Deep lithospheric structure between Pamir and Tarim

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Federal Ministry of Education and Research

CLIENT II
International Partnerships for Sustainable Innovations

CATENA
CLIMATIC AND TECTONIC NATURAL HAZARDS IN CENTRAL ASIA

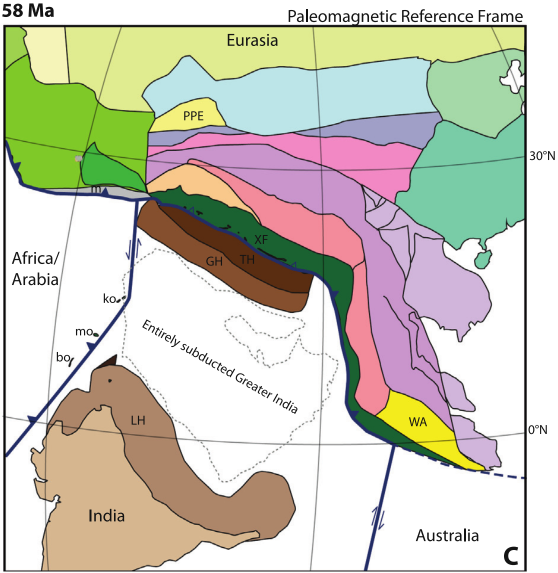
GFZ
Helmholtz-Zentrum Potsdam

Tectonic units

Imagery ©2020 Landsat / Copernicus, Map data ©2020 Google 50 km

- The Pamir is the northwestern prolongation of the Tibetan plateau
- It protrudes approx. 300-km into the formerly connected Tajik-Tarim basin

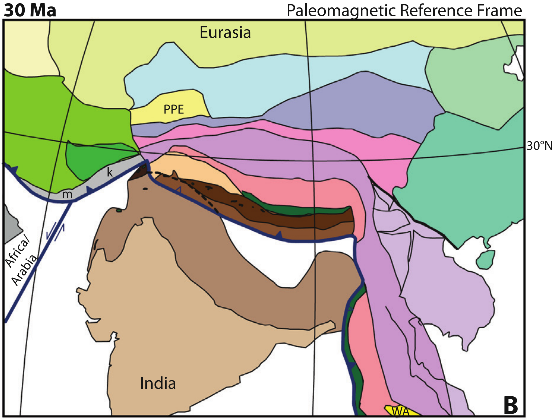
Tectonic history



- In the Paleocene the southern rim of Asia consisted of micro-continents, magmatic arcs, and subduction-accretion complexes (purple and pink, e.g. Burtman and Molnar (1993))

(van Hinsbergen et al., 2019)

Tectonic history



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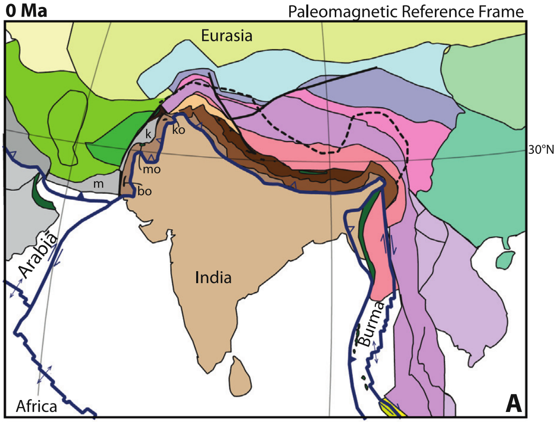
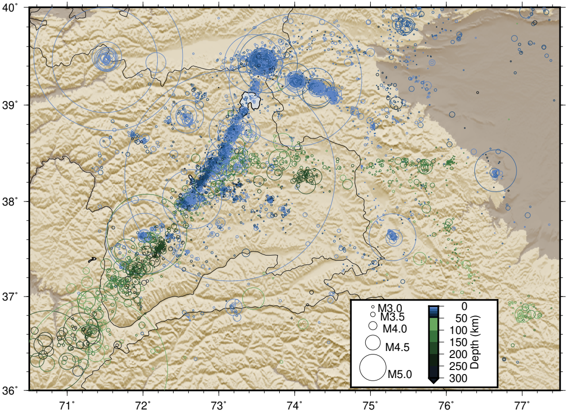


