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Lateral variation of crustal structure and composition in the Cathaysia block of South China and its geodynamic implications

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ABSTRACT

In order to clarify lateral variations in the crustal structure and composition of the Cathaysia block in South China which was affected by violent Mesozoic and Cenozoic tectono-magmatic activities, we studied the crustal thickness and the Poisson's ratio in this region using the H–κ stacking method of teleseismic receiver functions. Our results show that the Poisson's ratio varies between 0.20 and 0.29 and the crustal thickness ranges from 26 to 34 km in the Cathaysia block. The crustal thickness and Poisson's ratio show considerable variations across the Lishui-Haifeng Fault. The Southeast Coast Magmatic Belt is characterized by Poisson's ratios >0.25 and a crustal thickness of 28–33 km, reflecting probably intermediate to mafic compositions of the crust. The southwestern part of the Cathaysia Fold Belt exhibits a crustal thickness of 27–30 km and Poisson's ratios <0.25, reflecting a more felsic crust. However, the northeastern part of the Cathaysia Fold Belt is characterized by an almost flat Moho at a depth of ~31 km and a strong variation of Poisson's ratio from 0.22 to 0.27. Our results revealed an ESE-WNW trending boundary between the southwestern and northeastern parts of the Cathaysia Fold Belt, which is consistent with previous results of geochemical studies. The lateral variations in the crustal thickness and composition of the Cathaysia block may reflect not only the lithological variations of the crustal rocks but also significant effects of tectonism and magmatism on the interior of the Cathaysia block during the Mesozoic and Cenozoic.

1. Introduction

As a major tectonic unit of East Asia (Fig. 1a), the Cathaysia block is a complex region affected by multiple stages of the Mesozoic and Cenozoic tectono-magmatic activity (e.g., Xu and Xie, 2005; Li and Li, 2007; Li et al., 2014), and it is mainly composed of Mesozoic granitoids-volcanic rocks with a total area of ~220,000 km^2 (e.g., Zhou et al., 2006; Chen et al., 2008). It can be subdivided into the Cathaysia Interior, the Cathaysia Fold Belt and the Southeast Coast Magmatic Belt by two tectonic lines, the Shi-Hang Zone and the Lishui-Haifeng Fault (Chen et al., 2008) (Fig. 1b). Contrasting geochemical and isotopic features of granites and basalts in the Cathaysia Interior, the Cathaysia Fold Belt and the Southeast Coast Magmatic Belt have resulted in different viewpoints on the geodynamic mechanism and tectonic evolution of the Mesozoic magmatism in the Cathaysia block. These viewpoints suggest that the Cathaysia block is (1) an Andean-type active continental margin (e.g., Guo et al., 1983), (2) an Alps-type collision belt (e.g., Hsu et al., 1990), (3) caused by the subduction of the paleo-Pacific plate (e.g., Zhou and Li, 2000; Li and Li, 2007), and (4) associated with intracontinental lithospheric extension and thinning (e.g., Chen et al., 2005, 2008; Cheng et al., 2013). Studying the bulk crustal seismic properties and spatial variations in the structure and composition across the Cathaysia block is very important for evaluating these contrasting tectonic models and improving our understanding of the geodynamic processes.

Many researchers have used seismic tomography (e.g., Huang and Zhao, 2006; Zhao et al., 2007, 2012; Wei et al., 2012, 2015; Xia and Zhao, 2014), wide-angle seismic surveys (e.g., Zhang and Wang, 2007; Zhao et al., 2013b), shear-wave splitting (e.g., Gao et al., 2009; Huang et al., 2011; Zhao et al., 2013a; Xue et al., 2013) and receiver functions (e.g., Ai et al., 2007; He et al., 2013; Zheng et al., 2013) to investigate the seismic structure of the crust and upper mantle beneath South China and East China, which revealed general features of seismic structure beneath these regions and suggested an important role of the subducted slab in the lithospheric evolution and the violent Mesozoic and Cenozoic

