New insights into the magmatic system southeast of El Hierro from high-resolution 2D seismic data

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Institute of Geosciences
Marine Geophysics and Hydroacoustics

Display for EGU2020-15205

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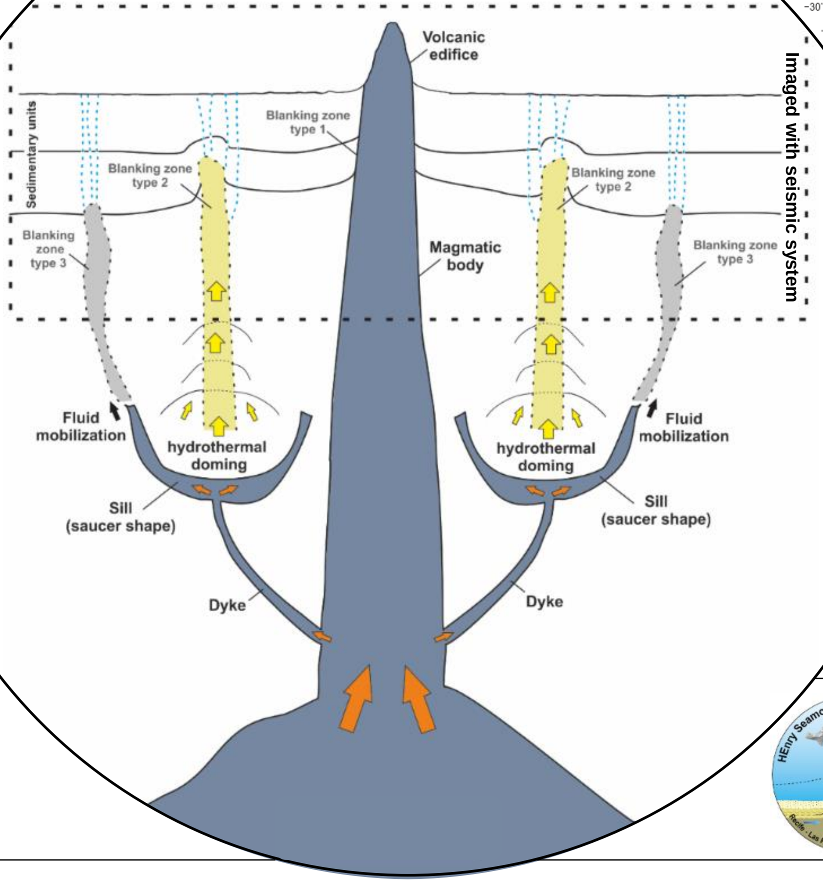
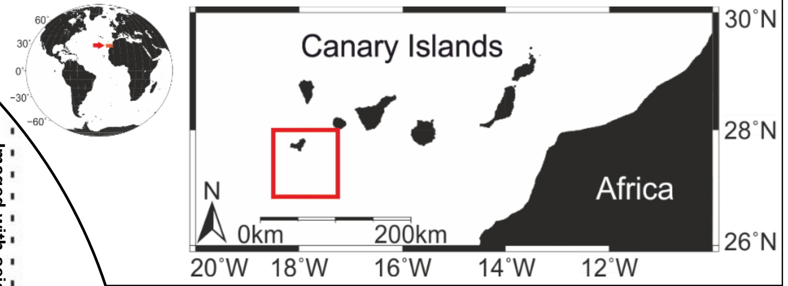
- **Analysis of the expression of the magmatic system southeast of El Hierro**
- **Three types of acoustic blanking zones (BZ) in seismic data**
- **Ascending magma builds up outcropping volcanic edifice and causes BZ type 1**
- **Intruding sills and associated hydrothermal doming are possible reason for BZ type 2**
- **Mobilized fluids leads to the occurrence of BZ type 3**

Schematic model of the magmatic system





Content / Links:

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Seismic Dataset - Profile P502

