

Recent Significant Seismic Activity in Greece

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Greece is located in the eastern end of Europe where a variety of geological procedures take place such as the Alpine orogenesis. The creation of the Alpine mountain chain, which is one of the most important geological features, is caused by the collision between Europe and Africa. Furthermore, the intense deformation observed in Greece and surrounding areas produces significant seismicity concentrated along active seismic zones such as the Hellenic Arc and the North Anatolian fault (Papazachos et al., 2000). In addition, the gulfs of Corinth, Evoikos and Saronikos also present important seismic activity. Since 2018, more than 10,000 events have been recorded by stations of the Hellenic Unified Seismological Network (HUSN; Papanastassiou, 2011) and were analyzed by the Seismological Laboratory of the National and Kapodistrian University of Athens. Recently, data from the Hellenic Strong Motion Network (HSMN; Theodulidis et al. 2004) were included in the framework of HELPOS project. The “scolv” tool of the SeisComP3 software was used in order to manually revise the automatically located events. The initial catalogue was further enriched with events that weren’t automatically detected, by extracting waveform data according to an initial origin time after visual inspection of the 24-hour recordings on reference stations.

In the present study we mainly focus on significant seismic activity that occurred during 2018-2019. In North Aegean, shallow aftershock activity associated with the earthquakes that occurred on the 6th February and 12th of June 2017, in the broader area of Lesbos Island, is still present in 2018. More than 200 events since June, manually analyzed, were used to obtain an optimized local velocity model. The newly developed seismic catalogue revealed distinct spatial ~E-W oriented seismic clusters, compatible with the strike of Quaternary faults in the area south-west of Canakkale and along the southern coasts of Lesbos Island, related to Lesbos-Psara pull-apart basins (e.g. Kiratzi, 2014).

In Central Greece, the greatest part of the seismicity is located in the southern termination of Saronikos gulf and in Attica area. The seismic activity in Saronikos gulf is concentrated around Leuces islands, north of Aegina and Methana in E-W striking neotectonic fault zones. In addition, a swarm located along the Poros Fault System (PFS) took place in 2016-2017. In Attica area a microseismic activity occurred in January 2018, north of Mt Penteli (Kaviris et al., 2018), Marathon Bay, Thriassion fault and its continuation in Athens basin. 450 events were located in the vicinity of Attica during 2018-2019 with magnitudes mainly between 1.8 and 2.6. Sporadic seismicity was also detected along the southern shores of Attica. The most notable events of this region occurred on 18 January 2018 (ML=4.2) and 1 May 2018, in the areas NNE of Mt Penteli and Oropos, respectively.

The earthquake activity in the broader area of Santorini volcanic center is strongly connected with the tectonic regime, as well as with the volcanic process (Bohnhoff et al., 2006; Dimitriadis et al., 2010; Papadimitriou et al., 2015). The highest rate of seismic activity in this area has been observed along the NE-SW striking Santorini-Columbo volcano-tectonic line, a deep-seated, strike-slip feature (Bohnhoff et al., 2006; Sakellariou et al., 2013; Nomikou et al., 2018). Within this zone, the submarine Columbo volcano exhibits strong seismic and hydrothermal activity which could be linked to the magma reservoir and therefore to the migration of magma and fluids towards the surface (Bohnhoff et al., 2006; Sigurdsson et al., 2006). A similar pattern of seismic activity is observed NE of Columbo, with small-scaled activity spots that might represent local pathways of upward migrating fluids or even developing volcanic activity within this zone of crustal weakness (Bohnhoff et al. 2006). The majority of the recorded seismic activity was located 38.2 km NE of Thira, SSW of Amorgos (Mw=4.5). This cluster lies on the southern boundary of the activated fault during the 1956 tsunamigenic M7.2 earthquake of Amorgos. Another significant portion of the seismic activity (13-14/01/2019) was located south of Akrotirion, 17.1 km SSW of Thira, aligned in a general WSW-ENE direction. The most notable event of this group occurred on 13 January 2019 (ML=3.6).

On October 25th, 2018 (22:54 GMT), an M6.8 earthquake occurred 57.0 km SW of Zakynthos Island, at a focal depth of ~11km. The mainshock was widely felt to the island and in many areas of Central Greece. More than 4,000 aftershocks were manually located. A local 1-D velocity model was developed upon a selected dataset (1,000 earthquakes). The aftershock locations reveal a complex hypocentral distribution, which indicates the activation of more than one structure in the area, with five main spatial groups being identified: one situated in the area around the mainshock; another likely associated with the southern prolongation of Cephalonia Transform Fault (CTF) WNW of Zakynthos (Papadimitriou et al., 2006; 2012); a third ~20km to the NNE of the mainshock; a fourth in Laganas bay (Southern Zakynthos) and a fifth close to Strofades islands, where the 1997 M6.6 earthquake took place. The obtained results highlight a complex fault pattern in Southern Ionian Sea, as a result of the intense deformation of the overriding crust.

