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The Xinchang peridotite xenoliths reveal mantle replacement and accretion in southeastern China

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ABSTRACT

The Xinchang mantle xenoliths, including garnet lherzolites, spinel lherzolites and harzburgites, have been studied for the nature and age of the lithospheric mantle beneath southeastern (SE) China. The spinel harzburgites have refractory compositions, with 0.95–1.73 wt.% Al_2O_3, 0.65–1.47 wt.% CaO, 0.03–0.16 wt.% TiO_2 and 2134–2422 ppm Ni. The lherzolites (both spinel- and garnet-) have more fertile compositions, containing 2.4–5.43 wt.% Al_2O_3, 2.17–3.22 wt.% CaO, 0.1–0.38 wt.% TiO_2 and 1733–2055 ppm Ni. Olivines in the harzburgites have Fo contents of 88.7–91.4, which is 88.4–90.2 for the lherzolites. Both clinopyroxene and orthopyroxene have lower Al_2O_3 but higher Cr_2O_3 contents than those in the lherzolites. Modeling of the Y and Yb contents in clinopyroxenes indicates that the spinel harzburgites have been subjected to ca. 20% degrees of partial melting. Reaction textures, in particular the sieve-texture in clinopyroxene, is widely developed in the Xinchang mantle xenoliths, which resulted from reaction with the host lavas. The sieve-textured clinopyroxenes show compositional zonation; the sieve-textured rims have lower Na_2O and Al_2O_3 but higher Cr_2O_3 and CaO than the inclusion-free cores. The inclusion-free cores of clinopyroxene in the harzburgites show clearly enriched characteristics in trace elements, reflecting they have been metasomatized before the entrainment in the host lavas. Clinopyroxenes have high Ti/Eu but low La/Ya ratios, suggesting that the Xinchang mantle xenoliths were metasomatized by silicate melts. The spinel harzburgites have $^{187}Os/^{188}Os$ of 0.11999–0.12258, giving T_{RD} age of 0.99–1.35 Ga relative to the primitive upper mantle (PUM). In comparison, both spinel and garnet lherzolites have more radiogenic $^{187}Os/^{188}Os$ ratios (0.12424–0.12801) and younger model ages (0.22–0.75 Ga). We explain that the spinel harzburgites represent the ancient lithosphere relic beneath the Xinchang region, whereas both spinel and garnet lherzolites represent the newly accreted mantle. This reflects that the lower portion of the Proterozoic mantle has been removed and replaced by younger, hotter and juvenile mantle that was accreted from the asthenosphere. The harzburgites have high equilibrium temperatures of 1112–1174 °C, which are indistinguishable from those of the garnet lherzolites (1108–1198 °C). This suggests that the lithosphere relic has been heated by the newly accreted asthenosphere. The mantle replacement and accretion is a common process in SE China and could be related to the lithospheric extension since the Mesozoic.

1. Introduction

While it is still highly controversial on the Mesozoic geodynamic environment of southeastern (SE) China (Li and Li, 2007; Zhou et al., 2006), it has been suggested that the South China continental margin evolved in an intraplate extensional setting during the late Cenozoic (Chung et al., 1997). Cenozoic basalts are widespread in South China, which are generally attributed to asthenosphere upwelling following the Indo–Eurasia collision (Chung et al., 1994; Smith, 1998). These Cenozoic basalts commonly contain a wide variety of deep-seated xenoliths (Fig. 1), which provide opportunity to study the nature and evolution of the lithospheric mantle beneath the SE China. A number of petrological and geochemical studies have been undertaken on mantle xenoliths trapped by the Cenozoic basalts from SE China (Fan et al., 2000; Huang and Xu, 2010; Lin et al., 1995; Qi et al., 1995; Xu et al., 1995, 2000, 2002, 2008; Yu et al., 2003, 2006; Zheng et al., 2004). Previous studies have shown that most of the peridotites from SE China are fertile and represent residues of low degrees (i.e., <5%) of partial melting (Qi et al., 1995; Xu et al., 2000), except some spinel peridotites from Mingxi (Fujian) and Qilin (Guangdong) with higher degrees of melt extraction (Qi et al., 1995; Xu et al., 2000, 2001). A previous study on trace elements of garnet has suggested that the garnet-bearing peridotite xenoliths from Mingxi represent juvenile lithospheric mantle (Xu et al., 2000). Therefore, the Archean or Proterozoic lithsopheric mantle that previously existed beneath this region, as confirmed by Re–Os isotopes of sulfides in mantle xenoliths