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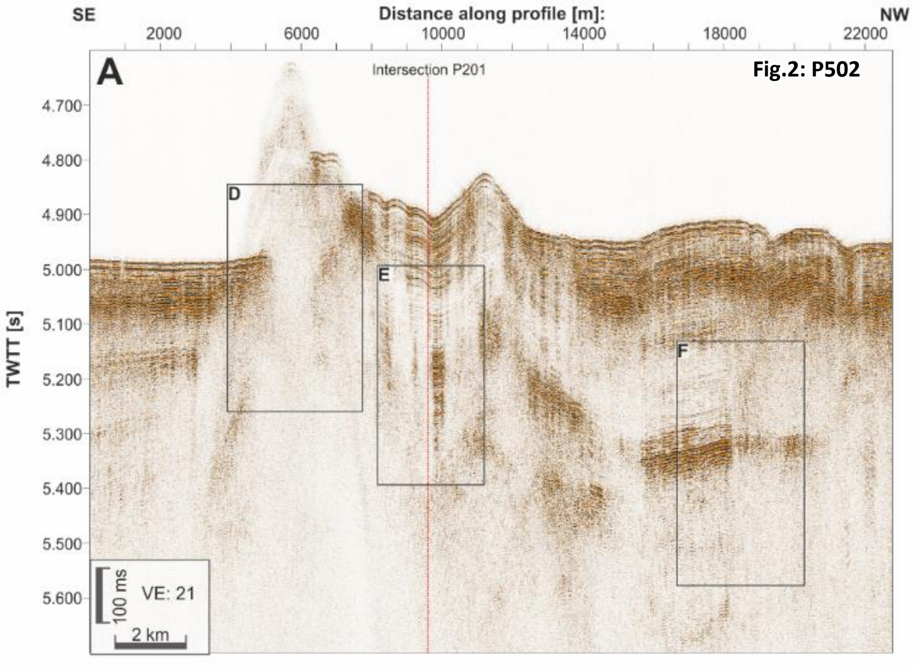

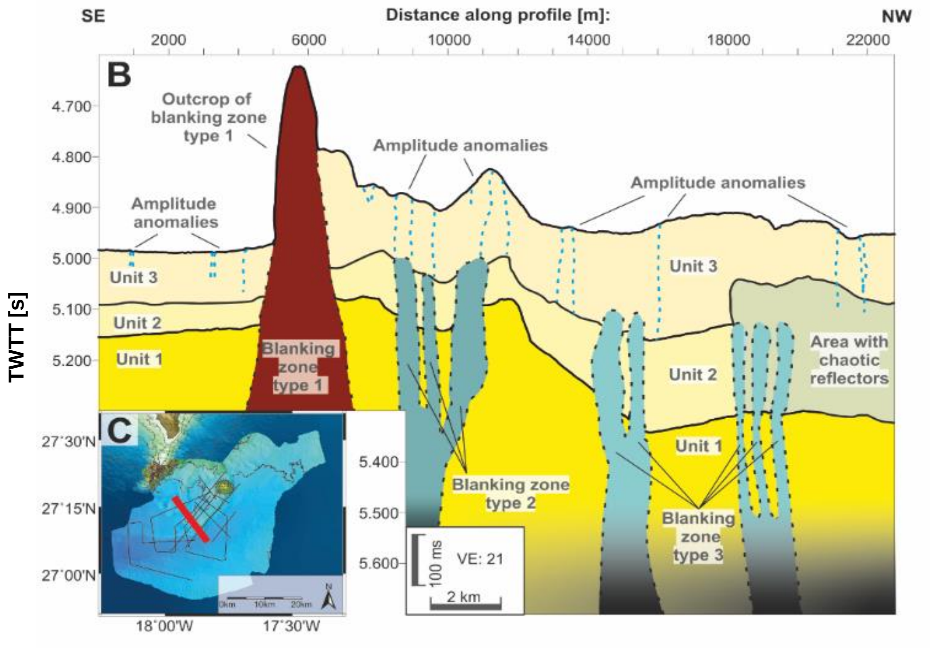

Profile P502:

- 22 km long; running from SE to NW
- Penetration of 790ms (TWTT) → ~600m
- Sedimentation rates of ~70 m/Ma
- Age of ~ 8 Ma is calculated for the lowermost imaged seismic reflections

Line drawing:

- Three seismic units; separated due to varying amplitudes
- Three different types of blanking zones
- Area with chaotic reflections (in the NW) → interpreted as mass wasting deposit.

Classification of Blanking Zone Types

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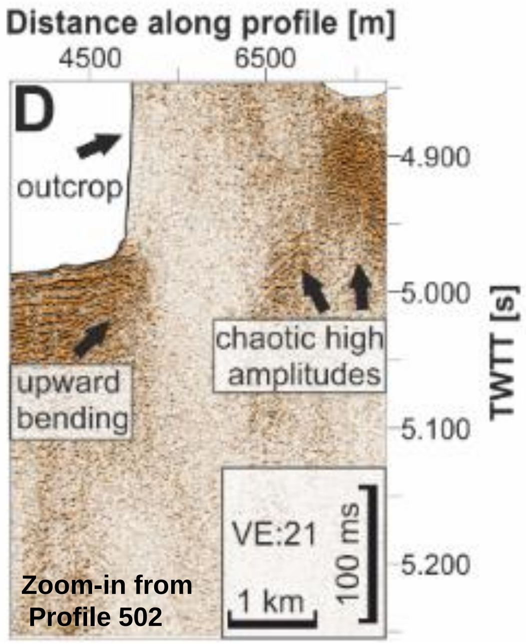
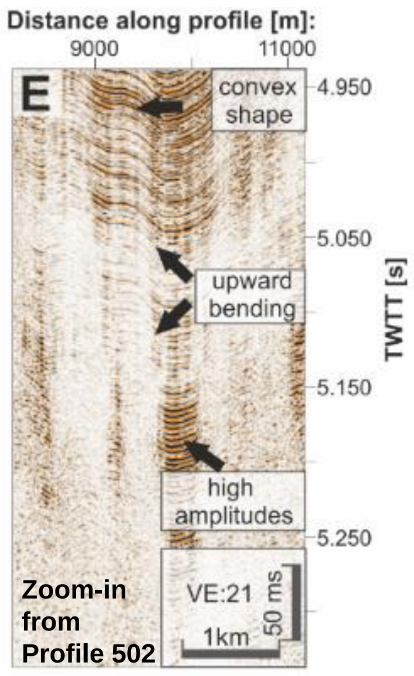
Type 1



