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New Gravimetrical Map of The Rieti Intra-Mountain Basin (Central Apennines, Italy)

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Summary

This paper describes the acquisition of the gravity data and their analysis to model and map the bedrock configuration of the Rieti Basin (hereafter RB); a typical intra-mountain tectonic depression of Central Apennines in Italy, related to a still active tectonic extensional regime.
The study involved a test area of 35 km2 occupied by 110 gravity stations. The new gravity measurements were merged with the gravity data of the 358 gravity stations collected during the 1995 gravity survey (Ciccollella et al., 1995). The gravity data resulted from the network adjustment were used to calculate the Bouguer anomaly map. To realize the 2-D gravimetric models of the RB, a realistic density of 2,15 g/cm3 for the unconsolidated Quaternary deposits, a density of 2.50 g/cm3 for the Travertine and a density of 2.60 g/cm3 for the Meso-Cenozoic pelagic basin deposits were used (Skrame, 2011).
The models obtained matched quite well with the exiting geological and geophysical data.
The new bedrock surface topography map of RB provides a new more detailed and representative image of the buried morphology, and gives a more accurate evaluation of the thickness of the Plio-Quaternary sedimentary infilling.

Introduction

In this work, it is intended to highlight the indispensable significance of the gravity methods for the determination of subsurface and bedrock structure of intra-mountain basins (Skrame et al., 2015).
To this purpose a detailed gravity survey was carried out to model and map the bedrock configuration of the Rieti Basin (hereafter RB); characterized by thick Plio-Quaternary deposits overlaying the "Umbria-Sabina" units (Ciccollella et al., 1995).
According to the most up-to-date Italian seismic catalogue, the city of Rieti has been severely damaged by strong earthquakes which caused major damage to its building heritage. The most important ones have been the 1298 Rieti earthquake, the 1703 Aquilano earthquake, the 1898 Rieti earthquake and 1979 Valnerina earthquake. The concentration of damage produced by these earthquakes is thought to have been caused by the characteristics of the earthquake ground motion affected by the local subsurface structure of the RB. Referring to these conditions, the authors think that RB could be an important case study for the prevention and mitigation of earthquake disasters.
In this paper we present a new image of the 3D bedrock configuration of the RB.

Regional geology

The RB is a wide spread post-orogenic intra-mountain basin in the Central Apennines, Italy. According to Cavinato (1994), it has been formed by the strong extensional tectonic phases during Plio-Quaternary period. During the Late Pliocene-Early Pleistocene period, the RB developed in the hangingwall of the SW-dipping, NW-trending, Rieti fault segment (hereafter RF). This segment is the north-western extension of a primary segmented normal fault system in the Central Apennines, about 100 km long. The main extensional tectonic phase occurred during the middle Pleistocene produced the subsidence of the basin and the formation of the E-W trending normal faults and NE-SW oblique-slip faults (Figure 1). These caused the more rapid subsidence of a small part of the basin and the formation of the Conca di Rieti, which has a NNW-SSE trending axis. From a paleogeographic point of view, the area of study is placed in the context of two interfering regional structural domains: the Umbro-Sabina transitional units and the Latium-Abruzzi carbonate platform, characterized by the wide outcropping of Meso-Cenozoic carbonate-siliceous-marly sediments of the Umbro-Sabina succession (Accordi & Carbone, 1988). Instead, referring to the study carried out by Cavinato, (1994) the Plio-Quaternary continental deposits, overlaying the Meso-Cenozoic deposits, consist of the three Villafranchian depositional units (made up of massive conglomerate sequences of alluvial fan facies, and conglomerate, sandstones and marl deposited of a fluvial environment), the reworked conglomerate deposits of Upper Pleistocene – Holocene, the lacustrine deposits of Upper Pleistocene – Holocene, the travertine of Holocene and the colluvial and alluvial deposits of Holocene.

