Ore Geology Reviews 78 (2016) 300–321

Contents lists available at ScienceDirect

Ore Geology Reviews

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

Tracking magmatic and hydrothermal Nb–Ta–W–Sn fractionation using mineral textures and composition: A case study from the late Cretaceous Jiepailing ore district in the Nanling Range in South China

Lei Xie, Ru-Cheng Wang *, Xu-Dong Che, Fang-Fang Huang, Saskia Erdmann, Wen-Lan Zhang

State Key Laboratory for Mineral Deposit Research, School of Earth Sciences and Engineering, Nanjing University, 163 Xianlin Avenue, Nanjing 210023, China

ARTICLE INFO

Article history:
Received 31 December 2015
Received in revised form 31 March 2016
Accepted 5 April 2016
Available online 16 April 2016

Keywords:
Columbite
Cretaceous Nb–Ta mineralization
Jiepailing
Magmatic–hydrothermal evolution
Mica
Zircon

ABSTRACT

The Jiepailing mining district in the Nanling range in South China is well-known for its granite-related Sn–Be–F-mineralization. Recently, drill holes have exposed an Nb–Ta–W–Sn mineralized granitic porphyry and topaz-bearing granite–greisen at depth, which we have studied here, using mineral (columbite, rutile, wolframite, cassiterite, zircon, and mica) major- and trace-element compositional data, mineral textures, and zircon and columbite U–Pb geochronology. Our age data shows that the porphyry and the granite and their mineralization formed at ~91–89 ± 1 Ma in the late-Cretaceous, and thus subsequent to the main ore-forming events of the region. Continuous mineral compositional trends indicate that the studied granitoids are related by progressive fractionation. We propose that: (1) subhedral–euhedral, low-Ta columbite crystallized from melt; (2) euhedral–subhedral rutile and wolframite and subhedral and subhedral cassiterite up to ~30 μm in size formed at the magmatic–hydrothermal transition of the system; and (3) high-Ta columbite and subhedral cassiterite up to ~10 μm in size formed from subsolidus hydrothermal fluids. In combination with the Nb, Ta, W, and Sn compositions of zircon and mica, their textures and compositional variation allow us to track the magmatic to hydrothermal rare-metal fractionation (concentration, mobilization, and deposition) of the system in detail, despite our limited access to it through only two exploration drill cores. Using the Nb, Ta, W, and Sn concentrations in zircon (refractory, early-crystallized) and in micas (late equilibrated), respectively, was particularly useful for tracing the partial loss of Sn and W ore components from the intrusion, and to constrain the information which is crucial for any rigorous ore exploration.

1. Introduction

The magmatic to hydrothermal crystallization of Nb–Ta–W–Sn-bearing minerals in granites has been investigated in a large number of studies in natural samples (e.g., Cuney et al., 1992; Belkasmi et al., 2000; Smith et al., 2000; Van Lichtervelde et al., 2007; Galliski and Marquez-Zavalia, 2008; Badanina et al., 2015) and in experimental systems (e.g., Linnen and Keppler, 1997; Linnen and Cuney, 2005; Borodulin et al., 2009; Che et al., 2013). In combination, these studies have highlighted that Nb–Ta–W–Sn-bearing minerals form as primary or secondary magmatic crystals, or by hydrothermal precipitation. Fewer studies have used rare-metal concentrations in oxides and in various silicate minerals for reconstructing ore fractionation in granitic systems, but important examples include the studies of: (i) a pegmatitic granite in Manitoba, Canada (Černý et al., 1986); (ii) a rare-element granitic pegmatite in N.W. Ontario, Canada (Tindle and Breaks, 2000); (iii) a topaz–lepidolite granite at Yichun, China (Huang et al., 2002; Wang et al., 2004); (iv) the Podlesí granite in the Czech Republic (Breiter et al., 2007); (v) the Cínovec A-type granite in the Czech Republic and the Beauvoir S-type grante in France (Breiter and Škoda, 2012; Wang et al., 1992); (vi) the Koktokay No. 1 granitic pegmatite in China (Yin et al., 2013); and (vii) the Songshugang granite in China (Zhu et al., 2015). In these studies, mineral compositions and mineral zoning have been used to characterize the closed- and open-system magmatic to hydrothermal evolution.

In our study we have focused on using the concentration of Nb, Ta, Sn, and W in various oxides (columbite, cassiterite, rutile, and wolframite) and in zircon and muscovite–zinnwaldite for tracking the fractionation of a largely unexposed porphyry–granite–greisen magma system at the Jiepailing mining district in South China. Zircon and muscovite–zinnwaldite were selected as study targets, because they have previously been successfully employed for unravelling rare-metal fractionation related to igneous systems and as vectors to ores (Breiter et al., 2014; Johan et al., 2012; Li and Huang, 2013; Raimbault and Burnol, 1998; Xie et al., 2015). We have also selected these two minerals because of their contrasting, refractory (zircon) and non-refractory (zinnwaldite–muscovite) mineralogical character, i.e. we

* Corresponding author.
E-mail address: rcwang@nju.edu.cn (R.-C. Wang).

http://dx.doi.org/10.1016/j.oregeorev.2016.04.003
0169-1368/

anticipated that a comparison of their compositional trends would allow us to reconstruct the partitioning of rare-metal between melts and fluids and their partial loss from the system. The porphyry–granite–greisen system in the Jiepailing mining district in the Nanling Range in South China was chosen for the study, because of (i) its evolved major- and trace-element compositions, which allowed us to characterize both magmatic and hydrothermal crystallization stages; and (ii) the occurrence of dispersed rare-metal mineralization in the granites and rare-metal mineralization in peripheral fluorite ore bodies and quartz veins.

