Lithos 172–173 (2013) 243–266

Contents lists available at SciVerse ScienceDirect

Lithos

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

Zircon ages of metamorphic and magmatic rocks within peridotite-bearing mélanges: Crucial time constraints on early Carboniferous extensional tectonics in the Chinese Tianshan

Ping Jian [a,*], Alfred Kröner [a,b], Bor-ming Jahn [c], Dunyi Liu [a], Wei Zhang [a], Yuruo Shi [a], Huadong Ma [d]

[a] Beijing SHRIMP Center, Institute of Geology, Chinese Academy of Geological Sciences, Baiwanzhuang Road 26, Beijing 100037, China
[b] Institut für Geowissenschaften, Universität Mainz, D-55099 Mainz, Germany
[c] Institute of Earth Sciences, Taiwan National University, Nangang, Taipei 11529, Taiwan
[d] National 305 Project Office, Western Kelamayi Road 2, Urumqi, China

ARTICLE INFO

Article history:
Received 5 January 2013
Accepted 13 April 2013
Available online 26 April 2013

Keywords:
Orogenic peridotite
Granulite
Dolerite
Garnet granite
Chinese Tianshan
Zircon chronology

ABSTRACT

We dated and geochemically characterized peridotite-bearing mélanges in the Chinese South Tianshan and within the Main Tianshan Shear Zone. The Yushugou-Tonghuashan mélange in the Chinese South Tianshan exposes a tectonic juxtaposition of a diapirically emplaced metaperidotite (predominantly lherzolite) massif with a high-grade metamorphic terrane (ca. 10 km long; protolith age ≥ ca. 445–466 Ma). Metamorphic zircons of a mafic granulite ($\varepsilon_{Nd(t)} = 5.0$) yielded a weighted mean $^{206}Pb/^{238}U$ age of 341 ± 8 Ma that we interpret as the time of granulite-facies metamorphism. The youngest zircon rims of an intermediate granulite ($\varepsilon_{Nd(t)} = -4.3$) have a mean age of 332 ± 13 Ma that records a retrogressive metamorphic event. These ages determine the timing (ca. 341–332 Ma) of mantle diapirism through continental crust. A dolerite dike ($\varepsilon_{Nd(t)} = 2.3$) emplaced into metaperidote has a crystallization age of 335 ± 5 Ma, that, on the basis of geochemistry, we interpret as representing E-MORB-OIB magmatism that accompanied mantle diapirism. An undeformed pink granite ($\varepsilon_{Nd(t)} = -3.6$) intrudes the mélange matrix and has an emplacement age of 324 ± 5 Ma, thus providing an upper time limit for a tectonic movement that led to mélange formation. The older time limit of deformation (ca. 362–352 Ma) is constrained by the youngest ages of thermo-tectonically modified zircons in a mylonitized metagabbro and a foliated meta-andesite. Magmatic zircons in the meta-andesite ($\varepsilon_{Nd(t)} = -3.3$) and a dacite ($\varepsilon_{Nd(t)} = -5.6$) have eruption ages of 433 ± 4 Ma and 435 ± 3 Ma that date formation of the mélange matrix. A microgabbro dike ($\varepsilon_{Nd(t)} = 10.0$) cutting metasediments (i.e. mélange matrix) has an emplacement age of 279 ± 3 Ma and contains abundant zircon xenocrysts ranging in age from Archean to late Paleozoic. Similarly, a dolerite dike, a meta-andesite, an intermediate granulite, and a metagabbro all contain inherited Precambrian to Paleozoic zircons. We accordingly conclude that the mélange was formed by mantle diapirism in the early Carboniferous and was subsequently affected by an early Permian volumetrically minor mafic episode. Two foliated garnet granites ($\varepsilon_{Nd(t)} = -7.0$ and -6.9), in direct contact with metaperidotite within the Main Tianshan Shear Zone have emplacement ages of 341 ± 2 Ma and 329 ± 4 Ma that reflect an early Carboniferous episode of crustal anatexis. They also contain Neoproterozoic zircon xenocrysts. Also within the Main Tianshan Shear Zone, a gabbro ($\varepsilon_{Nd(t)} = 8.7$) has an emplacement age of 297 ± 3 Ma and contains abundant Neoproterozoic to late Paleozoic zircon xenocrysts. Based on the regional geological relationships, we associate early Carboniferous mantle diapirism and crustal anatexis with lower crustal delamination-induced asthenospheric upwelling. The numerous Precambrian zircon xenocrysts support a Chinese Tianshan–Tarim connection. The early Permian mafic episode coincided in time with the development of an early Permian unconformity in the Chinese North Tianshan.

