Tectonophysics 627 (2014) 108–121

Contents lists available at ScienceDirect

Tectonophysics

journal homepage: www.elsevier.com/locate/tecto

Moho depth, seismicity and seismogenic structure in China mainland

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ARTICLE INFO

Article history:
Received 3 July 2013
Received in revised form 5 September 2013
Accepted 3 November 2013
Available online 13 November 2013

Keywords:
Moho depth
Earthquake hypocenters
Seismic energy
Seismogenic layer
East Asia

ABSTRACT

The study of the crust–upper mantle structure based on wide-angle seismic profiles performed in China mainland since 1958, has provided tighter constraints on the architecture and deformation of the lithosphere; but the link between the seismic velocity structure and the seismogenic layer of the crust is still an open problem in which we are particularly interested. Starting from the crustal P-wave velocity models obtained along numerous seismic profiles, we have mapped the Moho depth beneath East Asia. The results demonstrate that the average Moho depth is about 35 km in Southeast China, 38 km in North and Northeast China, 51 km in Northwest China and 65 km in Tibet. The Moho depth varies between 20 and 28 km in the continental margin and sea area. Most of the earthquakes in China mainland have magnitude lower than 4.0 and generally occur in the uppermost 20 km of the crust and therefore above the Moho discontinuity; the average focal depth is found at 10 km in Southeast China, 12 km in North and Northeast China, 15 km in Northwest China and 13 km in the Tibetan Plateau. The ratio of the average focal depth to the Moho depth is approximately 0.3. Taking the lower bound of the natural seismicity as the depth above which is located 90% of the foci of earthquakes, we have found this limit at depths of 21, 41, 30 and 36 km in each of the mentioned blocks, respectively. In North and Northeast China some earthquakes occur below the Moho (at 41 km depth on average versus 38 km), although the average focal depth observed here is of only 12 km. Once defined the seismogenic layer as the layer that concentrates 80% of the released seismic energy, we have found that the difference in seismic velocity with respect to the other two crustal layers which extend above and below varies from 0.1 to 0.9 km/s in East Asia. This finding enables to discriminate the place with greater or lesser capacity to generate seismic energy. A difference in seismic velocity bigger than 0.9 km/s would mean that the layer has an earthquake generating capacity lesser than the seismogenic layer, as greatly happens in South China and Northwest China; while a smaller velocity difference would imply that the layer has a comparable seismogenic capacity, as happens in Tibet.

1. Introduction

Special attention has been paid to several topics (the spatial variation of the Moho depth, the deep structure of the crust, the seismicity pattern, etc.) related to the tectonic and geodynamics in very different areas of the world. These issues have been addressed through a series of research projects which have provided important geophysical, geochemical and geological information. As examples, we cite some works that have contributed to get accurate images of the Moho depth and the structure of the earth crust in western North America (Gorman et al., 2002), South America (Lloyd et al., 2010), Europe (Grad and Tiira, 2009) and eastern Asian continent (Teng et al., 2003). But at least in China the link between the seismic velocity structure and the seismogenic layer of the crust is still an open problem that we want to tackle in this study.

The crustal thickness in China has been mapped from gravity data and deep seismic soundings (DSS) performed in the last years. Although the gravity data are usually affected by the undulating geometry of the topographic relief and the different accuracy of the field measurements made in the course of geophysical surveys during different time periods, such data have helped to investigate the crustal thickness in those regions with lack of seismic data (Chen et al., 2001; Deng et al., 2013; Feng, 1985; Wang, 1985; Zhu et al., 1996). Recently, the Moho depth in East Asia has been investigated from quality DSS data (specifically Pm and Pn seismic phases) by block modeling and segmentally interactive ray tracing (Xu et al., 2006, 2010) with precision of ± 1 km (Teng et al., 2003). Recognizing the merit of pioneer works (Liu et al., 1994; Song et al., 1994; Teng et al., 1982; Yin et al., 1990), the mapping of the Moho discontinuity has contributed to obtain valuable information on the deep structure of the crust and thereby about the tectonics and continental dynamics in East Asia (Li et al., 2006, 2013; Prodehl et al., 2013; Teng et al., 2003, 2013; Thybo and Artemieva, 2013; Yang et al., 2013; Zhang et al., 2005, 2011c).

The focal mechanism and the focal depth of the earthquakes are some of the most accessible indicators to study its origin and the mechanical properties of the lithosphere (Teng et al., 2003); together with the magnitude and released energy are the basic elements to

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http://dx.doi.org/10.1016/j.tecto.2013.11.008

