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Focal depth of some South Atlantic earthquakes using teleseismic P-wave and water reverberations

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INTRODUCTION AND MAIN RESULTS

Oceanic transform faults are tectonic structures which connect mid-ocean ridge segments, and despite their importance to the dynamics of the oceanic lithosphere, their rupture process are still not completely explained. As an essential parameter for tectonic studies, focal depth is estimated in this work through the methodology proposed by Huang et al. (2015) based on water reverberations and a grid search approach for simultaneous calculation of focal depth and the sea floor depth using stacked seismograms. The method was effective under different conditions for synthetic data and South-Equatorial Atlantic earthquakes.

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Introduction

Focal depth determination is crucial for stress and rupture analysis in oceanic transform faults, yet accurate measurements are difficult to obtain due to instrument-limited global distribution at teleseismic distances. In this context, water column reverberations (pwP) and their multiples $(pw_{n+1}P; n = 1, 2, \ldots)$, which are generated as acoustic energy travels through the water and reflects at the surface[1,2] (**Fig. 1**), provide an efficient and viable approach.

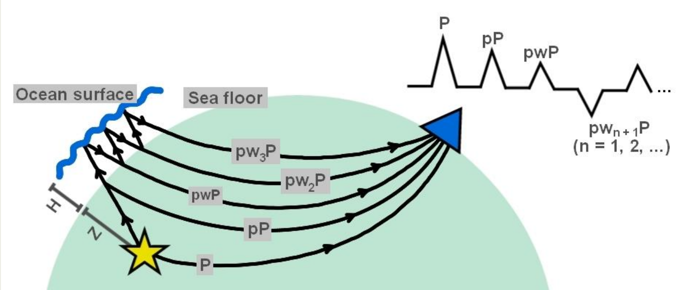

Fig. 1

Since focal depth (Z) and sea floor depth (H) are key factors in pwP generation, our study aims to apply these seismic phases for investigating the South-Equatorial Atlantic lithosphere.

Methods/Data

We follow the methodology by Huang et al.[1]:

- pwP + grid search technique: determination of the optimal values of Z and H, adjusted to maximize stacked amplitude, implemented in Python.
- Multiple tests with synthetic seismograms produced using different (Z, H) combinations, with triangular pulses as seismic phases waveforms, epicentral distances (Δ) between 30º and 90º, and added random noise (N), followed by the application on observed data from selected Atlantic Ocean events.
- Linear stacking: emphasize coherent seismic phases and reduce uncorrelated noise.
- Filtering: band-pass (synthetic data, 0.1-5 Hz) and low-pass filter (observed data, <5 Hz).

Results

Synthetic seismograms:

- The Z-H search successfully recovered the source parameters, which shows that the method reliably recovers source parameters under realistic conditions.
- However, accuracy decreases for Δ > 70º and N > 75%.
- Example in **Fig. 2**: Z-H = (12, 3,5) (expected) vs. (11.8, 3,5) (obtained).
- Z parameter was most sensitive to changes, mainly for extremely low H values (<1.5 km).

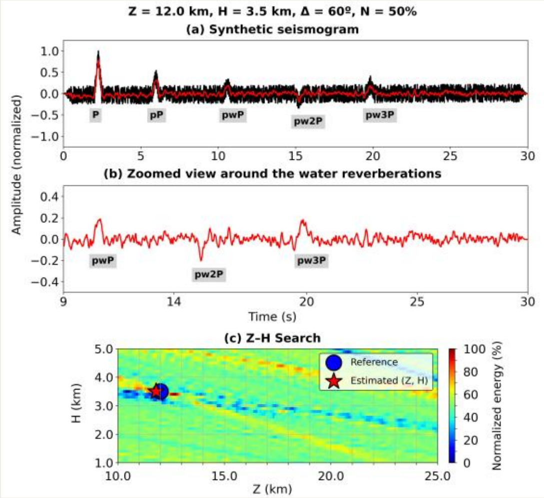

Fig. 2

Observed seismograms:

- August 30, 2020 (Mw6.5) event had Z estimated at 21 km (GFZ Helmholtz Centre for Geosciences) and 27.5 km (International Seismological Centre Probabilistic Point Source Model). We used data from 7 networks (**Fig. 3**) (9 to 22 stations each), downloaded through the IRIS Wilber 3 system[3].
- The Z-H search results ranged from 18.7–21.0 km and H from 2.6–3.7 km among the presented networks. **Fig. 4** and **Fig. 5** shows the seismograms and the Z-H search for NO and US network, respectively.

