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CRUSTAL STRUCTURE OF THE SOUTHERN PAMIR

Insights from the TIPTIMON magnetotelluric experiment

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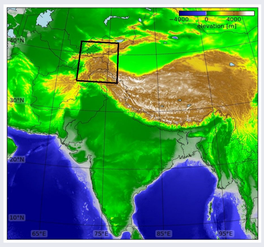
Introduction

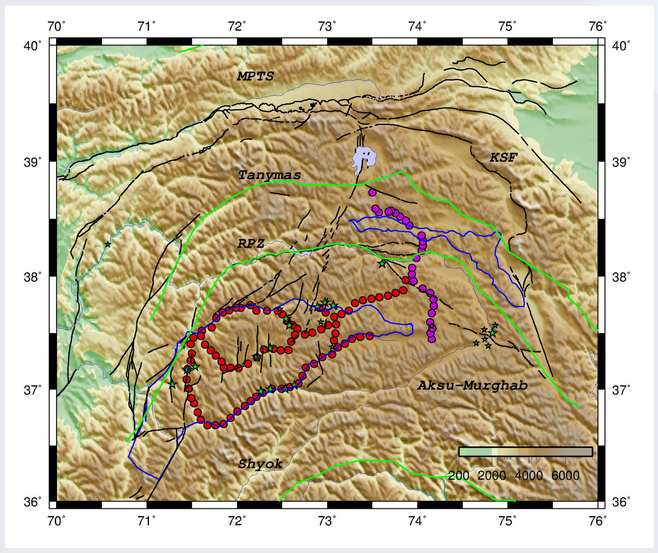
Area of investigation



The Pamir is a high plateau located at the N-W corner of the India-Asia collision zone with several unique features:

- 55-64% N-S internal shortening
- exposure of middle-lower crustal crystalline rocks with Cenozoic metamorphism in several domes
- occurence of intermediate depth seismicity caused by forced continental subduction.

Fig. 1: Geological map with site locations (green lines: sutures, RPZ Rushan-Pshart Zone; black lines: active faults, MPTS Main Pamir Thrust System; green stars: hot springs; blue contours: domes)
Magnetotelluric sites are marked as red (TIPTIMON experiment, 2013) and purple (previous TIPAGE experiment, Saß et al., 2014) dots.



Geodynamic puzzle

From seismological data two subducting slabs can be recognized in the Pamir (ref. Fig. 2 and 3): a north-dipping Hindu-Kush slab that belongs to India and an arcuate (from east to south dipping) Pamir slab belonging to Asia. At present, cratonic India underthrusts the Pamir and forces the Asian lithosphere to roll back. Before the Indian cratonic lithosphere arrived at the Asian margin, some 1000km of passive margin (Greater India) was subducted, leading to the break-off of the Greater Indian slab.

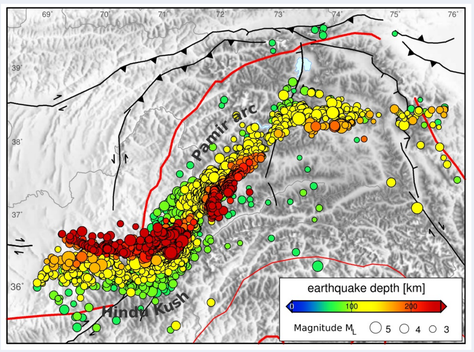


Fig. 2: Earthquake catalogue at sub-crustal depth with hypocenters deeper than 50km (from Kufner et al. 2016).

Magnetotelluric experiment

The magnetotelluric survey was conducted in the Southern Pamir as a part of the interdisciplinary TIPTIMON (Tien-Shan-Pamir Monitoring Program) project. We installed 85 wideband (10 000 Hz - 1000 s) magnetotelluric stations covering a 200 km x 100 km wide region between Murghab and Chorog in Tajikistan, with site spacing of ca. 8km. Recording time was 3 days.

