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Analyzing earthquakes and hybrid events on Fogo and Brava, Cape Verde, with multiple arrays

Carola Leva[1*], Georg Rümpker[1], Ingo Wölbern[1]

[1]Institute of Geosciences, Goethe-University Frankfurt, Germany

*corresponding author: Leva@geophysik.uni-frankfurt.de

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Introduction

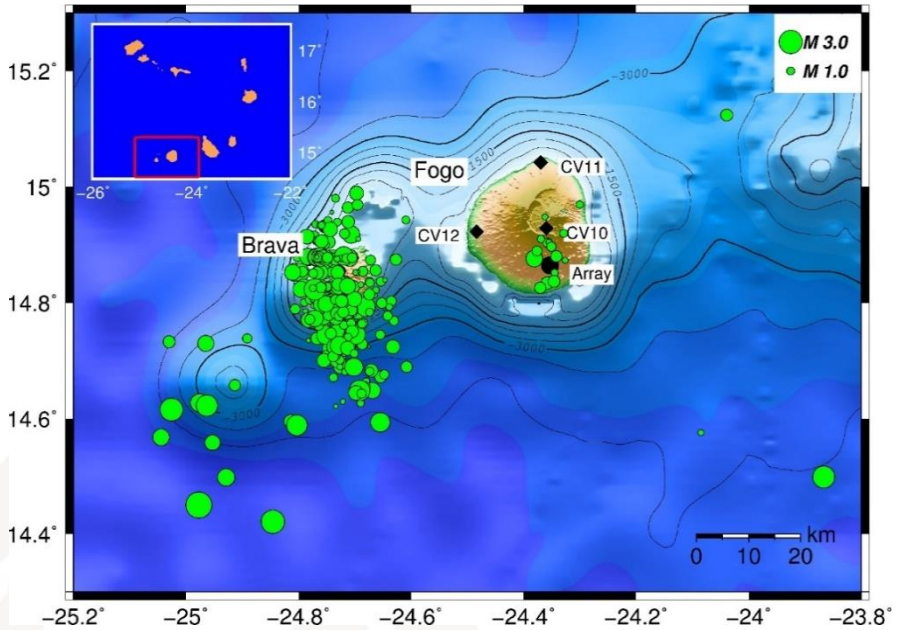

Fig. 1: Earthquakes around Fogo and Brava from Oct. 2015 to Dec. 2016. Marked in black: Network from Oct. 2015 to Dec. 2016. Inlet: Major islands of Cape Verde.

- In 2016 we observed many earthquakes around Brava (Fig. 1) with our seismic array on Fogo (Leva et al., 2019, https://doi.org/10.1016/j.jvolgeores.2019.106672).
- Beamforming in the time domain yields backazimuth BAZ and slowness s.
- Single array: Epicentral distance from S-P-traveltime difference.
- Multiple arrays: intersection of the beams to retrieve the event location.
- In 2017 we operated three arrays and 7 short-period single stations on Brava and Fogo (Fig. 2).

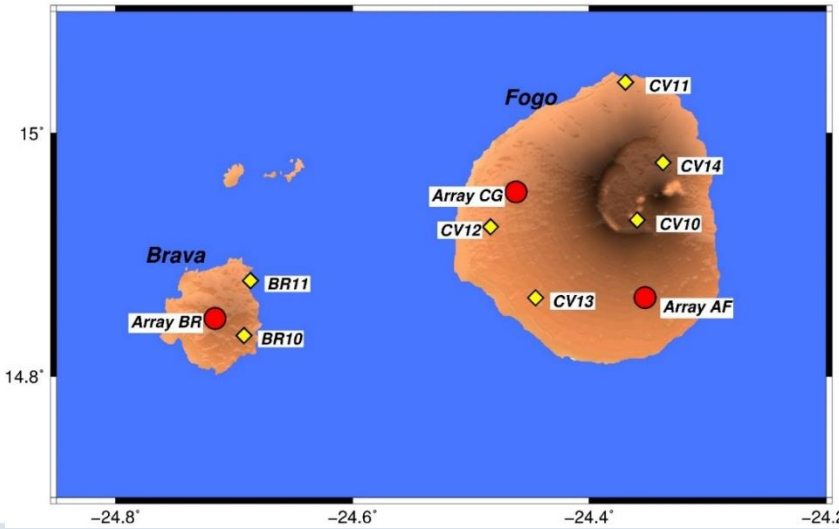

Fig. 2: Network from Jan. 2017 to Jan. 2018. Marked in red: Location of the arrays. Marked in yellow: additional short-period single station.

