Lithos 113 (2009) 748–766

Contents lists available at ScienceDirect

Lithos

journal homepage: www.elsevier.com/locate/lithos

Devonian to Permian plate tectonic cycle of the Paleo-Tethys Orogen in southwest China (I): Geochemistry of ophiolites, arc/back-arc assemblages and within-plate igneous rocks

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ARTICLE INFO

Article history:
Received 28 March 2008
Accepted 8 April 2009
Available online 18 April 2009

Keywords:
Geochemistry
Ophiolite
Arc/back-arc assemblages
Within-plate igneous rocks
Paleo-Tethys
Southwest China

ABSTRACT

The Paleo-Tethys Orogen in southwest China is an amalgamation of continental terranes (Sibumasu, Simao and Yangtze), which are bounded by ophiolite belts (Ailaoshan, Jinshajiang and Changning–Menglian) that represent former ocean basins. This study concentrates on ophiolites, arc/back-arc assemblages, and within-plate igneous rocks that occur in this complex orogen. Mainly based on geochemical fingerprinting of basalts, the Paleo-Tethys ophiolites are here classified as MORB and SSZ types. The Ailaoshan ophiolite (NMORB-type; ca. 387–374 Ma) is associated with a non-volcanic segment of the rifted western Yangtze margin. The Jinshajiang ophiolite (EMORB-type; 346–341 Ma), which has ophiolite structure but some samples bear crustal contamination signatures, is associated with a volcanic segment of the rifted Yangtze western margin. These MORB-type ophiolites are interpreted to have formed in the continent-ocean transition zones. The Changning–Menglian ophiolite, which marks the main Paleo-Tethys suture, that is, the boundary between the Gondwana-derived Sibumasu terrane and the Yangtze-derived Simao terrane, has traditionally been thought to have a mid-ocean ridge (MOR) origin. New trace element data of basalts, however, indicate that this ophiolite (ca. 270–264 Ma) was formed at a supra-subduction zone (SSZ). Arc and back-arc assemblages are represented by the Gicha (ca. 311–277 Ma) and Banpo (ca. 288–284 Ma) zoned mafic-ultramafic complexes and the Yaxianqiao arc volcanic rocks (ca. 268–264 Ma). Geochemical data suggest that the Gicha complex originated in a back-arc rift. The Banpo complex makes a plutonic arc that contains low-Ti gabbro and tonalite with volcanic arc granite (VAG) affinity. Within-plate igneous rocks are recognized as xenoliths (amphibolites; ca. 443–401 Ma) in the Jinshajinag ophiolite mélange and the Dalongkai small differentiated mafic-ultramafic intrusion (ca. 247–244 Ma) that intruded the Yaxianqiao Arc. The amphibolite xenoliths are similar to low-Ti continental flood basalts (CFB) in composition. Rocks from the small mafic-ultramafic intrusion have superimposed subduction and within-plate geochemical signatures. These ophiolites, arc/back-arc assemblages and within-plate igneous rocks, are summarized as the magmatic records for the Plaeo-Tethys evolution in the context of a plate tectonic cycle.

1. Introduction

The plate tectonic cycle, or Wilson Cycle (Wilson, 1966), i.e., continental rifting and ocean spreading, followed by ocean closure and continental collision, is a traditional way of viewing continent-ocean transition zones and collisional orogens. Investigations of modern and ancient continent-ocean transition zones (Coleman and McGuire, 1988; Favre and Stampfli, 1992; Geoffroy, 2005; Mjelde et al., 2007) resulted in two end-members of rifted continental margins to be distinguished: non-volcanic (Malod et al., 1993; Froitzheim and Manatschal, 1996; Schaltegger et al., 2002; Hopper et al., 2004; Geoffroy, 2005) and volcanic rifted margins (Geoffroy, 2005; Wolfenden et al., 2005). The rifted margins pass laterally into oceanic crust, i.e., mid-ocean-ridge basalt (MORB) type oceanic crust (Pearce, 2008). In contrast, convergent margins are sites of ocean-continent transformation through oceanic lithosphere subduction and continental growth, giving rise to supra-subduction zone (SSZ) type ophiolites and island arc/back-arc assemblages (Stern, 2004). Oceanic subduction often ends with arc or continental accretion and regional uplift (e.g. Davies and Blanckenburg, 1995).

In this paper we present geological and geochemical data to link magmatism to evolutionary phases of the Paleo-Tethys Orogen in southwest China. In a companion paper (Jian et al., 2009), we provide

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0024-4937/$ – see front matter © 2009 Elsevier B.V. All rights reserved.
doi:10.1016/j.lithos.2009.04.004

a detailed time-scale for a complete plate tectonic cycle, achieved by SHRIMP zircon dating of ophiolites, arc/back-arc assemblages and within-plate igneous rocks.

