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# Paleotethyan subduction process revealed from Triassic blueschists in the Lancang tectonic belt of Southwest China

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ABSTRACT

The subduction of the Paleotethyan Ocean and subsequent continental collision along the Lancang tectonic belt of the southeastern Paleotethyan belt is a major tectonic event in Southwest China, but the event of the subduction preceding the final collision is still not well-constrained. The mafic blueschists exposed in the Lancang accretionary complex provide crucial records of the Paleotethyan subduction process. In this paper, we present a set of new petrologic, geochronological and geochemical data for the Suyi mafic blueschists in the Lancang metamorphic zone. The mineral assemblage of these blueschists consists of zoned sodic amphibole (25–30%), albite (15–20%), epidote (25–30%), phengite (5–10%), chlorite (~5–10%), and minor amounts of actinolite, apatite, sphene, zircon, ilmenite, quartz and secondary limonite. This suggests a prograde metamorphism from ~0.5 to ~0.9 GPa and retrograde metamorphic overprinting (back to ~0.6 GPa) within the temperature range of 300–450 °C. The Suyi blueschists give a zircon U–Pb age of 260 ± 4 Ma and glaucophane minerals formed during prograde metamorphism yield a $^{40}Ar/^{39}Ar$ plateau age of 242 ± 5 Ma (MSWD = 0.77; P = 0.54). The blueschists have geochemical compositions of subalkaline basalt and show typical OIB-type REE and multi-elemental patterns and $\varepsilon_{Nd}(t)$ values ranging from +3.35 to +4.85. Based on available data, it is inferred that the protolith formed at 260 Ma and originated from a basaltic seamount. The basaltic rocks subducted down to 30–35 km depths beneath the Lincang arc to form the epidote blueschists at ~242 Ma. The blueschists were subsequently transported to shallower crustal levels in response to the continuous underthrust of the subducted slab and the continent–continent collision in the middle–late Triassic. These results provide a systematic constraint on the tectonic evolution and temporal framework of the southeastern Paleotethyan belt in Southwest China.



## 1. Introduction

The Paleotethyan Ocean extended from Alps through Afghanistan to Southwest China and then to Peninsular Malaysia (Fig. 1a; Bullard et al., 1965; Hsü and Bernoulli, 1978; Metcalfe, 1996, 2002, 2009; Sengör and Hsu, 1984). An important element of the Paleotethyan Ocean was named as the Changning–Menglian Ocean in Southwest Yunnan Province of Southwest China, which separated the Sibumasu Block from the Simao–Indochina Block. Its subduction and subsequent continent–continent collision resulted in the development of the Lancang tectonic belt consisting of the Changning–Menglian suture, Lancang metamorphic zone and Lincang igneous zone (Fig. 1). Along the tectonic belt, ophiolite suite, radiolarian siliceous rock, high-pressure metamorphic rocks and arc-collisional igneous rocks are well preserved. This belt is thus considered to be a key window for investigating and understanding the Paleotethyan evolution (e.g., Fan et al., 2009, 2010; Feng, 2002; Fontaine, 2002; Hennig et al., 2009; Jian et al., 2009a, 2009b; Metcalfe, 1996, 2002; Mo et al., 1998; Peng et al., 2008; Sengör, 1979; Wang et al., 2010; Zhong, 1998).

Previous studies on the Lancang tectonic belt mostly focused on the paleoecological and palaeobiostratigraphical patterns and associated magmatism (e.g., Jian et al., 2009a, 2009b; Mo et al., 1998; Zhong, 1998), but much less attention was paid to the high-pressure metamorphism associated with subduction and collision (e.g., Zhao et al., 1994a, 1994b). The timings of the subduction and initial orogen along the Lancang tectonic belt are poorly known. Mafic blueschists, as a possible marker of oceanic subduction preceding the continental collision, can provide key information on their basaltic precursors and subduction history (e.g., Angiboust and Agard, 2010; Angiboust et al., 2012; Bousquet et al., 2008; Brown, 2007; John et al., 2010; van der Straaten

