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Physical properties of tuffs from a scientific borehole at Albani hills volcanic district (central Italy)

S. Vinciguerra (1), P.M. Benson (2), P. Del Gaudio (1), M. Heap (2), M.T. Mariucci (1), F. Marra (1), P.G. Meredith (2), P. Montone (1), S. Pierdominici (1), P. Scarlato (1)

Department of Seismology and Tectonophysics, Istituto Nazionale di Geofisica e Vulcanologia, Via di Vigna Murata 605, 00143, Rome, Italy (Tel ++39 06 51860478; Fax. ++39 06 51860507; e-mail: vinciguerra@ingv.it); 2) Department of Earth Sciences, University College London, London, U.K.

Recent seismic swarms and hydrothermal activity indicate that the Quaternary volcanic complex of Albani hills may pose a threat to the city of Rome. A 350m scientific borehole was drilled for the first time in Italian volcanic areas to understand the inner structure and define the stress field, by means of down-hole measurements and laboratory analysis. We ran wire-line logs in the borehole in order to characterize the physical properties of the volcanic rocks and their variations with depth. In particular, we ran a detailed sonic log to measure P-wave velocities from the well-head down to 110m. To further investigate velocity changes in detail, we carried out laboratory measurements on selected core samples representative of the main volcanic units. The main lithology cored was a pyroclastic-flow deposit (tuff) from the explosive phase of activity (561-366 ka), which shows a wide variability in terms of grain-size and cohesiveness. We have studied two pyroclastic units that are the most representative of the whole volcanic succession: (1) a coarse-grained, extremely lithified facies, containing abundant mm-to-cm lava clasts and pyroxene and biotite crystals ('Pozzolane Rosse' unit), and (2) a fine-grained, matrix-supported pyroclastic deposit, with rare lithic lava clasts and sparse pumice and carbonatic clasts ('Tufo Pisolitico' unit).

Preliminary measurements of elastic wave velocities indicate that P-wave velocities of Pozzolane Rosse vary between 3.7 and 4.2 km/s, and S-wave velocities vary from 3.2 to 4.1 km/s. In contrast, P-wave and S-wave velocities for the Tufo Pisolitico are much lower at 2.9 km/s and 2.6 km/s, respectively. Radial P-wave velocity measurements made every 10° around vertical cores show that Pozzolane Rosse has an anisotropy of about 25%, whereas the corresponding anisotropy for Tufo Pisolitico is just 3%. We interpret this difference in anisotropy as being due to the abundant clasts in the Pozzolane Rosse matrix controlling the heterogeneity, and hence producing the large anisotropy observed. Similarly, the difference in the velocity between the two units can be explained by the much greater lithification of the Pozzolane Rosse unit. Overall, this indicates how variations are significant, even within the same tuff lithology, and can therefore influence values adopted as input to models (e.g. velocity models for seismic tomographies). In order to understand the variation of rock properties with depth, we also present data from simultaneous measurements of elastic wave velocities and fluid permeability made in a servo-controlled steady-state-flow permeameter at effective pressures from 5 to 80 MPa, during both increasing and decreasing pressure cycles. Selected samples were also thermally treated in order to take account of the role of thermal stresses. The results obtained from laboratory measurements and their comparison with field determinations, such as sonic logs, provide crucial information for the interpretation of the inner volcanic district structure, and in turn suggest if/how mechanical and thermal stress can significantly change the rheology and permeability of the Albani hills tuffs, opening new perspectives for the interpretation of the volcanic district dynamics.