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Methana volcanic observatory: Towards a seismic and geodetic network deployment to monitor seismicity, seismic velocity changes and deformation

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An effort to monitor seismicity and deformation across the Methana volcanic complex is under implementation. Our target is to monitor continuously any potential volcanic activity and deformation across the volcano using pilot applications of innovative seismic and geodetic methods. Aim of the project "GEORISK – Developing Infrastructure and Provision of Services through Actions of Excellence to Reduce the Impact of Geodynamic Hazards" is to assess the volcanic risk in the broader area that may affect maritime and air transport, in order to determine preventive measures. Even in the case of volcanic quiescence, seismological and geodetic data, derived from a permanent and temporary infrastructure, will define the level of volcanic status, hence the continuous (background) seismic-volcanic activity. We are deploying a network of permanent broadband seismic stations at the volcano and the neighboring islands. These stations will be incorporated in the Hellenic Unified Seismic Network (HUSN). A complementary deployment of temporary seismic stations will cover the entire volcanic complex aiming at the microseismicity monitoring and its association with tectonic or volcanic processes. In recent years, ambient noise interferometry (ANI) methods have been successfully used to detect temporal seismic velocity changes in volcanoes. Travel times between neighboring seismic stations are constantly obtained from their cross-correlation function (CCF) of ambient seismic noise. Thus, relative velocity changes in the Earth crust are likely to be caused by the change of stress and/or volume within the volcano and are accounted as precursors to volcanic events. The ground motions in the Methana volcanic complex will be also investigated geodetically by means of a non-permanent GNSS network along with one continuously recording GNSS station. An extensive experience on similar studies and network deployments in Santorini, Milos and Nisyros volcanic complexes assists on the optimal design of the seismic and geodetic network able to monitor, in a cost effective way, temporal changes across Methana volcano.

Methana volcano

Methana peninsula, located in the Saronicos Gulf at the westernmost part of the South Aegean active volcanic arc and 50km south of Athens, shows a long recorded volcanic history from Upper Pliocene to recent times. It is composed by andesitic and dacitic volcanic rocks with the more recent dated at 0.2 ± 0.3 Ma (Pe-Piper and Piper, 2013). The latest eruption giving andesitic lava is described by the ancient geographer Strabo at about 230 BCE. Moreover, Pausanias volcanic field is the offshore continuation of northern Methana and is comprised of six cones or domes (Foutrakis and Anastasakis, 2018). The long lived volcanic field is characterized by relatively low rates of magma supply and absence of Plinian phreatomagmatic eruptions. Recent tomographic results of the Hellenic arc show a thinned lithosphere associated with an horizontal slab tear that coincides with the volcanic centers in this area (Hansen et. al., 2018).

Volcanic observatory network

Current permanent seismic networks are not covering adequately the Saronikos Gulf area. Thus, the magnitude completeness of the recorded microseismicity is considered high. Our aim is to develop a local network surrounding the Methana peninsula able to detect microseismicity (Fig. 1). Additionally, our target is to monitor continuously any potential volcanic activity and deformation across the volcano using innovative ANI methods. The inter-station paths of such a local network will be able to sample with adequate resolution this part of the Saronic Gulf (Fig. 1). Within the project "GEORISK", the first phase of seismic station deployment was succeeded. Three temporary short -period stations were installed at Agious Theodorous (MET4), Makriloggos (MET5) and Megalochori (MET6) at Methana peninsula on February 2019 (Fig. 1). The vaults of two permanent broadband seismic stations are under construction at Methana village (MET1) and Kameni Chora (MET2) and the stations will be installed on May 2019 Fig. 1). The vault design of the broadband seismic stations is developed by NOA engineers and forms a totally independent free-field installation site (Fig. 1). The seismometer will be placed in bedrock totally independent from the cemented vault cell. Within the vault a higher level in a "step-wise" design will ensure that the rest of the equipment would be placed safely avoiding potential flooding but also having the adequate distance from the thermally insulated seismic sensor itself. In site MET1 a permanent GNSS station will be also stably installed (Fig. 2), following strict criteria on selecting an unobstructed horizon site (Fig. 2)..

Apart from monitoring the ongoing microseismicity in the area, we are interested in monitoring volcanic edifices for temporal changes of the velocity of the seismic waves. When magma pressure increases inside a volcano, the added pressure results into the inflation of the volcano, and small cracks around the magma chamber will decrease the velocity of seismic waves. That small decrease in velocity can be detected successfully using ambient noise interferometry (ANI) techniques. Based on previous ANI studies in Milos and Santorini (Daskalakis et. Al, 2016) we can resolve any potential velocity change of ±0.1%.

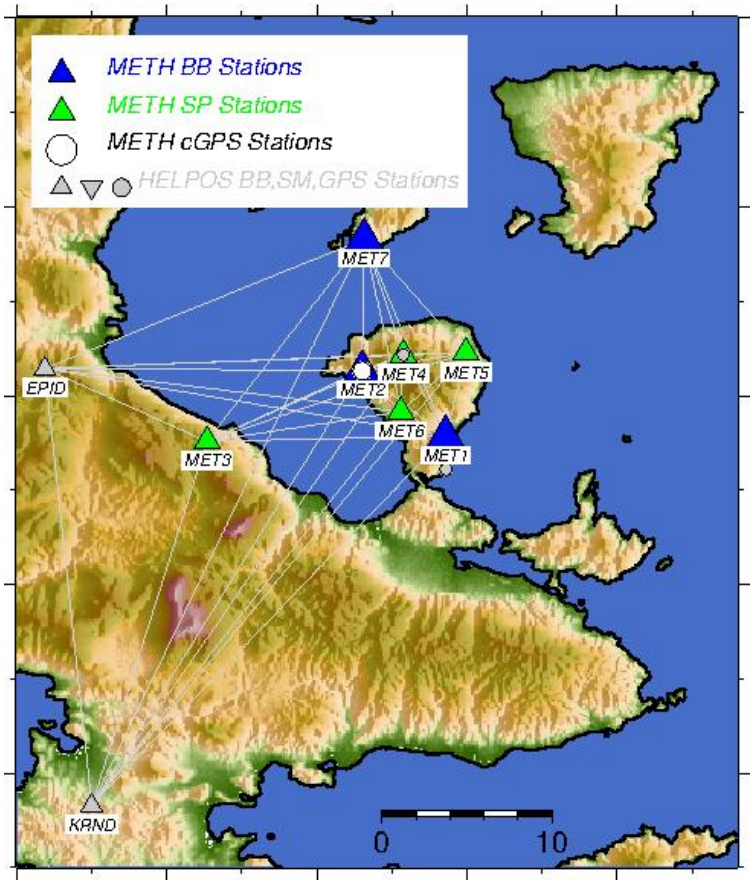

Figure 1. Network of permanent (blue) and temporary (green) seismic stations in Methana and their inter-station paths.

Figure 2. MET2 seismic vault under construction. The GNSS antenna will be installed on the concrete pillar.

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