SO297: Investigating the seismic structure, geometry and seismicity offshore Northern Chile (25° - 27.5°S)

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Introduction & Aims

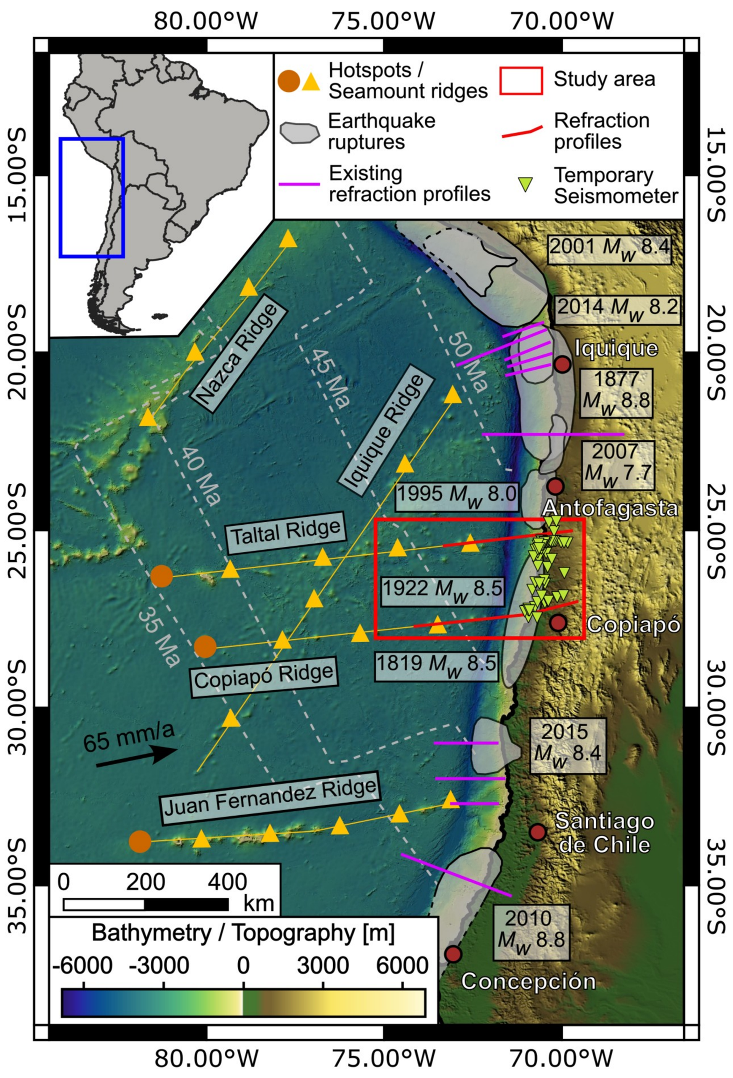

Figure 1:
Overview of the subduction zone in central and northern Chile. White areas denote rupture planes from past earthquakes, purple lines denote existing seismic refraction experiments and red box denotes our study area.

Introduction

- Extremely active plate boundary
- Margin-wide history of repeated tsunamigenic megathrust earthquakes
- Seismic gap in the Atacama region (24° - 30°S)
- High-level of low and medium magnitude seismicity in the Atacama region
- Underexplored margin between 22°S and 31°S

Aims

- Investigate the seafloor morphology, crustal thickness and velocity structure of the incoming plate near Taltal (25.5°S) and Copiapó (27.5°S)
- Analyze the geometry of down going slab
- Relate characteristics of the incoming plate to observed onshore seismicity

