Tearing of Indian mantle lithosphere from high-resolution seismic images and its implications for lithosphere deformation coupling in southern Tibet

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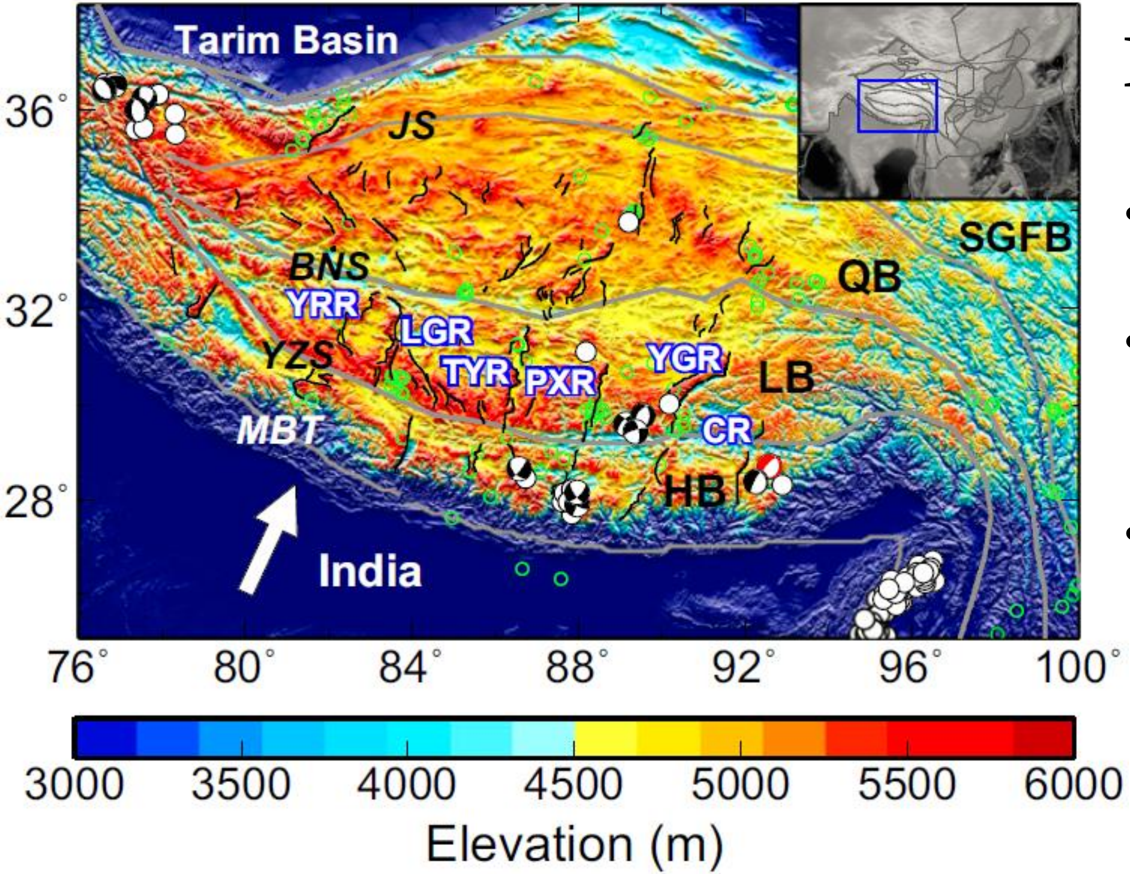
Outline

- Introduction
- Pn tomography of western china
- Surface-wave tomography of western china
- Model of lithosphere tears: correlations of structure with other observations (seismicity, focal mechanism, surface strain rate, SKS splitting, and surface rifting and geochemistry)
- Conclusions

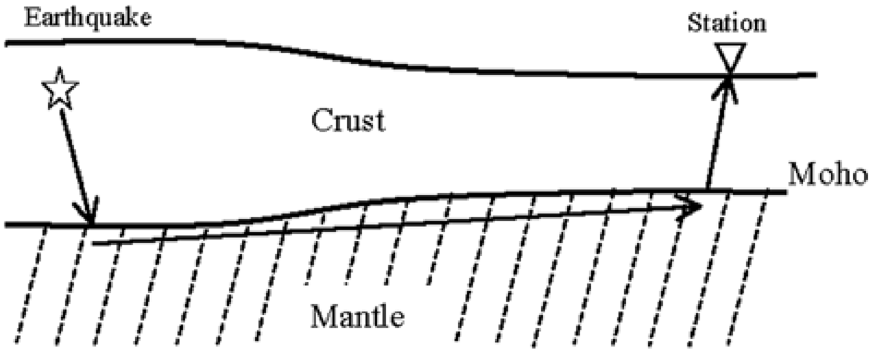
(Reference: Li and Song, 2018, doi: 10.1073/pnas.1717258115)



Mysteries

- What causes the N-S rifts?
- What causes lower crust and mantle earthquakes?
- What happens to the Indian mantle lithosphere (IML) after collision?

