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Crustal and uppermost mantle structure and seismotectonics of North China Craton

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ABSTRACT

We determined a 3-D P-wave anisotropic tomography of the crust and uppermost mantle beneath North China Craton (NCC) using 107,976 P-wave arrival times from 16,073 local earthquakes recorded by 380 seismic stations. Our results show significant lateral heterogeneities beneath NCC. The lower crust and uppermost mantle beneath the North China Basin show widespread low-velocity anomalies which may reflect high-temperature materials caused by the late Mesozoic basaltic magmatism in the NCC. Low-velocity anomalies also exist beneath the Trans-North China Orogen, which may reflect asthenospheric upwelling since late Mesozoic. Large crustal earthquakes generally occurred in high-velocity zones in the upper to middle crust, while low-velocity and high-conductivity anomalies that may represent fluid-filled, fractured rock matrices exist in the lower crust to the uppermost mantle under the source zones of the large earthquakes. The crustal fluids may lead to the weakening of the seismogenic layer in the upper and middle crust and hence cause the large crustal earthquakes. The NW–SE P-wave fast velocity directions seem to be dominant in the uppermost mantle under the central parts of eastern NCC, suggesting that these mantle minerals were possibly regenerated but keep the original fossil anisotropy formed before the new lithospheric mantle was produced during the Mesozoic to Cenozoic.

1. Introduction

Cratons are the stable tectonic units characterized by a cold and thick lithosphere keel. Different from other cratons having thick lithosphere of ~200 km, such as the Kaapvaal craton (Chevrot and Zhao, 2007; Fishwick, 2010), the North American craton (Frederiksen et al., 2001), and the Australia craton (Fichtner et al., 2010; Fishwick and Reading, 2008), the eastern North China Craton (NCC) is suggested to have experienced significant lithospheric thinning and modification during the Mesozoic–Cenozoic by examining the physical and chemical properties of the sub-continental lithospheric mantle (e.g., Griffin et al., 1998; Menzies and Xu, 1998; Zheng et al., 1998). Accordingly, the NCC, the Chinese part of the Sino-Korean Craton, is extraordinary that consists of a relatively intact western part and a destroyed eastern part, which are separated by the Central Orogenic Belt also known as the Trans-North China Orogen (TNCO) (Fig. 1) (Zhao et al., 2001). Traditionally, the NCC is described as a collage of two blocks (the eastern and western blocks) dissected by the TNCO (G. Zhao et al., 2005, 2009). However, recent studies (Santosh, 2010; Tsunogae et al., 2011) revealed that the western NCC is composed of two distinct sub-blocks termed the Ordos and Yinshan welded along the Inner Mongolia Suture Zone, rather than a uniform block.

The NCC has recently been paid much attention as a typical region to study the continental seismotectonics and geodynamics (e.g., Chen et al., 2006; Fan et al., 2000; Gao et al., 2002; Wu et al., 2005; Xu et al., 2004; Zhai and Liu, 2003; Zhang et al., 2004; Zheng et al., 2009; Zhu and Zheng, 2009). Seismic tomography is one of the most powerful tools to study the three-dimensional (3-D) velocity structure beneath North China and its adjacent areas (e.g., Chang et al., 2007; Huang and Zhao, 2004, 2006, 2009; Priestley et al., 2006; Qi et al., 2006; Tian and Zhao, 2011; Tian et al., 2009; Xu and Zhao, 2009). Seismic tomography clearly imaged the high-velocity (high-V) subducted Pacific slab stagnating in the mantle transition zone beneath the eastern NCC (Huang and Zhao, 2006; Zhao, 2004). A high-V root extending down to about 200 km depth beneath the western NCC is revealed (Tian and Zhao, 2011; Tian et al., 2009; Xu and Zhao, 2009). In addition, a high-V anomaly is detected atop the 410 km discontinuity beneath the eastern NCC, which may reflect the delaminated lithosphere (Huang and Zhao, 2009; Xu and Zhao, 2009). Recently, Santosh et al. (2010) investigated the mantle dynamics of the Paleo-proterozoic NCC by synthesizing the recent tomographic images (Tian et al., 2009; Xu and Zhao, 2009) and their correlation with the surface geological features in NCC. However, the seismic velocity structure of the crust and upper mantle has been assumed to be isotropic in these previous tomographic studies.

Shear-wave splitting measurements reveal that seismically anisotropic materials are common in the Earth's interior (for reviews, see Helbig and Thomsen, 2005; Maupin and Park, 2007; Savage, 1999). Seismic anisotropy can record very important information for studying the present or past tectonic deformation in the Earth (Savage, 1999; Silver, 1996). Recently, Zhao and Xue (2010) studied

