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Structural, porosity and permeability properties of basin-boundary extensional fault zones in poorly lithified sandstones of the Rio do Peixe basin, Brazil

Fabrizio Balsamo (1), Francisco CC Nogueira (2), Chiara Febbrari (1), Alessandra Cantoni (1), Angela Dettori (1), Fabrizio Storti (1), Francisco HR Bezerra (3), Bruno RBM Carvalho (4), and Jorge André De Souza (4)

(1) Università di Parma, Department of Chemistry, Life Science and Environmental Sustainability, Parma, Italy (fabrizio.balsamo@unipr.it), (2) Universidade Federal de Campina Grande, Brazil, (3) Universidade Federal do Rio Grande do Norte, Brazil., (4) Petrobras, Research and Development Center (CENPES)

In this contribution we describe the structural architecture, microstructural features, porosity and permeability properties of basin-boundary fault zones developed in Cretaceous, poorly lithified sandstones and conglomerates of the Rio do Peixe basin, NE Brazil. The Rio do Peixe basin is an intracontinental half-graben basin developed along the Precambrian Patos shear zone formed during the rifting between South America and Africa plates. Sediments in the basin consist of an heterolithic sequence of feldspar-rich sandstones, gravel, siltstone and clay-rich layers, which are generally friable far from the major fault zones. Basin-boundary extensional fault zones juxtapose crystalline basement rocks with siliciclastic sediments and consist of a fault core surrounded by a damage zone. Fault cores are characterized by distributed deformation (without pervasive strain localization) in which bedding is transposed into foliation imparted by grain preferred orientation. Microstructural observations show dominant non-destructive particulate flow with cataclasis concentrated in feldspar grains, suggesting that extensional fault zones developed in soft-sediment conditions in a water-saturated environment.
The footwall damage zone in the crystalline rocks is characterized by a network of joints and secondary faults. The hangingwall damage zone, developed in the high-porosity sandstone, is characterized by deformation bands and secondary faults whose frequency decrease moving away from master slip surfaces. Deformation bands are organized both in clusters or single tabular bands. All deformation structures show systematically a positive relief with respect to the host rocks.
Mercury-intrusion porosity (n=61 samples) and in situ air-permeability (n=933 measurements) indicate that: (i) undeformed rocks have an average porosity of 25,3 % and mean permeability of 3.4x10E3 mD, (ii) deformation bands in the damage zone have an average porosity of 11.2 % and mean permeability of 2.7x10E2 mD, i.e. 1-2 order less than undeformed rock, (iii) fault core rocks have an average porosity of 10,7 % and permeability up to 2-3 orders of magnitude less than undeformed rock with mean value of 7.5x10E1 mD. In addition, the sandstone between deformation bands in the fault damage zone has a tight fabric with an average porosity of 14.2% and mean permeability of 1.4x10E3 mD, i.e. less than undeformed rocks.
The integration of field data with microstructural observation and petrophysical results allowed us to propose a conceptual model for basin-boundary extensional fault zones developed in high-porosity, poorly lithified sandstone of the Rio do Peixe basin.