The 2018 Zakynthos Island, Greece, Earthquake Sequence: Implications in a Region of Distributed Deformation

V. Karakostas[1], E. Papadimitriou[1], A. Kostoglou[1], D. Chorozoglou[1]

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

An M_w6.8 earthquake occurred on 25 October 2018, 30 km offshore of the west-southwest coastlines of Zakynthos Island. The aftershock sequence being still in progress, appeared very productive with 6 aftershocks of M≥5.0 in the first month and tens of M≥4.0 ones. Centroid moment tensor solutions (https://www.globalcmt.org/CMTsearch.html) for the main shock are predominantly indicative of thrust faulting in response to northeast – southwest compression, with a very low angle plane (dip=24^o) for a significant dextral strike slip component (rake=165^o), alike for the the largest aftershock (M_w5.9, dip=7^o, rake=169^o) that occurred five days afterwards.

The affected area occupies the northwesternmost part of the Hellenic Arc – Trench System is characterized by remarkably high seismic activity, with frequent strong (M>6.0) earthquakes that have caused severe casualties and damage during the last six centuries since historical information is available. The recurrence of these shocks is rather in the order of few decades, given that in the vicinity of the main rupture, an M_w=6.6. occurred in 1997. The 2018 Zakynthos earthquake and accompanying activated secondary faults suggest strong distributed crustal deformation in the area, highlighting the need for better understanding of active faulting and seismic hazard in this region.

Aftershock Location and Evolution of the Sequence

The Hellenic Arc–Trench System was recognized as a subduction zone with the oceanic plate of eastern Mediterranean being subducted under the Aegean microplate and constitutes the most prominent seismotectonic feature of the broader Aegean region. The seismicity is well delineated along the subduction front with the stronger events exhibiting thrust faulting along NW–SE striking faults and NE–SW striking axis of the maximum compression, placed perpendicular to this front in the study area. West – Northwest of the Zakynthos Island the Kefalonia Transform Fault Zone (KTFZ), with dextral strike slip motion, connects the oceanic subduction with the continental collision between the Outer Hellenides and the Adriatic microplate. This dextral strike–slip faulting was recognized as a major discontinuity between the Apulian platform and the western Hellenic Arc and was firstly suggested by Scordilis *et al*. (1985).

The properties of the activated structure were investigated with accurate relocated data and the available fault plane solutions of some of the stronger events. Station delays were calculated for further refining the locations of the aftershocks provided by the catalogs of Geophysics Department of the Aristotle University of Thessaloniki (GD–AUTh), following a procedure described in Karakostas *et al*. (2014) and the HYPOINVERSE (Klein, 2002) computer program. The double–difference location technique along with a cross – correlation algorithm was employed for further refining the locations, revealing a seismogenic layer extending from 3 to 15 km depth, whereas all the aftershock locations do not obviously align with the strike or dip of the mainshock focal mechanism; however, location uncertainties are expected in this region, with the depth control of the smaller events to be difficult constrained.

Figure 1 shows the relocated aftershock spatial distribution where different magnitude ranges are depicted with different symbols and the main shock epicenter by the star. The activity is spreading offshore the southwestern Zakynthos coastline, and persistently in an area activated since the first hours of the emergence of this seismic excitation, which is remarkably continuing with frequent M3.0 and M4.0 aftershocks for almost six months. The general trend of the relocated seismicity shows a strike agreeing well with the northwest–striking plane from the moment tensor solutions. The location refinement contributes in documenting kinematic details of the seismicity in relation to the active structures, whereas the inclusion of smaller magnitude earthquakes in the relocated data set provide the means for a more detailed analysis of the spatiotemporal evolution of the sequence.

Both the distribution of seismicity and fault plane solutions show that thrusting with strike slip motion are both present in low angle fault segments. The segmentation of the activated structure could be attributed to the faulting complexity combining the regional compressive tectonics with the dextral strike slip motion, mainly manifested along the KTFZ. Investigation of the spatial and temporal behavior of seismicity revealed possible triggering of adjacent fault segments that may fail individually thus preventing coalescence in a large main rupture. Multiple activation of secondary faults is observed, since the activity is extended over 60 km, an area well above from what is expected from known scaling laws expressing the fault length and rupture area as a function of the main shock magnitude. This implies that strain energy was not solely released on a main fault only, but on secondary and adjacent fault segments as well. The as much as possible reliable definition of their geometry forms the basis for the structural interpretation of the local fault network.

