A new style of rare metal granite with Nb-rich mica: The Early Cretaceous Huangshan rare-metal granite suite, northeast Jiangxi Province, southeast China

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ABSTRACT

In rare-metal granites, niobium and tantalum are generally hosted by Nb–Ta oxides. However, in SE China, the Nb-specialized Huangshan granites are a unique occurrence in which Nb is essentially hosted by Li–Fe micas. The Huangshan granites are part of the Early Cretaceous (Late Yanshanian) Lingshan granite complex and belong to the A-type granite series, with two facies differing by their mica compositions: medium-grained “protolithionite” granite and medium-grained lithian (lithium-rich) annite granite. The granites are characterized by elevated whole-rock Nb contents (average 144 ppm in “protolithionite” granite and 158 ppm in annite granite), quite low Ta contents (average 9 and 4 ppm, respectively), leading to very high Nb/Ta ratios (average 15.3 and 31.2). Niobium is mainly hosted in the micas, with an average Nb content of 1347 ppm in the lithian annite and 884 ppm in the “protolithionite,” which is the highest ever reported in granitic mica. With an estimated endowment of ~80 kt Nb, the Huangshan granites represent a new style of potential Nb resource. Contrasting with the great rarity of columbite, there is abundant Hf-rich zircon, Y-rich fluorite, and Th-rich fluorocerite included in the Huangshan micas. Such accessory minerals being typical of alkaline rhyolitic magmas and niobium enrichment in the Huangshan granites results from A-type melt. The extreme Nb enrichment in the micas results from the highly compatible behavior of Nb in this melt, combined with the high magma temperature (estimated at 790–800 °C) and possibly enhanced magma oxidation.

Keywords: Nb-rich mica, huangshan granite, rare metal, south China; From Magmas to Ore Deposits

INTRODUCTION

Niobium is regarded as a “strategic resource” or a “critical material” by the European Commission (2014) and the U.S. Department of Energy (2011). About 90% of Nb mine production is from pyrochlore and the rest from other oxide minerals such as columbite group minerals (Table 1; Linnen et al. 2014). Consequently, most research and exploration programs have been focused on Nb–Ta oxides (paragenesis, compositional variations, behavior at the magmatic–hydrothermal transition; e.g., Černý and Ercit 1985; Linnen and Keppler 1997; Novák and Černý 1998; Marignac et al. 2001; Linnen and Cuney 2005; Kontak 2006; Van Lichtervelde et al. 2007; Rao et al. 2009; Zhu et al. 2015).

Micas are one of the key rock-forming minerals in several rock types and are currently used for tracking the magmatic and magmatic–hydrothermal evolution of rare-metal granites (RMG) and pegmatites (e.g., Yashan or Yichun granite, China, Li et al. 2015; Tanco pegmatite, Canada, Van Lichtervelde et al. 2008; Cinovec granite, Czech Republic, Johan et al. 2012; Brazil Lake pegmatite, Nova Scotia, Kontak 2006; Karibib pegmatite, Namibia, Roda et al. 2007; Keketuohai region, China, Zhu et al. 2006; Cap de Creus pegmatite field, Spain, Alfonso et al. 2003; Gatuba area pegmatites, Rwanda, Hulsbosch et al. 2014). In addition, mica was proposed to be the major player in the fractionation of Nb and Ta within the crust and in the magmatic enrichment of Ta (Stepanov and Hermann 2013; Stepanov et al. 2014). However, only a few studies have addressed the trace-element concentrations in micas (e.g., Van Lichtervelde et al. 2008; Li et al. 2015; Legros et al. 2016, 2018), and until now they have not been considered as a potential source for economic Nb or Ta.

Southeast China is well endowed with RMGs of different ages and types, and the Yashan (Yichun) and Songshugang RMGs have been particularly well studied (e.g., Yin et al. 1995; Belkasmi et al. 2000; Huang et al. 2002; Zhu et al. 2015). The Huangshan granite/aplite/pegmatite suite (southeast Jiangxi Province, southern China) in the Lingshan plutonic complex displays high Nb and low Ta contents, with some of the highest Nb/Ta ratios reported for RMGs worldwide (Xiang et al. 2017). The granites from this suite contain surprisingly very few Nb–Ta oxides, also in strong contrast to general Nb–Ta-rich RMGs worldwide, and the Nb is almost exclusively concentrated in the micas. Thus the present study aims to provide the first description of the Huangshan RMG, to characterize their Nb-rich and Ta-poor micas, and to address the formation conditions of such exceptional micas.

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