Imperial College London

Magma chamber imaged beneath an arc volcano

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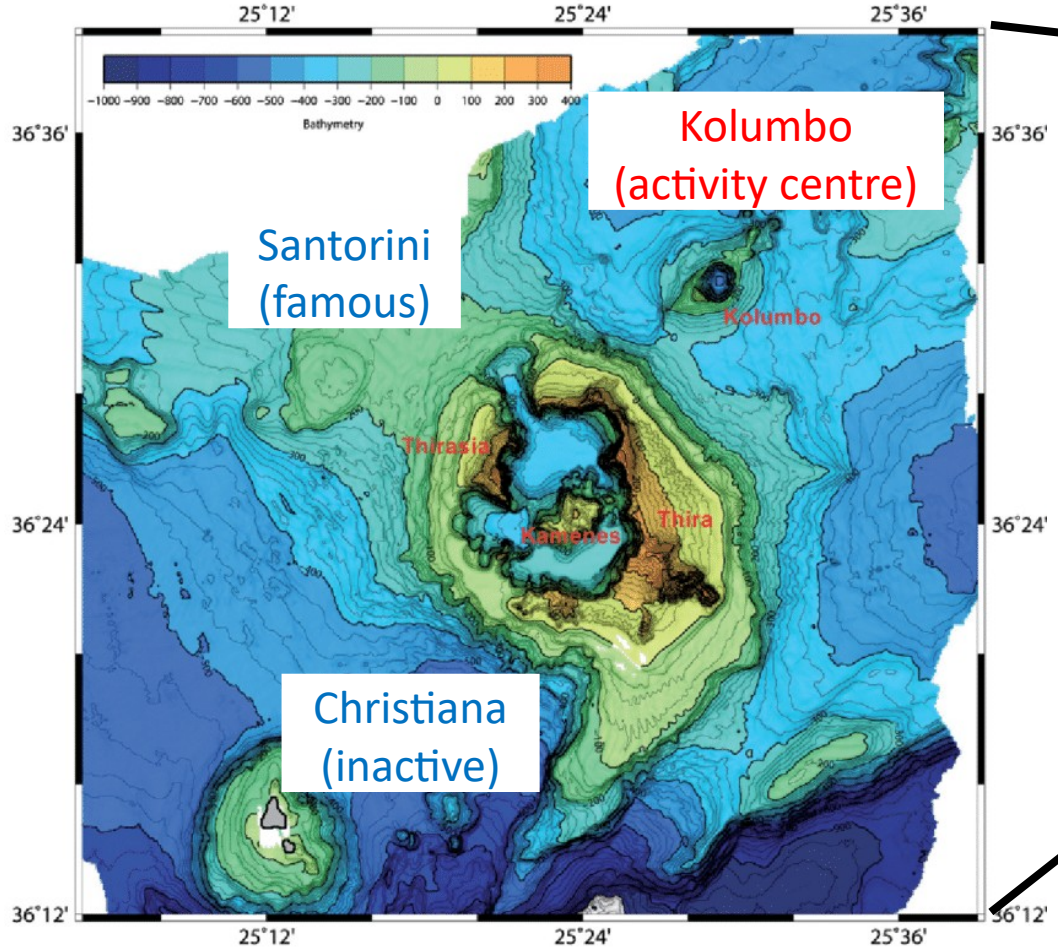
EGU General Assembly 2022

