Foreland thrusting and slab formation in the Pamir

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Introduction

The western and northern sectors of the northward convex Pamir arc are underlain by a Benioff zone dipping steeply east to south, traced by earthquakes to depths of 250 km in the southwest and 150 km in the northeast. This slab has been interpreted to indicate intracontinental subduction. However, the convergence accommodated in thrust belts around the western and northern Pamir margins seems to fall short of the values required to produce the observed slab lengths. Delamination models in which the slab only consists of Asian mantle lithosphere avoid that problem but predict shallow asthenosphere beneath the Pamir, conflicting with geophysical evidence. This contradiction is resolved in a forced delamination scenario (Kufner et al. 2016) where indenting/underplating Indian lithosphere forces down and immediately replaces the delaminating Asian lithosphere.

We try to reassess the link between shortening of the foreland and formation of the Pamir slab.

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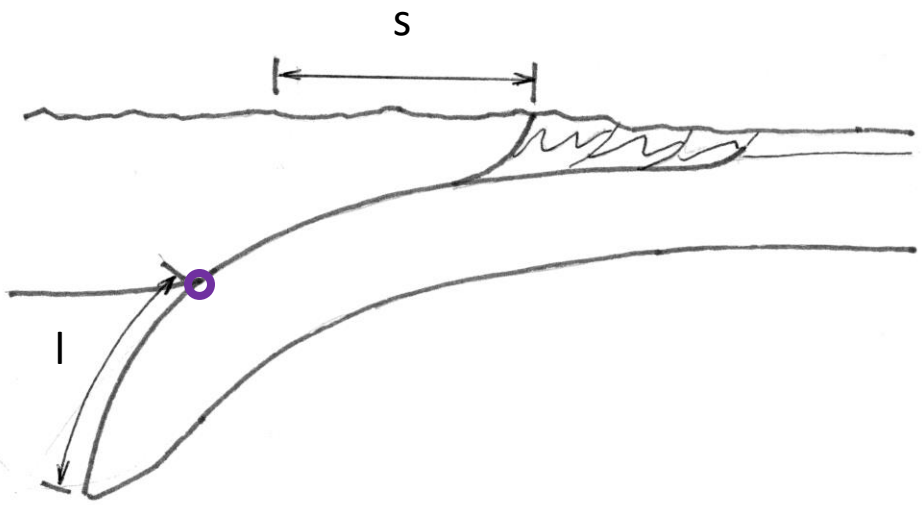
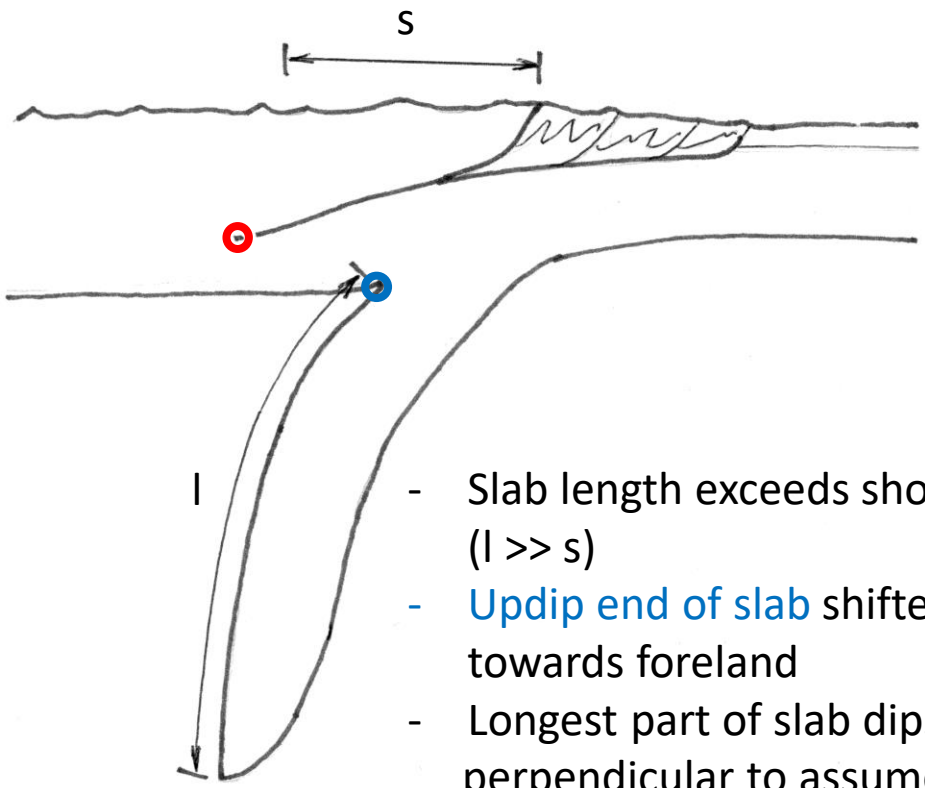
Intracontinental subduction in the Pamir: Expectation vs. observation



