A 3-D crustal model of the eastern Arabian plate margin below the Oman Ophiolite

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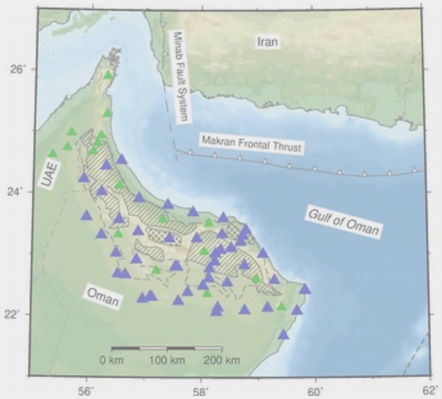
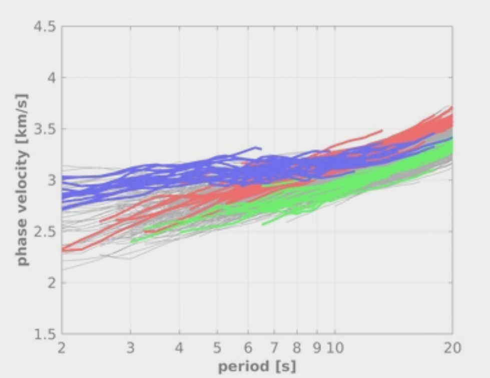
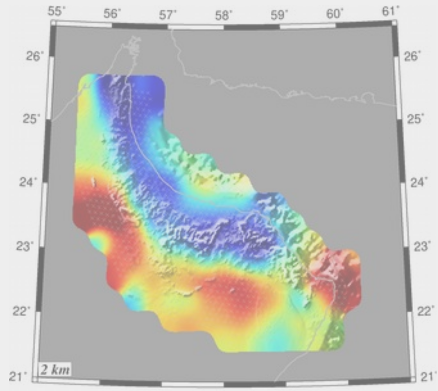
Summary

- Temporary seismic experiment across Oman Mountains
- Ambient noise tomography provides 3D crustal-scale model for northern Oman
- NE trending lateral changes in middle to lower crust from plate assembly
- Distinctly different crustal architecture along east coast
- Crustal deformation below topography







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Motivation

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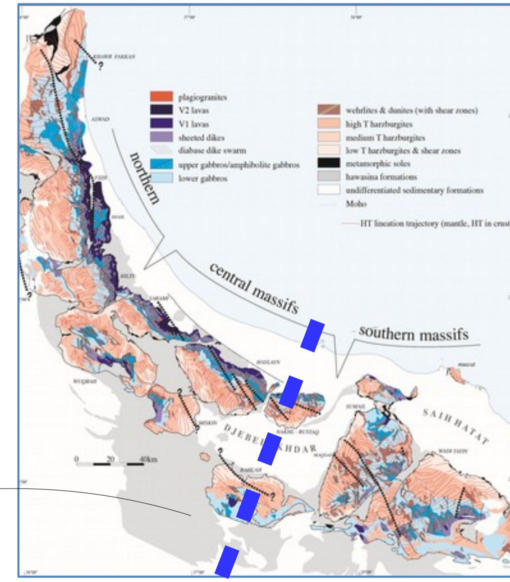
What is the state of the northern Arabian continental margin?

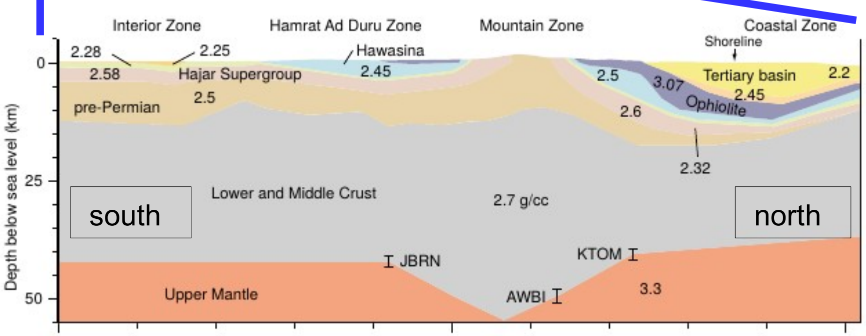
- Late Paleozoic opening of Neo-Tethys → continental stretching
- Early Cretaceous closure of Neo-Tethys
- Late Cretaceous formation of Semail Ophiolite offshore Arabia
- … and obduction of ophiolite on continent → continental subduction, mountain building

after Agard et al. (2007)

