# 一个青藏高原的“传说”

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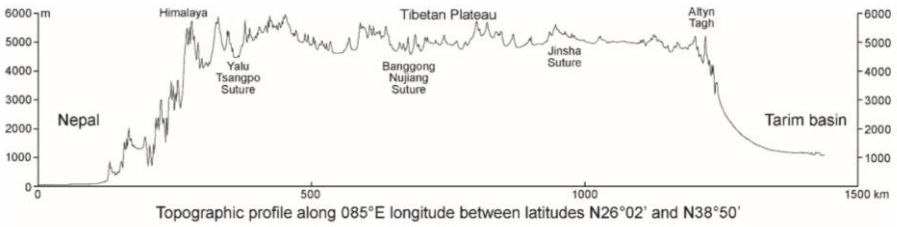
# 区域构造背景

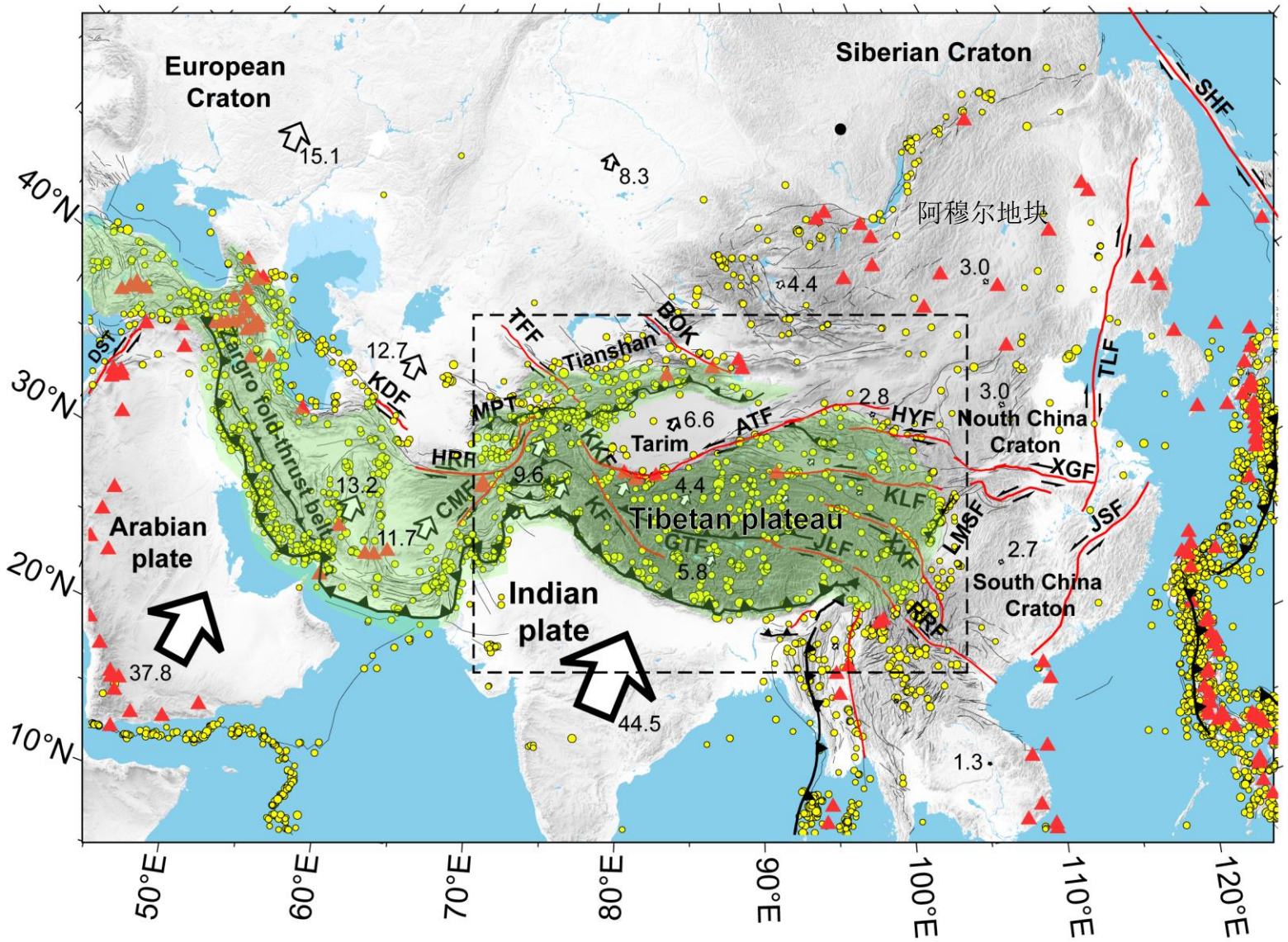
**Cratons：**
East European Craton, Siberia Craton, North China Craton, South China Craton, Indian craton and Arabian Craton

**Tibetan plateau:**

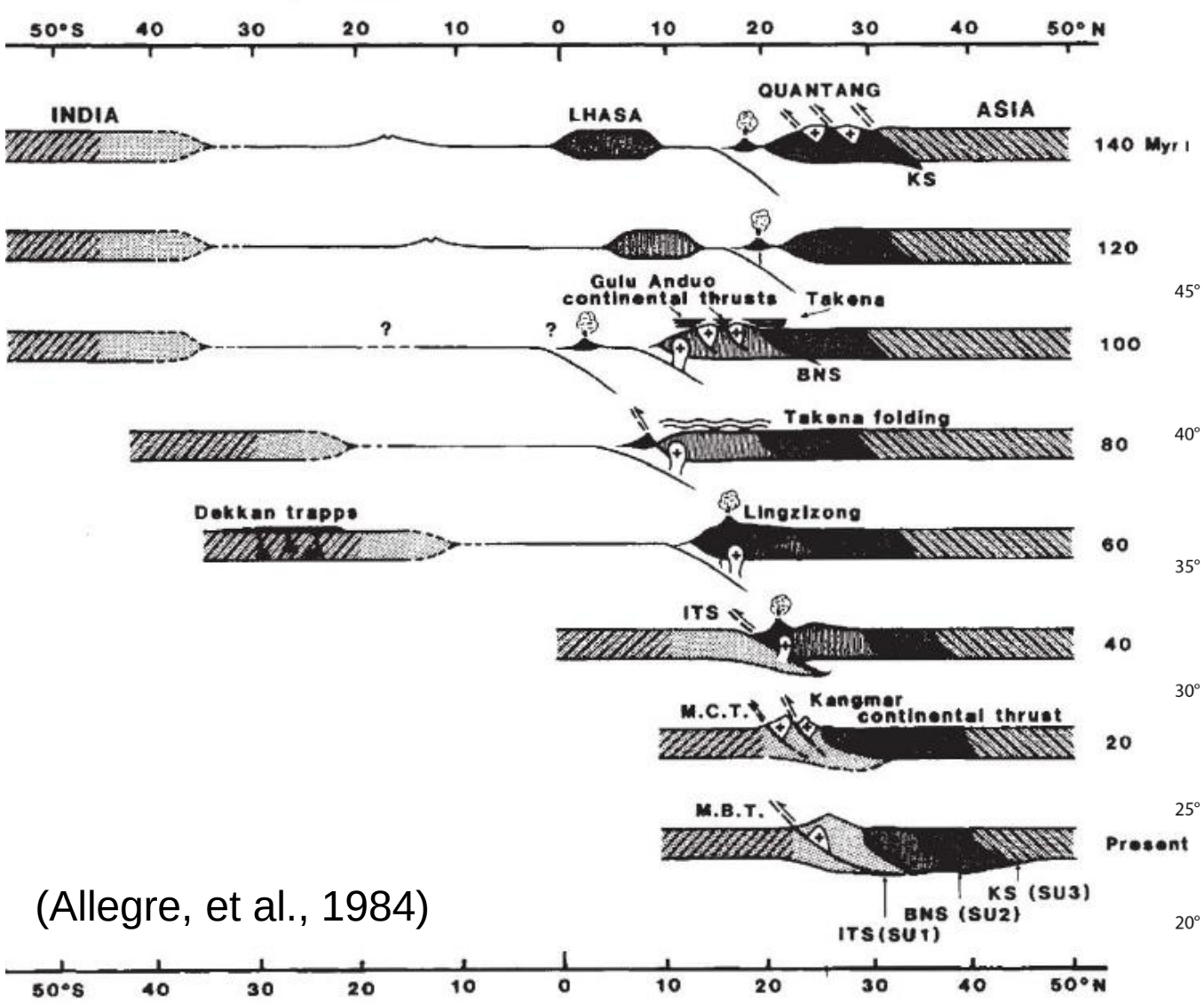
- Alpine-Himalayan Orogeny
- Mediterranean-Himalayan seismic belt
- High plateau with a flat top, with an altitude reaching 5000 m.



Topographic profile along 085°E longitude between latitudes N26°02' and N38°50'

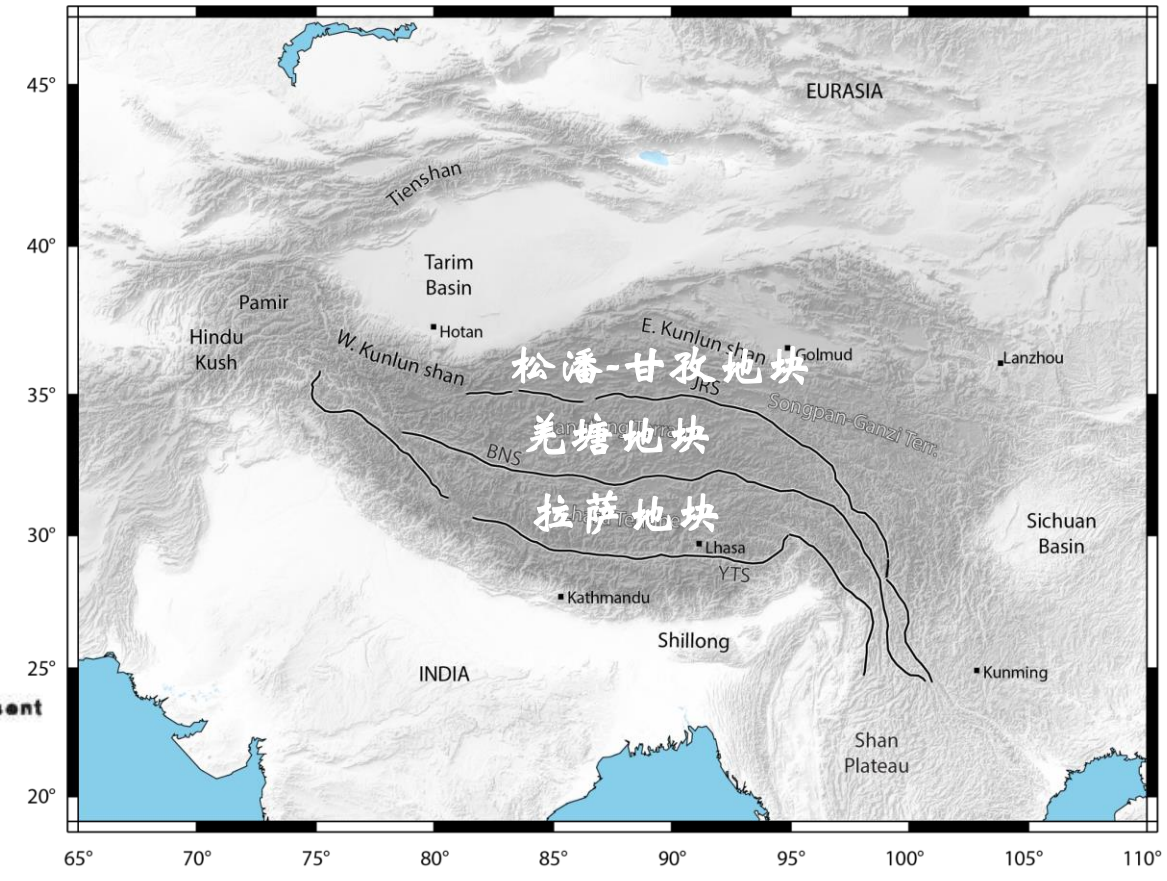


# 青藏高原是一个大陆拼图




(Allegre, et al., 1984)

- Tibetan plateau forms as a continental mosaic

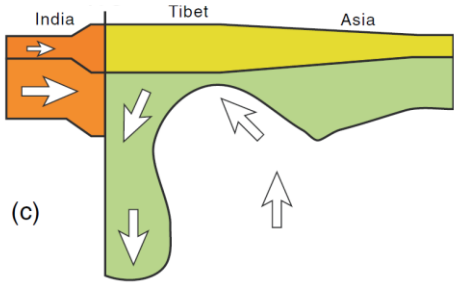


# 青藏高原的生长机制

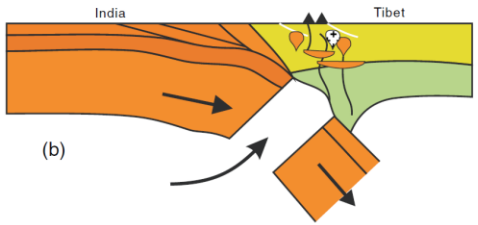
Continental underthrusting

Distributed shortening

**Mantle delamination**




**Slab breakoff**




(Harisson et al., 1992;
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**Continental underthrusting**

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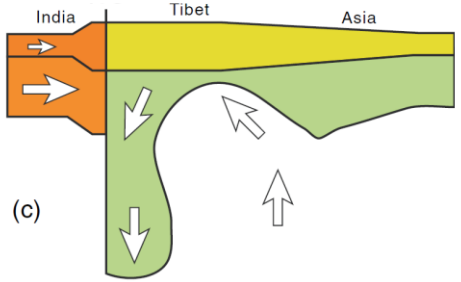