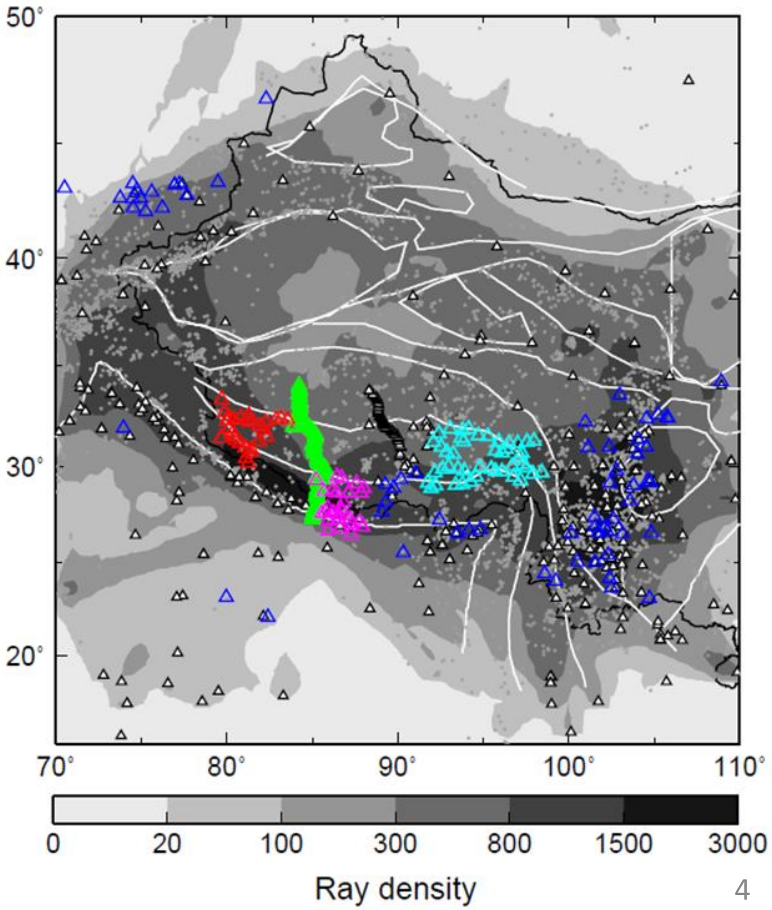
Pn tomography



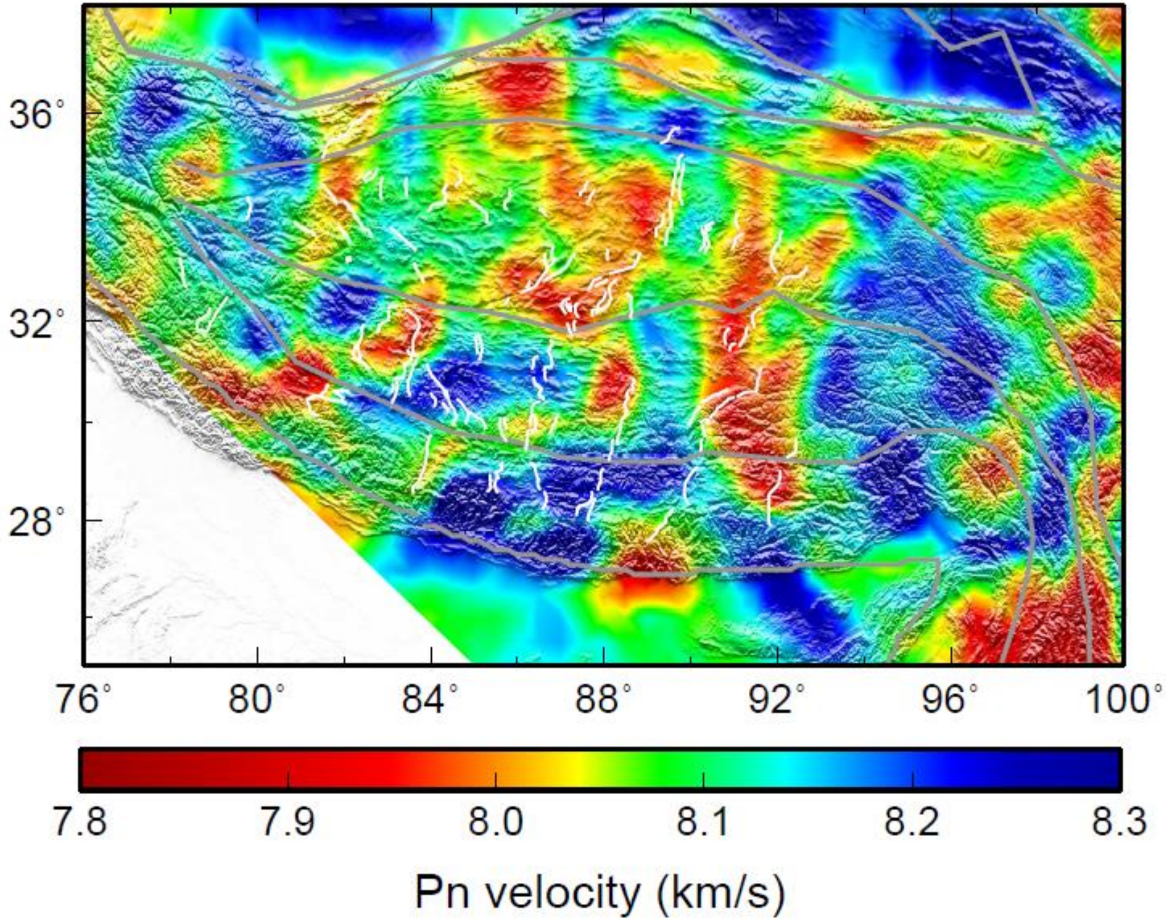
Stations used:

(1) Liang et al. (2004) & Liang and Song (2006), bulletin and some hand-picked arrival times (white);

(2) New hand-picked data: Y2 (red), XF (green), YL (magenta), XE (cyan), and some others (blue).



Results: Pn velocity

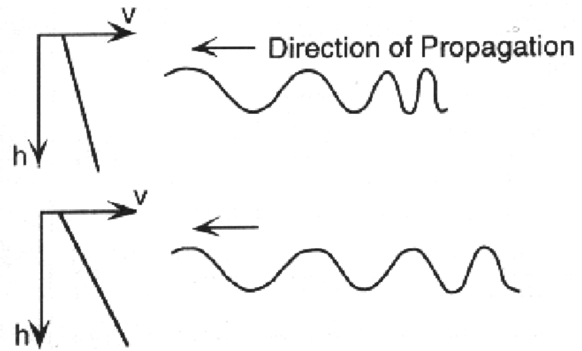


Surface-wave tomography

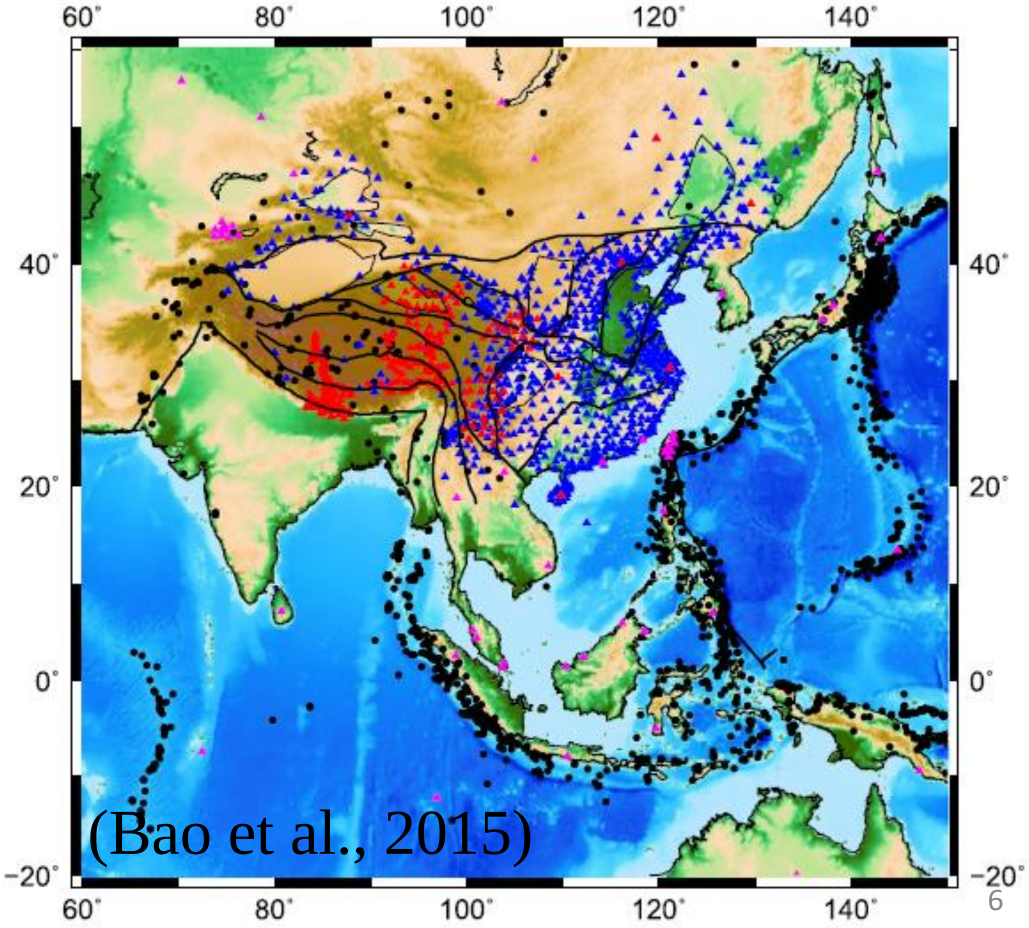
Rayleigh waves:

Group and phase dispersions from ambient noise (10-70 s)

Group dispersions from earthquakes (10-140 s)

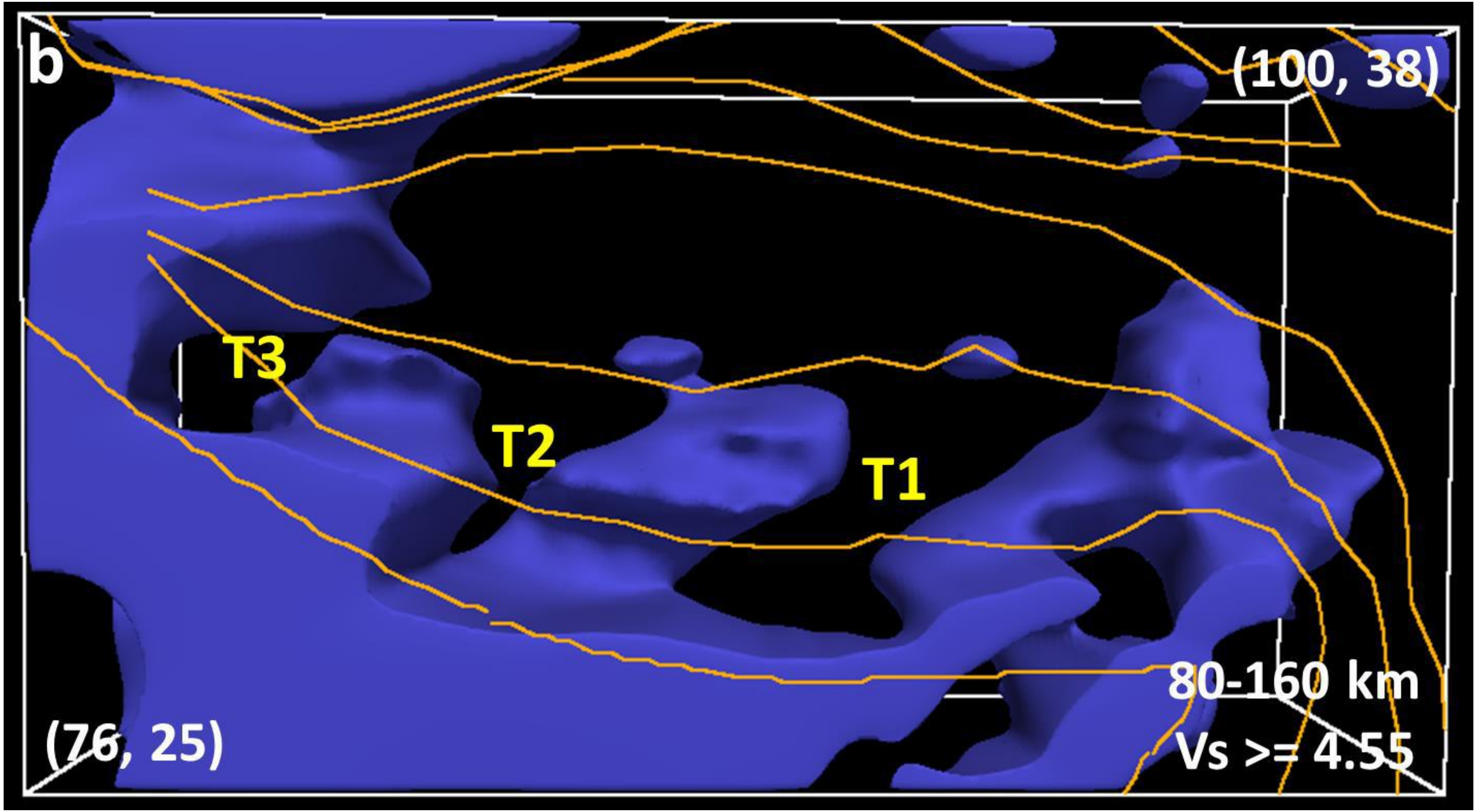


