Gondwana Research 23 (2013) 176–189

Contents lists available at SciVerse ScienceDirect

Gondwana Research

journal homepage: www.elsevier.com/locate/gr

Coexistence of the moderately refractory and fertile mantle beneath the eastern Central Asian Orogenic Belt

Shaokui Pan [a], Jianping Zheng [a,*], Linlin Chu [a], W.L. Griffin [b]

[a] State Key Lab of Geological Processes and Mineral Resources, China University of Geosciences, Wuhan 430074, China
[b] GEMOC ARC National Key Centre, Department of Earth and Planetary Sciences, Macquarie University, NSW 2109, Australia

ARTICLE INFO

Article history:
Received 30 September 2011
Received in revised form 20 February 2012
Accepted 2 March 2012
Available online 9 March 2012

Keywords:
Peridotite xenoliths
Lithospheric mantle
The Central Asian Orogenic Belt

ABSTRACT

Relative to the North China Craton, the subcontinental lithospheric mantle (SCLM) beneath the Central Asian Orogenic Belt is little known. Mantle-derived peridotite xenoliths from the Cenozoic basalts in the Xilinhot region, Inner Mongolia, provide samples of the lithospheric mantle beneath the eastern part of the belt. The xenoliths are predominantly lherzolites with minor harzburgites, and can be subdivided into three groups, based on the REE patterns of clinopyroxenes. Group 1 peridotites (LREE-enriched), with low modal Cpx (3–7%), high $Mg^{\#}$ in olivine (>90.6) and $Cr^{\#}$ in spinel (>43.8), low whole-rock $CaO+Al_2O_3$ contents (1.62–3.22 wt.%) and estimated temperatures of 1043–1126 °C, represent moderately refractory SCLM that has experienced carbonatite-related metasomatism. Group 2 peridotites (LREE-depleted), with high modal Cpx (9–13%), low $Mg^{\#}$ in olivine (<90.6) and $Cr^{\#}$ in spinel (<20.0), high whole-rock $CaO+Al_2O_3$ contents (4.93–6.37 wt.%) and estimated temperatures of 814–970 °C, show affinity with Phanerozoic fertile SCLM that has undergone silicate-related metasomatism. Group 3 peridotites (convex-upward REE patterns), show wide ranges of olivine-$Mg^{\#}$ (88.4–90.6), spinel-$Cr^{\#}$ (11.5–47.6), and modal Cpx (3–14%) that overlap Groups 1 and 2. Their spinels have high TiO_2 contents (>0.41 wt.%), implying involvement of reactions between melt and peridotites. The estimated temperatures of Group 3 (1033–1156 °C) are similar to those of Group 1. We suggest that the pre-existing moderately refractory lithospheric mantle (i.e., Group 1) beneath the eastern part of the Central Asian Orogenic Belt was strongly penetrated by upwelling asthenospheric material, and the cooling of this material produced fertile lithospheric mantle (i.e., Group 2). The present lithospheric mantle of this area consists of interspersed volumes of younger fertile and older more refractory lithosphere, with the fertile type dominating the shallower levels of the mantle.

1. Introduction

The Central Asian Orogenic Belt (CAOB), extending from Kazakhstan to the western Pacific Ocean, is a tectonic collage that separates the Siberian Craton to the north from the Tarim block and the North China Craton (NCC) to the south. The major tectonic components of the fold belt include ophiolites, island arcs, oceanic islands, accretionary wedges and some Precambrian microcontinents (Sengör, 1993; Khain et al., 2002, 2003; Xiao et al., 2003; Dobretsov et al., 2004; Xiao et al., 2010). Geophysical and geochemical studies have documented the complicated history of this orogenic belt, involving Phanerozoic subduction of oceanic crust, closure of paleo-oceans and prolonged extensive magmatism (Sengör and Natalin, 1996; Khain et al., 2003; Kheraskova et al., 2003; Windley et al., 2007; Glorie et al., 2011; Cai et al., 2012), although the accretion model and origin of the Precambrian microcontinents have been controversial (Windley et al., 2007; Xiao et al., 2010; Jiang et al., 2011; Rojas-Agramonte et al., 2011). However, the nature and evolution of the subcontinental lithospheric mantle (SCLM) beneath the fold belt is weekly known.

