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Geochemistry of the Mian-Lue ophiolites in the Qinling Mountains, central China: Constraints on the evolution of the Qinling orogenic belt and collision of the North and South China Cratons

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Abstract

The Anzishan ophiolite, a typical ophiolitic block of early Carboniferous age in the Mian-Lue suture zone of the Qinling Mountains, central China, consists of amphibolites/metabasalts, gabbros and gabbroic cumulates. All of these rocks, as well as those in the Hunshuiguan-Zhuangke (HZ) block, have compositions similar to normal MORB and back-arc basin basalts (BABB) with high $\varepsilon_{Nd(t)}$ values, indicating that they were derived from a depleted mantle source. The Mian-Lue suture zone also contains blocks of other lithologies, e.g., rift volcanic rocks in the Heigouxia block and arc volcanic rocks in the Sanchazi block. Although they are in fault contact with each other, the presence of these different blocks in the Mian-Lue suture zone may represent a complete Wilson cycle, from initial rifting to open ocean basin to final subduction and continent-continent collision, during the late Paleozoic-early Triassic. In this region, the North and South China Cratons were separated by Paleo-Tethys at least until the early Carboniferous, and final amalgamation of both cratons along the Qinling orogenic belt took place in the Triassic.

Keywords: Geochemistry; Mian-Lue suture; Ophiolite; Qinling orogenic belt; Central China

1. Introduction

Ophiolites contain valuable information on the genesis and evolution of oceanic lithosphere and provide clues to the tectonic history of orogenic belts. Ophiolites were previously believed to represent fragments of oceanic crust produced by spreading at mid-oceanic ridges (e.g., Coleman, 1977), but by the early 1980s, it was recognized that they can also form in supra-subduction zones (SSZ) (Pearce et al., 1984). It is now generally accepted that ophiolites can be produced in a variety of tectonic settings, but that most have a suprasubduction zone signature (Bloomer et al., 1995; Dilek et al., 2000; Dilek and Robinson, 2003).

However, identification of the precise paleotectonic environments of ophiolites is difficult. For example, MORB produced by extension at a mid-ocean ridge may be very similar to lavas formed in a mature back-arc basin (Wallin and Metcalfe, 1998; Nicholson et al., 2000). Thus, constraining the geochemistry of the ophiolites and determining their geological relationships with adjacent lithotectonic elements are critical to identifying specific tectonic settings.

The Qinling orogenic belt separates the North and South China Cratons in north-central China (Fig. 1). Previous studies suggested that these two cratons were joined along the Shangdan suture zone (Fig. 1) (Zhang, 1988; Xu et al., 1988, 1996), but there was little agreement on the timing of collision. Contrasting models proposed collision ages ranging from middle Paleozoic to Triassic (e.g., Xue et al., 1996; Gao et al., 1995; Li et al., 1993; Enkin et al., 1992). More recently, a second

