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The Cenozoic lithospheric mantle beneath the interior of South China Block: Constraints from mantle xenoliths in Guangxi Province

Xi-Yao Li [a,b], Jian-Ping Zheng [a,*], Min Sun [b], Shao-Kui Pan [a], Wei Wang [a,b], Qun-Ke Xia [c]

[a] State Key Laboratory of Geological Processes and Mineral Resources, Faculty of Earth Sciences, China University of Geosciences, Wuhan 430074, China
[b] Department of Earth Sciences, The University of Hong Kong, Hong Kong, China
[c] CAS Key Laboratory of Crust–Mantle Materials and Environments, School of Earth and Space Sciences, University of Science and Technology of China, Hefei 230026, China

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ABSTRACT

In contrast to the coastal regions of the South China Block (SCB), little is known about the subcontinental lithospheric mantle beneath the interior of the SCB. Mantle xenoliths entrained in Cenozoic basalts in the eastern and central Guangxi Province, the interior of the SCB, includes spinel harzburgites, clinopyroxene-poor lherzolites, lherzolites and olivine websterites. The mineral chemistry of the harzburgites and clinopyroxene-poor lherzolites is moderately refractory [Mg# value of olivine ($Mg\#_{Ol}$) = 90.2–91.3], whereas other lherzolite is more fertile ($Mg\#_{Ol}$ = 89.3). Zoned olivines ($Mg\#_{Ol}$ = 83.7–88.8) in the harzburgites and zoned olivine xenocrysts ($Mg\#_{Ol}$ = 75.2–82) in the basalts reflect disequilibrium between olivines and the basaltic host melts during magma ascent. An olivine websterite ($Mg\#_{Ol}$ = 87.5) is similar to the lherzolite in mineral chemistry. The REE patterns of clinopyroxenes in these xenoliths vary from LREE-depleted, to flat, to LREE-enriched patterns, and commonly exhibit positive Sr anomalies and negative Nb, Zr and Ti anomalies. The peridotitic xenoliths mostly experienced moderate to high degree of melt extraction (F = 10–20%) and were modified by silicate metasomatism. We thus suggest that the harzburgites and clinopyroxene-poor lherzolites with high $Mg\#_{Ol}$ values represent ancient (Proterozoic) lithospheric mantle, preserved beneath the Guangxi Province. In contrast, the minor, fertile (low-$Mg\#_{Ol}$) lherzolites represent lithospheric mantle accreted during the Phanerozoic, and a small amount of pyroxenite was produced via interaction between peridotite and silicate-rich melts. The mantle-accretion process that occurred beneath the SCB during the Mesozoic to Cenozoic time extended into Guangxi Province. The lithospheric mantle beneath the interior of the SCB is heterogeneous, featuring various types of peridotite and co-existing pyroxenite. This heterogeneity also indicates that the lithospheric mantle beneath the regions affected by translithospheric faults could be wholly or partially replaced by the juvenile accreted mantle. In contrast, the most stable regions in the interior of the SCB probably are dominated by moderately to strongly refractory, ancient (Proterozoic) lithospheric mantle.

1. Introduction

The sub-continental lithospheric mantle (SCLM) is the non-convective, uppermost part of the Earth's mantle beneath the continental crust (Griffin et al., 2013). Mantle xenoliths entrained in basalts represent fragments of the SCLM and provide a means to probe the nature and evolution of the SCLM. Generally, the lithospheric mantle has experienced a complex evolution of melt extraction and metasomatism (O'Reilly and Griffin, 1988; Rudnick et al., 1993), and its composition is broadly correlated with the age of the overlying crust and/or tectonic setting (Boyd, 1989; Griffin et al., 1999; Sleep, 2005). However, ancient (Archaean–Proterozoic) SCLM may also be modified or changed by tectonic–magmatic processes during the Phanerozoic (Carlson et al., 2005; Griffin et al., 1998a, 2003), e.g., the destroyed or removed lithospheric mantle associated with the North China Craton (e.g., Griffin et al., 1998b; Xu, 2001; Zhang, 2005; Zhang et al., 2008; Zheng et al., 2001, 2007) and the Wyoming Craton (O'Neill et al., 2008).

The South China Block (SCB) makes up a major part of the crust of eastern China (Fig. 1a). Abundant mantle xenoliths are found in Cenozoic basalts (<19 Ma) in the southeast coastal region of the SCB and reveal the mantle heterogeneity beneath this region (Huang and Xu, 2010; Liu et al., 2012a; Xu X.S. et al., 2000, 2008; Xu Y. G. et al., 2001, 2002; Yu et al., 2003, 2006; Zheng et al., 2004). Most of the xenoliths have geochemically fertile compositions and represent a thin (<80–100 km) and fertile lithospheric mantle which could have been relatively recently accreted in Phanerozoic time (Xu et al., 2000). However, a few refractory xenoliths, which have old Re–Os model ages dating from Paleoproterozoic to Neoproterozoic time, have been interpreted as relics of the older lithospheric mantle (Liu et al., 2012a; Xu et al., 2008; Zheng et al., 2004). The SCLM beneath the coastal region

* Corresponding author. Tel.: +86 27 67883001; fax: +86 27 67883002.
E-mail address: jpzheng@cug.edu.cn (J.-P. Zheng).

