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The scaling effect on rock behavior by comparing seismic P-wave laboratory and in situ velocities – A case study from the POSE experiment at OLKILUOTO Finland

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A careful comparison of rock behavior at different scales is critical to determine if laboratory experiments can be useful for understanding the field scale. This research aims to investigate the scaling effect on rock material by comparing the compressional wave velocities passing through rock at different scales in field and laboratory experiments. To avoid complexities involved with anisotropic foliated rocks, field P-wave velocities were measured at specific ray paths in an anisotropic pegmatitic zone known as the target zone. This target zone was located at the EH3 experimental hole of the POSE tunnel at OLKILUOTO site, Finland. At each point in the target zone, the rock experiences a different stress path due to excavation and heating. Three true-triaxial experiments have been carried out in a unique geophysical imaging cell at the University of Toronto to duplicate the stress path which is believed to exist in the most critical regions around the EH3. 80mm pegmatite samples taken from the POSE niche located close to the experimental hole were used in these polyaxial experiments. Ultrasonic surveys have been performed during these experiments and the sensors used in these surveys had similar operational frequency range as those used in field ultrasonic measurements. During the preliminary stages of this research, reproducibility of these polyaxial experiments was verified by comparing the evolution of the compressional wave velocity along three principal stresses as a function of the corresponding principal stresses. In this regard, a very good match observed between the three samples. Moreover, these true triaxial laboratory tests revealed the linear elastic behavior of the samples at the stress levels observed during the heating phase of EH3. Therefore, the linear elastic solutions such as analytical thermo-elastic and hoop stress calculations were employed to calculate the evolution of the stress tensor around the EH3. Then, by using the lab velocity data and the field stress tensors in an ellipsoidal model, P-wave velocities were estimated for all the points located on the ray paths in the field. Calculated field P-wave velocities along the ray paths are in very good agreement with those measured in the field. On the most critical ray path and during the heating phase of the EH3, deviation of the calculated P wave velocity and the field measurement is limited to 100 m/s. Overall, field velocity measurements are slightly lower than those calculated based on the lab data. This can be attributed to the existence of additional flaws or discontinuities when dealing with the larger scale rock mass.