https://doi.org/10.5194/egusphere-egu2020-4539

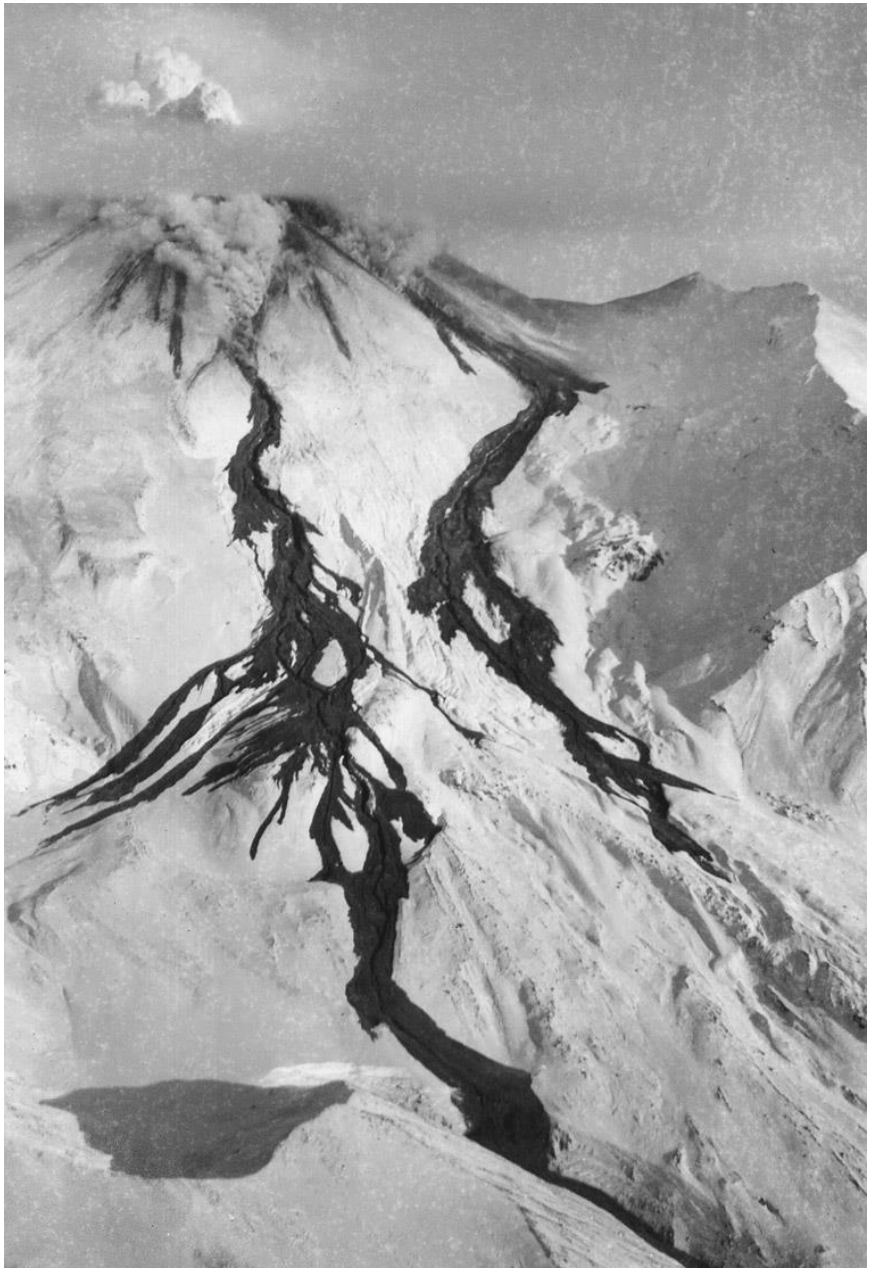
Tomographic images of Avacha and Koryaksky volcanoes in Kamchatka

Natalia Bushenkova[1,2], Ivan Koulakov[1,2], Sergey Senyukov[3], Evgeny I. Gordeev[4], Hsin-Hua Huang[5], Sami El Khrepy[6,7], Nassir Al Arifi[6]

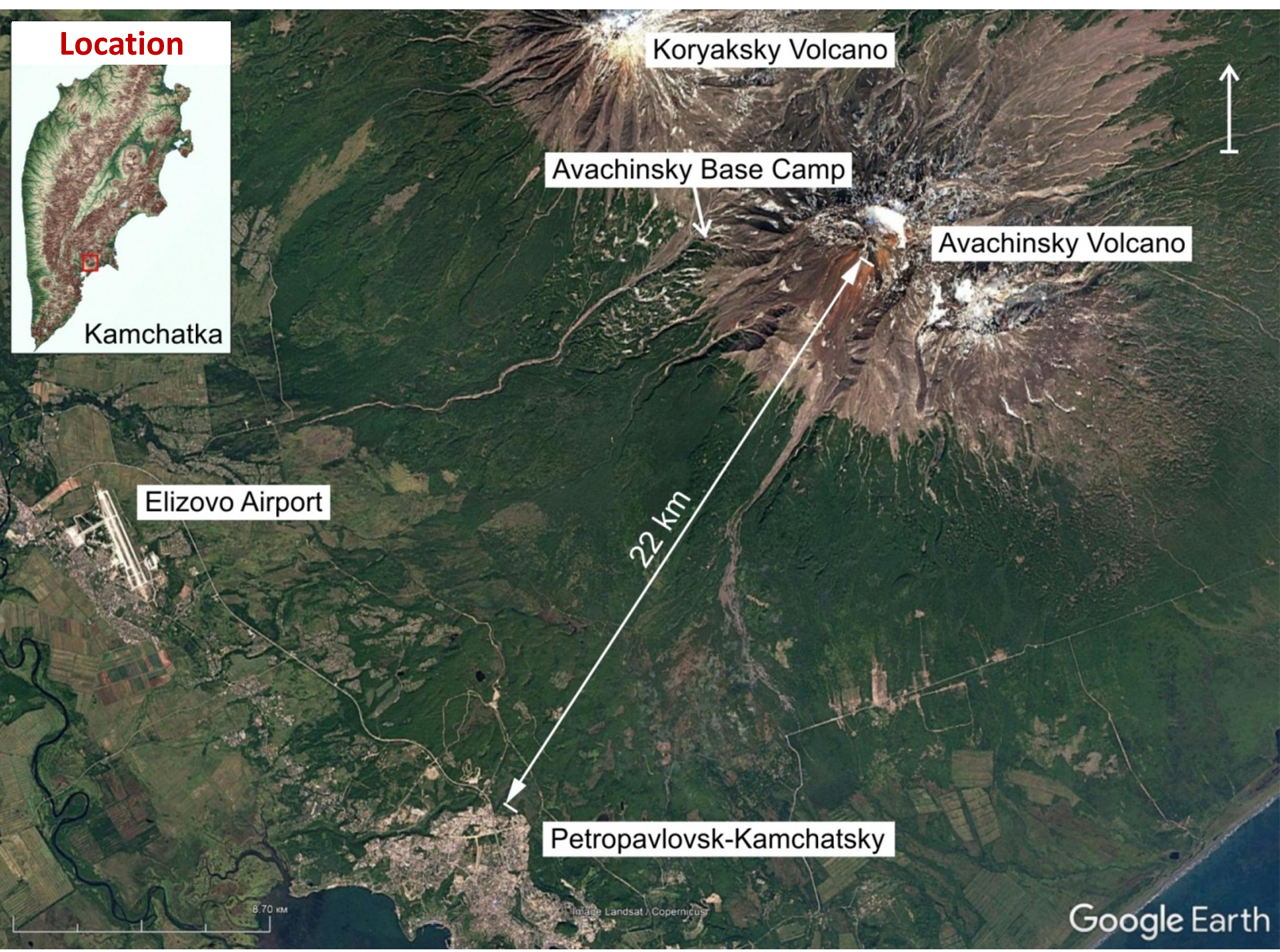
[1]IPGG SB RAS, Geophysics (bushenkova@gmail.com, ivan.science@gmail.com) and [2]NSU, Novosibirsk, Russian Federation;
[3]KB GS RAS (ssl@emsd.ru) and [4]IVS FEB RAS (gordeev@kscnet.ru, Petropavlovsk-Kamchatsky, Russian Federation;
[5]IES AS, Taipei, Taiwan (hhhuang@earth.sinica.edu.tw); [6]KSU, Riyadh, Saudi Arabia (k_sami11@yahoo.com, nalarifi@ksu.edu.sa); [7]NRIAG, Helwan, Egypt

Avacha and Koryaksky are the home volcanoes of Petropavlovsk-Kamchatsky. Pride and the main attraction of the city, but represent real hazard.

