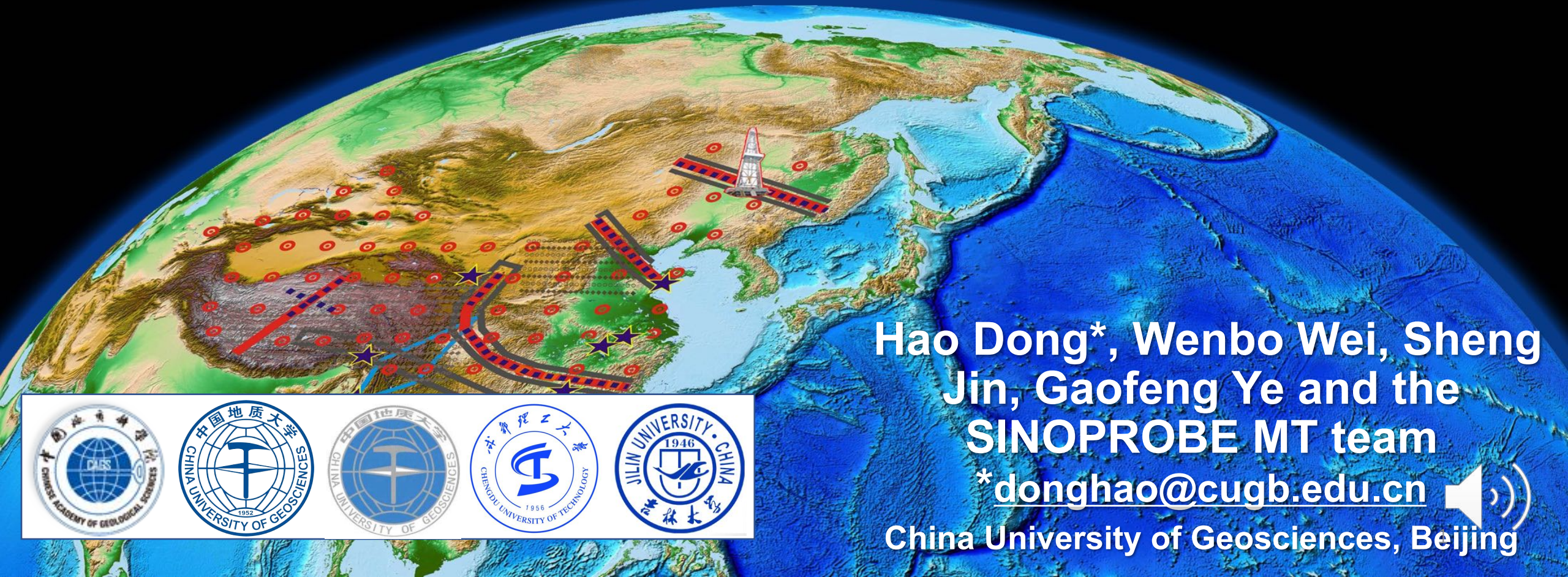
EMinar 2020

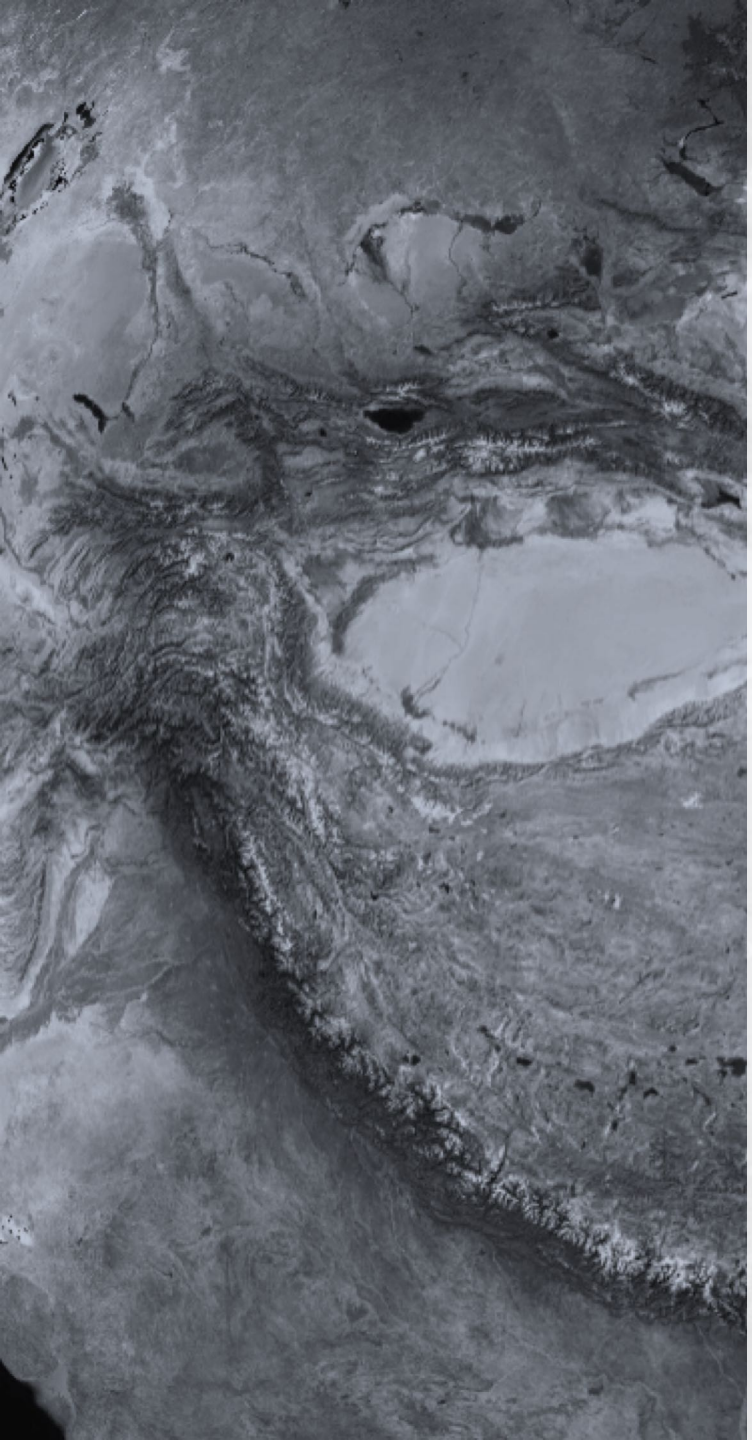
Magnetotellurics in SINOPROBE Project: an Overview



Hao Dong*, Wenbo Wei, Sheng Jin, Gaofeng Ye and the SINOPROBE MT team

*donghao@cugb.edu.cn

China University of Geosciences, Beijing



- **Outline**
  - Electromagnetic Component in SINOPROBE
  - The science and discoveries of SINOPROBE-MT
    - North China Craton
    - Tibetan Plateau
    - South China
  - Conclusion and Outlooks
    - Following-up projects

The EM Component in SINOPROBE

- **SINOPROBE**: a multi-discipline geophysical project for Continental China.
- Project approved by ministry of land and resources and ministry of science and technology in 2008.
- **EM components -in SINOPROBE-01 and SINOPROBE-02 sub-projects (mission duration 2009-2013). – finished 7(!) years ago.**
- **Total EM budget: 41 million RMB (around six million dollars)**

~~Its five year mission~~ The Goal

- **Developing the *observation, processing, and interpretation methods* for the future national EM array, and making necessary *personnel and technical* preparations.**

- Providing demonstrational results of the deep structure and evolution of the continental China, with emphasis on geo-electrical imaging of the lithosphere and its dynamic processes.

The Team

All the SINOPROBE projects are administrated by Chinese Academy of Geosciences. Data were collected by five individual institutions:

- **China University of Geosciences, Beijing/Wuhan (CUGB/W)**
- **Institution of Geophysical and Geochemical Exploration (IGGE,CAGS)**
- **Chengdu University of Technology (CDUT)**
- **Jilin University (JLU)**

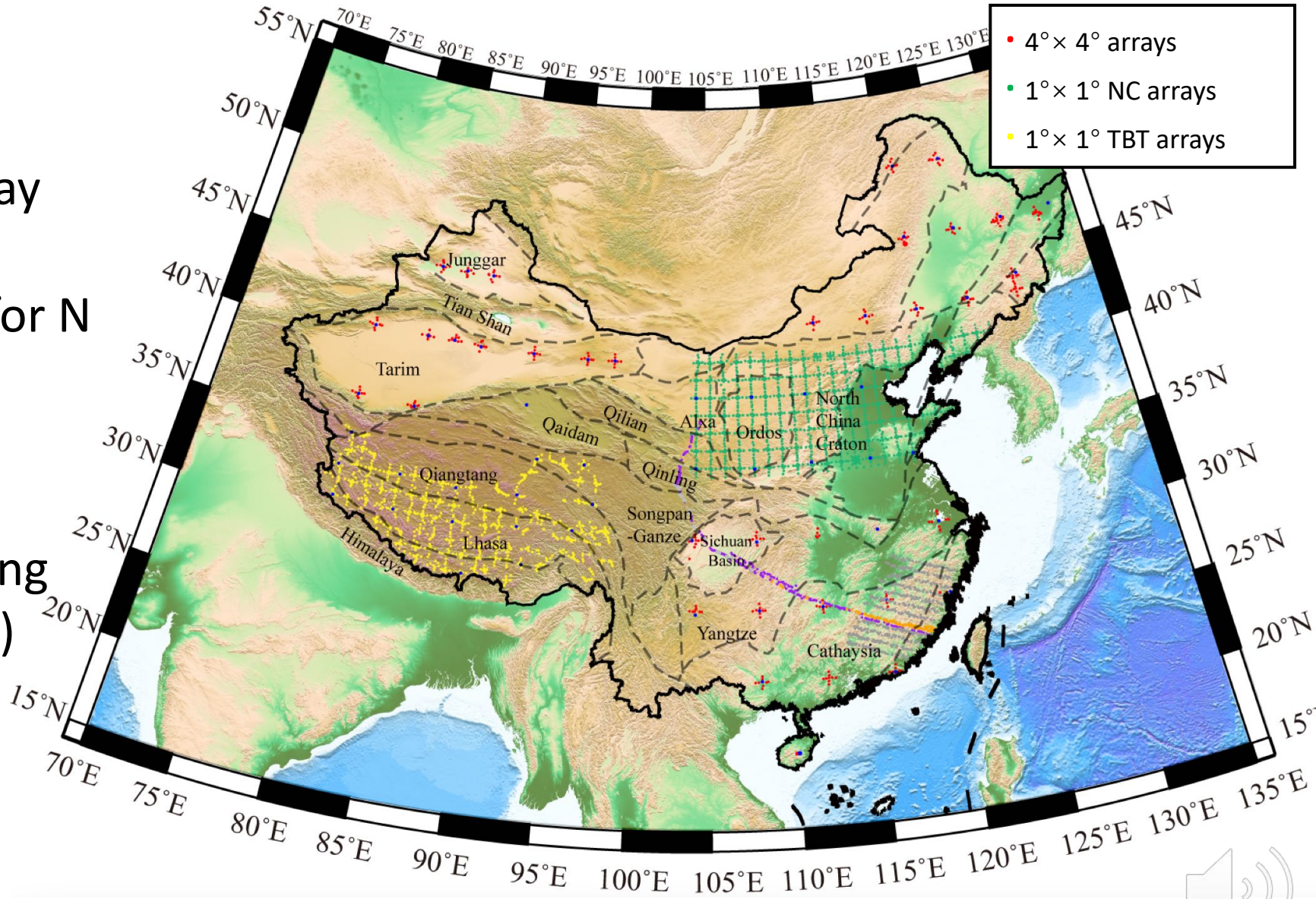
The Data

“Standard Grid” Array

- 4°× 4° continental array
- 1°× 1° regional array for N China and Tibet

Conventional Profiles

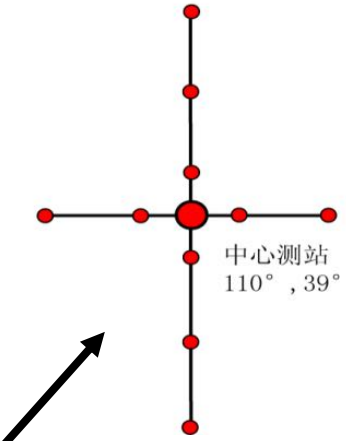
- Profile and Arrays (along with reflective seismic)



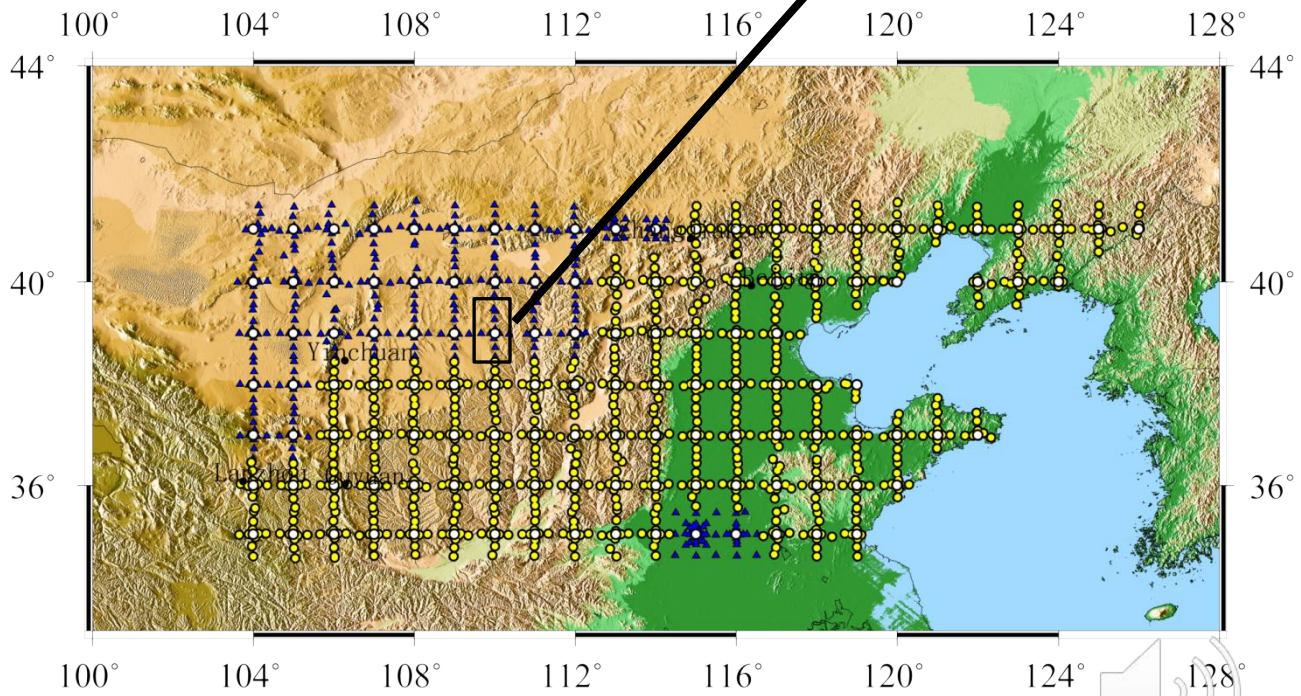
The “Standard Grid”

- 11-station setup at each “node”:

  1 central LMT and 10 auxiliary BBMT stns.



- This includes much more BBMT stations - concentrates on crustal structure.