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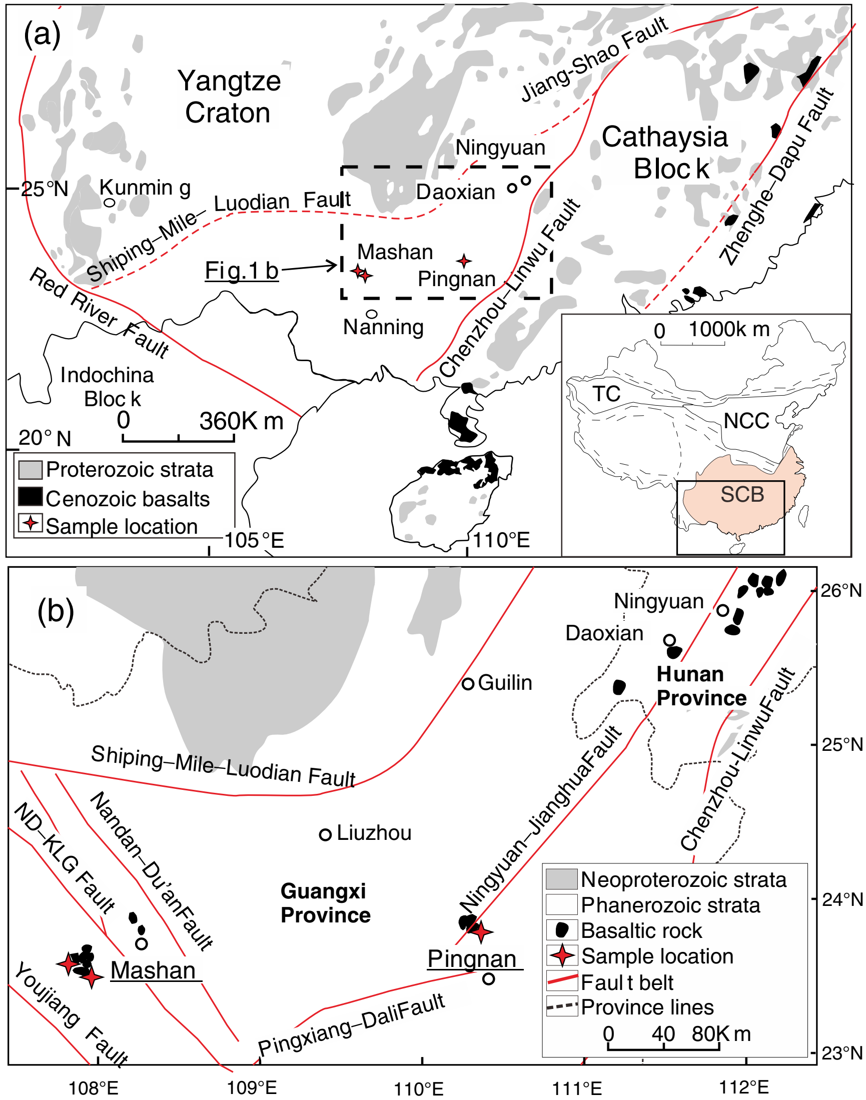

Fig. 1. (a) A tectonic sketch map of the interior of the South China Block (modified after Xu et al. (2007), Zhao and Cawood (2012) and Wang et al. (2013a)). SCB: South China Block, TC: Tarim Craton, NCC: North China Craton. (b) The distribution of Cenozoic basaltic rocks and sample locations in eastern and central Guangxi Province, in the interior of South China Block. Sample locations are marked with a solid star. ND-KLG Fault: Nandan-Kunlunguan Fault.

of the SCB may have suffered lithospheric thinning or mantle replacement, during which the ancient, refractory SCLM was thinned or replaced by the juvenile, fertile mantle in Mesozoic to Cenozoic time (Liu et al., 2012a; Xu et al., 2000, 2002; Zheng et al., 2004).

Mantle xenoliths are rarely found in basaltic rocks in the interior of the SCB, with the exception of the Daoxian–Ningyuan xenoliths in southern Hunan Province (Fig. 1b). Thus, the nature and evolution of the SCLM beneath most regions in the interior of the SCB are not well constrained. The Daoxian–Ningyuan region has experienced intense tectonic–magmatic events since the Mesozoic, generating little xenolith-bearing basaltic magmatism (Li, 2000). The majority of the Daoxian–Ningyuan xenoliths are fertile in terms of mineral composition, exhibit primitive-mantle-like features, and are considered to represent the newly-accreted lithospheric mantle beneath the major translithospheric faults (Liu et al., 2012b; Zhao et al., 2012; Zheng et al., 2004). However, most regions in the interior of the SCB experienced fewer tectonic–magmatic events than the Daoxian–Ningyuan region during the Mesozoic to Cenozoic (Wang et al., 2013a).

Eastern and central Guangxi Province is a relatively stable region in the interior of the SCB (Fig. 1a). Some peridotite and pyroxenite xenoliths have been found in the Cenozoic basaltic rocks from the eastern and central Guangxi Province. These xenoliths provide us an opportunity to understand the nature and evolution of the SCLM beneath the interior of the SCB. In this paper, we present the detailed petrography and mineral chemistry of the peridotite and pyroxenite xenoliths. Our aim is to investigate the nature and evolution of the lithospheric mantle beneath the interior of the SCB.

2. Geological setting and sample locations

2.1. Geological setting

The SCB consists of the Cathaysia Block in the southeast and the Yangtze Craton in the northwest, which amalgamated in the Neoproterozoic (Li, 1999; Wang et al., 2013a,b; Zhou et al., 2002) (Fig. 1a). The Yangtze Craton contains scattered areas Archaean to Paleoproterozoic crystalline basement (Gao et al., 1999; Zheng et al., 2006) with abundant Neoproterozoic to early Mesozoic sedimentary cover (Wang et al., 2012, 2013b). The Cathaysia Block is predominantly composed of Neoproterozoic rocks with minor Paleo- to Mesoproterozoic rocks (Yu et al., 2012; Zhao and Cawood, 2012), whereas Archean components have only been identified through xenocrystic zircons in volcanic rocks (Zheng et al., 2011), detrital zircons from a modern river (Xu et al., 2007) and as protoliths to basement