15th International Congress of the Geological Society of Greece
Athens, 22-24 May, 2019 | Harokopio University of Athens, Greece
Bulletin of the Geological Society of Greece, Sp. Pub. **7** Ext. Abs. GSG2019-369

Focal mechanisms database of moderate and strong events in the broader area of Greece

P. Papadimitriou[1], V. Kapetanidis[1], A. Karakonstantis[1], I. Spingos[1], K. Pavlou[1] and I. Kassaras[1]

(1) Section of Geophysics–Geothermics, Department of Geology and Geoenvironment, National and Kapodistrian University of Athens, 15784 Panepistimiopolis, Zografou, Athens, Greece, ppapadim@geol.uoa.gr

The Aegean is the most rapidly deforming region in the Mediterranean, as evidenced from seismological and geodetic observations (McKenzie,1972; 1978; Jackson, 1994; Jackson and McKenzie, 1988). The Aegean is located between two lithospheric plates, the Eurasian and the African, that are converging in an approximately N-S direction with a rate ranging 2-4 cm/yr (Floyd et al., 2010). The deformation becomes more complicated, due to the collision of the Arabian plate with Eurasia, resulting to the westward motion of Turkey towards the Aegean. All the above-mentioned movements lead to a complex deformation pattern: (a) the northern Aegean is dominated by the right lateral strike-slip motion of the westernmost part of the North Anatolian fault (McNeill et al., 2004), (b) the central part of the Aegean is characterized by normal faulting and extension in an approximately N-S direction and (c) the southern part is characterized by a subduction zone along the Hellenic Arc, where intermediate depth earthquakes occur, leading to the formation of the Volcanic Arc. The average distance between the two arcs is 120 km. The subduction zone is characterized by a general NE dip direction. However, the located events along the Benioff zone indicate that the slip and the shape vary along an amphitheatric, asymmetrical scheme, presenting significant differences between its eastern and western parts. The above-mentioned complex deformation results in high seismic activity consisting of small-intermediate as well as large earthquakes (Papazachos et al., 1998).

In a such complex environment, it is crucial to determine earthquake focal mechanisms of intermediate, as well as of large magnitude events for understanding physical processes on faults during earthquakes. It is worth noting that since 2007 all Greek seismological networks have been integrated into the Hellenic Unified Seismological Network (HUSN; Papanastassiou, 2011). This important effort has contributed to the increase of detectability as well as to the improvement of the location parameters of earthquakes. The Seismological Laboratory of the National and Kapodistrian University of Athens (SL-NKUA), by taking into account phases from Greek Seismological institutions, has compiled a data set of more than 180.000 events and 1000 focal mechanisms located in Greece and the surrounded areas for the time period 1996-2018. Since 2018, more than 20,000 events have been recorded by HUSN stations and ~150 fault plane solutions have been analyzed by SL-NKUA.

The determination of the seismic source parameters is based on a software developed at SL-NKUA (Papadimitriou et al., 2012). Two different techniques were applied to determine the source parameters of the selected earthquakes:

a) Teleseismic body-wave modelling using waveforms at epicentral distances between 30° and 90° was employed for the large events (Mw > 5.8). Synthetic seismograms of P, SV and SH were calculated, taking into account the geometric spreading, the Earth's radius, the radiation pattern of the considered component, the density, the angle of incidence at the source and the receiver as well as the free surface effect.

b) For local to regional distances, the method of the P-wave first-motion polarities has been, for several years, the only one to constrain focal mechanisms. The installation of regional seismological networks worldwide, gave the opportunity to develop new methods based on the generation of synthetic waves using inversion techniques (Dreger and Helmberger, 1990; Fukuyama and Dreger, 2000; Ichinose et al., 2003; Kiratzi and Louvari, 2003). The main advantage of this approach is that moderate events can be analyzed in order to obtain reliable solutions. Thus, the knowledge on the type of the earthquake rupture is increased and contributes to the seismotectonic analysis of the study area. These techniques are based on the calculation of synthetics representing the complete wavefield, using the frequency–wavenumber method at local-regional distances (Bouchon, 2003). This method, applied in the present study, calculates synthetic waveforms directly comparable with the observed ones for a given velocity structure. Synthetics were generated by computing 9 fundamental Green's functions, which are then combined with the elements of a moment tensor to produce the tangential, radial and vertical component of motion.

The number of fault plane solutions based on moment tensor inversion for moderate magnitude events (M>3.5) is increasing the last years due to the quality and the density of broad band seismological stations. In this study, well-constrained focal mechanisms using the above-mentioned moment tensor inversion technique are presented and analyzed. The determined focal mechanisms can be viewed, selected and exported through an online platform at the web-site of the Department of Geophysics-Geothermics of NKUA (Fig. 1). The local-regional stress deducing from the focal mechanisms improves the knowledge of the physical state of the local seismogenic structures. This is important, considering that, in the same area, the type of the fault plane solutions of the moderate events has no significant differences in comparison with the type of the large ones. The recent calculated focal mechanisms in the broader area of Zakynthos (not only the aftershocks) indicate small differences from the main event of the 25 November 2018. Complexity of the focal mechanisms type is observed mainly southern of Greece along the Hellenic Arc.