- In the Paleocene the southern rim of Asia consisted of micro-continents, magmatic arcs, and subduction-accretion complexes (purple and pink, e.g. Burtman and Molnar (1993))
- Indian mantle reaches far below the present day Pamir and Tibet plateaus

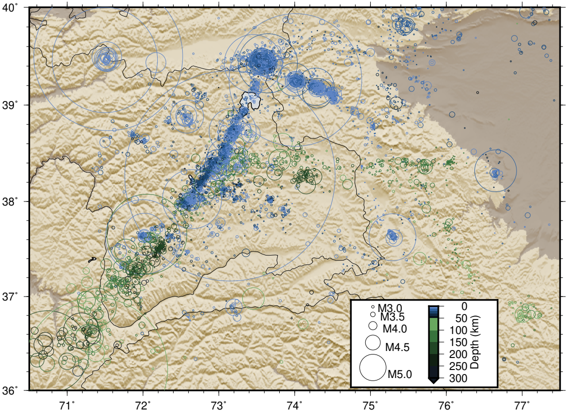
(van Hinsbergen et al., 2019)

Seismotectonic map



The Pamir is tectonically active

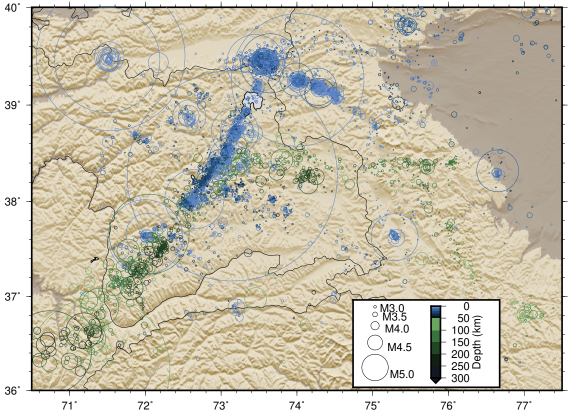
Seismotectonic map



The Pamir is tectonically active

- Crustal earthquakes (blue) with magnitudes up to 7.2 are documented (2015 Sarez earthquake, e.g. Metzger et al. (2017))

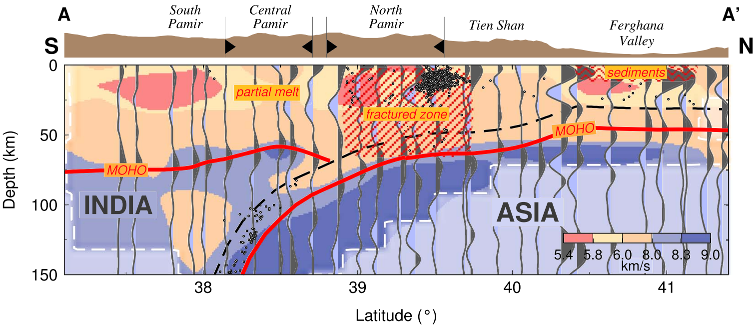
Seismotectonic map



The Pamir is tectonically active

- Crustal earthquakes (blue) with magnitudes up to 7.2 are documented (2015 Sarez earthquake, e.g. Metzger et al. (2017))
- Mantle earthquakes (green) form a band from the Hindu Kush, through the Central Pamir, to eastern Pamir and Kunlun (e.g. Pegler and Das (1998))
  - They reach from 50 to 250 km depth

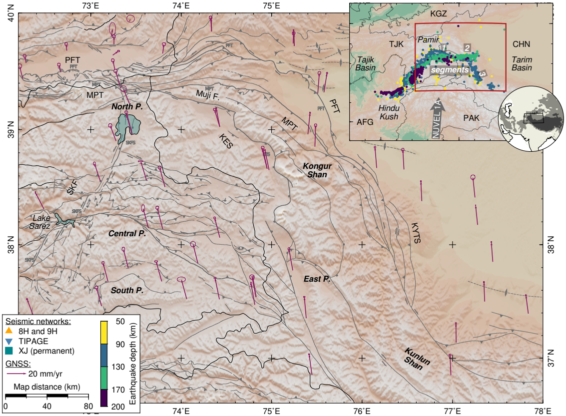
Profile through central Pamir



(Schneider et al., 2019; Sippl et al., 2013)

