Studying collision and subduction mechanisms based on regional tomography inversion of the ISC data

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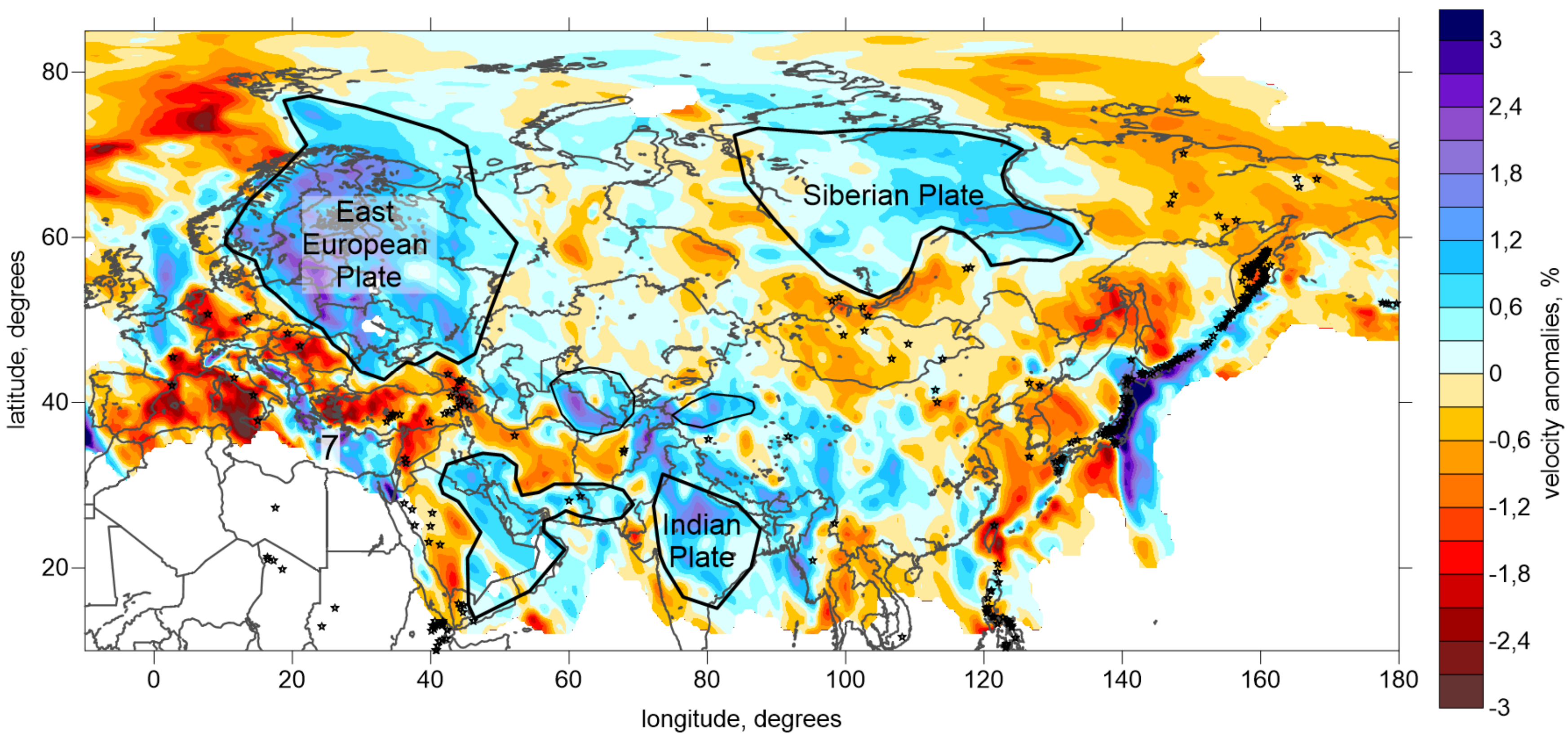


26th IUGG General Assembly, 27 of June, 2015, Prague, Czech Republic

ISC data:

- Huge amount of travel time data resulted from work of thousands specialists worldwide.
- Global coverage and large time span.

1997-1998: breakthrough in tomography modeling:

Van der Hilst, R. D., Widiyantoro, S., & Engdahl, E. R. (1997). Evidence for deep mantle circulation from global tomography. *Nature*, *386*, 578-584.

Grand, S. P., van der Hilst, R. D., & Widiyantoro, S. (1997). High resolution global tomography: a snapshot of convection in the Earth. *GSA Today*, *7*(4).

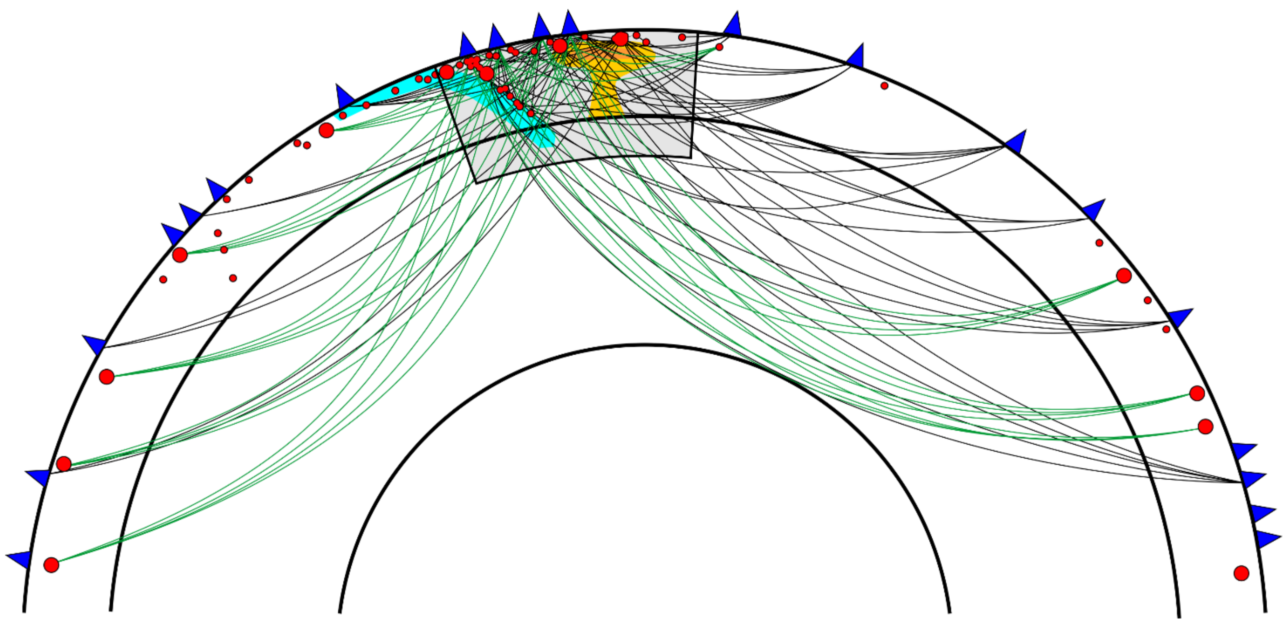
Bijwaard, H., W. Spakman, and E. R. Engdahl (1998), Closing the gap between regional and global travel time tomography, J. Geophys. Res., 103, 30,055–30,078.

Despite progress in data amount, computing power and algorithms, these models remain actual

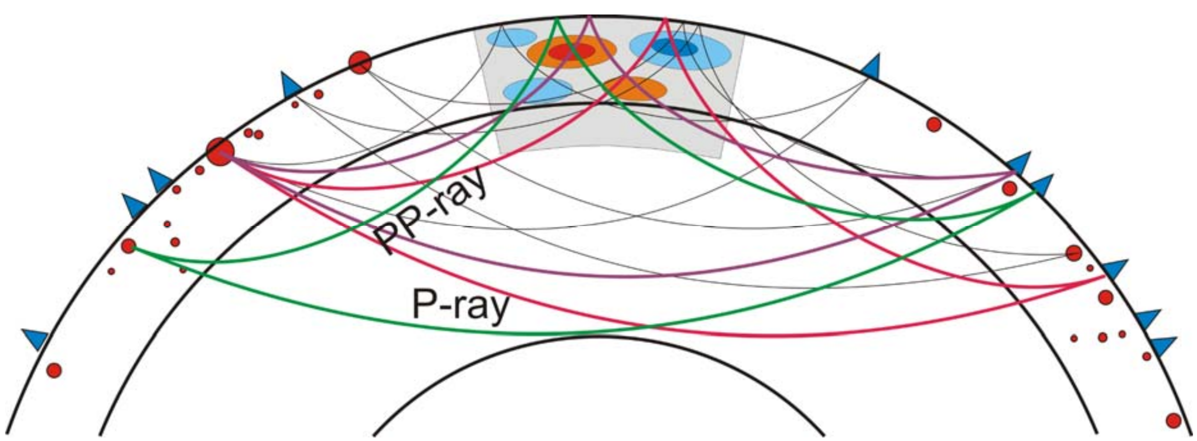
Presently there are advanced methods based on waveform analysis…
but still global and regional models based on inversion of travel times from the ISC catalogues are strongly demanded!

Data for the regional tomography

A. Regional scheme (sources or events in the study area)



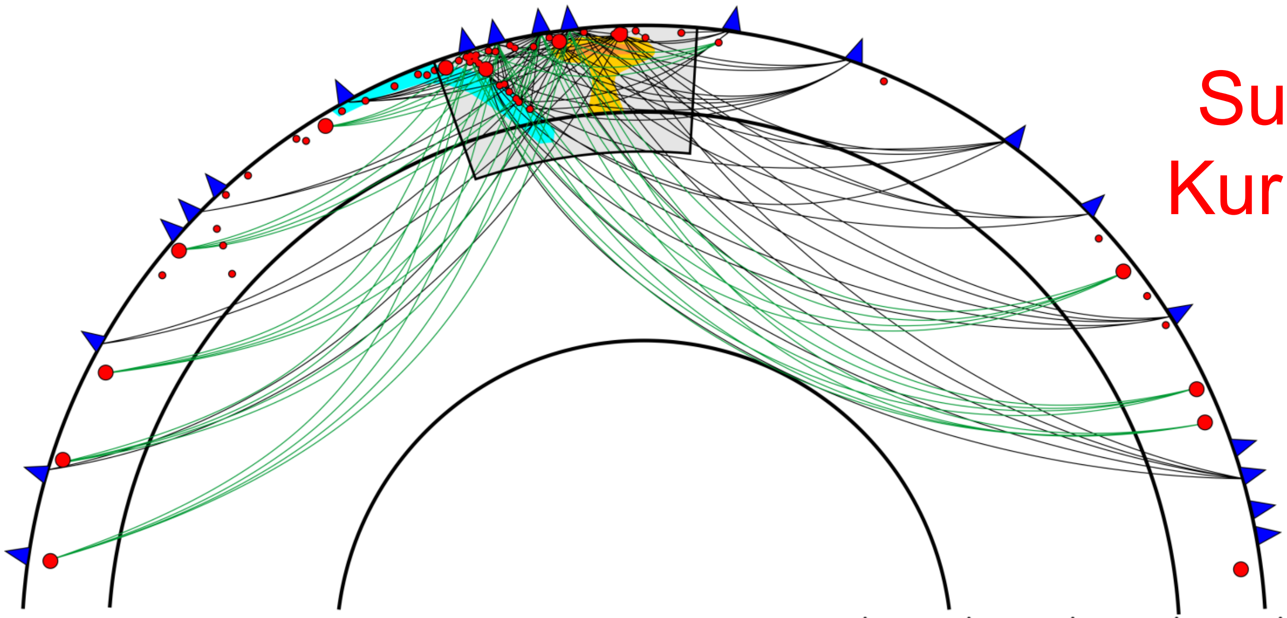
B. PP-P scheme: reflection points of PP rays in the study area



