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Relicts of the Early Cretaceous seamounts in the central-western Yarlung Zangbo Suture Zone, southern Tibet

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ABSTRACT

Despite more than 30 years' studies in the Yarlung Zangbo Suture Zone (YZSZ), southern Tibet is still a region of discovery and the geological evolution of the Neo-Tethys here remains controversial. In this paper we present the new field observation, petrography, zircon U–Pb dating and geochemistry of the Zhongba mafic rocks in the western segment of the YZSZ. Zircon U–Pb analyses from a diabase using SIMS (Secondary Ion Mass Spectrometry) yielded a concordant age of 125.7 ± 0.9 Ma. All the Zhongba mafic rocks exhibit LREE enrichment ($La_N/Yb_N = 4.7–15.8$) without Eu anomalies ($\delta Eu = 0.97–1.01$). Their Primitive-Mantle-normalized trace element patterns are similar to those of the average OIB and Hawaii alkaline basalts, as well as other OIB-type rocks already reported in the central-western YZSZ. These observations lead us to suggest the existence of a series of seamounts within the Neo-Tethys during the Early Cretaceous. These OIB-type rocks could be originated from (1) hotspot mantle; (2) near-ridge seamounts by melting-induced mixing of two distinct mantle sources; (3) late-stage magmatism fed by melts that originated from an asthenospheric window due to slab delamination. Combining literature data from the entire YZSZ, which include studies of the MORB- and IAB-type rocks and mantle peridotites, we prefer the third explanation that the OIB-type rocks represent a late-stage magmatic activity above an intra-oceanic supra-subduction zone within the Neo-Tethys.

1. Introduction

The Yarlung Zangbo Suture Zone (YZSZ) is the southernmost suture across the Tibetan Plateau, which separates the India to the south from the Lhasa terrane to the north (Fig. 1). It is believed to represent remnants of the Neo-Tethyan ocean lithosphere. Much remains to be understood about what was the geodynamic configuration of Neo-Tethys prior to its demise by the northward subductions during Mesozoic and early Cenozoic. The Yarlung Zangbo ophiolites could provide such information. In the 1980s, they were interpreted as remnants of oceanic lithosphere formed at a spreading center (e.g. Allègre et al., 1984; Girardeau and Mercier, 1988; Girardeau et al., 1985a, 1985b; Nicolas et al., 1981; Pearce and Deng, 1988). However, more and more studies have reached a consensus that the Yarlung Zangbo ophiolites were formed in a supra-subduction zone setting (e.g. Aitchison et al., 2000; Bédard et al., 2009; Dubois-Côté et al., 2005; Dupuis et al., 2005; Guilmette et al., 2008, 2009; Hébert et al., 2003; Wang et al., 2000; Zhou et al., 1996, 2005; Ziabrev et al., 2004; please see Hébert et al., in press for a review). Recently, several studies have reported the existence of the OIB-type (Oceanic Island Basalt) mafic rocks in the YZSZ (Bezard et al., 2011; Dupuis et al., 2005; Xia et al., 2008a; Zhang et al., 2005; Zhu et al., 2008a), which have been interpreted as the chains of seamounts or plateau developed within the Neo-Tethyan ocean but south of the intra-oceanic subduction zone (Hébert et al., in press). However, no geochronological constraints on these OIB-type mafic rocks have been reported so far.

Previous studies of the YZSZ ophiolites have mainly focused on radiometric and paleontological ages (e.g. Li et al., 2008, 2009a; Malpas et al., 2003; Matsuoka et al., 2002; McDermid et al., 2002; Miller et al., 2003; Wei et al., 2006b; Xia et al., 2008b; Zhong et al., 2006; Zhou et al., 2002; Ziabrev et al., 2003), geochemical compositions of mafic and ultramafic rocks (e.g. Bédard et al., 2009; Dubois-Côté et al., 2005; Dupuis et al., 2005; Hébert et al., 2003; Liu et al., 2010; Xia et al., 2008a; Zhang et al., 2005; Zhou et al., 1996, 2005; Zhu et al., 2008), and the origin of the metamorphic soles (Guilmette et al., 2008, 2009, in press). Most of these studies did not combine geochemistry and geochronology together, making the interpretations of the tectonic setting and the evolution of the Neo-Tethys to be ambiguous.

