An Iterative Travel Time Inversion and Waveform Modeling Method to Determine the Crust Structure and Focal Mechanism: Case Study of 2015 Alxa Left Banner M_s5.8 Earthquake

Chao Song[1], Zengxi Ge[1]

1. Institute of Theoretical and Applied Geophysics, School of Earth and Space Sciences, Peking University, Beijing 100871, China

E-mail: chsong@pku.edu.cn **Birth Date: 06/08/1993**

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ABSTRACT

The boundary region between Alxa Block and Ordos Block is an area of stress concentration with strong seismicity and frequent small earthquakes. However, the knowledge of this area is limited since only a few seismic stations were deployed in this area.

The 2015 Ms5.8 Alxa Left Banner Earthquake on April 15 is the largest one occurred in the surroundings since the 1976 Ms6.2 Bayinmuren Earthquake. Abundant stations built in the northern part of Chinese North-South Seismic Belt recorded this event sequence well within short distances, which provides us a great opportunity to carry out studies. We use these data to obtain a mean 1-D layered velocity structure via iterative inversion based on both travel time and waveform misfits. Then we use the travel time difference between data and synthetic seismograms to relocate the epicenter. Finally we invert the best double-couple focal mechanism and centroid depths of the source. As the result, the source was located at (39.7663° N, 106.4304° E) with a depth of 18 km and Mw 5.25. Nodal plane 1 had strike 176° , dip angle 85° and slip angle -180° , while plane 2 had strike 86° , dip angle 90° and slip angle -5° . Considering the tectonic characteristics of regional fault zone, we believe this earthquake was caused by a nearly pure left-lateral strike-slip fault with a slight normal component, while the nodal plane 2 striking towards NEE (near E-W) was the fault plane. The seismogenic structure was likely to be an E-W striking buried fault nearby.

From our study, the corresponding fault of this event may indicate all groups of faults with same E-W strike has the common character of large-dip left-lateral strike slip. Moreover, there may be some buried faults being newly born or not found yet. These results could be an important supplement to the future research of regional seismicity and modern fault zone structure.

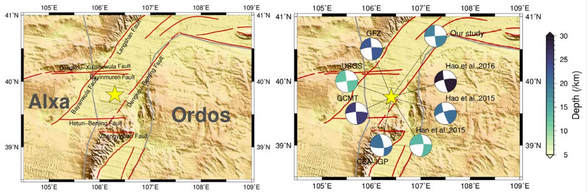

Fig. 1 Regional tectonics and previous studies

MOTIVATION

CAP method is stable for resolving focal mechanisms of moderate magnitude earthquakes. However, previous results have great discrepancies in focal depth, which is mainly caused by rough velocity structure. To mitigate this effect, we could take advantage of its insensitivity to velocity, using cross-correlation time shifts between seismograms and synthetics to revise the velocity model via iteration, thus to obtain a better velocity structure and focal mechanism simultaneously.

DATA and METHOD

Stations built in Project Himalaya Ⅱ;
Distance ≤ 400 km;
Z and T component of 155 stations

