Journal of Asian Earth Sciences 113 (2015) 748–765

Contents lists available at ScienceDirect

Journal of Asian Earth Sciences

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

Structural style and metamorphic conditions of the Jinshajiang metamorphic belt: Nature of the Paleo-Jinshajiang orogenic belt in the eastern Tibetan Plateau

Wentao Cao [1], Dan-Ping Yan *, Liang Qiu, Yixi Zhang, Jingwei Qiu

The State Key Laboratory of Geological Processes and Mineral Resources, China University of Geosciences, Beijing 100083, China

A R T I C L E I N F O

Article history:
Received 30 April 2015
Received in revised form 14 August 2015
Accepted 2 September 2015
Available online 11 September 2015

Keywords:
Jinshajiang suture
Barrovian metamorphism
Thermobarometry
Paleotethys tectonics
Tibetan Plateau

A B S T R A C T

The Jinshajiang metamorphic belt is a Barrovian sequence distributed within the Jinshajiang Suture Zone (JSZ), which was formed in the thickened Paleo-Jinshajiang orogenic belt after closure of the Jinshajiang Ocean. We have identified three metamorphic phases, M_1, M_2 and M_3, corresponding to deformation stages D_1, D_2 and D_3, in the Barrovian sequences. The metamorphic belt exhibits a metamorphic field gradient from chlorite to biotite, garnet, staurolite–kyanite and sillimanite grades. Inclusions in garnet and staurolite (chlorite, mica, quartz, feldspar, ilmenite and graphite) indicate that M_1 reflects greenschist facies metamorphism. Pervasive M_2 metamorphism formed a dominant S_1 schistosity within the Barrovian sequence. Peak metamorphic conditions for metapelites of the garnet–staurolite and staurolite–kyanite grade were ~580 °C and ~0.65 GPa according to petrogenetic grids. Peak metamorphism was in conditions of ~635 °C and 0.50 GPa for the metapelites and ~650 °C and ~0.61 GPa for amphibolites in sillimanite grade. Greenschist facies retrograde metamorphism, M_3, followed D_2 deformation, a top-down-to-southeast shear in the JSZ. The D_3 deformation is characterized by well-developed brittle faults with fault gouge and breccia. Zircon grains from an amphibolite sample have cores with igneous oscillatory zoning and metamorphic rims. However, the metamorphic rims are too narrow to analyze. Laser ablation-inductively coupled plasma mass-spectrometry (LA-ICPMS) analyses of the igneous cores of zircons yielded a crystallization age of 242 Ma. $^{40}Ar/^{39}Ar$ dating of white mica from a garnet-schist gave a plateau age of 224 Ma. The peak metamorphism is thus limited to be between 242 and 224 Ma. We thus suggest a tectonic shift from collision to extension of for the Permian to Triassic Paleo-Jinshajiang orogenic belt.

1. Introduction

The Paleo-Jinshajiang Orogenic Belt (POB) includes the curvilinear Jinshajiang Suture Zone (JSZ), which is an ophiolitic mélange zone containing peridotites, gabbros and basalts interlayered with volcanoclastic sediments, and metamorphic complexes. The POB was formed by closure of the Jinshajiang Ocean, a branch of the Paleotethys, and later collision between the Qiangtang Block and the Songpan-Ganze terrane during Triassic (Fig. 1; Mo et al., 1993; Roger et al., 2003). However, experience multi-stage tectonic overprinting, nature of the POB is not well-understood due to poor geological constraining. For example, based on magmatic and local metamorphic constraints, previous studies proposed various models for the formation of the POB. The eastward subduction of the Jinshajiang Oceanic plate and immediately collision produced the POB was proposed based on occurrences of subduction-generated plutonic arc complexes in eastern Qiangtang Block and blueschist-bearing metamorphic belt in the northern Qiangtang Block (e.g. Hou et al., 2003; Kapp et al., 2000), while westward subduction was suggested according to a west-vergent imbricated thrust system (Reid et al., 2005a). The third school advocates a double-vergent subduction of the Jinshajiang Oceanic plate on the basis of buildup of accretionary prism and backarc volcanic system (Leeder et al., 1988). Therefore, re-establishing of the deformation–metamorphic sequence is the key to understand the nature of the POB.

