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Continental vertical growth in the transitional zone between South Tianshan and Tarim, western Xinjiang, NW China: Insight from the Permian Halajun A1-type granitic magmatism

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ABSTRACT

The South Tianshan Collisional Belt (STCB) and northern margin of the Tarim Block (NTB) are key areas for understanding the prolonged tectonic evolution of the Central Asian Orogenic Belt (CAOB). The Halajun region in Xinjiang province, NW China is located within the tectonic transition zone between STCB and Tarim Blocks. Several granitic intrusions and one mafic–ultramafic complex (Piqiang complex) are exposed in this region. Zircon U–Pb dating, whole-rock major oxide, trace element and Nd isotopic data are presented for the Huoshibulake, Tamu, Kezi'ertuo and Halajun II granitic intrusions in this area. New LA-ICP-MS U–Pb age for Kezi'ertuo intrusion, coupled with previously published SHIRMP U–Pb ages for Huoshibulake and Halajun II intrusions and Piqiang complex, reveals that all the igneous rocks in the Halajun region are coeval (~275 Ma). Geochemically, the four granitic intrusions show high contents of SiO_2, K_2O and total alkalis and possess trace element patterns characterized by Rb, Nb, Ta, Zr and Hf enrichment and significantly negative Ba, Sr, P, Eu and Ti anomalies. These features strongly favor an A1-type affinity for the Halajun granitic intrusions. Among the four intrusions, the Kezi'ertuo, Tamu and Halajun II intrusions possess positive to slightly negative $\varepsilon_{Nd}(t)$ values ranging from −0.9 to +0.6, whereas the Huoshibulake intrusion displays less depleted $\varepsilon_{Nd}(t)$ values of −2.6 to −2.9. Our new elemental and isotopic data suggest that the four granitic intrusions were generated by the partial melting of a common Neoproterozoic gabbroic source, probably as a result of the ~275 Ma underplating of the asthenosphere mantle-derived magmas. The variable involvement of the mantle components accounts for the range of $\varepsilon_{Nd}(t)$ values. After the generation of the parental magma, alkali feldspar, arfvedsonite, biotite, Fe–Ti oxides and zircon seem to have fractionated prior to the final emplacement of the granitic magmas. In combination with the regional geological history, we propose that the ~275 Ma A1-type granitic magmatism in the Halajun region and other areas of the NTB provides a good proxy record for the vertical continental crustal growth in the southern margin of the CAOB during the Permian. Our study, in combination with other geological evidence, indicates that these A1-type felsic and OIB-like mafic–ultramafic rocks, with ages from ~282 Ma to ~275 Ma, in the southern margin of the CAOB are parts of the Permian Tarim large igneous province and could be genetically related to the Tarim mantle plume.

1. Introduction

The Central Asian Orogenic Belt (CAOB), also known as the 'Altaid tectonic collage', is one of the world's largest accretionary orogens with considerable juvenile crustal growth during Phanerozoic (Rojas-Agramonte et al., 2011; Şengör and Natal'in, 1996a,b; Windley et al., 2007; Xiao et al., 2010, 2012). In contrast to typical collisional orogenic belts (e.g., Alps and Himalayas), the CAOB comprises numerous tectonic terranes with different amalgamation history, probably including fragments of many island arcs, seamounts, accretionary prisms and ophiolites, interspersed with blocks of older continental crust and slivers of oceanic crust (Cai et al., 2011, 2012; Long et al., 2012; Xu et al., 2012; Zhang et al., 2010a). Due to the difficulty in identifying the nature of individual terranes, the tectonic evolution of this huge and complex accretionary belt is still poorly understood.