SO297 Data & Methods

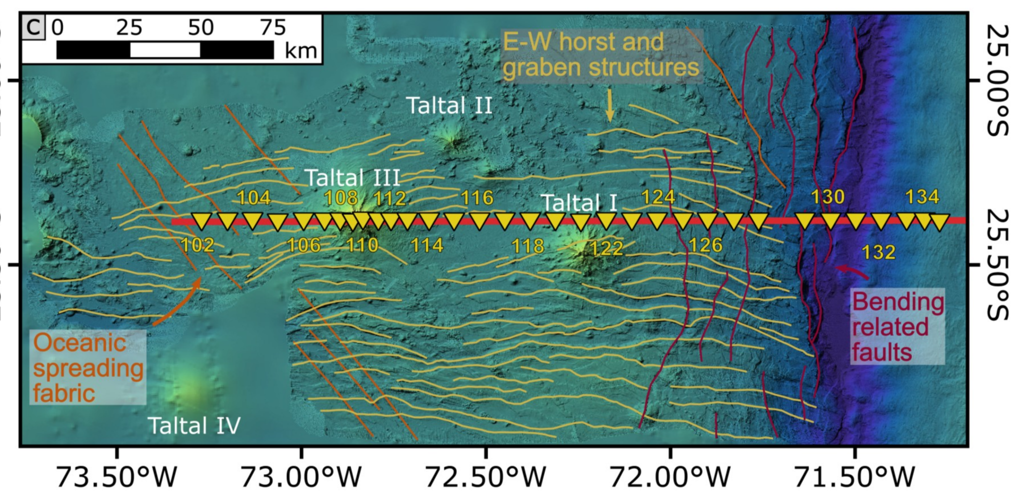

Figure 2:
Multibeam bathymetry offshore Taltal (~25°S). Yellow triangles and red line denote OBS/OBH locations and the corresponding refraction profile, respectively. Other lines illustrate different fault structures (Warwel et al., 2025b)

Multibeam bathymetry

- High-resolution mapping of morphological structures and different fault systems

Refraction tomography

- Active OBS/OBH data to invert for the P- and S-wave velocity structure
- Use velocity models to calculate the Vp/Vs ratio (Taltal profile only)
- Use PmP and PintP reflections to model the depth and geometry of the Moho and the plate interface

Local seismicity

- Automatic picking, associating and locating seismicity recorded on temporary stations
- Analyze local seismicity pattern and distributions

Results

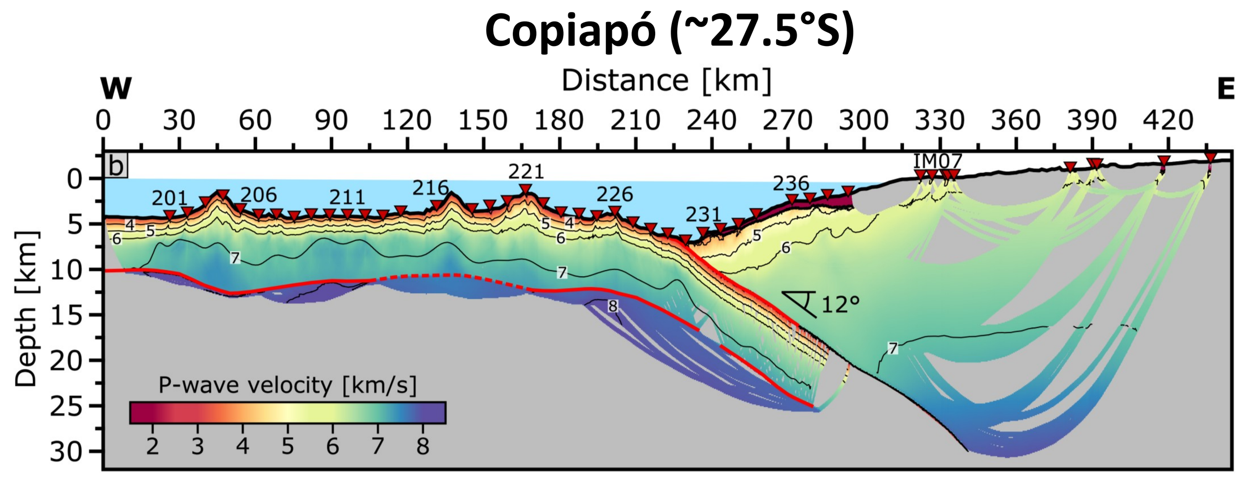

Figure 3:
Final P-wave velocity model derived from travel time inversion. The velocity model is shown only in areas with ray coverage. The plate interface and Moho are marked in red. Dotted red line marks potential underplating (Warwel et al., 2025a).