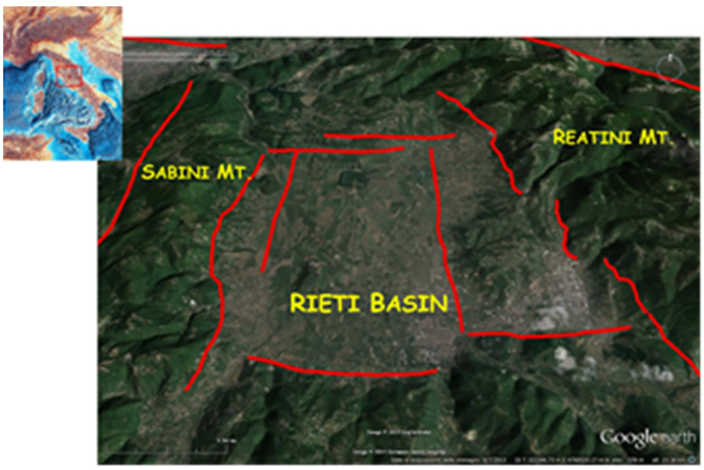

***Figure 1** Satellite image of the Rieti Basin (RB) with the location of the faults (source ITHACA Dataset Project, ISPRA-SGI, 2011).*

Data acquisition

The study involved a test area of 35 km^2 covered by 110 gravity stations. The test area encloses the most damaged area by the earthquake of 27 June 1898 and the new designated areas for urban expansion of the city.

The gravity measurements were performed using a LaCoste & Romberg gravimeter mod. D60 that has a reading resolution and an accuracy of 0.01 mGal. The stations were accurately located with differential GPS (Ashtech Z-Xtreme dual-frequency GPS) that provided centimetric accuracy in elevation. The GPS base station was located near the survey area in a place with good sky visibility.

The gravity stations were distributed homogeneously throughout the territory, with an average density of about 5 stations per km^2. Measurements were made inside the RB, along the basin edge and also over the outcropping bedrock in order to determine the distribution of the gravity anomalies of the study area. Locations of the gravity stations are shown in Figure 2.

The new gravity measurements were merged with the gravity data of the 358 gravity stations collected during the 1995 gravity survey (Ciccollella et al., 1995).

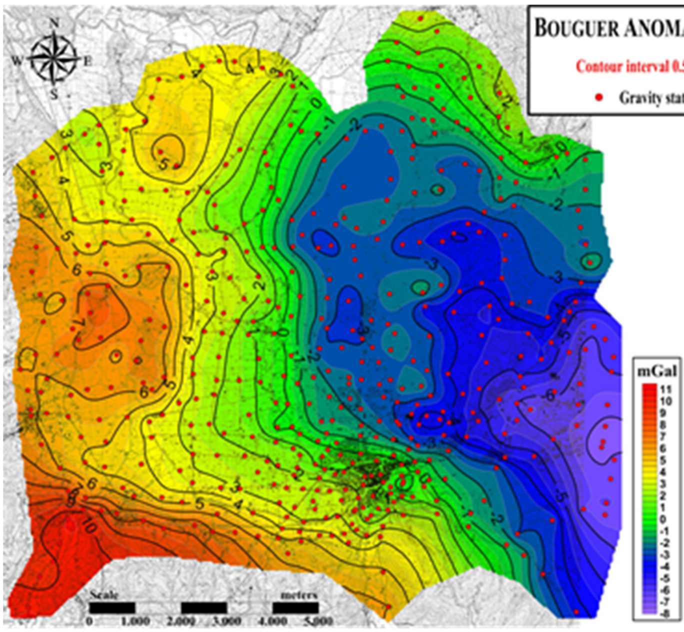

Figure 2 Bouguer anomaly map of the RB showing the locations of the gravity stations (red circles). The contour interval is 0.5 mGal plotted on the Regional Technical Maps.