Western Xinjiang, NW China, located in the southwestern part of the CAOB (Fig. 1a), is tectonically composed of, from north to south, Altay, Junggar Block, North Tianshan Collisional Belt (NTCB), Central

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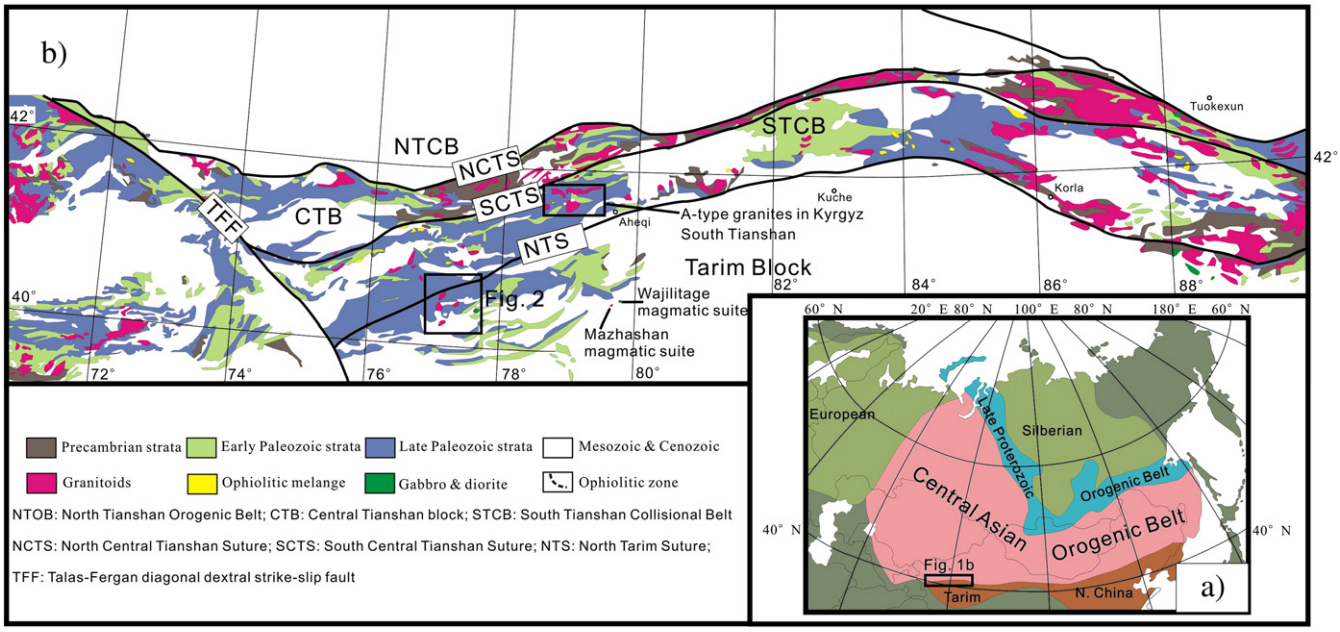

Fig. 1. (a) Tectonic sketch map of the Central Asia Orogenic Belt showing the location of South Tianshan Collisional Belt and the northern margin of the Tarim Block. (b) Geological map of the South Tianshan Collisional Belt and northern margin of the Tarim Block.
Modified from Gao et al. (2011) and Huang et al. (2012).

Tianshan Block (CTB), South Tianshan Collisional Belt (STCB) and the northern margin of the Tarim Block (NTB). Among these tectonic units, STCB and NTB constitute the southern margin of the CAOB. Since almost all paleogeographic studies put the Tarim Block as the last block to dock with the CAOB, the formation of STCB, as a result of the collision between Tarim and Central Tianshan Blocks, represents the termination of the prolonged accretionary orogeny of the CAOB (Xiao et al., 2010, and references therein). Thus, the STCB and NTC are key areas for understanding the tectonic history of the CAOB. In recent years, several studies have attempted to unravel the enigmatic tectonic history of the STCB and NTB (e.g., Gao et al., 2011; Long et al., 2011a; Yang et al., 2007; Zhang et al., 2009, and references therein). However, the nature and tectonic evolution of STCB and NTB is still debated, and some contrasting tectonic models have been proposed. The controversy mainly focuses on the nature of their tectonic affinities during the Permian, which were variously proposed as arc-related, collision-related, or anorogenic (Long et al., 2011a; Zhang et al., 2008, 2010b). Moreover, understanding of the accretionary process is still handicapped by the lack of a fully developed geological record.