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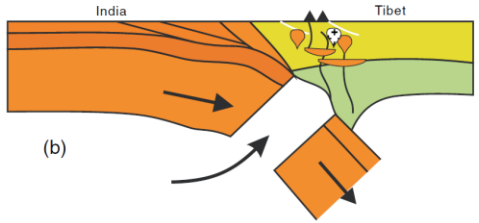
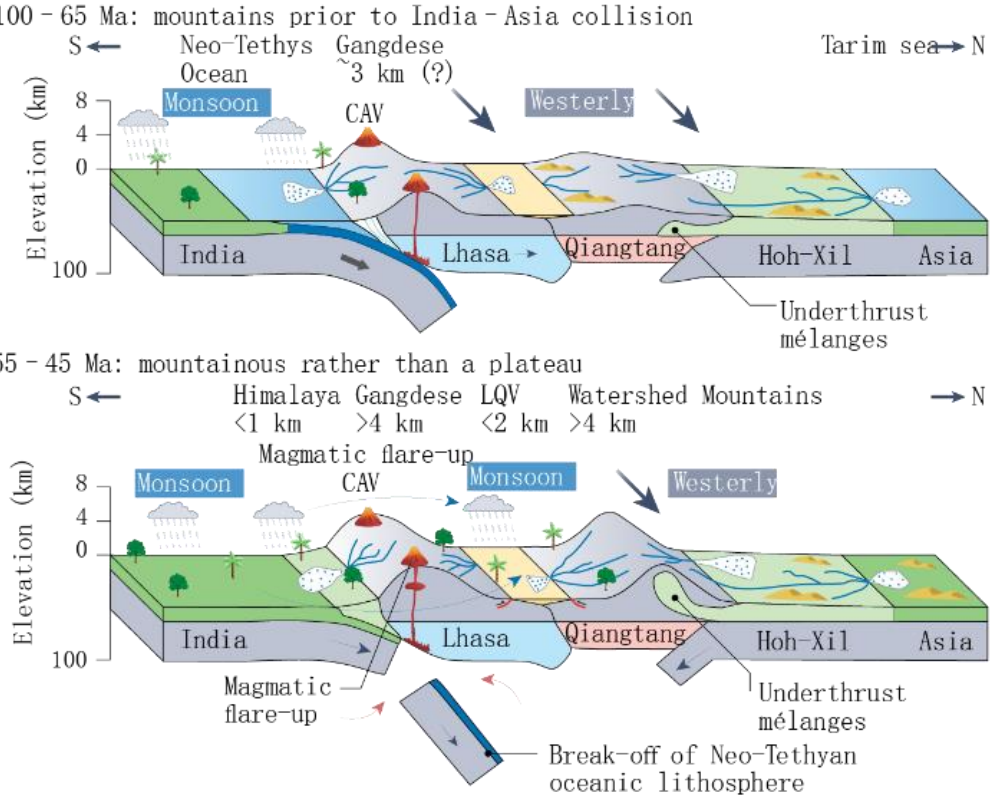
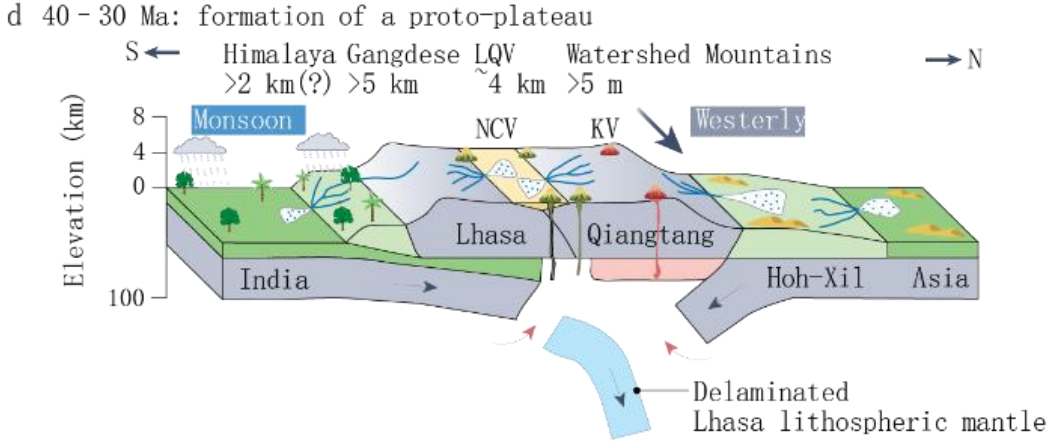
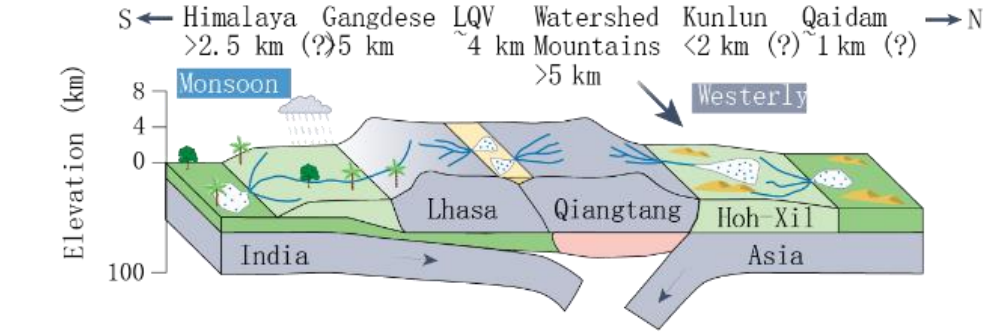
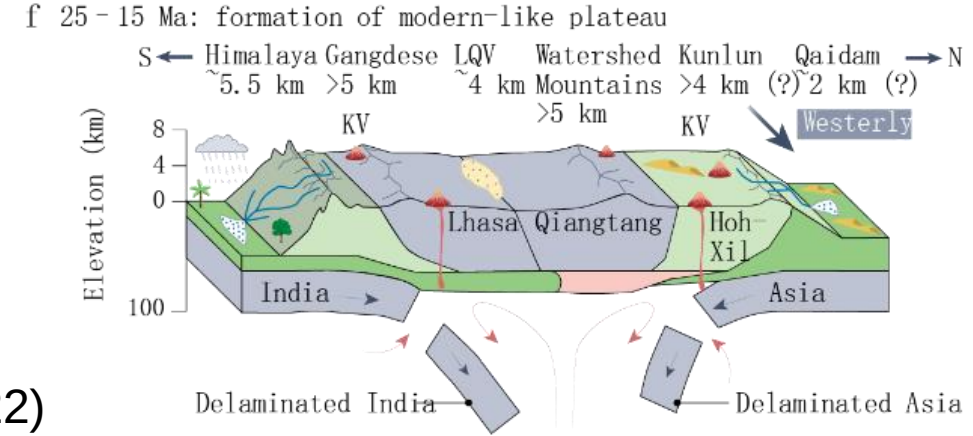



(Harisson et al., 1992; Zhang, et al., 2014)



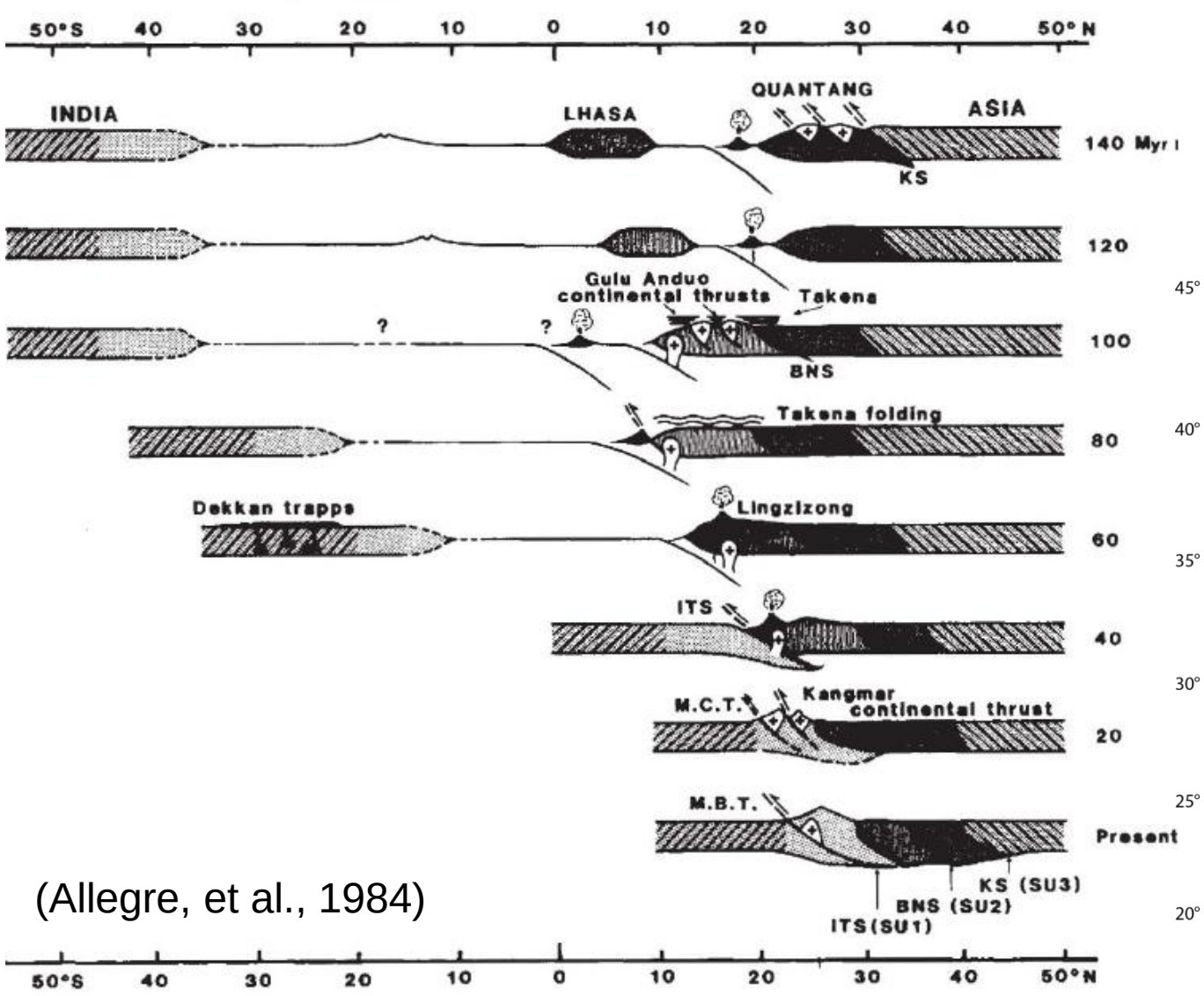



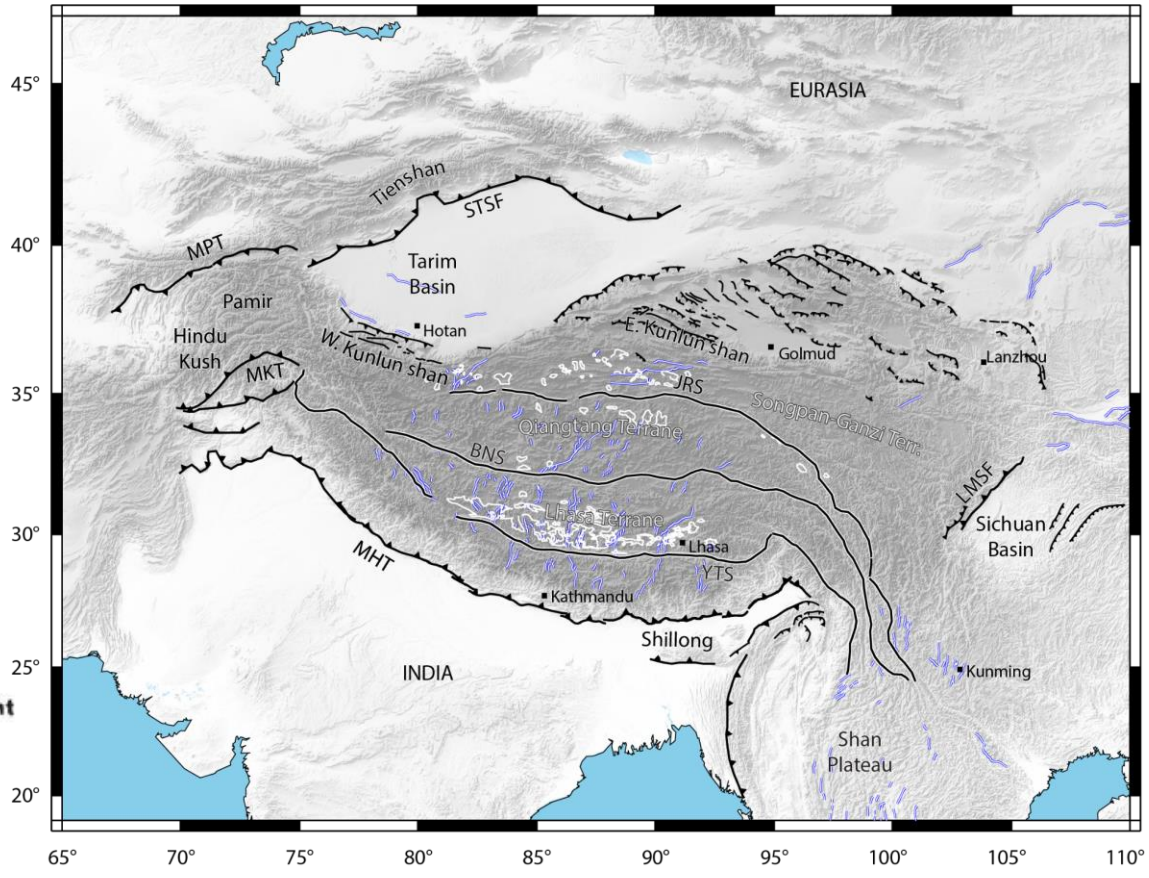

(Ding, et al., 2022)

# 青藏高原的构造分布特征——火山、正断层、逆断层



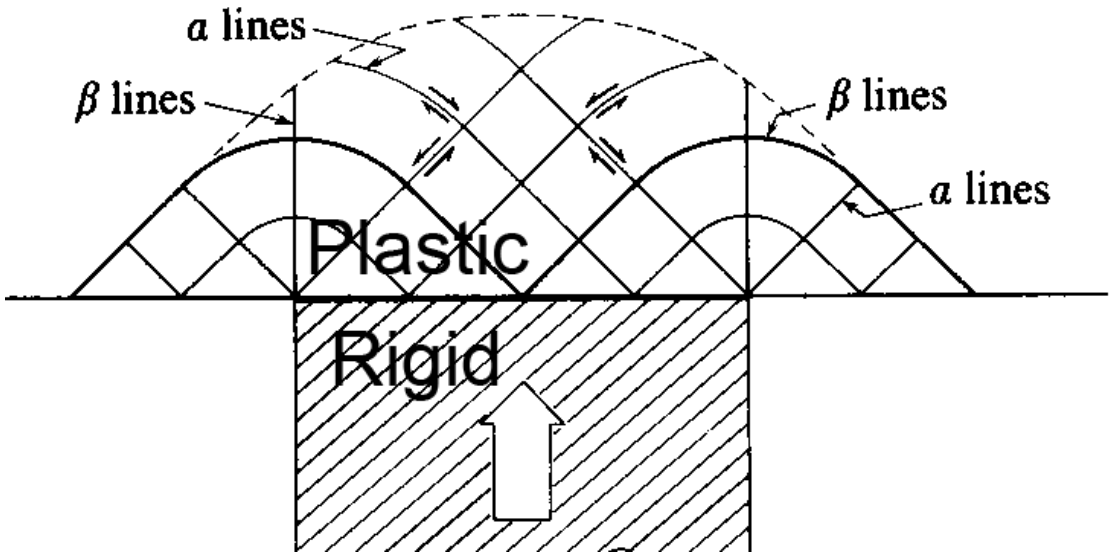

(Allegre, et al., 1984)

- Tibetan plateau forms as a continental mosaic
- The collision processes were accompanied with **volcanic activities, folding and thrust faulting**.



