Journal of Asian Earth Sciences 127 (2016) 100–118

Contents lists available at ScienceDirect

Journal of Asian Earth Sciences

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

Late Paleozoic tectonics of the Solonker Zone in the Wuliji area, Inner Mongolia, China: Insights from stratigraphic sequence, chronology, and sandstone geochemistry

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ARTICLE INFO

Article history:
Received 2 March 2016
Received in revised form 22 June 2016
Accepted 23 June 2016
Available online 23 June 2016

Keywords:
Stratigraphic sequence
Sandstone geochemistry
Solonker Zone
Altaids (CAOB)
Inner Mongolia

ABSTRACT

The geology in the Wuliji area (including the Enger Us and Quagan Qulu areas) is important for understanding the Late Paleozoic tectonics of the Solonker Zone. Ultramafic/mafic rocks in the Enger Us area, previously interpreted as an ophiolitic suture, are actually lava flows and sills in a Permian turbiditic sequence and a small body of fault breccia containing serpentinite. Subduction zone features, such as accretionary complexes, magmatic arc volcanics or LP/HP metamorphism are absent. Early Permian N-MORB mafic rocks and Late Permian radiolarian cherts accompanied by turbidites and tuffeous rocks indicate a deep water setting. In the Quagan Qulu area, outcrops of the Late Carboniferous to Permian Amushan Formation are composed of volcano-sedimenary rocks and guyot-like reef limestone along with a Late Permian volcano-sedimentary unit. A dacite lava in the Late Permian volcano-sedimentary unit yields a zircon U-Pb age of 254 Ma. The gabbros in the Quagan Qulu area are intruded into the Amushan Formation and caused contact metamorphism of country rocks. Sandstones in the Upper Member of the Amushan Formation contain detrital clasts of volcanic fragments and mineral clasts of crystalline basement rocks (i.e. biotite, muscovite and garnet). Geochemical analysis of volcaniclastic sandstones shows a magmatic affinity to both continental island arc (CIA) and active continental margin (ACM) tectonic settings. A Late Permian incipient rift setting is suggested by analyzing the lithostratigraphic sequence and related magmatism in the Wuliji area. The volcano-sedimentary rocks in the Wuliji area experienced a nearly N-S shortening that was probably related to the Early Mesozoic nearly N-S compression well developed in other areas close to the Wuliji area.

1. Introduction

The Altaids (Şengör et al., 1993; Xiao et al., 2009, 2010) or Central Asian Orogenic Belt (CAOB; e.g., Windley et al., 2007) was formed by accretion of various island arcs, ophiolites, oceanic islands, seamounts, accretionary wedges and continental fragments in a pattern similar to circum-pacific Mesozoic-Cenozoic accretionary orogens over a long period of time (Jahn et al., 2000; Badarch et al., 2002; Windley et al., 2002; Khain et al., 2003; Dobretsov et al., 2004; Kröner et al., 2008; Xiao et al., 2008; Choulet et al., 2012). Lateral accretion and vertical growth were the most significant crustal growth mechanisms in the CAOB (Şengör and Natal'in, 1996; Jahn et al., 2004; Windley et al., 2007) but abundant melting and reworking of crystalline basement rocks led to significant magmatism (Rytsk et al., 2011; Liu et al., 2012; Kröner et al., 2007, 2014). The Solonker Zone (SZ) is an important tectonic part of the CAOB because many researchers have interpreted its mafic rocks as ophiolites and regarded this zone as a Permian or Triassic suture (e.g., Xiao et al., 2003; Feng et al., 2013). However, others have viewed the SZ as an intracontinental deformation zone, perhaps a rift or pull-apart basin, that overprinted an Early Paleozoic suture (Shi et al., 2013; Xu et al., 2013; Yang et al., 2014; Zhao et al., 2016; Luo et al., 2016). Tectonics, magmatism and associated basin-filling processes in the SZ provide good examples for understanding intracontinental reworking processes.

The Wuliji area is located at the northern margin of the Alxa block (Fig. 1) within the Solonker Zone that extends from eastern Inner Mongolia to the Beishan region to the west (Xiao et al.,

