Precambrian Research 186 (2011) 220–232

Contents lists available at ScienceDirect

Precambrian Research

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

The 1.85 Ga Mo mineralization in the Xiong'er Terrane, China: Implications for metallogeny associated with assembly of the Columbia supercontinent

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ARTICLE INFO

Article history:
Received 7 October 2010
Received in revised form 16 January 2011
Accepted 27 January 2011
Available online 2 February 2011

Keywords:
Re–Os isochron age
Longmendian
East Qinling Mo belt
North China Craton
Columbia supercontinent

ABSTRACT

The East Qinling region in China, hosting several tens of Mesozoic magmatic-hydrothermal Mo deposits, is one of the largest molybdenum belts in the world. The recently discovered Longmendian Mo deposit, Luoning County, Henan Province, occurs within the Xiong'er Terrane of the East Qinling Mo belt. Here, the Mo mineralization is confined to altered amphibolite which is replaced by microcline, actinolite, tremolite, epidote and carbonate. Molybdenite is also observed in microcline-dominated felsic differentiates, but occurs within the altered amphibolite enclaves. Here we report Re–Os isotope analyses of five molybdenite and four pyrite samples from Longmendian which yield Re–Os isochron ages of 1853 ± 36 Ma and 1855 ± 29 Ma, respectively. These ages are in good agreement with the metamorphic age of the Taihua Supergroup (1.87–1.84 Ga). The Re–Os data presented in this study indicate that the period of ~1.85 Ga was a time of widespread melting generating leucocratic microcline-dominated granitic melts. The timing also coincides with the collision of the Eastern and Western Blocks of the North China Craton and its final cratonization at ~1.85 Ga, coinciding with the incorporation of the North China Craton within the Paleoproterozoic supercontinent Columbia.

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1. Introduction

The East Qinling Mo belt (EQMB), trending eastward at the southern margin of the North China Craton (Fig. 1), contains six giant Mo deposits (each with Mo reserve of >0.5 Mt in metal) and tens of small (<0.01 Mt), medium (0.01–0.1 Mt) and large (0.1–0.5 Mt) deposits, with total reserve of ~6 Mt Mo metal (Li et al., 2007; Mao et al., 2008). This belt ranks as one of the most important Mo provinces in the world. The major deposits in EQMB are associated with Mesozoic porphyry/skarn systems and have been the targets of previous exploration. In the last decade, a number of high-grade, variably sized Mo deposits were discovered in quartz or fluorite vein-systems in the EQMB, such as the Dahu (Ni et al., 2008; Li et al., 2011), Zhaiwa (Deng et al., 2008a) and Zhifang (Deng et al., 2008b) quartz vein systems, and the Tumen fluorite vein system (Deng et al., 2009). These vein-systems occur in various terranes or different lithologies, show distinct geological characteristics, yield isotope ages ranging from Paleoproterozoic to Cretaceous, and are possibly related to the multiple tectonothermal events in the EQMB (Li et al., 2007; Deng et al., 2008a; Chen et al., 2009b). Detailed studies on the Mo-bearing vein-systems would help to clarify the nature of mineralization and ore genesis, improve our understanding of the origin and tectonic evolution of the EQMB, and also help in formulating future exploration strategies.

The Mo-bearing vein-systems of EQMB are mostly developed in the Xiong'er Terrane, such as the Zhaiwa, Longmendian and Zhifang Mo deposits (Fig. 2A). Those in the Xiong'er Terrane usually show close affinity with orogenic Au or Ag–Pb–Zn lodes in space, time and genesis (Deng et al., 2008b). The Mo-bearing veins at Longmendian, Geliaogou and Xianglugou areas were recently discovered during the on-going prospecting of the Longmendian Ag deposit (Fig. 2B; He et al., 2007) and is expected to be a large deposit with inferred resource of >3000 t Ag. Some of the Mo-bearing felsic veins are crosscut by the Ag–Pb–Zn quartz veins; occasionally, breccias or blocks of Mo-bearing veins can be observed as enclaves within the Ag–Pb–Zn veins. This suggests that the formation of the Mo-bearing veins predates the Ag–Pb–Zn veins, possibly before Mesozoic, because all the Ag–Pb–Zn deposits in Qinling area were formed no later than early Cretaceous (Chen et al., 2009b and references therein).

Re–Os geochronology of molybdenite and pyrite is a powerful tool to elucidate the age of mineralization. Relative to other isotopic systems, the low ^{187}Re decay constant ($\lambda = 1.666 \times 10^{-11}$ year^{-1}, Smoliar et al., 1996) and resistance to subsequent hydrothermal alteration (Suzuki et al., 1996; Frei et al., 1998) allow the Re–Os

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doi:10.1016/j.precamres.2011.01.019

