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In-situ application of Ultrasonic Pulse Velocity measurements to determine the degree of zeolitic alteration of ignimbrites

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The velocity of P-waves passing through a rock body is strongly dependent on the petrographical properties such as texture, crystallinity, porosity and fracture network. For this reason, the measurement of ultrasonic pulse velocities (UPV) has been widely used in various applications interested in mechanical properties of solid rock bodies.

An ignimbrite is a deposit of pyroclastic density current originating from an explosive volcanic eruption and comprises of vitric volcanic ash, free crystals, juvenile magma fragments (pumice) and accidental xenoliths. The complex nature of the componentry of ignimbrites also exhibits spatial variation depending on the location of deposition. Furthermore, both syn- and post-depositional processes (i.e. welding, alteration etc.) may have drastic impact on the mechanical characteristics of the ignimbrites. Alteration can be defined as the devitrification and the crystallization of vitric components and the transformation of pre-existing minerals of the ignimbrite into new minerals under changing thermodynamic conditions. In this context, zeolitization is an alteration process in which metastable (vitric) components of an ignimbrite body are replaced by zeolite group of minerals under low temperature and pressure induced by hydrothermal activity. The crystallization of zeolite minerals in the pore space promotes an increase in crystallinity and therefore a decrease in porosity. Hence, the velocity of P-waves passing through a zeolitized ignimbrite will be considerably higher compared to those in unaltered counterparts.

Within the scope of a TUBİTAK project (No:113Y439) in which the alteration properties of Cappadocian Ignimbrites (Nevşehir, Turkey) are being investigated, in-situ UPV measurements have been performed using a portable pulse test instrument. The acquired velocity data has been correlated with the modal proportions of secondary zeolite minerals obtained by SEM-EDS. The results demonstrate that the measured P-wave velocities are positively correlated with the degree of zeolitization, where the highest velocities correspond to the intensely zeolitized ignimbrites. In-situ application of UPV measurements in the field can be utilized for revealing the spatial variation in zeolitization and for locating the probable sources responsible for hydrothermal alteration.

Keywords: ultrasonic pulse wave, in-situ, ignimbrite, hydrothermal alteration, zeolitization