- Slab length equals shortening (l = s)
- Downdip end of thrust belt basal décollement coincides with updip end of slab
- Slab dip azimuth parallels convergence direction



- Slab length exceeds shortening (l >> s)
- Updip end of slab shifted towards foreland
- Longest part of slab dips perpendicular to assumed convergence direction (E instead of S)

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Questions

- Why are shortening estimates from the foreland thrust belts smaller than the length of the Pamir slab?
- Is the basal detachment of the foreland belt connected to the slab?
- Why are shortening estimates and slab lengths highest in the western Pamir (Tajik fold-thrust belt and east-dipping slab)?

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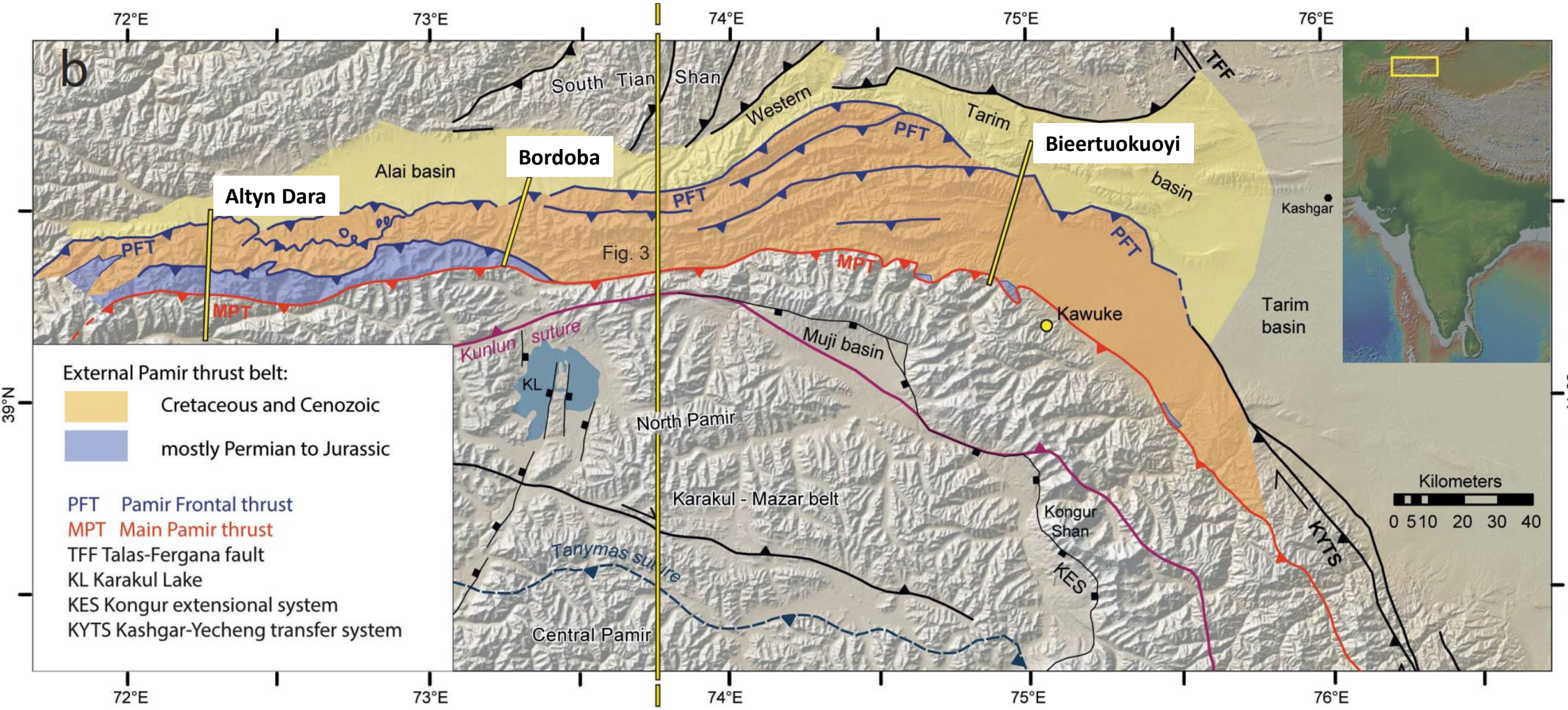
Main Pamir Thrust (MPT) and External Pamir thrust belt