Motivation

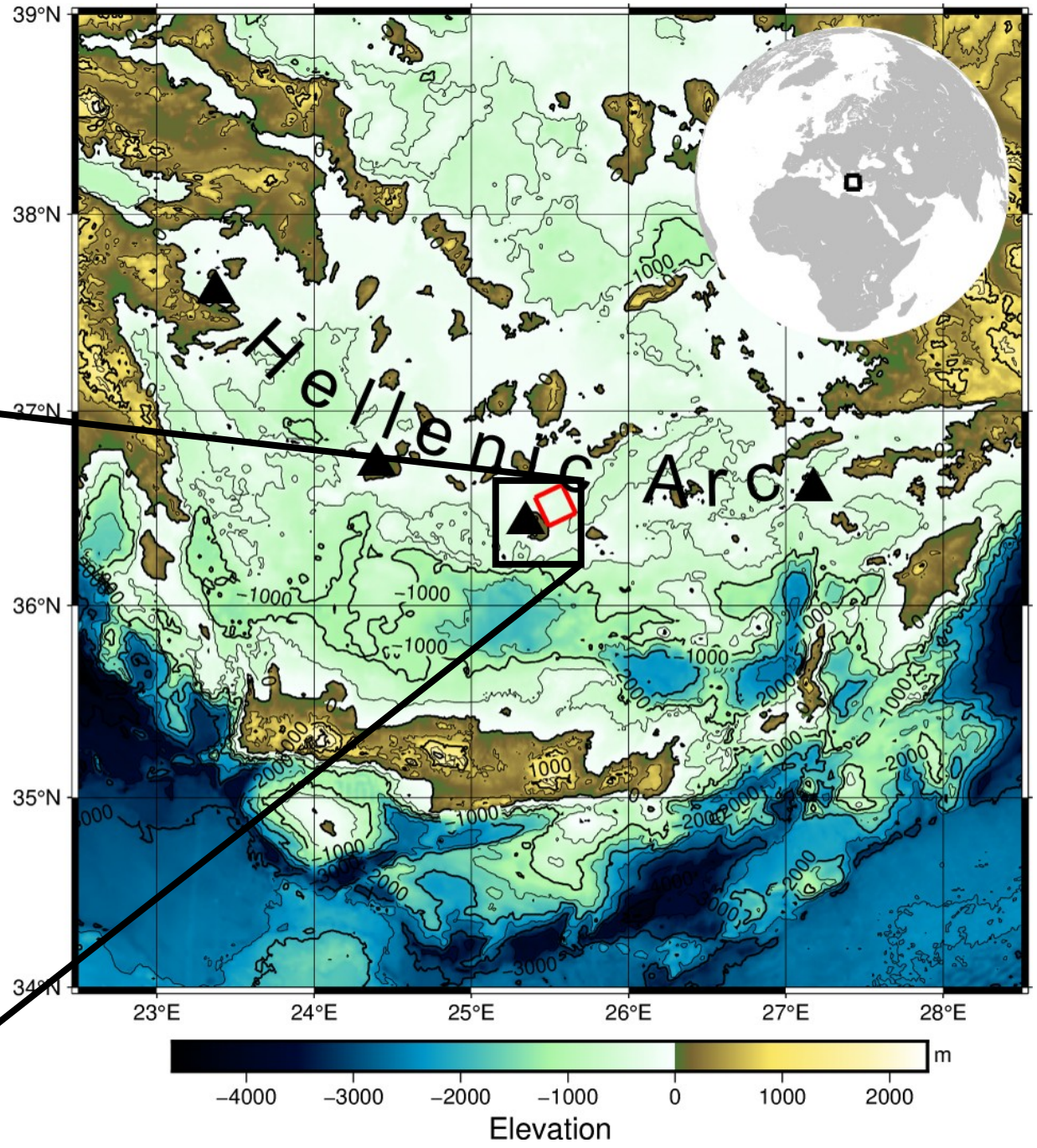
- arc volcanoes are hazardous (viscosity, volatiles, human population)
- especially if submarine - Tonga!
- key for hazard assessment: magma or mush?
- very few magma chambers imaged so far…
- how common are long-lived but smaller magma chambers?

Christiana-Santorini-Kolumbo volcanic field

- very active (volcanically & seismically)
- accessible to 3D marine acqusition



Nomikou et al. (2013)



