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From enriched to depleted mantle: Evidence from Cretaceous lamprophyres and Paleogene basaltic rocks in eastern and central Guangxi Province, western Cathaysia block of South China

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ABSTRACT

Much of Eastern China underwent significant lithospheric thinning during Phanerozoic time. Compared to the wealth of detailed research on the destruction of the North China Craton since the Mesozoic, the lithospheric evolution of South China (including the Yangtze Craton and the Cathaysia block) is still unclear. In particular, studies of the western part of the Cathaysia block, which connects the Yangtze Craton in the west to the eastern Cathaysia block in the east, are sparse. The study of the mantle-derived magmatic rocks from the western Cathaysia block can provide a better understanding of the continental evolution of South China, and of greater East Asia. Elemental and Sr–Nd isotopic compositions of the Cretaceous (89 Ma) lamprophyres and Paleogene (51–28 Ma) basaltic rocks in eastern and central Guangxi Province, western Cathaysia block, were analyzed to reveal the nature of their mantle sources. The Cretaceous lamprophyres are ultrapotassic, strongly enriched in LILE–LREE and depleted in HFSEs (e.g., Nb, Ta, Ti), and have high $(^{87}Sr/^{86}Sr)_i$ and negative ε_{Nd} (t) values. They probably were derived from low-degree partial melting of an EM2-type garnet-facies (>80 km) subcontinental lithospheric mantle (SCLM), followed by the fractionation of olivine and clinopyroxene. The modeled SCLM, mainly a phlogopite-bearing harzburgite, represents a refractory mantle that was metasomatically enriched by subduction, prior to the Pacific subduction during Mesozoic. The Paleogene basaltic rocks are enriched in alkalis, LILEs and LREE but positive Nb–Ta anomalies, and are similar to alkali oceanic-island basalts. These basaltic rocks have DM-type Sr–Nd isotopic signatures, with low $(^{87}Sr/^{86}Sr)_i$ and high ε_{Nd} (t). They probably were derived from the low-degree partial melting of fertile (asthenospheric) mantle in spinel- to spinel-garnet-facies lherzolite (<80 km). The differences imply that the source region was transformed from EM2 in Cretaceous time to DM-mantle in Paleogene time, and that lithospheric replacement occurred over Cretaceous–Paleogene time. It was driven by the two-sided dynamics around the Cathaysia block, with Pacific subduction in the east and the Eurasian–Indian plate collision in the west. The complex subduction dynamics led to complex asthenospheric convection, a regional lithospheric extension beneath the Cathaysia block, and the removal or modification of the ancient SCLM.

1. Introduction

Mantle-derived magmatic rocks (e.g., lamprophyres and basalts) can be used to probe of the composition and thermal state of the deep mantle (Foley et al., 1987; Niu et al., 2011) and other tectonic environments (H.F. Zhang et al., 2001; M. Zhang et al., 2001; Turner et al., 1996). Different generations of mantle-derived magmatic rocks have been widely used to reconstruct the evolutionary history of the continental lithosphere. For instance, they were crucial in reconstructing the lithospheric thinning processes in the southwest Basin and Range Province, USA (DePaolo and Daley, 2000) and eastern China (Xu, 2001; Zhang et al., 2002).

East China is composed of three Precambrian blocks: the North China Craton (NCC), the Yangtze Craton and the Cathaysia block (Fig. 1a). East China is a good area to study the effect of lithospheric thinning on different Precambrian blocks. The Meso-Cenozoic destruction of the lithospheric root of the eastern NCC has been intensively studied (Gao et al., 2004; Griffin et al., 1998; Menzies et al., 1993; Wu et al., 2006; Xu, 2001; Zhang et al., 2002; Zheng et al., 1998, 2005, 2006, 2007, 2012). In contrast, most of the Yangtze Craton was relatively stable with rare tectono-thermal events during Meso-Cenozoic time (Wang et al., 2013). Recently, studies of lithospheric replacement of the Cathaysia block, mainly in the eastern Cathaysia block, have begun to shed more light on its history (Huang et al., 2013; Li, 2000; Liu et al., 2012a,b, 2013; Xie et al., 2006; Xu et al., 2000, 2002, 2003; Zheng et al., 2004). Early studies (e.g. Xu, 2007) considered that

