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Crustal structure and geodynamics of the Middle and Lower reaches of Yangtze metallogenic belt and neighboring areas: Insights from deep seismic reflection profiling

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ABSTRACT

A 300 km long seismic reflection profile was acquired across the Middle and Lower Reaches of the Yangtze River (MLY) metallogenic belt and its adjacent areas. The objective of the survey was to establish the deep architecture and geodynamic framework of the region. Results based on the interpretation of the deep seismic data include (1) Tan-Lu fault appears as a subvertical thrust fault or transpression fault with its deep portion dipping toward the southeast; (2) the Zhangbaling uplift is squeezed out along this fault; (3) complex upper crustal deformation structures beneath the Chuquan depression include both kink bands, thrusts, imbrication and fold structures reflecting contraction deformation, and detachment fault and normal-fault structures reflecting extensional deformation; (4) the "crocodile" reflection structure emerging beneath the Tan-Lu fault and Ningwu–Lishui volcanic basin, which represents the decoupled deformation process of the upper and lower crust associated with intra-continental subduction; (5) further to the southeast, the upper crust deformation shows a large-scale "wave-form" pattern, making crustal scale syncline and anticline; (6) the entire section of the reflection Moho is clearly discernible at depth of 30.0–34.5 km, and the Moho beneath the Middle and Lower Reaches of Yangtze River metallogenic belt is shallowest, while the Moho beneath the North China block is deeper than that beneath the Yangtze block. The Moho offsets could be seen beneath the Ningwu volcanic basin.

The seismic reflection data suggest that lithosphere delamination and asthenosphere upwelling that may result from the Mesozoic intra-continental orogenesis is responsible for the formation of large scale magmatism and mineralization in the MLY metallogenic belt.

1. Introduction

The Middle and Lower Reaches of the Yangtze River (MLY) is one of the most important metallogenic belts in the eastern part of China. This belt contains seven ore districts, from west to east: Erdong (Southeastern Hubei province), Jiurui, Anqing-Guichi, Lujiang-Zongyang, Tongling, Ningwu, and Ningzhen, and more than 200 large- and medium-sized ore deposits (Pan et al., 1999; Chang et al., 1991). The question of why so many metal ore deposits occurred in such a narrow region has interested ore geologists for decades. Many studies (Xing and Xu, 1996; Wang et al., 2003; Yuan et al., 2008; Zhou et al., 2008) have shown that the deposits in the MLY metallogenic belt are closely associated with high-K calc-alkaline rocks and olivine trachyandesite series rocks, many of which are of have adakite features (Wang et al., 2006, 2007) and were emplaced under conditions of high oxygen fugacity with a large amount of contribution from mantle components (Hou et al., 2007). However, there has been considerable debate about the dynamic processes that were responsible for the generation of the ore-related magma.

One hypothesis is that the magma formation was linked to the subduction of the paleo-Pacific plate. The combination of the subduction angle change, the mantle wedge melting, and the underplating of basaltic magma was responsible for the nearly 1000 km long magmatic belt in South China as proposed by some authors (Jahn et al., 1990; Zhou and Li, 2000). Other authors have explained the spatiotemporal distribution of the tectono-magmatic complex in South China using flat-subduction, slab delamination and roll-back mechanism (Li and Li, 2007). In addition, some

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authors have argued that the Cretaceous ridge between the paleo-Pacific and the Izanagi plates was subducted beneath the lower Yangtze River belt. Partial melting of subducting young, hot oceanic slabs close to the ridge formed adakitic rocks. A slab window opened during ridge subduction which is responsible for the formation of the A-type granitoids in the center of the inner belt (Ling et al., 2009; Sun et al., 2010).

Alternatively, it has been proposed that the large scale magmatism and mineralization during the Mesozoic were the results of the lithospheric delamination and asthenosphere uplift in east China (Deng et al., 1994, 2001; Zhang, 2013), which is unrelated to the subduction of the paleo-Pacific plate. The large scale magmatism may result from huge mantle plumes (Zhang et al., 2009).

The continental crust is the archive of its dynamic evolution (Hawkesworth et al., 2013). Major geological events and deep processes may leave varied relics of different scales, which can be detected by various methods, including geophysics, isotopic techniques, tectono-stratigraphy, and rock geochemistry (Blewett et al., 2010). It has been repeatedly shown that deep seismic reflection and other geophysical methods are effective for revealing the deep crustal structure of the lithosphere and deep processes (Allmendinger et al., 1987; Zhao et al., 1993; Velden and Cook, 2005; Goleby et al., 2009).

To study the fine crustal structure and deep processes of the MLY metallogenic belt, and further understand the deep dynamic processes that are responsible for the petrogenesis and ore-formation of the metallogenic belt, we have conducted a 300 km long deep seismic reflection profile across the MLY metallogenic belt with the support of the SinoProbe project. In this paper, we first introduce the details of the regional geology, profile deployment, data acquisition and processing of the deep seismic reflection profile. Subsequently, an analysis is performed on the seismic reflection character, reflection patterns, and geological significance revealed by the migrated seismic section and associated linedrawings. Finally, based on the results from the reflection seismic profile, the crustal and upper mantle structure in the MLY metallogenic belt, and the deep processes and dynamic mechanisms are discussed.