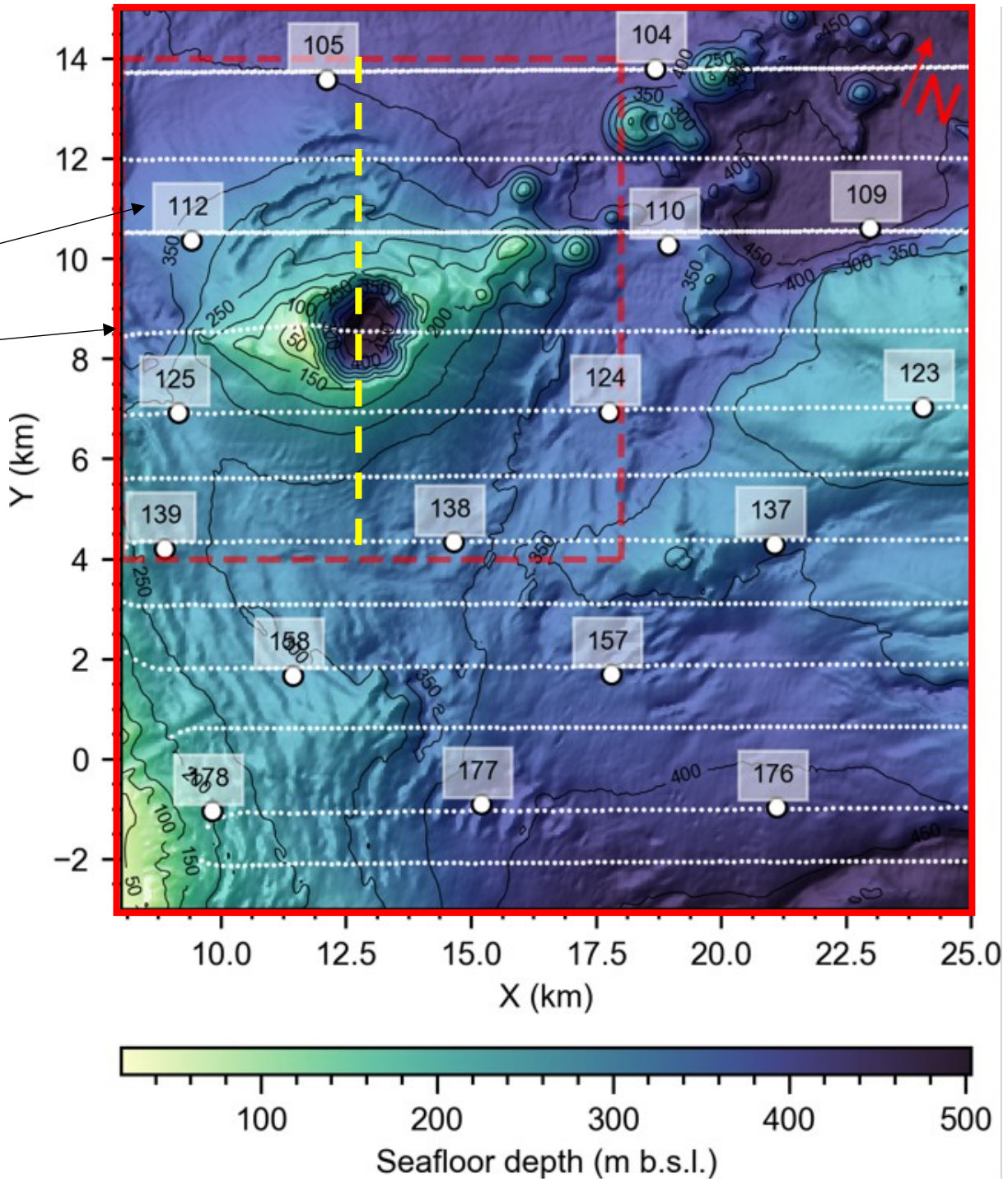
Full-waveform inversion

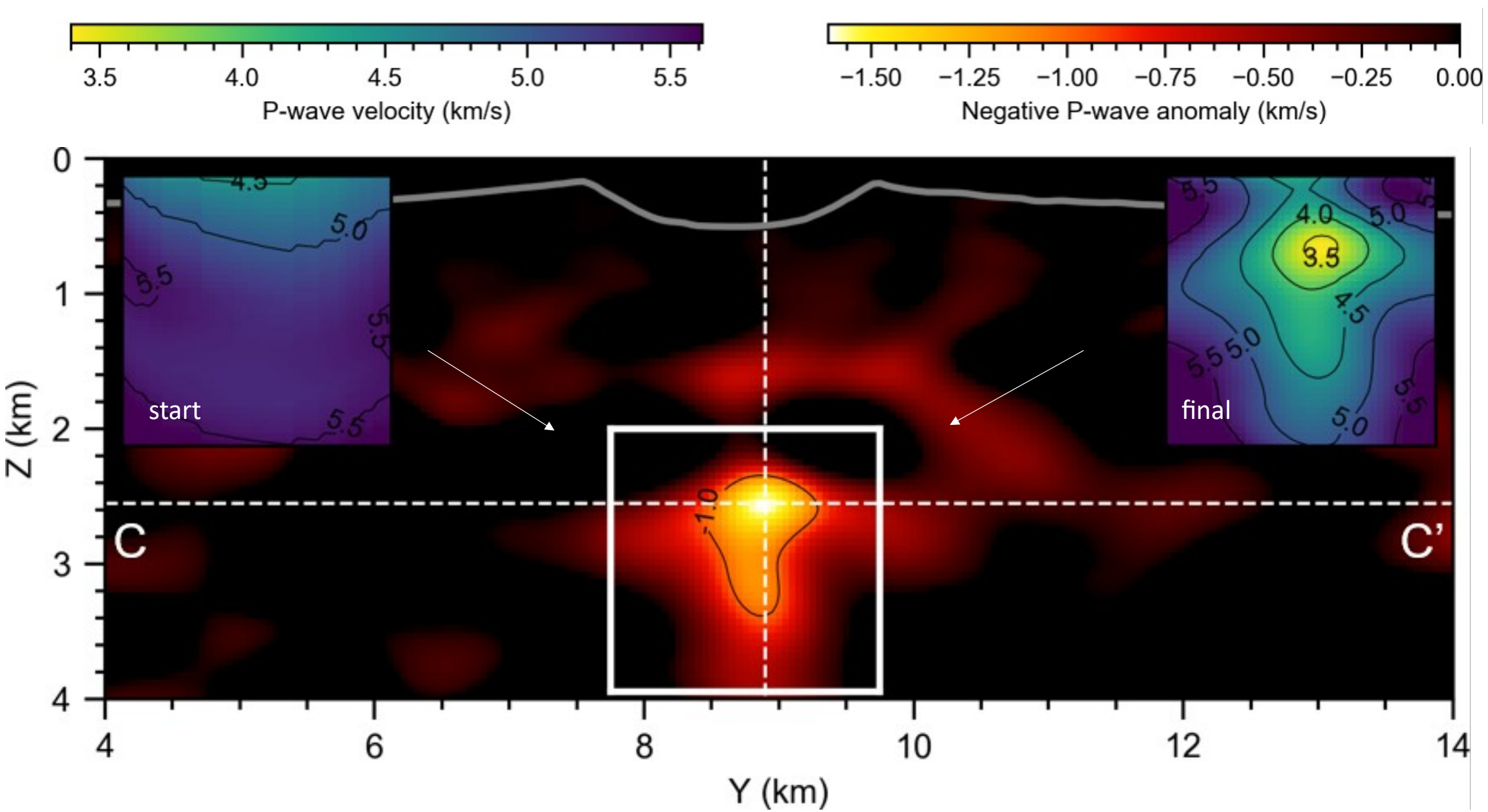
- 16 ocean-bottom hydrophones
