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Structural analysis and $^{40}Ar/^{39}Ar$ thermochronology of Proterozoic rocks in Sailimu area (NW China): Implication to polyphase tectonics of the North Chinese Tianshan

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ABSTRACT

Understanding the tectonothermal history of the Central Asian Orogenic Belt (CAOB), is of significance in revealing the amalgamation of microcontinents or continental fragments during the accretion and collisional processes of the CAOB. A Precambrian metamorphic basement of the continental block may have been involved in the accretion and collisional processes and thus recorded complete tectonothermal information that is essential in understanding the tectonic evolution of the studied area. The Precambrian Wenquan Group in the Northwest Chinese Tianshan is commonly thought as the basement of the Yili Block. Here we try to reveal the tectonothermal history of this basement by detailed structural analyses and associated Ar–Ar datings. Four main events are recognized, the first one (D1) corresponds to ductile deformation characterized by NNW–SSE stretching lineation and top-to-the south sense of shear. $^{40}Ar/^{39}Ar$ datings on amphibole from an amphibolite and on muscovite from an orthogneiss and a migmatite constrain the age of the D1 event as ~443–413 Ma. The second event (D2) is represented by north-verging folding that variably overprinted the D1 structures. Muscovite on D2 foliation in a micaschist yielded a $^{40}Ar/^{39}Ar$ intercept age of 338 ± 4 Ma providing an oldest limit for the D2 event. The D3 event is marked by localized strike-slip ductile shearing producing sub-E–W trending steep foliation with shallow lineation, occurring at around 289 ± 12 Ma. Finally, the D4 event is widespread brittle thrusting and open-upright folding.

The Proterozoic rocks in the Wenquan Group underwent and recorded main tectono-thermal events relating to the Paleozoic orogenic processes of the CAOB. The D1 event corresponds to the Early Paleozoic continent-arc accretion forming the Kazakhstan–Yili microcontinent (North Tianshan), the D2 event could be correlated to the Late Paleozoic southward subduction of Junggar–Balkash Ocean beneath the Kazakhstan–Yili block and final amalgamation of the Tianshan belt, and the D3 event reflects the Permian post-collisional transcurrent tectonics in the North Chinese Tianshan.

1. Introduction

The Central Asian Orogenic Belt (CAOB) is a typical accretion–collision orogen situated between the Siberian, Baltica and Tarim cratons, and it is an analog to the orogenic belt in modern south-western Pacific (Shu et al., 2002; Xiao et al., 2004, 2010; Windley et al., 2007; de Jong et al., 2009). In CAOB, various microcontinents, continental fragments, accretionary prisms and arc complexes are involved in the orogenic processes (Jahn, 2004; Kröner et al., 2007; Windley et al., 2007; Xiao et al., 2010). The Tianshan belt, south-western part of the CAOB, resulted from accretion and amalgamation between several continental blocks within the Kazakhstan microcontinent with the Tarim craton, and therefore is a key area for studying the Paleozoic tectonic evolution of the CAOB (Fig. 1A). Proterozoic rocks occurring discontinuously in the north-western of Yili, Central and southern part of the Chinese Tianshan belt (Fig. 1B) are considered to represent the continental basement (Hu et al., 2000, 2006; Allen et al., 1993; Gao et al., 1998; Wang et al., 2008). Thus, understanding deformation history of this basement complex becomes essential in revealing tectonic evolution of the Tianshan belt and the CAOB as well.