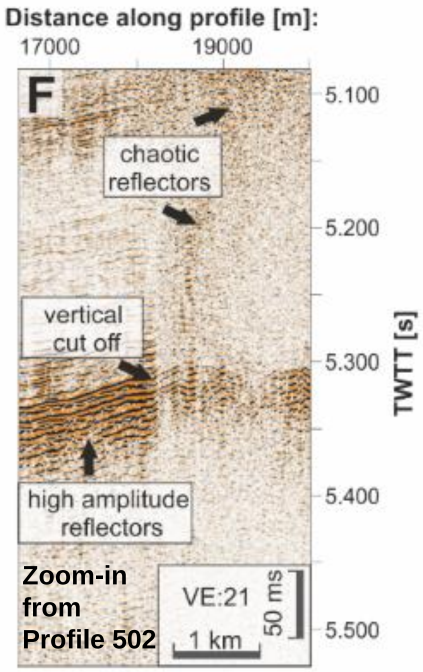
- Morphological features cropping out
- Upward bending of reflections at the sides

Type 2



- Pronounced upward bending of reflections at the sides
- Convex shape on top
- High amplitudes at the sides

Type 3



- Vertical cut of the bordering reflections
- No upward bending
- High amplitudes at the sides

Seismic Dataset - Profile P201

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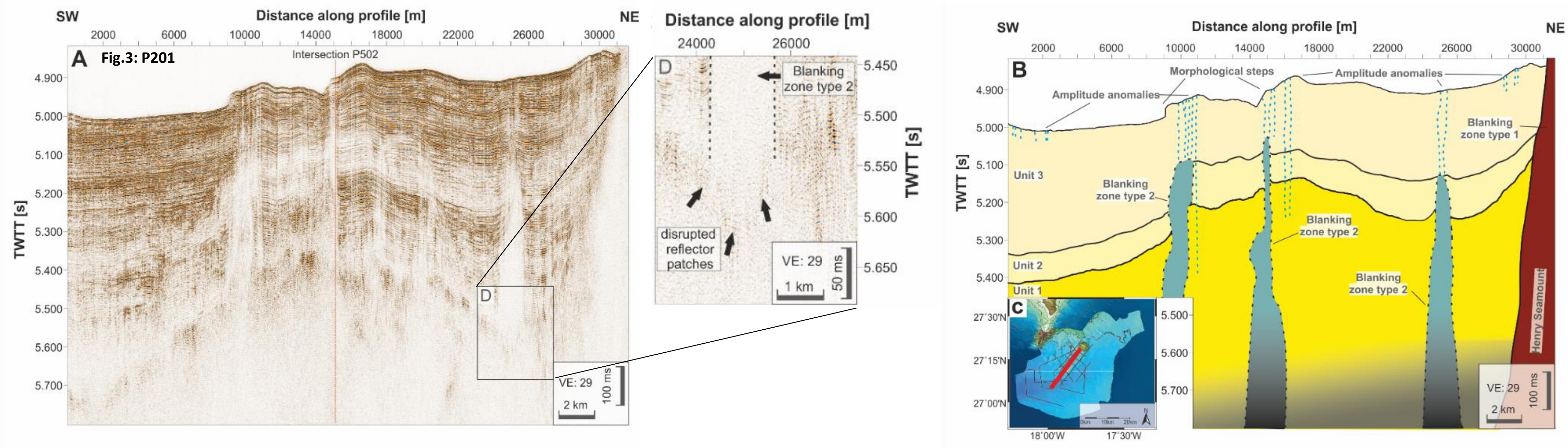

Profile P201:

- 30 km long; running from SW to NE
- Disrupted reflection patches beneath a blanking zone of type 2 (Zoom-in)

Line drawing:

