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Mesozoic metamorphism and its tectonic implication along the Solonker suture zone in central Inner Mongolia, China

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ABSTRACT

The Xing'an–Inner Mongolia Orogenic Belt (XIMOB) exposed in the eastern section of the Central Asian Orogenic Belt (CAOB) is generally thought to have resulted from closure of the Paleo-Asian Ocean. However, disputations still exist on the age and detailed tectonic processes involved in its final amalgamation. The Solonker suture zone in the central Inner Mongolia, once recognized as the major paleo-plate boundary recording the terminal collision of the XIMOB, is characterized by extensive regional low-temperature metamorphism of greenschist to epidote–amphibolite facies with local presence of blueschists, which lacks systematic study. Four metabasite and garnet–mica schist samples were studied for determination of metamorphic *P–T* evolution using pseudosection and conventional thermobarometry. The two metabasite samples from Wulangou and Daqing Pasture contain actinolite, albite, epidote, chlorite and hornblende (in Daqing Pasture) and are estimated to have peak *P–T* conditions of 5.2–5.9 kbar/415–450 °C in Wulangou and 7.0–7.9 kbar/470–475 °C in Daqing Pasture. Two garnet–mica schist samples from Shuangjing (or Shuangjing schist) contain garnet porphyroblasts, muscovite, quartz, plagioclase, chlorite with or without potassium feldspar, biotite, and calcite, and are modeled to record prograde *P–T* vectors respectively of 3.0 kbar/482 °C–3.3 kbar/495 °C and 4.2 kbar/478 °C–4.8 kbar/483 °C, followed by near-isothermal decompression. The zircon U–Pb dating analyses suggest that the metamorphism probably occurred soon afterwards in the Early Mesozoic. The peak *P–T* conditions for the metabasite and garnet–mica schist samples yield thermal gradients respectively of 18–22 °C/km and 26–33 °C/km, being intermediate and low *P/T* series, and the metamorphic evolution in these rocks characteristic of clockwise *P–T* paths may correspond to tectonic thickening and thinning processes. The extensive low-temperature metamorphism of intermediate to low *P/T* types along the Solonker suture zone is alternatively interpreted to have resulted from closure of limited ocean basins. Thus, the Solonker suture zone may not represent a typical suture after closure of the Paleo-Asian Ocean but a tectonic belt that records the closure of the limited basins. The closure of the Paleo-Asian Ocean in the central Inner Mongolia should have occurred much earlier in the Devonian.

1. Introduction

The Xing'an–Inner Mongolia Orogenic Belt (XIMOB) exposed in the eastern section of the Central Asian Orogenic Belt (CAOB) is generally thought to have resulted from closure of the Paleo-Asian Ocean and occupies an important position as it records the long-lived tectonic evolution of CAOB from the Neoproterozoic to Mesozoic (Badarch et al., 2002; Buslov et al., 2001; Jahn et al., 2000, 2009; Kröner et al., 2007; Sengör and Natal'in, 1996; Sengör et al., 1993; Windley et al., 2007; Xiao et al., 2009a, 2009b, 2013). Many studies have attempted to unravel its architecture and reconstruct the tectonic evolution history (e.g. Chen et al., 2000; Eizenhöfer et al., 2014; Jahn, 2004; Jian et al., 2008, 2010; Shao, 1991; Tang, 1990; Xiao et al., 2003; Xu et al., 2013, 2015). The current hot debate is focused on two models (Windley et al., 2007): either the orogen formed through continuous subduction and accretion over a prolonged period of time until the late-Permian to mid-Triassic termination of the accretionary processes (Chen et al., 2000, 2009a; Hsü et al., 1991; Jian et al., 2008, 2010; Li, 2006; Ruzhentsev et al., 1989; Wang and Liu, 1986; Wang et al., 1991; Xiao et al., 2003, 2009a), or the late Devonian closure of Paleo-Asian Ocean occurred along Ondor Sum in the south and Sunid Zuoqi in the north (Tang, 1990; Tang and Yan, 1993; Xu et al., 2013, 2014), followed by a Permian intra-oceanic arc trench system (Jian et al., 2008, 2010) or by post-orogenic extension until the Late Triassic (Shao et al., 2014, 2015; Zhang et al., 2008, 2015b). Consequently, the tectonic setting in the Late-Paleozoic to Mesozoic has been a pivotal issue in elucidating the evolution of XIMOB.

