Journal of Geochemical Exploration 110 (2011) 126–135

Contents lists available at ScienceDirect

Journal of Geochemical Exploration

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

Uranium-bearing and barren granites from the Taoshan Complex, Jiangxi Province, South China: Geochemical and petrogenetic discrimination and exploration significance

Kui-Dong Zhao, Shao-Yong Jiang *, Chen-Yang Dong, Wei-Feng Chen, Pei-Rong Chen, Hong-Fei Ling, Jian Zhang, Kai-Xing Wang

State Key Laboratory for Mineral Deposits Research, School of Earth Sciences and Engineering, Nanjing University, Nanjing, 210093, PR China

ARTICLE INFO

Article history:
Received 17 April 2010
Accepted 19 April 2011
Available online 30 April 2011

Keywords:
U-bearing granite
U-mineralization
Geochemistry
Taoshan Complex
South China

ABSTRACT

The Taoshan uranium ore district is one of the most important granite-hosted uranium producers in South China. The Taoshan granitic complex can be petrographically classified into several units of Caijiang, Huangpi, Daguzhai, and Luobuli, but the uranium deposits only occur within the Daguzhai granite unit. LA-ICP-MS zircon U–Pb dating indicates that both the Daguzhai granite and the Huangpi granite were emplaced at 154 ± 2 Ma. U contents (average 19.5 ppm) of the Daguzhai granite are higher than those of the Huangpi granite (average 7.3 ppm). The Daguzhai granite is composed of medium-grained two-mica granite, and the Huangpi granite is composed of medium- to coarse-grained biotite granite. These two granites show obvious differences in major element, trace element and isotopic geochemical characteristics. Compared to the Huangpi granite, the Daguzhai granite has higher A/CNK ratios, higher P_2O_5 contents and lower CaO contents, and is more enriched in Rb, Ba, U, and more depleted in Sr, Eu and Ti. The $\varepsilon_{Nd}(t)$ values of the Daguzhai granite vary from −12.2 to −11.0 with two-stage model ages of 1.84 to 1.93 Ga. The $\varepsilon_{Nd}(t)$ values of the Huangpi granite are slightly higher (−9.7 to −8.6) and the Nd model ages are younger (1.64 to 1.73 Ga). Comparative studies imply that the Daguzhai granite belongs to typical S-type and might be derived from the partial melting of parametamorphic rocks from metamorphic basement of the Zhoutan Group. In contrast, the Huangpi granite belongs to fractioned I-type, which might be derived from the partial melting of a mixture of ortho- and para-metamorphic rocks of the Zhoutan Group. These different magma sources might explain the different U contents of the two granites. In general, the source factor is an important controlling factor for the genesis of U-bearing granites in South China. U-bearing granites in South China show some common mineralogical and geochemical characteristics, which can be used to guide further exploration of granite-hosted U deposits.

1. Introduction

Granite-hosted uranium ore deposits are important commercial U-producers in South China (Hu et al., 2008). This type of deposit has contributed about 30% of the U production in China. Previous exploration and studies (Deng et al., 2003; Du, 1982, 1986; Hu et al., 1993; Li and Huang, 1986; Min et al., 1999; Wang and Liu, 1987) have indicated that such deposits only occur within a few granitic bodies, which were called U-bearing granites (Zhang and Zhang, 1991). These U-bearing granites are generally rich in U (>10 ppm) and have been regarded as the sources of uranium mineralization. Uranium ores in granite-hosted deposits in South China are mainly of the hydrothermal vein-type, according to the classification of Cuney (2009), and controlled by regional faults. These deposits formed from meteoric fluids that circulated during the Cretaceous to Tertiary crustal extension in South China (Hu et al., 2008). Discrimination of U-bearing and barren granites is important not only for exploring more U-bearing granites and granite-hosted U deposits in South China, but also for a better understanding of the mechanism of U enrichment in the granites.