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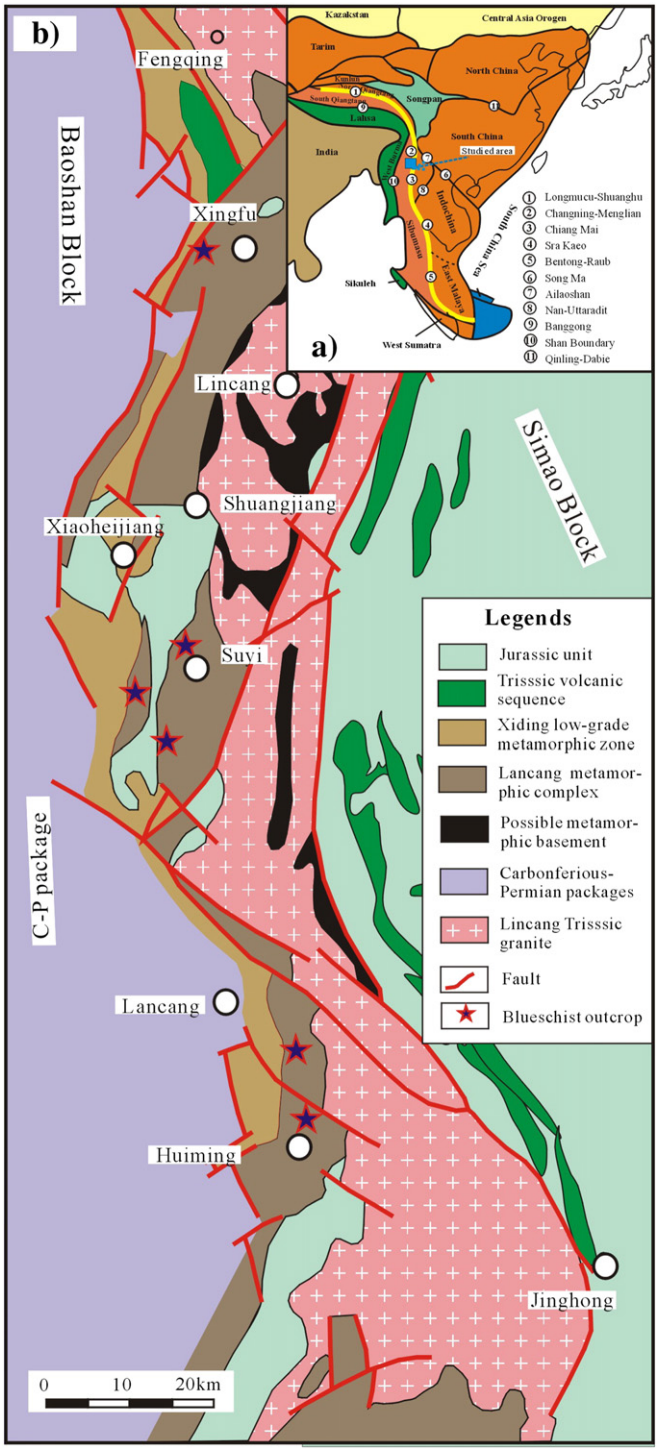


**Fig. 1.** (a) Tectonic outline of Southeast Asia and, (b) simplified geological map of the Lancang metamorphic zone in Southwest China showing the outcrops of the blueschist.

et al., 2012; Warren et al., 2011, 2012). The occurrence of the mafic blueschists in the Lancang metamorphic zone in Southwest Yunnan has been reported in spite of their poor exposure (e.g., Yunnan BGMR, 1990; Zhao et al., 1994a, 1994b; Zhong, 1998). They represent the crucial geological records of the Paleotethyan tectonic evolution, and as such a systematic study of these rocks can lead to important insight into the timing of the subduction (e.g., Maruyama et al., 1986, 1996). In this paper, we present a set of new petrological, geochronological and geochemical data for the mafic blueschists from the Lancang metamorphic zone. Based on our new data and available data from previous studies, we further present a proposal on the timing of the subduction of the eastern Paleotethyan Ocean and the tectonic framework of the eastern Paleotethyan belt in Southwest China.

