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Neoproterozoic amalgamation of the Northern Qinling terrain to the North China Craton: Constraints from geochronology and geochemistry of the Kuanping ophiolite

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ABSTRACT

The Proterozoic tectonic evolution of the Qinling Orogenic Belt is a key to understanding the convergent processes between the North China and South China Blocks. The widely exposed Kuanping ophiolite melange between the North Qinling Terrain and the North China Block provides important constraints on the Meso-Neoproterozoic tectonic evolutionary processes between the North Qinling Terrain and North China Block. Detailed geological mapping reveal that the Kuanping ophiolite melange consists of an ophiolite and a meta-sedimentary unit. According to our new geochemical investigations, the ophiolite unit can be briefly divided into two groups: (1) N-MORB and (2) E-MORB. The former is characterized by depletion in light rare earth elements, large-ion lithophile elements, and non-differentiation in high field strength elements. The latter shows slight enrichment in light rare earth elements, large-ion lithophile elements, and minor differentiation in high field strength elements. Accordingly, it is inferred that the Kuanping ophiolite likely represents remnants of an oceanic crust (named as Kuanping Ocean) between the North Qinling Terrain and the North China Block. One metamorphosed N-MORB sample from the Kuanping ophiolite was selected for LA-ICPMS zircon U–Pb dating, which displays an age of 1445 ± 60 Ma, probably represents the formation time of the Kuanping Ocean. Integrated with the regional geological, geochemical and geochronological data, we propose that the North Qinling Terrain amalgamated to the North China Block after a southward subduction of a Mesoproterozoic ocean represented by the Kuanping ophiolite.

1. Introduction

The Qinling Orogenic Belt (QOB), middle part of the China Central Orogenic Belt, is well documented that it was formed by northward subduction and collision between the South China Block (SCB) and North China Block (NCB) (Fig. 1) (Ames et al., 1996; Bader et al., 2013a,b; Dong et al., 2011a,b,c, 2013; Enkin et al., 1992; Hacker et al., 1998; Hsü et al., 1987; Kröner et al., 1993; Li et al., 1993; Mattauer et al., 1985; Meng and Zhang, 1999; Okay and Sengör, 1993; Sengör, 1985; Wang et al., 1989; Zhai et al., 1998; Zhang et al., 2001) along the Shangdan suture zone in the Paleozoic time (Dong et al., 2011a,b,c, 2013). The Shangdan suture (SDS) is marked by largely exposure of Early Paleozoic ophiolites and subduction-related magmatism, and was suggested as a major convergent boundary separating the NCB from the SCB (Dong et al., 2011b). By this boundary, the QOB can be divided into the South Qinling Belt (SQB) and the North Qinling Belt (NQB), which were traditionally regarded as parts of the SCB and NCB, respectively (Zhang et al., 2001). Detailed investigations revealed that the NQB can be further subdivided into the North Qinling Terrain (NQT) to the south and the Southern sector of the NCB (S-NCB) to the north by the Luonan-Luanchuan fault (LLF). It is commonly accepted that the S-NCB was once attributed to NCB due to their well correlation in tectono-lithostratigraphic characteristics of the Neoarchean-Paleoproterozoic basements and Mesoproterozoic–Paleozoic cover successions between each other. However, the correlation between the NQT and NCB was largely disputed during the past decades. Most authors suggested that the NQT was originally the southern part of the NCB, and was splitted from the S-NCB since the spreading of the Erlangping back-arc basin in the Paleozoic (Dong et al., 2011a,b; Meng and Zhang, 1999; Zhang et al., 1986, 1994a, 1995a, 2001) or the Kuanping back-arc basin in the Proterozoic (Dong et al.,

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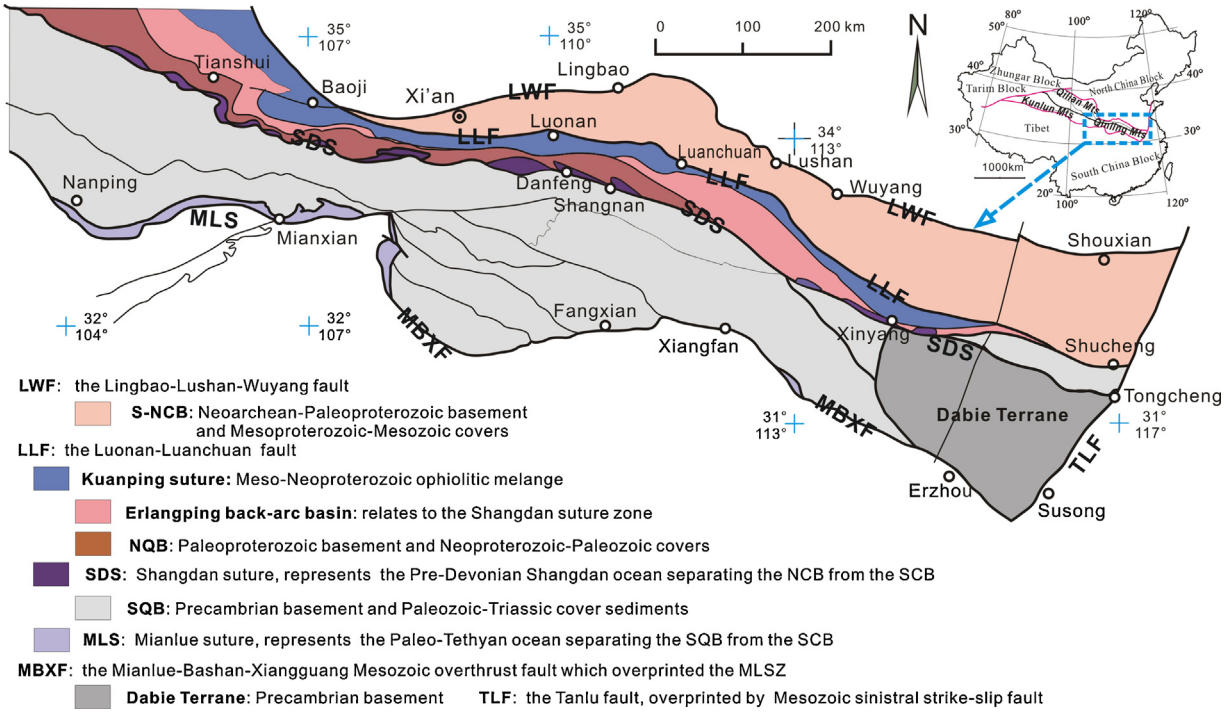