1. Introduction

Peridotites in mountain belts represent tectonically emplaced upper mantle rocks of diverse provenance, namely subcontinental, suboceanic and subarc (e.g., Bodinier and Godard, 2007). In terms of rock associations in the field the peridotites can be subdivided into two principal types, namely orogenic and ophiolitic (e.g., Menzies and Dupuy, 1991; Vielzeuf and Kornprobst, 1984). Orogenic peridotites are generally characterized by a predominance of subcontinental lherzolite (e.g., Bodinier and Godard, 2007; Shervias and Mukasa, 1991). In most cases, they are associated with granulite-facies lower continental rocks such as in the Alpine Malenco (Müntener et al., 2000), Pyrenean (Vielzeuf and Kornprobst, 1984) and Ivrea Zone (Quick et al., 1994; Schnetger, 1994; Shervias and Mukasa, 1991; Vavra et al., 1999) peridotite massifs. A lherzolite–granulite association is interpreted to reflect the structural

* Corresponding author. Tel.: +86 10 68999765; fax: +86 10 68311545.
E-mail address: jianping_510@yahoo.com.cn (P. Jian).

0024-4937/$ – see front matter © 2013 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.lithos.2013.04.018

juxtaposition of an exhumed subcontinental mantle with lower continental crust, generally in an extensional tectonic setting. Such associations also occur in Zabargad Island of the Red Sea Rift (Bonatti and Seyler, 1987) and in central Yukon of the northern Cordillera (Canil et al., 2003; Johnston et al., 2007).

Theoretically, orogenic peridotites are distinct from ophiolitic peridotites in being spatially unrelated to oceanic magmatic and ocean floor volcano-sedimentary rocks (e.g., Menzies and Dupuy, 1991; Shervias and Mukasa, 1991). In practice, however, an orogenic peridotite could potentially be mistaken for an ophiolite component, largely due to incomplete investigation of field relationships and a biased, model-dependent understanding of tectonic setting.

We present SHRIMP zircon ages and whole-rock geochemical data for magmatic and metamorphic rocks from several peridotite-bearing mélanges (Figs. 1 and 2) in the Chinese Tianshan Mountains. These mélanges were previously viewed as ophiolitic mélanges (e.g., Allen et al., 1992; Dong et al., 2001; Shu et al., 2004; Wang et al., 1999a,b; Xu et al., 2011) and were associated with accretionary tectonics (e.g., Allen et al., 1992; Charvet et al., 2007; Xiao et al., 2004, 2013). Based on our new data and by incorporating regional data from the literature, we reassess the tectonic significances of these mélanges and place crucial time constraints on early Carboniferous extensional tectonics in the Chinese Tianshan.

2. Regional geology

The Tianshan mountain range forms part of the Central Asian Orogenic Belt (CAOB; Jahn et al., 2000; Fig. 1 inset) and extends from Xinjiang Province in NW China across Kyrgyzstan and Kazakhstan to Uzbekistan. This large area borders the Tarim craton in the south and in China is tectonically subdivided into Chinese South, Central and North Tianshan domains and the Yili block by a number of fault systems (e.g., the Main Tianshan Shear Zone, MTSZ) (Fig. 1).

2.1. Tarim craton

This craton (Fig. 1) is predominantly composed of Archean to Neoproterozoic basement rocks with a late Neoproterozoic to early Paleozoic sedimentary cover (Zhang et al., 2013). On the northern margin it is unconformably overlain by early Carboniferous conglomerates (Carroll et al., 1995). Zircon dating of an undeformed granodiorite from this marginal area yielded emplacement ages of ca. 420 Ma (Ge et al., 2012).

2.2. Chinese South Tianshan

The Chinese South Tianshan (Fig. 1) extends into neighboring Kyrgyzstan Tianshan and constitutes a major fold-and-thrust-belt (Biske et al., 2012). In China it comprises numerous peridotite massifs (Fig. 1), set in a variably sheared matrix of Ordovician to Devonian carbonate and volcaniclastic rocks (Li et al., 2009). The Heiyingshan (Fig. 1) peridotites, together with co-existing gabbro, basalt, diabase and chert were thought to form a coherent ophiolite suite (Shu et al., 2007; Wang et al., 2011). However, the gabbros have significantly different zircon ages of 425 ± 5 Ma (Fig. 1; Han et al., 2011) and 392 ± 5 Ma (Wang et al., 2011), and the cherts contain radiolarian fossils of diverse Famennian (ca. 375–359 Ma) and Visean (ca. 345–326 Ma) ages (Shu et al., 2007). The assumed coherence is thus problematic. To the east, at the Kulehu locality (Fig. 1), a gabbro zircon age of 425 ± 8 Ma was interpreted to represent the time of ophiolite formation (Long et al., 2006). However, many Precambrian zircon xenocrysts (ca. 1059–794 Ma), together with two Carboniferous (ca. 334 Ma and 313 Ma) grains were present in the dated sample (see Long et al., 2006), and

