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Geochemistry and petrogenesis of the Permian mafic dykes in the Panxi region, SW China

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Abstract

Numerous intrusive bodies of ultramafic–mafic to felsic compositions are exposed in association with volcanic rocks in the Emeishan large igneous province (LIP), southwestern China. In this paper, we present new elemental and isotopic data for the Permian mafic dykes from the Panxi region which is located in the western part of the Emeishan LIP. The characteristics of major and trace elements and Sr–Nd isotopes, in combination with isotopic ages, suggest that these mafic dykes were originated from a similar mantle source related to an upwelling mantle plume and their formation was involved in a process of variable degrees of fractional crystallisation coupled with assimilation of enriched crustal materials. The mafic dyke samples from the Panxi region show some systematic variations in geochemical compositions. The gabbros in Yanyuan contain the lowest REE (e.g., La=5–12 ppm), the highest MgO (8.38–21.33%) and compatible elements (e.g. Cr=104–2610 ppm, Ni=135–496 ppm), and display depleted Sr–Nd isotopic ratios (initial $^{87}Sr/^{86}Sr$=0.703752–0.703844; $\varepsilon_{Nd}(t)$=+4.87 to +5.13). These gabbros likely represent an undifferentiated composition similar to primary melts derived from a depleted mantle source. In contrast, the gabbro samples from Panzhihua and Huili have more enriched LREE abundances and incompatible elements, and display depleted to slightly enriched Sr and Nd isotopic signatures (initial $^{87}Sr/^{86}Sr$=0.704354–0.705436; $\varepsilon_{Nd}(t)$=−0.29 to +4.58), though their trace element spidergram patterns are similar to those of the Yanyuan samples. These gabbros were formed probably through the removal of a few percent of olivine, clinopyroxene, plagioclase and apatite from the melts that formed the Yanyuan gabbros. All the mafic intrusives in the region exhibit elemental and Sr–Nd isotopic features generally comparable with those of the nearby volcanic rocks. In addition, their emplacement immediately preceded or was synchronous with the main pulse of volcanism that formed lavas over a large area along the western margin of the Yangtze Craton. These lines of evidence suggest that there is a genetic link between the mafic dykes and flood basalts in the Emeishan LIP, and the both share a common mantle source related to the Emeishan plume.

Keywords: Geochemistry; Emeishan large igneous province; Petrogenesis; Mafic dykes; Panxi region

1. Introduction

The geochemical characteristics of mafic magmatism with respect to the tectonic evolution of the major crustal blocks in China have been investigated in several recent studies (e.g., Peng et al., 2007; Zhou et al., 2007; Hou et al., 2008). The Emeishan large igneous province (LIP) consists of voluminous outcrops of high- and low-Ti basalts, mafic–ultramafic intrusions and the associated alkaline and felsic rocks in Sichuan, Yunnan, Guizhou, and western Guangxi provinces, SW China (Lin, 1985; Fig. 1). The high- and low-Ti flood basalts are believed to be the products of the Emeishan mantle plume (Chung and Jahn, 1995; Chung et al., 1998; Xu et al., 2001; Zhang et al., 2004), and erupted during the late Permian period (~260 Ma; Yin et al., 1992; Jin and Shang, 2000; Ali et al., 2002; Ali et al., 2004). Similar to the case for the volcanic successions, the associated layered mafic–ultramafic intrusions