The Solonker suture zone in the central Inner Mongolia is usually recognized as a major paleo-plate boundary and records the terminal collision of the XIMOB (Sengör et al., 1993; Tang, 1990). Previous studies mostly focus on the geochronology and geochemistry of ophiolites,

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plutonic and volcanic rocks of Late-Paleozoic to Early Mesozoic (Chen et al., 2000, 2009a; Chu et al., 2013; Jian et al., 2010; Li et al., 2007, 2009; Miao et al., 2008; Shi et al., 2014; Xiao et al., 2003, 2009a; Zhang et al., 2015a). However, the tectonic discriminations through geochemical data analysis in the previous researches were usually multiple in solutions thus resulted in dispute on the tectonic environment in the Late-Paleozoic to Mesozoic and significance of the Solonker suture zone (Jian et al., 2008, 2010; Tong et al., 2015; Xiao et al., 2003; Xu et al., 2013). Field investigations since the late 1980s have indicated that the central Inner Mongolia is characterized by extensive regional metamorphism in greenschist to epidote–amphibolite facies in Late Paleozoic–Early Mesozoic terranes (Dong et al., 1986; IMBGMR, 1991). These metamorphic rocks may record information that can be used to evaluate the thermal and tectonic regimes in an orogenic process. However, few investigations on the metamorphism were carried out in the previous studies probably because the metamorphism is mostly in low grade and is generally supposed to represent simple metamorphic settings (Pattison and Debuhr, 2015). Moreover, low-grade metamorphic rocks generally develop simple mineral assemblages, the *P–T* conditions of which cannot be easily addressed for lack of available thermobarometries (Spear, 1993). With improvement of the internally consistent thermodynamic dataset of Holland and Powell (1998) and mixing models for complicated solid solutions, quantitative phase diagrams calculated using the software THERMOCALC (Powell et al., 1998) have proved to be a powerful approach to elucidate phase relations in greenschist to epidote–amphibolite facies metamorphism and is available to say more about the mineral equilibria in the rocks.

There are three objectives in this paper: (1) to determine the *P–T* evolution for the regional metamorphism along the Solonker suture zone using pseudosection approach; (2) to constrain the metamorphic age using LA-ICP-MS zircon U–Pb dating methods; and (3) to reinterpret the tectonic regime for the regional metamorphism in the central Inner Mongolia.

2. Geological background

The Solonker suture zone located in the eastern segment of the CAOB, extends in NEE for over 700 km from Solonker, via Sonidyouqi, to Linxi in central Inner Mongolia (Fig. 1). It is bordered by the Linxi Fault to the north and Xar Moron Fault` to the south (Xiao et al., 2003). This suture zone was once nominated by Xiao et al. (2003) as the Erdaojing accretion complex, flanked by the Baolidao arc–accretion complex in the north and the Ondor Sum (Bainaimiao) arc–accretion complex in the south. However, it was alternatively supposed by Jian et al. (2010) as a tectonic belt separating the southern and northern opposite subduction-orogenic belts formed in the Early Paleozoic. Along the suture zone there are a number of metamorphic units, stratigraphic sequences, basic–ultrabasic blocks, and granitoid intrusions.

2.1. Metamorphic units

Metamorphic units along the Solonker suture zone and the neighboring zones include the Xilingol Complex, the Ondor Sum 'Group', and the Shuangjing Complex.

The Xilingol Complex occurs discontinuously from Sunidzuoqi, Xilinhot to Daqing Pasture and mainly consists of metamorphosed sedimentary and igneous rocks in amphibolite-facies. It has been considered as an ancient terrane in the XIMOB (Shao, 1991; Xu et al., 2013). Recent studies reveal that the complex is mainly derived from Early-Paleozoic fore-arc turbidite sequences and granitic intrusives with a metamorphic age of 337 Ma (Chen et al., 2009b; Li et al., 2011; Shi et al., 2003; Xue et al., 2009). Sun et al. (2013) reported a few Mesoproterozoic granitic gneisses of 1516 ± 31 Ma and 1390 ± 17 Ma in Sunidzuoqi, suggesting the complex may have experienced a protracted evolutional history.

