Lateral Variation of Crustal Structure Beneath a Stable Craton: Seismic Evidence from Ordos, China

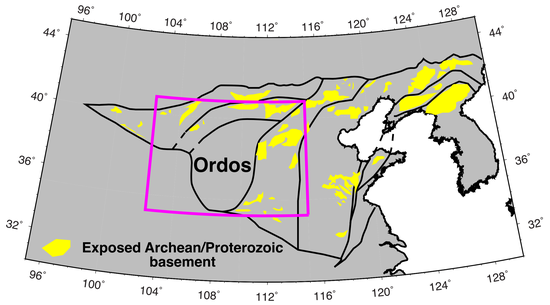
T11B-2893

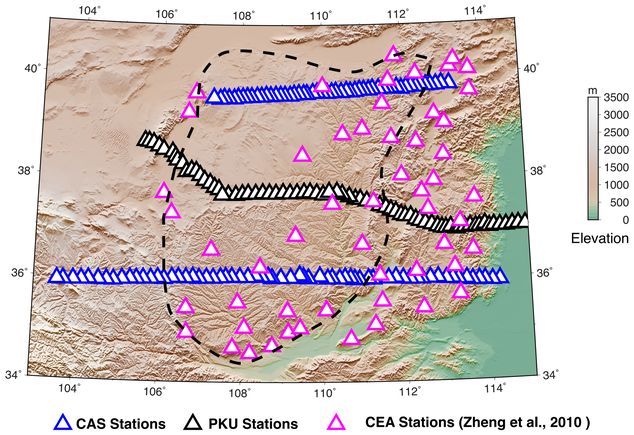
Tianze Liu (tianze@stanford.edu)[1], Chunquan Yu[2], Simon L. Klemperer[1], Jieyuan Ning[3]

1. Department of Geophysics, Stanford University 2. Department of Earth, Atmospheric and Planetary Sciences, Massachusetts Institute of Technology 3. School of Earth and Space Sciences, Peking University

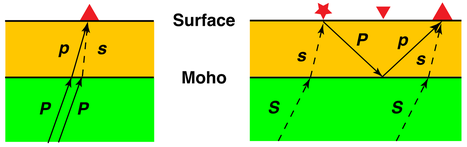
1. Ordos: the Mysterious Basement

- Ordos has Archean/Proterozoic basement covered with thick Phanerozoic sediment.
- Ordos has thick lithosphere (~200km) and very low seismicity.
- **Recent studies have proposed uniform crustal thickness of ~40km (Wang et al., 2012) or nonuniform crustal thickness locally up to ~60km (Yu et al., 2012) in Ordos.**
- **Does possible lateral variation reflect amalgamation of Precambrian blocks or Phanerozoic modification?**