Travel times from the revised ISC catalogue:
all available data which have rays partly traveling through the study volume

All events are relocated.
Outlier analysis: ~30% of data are rejected

Target: upper mantle
Depth: 1000 km,
lateral size: ~2000 km

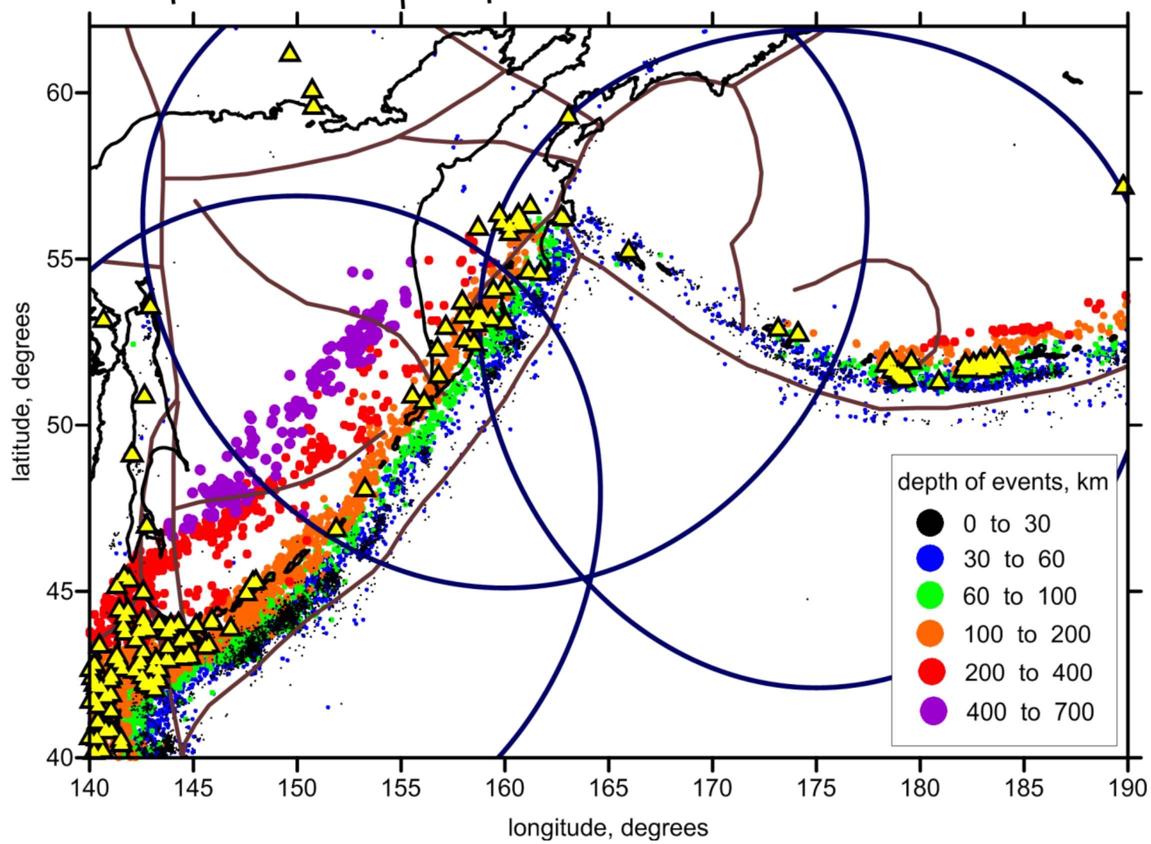


Subduction zones: Kuril-Kamchatka Arc

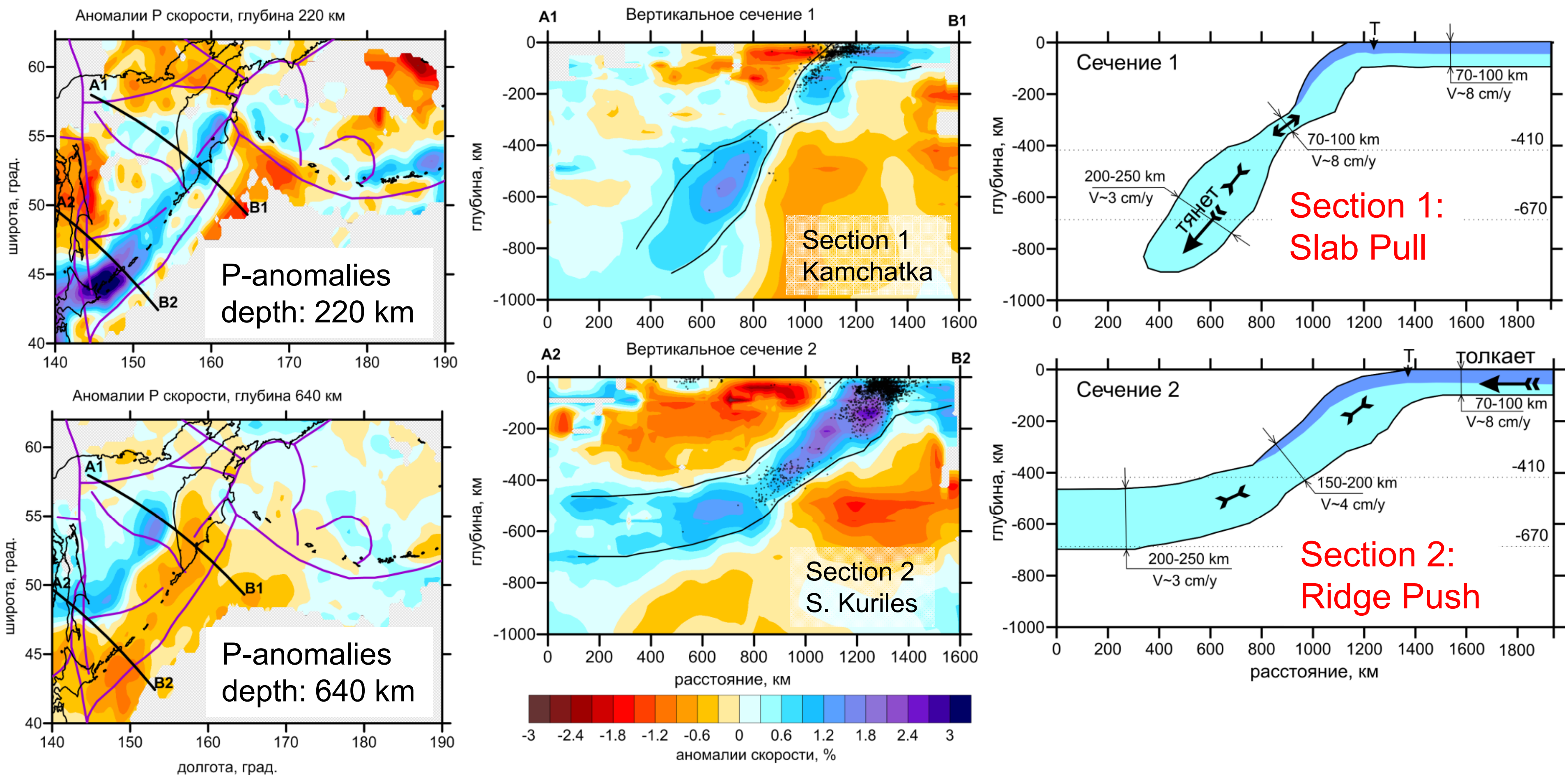
Data used: stations and events from the ISC catalogue

Inversions in three overlapping windows (630, 270 and 240 thousand rays in each)