# 青藏高原的构造分布特征——走滑断层

## 滑移线理论




(Tapponier et al., 1976)

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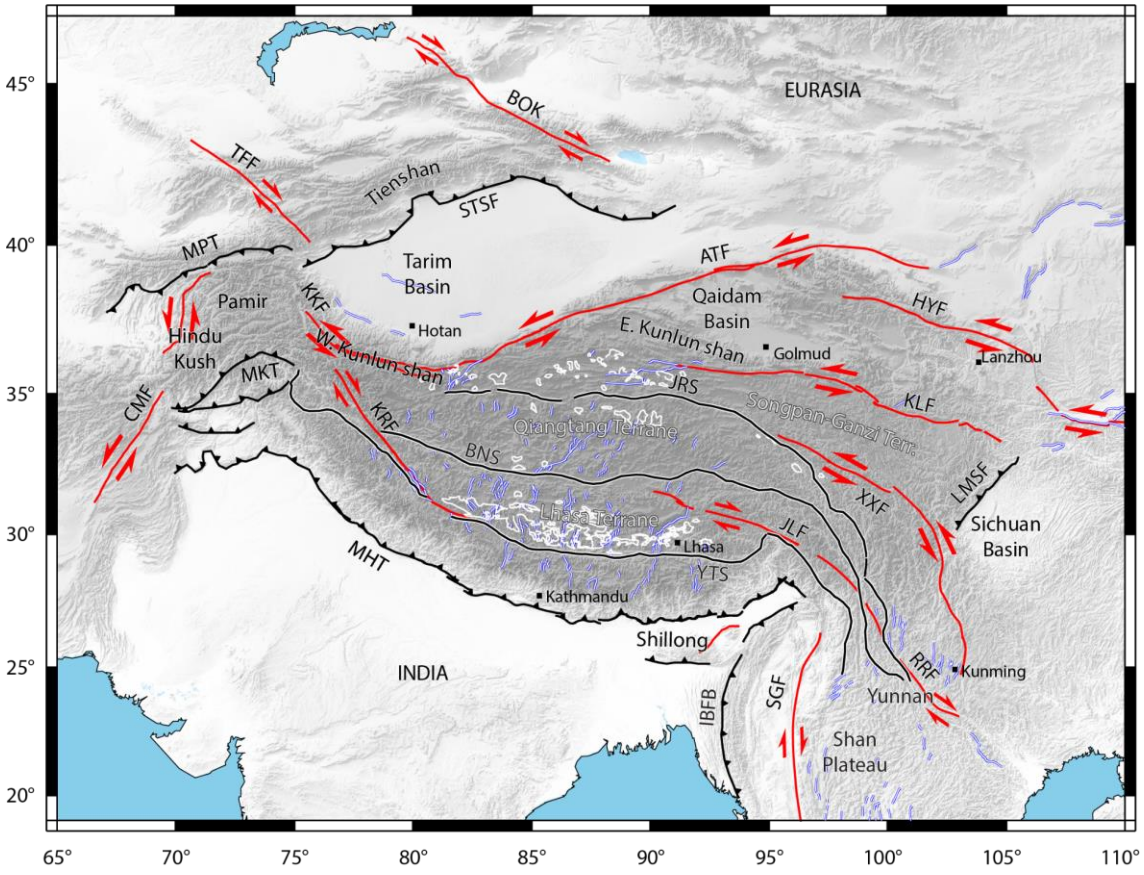
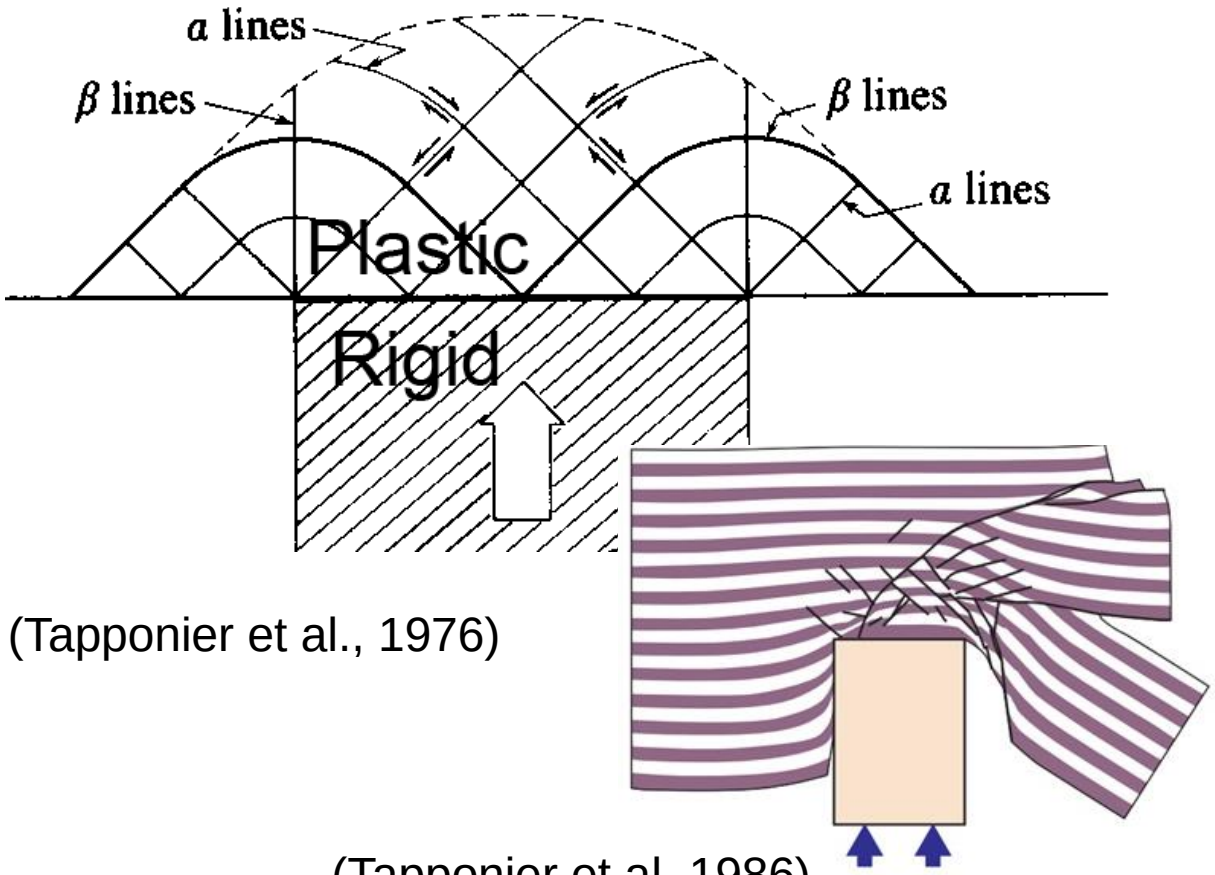


# 青藏高原的构造分布特征——走滑断层

滑移线模型




(Tapponier et al., 1976)

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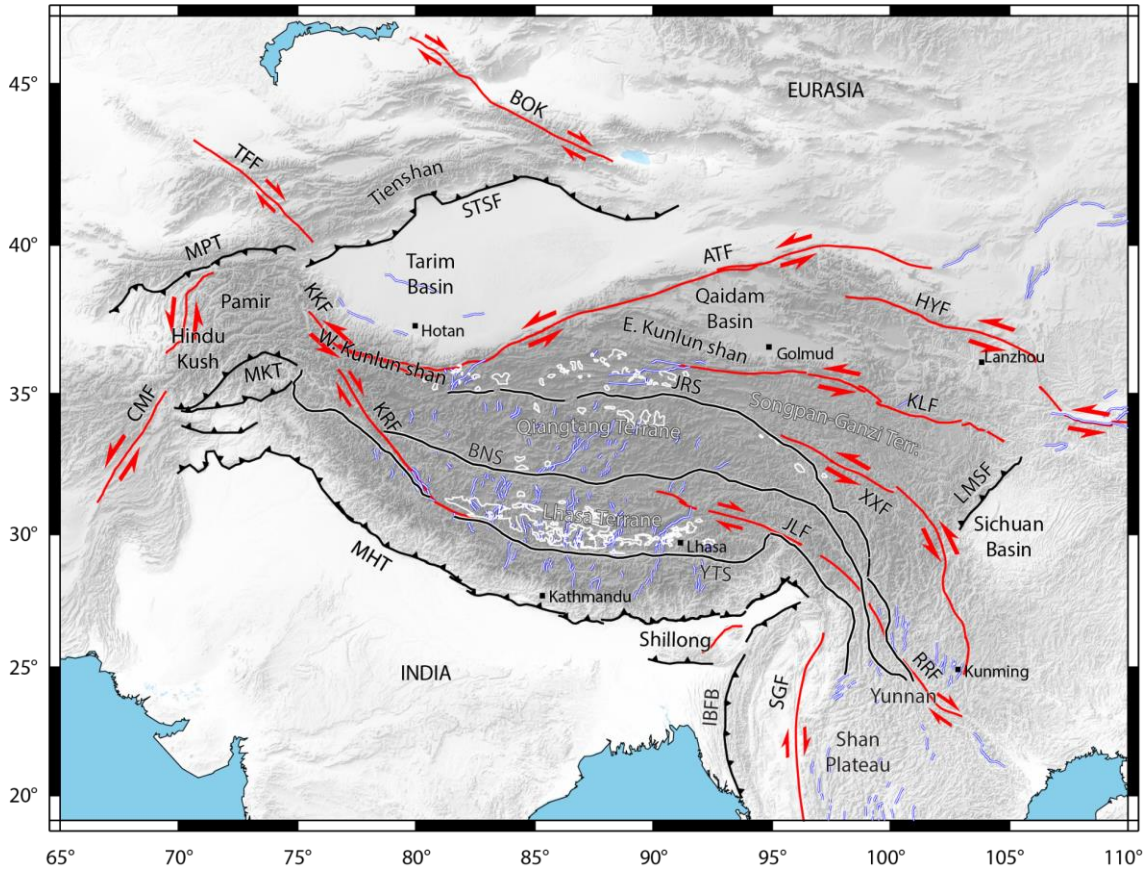
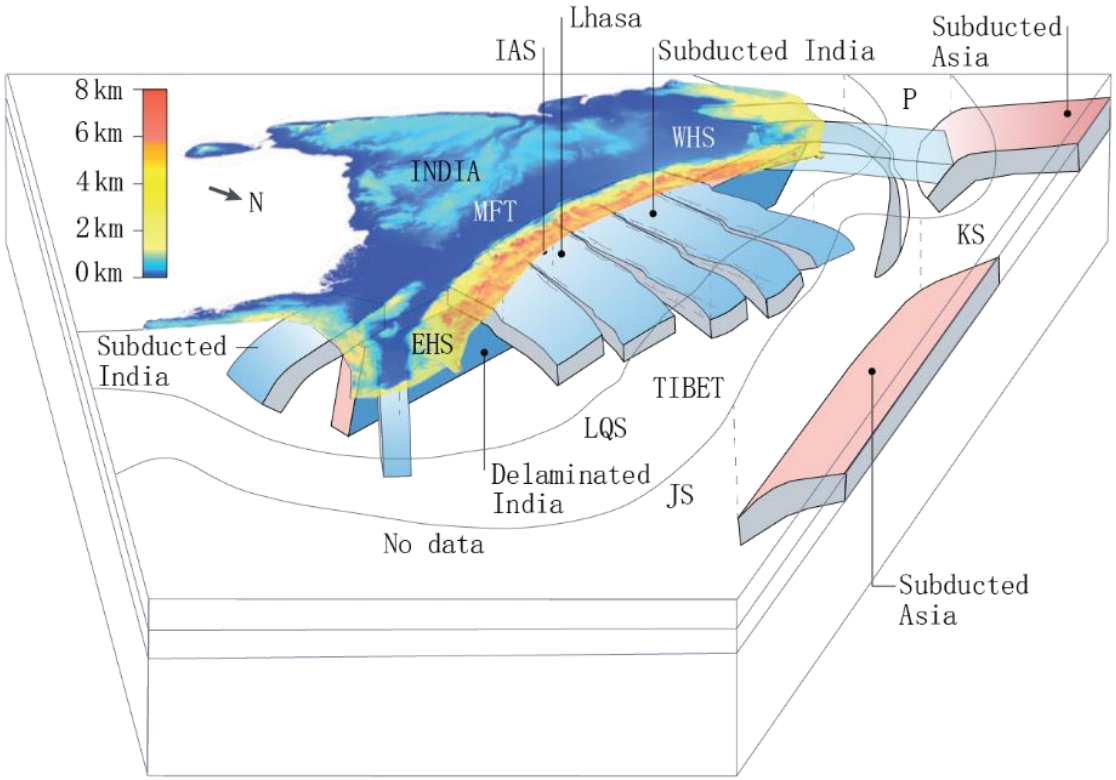
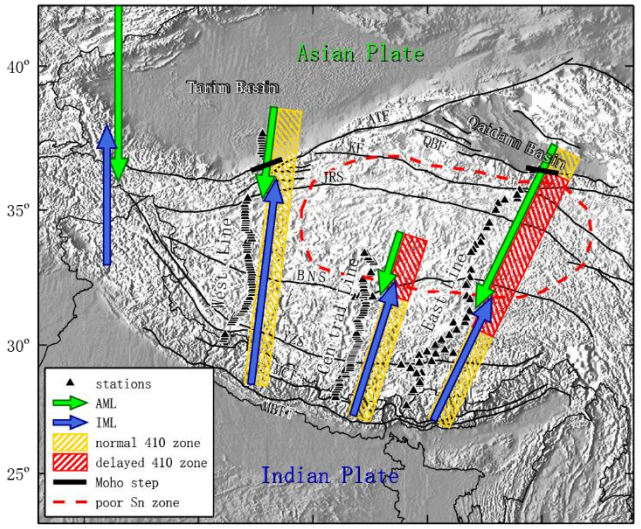


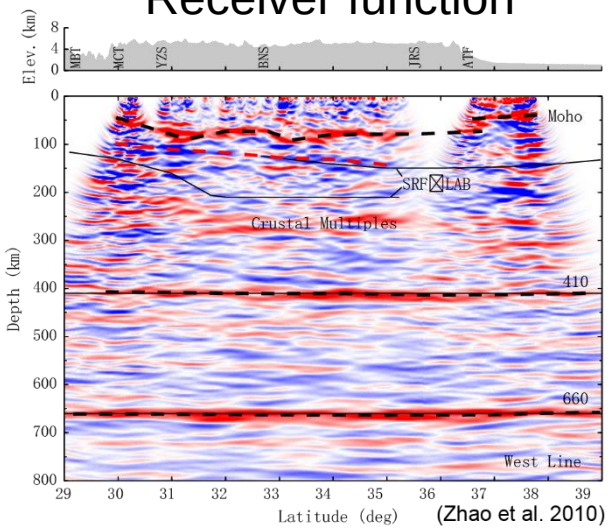
# 印度-欧亚的汇聚形态




(Ding, et al., 2022)

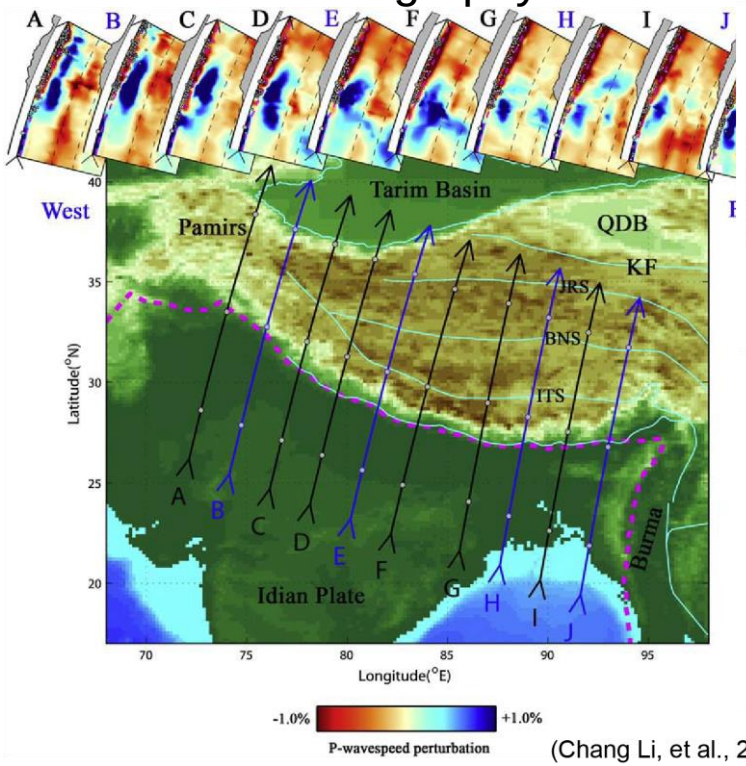



## Receiver function



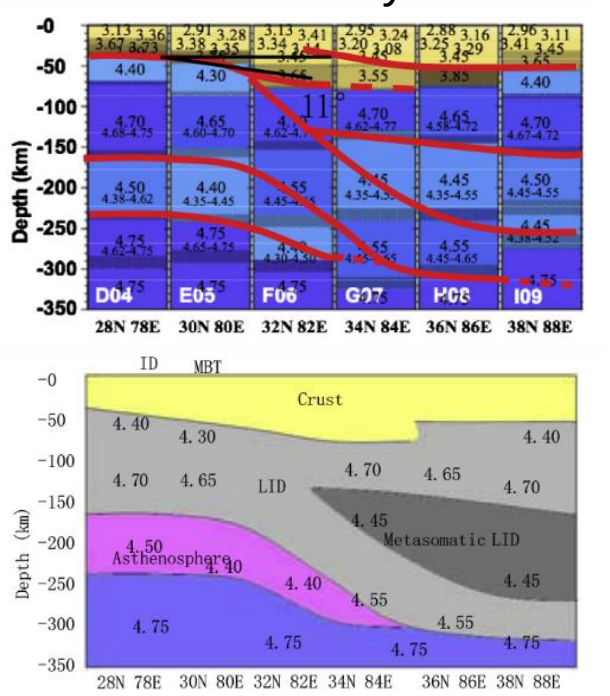

(Zhao et al. 2010)

