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Micro-mechanical characterization of a basaltic geothermal reservoir from laboratory geophysical tools

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According to the stress state and to the time scale, deformation observed in rocks may be quite different. In addition, modes of deformation control many hydrodynamic factors such as permeability and porosity. In this study, we investigate different modes of deformation in an Icelandic basalt using laboratory seismological tools. The studied rock is a basalt sample on the Reykjanes peninsula (SW Iceland). It consists in an alkali basalt with a dual connected porosity (cracks and equant pores). Ultrasonic waves velocities are recorded during different triaxial tests and acoustic emissions are located and characterized (counting, focal mechanisms...). All the triaxial tests are realized with samples saturated with water During most of them the pore pressure was maintained constant at 5 MPa. We performed also a test of hydraulic fracturing by increasing the pore pressure until reaching brittle failure. We studied the microstructure of the post-mortem samples through SEM pictures.
We show that at low effective pressure the axial loading induces a shear failure in the Reykjanes basalt with a principal plan of shearing inclined at about 45°. On the contrary at high effective pressure (75 MPa and more) the increasing of the axial stress induces a localization of the deformation in the form of subhorizontal bands. Focal mechanisms of the acoustic emissions reveal an important part of compression events (mode I rupture) suggesting pore collapse mechanisms. Microstructure data confirm this assumption. Such compaction structures are usually obtained for porous rocks (20 – 25 %) whereas the Reykjanes basalt has a initial total porosity of about 10 %. The subhorizontal bands are also the location of shear events, a part of the focal mechanisms are actually in double couple. Then we can conclude on a dual mode of deformation coupling compacting and shearing processes. Finally we deduce a yield envelop for the Reykjanes basalt which can be compared to the envelops of some porous sedimentary rocks.