Resistivity Structures underneath the Southern Pamir and the Darvaz Fault, Tajikistan

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1. Introduction

Regional Geology

Pamir is a high plateau which was formed by crustal shortening and thrusting during the India-Asia collision.

Fig 1: Geological map of Tajikistan with site locations in the Southern Pamir and along the Darvaz Fault

Interesting questions:

- Is there a crustal flow underneath the Southern Pamir?
- In the previous results a remarkable zone of high electrical conductivity (resistivities below 1 Ohmm) was found below the Pamir Plateau (Saß et al. 2014). How wide is the east-west extent of the conductive anomaly?

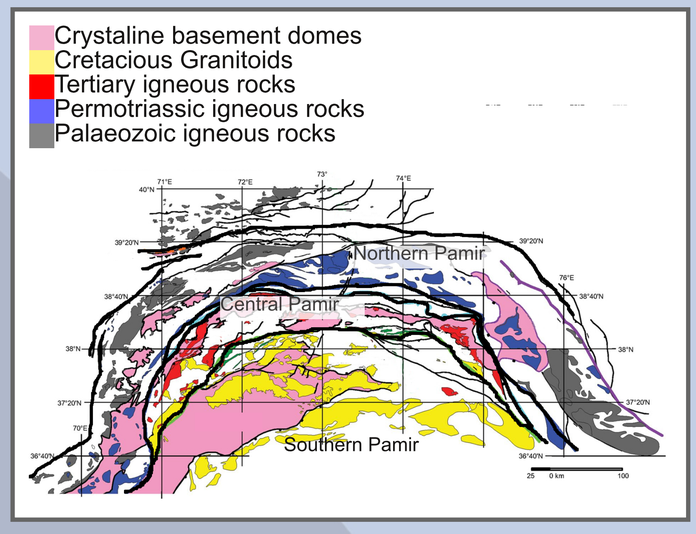


Fig. 2: Geological map of Pamir slightly modified from Mechie et al. (2012)

Field experiment

Used instruments: Metronix MFS05/06 induction coils, non polarizable Ag-AgCl electrodes, horizontal dipole length ~60m.

Southern Pamir Array:
85 magnetotelluric stations, region between Murghab and Chorog, and between the Pamir Highway and the Panj-/Pamir-rivers (250km x 100km), site spacing ~8km, installation duration 3days

Darvaz Profile:
11 stations, 30km long profile across the Darvaz fault, site spacing: ~3km, time duration 2 days.

Magnetotelluric Method

In the magnetotelluric experiment, we measure the natural electric and magnetic fields E and B at the surface of the Earth for each site of the survey from which we derive the information about the conductivity distribution of the subsurface.
In nature, the electrical resistivity varies over many orders of magnitude. Low values of electrical resistivities (anomalies) are due to fluids, melts, ores, graphite/sulfide.

2. Inversion Results

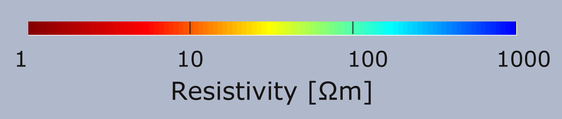
Southern Pamir - 3D Inversion

We run a series of 3D inversions using the "Modular Electromagnetic Inversion System" (ModEM, Meqbel 2009, Egbert and Kelbert 2012).
All components of the impedance tensor as well as vertical magnetic transfer functions were used. Not all sites from the field experiment were taken into acount, since the data processing has not been completed yet. While the data quality is excellent in the sparsely populated southeastern Pamir plateau, it is heterogeneous or disturbed by EM noise in the populated southwestern Pamir.
Additionally, the Southern Pamir data of the TIPAGE experiment (Saß et al. 2014) were included.

Interpretation

3D inversion reveals following features:

- At the shallow depths, the entire Pamir appears to be resistive reaching values around 1000 Ωm.
- There is a conductive anomaly, which starts in the most eastern part of the Pamir plateau at approximately 9 km, becomes larger with the depth and spreads over the entire eastern half of the plateau at the depths of 20 - 25 km. The conductivity anomaly is delimited to the west. This may be an indication against the crustal flow assumption (Saß et al. 2014).
- The limit of the conductivity zone is possibly the gigantic metamorphic Shakdara dome, which dominates the whole southwestern Pamir and is expected to be resistive. However, the data of the southwestern Pamir used in the inversion were incomplete, because processing of the noisy sites (western survay area) has not been finished yet.
- Future work will focus on a further improvement of the transfer function quality and probing of the inversion results. Interesting investigation issues would be the extension of the experiment to the east, or a longer recording time for the sites in southwestern Pamir, in order to test the possibility that the conductor starts at a greater depth in this



