

Three-dimensional velocity structure of the 25 °S Oceanic Core Complex and seismicity at the Rodriguez Triple Junction in the Central Indian Ocean - SO301

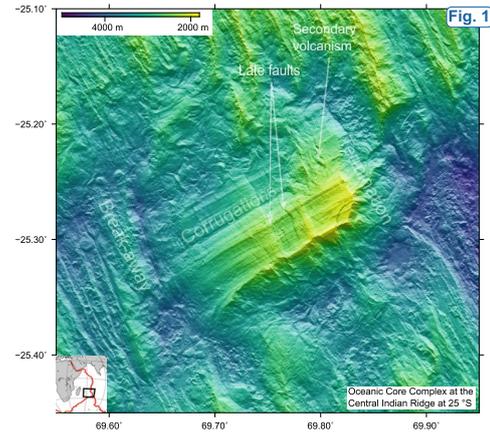
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Introduction

From November 2023 to January 2024, RV Sonne research cruise SO301 investigated the Central Indian Ridge (CIR) at 25 °S / 70 °E in the immediate vicinity of the Rodriguez Triple Junction (RTJ). Main target of the project SCIROCCO is to study the oceanic core complex (OCC) north of the RTJ at 25 °S (Fig. 1) and the hydrothermal vent field Kairei on the eastern side of the CIR. Here we show preliminary results of travel time tomography along the 150 km profiles p100 and p200.



Scientific questions:

- (1) Structure and physical properties of the crust over both conjugated ridge flanks
- (2) Composition and evolution of the 25 °S OCC
- (3) Ratio of magmatic accretion and amagmatic tectonic extension
- (4) Seismicity at the Rodriguez Triple Junction

Data

The SCIROCCO experiment layout can be seen in Figure 2. A total of 102 ocean bottom seismometers (OBS) were deployed (coloured triangles) for active and passive seismic data recording. During SO301 an 8 km long streamer for multi-channel seismic (MCS) data recording was towed. As seismic source for ~47000 shots served a 3100 cubic inches airgun array. The grey dots show every ten's shot for both refraction seismic (OBS) and MCS lines. A magnetometer was towed behind the vessel during seismic profiling. Gravimetric and bathymetric data were recorded continuously during the entire cruise with systems installed on the vessel. A broadband seismometer array of 16 OBS was deployed for a period of 8 months (green triangles) around and north of the RTJ. Profile p100 (150 km long) crosses the OCC from east to west (33 OBS) and p200 crosses the OCC north to south (100 km long / 30 OBS).

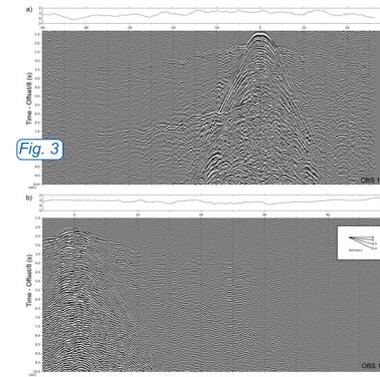
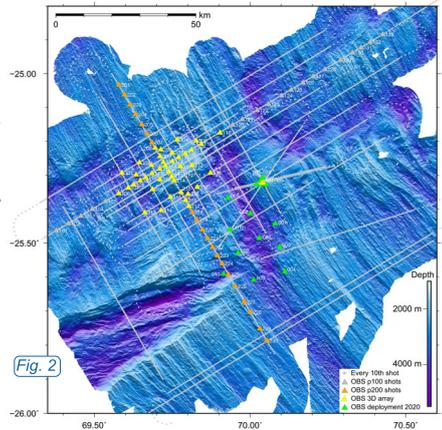
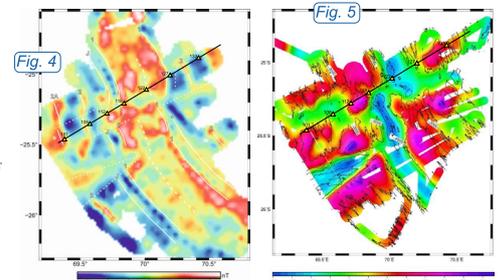


Figure 3: Seismic sections of two OBS along p100: (a) hydrophone component of OBS132 and (b) horizontal component of OBS101.



Figures 4 and 5: Magnetic and gravimetric data acquired during SO301, respectively. Profile p100 is indicated in the maps.

Preliminary results

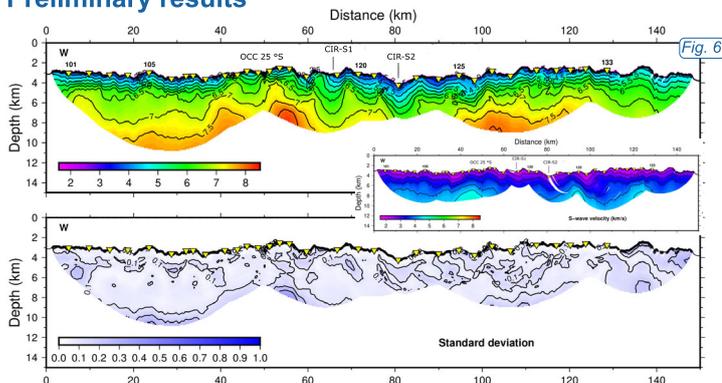


Figure 6: Preliminary average P-wave velocity model along profile p100. The lower panel displays the standard deviation calculated from 90 models. Models with a $\chi^2 < 2$ were included. The RMS misfit is 45 ms. Inset shows the corresponding preliminary average S-wave velocity model. Models with a $\chi^2 < 3$ were included and the RMS misfit is 140 ms.

