Tectonophysics 499 (2011) 118–131

Contents lists available at ScienceDirect

Tectonophysics

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

The collision between the Yili and Tarim blocks of the Southwestern Altaids: Geochemical and age constraints of a leucogranite dike crosscutting the HP–LT metamorphic belt in the Chinese Tianshan Orogen

Jun Gao [a,*], Reiner Klemd [b], Qing Qian [a], Xi Zhang [a], Jilei Li [a,b], Tuo Jiang [a], Yongqiang Yang [c]

[a] Key Laboratory of Mineral Resources, Institute of Geology and Geophysics, Chinese Academy of Sciences, P.O. Box 9825, Beijing 100029, China
[b] GeoZentrum Nordbayern, Universität Erlangen, Schlossgarten 5a, 91054 Erlangen, Germany
[c] State Key Laboratory of Geological Processes and Mineral Resources, China University of Geosciences, Beijing 100083, China

ARTICLE INFO

Article history:
Received 2 December 2009
Received in revised form 14 December 2010
Accepted 3 January 2011
Available online 7 January 2011

Keywords:
Leucogranite dike
Collision
Yili block
Tarim block
Tianshan
Southwestern Altaids

ABSTRACT

A *ca.* 600 m-long, 0.5–20 m-wide NW–SE trending granite dike crosscuts the high pressure–low temperature (HP–LT) Tianshan metamorphic belt, the foliation of which is parallel to the main ENE regional trend in the Chinese South Tianshan Orogen. It is mainly composed of plagioclase, K-feldspar, quartz, muscovite, biotite and secondary chlorite, while fluorite, zircon and xenotime occur as accessories. The immediate country rock is a quartz–biotite–plagioclase schist, which grades several tens of meters away from the granite dike into a chlorite–mica–albite schist. The latter schist is intimately intercalated with blueschist layers and boudins. The A/CNK value of the granite dike samples varies from 1.15 to 1.27 indicating a strongly peraluminous composition. CaO/Na_2O ranges from 0.06 to 0.17 and Al_2O_3/TiO_2 from 240 to 525, similar to the ratios of strongly peraluminous (SP) granites exposed in 'high-pressure' collision zones such as the Himalayas. A zircon U–Pb age of 285 Ma was obtained for the granite dike, thus constraining the upper limit for the age of HP–LT metamorphism. The petrological and geochemical data suggest that the SP leucogranite dike intruded during the exhumation of overthickened crust in the post-collisional setting between the Yili (–Central Tianshan) and Tarim blocks. The dataset presented here in conjunction with previously published data corroborate that the HP–LT metamorphism must have occurred earlier than the Permian in the Tianshan Orogen. Therefore, the collision between the Yili (–Central Tianshan) and Tarim blocks and the final amalgamation of the Southwestern Altaids must have been terminated in Late Paleozoic and not in Triassic times as previously suggested.

1. Introduction

The Central Asian Orogenic Belt (CAOB; Zonenshain et al., 1990; Jahn et al., 2000a) or the Altaid Tectonic Collage (Altaids; Sengör et al., 1993) which is sandwiched between the Siberian and Sino-Korean–Tarim–Karakum cratons (Fig. 1a) is the largest Phanerozoic accretionary orogen in the world (Windley et al., 2007; Xiao et al., 2009a, b). Considerable continental growth in the Phanerozoic eon has been advocated for the Altaids as a consequence of lateral accretion of young arc complexes and vertical underplating of mantle derived magmas (Jahn et al., 2000a, b; Gao et al., 2002; Chen and Jahn, 2004; Li et al., 2006; Kröner et al., 2007, 2008). Although arc accretion appears to have been the dominant process in the Altaids, post-collisional mantle-derived magmatic intrusions may also have been involved (Han et al., 1997, 2010; Zhao et al., 2000, 2008; Jahn, 2004; Zhou et al., 2004). The time of the final closure of the Paleo-Asian Ocean and the amalgamation of terranes including oceanic plateaus, oceanic island-arcs, seamounts and Precambrian microcontinents within the Altaids is critical to understanding the mechanism of the Phanerozoic continental growth, which is interpreted as lateral accretion related to oceanic subduction with or without vertical addition of post-collisional mantle-derived magmas (Sengör et al., 1993; Han et al., 1997, 2010; Jahn et al., 2000a, b; Gao et al., 2002; Li et al., 2006; Xiao et al., 2009a, b). The final amalgamation of the southern active margin of the Siberian craton with the passive margin of the Tarim block along the South Tianshan Orogen was proposed to have marked the termination of the Paleo-Asian Ocean in the southwestern corner of the Altaids (Sengör et al., 1993; Xiao et al., 2009a). Therefore, the exact timing of the collision between the Tarim and Yili blocks is decisive for constraining the tectonic evolution and continental growth of the Altaids.

