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. GSG2019-108

Spatiotemporal analysis of the early 2019 seismic excitation offshore north Lefkada Island

V. Karakostas[1], E. Papadimitriou[1], T. Kostoglou[1], O. Mangira[1], P. Bountzis[1]

(1) Geophysics Department, School of Geology, Aristotle University of Thessaloniki, GR54124 Thessaloniki, Greece, vkarak@geo.auth.gr

A moderate magnitude M_w5.4, earthquake occurred on the 5th of February 2019 in the offshore area north of Lefkada Island, strongly felt in the Lefkada city and the onshore continental area to the east, with no major damage or injuries reported. The main shock was followed by a very productive aftershock sequence with more than 400 recorded, and about 370 of them being relocated, by the 15 March 2019. An M_w4.2 earthquake has occurred on the 15th of January 2019, to the northeast of the 05/02/2019 event, also followed by several aftershocks. The affected area has been frequently visited by moderate earthquakes in the last decades with no one of them exceeding in magnitude M6.0.

The activated area is located at the boundary between the Kefalonia Transform Fault Zone (KTFZ) to the south and the Adriatic – Eurasian Collision to the north. The continental collision is expressed by a belt of thrust faulting with a NE – SW direction of the axis of maximum compression, runs along the eastern coastline of Adriatic Sea and terminates just north of Lefkada Island. The KTFZ is a major dextral strike slip fault zone that accommodates frequent strong earthquakes, clustered in space and time probably due to the stress transfer between the fault segments comprised in the fault system (Papadimitriou, 2002). The northernmost fault segment of KTFZ was activated in 2003 with an M_w6.2 main shock and a rich aftershock sequence, the accurate location of which provided for the first time the indication that the major fault segments bound the western coastlines and the contemporaneously activated secondary ones lie onshore (Karakostas *et al*., 2004).

The investigation of this activity is challenging to shed light in the seismogenic setting and the complex geodynamics of the area, prerequisite for any seismic hazard assessment study. Its location is critical to decipher how these secondary structures play a role in accommodating strain at the borderline of the KTFZ, an area where also reverse focal mechanisms were determined for moderate earthquakes that occurred in the last few decades.

Seismicity relocation and spatial characteristics

Seismicity was relocated after manually picking the P and S arrivals and using the 1–D velocity model along with a recalculated v_p/v_s ratio suggested by Papadimitriou *et al*. (2017) for the relocation of the 2015 Lefkada aftershock sequence. Station delays were calculated for further refining the locations, following a procedure described in Karakostas *et al*. (2014) and the HYPOINVERSE (Klein, 2002) computer program. The relocated seismicity allowed refined and more reliable picture than the disperse epicentral distribution derived from the regional catalogue, revealing seismicity concentrations mainly close to the stronger earthquakes' epicentres (Figure 1). The total earthquake set includes ~370 events that could be detected by an adequate number of seismological stations and relocated.

The first strong M_w4.2 earthquake triggered the activity in the northern cluster, with a comparatively noticeable aftershock frequency and magnitudes, with 15 aftershocks in the first 24 hours and additional 20 in the next five days. It is noteworthy that the activity continued and even intensified at this location after the M_w5.4 main shock. The close distance of the two concentrations could be investigated through interaction of small – magnitude earthquakes within the sequence.

The February aftershocks delineate an ~10 km long zone, which seems larger than expected from known scaling laws connecting rupture length with earthquake magnitude. Given that the locations are highly accurate, it implies that several secondary fault segments were activated in a cascade mode through stress transfer firstly due to the main shock coseismic slip and in the following among the activated fault patches. Independently of the moderate main shock magnitude this seismic sequence appeared remarkably productive with an M_w4.2 aftershock, a handful of $M \geq 3.0$ aftershocks and numerous smaller magnitude events (shown with different symbol size and colour, according to their magnitude). The sequence behaves as a foreshock – mainshock – aftershock – like sequence, with a 3 located foreshocks in the five days preceding the main shock occurrence and about 163 events occurred in the first five days, an interval taken the same in length for comparison reasons, the 72 of them being occurred in the first 24 hours.

The fault plane solutions of all the three stronger earthquakes, which are depicted in Figure 1 as lower hemisphere equal area projections, exhibit strike slip motion either dextral on an almost N–S striking fault plane, or sinistral on an E–W conjugate one. Although the N–S fault strike and the dextral motion is compatible with KTFZ geodynamic properties, motion on the conjugate faults cannot be ruled out and further investigation is stimulating.

