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Use of gravity potential field methods for defining a shallow magmatic intrusion: the Mt. Amiata case history (Tuscany, Central Italy)

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We analyzed the Bouguer gravity anomaly signal beneath the Mt. Amiata area in order to reconstruct the subsurface setting. The study area is characterized by a pronounced gravity minimum, possibly correlated with the observed anomalous heat flow and hydrothermal activity. Using different approaches, previous authors defined a low density body (generally interpreted as a magmatic intrusion) beneath this area, which could explain the observed gravity anomaly minimum. However the proposed geologic models show different geometries and densities for the batholith.

The gravity data used in this study (kindly provided by eni) were acquired from different institutions (eni, OGS, USDMA and Servizio Geologico d'Italia) and collected in a unique dataset, consisting of about 50000 stations, randomly distributed, which cover Central Italy, with a spacing of less than 1 km. For each station the elevation and the Bouguer gravity anomaly data are given. From this dataset, we created two maps of the Bouguer gravity anomaly and the topography, using the Minimum Curvature gridding method considering a grid cell size of 500m x 500m. The Bouguer gravity anomaly has been computed using a density of 2.67 g/cm3. From these maps we extracted a window of about 240 km2 (12x20 km) for the study area, which includes the Mt. Amiata region and the adjacent Radicofani sedimentary basin.

The first part of this study was focused on calculating the first order vertical derivative and the power spectra analysis of the Bouguer gravity anomaly to enhance the effect of shallow bodies and estimating the source depth respectively.

The second part of this study was focused on constructing a 3D geological density model of the subsurface setting of the studied area, implementing a forward modelling approach.

The stratigraphy of the study area's upper crust schematically consists of six litho-mechanical units, whose density was derived from velocity data collected by active seismic surveys. A preliminary, simplified geological model was constructed, by integrating all the available information, derived from a composite data-set of surface geology surveys, seismic reflection profiles and deep wells. In this starting geological model the geologic complexity of the study area was simplified, in order to manage easily the 3D forward gravity modelling procedure.

By comparing the calculated and the measured gravity fields, we modelled the 3-D geometry of a low density body, located beneath Mt. Amiata, characterized by an upward-convex geometry, at a depth of 2.5-6 km and with a maximum thickness of 4 km. In our interpretation, this low-velocity body represents the residual magmatic chamber of the Mt. Amiata Late Pleistocene volcano.

Our gravity analysis also allowed us to refine the 3D geometry of a shallower target, i.e. the Neogene Radicofani basin, close to the eastern flank of the Mt. Amiata.