Separate tuning of inversion parameters in every window depending on data



Seismic structure beneath the Kuril-Kamchatka and Aleutian arcs

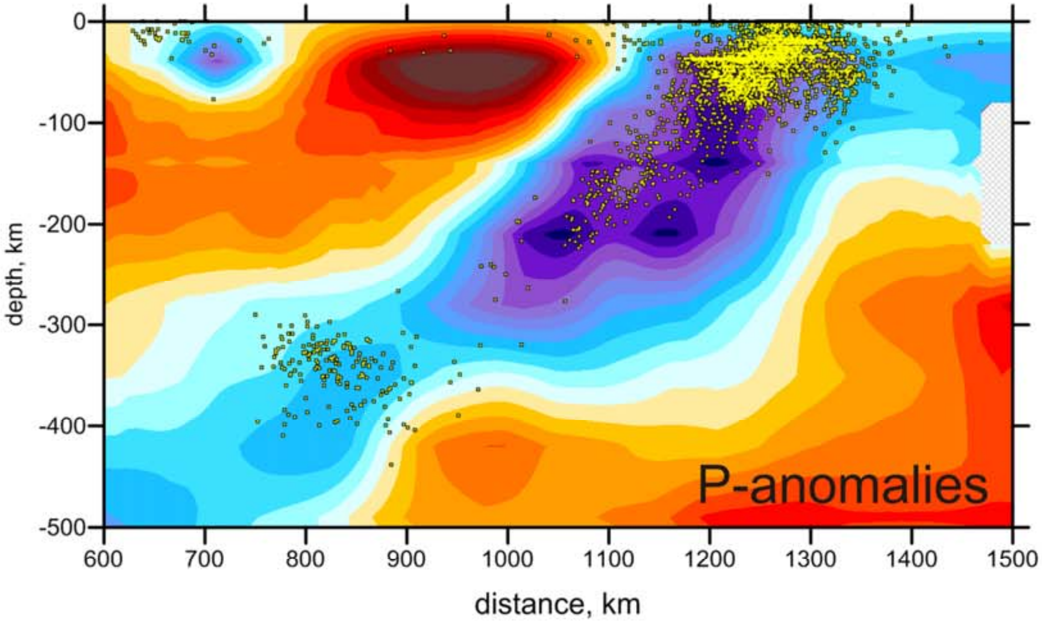


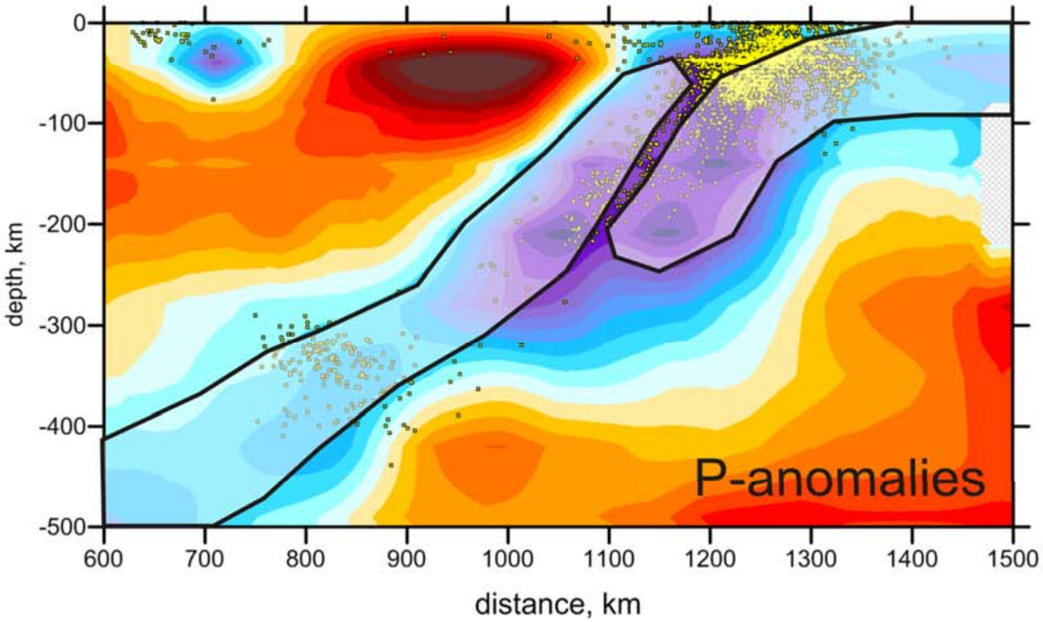
Along the Kur-Kam arc we observe a clear image of the subducting plate

S.Kuriles: thicker and flatter slab; does not penetrate to the lower mantle (**ridge push**)

N.Kuriles-S.Kamchatka: thin in the upper part; large drop in the lower part which penetrates to the lower mantle (**slab pull**)

Possible slab coupling in S. Kuriles (?)

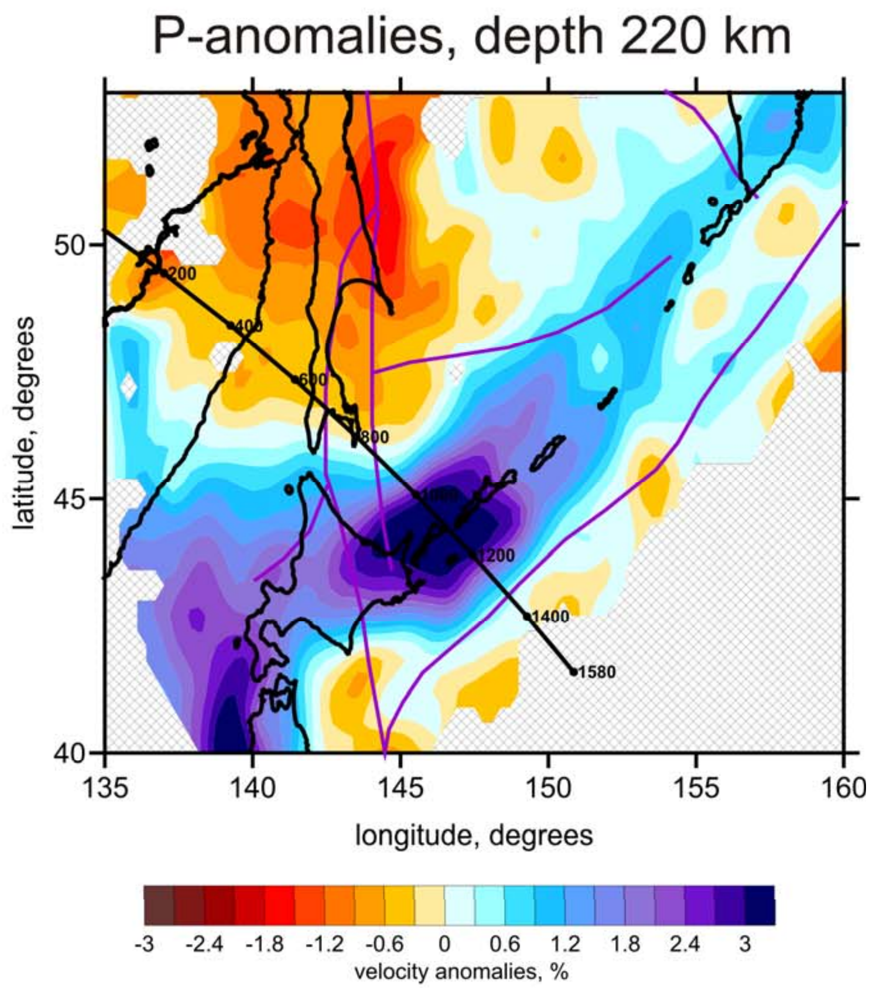




Facts:

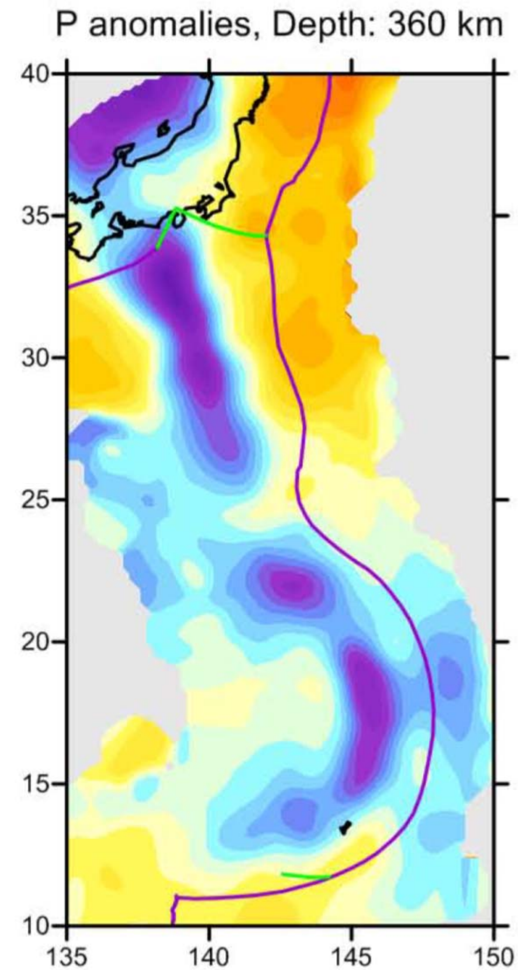
seismicity in the slab

too thick slab down to 300 km depth

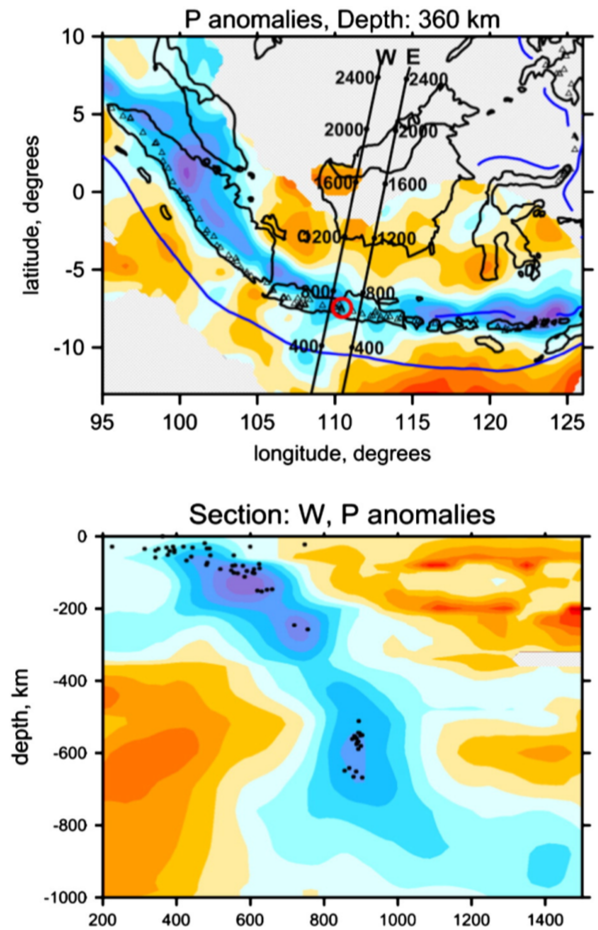


Same method was used to study other subduction zones

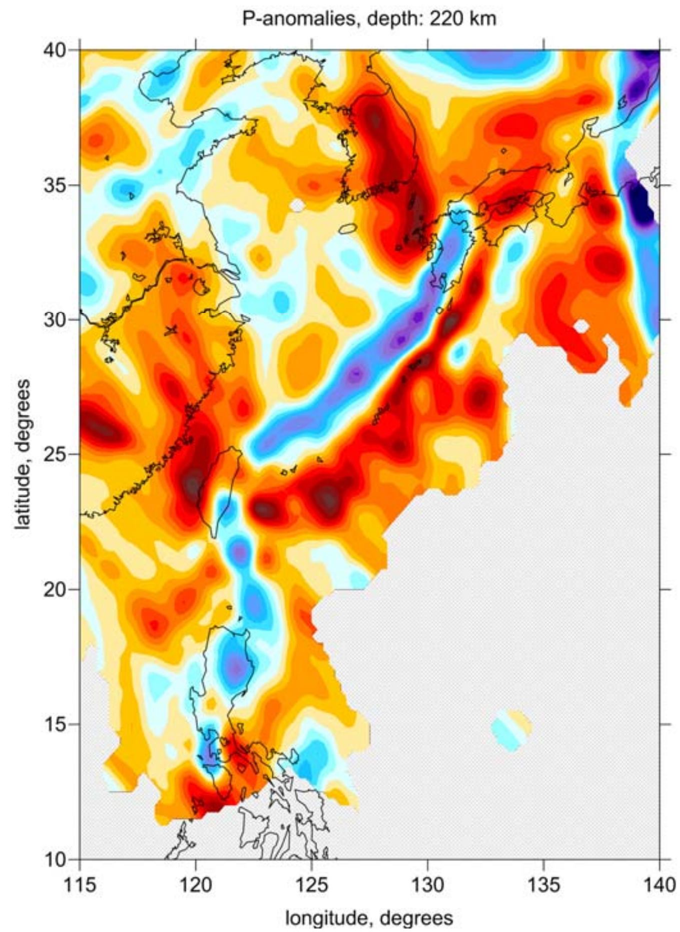
Izu-Bonin and Mariana arcs:



Sunda arc:



Ryu-Kyu and Luzon arcs:

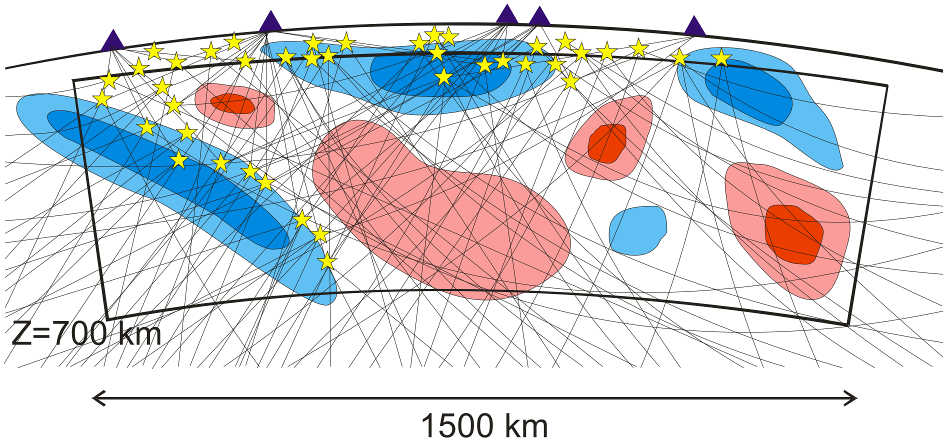


Jaxybulatov K., Koulakov I., Dobretsov N.L., (2013), Solid Earth, 4, 1–15,

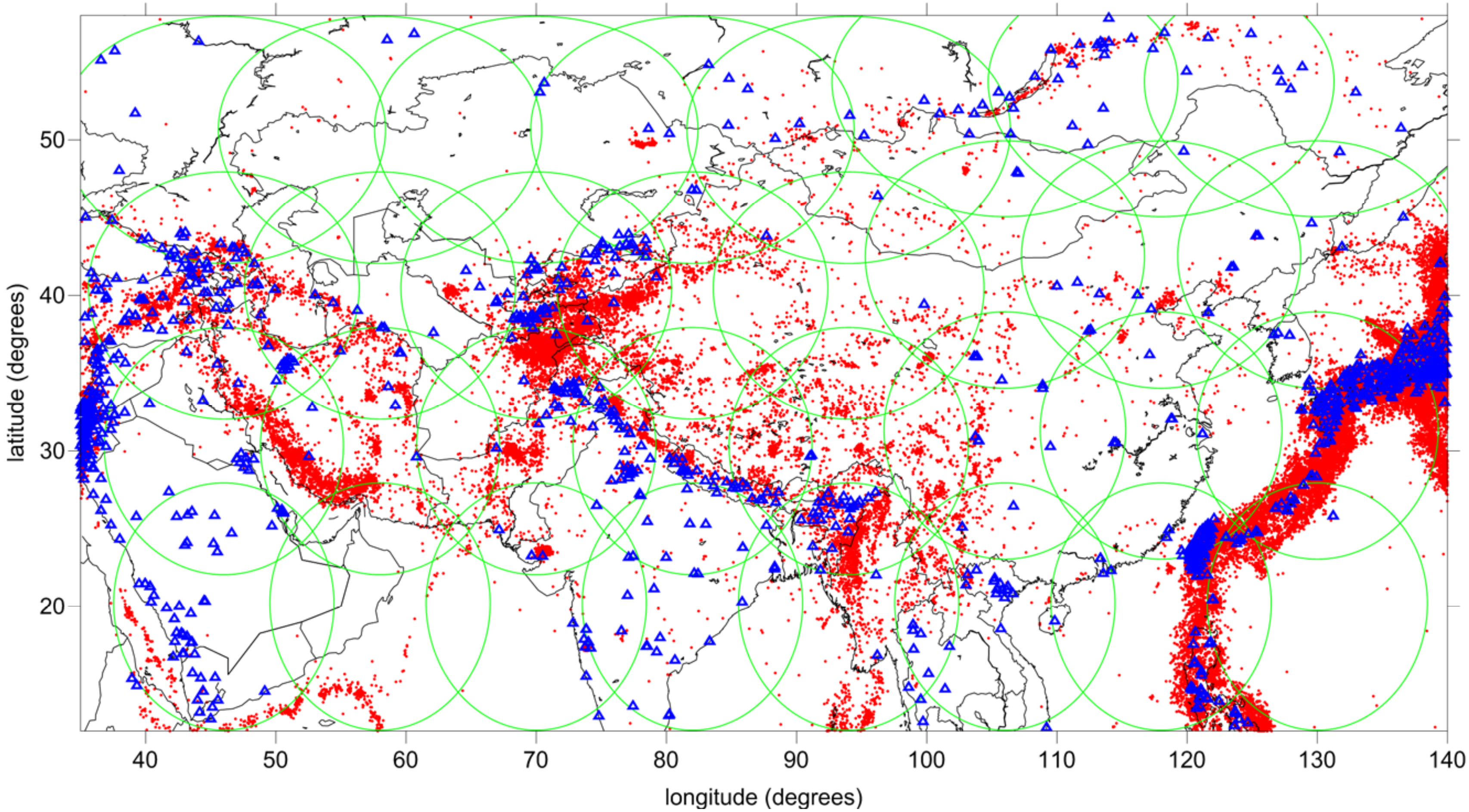
Luehr B.-G., I. Koulakov, W. Rabbel, J. Zschau, A. Ratdomopurbo, K.S. Brotopuspito, P. Fauzi, D.P. Sahara, (2013). JVGR, 261, 7-19

Koulakov, I., Y.-M. Wu, H.-H. Huang, N. Dobretsov, A. Jakovlev, I. Zabelina, K. Jaxybulatov, and V.Chervov, (2014), JAES, 79, 53-64,

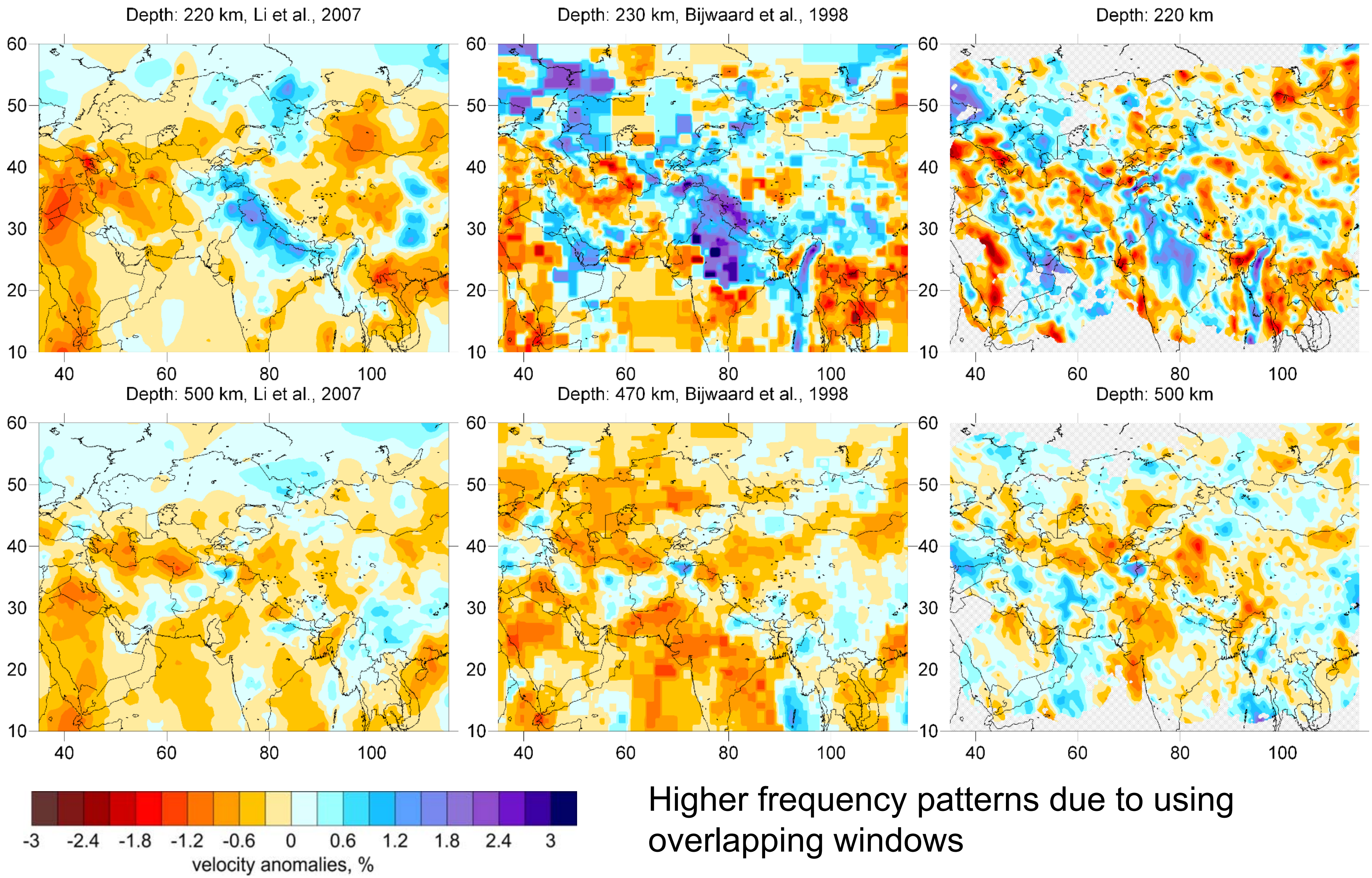
Tomography model of the upper mantle beneath Eurasia



Distributions of the study windows, stations and events from the ISC catalogue:

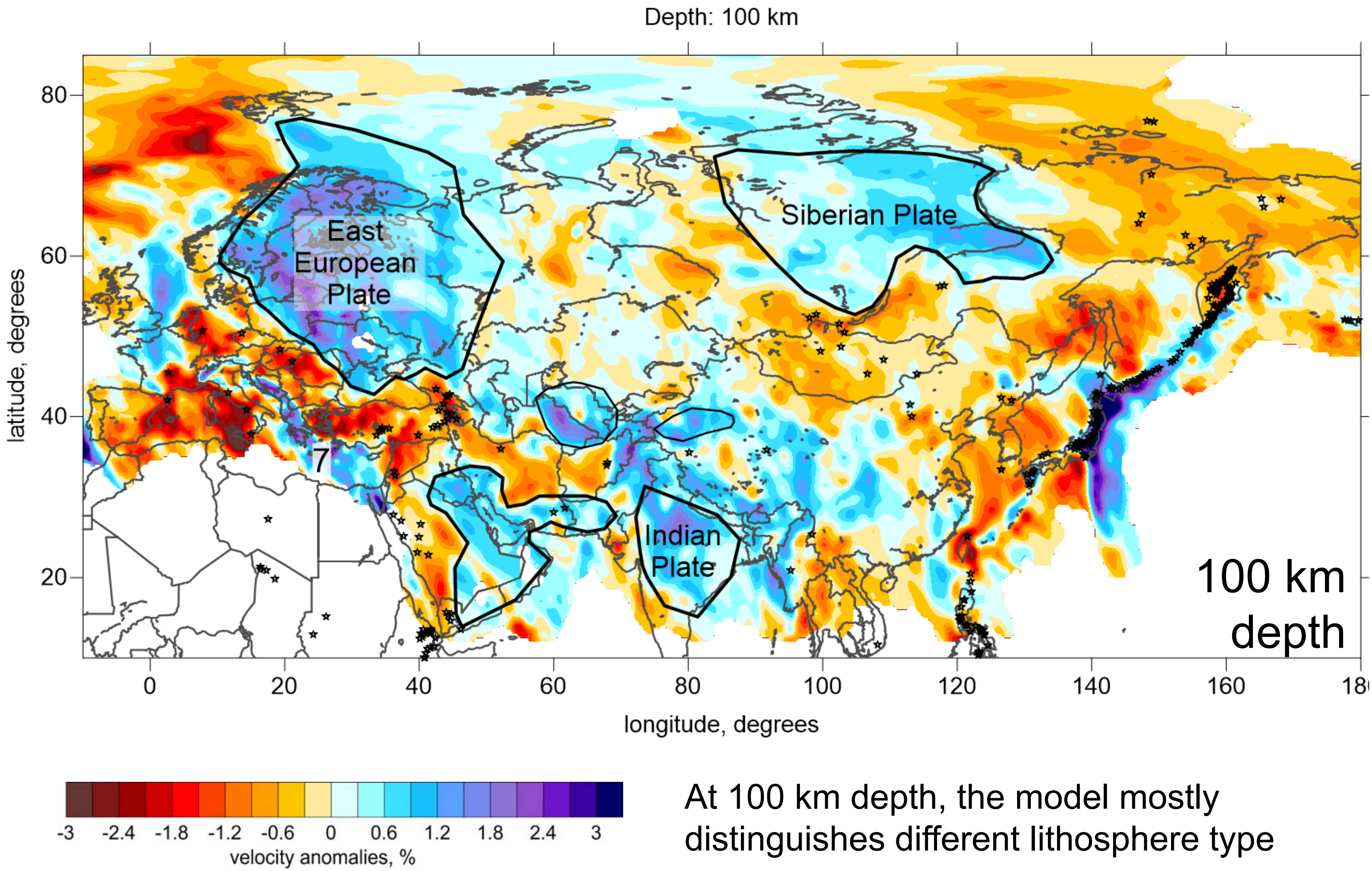


Comparison of three models based on the ISC data



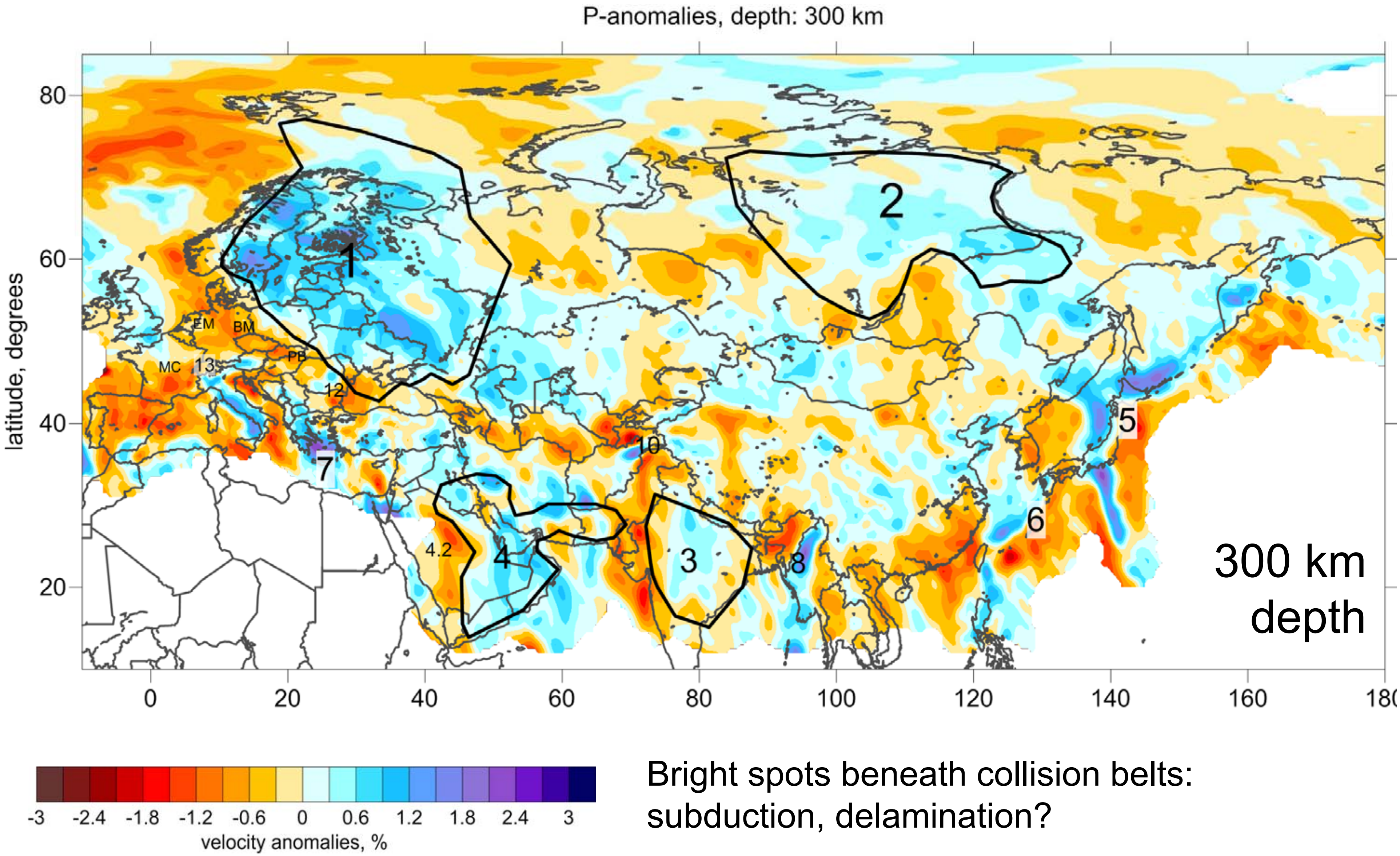
Higher frequency patterns due to using overlapping windows

Upper mantle structure beneath EURASIA



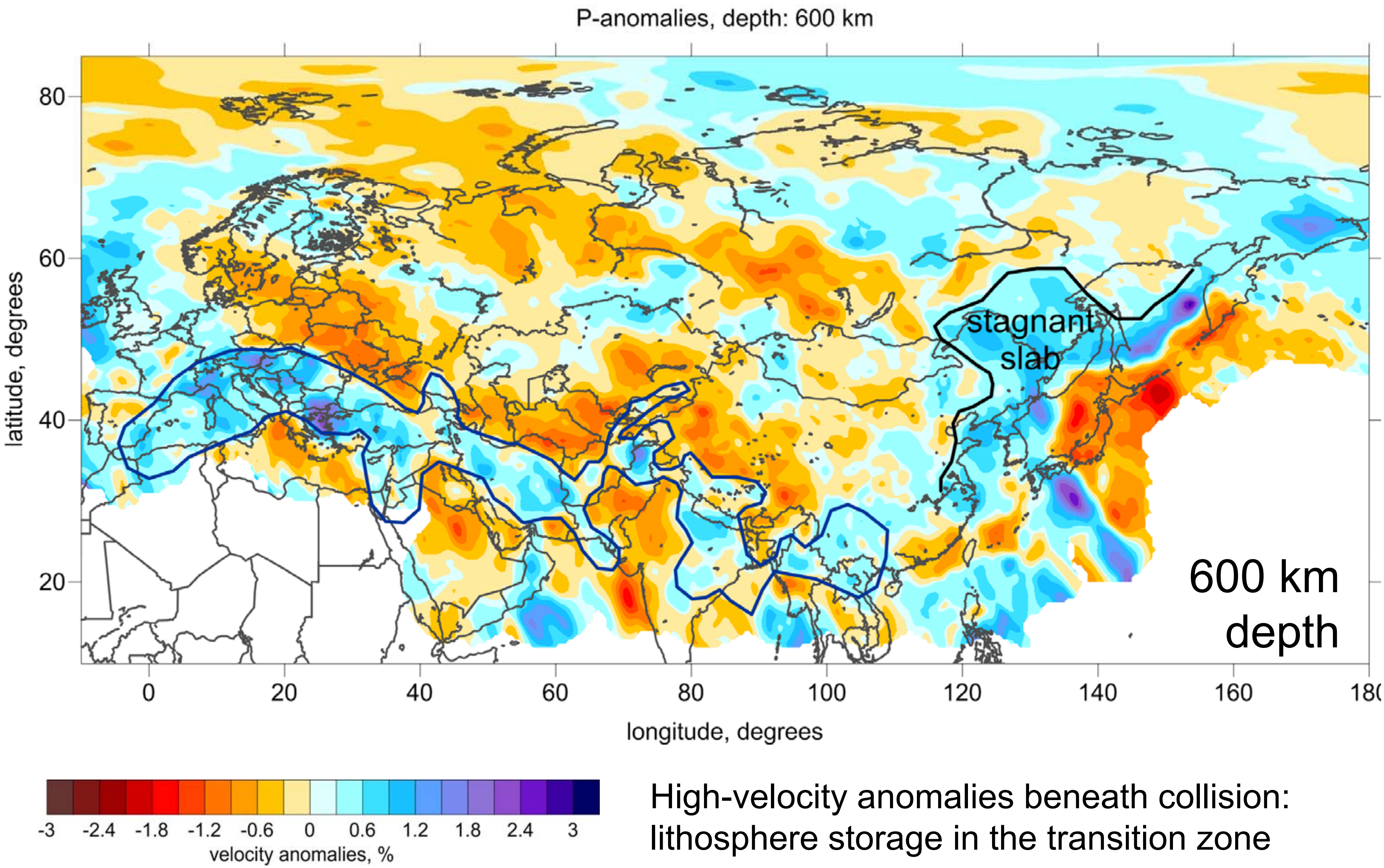
At 100 km depth, the model mostly distinguishes different lithosphere type