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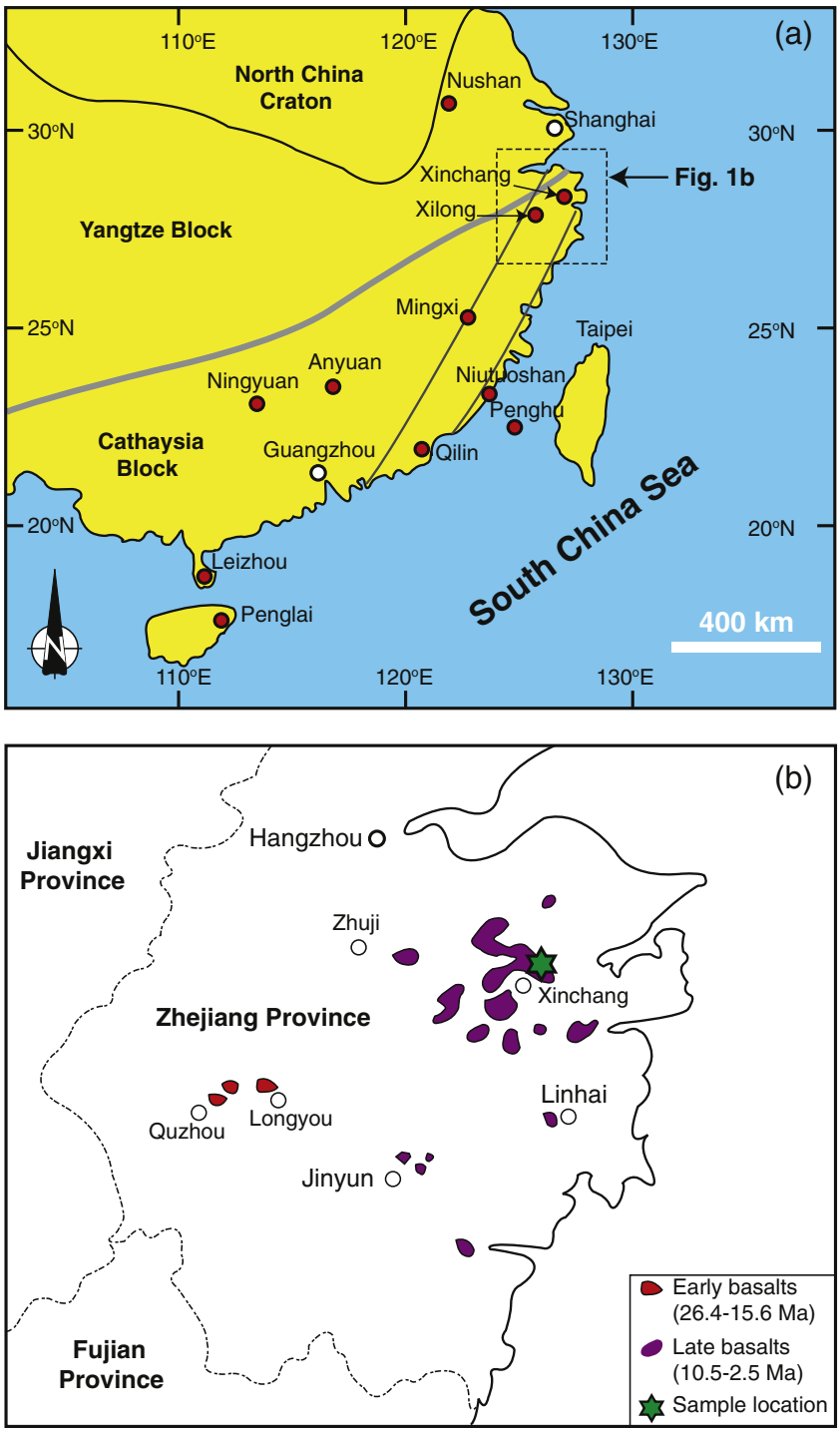

Fig. 1. Distribution of mantle xenoliths in southeastern China (a) and Cenozoic basalts in Zhejiang Province (b). GPS location of Xinchang mantle xenoliths: 29°17′53.0″N, 120°50′02.6″E.

(Wang et al., 2003, 2009; Xu et al., 2008), has been largely removed and replaced by younger, hotter and fertile mantle (Fan et al., 2000; Xu et al., 2000).

However, the ancient lithospheric mantle beneath the SE China might have not been completely removed (Xu et al., 2000). For example, a previous study on mantle xenoliths from Leizhou Peninsula (Guangdong) and Penglai (Hainan) indicates a stratified lithosphere architecture, with the presence of old lithospheric relicts above the young fertile mantle (Xu et al., 2002). The mantle replacement and accretion processes might be well recorded in the Cenozoic Xinchang mantle xenoliths, Zhejiang Province. In this study, we present the geochemical compositions different types of Xinchang mantle xenoliths, including five spinel lherzolites, eight spinel harzburgites and six garnet-bearing lherzolites, to reveal the stratified lithosphere architecture and discuss the mantle replacement and accretion processes in this region. Both major and trace elements suggest that the harzburgites have subjected to high degree of partial melting. They also have unradiogenic $^{187}Os/^{188}Os$ ratios, and thus, may represent the refractory lithospheric mantle relicts in this region. On the other hand, both spinel and garnet-bearing lherzolites have more fertile compositions and more radiogenic $^{187}Os/^{188}Os$ ratios, which might represent the newly accreted mantle from the asthenosphere beneath this area.