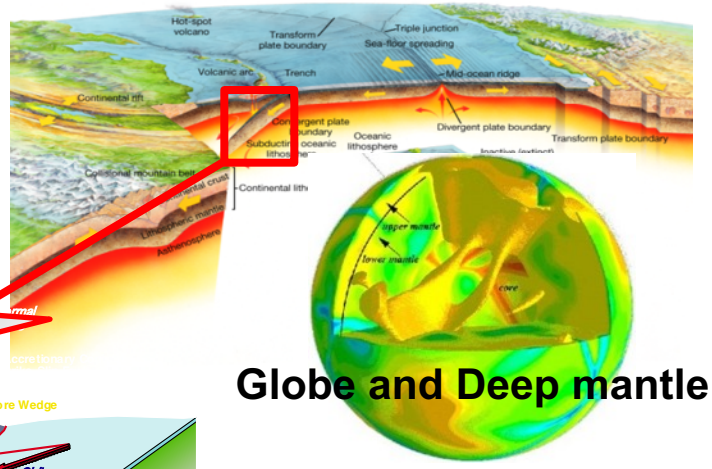
Understanding world-class mineral systems using multi-scale and integrated geophysical data: A synthesis from SinoProbe

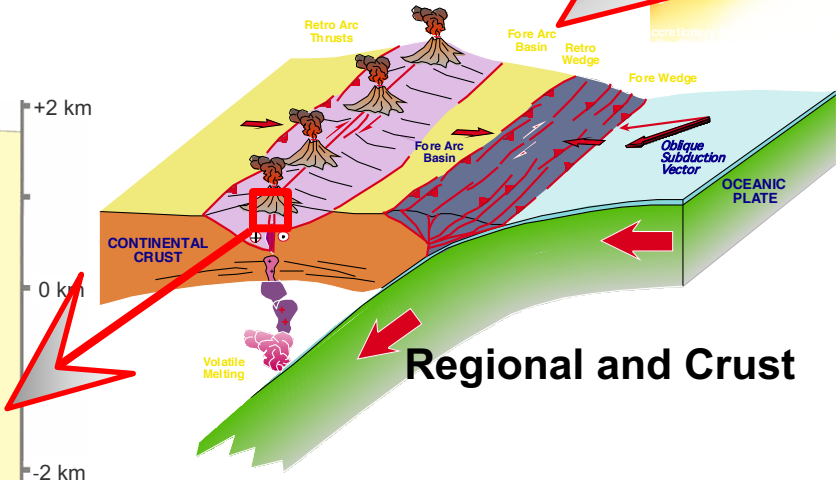
Lyu Q T, and SinoProbe-03 Group

China Deep Exploration Center—SinoProbe Center
Chinese Academy of Geological Sciences

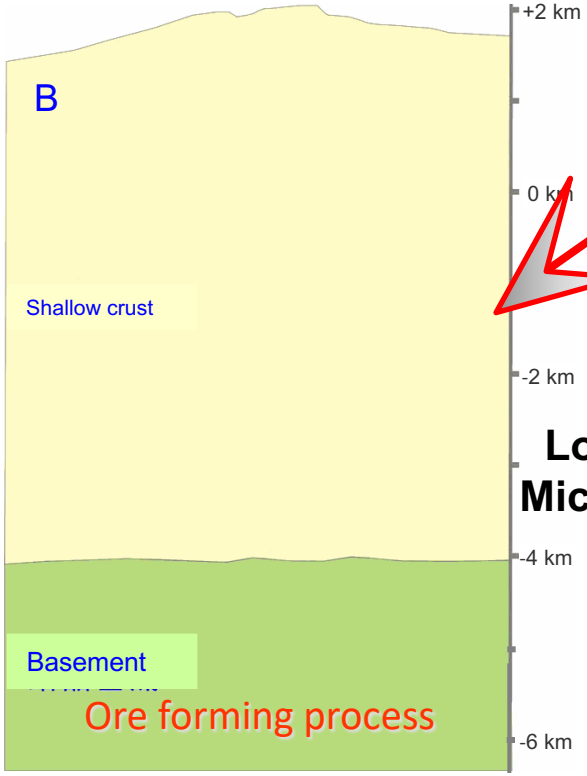
The Super-large mineral deposits are consequence of geodynamic systems which operated at a range of scales.



Globe and Deep mantle



Regional and Crust



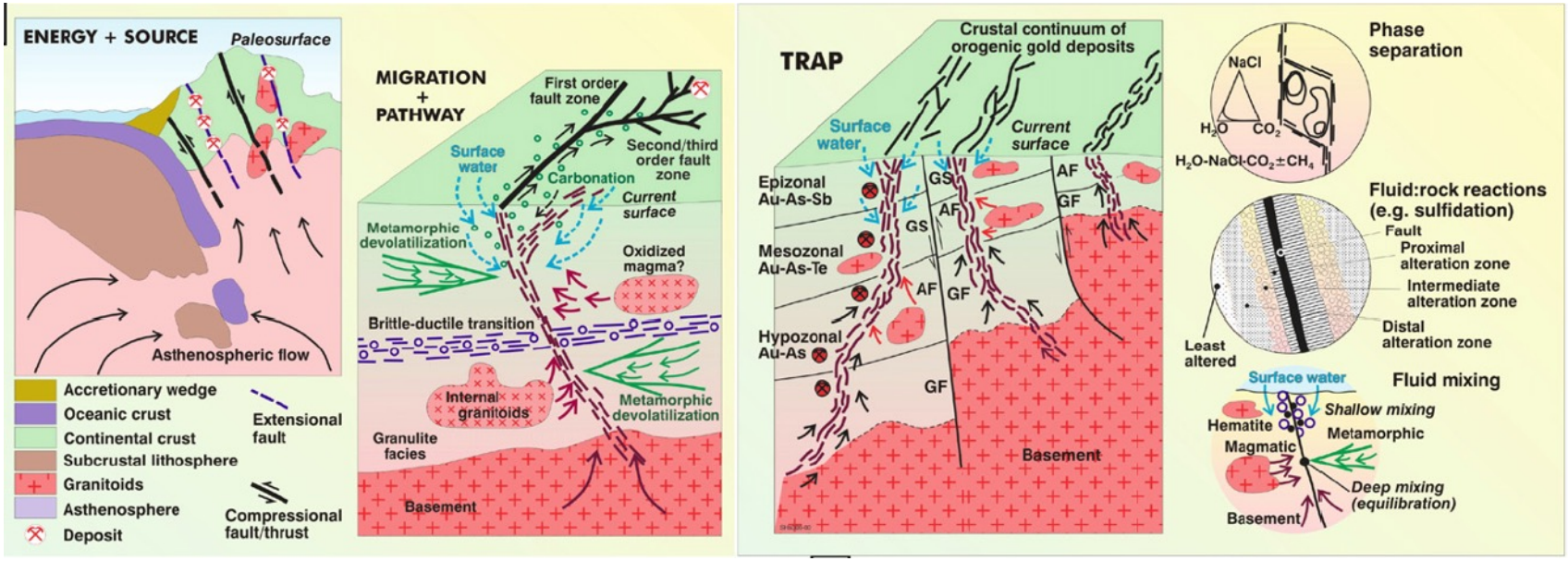
Local and Microscopic

One way to consider a mineral deposit is to understanding it in the context of an holistic mineral system.

The mineral system can be viewed in terms of:

Five elements

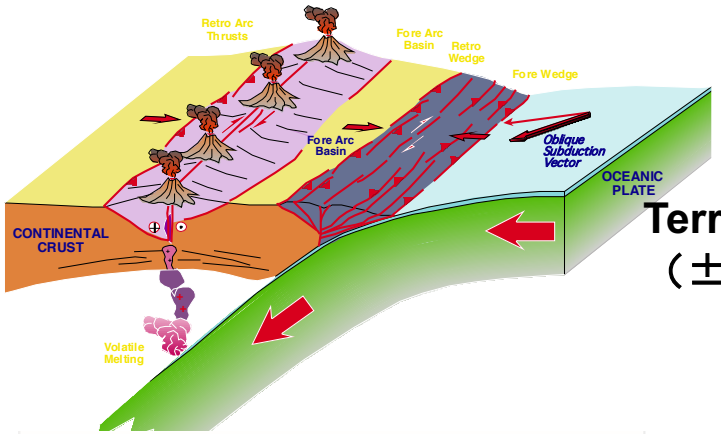
- Geodynamics
- Architecture
- Fluid sources and Reservoirs
- Fluid pathways and drivers
- Depositional mechanism



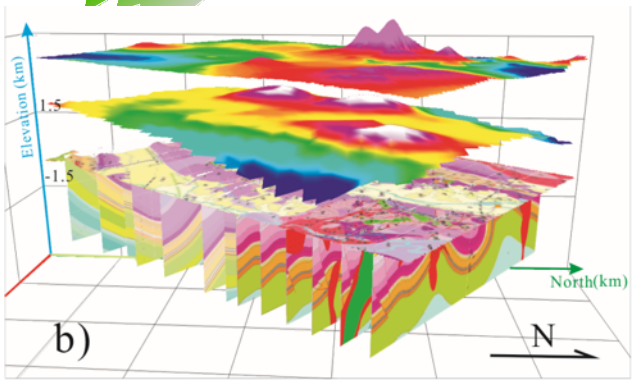
Hagemann et al., 2016.

Objectives

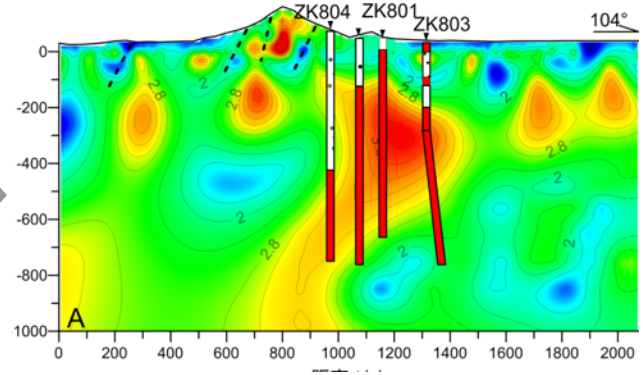
Multiscale Exploration for a typical metallogenic Belt