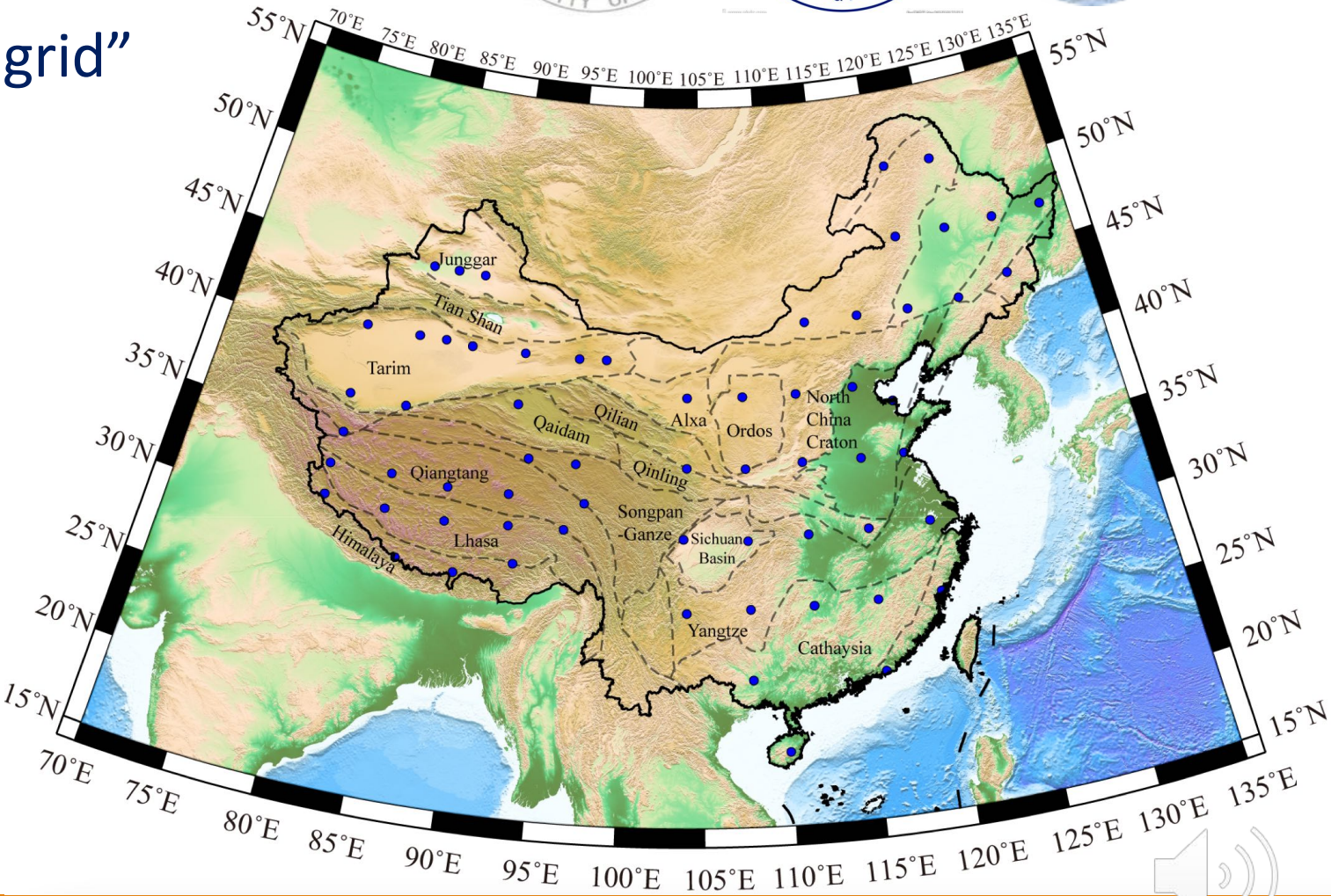


- The stations can also be treated as in ***longitudinal and latitudinal*** profiles for 2D interpretations.

SINOPROBE MT deployments

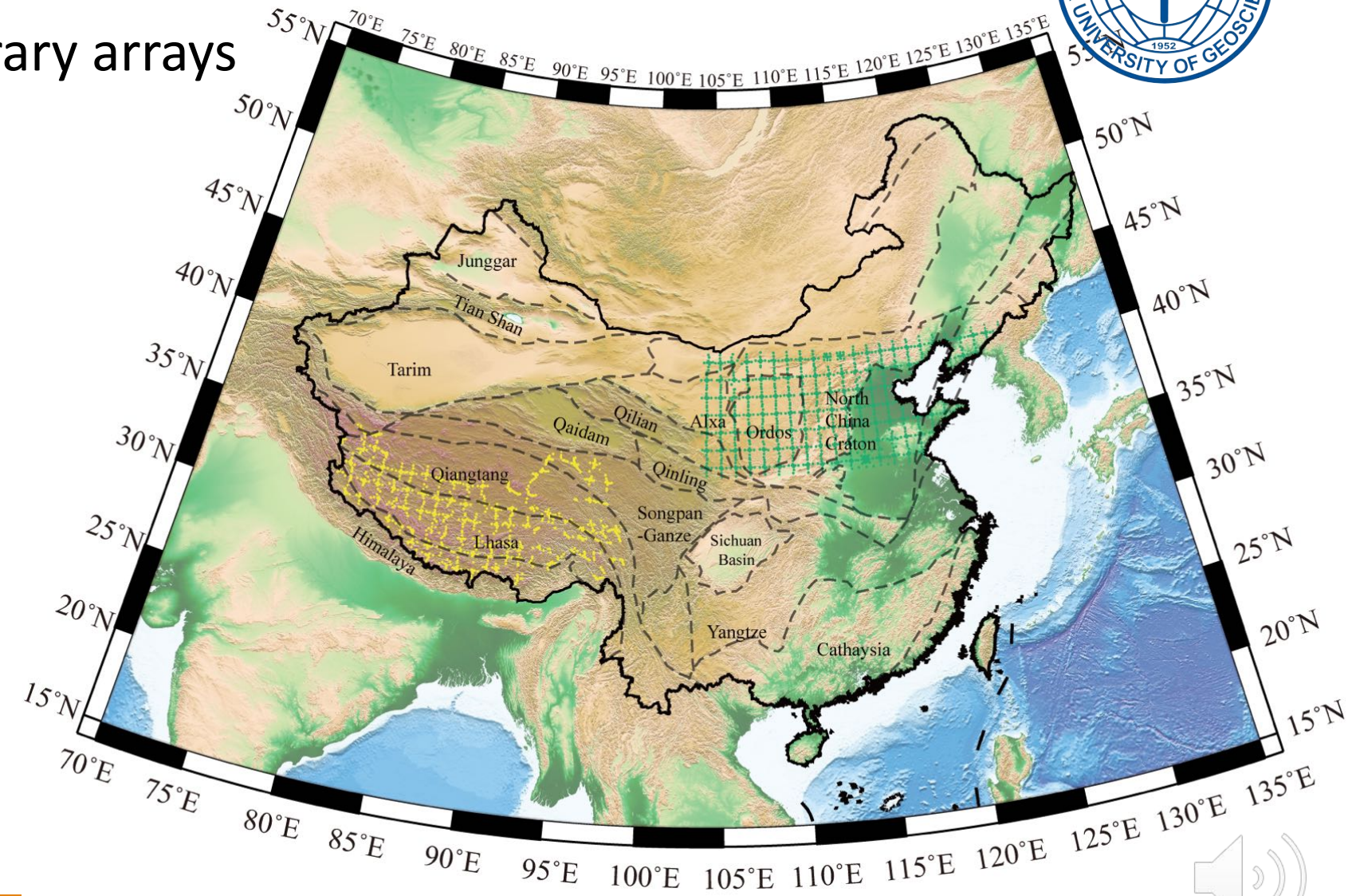
4°× 4° continental “standard grid” temporary array

- *989* LMT and BBMT sites in *64* “standard nodes”.
- Stations deployed by CUGW, IGGE, CAGS



SINOPROBE MT deployments

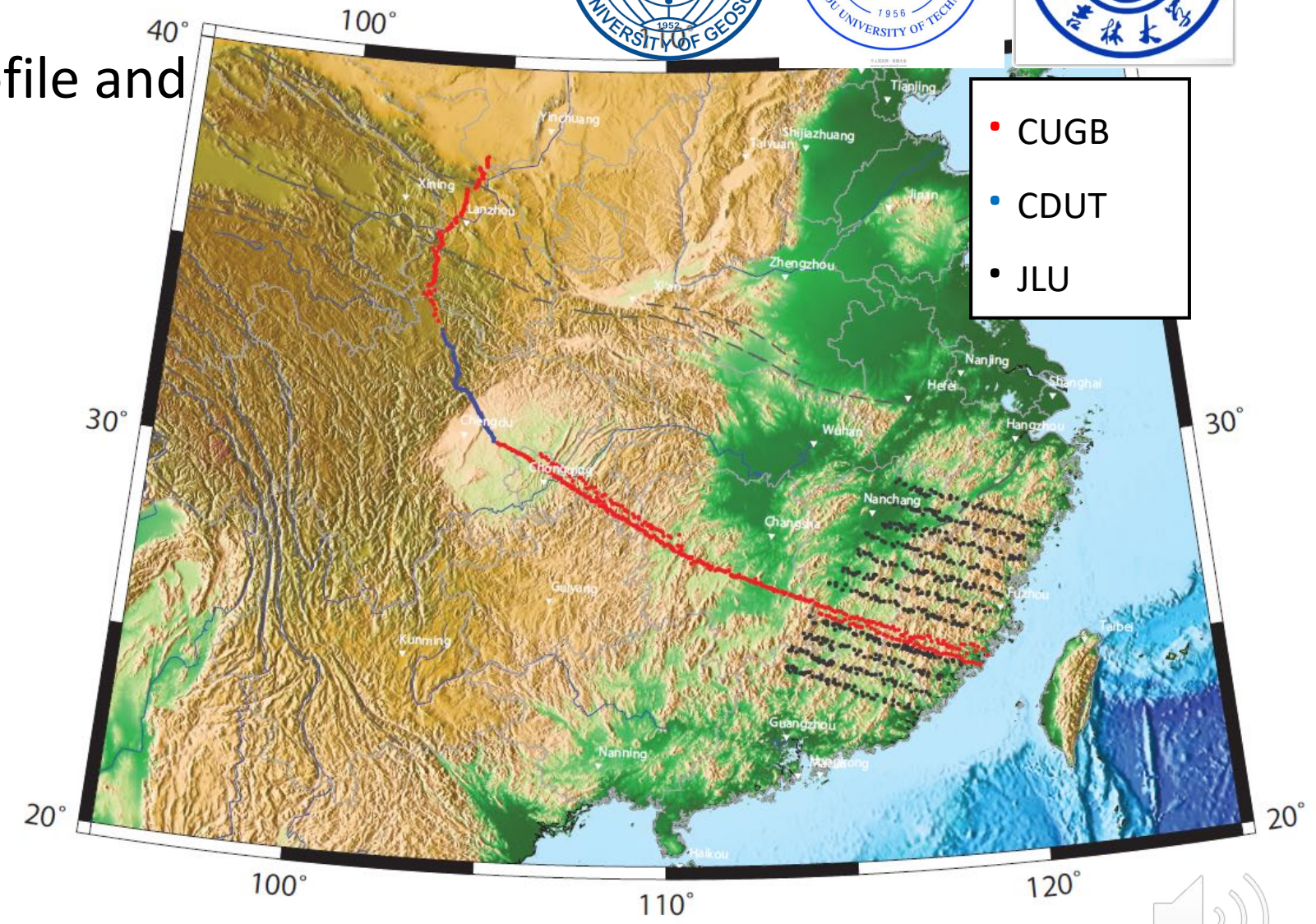
1°× 1° regional temporary arrays



- *1380* LMT and BBMT stations in North China
- *1089* stations in Tibetan Plateau
- Stations deployed by CUGB

SINOPROBE MT deployments (02-02)

Conventional MT Long profile and array in South China



- Over 2500km of profile
- *1293* BBMT and LMT stations
- Stations deployed by CUGB, CDUT and JLU

SINOPROBE MT: The Challenges

- Inconsistent instrumentation/data format for different Institutions.
  - each processed with its own code…




- Even if those can somehow be converted to EDIs...
- How about the parameters? Estimation methods? Units/Variances/Covariances? FREQ table?

SINOPROBE MT: How deep can we see?

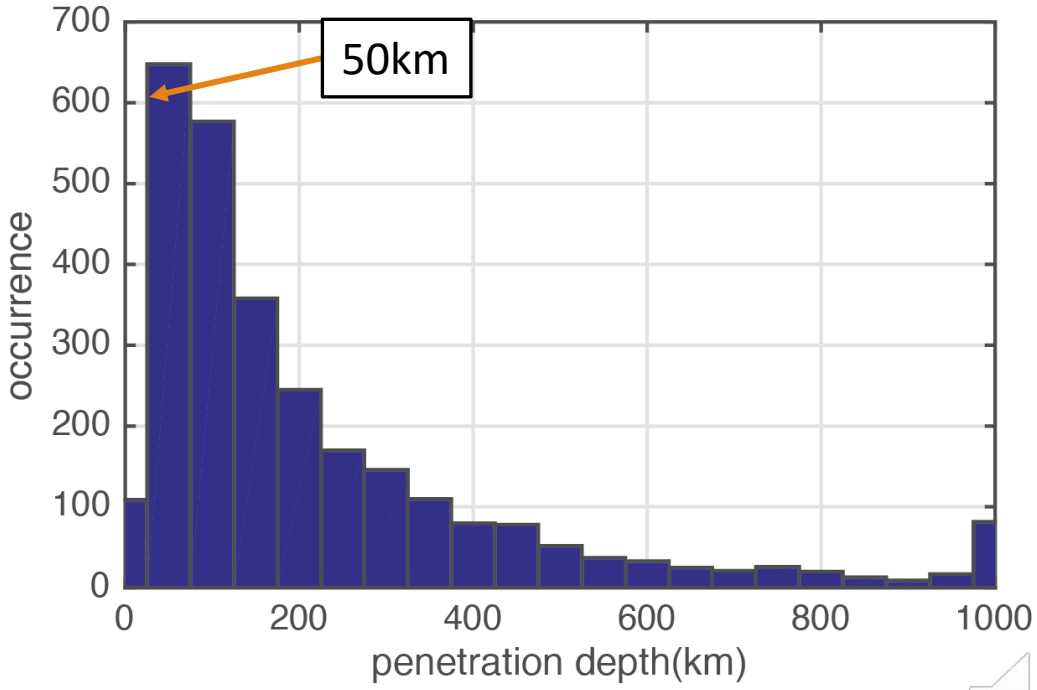
- 3,870 individual BBMT and LMT stations (excluding repeated acquisitions for QC/consistency experiments)

- *3430* BBMT stations (~ 1 day acquisition time)
- 0.01 ~ 2300s (median longest period)

- median penetration depth ~ 140km

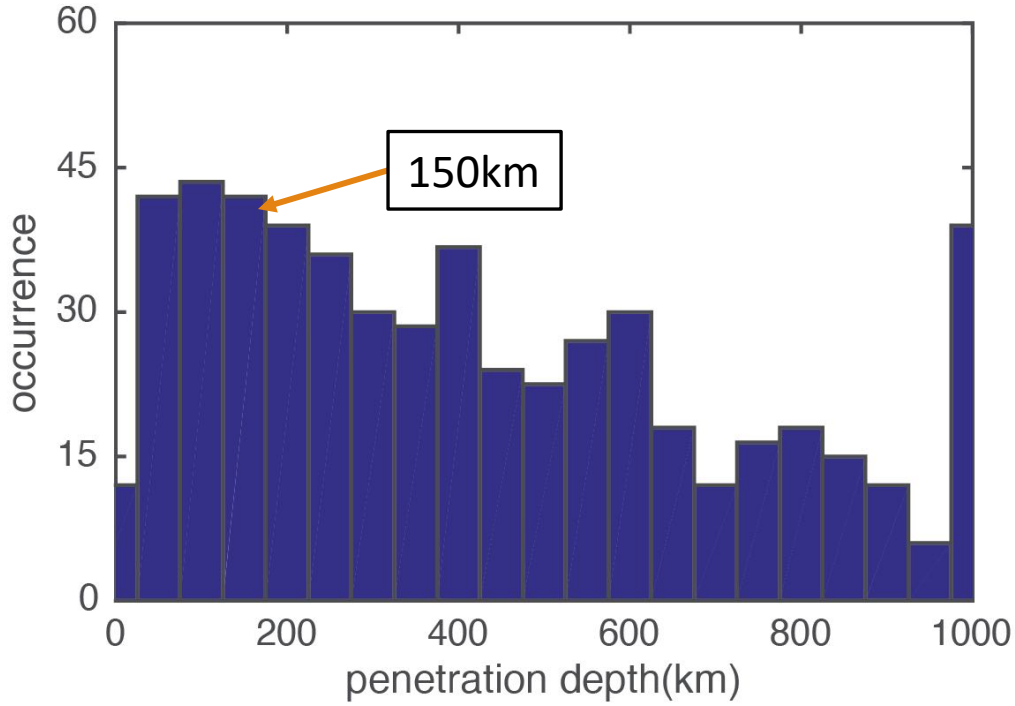
- estimated with Bostick transformation from Berdichevsky averaged imped.

