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Seismicity: A tool in forecasting Volcanic eruptions

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The recent activity in the broader area of Hellenic Volcanic Arc (HVA) highlights the importance of continuous monitoring of selected volcanic centers (Papadimitriou et al., 2015). Volcanic activity is often accompanied by precursors which are related to the movement of magma, causing localized increase of stress, developing cracks and fissures in the crust and triggering seismicity. These effects can be investigated by local seismological networks that permit earthquakes and ambient seismic motions to be recorded and analyzed. The construction of high precision catalogues of earthquake hypocenters can enhance the spatiotemporal distribution, highlighting activated structures and revealing pertinent seismicity migration patterns that may be related to the diffusion of magmatic process. Due to lack of data in the HVA, the case of 2018 Kilauea eruption will be examined, where high-quality seismological data were used in order to recognize certain seismic precursory patterns.

Kīlauea is an active shield volcano and the most active of the five volcanoes that form the island of Hawaii. Located along the southern shore of the island, the volcano is between 210,000 and 280,000 years old and emerged above sea level about 100,000 years ago. It is the second youngest product of the Hawaiian hotspot and the current eruptive center of the Hawaiian-Emperor seamount chain. Kilauea Volcano nestles on the southeast slope of Mauna Loa and merges so imperceptibly with its giant neighbor that significant dimensions cannot be assigned. Hawaiian volcanoes can erupt either at their summits or on their flanks. Summit eruptions of Kilauea occur within or near its caldera. Flank eruptions usually take place along rift zones, which are highly fractured zones of weakness within the volcano (e.g. Bevins *et al.*, 1988; Carey *et al.*, 2015). The most recent major eruption at Kīlauea had the longest duration of any other observed eruption. The current Kīlauea eruption began on January 3rd, 1983, along the eastern rift zone and resulted in the construction of the Pu'u'O'o cone. In 1986, activity shifted down the rift to a new vent, named Kūpa'ianahā, where it took on a more effusive character (Bevins *et al.*, 1988).

The Island of Hawaii experiences intense microseismic activity each year. Most of Hawaii's earthquakes are directly related to volcanic activity. These events may occur before or during an eruption, or they may result from the underground movement of magma that comes close to the surface but does not erupt. During the last decades (1983-today) the area of Kilauea has been characterized by intense seismic activity (Kirby and Klein, 2006). In this study, we collected and processed earthquake waveforms recorded by the Hawaiian Volcano Observatory (HVO) seismological network, providing P- and S-wave phase arrival-time data for events that occurred in the period April 2018-May 2018. The obtained catalogue contains phase data for more than 500 microearthquakes. A preliminary hypocenter location has been performed for the seismicity of the broader area, using the HYPOINVERSE code (Klein, 1989) and a custom 1-D velocity model. The waveform data of HVO were acquired from the Incorporated Research Institutions for Seismology (IRIS) (http://service.iris.edu/) via the International Federation of Digital Seismograph Networks web-services (FDSN-WS) data request protocol, facilitating prompt data availability. A subset of the phase data was employed in order to investigate the average Vp/Vs ratio and local 1-D velocity structure, using the mean travel-time residuals and location uncertainties (RMS, ERH, ERZ) minimization method (e.g. Kissling *et al.*, 1994).

The broader area of Kilauea and the Lower East Rift Zone (LERZ) showed several signs of volcano unrest leading up to the events of May-August 2018. Clustered activity of VT-earthquakes along a ENE-WSW fault zone, in Lower East Rift Zone (LERZ), has been identified during April 30th-May 3rd, 2018. The density of the HVO seismic network made feasible the categorization of the event type according to the source properties and, hence, the origin of the excitation (either volcanic or tectonic). During LERZ eruption, three main classes of seismic signals were discriminated: Volcano-Tectonic (VT), Long-Period (LP) and Hybrid (HB) earthquakes (Zobin, 2003). The classification of volcanic earthquakes was performed by visual inspection. The signals were selected from nearby seismic stations of the HVO at distances of 0.5 km to 20 km from the active fissures respectively. High amplitude volcanic tremor began on May 2nd following a swarm of VTs, as the real-time seismic amplitude measurement (RSAM) plot clearly showed. May 4th, 2018 M6.9 earthquake resulted to the collapse of the Pu'u'O'o cone, opening twenty (20) new fissures and to the interaction of magma with the water table in Halema'uma'u crater. Since May 17th, this interaction has led to a series of volcanic explosions of energy equivalent to M5.0 earthquakes that were connected to the inflation-deflation cycles of Kilauea volcano (USGS, 2018; Neal *et al.*, 2019).

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