- Intermediate depth (50–300 km) earthquakes reside inside a 10 km thick low velocity zone connected to the bottom of the Asian lithosphere
- The *Asian slab* is likely delaminated from the base of the Asian continental lower crust by an Indian mantle indenter (Schneider et al., 2013; Kufner et al., 2016)

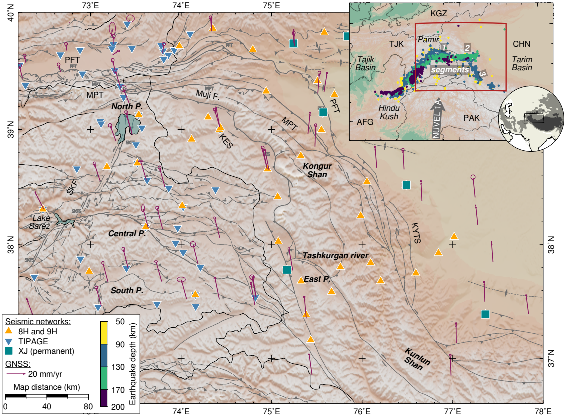
Seismotectonics of the eastern Pamir



Bloch et al. (prep)

- Surface plate motion N20°W to N5°W (Metzger et al., 2020; Rui and Stamps, 2019; Zubovich et al., 2010)
- Convergence accommodated along Pamir Frontal thrust
- Dextral Kashgar-Yencheng-Transfer system inactive

Seismotectonics of the eastern Pamir



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- We operated a local seismic network in the eastern Pamir and western Tarim basin
- Additional stations from Xinjiang regional network and TIPTIMON experiment

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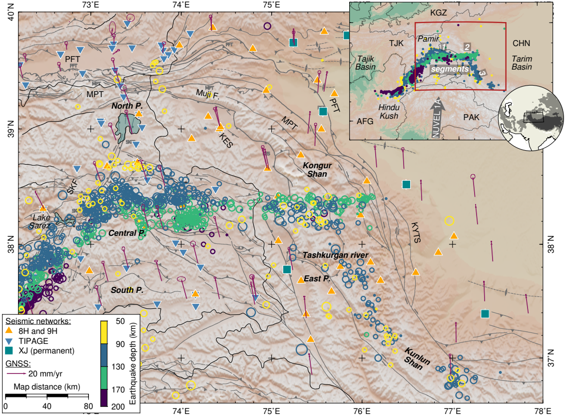

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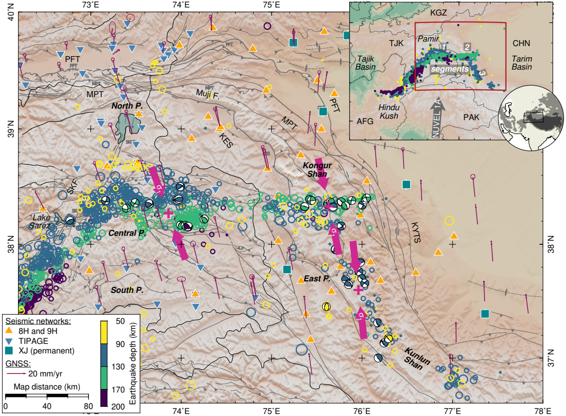

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- We operated a local seismic network in the eastern Pamir and western Tarim basin
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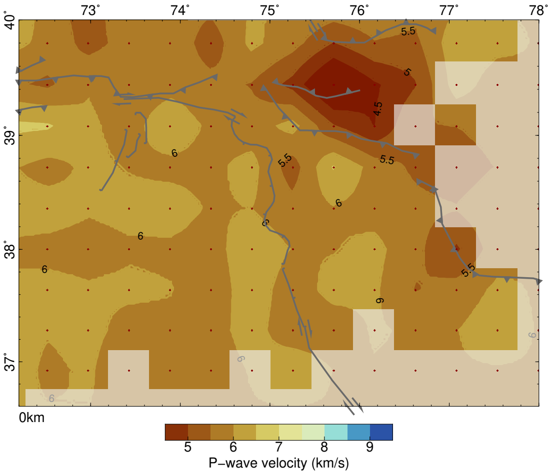
- Intermediate-depth seismicity reaches eastern flank of Pamir and beneath Kunlun
- Maximum principal stress is parallel to surface plate motion