- *Architecture and Deep processes* → 

Terrane-scale（±50km）

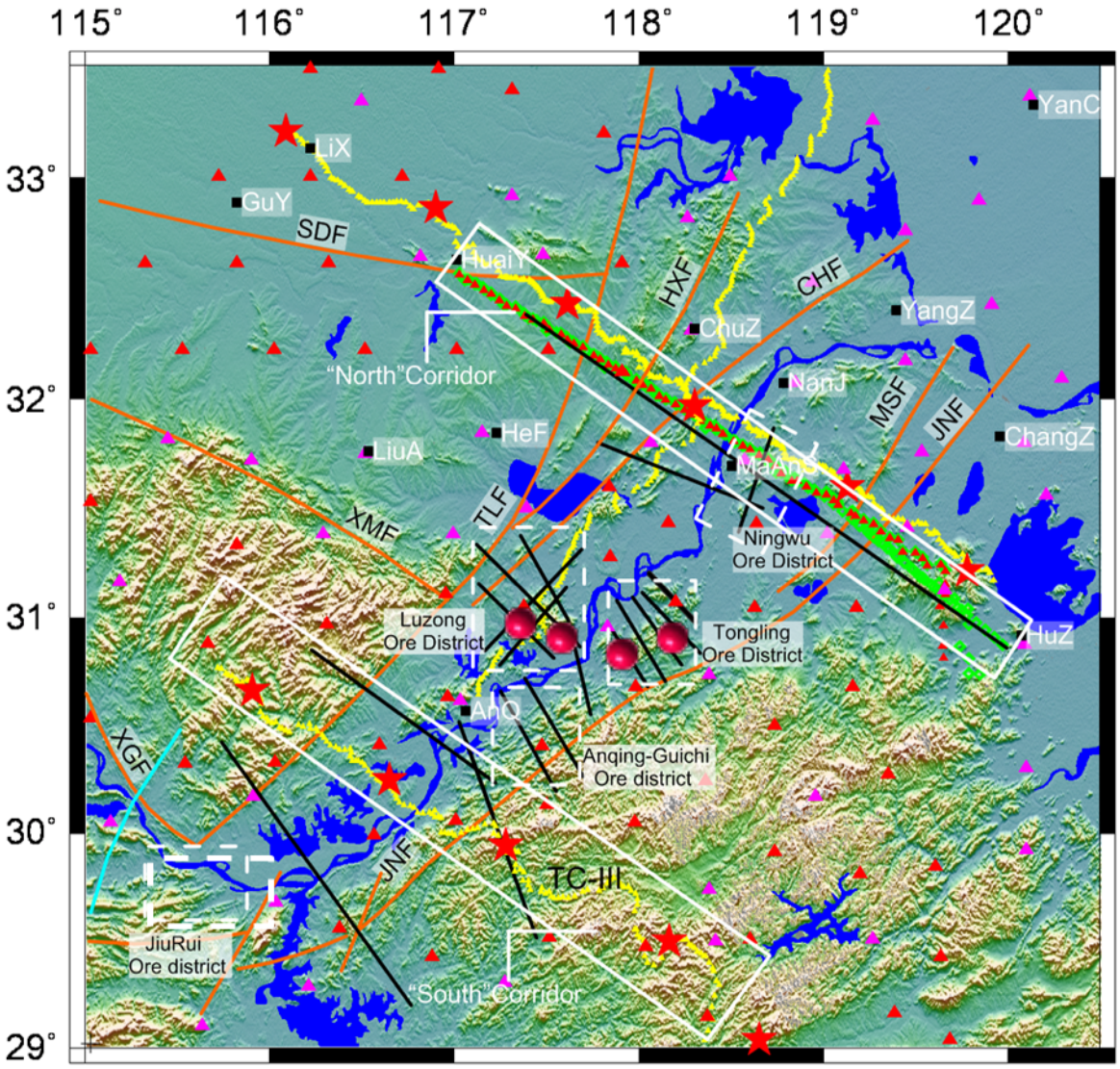
- *3D mapping and targeting* → 

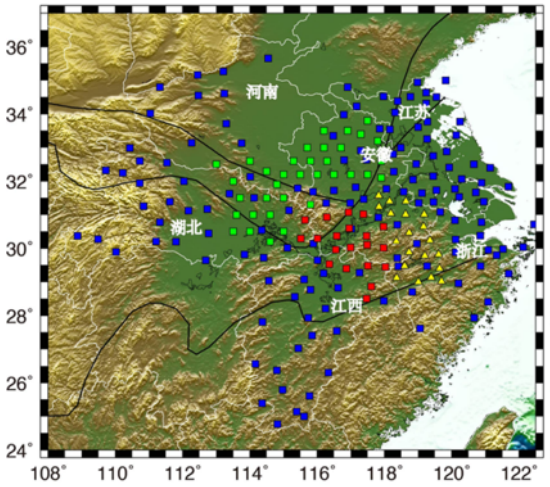
Domain-scale（±5km）

- *Prospect-scale evaluation* → 

Camp-scale（±2km）

Example of SinoProbe 3D-Min. Project

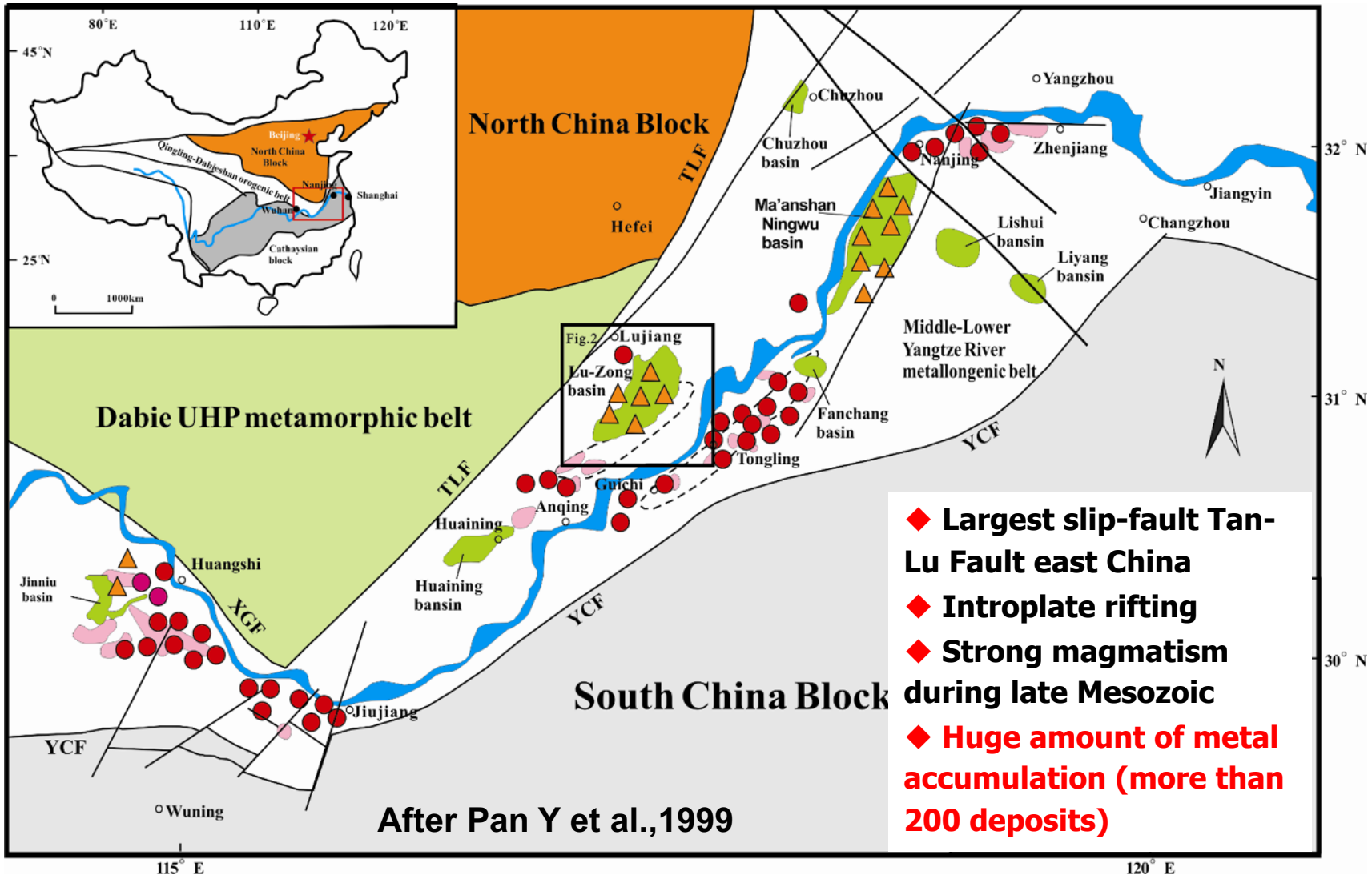




- Terrane Scale:
  BBS +integrated geophysical TRANSECT
- Domain Scale: 2D integrated geophysical profile +3D M&G modeling
- Camp Scale: 2D/3D CSAMT+AMT+IP+G&M

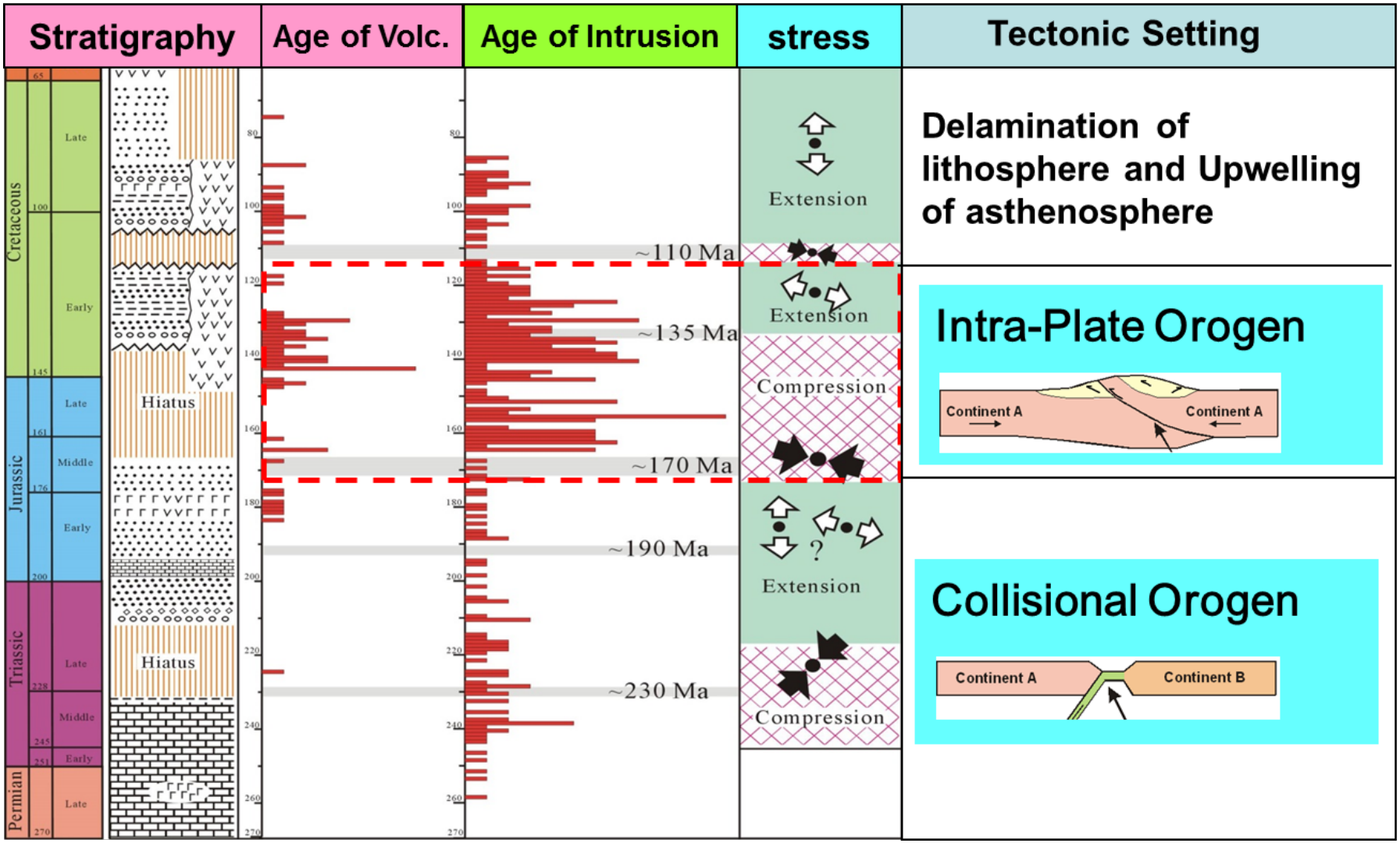
Middle and Lower Yangtze Metallogenesis Belt, East China

Geologic Setting of M & L Yangtze MB



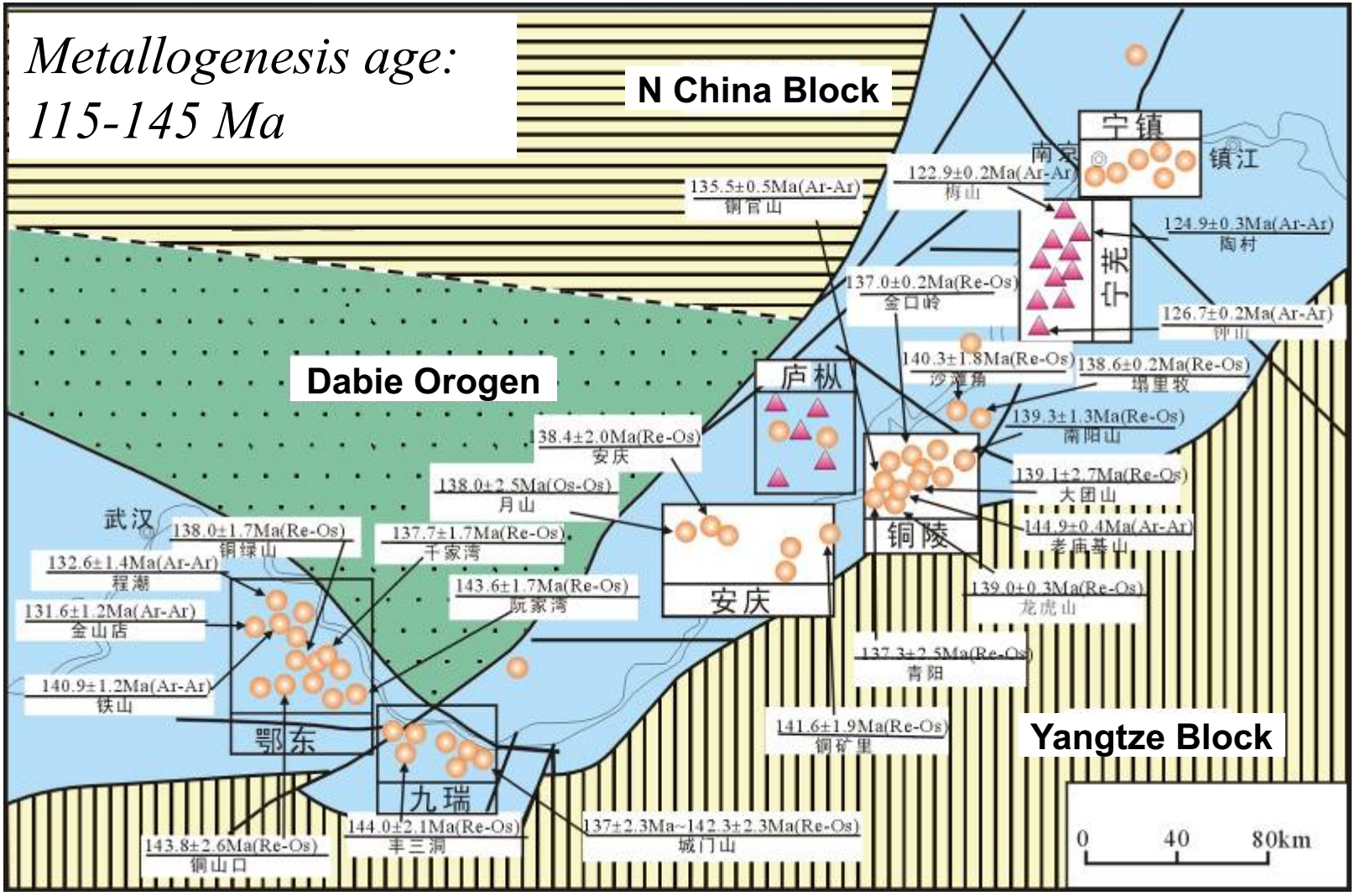
◆ Best place to study intraplate geodynamic and Metallogenesis

