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Seismotectonic study in Vilia, Eastern Gulf of Corinth, Greece

A. Billia[1],I. Spingos[1], H. Kranis[1], G. Kaviris[1]

(1) Department of Geology and Geoenvironment, National and Kapodistrian University of Athens, 15784 Panepistimiopolis, Zografou, Athens, Greece, alexandrabillia@gmail.com

The Gulf of Corinth (GoC) is a unique site for seismotectonic studies in Europe.The eastern side of the GoC (Fig. 1) is subject to extensional directions similar to the western, i.e. NNE-SSW (Armijo *et al.*, 1996). The highest extensional rate is located in the western side (15 mm/yr), while in the eastern part it is constrained at 10 mm/yr. The main part of the deformation is found offshore, within the gulf (Briole *et al.*, 2003). The gulf is dominated by normal faulting trending WNW-ESE. The geologic substratum in the eastern side is comprised of Permian and Upper Carboniferous formations. Lithology is generally dominated by limestones (Triassic-Cretaceous). Overlying, Pleistocene and Pliocene deposits are found. Recent scree and alluvial deposits cover locally the aforementioned formations (IGME, 1971, 1984).

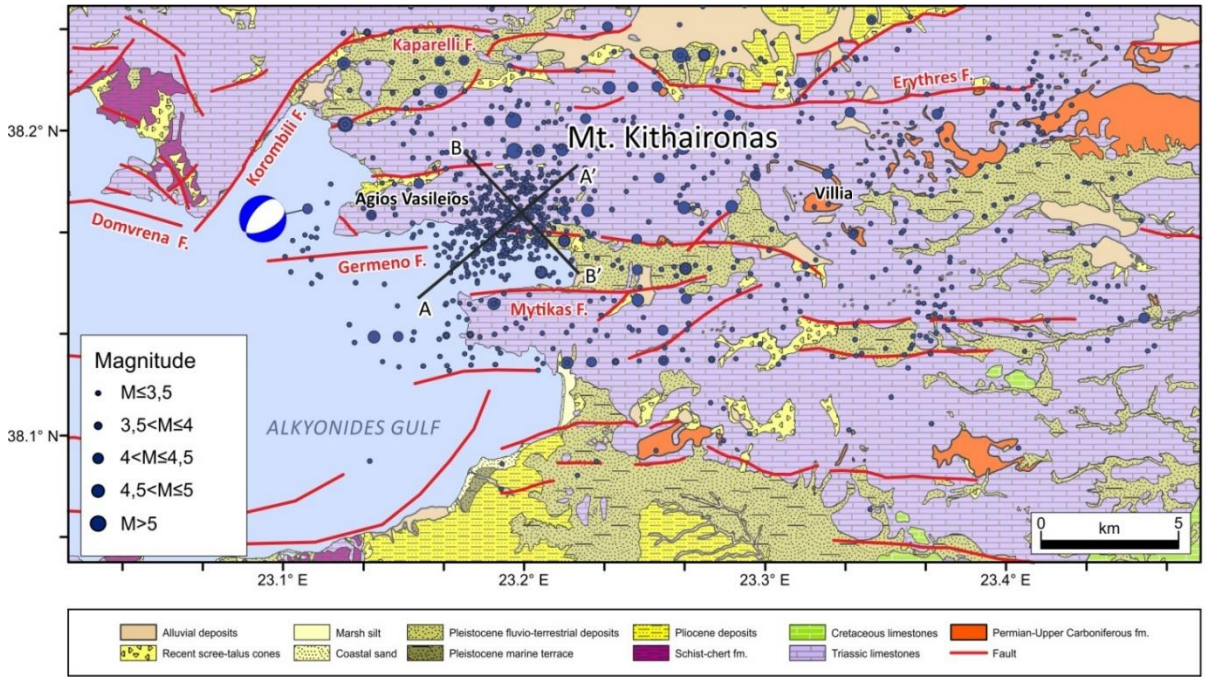

Figure 1.Seismotectonic map of the broader study area. Blue dots indicate epicenters between 1900 and 2017. Focal mechanism of the 20 September 2013 (M_L=4.4) is also shown. Lines AA' and BB' denote the foci cross-sections in Fig. 2.

The extension in the Eastern Gulf of Corinth (EGoC) is related to a highly segmented fault system. The main strike of these faults is E-W, although secondary directions (NW-SE and NE-SW) are also observed. The major structures in the study area are the Kaparelli, Erithres, Germeno and Mytikas faults (Ganas *et al.*, 2013). The Kaparelli fault is an approximately E-W striking, south dipping normal fault which consists of three segments (Kokkalas *et al.*, 2005).