Lithosphere-scale cross section

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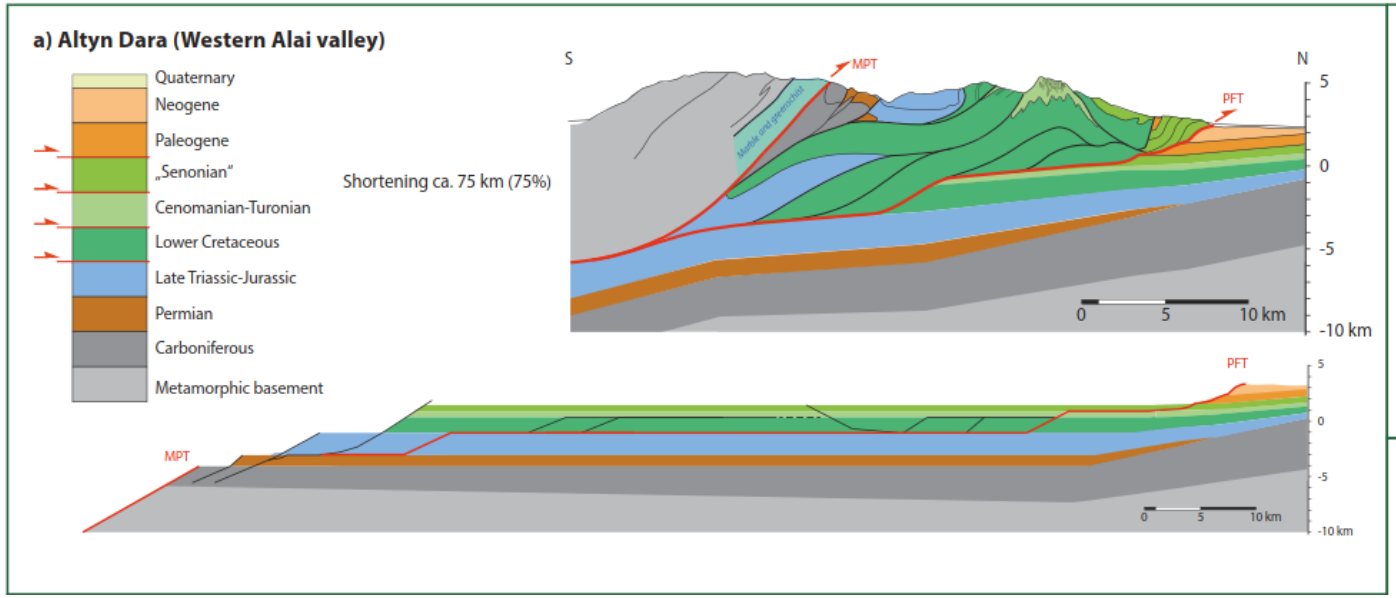
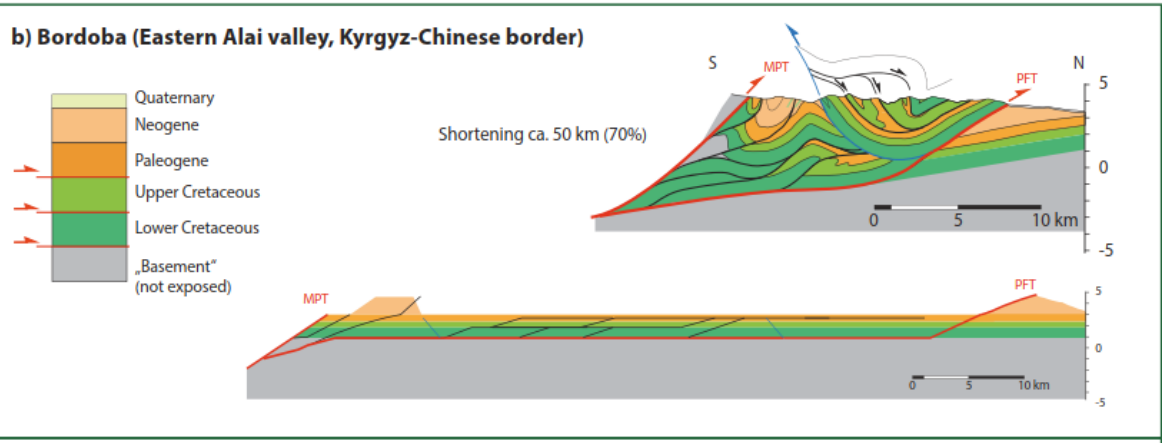