The Sailimu area, NW of Yili block is one of the largest regions with mass exposure of Precambrian rocks in the Tianshan belt (Fig. 1C). Available studies suggest that these Precambrian rocks formed mainly in Paleoproterozoic to Neoproterozoic (XBGMR,

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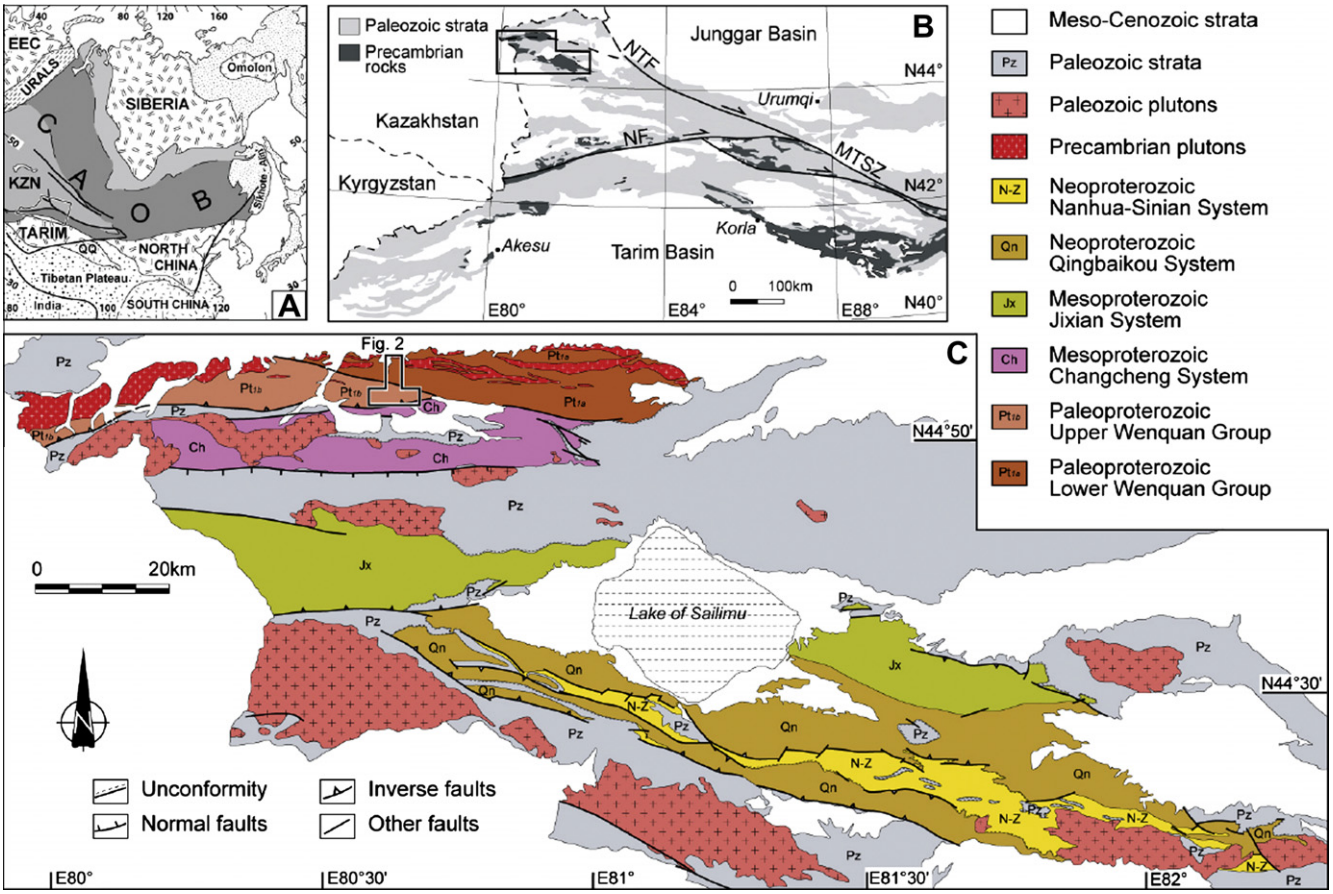

Fig. 1. (A) Simplified tectonic divisions of Eastern Asia showing the location of the Tianshan Belt. CAOB = Central Asian Orogenic Belt; EEC = East European Craton; KZN = Kazakhstan; QQ = Qaidam Qinling. (B) Distribution of Proterozoic rocks in the Chinese Tianshan belt and location of the study area. NTF = North Tianshan Fault, NF = Nalati Fault, MTSZ = Main Tianshan Shear Zone. (C) Simplified geological map of the Sailimu area (modified from XBGMR, 1988a,b, 1992).