- Three seismic units; separated due to varying amplitudes
- Three type 2 blanking zones
- Flank of Henry Seamount (in the NE) classified as type 1 blanking zone

Distribution Map of Blanking Zones

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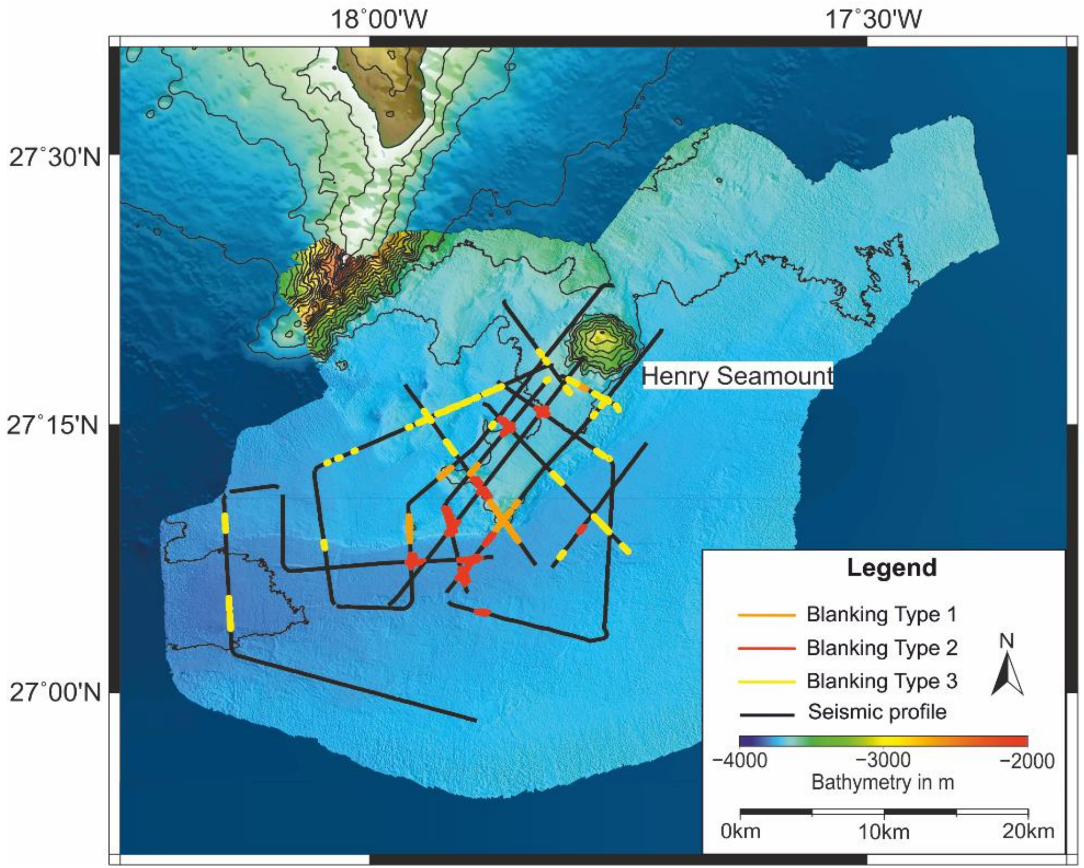

- Extent of the blanking zones was picked along the prominent reflections separating the seismic units 1 and 2
- Blanking zone type 1 (orange) and type 2 (red) cluster in the centre of the investigated area
- Blanking zone type 3 (yellow) is located at the outer parts of the investigated area

Content / Links:

- Model Description
- Location of Dataset
- Methods
- Geological Background

Schematic Model of the potential Magmatic System

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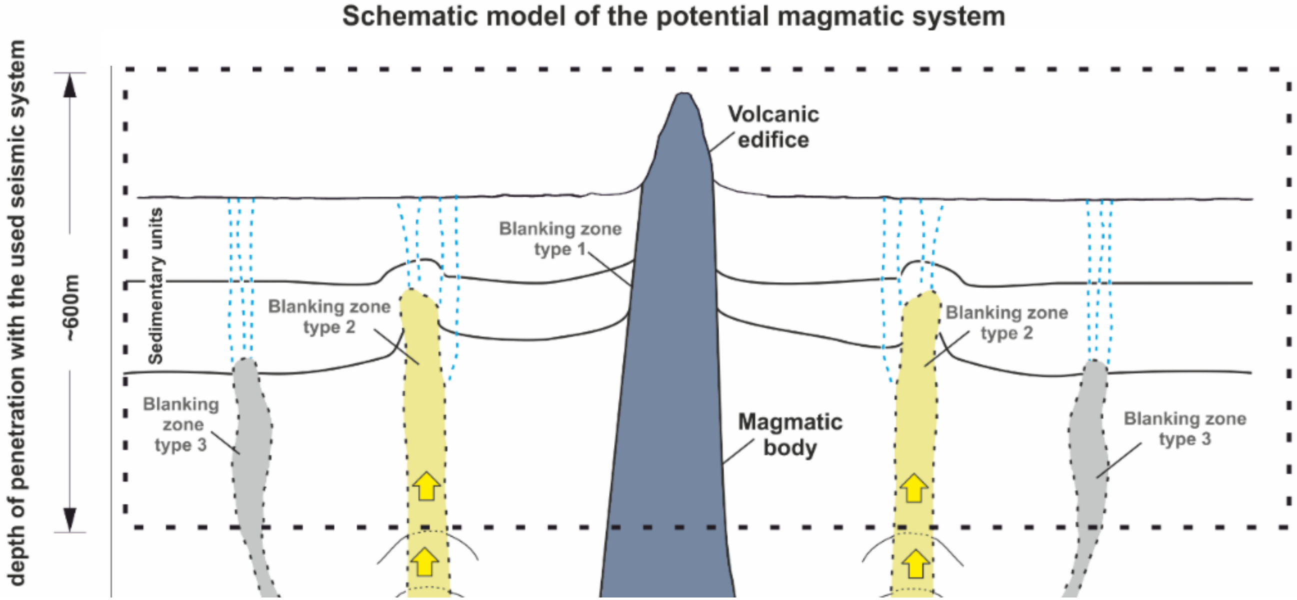

Schematic model of the area of the subsurface (upper ~600 m) imaged with the seismic system containing all three blanking types.

The cyan-dotted lines indicate assumed fluid anomalies in the upper sedimentary units.

Assumed reasons for the occurrence of the blanking zones:

- Type 1 blanking zones are most likely caused by volcanic intrusions, which crop out at the seafloor.
- Type 2 blanking zones are not caused by magmatic bodies, because of the disrupted reflections patches observed beneath them. Most likely, they are caused by overpressurized fluids, which cause the observed upward bending.
- Type 3 blanking zones are related to fluids, which are not overpressurized, because of the missing upward bending.

Schematic Model of the potential Magmatic System

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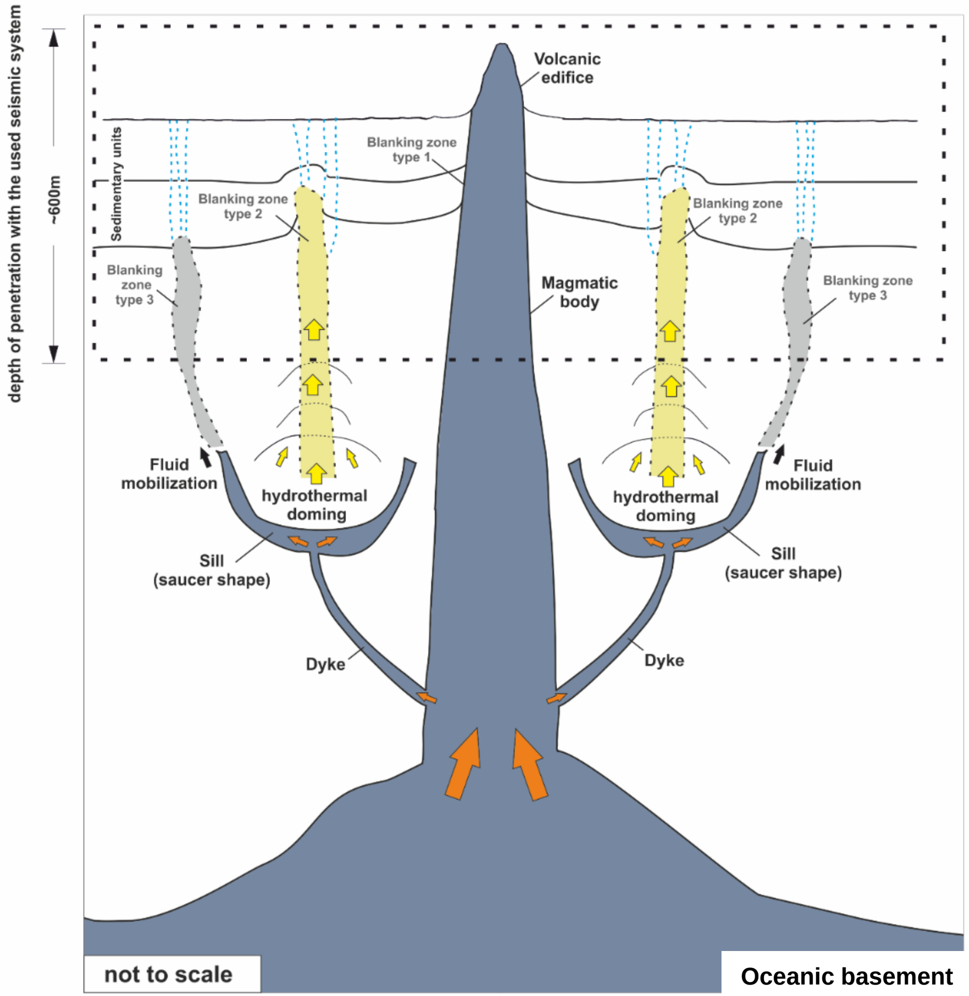
Schematic model of the potential magmatic system