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http://dx.doi.org/10.1016/j.jseaes.2016.06.022
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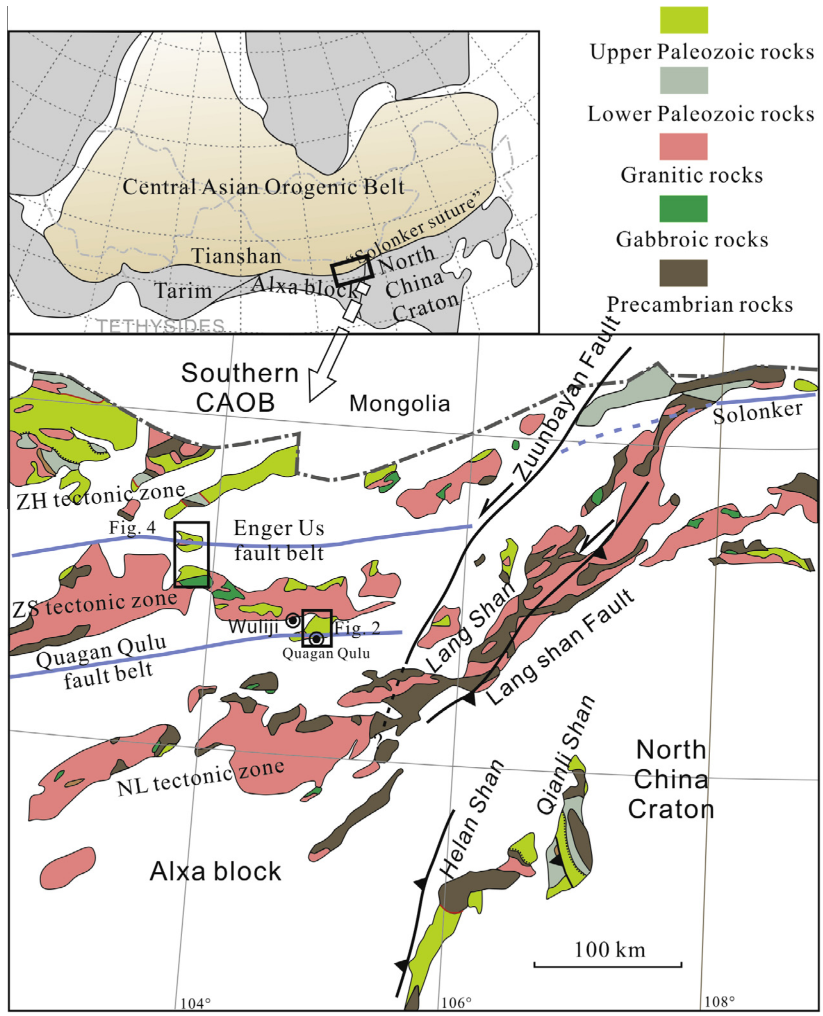

Fig. 1. Tectonic sketch map of the western Inner Mongolia area, modified from Zheng et al. (2014), Ren et al. (2013), Zhang J. et al. (2013), Darby and Ritts (2002), and Faure et al. (2012). Late Mesozoic-Cenozoic rocks are omitted for clarity. Red line represents small fault trace; dashed line represents sedimentary unconformity. ZH: Zhusileng-Hangwula tectonic zone; ZS: Zongnaishan-Shalazhashan tectonic zone; NL: Nuru-Langshan tectonic zone. CAOB: Central Asian Orogenic Belt. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

2003; De Jong et al., 2006; Zheng et al., 2014; Tian et al., 2015; Song et al., 2015). Pioneering survey work in the Enger Us and Quagan Qulu areas revealed that the geology in this region documents the final closure of Palaeo-Asian Ocean accompanied by crustal accretion and reworking (Wu and He, 1993). They mapped rocks in Enger Us as ophiolitic mélange and considered that the basaltic rocks are oceanic crust relicts on the basis of geochemical analysis. Wang et al. (1998) studied structural styles in the same area and recognized forearc ophiolitic mélange and a foreland thrust and fold belt. More recently, researchers have argued that an ophiolitic suture zone is present in Enger Us on the basis of the petrology and geochemistry of mafic rocks as (e.g., Zheng et al., 2014; Zhang W. et al., 2013; Xu et al., 2014; Zhao et al., 2014). To the south of Enger Us, in the Quagan-Qulu tectonic zone, volcano-sedimentary rocks and associated mafic rocks have been interpreted as products of a back-arc basin that formed by the southward subduction of Palaeo-Asian oceanic crust (Wu and He, 1993; Wang et al., 1994; Zheng et al., 2014). However, the presence of a Late Paleozoic subduction system raises questions such as: (i) What is the significance of vast areas of Permian volcano-sedimentary rocks, and plutons intruding the Enger Us "opholitic mélange"? (ii) Why is the HP/LT metamorphism characteristic of subduction zones absent in the Enger Us tectonic belt? (iii) What are the lithological, structural and temporal relationships between the "foreland thrust and fold belt" and the "opholitic belt" in the Enger Us area and the "back arc basin" in the Quagan Qulu area? (iv) What are the lines of evidence for back arc basin closure by oceanic subduction in the Quagan Qulu area? The few geochemical diagrams available for the mafic rocks are insufficient to decipher the complicated geodynamic process (e.g., Li et al., 2015). In order to answer these questions, in this paper we present a stratigraphic sequence, and sandstone geochemistry and structural study in the Wuliji area. The time scale used in this paper is from the International Chronostratigraphic Chart (version 2016/04).

2. Geological background

Three main litho-tectonic zones are recognized in the study area, from north to south, namely, the Zhusileng-Hangwula (ZH) tectonic zone, the Zongnaishan-Shalazhashan (ZS) tectonic zone and the Nuru-Langshan (NL) tectonic zone. They are separated by two main fault belts, the Enger Us fault belt and the Quagan Qulu fault belt (Wu and He, 1993; Zheng et al., 2014; Fig. 1). To the east of the study area, the Zunnbayan fault zone and the Langshan fault zone constitute a significant tectonic break between the Alxa block and the North China Craton (Huang et al., 1999; Geng and Zhou, 2010; Zhang J. et al., 2013).