Journal of Asian Earth Sciences 103 (2015) 169–183

Contents lists available at ScienceDirect

Journal of Asian Earth Sciences

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

Nd–Hf isotopic mapping of Late Mesozoic granitoids in the East Qinling orogen, central China: Constraint on the basements of terranes and distribution of Mo mineralization

Xiaoxia Wang [a,*], Tao Wang [b], Changhui Ke [a], Yang Yang [c], Jinbao Li [d], Yinghong Li [a], Qiuju Qi [e], Xingqiu Lv [c]

[a] MLR Key Laboratory of Metallogeny and Mineral Assessment, Institute of Mineral Resources, Chinese Academy of Geological Sciences, Beijing 100037, China
[b] Institute of Geology, Chinese Academy of Geological Sciences, Beijing 100037, China
[c] China University of Geosciences, Beijing 100083,China
[d] Chang'an University, Xi'an 710054, China
[e] Institute of Resource Survey and Assessment, ECE, Nanjing 210007, Chian

ARTICLE INFO

Article history:
Received 2 April 2014
Received in revised form 30 June 2014
Accepted 1 July 2014
Available online 12 July 2014

Keywords:
Granitoid
Nd–Hf isotope
Source
Basement
Mo deposit

ABSTRACT

Voluminous Late Mesozoic granitoids and the world's largest Mo deposits occur in the East Qinling. This paper presents the results of Nd–Hf isotopic mapping for the Late Mesozoic granitoids (155–105 Ma) and demonstrates their constraint on the basements and distribution of the Mo deposits in the East Qinling. This isotopic map, made by 98 (21 new and 77 published) whole-rock Nd isotopic and 29 (7 new and 22 published) average zircon Hf isotopic data, shows large variations of whole-rock $\varepsilon_{Nd}(t)$ values from −22.1 to −1.5, and the correspondingly Nd model ages ($T_{DM(Nd)}$) from 2.83 to 0.79 Ga, and zircon $\varepsilon_{Hf}(t)$ values from −26.3 to +0.1 and two-stage Hf model ages ($T_{DM2(Hf)}$) from 2.86 to 0.96 Ga. Three regions of variations have been identified from north to south: (a) $\varepsilon_{Nd}(t)$ values range from −22.1 to −10.9 with $T_{DM(Nd)}$ of 2.82–1.47 Ga, and $\varepsilon_{Hf}(t)$ values 26.3 to −13.5 with $T_{DM2(Hf)}$ 2.86–2.04 Ga; (b) $\varepsilon_{Nd}(t)$ values −13.9 to −1.5 with $T_{DM(Nd)}$ 2.02–0.79 Ga, and $\varepsilon_{Hf}(t)$ values −16.2 to +0.1 with $T_{DM2(Hf)}$ 1.96–0.96 Ga; and (c) $\varepsilon_{Nd}(t)$ values −6.3 to −4.5 with $T_{DM(Nd)}$ 1.28–1.12 Ga, and $\varepsilon_{Hf}(t)$ values −1.0 to −0.3 with $T_{DM2(Hf)}$ 1.25–1.22 Ga, respectively. The three regions approximately correspond to the three different terranes, the southern margin of the North China Block (NCB), the North Qinling Belt (NQB) and the South Qinling Belt (SQB), respectively. These demonstrate that the granitoids in the different terranes have distinct sources and their sources change from old to more juvenile from the north (southern margin of the NCB) to the south (SQB). These also reveal the distinct basements for the terranes in Late Mesozoic. The southern margin of the NCB contains widespread Neoarchaean to Paleoproterozoic basement, the NQB comprises Archaean to Neoproterozic basement and the SQB Mesoproterozic to Neoproterozic basement. All these suggest that the three terranes underwent different tectonic evolution and the continental crust of the East Qinling were mainly formed during Archaean to Neoproterozic, different from a typical accretion orogen. The old sources of the granitoids and basements of the terranes constrain the distribution, scale and number of the Mo mineralization and deposits. Mo mineralization is closely related to the small granitic bodies with old continental component sources and Mo deposits are mainly hosted by the terranes with oldest basement. The scale and number of the Mo mineralization and deposits decreased from the southern margin of the NCB to SQB.