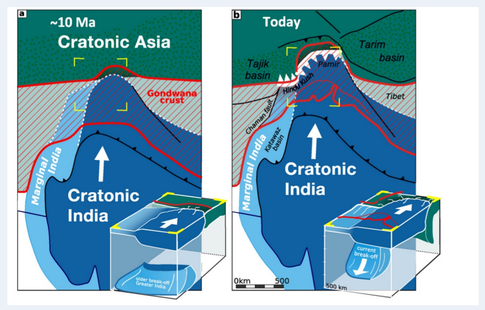


Fig. 3: Outline of the tectonic plates at depth (from Kufner et al. 2016).

Electrical resistivity models

3D Inversion results

We run a series of 3D inversions using the "Modular Electromagnetic Inversion System" (ModEM, Meqbel, 2009; Egbert and Kelbert, 2012). In addition to TIPTIMON data, a part of the TIPAGE data (Saß et al., 2014) were included for the inversion. Presented models are obtained from a joint inversion where we assigned error floors of 3% for the off-diagonal and 5% for the diagonal components of the impedance tensor and a constant value of 0.02 for the vertical magnetic field transfer functions.

The data fit was generally very good. Some exceptions occur in the western part due to poor data quality.

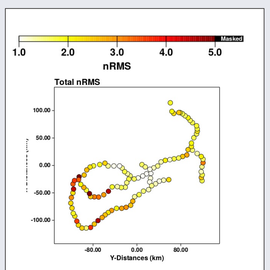


Fig. 4: Total RMS

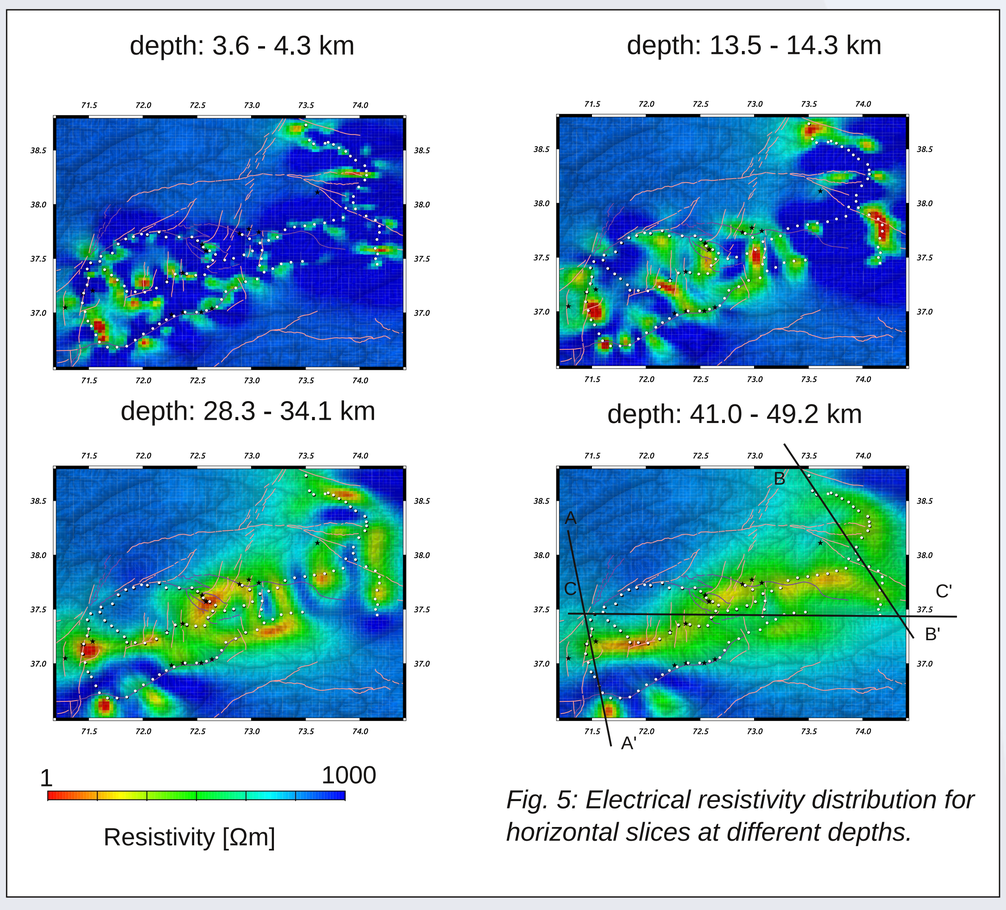


Fig. 5: Electrical resistivity distribution for horizontal slices at different depths.