Mesozoic Tectonic evolution of the Region



Modify from Zhang Y Q, 2011

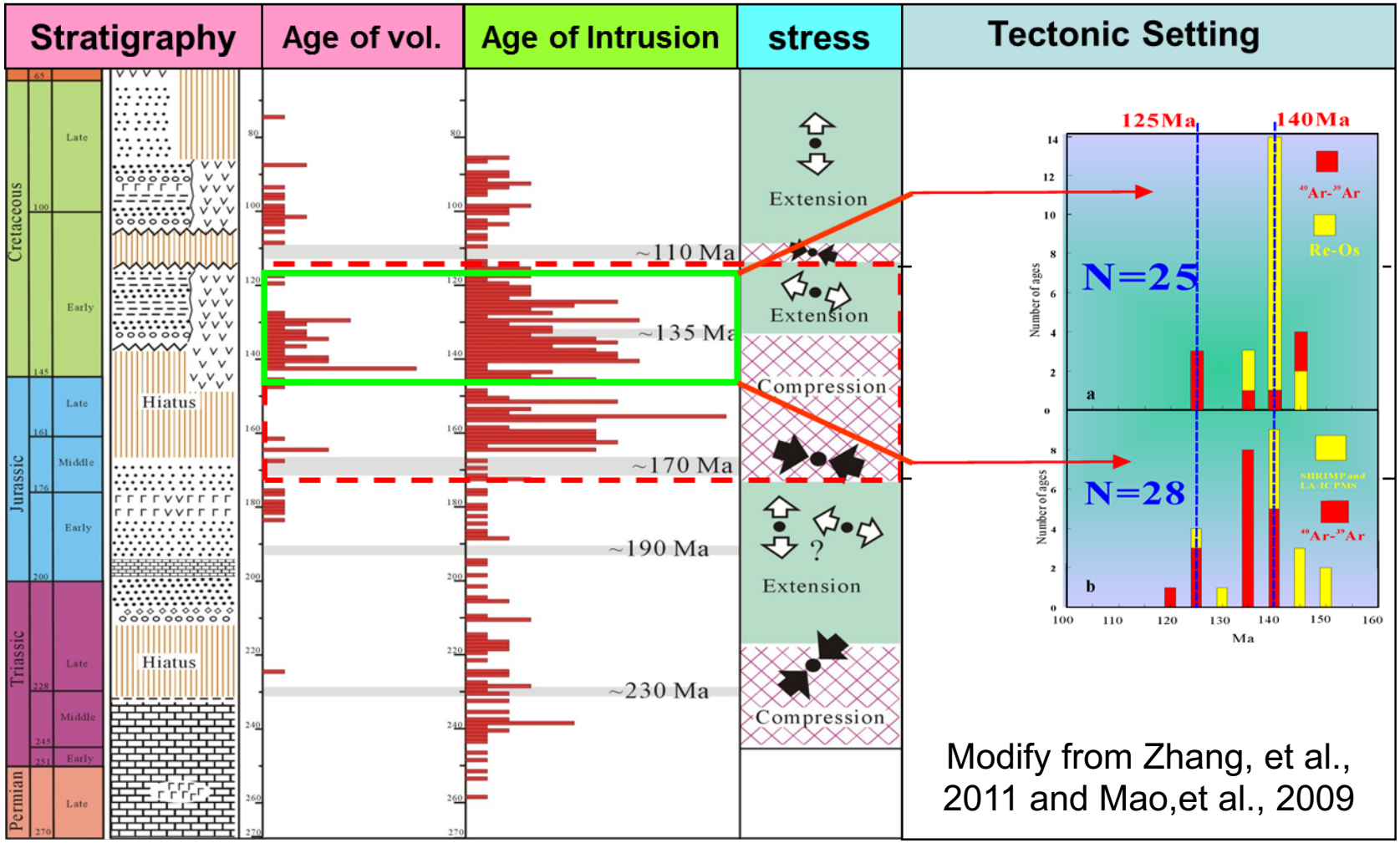
Metallogenesis ages of M&L Yangtze MB



（after Mao et al.,2009; Zhou et al., 2008）

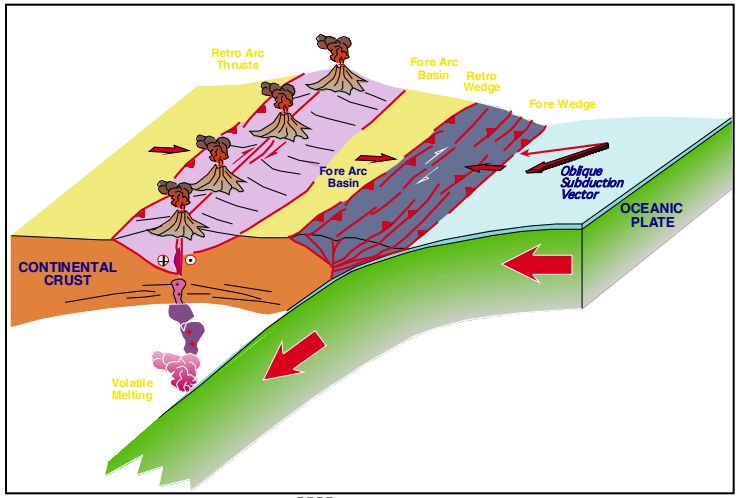
Metallogenesis and tectonic shifting

The metallogenic age corresponds tectonic regime shifting from compression to extension



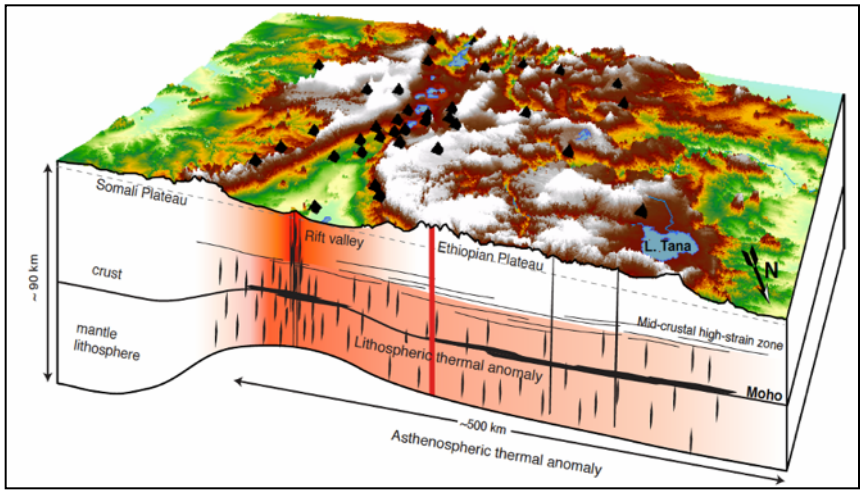
Questions

Tectonomagmatic model for Andean type metallogeny



Sillitoe R.H, 1972;2010

What model for intracontinental metallogeny?



S. Klemperer, 2011

- Subduction of Oceanic Plate
- Melting of mantle wedge
- Underplating of basalts at CMB
- MASH process, andesitic magma
- Most metals coming from Mantle
- Conti. Marg. shear fault channeling

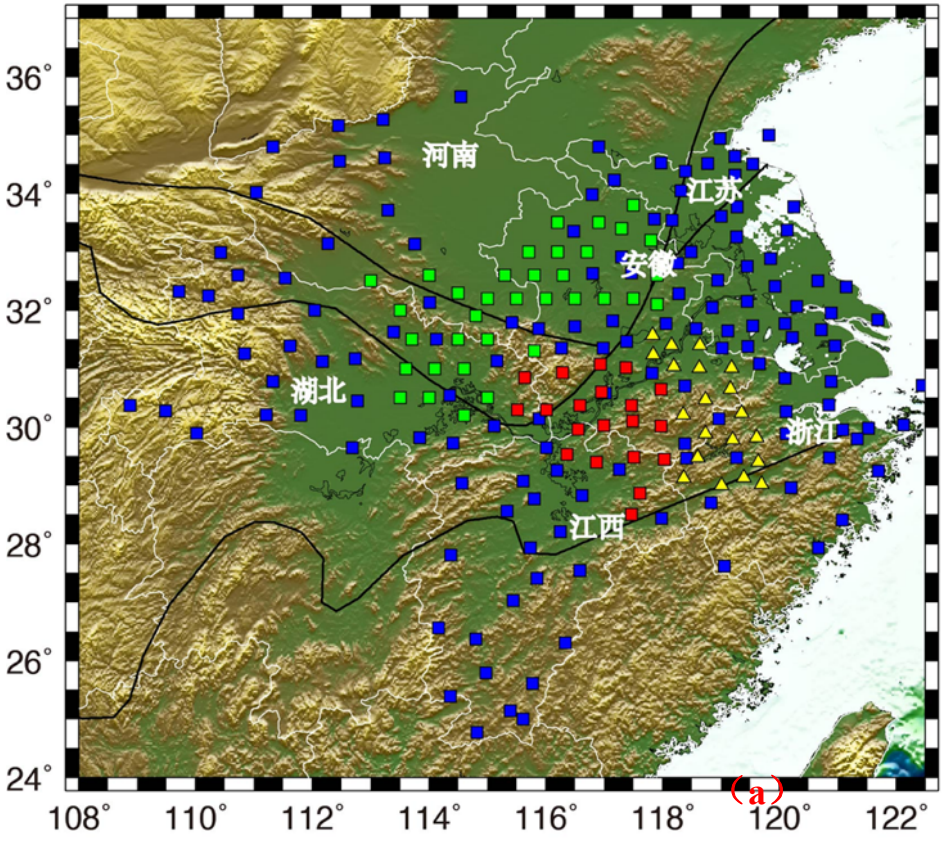
magma from CMB to U crust

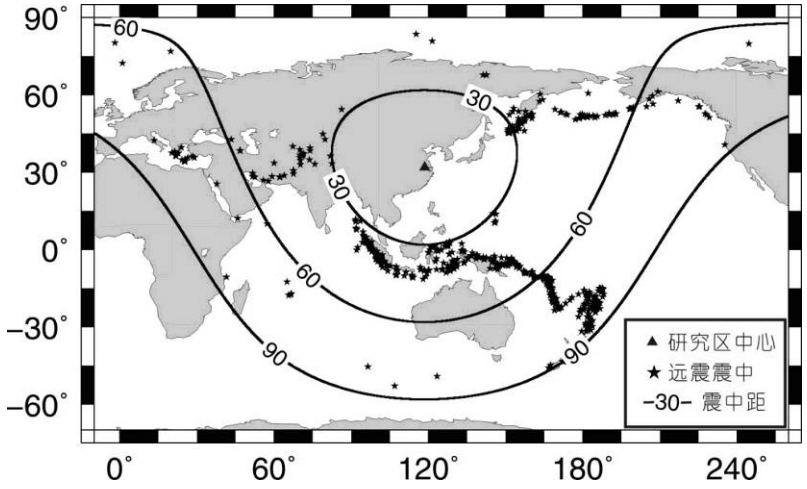
Questions:

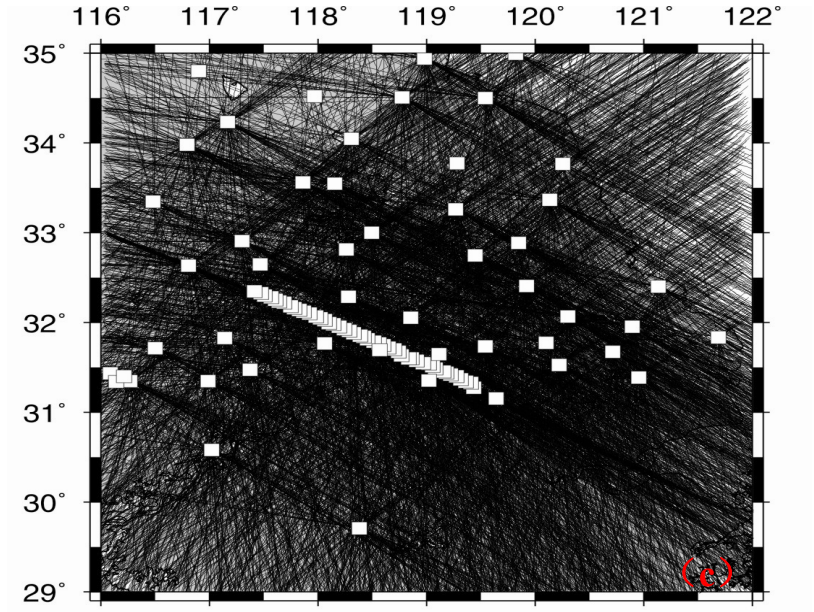
What's the deep processes for intraplate metallogeny?