Seismic tomography results

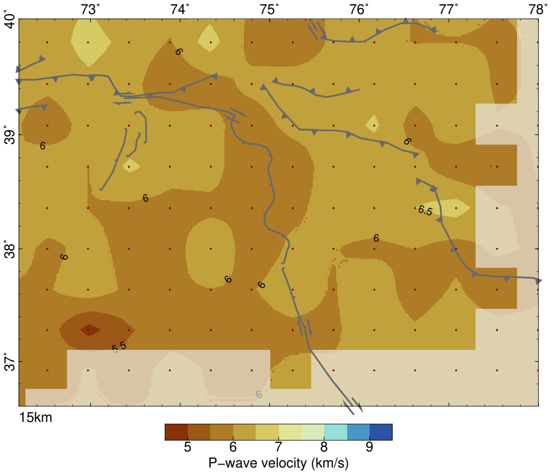


- Tarim basin appears as a LVZ

Bloch et al. (prep)

LVZ: Low velocity zone
HVZ: High velocity zone

Seismic tomography results



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- Tarim basin appears as a LVZ
- Mid-crustal LVZ beneath North Pamir, Kongur Extensional System, Kunlun

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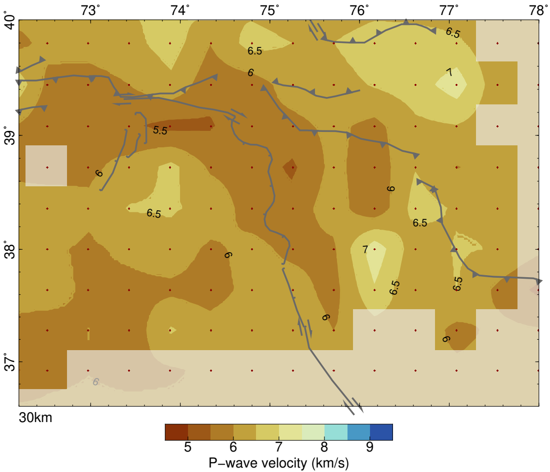

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- Central HVZ inside the Pamir

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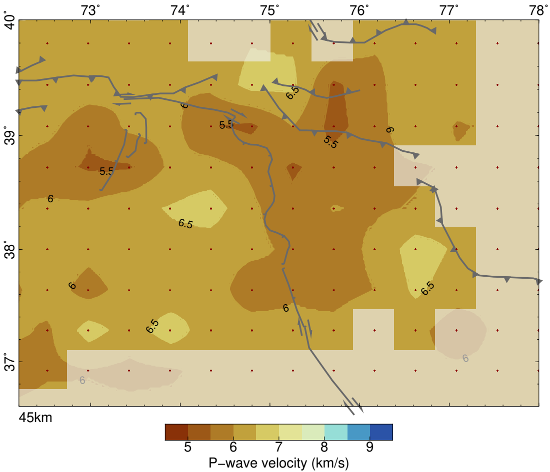

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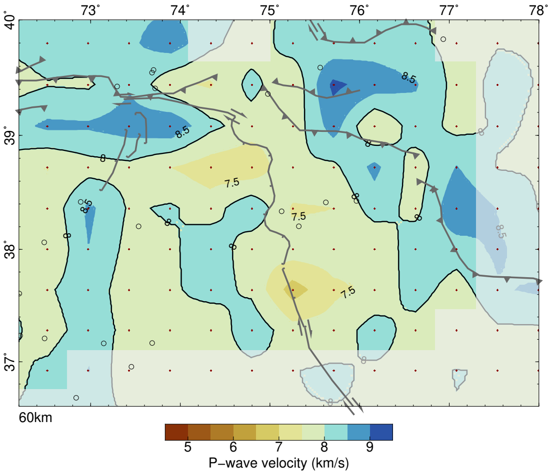

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- Thickened crust beneath north and south-east Pamir