Interpretation

- A resistive shallow crust (<10-15 km) is observed throughout the southern Pamir plateau and hosts the shallow seismicity.
- In the south-western part, the zones of high conductivity are interpreted as faults. Especially in the central part, the normal faults seem to reach very deep and may provide pathways for metamorphic and meteoric fluids or for ascending melts from the lower crust.
- The Shakdara dome does not seem to influence the electrical resisitivity distribution.
- In the east, a prominent conductivity anomaly corresponds to the Aksu-Murghab fault system.
- At lower crustal depths, the resistivity structure is probably influenced by the subduction regime. The conductive anomalies have an arcuate form which could reflect the margin of the Indian lithosphere underneath (ref. Fig. 3).

The conductive structures in Fig. 6 coincide with the occurence of faults at surface. The enhanced conductivites may also be caused by the subduction related metamorphic fluid release. Note, the left anomaly belongs to the Pamir slab and the right to the Hindu-Kush slab. The resistive barrier is located exactly where the plates meet. Black dots mark earthquake locations (from Sippl et al., 2013, Sofia Kufner, personal communication).

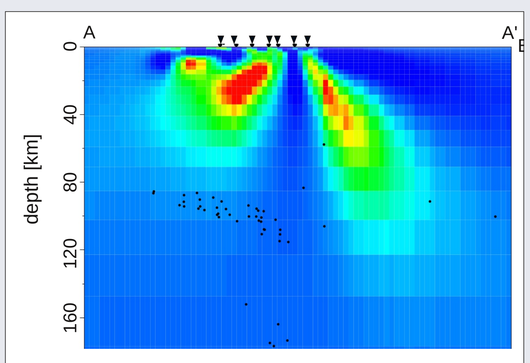


Fig. 6: North-south profile across the western Pamir (profile A) reveals deep reaching faults and strong electrical resistivity contrasts.

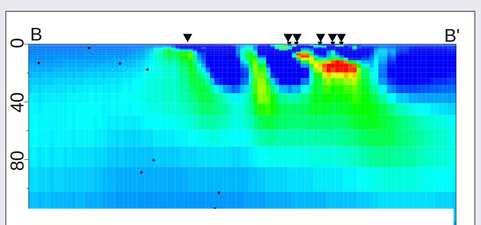


Fig. 7: North-south profile across the eastern Pamir (profile B). A prominent conductive anomaly is located in the Southern Pamir and may be correlated with the Aksu-Murghab fault system. In the northern part conductive anomalies represent the Tanymas and the Rushart-Pshart sutures.

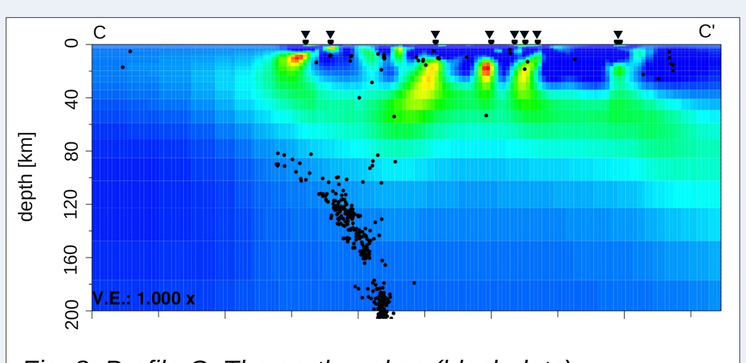


Fig. 8: Profile C. The earthquakes (black dots) correspond to the subducting Pamir slab. Ascending earthquakes may indicate methamorphic fluid release. Anomalously conductive lower crust extends throughout the Southern Pamir.

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