## Tomography




(Chang Li, et al., 2008)

## Gravity




(Zhang et al., 2014)

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# Three-dimensional kinematics of the India–Eurasia collision

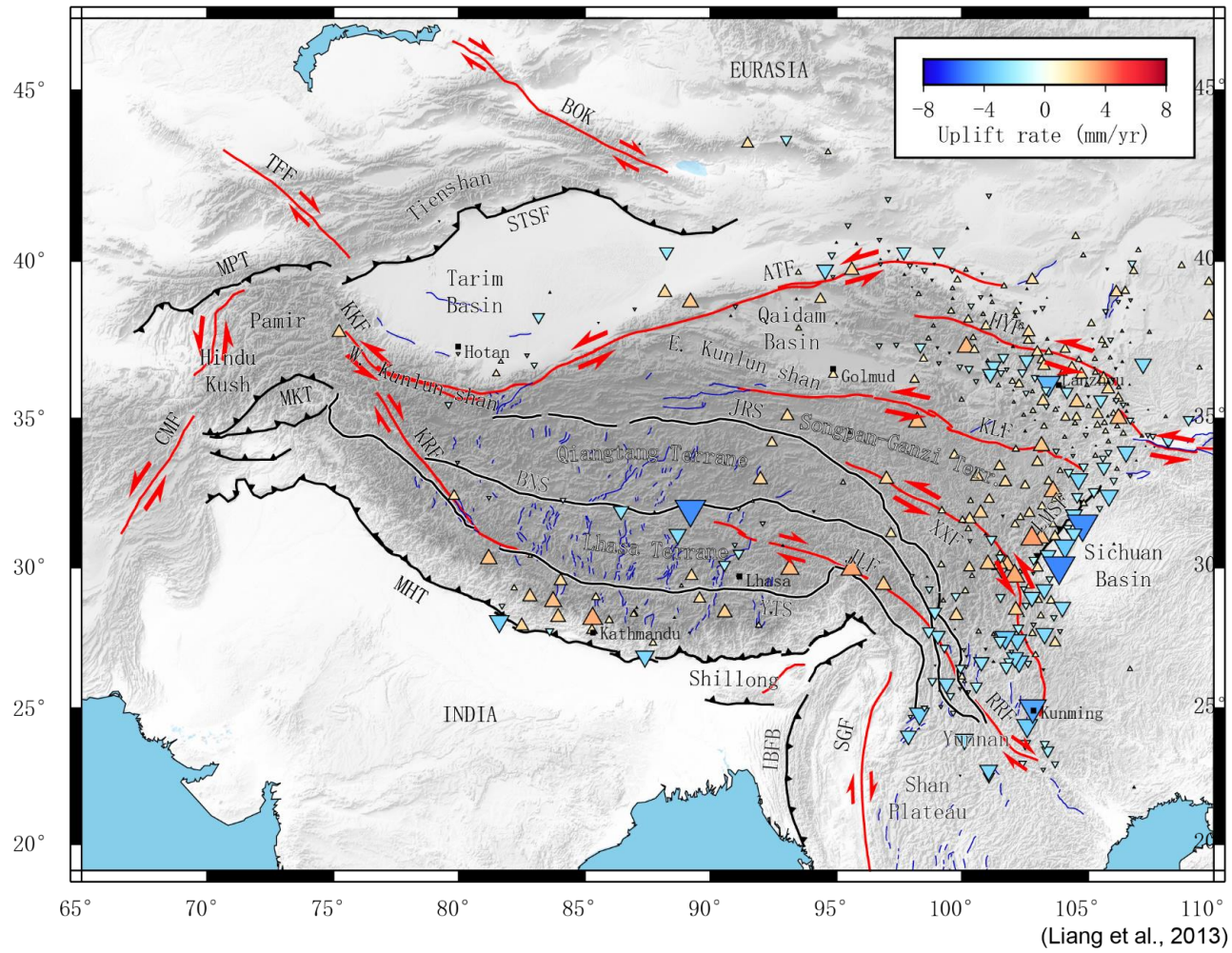
Lifeng Wang [1,2,3]✉ & Sylvain Barbot [4]✉

The collision between India and Eurasia mobilizes multiple processes of continental tectonics. However, how deformation develops within the lithosphere across the Tibetan Plateau is still poorly known and a synoptic view is missing. Here, we exploit an extensive geodetic observatory to resolve the kinematics of this diffuse plate boundary and the arrangement of various mechanisms down to upper-mantle depths. The three-dimensional velocity field is compatible with continental underthrusting below the central Himalayas and with delamination rollback below the western syntaxis. The rise of the Tibetan Plateau occurs by shortening in the Indian and Asian crusts at its southern and northwestern margins. The subsidence of Central Tibet is associated with lateral extrusion and attendant lithospheric thinning aided by the downwelling current from the opposite-facing Indian and Asian collisions. The current kinematics of the Indian-Eurasian collision may reflect the differential evolution of the inner and outer Tibetan Plateau during the late Cenozoic.

- 现今青藏高原的变形特征
- 构造(逆冲/走滑/拉张)解释
- 现今青藏高原的隆升状态
- 印度-欧亚三维汇聚模式

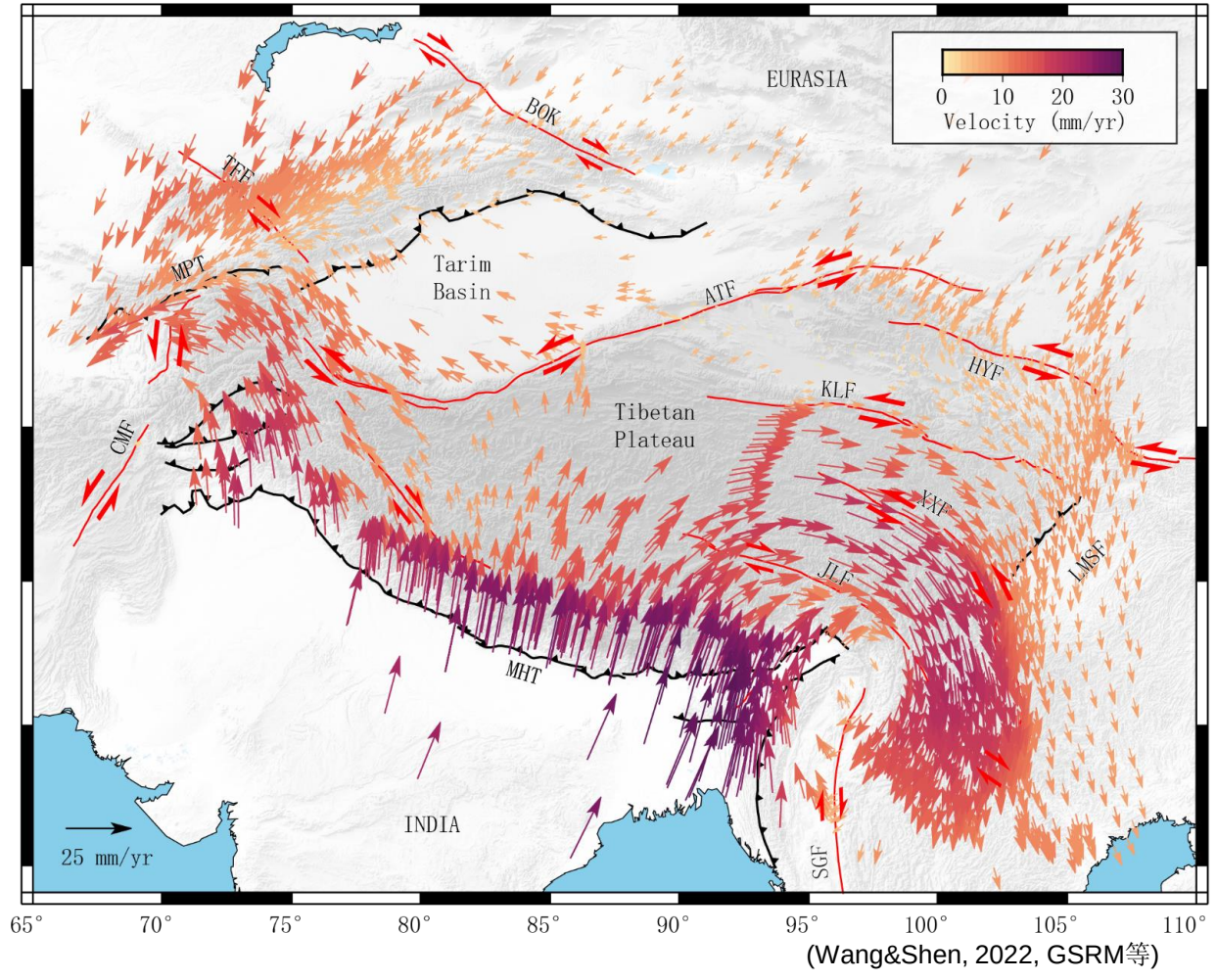
# 观测数据

## Vertical GPS velocity



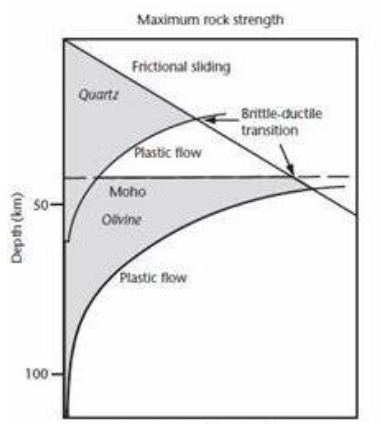

(Liang et al., 2013)

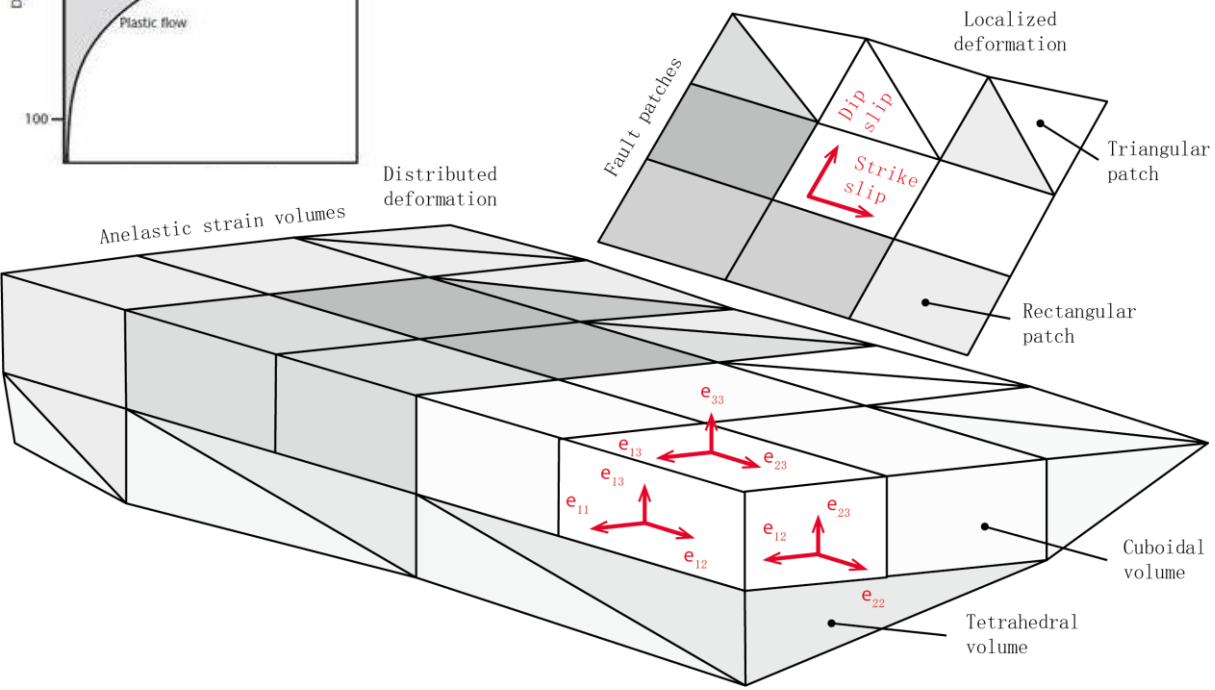
## Horizontal GPS velocity

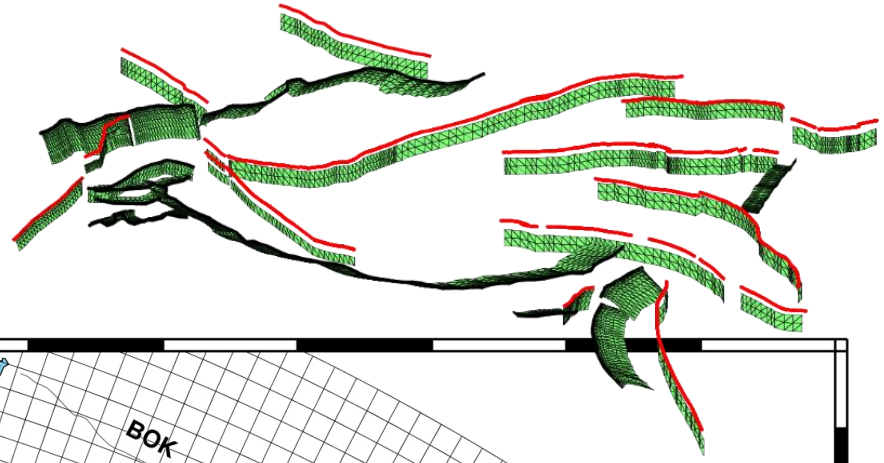


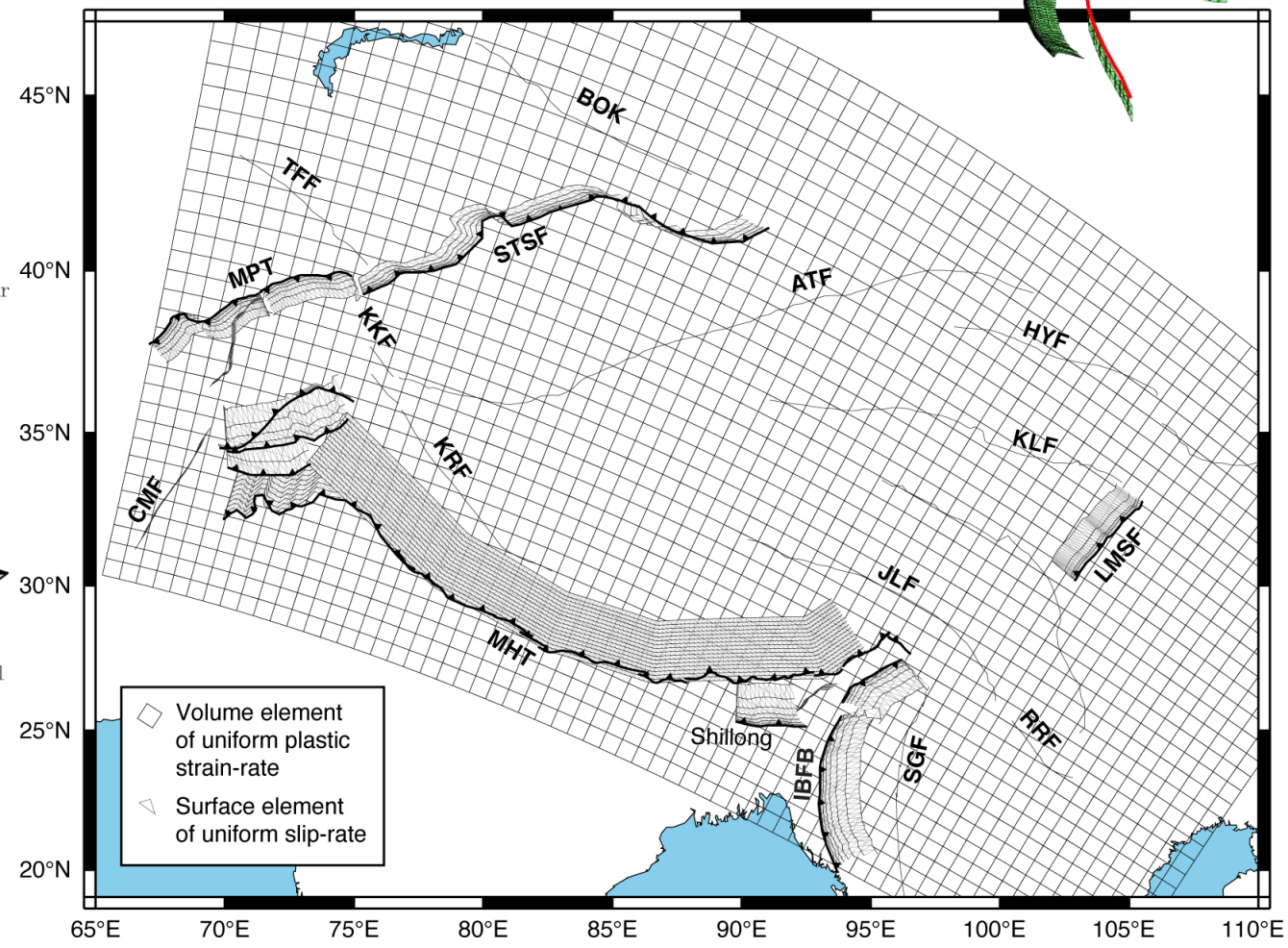

(Wang&Shen, 2022, GSRM等)