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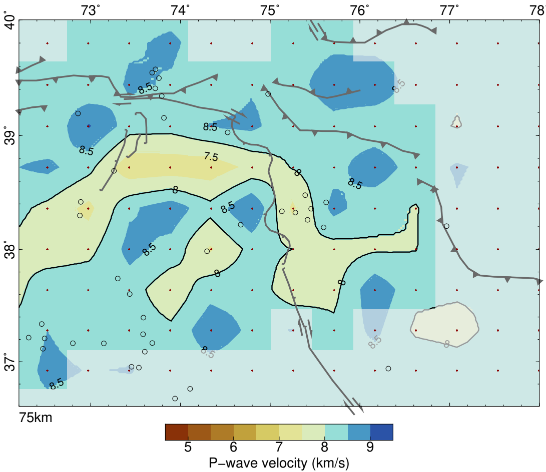

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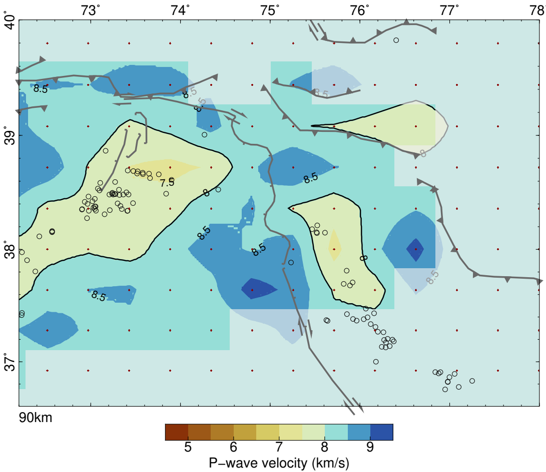

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- South dipping structure in the north
- East dipping structure in the south-east

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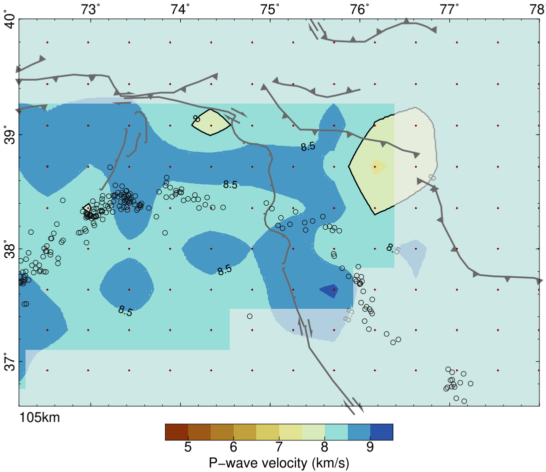

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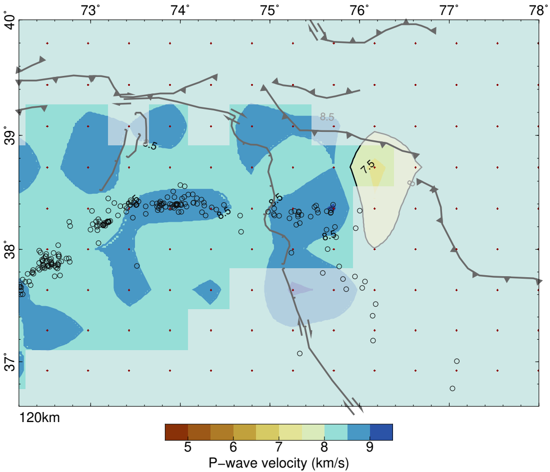

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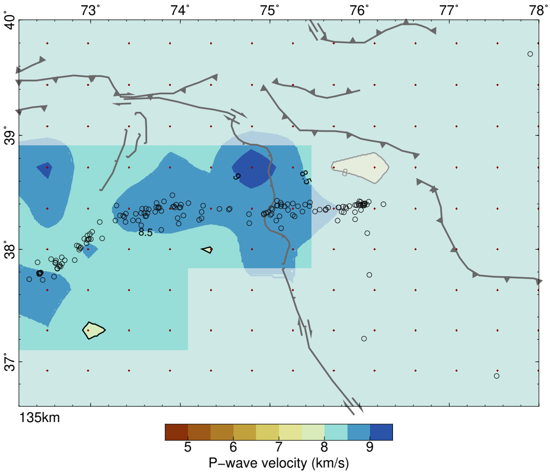