Generally, the composition of the SCLM worldwide is broadly correlated with crustal age and/or tectonic setting (Boyd, 1989, 1997; Griffin et al., 1998a, 1999). The SCLM beneath Archean crust is usually refractory, such as in the Kaapvaal craton (Boyd, 1989; Griffin et al., 2004a) and the North American Craton (Schmidberger and Francis, 1999; Griffin et al., 2004b). In contrast, the Phanerozoic fold belts typically are underlain by more fertile lithospheric mantle. However, in some areas, the SCLM has been changed by tectonic processes and decoupled from its overlying crust. The NCC is a classic case; its eastern part is underlain by young fertile SCLM beneath the Archean crust (Zheng, 1999; Fan et al., 2000; Xu, 2001; Gao et al., 2002; Wu et al., 2006), especially in the areas associated with the translithospheric Tanlu Fault Zone (Zheng et al., 1998). The CAOB is known for large-scale juvenile crust growth during the Phanerozoic period (Chen et al., 2000; Jahn et al., 2000; Wu et al., 2000, 2002). In addition to voluminous widespread

* Corresponding author at: State Key Laboratory of Geological Processes and Mineral Resources, China University of Geosciences, Wuhan 430074, China. Tel.: +86 27 67885100 8301; fax: +86 27 67883873.
E-mail addresses: jpzheng@cug.edu.cn, jpzheng2003@yahoo.com (J. Zheng).

1342-937X/$ – see front matter
doi:10.1016/j.gr.2012.03.001

granitoids, scattered Precambrian microcontinents are also preserved (Sengör, 1993; Dobretsov et al., 2004; Xiao et al., 2010).

Mantle-derived peridotite xenoliths hosted by Cenozoic alkali basalts (Abaga basalts), in the province of Inner Mongolia, represent samples of the lithospheric mantle beneath the eastern CAOB. Deng and Macdougall (1992) presented Sm–Nd isotopic data for clinopyroxene from peridotite xenoliths contained in the basalts, and suggested that they record the Proterozoic depletion of the SCLM. The author argued that the lithospheric mantle beneath the eastern CAOB is decoupled from the overlying crust and does not seem to have recorded the Phanerozoic tectonic events seen in the crust. Here, we provide detailed petrographic, major-element and trace-element data of peridotite xenoliths from the Hueiterngshilii lava platform (the southern part of the Abaga basalt field) in the Xilinhot (XLHT) region, and compare these with data on peridotite xenoliths from other places, such as Hebi (Zheng et al., 2001) and Shanwang (Zheng et al., 1998) in the NCC and Wudalianchi–Erkeshan–Keluo (WEK) areas (Zhang et al., 2000; Zhang et al., 2011c), the Vitim plateau (Glaser et al., 1999; Litasov et al., 2000), Sikhote-Alin (Ionov et al., 1995), the Tariat region (Preβ et al., 1986; Kopylova et al., 1995; Ionov et al., 1997), and the Dariganga lava plateau (Wiechert et al., 1997; Ionov et al., 2002) in the eastern CAOB (Fig. 1a) to further constrain the nature and evolution of the lithospheric mantle beneath this huge orogenic belt.

2. Geological setting

The Central Asian Orogenic Belt, also called the Altaid Tectonic Collage, consists of two main parts: the Altaids in the north and the Manchurides in the south (Fig. 1b; Sengör and Natalin, 1996). They are separated by the Solonker suture zone which is widely regarded as the locus of the terminal closure of the Paleo-Asian Ocean (Xu and Chen, 1997; Xiao et al., 2003). The Solonker suture zone is marked by a belt of melanges, blueschists and ophiolites. Extending from west to northeast, the suture alternatively has been called the Suolun suture (Davis et al., 2001), the Tian Shan-Ying Shan suture (Yin and Nie, 1996), the Suolunshan-Hegenshan suture, the Hegenshan-Nenjiang-Heihe suture (Wu et al., 2002), and the SolonObo-Linxi suture (Liu et al., 2005). To the south of this suture zone, there lies the Mid Ordovician–Early Silurian Ulan island arc — Ondor Sum subduction-accretion complex and the Bainaimiao arc. To the north is an accretionary zone that extends southward from a Devonian to Carboniferous active continental margin, through the Hegenshan ophiolite-arc accretionary complex to the Late Carboniferous Baolidao