In this study, we report the field geology, zircon U-Pb ages, whole-rock major and trace element compositions of mafic rocks

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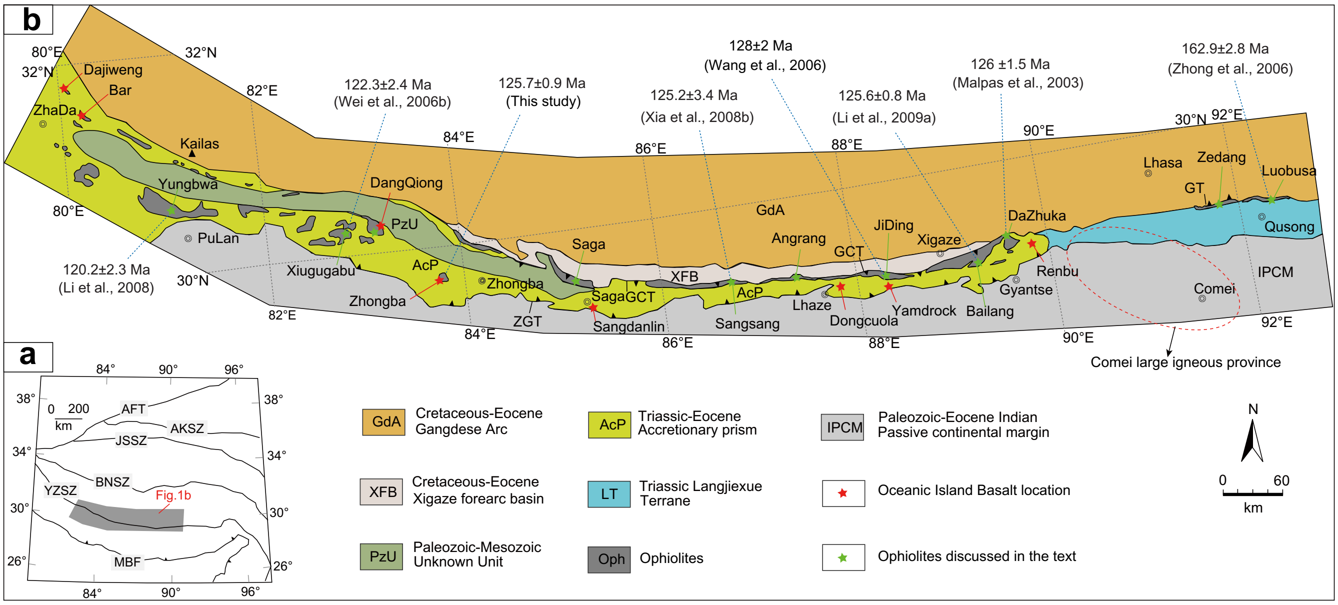

Fig. 1. (a) Simplified tectonic map of Tibetan Plateau showing major sutures (modified from Yin and Harrison, 2000; Chung et al., 2005). The major sutures are: AKSZ, A'nemaqin-Kunlun suture zone; JSSZ, Jinshajiang suture zeone; BNSZ, Bangong-Nujiang suture zone; YZSZ, Yurlung Zangbo suture zone. (b). Schematic tectonic map of southern Tibet showing the ophiolitic massifs within the YZSZ based on Pan et al. (2004) and Ding et al. (2005). The zircon U–Pb ages of the mafic rocks across the whole YZSZ are also presented. The data sources are from Li et al. (2008, 2009a), Malpas et al. (2003), Wang et al. (2006), Wei et al. (2006b), Xia et al. (2008b), and Zhong et al. (2006). The outline of Comei large igneous province is from Zhu et al. (2008b, 2009). Major faults: GCT, Great Counter thrust; ZGT: Zhongba-Gyangze thrust; GT: Gangdese thrust.

from the Zhongba ophiolite in the western YZSZ. These data reveal the existence of seamounts with Early Cretaceous age within the Neo-Tethyan Ocean. These new observations, in combination with published data, provide new constraints on the evolution of the Neo-Tethys.