1. Introduction

The Qinling orogen, one of the largest orogenic belts in Asia (Mattauer et al., 1985), underwent multi-stage (e.g., Neoproterozoic, Paleozoic, and Early Mesozoic) orogenic processes and finally formed by collision of the North China Block (NCB) and South China Block (SCB) during the Early Mesozoic (e.g., Mattauer et al., 1985; Kröner et al., 1993; Meng and Zhang, 1999; Zhang et al., 2001; Ratschbacher et al., 2003). Correspondingly, multi-stage magmatisms (e.g., Neoproterozoic, Paleozoic, and Early Mesozoic) occurred (Wang et al., 2013). Significantly, after final formation of the orogen,

* Corresponding author. Tel.: +86 10 68999043.
E-mail address: xiaoxiawang@hotmail.com (X. Wang).

http://dx.doi.org/10.1016/j.jseaes.2014.07.002
1367-9120/

voluminous Late Mesozoic (Jurassic–Cretaceous) granitoids (e.g., Lu, 1999; Wang et al., 2013) and the world's largest Late Mesozoic Mo deposits, including porphyry and porphyry–skarn types (e.g., Li et al., 2007, 2011, 2012a; Mao et al., 2011), occurred in the East Qinling. Many investigations have been made for these granitoids and Mo deposits (e.g., Chen et al., 2000; Lu et al., 2002; Zhu et al., 2008; Bao et al., 2009, 2014; Li et al., 2009a, 2009b, 2012b; Mao et al., 2008, 2009, 2010, 2011; Wang et al., 2013; and references therein). However, the sources and origin of the granitoids and Mo deposits, particularly their relations have not been well understood. The main debates include: (1) the sources of the Late Mesozoic granitoids were derived from partial melting of the crystalline basement, such as the Archaean Taihua Group in the southern margin of the NCB (e.g., Chen et al., 2000), or from the old crust with contribution of the juvenile compositions (e.g., Luo et al., 1993; Sun and Liu,1987; Zhang et al., 2010; Zhu et al., 2010; Li et al., 2012c; Wang et al., 2013), or from subducted continental crust of the SCB (Bao et al., 2009, 2014; Li et al., 2012d). (2) The source of Mo was mainly derived from the lower crust, or from the Archaean basement and Paleoproterozoic rocks of the NCB (e.g., Liu et al., 2007; Lu et al., 2002). Some researchers suggested that the carbonaceous sedimentary rocks may be the main source for the Mo mineralization (e.g., Li et al., 2012d; Zhang et al., 2010); while few others considered the upper mantle (Bao et al., 2009; Zhu et al., 2010) or subducted continental crust of the SCB (Bao et al., 2014) as their major sources. The key problem is the major factor controlling the distribution of the Mo related granitoids and Mo deposits.

In this paper we present the results of Nd–Hf isotopic mapping for the Late Mesozoic granitoids in the East Qinling, using 28 new and 99 published data to study isotopic variations and sources of the granitoids. The results can help us to better understand the sources of the granitoids and basement nature of this orogen, as well as their constraint on the Mo mineralization.

2. Geological setting

The Qinling orogen extends more than 1500 km across central China and links the Kunlun Orogen in the west and the Dabie Orogen in the east (Fig. 1), and separates the NCB and SCB (e.g., Zhang et al., 2001; Ratschbacher et al., 2003). This orogen is composed of four major blocks or terranes, from north to south, i.e., the southern margin of the NCB, North Qinling Belt (NQB), South Qinling Belt (SQB) and northern margin of the SCB, which are separated by one fault and two sutures, i.e., the Luonan-Luanchuan fault, and the Shangdan and Mianlue sutures (Fig. 1, Meng and Zhang, 1999, 2000), respectively. The Shangdan suture is generally considered to be the result of a Middle Paleozoic collision of the NCB and SQB (Meng and Zhang, 2000; Dong et al., 2011b) and a multistage accretion of the SQB to NQB. The Mianlue suture was formed by the Early Mesozoic (Triassic) collision between the SQB and SCB (Zhang et al., 2004).