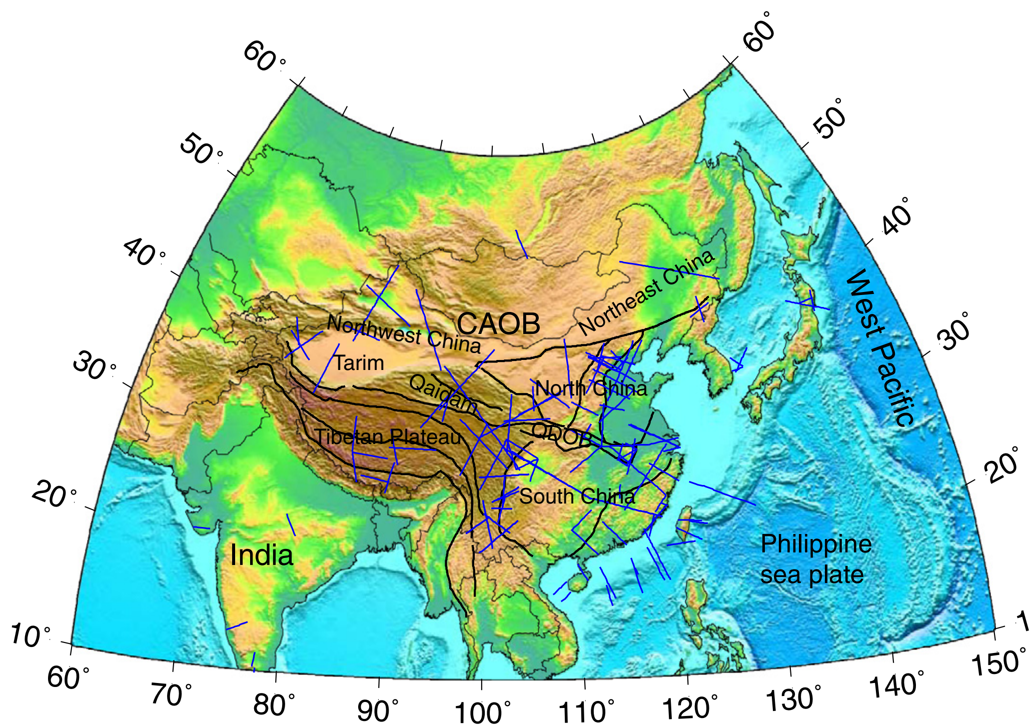

Fig. 1. Major tectonic regions considered in this study: Southeast China, North and Northeast China, Northwest China and Tibetan Plateau. Key to symbols: CAOB, Central Asian orogenic belt; QDOB, Qinling–Dabie orogenic belt. The solid black lines stand for tectonic boundaries; blue straight lines represent deep seismic profiles performed in East Asia during the period 1974–2010 (a detailed description can be seen in Teng et al., 2013).

analyze the rheology of the crustal lithosphere and its seismogenic structure (Foster and Jackson, 1998; Maggi et al., 2000; Molnar and Chen, 1983; Zhang et al., 2013a). For example, the earthquake occurrence in an active plate margin presents very significant features of these elements besides a characteristic bias consisting in a foci clustering with progressive tilt as the depth increases, what led to the

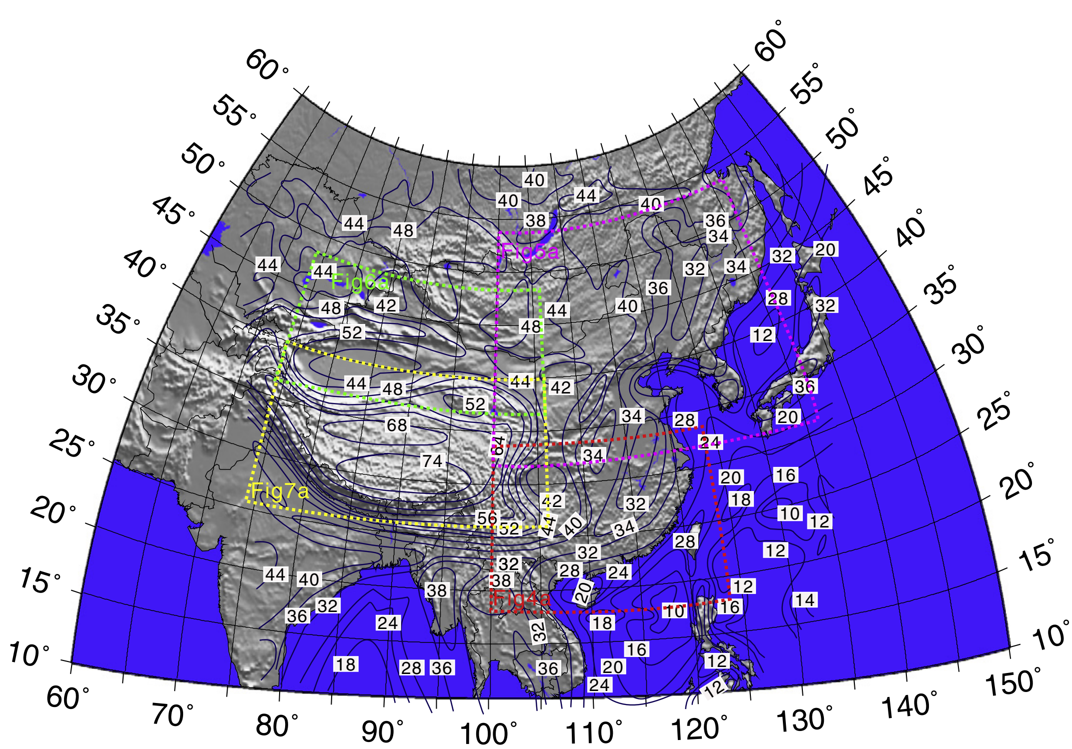

Fig. 2. Mapping of the Moho depth in East Asia (the values associated to isolines both inland and offshore indicate depth in km). The areas to which we refer in Figs. 3a, 4a, 5a and 6a are delimited by contour lines.