Journal of Asian Earth Sciences 113 (2015) 61–74

Contents lists available at ScienceDirect

Journal of Asian Earth Sciences

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

Petrogenesis of the Devonian high-Mg rock association and its tectonic implication for the Chinese Altai orogenic belt, NW China

Yulin He [a], Min Sun [a,*], Keda Cai [b], Wenjiao Xiao [b,c], Guochun Zhao [a], Xiaoping Long [d], Pengfei Li [a]

[a] Department of Earth Sciences, The University of Hong Kong, Pokfulam Road, Hong Kong, China
[b] Xinjiang Research Center for Mineral Resources, Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences, Urumqi 830011, China
[c] State Key Laboratory of Lithospheric Evolution, Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing 100029, China
[d] Key Laboratory of Isotope Geochronology and Geochemistry, Guangzhou Institute of Geochemistry, Chinese Academy of Sciences, Guangzhou 510640, China

ARTICLE INFO

Article history:
Received 2 August 2014
Received in revised form 28 January 2015
Accepted 7 February 2015
Available online 12 March 2015

Keywords:
High Mg igneous association
Subduction–accretion
Paleozoic magmatism
Chinese Altai
CAOB

ABSTRACT

The Chinese Altai is a key region to decipher the accretionary history of the gigantic CAOB, one of the largest accretionary orogenic belts on the earth. However, tectonic implication of the widely distributed Paleozoic magmatic rocks remain debated. In this study, a suite of igneous rocks, including high Mg dacite of the Kangbutiebao Formation and the associated gneissic granodiorites, have been studied for their petrogenesis and tectonic implication. The high Mg dacite is dated at 400 ± 2 Ma, which broadly resembles the emplacement age of the high Mg gneissic granodiorites of 406 ± 9 Ma, possibly suggesting that they were generated in the same tectono-magmatic event. Both rocks have predominant zircon inheritances of ~500 Ma, which is consistent with the age of predominant zircon population for the widespread Habahe sedimentary sequence, indicating that their precursor magmas were probably mainly derived from the Habahe sediments. The high-Mg rock association has similar REE and trace element patterns to those of the Habahe sediments and they plot close to the field of the Habahe sediments in Th/Ta versus La/Ta diagram. Their high A/CNK ratios (1.33–2.05) imply, magma source dominated by sedimentary rocks. Similarly, their high La/Sm ratios also suggest a greater contribution of sediments rather than altered oceanic crust in the magma generation. However, the high Mg# values (~51) of the studied rocks argue against derivation purely from remelting of the Habahe sediments. In order to explain the high Mg# values of these rocks, the participation of mantle-derived melt into the precursor magma is considered. Zircons from this rock association mostly yield $\varepsilon_{Hf}(t)$ values from +0.85 to +9.71, supporting the involvement of juvenile materials in the magma generation. Samples from the high Mg rock association fall in the same field as the sanukitoids in TiO_2 versus Mg# and Sr/Y versus Y diagrams, and they plot in the fractional crystallization trend of differentiated sanukitoids in Harker diagram, possibly suggesting a petrogenetic process like the typical sanukitoid magma elsewhere. This study shows that similar to the sanukitoids in the Setouchi area, our high Mg rock association also involved melting of subducted sediments in a hot subduction regime. Combined with previous work, a ridge subduction regime is considered to interpret the early Devonian tectonic evolution of the Chinese Altai.

