Inherited Eocene magmatic tourmaline captured by the Miocene Himalayan leucogranites

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ABSTRACT

The Miocene Cuonadong leucogranites in the easternmost section of the Tethyan Himalaya, Southern Tibet, are characterized by two types of tourmaline. Tourmaline occurs as needle-like crystals in the two-mica ± tourmaline granites (Tur G) and large patches in the pegmatites (Tur P). Both the granite and the pegmatites yield Miocene ages (ca. 20 Ma) based on monazite U(-Th)-Pb dating, whereas 40Ar/39Ar geochronology of the coarse-grained tourmalines (Tur P) crosscut by pegmatite veins yielded an Eocene mini-plateau age of 43 ± 6 Ma. Major element concentrations of tourmaline indicate that both Tur P and Tur G belong to the schorl group with a magmatic origin, but trace elements such as V indicate that they are not cogenetic. Boron isotopes suggest that Tur P (average ~9.76‰) was derived from typical crustal sources, whereas Tur G (average ~7.65‰) contains relatively more mafic input. The capture of Eocene tourmaline by the Miocene leucogranites at Cuonadong suggests that the crustally derived Eocene magmatism may have occurred in the southern Tethyan Himalaya. Identification of the inherited magmatic tourmaline (Tur P), although not common, challenges the current application of tourmaline chemistry to the investigation of magmatic-hydrothermal systems.

Keywords: inherited tourmaline, Himalayan leucogranite, 40Ar/39Ar and U(-Th)-Pb geochronology, B isotope

INTRODUCTION

The Himalayan continent-continent collisional belt resulted from the convergence and collision of India and Asia along the Indus-Tsangpo Suture zone that began in the Cenozoic (Yin and Harrison 2000). Crustal anatexis related to this large-scale continental collision resulted in the formation of a series of leucogranites (Yin 2006), which generally consist of cogenetic two-mica-, tourmaline-, and garnet-bearing rocks with widespread dikes and stocks of pegmatite (Wu et al. 2020). Two sub-parallel E-trending leucogranite belts, the Higher Himalayan and Tethyan Himalayan (Supplemental Figs. S1a and S1b), have been recognized, with the former exposed along the South Tibetan Detachment System (STDS) in the Higher Himalayan Sequence (HHS) and the latter mainly occurring in the core of the North Himalayan Gneiss Domes (NHGDS) (Supplemental Fig. S1b; Wu et al. 2020). The majority of the leucogranites have yielded Miocene ages (26–7 Ma), with a small number of samples with Eocene ages (46–30 Ma) being found in the easternmost region of the Tethyan Himalayan (Wu et al. 2020). The Miocene and Eocene leucogranites were proposed to have formed from distinct episodes of crustal anatexis with clearly separated distribution in Southern Tibet (Supplemental Fig. S1; Patiño Douce and Harris 1998; Hou et al. 2012). Tourmaline, which is very common in the Himalayan leucogranites and typically the dominant reservoir of B in the rocks, is stable in various P-T-X conditions and could record the physical and chemical conditions under which it formed (Marchall and Jiang 2011; Slack and Trumbull 2011). Due to its robustness, tourmaline chemistry has recently been used to investigate the genesis of Himalayan leucogranites (Yang et al. 2015; Hu et al. 2018). However, these studies relied on the assumption that the tourmalines formed cogenetically with their magmatic host rocks as is widely interpreted in most of the global tourmaline occurrences (van Hinsberg et al. 2011). Following the approach illustrated by Thern et al. (2020), we applied the 40Ar/39Ar dating method to coarse-grained tourmalines from the Miocene Cuonadong leucogranite, which yielded Eocene ages. The identification of inherited tourmalines not only contributes new insights into the Himalayan collisional orogeny but also provides constraints on application of tourmaline chemistry to petrological studies.

CUONADONG TOURMALINE PETROGRAPHY

The Cuonadong leucogranite is located in the easternmost section of the Tethyan Himalaya (Supplemental Fig. S1a) and consists mainly of two-mica ± tourmaline granite and granitic pegmatite. The pegmatites commonly occur as veins or pockets in the leucogranites, without clear boundaries between them (Supplemental Fig. S2). The wall rocks consist mainly of sandstone, mudstone, slate, and schist intercalated with carbonates (Li et al. 2017; Zhou et al. 2019). Two types of tourmalines have been identified in the Cuonadong leucogranites, large tourmaline crystals in the pegmatites (Tur P; Figs. 1a–d) and needle-like tourmaline crystals in the two-mica ± tourmaline granite (Tur G; Fig. 1e). The Tur P are

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