- 1500 air-gun shots

- starting model from travel-time tomography (Heath et al., 2018)

- acoustic, isotropic wave equation

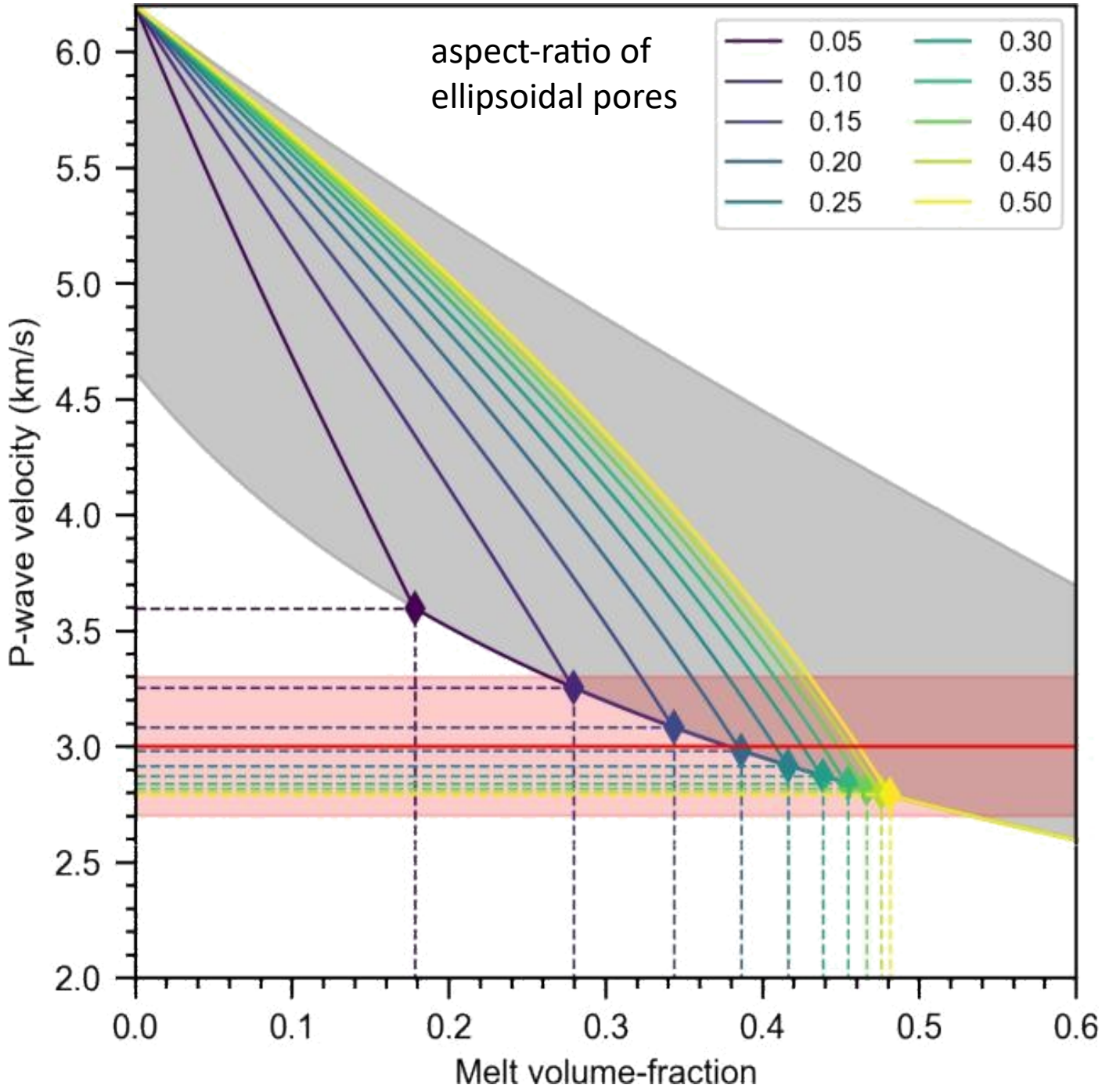
- careful quality control of data-fit
- error - from jackknife resampling
- resolution - from spike recovery tests




