

Unusual Volcanic Tremor Observations from Fogo Island, Cape Verde

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ABSTRACT

Fogo Island, in the Cape Verde Archipelago, is a 30-km wide active stratovolcano with a historical record of eruptions at average intervals of 20 years over the last 500 years. A 9-km wide summit caldera has its floor at an average 1700m of altitude, and opens towards the East due to a lateral collapse (Day et al., 1999). Pico do Fogo, the main volcanic cone, rises from the caldera floor to an altitude of 2829m, and has not erupted since 1785. More recent eruptions were emitted through its flanks, the last one in 1995.

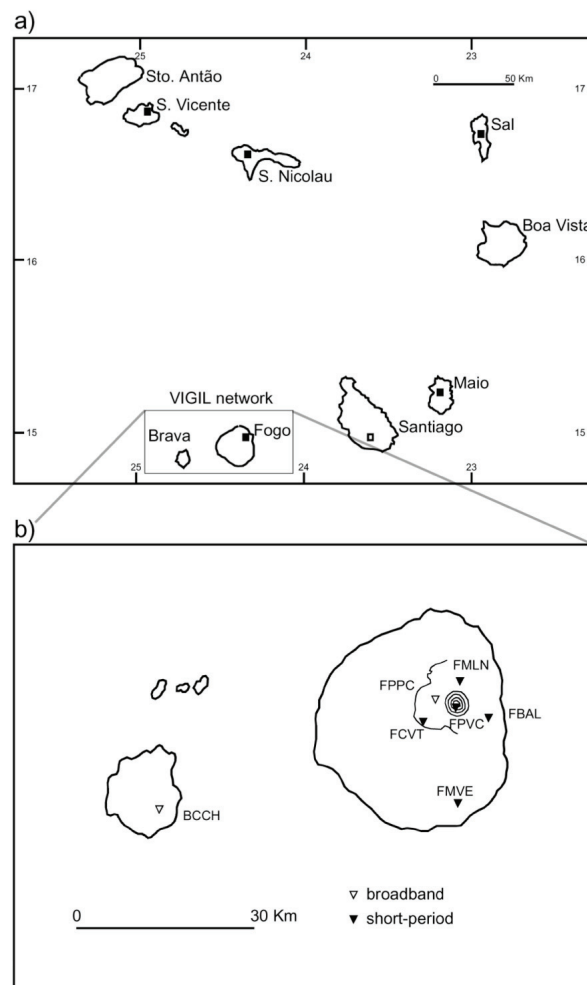


Fig. 1 - Map of the Cape Verde Islands, showing the location of the seismic stations used in this study. a) Solid squares depict CMG-3T seismometers from the CVULVZ Network (Lodge et al., 2004). The open square marks the location of the IRIS/IDA SACV station. b) VIGIL Seismic Network (Fonseca et al., 2003).

The volcano is monitored with a multiparametric telemetric network of instruments (VIGIL Network) in Fogo Island and in neighbour Brava Island, including broadband and short period seismic stations and tiltmeters (Fonseca et al., 2003). Besides (rare) volcanotectonic and long-period seismic events, volcanic tremor is a common observation in the data. This study focuses on:

- 1) conspicuous observations of high frequency (5-20 Hz) volcanic tremor with low attenuation;
- 2) Tidally modulated volcanic tremor;
- 3) High-amplitude tremor due to interaction between hot rock and freatic water.

The main motivation is the use of these signals for eruption forecasting.

Site-effect corrected amplitudes of the high-frequency tremor decrease from the shore towards the interior of Fogo Island. Amplitudes at the Brava station are larger than those in the volcano caldera. This indicates an offshore source close to Fogo Island. IRIS/IDA station SACV in Santiago Island, about 100 km East from Fogo Volcano, and the temporary CVULVZ broadband stations deployed by the University of Bristol in several Capeverdian islands between 2002 and 2004, allowed the investigation of the spatial reach of the high frequency volcanic tremor. This comparison led to the identification of faint spectral peaks detected simultaneously in the VIGIL Network and in Santiago and Maio Islands. The long reach of the signal indicates that the propagation is made partially through the SOFAR channel. The signal was never detected in the Northern Islands of the archipelago. A detailed investigation allowed us to dismiss alternative biological or cultural sources (Heleno et al., submitted).