The southern margin of the NCB, which previously belongs to the NCB, but was involved in the Qinling orogeny, consists mainly of an Archaean (~2.5 to ~2.8 Ga) basement and Proterozoic overlying volcanic and sedimentary sequences (Zhang et al., 2001). The Archaean basement is composed of the amphibolite- to granulite-facies metamorphic rocks of the Taihua Group. The Proterozoic volcanic and sedimentary sequences consist of the Paleoproterozoic mafic to felsic volcanic rocks and minor sedimentary rocks of the Xiong'er Group, Mesoproterozoic quartzite and schist with intercalated dolomitic marble of the Guandaokou Group, and Neoproterozoic meta-sandstone, marble, and schist of the Luanchuan Group.

The NQB is composed predominately of, from north to south, the Proterozoic Kuanping Group, Paleozoic Erlangping Group, Proterozoic Qinling Complex and Paleozoic Danfeng Group (Zhang et al., 2001). These groups and complex are composed predominantly of medium-grade metasedimentary and metavolcanic rocks. The Qinling Complex constitutes the Precambrian basement in the NQB, which underwent strong Proterozoic and Paleozoic tectonothermal events (e.g., Hu et al., 1993; Wang et al., 2003, 2005; You et al., 1993).

The SQB, bounded to the north by the Shangdan suture and to the south by Mianlue suture (Fig. 1), constitutes mainly Proterozoic crystalline basement and a thick pile of Late Proterozoic to Triassic (e.g., the Paleozoic Liuling group) overlying sedimentary sequences (Zhang et al., 2001, 2006, Lu et al., 2004). Its Proterozoic basement consists of low to high greenschist facies of volcanic to sedimentary metamorphic rocks such as Wudang and Yaolinghe groups.

Paleozoic and Mesozoic intrusions occur widely in the Qinling orogen. The Paleozoic intrusions are regarded as the recording accretion and collision between the NCB and SQB (Lerch et al., 1995; Xue et al., 1996; Wang et al., 2009a, 2013). The Early Mesozoic magmatism is interpreted as the result of subduction and/or collision of the NCB and SCB (Dong et al., 2011a; Wang et al., 2013; Li et al., 2013). The Late Mesozoic magmatism is response to an intraplate setting (Zhang et al., 2001; Dong et al., 2011b; Mao et al., 2010; Wang et al., 2011, 2013).

Late Mesozoic Mo deposits mainly occur in the southern margin of the NCB, with minor in the NQB and a few in the SQB (Fig. 2). They are mostly of Late Jurassic to Early Cretaceous in age and show a close spatial–temporal relationship to the contemporaneous granitoid porphyries (Mao et al., 2008, 2011; Bao et al., 2014; and reference therein).

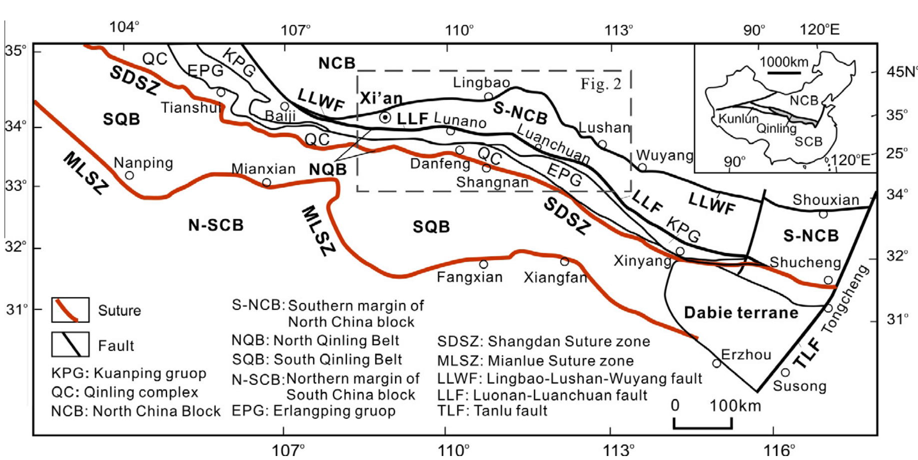

Fig. 1. A tectonic sketch map of the Qinling orogen. Modified after Zhang et al. (2001) and Dong et al. (2011a).