David and Le Ravalec-Dupin, 2007 for a review). These models could still be improved taking into account several key points, such as the relationships between permeability and stress for different stress paths (Dautriat et al., 2009) or the formation of compaction bands modifying the fluid flow patterns (Vajdova et al., 2004).

The repository problem is different in the sense that the key issue is to find a site as safe as possible for the storage of nuclear hazardous waste, and the focus is here both on environmental and economic issues. The challenging task is to define scenarios that are as precise as possible for the long-term evolution of repositories from experiments run on short time scales (David and Le Ravalec-Dupin, 2007). The accuracy and predictability of models rely significantly on work performed in underground research laboratories in both soft rocks (ANDRA, 2005a; Bossart and Thury, 2007) and hard rocks (ANDRA, 2005b; Tsang et al., 2005). On the other hand, technologies for carbon dioxide capture and storage are nowadays considered as a viable option to reduce CO_2 emissions. Several geological settings, may act as host rocks, in particular former oil reservoirs and coal mines (Intergovernmental Panel on Climate Control (IPCC), 2005, 2007). CO_2 sequestration raises many important questions related primarily to the chemical and mechanical interactions between CO_2, generally in supercritical state, and the reservoir rock, the cap-rock and the drillhole casings (Fabbri et al., 2009).

The 8th Euroconference of Rock Physics and Geomechanics, sponsored by academic institutions (ETH Zürich, CNRS-INSU, EOST Strasbourg, INGV Roma) and industries (NAGRA, Schlumberger Carbon Services, British Petroleum, Spectraseis, IFP, ANDRA), was held from the 13th to the 18th of September 2009, in Ascona (Switzerland). The goal of the meeting was to present cutting-edge fundamental scientific results and to foster cross-disciplinary collaborations in order to explore how they could be applied at larger scale for industrial purposes. The conference was organized around five sessions: 1) Thermo–hydro–cmechanical couplings during rock deformation: experiments, modeling and field studies, 2) Continental and oceanic drillings, 3) Reservoirs and resources, 4) Underground CO2 storage, 5) Radioactive waste disposal. The present topical issue originated from the desire to assemble in a single volume some contributions of the Ascona conference. This volume presents new laboratory data, theoretical and numerical rock physics models and field observations.

The conference was initially proposed and in large part organized by Pr. Luigi Burlini. Although he had been fighting against a cancer for several months, Luigi managed to come to Ascona making sure that everything was in place for the five days of the conference. He was an example of courage for our community. Last December, Luigi unfortunately passed away in Zurich. This volume is dedicated to him, his memory and his family. In the first paper, some of his closest colleagues and friends come back on his career and highlight his many major scientific contributions.

The first part of this topical issue is dedicated to the measurement of rock physical and mechanical properties under varying conditions in the laboratory. Charalampidou et al. present new insights on the development of shear and compaction bands in porous sandstone, combining acoustic emissions, ultrasonic and X-ray tomographies. In both cases, they observed that similar mechanisms were active at the grain scale, but were occurring in different order in time and in different proportions. Casteleyn et al. propose an integrated study of the physical properties of a porous oolithic carbonate. They found that permeability in this type of rocks is mainly related to the connectivity of the ooids and therefore certainly related to the geological horizons. Dewurst et al. investigate the ultrasonic response of low porosity shales to both isotropic and anisotropic stress fields. They show that the magnitude and orientation of the stress anisotropy with respect to the shale microfabric has a significant impact on the elastic response to changing stress fields. Haimson present results from true triaxial compression experiments on samples coming from several ICDP sponsored scientific boreholes. In all cases, rock strength increases with the intermediate principal stress, while the minimum principal stress is maintained constant, leading Haimson to advance that Mohr-type criteria typically underestimate rock strength. While Nara et al. investigate the influence of micro and macro fractures on

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the permeability of Icelandic basalt, Fortin et al. use an effective medium model to interpret new results for triaxial experiments on dry and wet basalt from Mt Etna. In the ductile regime, Brujn et al. explore the mechanical behavior and the development of new microstructures in Carrara marble as a function of pre-existing strain variations. Here, series of torsion experiments were performed at high pressure and high temperature. Brujn et al. conclude that grain shape by shearing of relict grains is defined by finite strain and thus affected by strain reversal, whereas recrystallization is controlled by absolute strain and not influenced by strain reversal. This first part of the volume is concluded by Turmakina et al.'s study on the role of deformation on the reaction kinetics. They find that in metapelitic systems, partial melting followed by crystallization are the dominant processes.

The second part of this volume is dedicated to the imaging, monitoring and modeling of thermo-hydro-mechanical couplings during rock deformation. Dautriat et al. and Nguyen et al. use Digital Image Correlation to analyze strain localization and failure in uniaxially deformed samples of a porous limestone and a fine grained Tuff, respectively. Stanchits et al. investigate the fracturing of a porous sandstone by fluid injection at various pressure conditions using acoustic emission monitoring. They show that the initial increase of pore pressure is followed by a significant increase in tensile type AE events, while approaching failure both shear and pore collapse events become dominant. At the field scale, Zimmerman et al. analyze several stimulation treatments (multiple hydraulic stimulations and acid treatment) in a geothermal well in Germany and assess the implications of their findings to Enhanced Geothermal Systems. Wassermann et al. investigate the evolution of permeability within the excavation damage zone of a tunnel within fractured gneiss in Roselend, France. While Guéguen and Sarout propose a model to analyze the frequency dependence of elastic waves (dispersion) in a cracked rock, Adelinet et al. study this effect in a material containing cracks and pores. In both cases, the authors assume that squirt flow is the dominant mechanism leading to the frequency dependence. For a cracked rock, the crack orientation distribution has strong impact on both wave anisotropy and dispersion. For a mixed porosity rock (cracks + pores), the maximum dispersion is predicted for a mixture of spheroidal pores and low aspect ratio cracks. Finally, Misra presents a theoretical analysis to account the variability of deformation localization in the vicinity of pre-existing shear cracks using an elastic–plastic rheological model.

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