In the eastern Tibetan Plateau, a sequence of biotite-, garnet-, staurolite-, kyanite- and sillimanite-bearing metamorphic zones crops out from the eastern JSZ. Previous workers termed these

* Corresponding author at: The State Key Laboratory of Geological Processes and Mineral Resources, China University of Geosciences, Beijing 100083, China

E-mail address: yandp@cugb.edu.cn (D.-P. Yan).

[1] Address: Department of Earth & Environmental Sciences, The University of Iowa, Iowa City, IA 52242, USA.

http://dx.doi.org/10.1016/j.jseaes.2015.09.003
1367-9120/

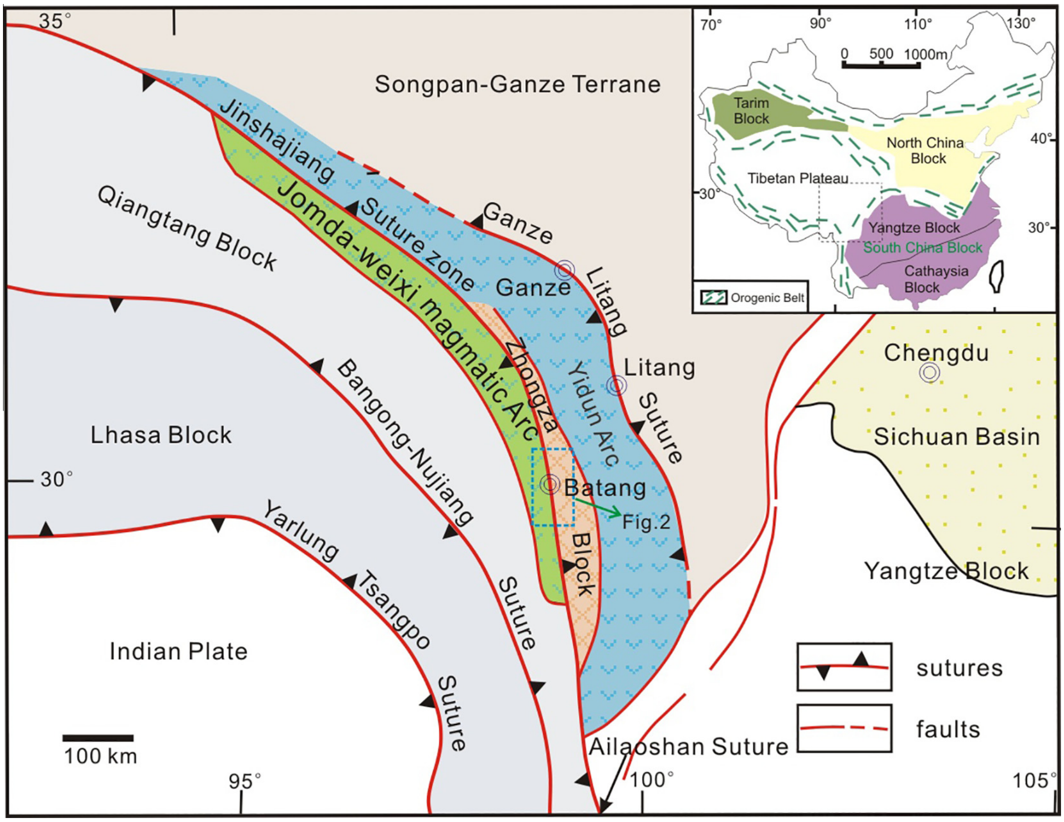

Fig. 1. Regional tectonic map showing locations of terranes and suture zones adjacent to the JSZ (Modified after Reid et al., 2005a and Yan et al., 2012).