Multi-array analysis of hybrid events

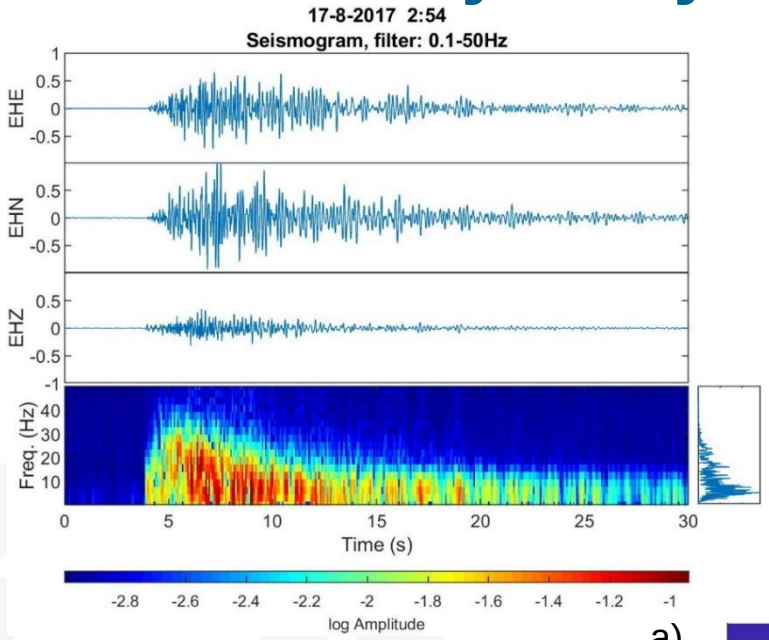

Fig. 3: Spectrogram of a hybrid event recorded on station CV10 on Fogo.

- We frequently record hybrid events on Fogo.
- These events exhibit transitions from high frequencies (20-40 Hz) to low frequencies (1-10 Hz), as can be seen in Fig. 3.
- Figure 4 shows the beams of a hybrid event, analyzed with the arrays AF and CG on Fogo.
- Mean apparent velocities ($v_{app} = 1/s$) are 7.7 km/s at array AF and 8.5 km/s at array CG.

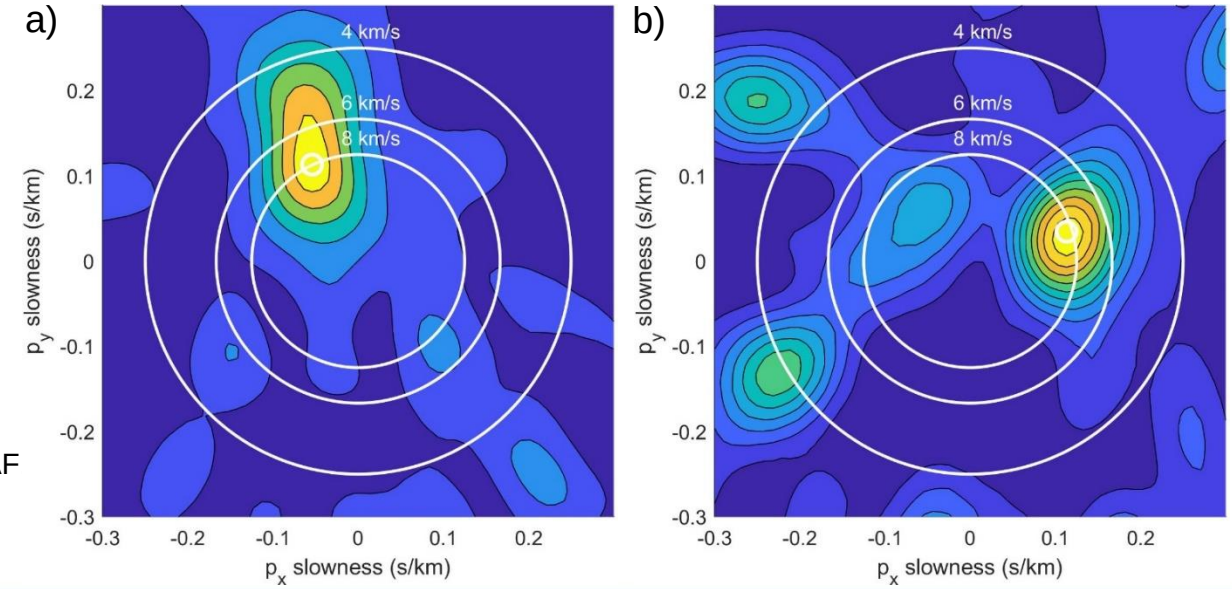

Fig. 4: a) Time domain energy stack of a hybrid event at array AF **b)** Time domain energy stack of the same event at array CG.

