Geophysical Research Abstracts
Vol. 20, EGU2018-9822, 2018
EGU General Assembly 2018

Constraining the structure of mud volcanoes with 3D inversion of gravity data

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To date little is known about the subsurface structure of mud volcanoes. Geophysical data of mud volcanic systems are usually acquired in the framework of broader reflection seismic experiments targeting oil and gas reservoirs or deeper geological structures. Sub-aerial mud volcanic systems are ideal natural laboratories to perform affordable geophysical experiments to shed light on the plumbing system of mud volcanoes.

The Nirano Mud Volcanic Field (NMVF) is situated 2.5 kilometers at the rear of the Pede-Apeninnic Thrust Front, structure affecting units nearby the northeastern topographic margin of the Nothern Apennines. We performed several geophysical campaigns over the years. Electrical resistivity tomography provided high-resolution images of the shallow surface of the system showing the occurrence of regions with lower resistivity beneath each mud cone. To investigate at greater depths we performed two gravity surveys in 2015 and 2017.

3D Inversion of the resulting Bouguer Anomalies allowed us to constrain the depth of the deep reservoirs and compare the anomalies with available geological data. The Bouguer Anomalies are inverted using a gradient-based least-square methodology granting a priori information introduction. Real model covariance matrix is used to compute cost function as well as depth weighting matrix. Resolution analysis helped us to evaluate the reliability of the resulting model.

Due to its non-unicity and the difficulty to constrain both geometry and density, complementary gephysical information are needed for further interpretation. However, this study represents the first attempt of a 3D density image of a mud volcanic system.