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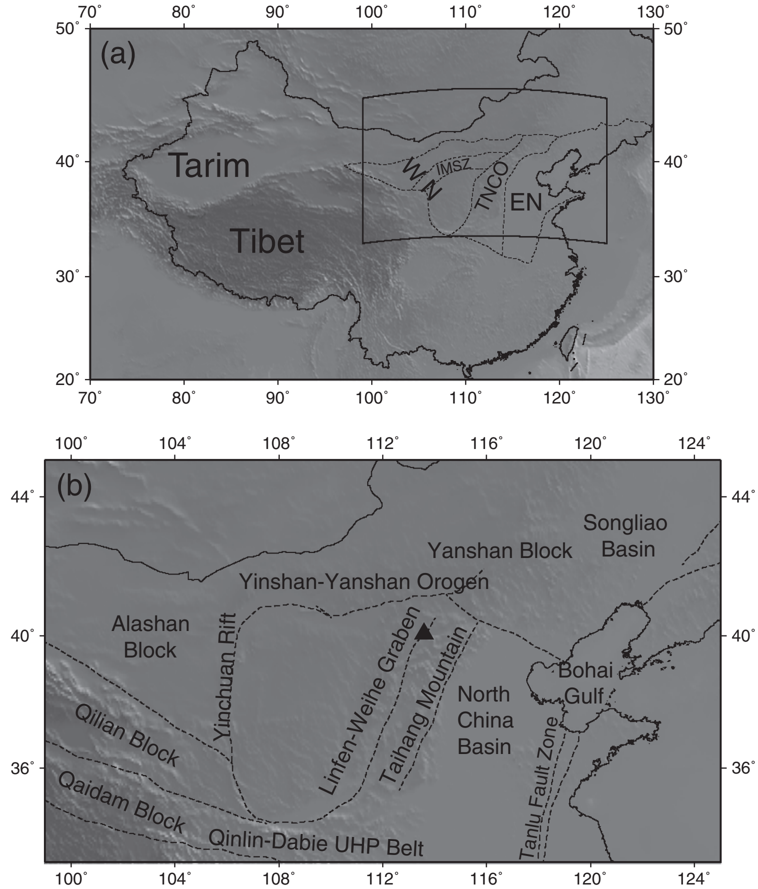

Fig. 1. (a) Map showing the major geological features of China and surrounding regions. The black box shows the location of the present study area. The dashed lines show the major tectonic units of the NCC (after Santosh, 2010; Zhao et al., 2001). EN, the Eastern NCC; WN, the Western NCC; TNCO, the Trans-North China Orogen; IMSZ, Inner Mongolia Suture Zone. (b) Tectonic background of the NCC. The dashed lines show the major faults or block boundaries (after Tian et al., 2009; Zhao et al., 2005). The black triangle denotes the Datong volcano group. The maps are plotted on a color background of the Asia topography (gtopo30).

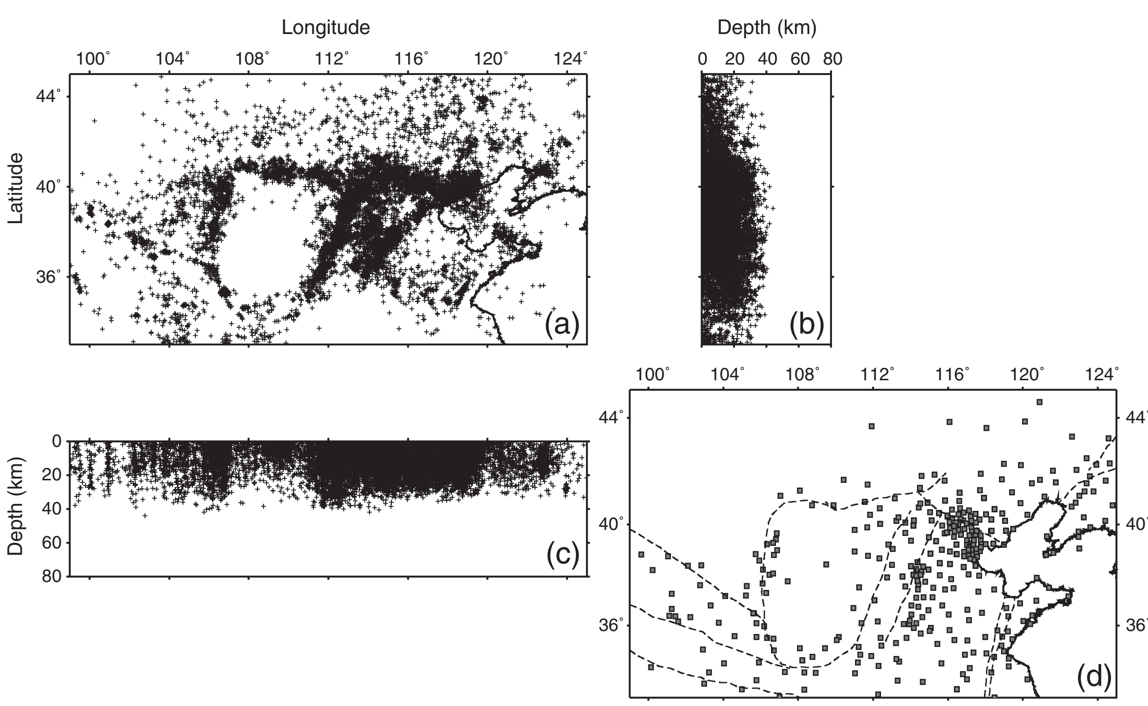

Fig. 2. (a-c) Hypocenter distribution of 16,073 local earthquakes (crosses) used in this study. (d) Distribution of 380 seismic stations (gray squares) used in this study. The dashed lines show the major faults or block boundaries as shown in Fig. 1b.