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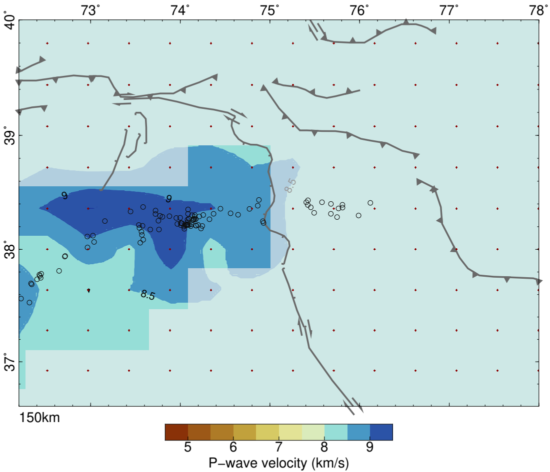

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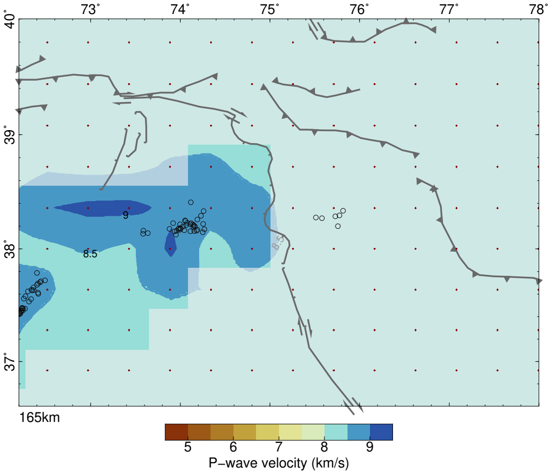

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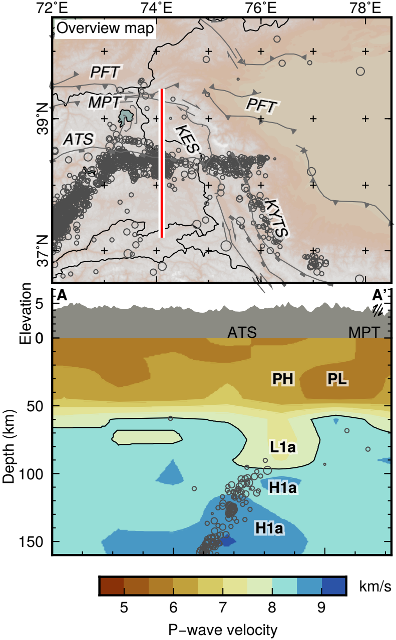

- A south dipping Asian slab in the central Pamir
  - with a LVZ in the updip continuation

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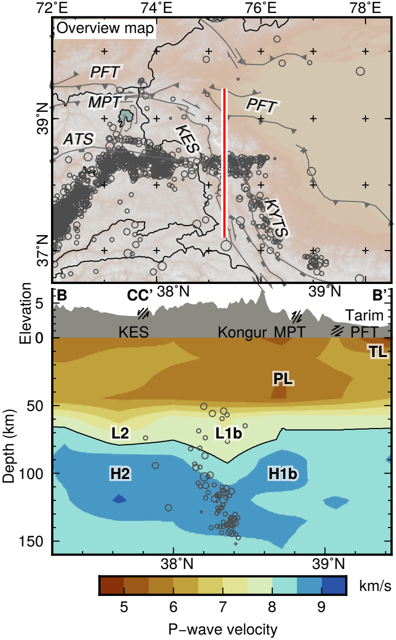
Seismic tomography results



- A south dipping Asian slab in the central Pamir
  - with a LVZ in the updip continuation
- An overturned north dipping slab in the eastern Pamir
  - mid-crustal LVZ further south