Teleseismic Tomography Results

Stations: 66 portable, 46 fixed





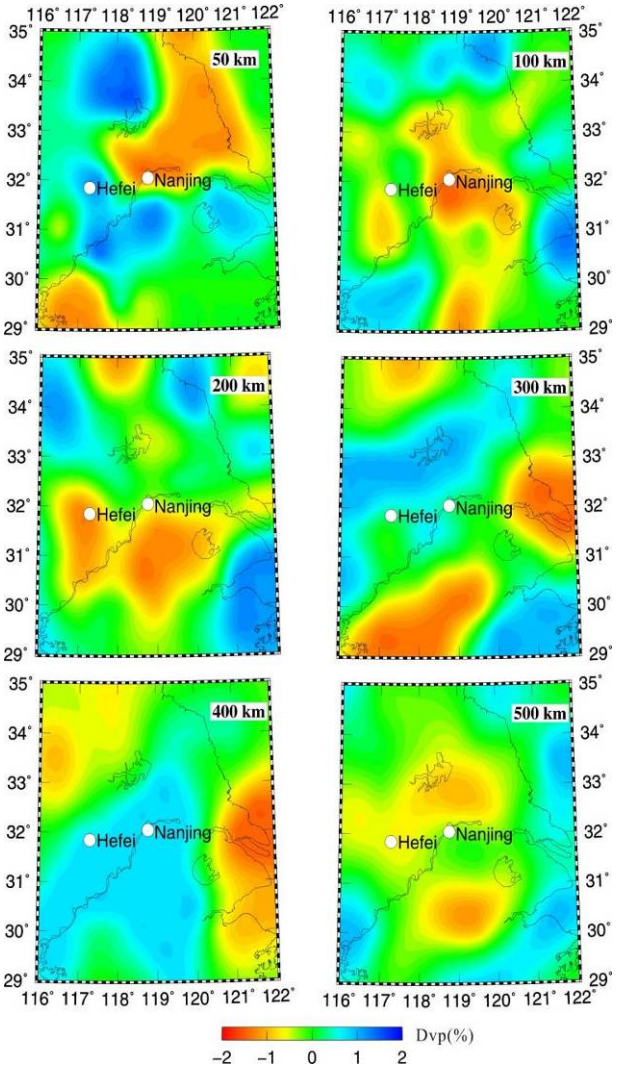


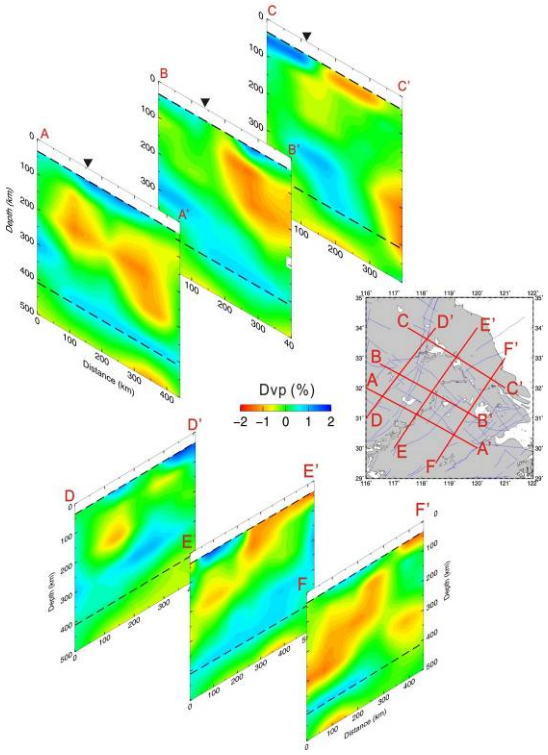
Ray coverage

Events: 678

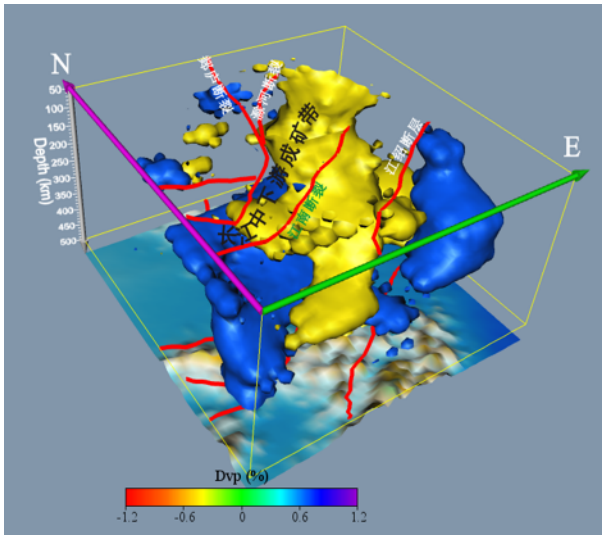
P wave data: 17,118

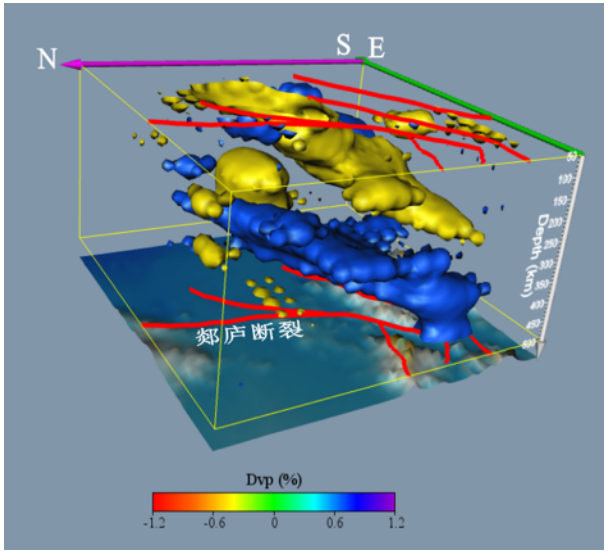
Evidence for lithosphere delamination





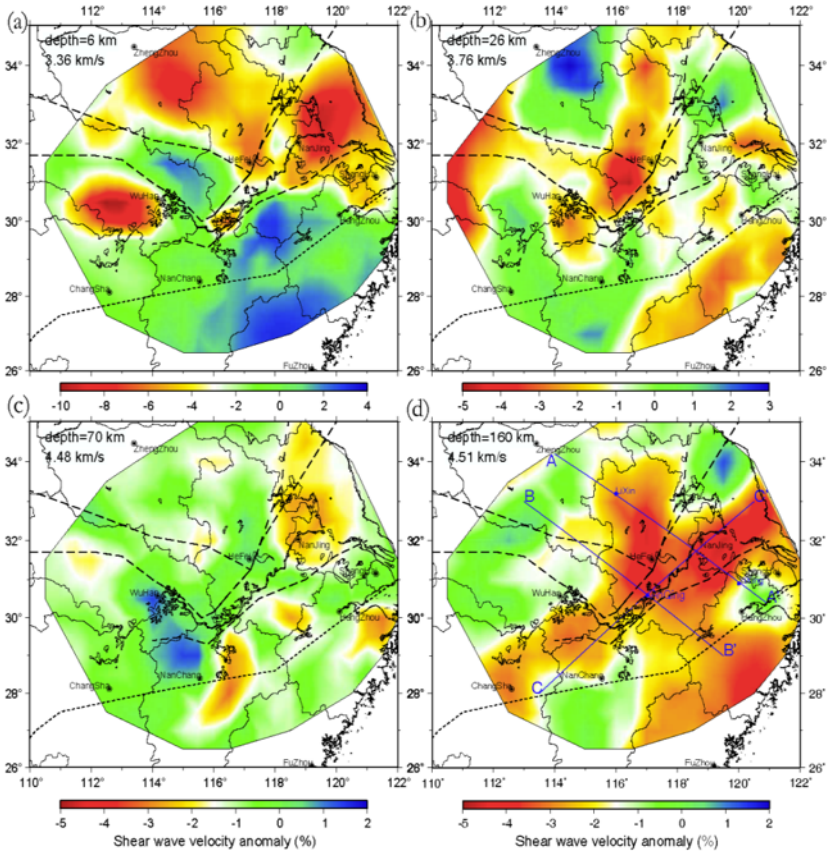
Jiang G et al., 2014



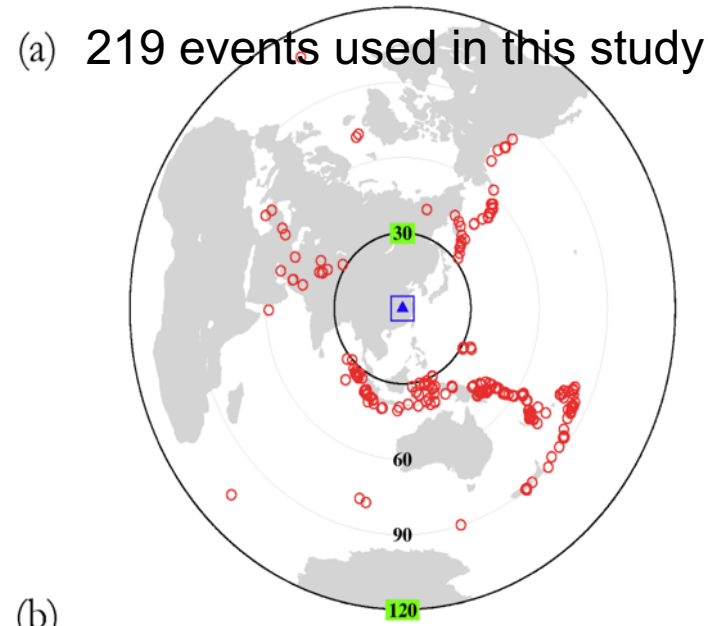


Ambient noise tomography

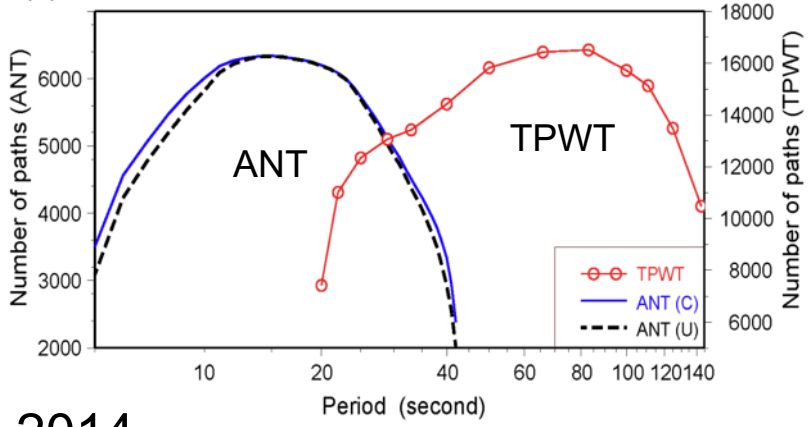
Estimated shear wave velocity maps at depths of 6, 26, 70 and 160 km



(a) 219 events used in this study



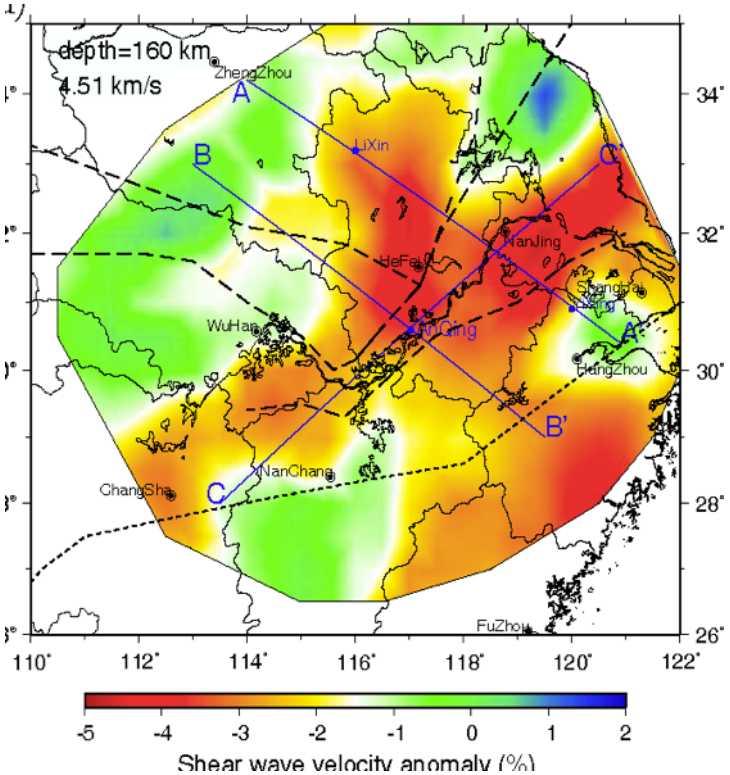
(b)