metamorphic units the Eaqing complex as a basement unit within the JSZ based on a pre-Devonian age of 423 ± 40 Ma by Rb/Sr dating of a sillimanite-bearing mica schist (Wang et al., 2000a,b). However, muscovite from a mica schist in the metamorphic complex was dated at 225–215 Ma using the $^{40}Ar/^{39}Ar$ thermochronometry, which indicates a Triassic cooling age of the metamorphic units (Reid et al., 2005b). Additionally, no detailed research on metamorphic evolution of the complex was conducted. The lack of consensus on the age of the metamorphic units has resulted in a misinterpretation in the relationship between tectonic activity and metamorphism in this Paleotethys domain, and a poor understanding of the nature of this part of the Paleotethys orogenic belt.

In this contribution, we conducted petrographic observation and thermobarometrical estimation on six representative metapelites and one amphibolite to study metamorphic evolution of the complex. U–Pb dating of zircon from an amphibolite, and $^{40}Ar/^{39}Ar$ thermochronometry of muscovite from a metapelite were employed to constrain timing of the metamorphism. A P–T–t path for the Barrovian belt is delineated combining conventional thermobarometry, U/Pb geochronometry and $^{40}Ar/^{39}Ar$ thermochronometry. In combination with previously published data, we present a new tectonic model from building of the Paleo-Jinshajiang orogenic belt, to a shift to collapse, and to later exhumation of the metamorphic complex.

2. Geological background

2.1. Tectonic framework

The Jinshajiang suture is inferred to extend from the Pamirs eastward to either the Ailaoshan suture (Jian et al., 2008; Metcalfe, 2006; Roger et al., 2003; Wang et al., 2000b) or the Ganze-Litang suture (Yang et al., 2012), where the divide locates in the Yushu region (Fig. 1). In the eastern Tibetan Plateau, the eastern segment of the JSZ, which is to the southeast of the Yushu region and equals to the south segment of the JSZ in Yang et al. (2012), separates the Qiangtang Block to the west from the Yidun arc to the east (Fig. 1). The Qiangtang Block is separated from the Lhasa Block by the Bangong-Nujiang suture further west, whereas the Yidun arc is separated from the Songpan-Ganze terrane by the Ganze-Litang suture in the east. To the south, the JSZ, Yidun Arc, Ganze-Litang suture and Songpan-Ganze terrane merge into western margin of the Yangtze Block (Wang et al., 2011, 2013) (Fig. 1).

The Qiangtang Block is located to the south and west of the JSZ and to the north and east of the Bangong-Nujiang suture (Fig. 1). Internal division of the Qiangtang Block is still under debate. The geology of the Qiangtang Block varies from the southeast to the northwest. In the southeastern part, the Qiangtang Block is mainly composed of weakly metamorphosed Paleozoic carbonates and clastic rocks unconformably overlain by Permian and Triassic shale, sandstone and volcanic strata (Reid et al., 2005a). The Jiangda-Weixi volcanic arc in the eastern margin of the Qiangtang Block consist of Triassic tholeiitic, calc-alkaline and shoshonitic volcanic rocks followed by Late Triassic intra-plate volcanic rocks, including calc-alkaline basalt, andesite, dacite, and rhyolite, in the inner part of the Block. Occurrence of the arc setting, along with determined ages, was argued to be generated by westward subduction of the Jinshajiang Oceanic block (Hou et al., 2003; Mo et al., 1994). In the northwestern part, ultrahigh-pressure (UHP) metamorphic rocks, which include garnet-bearing blueschist and eclogite (Li et al., 2006), and Late Paleozoic shallow marine strata crops out the Qiangtang Block (Yin and Harrison, 2000 and references therein). The metamorphic rocks are regarded as an extensional core complex from the tectonic mélange underthrust beneath the Qiangtang Block during southward/westward flat subduction of the Jinshajiang oceanic crust (Kapp et al., 2000, 2003;