Fig. 1. Simplified tectonic and lithostratigraphic map of the Qinling orogenic belt (Modified from Dong et al., 2011a). Insert map in upper-right corner shows the location of the Qinling orogen within China.

2008a). However, the Pb isotopic compositions and Nd model ages argued that the NQT was rather different from the NCB (Zhang et al., 1996a; Zhu, 2001). Therefore, the tectonic affinity of the NQT is still controversial, which plays a key role to understanding the tectonic framework and orogenic processes between the NCB and SCB.

Based on detailed geological investigation, this study undertakes petrological, geochemical and geochronological survey of the ophiolite and related volcanic rocks, as well as U–Pb zircon dating on a representative metabasaltic rock from the Kuanping ophiolitic melange on the northern margin of the NQT. According to the new dataset, we characterize their original magma compositions and likely mantle source environments, and advance the understanding of the Proterozoic tectonic framework and evolutionary history of the Qinling Orogen, as well as formation of the Rodinia supercontinent.

2. Tectonic framework and geological units

The QOB is bordered by the Lingbao-Lushan-Wuyang thrust fault (LWF) to the north and the Mianlue-Bashan-Xiangguang thrust fault (MBXF) to the south, respectively (Fig. 1). The LWF is an intra-continental thrust fault along which the North China Craton subducted southward beneath the QOB during the Mesozoic time (Zhang et al., 2001). The MBXF is a southward overthrust fault along which the SQB emplaced onto the South China Block (Dong et al., 2008b). The QOB can be divided into four tectonic belts which are the S-NCB, NQT, SQB and the N-SCB, by three sutures including the Kuanping suture, Shangdan suture and the Mianlue suture from north to south, respectively (Figs. 1 and 2).

2.1. Major tectonic belts

2.1.1. North-sector of the South China Block

The N-SCB predominantly consists of metamorphosed pre-Sinian basement and nearly non- metamorphosed Sinian-Mesozoic cover sequences (Dong et al., 2008b, 2012). The Neoarchean–Neoproterozoic basements of the SCB are exposed and represented by the scattered Bikou, Hannan terranes and Huangling massif. They are unconformably overlain by the continuous sedimentary sequences of Sinian clastic rock and carbonate, Cambrian–Ordovician limestone, Silurian siltite and shale, and subsequently covered by Permian-Middle Triassic limestone with pseudo-conformity. Afterwards, the strata are unconformably overlain by Upper Triassic-Cretaceous continental facies clastic rocks.

2.1.2. South Qinling belt

The SQB is characterized by thin-skinned structures, which includes south-vergent thrust-fold system comprising a Pre-Sinian basement and overlying Sinian to Phanerozoic sedimentary rocks (Dong et al., 2013; Zhang et al., 2001). The basement contains several Precambrian complexes (e.g. the Xiaomoling, Douling, Tongbai-Dabie and Yudongzi complexes) with Meso- to Neoproterozoic rift-type volcanic-sedimentary assemblages metamorphosed at greenschist facies conditions (Zhang et al., 1995a). The sedimentary cover includes Sinian to Carboniferous clastic and carbonate rocks. A few Permian to Lower Triassic clastic sedimentary rocks are present in the northern part of the SQB (Zhang et al., 2001). It is noticeable that the most portions of the western SQB were intruded by Triassic granitoids (Dong et al., 2011a), while the eastern SQB only exposed Neoproterozoic mafic dyke swarms and minor granitoids (Wang et al., 2013).

2.1.3. North Qinling Terrain

The NQT is located between the Kuanping suture to the north and Shangdan suture zone to the south. It mainly comprises the Precambrian basement unit of Qinling Group, metamorphosed Neoproterozoic and Lower Paleozoic ophiolites, volcanic-sedimentary assemblages, and are unconformably covered by locally occurring Carboniferous and/or Permian-Triassic clastic sediments. From north to south, the main lithostratigraphic units in NQT are the Erlangping Group and Qinling Group, which