The upper subsurface imaged with the seismic system is marked with the bold black-dotted line. From our observations, we draw conclusions regarding the possible deeper structures of the magmatic system:

The depth of the oceanic basement controls how far ascending magma can intrude into the shallow subsurface. By implication, the intruding magma which we assume in the centre of our investigated area indicates that the basement must be higher there. The ascending magma in the centre builds up the outcropping volcanic edifice and causes blanking zone type 1. Intruding sills with a saucer shape and associated hydrothermal doming are the possible reason for overpressurized fluids and the blanking zones of type 2. Further, the intruding sills cause a fluid mobilization and a fluid migration, which leads to the occurrence of blanking zone type 3.

Conclusion

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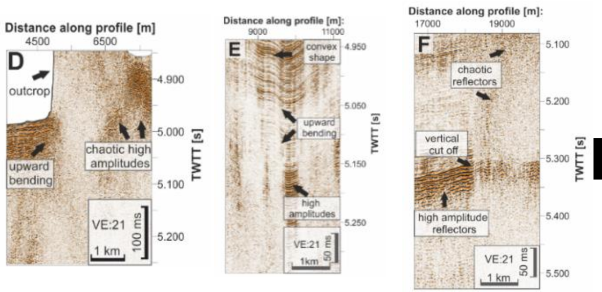
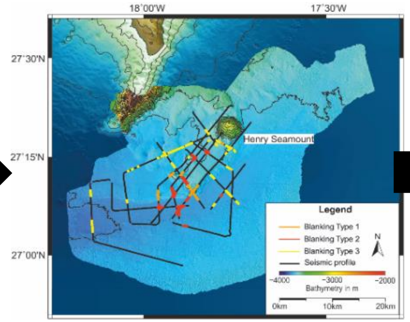
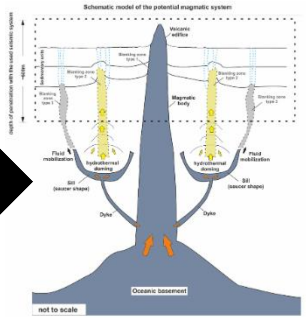
New insights into the complex magmatic systems in the southeast of El Hierro are gained by the analysis and interpretation of the expressions of that system in the upper sub-surface:







- **Three types of blanking zones (BZ) are classified in the 2D high-resolution seismic dataset**
- **All BZ types are interpreted as indicators for different features and processes related to magmatic activity in the investigated area**
- **Magmatic bodies cause type 1 BZ**
- **Type 2 BZs are the result of hydrothermal doming, which is caused by saucer-shape sill intrusions**
- **Type 3 BZs are related to fluid migration.**
- **The observed BZs are distributed over the whole investigated area, which shows that the magmatic system is widespread in the southeast of El Hierro**

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Location and Distribution of the Dataset

