Intermediate scientific report of the project

IFMMALPO (SPP 2017 4D MB)

A.G. Petrunin (PI) in cooperation with M.K. Kaban (GFZ)

The mantle flow is one of the major factors influencing on the lithosphere's loading from below (both normal and tensile) and responsible largely for the lithosphere dynamics and stress distribution within continental plates. However, to calculate the mantle flow pattern regionally, the entire Earth convection (present day, snap-shot) model consistent with GPS measurements and local stress field data must be carried out. To accomplish the goal, we have developed refined density-temperature model of the lithosphere based on most recent tomography, gravity, and crustal structure data with further inversion for the density. The method allows for reducing the crust influence that significantly enhances tomographic inversion results. As a result we got the density distribution map beneath the Alpine region and its surroundings for the lithosphere and upper mantle. For the inversion for the upper mantle we used the tomography model UU-P07 (Amaru 2007). Figure 1 demonstrates the difference in resulting density distribution and final resolution, obtained with the direct inversion for density from seismic velocity using the direct method and the joint inversion method. The results are relevant to the research theme 1 of the 4D-MB project.

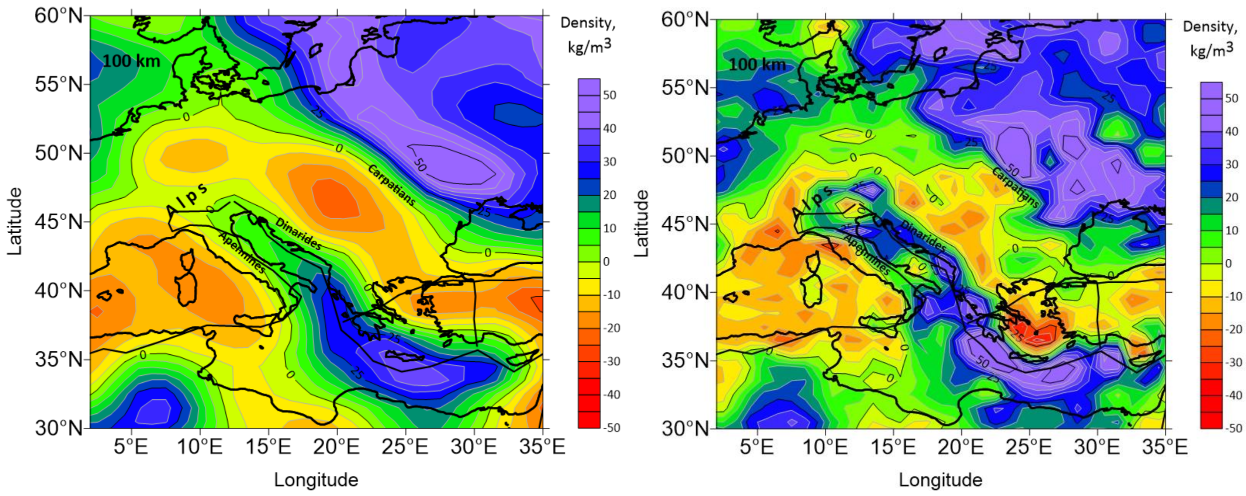

Fig. 1 An example of the joint inversion of the density structure of the Alpine region. The left panel demonstrates an initial inversion of tomography data for the density using a direct method. The right part is a result of the joint inversion method.

Using the data for the global mantle convection modeling, we calculated mantle flow patterns, stresses, and estimates for seismic anisotropy in resolution of 1x1 degree. The most revealing result, demonstrating reliability of our model, is the map of calculated maximum principal stress directions (Figure 2). It shows a good correspondence to the SKS splitting observations.