Geodynamic models of obduction are typically schematic on the state of the continental lithosphere



Nicolas et al. (2000)



Al-Lazki et al. (2002)

A singular crustal-scale profile across Jebel Akhdar (JA):

- Crustal thickening below JA
- No significant Moho shallowing in coastal zone
- Thick pre-rifting sediments below and south of JA
- Ophiolite thickness ~5km north of JA, extending offshore

Motivation – COOL Project

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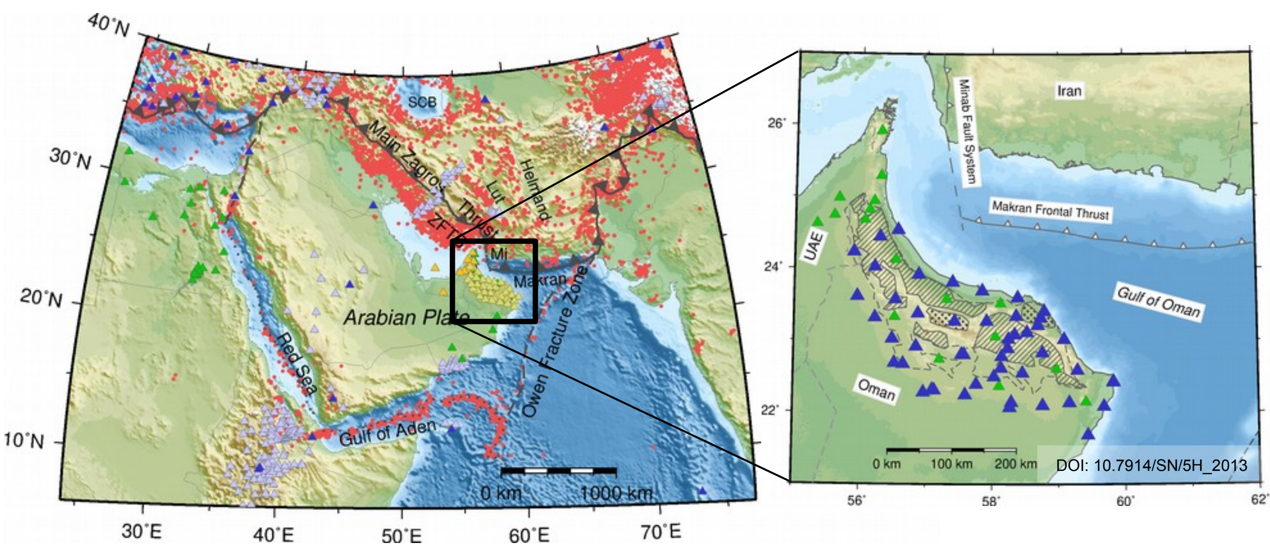
What is the state of the northern Arabian continental margin?

- Lateral changes in crustal architecture?
- Moho topography?
- Crustal root below Oman Mountains?
- Variability in properties of subducted (Saih Hatat) vs. non-/less subducted continental crust (Jebel Akhdar)?
- Lateral variations of ophiolite thickness, anisotropy, … ?
- Properties of the eastern Arabian Plate?

COOL Project

(**C**rust of the **O**man **O**phiolite and ist **L**ithosphere)



- 40 temporary broadband seismometers*
- 15 stations from permanent networks
- Continuous waveforms Nov 2013 – Feb 2016

<u>Methods</u>

→ Ambient noise tomography
→ Receiver Functions

*) provided by the German Geophysical Instrument Pool Potsdam (GIPP)