Avacha eruption in 1945



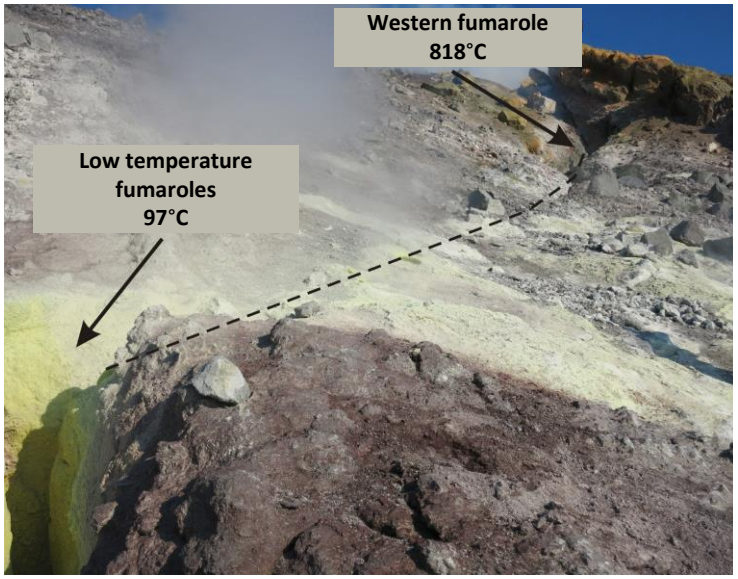
Lahars on Avacha
during the eruption in 1991


Location
Kamchatka
Koryaksky Volcano
Avachinsky Base Camp
Avachinsky Volcano
22 km
Elizovo Airport
Petropavlovsk-Kamchatsky
8.70 км
Image Landsat / Copernicus
Google Earth


Presently, the crater is filled by the lava cork. The fissure may lead to a large landslide and trigger an explosive eruption.
Photo by Ivan Koulakov

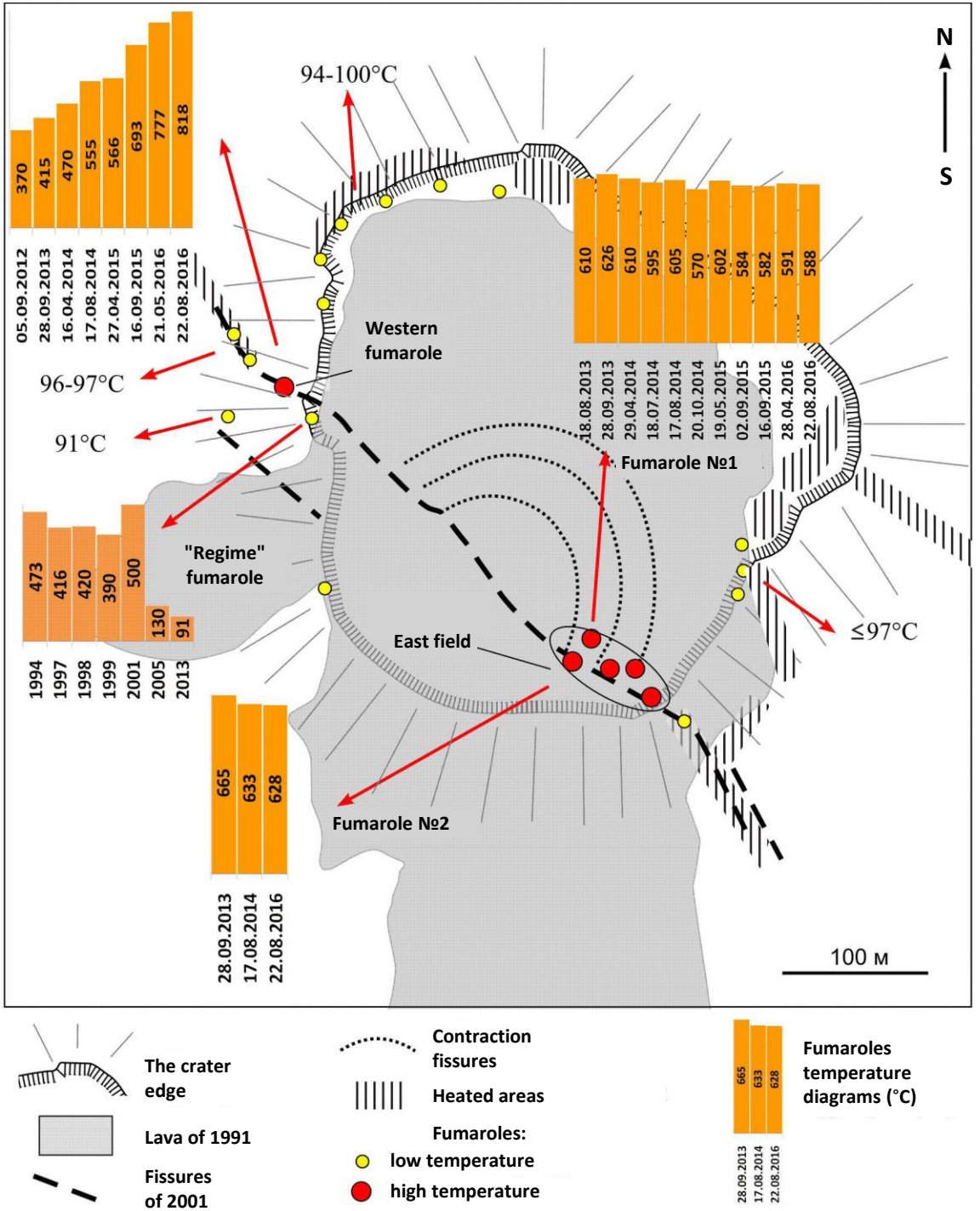
Fumarolic activity of the Avacha volcano

Malik et al., 2017,
http://www.kscnet.ru/journal/kraesc/article/view/115



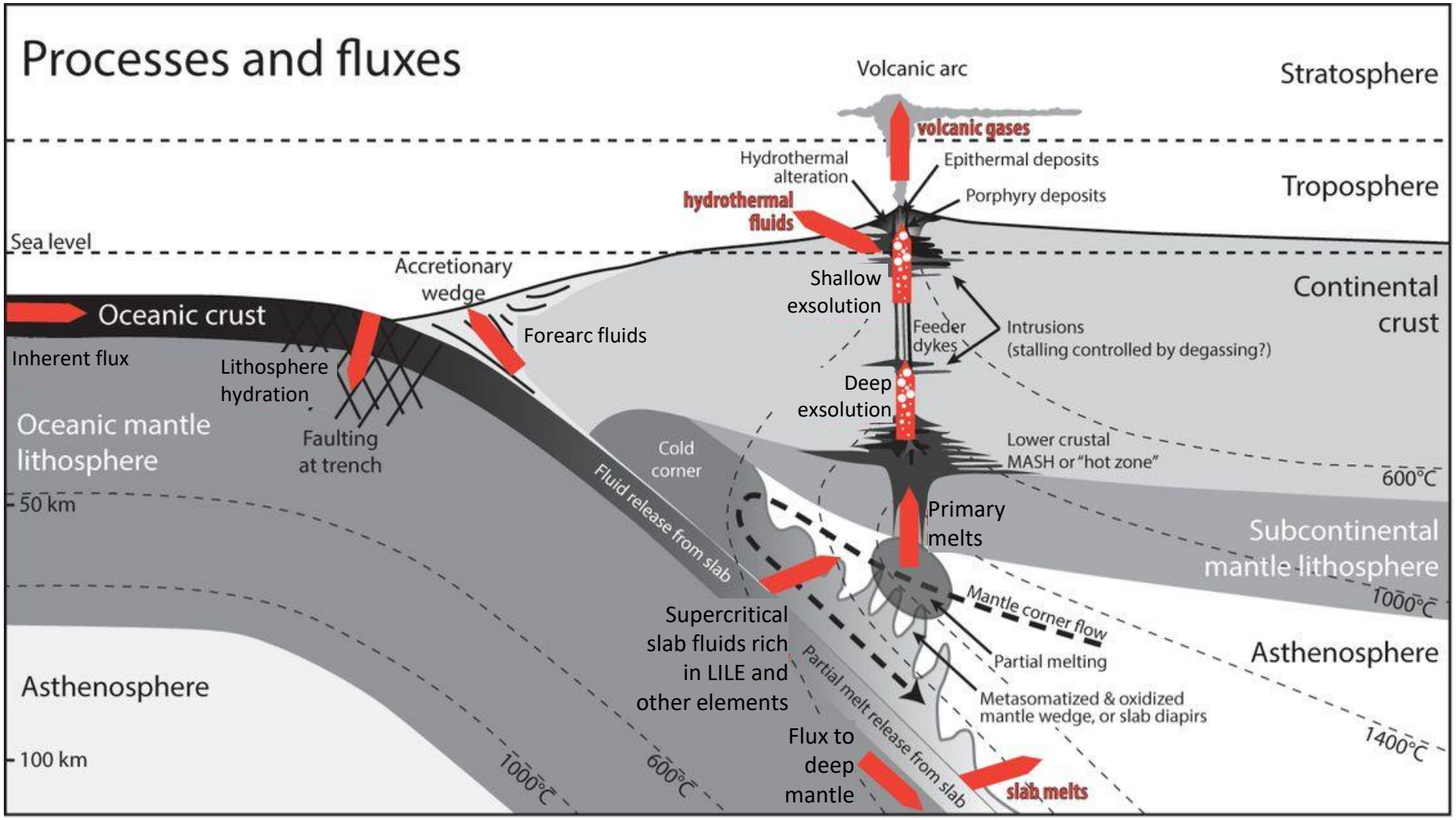
Temperature is more than 800°C

5.5 kTons per day
92% - water,
5.6% - CO_2,
5.1% - SO_2 ,
0.58% - H_2S.