Upper mantle structure beneath EURASIA

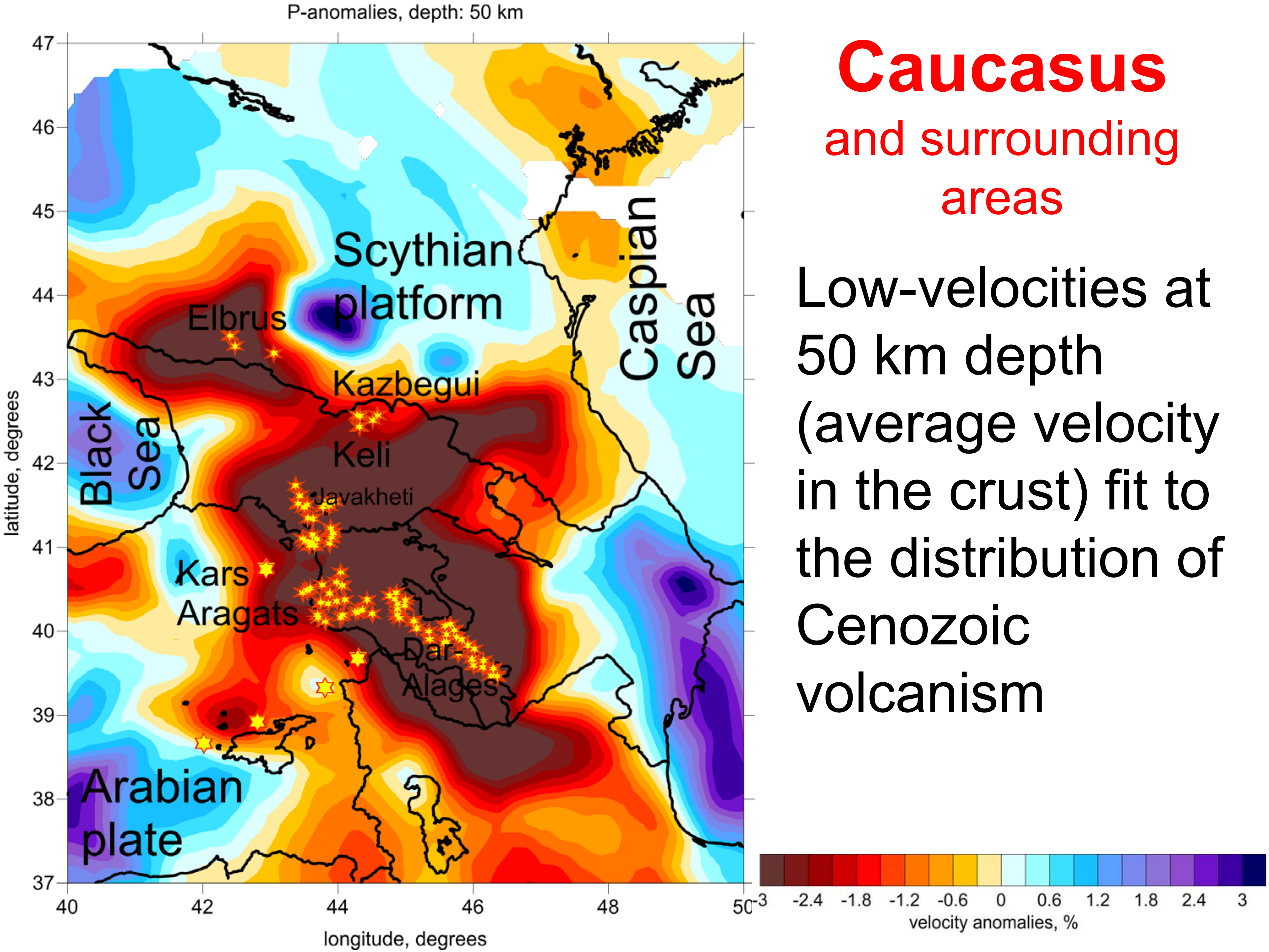


Bright spots beneath collision belts: subduction, delamination?

Upper mantle structure beneath EURASIA



High-velocity anomalies beneath collision: lithosphere storage in the transition zone

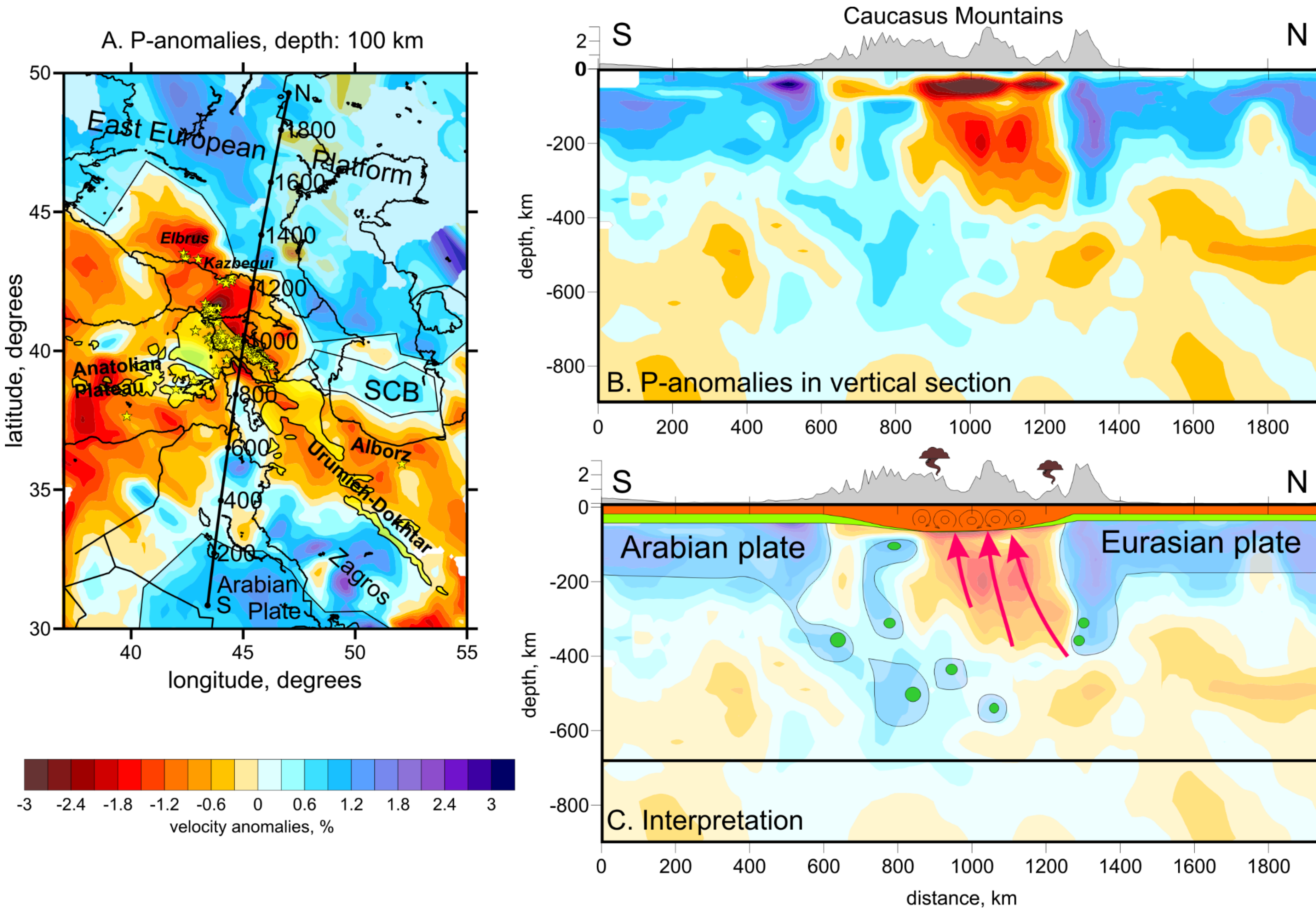


Caucasus

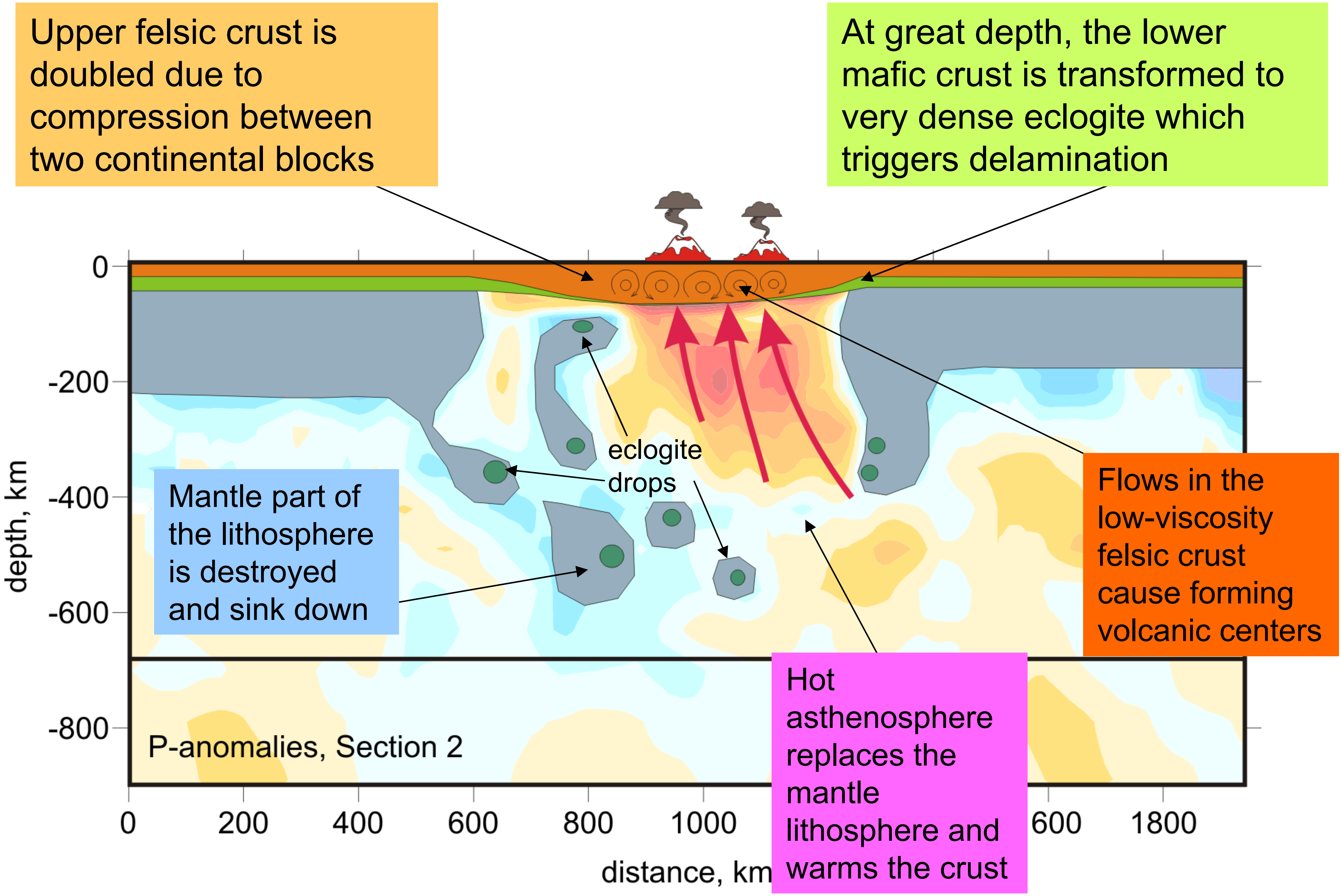
and surrounding areas

Low-velocities at 50 km depth (average velocity in the crust) fit to the distribution of Cenozoic volcanism