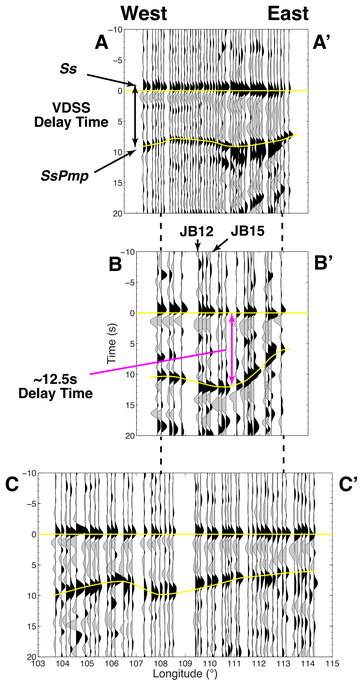


2. Method: RF & VDSS

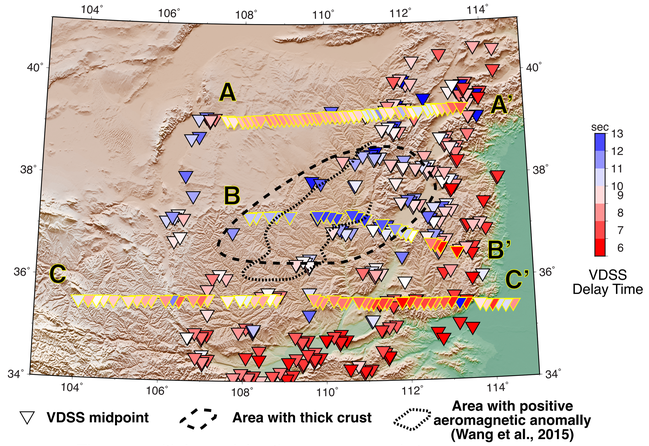


- Receiver Function (RF) imaging uses teleseismic *Ps* conversions at the Moho.
- Virtual Deep Seismic Sounding (VDSS) uses teleseismic *Ss* conversions at the free Surface ("Virtual Source"), which gets reflected from the Moho as *SsPmp*.
- We use high amplitude post-critical *SsPmp* so stacking multiple records is unnecessary.

3. VDSS Observations: Large Lateral Variation in Crustal Thickness

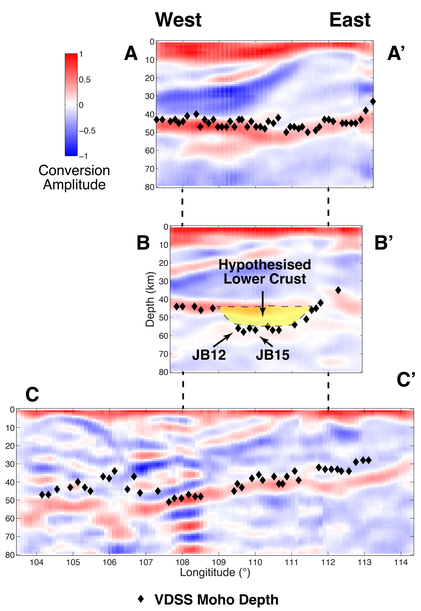


- Yu et al. 2012 showed VDSS delay times up to 12.5s on BB', corresponding to crustal thickness of ~60km.
- **We used more data to constrain the lateral variation and found that Only east-central Ordos has VDSS delay times >10s.**

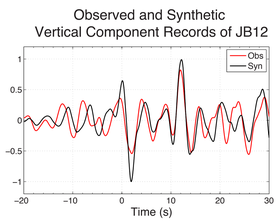


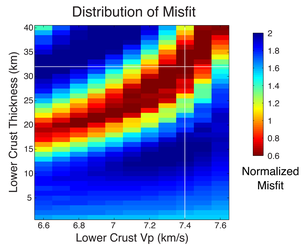
- The area with large delay times corresponds to a positive aeromagnetic anomaly (Wang et al., 2015) and is hypothesised to be the Archean core of Ordos.
- The rest of Ordos with typically delay times <10s could have Proterozoic basement.

4. RF Observations: Uniform Crustal Thickness



- Yu et al., 2012 reconciled VDSS observations (thick crust) and RF CCP image (thin crust) on BB' by assuming a lower crust between the two Mohos with Vp=7.x km/s.
- **We compared VDSS observations with RF CCP images along AA', BB' and CC'.**
- **Along AA' and CC', as well as west of 109ºE on BB', the VDSS Moho agrees with RF Moho.**
- **We modeled VDSS waveform of JB12 with a two-layer crust model:**





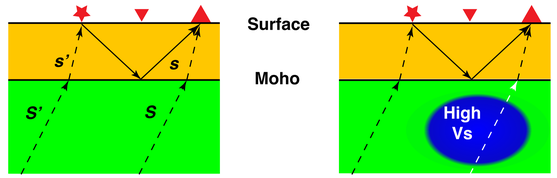
Best-fit Model Parameters (Red ones are varied in the grid-search)