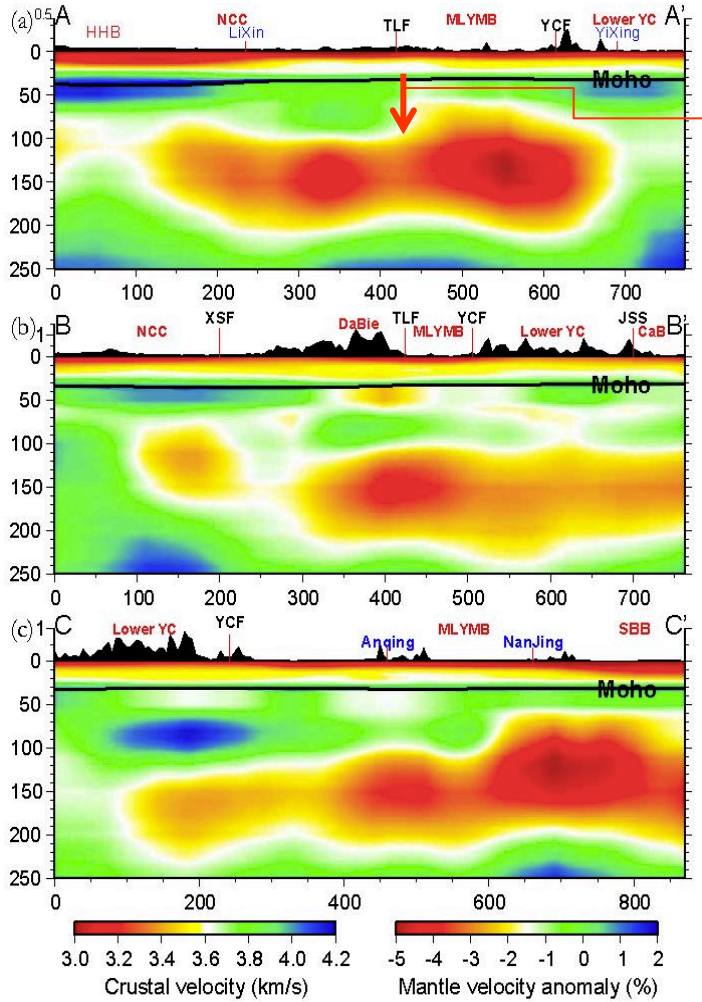


Ouyang et al., EPSL, 2014

Ambient noise tomography

Further evidence the existence of lower velocity body located at 100-200km



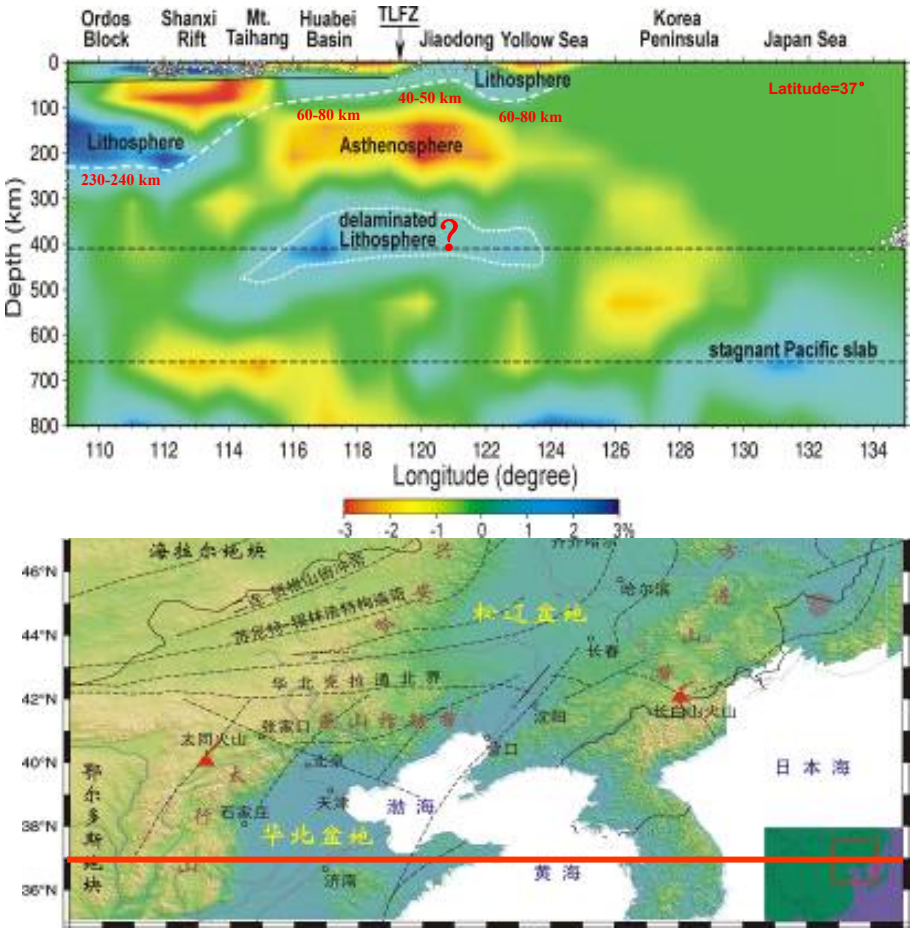


Step

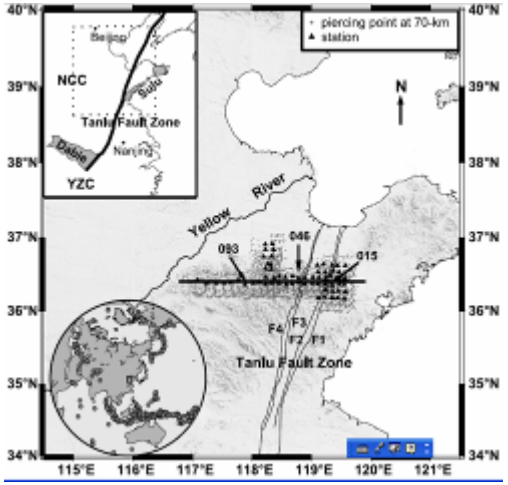
SW dipping

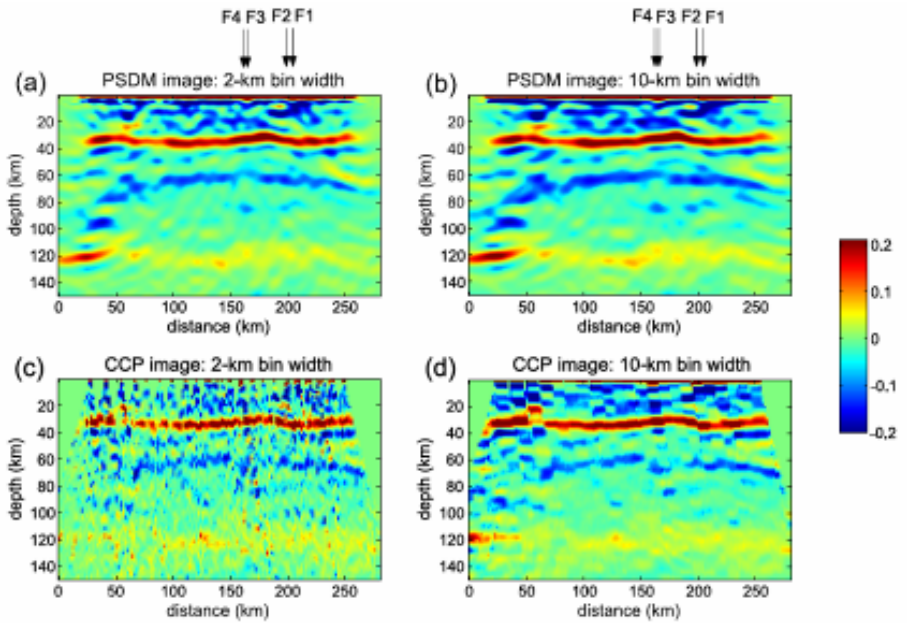
Ouyang et al., EPSL，2014

Other studies confirm lithosphere delamination and asthenosphere upwelling



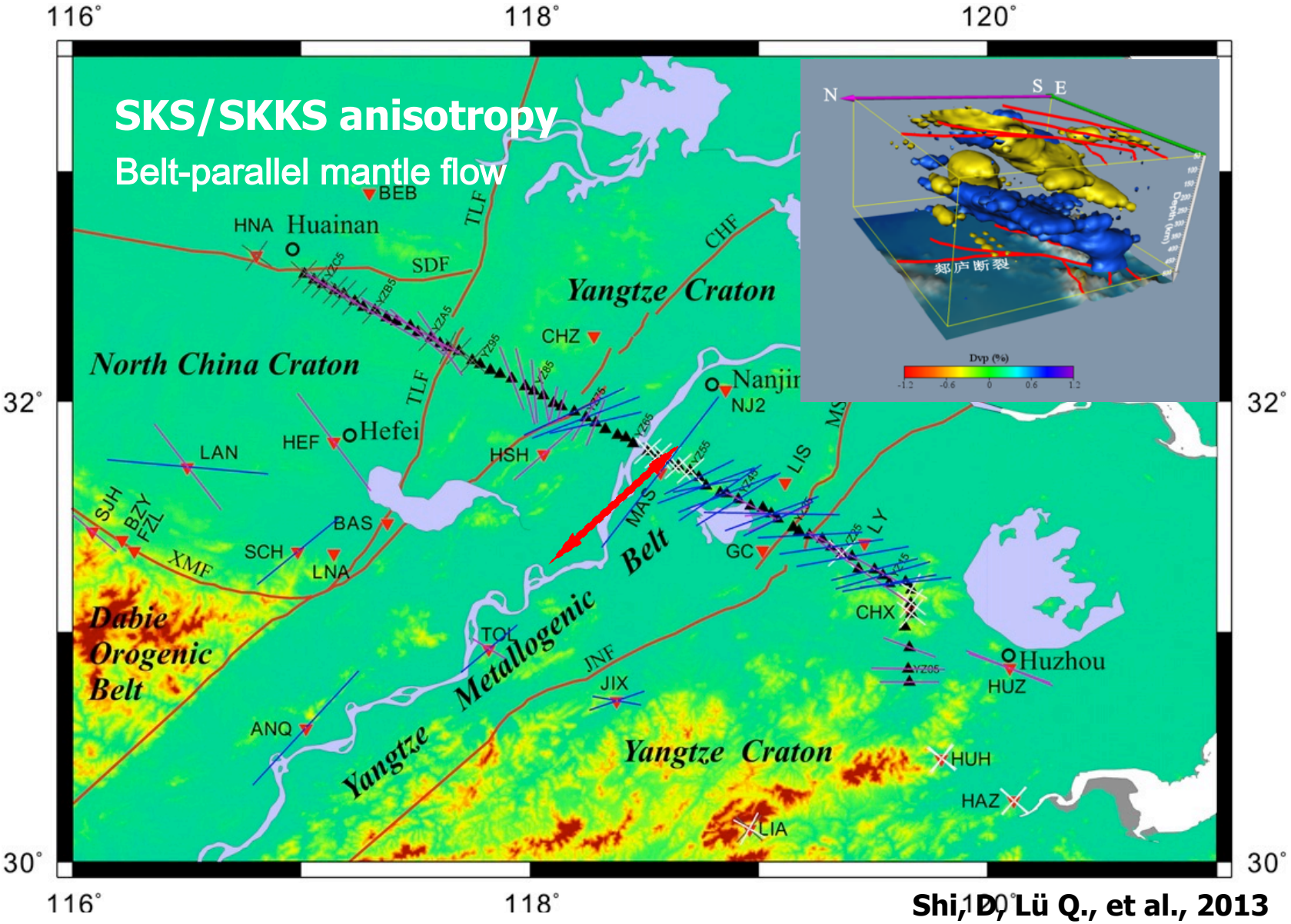
Xu P F，2009





L. Chen, T.Y Zheng,et al.,2006

Upper Mantle Anisotropy



Shi, D., Lü Q., et al., 2013

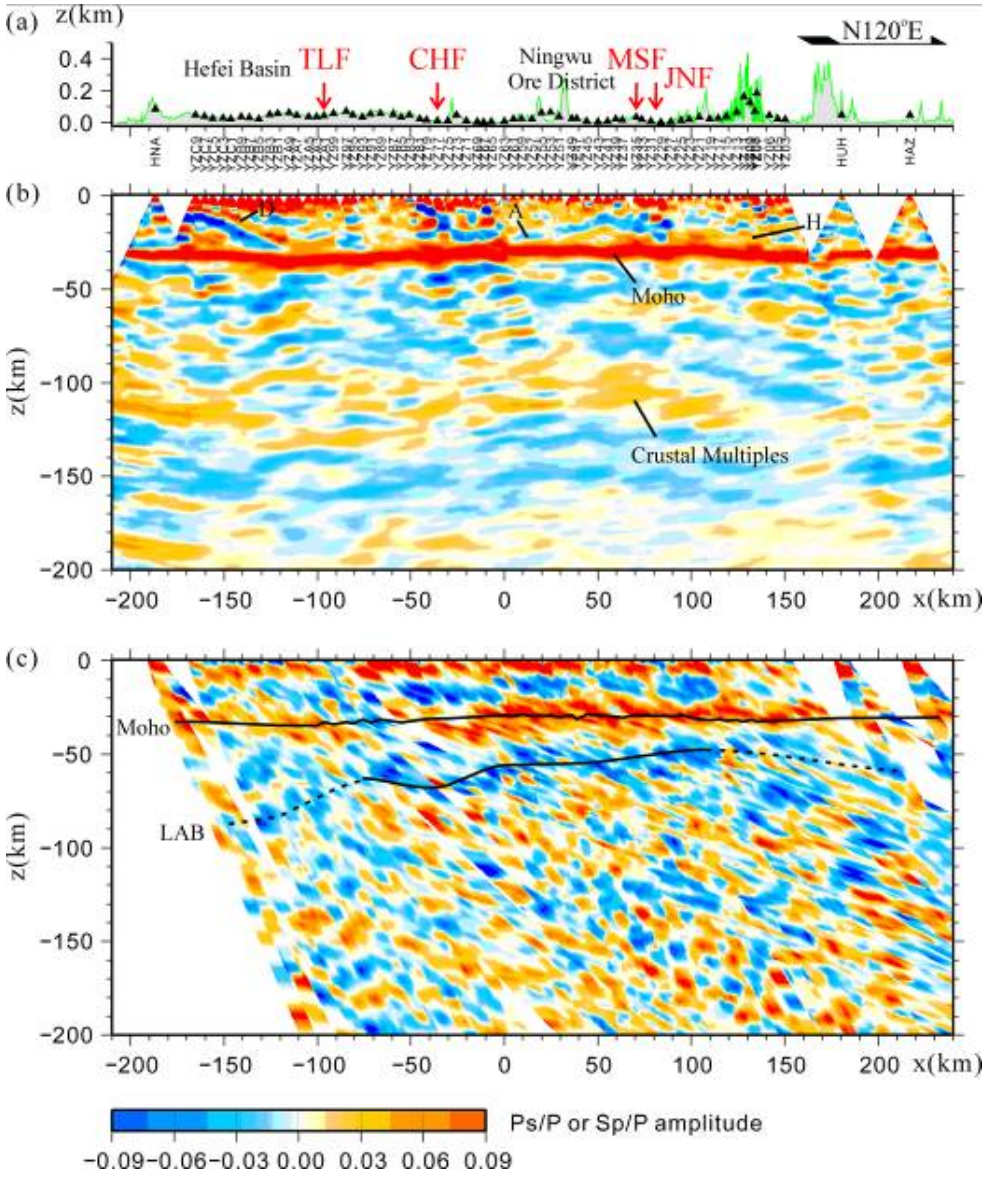
Receiver function images (LAB)

(a) Topography and station positions along the profile

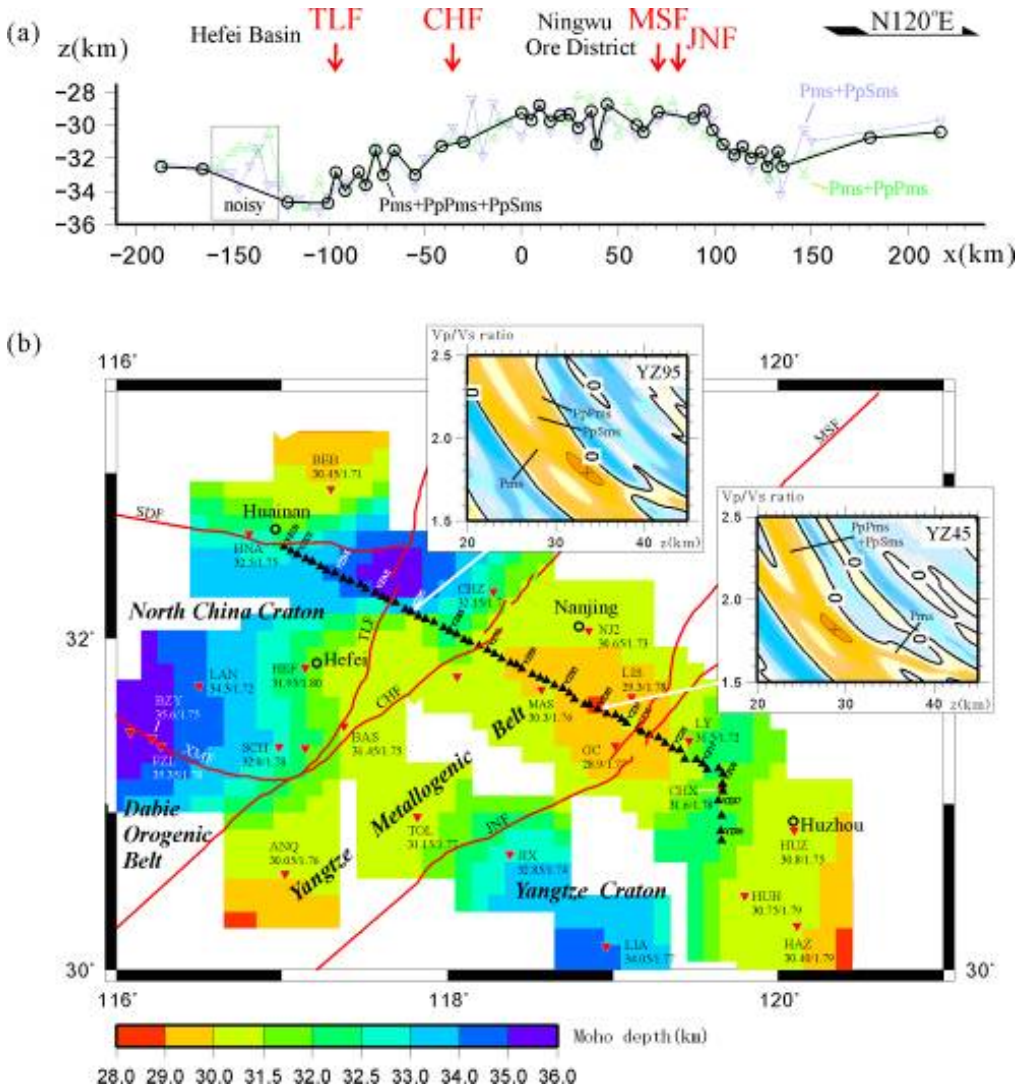
(b) P-wave receiver function cross-section shows shallower Moho