Stronger gradient cause greater dispersion

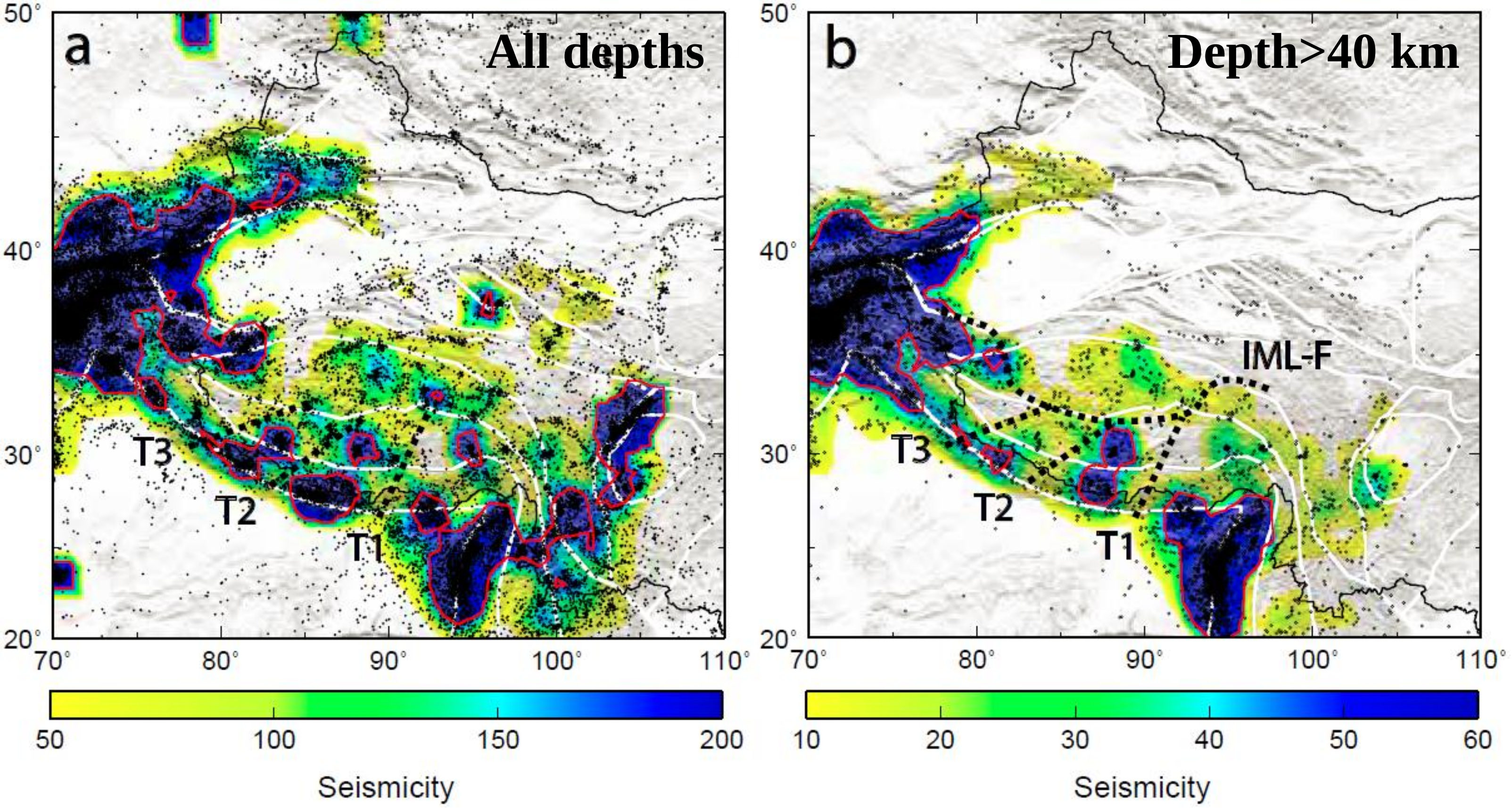


(Bao et al., 2015)

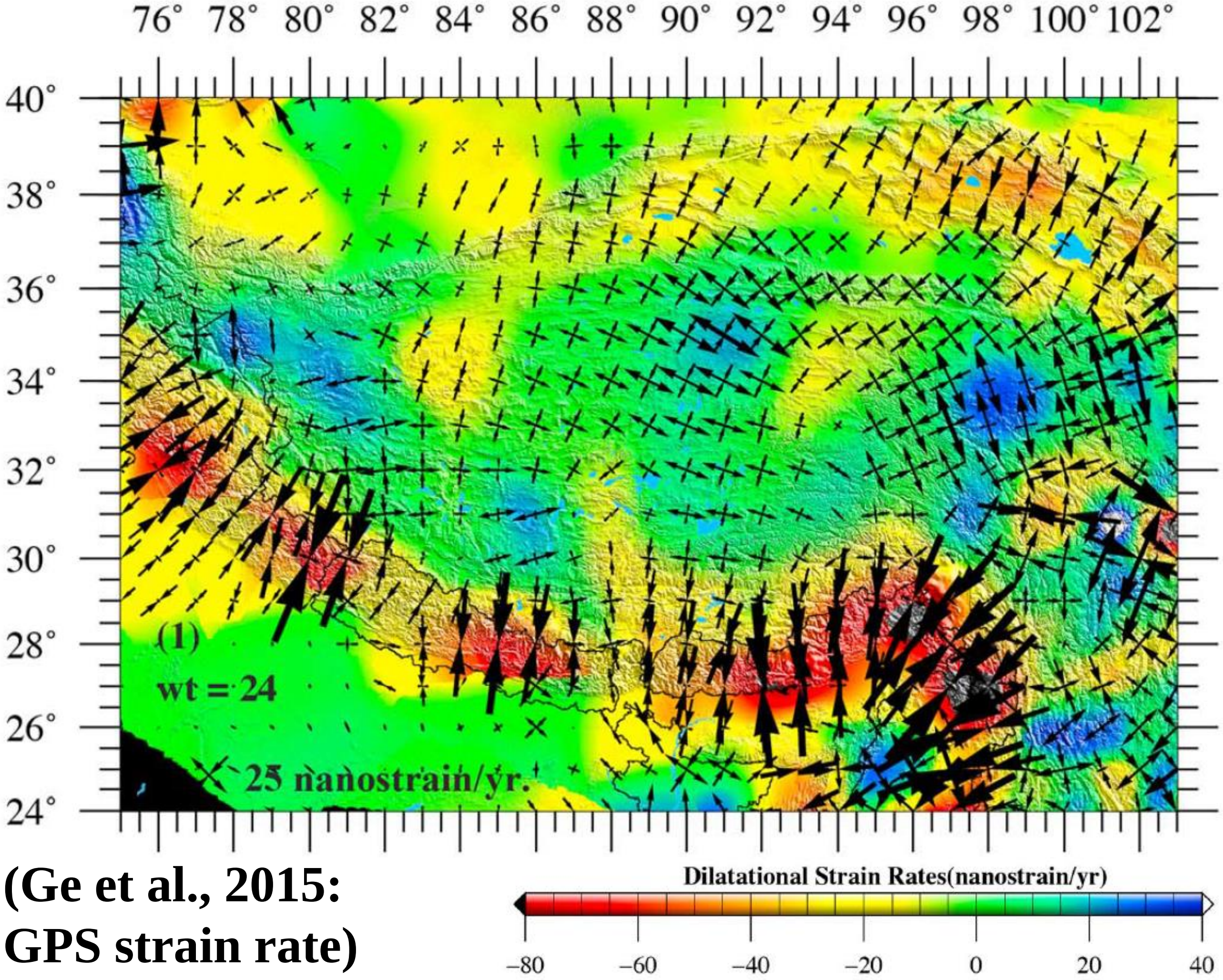
S-velocity model from Bao et al. (2015)



