Lithos 179 (2013) 36–47

Contents lists available at ScienceDirect

Lithos

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

Geochemistry, zircon U–Pb geochronology and Hf isotopes of granites in the Baoshan Block, Western Yunnan: Implications for Early Paleozoic evolution along the Gondwana margin

Meiling Dong [a], Guochen Dong [a,b,*], Xuanxue Mo [a,b], M. Santosh [c,d], Dicheng Zhu [a,b], Junchuan Yu [a], Fei Nie [a], Zhaochu Hu [e]

[a] China University of Geosciences, Beijing 100083, China
[b] State Key Laboratory of Geological Processes and Mineral Resources, China University of Geosciences, Beijing 100083, China
[c] Division of Interdisciplinary Science, Faculty of Science, Kochi University, Akebono-cho, Kochi 780-8520, Japan
[d] School of Earth Sciences and Resources, China University of Geosciences Beijing, No. 29, Xueyuan Road, Haidian District, Beijing 100083, China
[e] State Key Laboratory of Geological Processes and Mineral Resources, China University of Geosciences, Wuhan 430074, China

ARTICLE INFO

Article history:
Received 7 November 2012
Accepted 24 May 2013
Available online 12 June 2013

Keywords:
Western Yunnan
Baoshan Block
Early Paleozoic leucogranites
Geochemistry
Zircon geochronology
Hf isotopes

ABSTRACT

The leucogranites in the Baoshan Block of the Tethyan belt in Western Yunnan, are composed mainly of two-mica granite with subordinate muscovite granite. Here we present zircon U–Pb ages from four intrusions that show ages of 448–476 Ma suggesting that these rocks were emplaced during the Ordovician. The leucogranites are high-K calc-alkaline and strongly peraluminous, with $K_2O/Na_2O > 1$ and $A/CNK = 1.12–1.54$. These rocks are enriched in large-ion lithophile elements (LILEs) and light rare-earth elements (LREEs) $[(La/Yb)_N = 1.13–32.4]$ and Pb, and are depleted in high field-strength elements (HFSEs). They show similar chondrite-normalized REE patterns, with negative Eu anomalies ($Eu/Eu^* = 0.03–0.46$). A wide range of zircon $\varepsilon_{Hf}(t)$ values (-9.6 to -2.6) and varying Hf-isotope crustal model ages (2.1–1.6 Ga) are also observed. The geochemical signatures indicate that the leucogranites are S-type granites derived mainly from the anatexis of ancient crustal materials. The ages, geochemistry and tectonics in the Baoshan Block and the Lhasa Terrane are closely comparable, suggesting that the Baoshan Block might represent part of an Early Paleozoic magmatic arc in the Gondwana continental margin facing the proto-Tethyan Ocean. The Pinghe granites of the early phase in the Baoshan Block which are coeval with the Cambrian magmatism (ca. 492 Ma) identified in the central and southern Lhasa subterranes can be interpreted as products of the slab break-off associated with the subduction of proto-Tethyan oceanic lithosphere. However, the late leucogranite stocks are analogous to the North Himalayan leucogranites, which formed in a short-lived extensional setting caused by the slab break-off associated with the subduction–collision system.

1. Introduction

The Late Neoproterozoic–Early Paleozoic time window marks an important period in the geological evolution of the Gondwana supercontinent, with the assembly of a number of continental fragments, and subduction initiation along the Peri-Gondwana margin (Aitchison and Buckman, 2012; Cawood and Buchan, 2007; Collins and Pisarevsky, 2005; Fernandez et al., 2012; Fiannacca et al., 2012; Meinhold et al., 2013; Murphy et al., 2011; Zhu et al., 2012a). Prior to the formation of Gondwana, the Neoproterozoic supercontinent Rodinia shaped the globe and was located in the southern hemisphere or near the equator (W.C. Li et al., 2010). In the end Neoproterozoic–Early Paleozoic, continental fragments were assembled within the Gondwana, Laurasia and a much smaller Pan Huaxia mainland amalgams with the Proto-Tethys Ocean realm (Li et al., 1999). Between Gondwana and Laurasia, numerous micro-continents or continent blocks (Nance et al., 2012), such as Cimmeria (Seng r et al., 1988), Sibumasu, and the Lhasa Terrane (Jin, 2002; Metcalfe, 1996, 2011; Wang et al., 2001; Zhang et al., 2012), rifted from the northern margin of Gondwana and subsequently accreted to the Eurasian continent during the Paleozoic and Mesozoic (Metcalfe, 1996; Ueno, 2000), constituting the global Tethyan orogenic belt. The Western Yunnan Province is one of the important branches of the eastern Tethyan tectonic belt, and therefore bears significance for the development of the Tethyan belt within Southeast Asia (Chen et al., 2004; Liu et al., 2009). The Tethyan orogen of Western Yunnan is composed of several continental blocks (terranes) and suture zones such as the Simao, Tengchong and Baoshan blocks and the Changning–Menglian suture zone (Zhong, 1998). Provenance analysis of these micro-continents is crucial for understanding the origin and tectonic processes which led to the formation of the Tethyan orogenic belt. Besides biogeographical constraints, systematic studies of the Early Paleozoic magmatic units are also critical. In this study, we investigate the leucogranites distributed across the Baoshan