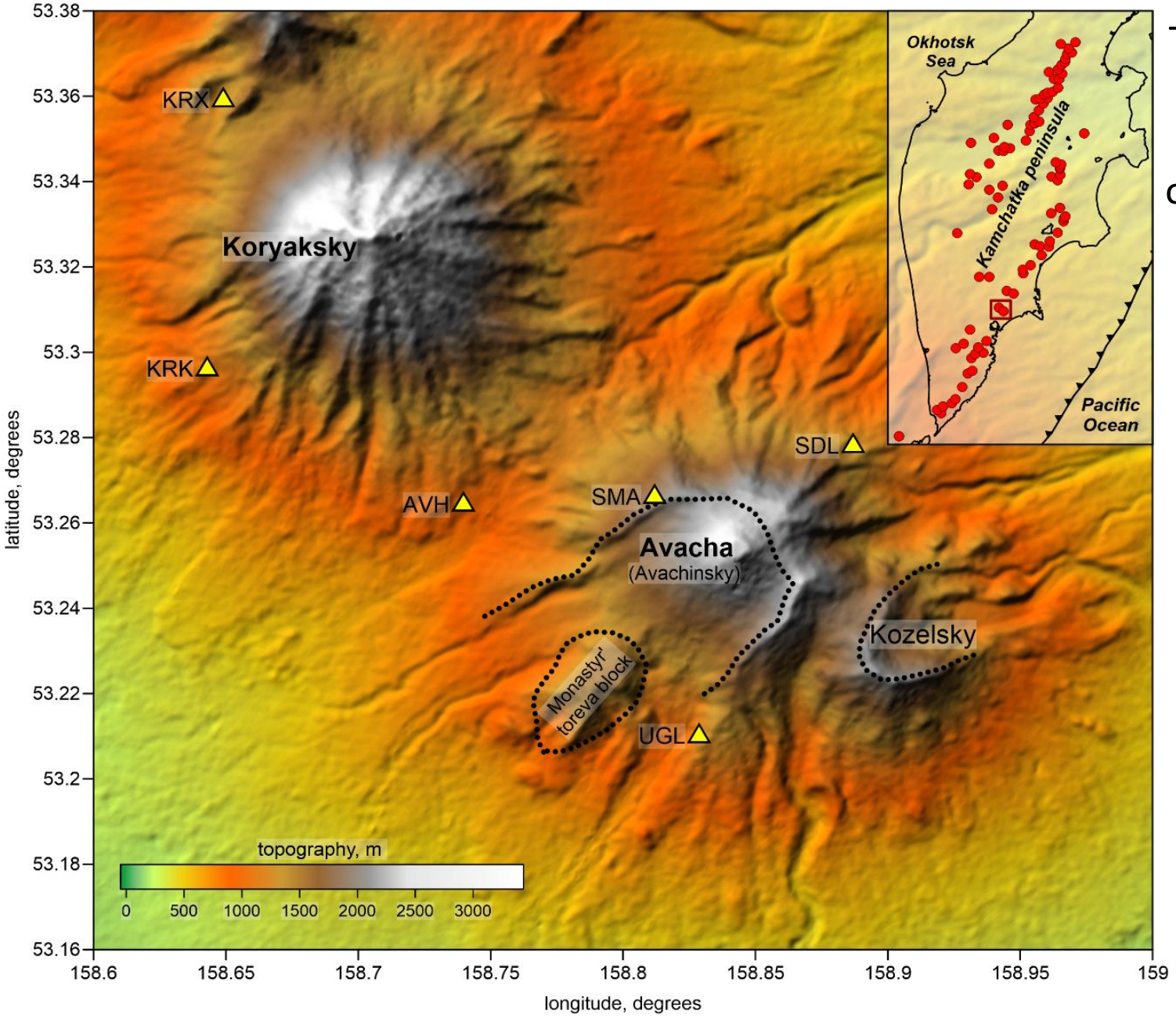
Crater of the Avacha volcano in 2018

Subduction is a complex system, in which several mechanical, chemical and thermal processes coexist, volatiles are the key elements in the system



(Zellmer et al., 2014, https://doi.org/10.1144/SP410.13)

Permanent seismic network on Avacha



Telemetric seismic stations of the KBGS: 7 stations on the Avacha and Koryaksky volcanoes + several stations in the surrounding areas

The place of local seismic tomography in multi-scale seismic studies of the volcanoes feeding process in subduction zones