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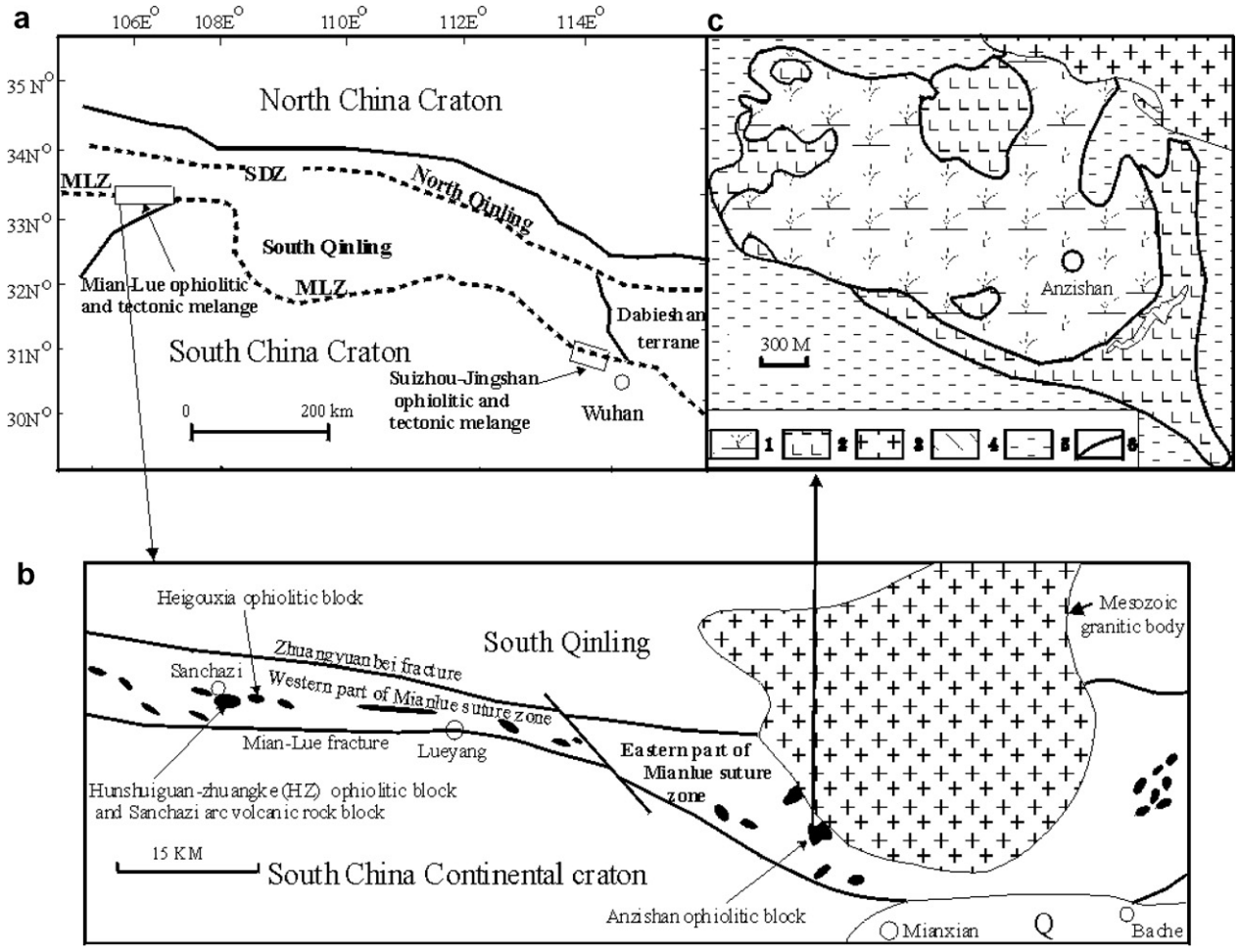

Fig. 1. Geological map of the Mian-Lue suture zone. (a) The location of the Mian-Lue suture zone. MLZ, Mian-Lue suture zone; SDZ, Shangdan suture zone. The location of the Suizhou-Jingshan ophiolite is also shown in the map (after Dong et al., 1999). (b) Distribution of ophiolitic blocks within the Mian-Lue zone. The area between the Mian-Lue and Zhuangyuanbei fractures is the Mian-Lue suture zone. Dark areas are ophiolitic blocks with mafic and ultramafic rocks. (c) Geological map of the Anzishan ophiolite. 1. serpentinized peridotite, 2. meta mafic rocks, 3. Mesozoic granite, 4. plagioclase granite dyke, 5. meta sedimentary rocks, 6. fault.

suture zone, marked by a discontinuous belt of ophiolites (the Mian-Lue ophiolites or MLO), was recognized in the southern Qinling Mountains (Xu et al., 1994; Zhang and Lai, 1995; Zhang et al., 1996). The presence of this suture zone and the MLO indicate that the Qinling orogenic belt underwent a more complex tectonic evolution than previously suspected. Previous workers suggested that the Mian-Lue suture zone marks the site of Paleo-Tethys (e.g., Zhang and Lai, 1995; Xu et al., 1998, 2000a, 2002; Xu and Han, 1996; Li et al., 1996; Meng and Zhang, 1999), but the evidence for this interpretation was inconclusive and the tectonic environment in which the MLO formed was still unresolved. Thus, we have undertaken a detailed investigation of the ophiolites in order to understand their origin and their role in the evolution of the suture zone. In this paper, we present new geochemical data on the MLO, which provide insights into their origin and emplacement. Combined with previous studies, this work places additional constraints on the tectonic development of the Qinling orogenic belt.

2. Geologic setting

The Mian-Lue suture zone (Xu et al., 1994; Zhang and Lai, 1995) extends for about 160 km from east to west through the southern Qinling Mountains (Fig. 1). A recent study by Dong et al. (1999) suggests that the suture zone extends eastward to the Suizhou-Jingshan area (Fig. 1) on the southern side of the Dabie orogenic belt where a contemporaneous ophiolitic belt is present.

The suture zone, which varies in width from 1 to 5 km in the Mian-Lue area (Fig. 1), contains a mélange composed of numerous tectonic slices or blocks of variable size. Most of the blocks or slices are strongly sheared and contain numerous lithologies, including ophiolitic material, arc volcanic rocks, Devonian-Carboniferous and Sinian-Cambrian sedimentary rocks and Precambrian metamorphic rocks. Radiolarian cherts and limestones are locally associated with the ophiolitic blocks. Nearly all of the rocks in the suture zone have been metamorphosed with the metamorphic grade generally increasing from lower greenschist facies in the west to upper greenschist or amphibolite facies in the east.