Lithos 154 (2012) 374–391

Contents lists available at SciVerse ScienceDirect

Lithos

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

Petrogenesis and magmatic–hydrothermal evolution time limitation of Kelumute No. 112 pegmatite in Altay, Northwestern China: Evidence from zircon U – Pb and Hf isotopes

Zheng-Hang Lv [a,b], Hui Zhang [a,*], Yong Tang [a], Shen-Jin Guan [a,c]

[a] *Laboratory for High Temperature & High Pressure Study of the Earth's Interior , Institute of Geochemistry, Chinese Academy of Sciences, Guiyang 550002, China*
[b] *Graduate University of Chinese Academy of Sciences, Beijing 100049, China*
[c] *State Key Laboratory for Mineral Deposits Research and Department of Earth Sciences, Nanjing University, Nanjing 210093, China*

ARTICLE INFO

Article history:
Received 10 March 2012
Accepted 4 August 2012
Available online 13 August 2012

Keywords:
Magmatic–hydrothermal evolution
Zircon U – Pb age
Hf isotope
Pegmatite
Granite
Altay, Xinjiang

ABSTRACT

Granitic pegmatites and associated rare-metal deposits, unique features in the Altay orogen, are located in a key tectonic position of the southern Central Asian Orogenic Belt (CAOB) and document the tectonic evolution of the Paleo-Asian Ocean. The Kelumute No. 112 pegmatite, which intruded into the Jideke two-mica granites, hosts abundant rare-metal (e.g., Li, Be, Nb, Ta) ore deposits and ranks only second to the Koktokay No. 3 pegmatite in both size and reserves. To explore the evolution time limitation of magmatic, magmatic–hydrothermal and hydrothermal stages in the pegmatite magma system, the tectonic setting and the genetic relationship between pegmatites and granites, this study presents zircon U – Pb and Hf isotopic compositions of the Kelumute No. 112 pegmatite and the wall rocks (two-mica granite and biotite granite) as determined by LA-ICPMS and LA-MC-ICPMS. The weighted mean $^{206}Pb/^{238}U$ ages of the internal textural zones of the pegmatite, including zones I, II, III, V and VI, are 238.3 ± 2.0 Ma, 233.5 ± 3.7 Ma, 188.3 ± 1.7 Ma, 218.8 ± 1.9 Ma and 210.7 ± 1.6 Ma, respectively. Wall rocks of two-mica granite and biotite granite are dated at 445.6 ± 4.3 Ma and 455.6 ± 5.4 Ma, respectively. Zircons from the Kelumute No. 112 pegmatite have lower positive $\varepsilon_{Hf}(t)$ values (+0.03 to +2.35), with T_{DM} model ages of 1112–1225 Ma. Wall rocks show similar zircon $\varepsilon_{Hf}(t)$ values (−1.41 to +4.13) and T_{DM} model ages (1172 to 1515 Ma). However, three xenocrystic zircons from the granites are characterized by larger negative εHf(t) values (−5.85 to −9.83) and older T_{DM} model ages (1839 to 2090 Ma). Thus, the following conclusions can be drawn: 1) the Kelumute No. 112 pegmatite and its wall rocks (Jideke two-mica granite and biotite granite) have no genetic relationship, as indicated by the large gaps between their formation ages. However, they did originate from a common source composed of ancient crust and mantle-derived materials under two different tectonic settings; 2) the magmatic, magmatic–hydrothermal transition and hydrothermal stages of the No. 112 pegmatite magma lasted for ~5 Ma, ~23 Ma and ~22 Ma, respectively; and 3) the No. 112 pegmatite magma was most likely formed in a post-collision tectonic setting, indicating that block amalgamation and collisional orogeny of the CAOB continued into the Triassic.

1. Introduction

The Central Asia Orogenic Belt (CAOB, also called the Altaids, or the Central Asia Fold Belt) is known as one of the largest Phanerozoic accretionary orogenic belts in the world (Yuan et al., 2007a; Xiao et al., 2008a) and is situated between the Siberian craton to the North and Tarim and the North China craton to the South (Fig. 1). It is now widely accepted that the tectonic evolution of the CAOB is dominated by the complicated accretion–collision of arcs, accretionary complexes, oceanic plateaus and seamounts (Buslov et al., 2001; Coleman, 1989), Precambrian micro-continents, island arcs, and ophiolites (Kröner et al., 2007; Windley et al., 2007; Xiao et al., 2004, 2008b, 2009) during the evolution of the Paleo-Asian Ocean from the Late Precambrian to the Mesozoic. Its prolonged and complicated orogenic process gave rise to formation of multiple types of world-class ore deposits including gold, silver, copper–molybdenum, nickel, lead–zinc and rare-metal, known as “the Central Asian Metallogenic Domain” (Zhu, 2007). Magmatic, metamorphic and relevant metallogenic events in this orogenic belt are a record that provides valuable information on the origin and evolution of the CAOB, but progress in unraveling its tectonic history has been retarded by a lack of reliable age data (Yuan et al., 2007a) and detailed studies of this vast area. Therefore, the time and mechanism of the final formation of the CAOB remains controversial (Xiao et al., 2009) and the final closure time of the Paleo-Asian Ocean is not clear: previous studies