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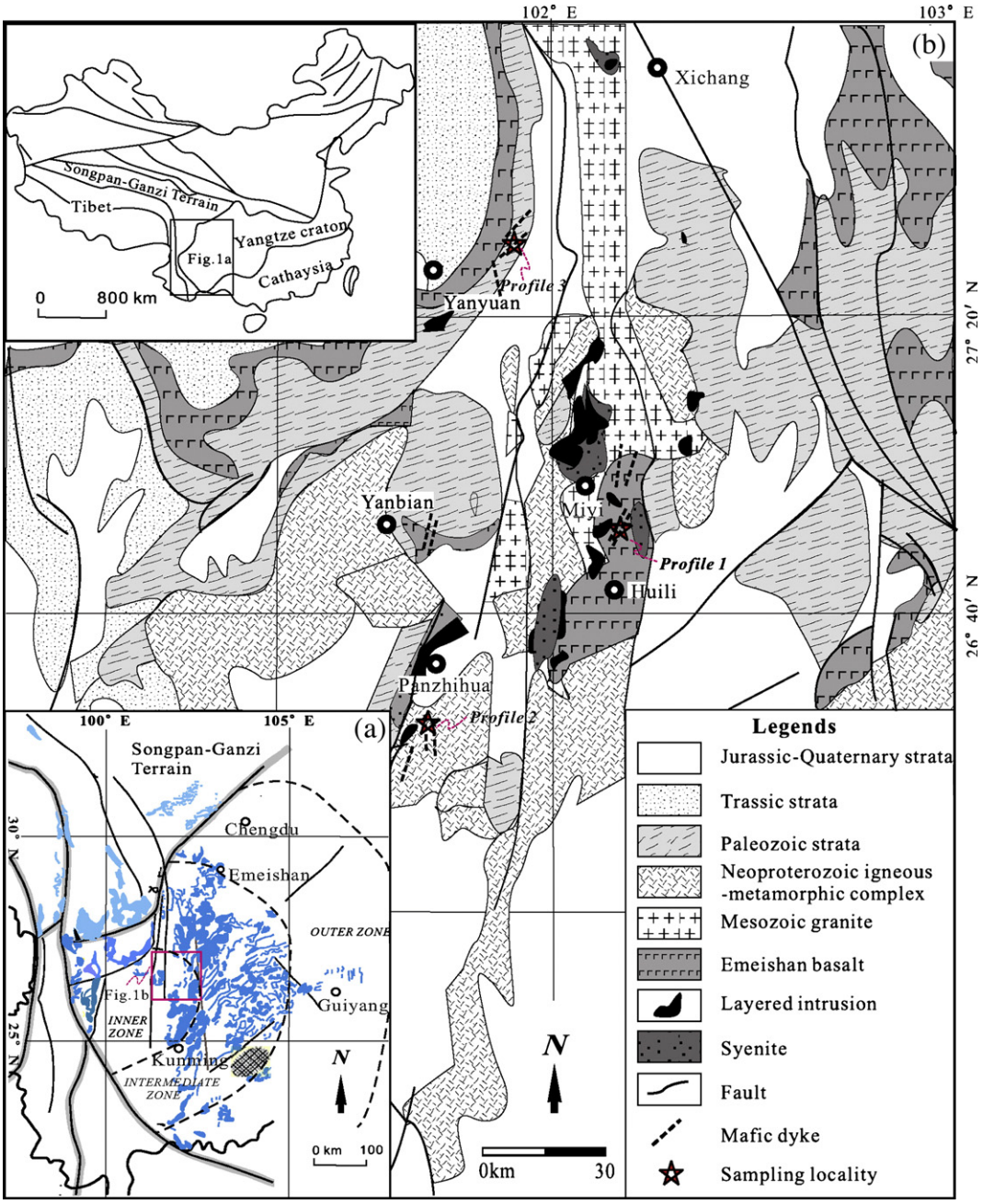

Fig. 1. (a) Distribution of the Emeishan flood basalts and associated intrusions in the Panxi region, SW China; and (b) regional geological map of the studied area (modified after Zhou et al., 2005a).

in the Emeishan LIP have also been paid considerable attention (Luo, 1981; Liu et al., 1985; Zhang et al., 1999) over the past several decades due to the presence of giant Fe–Ti–V deposits in, such as, the Hongge intrusion (PXGT, 1987; Zhong et al., 2002) and the Panzhihua intrusion (Zhou et al., 2005a), and the Cu–Ni–PGE sulfide mineralization in the Yangliuping, Hongge and Xinjie intrusions (Zhong et al., 2003, 2004).

The various rocks in the Emeishan LIP are considered to be associated with variable mantle sources and complex magma processes such as plume–lithosphere interaction and crust contamination (Chung and Jahn, 1995; Song et al., 2001a; Xu et al., 2001; Zhang and Wang, 2002). This is similar to the hypothesis proposed for rocks in many other LIPs (e.g., Lightfoot et al., 1990, 1993; Arndt and Christensen, 1992; Naldrett et al., 1992; Arndt et al., 1993; Arndt et al., 1998).

In the Panxi (Panzhihua–Xichang) region as well as western Sichuan Province (Fig. 1), there are abundant ultramafic–mafic dykes in association with flood basalts and layered intrusions. Dykes in large igneous provinces are traditionally proposed to be representative of plumbing systems, which presumably fed the lava flows. Therefore, studies of mafic dykes are of great importance for understanding of the plumbing systems, total magma volume and source characteristics of large igneous provinces.