Data analysis

All the gravity data resulted from the network adjustment were used to calculate the new Bouguer anomaly map (Figure 2). Free air and Bouguer corrections were applied to the data. Terrain corrections were calculated using the CTR (Regional Technical Maps) with 1:5.000 site plan scale and a digital terrain model (DEM). All the above mentioned calculations have been carried out using an average density of 2.60 g/cm3 for the Meso-Cenozoic carbonate-siliceous-marly deposits.

In order to isolate the regional signal different filtering and mathematical functions were tested. The first-degree polynomial expression of the Bouguer anomaly field result to be the most appropriate regional field, since it reproduce well the NNE trend and is not correlated with the morphology of the valley. Subtracting the regional field from the Bouguer anomaly produced the new residual anomaly map of the RB (Figure 3).

The resulting anomaly map is a better reflection of variations in the thickness of overburden than the Bouguer anomaly map. The lower negative values (shown in blue on Figure 3) could be related to the thick Plio-Holocene deposits dominated by low density, located in the central part of the RB. Instead, the higher positive residual anomalies (shown in red on Figure 3) are located on the northeastern, western and southern sector of the RB.

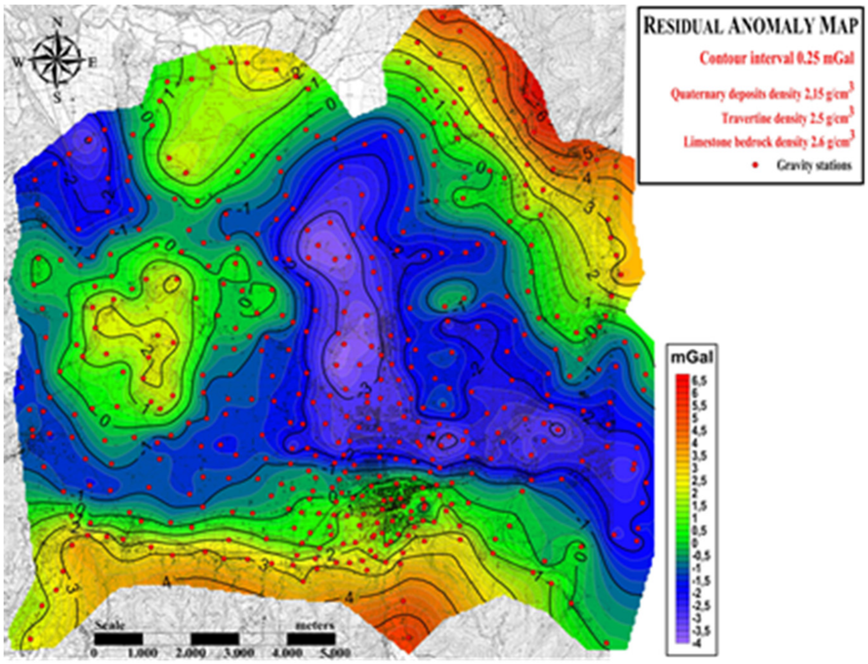

Figure 3 *Residual anomaly map of the RB, representing the Bouguer anomaly grid (Figure 2) minus the regional field. The contour interval is 0.25 mGal plotted on the Regional Technical Maps.*

