Reprocessing, depth conversion and structural restoration of vintage seismic data: New insights into the volcano-tectonic evolution of the Christiana-Santorini-Kolumbo marine volcanic zone

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Located on the Hellenic Volcanic Arc, the Christiana-Santorini-Kolumbo (CSK) marine volcanic zone is notorious for its catastrophic volcanic eruptions, earthquakes and tsunamis. Here, not only the largest volcanic eruption in human history, the so-called "Minoan" eruption took place in the Late Bronze age 3600 years ago, but also the largest 20th-century shallow earthquake in Europe of magnitude 7.4 in 1956. Although the region is heavily populated and a fully developed touristic region, the acting tectonic forces are not fully understood to this day aggravating the necessary assessment of geohazards.

Recent bathymetric and seismic studies revealed that the CSK zone comprises a system of neotectonic horst and graben structures with extended internal faulting that is thought to be the result of the ongoing extension in the southern Aegean. The NE-SW alignment of volcanic edifices within the CSK underlines the tectonic control of volcanism in this area. In this study, we show how advanced reprocessing of selected seismic lines leads to significantly improved seismic images revealing new details of the complex rift system. Moreover, using a unique diffraction-based approach for velocity model building, we perform pre-stack depth migration (PSDM) and present for the first time depth-converted seismic sections from the CSK zone. This allows for the proper estimation of fault angles, sedimentary thicknesses and performing structural restoration in order to reconstruct and measure the amount of extension in the individual rift basins. We revise the previous seismostratigraphic scheme and propose a new correlation between the horst and graben units.

Structural restoration indicates an extension of approx. 3 km along the Santorini-Anafi basin while PSDM indicates the sedimentary strata to be of maximum 1500 m thickness. According to the new stratigraphic model, we infer a four-stage evolution of this basin in which early marine deposition, syn-rift deposition, complex infill deposition and neotectonic syn-rift deposition are distinguished. Moreover, we identify negative flower structures within the basin centre indicating the presence of a strike-slip component, which superimposes the dominant NW-SE directed extension. Based on these findings, we are confident that by applying the proposed workflow to the complete regional dataset, the understanding of the relationship between tectonics and volcanism in the CSK zone will be significantly improved, and, consequently, will lead to an improved risk assessment of the central Aegean Sea.