---

[*] Corresponding author. Tel.: +86 851 5891494; fax: +86 851 5895161.
E-mail address: zhanghui@vip.gyig.ac.cn (H. Zhang).

0024-4937/$ – see front matter © 2012 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.lithos.2012.08.005

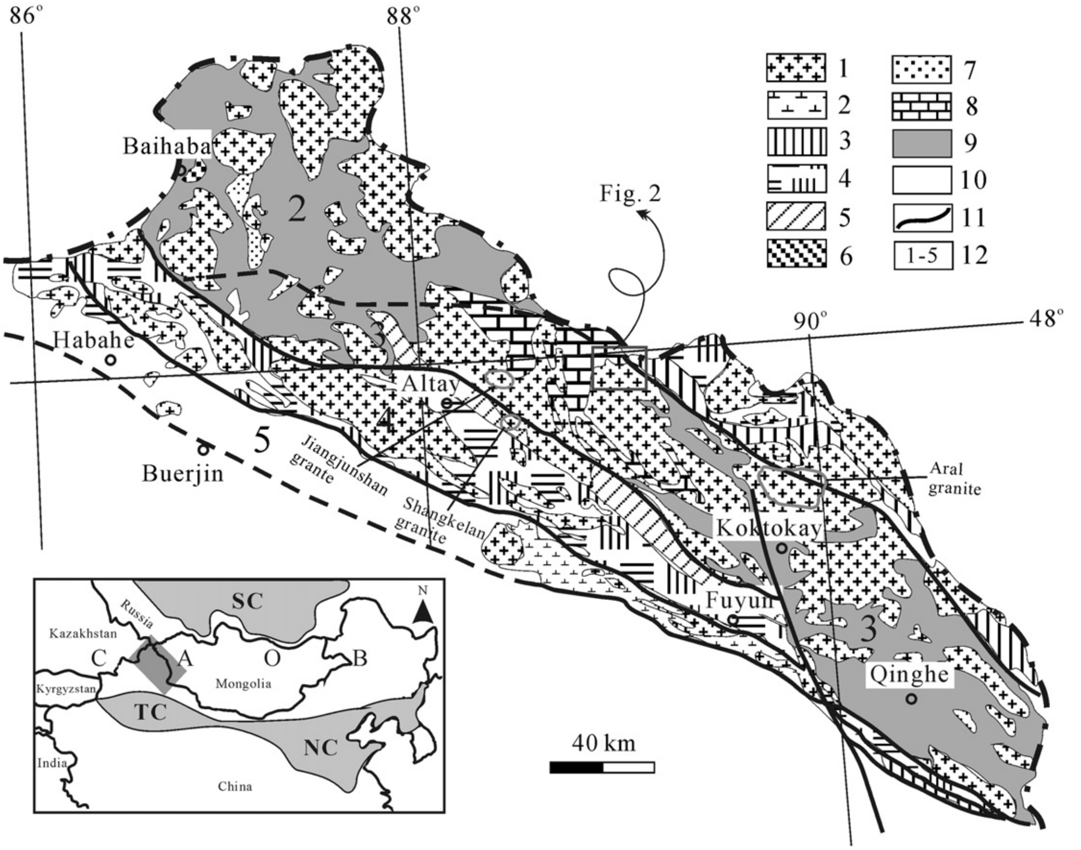

Fig 1. Geological sketch map of the Chinese Altay, showing the tectonic setting of the Kelumute No.112 pegmatite (modified from He et al., 1990; Li et al., 1996; Windley et al., 2002). Abbreviation: CAOB = Central Asian Orogenic Belt; SC = Siberia Craton; TC = Tarim Craton; NC = North China Craton. 1, granite; 2, undivided gneiss; 3, Carboniferous; 4, Altay Formation; 5, Kangbutiebao Formation; 6, Bahaba Formation; 7, Dongxilieke Formation; 8, Kulumuti Group; 9, Habahe Group; 10, Cenozoic sedimentary; 11, Fault; 12, Terrane numbers.

