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Complex dynamics of dyke propagation deduced from seismic monitoring and physical models

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Seismicity monitoring is potentially the most powerful technique but is not used to its full potential for several reasons. In a period of unrest, activity may take the form of seismic swarms including many small events that are difficult to separate, so that one may not use the efficient localization methods that have been devised for single earthquakes and rupture events. Only those events that are well identified can be treated with current methods and a large part of the seismic signal is left unused, and the interpretation of the data in term of the dynamics of magma migration is difficult.

We propose a simple but robust analysis of the continuous seismo-acoustic emission associated with magma migration through the Earth's crust to constrain the dynamics of the propagation. The method is based on amplitude ratio of seismic signals recorded at different stations which is independent of the amplitude at the source and depends only on the 2 distances between the source and receivers (once the attenuation law calibrated).

Tracking magma ascent in real time is one of the main targets for forecasting volcanic eruptions. Combining such analysis with theoretical model may lead to quantitative estimation of key physical parameters controlling the injection.

At shallow depth beneath Earth's surface, magmas propagate through cold host rocks that may be less dense than them. Inversion of buoyancy, solidification or degassing have strong impacts on the dynamics of propagation without any change of magma supply. Numerical and experimental studies are used to document how dyke ascent depends on parameters such as the input rate of magma, density stratification, temperature of the host rock and initial gas content. Calculation of dyke-induced stress perturbations indicates that most of the seismicity occurs in the vicinity of the dyke tip. Thus the time evolution of the stress field and of the induced seismicity may provide information on the control variables for dyke propagation.