(c) S-wave receiver function cross-section shows shallower LAB beneath the MLYMB

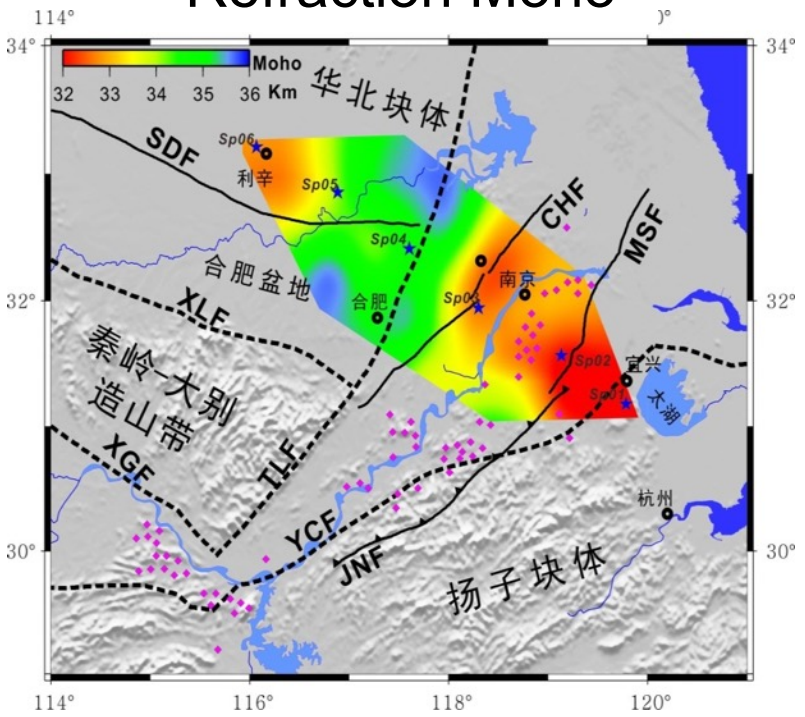
4851 P-wave and 205 S-wave receiver functions were used in the construction of the seismic cross-sections.



Moho Depth investigation



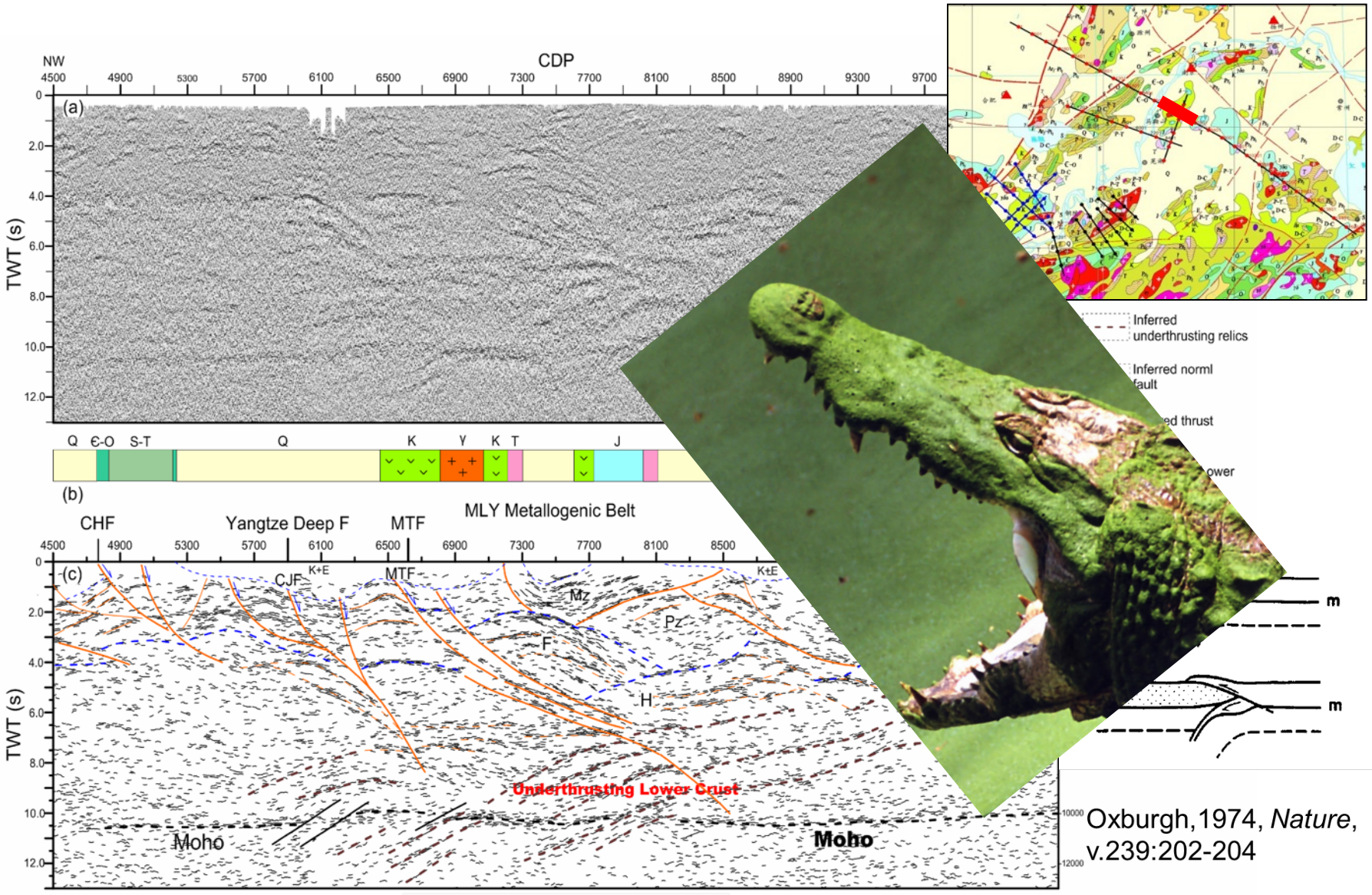
Refraction Moho



Moho depths estimated from the Moho directly converted phase (Pms) and its two multiply coverted phases (PpPms, PpSms) by grid-search method