1. Introduction

The Central Asian Orogenic Belt (CAOB), also named Altaids or Altaid collage, is one of the largest accretionary orogens in the world, extending from the Urals in the west to the Pacific in the east and from Siberia in the north to the Tarim and North China Cratons in the south (Şengör et al., 1993; Jahn, 2004; Windley et al., 2007; Zonenshain et al., 1990). The CAOB is composed of various allochthonous terranes, such as island arcs, ophiolites, seamounts, oceanic islands, accretionary prisms and micro-continental blocks (Şengör et al., 1993; Şengör and Natal'in, 1996; Windley et al., 2002; Khain et al., 2002, 2003; Xiao et al., 2008, 2009, 2010; Kröner et al., 2008, 2010; Cawood et al., 2009; Safonova, 2009). The tectonic history of this huge and complex accretionary orogenic belt is controversial and some competing models have been proposed. For example, Şengör et al. (1993) and Şengör and Natal'in (1996) considered that the entire CAOB underwent long-lived subduction and oroclinal bending of a single arc called Kipchak–Tuva–Mongol arc. On the other hand, many other researchers (e.g. Mossakovsky et al., 1993; Didenko et al., 1994; Windley et al., 2002; Xiao et al., 2008, 2009) viewed the CAOB as an amalgamation

* Corresponding author. Tel.: +852 2859 2195; fax: +852 2517 6912.
E-mail address: minsun@hku.hk (M. Sun).

http://dx.doi.org/10.1016/j.jseaes.2015.02.014
1367-9120/

of various edifices including some microcontinents and multiple arc terranes. Therefore, it is critical to unravel the tectonic evolution of each of the specific terranes of the CAOB in order to understand the tectonic nature of the whole CAOB.

The Chinese Altai is an important part of the CAOB, abundant polymetallic deposits were formed in the Devonian and are distributed in the southern margin of the Chinese Altai. Therefore, the Chinese Altai became a spotlight region in recent years (e.g. Hong et al., 2003; Wang et al., 2007; Zhang et al., 2009; Yuan et al., 2007; Long et al., 2007; Sun et al., 2008; Cai et al., 2012a,b; Jiang et al., 2010). High Mg rock associations in this region, such as boninites and high Mg andesites, have attracted some attention (Niu et al., 2006; Zhang et al., 2003; Wang et al., 2011), but their petrogenesis and tectonic implications are still controversial. The source of these high Mg rock associations has not been studied in detail, which is critical in understanding the specific tectonic setting and evolutionary history of the southern Chinese Altai.

Here we report new geochemical data, zircon U–Pb and Hf isotopic composition for the dacites from the Kangbutiebao Formation and the associated gneissic granodiorites in the southern Chinese Altai to unravel their magma source and petrogenesis, which provide valuable clues for the interaction between the crust and mantle, and further provide new insights into the tectonic setting of the southern Chinese Altai in the late Paleozoic.

2. Geological background

The Chinese Altai is bounded by the Junggar Block in the south, extending eastward to Mongolia and westward to Kazakhstan and Russia (He et al., 1990; Windley et al., 2002; Xiao et al., 2004; Sun et al., 2008; Cai et al., 2010). Based on the distinctive stratigraphy, the Chinese Altai was divided into six NW-SE extending terranes (He et al., 1990; Windley et al., 2002; Chen and Jahn, 2002; Xiao et al., 2004) and a four-domain scheme is accepted in this study. The four major NW-SE trending domains, namely the North Altai, Central Altai, Qiongkuer and Erqis, are separated by sub-parallel faults (Buslov et al., 2004; Sun et al., 2008; Cai et al., 2012a). Early Paleozoic sedimentary rocks mostly occur in the Central Altai domain, which is made up of the thick Middle Ordovician turbiditic and pyroclastic sequence called Habahe Group. The Habahe sediments were deposited on an active continental margin in the Early Paleozoic (e.g. Long et al., 2007; Sun et al., 2008) and are intruded by a large number of Silurian to Permian I-type and S-type granite plutons and several mafic–ultramafic rocks (Cai et al., 2010; 2011a,b,c; 2012a,b).