The South Tianshan Orogen, which extends west–east for about 2500 km from Uzbekistan, Tajikistan, Kyrgyzstan, and Kazakhstan to Xinjiang in northwestern China, has traditionally been considered to be a Paleozoic collisional orogen, which had been reactivated during the Cenozoic (Windley et al., 1990; Yin et al., 1998). The collision of the Yili and Tarim blocks is thought to have occurred during the Late Devonian (Xiao et al., 1992; Wang et al., 1994; Xia et al., 2004),

* Corresponding author. Tel.: +86 10 82998245; fax: +86 10 62010846.
E-mail addresses: gaojun@mail.igcas.ac.cn (J. Gao), klemd@geol.uni-erlangen.de (R. Klemd).

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doi:10.1016/j.tecto.2011.01.001

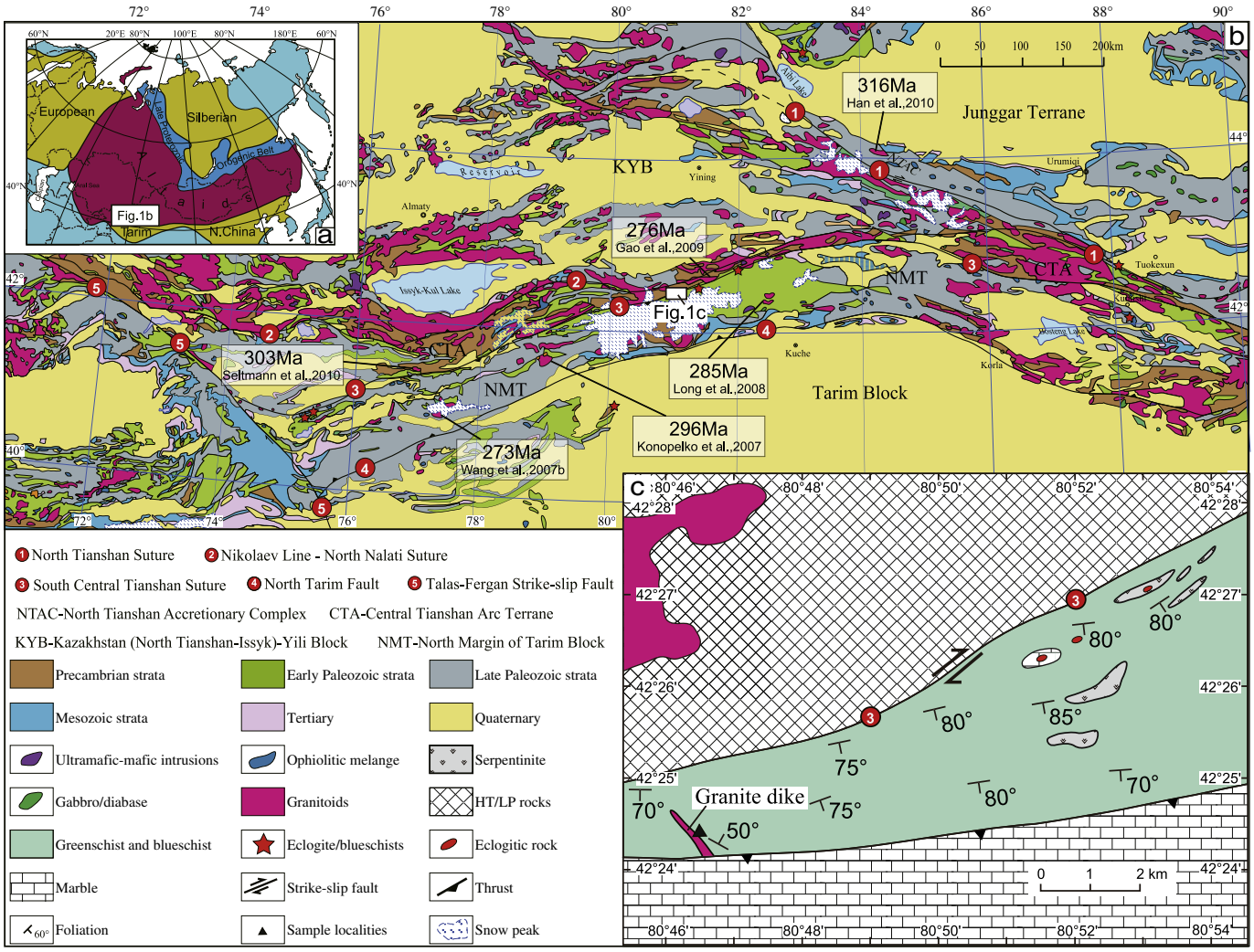

Fig. 1. Tectonic sketch map of the Central Asia Orogenic Belt and the location of the western Tianshan orogen (a; modified after Yakubchuk, 2004), the geological map of the western Tianshan orogen (b; modified after Gao et al., 2009) and the geological map showing the occurrence of a granite dike crosscutting the HP–LT metamorphic belt (c; modified after Liao Ning Institute of Geological Survey, 2005).

Late Devonian–Early Carboniferous (Allen et al., 1992; Charvet et al., 2007; Wang et al., 2010; 2011), Early–middle Carboniferous (Coleman, 1989; Gao et al., 1998; Zhou et al., 2001; Gao and Klemd, 2003; Gao et al., 2009; Su et al., 2010; Biske and Seltmann, 2010), and at the end of Carboniferous to Early Permian (Zonenshain et al., 1990; Chen et al., 1999; Heubeck, 2001; Bazhenov et al., 2003; Xiao et al., 2004, 2006; Klemd et al., 2005; Gao et al., 2006; Li et al., 2006; Solomovich, 2007; Konopelko et al., 2007; Li et al., 2008; Burtman, 2010; Glorie, et al., 2010; Seltmann et al., 2010). A Paleozoic collision has been supported by recent age data from high pressure–low temperature (HP–LT) rocks of the Tianshan Orogen comprising Sm–Nd isochron (omphacite–garnet–glaucophane–whole rock) ages of 343 ± 44 Ma (Gao and Klemd, 2003) and 319 ± 4 Ma (Hegner et al., in press), a $^{40}Ar/^{39}Ar$ crossite age of 344 ± 3 Ma, Rb–Sr isochron ages of 313–302 Ma (mica–whole rocks), $^{40}Ar/^{39}Ar$ phengite ages of 331–310 Ma — (Gao and Klemd, 2003; Klemd et al., 2005; Wang et al., 2010), $^{40}Ar/^{39}Ar$ phengite and glaucophane ages of 327–324 Ma (Simonov et al., 2008) and a U–Pb metamorphic zircon rim age of ca. 320 Ma (Su et al., 2010). However, it was also suggested that the collision for the South Tianshan Orogenic belt in Uzbekistan–Tajikistan–Kyrgyzstan (Brookfield, 2000) and NW China (Zhang et al., 2007a; 2007b; Xiao et al., 2009a) had occurred during the Triassic. The Triassic collision is mainly based on recent SHRIMP U–Pb ages of 233–226 Ma obtained for zircon rims separated from eclogites in NW China (Zhang et al., 2007a). More recently, two HP–LT metamorphic events with Sm–Nd and Lu–Hf garnet ages varying from 308.9 ± 2.0 to 326.8 ± 5.2 Ma and from 243.3 ± 2.9 to 263 ± 10 Ma were proposed for the Tianshan eclogitic rocks (Zhang et al., 2009). Thus, as of yet, no consensus has been reached on the timing of the regional HP–LT metamorphism, which constitutes an excellent collisional marker for an orogeny (Windley, 1995; Liégeois, 1998).

Besides HP–LT rocks, strongly peraluminous (SP) granites are commonly associated with the collision of continental lithosphere (e.g. Le Fort et al., 1987; Nabelek and Bartlett, 1998; Barbarin, 1999). These granites have been suggested to be the result of melting of meta-shales or meta-greywackes during post-collisional processes in various orogens (e.g. Sylvester, 1998). Thus, the presence of SP granites in collisional orogens represents a good hallmark to constrain the collision time of two continents. In this paper we present geochemical and geochronological data of a leucogranite dike which runs across the HP–LT metamorphic belt in the Chinese South Tianshan Orogen and thus constrain the upper age limit for HP–LT metamorphism and subsequent collision between the Tarim and Yili blocks in order to understand the geotectonic framework and the Phanerozoic continental growth of the Altaids.