Shi, D, Lyu Q., et al., 2013; Zhang M, Xu T, et al., 2015

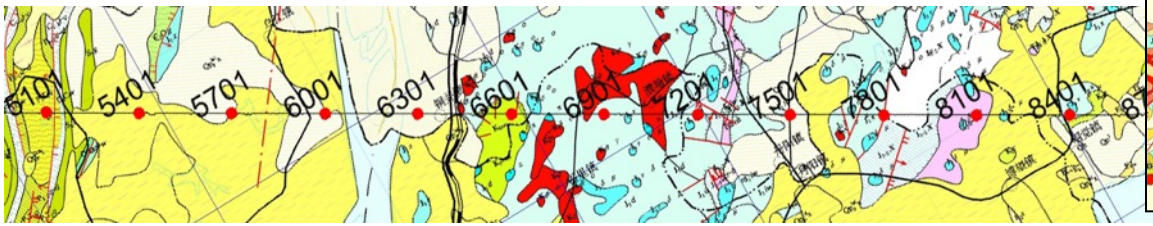
Crustal defor. and Crocodile Structure

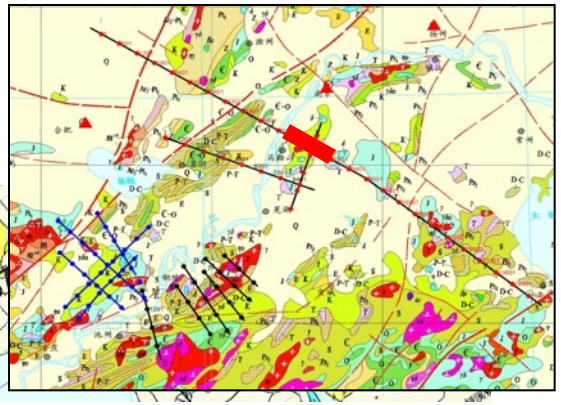


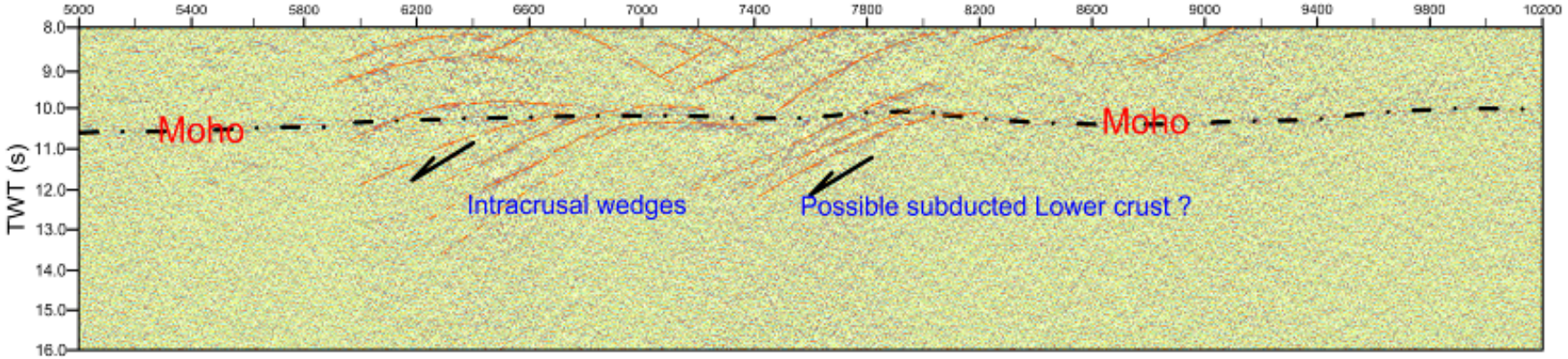
Oxburgh,1974, *Nature*, v.239:202-204

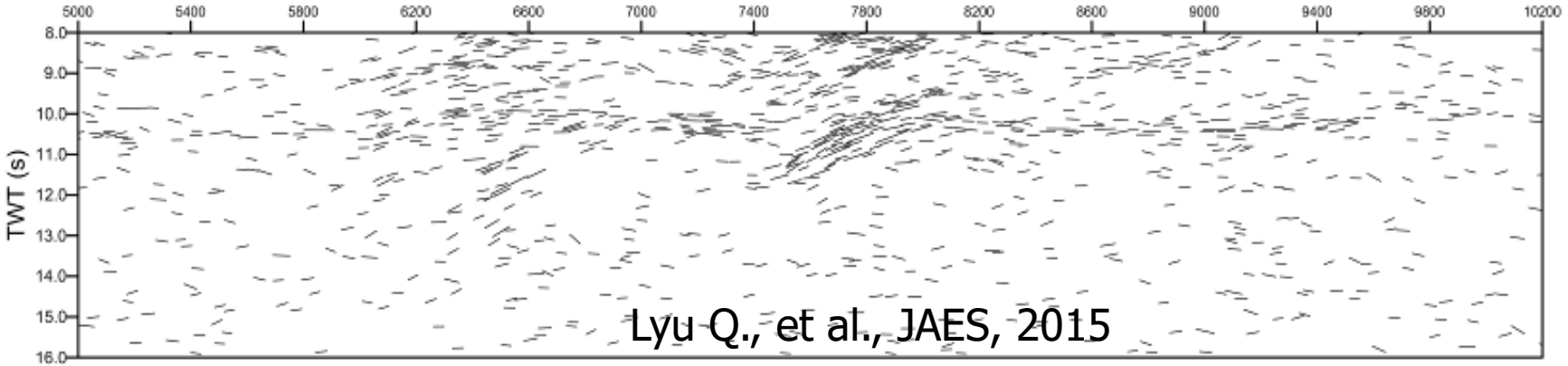
Lyu Q., et al., JAES, 2015

LC and UM NW-dipping relic reflections Beneath Ningwu volcanics





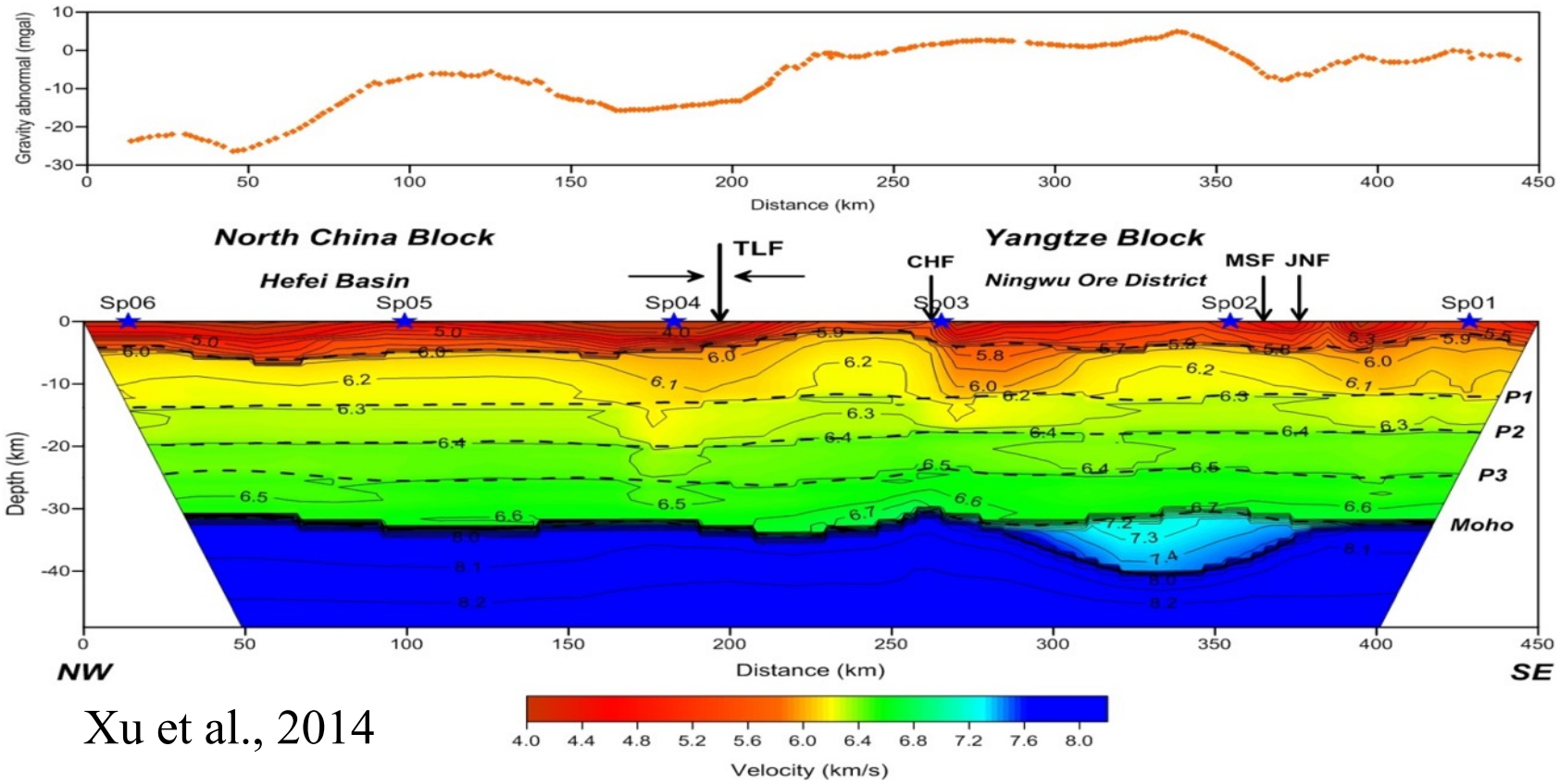




Lyu Q., et al., JAES, 2015

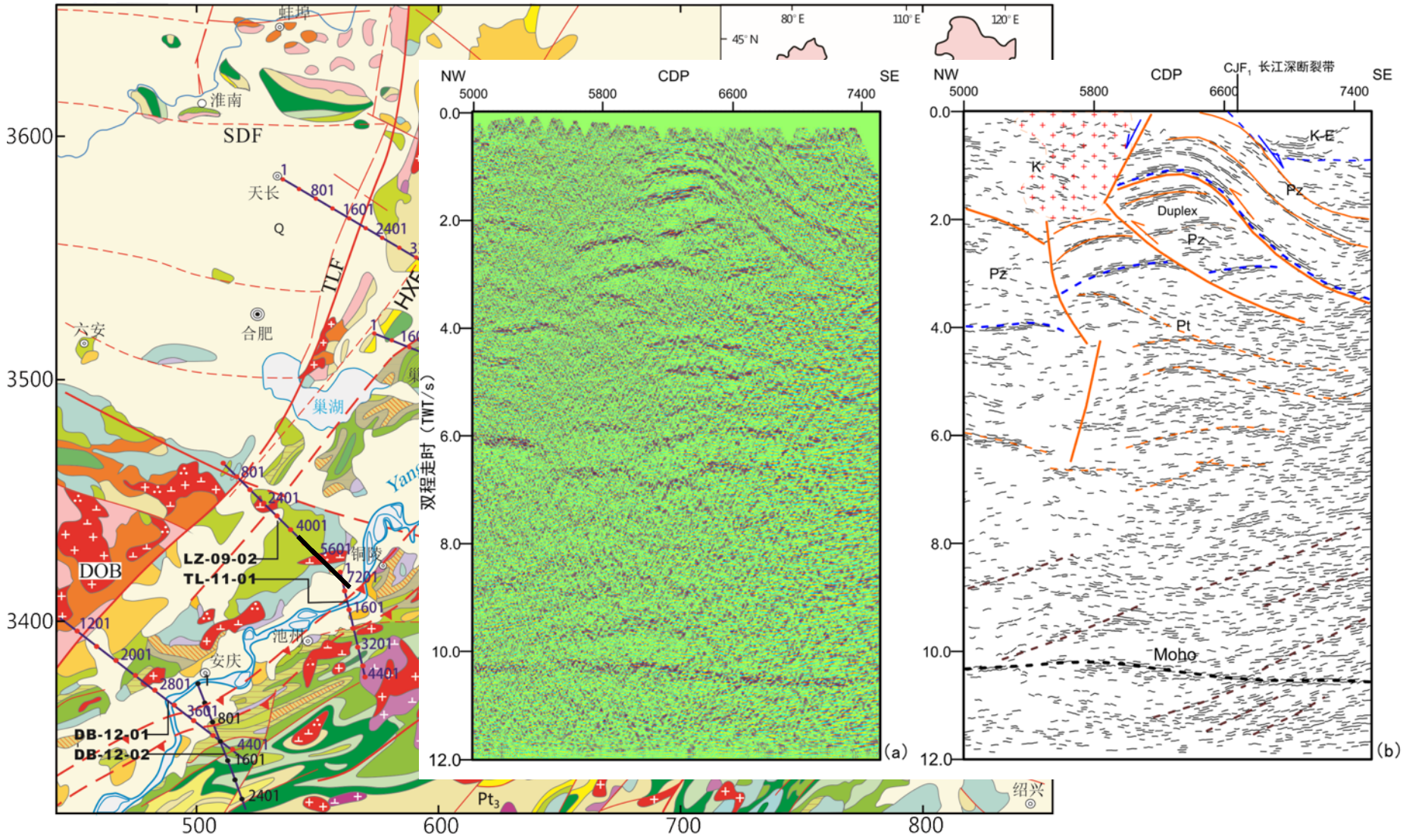
Crustal velocity section

Crustal P velocity from Wide-angle Seismic evidence the lower velocity anomaly around the CMB beneath the Niwu volcanic basin

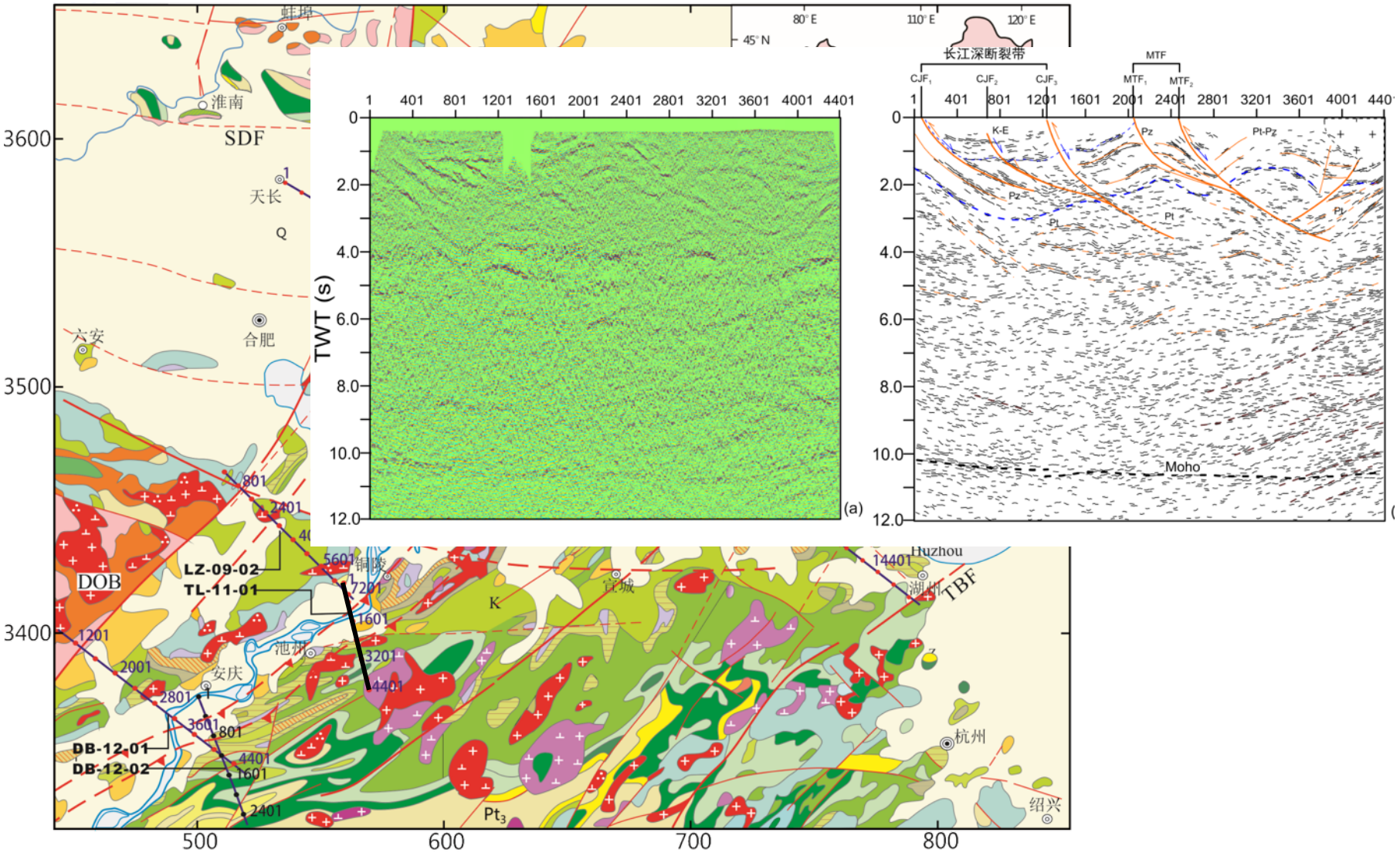


Xu et al., 2014

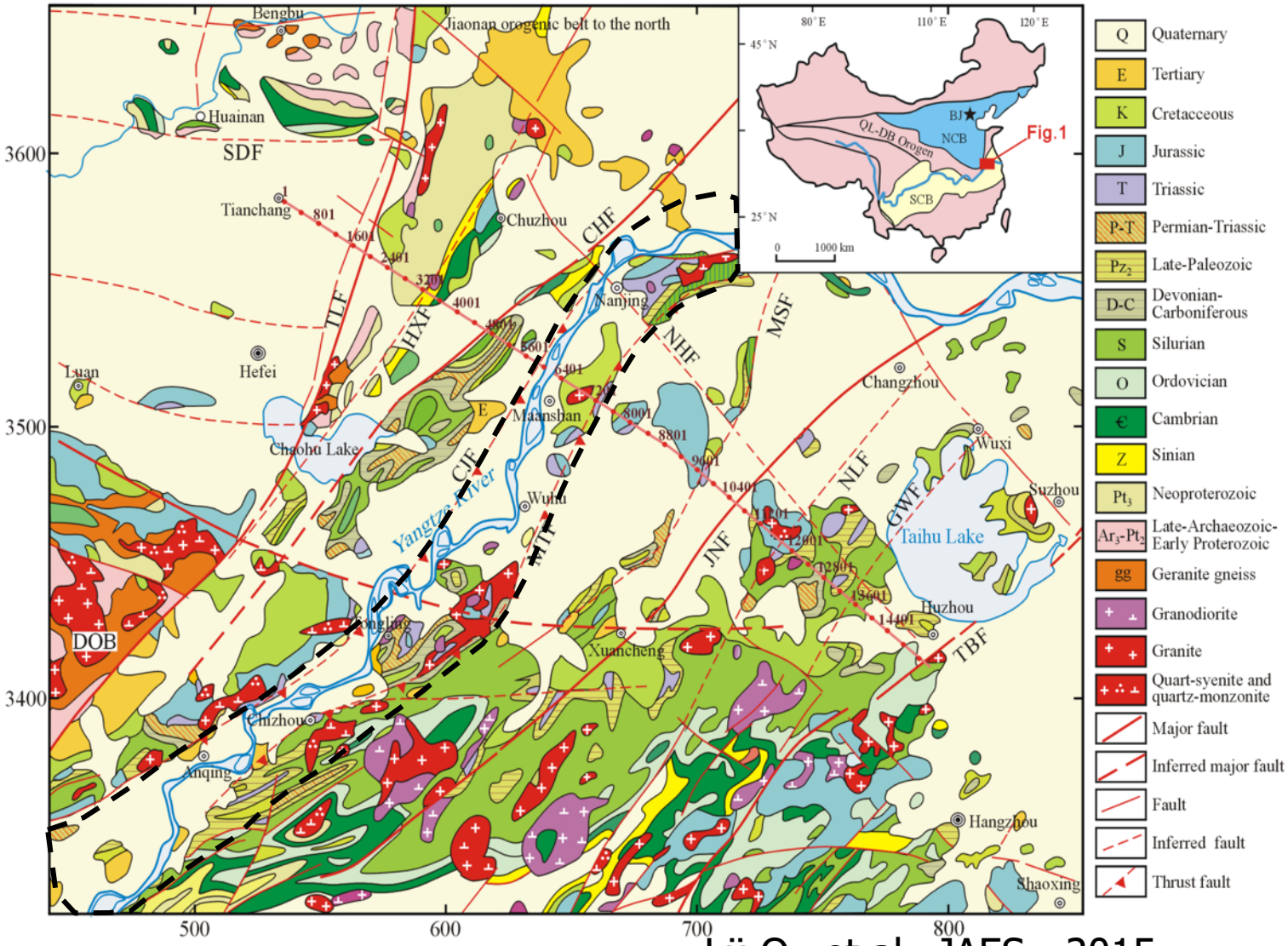
Other Seis. sections showing similar features