2. Geological setting

2.1. Regional geology

The Middle and Lower Yangtze River region (MLY) is located on the northeastern margin of the Yangtze block. It is separated from the Cathaysia block to the south by the Jiangshan-Shaoxing fault (see inset in Fig. 1), which is the Proterozoic suture between the Cathaysia and Yangtze blocks (Li et al., 2005). Structurally, the MLY is bounded by three major fault zones: the Xiangfan–Guangji Fault in the southwest, the Tancheng–Lujiang Fault (i.e. the Tan–Lu fault; Chang et al., 1991) (TLF) in the northwest and the Jiangnan fault (also called Yangxing–Changzhou Fault) in the southeast (Fig. 1). Adjacent to this belt to the west is the Dabie orogenic belt (DOB), the largest known ultrahigh-pressure

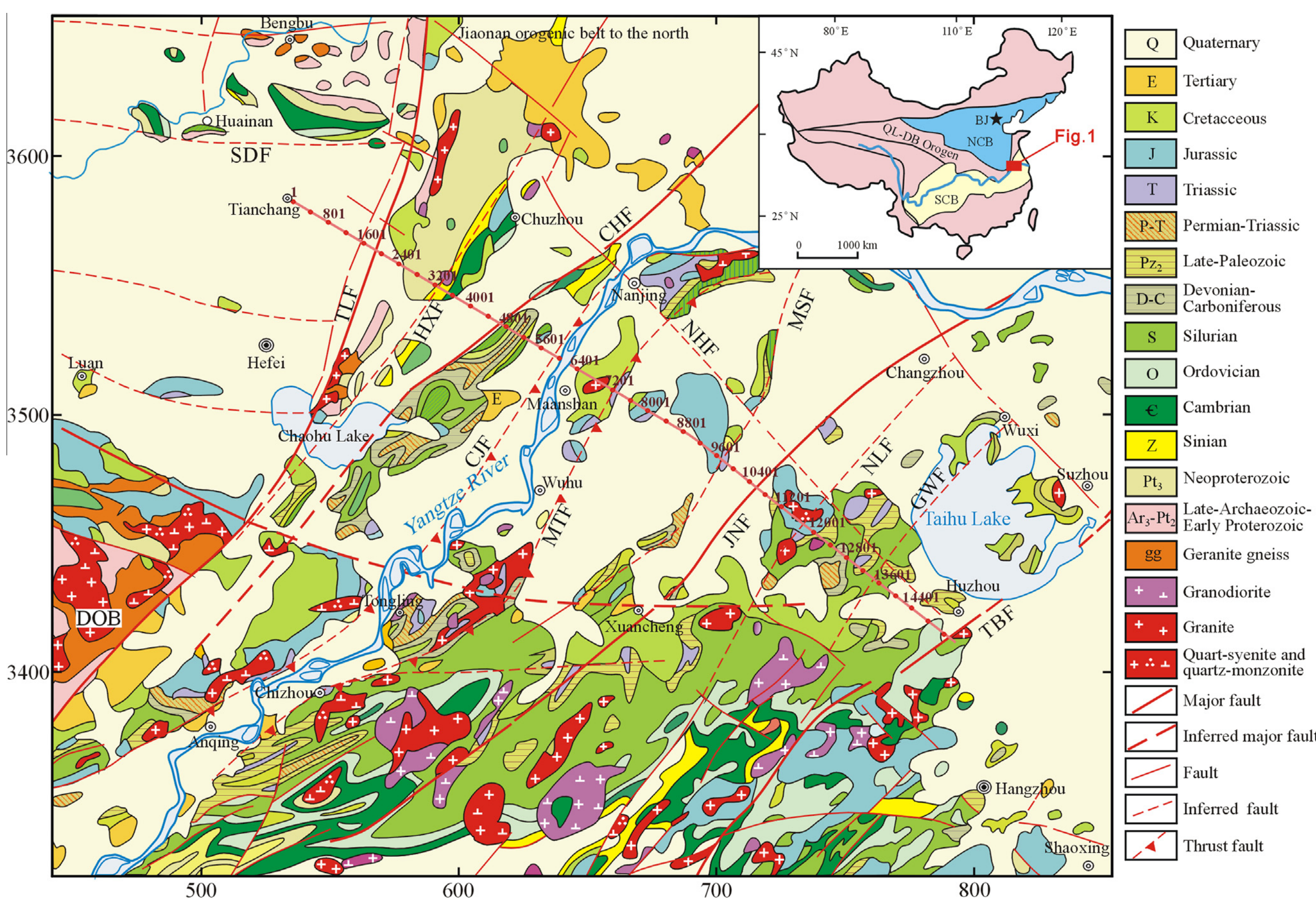

Fig. 1. Geological map of the Middle and Lower reaches of the Yangtze River showing the location of deep seismic reflection profile with CDP numbers. The faults are modified from this study. Refer to the inset (upper right) for the location of study area. SDF: Shouxian-Dingyuan fault; TLF: Tan-Lu fault; HXF: Huaiyin–Xiangshui fault; CHF: Chuhe fault; CJF: Changjiang thrust fault; MTF: Major thrust fault; MSF: Maoshan fault; JNF: Jiangnan fault; NLF: Ningguo-Liyang fault; GWF: Guangde-Wuxi fault; TBF: Tianmushan-Baijishan fault; NHF: Nanjing-Huzhou fault; DOB: Dabieshan Orogenic belt; NCB: North China Block; SCB: South China Block; QL-DB Orogen: Qinling-Dabie Orogen; BJ: Beijing.