Active tectonics in the EGoC have led to several major earthquakes since 1900, with moment magnitudes (M_w) ranging between 4.1 and 6.2 (Makropoulos *et al.*, 2012). The largest events are the main shocks of the Alkyonides sequence of February-March 1981, with three M_w>6.0 earthquakes causing extensive damage to buildings and infrastructure in the EGoC, as well as to Athens (Papazachos and Papazachou, 2003). Since then, seismicity has been scarce (e.g. Papadimitriou *et al.*, 1999). However, small episodes of seismic outburst have been recorded. A prime example is the sequence that occurred close to the town of Vilia. A total of 560 events were located in 2013, with local magnitudes (M_L) between 0.5 and 4.4 (Kaviris *et al.*, 2014).

The current study incorporates a comprehensive seismic catalogue from 1900 up to 2017 for the broader area of Vilia. Event information was acquired from four sources: (a) the updated and extended catalogue of Makropoulos *et al.* (2012) between 1900 and 2009, (b) the catalogue of the Seismological Laboratory of the National and Kapodistrian University of Athens between 2009 and 2016, (c) the detailed catalogue of the 2013 Vilia sequence (Kaviris *et al.*, 2014) and (d) newly located events of a local sequence near Vilia during 2017. For the latter, the arrivals of the P- and S-waves were manually determined from local and regional recordings of stations belonging to the Hellenic Unified Seismological Network (HUSN). The location of the foci was later acquired using a local velocity model (Kaviris *et al.*, 2014) and the Hypoinverse software (Klein, 2002). The 2017 catalogue contains 53 events.

The spatial features of the 2013 sequence do not present a definite correlation with the faults mapped in the area. The plane defined by the spatial distribution of hypocenters is striking N58°E and dipping SE (Fig. 2), whereas the focal mechanism of the main shock indicated a similar fault with a 46° dip, a N64°E strike and a -71° rake. Both, however,

indicate the existence of NE-SW, SE-dipping structures. This is in agreement with the depths of the foci (concentrated between 7 and 15 km). However, it is important to note that the accuracy of the hypocentral locations is compromised by the sparse network. Only one station (VILL) was located in a small distance from the seismogenic area (approximately 12 km). Thus, the causative fault(s) for the 2013 sequence could be a blind normal fault, or the NE-SW, SE-dipping Korombili fault. The latter suggestion can be valid if we accept a much steeper fault than the one indicated by the focal mechanism of the main shock; indeed, field mapping shows that this is a very steep fault (dip>65°), which could have a bi-planar or curved geometry, flattening downdip. In addition, a smaller, SSE dipping fault is also observed near Agios Vasileios village: this could also be connected to the 2013 sequence.

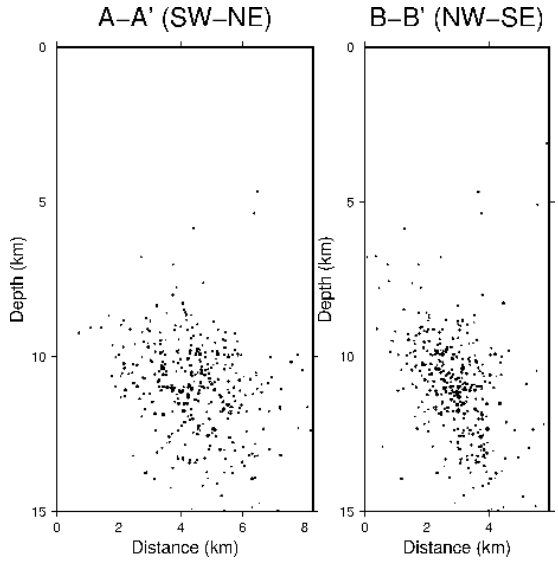

Figure 2. Cross-sections of the foci that belong to the 2013 sequence, as indicated in Fig. 1.

Placed in a broader tectonic context, the fault(s) responsible for the 2013 events is located between major E-W normal and oblique-normal faults, such as the Erythres fault to the east, the Kaparelli fault to the north, the Mytikas and Germeno faults tothe south and the Domvrena fault to the west, the latter being the northern marginal fault in the eastern part of the active GoC. The 2013 seismic activity, attributed to NE-SW faults, such as the Korombili fault and/or possible blind structures indicates a possible linkage between major E-W faults, such as the Kaparelli-Erythres and Domvrena faults. If this assumption is valid, then Mt Kithaironas can be considered as a transfer zone between major E-W faults; Korombili fault can be acting as a link between the Kaparelli and Domvrena faults, defining the western border of the transfer zone; its eastern border is much less well defined, however, with only a few NE-SW minor faults mapped.

The study of faulting in the EGoC is of great importance. As evidenced by the events of 1981, the knowledge of seismotectonics in an active area close to Athens, the largest metropolitan area in Greece, is crucial for improving the estimates of seismic hazard and for taking steps towards risk mitigation and refining the building code. A more detailed mapping of the faults in the area and the densification of the network can aid in identifying potential sources of intense tectonic activity.

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