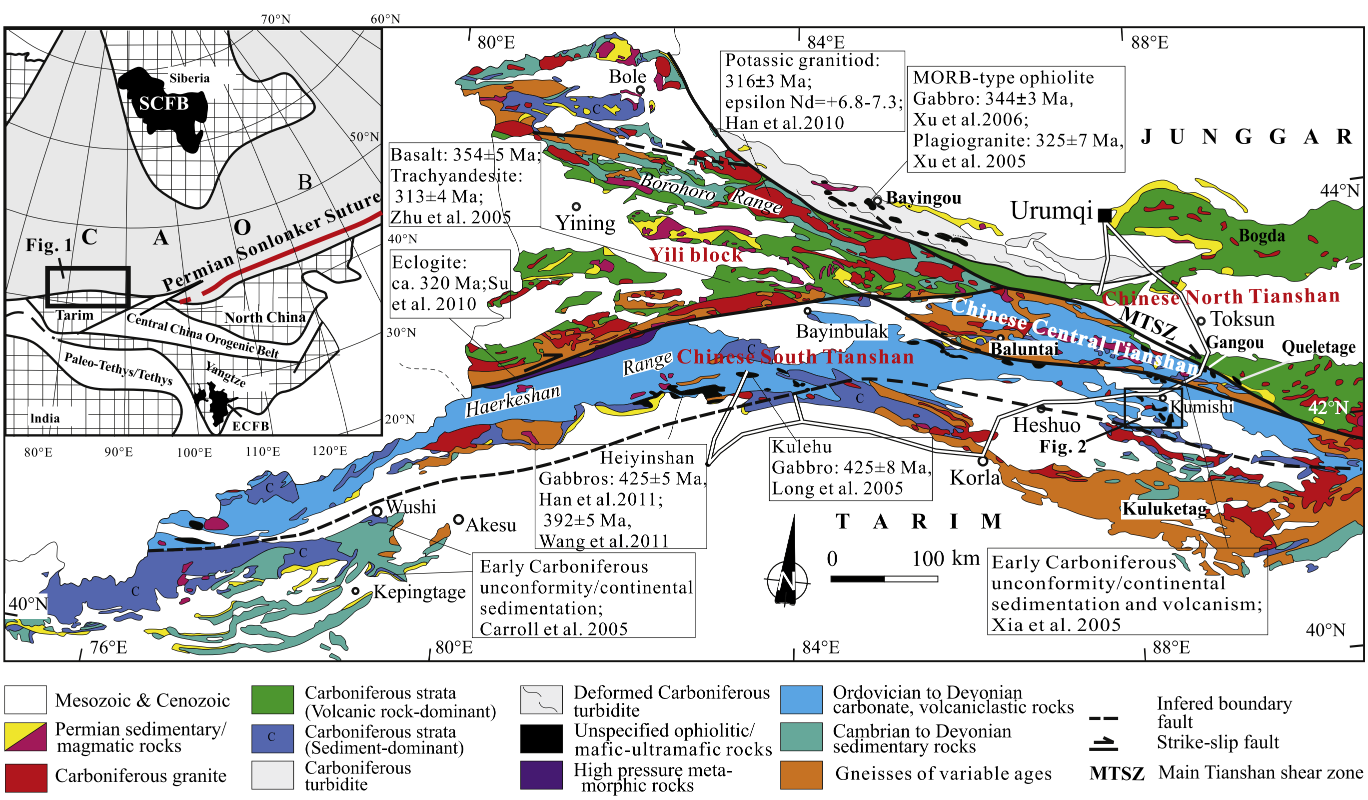

Fig. 1. Simplified geological map of the Chinese Tianshan (after Wang et al., 2010). Position of Fig. 2 and important regional data are marked. Inset shows tectonic framework of Asia (after Li, 2006) and the location of the Chinese Tianshan in the Central Asian Orogenic Belt (CAOB) (Jahn et al., 2000). In order to avoid confusion on Tianshan nomenclature this paper refers to Chinese domains as Chinese North, Central and South Tianshan and Yili block. Most of the Chinese Central Tianshan correlates to the west with the combined Kyrgyz Middle and North Tianshan, and the Yili block is equivalent, to a large extent, to the Kyrgyzstan/Kazakhstan North Tianshan (c.f. Biske et al., 2012; Kröner et al., 2012, 2013).