Modelling

In order to determine the distribution of the sedimentary infill, a 2D gravity modeling was developed in the region, including six profiles orthogonal to the depression edge. To realize the 2-D gravimetric models of the RB, the 3dGRVT software (developed by prof. Michele Di Filippo) was used (Skrame, 2011; Skrame, 2015; Skrame & Di Filippo, 2015). A realistic density of 2.15 g/cm3 for the unconsolidated Plio-Quaternary deposits, a density of 2.50 g/cm3 for the Travertine and a density of 2.60 g/cm3 for the Meso-Cenozoic pelagic basin deposits were used (Skrame, 2011).
The 2-D gravity models obtained by the 468 gravity stations matched quite well with the information determined from a collection of existing well logs and geophysical data kindly provided by the colleagues of Sapienza University and ENEA; specifically: 146 sites of microtremor observations, 70 geophysical prospecting (MASW and Down-Hole), 166 boreholes and 228 geotechnical field testing.
These models allowed us to reconstruct the geometry of the depression, to evaluate the thickness of the Plio-Quaternary sedimentary infilling and to recognize the paleo-morphology arrangement of the RB. Finally, referring to the obtained paleo-morphology, we were able to reproduce and to define a new image of the 3D bedrock configuration of the RB (Figure 4).
The 3D model shows that the geometry of the Meso-Cenozoic carbonate-siliceous-marly deposits is extremely articulated defining clearly two big negative gravimetric areas located on the central part of the basin. These two gravity lows follows an N-S trend and identify the maximum depth of the depression (of about -50 m a.s.l.). They can be interpreted as the effect of great thickness of the Plio-Quaternary sedimentary infilling of the RB, of about 450 m.
The location and the geometry of the normal faults which interests the RB was constructed by identifying the regions where the depth contour change sharply over short distances, and trying to find a connection with the exciting faults of the basin.

Conclusions

The study here presented aims at providing a new image of the buried morphology on the RB, hence the accurate modelling of the rock structure. To this purpose a detailed gravity survey was carried out.

The 2D gravity models obtained by 468 gravity stations allowed us to reconstruct the geometry of the depression and to evaluate the thickness of the Quaternary sedimentary infilling with a maximum of about 450 m. Instead, the maximum bedrock depth was found about -50 m a.s.l.

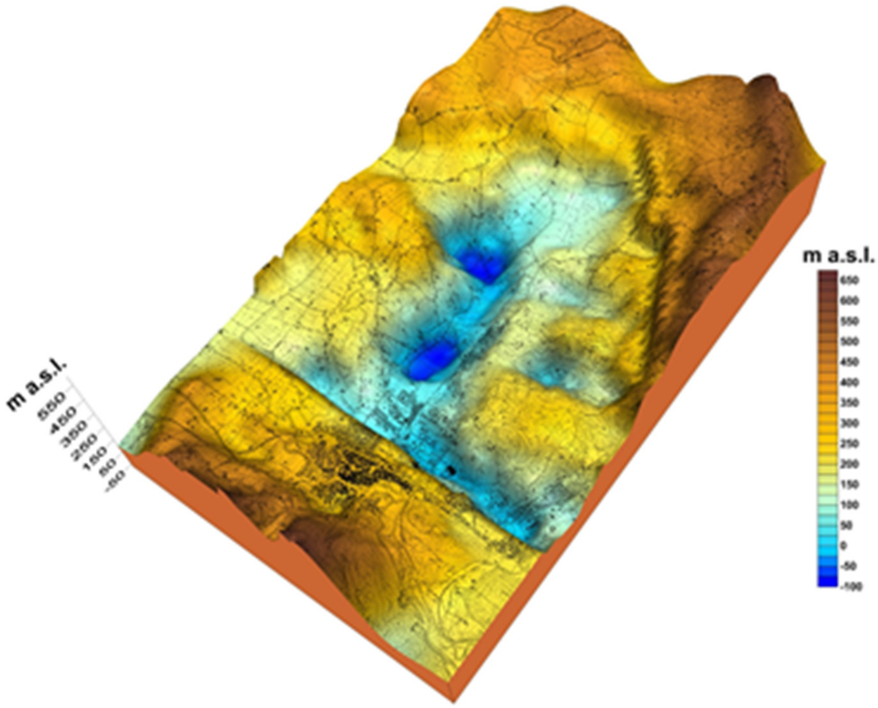

Figure 4 *3-D Bedrock model of the RB.*

Acknowledgments

The authors wish to thank Prof. Gabriele Scarascia Mugnozza and the ENEA colleagues for their support and the fruitful collaboration.

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