# 运动学建模方法



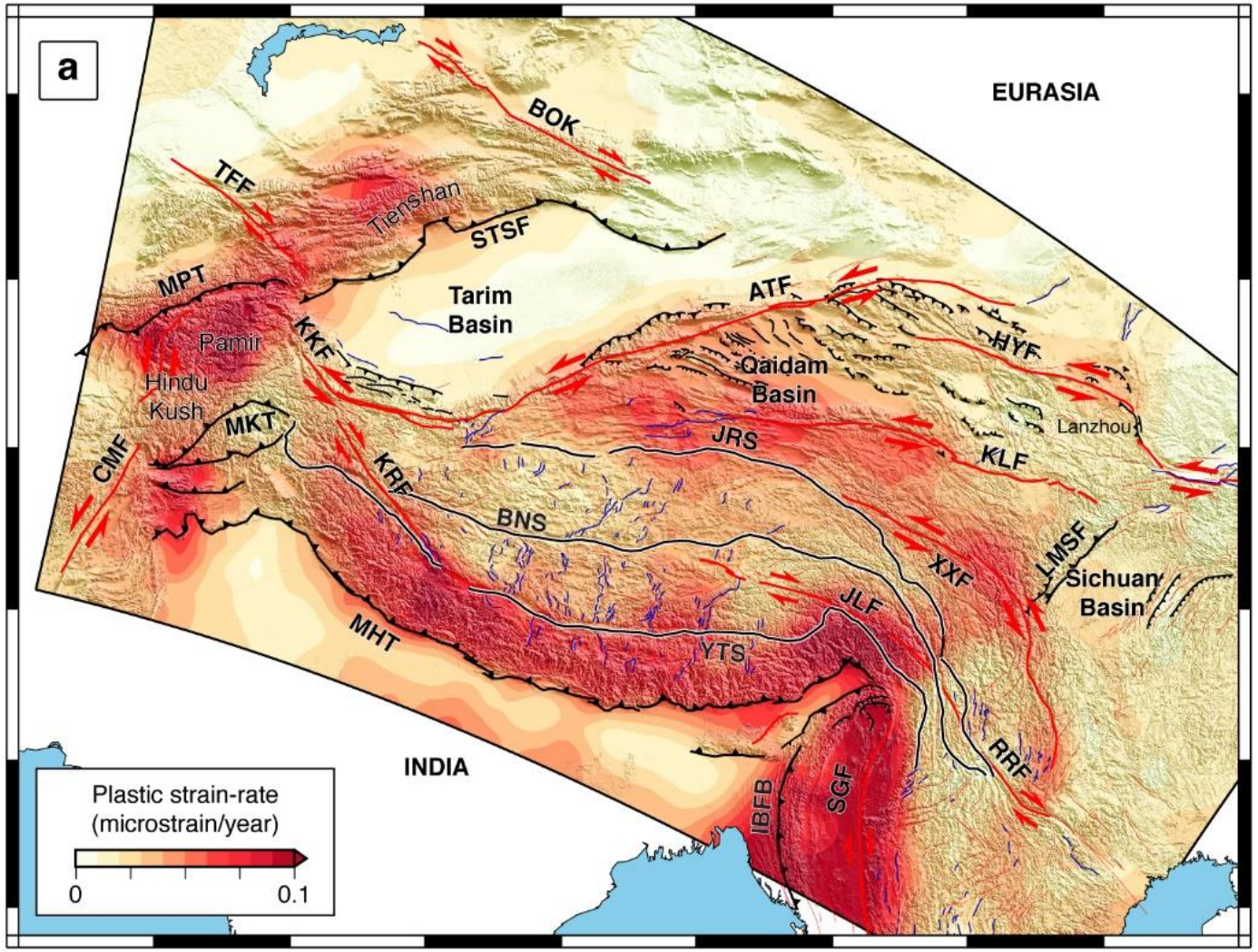



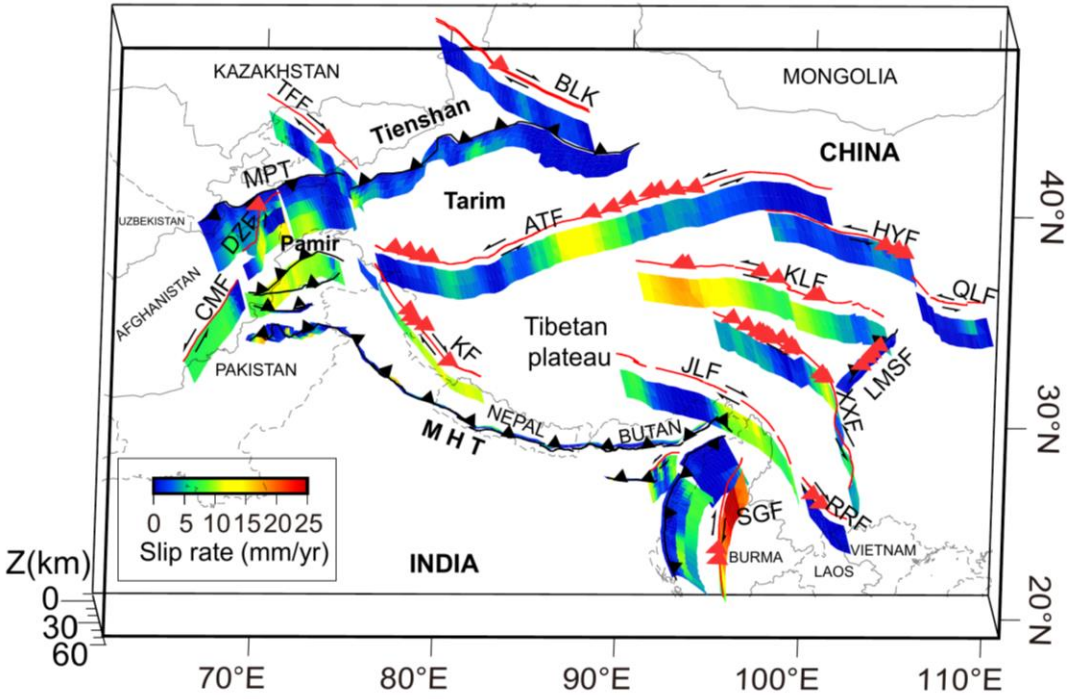



(Meade, 2007; Okada, 1992;Barbot, 2018; Landry & Barbot, 2019)

# 岩石圈塑性层的应变分布




# 脆性上地壳断层滑动分布



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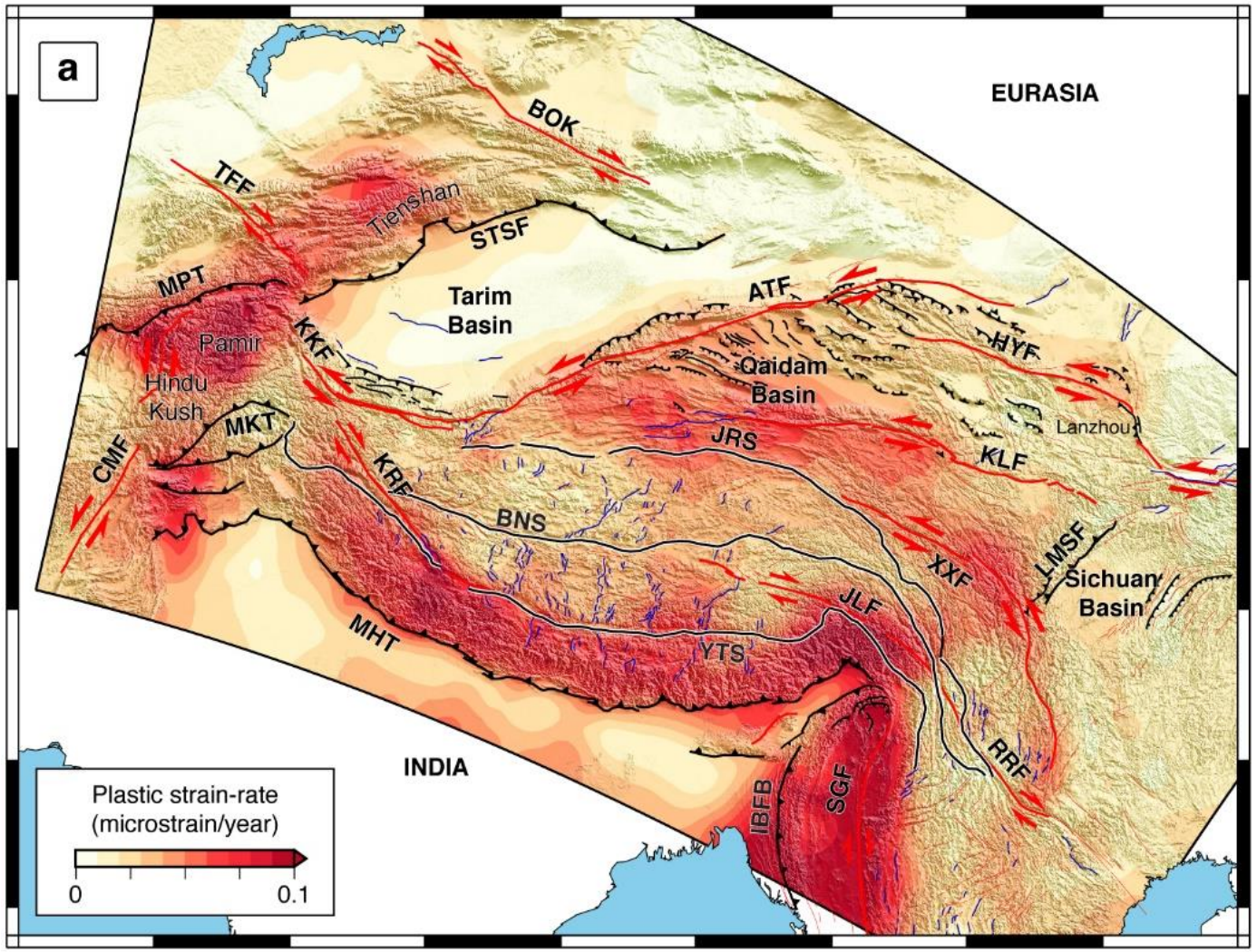
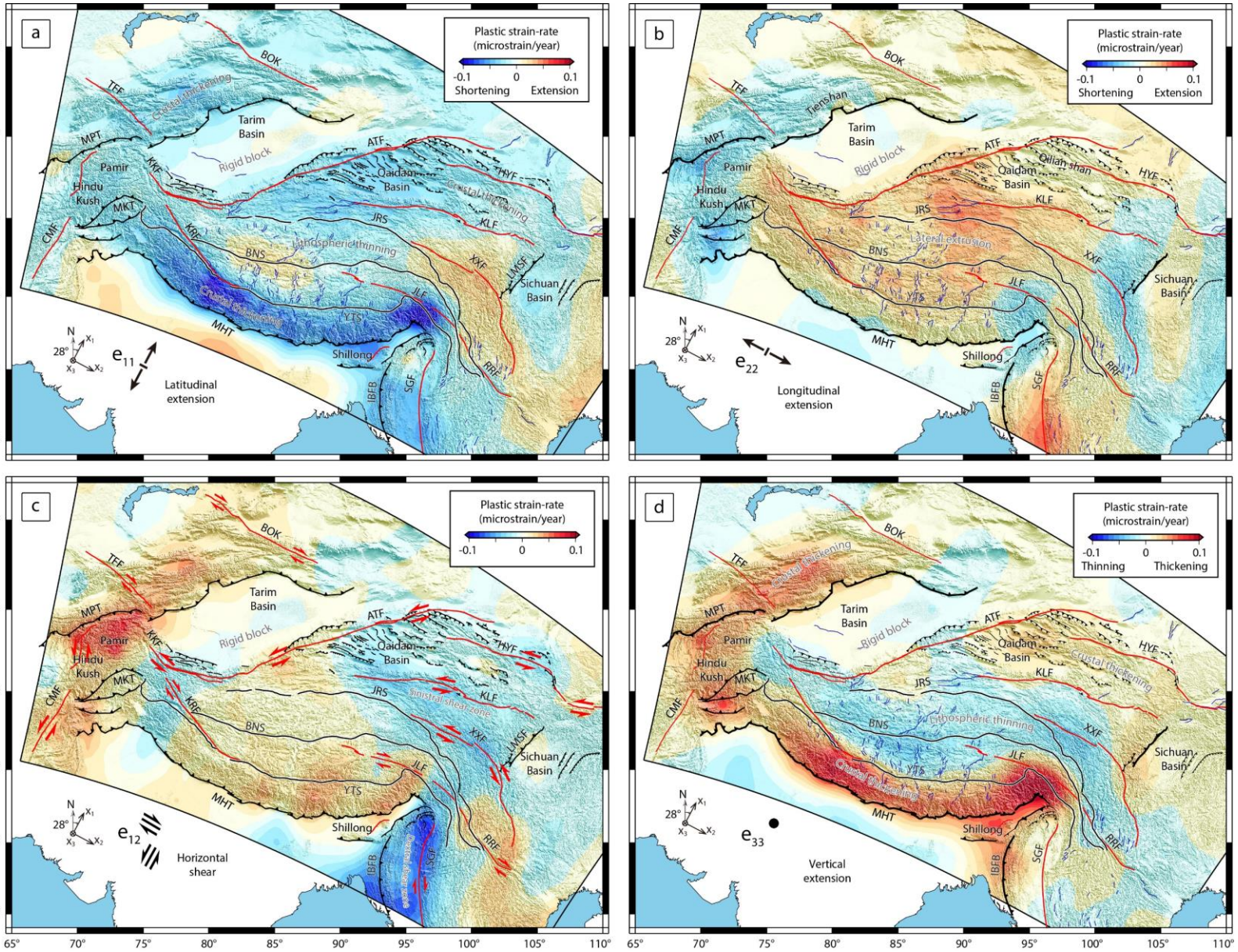



## 应变集中带：

1）Thrust belts: Himalayas, Pamir, Tien Shan, Indo-Burman fold beld

2）Strike faults: KLF, mid-ALF, XXF, SGF, HYF

# 四个主要应变分量的分布特征




- **Collision zone**: from Himalayas to Qilian shan; from Tien shan to Longmen shan.
- **Extension & thinning**: central Tibet
- **Horizontal shear**: SGF, Pamir; ATF, KLF, XXF and HYF related to horizontal pure shear.
- **Shortening & thickening**: Himalayas, Pamir, Tien shan, Qilian shan and Longmen shan

