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Evolution of mechanical properties under cyclic stress experiments: results and microstructures of Triassic Evaporites

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Rocks are likely to be exposed to cyclic loading stress regimes during their whole history due to different phenomena like seismic cycles, glaciations or human activities (for example gas multiple injections). Repeated loading/unloading cycles can lead to significant variations in the physical properties of rocks. Thus quantifying changes of elastic moduli, strength, seismic output and microstructures, is of key importance for establishing rock properties evolution under stress. We report measurements of Uniaxial Compressive Strength, UCS, Young's Modulus, YM, and Poisson's Ratio, PR of Triassic Evaporites: a sedimentary sequence made of dolostones and sulphates (anhydrites and gypsum). Samples were collected in outcrops and boreholes. Borehole anhydrite samples show a wide range of UCS spanning from 52 to 144 MPa. Outcrop gypsum show the lowest values of UCS (from 10 MPa to 26 MPa). Dolostones show a wide range of UCS with the highest value of 228 MPa measured for borehole samples.
A general increment of the YM with increasing cycle number is observed, however larger increase in YM is documented in the first for the early cycles, after which nearly steady values of YM are found. Prior failure, i.e. in the last cycle, YM slightly decreases. We also observe a significant steep increase in PR followed by an almost steady values of PR and prior failure PR increases abruptly. Microseismicity, in terms of acoustic emission (AE) output, was also recorded throughout each experiment. Our data show that the stress needed for AE outputs increases greatly for the initial cycles, then is almost constant. The integration of mechanical and microstructural data suggests a first stage dominated by compaction and strengthening, a second stage characterised by quasi elastic behaviour associated to the development of randomly oriented microfractures, and a third stage of weakening and axial macrofractures development. Static elastic moduli calculated from deformation tests have been also compared to dynamic moduli calculated throughout Vp and Vs measurements. We observe a positive correlation between the two moduli but dynamic values are 2 or 3 time higher than static. Results are discussed in terms of their applicability to crustal scale modelling.