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Crustal architecture of the Shangdan suture zone in the early Paleozoic Qinling orogenic belt, China: Record of subduction initiation and backarc basin development

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ABSTRACT

The early Paleozoic Shangdan suture zone in the Qinling orogenic belt (China) marks the main tectonic boundary between the North China and South China blocks. The mafic rocks along this suture zone make up three distinct geochemical groups: (1) MORB-like; (2) boninite-like, and (3) island arc type. The MORB-like basalts display the highest values of TiO_2 (0.86 wt.%–1.99 wt.%), LREE depletion and no negative Nb–Ta anomalies. However, their enrichment in LILEs relative to N-MORB indicates subduction influence in their melt source. The boninite-like rocks display lower TiO_2 (0.09 wt.%–0.41 wt.%) and FeO* (4.3 wt.%–10.25 wt.%) contents, lower Ti/V ratios and total REEs, and high Cr (303–1495 ppm) and Ni (102–383 ppm) values. These geochemical features collectively indicate that magmas of the boninite-like rocks were derived from partial melting of a refractory mantle source. However, distinctly different ages of the boninite-like rocks imply that not all boninite-like rocks in the Shangdan suture zone formed in association with subduction initiation. The 524 Ma boninite-like doleritic rocks record the subduction initiation magmatism, whereas the younger boninite-like dolerites with more depleted geochemical signatures represent a magmatic stage associated with backarc spreading around 474 Ma. The arc-type lavas display strong negative Nb–Ta and Zr–Hf anomalies, characteristic of intra-oceanic island arc rocks. The combined geological, geochemical and regional tectonic features of the ophiolitic rocks along the Shangdan suture zone in the North Qinling orogenic belt provide a record of subduction initiation, island arc development and backarc rifting in the early Paleozoic, reminiscent of the modern IBM arc-trench system.

1. Introduction

The Central Orogenic Belt (COB) between the North China (NCB) and South China blocks (SCB) in China represents the northernmost orogenic collage within the Tethyan domain that experienced a series of subduction–accretion events in the early Paleozoic, and an intra-continental orogenic event in the Cretaceous. It is bounded by the early Paleozoic tectonic belt in the North Central Orogenic Belt (N-COB) and the early Mesozoic tectonic belt in the South China Orogenic Belt (S-COB) (Fig. 1). Several Gondwana-derived blocks (i.e. the Qaidam, Central Qilian and North Qinling blocks) in the N-COB are separated from each other by the early Paleozoic suture zones (Li et al., 2002; Wang et al., 2004; Darby and Gehrels, 2006; N.S. Chen et al., 2006; Wan et al., 2006; Zhang et al., 2006). Documenting the crustal architecture and geochronology of these early Paleozoic sutures is critical to understand the tectonic evolution of the Qinling orogenic belt in Central Asia (Dilek and Robinson, 2003; Furnes et al., 2014).

The early Paleozoic Shangdan suture zone (Fig. 2) is an important tectonic entity within the Qinling orogenic belt and marks the main boundary between the North China and South China blocks (Meng and Zhang, 1999, 2000; Zhang et al., 2001; Dong et al., 2011b). It contains the early Cambrian to early Silurian ophiolites, volcanic arc assemblages and subduction–accretion complexes (Cui et al., 1995; Zhang et al., 2001; Lu et al., 2003a, 2003b; Z.H. Chen et al., 2004; Su et al., 2004; Pei et al., 2005; Li et al., 2006; Yang et al., 2006; Li et al., 2007; Liu et al., 2007; Pei et al., 2007; Chen et al., 2008; Yan et al., 2008a; J.F. Liu et al., 2009; Jiang et al., 2009; Wang et al., 2009; Dong et al., 2011a), indicating that its evolution involved the creation and consumption of an early Paleozoic ocean basin. The existing models on the tectonic evolution of the Shangdan suture zone vary in terms of the inferred paleogeography of this early Paleozoic basin and the polarity and duration of the subduction zone(s) that facilitated its demise (Xia et al., 1996; Yin et al., 2004; Xu et al., 2006; Wang et al., 2009; Dong et al., 2011a, 2011b). The relative lack of detailed information and structural, geochemical and geochronological data

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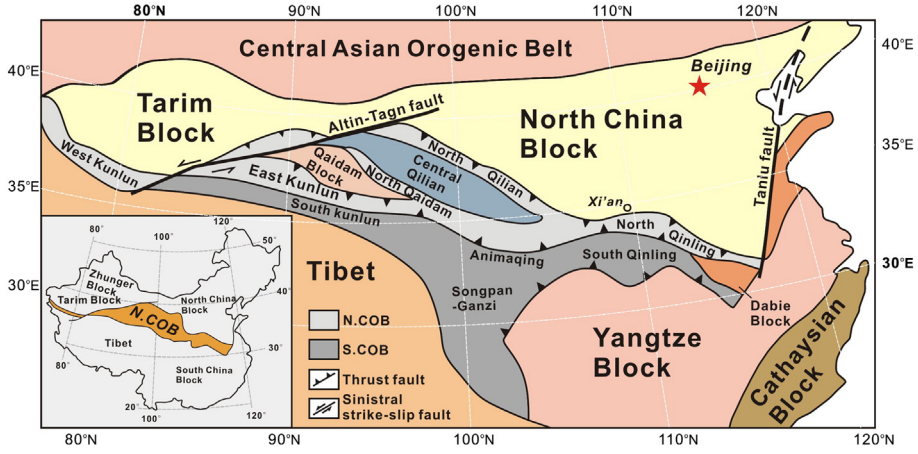

Fig. 1. Simplified geological map of the Central Orogenic Belt, showing various continental blocks, suture zones and tectonic features. Key to symbols: N.COB — Northern Central Orogenic Belt; S.COB — Southern Central Orogenic Belt.
Modified from Yang et al. (2003) and Xu et al. (2006).

on the ophiolitic rocks along and across the suture zone is largely responsible for the poorly constrained tectonic models on its development through time.

