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Structural overprints of early Paleozoic arc-related intrusive rocks in the Chinese Central Tianshan: Implications for Paleozoic accretionary tectonics in SW Central Asian Orogenic Belts

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ABSTRACT

The Chinese Central Tianshan constitutes the centric and vital component of the Tianshan orogen, it contains important information for understanding the accretionary orogeny of the Central Asian Orogenic Belt (CAOB). To better constrain the Paleozoic evolution of the Chinese Central Tianshan, we present new field observations, fabric analyses, zircon U–Pb ages, zircon Lu–Hf isotopic and whole rock geochemical data of mafic, intermediate and felsic intrusive rocks in the Baluntai area, Chinese Central Tianshan. Field-scale and microscopic structural patterns of the intrusive rocks reveal that the early Paleozoic gabbro-diorite intrusions underwent multistage structural reworking, and generally exhibit gently south- or north-dipping foliations and microscopic kinematic fabrics indicating top-to-the-north shearing. These ductilely deformed intrusive rocks were intruded by granitic sills or dikes that are generally sub-parallel or with low angle to the main foliations of the host rocks. Gentle foliations and top-to-the-north kinematics can be rarely noticed within the granitic intrusions. At the sites close to the Baluntai Fault, locally intense mylonitization occurred in the felsic intrusions and deformed mafic-intermediate ones, where earlier shallow foliations were completely or partially transformed to steep ones bearing sub-horizontal stretching lineations, and asymmetric kinematic indicators suggest dextral shearing. Zircon LA-ICP-MS U–Pb datings constrain the emplacement ages of the gabbroic and dioritic intrusive rocks at 452–420 Ma, and the crystallization age of one mylonitic K-granite at 417 Ma. Two samples of granitic sill contain plenty of zircons inherited from the host gabbroic and dioritic rocks, and a few such zircons have dark rims probably formed during granitic injection, dating on these rims roughly constrains the crystallization ages of the felsic sills at ca. 370–360 Ma. The $\varepsilon Hf(t)$ values of a gabbro (420 Ma), two diorite samples (425 and 445 Ma) and a mylonitic granite (417 Ma) vary from −15.45 to −2.06, corresponding to two-stage crustal model ages $(T_{DM})_C$ ranging from ~2.4 Ga to ~1.5 Ga, suggesting variable degrees of involvement of the Proterozoic crustal basement and the juvenile mantle components during the early Paleozoic magmatic generation. The geochemical data of the mafic-intermediate plutons exhibit features of magmatic rocks formed in continental arcs. The mylonitic granite and one undeformed granite resemble A-type granite in terms of geochemical features, suggesting that these granites were produced in a post-collisional/extensional environment. Considering the previously published data, the early Paleozoic arc-type magmatic rocks within the Chinese Central Tianshan likely resulted from the southward subduction of an oceanic basin located to the north, and ceased progressively during 420–400 Ma. The amalgmation between Chinese Central Tianshan and Tarim most likely completed at ca. 360 Ma following the closure of the South Tianshan back-arc basin. This event reworked the Chinese Central Tianshan arc and formed the top-to-the-north kinematics. Thereafter, the Chinese Central Tianshan was affected by the early Permian dextral strike-slip faulting due to the regional large-scale transcurrent tectonics and overprinted by the Permian mafic magmatism.

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1. Introduction

The Central Asian Orogenic Belt (CAOB, Jahn et al., 2000; Jahn, 2004; Fig. 1A), also known as Altaids (Sengör et al., 1993), is a huge orogenic system sandwiched between the European, Siberian, North China and Tarim cratons (Windley et al., 2007; Xiao et al., 2010; Wilhem et al., 2012). It is formed during latest Proterozoic to end Paleozoic by the closure of the Paleo-Asian ocean (e.g. Safonova, 2009) and the subsequent amalgamation of various island arcs, oceanic plateaus, seamounts, accretionary wedges and microcontinents (Gao et al., 1998, 2009b; Shu et al., 2002; Safonova et al., 2004; Xiao et al., 2004, 2008, 2009; de Jong et al., 2006; Windley et al., 2007; Wang et al., 2009a, 2011a, 2011b; Charvet et al., 2011; Choulet et al., 2011; Jiang et al., 2011; Zhao et al., 2013; Kröner et al., 2014). Significant continental growth in the Phanerozoic times was associated with such long lasting accretionary processes (Jahn et al., 2000; Jahn, 2004; Chen and Arakawa, 2005; Wang et al., 2009b, 2014a).

The Tianshan belt, extending east-west for ca. 3000 km in the southernmost part of the CAOB, plays a crucial role in the formation of the CAOB and Eurasia (Gao et al., 1998, 1999, 2000, 2006, 2009a, 2011; Shu et al., 2002, 2004, 2011; Xiao et al., 2003, 2004, 2008, 2013; Xu et al., 2006; Wang et al., 2007a, 2007b, 2009a, 2010a, 2011a, 2011b; Charvet et al., 2007, 2011; Han et al., 2010, 2011; Jian et al., 2013). It is widely accepted that the Tianshan belt was built in late Paleozoic (Allen et al., 1993; Gao et al., 1998, 2009a, 2011; Shu et al., 2002; Klemd et al., 2005; Wang et al., 2008, 2010a, 2011a; Han et al., 2010, 2011; Hegner et al., 2010; Su et al., 2010), and strongly reworked by subsequent large-scale strike-slip faulting (Yin and Nie, 1996; Shu et al., 1999; Laurent-Charvet et al., 2003; Xu et al., 2003; Wang et al., 2006, 2007b, 2008, 2009a, 2014b; Branquet et al., 2012). However, the accretionary orogenic progress of the Tianshan belt in early Paleozoic time is still poorly constrained (Windley et al., 1990; Han et al., 2004; Xu et al., 2011).