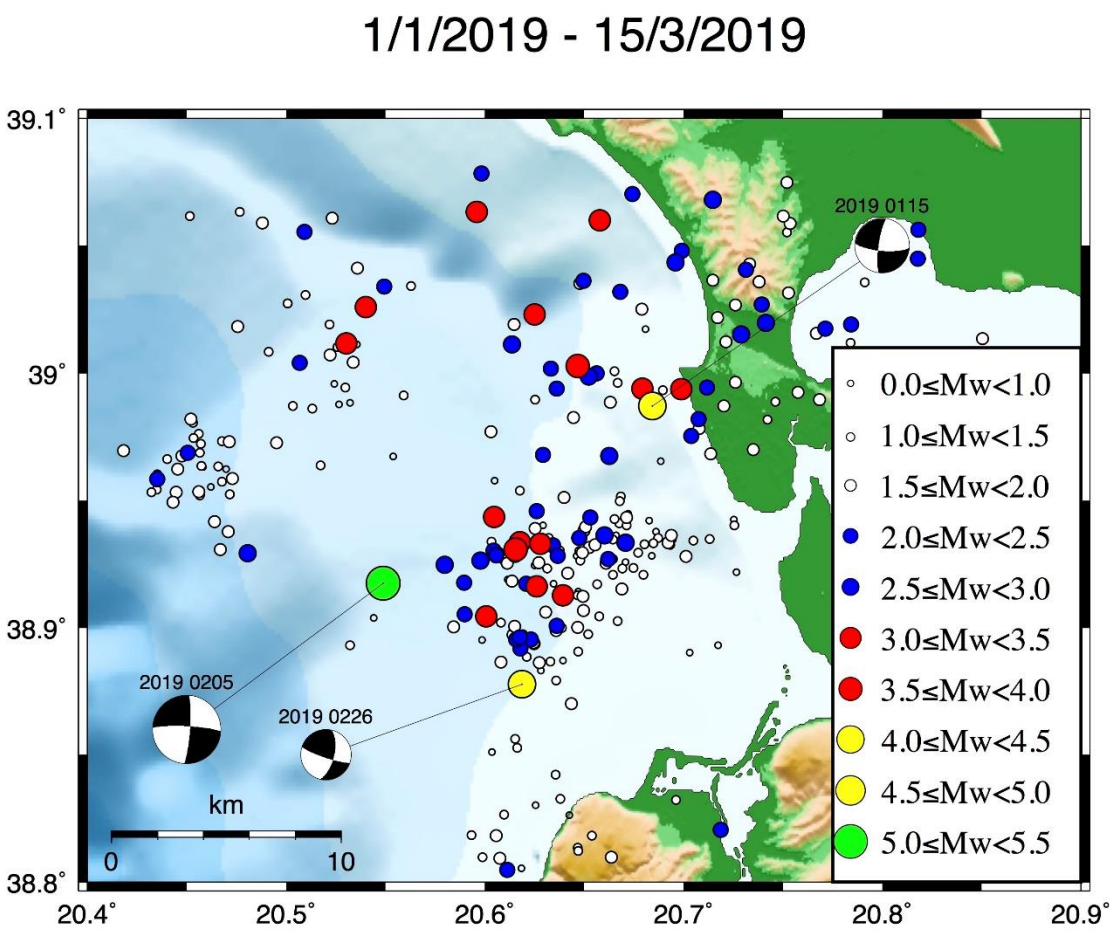

Figure 1. Relocated seismicity in the study area along with the fault plane solutions of the 3 stronger earthquakes shown as equal area lower hemisphere projections.

Summary

The as much as possible accurately relocated intense activity that observed in the first few weeks of the year (2019) beyond the northern termination of the KTFZ, forms distinctive clusters, the most prominent of which is associated with the 05/05/2019 M_w5.4 earthquake. The spatial distribution and the fault plane solutions of the three (3) stronger events evidence the prevalence of strike slip motion in this area, as a continuation of the KTFZ to the north of Lefkada Island. The complexity of the active structures, which in addition to the primary segments of the KTFZ are capable of producing disastrous earthquakes, highlights the need for intensive maintenance and careful analysis of the seismicity.

Acknowledgements

The financial support by the European Union and Greece (Partnership Agreement for the Development Framework 2014 -2020) under the Regional Operational Programme Ionian Islands 2014-2020, for the project "Telemachus – Innovative Operational Seismic Risk Management System in the Region of Ionian Islands" is gratefully acknowledged.

References

Karakostas, V.G., Papadimitriou, E.E., Papazachos, C.B., 2004. Properties of the 2003 Lefkada, Ionian Islands, Greece, earthquake seismic sequence and seismicity triggering. Bulletin Seismological Society America 94, 1976–1981.

Karakostas, V.G., Papadimitriou, E.E., Gospodinov, D., 2014. Modeling the 2013 North Aegean (Greece) seismic sequence: geometrical and frictional constraints, and aftershock probabilities, Geophysical Journal International 197, 525–541, doi: 10.1093/gji/ggt523.

Klein, F.W., 2000. User's Guide to HYPOINVERSE–2000, a Fortran program to solve earthquake locations and magnitudes, U. S. Geological Survey Open File Report 02–171 Version 1.0.

Papadimitriou, E.E., 2002. Mode of strong earthquake occurrence in central Ionian Islands (Greece). Possible triggering due to Coulomb stress changes generated by the occurrence of previous strong shocks. Bulletin Seismological Society America 94, 3293–3308.

Papadimitriou, E., Karakostas, V., Mesimeri, M., Chouliaras, G., Kourouklas, Ch., 2017. The M_w6.7 17 November 2015 Lefkada (Greece) earthquake: structural interpretation by means of aftershock analysis. Pure & Applied Geophysics, DOI 10.1007/s00024–07–1601–3.