2. Geological setting

The Tibetan Plateau is an amalgamation of several terranes bounded by suture zones, namely A'nemaqin-Kunlun, Jinshajiang, Bangong-Nujiang, and Yarlung Zangbo (Fig. 1a; Yin and Harrison, 2000). The southernmost Yarlung Zangbo Suture Zone (YZSZ) has been widely accepted as the youngest suture that represents the southward obducted remnants of the Neo-Tethyan Ocean floor accreting to Eurasia (e.g. Allègre et al., 1984; Bédard et al., 2009; Dupuis et al., 2005; Pearce and Deng, 1988). However, recent studies indicate that the YZSZ is a complex subduction system probably preserving vestiges of both Paleo-Tethys and Neo-Tethyan Ocean (Dai et al., 2011a). The YZSZ comprises three basic lithotectonic units and from north to south they are: (1) the Xigaze forearc basin; (2) the Yarlung Zangbo ophiolitic belt; and (3) and the accretionary prism (Fig. 1b). The Xigaze forearc basin, extending from Xigaze in the east to Zhongba in the west, consists of the Cretaceous to Paleocene sedimentary rocks (Fig. 1b; Dürr, 1996; Wu et al., 2010). The accretionary prism is dominantly composed of the Triassic to Eocene sediments. However, in the eastern part of this suture, the Late Triassic Langjiexue Group is different from the strata of the accretionary prism, as these might have been derived from the Lhasa terrane to the north rather than the India to the south (Dai et al., 2008; Li et al., 2010). The Yarlung Zangbo ophiolitic belt consists of disrupted ophiolitic massifs, which represent remnants of part of Neo-Tethyan ocean lithosphere. East of Lhasa, the north-dipping Gangdese Thrust juxtaposes the Gangdese batholith over Yarlung Zangbo ophiolitic belt, resulting in the disappearance of the Xigaze forearc basin. West of Renbu, the south-dipping Great Counter Thrust juxtaposes the Yarlung Zangbo ophiolitic belt and the accretionary prism over the Xigaze forearc basin (Yin, 2006; Yin et al., 1994).

The Zhongba ophiolitic massif is a recently discovered complex (Dai et al., 2011b) in the western segment of YZSZ since it was mistakenly mapped as the Cenozoic strata in previous geological maps. From north to south, this ophiolitic massif comprises fresh mantle peridotites, the associated mafic rocks and the uppermost crustal unit. The mantle section is mostly composed of harzburgites with minor dunites. The petrology and geochemistry studies of the harzburgites indicate their generation involved two-stage evolution: they were originally formed in MORB-source upper mantle, and then they were trapped in the mantle wedge above a subduction zone (Dai et al., 2011b). The mafic rocks include the diabase dikes and the pillow basalts. The uppermost crustal unit is dominated by massive basalt, radiolarian cherts and limestone.

3. Field occurrence and petrography

In the Zhongba ophiolitic massif, the mantle peridotites are dominated by the fresh harzburgites with minor dunites. The harzburgites exhibit a strong high temperature mantle foliation. The ophiolite crustal sequence includes diabase dikes and pillow basalts. The ophiolitic massif is surrounded by the mélange that comprises purplish red and greenish gray chert, massive basalt and limestone (Fig. 2a). Packages of layered and massive cherts are often associated with massive basalts. However, contact metamorphism has not been observed in the boundary between the radiolarian cherts and basalts, indicating the cherts were deposited conformably above the basalts (Fig. 2b). The limestones are massive to thinly bedded, interlayed with cherts or black shales, and they are also associated with basalts (Fig. 2c). The limestone beds are intensely deformed (Fig. 2d).

The diabase dike closely outcrops south of the mantle peridotite (Fig. 2e) and north of the pillow basalt, but it does not intrude into the mantle peridotite. This indicates that the diabase dike should be the basaltic crust of the ophiolite sequence, although it is not a typical sheeted dike (e.g. Dilek and Furnes, 2011). The diabase samples display the granular to medium grained intersertal texture with idiomorphic plagioclase, pyroxene and olivine. Opaque minerals (Fe-Ti oxides) were also observed in the diabase samples.