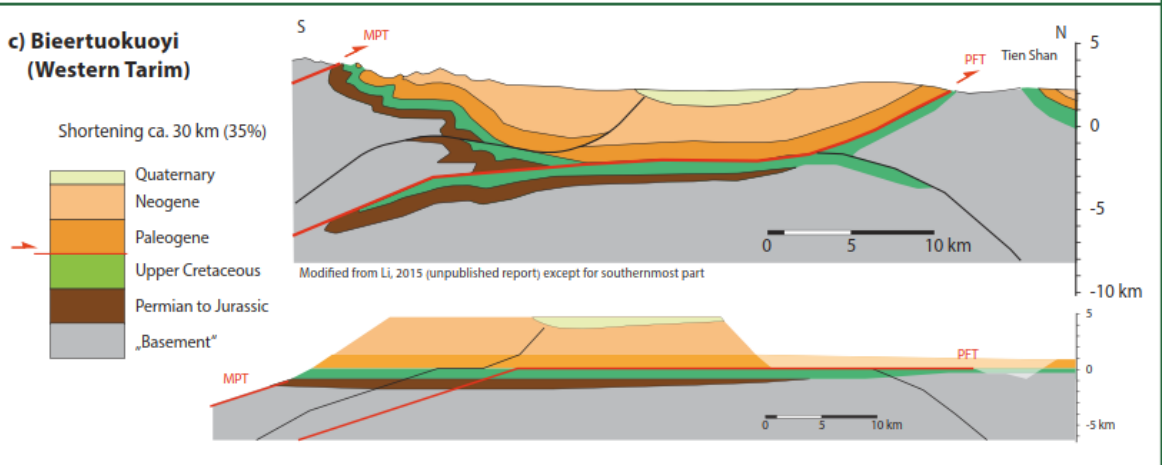
Shortening estimates from the Alai Valley







Shortening in Tajik Basin / thrust belt is higher, between 90 and 175 km (Gagała et al. 2020; Chapman et al. 2017)