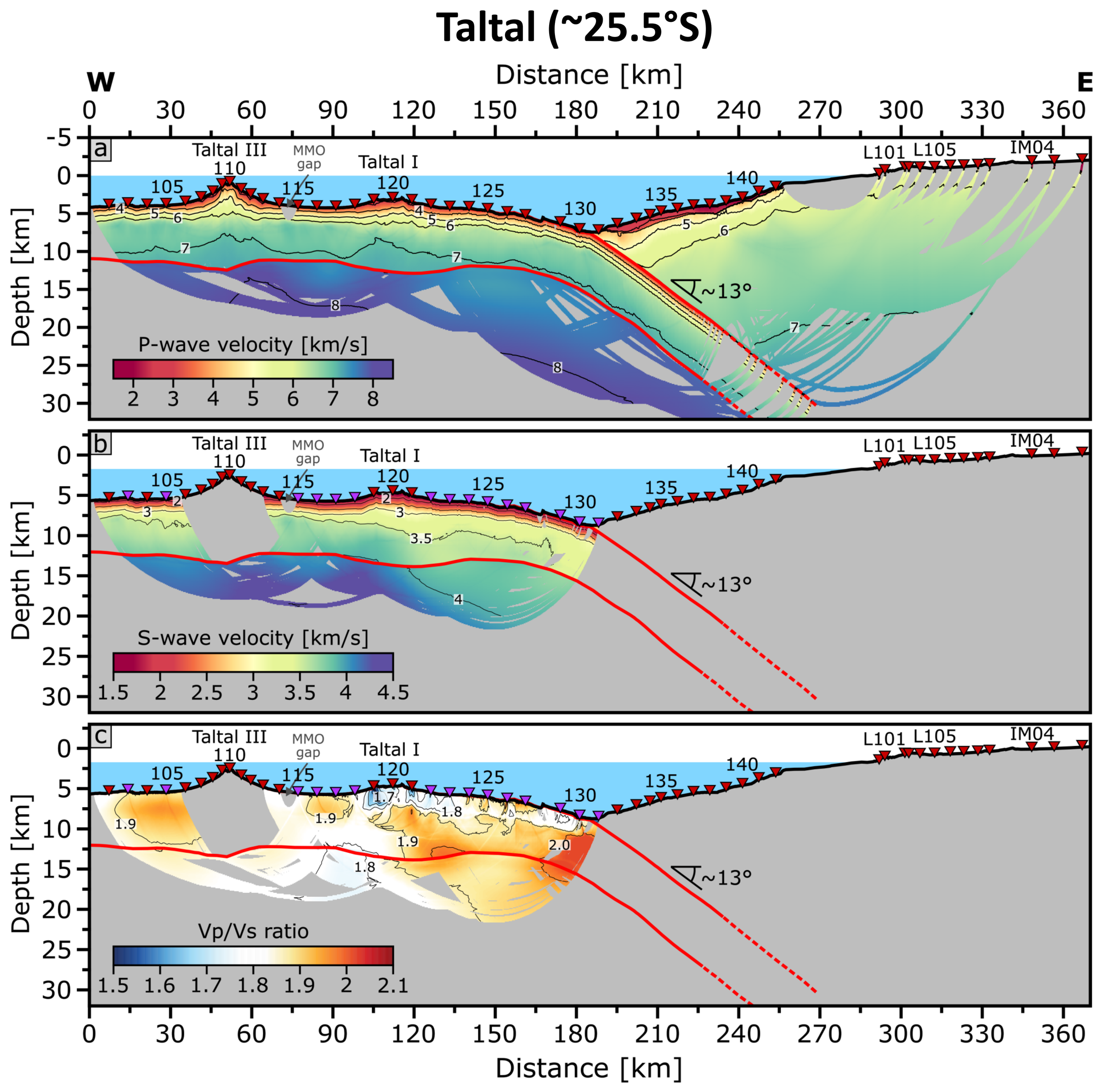

Figure 4:
(a) Final P-wave velocity model derived from the travel time inversion. Gray areas were not covered by rays. The plate interface and the oceanic Moho are marked in red. (b) Final S-wave velocity model derived from the travel time inversion. Purple triangles denote OBS stations used for the S-wave inversion. The plate interface and Moho were derived from the P-wave velocity model. (c) Vp/Vs ratio derived from dividing the Vp and Vs velocities. MMO: Region without airgun shots due to Marine Mammal Protection (Warwel et al., 2025b).

Seafloor morphology

- Three different faults and lineaments: lineaments related to the paleo-spreading fabric, E-W oriented horst and graben structures, bending-related normal faults (Fig. 2)

Refraction tomography

- Crustal thickness: **6 - 7 km**, increasing up to **12 km** underneath seamounts (Figs. 3, 4a)
- Slab dip angle: **12° - 13°** (Figs. 3, 4a)
- Reduced crustal velocities underneath / at the flank of the seamounts -> **extrusive volcanism** (Figs. 3, 4a)
- Reduced lower crust / upper mantle velocities and high Vp/Vs ratios close to the trench -> **hydration / serpentinization up to 30%** (Fig. 4c)
- Possible **magmatic underplating** in the Copiapó profile between 120 and 170 km (Fig. 3)

Local seismicity

- **Increase in** low and medium magnitude (Mw < 5) **seismicity** in the vicinity of the Copiapó and Taltal Ridge (see full text with QR code)
- **Seismicity** is distributed into **different clusters** at different depths (Fig. 5)
- Near Copiapó, **sparse seismicity corelates** with **slow slip events** (Klein et al., 2018)