1993; Hu et al., 1997, 2000, 2006; Chen et al., 1999), and are considered as the basement of the Yili microcontinent (Allen et al., 1993; Wang et al., 2006, 2008) or as the part of the Aktau–Junggar continental fragment (Windley et al., 2007). The continental block was involved in the accretion and formation of the Kazakhstan continent during Early Paleozoic (Windley et al., 2007; Biske and Seltmann, 2010). However, the tectonic signature of these Precambrian rocks and their correlation to the Paleozoic orogenic evolution of the Tianshan belt remain poorly understood. Specifically, structural features and deformation history are still rarely studied. Lack of such data certainly encumbers our understanding of the geodynamic processes of the Tianshan and whole Central Asia.

In this paper, we conduct a structural study on the metamorphic rocks of the Wenquan Group, north of the Sailimu Lake (Fig. 1C), and $^{40}Ar/^{39}Ar$ dating on the multi-minerals from rocks with different deformation characteristics. The results allow us to recognize main deformation events that affected the studied rocks, and to discuss the tectonic significance of each event during the evolution of the Tianshan belt and the CAOB.

2. Geological background

The Tianshan belt is a Paleozoic orogen that was reactived by post-orogenic transcurrent tectonics and Cenozoic intracontinental shortening (e.g. Windley et al., 1990; Allen et al., 1993; Shu et al., 2003; Laurent-Charvet et al., 2002, 2003; Wang et al., 2006, 2008, 2010, 2011; de Jong et al., 2009). The formation of the Paleozoic Tianshan is paid much attention during last several decades, and it gradually comes to a consensus that the Tianshan belt was built up by polyphase accretion of various micro-continents and magmatic complexes (e.g. Gao et al., 1998; Shu et al., 2002; Xiao et al., 2004; Charvet et al., 2007, 2011; Windley et al., 2007). Though, debate continues on several key issues, such as subdivision of tectonic units, in which Kazakhstan and Yili form the biggest continental assemblage between the Siberia and Tarim (Fig. 1A). This assemblage correspond to the "Kazakh (northern Tien Shan)–Yili Plate" (Mikolaichuk et al., 1995; Konopelko et al., 2008; Gao et al., 2009) that is alternatively named as "Yili–North Tianshan Block" (Charvet et al., 2007; Wang et al., 2008). The Yili–North Tianshan to the north is separated from the Central and South Tianshan to the south by the high-pressure metamorphic rocks of Kekesu–Atbashy zones and associated ophiolitic mélange discontinuously distributed along the Nikolaev Line and Nalati Fault (Fig. 1B; Gao et al., 1998, 2009; Gao and Klemd, 2003; Qian et al., 2009; Wang et al., 2010 and references therein). The equivalent tectonic domain of the Yili–North Tianshan in the western segment is separated into Kyrgyz North Tianshan to the south and the Central Kazakhstan to the north by an Early Paleozoic accretionary wedge (Windley et al., 2007).

The Early Paleozoic evolution of the Tianshan belt is characterized by subduction of oceanic lithosphere and formation of island or continental arc magmatism followed by continental-arc collision. Continental arc magmatism has been documented in the Yili–North Tianshan (or alternatively named as Kazakhstan–Yili) domain. Early Ordovician to Middle Silurian (480–430 Ma) magmatic rocks in Central Kazakhstan (Kröner et al., 2008), Kyrgyz North Tianshan (Konopelko et al., 2008) and Yili block (Zhu et al., 2006; Gao et al., 2009; Yang and Zhou, 2009) formed in an Andean-type active margin setting. This setting is considered to have