/Journal of Applied Geophysics 140 (2017) 62–74

Contents lists available at ScienceDirect

Journal of Applied Geophysics

journal homepage: www.elsevier.com/locate/jappgeo

Indications of correlation between gravity measurements and isoseismal maps. A case study of Athens basin (Greece)

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ARTICLE INFO

Article history:
Received 10 October 2016
Received in revised form 9 January 2017
Accepted 23 March 2017
Available online 30 March 2017

Keywords:
Gravity method
Bouguer
Residual
Isoseismal contours
Earthquake
Urban areas

ABSTRACT

In this paper, we discuss the correlation between isoseismal contour maps and gravity residual anomaly maps and how it might contribute to the characterization of vulnerable areas to earthquake damage, especially in urban areas, where the geophysical data collection is difficult. More specifically, we compare a couple of isoseismal maps that have been produced and published after the catastrophic earthquake of 7th September 1999 (5.9R) in Athens, the metropolis of Greece, with the residual map produced from the processing and data reduction of a gravity survey that has been carried out in the Athens basin recently. The geologic and tectonic regime of the Athens basin is quite complicated and it is still being updated with new elements. Basically it is comprised of four different geotectonic units, one of them considered as the autochthon. During the gravity investigation, 807 gravity stations were collected, based on a grid plan with spacing almost 1 km, covering the entire basin and supported by a newly established gravity base network comprised by thirteen bases. Differential DGPS technique was used for the accurate measurement of all the gravity stations and bases coordinates. After the appropriate data reduction and the construction of the Complete Bouguer Anomaly map, we applied FFT filtering in order to remove the regional component and produce the Residual Anomaly Map. The comparison of the Residual Anomaly Map with the isoseismal contours revealed that the areas with the most damage because of the earthquake were located in the areas with the minimum values of the Residual Anomaly Map.

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1. Introduction

On 7th September 1999, a 5.9R earthquake occurred in Greece metropolis, Athens city (Fig. 1), causing enormous damages in almost 70,000 buildings with almost 100 of them collapsing. More than 2,000 injuries were recorded along with 143 dead people and at least 100,000 homeless people (Bouckovalas and Kouretzis, 2001). Although a lot of major earthquakes had occurred during the last 100 years in the greater area of Athens basin, this one caused the most damage.

Especially in urban and fully residentially developed areas, knowledge on the existence of concealed active faults is absolutely useful because the damage distribution of an earthquake is usually related to the tectonic structures of the area. Unfortunately, since the areas are covered with buildings, the geological research is quite complicated, with the obtained information being restricted to quite older observations, geological maps, boreholes and data. Also, the geophysical research in urban areas is quite difficult to develop, especially for deep investigations (Xu et al., 2015). For example, it is almost prohibitive to apply the electromagnetic and magnetic methodologies due to the effects from the current cables and buildings. Geoelectrical methods are also difficult to carry out, since most of them require space and straight long lines to measure on. The seismic methods are widely applied in urban areas (Hutchinson et al., 2009; Krawczyk et al., 2012; Symeonidis et al., 2005) but it is quite expensive most of the times and usually they focus on the shallow. The gravity methodology can be applied in urban areas for deeper investigation but the field measurements should be planned with caution, taking into consideration the traffic and the building effects.

A gravity research was organized, focused on the Athens basin structural investigation, in order to reveal possible concealed (blind) faults which could affect the city in the future by generating disastrous earthquakes. The 7th September 1999 earthquake had its epicenter at a fault that hadn't generated severe earthquakes until then. Since Athens basin is covered with human constructions (building, roads, playgrounds, public services station etc.) in a very large percentage, the appliance of great scale geophysics is restricted and expensive. The only cost-effective method for structural investigation seems to be the land gravity measurements.