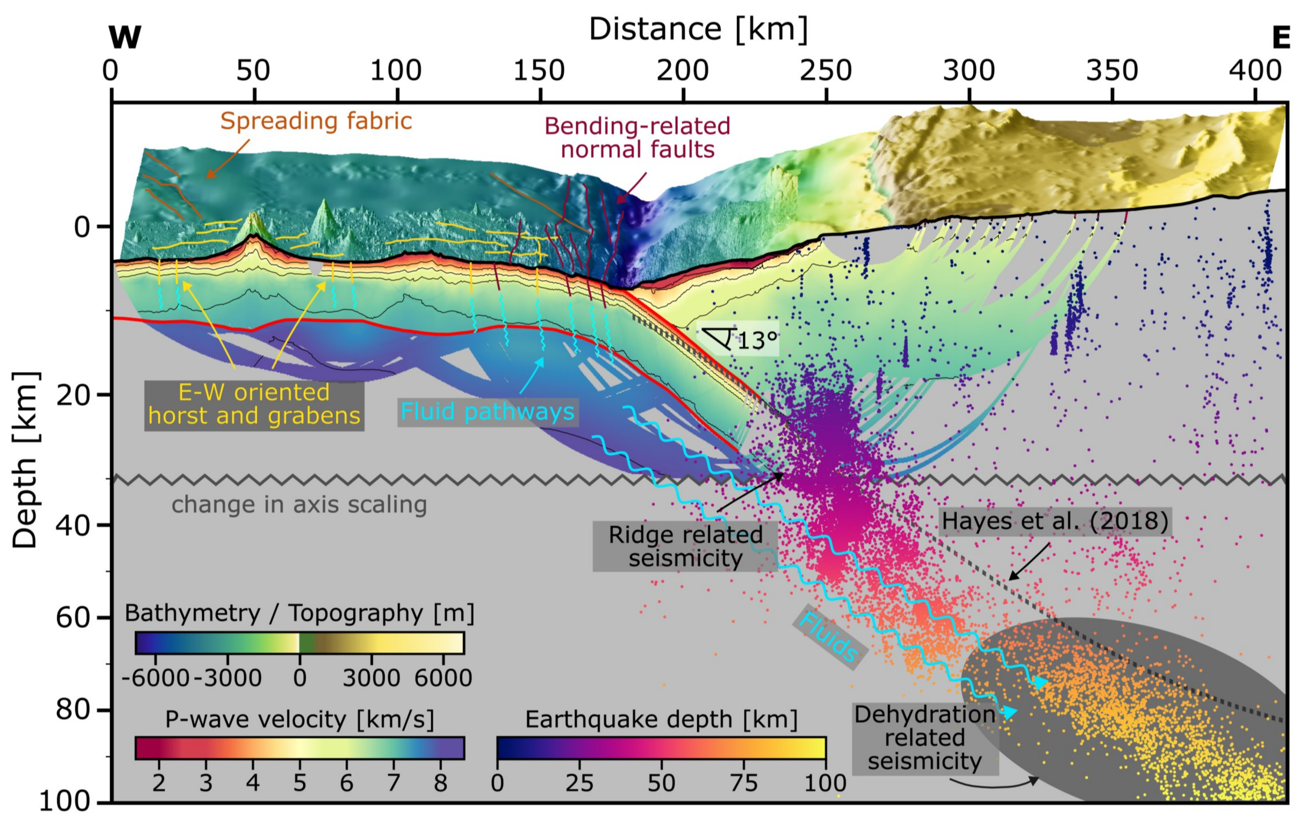

Figure 5:
Schematic representation of the incoming and overriding plate, faults and the seismicity at the Chilean subduction zone at ~25.5°S. Faults in the incoming plate facilitates fluid flow into the crust and upper mantle leading to reduced velocities and high Vp/Vs ratios. During subduction, the water is released at depths below 60 km causing dehydration related seismicity (Warwel et al., 2025b)

Conclusions

Seafloor morphology:

- Seamounts exhibit stellate-shapes or are in the transition to a stellate-shape
- Cross-cutting of faults close to the trench facilitates fluid flow into the crust and upper mantle leading to reduced velocities
- E-W oriented horst and graben structures near Taltal may indicate N-S extension within the last 10 Ma

Local seismicity:

- Shallow interface seismicity (~20 - 60 km depth) is related to seamount ridge subduction
- Intermediate-depth seismicity (~70 - 100 km depth) is related to dehydration processes
- Near Copiapó, we can link sparse seismicity, slow-slip events and low degree of locking
- Different seismicity cluster are not active simultaneously

Refraction tomography:

- Normal oceanic crust (thickness, velocity structure)
- Predominantly extrusive seamounts, deep intrusive component possible
- Constant slab dip angle -> no change in dip angle as proposed by Contreras-Reyes et al. (2012) at 22° S
- Up to 30% of mantle hydration / serpentinization near the trench
- Seamounts are not the main driver of the hydration
- Possible magmatic underplating related to seamounts

More results here!

Taltal (~25.5°S) | Copiapó (~27.5°S)

References

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