Ambient Seismic Noise Tomography

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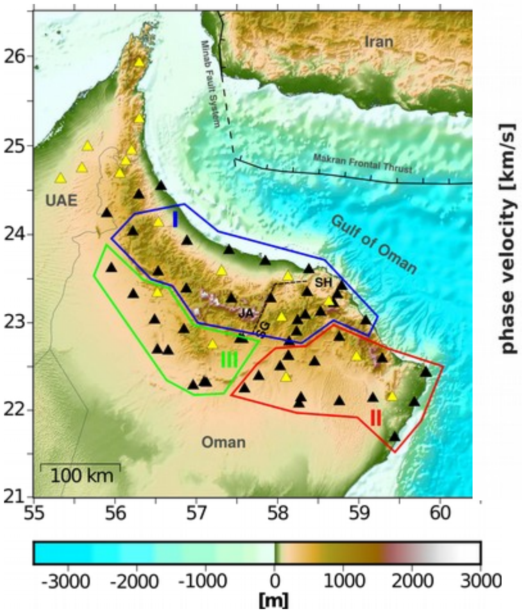
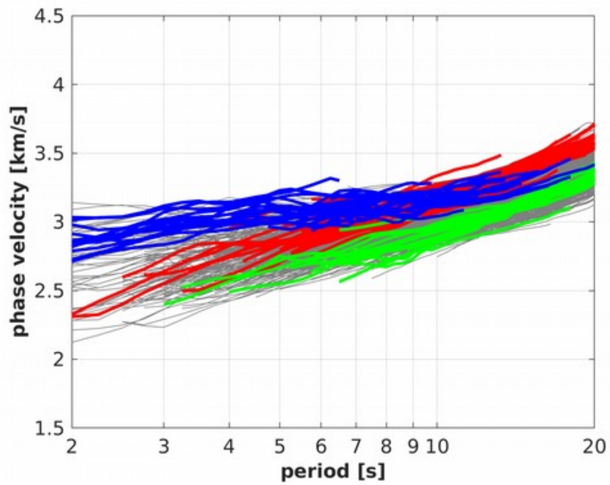
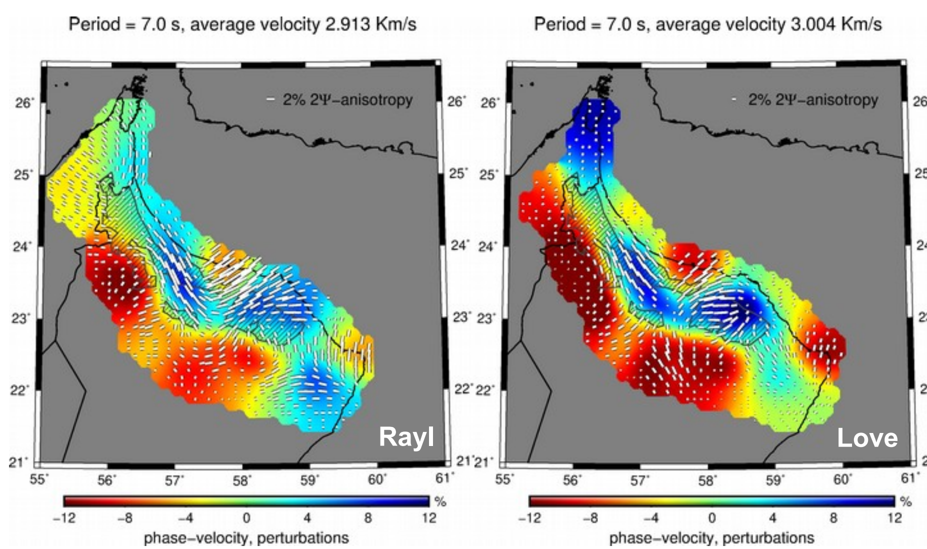




<u>Rayleigh wave phase velocity dispersion curves</u> across COOL network derived from ambient seismic noise cross correlations
→ different geologic regions show distinctly different velocities
→ high velocities at low periods beneath the Oman Mountains
→ increase in velocity towards the east at highest periods