The Paleo-Tethys Orogen in southwest China and East Asia is an amalgamation of Gondwana-derived continental terranes including Sibumasu, Qiangtang, Simao, Indochina and Yangtze, which are presently bounded by ophiolite-decorated sutures (Changning–Menglian, Ailaoshan and Jinshajiang in China, and Nan-Uttaradit in Thailand) (Metcalfe, 2002, 2006) (Fig. 1, inset). Despite their common parent craton, the time of rifting and northwards drifting of the various

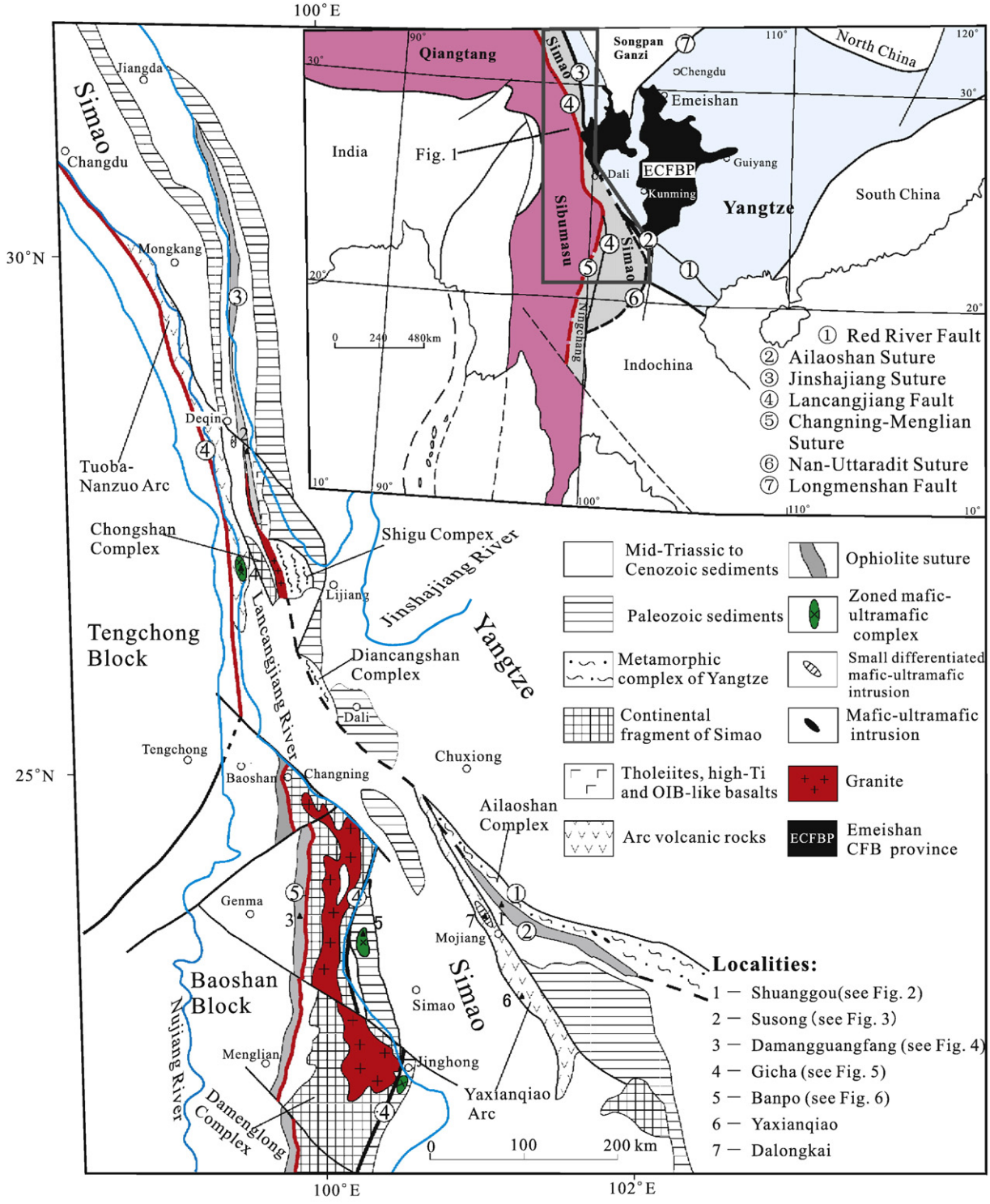

Fig. 1. Geological map of the Paleo-Tethys Orogen in southwest China (modified from Wang et al., 2000b and Zhong, 1998). The positions of localities shown in Figs. 2–6 are also indicated. Inset shows distribution of principal continental terranes, faults and sutures of the Paleo-Tethys Orogen (Metcalfe, 2006). Areas in color: blue—Yangtze craton; grey—Simao; pink—Sibumasu–Qiangtang. Note that the red line in this figure and inset marks the Gondwana–Cathaysia Divide, which coincides with the Changning–Menglian ophiolite belt and the north Lancangjiang Fault (Metcalfe, 2006). The Red River Fault is within the Yangtze craton and has a record of displacement of several hundred kilometers in the Tertiary (Burchfiel et al., 2007). Also shown in inset is the distribution of the Emeishan continental flood basalts (ECFBP, two black areas) (after Chung and Jahn, 1995); see the Jian et al., 2009 for discussion.