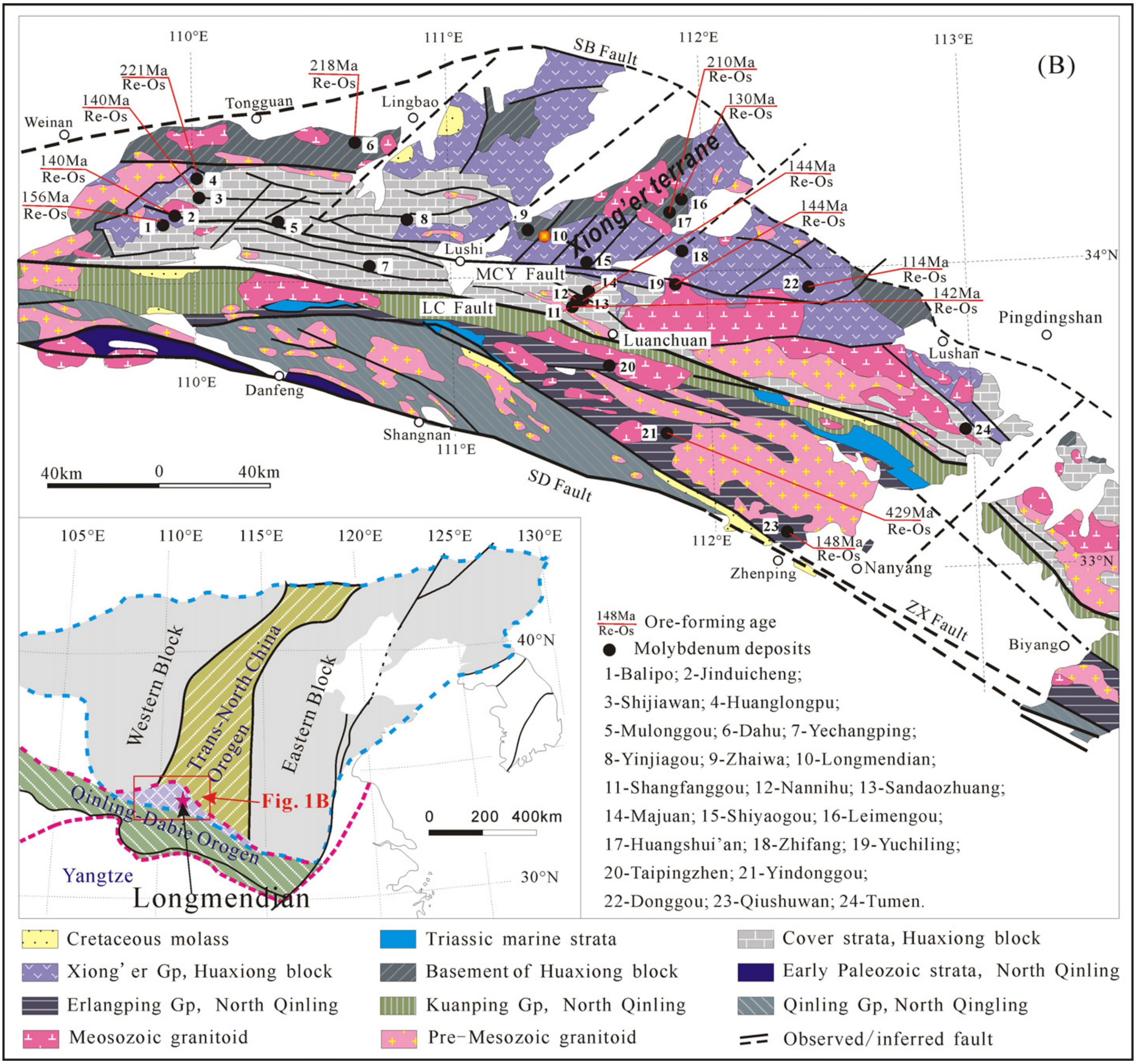

Fig. 1. (A) Tectonic subdivision of the North China Craton (after Zhao et al., 2005) and the Qinling-Dabie Orogen, showing the location of the East Qinling Mo belt; (B) geological map of the East Qinling Mo belt. Abbreviations for fault name: SB, San-Bao; MCY, Machaoying; LC, Luanchuan; ZX, Zhu-Xia; SD, Shang-Dan.

system to be used as a potential tool for tapping geochronological information of Precambrian mineralizations. Examples for the application of Re–Os system in Precambrian mineralizations include the 3.3 Ga Witwatersrand gold deposit (Kirk et al., 2002), the 1.89 Ga Kåtaberget deposit and the 1.86–1.75 Ga Allebuoda and Munka deposits (Stein, 2006).

In this contribution, we introduce the geological context and ore geology of the Mo mineralization in the Longmendian area, and present new Re–Os isotope age on molybdenite and pyrite. These data show that at least in one case, a syn-orogenic Mo mineralization developed in the Xiong'er Terrane at about 1.85 Ga, coinciding with the time of collisional assembly of the Western and Eastern Blocks in the North China Craton along the Trans-North China orogen, and the incorporation of the North China Craton within the Paleoproterozoic Columbia supercontinent assembly.

2. Regional geology

The Xiong'er Terrane is bounded by the Machaoying fault to the south and the San-Bao fault to the north (Fig. 2A). The EW-trending Maochaoying fault, with a strike of over 200 km and inferred depth of 34–38 km, has been interpreted as a major north-dipping thrust zone formed during Mesozoic continental collision (Chen and Fu, 1992; Zhang et al., 1998; Chen et al., 2004). Its subsidiary fault-splays are common, especially NE- to NNE-trending compressive shears. These subsidiary faults are generally spaced at more or less regular intervals and spatially control the locations of orogenic Au and Ag deposits and shallow intrusions (Fig. 2A, Qi et al., 2005; Chen et al., 2009a). Structural analysis shows that these NE-trending structures have undergone early compression, followed by a tensional regime and late extensional shearing (Chen et al., 2008). The

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