The Ondor Sum 'Group' is divided into southern and northern zones: the southern zone lies in Wulangou and Tulinkai and the northern zone

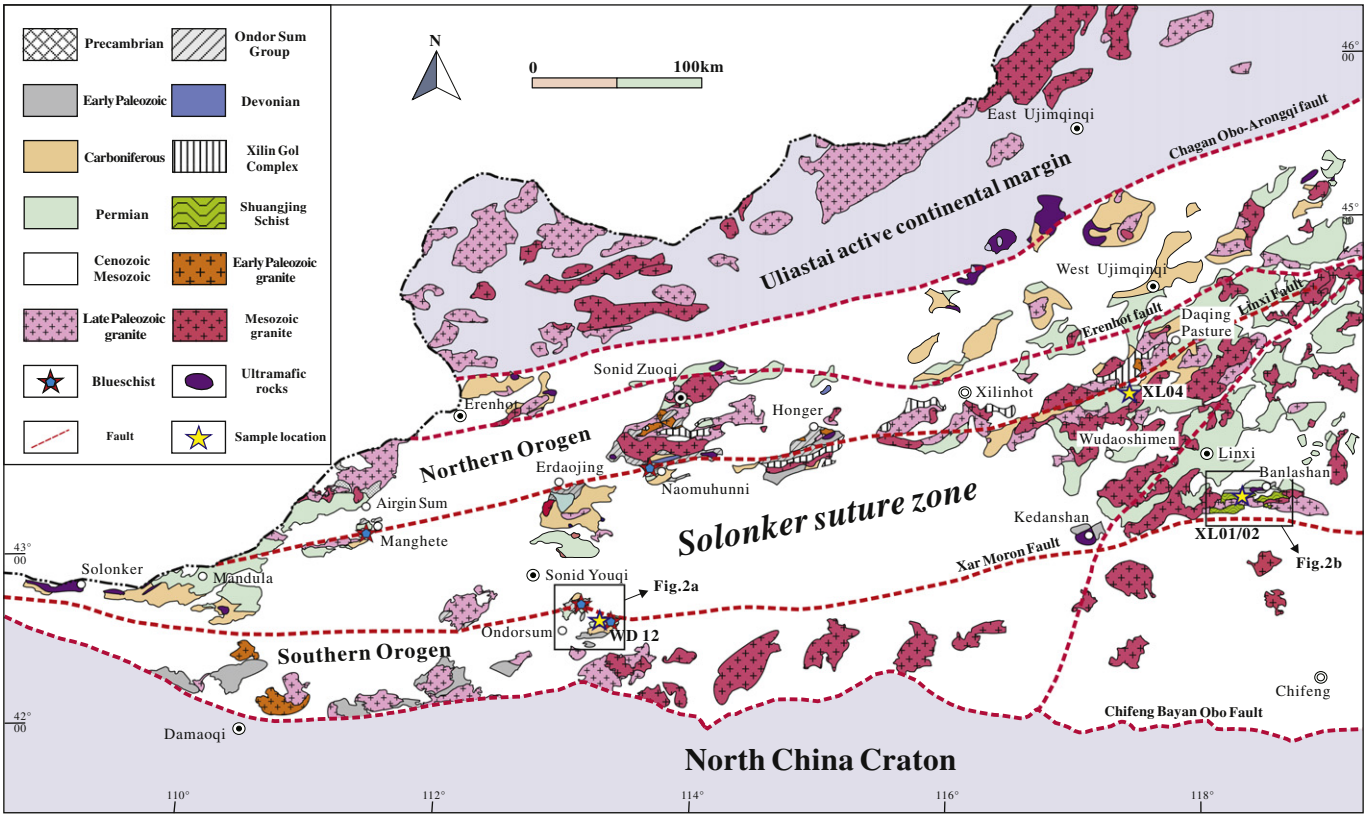

Fig. 1. Geological sketch map of the Central Inner Mongolia showing distribution of the Solonker suture zone and the sample locations (modified after Chu et al., 2013; Jian et al., 2010; Xiao et al., 2003; Xu et al., 2013). Positions of Fig. 2a and b are marked.