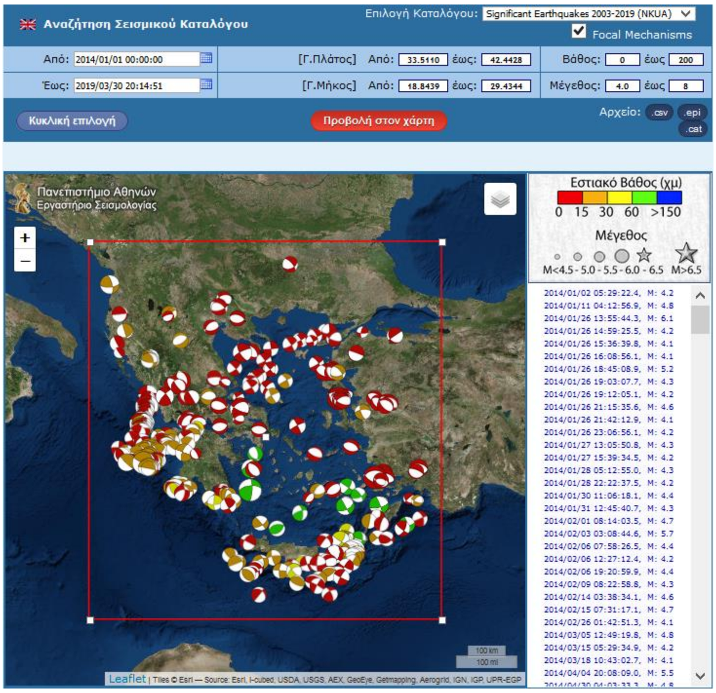

Figure 1. Focal mechanisms of earthquakes with $M_w \geq 4.0$ for the period 2014 – March 2019 resolved by SL-NKUA, as presented in the catalogue search platform available online at: http://www.geophysics.geol.uoa.gr/stations/gmapv3_db/index.php.

Acknowledgements

We acknowledge support of this study by the project "HELPOS – Hellenic Plate Observing System" (MIS 5002697) which is implemented under the Action "Reinforcement of the Research and Innovation Infrastructure", funded by the Operational Programme "Competitiveness, Entrepreneurship and Innovation" (NSRF 2014-2020) and co-financed by Greece and the European Union (European Regional Development Fund).

References

Bouchon, M., 2003. A Review of the Discrete Wavenumber Method. Pure Appl. Geophys. 160, 445–465.
Dreger, D., and Helmberger, D., 1990. Broadband modelling of local earthquakes. Bull. Seismol. Soc. Am.,. 80, 1162–1179.
Fan, G., Ni, J.F., Wallace, T.C., 1994. Active tectonics of the Pamirs and Karakorum. J. Geophys. Res. 99, 7131–7160.
Floyd, M.A., Billiris, H., Paradissis, D., Veis, G., Avallone, A., Briole, P., McClusky, S., Nocquet, J.-M., Palamartchouk, K., Parsons, B., England, P.C., 2010. A new velocity field for Greece: Implications for the kinematics and dynamics of the Aegean. J. Geophys. Res. 115, B10403. doi:10.1029/2009JB007040
Fukuyama, E. & Dreger, D.S., 2000. Performance test of an automated moment tensor determination system for the future "Tokai" earthquake, Earth Planets Space, 52, 383–392.
Ichinose, G., Anderson, J., Smith, K. & Zeng, Y., 2003. Source parameters of Eastern California and Western Nevada earthquakes from regional moment tensor inversion, Bull. Seism. Soc. Am., 93, 61–84.
Jackson, J., 1994. Active Tectonics of the Aegean Region. Annu. Rev. Earth Planet. Sci. 22, 239–271.
Jackson, J. and McKenzie, D., 1988. Rates of active deformation in the Aegean Sea and surrounding regions. Basin Res., 1, 121-128.
Kiratzi, A., and Louvari, E., 2003. Focal mechanisms of shallow earthquakes in the Aegean Sea and the surrounding lands determined by waveform modelling: a new database. J. Geodyn., 36, 251–274.
McKenzie, D., 1972. Active tectonics of the Mediterranean region. Geophys. J. R. astr. Soc., 30, 109-185.
McKenzie, D., 1978. Some remarks on the development of sedimentary basins. Earth Planet. Sci. Lett. 40, 25–32.
McNeill, L.C., Mille, A., Minshull, T.A., Bull, J.M., Kenyon, N.H., Ivanov, M., 2004. Extension of the North Anatolian Fault into the North Aegean Trough: Evidence for transtension, strain partitioning, and analogues for Sea of Marmara basin models. Tectonics 23, TC2016. doi:10.1029/2002TC001490
Papadimitriou, P., Chousianitis, K., Agalos, A., Moshou, A., Lagios, E., Makropoulos, K., 2012. The spatially extended 2006 April Zakynthos (Ionian Islands, Greece) seismic sequence and evidence for stress transfer. Geophys. J. Int. 190, 1025–1040.
Papadimitriou, P., et al., 2018. The 12 th June 2017 M w = 6.3 Lesvos earthquake from detailed seismological observations. J. Geodyn. 115, 23–42. doi: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., Papadimitriou, E.E., Kiratzi, A.A., Papazachos, C.B. and Louvari, E., 1998. Fault plane solutions in the Aegean Sea and the surrounding area and their tectonic implication. Boll. Geof. Teor. App., 39, 199-218.