Results: seismicity

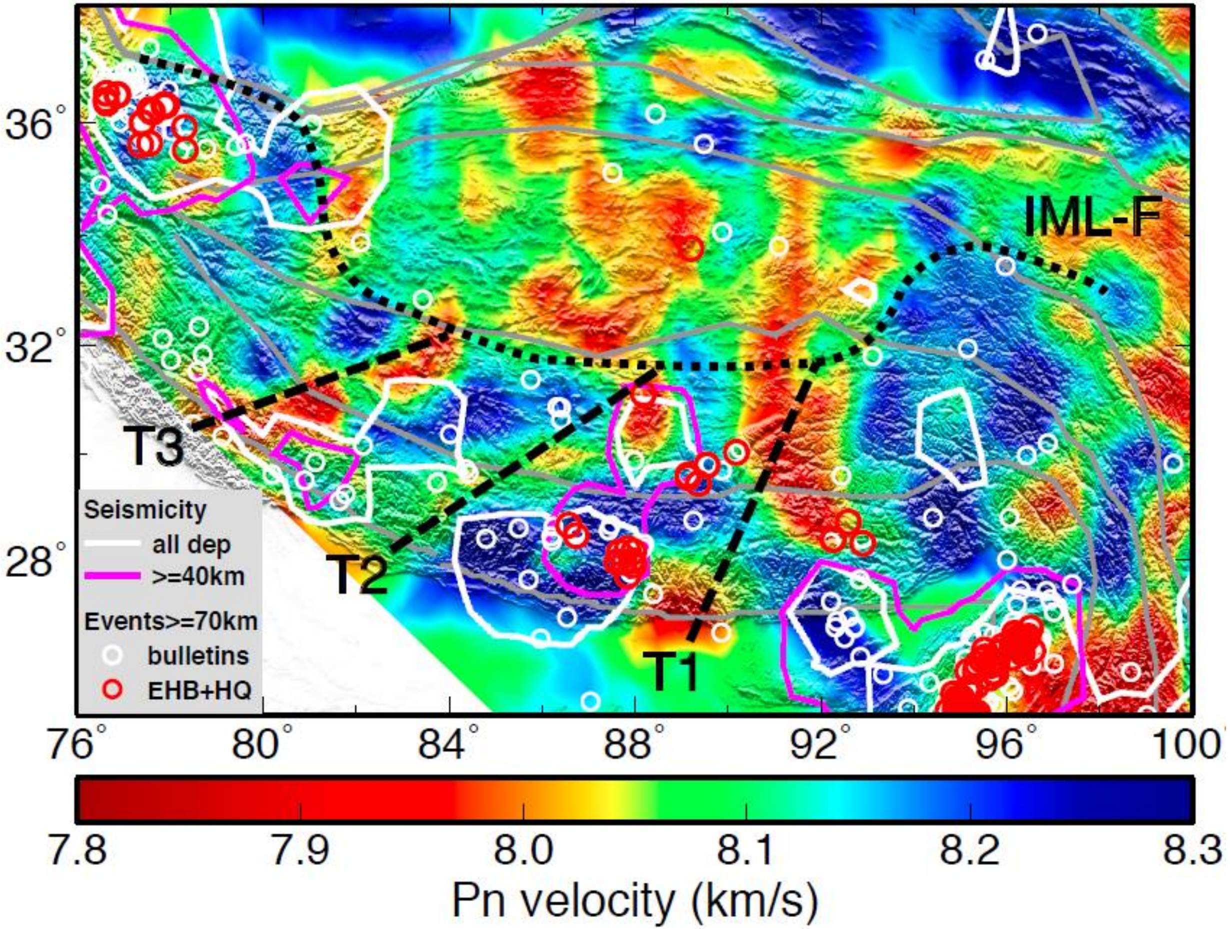


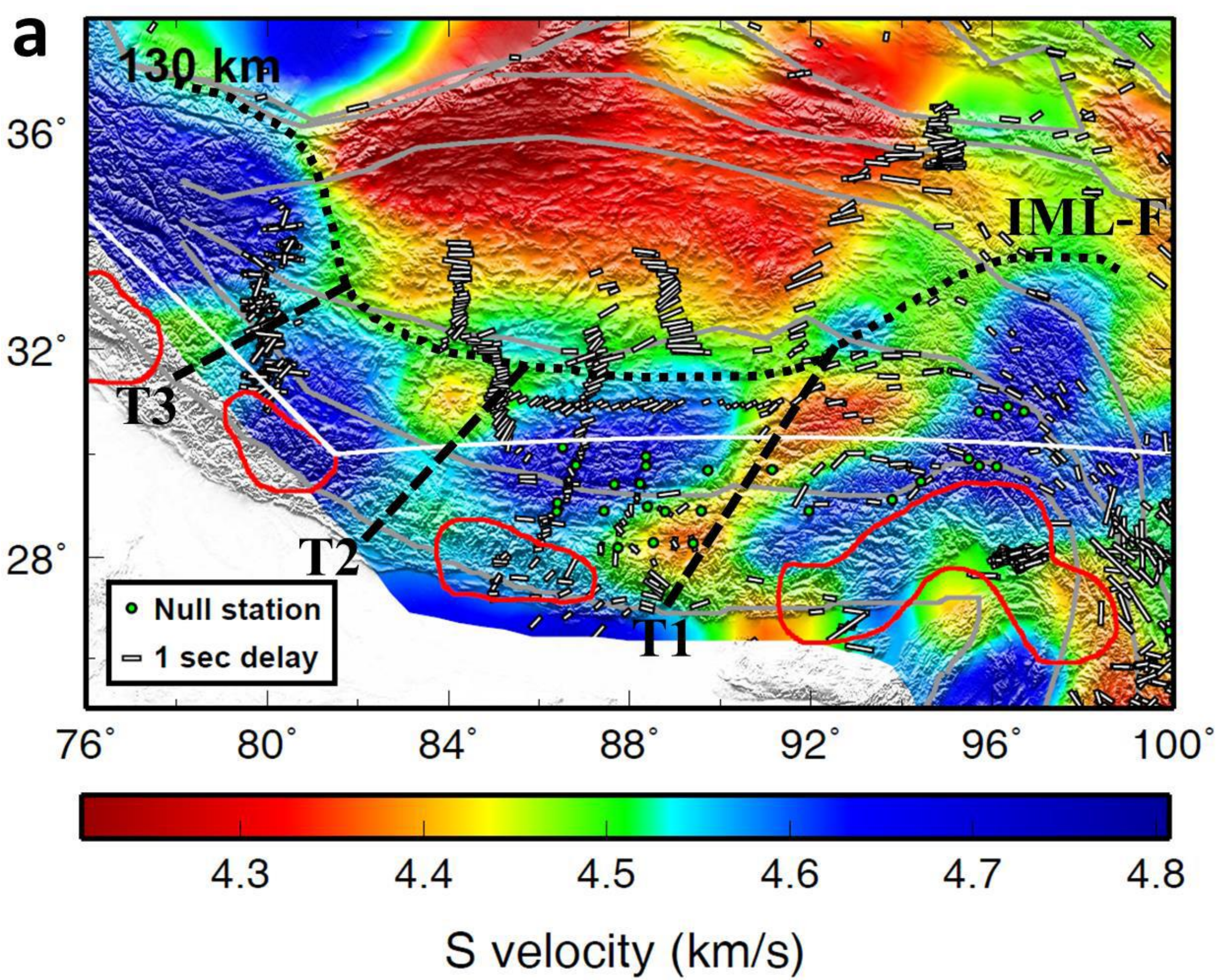
ISC catalog: 1 by 1 ºgrid, # of M>=4 within 1 º, contour of 190 and 50

