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The influence of alteration on the rock mass permeability of the Ohakuri ignimbrite (Taupō Volcanic Zone, New Zealand)

Michael Heap (1), Darren Gravley (2), Ben Kennedy (2), H. Albert Gilg (3), Liz Bertolett (2), and Shaun Barker (4)

(1) EOST, Université de Strasbourg, EOST, Strasbourg, France (heap@unistra.fr), (2) University of Canterbury, Christchurch, New Zealand, (3) Technische Universität München, Munich, Germany, (4) University of Waikato, Hamilton, New Zealand

Ignimbrites are among the most compositionally and texturally diverse deposits on the planet. As a result, their physical properties (e.g., porosity, permeability, and strength) also vary considerably. Post-depositional hydrothermal alteration can further modify their physical properties, factors important for geothermal energy production, epithermal Au-Ag mineralisation, and volcano modelling. Our goal here is to quantify the varied appearance of an ignimbrite—the Ohakuri ignimbrite (Taupō Volcanic Zone, New Zealand)—that hosts a palaeo-hydrothermal system. This deposit was selected as it ranges from an unaltered, loose ash-lapilli mixture up to a hard and dense rock. We provide here laboratory data on the chemical componentry, porosity, matrix permeability, fracture permeability, uniaxial compressive strength, stiffness, and failure modes (brittle versus ductile) of blocks of material collected from the Ohakuri ignimbrite that preserve differing degrees of alteration. The unaltered deposit is cohesionless and characterised by high porosity (∼0.5) and high permeability (∼10-13 m2). The most intensely altered rock (that contains 0 wt.% glass) contains a porosity as low as 0.24 and a permeability as low as 2 × 10-17 m2: hydrothermal alteration reduced permeability by about four orders of magnitude. Although it is intuitive that a reduction in matrix permeability will inhibit fluid flow, an increase in strength and, importantly, stiffness fosters brittle behaviour, creating high permeability pathways that are favourable for channelling hydrothermal fluids. Indeed, the intensely-altered deposit next to the Ohakuri Dam hosts many large fractures. Triaxial deformation experiments also show that a moderately-altered sample is ductile at an effective pressure of 5 MPa, while the intensely-altered is still brittle at the maximum tested pressure of 20 MPa (∼1-1.5 km depth): alteration therefore also extends the depth at which we can expect brittle behaviour. Alteration can therefore change permeability behaviour from distributed to discretized fluid flow, thereby increasing the equivalent permeability of a rock mass. These data are important for geothermal energy production, epithermal Au-Ag mineralisation, and volcano modelling.