To the south, the Qiongkuer domain is separated from the Central Altai domain by north-dipping thrust faults and is mainly composed of two formations, called the Kangbutiebao and Altai Formations (Fig. 1; He et al., 1990; Windley et al., 2002). The former consists of early Devonian volcanic and pyroclastic rocks while the latter is composed of middle Devonian marine clastic rocks and minor pillow basalts (Cai et al., 2011b,c; Chai et al., 2009). More specifically, metasilicic pyroclastic rocks and lavas intercalated with meta-basaltic rocks and meta-sedimentary rocks in the lower part of the Kangbutiebao Formation, and meta-silicic lavas intercalated with metapyroclastic rocks and marble in the upper part of this formation. Both lower part and upper part of the Kangbutiebao Formation have undergone regional greenschist to lower amphibolite facies metamorphism and crop out in three NW-trending fault-bounded volcano-sedimentary basins, the Kelang, Maizi and Chonghuer, which extend about 200 km from southeast to northwest (Chai et al., 2009; Windley et al., 2002). Moreover, some igneous rocks with special compositions such as adakite, boninite and high-Mg andesite occur in this area. Previous studies that the Qiongkuer domain formed along an active continental margin in the Devonian (Niu et al., 1999, 2006; Chen et al., 2006; Long et al., 2008; Cai et al., 2010; Wang et al., 2011).

3. Sample description

Our dacite samples were collected from the Kangbutiebao Formation in the southeastern Chinese Altai (N46°58′9.7″

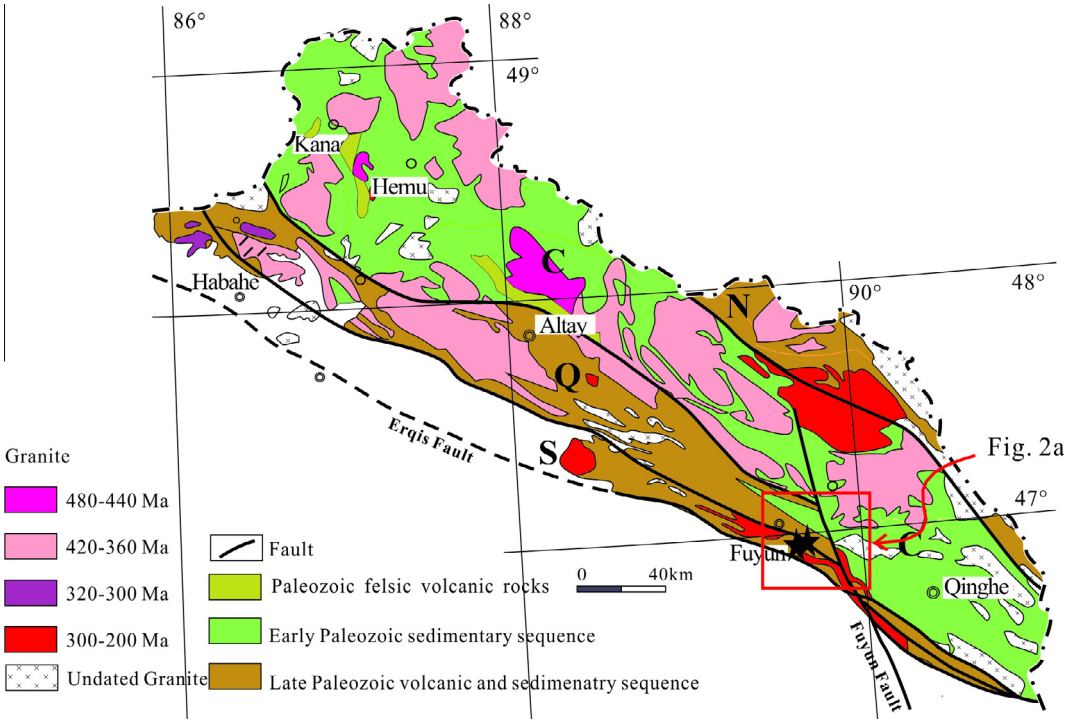

Fig. 1. Simplified geological map of the Chinese Altai (He et al., 1990; Windley et al., 2002). N – Northern Domain, C – Central Domain, Q – Qiongkuer Domain, S – South Domain. Our study area is indicated by a box.