- *OK for the crust*



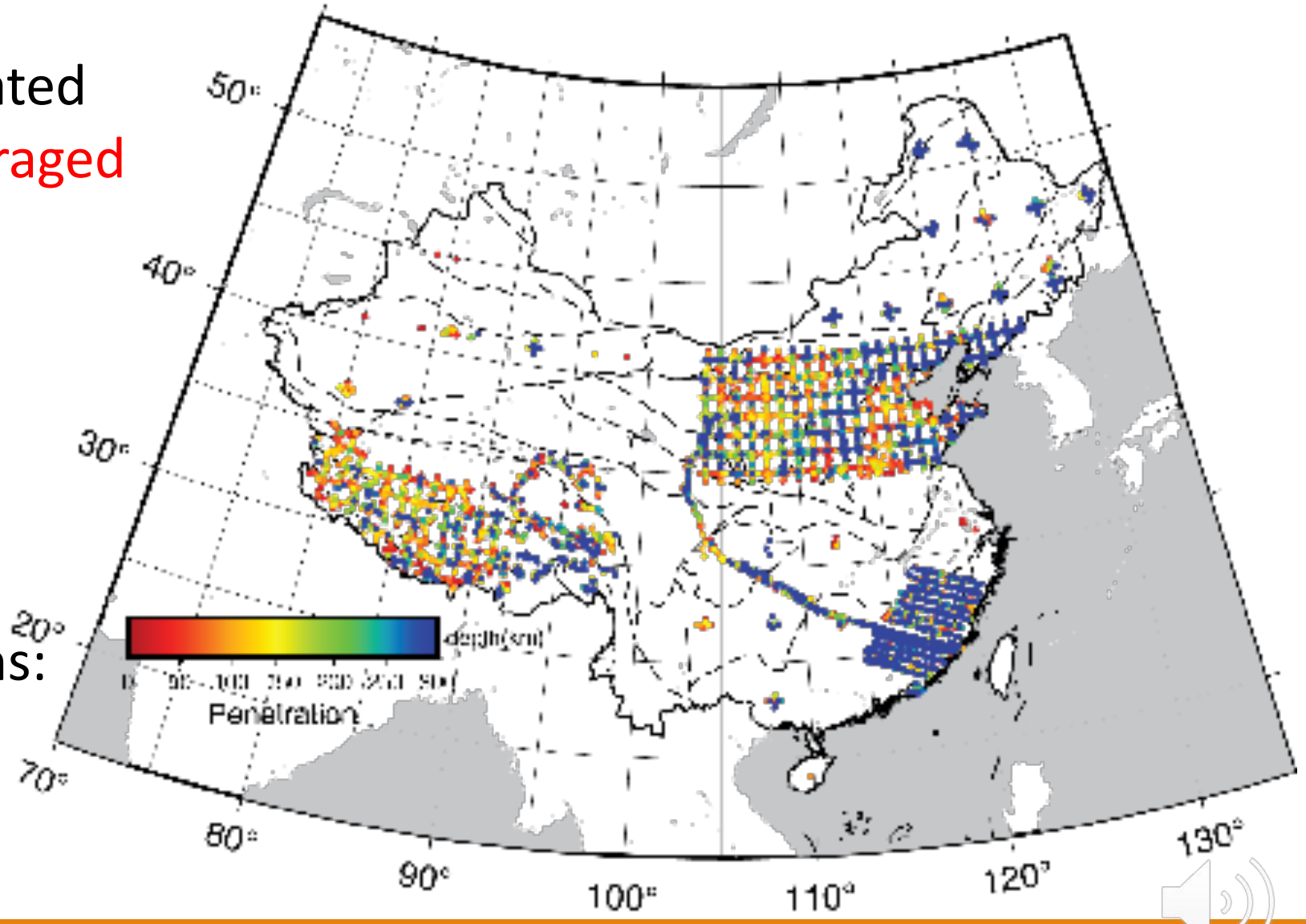
SINOPROBE MT: How deep can we see?

- *460* LMT stations, normally (only) 7-day acquisition
- 10 ~ 9500s (median longest periods)
- median penetration depth ~ 390km
- (Probably) OK for ~150km

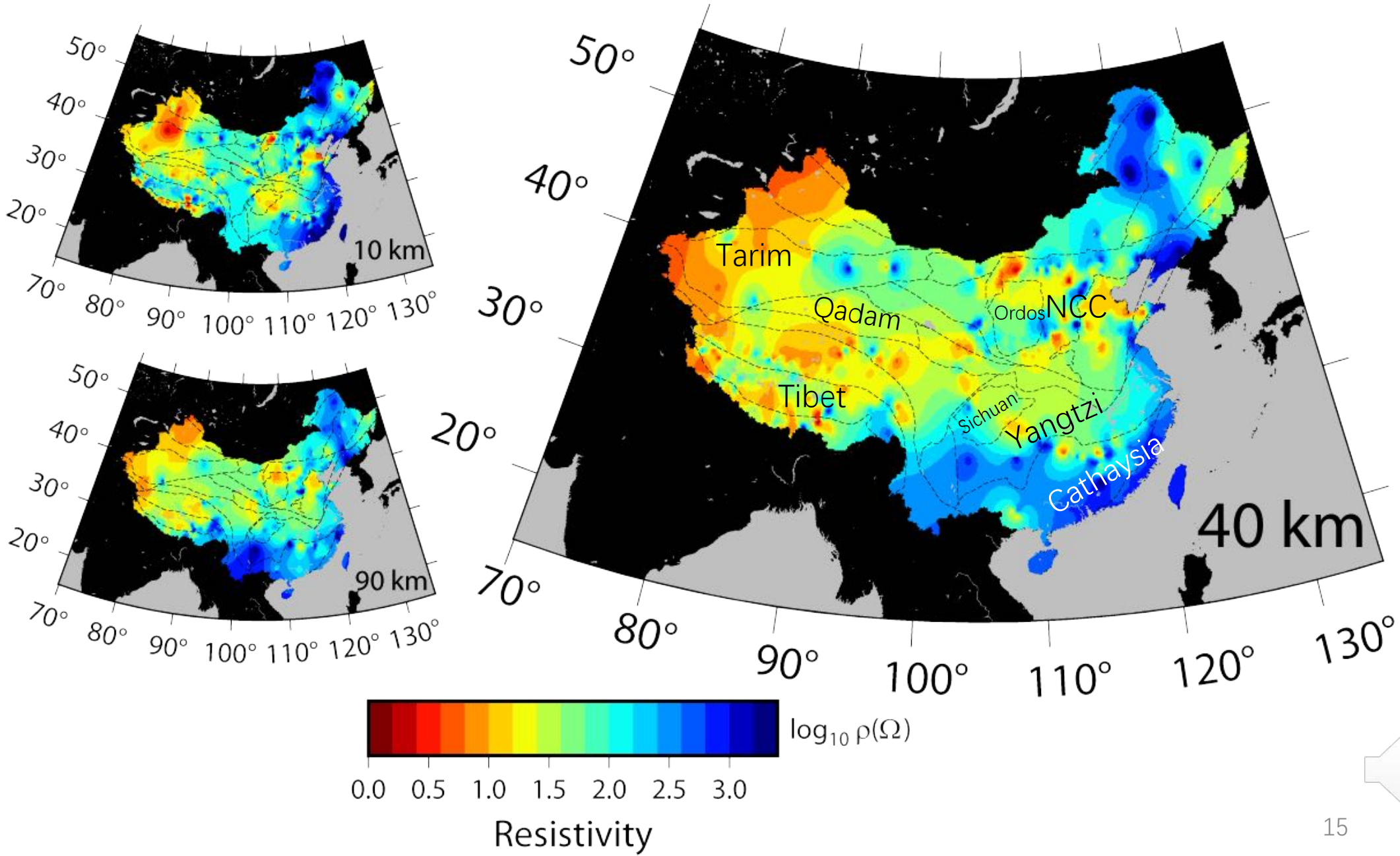


SINOPROBE MT: How deep can we see?

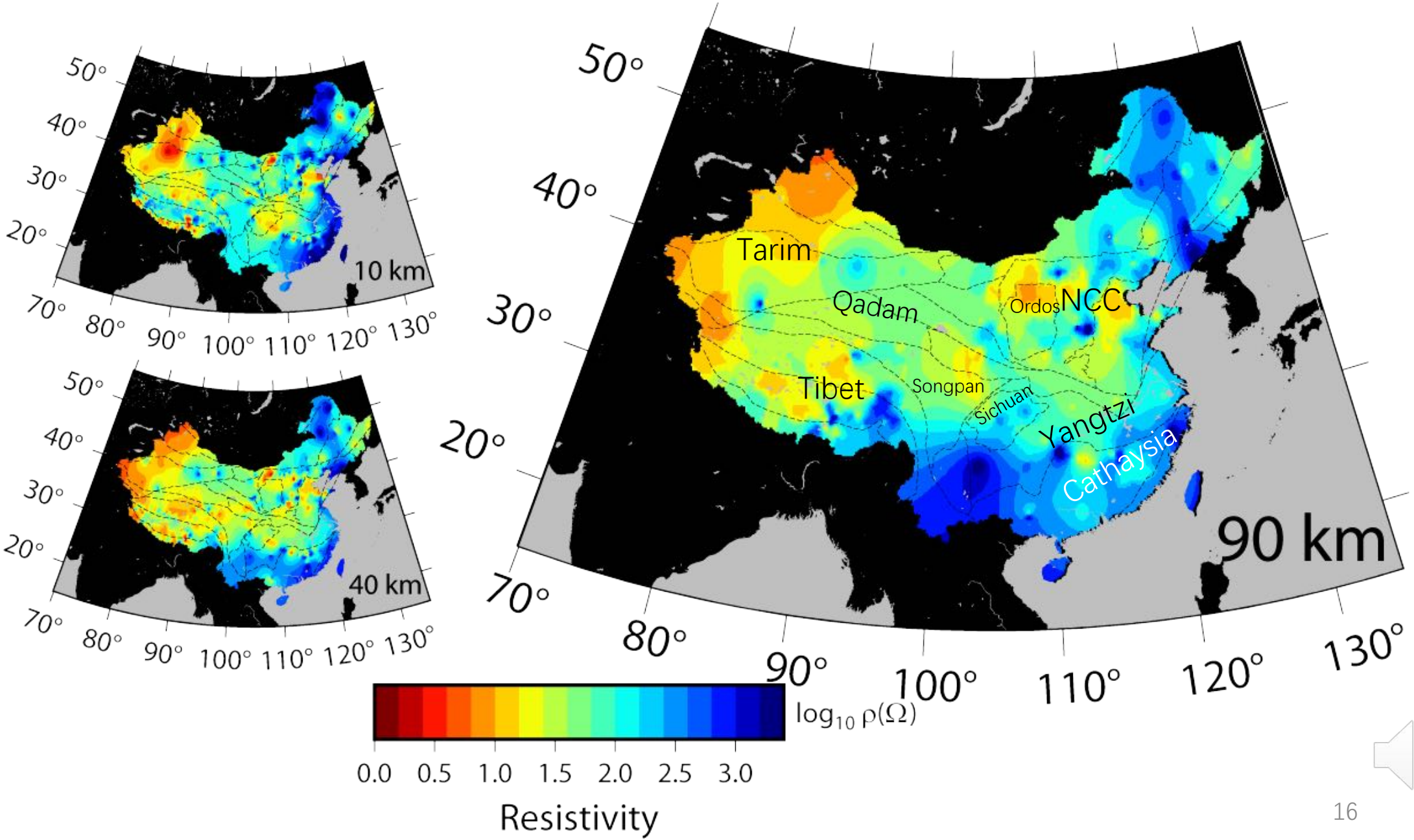
- Penetration map estimated from (Berdichevsky averaged imped) longest periods
- Essentially this tells you where structures are more conductive…
- >150km for most regions: structure for crust and uppermost mantle