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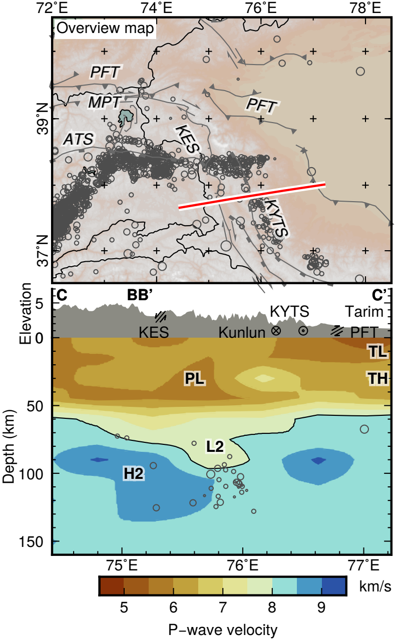
Seismic tomography results



- A south dipping Asian slab in the central Pamir
  - with a LVZ in the updip continuation
- An overturned north dipping slab in the eastern Pamir
  - mid-crustal LVZ further south
- An east dipping crust and mantle stack in the south east

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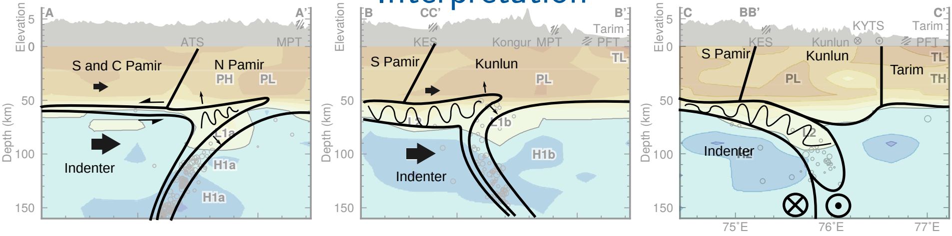
Interpretation



- The Indian indenter delaminates the base of the Asian crust
- The mid-crustal LVZ marks the delamination front
- Reworked crust and damaged mantle at the tip of the indenter marks is also expressed as low mantle velocities

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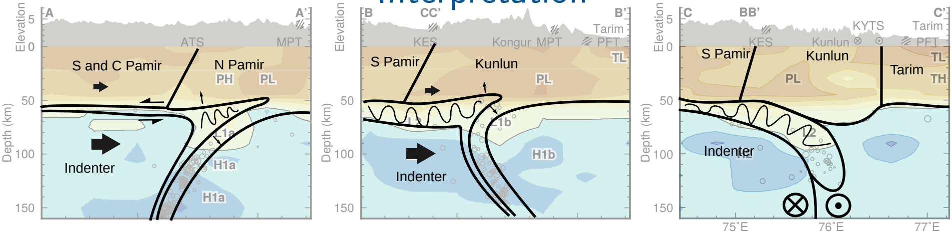

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- The Asian slab is overturned
- The delamination front is located 60 km farther south
- A thickened pile of reworked crust separates the indenter from the overriding crust

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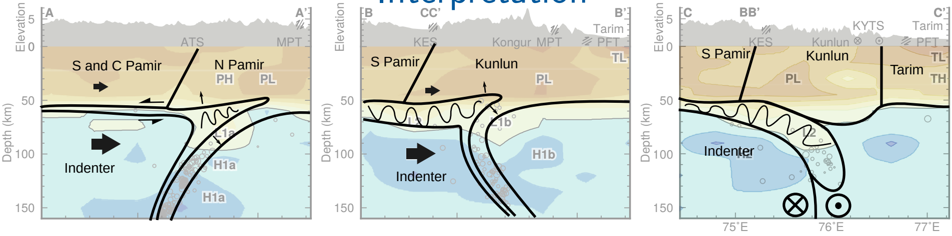