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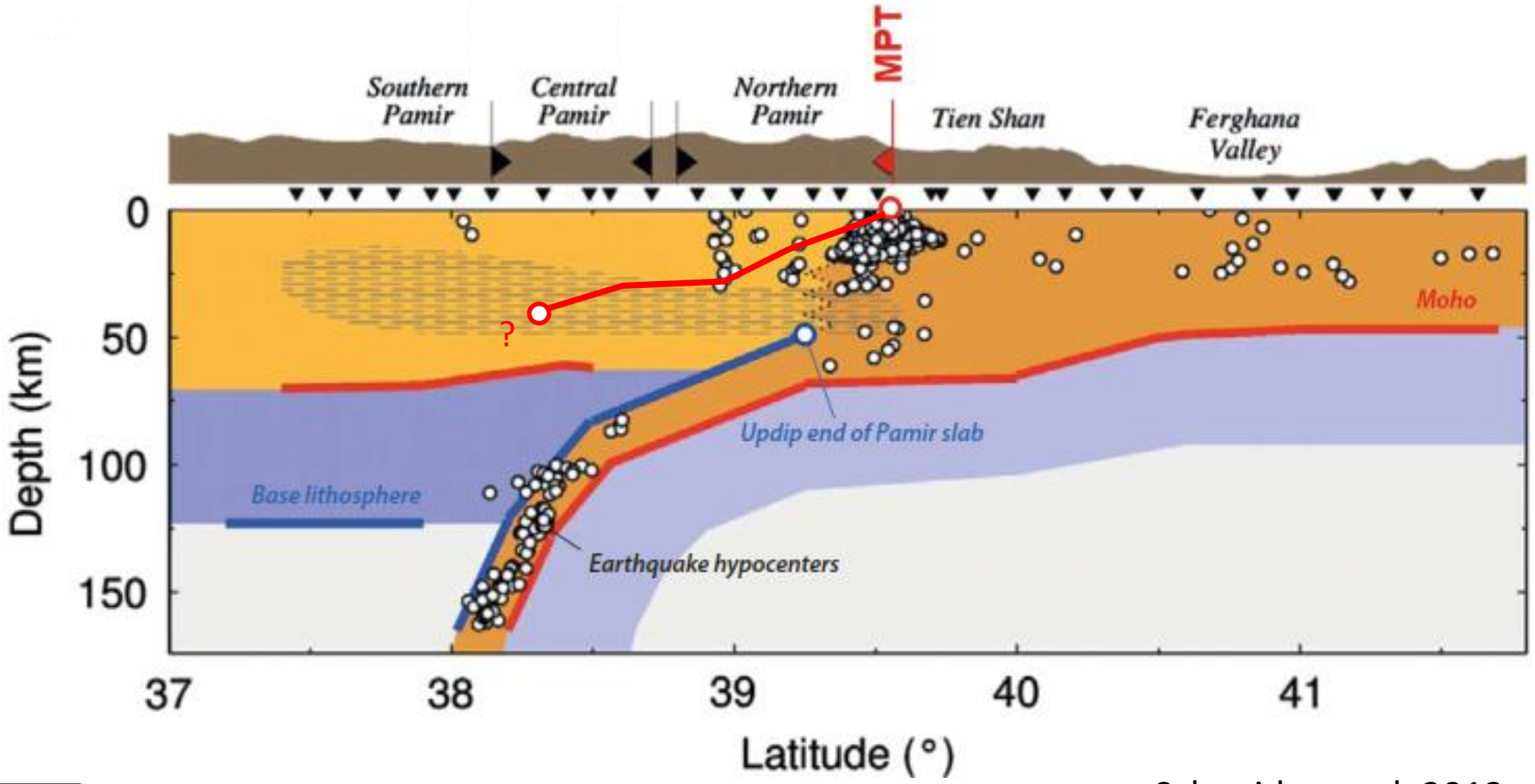
Geometry of MPT and slab (section location in slide 4)