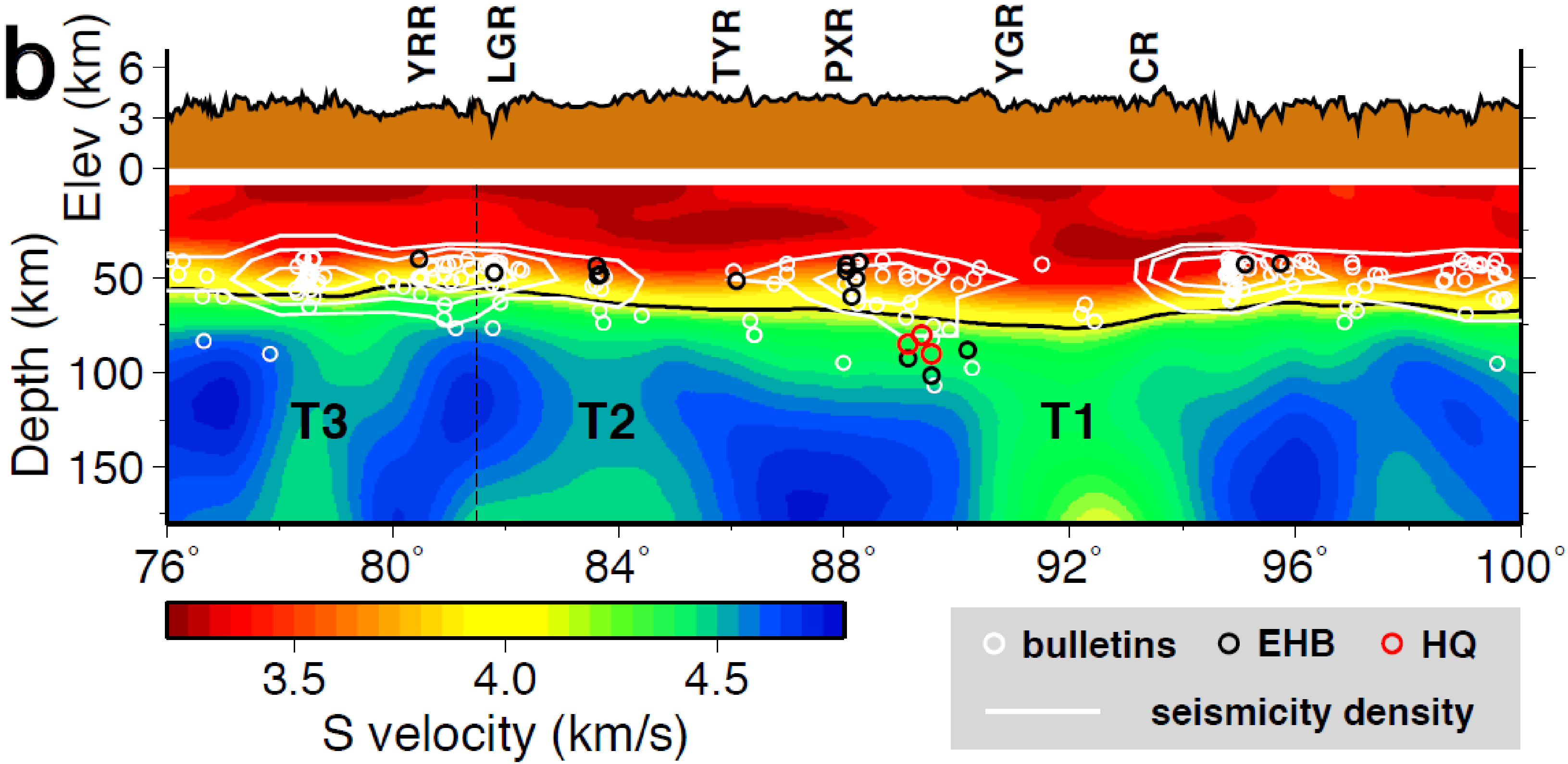


(Ge et al., 2015: GPS strain rate)

Implications

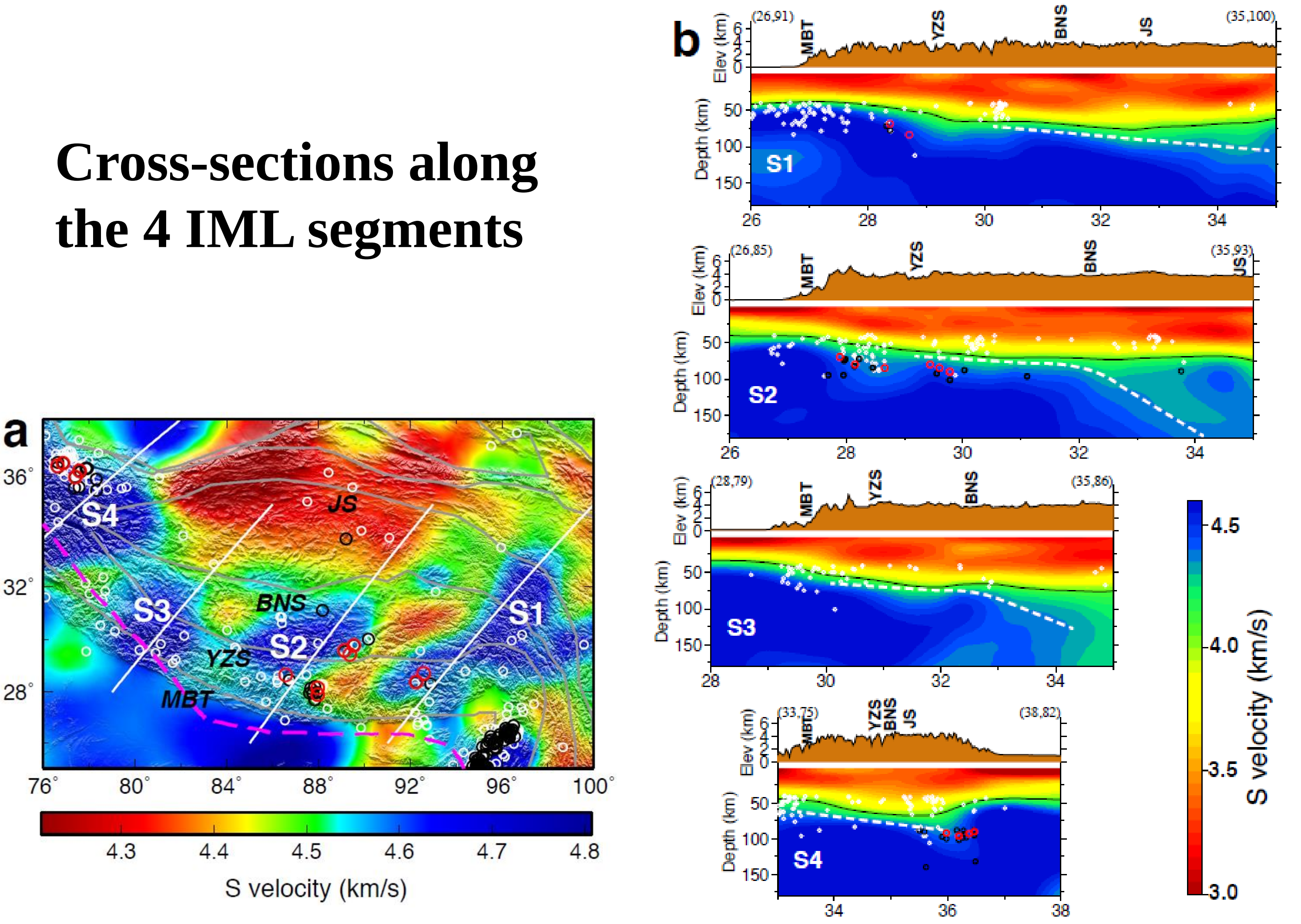



a
130 km
IML-F
36°
32°
28°
T3
T2
T1
Null station
1 sec delay
76°
80°
84°
88°
92°
96°
100°
4.3
4.4
4.5
4.6
4.7
4.8
S velocity (km/s)