Active source deep seismic sounding

DSS

LET

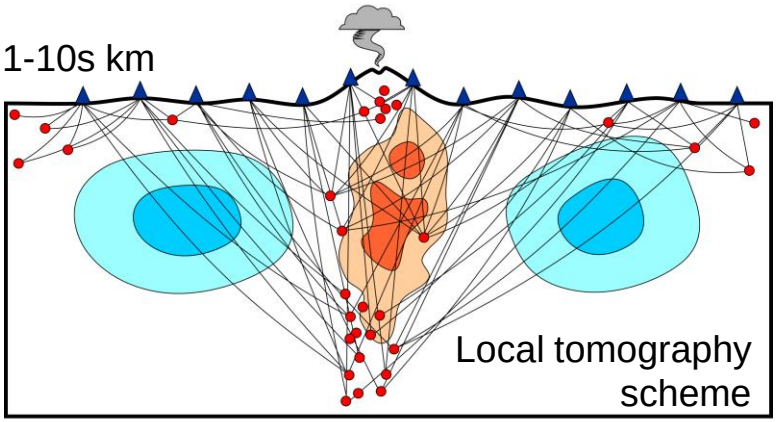
Local earthquake tomography

100-150 km

250-350 km

550-650 km

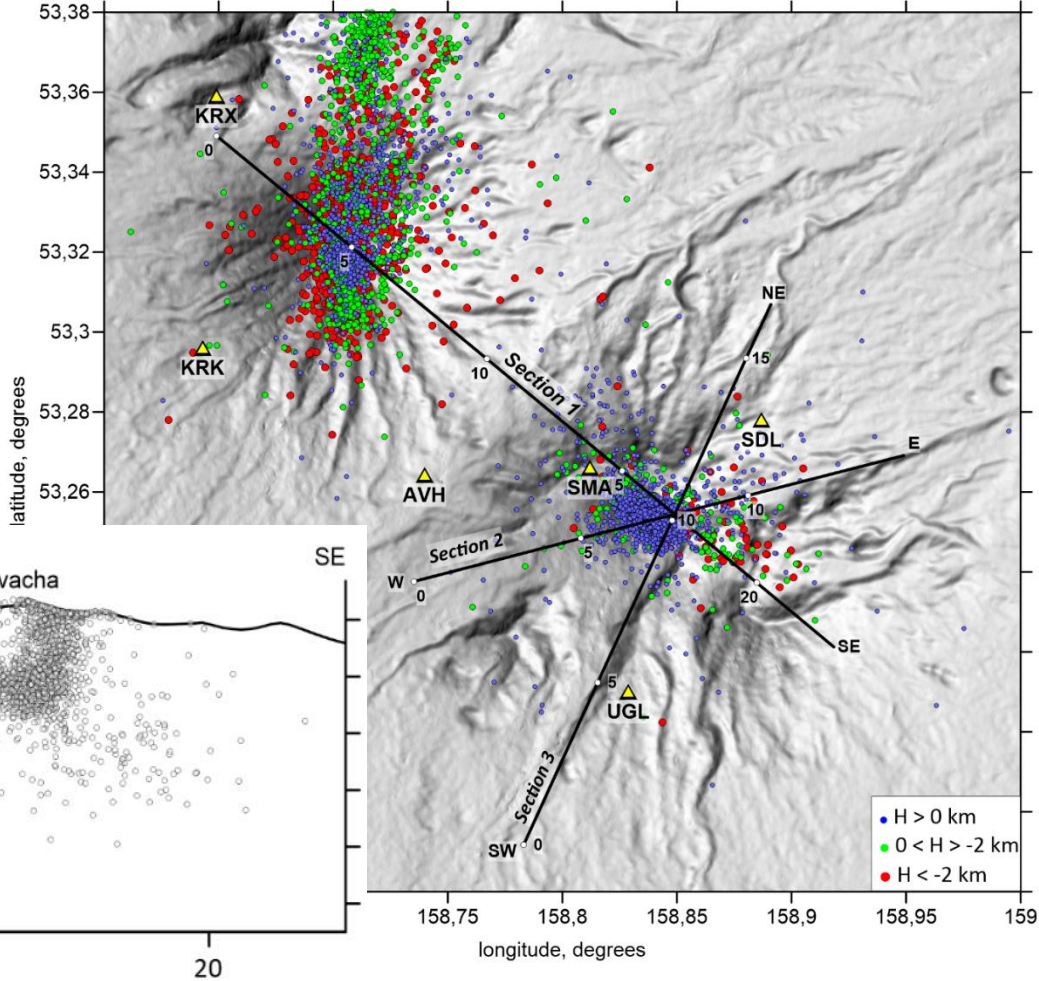
Global

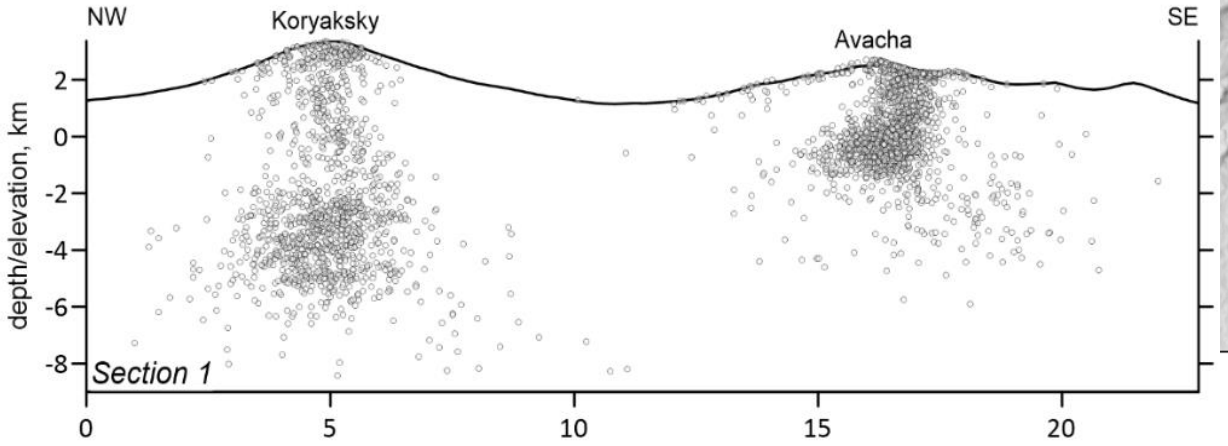


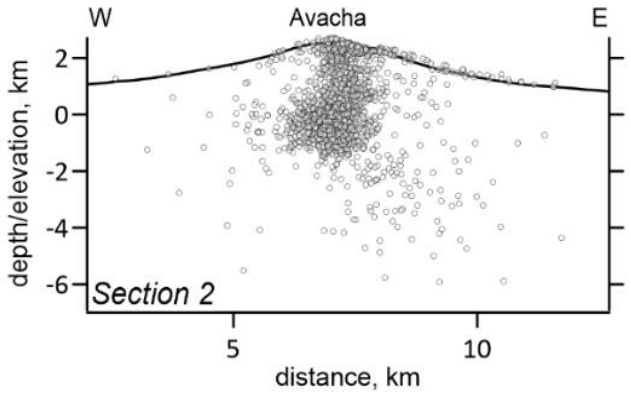
Regional modeling based on global catalogues

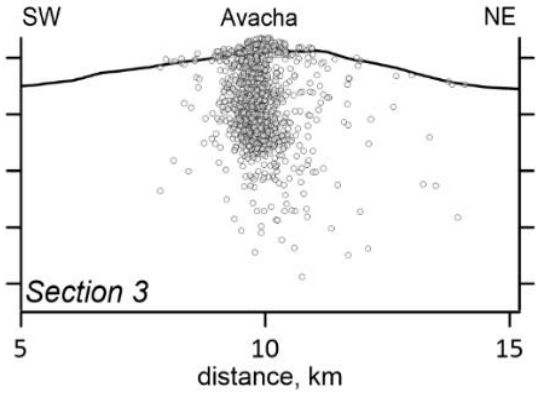
Seismic data for tomography

Large amount of local events in the period from 01.01.2009 to 31.12.2018

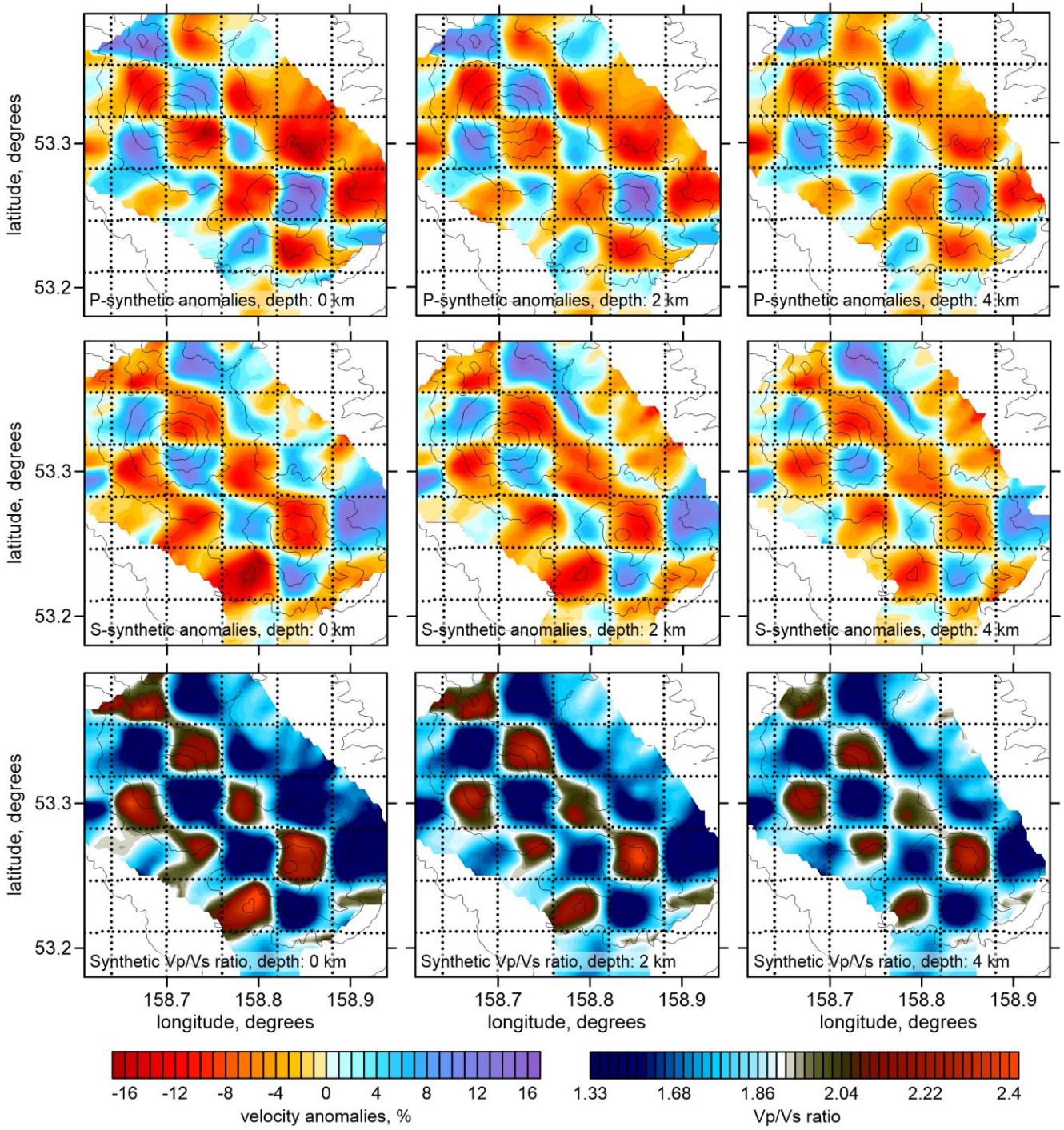








For tomography, we used:
4,819 events,
24,645 P-waves,
18,876 S-waves.
~9 picks per event.