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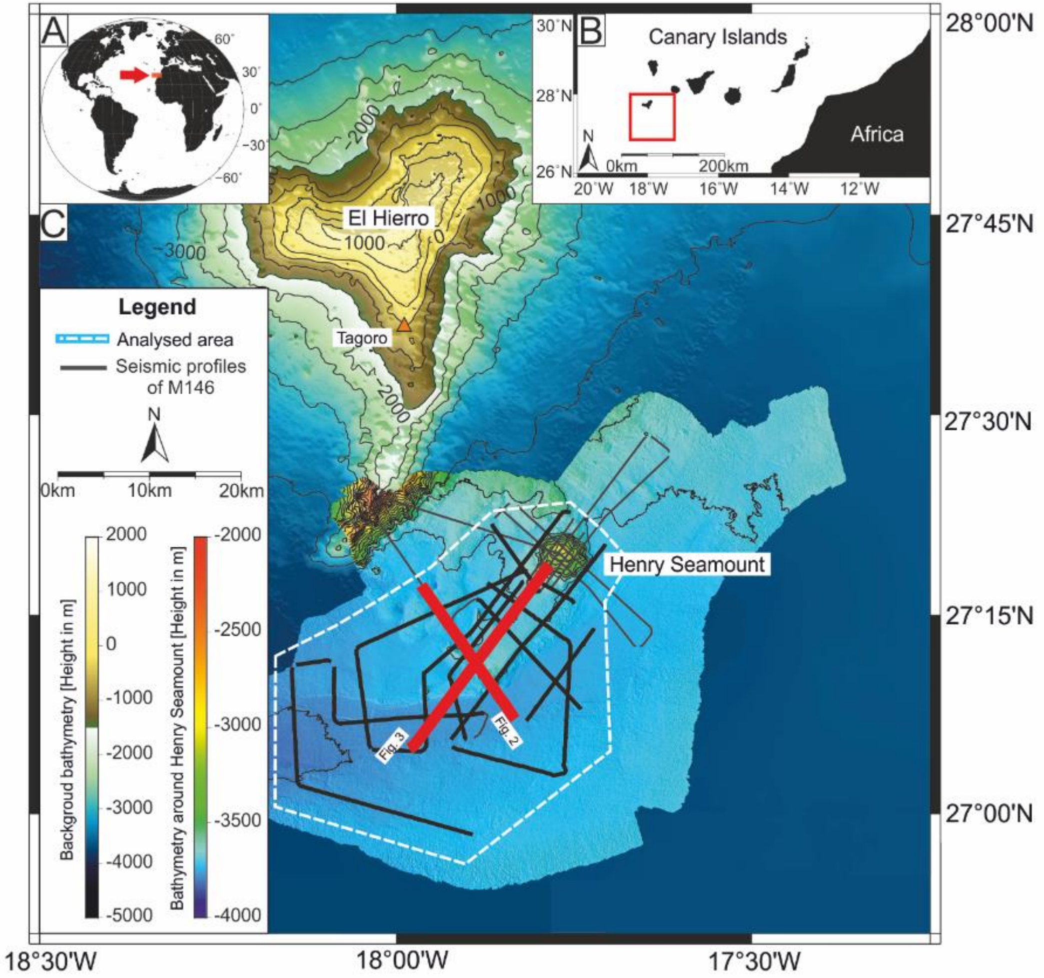

Background grid from the Global Multi-Resolution Topography Data Synthesis (Ryan et al. 2009)

- Map of the area around El Hierro and Henry Seamount
- Detailed bathymetry was acquired during RV Meteor M146 (Grid cell size 50 × 50 m).
- Dashed white line indicates the investigated area of this study
- All track lines of the seismic profiles recorded during M146 are plotted in black
- Seismic profiles shown in this display are highlighted in red.

Methods and Data

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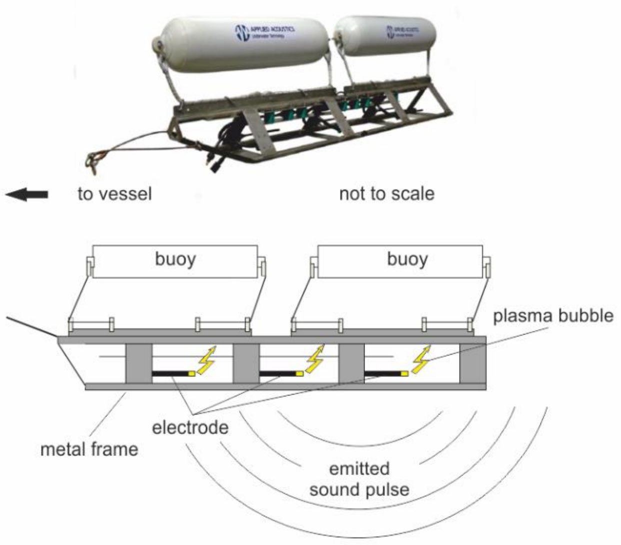
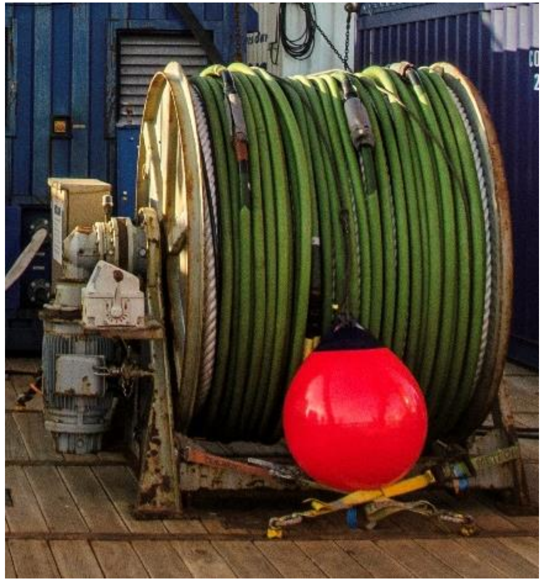
Generation of seismic signals with an Applied Acoustics® DeltaSpark array