Schneider et al. 2013, modified

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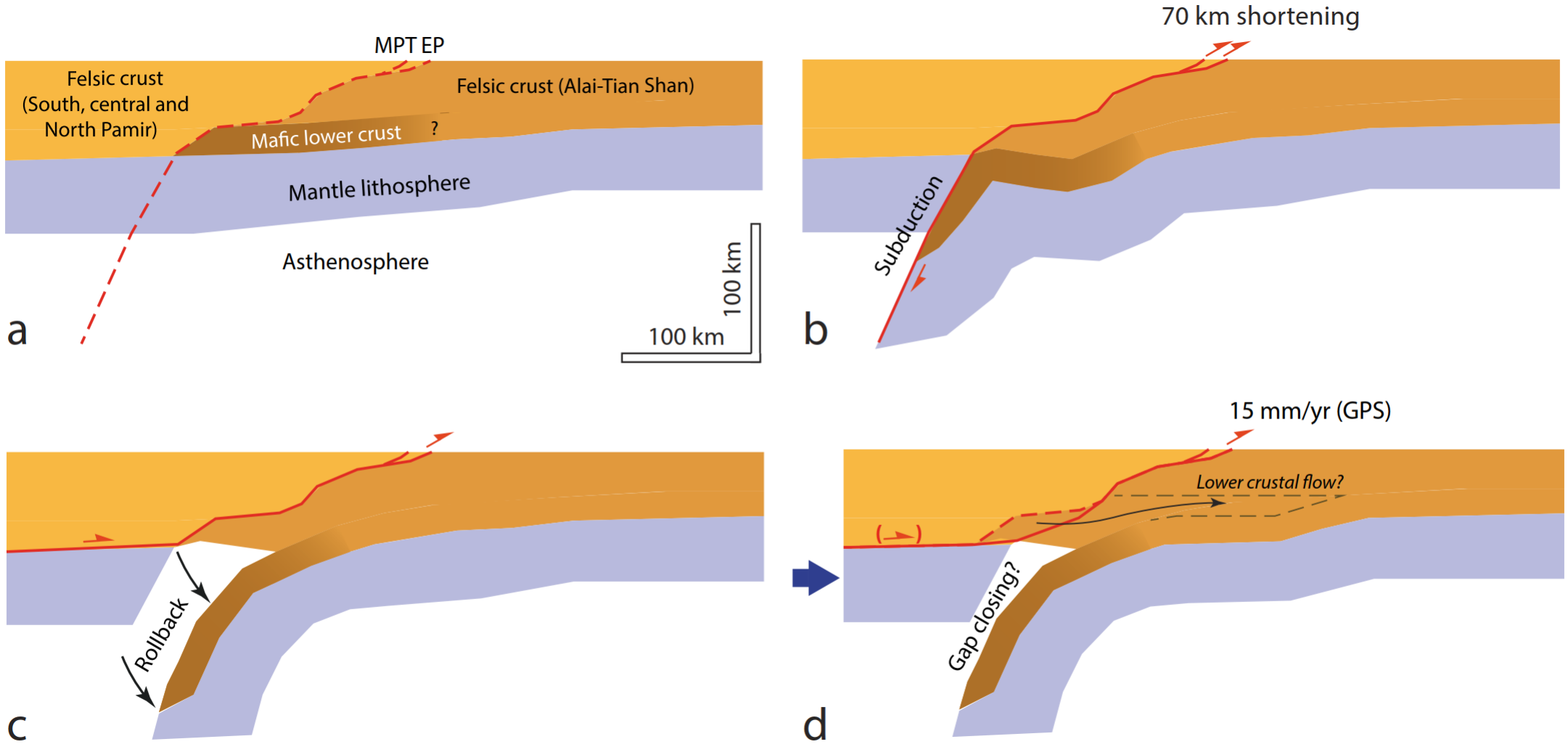
Hypothesis: the Pamir slab initiated by intracontinental subduction and then lengthed by rollback delamination