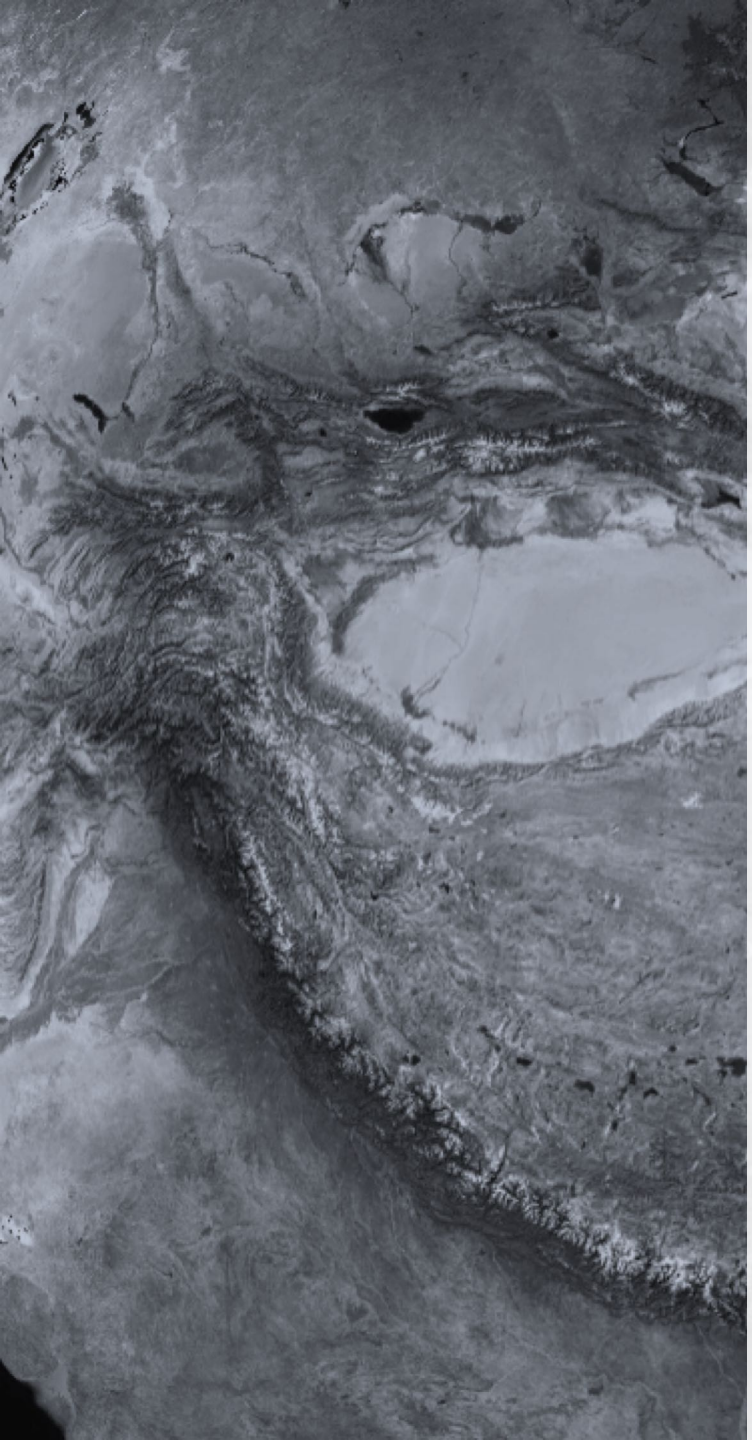


SINOPROBE MT: 1D structures



SINOPROBE MT: 1D structures





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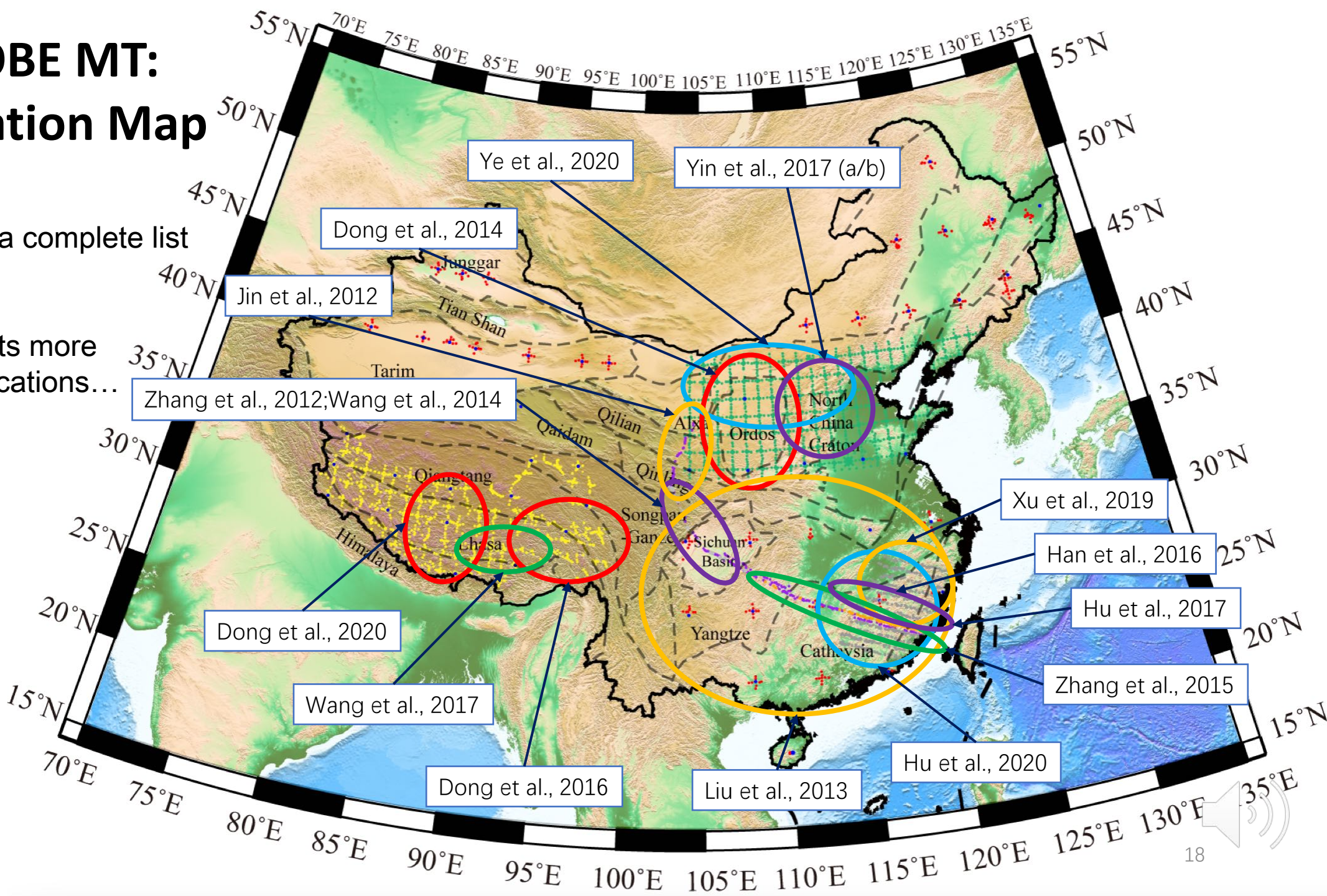
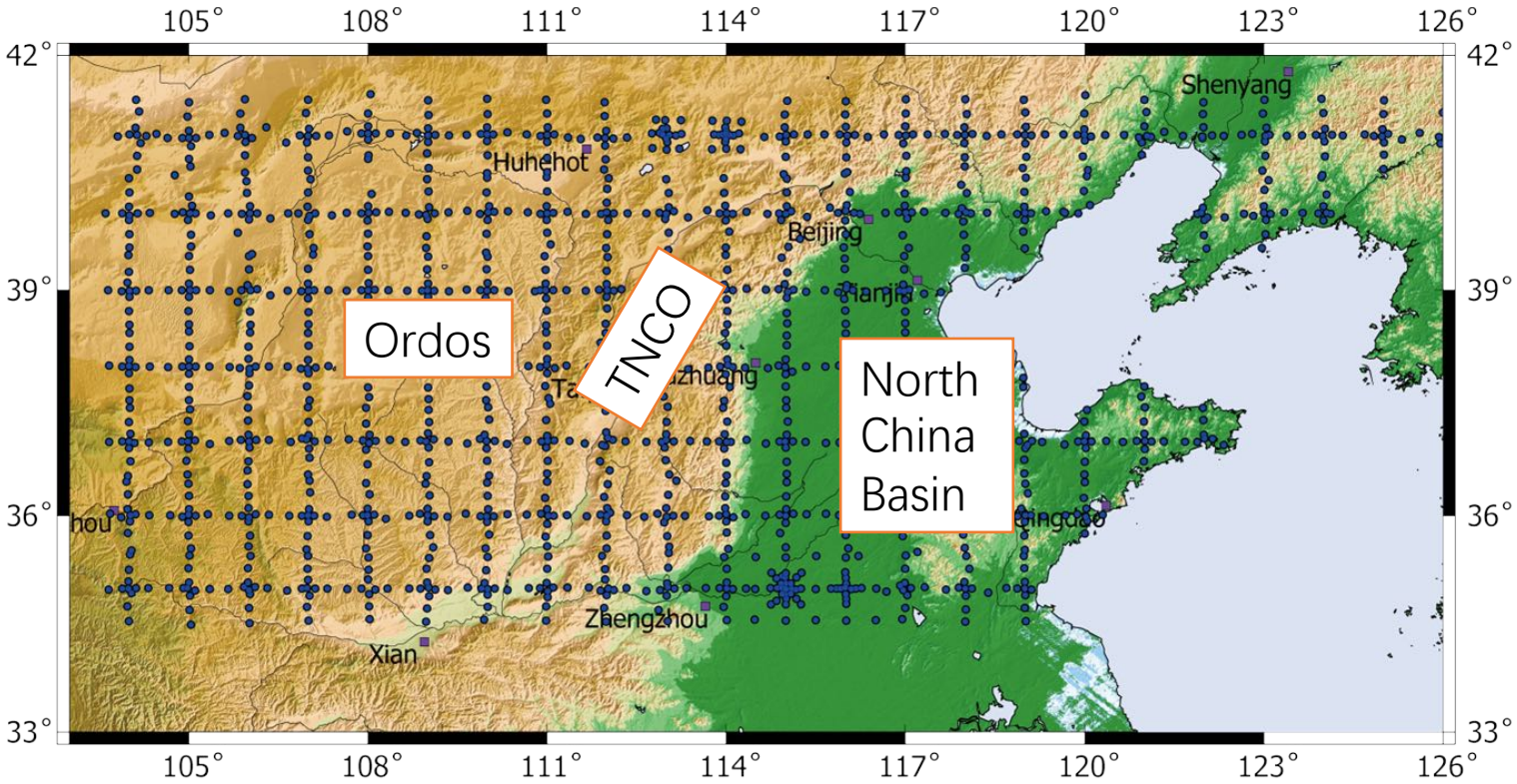
SINOPROBE MT: A publication Map

- Not (close to) a complete list
- Full list consists more than 100 publications…



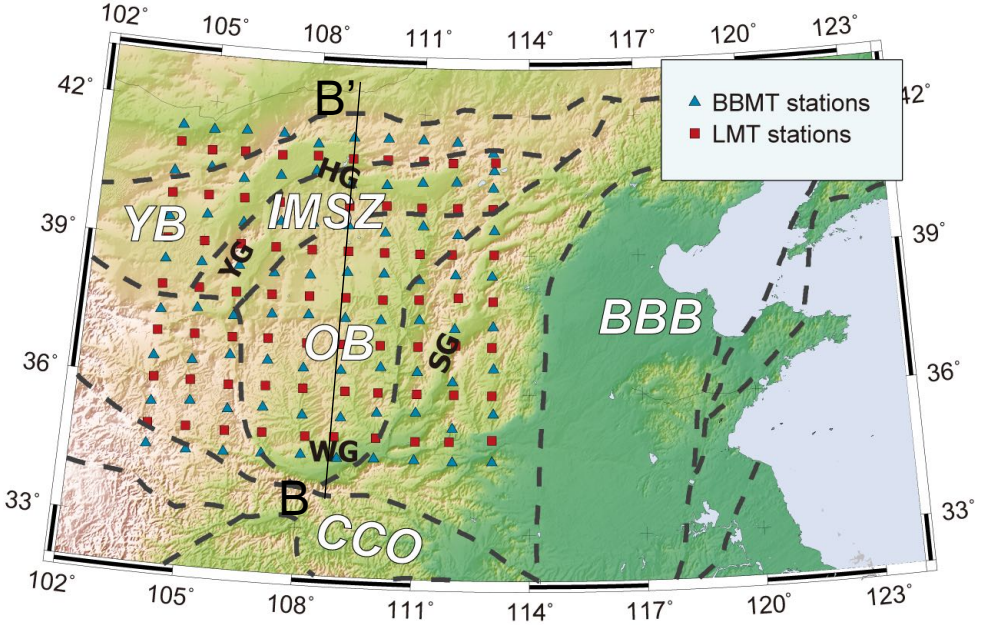
North China: Regional array

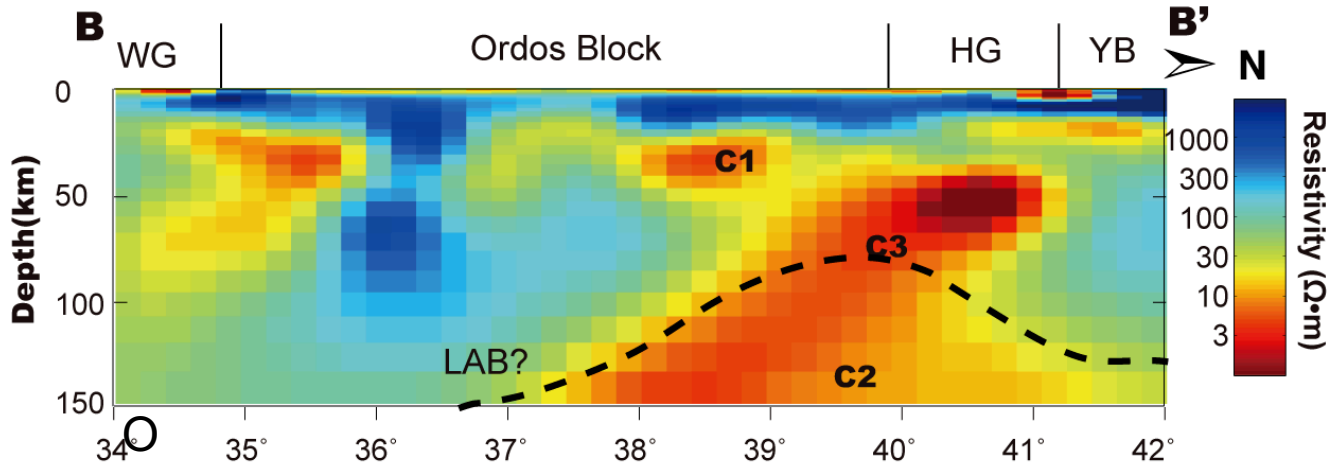
- MT data help understanding the lithospheric structure of the NCC
- MT helps locating the fossil suture/subduction zones and understanding the modification of lithosphere.

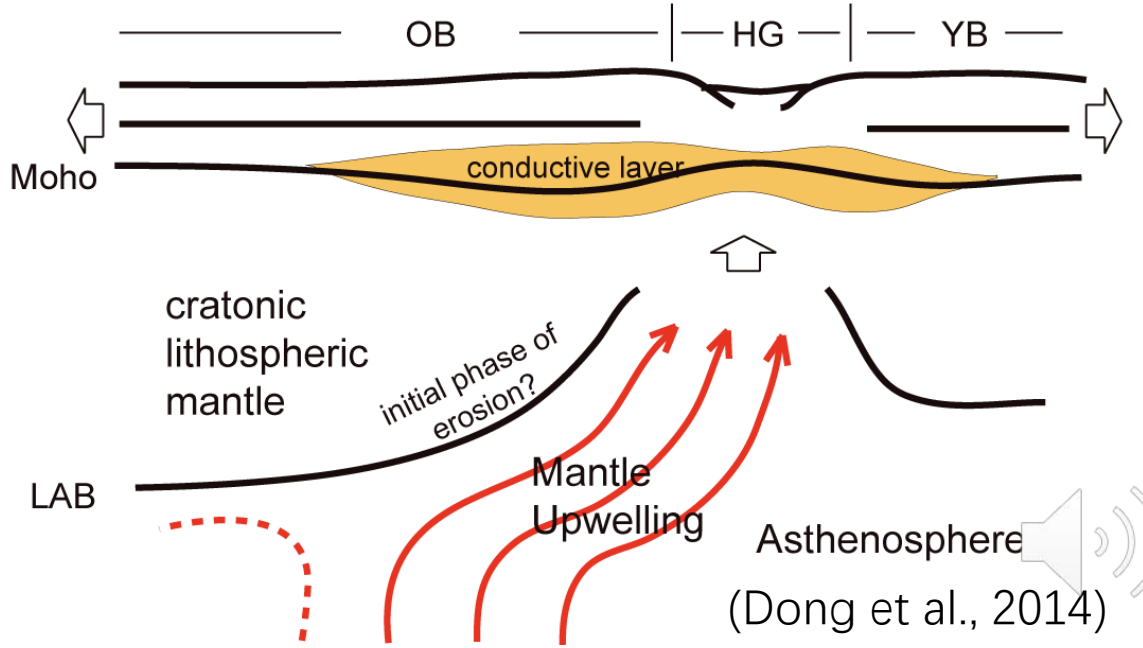


North China: Ordos

- Ordos: West block of NC “Craton”
- (considered) old and cold, retains a thick lithospheric root
- MT reveals large scale conductive structure in the north Ordos
- (Partially) modified lithosphere