2. Geological setting and studied samples

The Nanling Range in southern China extends across four major metallogenic districts: Southern Jiangxi (Gan'nan), Southern Hunan (Xiang'nan), Northern Guangdong (Yue'Bei), and Northern Guangxi (Gui'bei) (Fig. 1a). Granite bodies of Yanshanian (Cretaceous–Jurassic) age make up ~30% of the exposed area (i.e. > 64×10^3 km^2, Zhou et al., 2006), which are commonly associated with extensive Sn–W ± Nb ± Ta mineralization (Xu and Zhu, 1988; Hua and Mao, 1999; Hua et al., 2003).

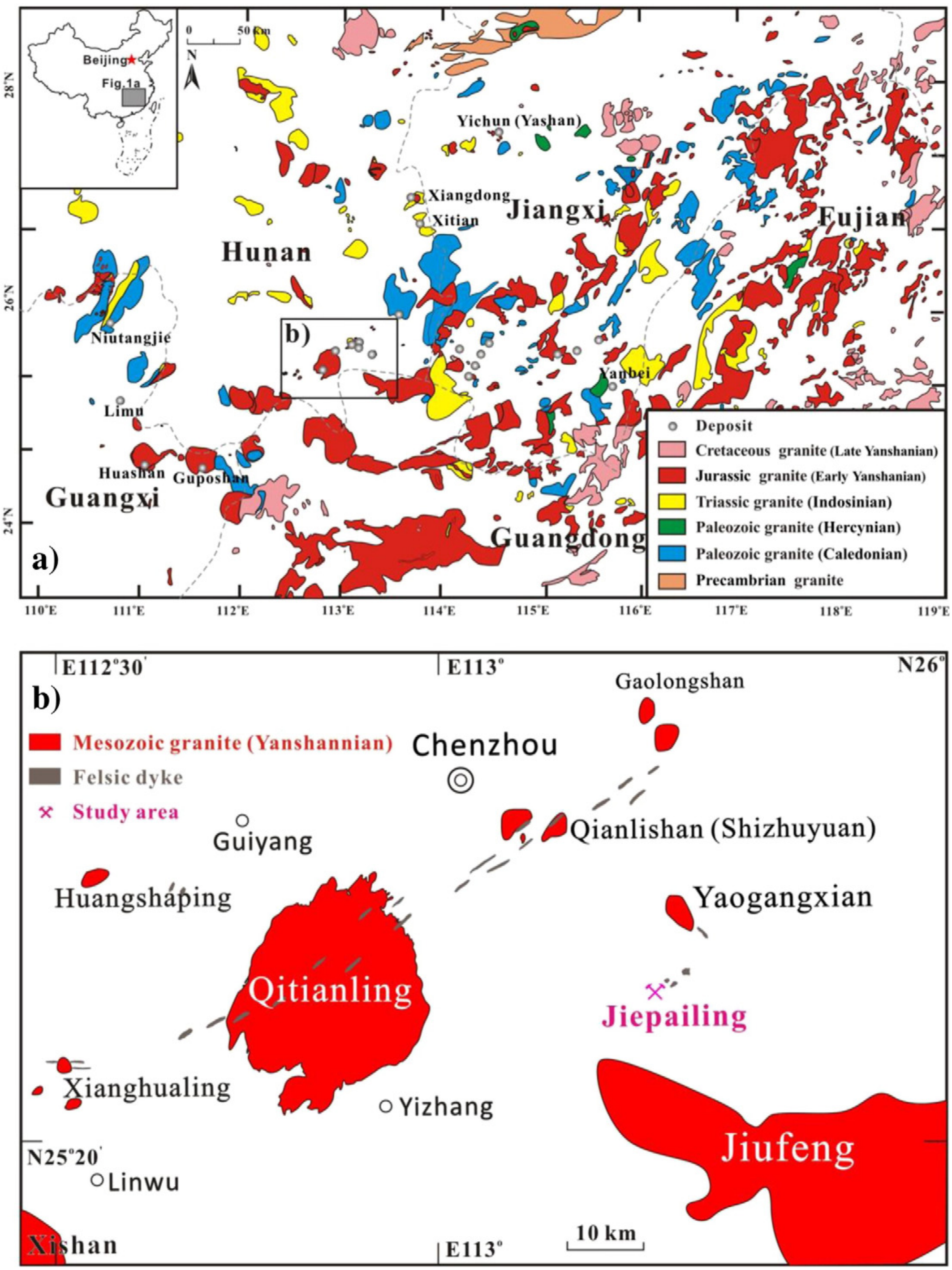

Fig. 1. Geological map of the Jiepailing district in Hunan Province, China.
Modified after Sun (2006) and Zheng et al. (2002).