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Effects of Water and Low-Medium Temperature on Limestone from Mt Etna basement

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Mount Etna volcano, Sicily, sits atop a structurally complex sedimentary basement continuously subjected to tectonic deformation. The flyschoid formations belonging to the Appenninic-Maghrebian Chain (AMC) and making up the accretionary wedge of a regional fold-and-thrust belt lie above carbonate Hyblean Plateau (HP) sequences, belonging to the African plate. Carbonate rocks represent a major component of the sedimentary basement: they are spread throughout the AMC as continuous strata and discontinuous lenses, and are the main constituent (e.g., Comiso Limestone) of the HP foreland. Etna is an active volcanic environment, characterized by complex stress field distributions, magmatic and non-magmatic fluid circulation, and elevated temperature gradients; the edifice has been constructed at various rates and with variable distribution of effusive products. These intrinsic and extrinsic parameters are known to impact the rheological behaviour of rocks. Previous triaxial deformation studies on carbonates (Tavel Limestone, Solnhofen Limestone and Comiso Limestone) have shown the importance of temperature, and the presence of water as pore fluid, on the mechanical strength and failure mode of the rocks. However, to our knowledge, no previous studies have considered the distal heating effect of intrusions on the carbonate mechanical strength from the basement. Here we investigate the behaviour under varying P-T conditions at constant strain rate (10-5 s-1) on both dry and water saturated samples of Comiso Limestone, a low-porosity (10.2% average) carbonate rock belonging to the HP. We ran separate conventional triaxial experiments at various confining effective pressure from 0 up to 50 MPa at room temperature (20°C), in both dry and drained water-saturated conditions, using natural samples, and thermally-treated samples (150°C, 300°C, and 450°C). Acoustic Emissions and P-wave velocities were recorded during the experiments. Sample failure covers the brittle and brittle-ductile transition (BDT) which occurs between Pc eff = 30–50 MPa. Water as a pore fluid promotes the transition toward a ductile behaviour (BDT) at lower confining pressures, and generally decreases the peak stress in all tests, as expected. Moreover, the thermal treatment below 450°C applied has mild effect on the mechanical strength of the limestone samples while the samples treated at 450°C show a decrease in Young's Modulus, and peak stress is associated with larger axial strains, both in dry and saturated conditions. However, the saturation condition has a much greater influence on the mechanical strength of the limestone samples, lowering the peak stress by about 30 MPa in the saturated tests relative to dry tests under the same conditions, and enhancing a strain weakening behaviour until failure. Generally, our results show that carbonate strength decreases before the onset of decarbonation, extending the current knowledge on mechanical behaviour of this lithology and are also highly relevant for models on edifice instability and important to constrain the volume of basement rock affected by sheet intrusions.