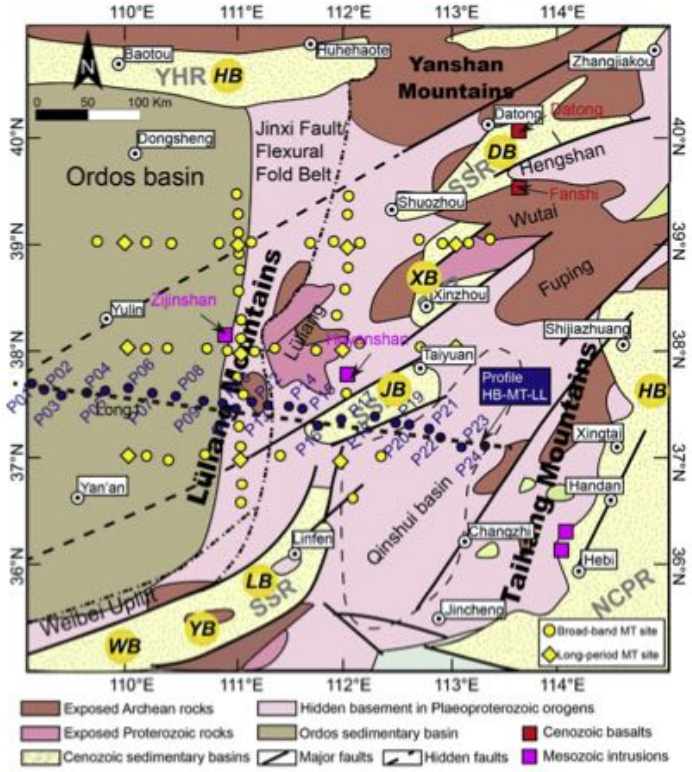


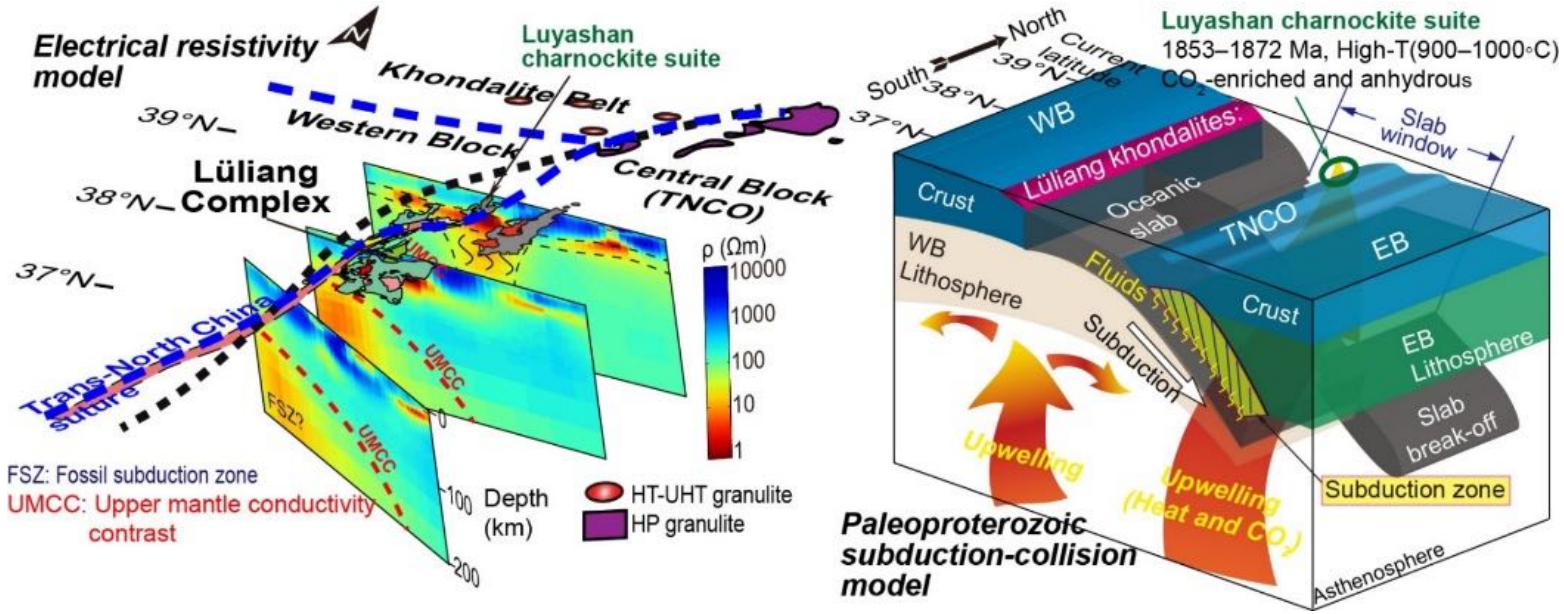


(Dong et al., 2014)

North China: Lüliang

- Lüliang: Orogenic belt between East and West NCC





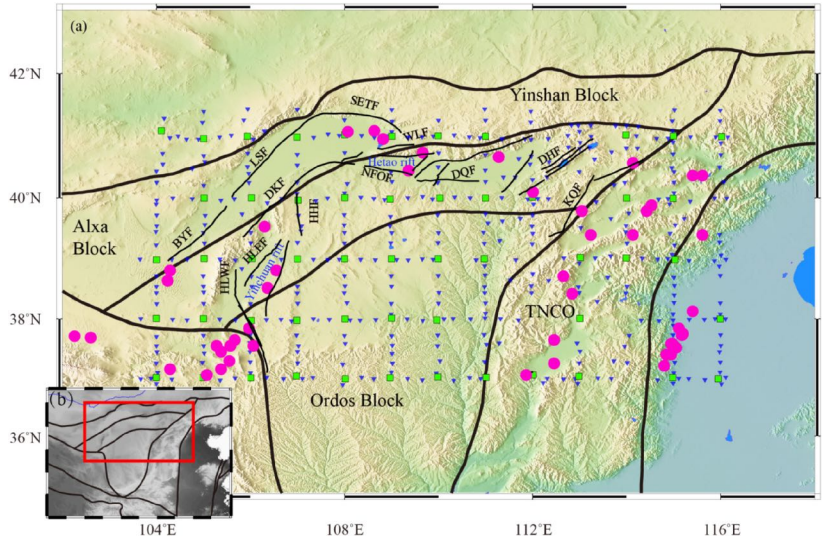
East-dipping lithospheric resistivity interface beneath the Lüliang Mts. Eastward subduction-collision events during the final Paleoproterozoic amalgamation between the central and western blocks of NCC

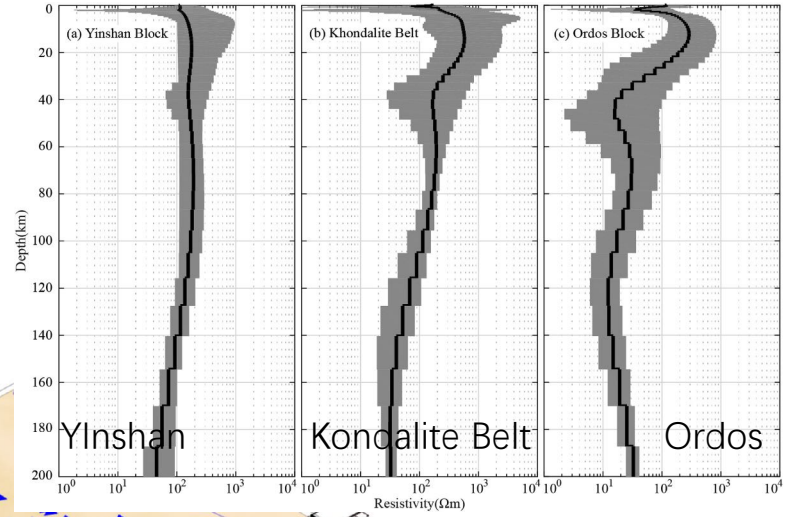
Yin et al., 2017, PR

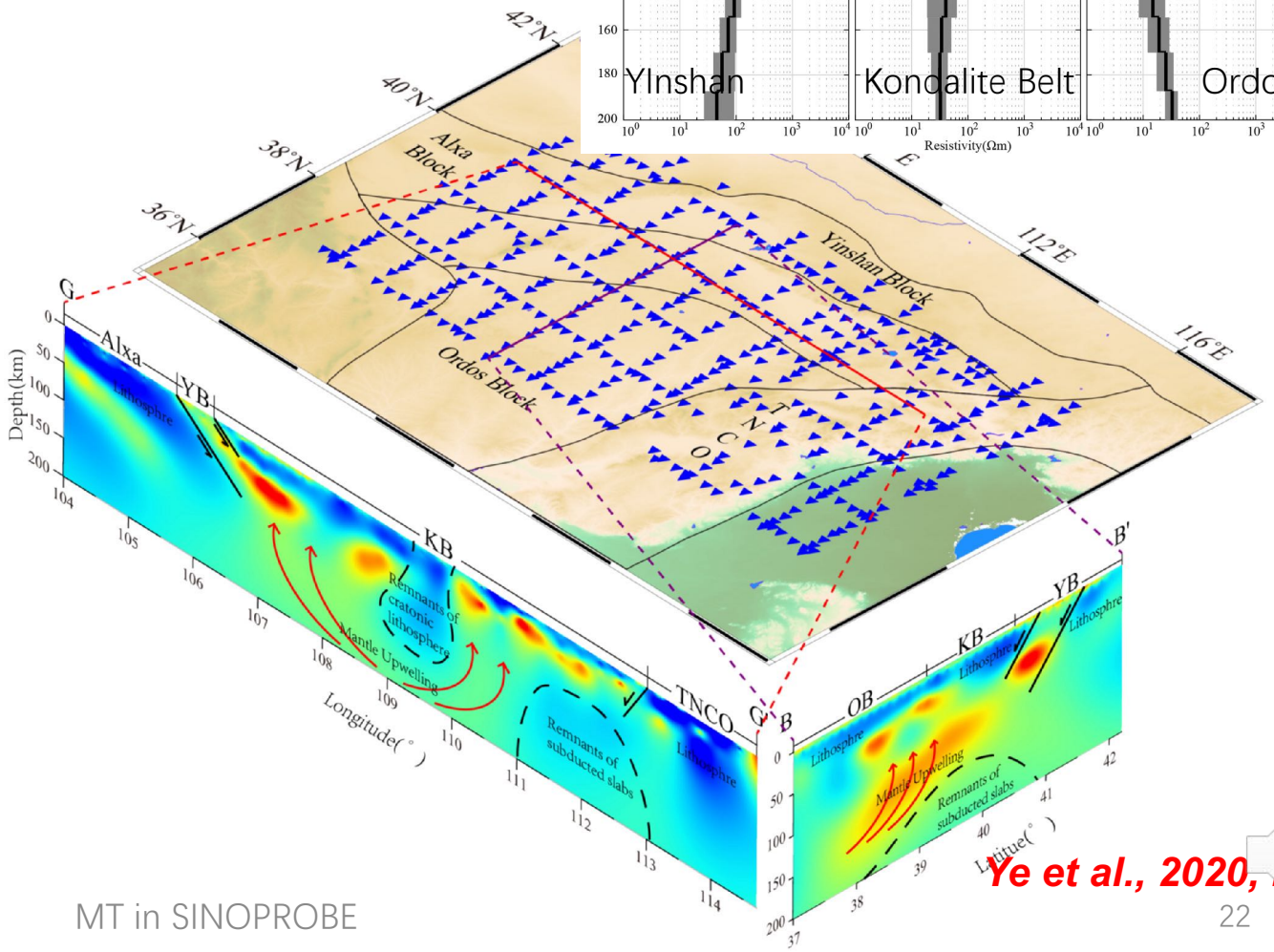
North China: Khondalite Belt

- Khondalite Belt: Orogenic belt between Ordos and Yinshan

- Key area for the modification of the West NCC
- Distinct resistivity structure for the Khondalite belt and the Yinshan block



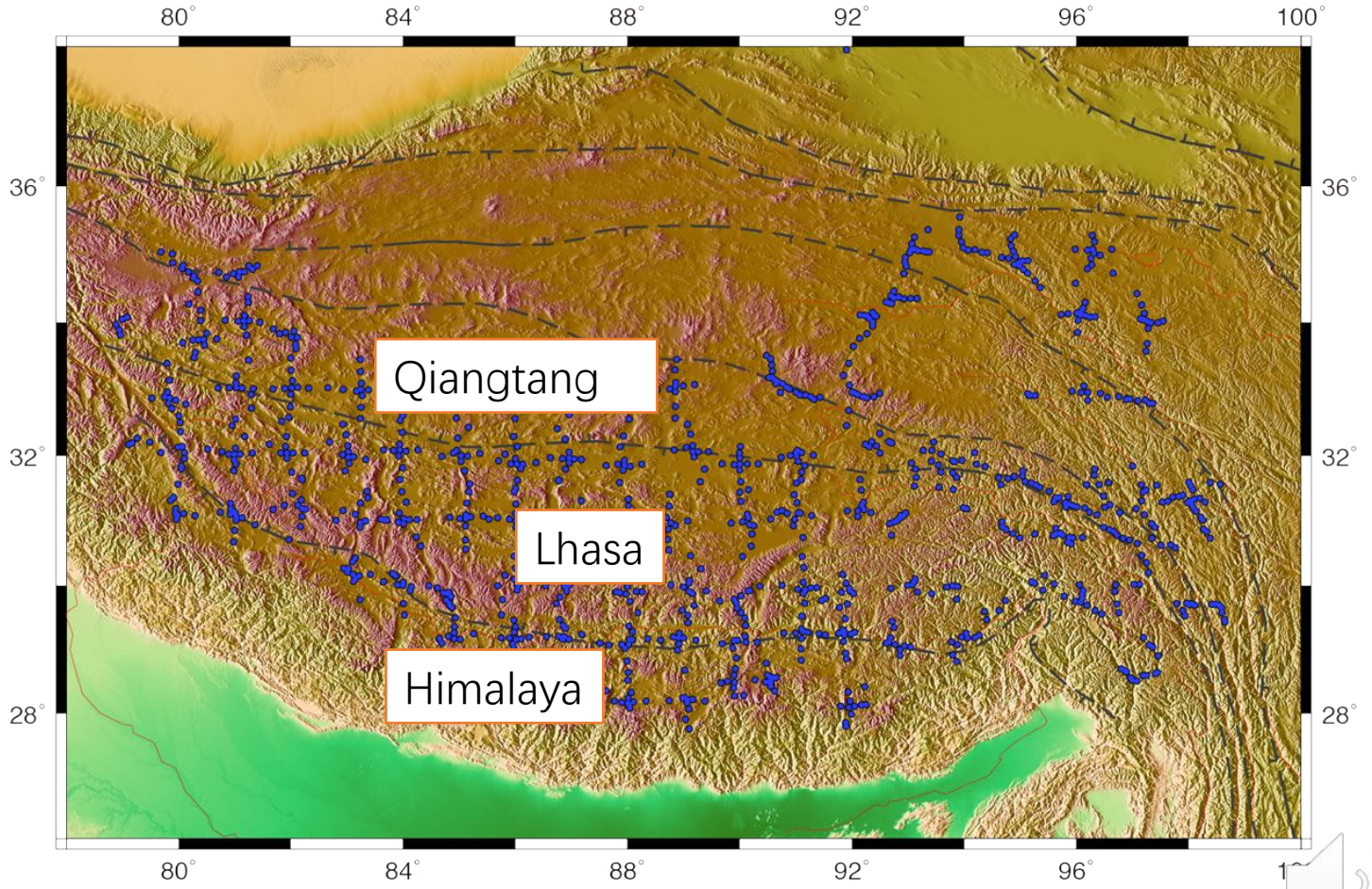




Ye et al., 2020, JGR

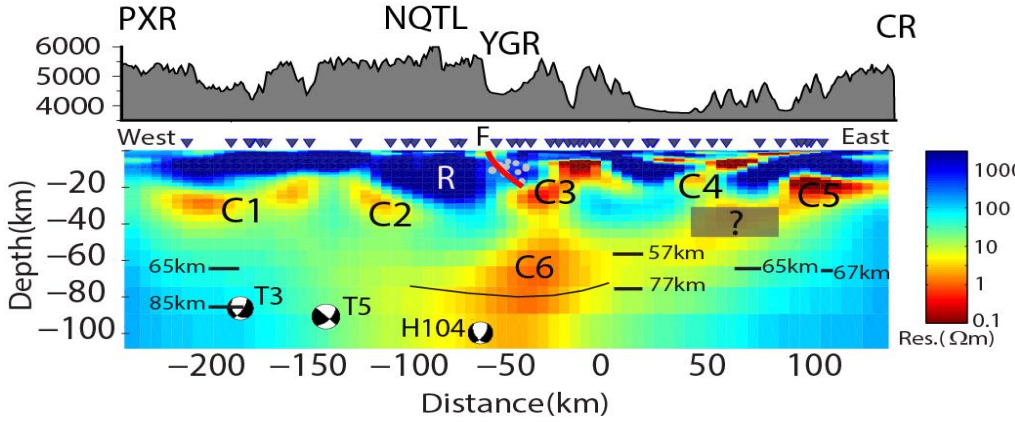
Tibetan Plateau: Regional array

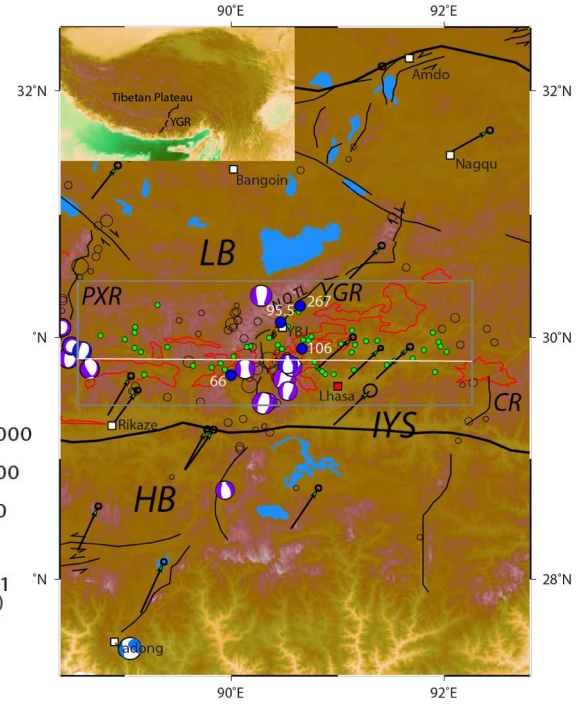
- MT data help understanding the viscosity structure of the Tibetan Plateau
- Resistivity models were also used to understand the formation of the surface structures of the plateau.

