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Understanding pre-eruptive patterns: the rock physics interpretation

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Changes of seismic wave velocities, rates of seismicity and different types of seismic signals are routinely observed before eruptions in volcanic areas. Anomalies and rapid changes of geophysical parameters have been interpreted as rapid changes of the mechanical properties of the medium and/or of magmatic pressurization (e.g. coupling of dyke emplacements and fracturing of the medium).

A thorough assessment of the physical properties of volcanic rocks and an improved understanding of the complex coupling between mass/heat transfer mechanisms and rock deformation/failure processes has been revealed to be essential for the interpretation of the geophysical signatures monitored in volcanic areas.

For instance seismic tomography can greatly benefit from simultaneous measurements of P and S wave velocities at simulated ‘in situ’ stress conditions, while time-to-failure models need better knowledge of the changes of mechanical and physical properties as a function of incremental thermal and mechanical damage.

Crucially, laboratory simulations can allow us to rebuild the physical mechanisms responsible for a given seismic signal, thus providing invaluable quantitative information for understanding and discriminating the different seismic signals observed before volcanic eruptions.

We report the results of recent laboratory advances where simulated volcanic conditions of corresponding geophysical parameters have been directly measured, while reproducing deformation, fluid decompression and magma emplacement processes acting in volcanic areas.

A direct relationship between seismic waveforms + spectrograms and physical phenomena can be assessed, by scaling length and frequency between the laboratory and the field. This provides a solid and well-constrained new experimental insight into the developing damage leading to faulting and geophysical signatures related to fluid flow.

The close agreement between laboratory and nature allows us to open a new research field where geophysical signatures can be directly linked to physical processes tested in the laboratory where these processes are very well constrained.