Checkerboard test

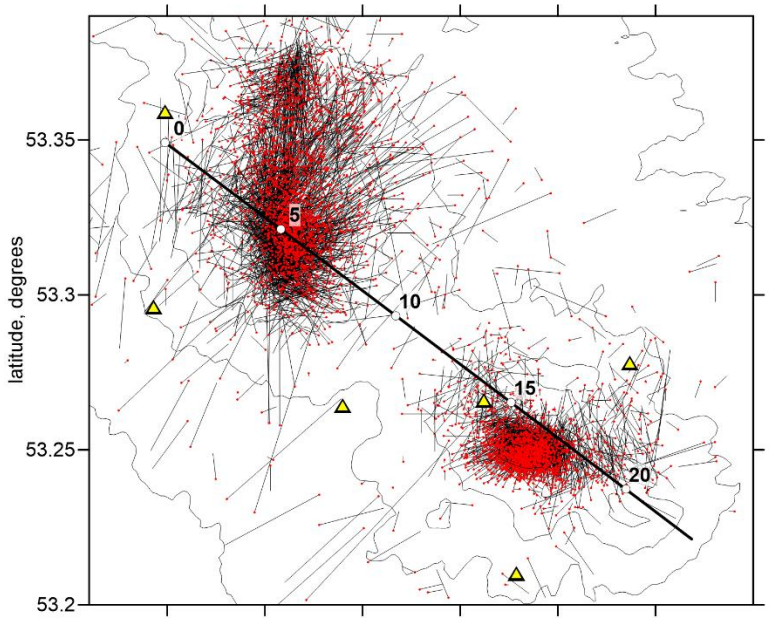
for checking the lateral resolution of the tomography results

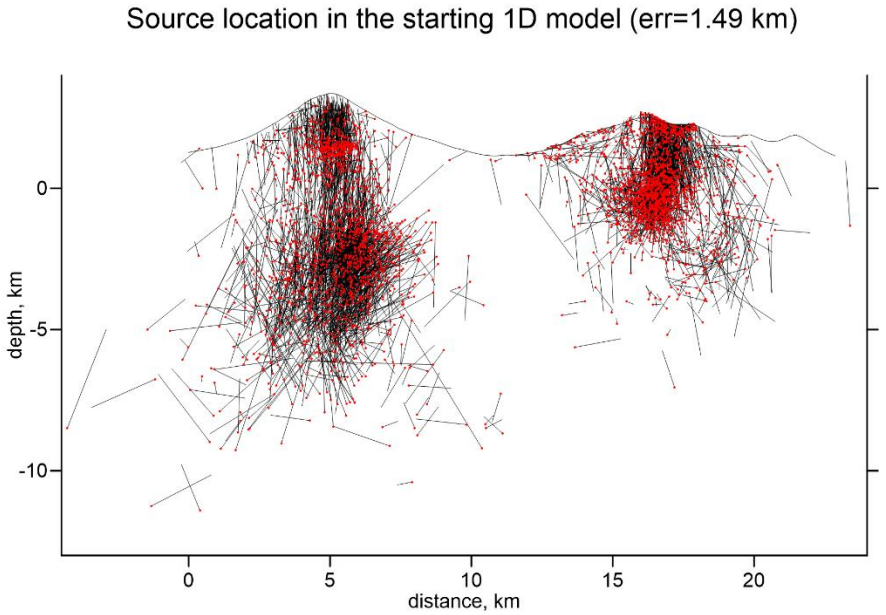
The test with alternating anomalies of 4 km lateral size, without changes in depth. Thin lines depict relief contours with a step of 500 km.

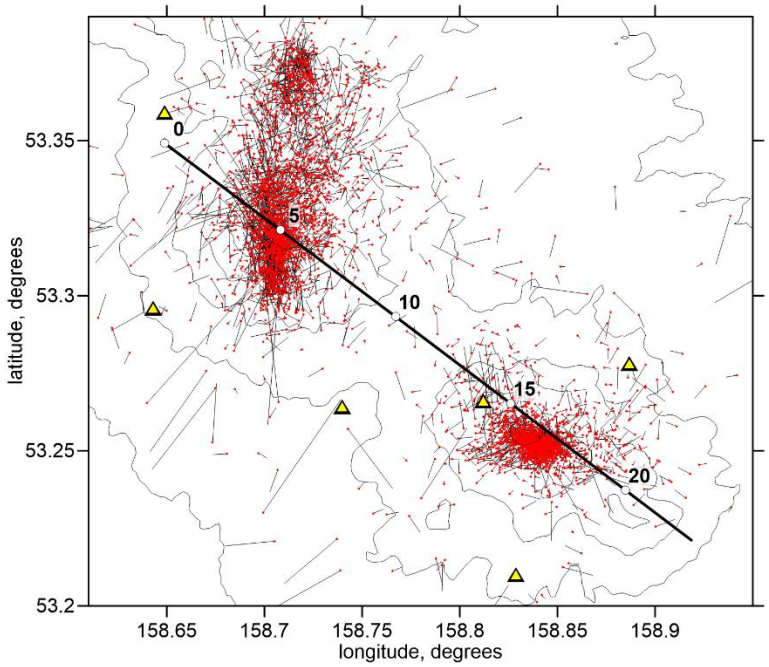
Dotted lines indicate the contours of the synthetic anomalies.

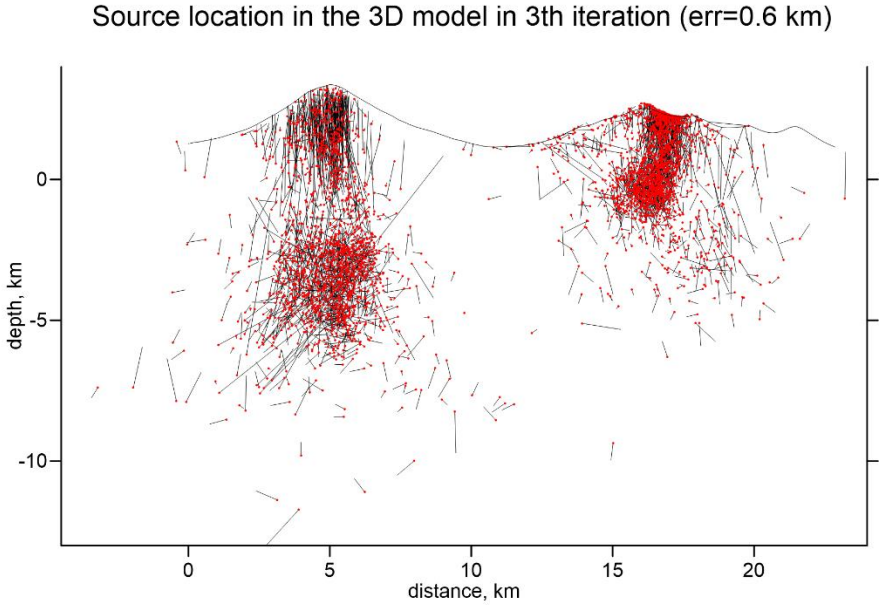
Source locations in the synthetic checkerboard model

Red dots depict modeled locations, and the ends of the black lines indicate the true locations.