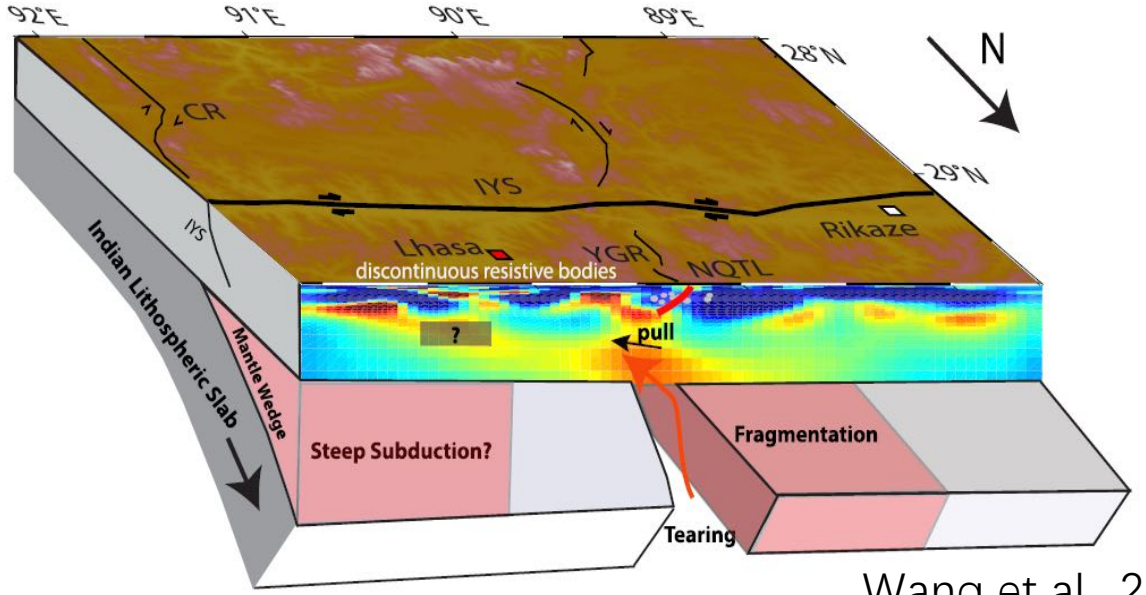


Tibetan Plateau: Yadong-Gulu Rift

- Yadong-Gulu Rift: one of the largest N-S rift in Tibetan Plateau
- The lower crust high conductive structures are not commonly observed beneath other rift/grabens;
- Support the “tear of Indian Plate model”



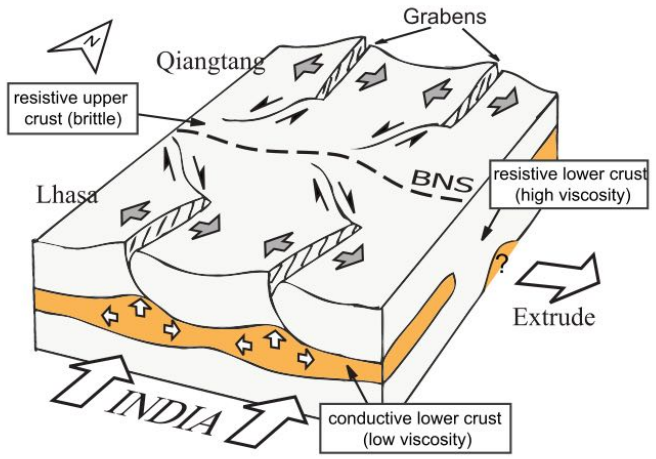


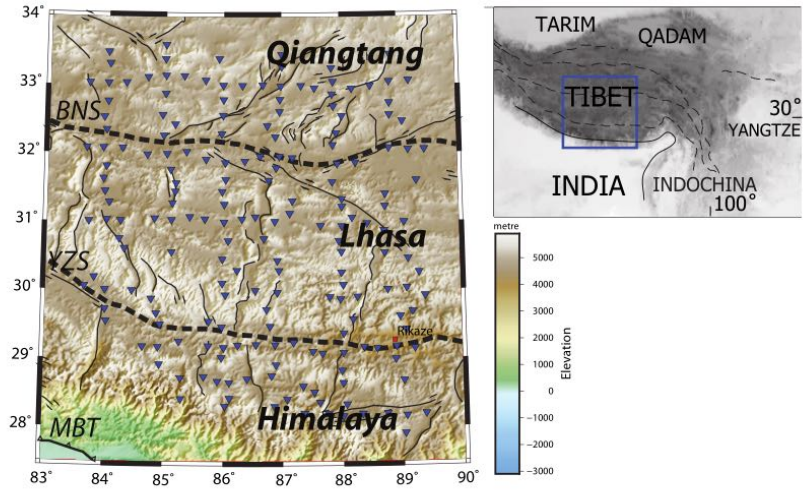


Wang et al., 2017, EPSL

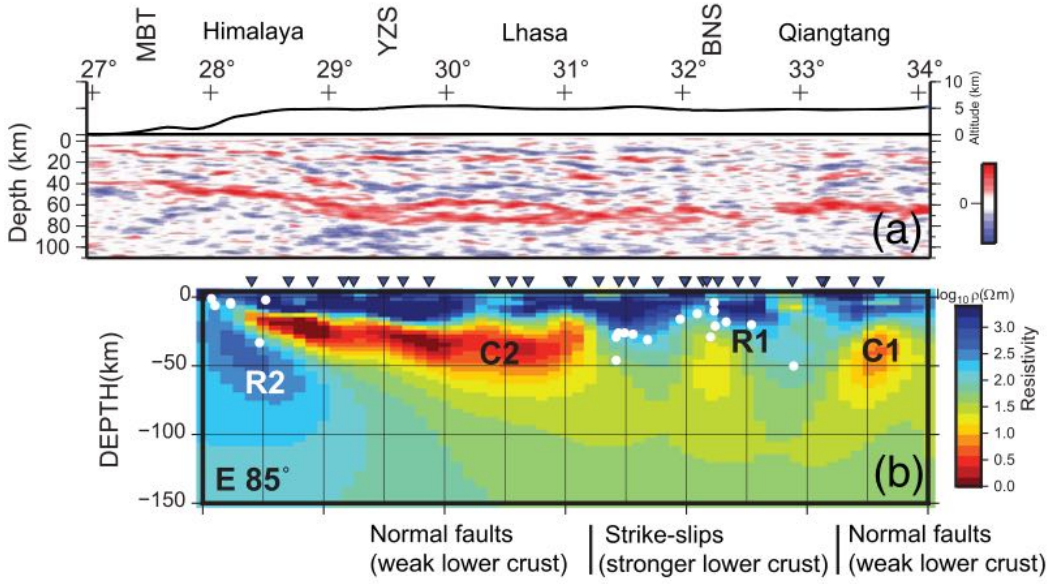
Tibetan Plateau: Surface deformation

- contrasting conductivity structures beneath to the graben and the strike-slip region
- Under the N-S stress background of the Indian-Eurasia collision the weak lower crust material may tend to expand
- E-W extension leads to the opening of the N-S grabens





Topographic map of centralTibet plateau superposed with major thrusts and suture zones. YSZ: Yarlung-Zampo Suture; BNS: Bankong-Nujiang Suture; MBT: Main Boundary Thrust

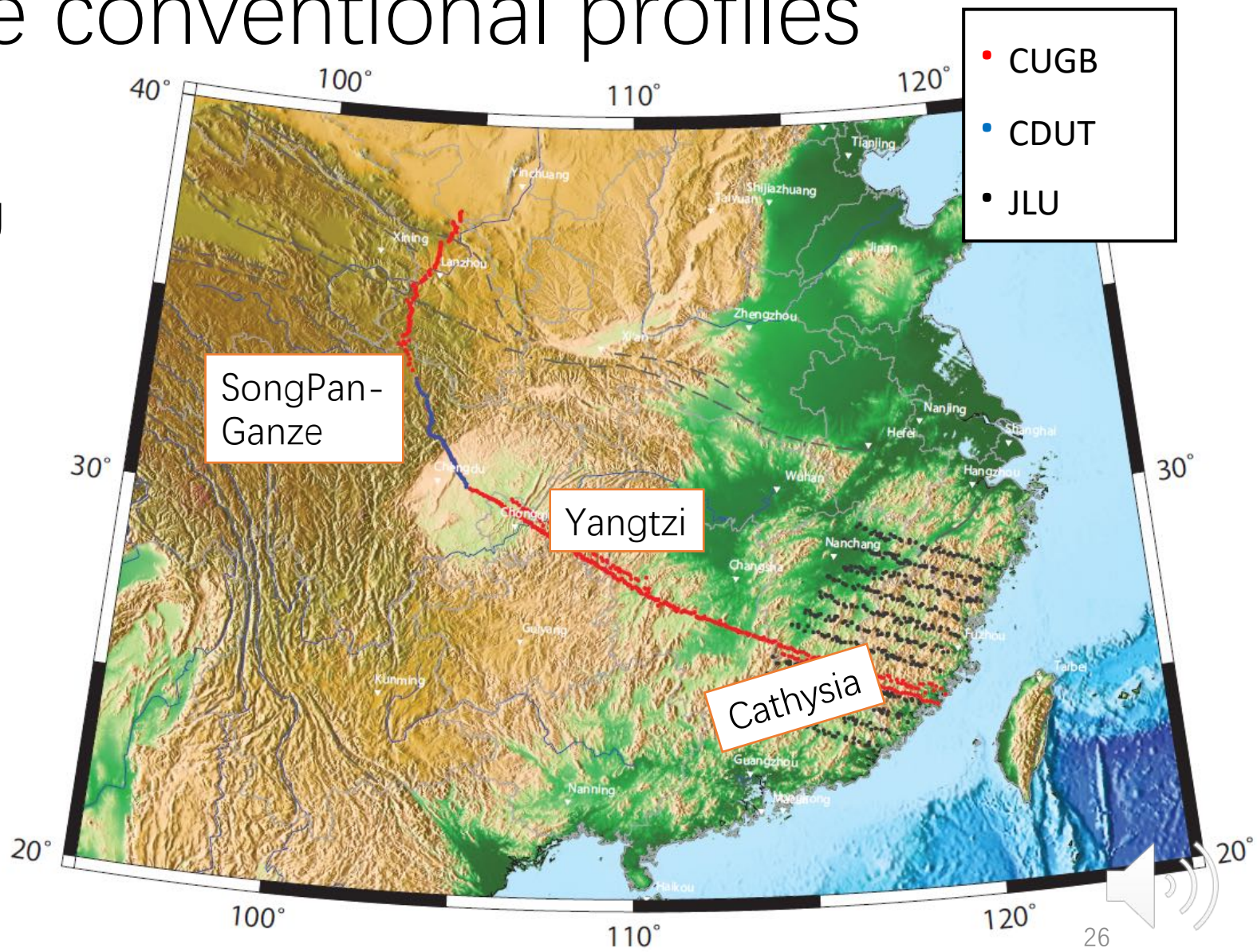


Dong et al., 2020, JGR

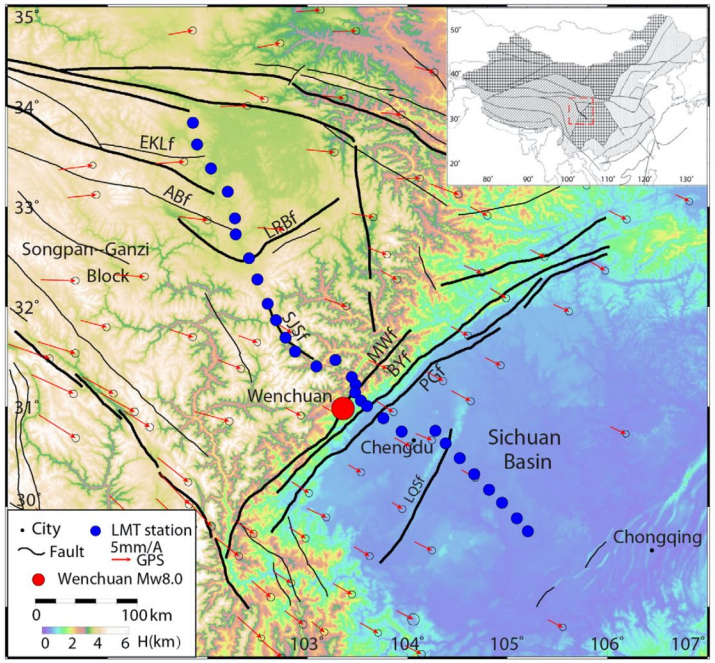
South China: the conventional profiles

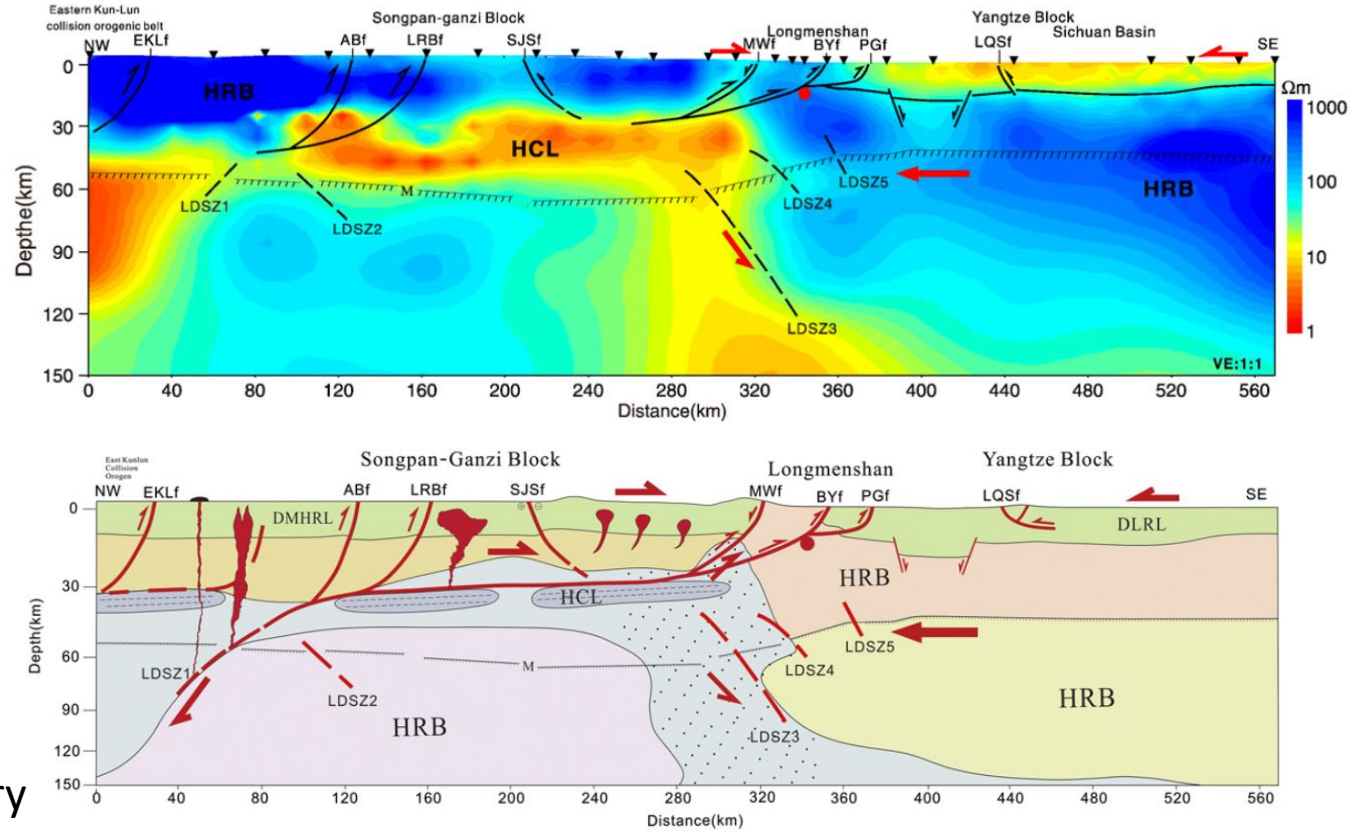
- MT data help understanding the lithospheric structure of several important tectonic blocks in South China