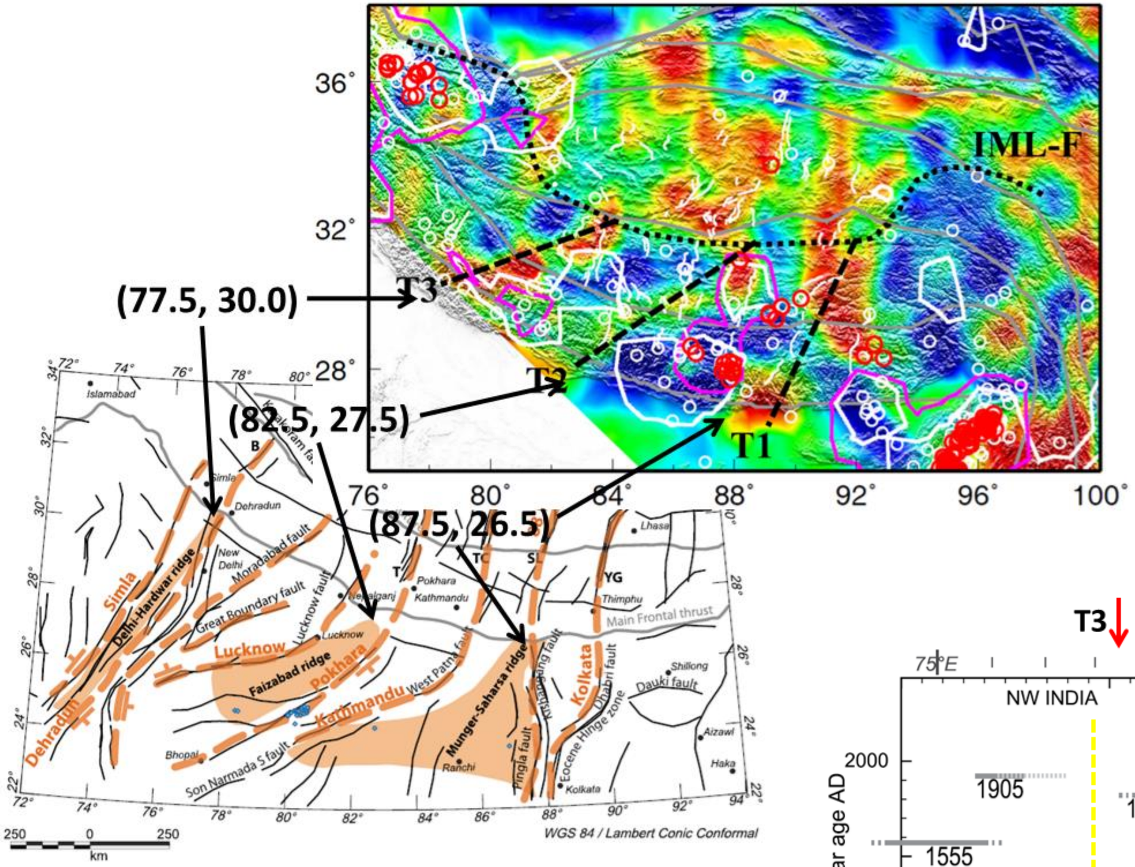


E-W cross-section

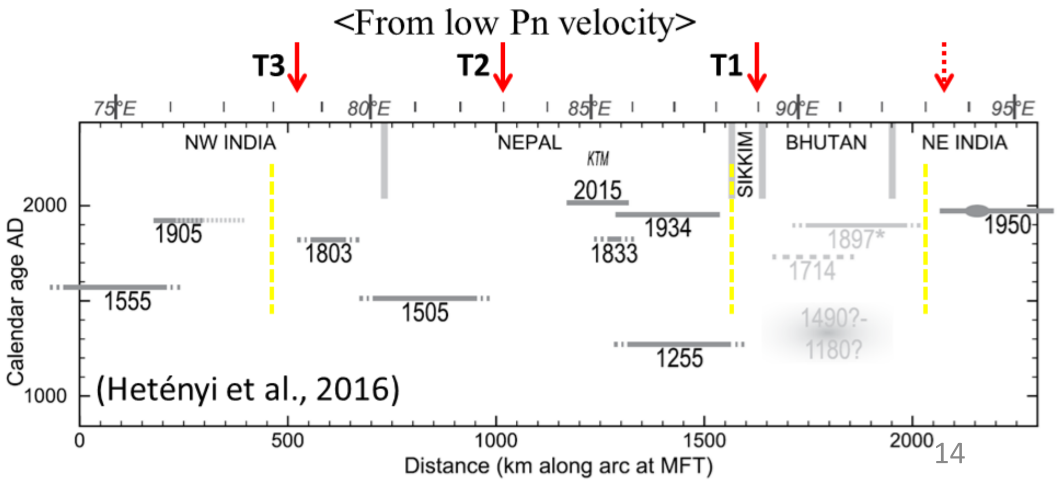
Cross-sections along the 4 IML segments

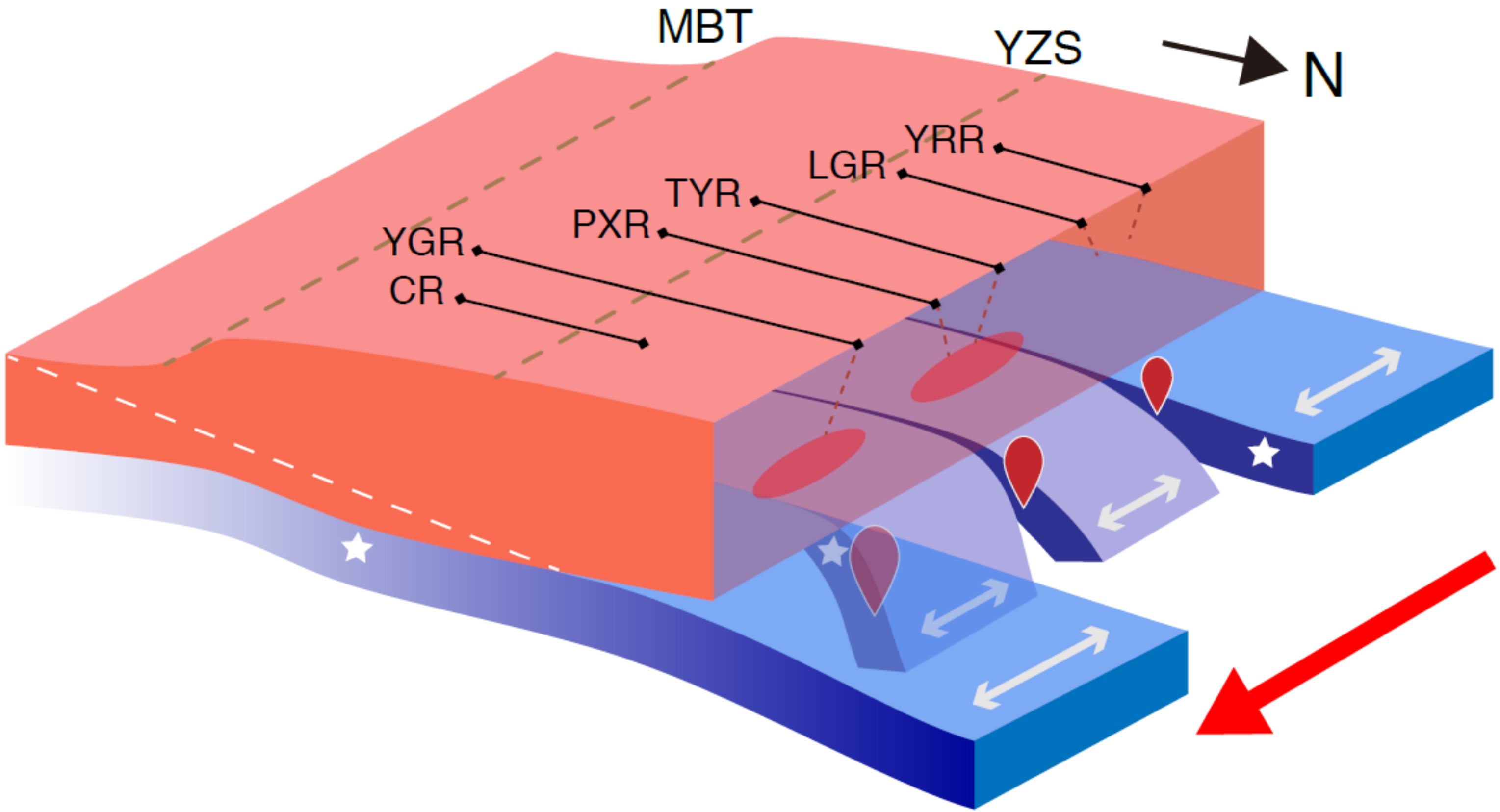


Correlation with Indian basement ridges and megathrust earthquakes

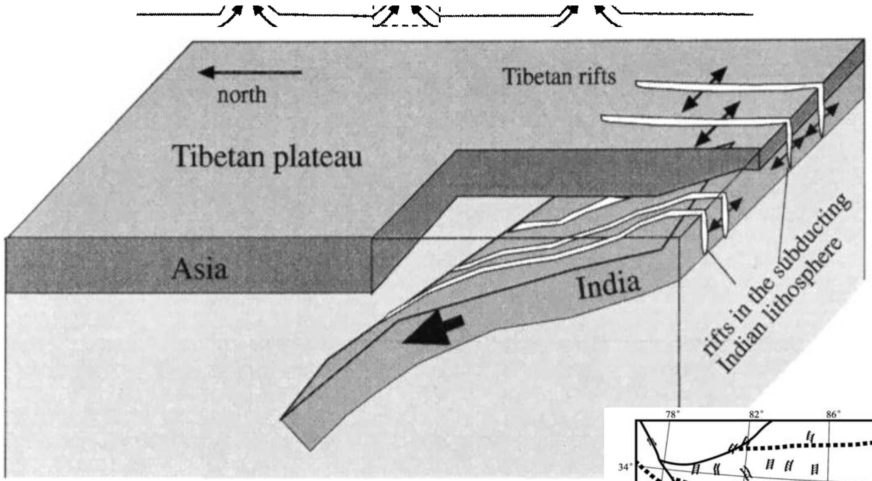


(Godin and Harris, 2014)

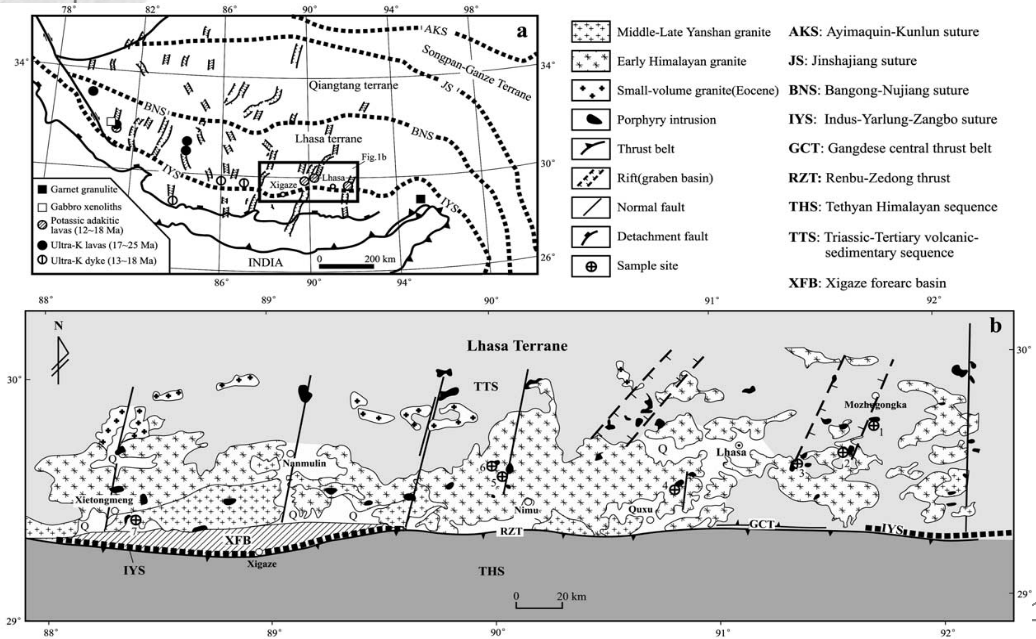




Proposed Model



Yin (2000) argued surface rifting in Himalaya and south and central Tibet must have involved mantle lithosphere



Distribution of Miocene adakitic extrusive rocks in southern Tibet (from Hou et al., 2004, 2006)

Conclusions

- High-resolution P and S images suggest that the subducted IML is torn into at least 4 pieces, with different angles and northern limits
- Deep earthquakes in the lower crust and mantle are located almost exclusively in high-velocity part of the Indian lithosphere
- Tearing of the IML provides a unified mechanism for late Miocene and Quaternary rifting, normal faulting, and deep earthquakes in southern and central Tibetan Plateau
- The deformation of the crust and mantle lithosphere is strongly coupled in southern Tibet
- The lateral extent of potential megathrust earthquakes may be limited by the segment boundaries