Acta Geologica Sinica (English Edition), 2019, 93(supp.2): 205–206

Refraction-based Study of Pn VelocityAnisotropy Beneath the Ordos Block

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Citation: Song et al., 2019. Refraction-based Study of Pn Velocity Anisotropy Beneath The Ordos Block. *Acta Geologica Sinica* (English Edition), 93(supp.2): 205–206.

Abstract: The Ordos block is located at the junction of three sub -plates of Qinghai-Tibet, North China and South China. It is surrounded by faults and fault-sag zones and affected by the westward subduction of Pacific plate as well as the northeast extrusion collision of Indian plate. The lithosphere beneath Ordos block periphery has activated. However, the Ordos block still maintains a stable cratonic feature. The special geological tectonic setting of Ordos block makes it important to study its deep structure and dynamics. Seismic anisotropy is a significant method to research the lithospheric deformation and plate motion. Previous studies processed earthquake data with S-wave splitting, Pn travel-time tomography and surface wave imaging methods to research the mantle anisotropy beneath Ordos block. But limited by the constraints of these methods and disadvantage of earthquake data, their results often contradict each other. Therefore, this paper uses the explosion refraction-based Pn seismic velocity to study the anisotropy of uppermost mantle beneath the Ordos block, and provide independent seismic anisotropy observation evidence, which is significant for understanding the dynamic process of Ordos block and its periphery. There are numbers of deep seismic sounding (DSS) lines in the Ordos block and the observations are relatively

