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Depth and density variations of hydrocarbon and mud reservoirs from Bouguer anomaly inversion at the Nirano Mud Volcanic Field, Italy.

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Mud volcanoes are dynamic and stress-sensitive geological systems. They are often found in hydrocarbon provinces and could sample underlying reservoir. However those systems are still geophysically poorly investigated and their plumbing structure and flow dynamics is still not very well understood.

Because of its accessibility, the Nirano Mud Volcanic Field (NMVF) was targeted as an experimental field to improve our understanding about the plumbing system of mud volcanic structures. Two gravity surveys were performed along dipole-dipole geoelectric profiles. We used the gravimeter Scintrex CG5 and the GPS Leica 1200 to conduct two profiles striking N45 and N135. Wavelength filtering of Bouguer anomalies indicate a 2000 m deep reservoir, two mid-depth reservoirs (i.e. 600 m deep) and three shallow ones (i.e. 100 m deep). Using these observations and previous studies (geology, ERT) as prior information, the Bouguer anomalies were inverted using a gradient-based least-squares method that uses the LSQR algorithm and accounts for data and model covariances. Depth weighting is taken into account by introducing a weighting matrix based on kernel decrease. Unconstrained inversion results suggest at least three subsurface bodies and one deeper one (1000 m deep). Constrained inversion results are in accordance with a model of two sub-spheroidal reservoirs located at about 1500 m depth that are tilted by 30° overlaid by two reservoirs at intermediate depths (i.e. 600 m deep). This is in agreement with the inferred tilting of the Ligurian Units occurring at such depths. Density variations range from 0 to 800 kg/m3. Due to the difficulty to constrain both geometry and density of the investigated reservoirs, complementary information (i.e. seismic and electrical resistivity tomography) will later be used to further improve the results. Despite the degree of nonuniqueness in our investigations, this study represents the first attempt to provide a gravity-based geophysical image of the plumbing system of a mud volcanic field.