- MT images the thrust fault zone (Longmenshan) that induced the 2008 M8.0 Wenchuan earthquake



South China: Longmenshan Fault (2D)

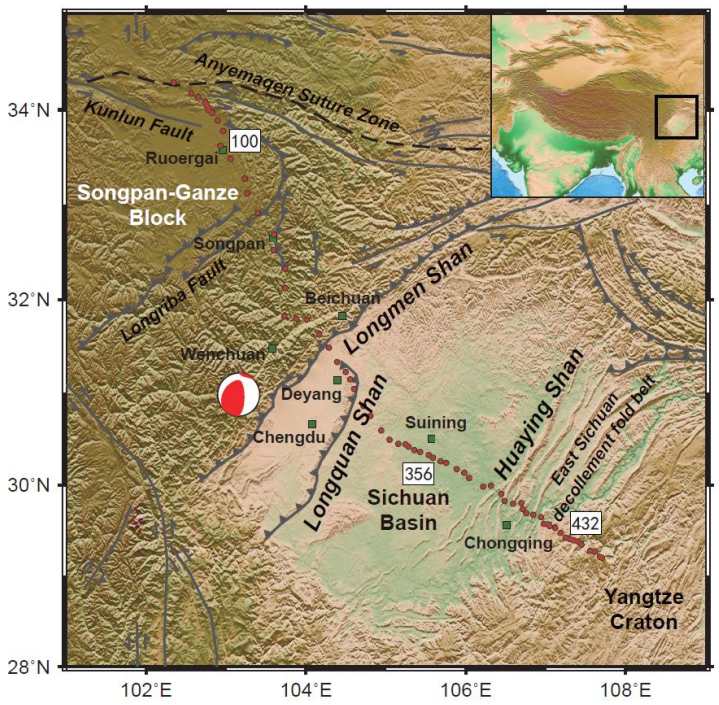


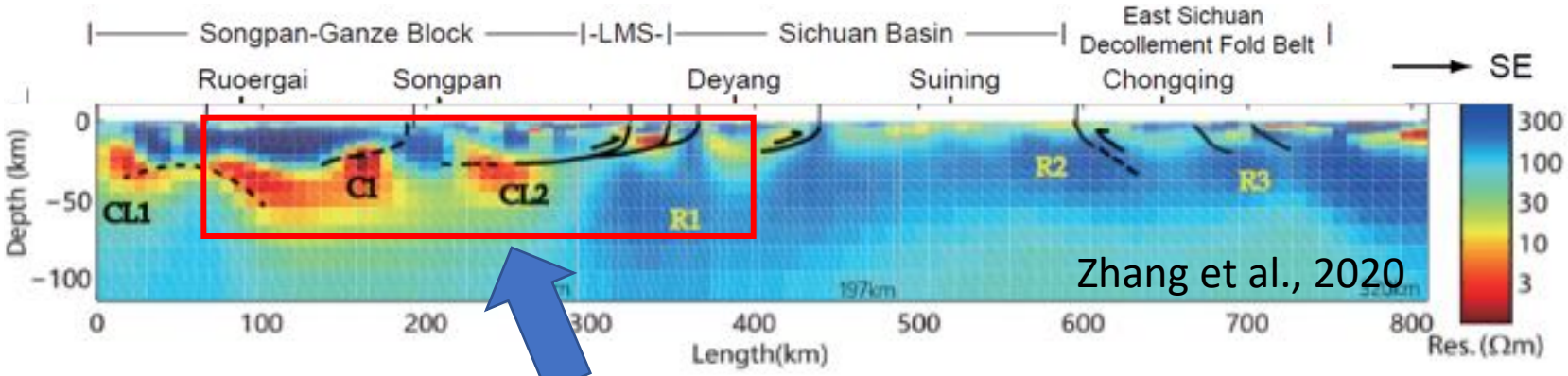


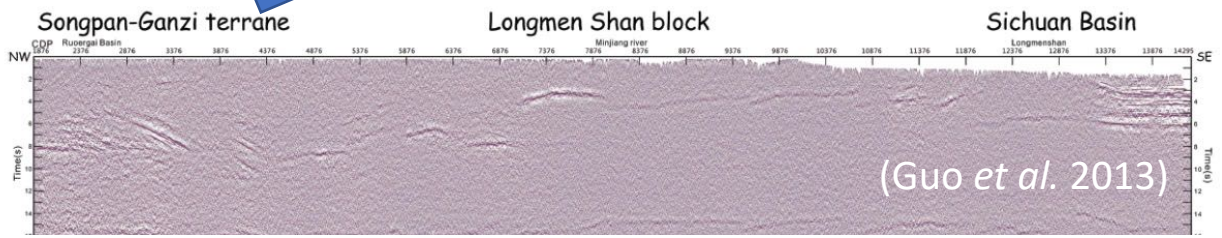
- The conductive layer beneath the Songpan–Ganzi may form a slip boundary
- Accumulation of thrust energy leads to the Wenchuan Earthquake

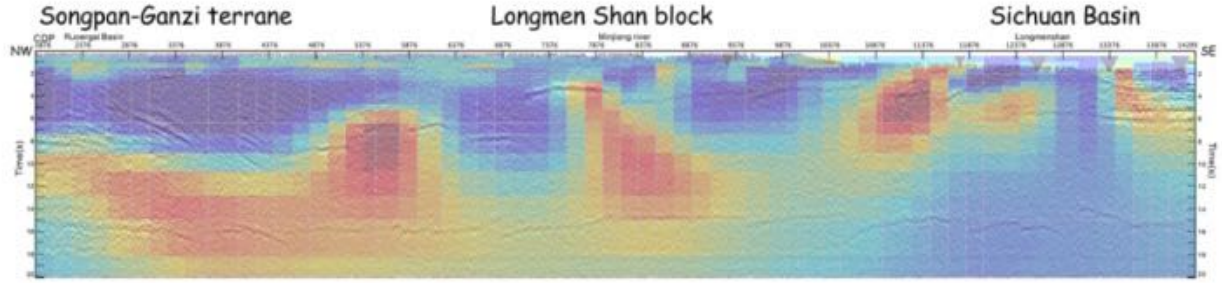
Wang et al., 2014 Tectonophysics

South China: Longmenshan Fault (3D)



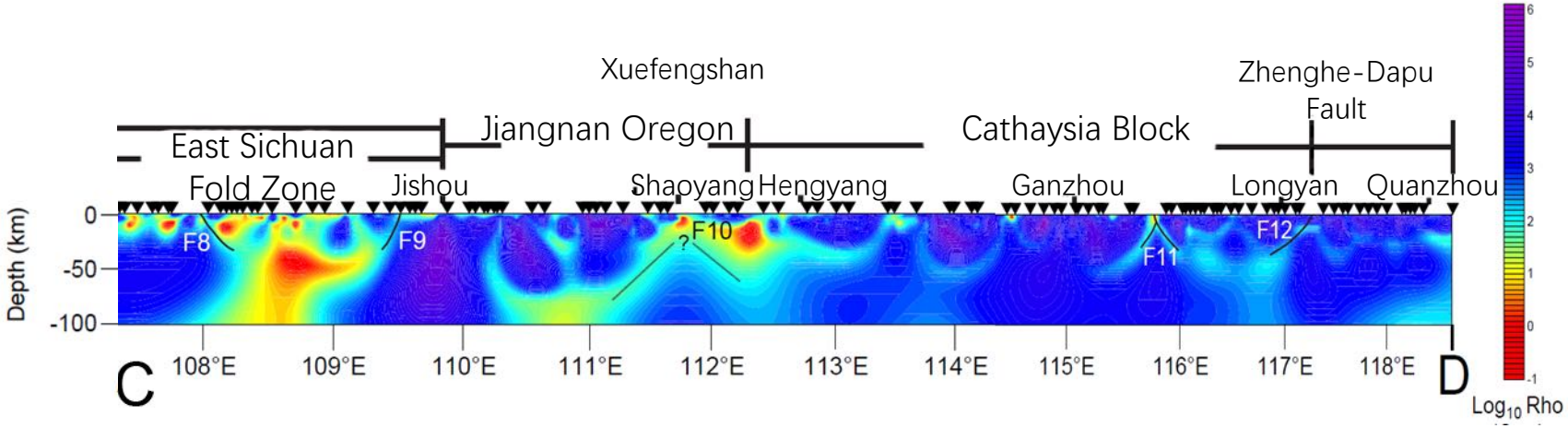


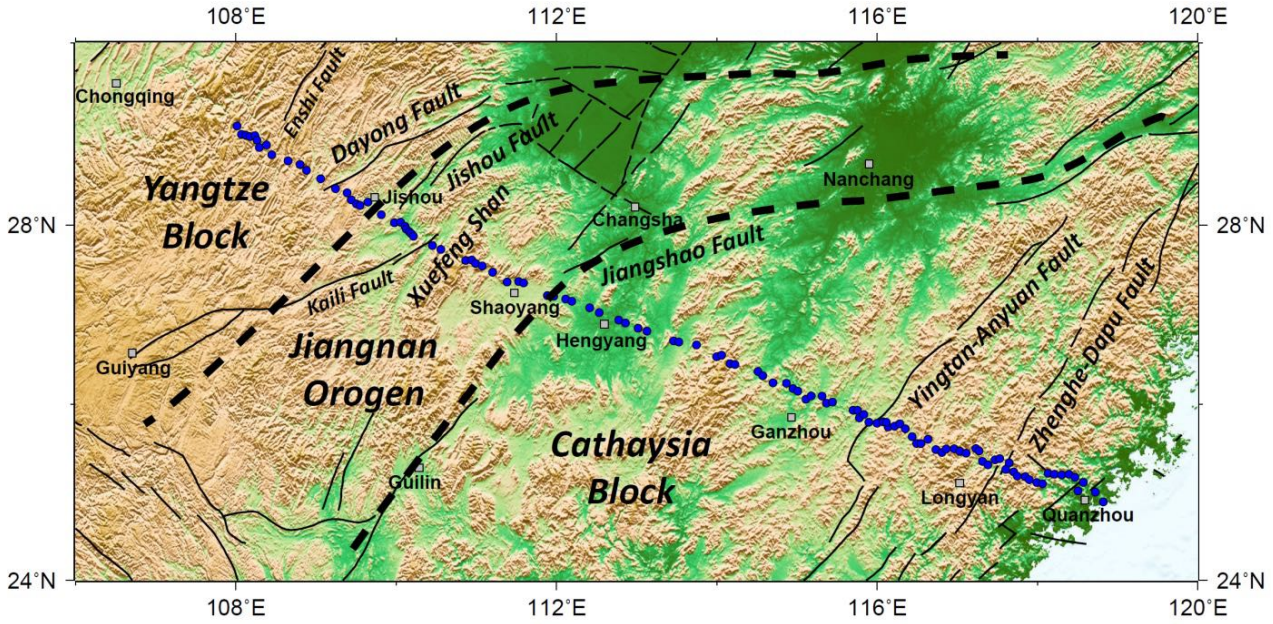




- The 3D model get a strikingly consistent structure as previous 2D results
- …without the steep conductors near LF

South China: Yangtze and Cathaysia



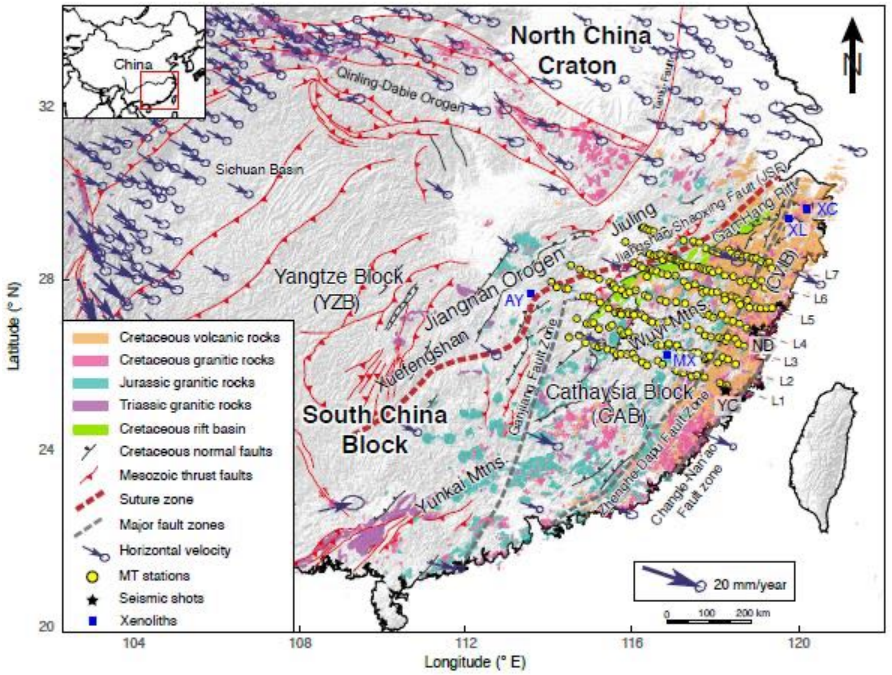


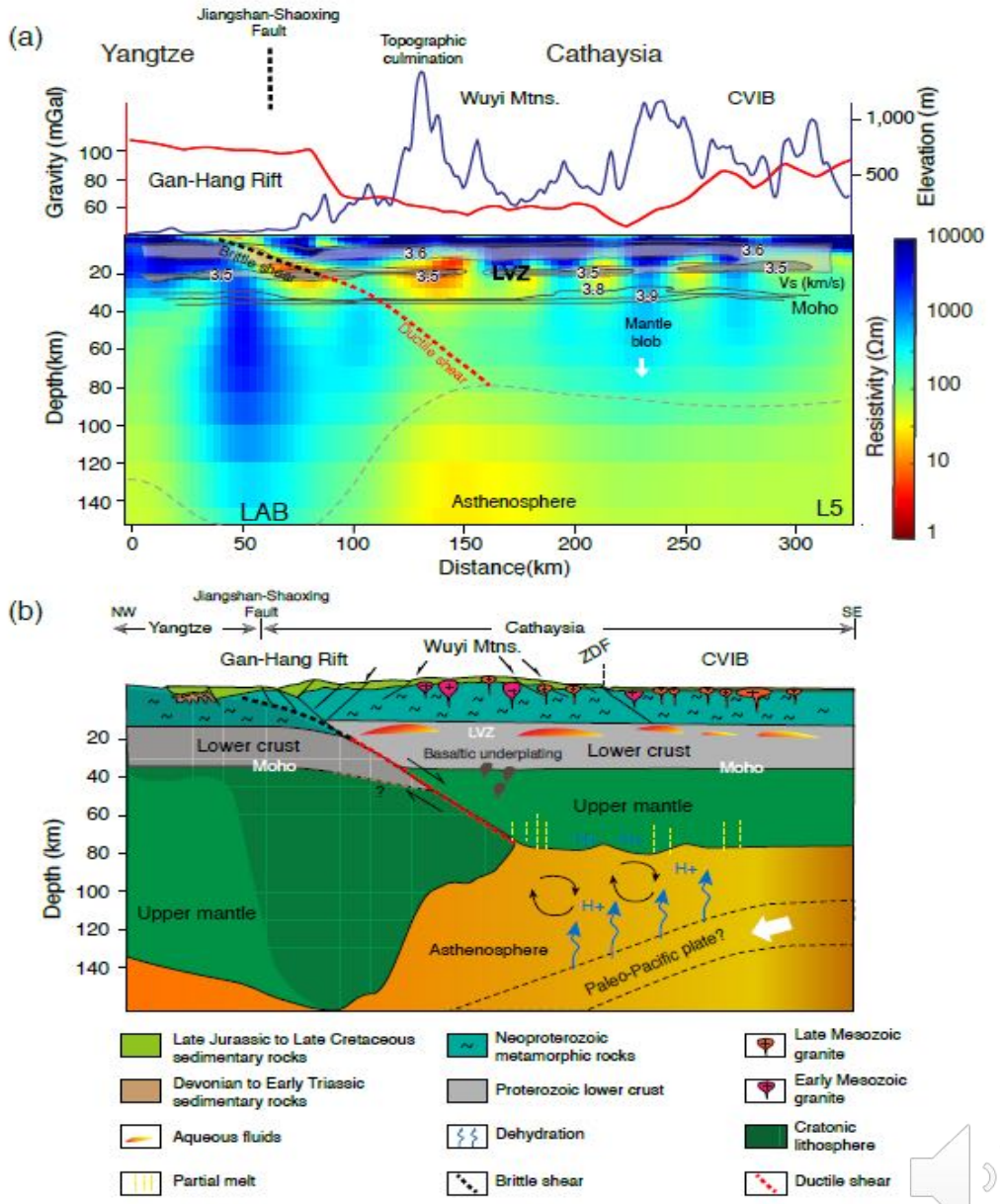
- Yangtze and Cathaysia: Join together by the Jiangnan Oregon to form the South China Block
- Low resistivity Zone beneath Jiangnan Oregon may reflect the subduction zone between the two blocks
- Cathaysia: resistive with ample volcanic activities – conductive magma channels?