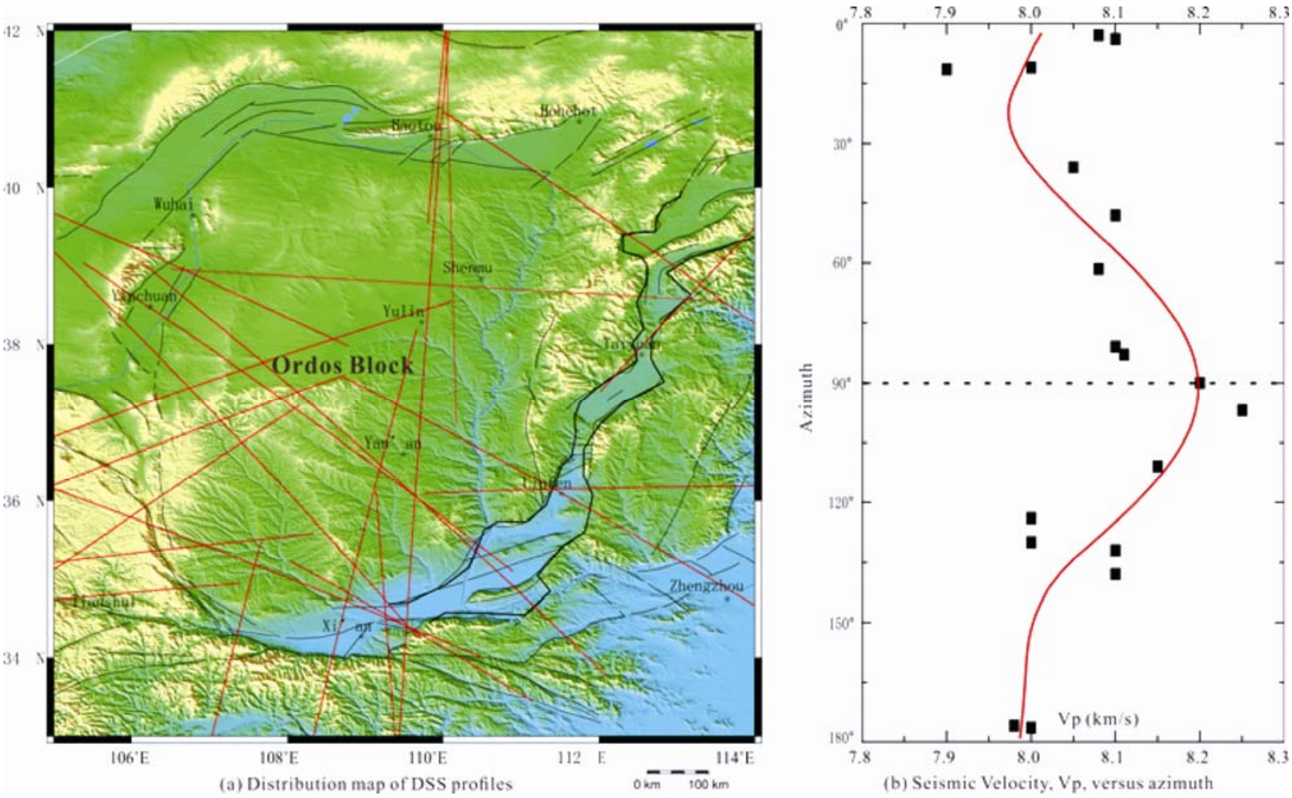

Fig. 1. Azimuthal anisotropy of Pn velocity beneath the Ordos block
(a) The distribution map of all DSS profiles in Ordos Block that contribute Pn data to this study. Red lines are the location of DSS profiles collected in this paper; (b) Seismic velocity, Pn, versus azimuth. Black blocks represent the collected Pn velocity data from previous DSS results.Red line is the anisotropy curve fitted to Pn velocity data.

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evenly distributed with respect to azimuth which cover all azimuths from 0° to 180° (with N being 0°, clockwise rotation), providing us an ideal experiment conditions to research Pn velocity anisotropy. We made statistics of refraction seismic Pn velocity and azimuth of all DSS lines, and plotted the curve of seismic velocity versus azimuth. The results show that Pn velocity of the Ordos block varies from 7.9km/s to 8.25km/s, indicating that the upper mantle lithosphere beneath the Ordos block is not as stable and uniform as craton block. Pn velocity has a distinct trend that changes along with azimuth. At the azimuth angle of 90° (E-W direction), Pn velocity reaches the maximum and gradually decreases toward both sides. This feature that Pn velocity versus azimuth is always explained as seismic anisotropy (Hess, 1964; Zhang et al, 2002). Anderson (1989) pointed out that when the upper mantle lithology is composed of 70% olivine and 30% orthopyrox, the seismic velocity of the upper mantle peridotite is 8.2km/s and 8.1km/s respectively. Pn velocity of the Ordos block (maximum 8.25km/s, minimum 8.0km/s or so) conforms to this lithology model. So we hold that Pn velocity anisotropy exists beneath the Ordos block. The anisotropy magnitude is 4.3%, which also coincides with the average mantle lithosphere anisotropy amount which ranges from 3~6%. Lateral heterogeneity may also cause similar feature that Pn velocity differs largely in different directions. But the crust beneath the Ordos block is simple and has no low-velocity layers, and moreover the Moho interface is a sharp interface with marked velocity contrast. These stable crustal features indicate that the internal deformation of the Ordos block is minor, and the uneven scale change of crust is not developed (Zhang et al., 2004). These features also indicate that the Ordos block may not have strong lateral heterogeneity in the uppermost mantle which is near Moho interface. Backus (1965) stated that the fluctuation of the Moho interface may also cause Pn velocity to vary in different orientations. However, the crustal thickness of the Ordos block is relatively uniform with a variation range of only 42-45 km. This range of Moho interface fluctuations is not enough to produce such a large Pn velocity variation from 7.9 to 8.25km/s. Therefore, the feature that Pn velocity versus azimuth revealed in this paper may be caused by the anisotropy of lithosphere peridotite, rather than the lateral heterogeneity or the fluctuation of Moho. Pn velocity anisotropy is generally considered to be caused by the creep deformation of the upper mantle. The E-W direction of Pn anisotropy beneath Ordos block revealed in this paper may be related with the north-south collision between the Siberian plate and the North China plate or the collage of the Yangtze Craton and the North China Craton. But the mantle anisotropy reflect the latest tectonic movement influence on mantle deformation, therefore, the E-W direction of Pn velocity anisotropy is more likely to be related with the Cenozoic westward subduction of Pacific plate (43~0 Ma) (Huang et al., 2011). During the subduction, the mantle convect in the big mantle wedge, and the orientation of olivine crystals is consistent with the mantle flow direction, thus causing the E-W direction of Pn velocity anisotropy beneath Ordos block, which is parallel to the subduction direction.

Key words: Ordos block, refraction seismic, Pn velocity anisotropy, western Pacific subduction

Acknowledgments: This work is granted by the National Natural Science Foundation of China (Grant No. 41474076).

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