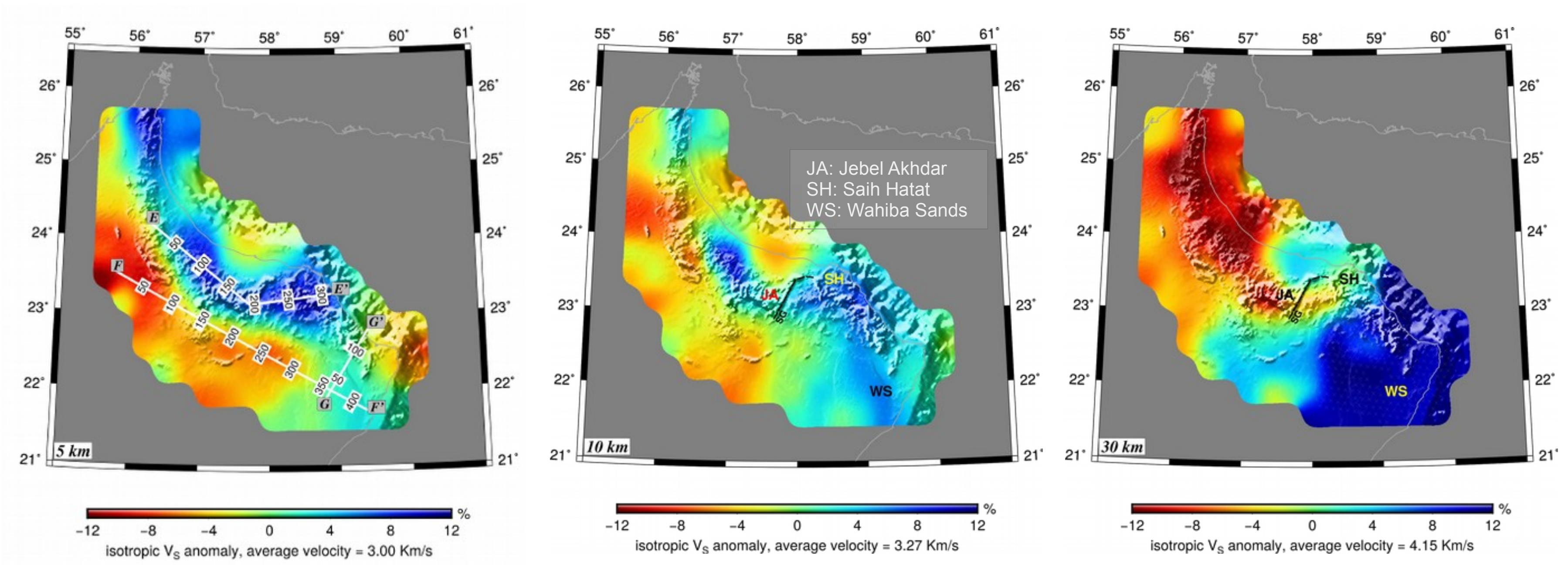


<u>Azimuthally anisotropic</u> Rayleigh and Love phase velocity maps
→ Arc-parallel azimuthal anisotropy in upper crust of mountains → deformation
→ Mostly W-E directed anisotropy in the east

Subsequent local 1-D inversion for radially anisotropic shear wave velocity profiles and compilation to 3D model

[all figures from Wiesenberg, PhD Thesis, CAU Kiel, 2020]

3-D Crustal Model – Horizontal Maps



Shallow crust:

- dominated by contrast mountains/ophiolite ↔ sediments
- shallow high velocities eastwards of Saih Hatat → northward extension of Huqf high below Wahiba Sands?
  → relates to reactivation of pre-Permian structures during Gondwana breakup

Middle to lower crust:

- general transition to east-west contrast
- linear, NE trending boundaries in middle, lower crust and Moho

→ Arabian plate assembly

- distinct velocity anomalies below topography
- slight crustal thickening below topography

→ obduction related

[all figures from Wiesenberg, PhD Thesis, CAU Kiel, 2020]

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3-D Crustal Model – Vertical Slices / Mohomap