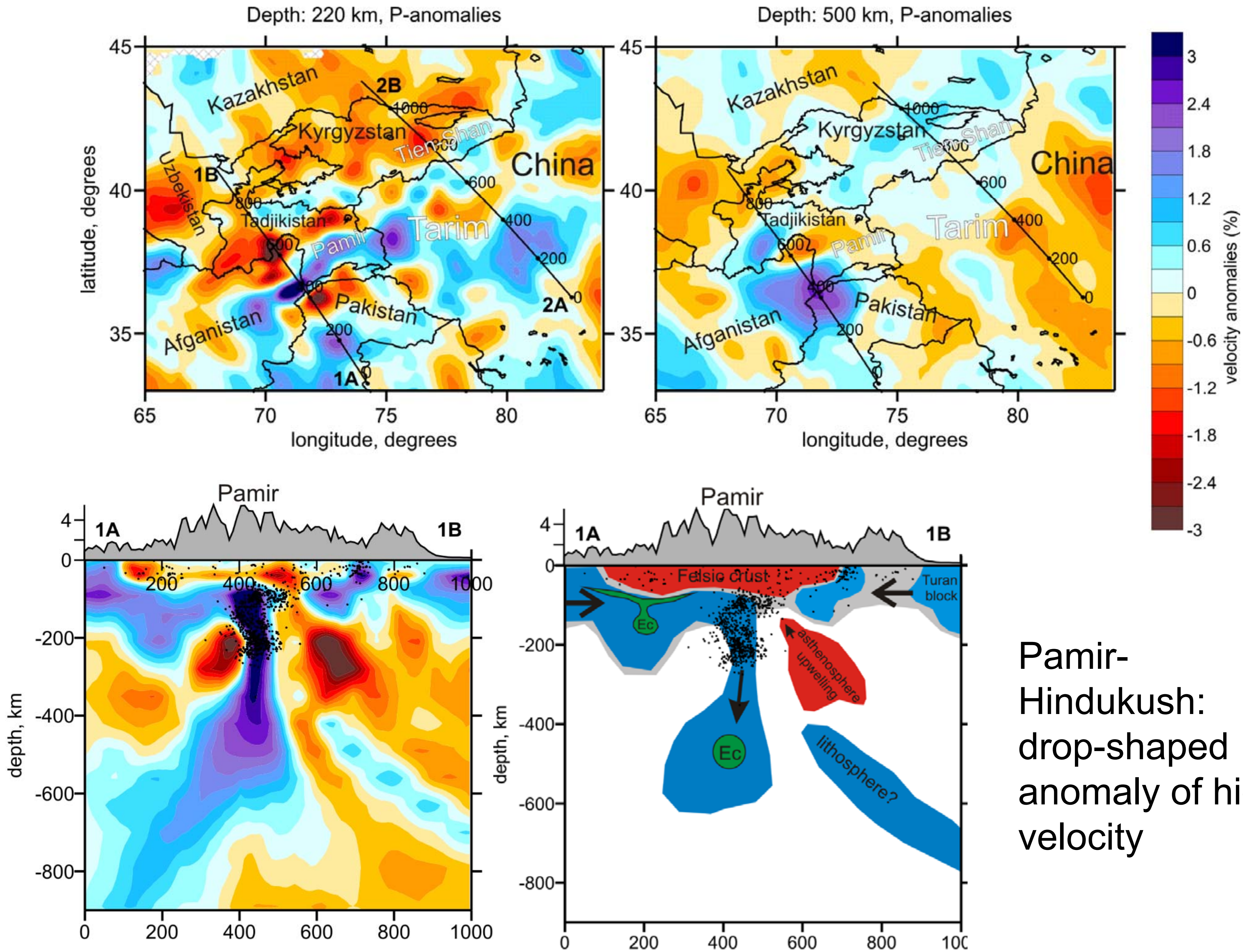
Collision of continental plates in Caucasus and surrounding areas



Interpretation of the tomography result:
destruction of the lithosphere in the collision zone

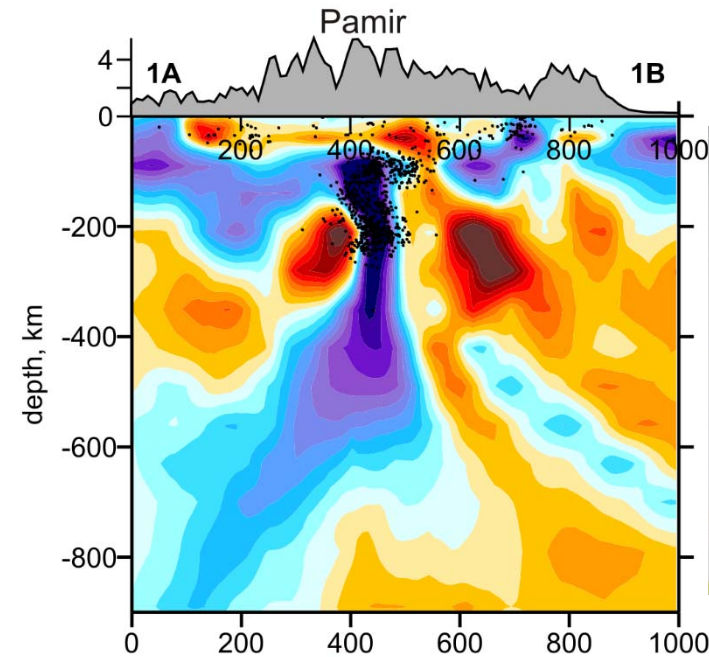


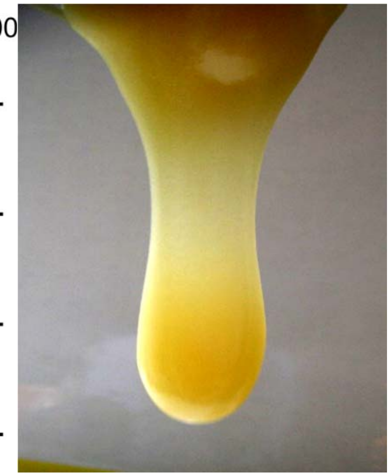
Delamination beneath Pamir and decoupled lithosphere beneath Tien Shan

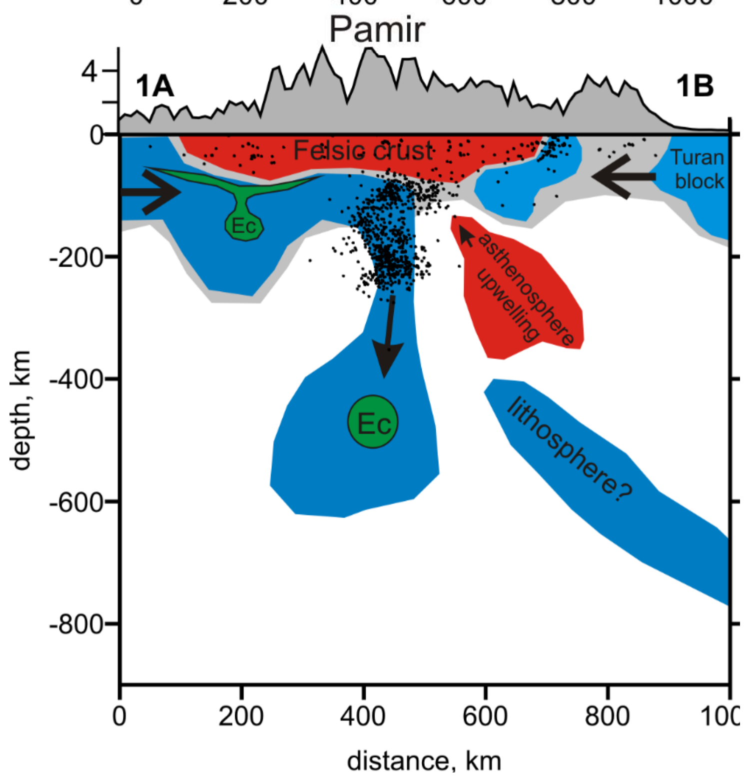


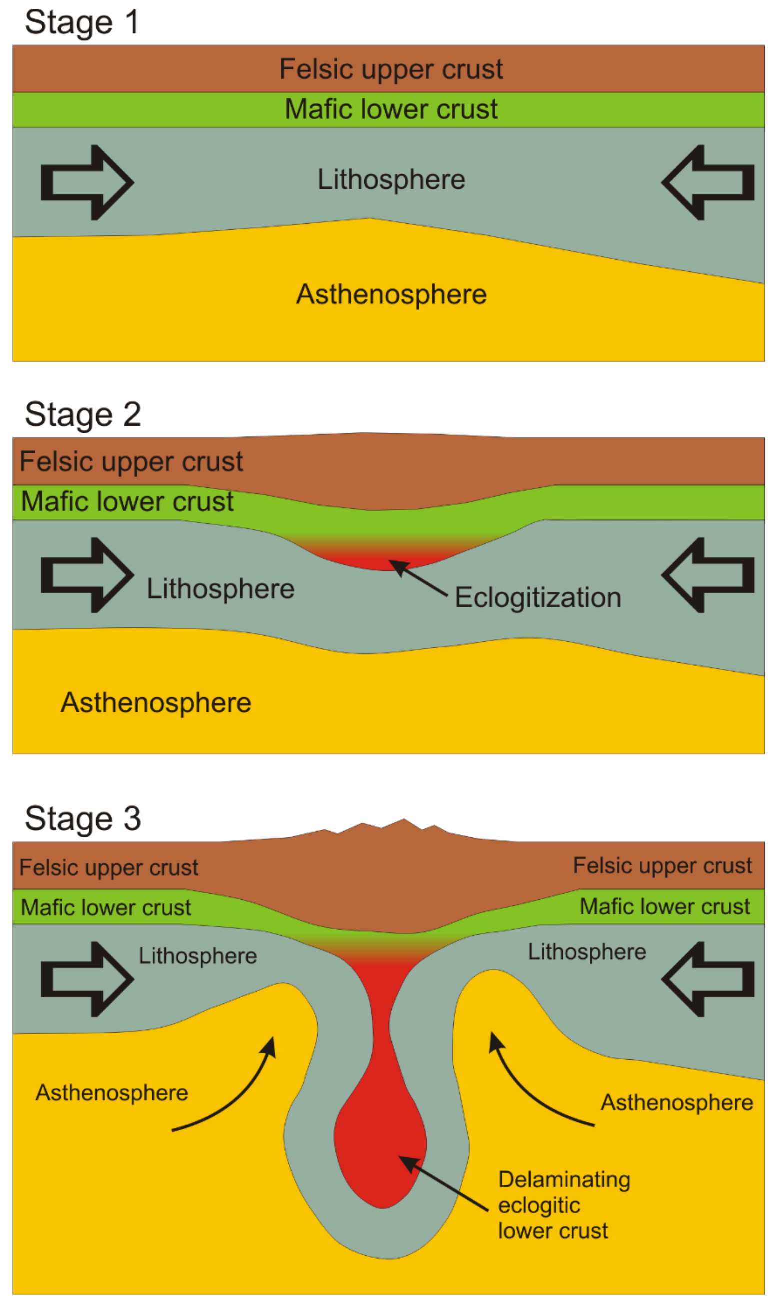
Pamir-Hindukush: drop-shaped anomaly of high-velocity