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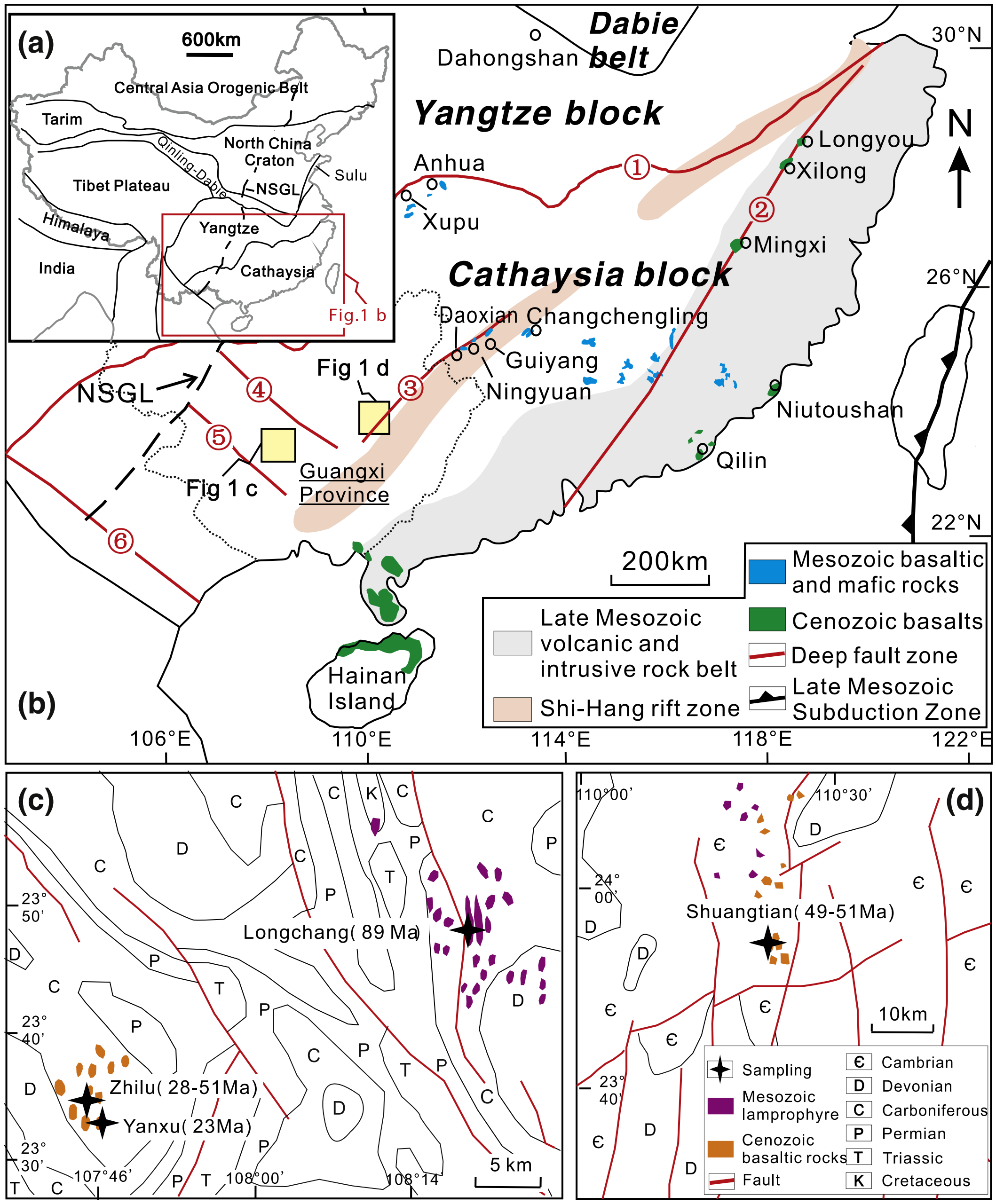

Fig. 1. (a) Major tectonic units in East Asia. NSGL: North–South Gravity Lineament (Ma, 1987). (b) A tectonic sketch map of the Cathaysia block (modified after Xu et al. (2007), Zheng et al. (2011), and Wang et al. (2013)). Shi-Hang rift zone is modified after Gilder et al. (1996). Names of the deep fault zones: 1, Jianshao–Pingyu fault zone; 2, Zhenghe–Dapu fault zone; 3, Ningyuan–Jianghua fault zone; 4, Ziyun–Luodian fault zone; 5, Youjiang fault zone; and 6, Red River fault zone. (c) Sampling location of Cretaceous Longchang lamprophyres and Paleogene Zhilu, Yanxu basalts in central Guangxi Province. (d) Sampling location of Paleogene Shuangtian basaltic rocks in eastern Guangxi Province.

lithospheric thinning was limited to the east side of the North–South Gravity Lineament (NSGL, Fig. 1a). However, the western Cathaysia block, which lies between the Yangtze Craton and the eastern Cathaysia block, is on the east side of the NSGL (Fig. 1b) and has a thin lithosphere (<100 km) (An and Shi, 2006).

Within the western Cathaysia block, studies of Meso-Cenozoic mantle-derived magmatic rocks have mainly concentrated on its eastern part (Fig. 1b). This magmatism has been interpreted as the product of either the subduction of the Pacific oceanic crust during Mesozoic (Jiang et al., 2009; Li ZX and Li XH, 2007; Meng et al., 2012) or intracontinental lithospheric extension indirectly linked to the subduction of the Pacific plate (Chen et al., 2008; He et al., 2010; Li et al., 2004; Wang et al., 2003, 2008). However, the Meso-Cenozoic mantle-derived magmatic rocks in the western part of the western Cathaysia block have been largely ignored. Fortunately, Cretaceous (89 Ma) lamprophyres in Longchang and three localities with Paleogene (51–28 Ma) basaltic rocks (Shuangtian, Yanxu and Zhilu) have been found in eastern and central Guangxi Province, the western part of the western Cathaysia block (Fig. 1b). Here, we report the elemental and Sr-Nd isotopic compositions of these rocks, in order to examine their petrogenesis and especially the possible temporal changes in the nature of their mantle sources, to gain further insights into the lithospheric evolution and geodynamic mechanisms beneath this key area.

2. Geological setting and sample petrography

South China's two Precambrian continental blocks (Fig. 1a), the Cathaysia block to the southeast and the Yangtze Craton to the northwest,