In this paper we describe the field occurrence of the mafic–ultramafic rock assemblages within the Shangdan suture zone in the Qinling orogenic belt (Fig. 2) and present new geochemical data and interpretations on them in order to determine the timing and tectonic setting of their formation in the early Paleozoic. Using the available geochronological data in the literature, we synthesize the regional geology and the geodynamic evolution of the ocean basin, whose multi-stage development produced several nested ophiolite complexes of different ages and tectonic environments that were juxtaposed during a series of collisional events. Our model provides an internally coherent explanation for the complex crustal architecture of the Shangdan suture zone and the Qinling orogenic belt.

2. Geological setting

The N-COB evolved via subduction–accretion and continental collision events that produced ophiolites, island arc assemblages, and high to ultrahigh pressure metamorphic rocks (e.g. Yang et al., 1996; Zhang et al., 2001; Yang et al., 2003; Song et al., 2005, 2006; Xu et al., 2006; Meng et al., 2012). The Qinling–Dabie orogen in the eastern part of the N-COB (Fig. 1) resulted from the collision between the NCB and SCB (Zhang et al., 1996; Ernst et al., 2007; Zheng, 2008; Liou et al., 2009; Zhang et al., 2009; Zheng et al., 2012; Wu and Zheng, 2013). In the western part of the Qinling orogen, the N-COB includes three major suture zones: the north Qilian, the north Qaidam and eastern Kunlun suture zones, indicating multiple subduction–accretion and collision events in the early Paleozoic (550–420 Ma) history of the N-COB (Fig. 1) (e.g. Lu et al., 2004; Yang et al., 2005; Xu et al., 2006; Xiao et al., 2009; Meng et al., 2014).

The early Paleozoic North Qinling orogenic belt (NQB) in the middle of the N-COB occurs on the southern margin of the North China Block and adjacent to the South Qinling Block to the south, and is bounded by the Luonan–Luanchuan fault (LLF) to the north and the Shangdan fault (SDF) to the south (Fig. 2). The NQB can be subdivided from north to south into several distinct tectonic domains, including the Kuanping Group, Erlangping Group, North Qinling Group and the Shangdan suture zone (Zhang et al., 2001).

2.1. Kuanping Group

The Kuanping Group (Fig. 2), bounded by the Luonan–Luanchuan fault to the north, is adjacent to the North China Block and merges with the Erlangping Group to the south. It mainly comprises

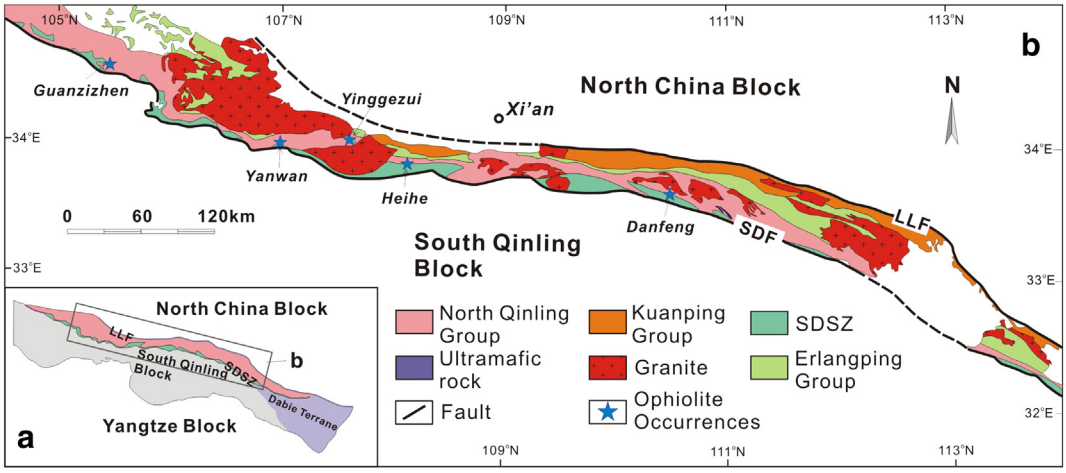

Fig. 2. Tectonic map of the North Qinling orogenic belt. a — Index map of the Qinling orogenic belt showing the main tectonic divisions and units: b — geological/tectonic map of the North Qinling orogen belt. Key to symbols: SDF — Shangdan fault; LLF — Luonan–Luanchuan fault; SDSZ — Shangdan suture zone.
Modified from Zhang et al. (2001).

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