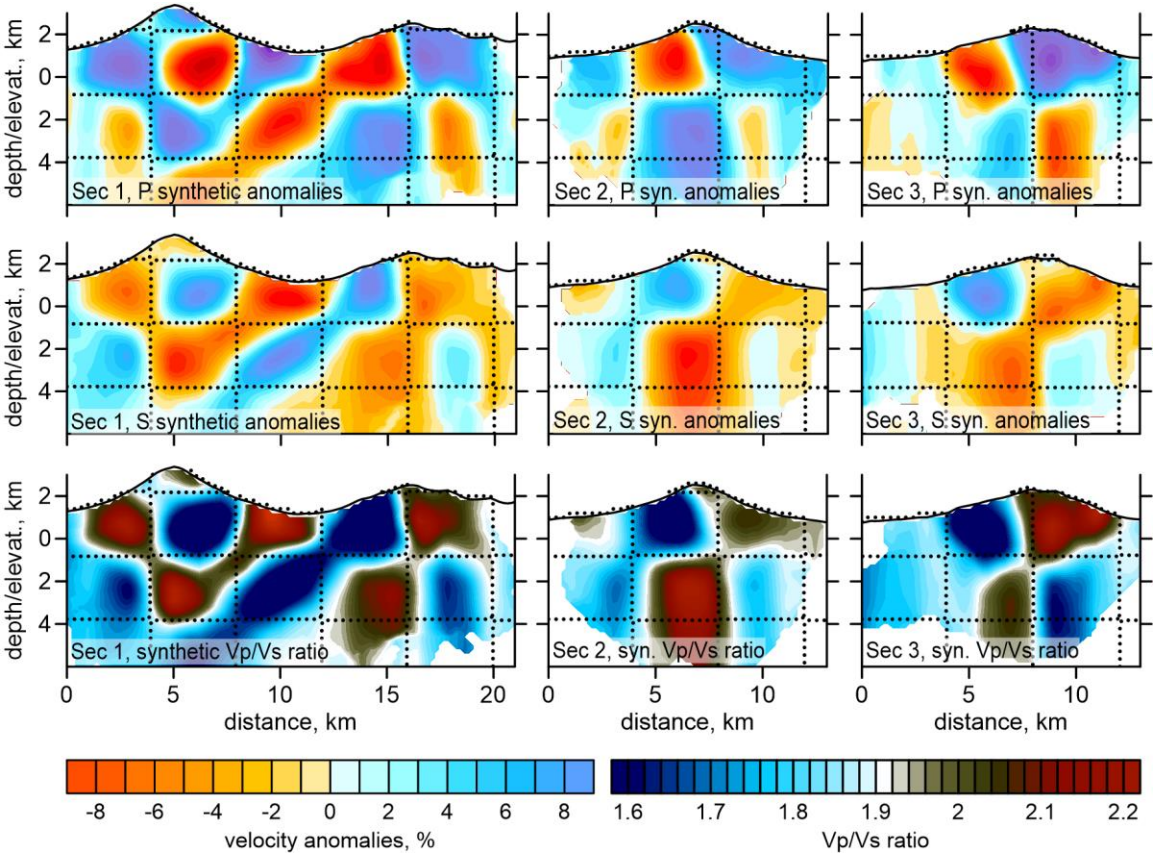






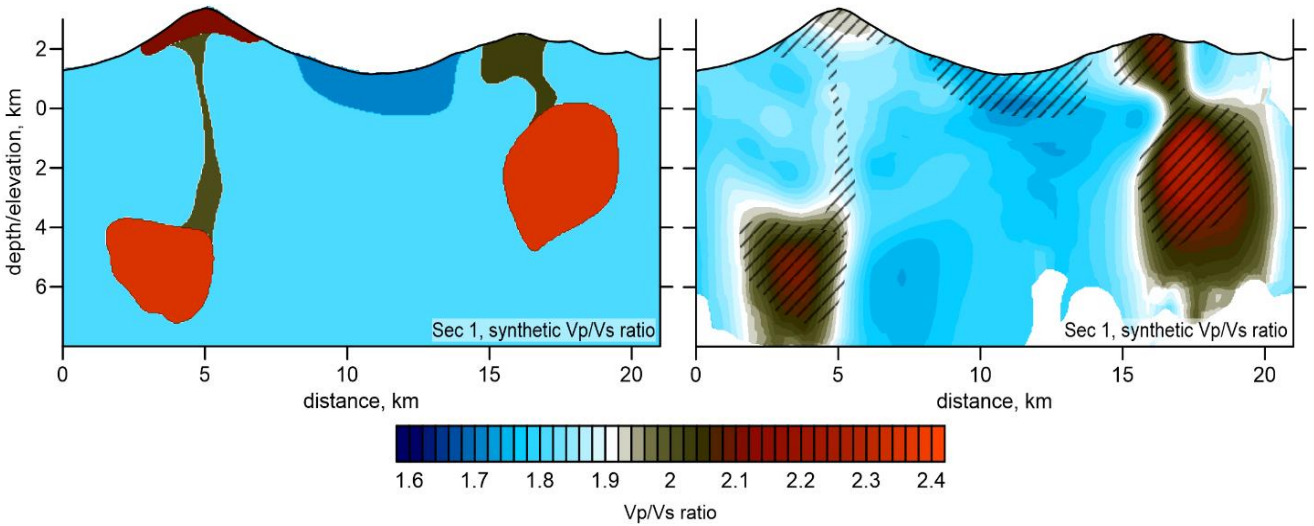


Vertical checkerboard is used to test the resolution along the vertical profiles



The test with realistic features shows satisfactory recovery of the magma reservoirs

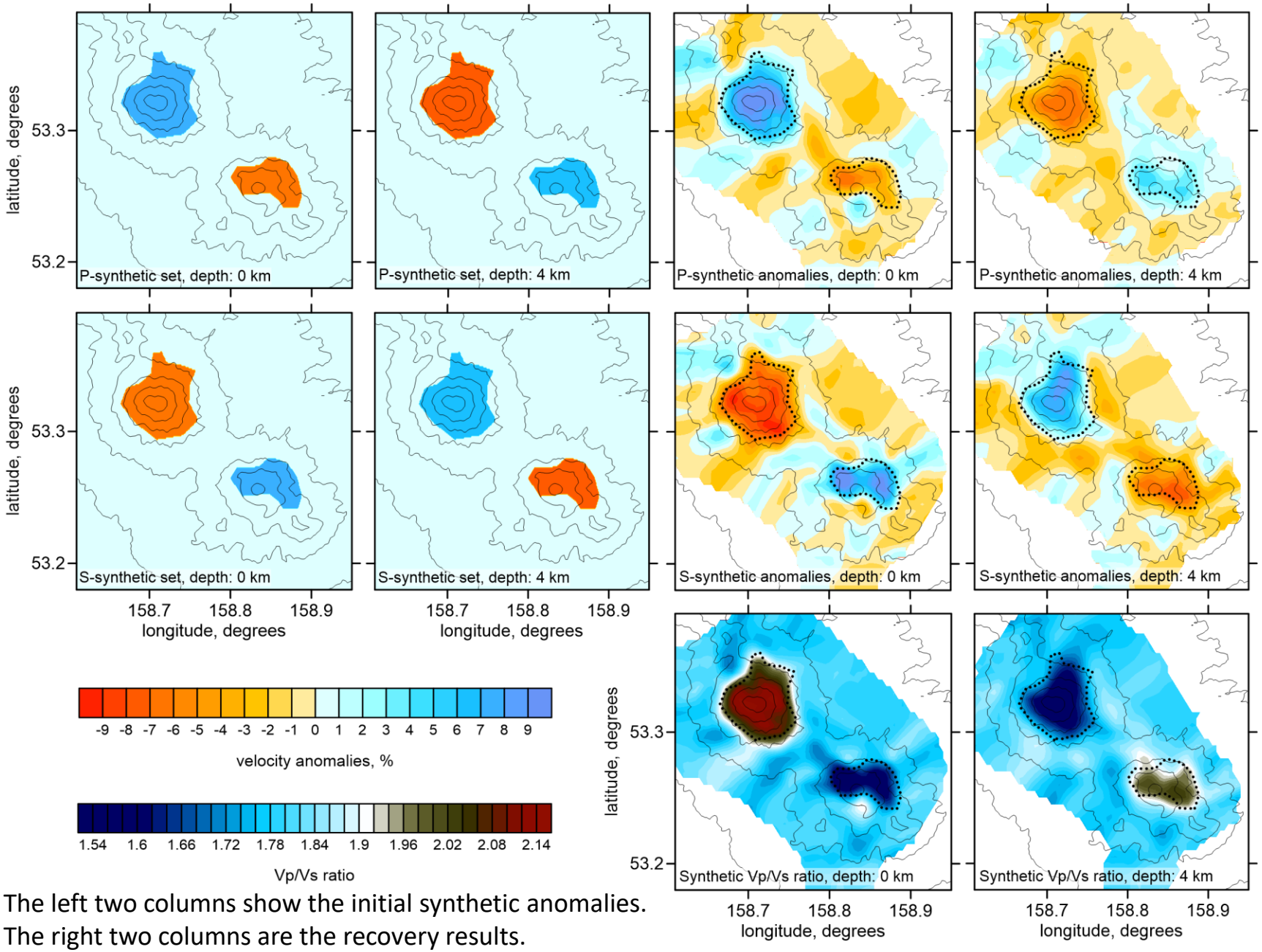
(the shaded areas in the right plot highlight the anomalous zones in the synthetic model)



Despite a limited number of stations, we have sufficient resolution to reveal the structure of the feeding system beneath the Avacha and Koryaksky volcanoes.