3.5
4.0
4.5
5.0
5.5
P-wave velocity (km/s)
−1.50
−1.25
−1.00
−0.75
−0.50
−0.25
0.00
Negative P-wave anomaly (km/s)
start
final
C
C'
-1.0
Z (km)
Y (km)
0
1
2
3
4
4
6
8
10
12
14

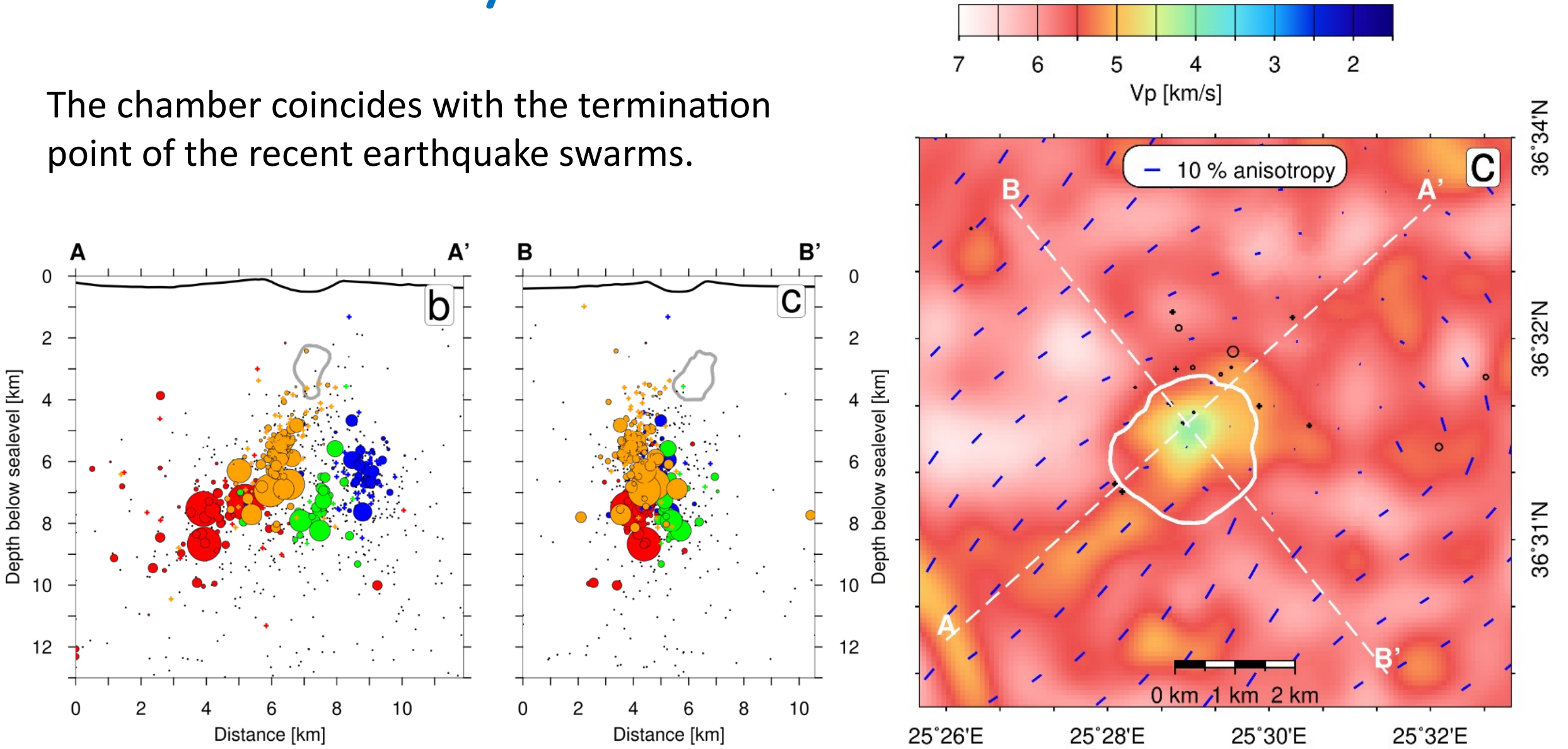
Melt fraction estimation

- calculated effective P-wave velocity of a partially molten granitic intrusion,
- 26-53% melt fraction explains the observed seismic anomaly