Gravity measurements are widely used in many cases and on different scales of investigation depending on the target. Some of their applications are in oil-gas and mineral exploration (Chen et al., 2015; Martinez et al., 2013; Wang et al., 2012), structural and basin

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http://dx.doi.org/10.1016/j.jappgeo.2017.03.012
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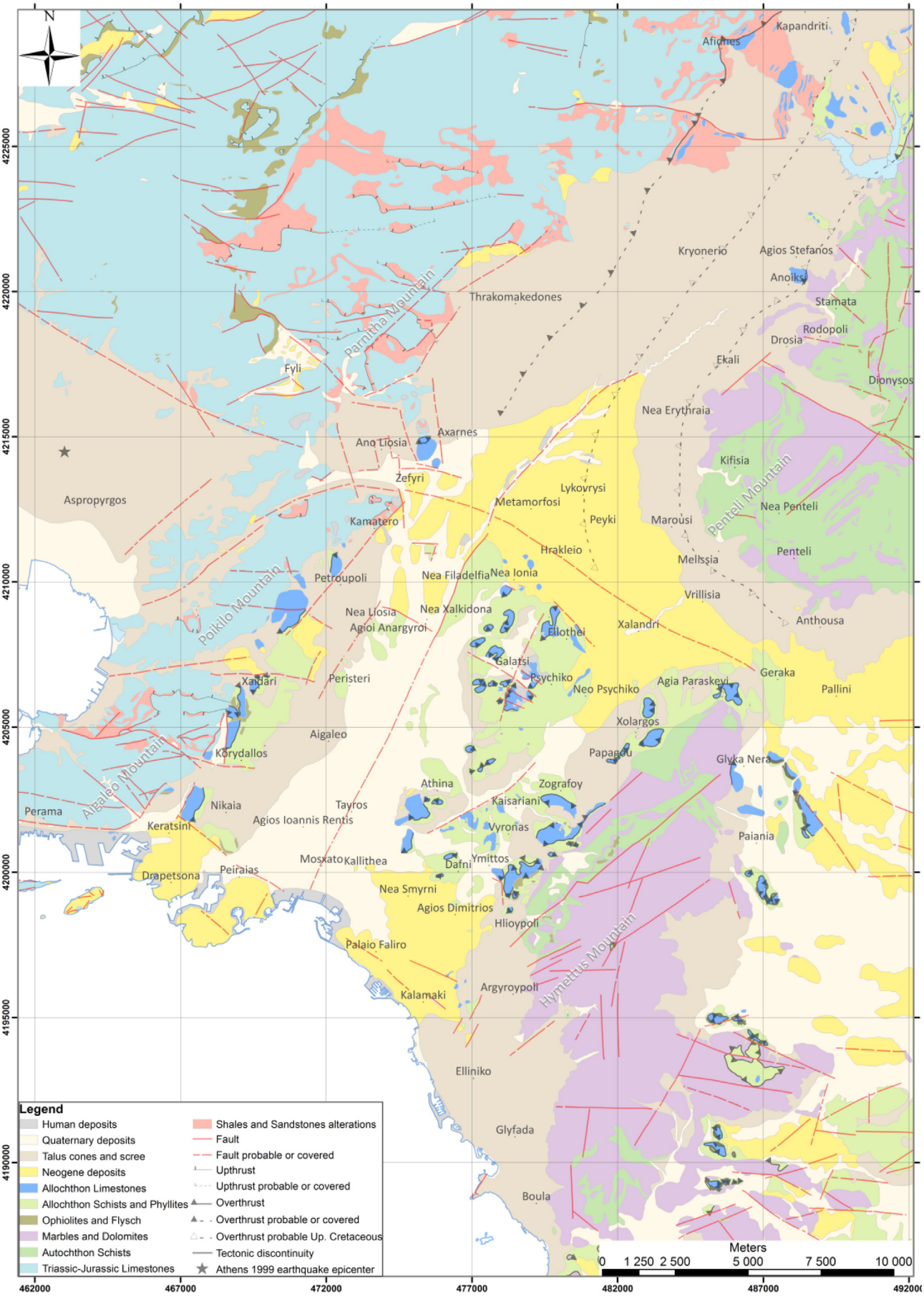

Fig. 1. Geologic and tectonic regime of Athens basin, along with the Athens earthquake of 7th September 1999.

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