	Vp (km/s)	Thickness (km)	Poisson's Ratio	Density (g/cm³)
Upper Crust	6.3	40	0.27	2.6
Lower Crust	7.4	32	0.25	3.0
Mantle	8.1	-	0.25	3.3

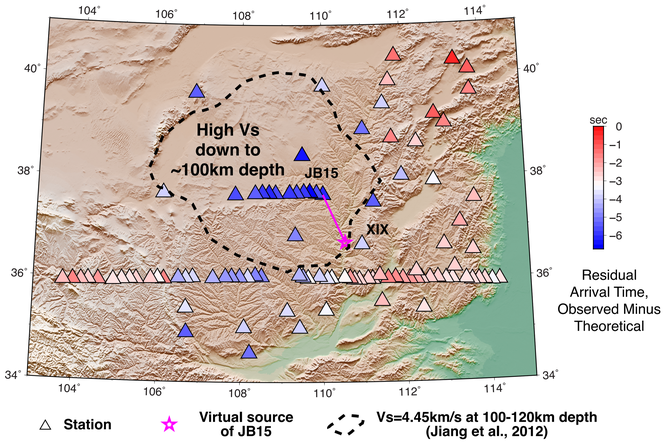
- The distribution of misfit shows strong trade-off between thickness and Vp of the lower crust.

5. Alternative: Uniform Crust, Nonuniform Mantle

- Previously we have assumed 1D velocity structure beneath the Moho.
- **However virtual sources and receivers are far apart (~120km) due to post-critical reflection, so that mantle velocity along *S's'* and *Ss* could be different.**



- Higher Vs in the mantle beneath the receiver will cause an increase in delay time of *S's'Pmp* and therefore an overestimation of crustal thickness.



- Stations with large negative residual arrival time fall in the area where tomography results show high Vs at large depth (Jiang et al., 2012)
- The virtual source of station JB15 with residual arrival time -6.25s is located close to station XIX that has residual time -4.00s.
- **The 2.25s difference between the two stations could account for most, if not all, of the thick crust observed at JB15.**

Conclusion

We don't know whether the large lateral variation of VDSS observations in Ordos arises from heterogeneity in the crust or upper mantle.

Acknowledgements

The study is funded by a Stanford Graduate Fellowship. The PKU array is funded by China NSF Grant 90814002. Waveform data of CEA stations is provided by Data Management Center of China National Seismic Network at Institute of Geophysics, China Earthquake Administration.We thank Tianyu Zheng for her valuable advices. We also thank all the people who have devoted effort to the PKU North China Project.

References

Jiang, M., Ai, Y., Chen, L., & Yang, Y. (2013). Local modification of the lithosphere beneath the central and western North China Craton: 3-D constraints from Rayleigh wave tomography. Gondwana Research, 24(3), 849-864.

Wang, C. Y., Sandvol, E., Zhu, L., Lou, H., Yao, Z., & Luo, X. (2014). Lateral variation of crustal structure in the Ordos block and surrounding regions, North China, and its tectonic implications. Earth and Planetary Science Letters, 387, 198-211.

Wang, Z., Zhou, H., Wang, X., & Jing, X. (2015). Characteristics of the crystalline basement beneath the Ordos Basin: Constraint from aeromagnetic data. Geoscience Frontiers, 6(3), 465-475.

Yu, C. Q., Chen, W. P., Ning, J. Y., Tao, K., Tseng, T. L., Fang, X. D., Chen Y. J., & van der Hilst, R. D. (2012). Thick crust beneath the Ordos plateau: Implications for instability of the North China craton. Earth and Planetary Science Letters, 357, 366-375.

Zheng, X. F., Yao, Z. X., Liang, J. H., & Zheng, J. (2010). The role played and opportunities provided by IGP DMC of China National Seismic Network in Wenchuan earthquake disaster relief and researches. Bulletin of the Seismological Society of America, 100(5B), 2866-2872.