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High Resolution Attenuation Images From Active Seismic Data: The Case Study of Solfatara Volcano (Southern Italy)

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The anelastic attenuation of rocks strongly depends on the contained fluid physical state and saturation. Furthermore, it is more sensitive than elastic parameters to changes in the physical state of materials. In a geologically complex volcanic context, where fluids play a very important role, anelastic imaging of the subsoil is therefore a very powerful tool for a better understanding of its dynamics.

In this study we present a robust workflow aimed at retrieve accurate 1-D and 3-D anelastic models from the processing of active seismic data, in terms of lateral and depth variations of P-wave quality factors Q_p . This methodology has been applied to data collected during a high resolution active seismic experiment in a very small-scale volcanic volume, the Solfatara crater, within Campi Flegri caldera, Southern Italy. The presented methodology is developed in three distinct steps: 1) the active seismic data have been properly processed and analyzed for measuring the t^* attenuation parameter for all possible source-receivers couples. First, the source contribution has been removed by cross-correlating the recorded signal with the sweep function of the Vibroseis, which was the adopted active seismic source. Then, the spectral decay method has been applied in order to compute the t^* values. 2) A reference 1-D attenuation model has been retrieved by means of a grid search procedure aiming at finding the 1-D Q_p structure that minimizes the residual between the average observed t^* and the theoretical t^* distributions. The obtained starting reference model allowed to build a preliminary map of t^* residuals through which the retrieved t^* dataset has been validated. 3) The 15,296 t^* measurements have been inverted by means of a linearized, perturbative approach, in a $160 \times 160 \times 45 \text{ m}^3$ tomographic grid.

The retrieved 3-D attenuation model describes the first 30 m depths of Solfatara volcano as composed of very high attenuating materials, with Q_p values ranging between 5 and 40. The very low Q_p values, correlated with low V_p values retrieved by a previous tomographic work carried out in the area, indicate the low consolidation degree of very superficial volcanic materials of Solfatara volcano. Finally, in the NE part of the crater, lower attenuating bodies have been imaged: it is a further hint for characterizing this area of the volcano as the shallow release of the CO_2 plume through the main fumaroles of the crater.