Multi-array analysis of hybrid events

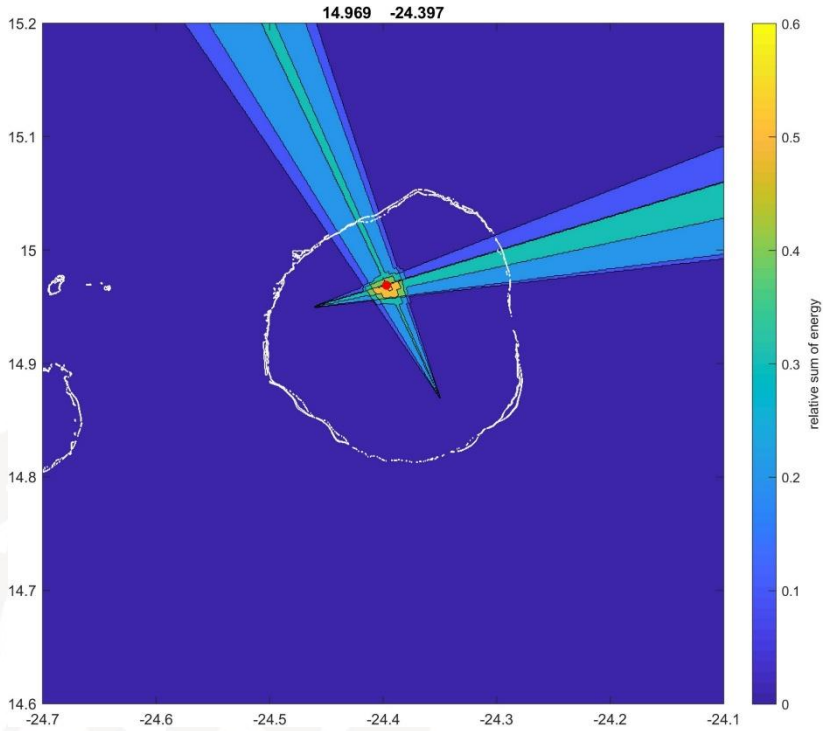

Fig. 5: Combination of the beams shown in Fig. 4, projected on a map with the coordinates of the region of interest.

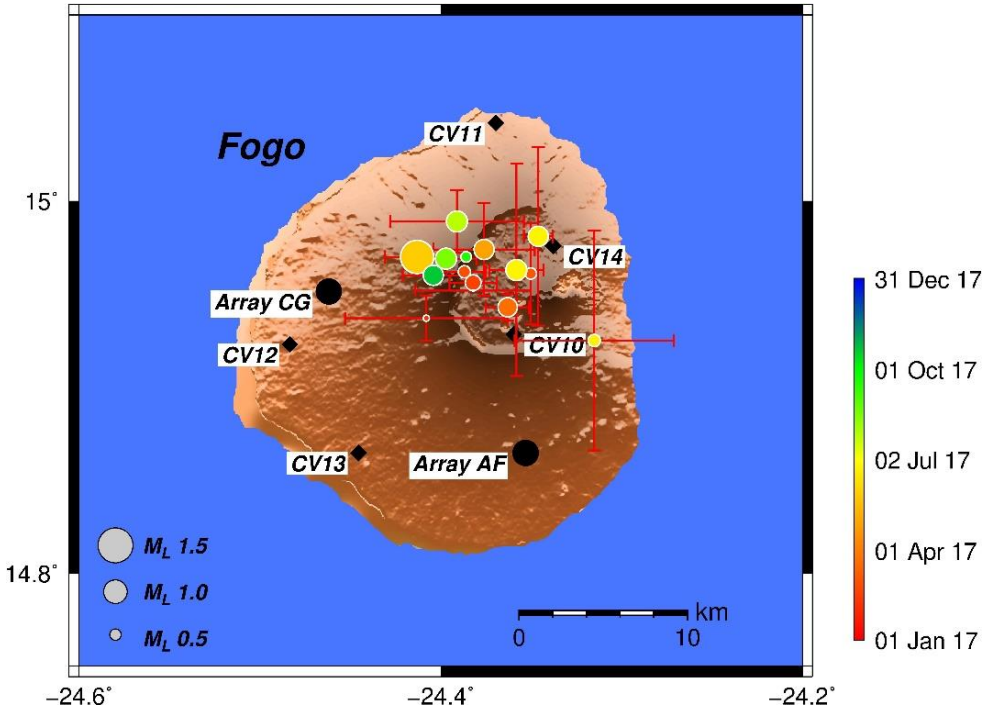

Fig. 6: Map showing the locations of hybrid events on Fogo in 2017.

- By intersecting the beams the event location is determined (Fig. 5).
- The multi-array analysis using the arrays AF and CG on Fogo reveals locations in the vicinity of the collapse scar, see Fig. 6.

Summary

- Applying a time domain multi-array analysis to hybrid events on Fogo results in locations in the collapse scar, where the latest eruptions of Fogo occurred.

- Possible explanations for these events are:
  - Rockfall
  - Fluid motions
  - Shallow low-frequency events
  - Volcano-tectonic earthquakes adjacent to a fluid-filled cavity, setting it into oscillation

- However, rather high apparent velocities point to deeper sources and may exclude shallow events, like rockfalls, as cause for the hybrid events.

- In light of this finding, processes like fluid motions or oscillating fluid-filled cavities seem more likely.