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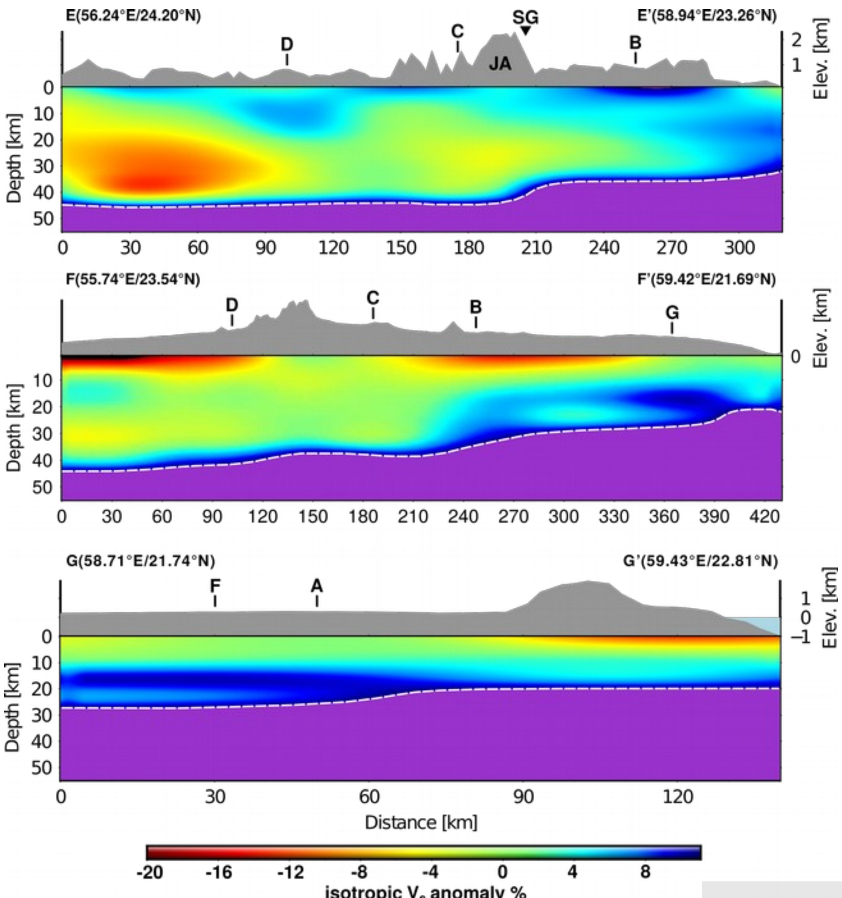


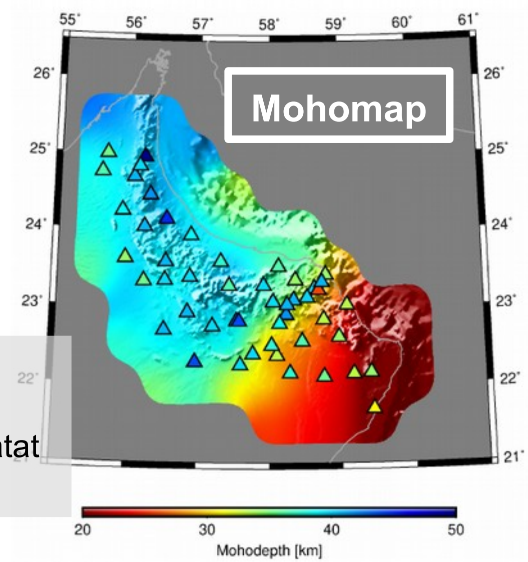
for profile locations see previous slide

(Post-) obduction processes (Mountain belt/ophiolite):

- Thickest (<10km) ophiolite south of Saih Hatat [Profile EE'], elsewhere ~5km
- Distinct differences in upper crustal velocities beneath tectonic windows (slower below JA than SH)
- Slight crustal thickening and lower velocities throughout the crust below topography are indicative of deformation during orogeny/obduction (also from anisotropy)

Pre-obduction processes (Arabian plate):

- 40 – 45km crustal thickness in northwest [EE‘ and FF‘]
- Inherited from plate assembly (with later reactivation):
  - NW to SE thinning of the crust (stepwise?) [FF‘]
  - Fast lower crust east of Saih Hatat [FF‘ and GG‘]
  - Shallow (20 – 30km) Moho in east [GG‘]



Ambient noise vs. Receiver Functions:

- Largely consistent west of Semail Gap
- 10 – 15km discrepancy west of Saih Hatat
- Origin uncertain, „double Moho“?

[all figures from Wiesenberg, PhD Thesis, CAU Kiel, 2020]