have proposed the Ordovician–Silurian (He et al., 1994; Kheraskova et al., 2003), Devonian–Carboniferous (Hendrix et al., 1996; Safonova et al., 2004), and Carboniferous–Permian (Buslov et al., 2004; Filippova et al., 2001; Li et al., 2003; Wang et al., 2010; Xu et al., 2001; Zhang et al., 2003). Recently, the argument has primarily focused on the Late Carboniferous (Chen et al., 2010; Han et al., 2010, 2011) and Permian–Triassic (Briggs et al., 2007; Xiao et al., 2006, 2008b, 2009, 2010). Although many reports have studied the evolution of the CAOB in terms of pre- to syn-orogenic records such as ophiolites, volcanic rocks and granites, the topic is still under debate.

An important part of the CAOB, the Chinese Altay has great potential for the exploitation of precious metals (Au, Ag), non-ferrous metals (Cu, Mo, Pb, Zn,), rare metals (Li, Be, Nb, Ta), iron ore and non-metallic mineral products such as gems and muscovite. The Chinese Altay was in a passive continental margin from the late Precambrian to the early Paleozoic, before orogenic movement began (Chen et al., 1999), at which point its tectonic setting changed to a continental magmatic arc (active continental margin) during the middle Cambrian to Ordovician (Windley et al., 2002), Middle Cambrian to late Devonian (Wang et al., 2006), and early Cambrian to late Carboniferous (Cai et al., 2011a,c). The corresponding subduction and accretion processes began at ca. 460 Ma and culminated at ca. 408 Ma, resulting in a generation of plentiful Early–Middle Paleozoic granites (Liu et al., 2008a; Cai et al., 2011a,b,c; Yuan et al., 2007a; Sun et al., 2008; Tong et al., 2005; Wang et al., 2005, 2006; Windley et al., 2002; Yuan et al., 2006). An extensional setting in a back-arc basin began during the Devonian–early Carboniferous, according to studies of bimodal volcanic rocks (407 Ma, Zhang et al., 2000), gabbro (405 Ma, Wang et al., 2006) and ophiolite (372 to 352 Ma, Wu et al., 2006; Xu et al., 2003; Zhang et al., 2003). Some scholars have proposed an extensional forearc setting during the Devonian, Late Carboniferous, and Permian (Yuan et al., 2007a). It was thus concluded that the Altay orogenic belt was mainly built up during the early–middle Paleozoic (500 to 380 Ma) (Wang et al., 2006; Windley et al., 2002). Late Paleozoic granites have also been reported systematically (Tong et al., 2006a,b, 2007, 2012), suggesting vertical growth (2.1 to 1.5%) of the continental crust in the Chinese Altay (Tong, 2006). The Mesozoic magmatism from this region appears to contribute very little (Chen et al., 1999; D.H. Wang et al., 2003; Wang et al., 2000; Zhang et al., 1994), but increasing numbers of granite and granitic pegmatite have been reported in recent years (Chen, 2011; Ren et al., 2011; Wang et al., 2007, 2010; Zhu et al., 2006). Previous work suggested that the Chinese Altay has mainly undergone three orogenic stages, including the syn-orogenic (460 to 380 Ma), post-orogenic (290 to 260 Ma) and anorogenic stage (after the end-Permian) (He et al., 1994; Hu et al., 2000; Li et al., 2003; Wang et al., 2005, 2010; Windley et al., 2002; Xiao et al., 2004; Xu et al., 2001).

Granitic pegmatite and associated rare-metal deposits are widely exposed in the Chinese Altay. According to previous work, there are nearly one hundred thousand pegmatite veins in a ~20,000 km^2 area (including the Rudny Altay and Gobi Altay) (Wu and Zou, 1989). As one type of independent deposit, pegmatites are enormously economically valuable in rare metal exploitation and are also excellent indicators of tectonic evolution (D.H. Wang et al., 2004b; Wang et al., 2002). Previous studies of the Altay pegmatites have mainly focused on the mineralogy, diagenesis and evolution of pegmatite (Lu et al., 1996; Wu and Zhu, 1995; Wang and Zou, 1981; Wu et al., 1994; Zhang, 2001; Zhang and Liu, 2001; Zhang et al., 2004; Zhu et al., 2000); little is known about the formation ages, provenance and tectonic settings of pegmatites in this