Drop forming beneath Pamir

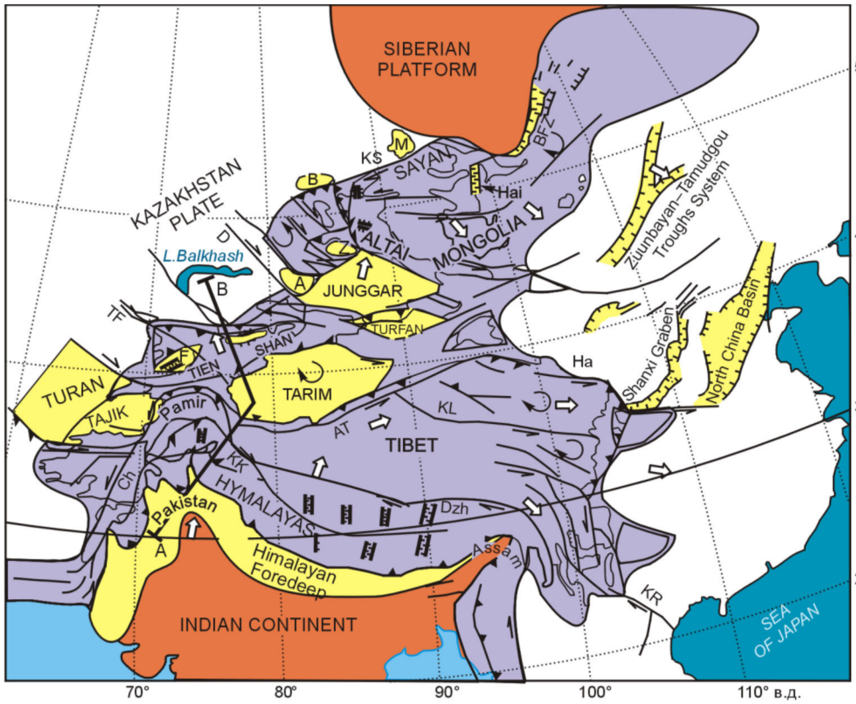


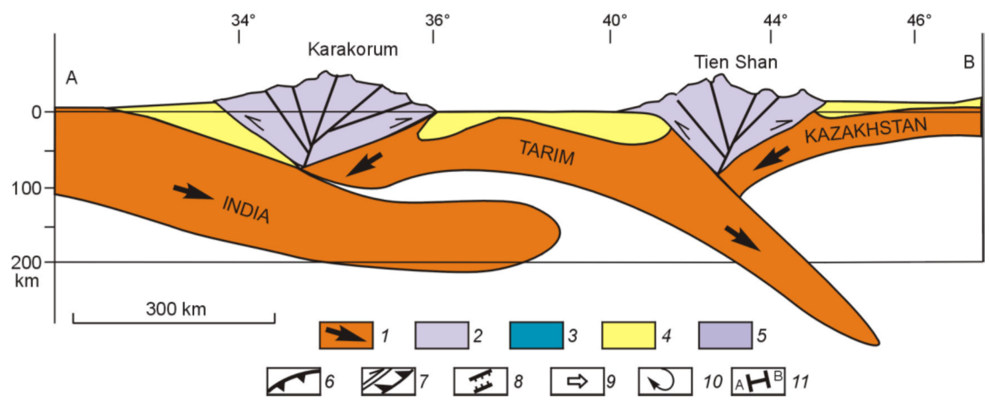


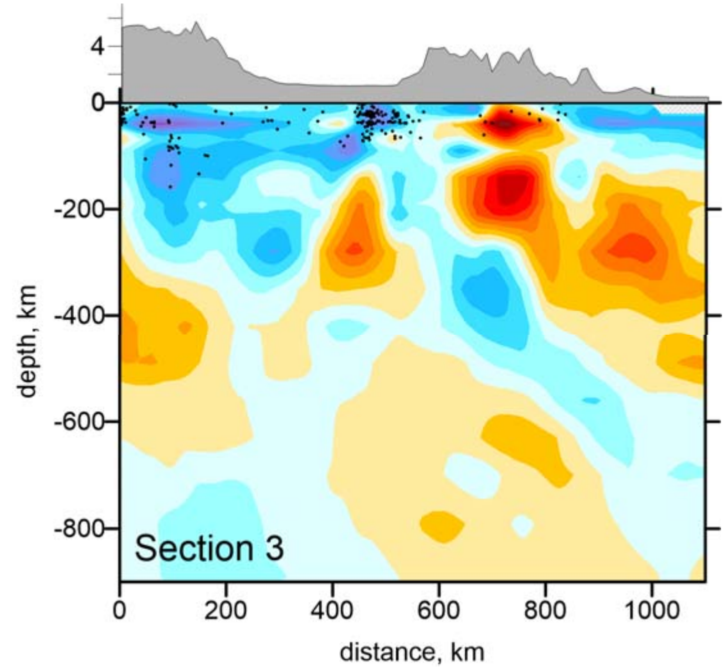


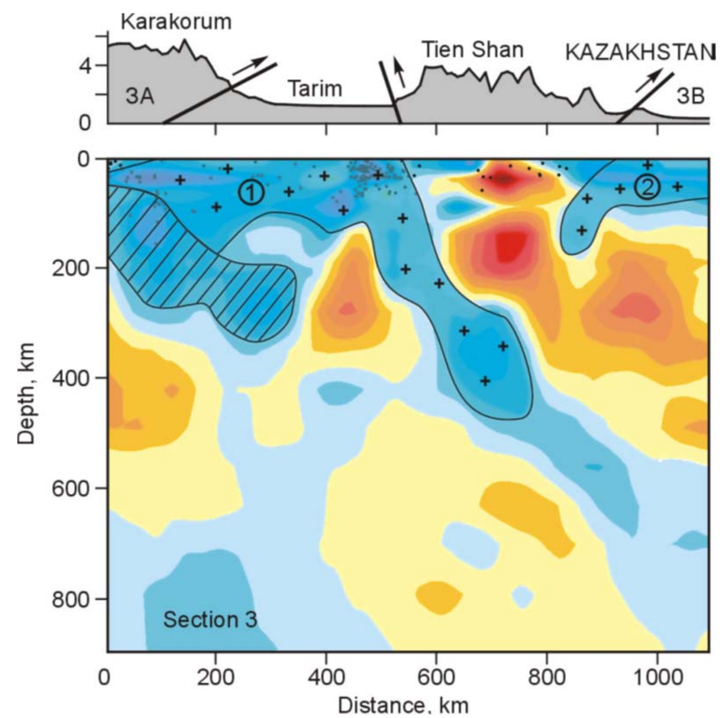


Underplating beneath Tien Shan?









Buslov, M.M., De Grave, J., Bataleva, E.A., 2004. Cenozoic tectonics and geodynamic evolution of the Tien Shan mountain belt as response to India-Eurasia convergence. Himalayan J. Sci. 2 (4), 106–107.

Conclusions:

1. ISC is a very important dataset providing valuable information for regional and global tomography models.

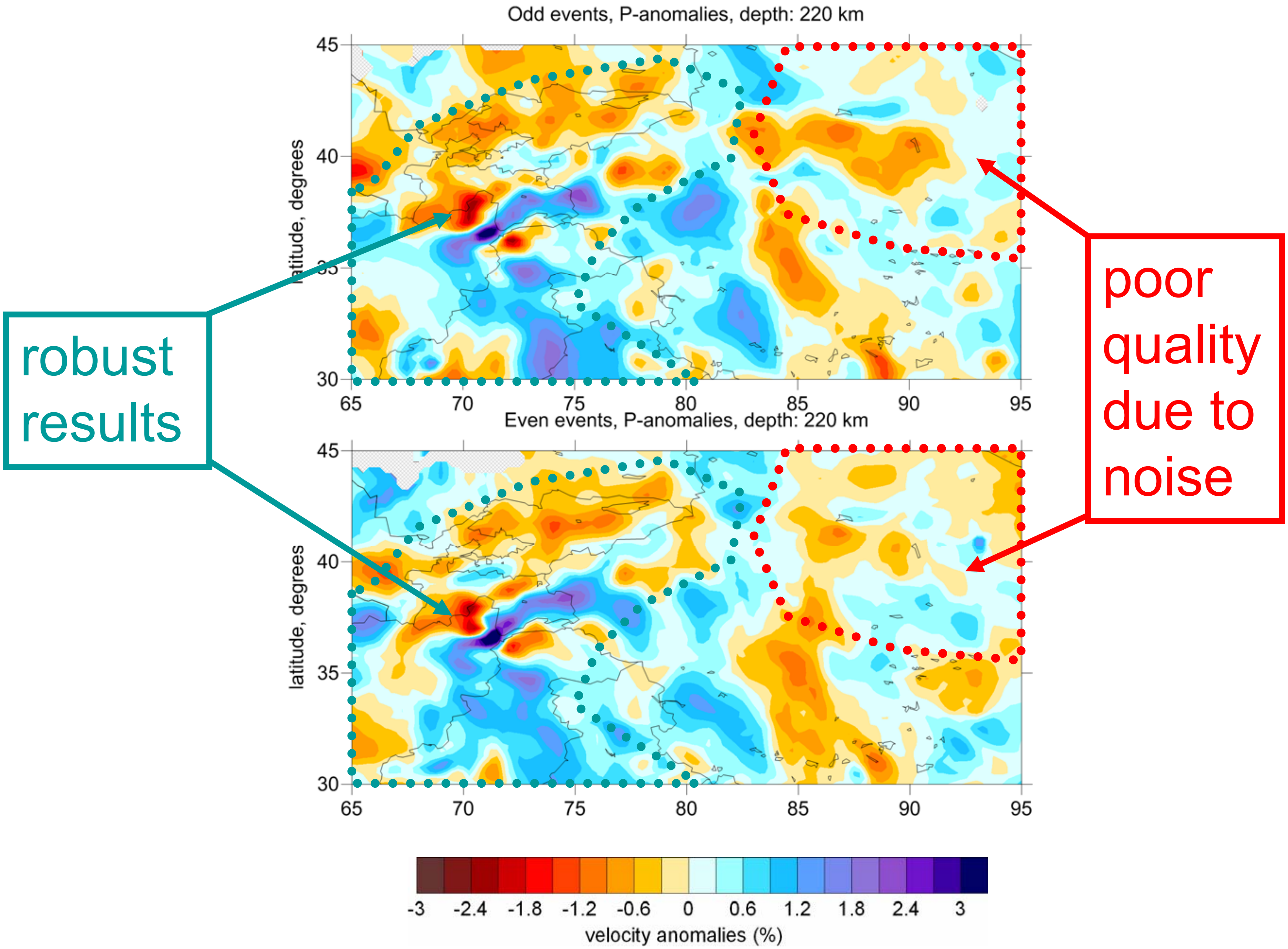
2. Subduction zones are the best targets for studying using the travel times from the ISC catalogue.

3. Studying shapes of the slabs help in identifying driving forces of subduction.

4. In areas of continental collision, seismic tomography reveals complex mechanisms of underplating and delamination of the lithosphere.

Many thanks to the ISC staff for their valuable work!

Odd/even test – most important for noisy data



Regional inversions in overlapping windows

Synthetic modeling to show weak influence of outside anomalies