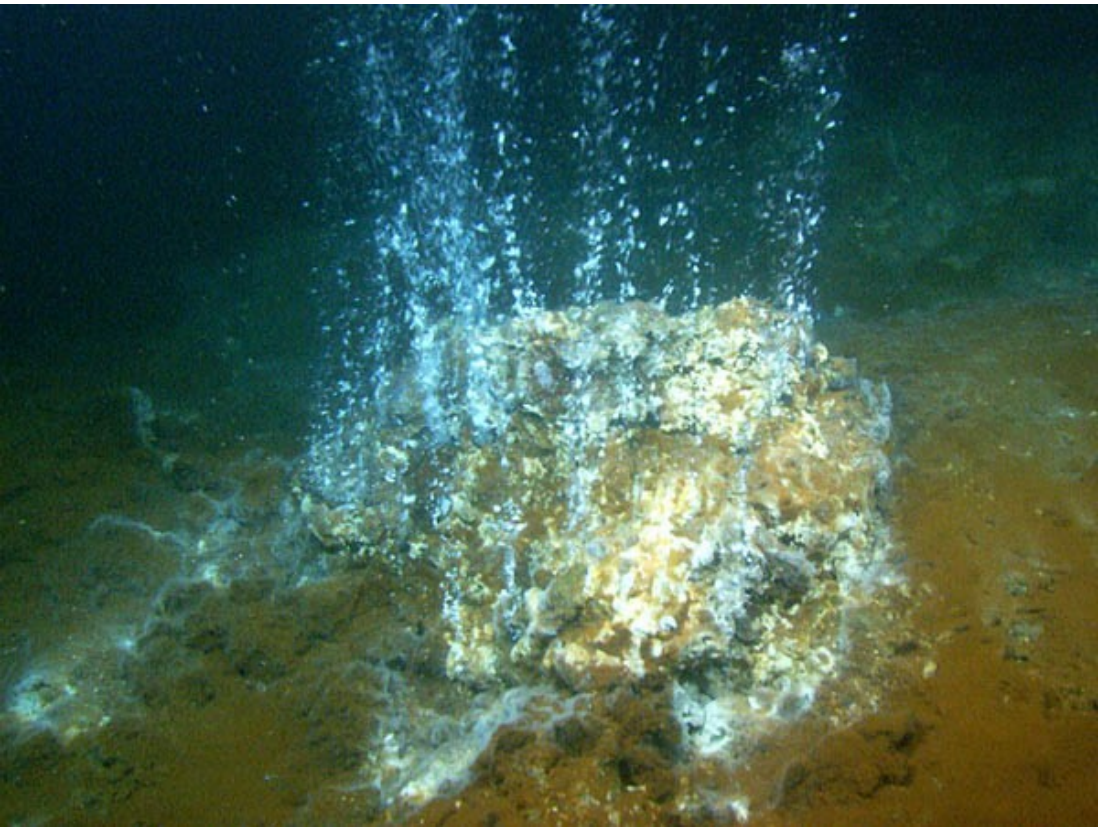
Microseismicity

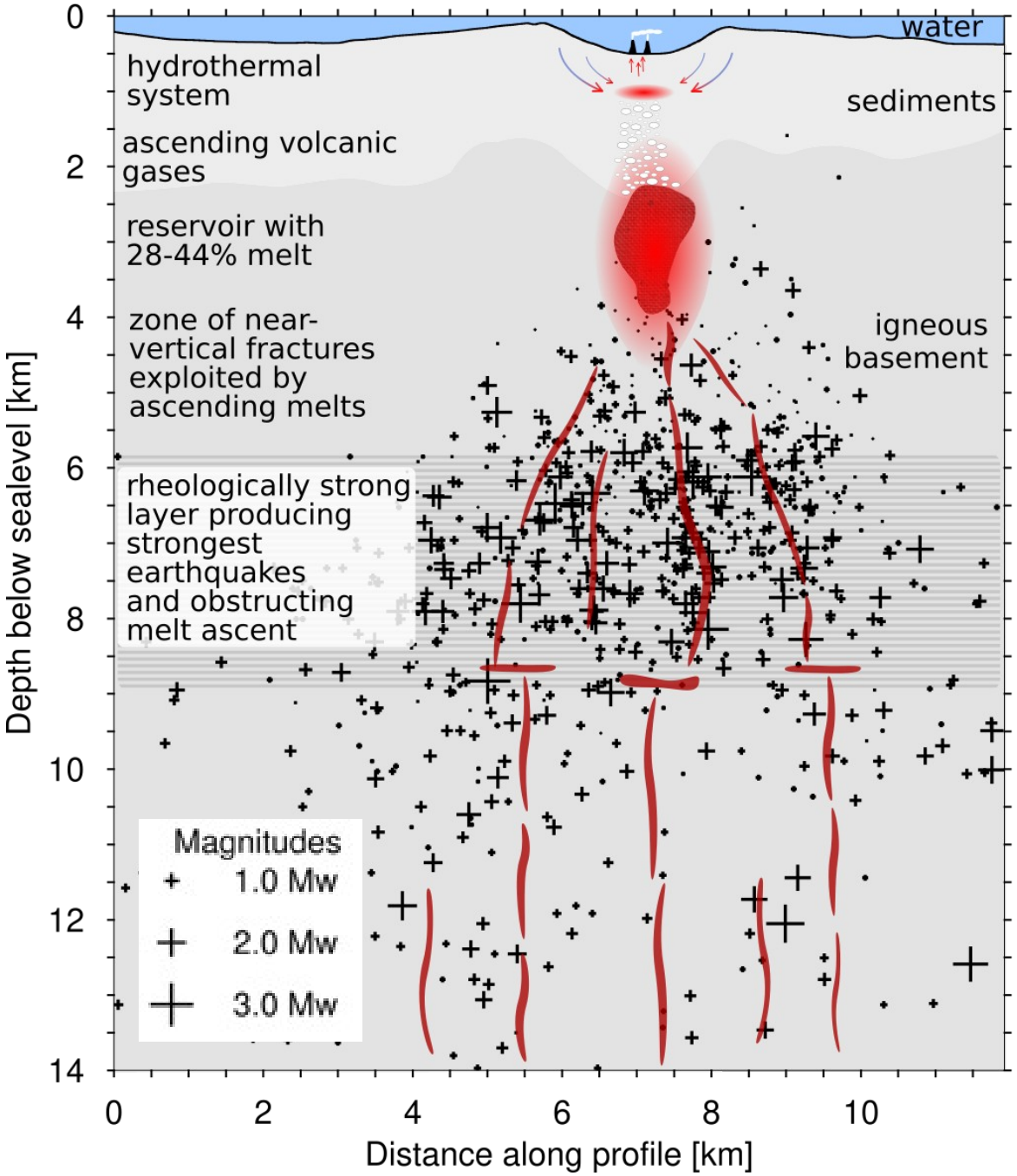
The chamber coincides with the termination point of the recent earthquake swarms.



