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Solfatara volcano subsurface imaging: two different approaches to process and interpret multi-variate data sets

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The need to reduce model uncertainty and produce a more reliable geophysical imaging and interpretations is nowadays a fundamental task required to geophysics techniques applied in complex environments such as Solfatara Volcano. The use of independent geophysical methods allows to obtain many information on the subsurface due to the different sensitivities of the data towards parameters such as compressional and shearing wave velocities, bulk electrical conductivity, or density. The joint processing of these multiple physical properties can lead to a very detailed characterization of the subsurface and therefore enhance our imaging and our interpretation.
In this work, we develop two different processing approaches based on reflection seismology and seismic P-wave tomography on one hand, and electrical data acquired over the same line, on the other hand. From these data, we obtain an image-guided electrical resistivity tomography and a post processing integration of tomographic results. The image-guided electrical resistivity tomography is obtained by regularizing the inversion of the electrical data with structural constraints extracted from a migrated seismic section using image processing tools. This approach enables to focus the reconstruction of electrical resistivity anomalies along the features visible in the seismic section, and acts as a guide for interpretation in terms of subsurface structures and processes.
To integrate co-registrated P-wave velocity and electrical resistivity values, we apply a data mining tool, the k-means algorithm, to individuate relationships between the two set of variables. This algorithm permits to individuate different clusters with the objective to minimize the sum of squared Euclidean distances within each cluster and maximize it between clusters for the multivariate data set. We obtain a partitioning of the multivariate data set in a finite number of well-correlated clusters, representative of the optimum clustering of our geophysical variables (P-wave velocities and electrical resistivities). The result is an integrated tomography that shows a finite number of homogeneous geophysical facies, and therefore permits to highlight the main geological features of the subsurface.