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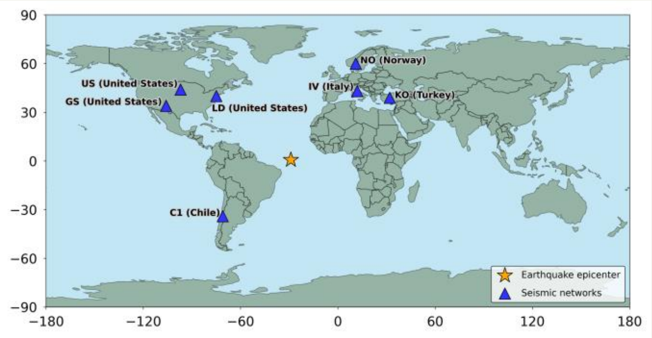

Fig. 3

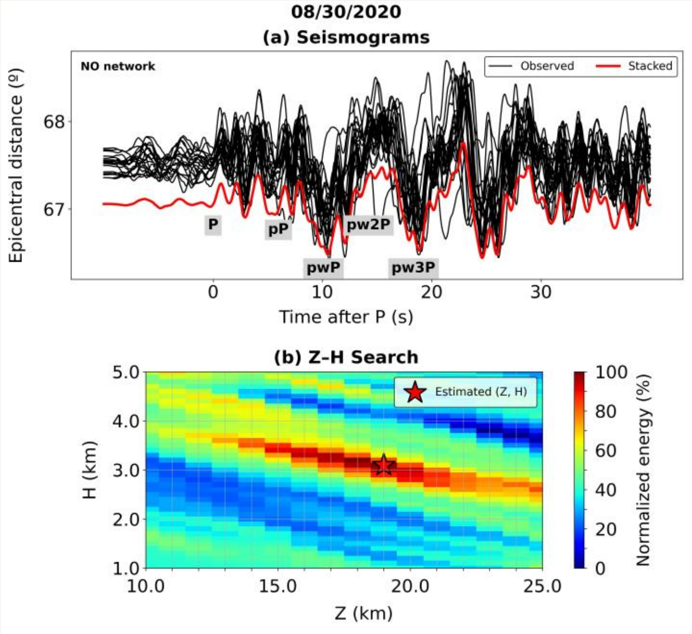

Fig. 4

Conclusions

Methodology of Huang et al. (2015)[1] as a tool for estimating Z and H:

- Tests with synthetic seismograms: consistent and effective performance, confirming the robustness.
- Observed seismic data: potential for improving Z estimations in the South-Equatorial Atlantic, with a specific focus on transform faults.

Next steps: use ISOLA[4,5] software for Z validation and to integrate additional seismic source parameters to improve understanding of target area tectonics.

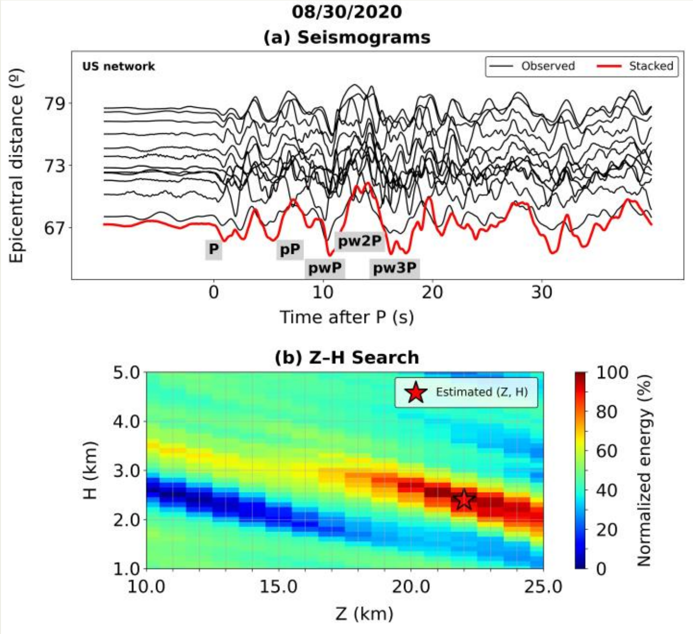

Fig. 5

Acknowledgements

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