# 构造域的分布特征

安德森断层模型：$r=\frac{\sigma_z-\sigma_x}{\sigma_y-\sigma_x}$

正断型：

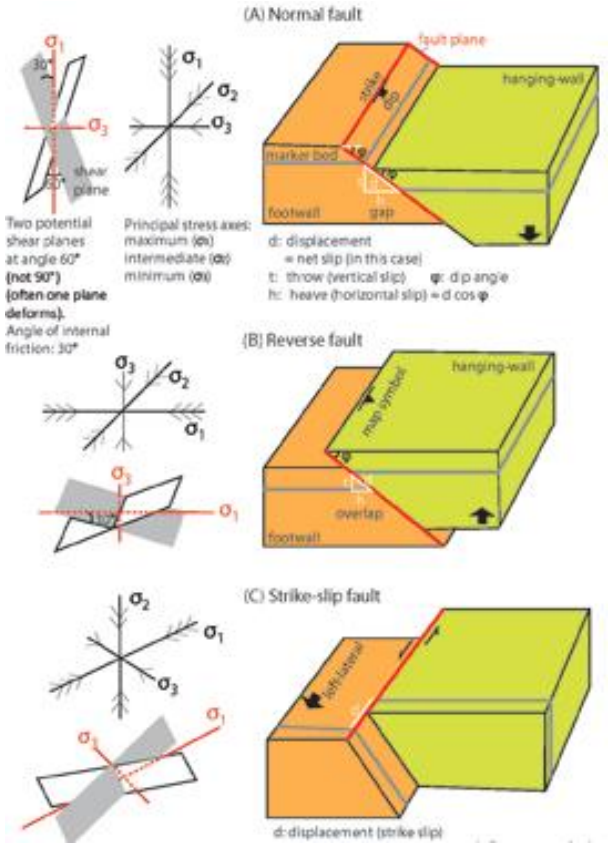
$r\geq 1$

逆冲型：

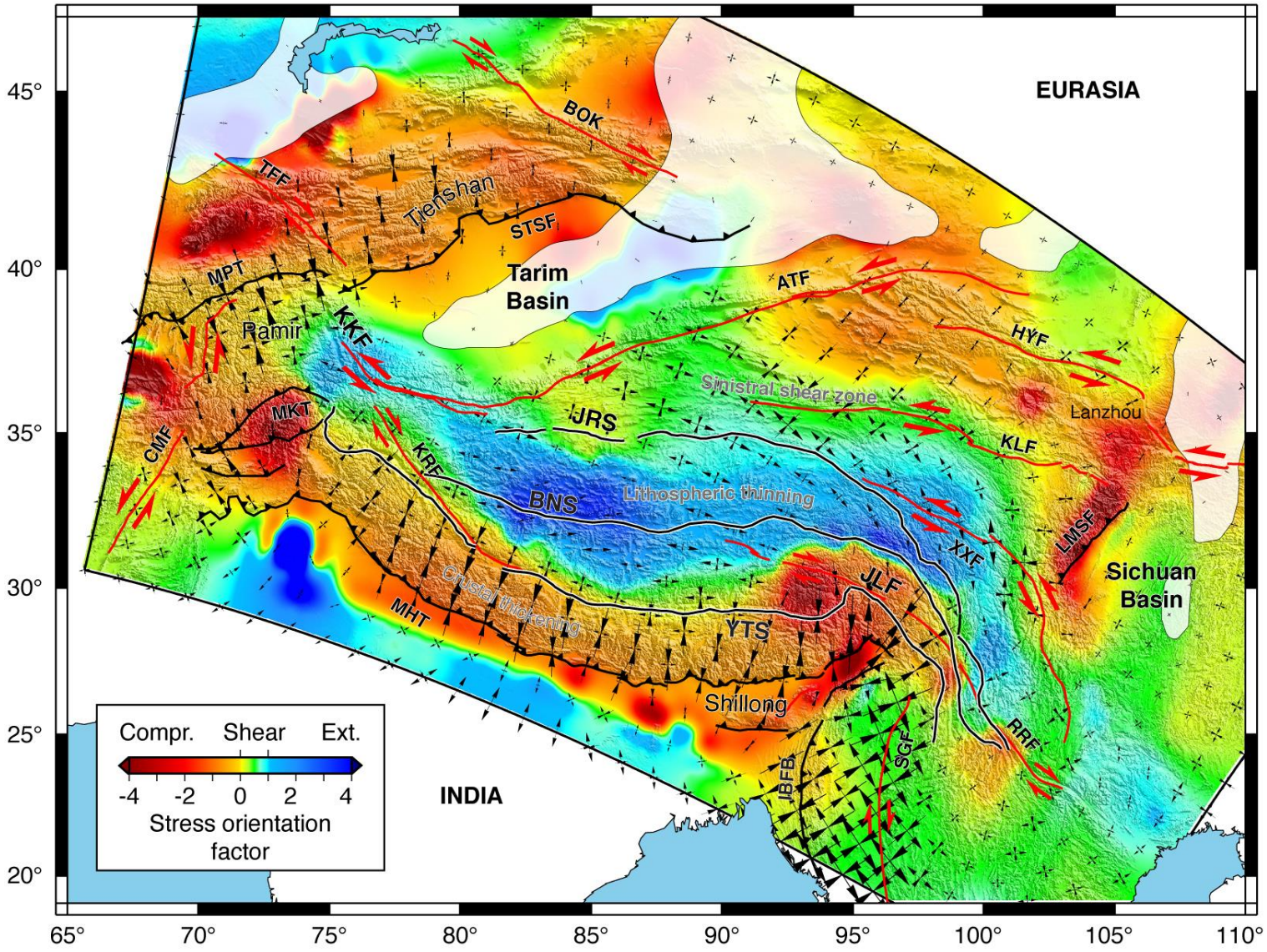
$r\leq 0$

走滑型：

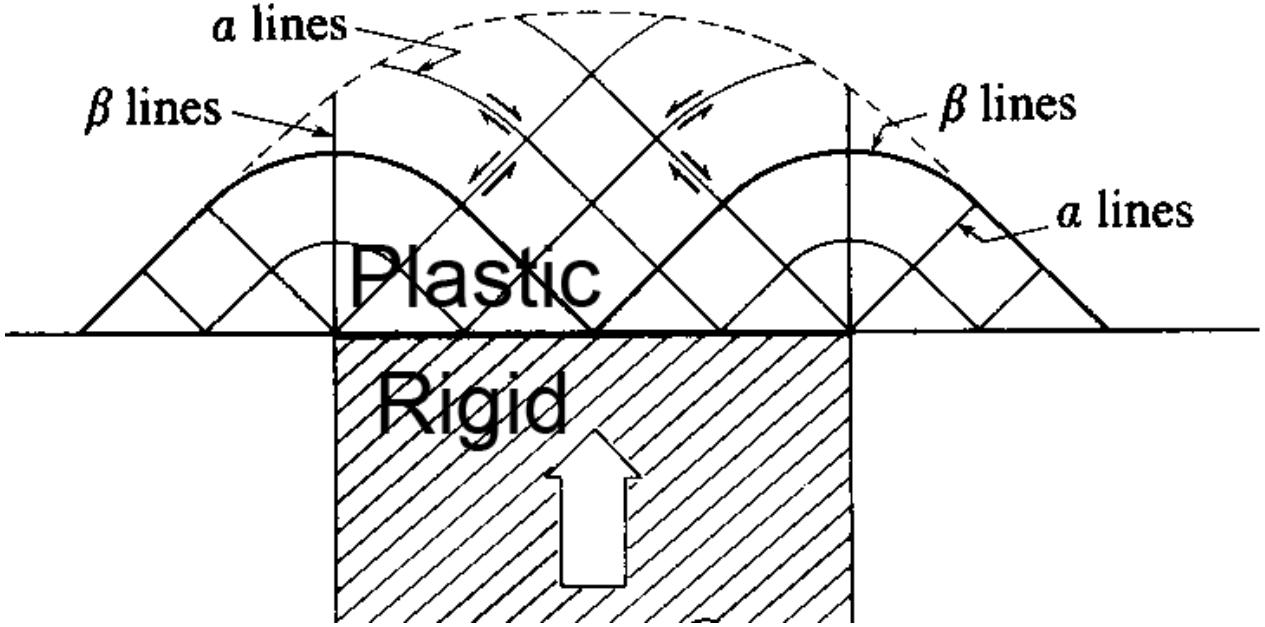
$0<r\leq 1$



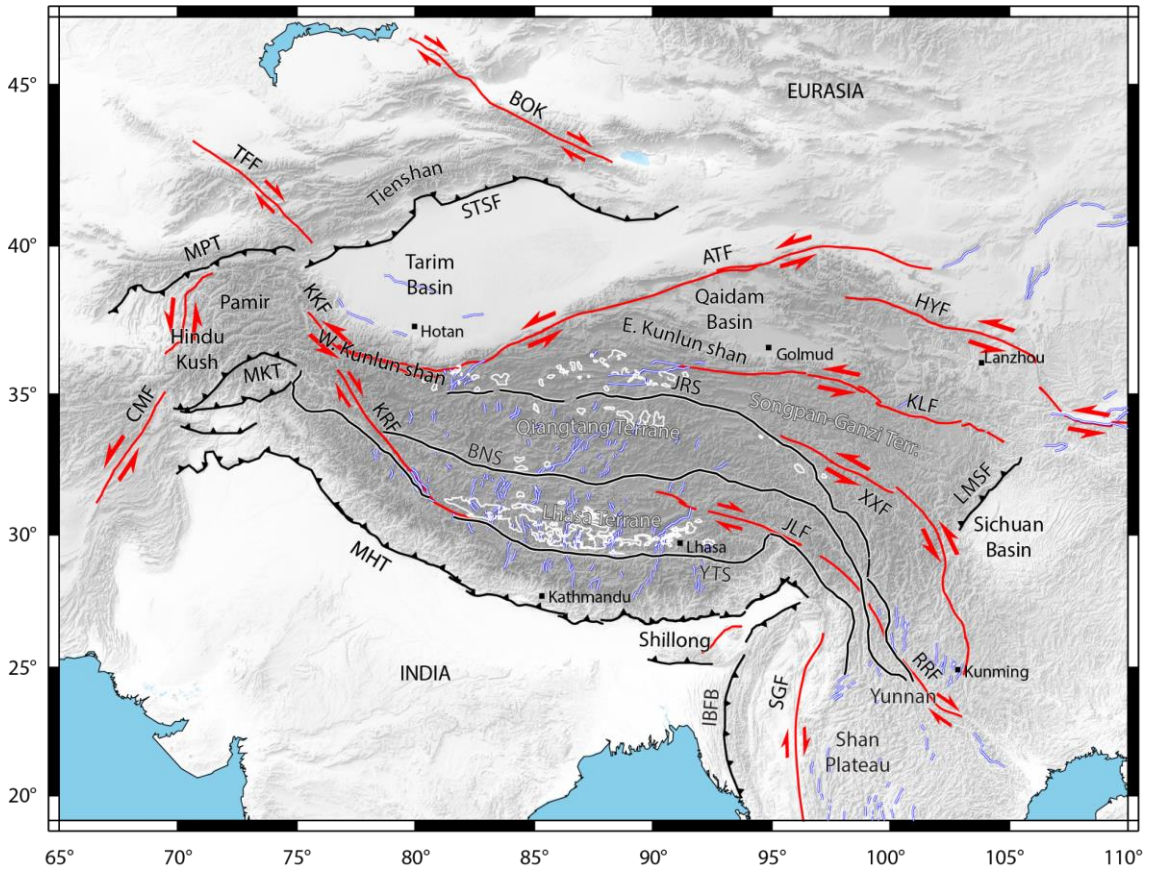

https://www.geoexpro.com/articles/2013/06/know-your-faults-part-ii



# 滑移线 ——— 走滑断层

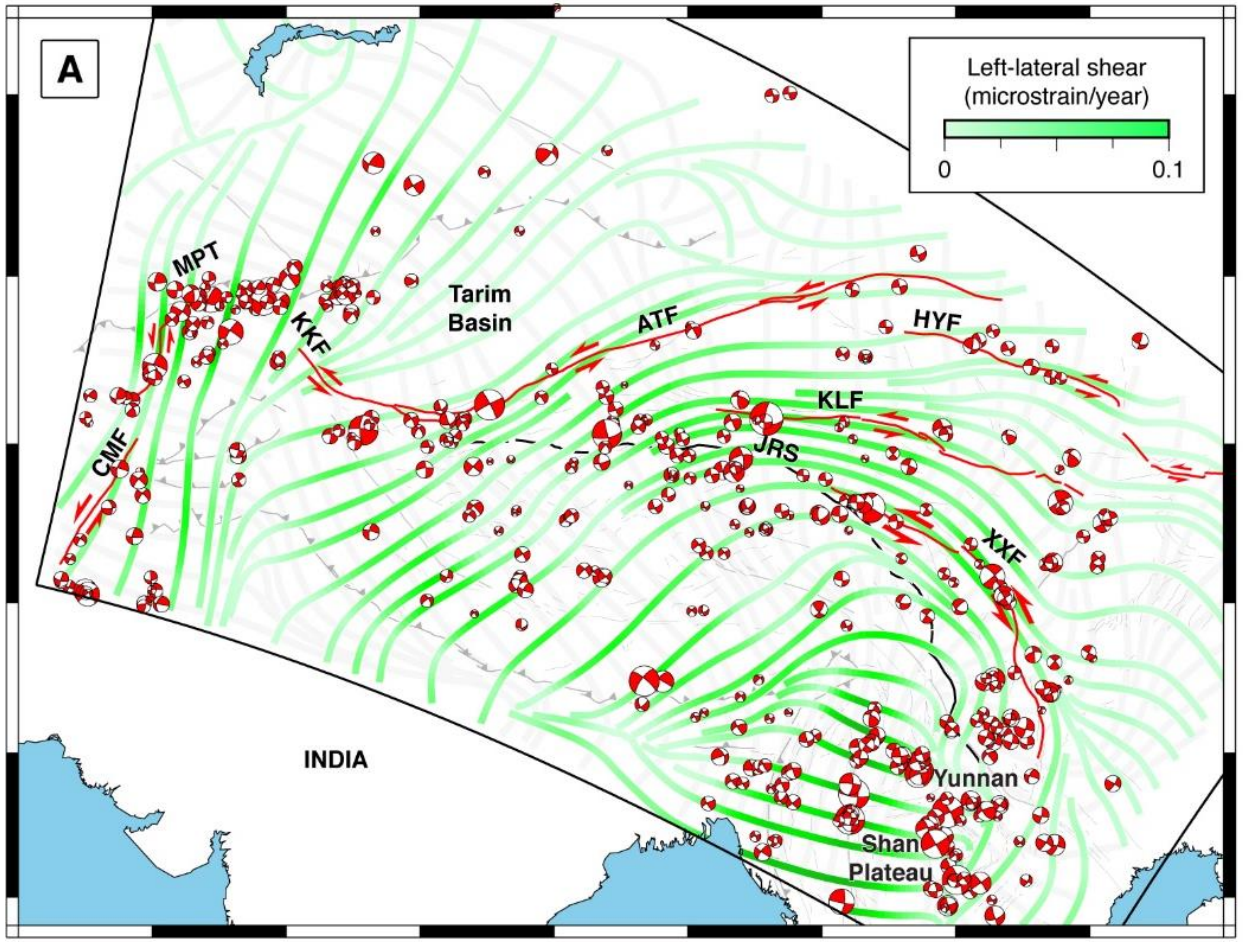


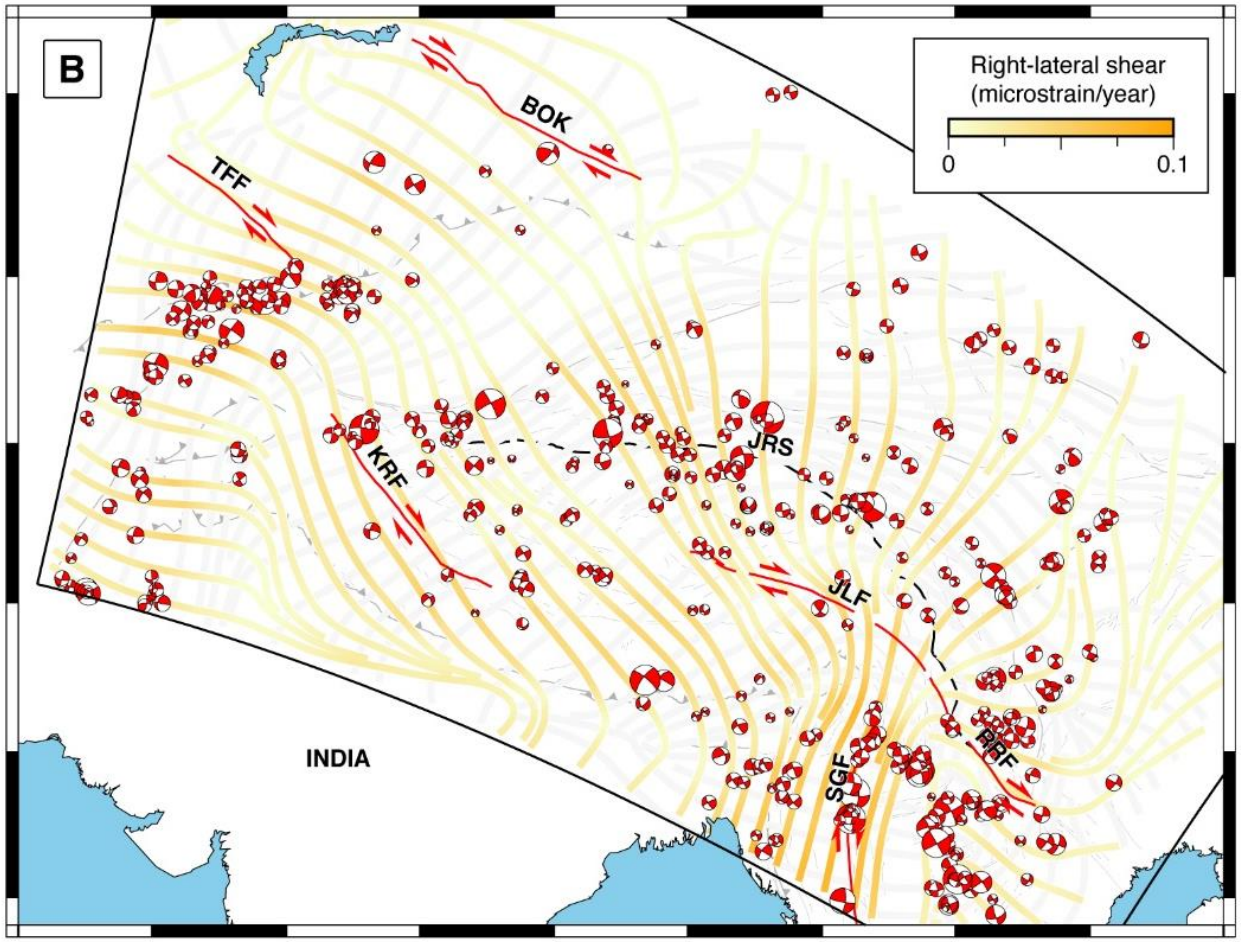

(Tapponier et al., 1976)



