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Analysis of the Structural Stability of Vesuvio Lava Tubes using Advanced Signal Processing of Acoustic Emission Signals

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Lava flows are the most common volcanic feature on Earth. Lava tube formation is one of the main mechanisms for lava flow propagation. Mt. Vesuvio was characterized by the emplacement of voluminous lava flow deposits, in some cases accompanied by the formation of lava tubes. The high urbanization in the proximity of the volcano implies a deep understanding of the condition responsible for the formation of lava tube. Understanding lava tube structural stability is of primary importance for hazard assessment and risk mitigation. In this research, we focus on investigating the structural stability of the largest of the lava tubes formed during the 1858 eruption of Mt. Vesuvio. The lava tube was formed through the development of the lava flow field during the eruption. Due to the prolonged usage of the lava tube by lava flows, several linings of molten lava of varying thickness were formed creating the walls of the lava tubes. Acoustic Emission (AE) tests are carried out on site in these different layouts of the lava tubes. A comprehensive analysis using time domain, frequency domain, and time-frequency domain parameters is carried out to investigate the structural stability of the different layouts. Peak amplitude and counts of the AE signals are used for time domain analysis and Fast Fourier Transform (FFT) is used for frequency domain analysis. The results show that the AE signals obtained from the lava tubes layouts are characterised by very low Signal-to-Noise Ratio (SNR). To mitigate this, an advanced signal processing approach is adopted, and the AE signals are analysed in their time-frequency domain using the Hilbert-Huang Transform (HHT). The HHT results in the time-frequency domain, when combined with the time domain and frequency domain AE descriptors revealed that the lava tubes formed by the 1858 eruption of Mount Vesuvio is indeed stable.

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