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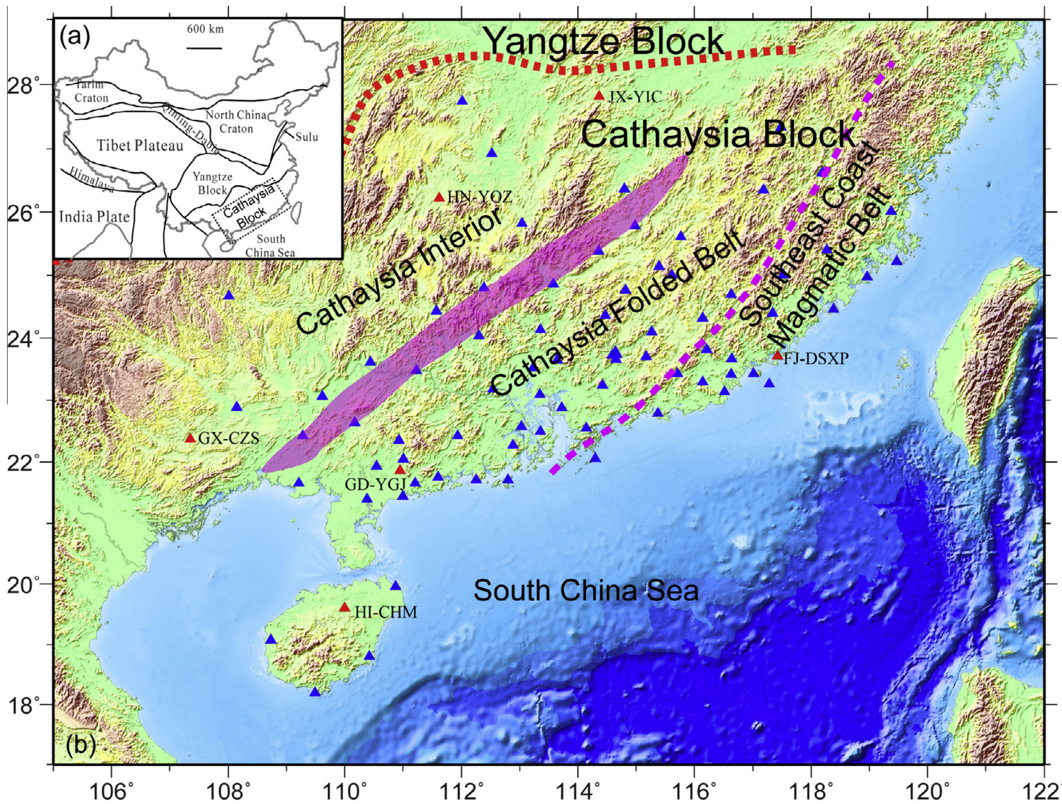

Fig. 1. (a) Major tectonic units in East Asia (Li et al., 2014). The rectangle shows the location of the Cathaysia block. (b) Map showing the distribution of permanent seismic stations in the Cathaysia block used in this study (the blue and red triangles). The six red triangles denote the seismic stations as examples showing the receiver functions and the H–κ stacking in Figs. 3 and 4. The Shi-Hang Zone (the purple belt) and the Lishui-Haifeng Fault (the purple dashed line) separate the Cathaysia block into three tectonic units: the Cathaysia Interior, the Cathaysia Folded Belt, and the Southeast Coast Magmatic Belt (modified from Chen et al., 2008). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

magmatism. However, the previous seismic studies were either based on data along a profile or focused on localized or continental-scale features. Lateral variations of the crustal structure and composition in different tectonic domains of the Cathaysia block are still not very clear.

In this work, we study lateral variations in the crustal thickness and Poisson's ratio in the Cathaysia block of South China using the H–κ stacking method of teleseismic receiver functions recorded by many permanent seismic stations in the study region (Fig. 1b). The present results provide new constraints on the crustal heterogeneity and composition in the interior of the Cathaysia block. We also discuss the magmatism and geodynamic processes by combining our new results with the previous findings of field geology, petrography and geochemistry of Mesozoic granites and basalts in the Cathaysia block.

2. Geological background

South China is composed of two Precambrian continental blocks, i.e., the Cathaysia block in the southeast and the Yangtze Craton in the northwest, along the Jiangnan orogeny during the Neoproterozoic time (e.g., Charvet et al., 1996; Li et al., 2009; Wang et al., 2007a). The Yangtze and Cathaysia blocks have distinctive crustal ages and tectonic evolution histories. The Yangtze block was mainly built upon a stable Archean-Proterozoic basement (Wang et al., 2013), whereas the Cathaysia block is much younger and consists of the Palaeo-proterozoic to Mesoproterozoic basement materials (Chen and Jahn, 1998; Jiang et al., 2009). Previous studies have shown that the Cathaysia block contains much information on the tectonic evolution associated with the collision between Indochina and South China, subduction of the paleo-Pacific plate, intraplate lithospheric extension, and the Cenozoic seafloor spreading of the South China Sea (e.g., Zhou and Li, 2000; Li and Li, 2007; Chen et al., 2005, 2008; Jiang et al., 2009; Cheng et al., 2013; Li et al., 2014). In turn, these tectonic events have also strongly affected the crustal evolution and resulted in significant temporal and spatial variations of the crustal structure and magmatism in the Cathaysia block.

The Triassic granite rocks are mainly distributed in the Cathaysia Interior and the Cathaysia Fold Belt, the Jurassic rocks exist in the Cathaysia Fold Belt, whereas the Cretaceous rocks are mainly located in the Southeast Coast Magmatic Belt (Chen et al., 2008), reflecting a general younger trend from inland to coast (Zhou and Li, 2000). A subduction model with an increasing dip angle of the subducted paleo-Pacific plate was proposed to explain the origin of the broad granitoids magmatism in the Cathaysia block (Zhou and Li, 2000). Now it is widely accepted that the magmatism of the Late Cretaceous Southeast Coast Magmatic Belt was associated with the subduction of the Paleo-Pacific plate (e.g., Chen et al., 2005, 2008; Li and Li, 2007), according to the basaltic compositions with high Al_2O_3 and low TiO_2 contents reflecting the effect of abundant fluids from the subducted slab (Chen et al., 2005). However, there is no consensus on the geodynamics of the western Cathaysia block. Petrological and geochemical characteristics of basalts show that the Jurassic mantle beneath the Cathaysia Interior and the Cathaysia Fold Belt was rather homogeneous and was not affected by the paleo-Pacific plate subduction (Chen et al., 2008), suggesting that post-orogenic extension accompanied by mafic underplating caused the vast Jurassic granitic magmatism