* Corresponding author at: State Key Laboratory of Geological Processes and Mineral Resources, China University of Geosciences, Beijing 100083, China.
E-mail address: donggc@cugb.edu.cn (G. Dong).

0024-4937/$ – see front matter © 2013 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.lithos.2013.05.011

Block in the Western Yunnan Province and present new geochronological and geochemical data including petrography, laser ablation ICP-MS (LA-ICP-MS) zircon U–Pb ages, whole-rock geochemistry, and zircon Hf isotopic data. Based on the results, we attempt to constrain the source characteristics of the magma and discuss their tectonic significance.

2. Geological setting and petrography

In its present tectonic position (Fig. 1a), the Baoshan Block is located in the middle of the Tibet–Yunnan–Thailand–Malaysia plate and connected with the Shan State Block in the south, bordered by NE-trending Kejie–Nandinghe fault to the east and NW-trending Nujiang–Longling–Luxi fault to the west. In the north, the block is connected with the Gongshan Block, and the two blocks are separated by a metamorphic zone. A sedimentary rock unit, known as the Gongyanghe Group of Late Precambrian (?) to Early Cambrian age is exposed in the study area (Fig. 1b). The Gongyanghe Group was formerly considered as part of the basement of the Baoshan Block in this area. This group is mainly composed of low-grade metamorphic arkose, sandstone, shale and limestone. Late Precambrian, Early Paleozoic and Late Mesozoic to Early Cenozoic magmatism are the main magmatic activities in the block. The Laojiezi granite in Ximeng and Zhibenshan two-mica granite in Luxi represent the Late Precambrian magmatism, respectively dated at 687 Ma (W.C. Li et al., 2010) and 645 Ma (Zhang et al., 1990) by Rb–Sr method. As the representative of the Early Paleozoic magmatic activity, the Pinghe granite batholith was previously dated at 486–502 Ma by U–Pb zircon method (Chen et al., 2007; Dong et al., 2012; Liu et al., 2009). The Huataolin granite, which was dated at 60–100 Ma (Chen et al., 2007; Jin and Zhuang, 1988), belongs to the Late Mesozoic to Early Cenozoic magmatic pulses.

The Pinghe batholith is the largest granitoid intrusion in the Baoshan Block, comprising an estimated outcrop area of approximately 800 km^2 (Fig. 1b). The studied granites comprise four intrusions: the Nansa, Pingda, Mengdui and Songpo (Fig. 1b). The Nansa, Mengdui, and Pingda plutons intrude the Pinghe batholith and the Gongyanghe Group. However, the Songpo pluton shows intrusive relation with only the Gongyanghe Group. Our field studies reveal that all the four intrusions are leucogranites, distinct from the Pinghe batholith. Two-mica granite is the dominant rock type, comprising more than 95% of the rocks; muscovite granite is subordinate. Samples collected for this study are white and gray medium-grained or minor medium- to coarse-grained granitoids (Fig. 2a). They are composed of anhedral granular quartz (30–44%), subhedral K-feldspar (24–30%) (Fig. 2b), subhedral and platy plagioclase (23–35%) with weak sericitization in the central domain (Fig. 2c), 3–8% muscovite and 2–3% biotite (Fig. 2d). The main ferromagnesian phase is biotite. Accessory minerals include zircon, apatite, magnetite and ilmenite.