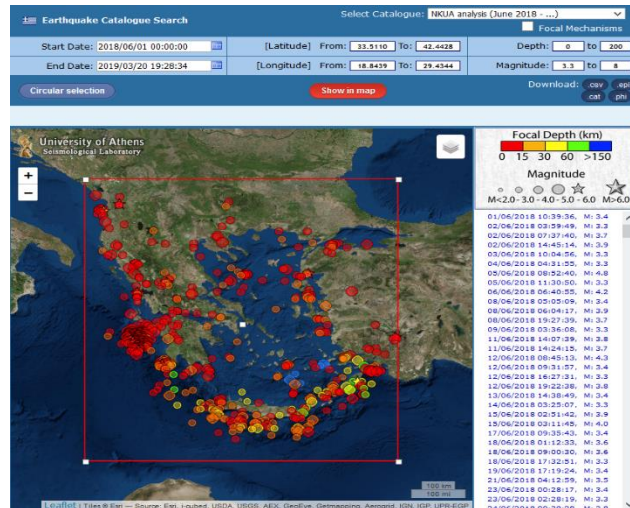


Figure 1. Seismic activity of earthquakes with $M \geq 3.3$ for the period Jun 2018 – March 2019 resolved by SL-NKUA, as presented in the catalogue search platform available online at: http://www.geophysics.geol.uoa.gr/stations/gmapv3_db/index.php

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References

- Dimitriadis, I. et al., 2010. P and S velocity structures of the Santorini-Colombo volcanic system (Aegean Sea, Greece) obtained by non-linear inversion of travel times and its tectonic implications. *J. Volcanol. Geotherm. Res.* 195 (1), 13–30
- Kaviris, G., Spingos, I., Millas, C., Kapetanidis, V., Fountoulakis, I., Papadimitriou, P., Voulgaris, N., Drakatos, G., 2018. Effects of the January 2018 seismic sequence on shear-wave splitting in the upper crust of Marathon (NE Attica, Greece). *Phys. Earth Planet. Inter.* 285, 45–58.
- Kiratzis, A., 2014. Mechanisms of Earthquakes in Aegean, *Encyclopedia of Earthquake Engineering*, 1-22, Springer Berlin Heidelberg, DOI: 10.1007/978-3-642-36197-5_299-1
- Nomikou, P. et al., 2018. Expanding extension, subsidence and lateral segmentation within the Santorini - Amorgos basins during Quaternary: Implications for the 1956 Amorgos events, central - south Aegean Sea, Greece. *Tectonophysics* 722:138-153, DOI: 10.1016/j.tecto.2017.10.016.
- Papadimitriou, P. et al., 2015. The Santorini Volcanic Complex: A detailed multi-parameter seismological approach with emphasis on the 2011–2012 unrest period. *J. Geodyn.*, 85, 32–57, doi: 10.1016/j.jog.2014.12.004.
- Papadimitriou, P. et al., 2018. The 12th June 2017 $M_w=6.3$ Lesbos earthquake from detailed seismological observations, *Journal of Geodynamics*, Volume 115, April 2018, Pages 23-42, ISSN 0264-3707, <https://doi.org/10.1016/j.jog.2018.01.009>.
- Papanastassiou D. 2011. Earthquake detection-location capability of the Hellenic Unified Seismological Network (HUSN) operating by the Institute of Geodynamics, National Observatory of Athens. *Hellenic J Geosc* 45: 209–216.
- Papazachos, B.C., Karakostas, V.G., Papazachos, C.B., Scordilis, E.M., 2000. The geometry of the Wadati-Benioff zone and the lithospheric kinematics in the Hellenic arc. *Tectonophysics* 319, 275–300.
- Sakellariou, D. et al., 2013. Strike slip tectonics and transtensional deformation in the Aegean region and the Hellenic arc: preliminary results. *Bulletin of the Geological Society of Greece, XLVII, Proceedings of the 13th International Congress, Chania, Sept. 2013.*
- Sigurdsson H. et al., 2006. Marine Investigations of Greece’s Santorini Volcanic Field, *EOS, Vol 87 N. 34, 22 August 2006.*
- Theodulidis N. et al., 2004. HEAD1.0: A unified accelerogram database”, *Seism. Research. Lett.*, 75, 41-50.