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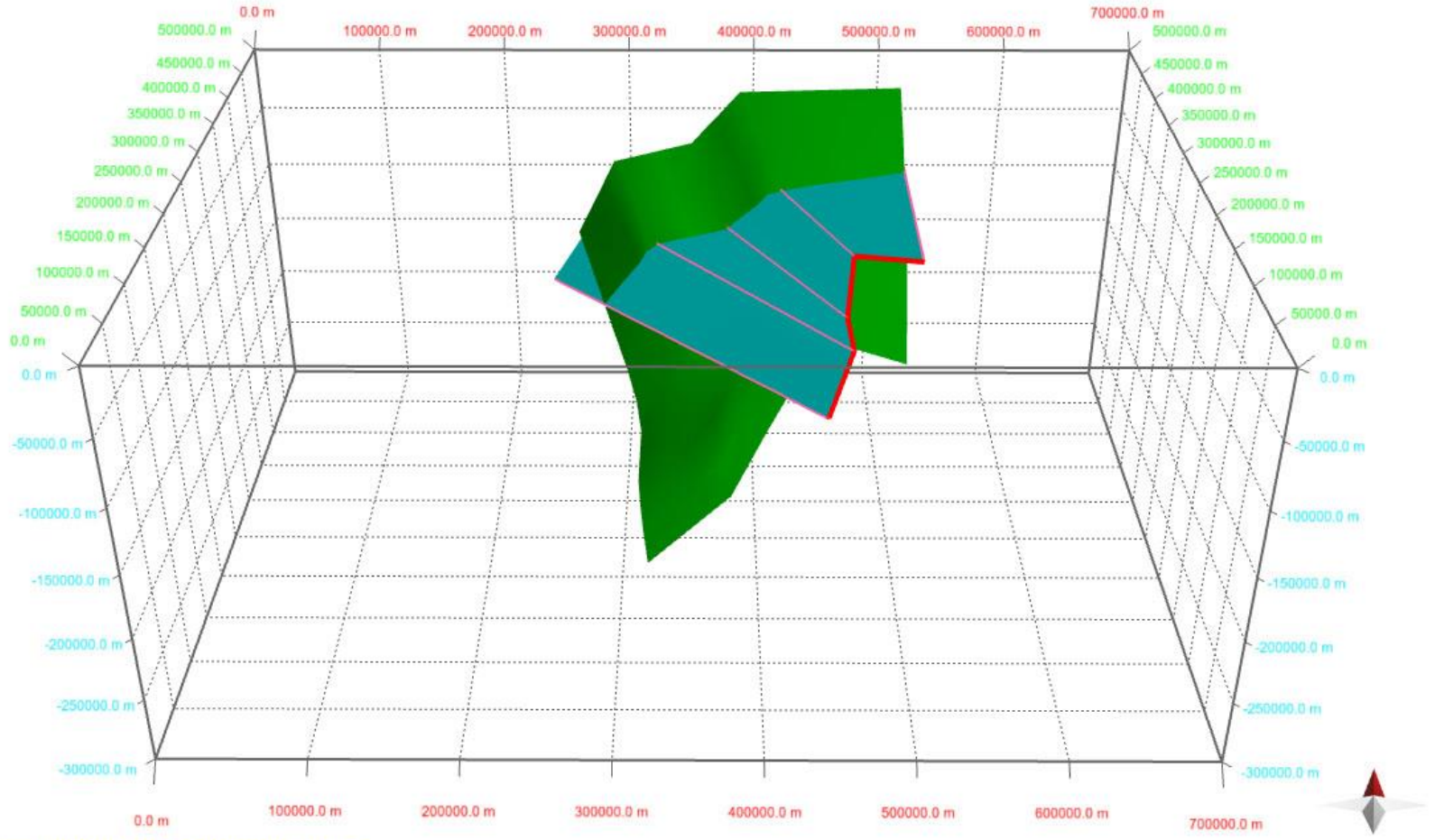
The Pamir slab restored to horizontal



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Bold red line: Restored downdip edge of slab

Present-day slab geometry (data from Sippl et al. 2013) projected to the surface using shallow crustal EQ clusters. Five sections (pink lines) rotated to horizontal about points at 50 km depth; approximately base of crust.