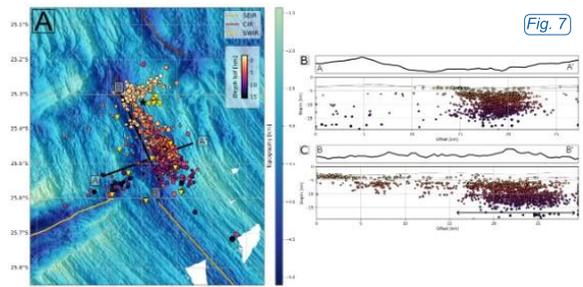


Figure 7: A: Absolute location of the final catalogue's events, colour-coded according to the events' depth below seafloor and sized relative to Mw. OBS are marked by yellow triangles, and the RTJ-proximal SEIR, CIR and SWIR segments are marked in orange, brown and yellow, respectively. B & C: Profile view of events projected onto transects AA' and BB', respectively. Parallel profiles passing through adjacent topographic elevations were added in dashed lines to visualise that the apparent locations in the water column are due to strong topography variations orthogonal to the ridge. The extent of the deep event cluster is marked in subplot C by an arrow. Top panels show vertically exaggerated bathymetry (factor 3).

Preliminary interpretation

- V_p/V_s in relation to V_p : Blue areas in Fig. 8 indicate hydrated rocks (serpentinised mantle or highly fractured crust).
- Magnetic data indicate asymmetric spreading with a change ~1.5 Ma which correlates with areas of high V_p and V_p/V_s at the seafloor at both conjugated ridge flanks.
- Faster spreading to the ridge flank with active tectonic extension, the conjugated site seems to be magmatically starved (missing Jaramillio anomaly).
- Seismicity is systematically offset from the ridge axes, suggesting that ridge migration is accommodated by progressive relocation of the ridge axes.

Figure 8 displays the V_p/V_s -ratio along profile p100. Isolines represent P-wave velocities as found in figure 6. Blue areas indicate rather hydrated rocks, serpentinised mantle ($V_p > 4.5$ km/s & $V_p/V_s > 1.9$) or highly fractured basalt ($V_p < 4.5$ km/s & $V_p/V_s > 1.9$). Red areas may indicate basalt ($V_p < 4.5$ km/s & $V_p/V_s < 1.9$), exposed mantle and/or gabbro ($V_p > 4.5$ km/s & $V_p/V_s < 1.9$).

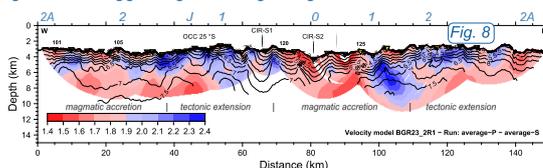


Figure 10 correlates the profiles to petrological data from dives (green dots) and dredges (black dots) in a map from Okino et al. (2015, https://doi.org/10.1007/978-4-431-54865-2_11).

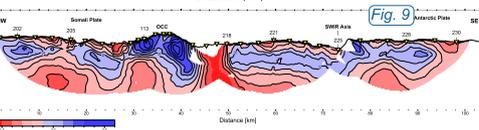
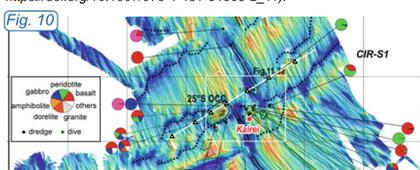
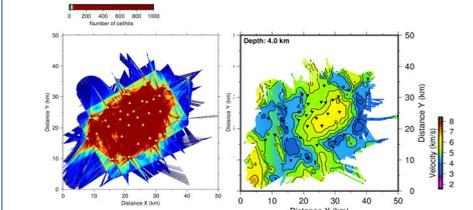


Figure 9 displays the V_p/V_s -ratio along profile p200. The OCC seems to be highly hydrated in the upper 2 km. Also the area directly north of the OCC seems to be highly fractured. The CIR south of the OCC was rather tectonically dominated during extension. The southern wedge of the SWIR seems to be highly fractured, while the Antarctic plate shows magmatically accreted crust.

Outlook

- 3D travel time tomography
- Downward continuation of the data for enhanced visibility of later phases i.e. near-offset refractions and wide-angle reflections (PmP)



- Modelling of the first multiple phases to enlarge the observed offsets and hence image the subsurface to greater depths- Density modelling using seismic velocities the measured Free-Air Anomaly
- Integrating MCS data
- Full wave form inversion along p100 above the OCC

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