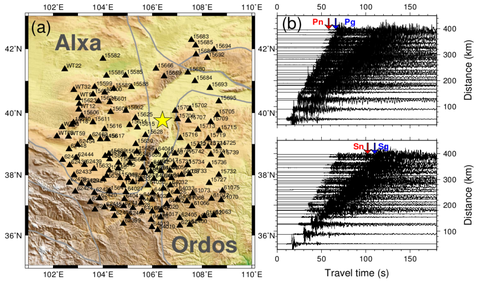

Fig. 2 Stations distribution and original waveforms

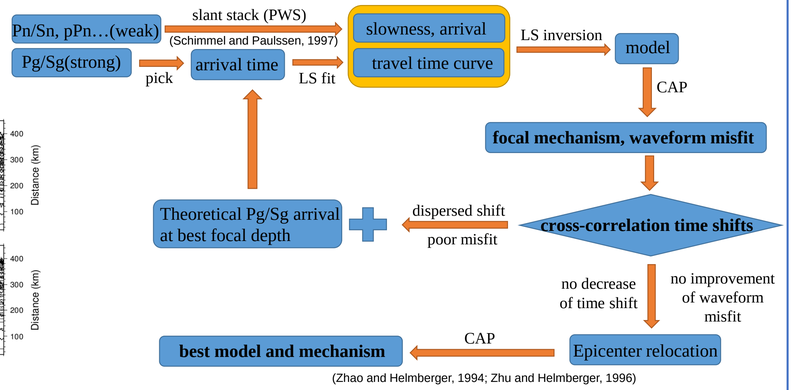

Fig. 3 Flow diagram of the iterative inversion method

RESULTS

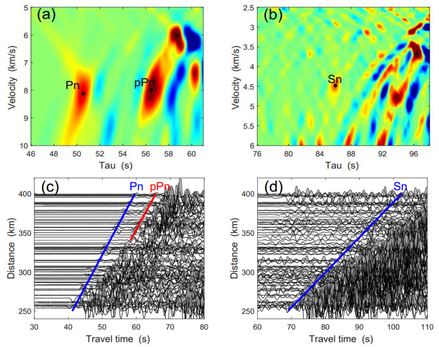

Fig. 4 Phase-weighted stacking results and phase check

Layer	Initial model			Best model		
	thickness (km)	P vel. (km/s)	S vel. (km/s)	thickness (km)	P vel. (km/s)	S vel. (km/s)
sediment	5.8	3.6	2.05	6.7	5.5	3.28
upper crust	14.0 12.8	6.08	3.64	18.2 13.2	5.96	3.55
lower crust	16.1	6.5	4.16	15.6	6.6	4.18
mantle	---	8.12	4.48	---	8.12	4.48

Tab. 1 Velocity model parameter

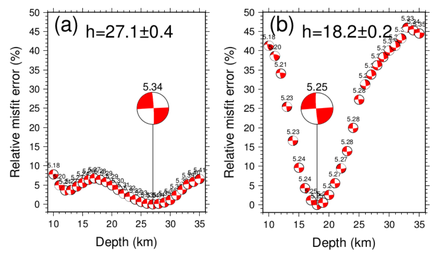

Fig. 5 Focal mechanisms, misfit errors variation with depth in each model

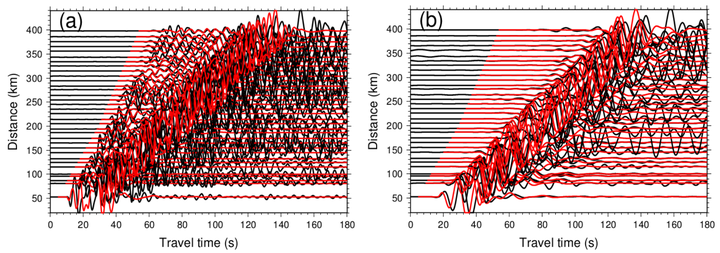

Fig. 6 The complete waveform fitting of observation and synthesis

DISCUSSION

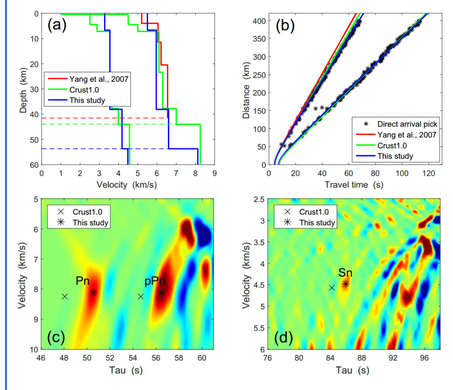

Fig. 8 Comparison between model inverted by this study and others

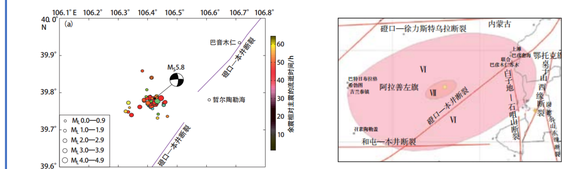

Fig. 9 AF relocation and intensity map (Han et al., 2015; Yang et al., 2016) (Chinese)

CONCLUSION

1. With abundant data, velocity model will affect more on focal depth and misfit, less on focal mechanism.
2. Through iterative travel time inversion and waveform modeling, velocity could be revised, which leads to epicenter location and utmost fitting.
3. Considering regional faults, we believe this event was caused by a nearly pure left-lateral strike-slip fault, while nodal plane 2 was fault plane striking towards NEE (near E-W).

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