Granitoid rocks are widely distributed in the STCB as well as in the NTB, and most of them are of Late Paleozoic age (Gao et al., 2011; Zhang et al., 2009, and references therein). These rocks not only serve as a diagnostic geodynamic tracer for constraining the tectonic evolution, but also represent an important mechanism of continental growth. The Halajun region, cut by numerous NE-SW-extending faults that form the southern border of the STCB, is considered to be situated in the tectonic transition zone between STCB and NTB. Granitic intrusions along the NE-SW-extending faults are exposed for more than 150 km^2 in area. In this paper, we report new laser ablation ICP-MS U–Pb zircon age, bulk-rock major and trace element, and Nd isotopic data for three granitic intrusions (Kezi'ertuo, Huoshibulake and Tamu intrusions) in Halajun region. Based on the results, together with previously published data of igneous rocks exposed in Halajun region (e.g., Halajun II intrusion and Piqiang complex) and other areas of the STCB and NTB, we attempt to: 1) track the sources and petrogenesis of the Halajun granitic intrusions, 2) provide important constraints on the tectonic setting and 3) address the mechanism of the continental vertical accretion of the CAOB.

2. Geological setting

Among the tectonic units in Western Xinjiang, the Altay, NTCB and STCB are Paleozoic accretionary belts whereas the Junggar Block, CTB and the NTB are microcontinental blocks or terranes (Li et al., 2006). Our study focuses on the area including STCB and NTB, which represent the southern margin of the CAOB.

The STCB is bounded by the Northern Tarim suture (NTS) to the south and the Southern Central Tianshan suture (SCTS) to the north. It has been envisaged that this collisional belt represents a collage of two microcontinental blocks amalgamated during the Late Paleozoic: the Tarim Block as a passive continental margin in the south, and Central Tianshan Block as an active continental margin in the north (Gao et al., 1998; Zheng et al., 2006). Before the amalgamation, the two blocks were separated by the Paleozoic South Tianshan Ocean, a branch of the large Paleo-Asian Ocean. Produced by the discontinuous northern subduction of the Paleozoic South Tianshan Ocean and subsequent final collision between the two blocks, ophiolites and ophiolitic mélanges are sporadically exposed along the Southern Central Tianshan suture (SCTS) that separates the STCB from CTB (Fig. 1a; Gao et al., 1998, 2011; Han et al., 2010; Long et al., 2011a). Recent geochronological studies of ophiolites and ophiolitic mélanges along the SCTS have suggested that the Paleozoic South Tianshan Ocean might have opened not earlier than the Cambrian and that the Central Tianshan and Tarim Blocks were part of the 'Rodinia supercontinent' throughout the latest Proterozoic (Gao et al., 1998, 2011, and references therein). Thus, the STCB and NTB share a common Precambrian basement, represented by Archean complexes sporadically exposed in the NTB, and the Paleoproterozoic Xingditagh Formation and Mid-Proterozoic Akesu Formation, both of which are exposed in the central part of the STCB (Fig. 1b). Lower to Middle Paleozoic marine chert, limestone, and flysch mainly crop out in the northern part of the STCB and the central part of the NTB. Upper Paleozoic limestone, sandstone, and shale with minor volcanic rocks, are widespread in the two units (Fig. 1b). Notably, the Permian strata in the northern and central parts of the STCB are characterized by typical terrestrial volcanic rocks (Xiaokantilike Formation) that unconformably overlie the strongly folded upper Carboniferous marine carbonate rocks (Huang et al., 2012). Nevertheless, the Permian