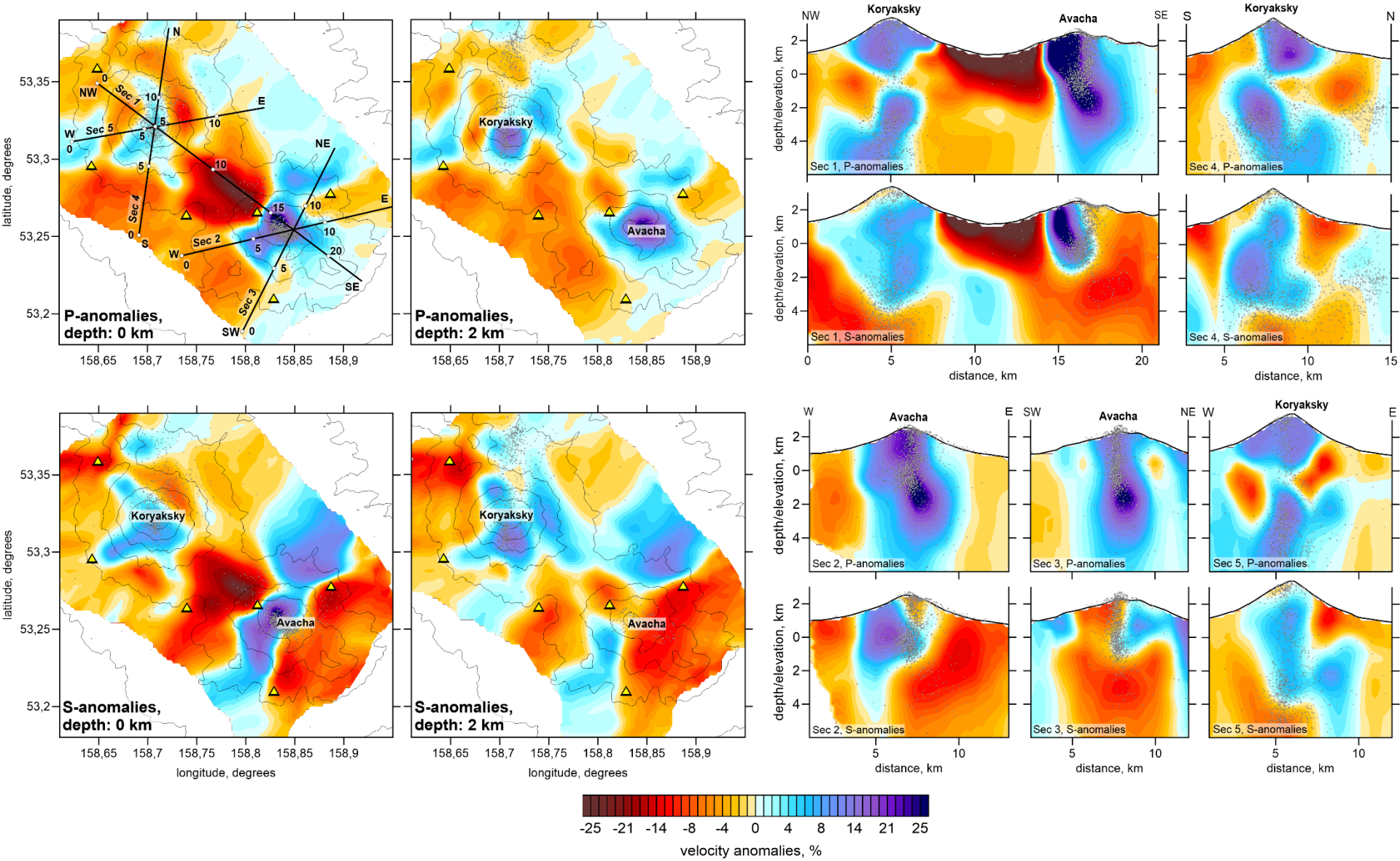
Synthetic test with free-shaped anomalies

defined in the horizontal projection



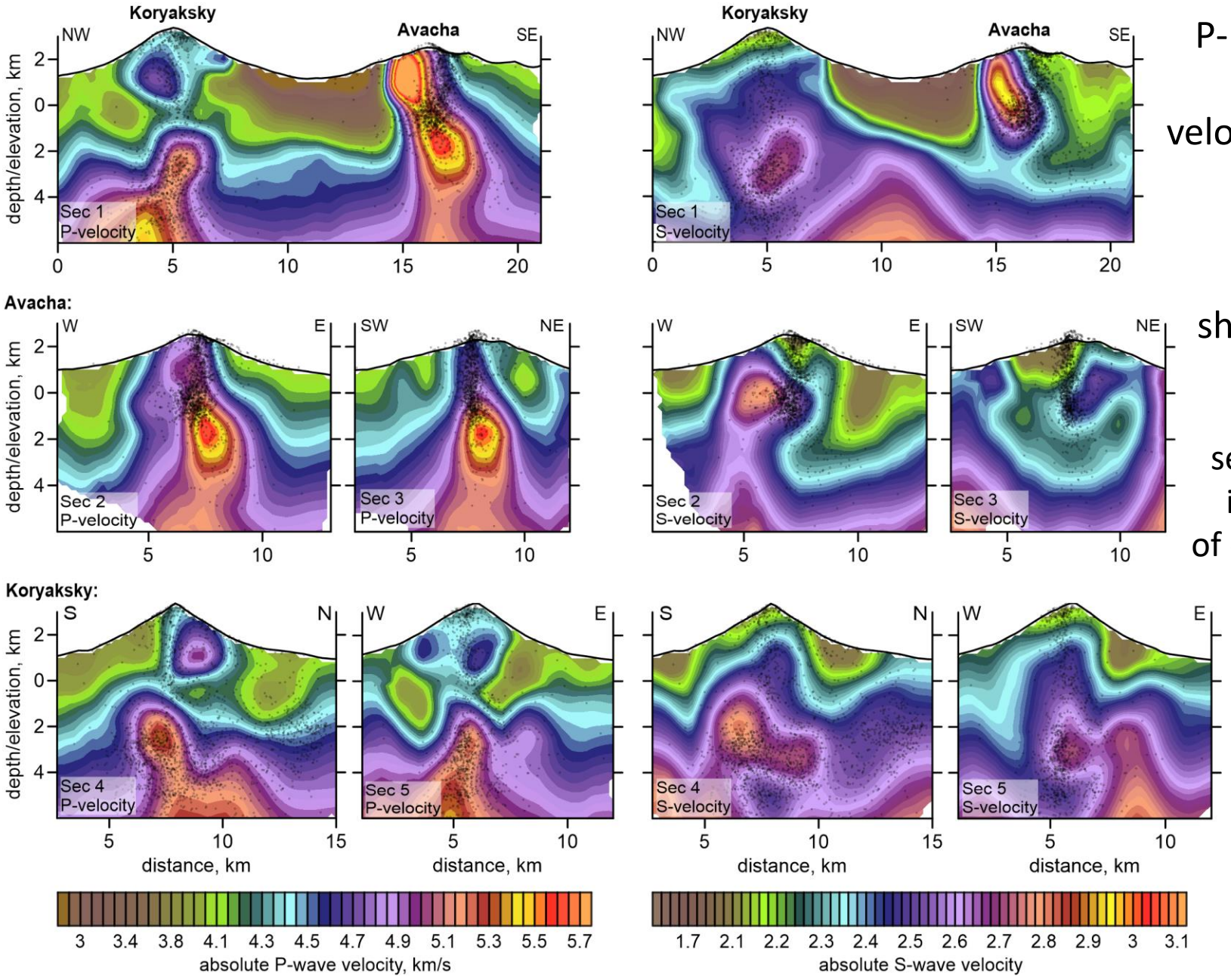
The left two columns show the initial synthetic anomalies.
The right two columns are the recovery results.

Results of experimental data analysis for the Avacha volcanic group



The P- and S-wave velocity anomalies in two horizontal (at a depths of 0 and 2 km) and five vertical sections. Triangles depict the seismic stations and dots are the events recorded at the sections. Thin lines depict relief contours with a step of 500 km.