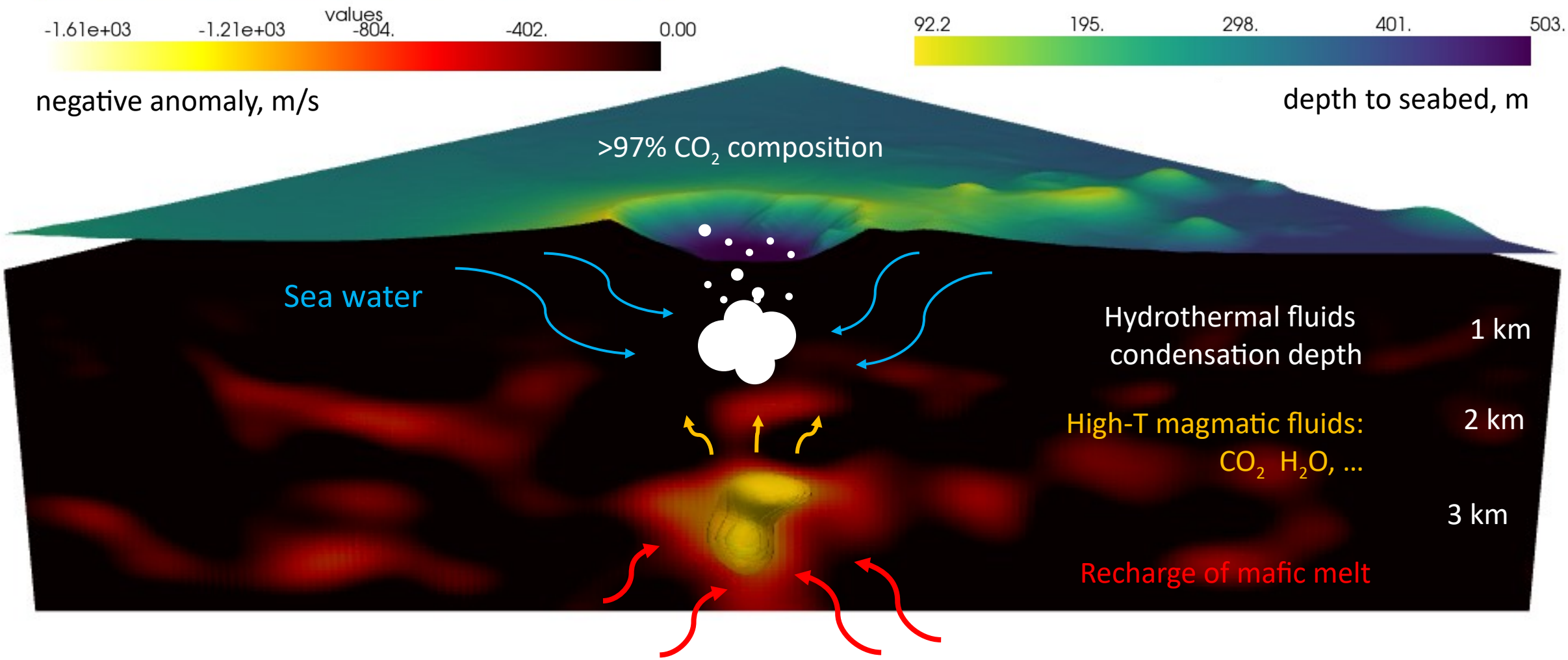
Interpretation

Near-vertical fractures through rheologically strong layer (6-9 km b.s.l.) exploited by ascending melt.





Shallow part of the magmatic system



Conclusions

- unique evidence of a small, shallow magma chamber in the process of replenishement,
- impossible to image by travel-time tomography despite dense active-source data,
- next-generation imaging may reveal similar reservoirs at other volcanoes,
- Kolumbo is smaller than Tonga, but the region is more populated,
- setting up a seafloor observatory is advisable even if melt fraction is over-estimated.

Thank you for your attention!

Geochemistry, Geophysics, Geosystems

Find out more about data acquisition, processing and imaging methods in:

Magma chamber detected beneath an arc volcano with **full-waveform inversion** of active-source seismic data

K. Chrapkiewicz, M. Paulatto, B. Heath, E. Hooft, P. Nomikou, C. Papazachos, F. Schmid, D. Toomey, M. Warner, and J. Morgan

Heralds of future volcanism: swarms of **microseismicity** beneath the submarine Kolumbo volcano indicate opening of near-vertical fractures exploited by ascending melts

F. Schmid, G. Petersen, E. Hooft, M. Paulatto, K. Chrapkiewicz, M. Hensch, T. Dahm

as well as the state of the art in seismic imaging beneath volcanoes, in:

Advances in seismic imaging of **magma** and crystal **mush**

M. Paulatto, E. Hooft, K. Chrapkiewicz, B. Heath, D. Toomey, J. Morgan