Zhang et al., 2017, JAES

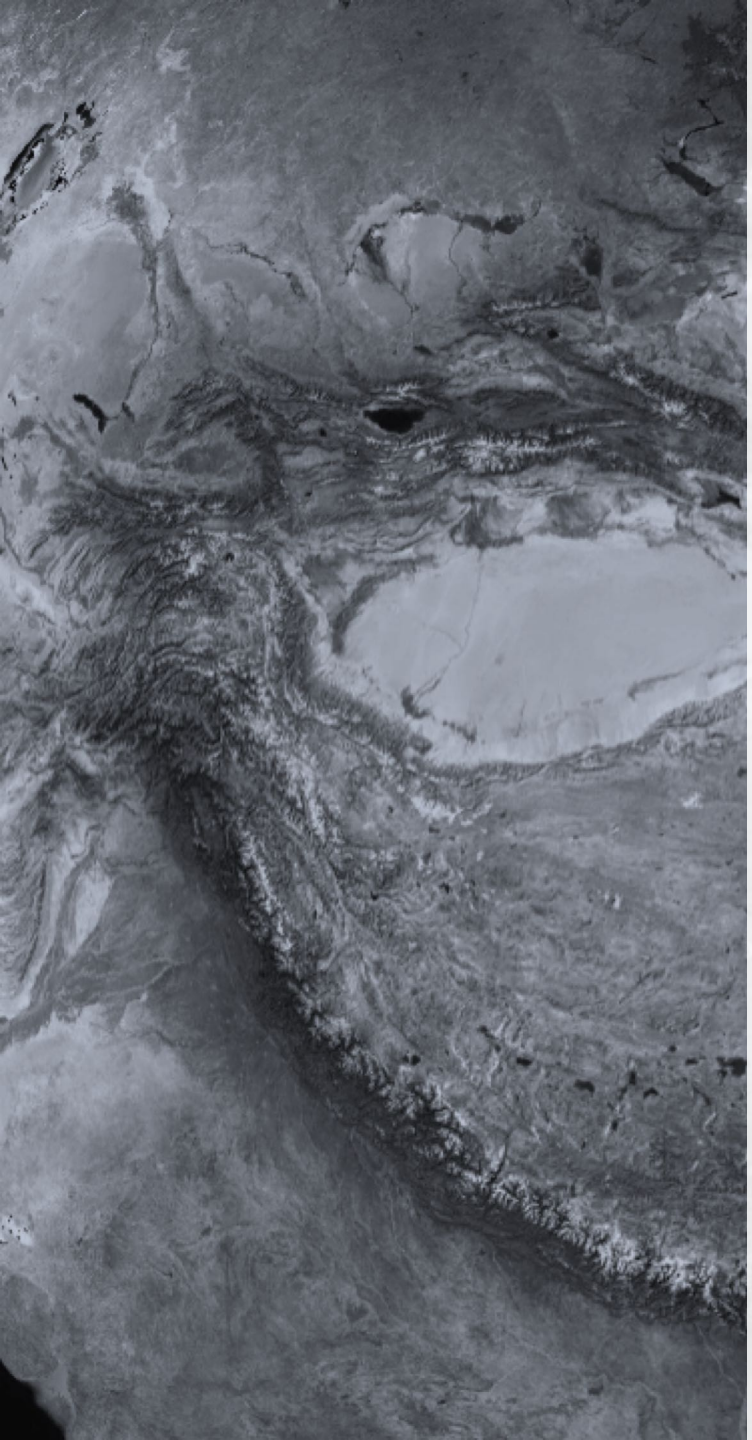
South China: Cathaysia

- MT resistivity model provides insights into the interaction of a fossil suture zone
- High conductivity anomaly associated with the hydration process related to P-Pacific Plate





Xu et al., 2019, JGR



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Conclusions

- The project has provided an electromagnetic array dataset that covers the continental China with unprecedented density and resolution.
- Though with limitations, the dataset has encouraged many a new insight into the important tectonic and dynamic discussions in China.
- Still need to think about the modelling strategy for a unified resistivity model for the lithosphere.

Lessons learned (in the 2008-2013 mission)

Need standardized QC and processing procedure

future data may be coming from more institutions and possibly more diverse instrumentations.

Need (standard) open-source Time series and Transfer function formats

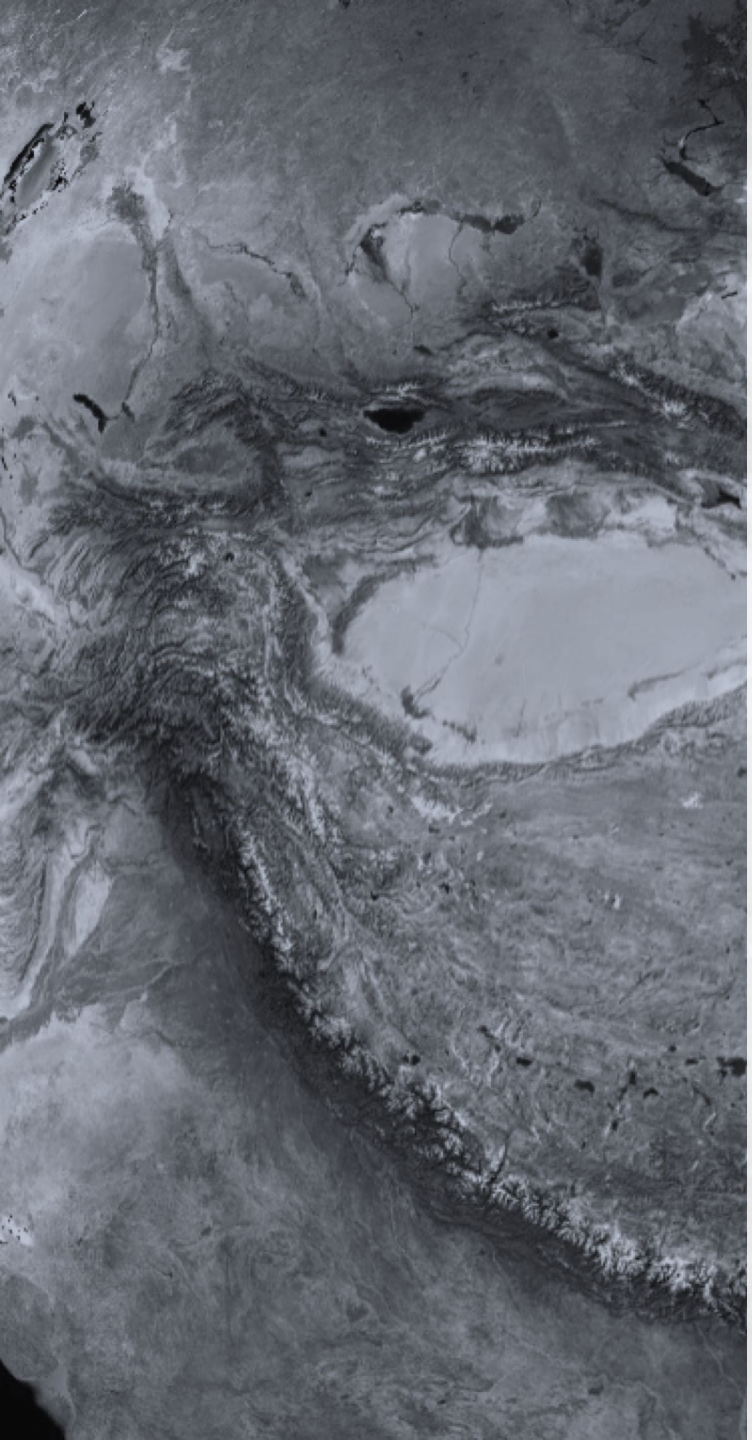
we would like to work together with the community on that…

Need the USArray Backbone-style stations

(reads: money)

Need more coverage and acquisition time for long period stations

(reads: more money)



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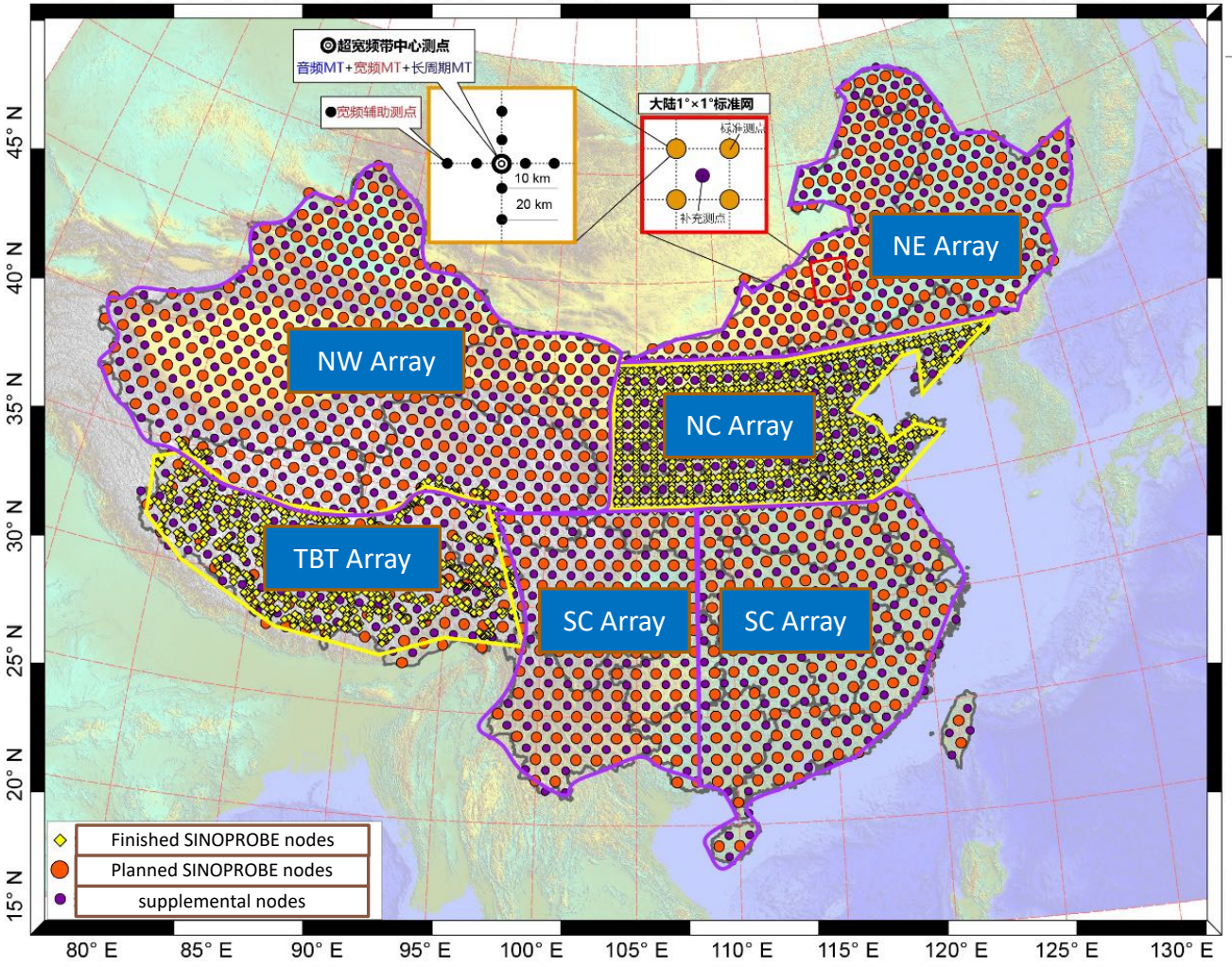
(Warning for Tropophobia)

Following-up projects



- 6000(!) more BBMT and LMT stations planed
- the 1 by 1 degree array is supposed to be extended…
- Supplement Nodes: Filling the ”gaps” with LMT stations
- New Ultra-LMT stations at previous 4 by 4 nodes.

Following-up projects

- **However, as the global pandemic of COVID-19 expands, we might have to further postpone the second phase of SINOPROBE…**
- **Still, we may be able to get past the sun activity low and get better data…**

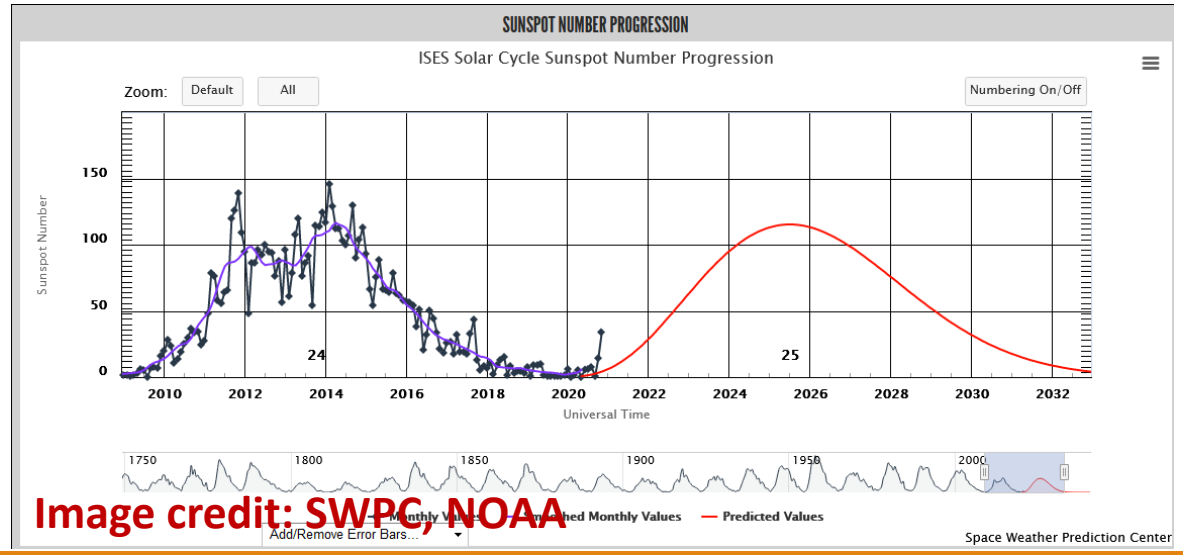


Image credit: SWPC, NOAA

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…and thank you for your attention!

Feel free to send comments/questions to donghao@cugb.edu.cn
Those regarding data sharing/collaborations should go to jinsheng@cugb.edu.cn