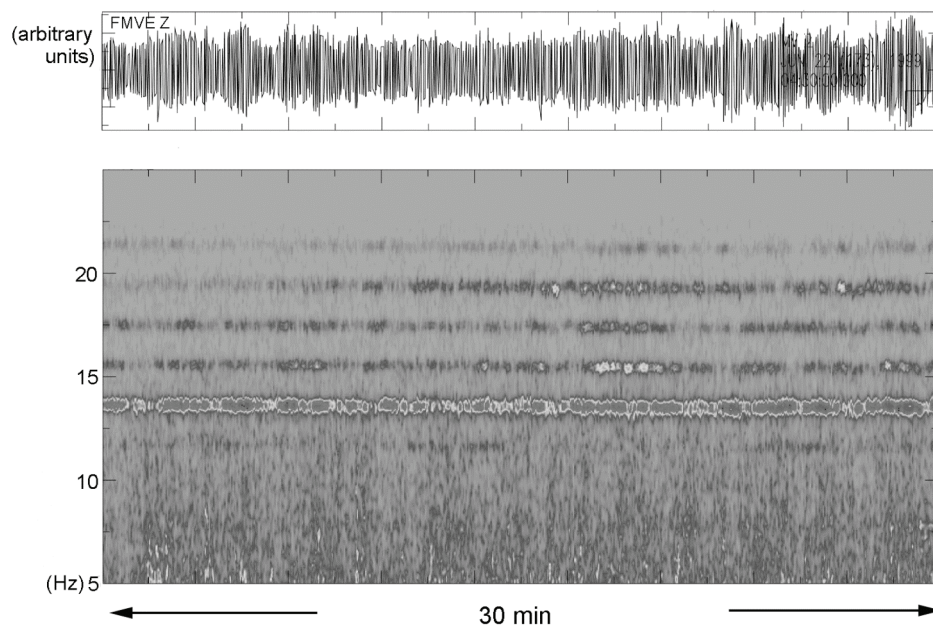


Fig. 2 – 30-minute spectrogram of the vertical component of ground velocity recorded at FMVE station, showing several spectral lines of harmonic tremor (fundamental mode obscured by noise). The same signal was also recorded at stations FBAL, FMLN, FPPC and FCVT.

Besides high-frequency tremor, lower frequency (2-3 Hz) tremor was also recorded, which displayed a peculiar tidal modulation of the amplitude envelope (Custodio et al., 2003). Another observation that has potential for eruption forecasting was a strong episode of seismic tremor coincident in time with tilt anomalies, which was interpreted as the result of interaction between an ascending dyke and underground water.

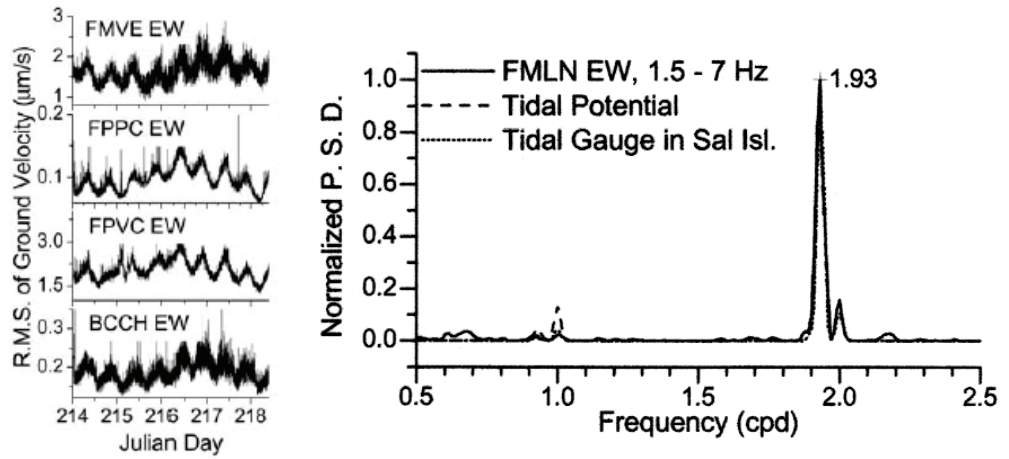


Fig. 3 –Left: tidally modulated envelope of low frequency (≈ 5 Hz) volcanic tremor, recorded at several VIGIL stations. Right: Power spectral density of the modulation envelope for station FMLN, compared with theoretical tidal potential and tide gauge data from Sal Island.

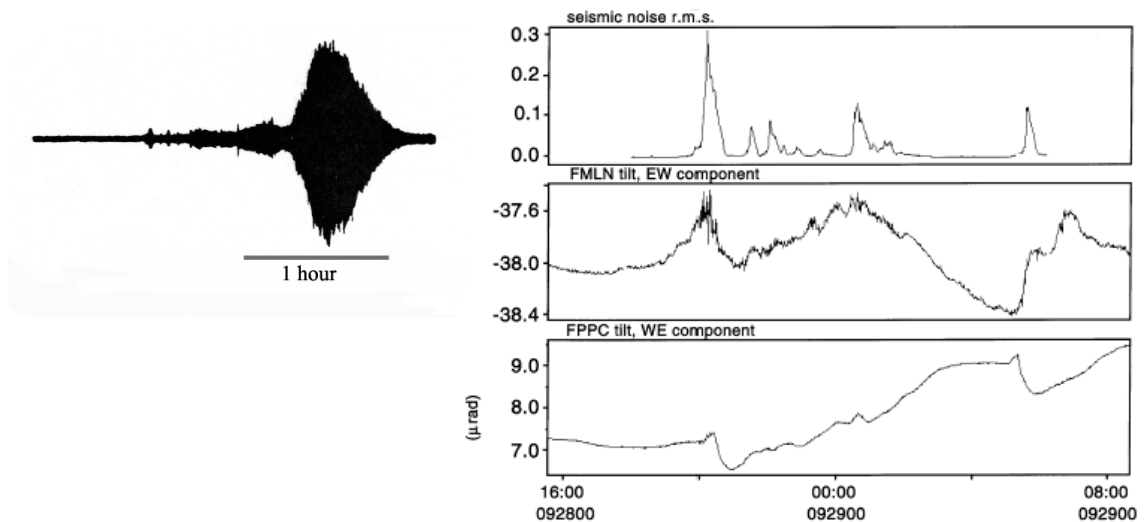


Fig. 4 – Episode of high amplitude seismic tremor, interpreted as the possible result of interaction between an ascending dyke and underground water. The FBAL seismogram is shown on the left, and on the right, from top to bottom, the plots show the envelope of the seismic noise (first peak corresponds to seismogram on the left) and tilt records at two separate tiltmeter stations in the caldera.

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