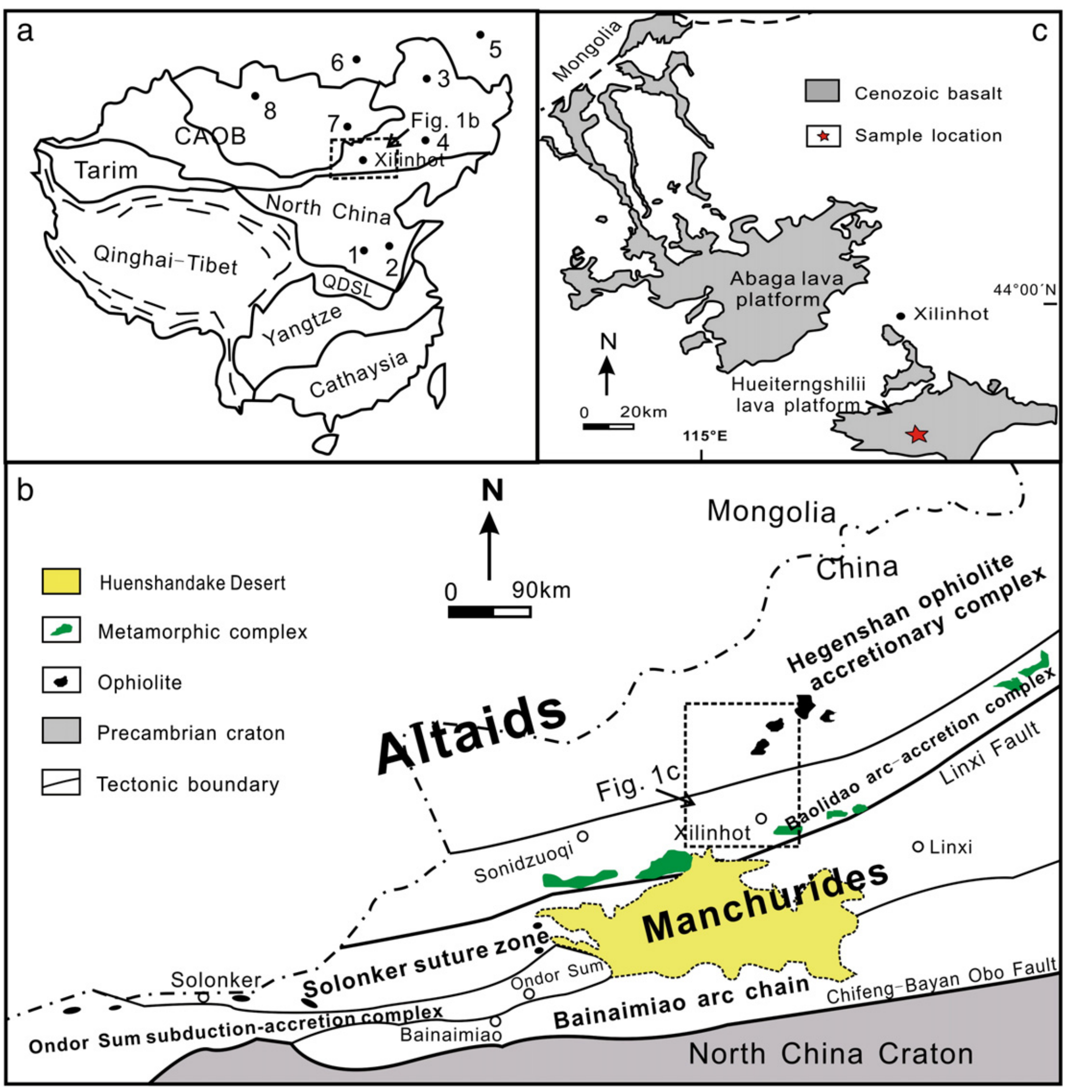

Fig. 1. (a) Locations of key peridotite–xenolith localities from the North China Craton (NCC) and eastern Central Asia Orogenic Belt (CAOB): 1. Hebi, 2. Shanwang from the NCC; 3. Wudalianchi–Erkeshan–Keluo (WEK, China), 4. Shuangliao, 5. Sikhote-Alin (Siberia), 6. Vitim, 7. Dariganga (Mongolia), and 8. Tariat (Mongolia). (b) Geological map showing major tectonic units of central Inner Mongolia (modified from Xiao et al., 2003). (c) The distribution of Cenozoic basaltic rocks and sample locations in the Xilinhot (XLHT) region, Inner Mongolia (modified from Deng and Macdougall (1992)).