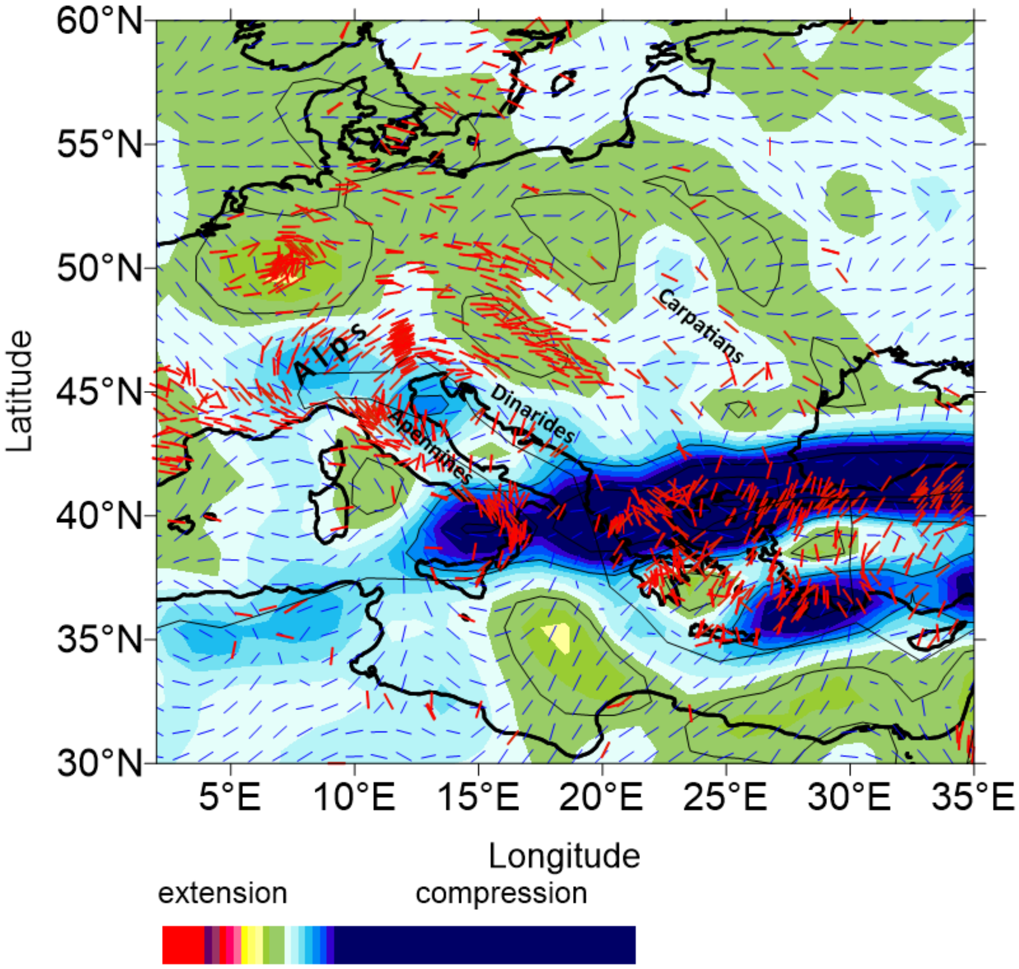

Fig. 2 . Maximum principal stress directions for the depth of 100-150 km (blue dashes). The red dashes indicate the SKS splitting observations and show the fast seismic velocity azimuth averaged by co-located stations (compilation of Wüstefeld et al., 2009, and Becker et al., 2012; updated on August 21, 2017). Colors denote tectonic settings from the modeling.

One of the reasons causing seismic velocity anisotropy is the finite strain, accumulated in the lithosphere or/and upper mantle. This parameter is not calculated in our “snap shot” model. However, we proceeded from the assumption that the directions of the principal axes of the finite strain tensor should correlate with those ones of the stress tensor, as the direction of the main forces in the lithosphere has not been changed significantly since at least 10-15 Ma. The results may be useful for interpretation of the AlpArray Experiment as well as contribute to the research themes 1 and 4 of the 4D-MB project.

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Manuscripts already published within the framework of the SPP2017 4D-MB project:

Petrunin, A. G., Kaban, M. K., El Khrepy, S., Al-Arifi, N. (2020): Mantle Convection Patterns Reveal the Mechanism of the Red Sea Rifting. - Tectonics, 39, 2, e2019TC005829.
DOI: https://doi.org/10.1029/2019TC005829

Haeger, C., Kaban, M. K., Tesauro, M., Petrunin, A. G., Mooney, W. D., 2019. 3-D Density, Thermal, and Compositional Model of the Antarctic Lithosphere and Implications for Its Evolution. *Geochemistry Geophysics Geosystems (G3)*, 20, 2, pp. 688-707.
DOI: http://doi.org/10.1029/2018GC008033

Chen, B., Haeger, C., Kaban, M. K., Petrunin, A. G., 2018. Variations of the effective elastic thickness reveal tectonic fragmentation of the Antarctic lithosphere. *Tectonophysics*, 746, pp. 412-424.
DOI: http://doi.org/10.1016/j.tecto.2017.06.012

Kaban, M. K., Chen, B., Tesauro, M., Petrunin, A. G., El Khrepy, S., Al-Arifi, N., 2018. Reconsidering Effective Elastic Thickness Estimates by Incorporating the Effect of Sediments: A Case Study for Europe. *Geophysical Research Letters*, 45, 18, pp. 9523-9532.
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Kaban, M. K., Petrunin, A. G., El Khrepy, S., Al-Arifi, N., 2018. Diverse Continental Subduction Scenarios Along the Arabia-Eurasia Collision Zone. *Geophysical Research Letters*, 45, 14, pp. 6898-6906.
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DOI: http://doi.org/10.1016/j.tecto.2017.03.004