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Editorial: Earthquake swarms and complex seismic sequences in tectonic and volcanic areas

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Editorial on the Research Topic
Earthquake swarms and complex seismic sequences in tectonic and volcanic areas

Earthquake swarms are characterized by a lack of a dominant mainshock and often culminate in the largest magnitude event occurring later in the sequence, contrary to mainshock-aftershock sequences which start with the largest in magnitude earthquake followed by aftershocks. On the other hand, complex seismic sequences may feature intense foreshock activity, doublets, or triplets of earthquakes with similar magnitudes, and thus deviating from traditional mainshock-aftershock sequences. Both swarm-like and complex sequences exhibit spatial and temporal migration patterns, extending over a significant seismogenic volume despite their typically small seismic moment release. While these phenomena are commonly associated with volcanic regions in relation to eruption processes, they have also been documented across various tectonic environments.

Numerous physical mechanisms can trigger swarm-like seismicity and complex seismic sequences in both volcanic and tectonic settings. Aseismic processes and local transients, such as creeping, slow slip events, magmatic intrusion, and the redistribution of crustal fluids, are frequently implicated as primary drivers. Additionally, earthquake-earthquake interactions, e.g., static stress transfer, occasionally account for the temporal evolution and spatial migration observed during complex sequences. However, the precise mechanisms underlying these processes and the fundamental reasons for the prevalence of swarm-like sequences over traditional mainshock-aftershock patterns remain only partially understood. To advance our understanding, further investigations spanning diverse geographic regions are imperative. Additionally, the application of techniques aimed at detecting and characterizing earthquakes can yield rich, high-resolution datasets, offering deeper insights into the underlying mechanisms driving earthquake swarms and complex seismic sequences.

Our Research Topic "*Earthquake swarms and complex seismic sequences in tectonic and volcanic areas*" has drawn the attention of five original research articles. These articles delve into analysis of seismic sequences in volcanic and tectonic settings, focusing on the spatio-temporal evolution and underlying mechanisms driving them. These studies play a crucial role in advancing our understanding of the occurrence and dynamics of earthquake swarms and complex seismic sequences alike.

Earthquake swarms have been frequently observed in volcanic areas and are typically associated with either hydrothermal fluids or magma movements or volcanic eruptions. The investigation of such swarms often necessitates a multidisciplinary approach, wherein multiple methodologies and datasets (e.g., geodetic data), are combined towards elucidating the underlying physical mechanism. Soares et al. examined an earthquake swarm within the Azores archipelago during a period of volcanic unrest. This study involved the augmentation of an earthquake catalog by applying an automatic workflow, moment tensor solutions, and geodetic measurements, which facilitated a comprehensive analysis of the seismicity's spatio-temporal evolution. The main conclusion drawn from this study is that the Fogo-Congro region is seismic-volcanically active, exhibiting both seismic and aseismic deformation processes. Momeni and Madariaga investigated the history of the Mosha fault and its correlation with the Damavand active volcano. A complex seismic sequence that occurred in 2020 indicated a plausible connection to the Damavand Volcano. Specifically, the proposed model suggests that heightened thermal activity might increase pore pressure on the fault, consequently reducing the effective normal stress, and thereby promoting the nucleation and expansion of the rupture. Lordi et al. analyzed an earthquake catalog that spans 11 years in the Azores, and showed that there is statistically significant correlation between earthquake rate, sea level anomaly, GRACE satellite anomalies, and ocean bottom pressure. That suggests that water load plays a key role to the Azores oceanic seismicity.

Earthquake swarms are not exclusive to volcanic areas but also observed in tectonically active regions, such as geothermal areas or continental fault systems. In such settings, these seismic sequences are often associated with the movement of fluids within the upper crust and exhibit characteristic spatio-temporal patterns. Whidden et al. studied an earthquake swarm that occurred in spring 2021 in south-central Utah. Utilizing an enhanced catalog, built using a template matching method, together with high resolution earthquake locations, the study showed that the earthquake swarm is the result of heterogeneous stress conditions in a pre-fractured region. De Gori et al. studied a long-lasting earthquake swarm in Pollino, southern Italy. Their study revealed that seismicity occurred on two normal faults that were formerly part of a thrusts and back-thrusts system.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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