## 2. Geological background

The Lancang tectonic belt, extending southwardly to northwestern Thailand and northwardly to the Central Qiangtang Block, separates the Baoshan Block in the west from the Simao–Indochina Block in the east (Fig. 1, e.g., Hutchinson, 1989; Li et al., 2006, 2009; Metcalfe, 2009; Metcalfe, 1996, 2002, 2009; Zhang et al., 2006a, 2006b). The Baoshan Block is considered a component of the Sibumasu continental fragment with the stratigraphic and paleontological affinities to Gondwanaland (e.g., Fang et al., 1994; Feng, 2002; Fontaine, 2002; Jin, 2002; Metcalfe, 1996, 2002; Zhong, 1998). Its stratigraphic system is characterized by the Proterozoic amphibolite-facies metamorphic basement overlain by the Paleozoic and Mesozoic sequences (e.g. Yunnan BGMR, Yunnan Bureau Geological Mineral Resource, 1990; Zhong, 1998). The Simao–Indochina Block is bounded by the Lancang tectonic belt to the west and the Ailaoshan tectonic belt to the east (Fig. 1b; e.g., Fan et al., 2010; Liu et al., 1989; Metcalfe, 1996, 2002; Zhong, 1998). In this block, the Paleozoic metasedimentary rocks show similar lithology to those of the Yangtze Block, with typical Cathaysia flora and fauna (e.g., Fang et al., 1998; Yunnan BGMR, 1990; Zhong, 1998).

The geological records related to the Paleotethyan evolution are abundantly preserved along the Lancang tectonic belt, which can be subdivided into, from west to east, the Changning–Menglian mélange zone, Lancang metamorphic zone and Lincang igneous zone (Fig. 1). The Changning–Menglian mélange zone contains a large quantity of broken late Paleozoic volcanosedimentary sequences (varying thickness and lithology), unmixed radiolarian silica-argillaceous sequences with mid-oceanic ridge basalts and a rock-association of oceanic island basalts as well as chert- and pelitic units (Yunnan BGMR, 1990; Zhong, 1998). The Lincang igneous zone is the most remarkable geological feature in Southwest Yunnan (Wang et al., 2010; Yunnan BGMR, 1990) due to the occurrence of the Lincang Triassic granite zone and associated volcanic sequences, which extends over 370 km (Fig. 1; e.g., Peng et al., 2006; Ueno and Hisada, 2001; Zhong, 1998). The granite suite in this zone is a composite batholith composed of monzonitic biotite granite, K-feldspar granite and granodiorite, with the predominant ages of 220–230 Ma (e.g., Peng et al., 2013 and references therein). The volcanic sequences comprise the Manghuai, Xiaodingxi and Manghuihe formations with the zircon U–Pb ages of 210–232 Ma (e.g., Helmcke, 1985; Liu et al., 1989; Peng et al., 2006, 2013; Wang et al., 2010), which are interpreted as syn-collisional or postcollisional magmatic products. The broad Lincang igneous package is angular-uncomfortably overlain by the basal conglomerate of the upper Triassic–lower Jurassic Yiwanshui Formation. The Lancang metamorphic zone is sandwiched between the Changning–Menglian suture and Lincang igneous zone. It is constituted of the Xiaoheijiang greenschist-facies and Lancang high-pressure metamorphic units (e.g., Zhong, 1998). These rocks have undergone strong folding and thrust imbrications and are uncomfortably overlain by the upper Triassic–lower Jurassic molasses deposits. The Xiaoheijiang unit is characterized by Carboniferous–lower Triassic greenschist-facies quartz sandstone, quartz greywacke and pelitic rocks with minor volcanoclastics (e.g., Zhong, 1998), and was metamorphosed at blueschist-facies conditions (e.g., crosstie and ferroglaucophane). The Lancang high-pressure metamorphic unit is dominated by mica schist, two-mica schist, greenschist and blueschist with minor metamorphic volcanics and marble. Zhang et al. (1993) reported the metamorphic grades from blueschist-facies to high-grade blueschist and epidote amphibolite-facies from west to east, similar to those of the Sanbagawa belt of Japan.

The blueschists are preserved in the Lancang high-pressure metamorphic zone as stratoid and lenticular structures. They discontinuously