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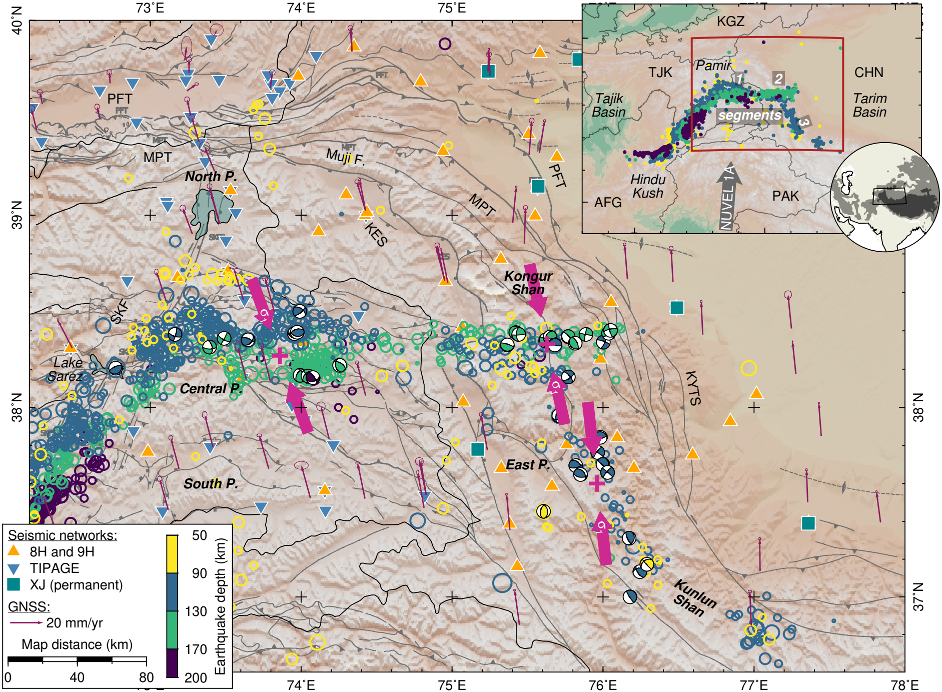
- Reworked crust thickens towards the east
- Crustal material enters the eclogite facies field and generates seismicity



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TJK
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CHN
Tajik
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segments
1
2
3
Hindu
Kush
AFG
PAK
NUVEL 1A
Seismic networks:
8H and 9H
TIPAGE
XJ (permanent)
GNSS:
20 mm/yr
Map distance (km)
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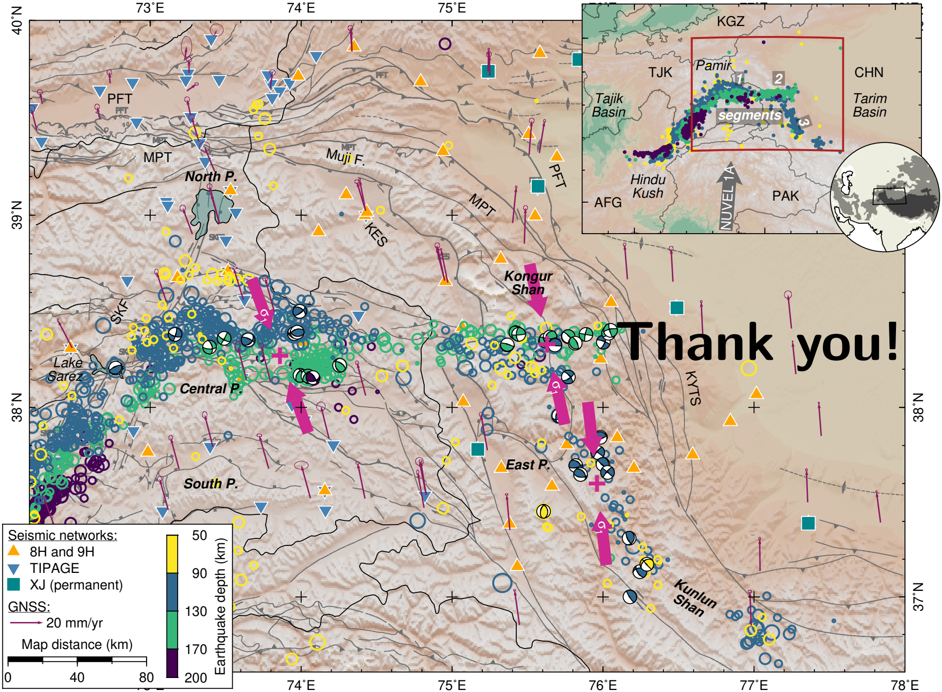
Earthquake depth (km)



Thank you!
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PFT
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SKF
Lake Sarez
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East P.
South P.
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Kunlun Shan
KGZ
TJK
Pamir
CHN
Tajik Basin
Tarim Basin
segments
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