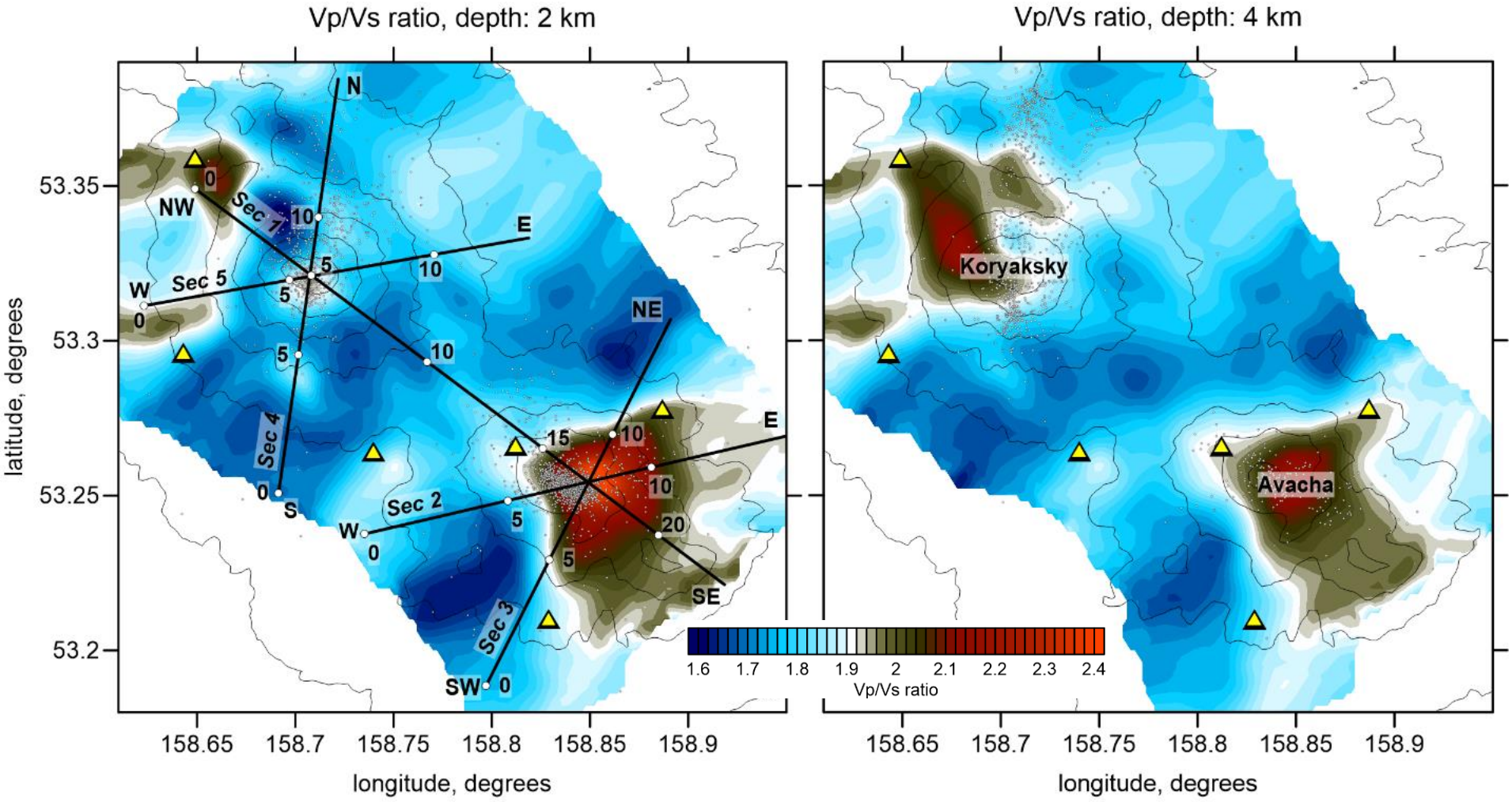
Results of experimental data analysis for the Avacha volcanic group



P- and S-wave absolute velocities in the same five vertical sections as shown above.

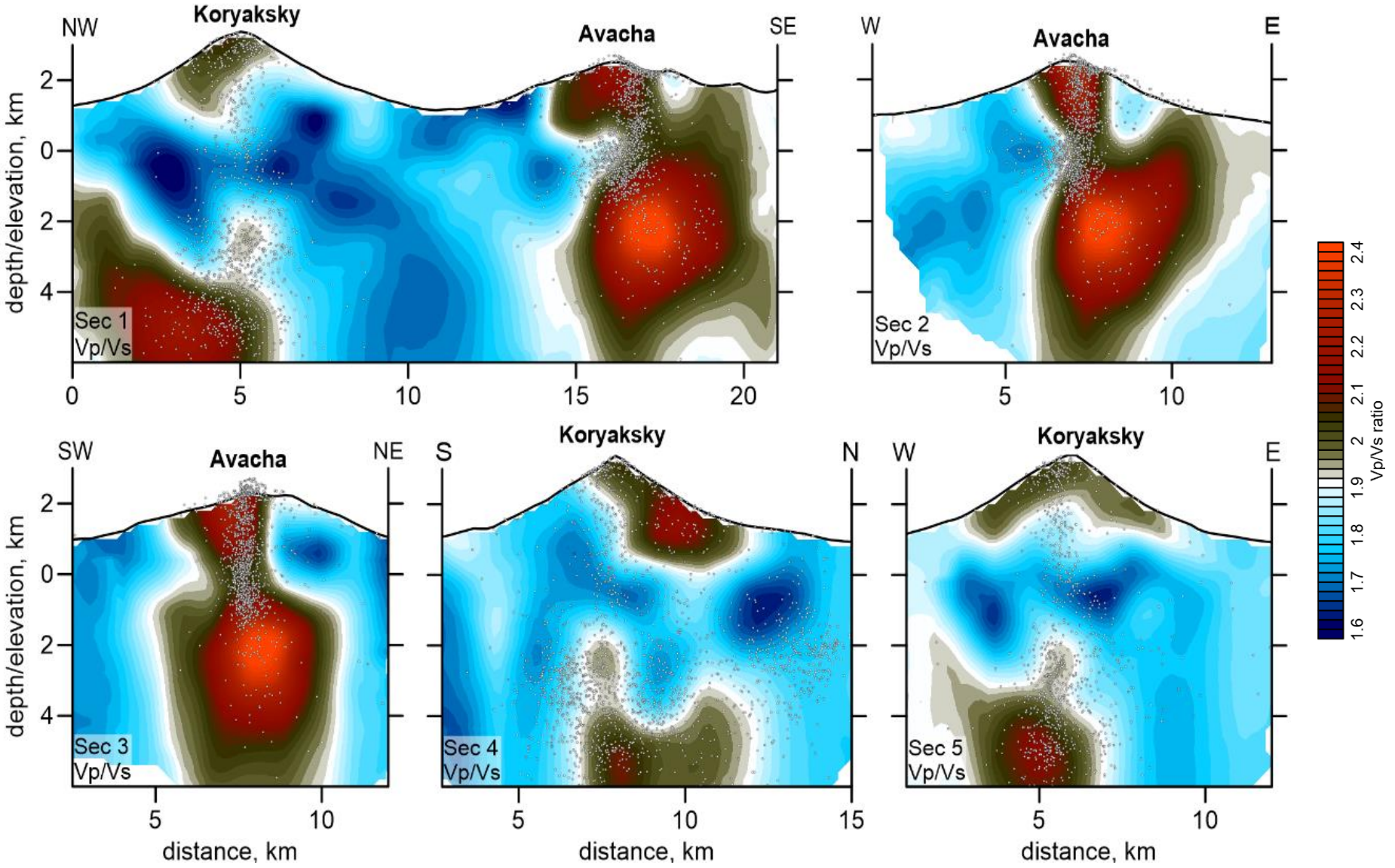
Dots depict seismic events in the vicinity of each section.

Results of experimental data analysis for the Avacha volcanic group



The tomography model reveals two anomalies of high V_P/V_S ratio located beneath the Avacha and Koryaksky volcanoes. The value of V_P/V_S>2.4 show that these zones are contaminated with liquids (fluids/melts).

Results of experimental data analysis for the Avacha volcanic group



In the vertical sections, we reveal two magma reservoirs: shallower one beneath Avacha and deeper one beneath Koryaksky

Bushenkova et al., 2019, https://doi.org/10.1029/2019JB017952

Summary

Seismic tomography is the powerful instrument for studying magmatic systems beneath volcanoes. We have robustly mapped the 3D structure of two upper-crustal magma reservoirs beneath the active Avacha and Koryaksky volcanoes. This information is extremely important for setting realistic plumbing models of these volcanoes and providing more reliable forecast of their activity.

As a result of tomographic inversion, it was found that beneath the Avachinsky and Koryaksky volcanoes there are anomalies with an extremely high V_P/V_S, which mark the locations of two independent magma chambers.

Beneath the Avachinsky volcano, the chamber has the shape of a bottle composed of the main isometric reservoir at a depth of 2 km below the volcano surface and a narrow neck, which represents an active magmatic conduit.

Beneath the Koryaksky volcano, the camera is located deeper, at ~7 km depth below the surface. In the distribution of seismic velocities, the chamber does not have a pronounced connection with the surface, but the presence of a large amount of seismic events between the chamber and the surface indicates active migration and degassing of fluids.

Between the volcanoes, a 2–3 km thick layer of very low V_P and V_S is interpreted as deposits of volcanoclastic sediments. Generally low V_P/V_S ratios in the area between the volcanoes show that the magma reservoirs in the upper crust are not interconnected.

This study was partially supported by the RFBR project # 18-55-52003.


Thank you for your attention