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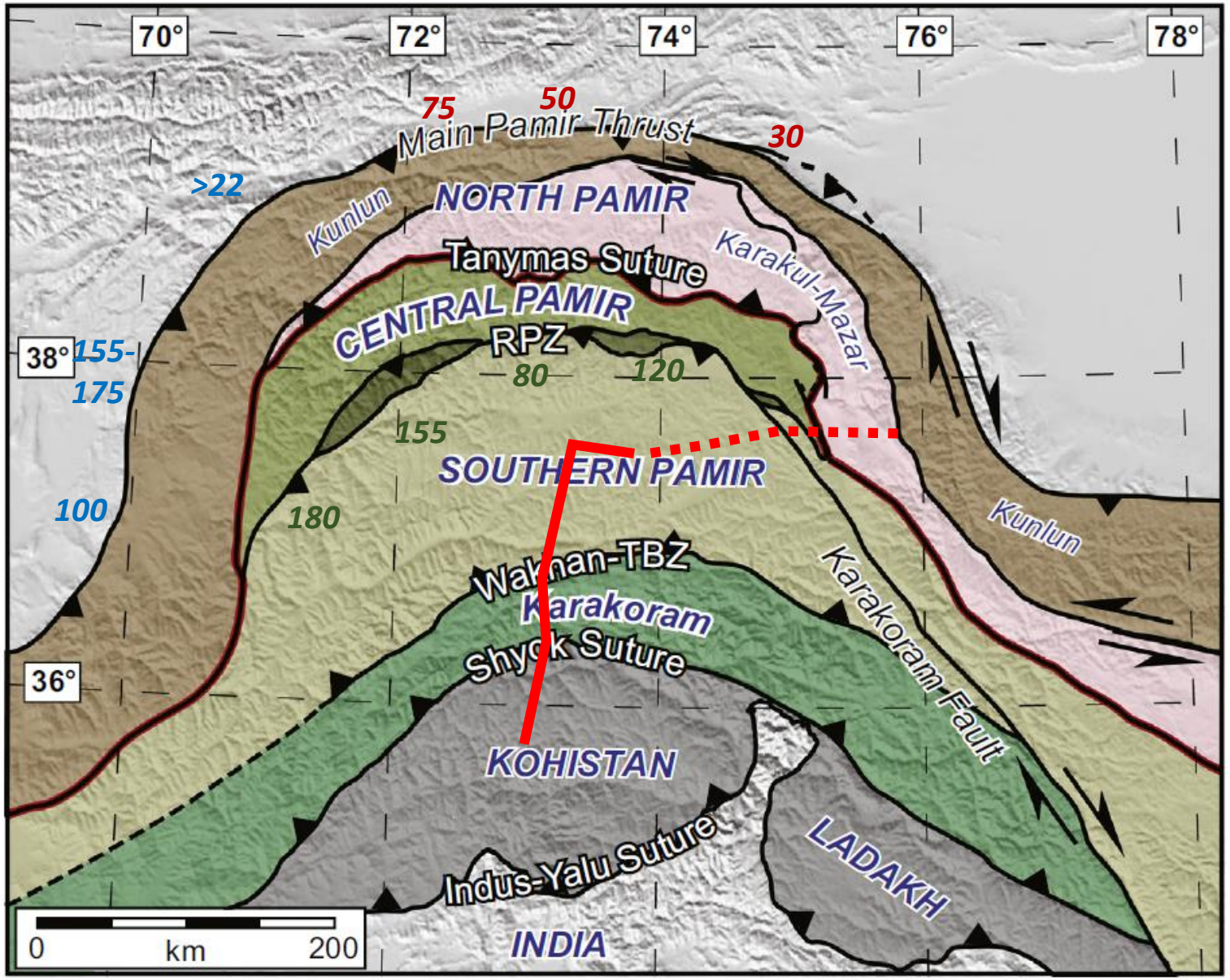
Foreland shortening, slab geometry and length



Restored downdip edge of slab (*from previous slide*) on tectonic map of Pamir. This would correspond to the map outline of the MPT´s intersection with the Moho. Notice N-S trend in the west.

Also shown is comparison of foreland shortening (km) from Gagala et al. 2020 (blue) and this presentation (red) with slab lengths (green; from Sippl et al. 2013). Maxima and minima of shortening and slab length approximately match along NW-SE trending lines.

Robinson 2015, modified

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Conclusions

- Shortening in the foreland thrust belts probably initiated the formation of the Pamir slab but only accounts for part of its length
- The remaining length was created by delamination and rollback of lithospheric mantle
- Rollback has separated the updip end of the slab from the downdip end of the MPT and shifted it towards the foreland (W to N)
- The slab geometry suggests that convergence was towards the NW or WNW, not N
- Slab lengths and shortening estimates suggest a clockwise(!) rotation of the Pamir

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