# 左旋剪切滑移线

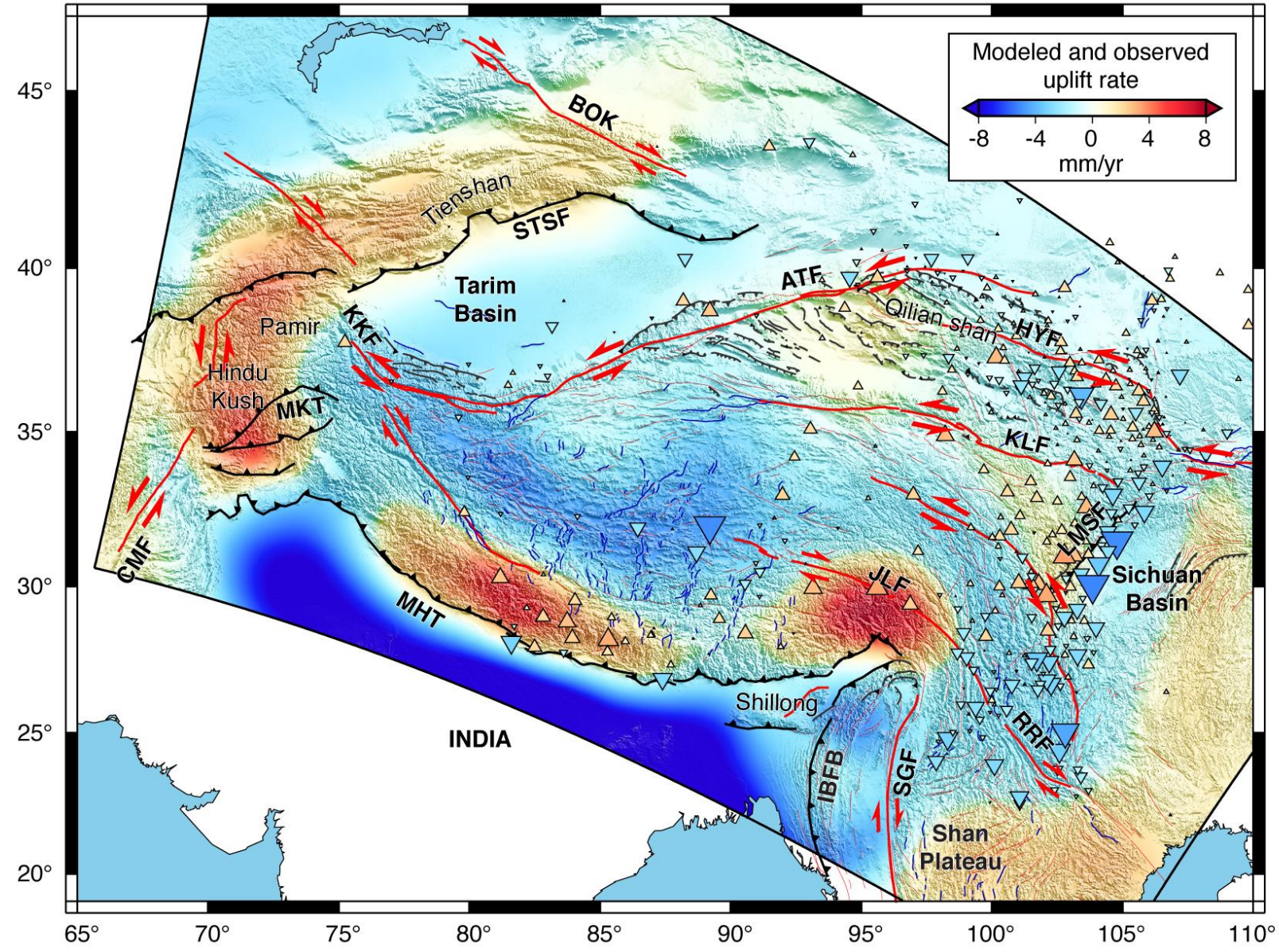
# 右旋剪切滑移线




- **Left-lateral**: ATF, HYF, KLF, XXF, CMF
- **Right-lateral**: SGF, RRF, KRF, TFF, BOK

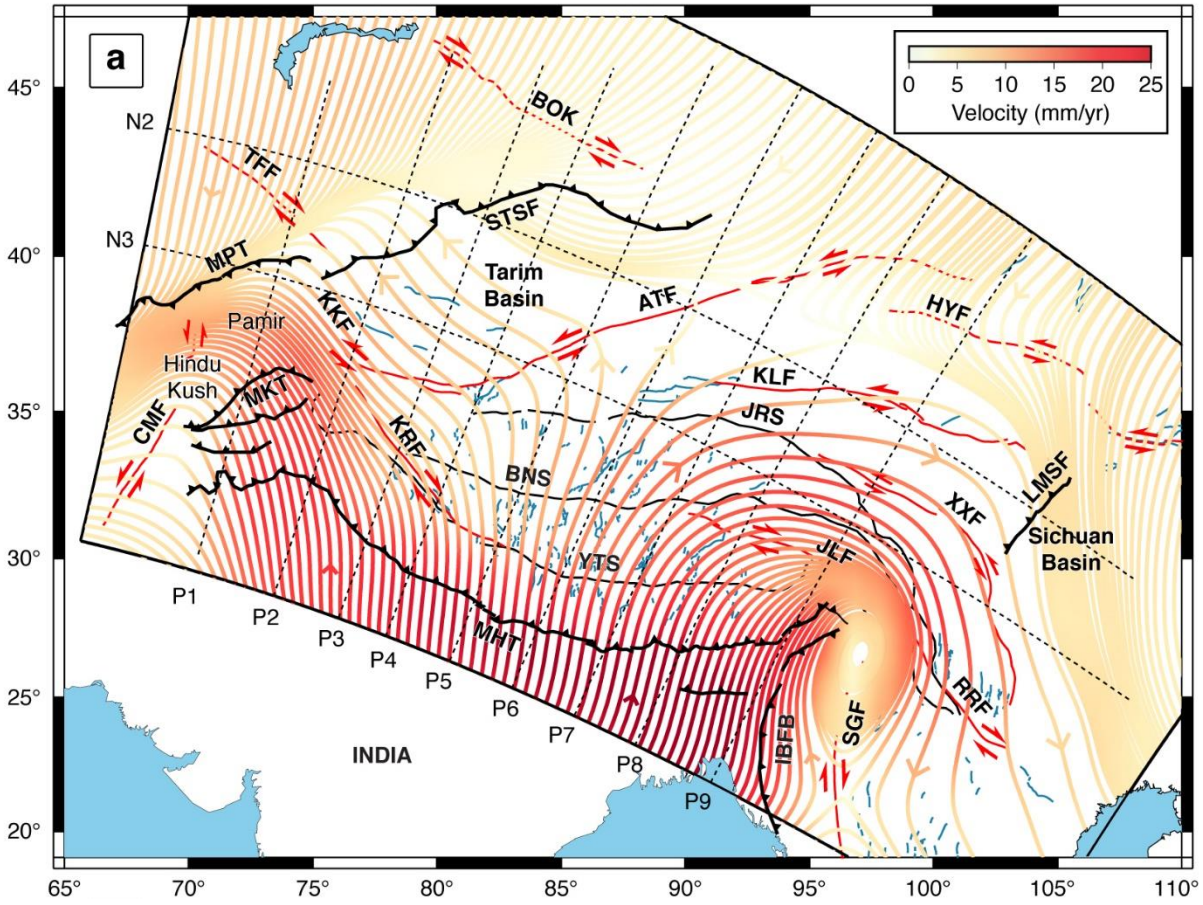
# 青藏高原现今隆升状态



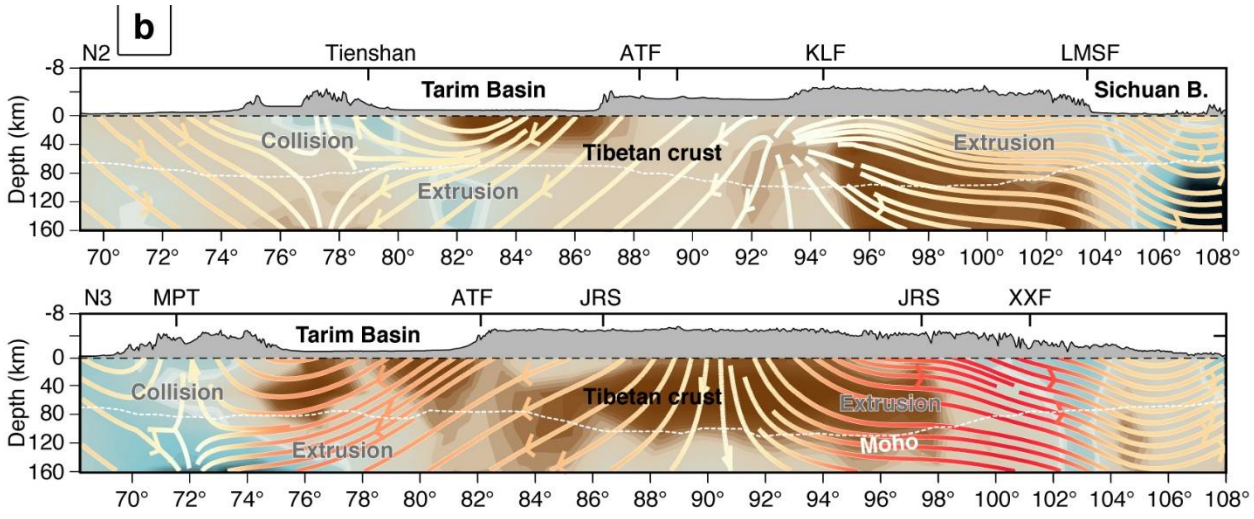

- **Rising**: Himalayas, Pamir, Tien shan, Qilian shan, Longmen shan
- **Falling**: Central Tibet, Yunnan

# 三维速度场

## 岩石圈塑性层的水平向速度场




## 东西向的深度剖面



# 印度-欧亚的三维汇聚模式

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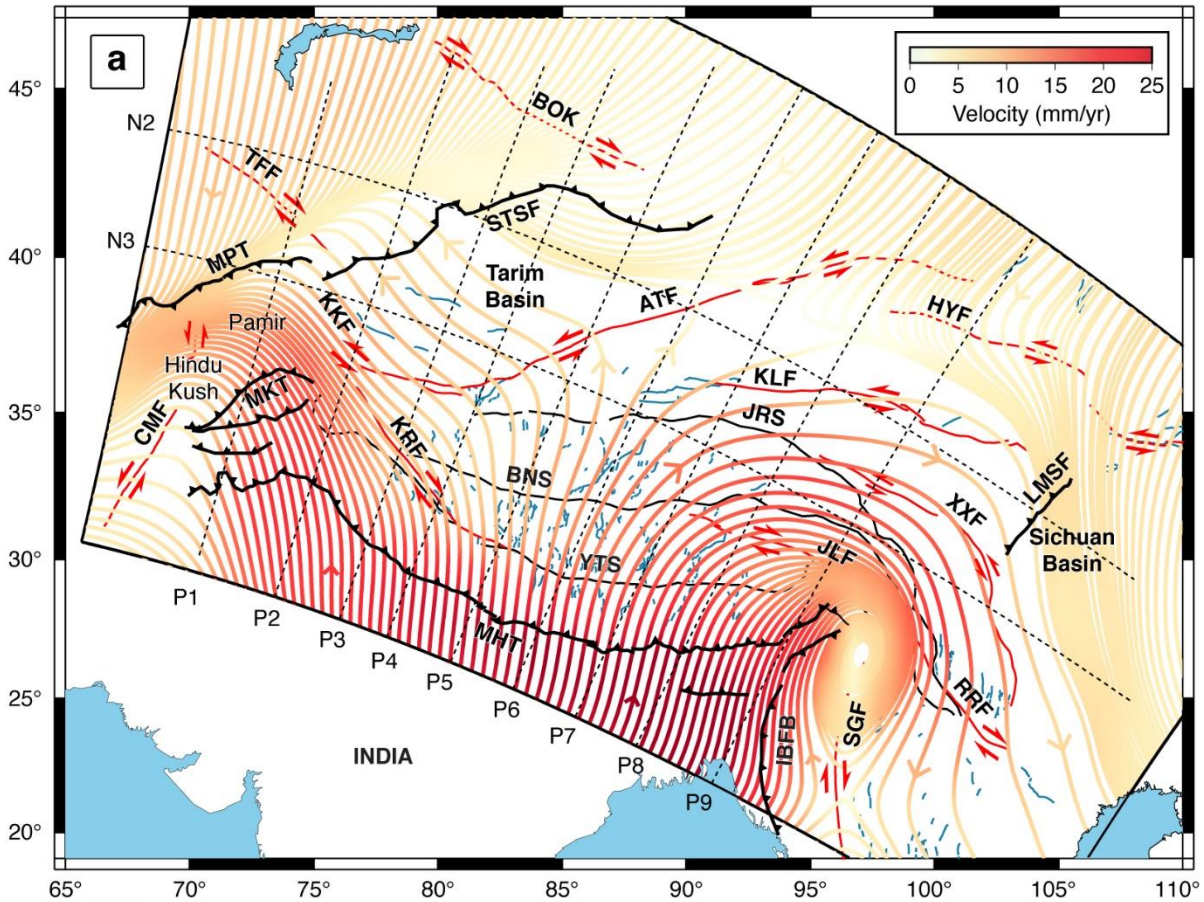