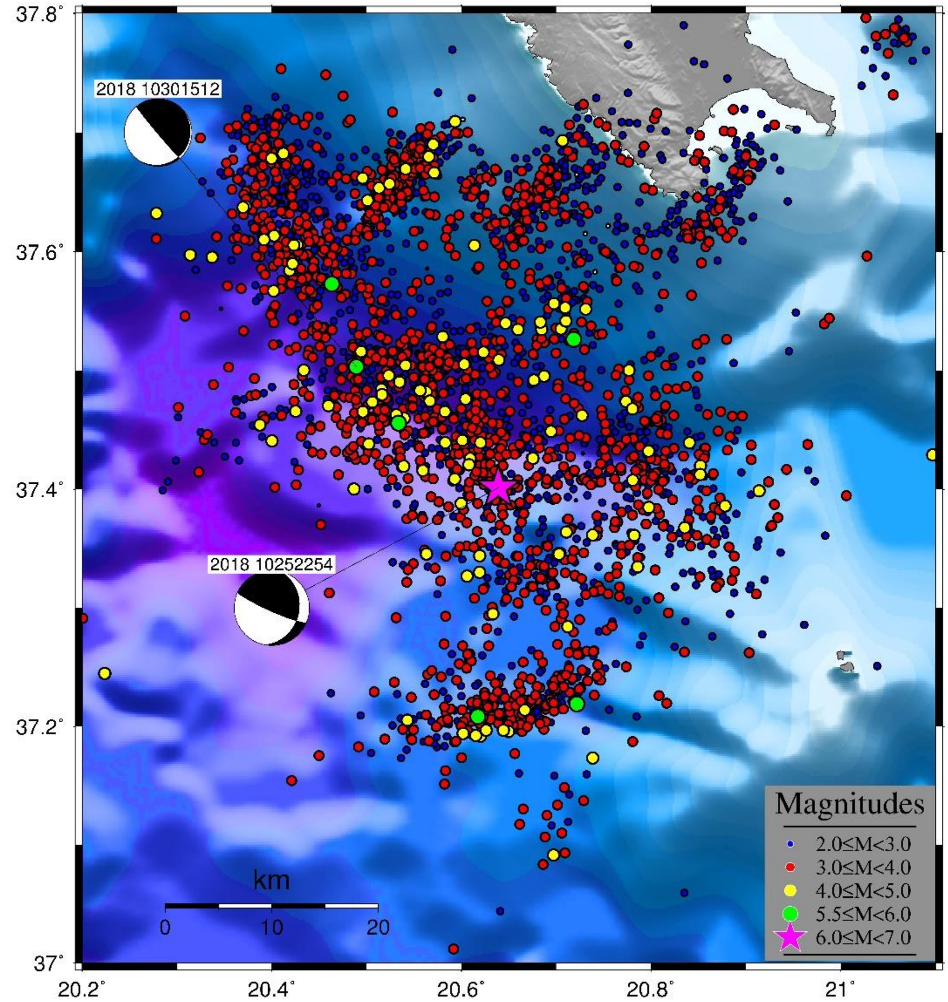

Figure 1. The 2018 Zakynthos relocated aftershock sequence in the first three months after the main shock occurrence, along with the focal mechanisms of the main shock and its largest aftershock shown as equal area lower hemisphere projections.

Summary

The 2018 M_w6.8 Zakynthos earthquake and its largest aftershock were crustal thrust – faulting events. The stress axes orientations are consistent with the regional stress field and with the focal mechanisms of past regional events (Papadimitriou, 1993). Complex earthquake sequences are common in the study area, where multiple adjacent and conjugate faults are contemporaneously activated. The abundance of aftershock activity appears to be correlated with structural complexity, in the sense that aftershock populations reflect fault populations surrounding major faults.

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