Other Seis. sections showing similar features

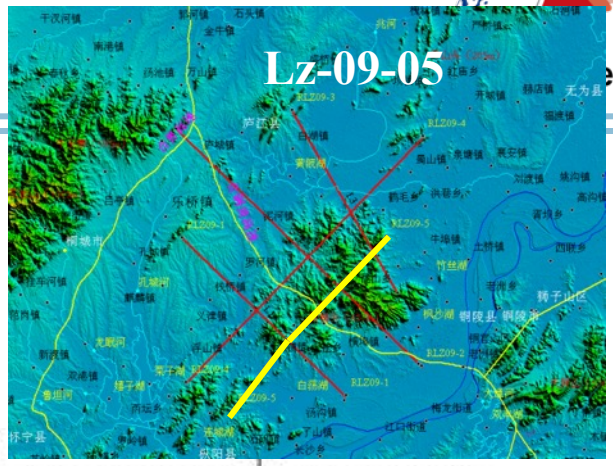


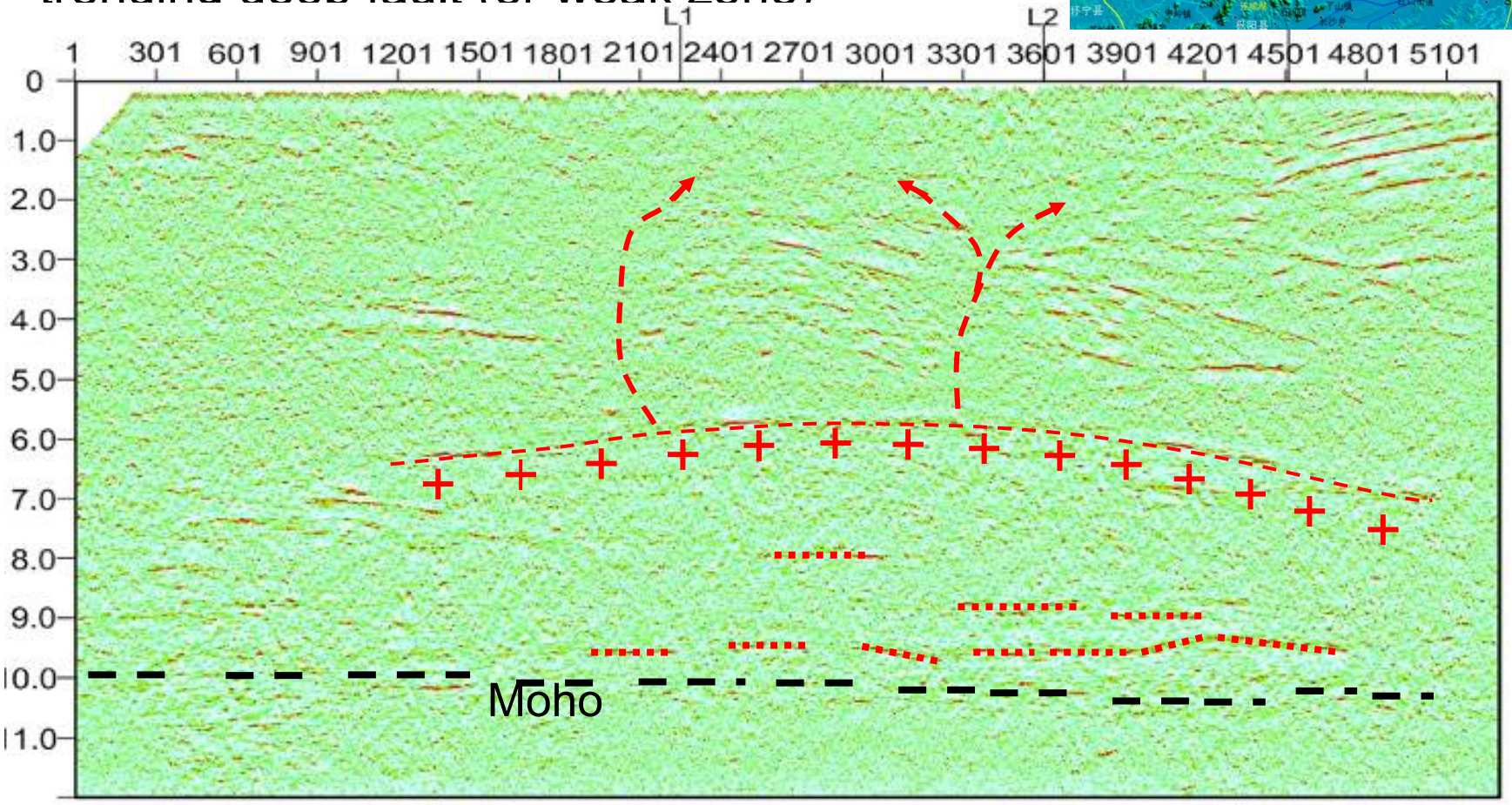
Crustal defor. and Crocodile Structure



Lü Q., et al., JAES，2015

LC shows strong reflective anisotropy; explained by a regional NE-elongating magmatic system emplaced through a NE-trending deep fault (or weak zone)





Summery of Highlights

Lithosphere and asthenosphere structure and dynamics of YMB

— Lower Velocity body (SW dipping) at top of the upper Mantle

— SW dipping High velocity body center at 300km

— YMB-Belt-parallel anisotropy both in the upper mantle and the lower crust

— Shallow Moho and Mantle uplift beneath YMB

Crustal structure, dynamic and magma system

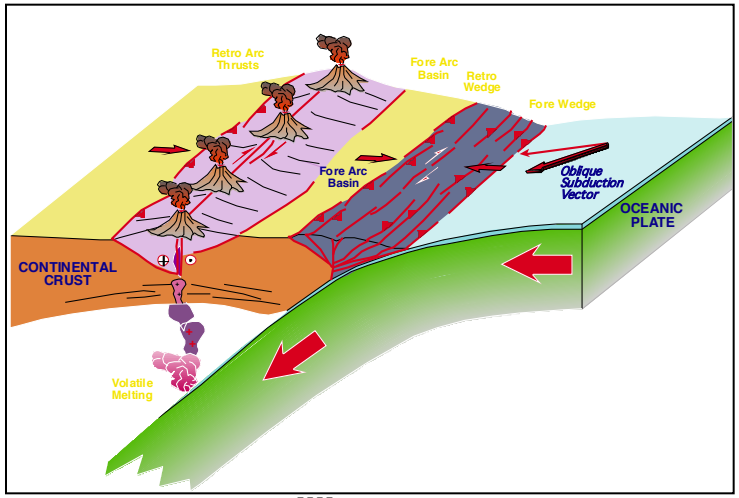
— UC and LC were detached during contraction tectonic regime; evidence for LC and UM subduction or stacking.

—Close relationship between LC reflectivities and magmatism, evidence for underplating and MASH processes

—Long distance middle crust “bright spot”, relics of magma chamber

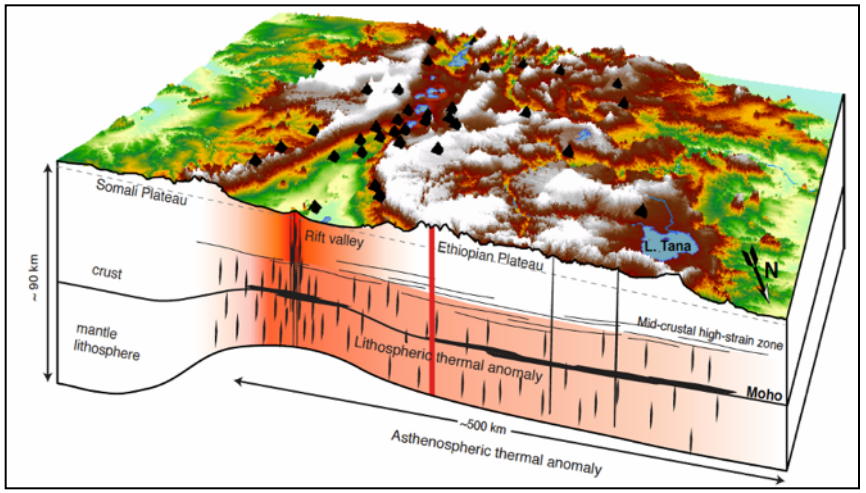
Questions

Tectonomagmatic model for Andean type metallogeny



Sillitoe R.H, 1972;2010

What possible model for intra-continental metallogeny?



S. Klemperer, 2011

- Subduction of Oceanic Plate
- Melting of mantle wedge
- Underplating of basalts at CMB
- MASH process, andesitic magma
- Most metals coming from Mantle
- Conti. Marg. shear fault channeling

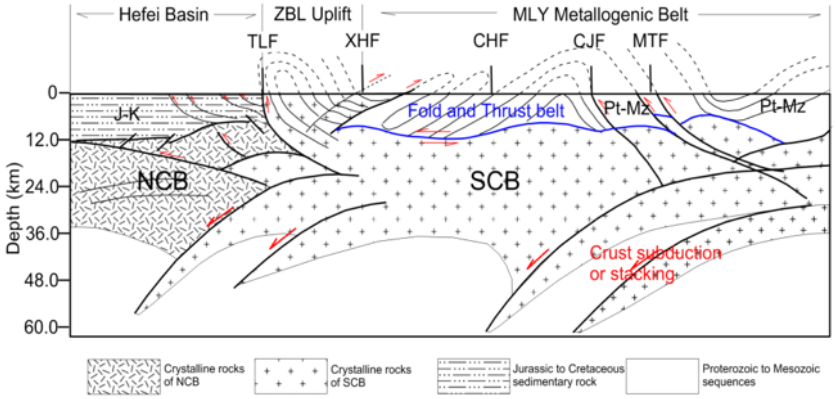
magma from CMB to U crust

Questions:

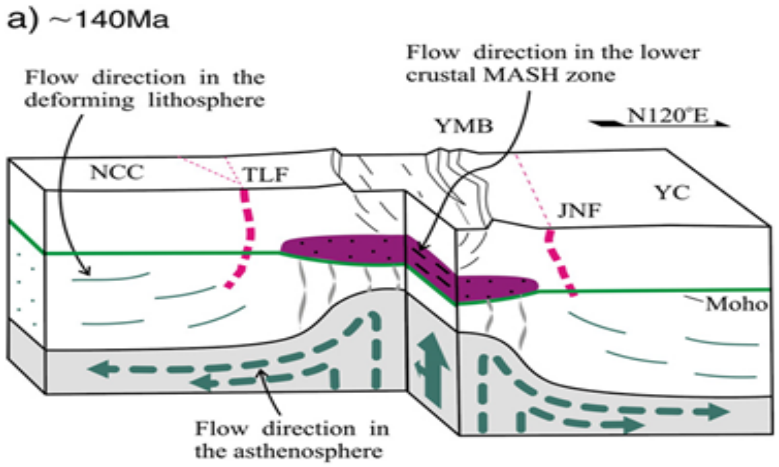
What's the deep processes for intraplate metallogeny?

Possible Model and Conclusions

175—140Ma: Compression Regime



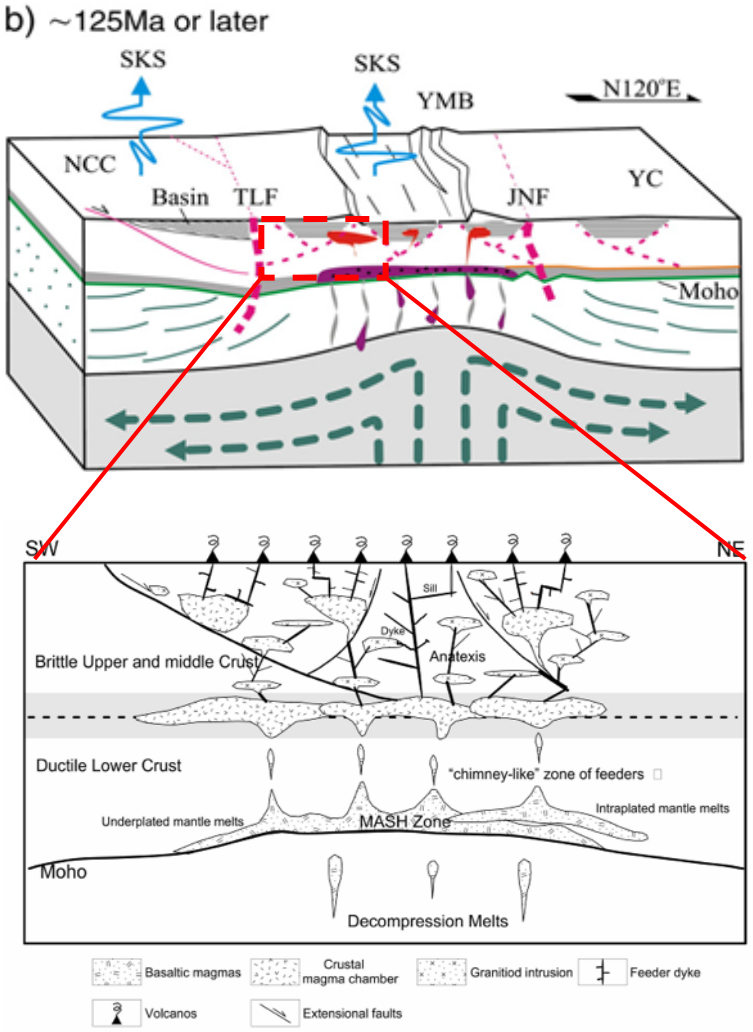
--140Ma: Extension Regime



- Intracontinental subduction or sublithosphere stacking between blocks, thickening Lithosphere
- Sublithosphere delamination and extention
- Asthenosphere upwelling, and basaltic magma underplating
- MASH process, andesitic magma
- Intracontinental deep faults channeling magma from CMB to Upper crust
- Multi-level magma chamber system

Shi D., et al., 2013; Lyu Q., et al., 2014

Possible Model and Conclusions



- Intracontinental subduction or sublithosphere stacking between blocks, thickening Lithosphere
- Sublithosphere delamination and extention
- Asthenosphere upwelling, and basaltic magma underplating
- MASH process, andesitic magma
- Intracontinental deep faults channeling magma from CMB to Upper crust
- Multi-level magma chamber system

Shi DN, et al., 2013;Lyu QT, et al., 2013

Thank you

Contact Address:
PI: Lyu Qingtian
Deep Exploration Center,CAGS
Baiwanzhuang Road 26, Xicheng District
Lqt@cags.ac.cn
0086-10-68999091
+86-13910406919