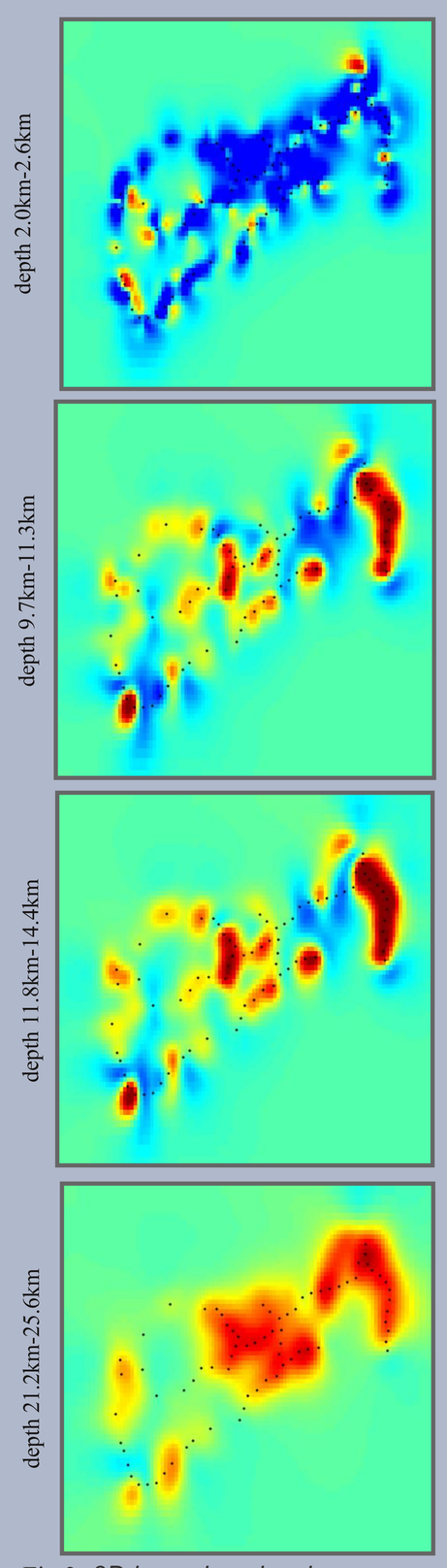


Fig 3: *3D inversion showing horizontal slices at different depths*

Darvaz Fault - 2D Inversion

The Pamir plateau slides past the Tajik Depression along the sinistral Darvaz Fault with an average motion of 10mm/yr.
Upper crustal fault zones are often appear as conductive anomalies as fault structure mesh may provide pathway for fluids and allow for electric current flow.
This can be observed in the Fig. 4.
A conductive anomaly is located between the station 0706 and 0707, which corresponds very well with the geological information. The anomaly reaches ca. 8-10km deep. This corresponds to the depth of the sedimentary rock cover of the Tajik depression, which is estimated to be10-km deep (after Burtman and Molnar 1993).

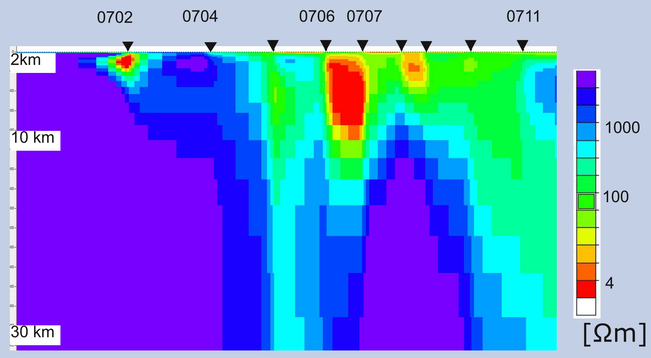


Fig 4 : 2D inversion with WinGlink. (Settings for the inversion: joint inversion of TE+TM+Hz mode, tau=30, rho start=500Ohmm, error floors: delta rho TE=100%, delta phi TE=5% delta rho TM=10%. We set error floors to emphasize fitting the phases, which are not affected by static shift.

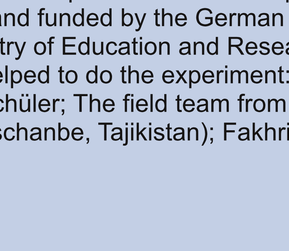


Fig 5: Regional strike analysis using a wide period range between 10Hz and 1000s (after Becken and Burkhardt 2004). With the regard of the geology information the geo-electrical strike is N-S.

3. References

Burtman, V.S. and Molnar, P.H., 1993. Geological and Geophysical Evidence for Deep Subduction of Continental Crust Beneath the Pamir, Special Papaer Geological Society of America, 281

Sass, P., Ritter O., Ratschbacher L., Tympel J., Matiukov V. E. , Rybin A. K., and Batalev V. Yu. 2014. Resistivity structure underneath the Pamir and Southern Tian Shan. Geophys. J. Int., doi:10.1093/gji/ggu146

Egbert, G.D. and Kelbert, A., 2012. Computational recipes for electromagnetic inverse problems. Geophys. J. Int., 189(1), 251-267

Meqbel, N., 2009. The electrical conductivity structure of the Dead Sea Basin derived from 2D and 3D inversion of magnetotelluric data. Dissertation. Freie Universität Berlin, Germany

Mechie, J., X. Yuan, B. Schurr, F. Schneider, C. Sippl, L. Ratschbacher, V. Minaev, M. Gadoev, I. Oimahmodov, U. Abdybachaev, B. Moldobekov, S. Orunbaev and S. Negmatullaev. 2012. Curstal and uppermost mantle velocity structure along a profile across the Pamir and southern Tien Schan as derived from project TIPAGE wide-angle seismic data. Geophys. J. Int., 188, 385-407

Ischuk, A., Bendik, R., Rybin, A., Molnar, P., Khan, S. F., Kuzikov, S., Mohadjer, S., Saydullaev U, Ilyasove, Z., Schelochkkov, G., and Zubovich, A. V., 2013. Kinematics of the Pamir and Hindu Kush regions from GPS geodesy, Journal of Geophysical Research: Solid Earth, 118, 2408-2416

Sass, P., 2013. Magnetotellurische Untersuchung der kontinentalen Kollisionszone im Pamir und Tian Shan, Zentralasien. Dissertation, Freie Universität Berlin, Germany

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