3. Analytical techniques

3.1. LA-ICP-MS zircon U–Pb methods

Four leucogranite samples were selected for in situ zircon U–Pb and Hf isotope analysis. Zircons were separated from each sample by heavy-liquid and magnetic techniques in the Laboratory of the Geological Team of Hebei Province, China. Cathodoluminescence (CL) images were taken at the Institute of Geology, Chinese Academy of Geological Sciences (Beijing) to investigate the internal structures of individual zircons and to select positions for zircon isotope analyses. Zircon U–Pb dating with a beam size of 32 μm was conducted by LA-ICP-MS at the State Key Laboratory of Geological Processes and Mineral Resources, China University of Geosciences (Wuhan). The detailed operating conditions for the laser ablation system, the ICP-MS instrument and data reduction are the same as those described by Liu et al. (2008, 2010a). Off-line selection and the integration of background and analyses of signals, time-drift correction, U–Pb dating, and quantitative calibration for trace element analyses were performed by *ICPMSDataCal* (Liu et al., 2008, 2010a, 2010b). Trace element compositions of zircons were calibrated against multiple-reference materials (BCR-2G and BIR-1G) combined with internal standardization (Liu et al., 2010a).

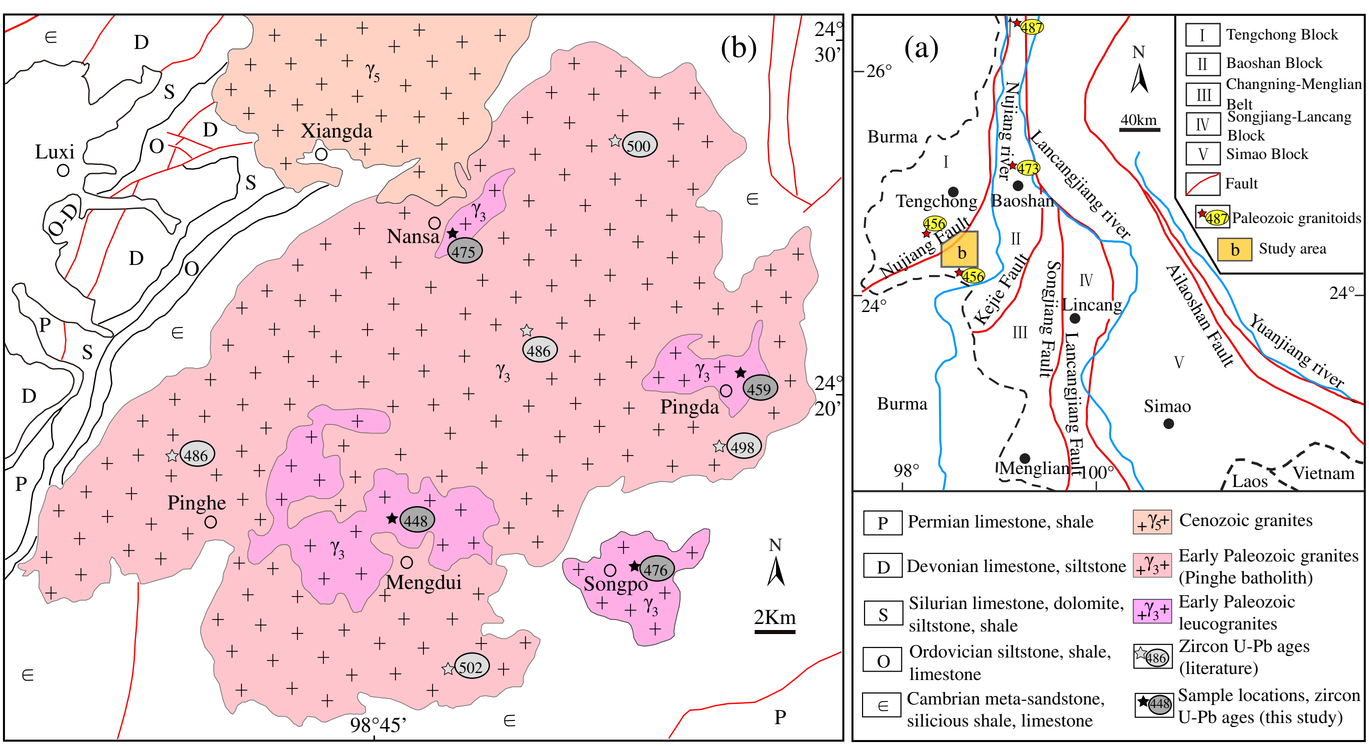

Fig. 1. (a) Generalized tectonic map of the Baoshan Block in Western Yunnan Province (modified after Shen et al., 2002). (b) Simplified geological map of the Early Paleozoic granitoids in Baoshan Block.