The Chinese Tianshan, the eastern segment of the belt, is tectonically subdivided into the South, Central, and North Tianshan units (Gao et al., 1998; Shu et al., 2002; Charvet et al., 2007; Wang et al., 2008) (Fig. 1B). As a critical component of the Chinese Tianshan, understanding the tectonic setting of Chinese Central Tianshan is essential for deciphering the accretionary processes of the whole Tianshan belt as well as that of the CAOB. One of the most important features of the Central Tianshan Belt is the occurrence of voluminous Paleozoic intrusive rocks (XBGMR, 1993; Fig. 1C). Several geochemical and geochronological studies have been conducted and available data indicate that the Paleozoic intrusive rocks in Chinese Central Tianshan resulted from multi-stage subductional, collisional and/or post-collisional events (Yang et al., 2006; Shi et al., 2007; Wang and Wang, 2010b; Dong et al., 2011; Chen et al., 2012; Ma et al., 2013, 2014). However, some issues related to the Paleozoic evolution of the Central Tianshan remain to be addressed, these issues include (1) the spatial and temporal distributions of the Paleozoic magmatism, (2) structural features and tectonic reworking characteristics of the Paleozoic magmatic rocks, and (3) origins and significances of the multi-staged arc-type magmatism in the tectonic evolution of the Tianshan Belt.

Detailed mapping has shown that plenty of mafic to felsic plutons were emplaced in the Baluntai area, Chinese Central Tianshan (XBGMR, 1993), and often occur as intrusive complex due to polyphase intruding and crosscutting of older plutons by younger ones (Figs. 1–3). In previous studies, the tectonic settings of Paleozoic granitoids were mainly inferred by their geochemical compositions, and the structures and fabrics of these rocks were rarely considered. In this study, we focus on these plutonic complexes and present field observations, fabric analyses, geochemical, and geochronological data of the multi-staged intrusive rocks from the Chinese Central Tianshan. On the basis of a synthesis of previous works, our new data are used to unravel the early Paleozoic tectono-magmatic events and later tectonic reworking of the

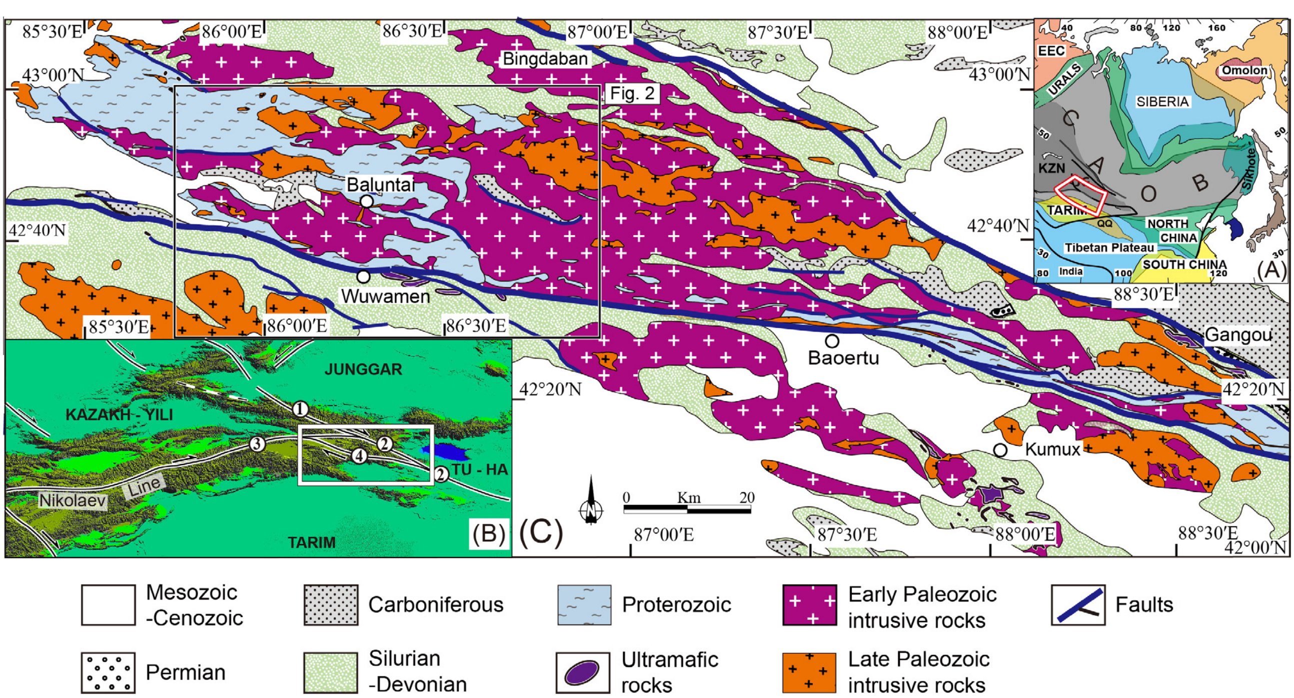

Fig. 1. (A) Tectonic framework of the Central Asia Orogenic Belt (after Jahn et al., 2000). CAOB = Central Asian Orogenic Belt. EEC = East European Craton; KZN = Kazakhstan; QQ = Qaidam and Qinling. (B) Tomographic map of the Tianshan belt. Numbers denote major faults, (1) North Tianshan fault; (2) Main Tianshan Shear Zone; (3) Nalati fault; (4) Baluntai fault. (C) Simplified geological map of the Chinese Central Tianshan, compiled from geological maps at scale 1:200,000 (XBGMR, 1959, 1960, 1967, 1969, 1972, 1976, 1977).