POSEIDON: New data on offshore structures in the west Peloponnese - Ionian Islands
Domain and implications for seismic hazards
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Our cruise POSEIDON from 10 to 22 June 2023, on Research Vessel (R/V) Laura Bassi, aimed at mapping the tectonic structure of arguably one of the most complex and comparatively little evaluated regions, with demonstrated seismic hazard, in the Mediterranean. The region encompassing this tectonic domain extends from the western Peloponnese across the Ionian Islands (Figure 1). Here, a complex fault system with numerous strands has developed in a region with dramatic lateral changes in deformation rates. This system has produced numerous large earthquakes, mostly offshore, recorded during the past few decades in the onshore Greek national seismological network (Hadad et al., 2020). However, the large Cephalonia 1953 $M_w$~6.8 event (Stiros et al., 1994) was recorded in comparatively few stations only. This earthquake is possibly the most destructive seismic event in recent Greek history, causing the collapse of ~85% of all buildings on Kefalonia, ~1000 deaths, and ~145k people homeless, (Saranga, 2017; Hore, 2019). The limited data on the 1953 earthquake has made it poorly understood comparatively with more recent, albeit less destructive events. The epicentre of the 1953 event is poorly located, and the location and dimensions of the causative fault are unconstrained. Likewise, the thrust fault focal mechanism, located E or SE of Kefalonia, has a hypocenter depth poorly defined from <50 km to <20 km, depending on the analysis. Surface geology studies of the islands interpret active shallow thrusting (Underhill, 1989), and it has been proposed that the 1953 event ruptured several of those faults. The goal of POSEIDON is to determine region fault system structure and kinematics.

The available bathymetric-topographic relief displays a rugged terrain from the Ionian Islands to the Peloponnese Peninsula with features that indicate active deformation. Major morpho-tectonic submarine structures around the islands trend from NE-SW to NNW-SSE, trending similar to the basins and ranges onshore the islands and their linear coastlines (Figure 1). Unfortunately, limited available seismic data has imaged those structures. A fold and thrust belt recognised onshore (Underhill, 1989), and imaged offshore in a bay SW of Kefalonia Island, appears with folds eroded and covered by Quaternary-to-recent unfolded sediment, indicating that at least locally they are inactive structures (Underhill, 2009). However, the elongated shallow troughs offshore that laterally project into the morphological trends of the islands, support widespread active faulting, and some of the larger structure may be have controlled the slip during the 1953 destructive event. Without proper seismic imaging, the seafloor relief is complicated for interpretation. It could potentially represent structures with a strike-slip to oblique component that kinematically link onshore and offshore structures or potentially with changes from trans-tension to oblique thrust component along strike.
Figure 1. Seismic profiles from POSEIDON cruise plotted over the bathymetry of the region.

An additional complexity in the POSEIDON research area is that the upper-crust fault system discussed above, might be located above the mega-thrust fault of the Hellenic subduction zone, inferred to dip in a NE direction at ~25-40 km depth under the surface (Hansen et al., 2019, Haddad et al., 2020). The transition from the upper-crust seismogenic zone to the mega-thrust seismogenic zone is yet not understood in this region (Karastathis et al., 2015; Chousianitis&Konca 2019; Cirella et al., 2020). Thus, we may speculate that the devastating 1953 thrust earthquake might have ruptured the inter-plate mega-thrust. Alternately it might have occurred on a major splay fault, i.e. a structure with relatively steep dip, with surface expression, and that the splay roots at the mega-thrust. However, there have not been seismic images to test all these hypotheses.

Finally, the area of research of POSEIDON is located at the edge of the Ionian subducting slab, which is bounded to the NW by a lithospheric tear (Hansen et al., 2019). Thus, the geodynamic evolution of the slab,
deep under the study area, may be partially driving shallow crustal tectonics, adding additional complexity to understanding the region. We may thus have the opportunity to study the (early) stages of a Subduction-Transform Edge Propagator (STEP) fault system (Govers&Wortel, 2005). This scenario is supported by deep imaging of the slab structure (Hansen et al., 2019), and appears in agreement with the abrupt lateral changes in the overriding plate deformation. Understanding the large-scale structure will be of importance to evaluate fault kinematics interpretation and model deformation numerically.

The seismic profiles recently collected during the POSEIDON cruise image the upper crust and the Moho discontinuity along many segments (Figure close up example). Therefore, the high-resolution bathymetry will able to image and map the structure of the main faults across the offshore region. The structure of the faults will be used to define their interrelations to understand the 3D fault systems, the kinematics of the main structures, their probable relation to the deep slab geodynamics and their potential relation to past earthquakes in the region. Furthermore the map of the fault structure in 3D will provide basic information necessary to help assess seismic hazards in this seismically very active region.

Figure 2. Segment of a POSEIDON seismic line imaging the seafloor, sediment cover and possibly the Moho boundary marking the base of the crust south of Zakynthos.

Acknowledgements
We acknowledge the professional and dedicated work of the Observatorio Geofisico Sperimentale (OGS-Trieste) technical party onboard the Italian Research Vessel (R/V) Laura Bassi, and the technical party of the Marine Technology Unit (UTM) from the Spanish National Research Council (CSIC), and their commitment to make the experiment a success. We also acknowledge the professional and dedicated work of the master, officers and crew of the R/V Laura Bassi during the POSEIDON experiment.

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