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Investigating the stability of the volcanic edifice at Volcán de Colima, Mexico

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Analytical studies and experimental research on representative volcanic samples are a principal requirement to understand the stability of volcanic edifice. Knowledge of their physical and mechanical properties are important for a wide range of monitory applications, from ground deformation modeling to the calibration of damage mechanics criteria. During magma ascent and eruption, the stability of volcano is challenged by heating and stressing, thereby affecting the physical state of the rocks. For testing the stability of active volcanic edifies, we test the strength of original as well as heat-treated volcanic rocks. In this study, andesitic rocks from Volcán de Colima in Mexico were chosen. We chose five different rocks with a range of porosity (between 8 % and 30 %) representative of the material observed in the upper edifice.

Firstly, each material was characterized in terms of its modal composition, density (air and water-saturated density) and initial microstructure. We then measured their porosity, dry and water-saturated ultrasonic velocities and dynamic elastic moduli. In general, measurements of ultrasonic velocity and Young's modulus are low and Poisson's ratio and the Vp/Vs ratio are high, indicative of an extensively cracked initial material. These measurements were carried out prior to, and after, thermal-stressing to 500°C (heated and cooled at 1°C/min). During thermal-stressing, we also monitored the generation of thermal cracking via two acoustic emission transducers. Microstructural alteration, as a result of thermal-stressing, was analyzed using optical microscopy.

We also provide the results of constant strain rate (10-5 s-1) triaxial deformation experiments, performed under effective confining pressures (Peff) of 10, 30 and 50 MPa (whilst maintaining a constant pore fluid pressure of 10 MPa) and at room temperature. The form of our stress-strain curves also indicates an extensive pre-existing crack density. The higher porosity (18% and above) andesites deformed in a largely compactive manner, even at the lowest Peff, and ductile behavior was observed in most at just 30 MPa. Experiments on dry samples and those thermally-stressed to 500°C are also presented. Post mortem optical microscopy analysis was performed, and the static Young's modulus computed, for each sample.

Using these data together, we try to understand the deformation processes operative at Volcán de Colima and the influence of pressure and temperature on the key physical and mechanical properties. We will discuss our mechanical findings in terms of volcanic edifice stability.