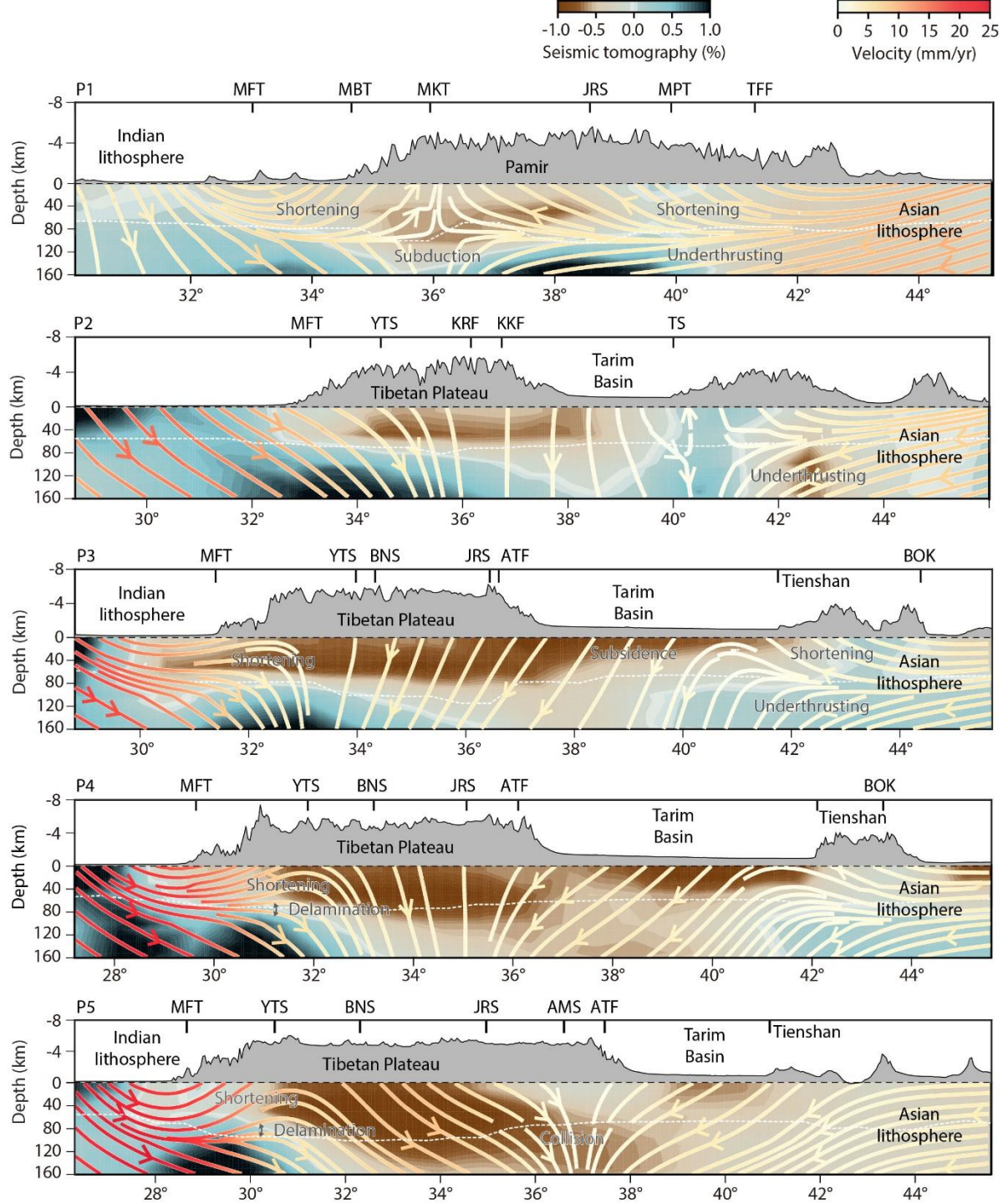

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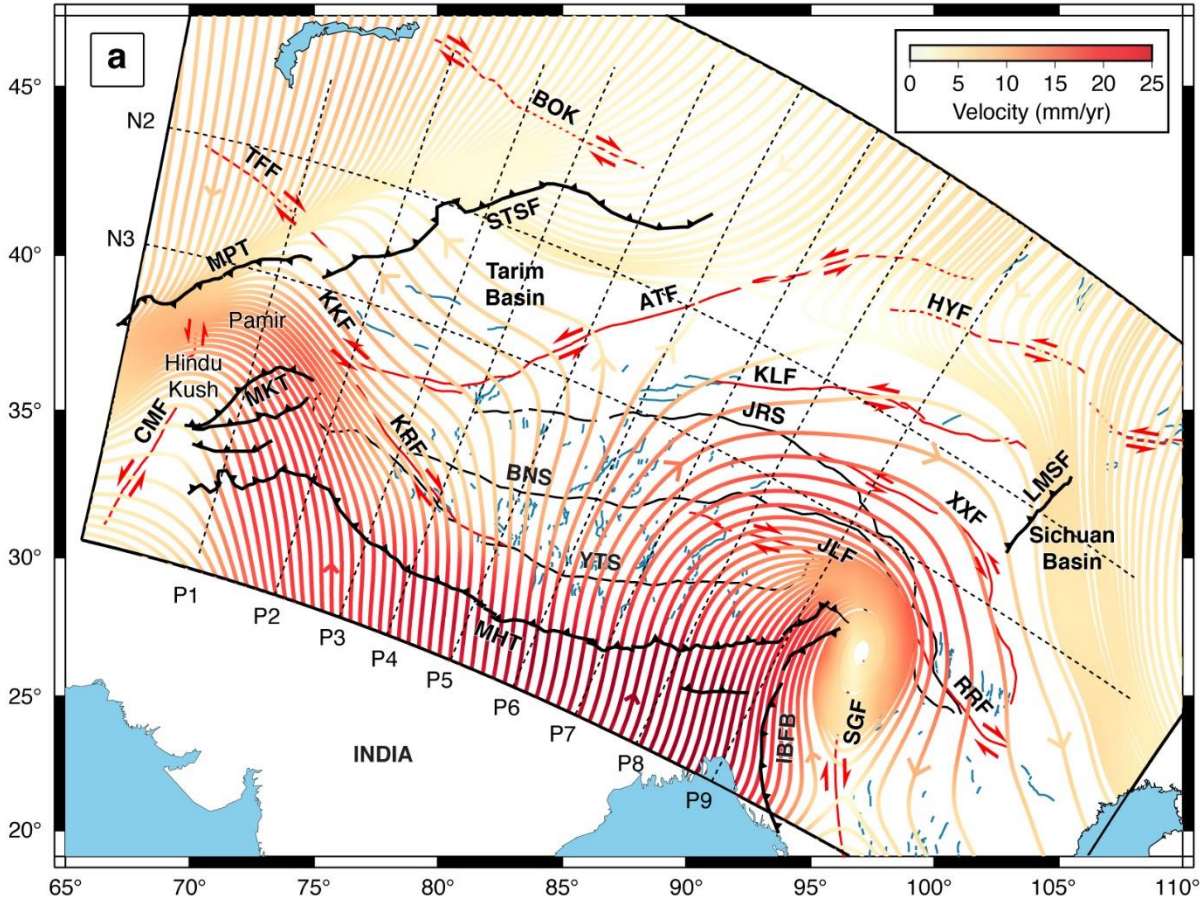


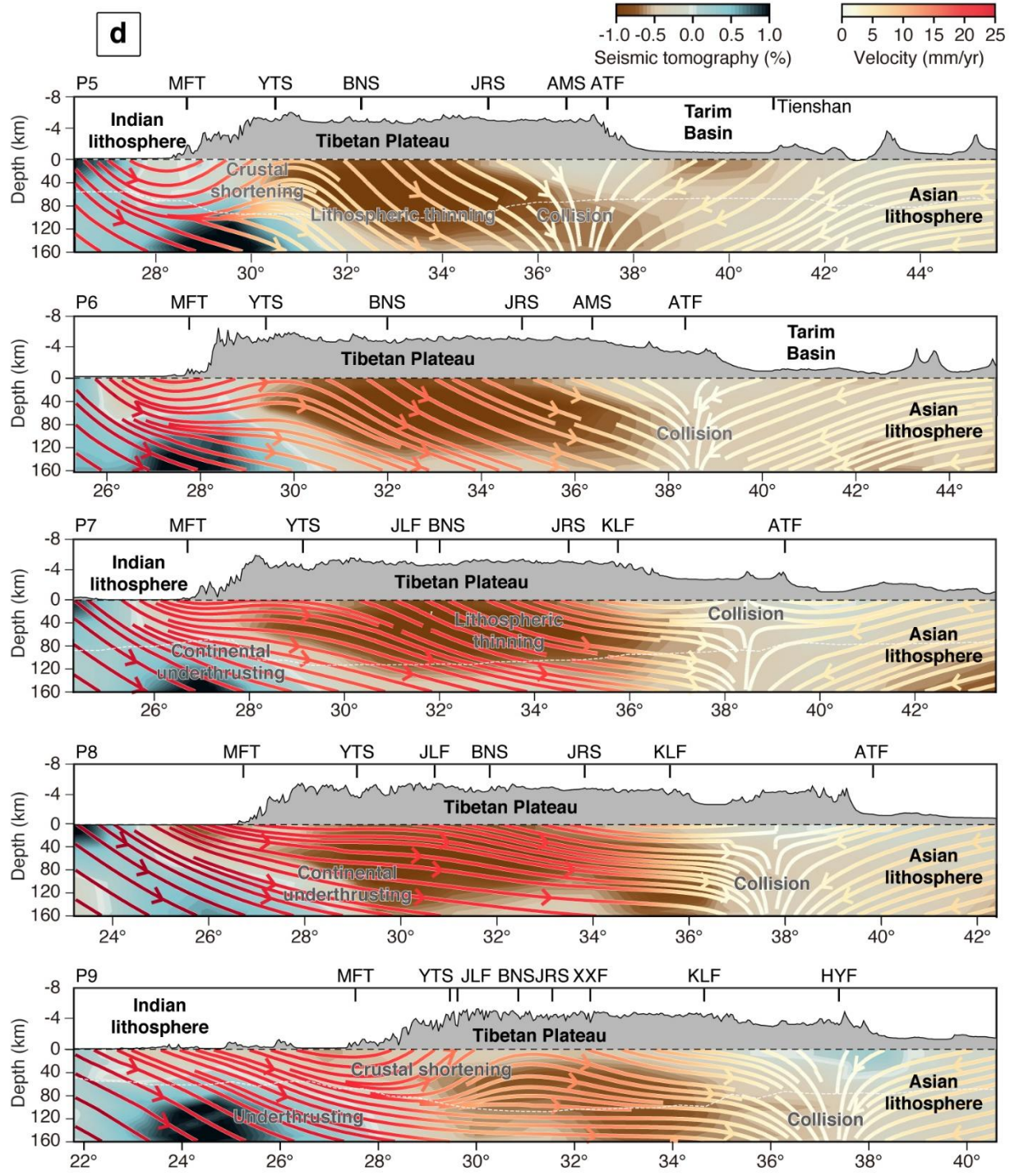

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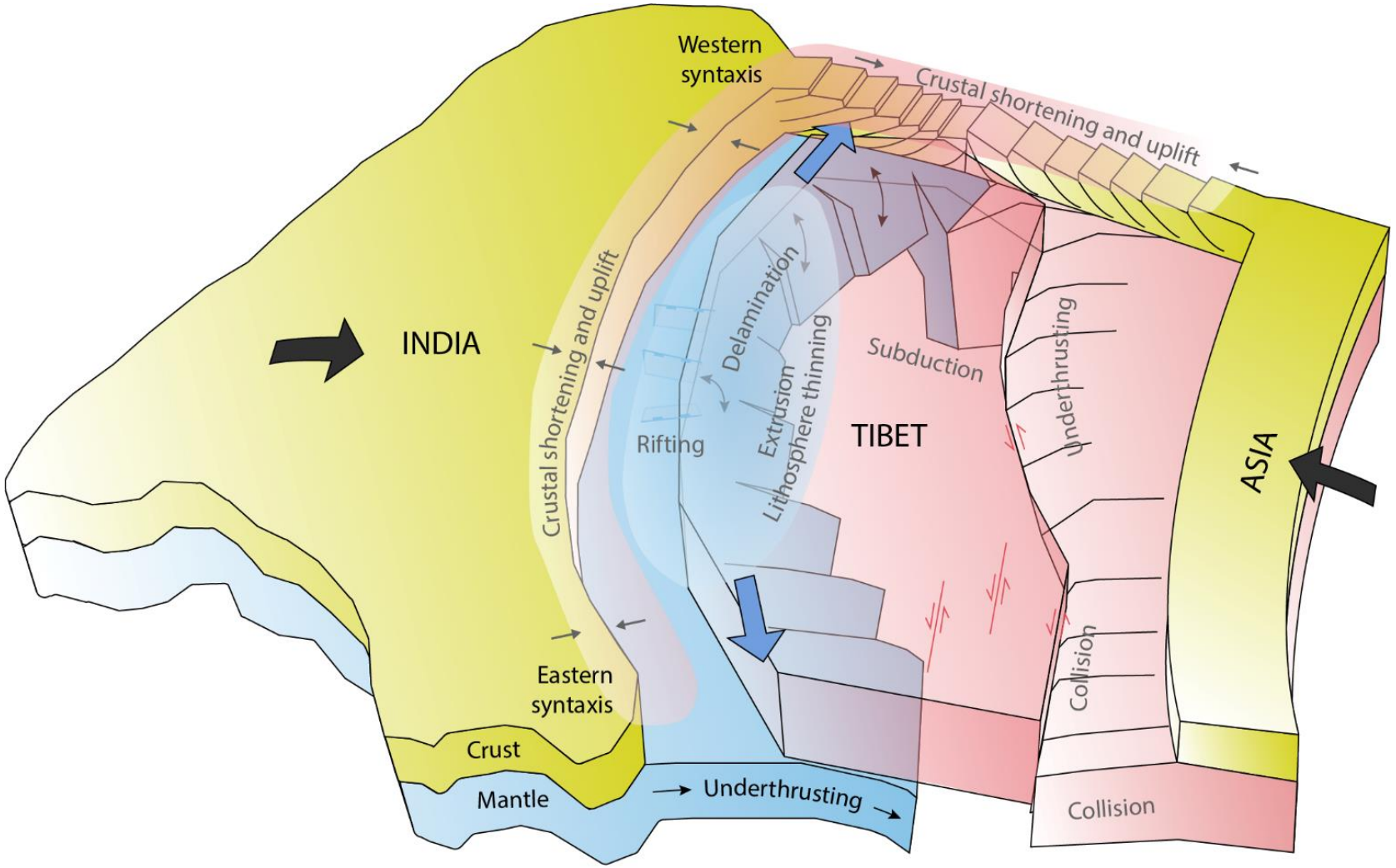


Suggestions and comments are very welcomed.
Please addressed to Lifeng Wang (wanglf@ies.ac.cn) or Sylvain Barbot (sbarbot@usc.edu).