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Seismological characteristics of the 2011 unrest in Santorini caldera: Implications for observed deformation and volcano-tectonics

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Santorini caldera has experienced several explosive eruptions in the past, the most well-known of these being the Late Bronze Age (ca. 1628 BC) eruption that may have been responsible for the demise of the Minoan civilization. Since the early 1950's the volcano has been dormant without exhibiting any significant activity except from discharge of low-temperature hydrothermal fluids. In January 2011 both deformation and seismic activity increased considerably signaling a period of unrest which however, did not result in an eruption. One permanent and seven temporary seismic stations equipped with three-component sensors were deployed by the National Observatory of Athens. These were combined with seismic stations from the University of Thessaloniki, seven with only a vertical component and four with three-component sensors and all operated under the Hellenic Unified Seismic Network, thus densely monitoring the Santorini Volcano. These seismic stations have recorded the seismic activity from its start up to now. About 290 micro-earthquakes recorded by at least 5 stations were analyzed for the purpose of obtaining accurate epicentral and hypocentral locations using both catalog and differential travel times from waveform cross-correlation. All of these events exhibit clear P- and S-phases indicating that they resulted from shear failure of rock rather than fluid-flow within volcanic conduits. Results show two well-defined clusters in Palea and Nea Kameni islands within the caldera with hypocentral depths ranging between 5-10 km. Interestingly, one more cluster of events with depths between 15-19 km appears near the area of Cape Coloumbo and developed almost simultaneously with the clusters within the caldera. The Mogi source depth inferred from geodetic observations previously is shallower ($\sim$4 km) and does not coincide spatially with the clusters within the caldera. This points to the possibility that seismicity and deformation may be excited by deeper pressure changes. Shear wave splitting measurements have also been performed using all available waveform data in order to understand the nature and spatial variation of the stress field during the unrest. Fast polarization directions exhibit some orientations consistent with the regional NW-SE extension in the area, but also orientations along NE-SW that signify the presence of a local stress field as well.