- Six single tipped sparker electrodes
- Charged with 6000J
- Shooting rate 9.5 s / Shooting distance 20 m



Recording of signals with a digital Geometrics® GeoEel solid state streamer

- Length ~175m
- 72 or 80 channels (depending on setup)
- Group spacing of 1.5625m



Dataset:
350 nm of seismic profiles were collected in the southeast of El Hierro. The seismic dataset was processed using the commercial software VISTA® Seismic Processing (Schlumberger)

Geological Background

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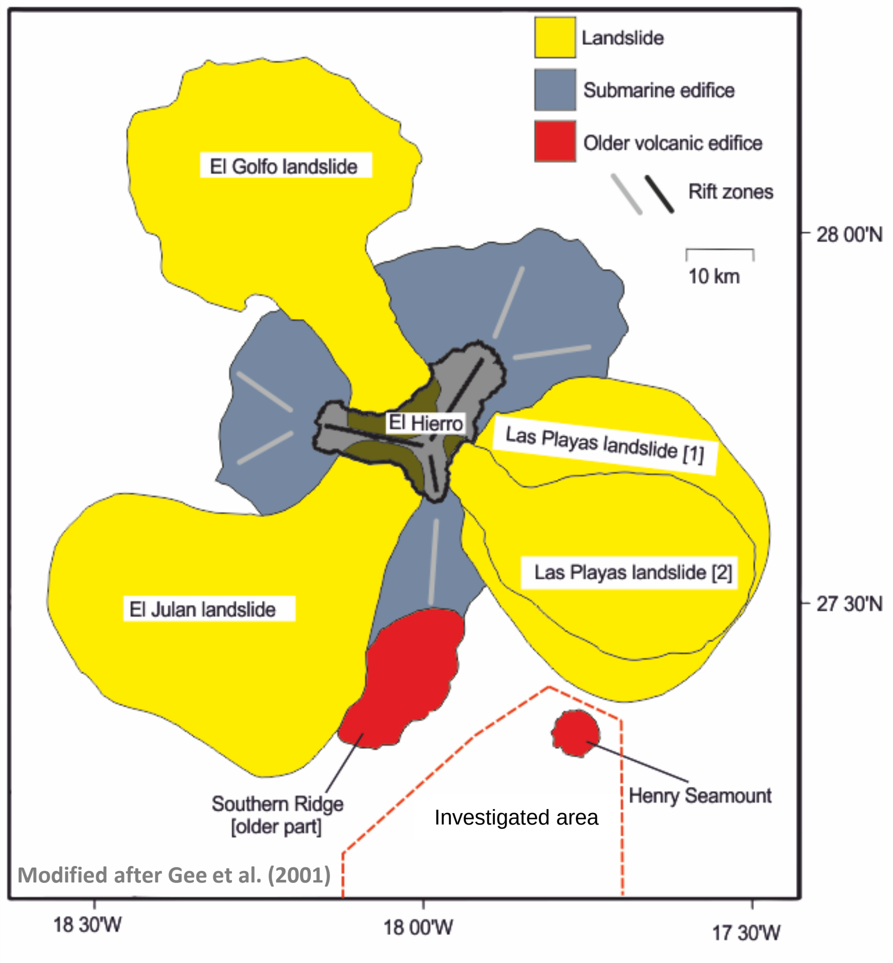

Canary Archipelago

Formed during the past 20 Myr (Araña and Ortiz 1991), but older volcanic features exist. The age progression follows a potential hotspot track from Fuerteventura in the northeast to El Hierro in the southwest. A complex hotspot model is supposed for the Archipelago (Schmincke 1982, Carracedo et al. 1998, Geldmacher et al. 2005). Recent volcanic activity over the whole archipelago is observed.

El Hierro

Is the youngest (1.1 Ma; Guillou et al. 1996) Island and has a triangular shape with three rift zones. The submarine ridge in the south is 133 Ma old (van den Bogaard 2013). There are three giant landslide complexes around El Hierro which are possibly linked to phases of major volcanic activity (Gee et al. 2001).

Henry Seamount

Is an extinct ~126 Ma old volcano, 10 km wide and 660 m high with a circular dome-shape (Klügel et al. 2011). We have evidence of fluid discharge from a dredging campaign in 2006. Additionally, we found evidence for comparatively young volcanic activity at Henry Seamount, probably contemporaneous to El Hierro in 2018 (Klügel et al. 2018). Hence, the area southeast of El Hierro is influenced by both older and younger magmatic activity.

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Thank you for your time!

Feedback on our analysis and interpretation of the dataset is very welcome in the comment section and in the live chat.

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