The Taoshan granitic complex is a ca. 1100 km^2 composite granitic batholith in Jiangxi Province, South China, and contains an important economic granite-hosted uranium ore district. This ore district was first discovered in the early 1960s during an airborne radiometric survey and follow-up studies of the anomalies on the ground, and was mined from 1963 to present. Granitoid rocks of the Taoshan Complex can be petrographically classified into several units, including the Indosinian Caijiang and early Yanshanian Huangpi, Daguzhai, and Luobuli granites. However, U ore deposits are only located within the Daguzhai granitic body, which has an outcrop area of only 30 km^2.

* Corresponding author. Tel.: +86 2583596832; fax: +86 2583592393.
E-mail address: shyjiang@nju.edu.cn (S.-Y. Jiang).

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doi:10.1016/j.gexplo.2011.04.006

Previous studies have focused on geology and geochemistry of the ore deposits (Min et al., 2005; Zeng et al., 2006; Zhang, 2008; Zhang et al., 2008; Zheng et al., 1989, 1996). The geochronology, geochemistry and sources of the granitoids, however, are poorly understood (Zheng et al., 1986, 1992). In this paper, we present LA-ICP-MS zircon U–Pb ages, major and trace element concentrations, and Sr–Nd isotopic data for the coeval U-bearing Daguzhai granite and U-barren Huangpi granite. The aim of this work is to compare the differences of geochemistry and sources of U-bearing and barren granites in the Taoshan Complex. This approach enables us to evaluate the petrogenesis of the granites and mechanism of U enrichment in granites of South China.

2. Geological setting and petrography

The Taoshan Complex is located in Central Jiangxi Province, South China (Fig. 1). It was emplaced into Sinian–Cambrian metamorphic rocks that are more than 7 km thick. The outcropping oldest basement in Central Jiangxi Province is the Mesoproterozoic Zhoutan Group, which consists mainly of schists, granulites and amphibolites. Hu (1998) suggested that the protoliths of the schists and granulites were of sedimentary origin, whereas the precursor to the amphibolites was basaltic. The amphibolites yielded a Sm–Nd isochron age of 1113 ± 49 Ma (MSWD = 0.22) (Hu et al., 1999). Phyllites, slates and metasandstones comprise the Sinian–Cambrian metamorphic rocks. Late Cretaceous–Tertiary reddish conglomerates, sandstones and shales are approximately 2500 m thick and fill fault-bounded basins in the region. They rest unconformably on the Sinian–Cambrian metamorphic rocks. Several regional NE-trending high-angle faults and fracture zones extend for more than 20 km and traverse the entire district. The fault zones comprise a multitude of individual reverse faults, and with variable widths from 1 to 10 m.

The granitoid rocks of the Taoshan Complex can be petrographically classified into five main unites (Fig. 1):

(1) The Indosinian Caijiang medium- to coarse-grained porphyritic biotite granite, with K–Ar ages of about 231 Ma (Min et al., 2005). This granite forms a stock with an outcrop area of 80 km^2, and intrudes the Sinian–Cambrian metamorphic rocks in the southwestern part of the district.

(2) The early Yanshanian Huangpi medium- to coarse-grained biotite granite (Fig. 2c–d). The granite is the major body of the Taoshan Complex and forms most of the batholith. The granite is composed of biotite (10 vol.%), plagioclase (An_{20-30}, 30 vol.%), K-feldspar (20 vol.%), quartz (40 vol.%) and trace amounts of zircon, apatite, monazite, and sphene.

(3) The early Yanshanian Daguzhai medium-grained two-mica granite (Fig. 2a–b). Uranium ore deposits are located within this granite. The granite occurs as stock with an outcrop area of 30 km^2 and occupies the central portion of the Taoshan Complex. The granite is composed of biotite (4 vol.%), muscovite (5 vol.%), plagioclase (An_{15-25}, 20 vol.%), K-feldspar (35 vol.%), quartz (35 vol.%) and trace amounts of zircon, apatite, monazite, sphene, uraninite, and allanite. Muscovite occurs as either epitaxial secondary growth upon biotite (Fig. 2a) or individual large crystals (Fig. 2b). As shown in Fig. 2a, biotite usually contains abundant U-rich accessory mineral inclusions, such as apatite, zircon, uraninite and monazite. Radiation halo occurs around with these minerals. Previously, the granite was dated by single zircon U–Pb isochron method and yielded variable

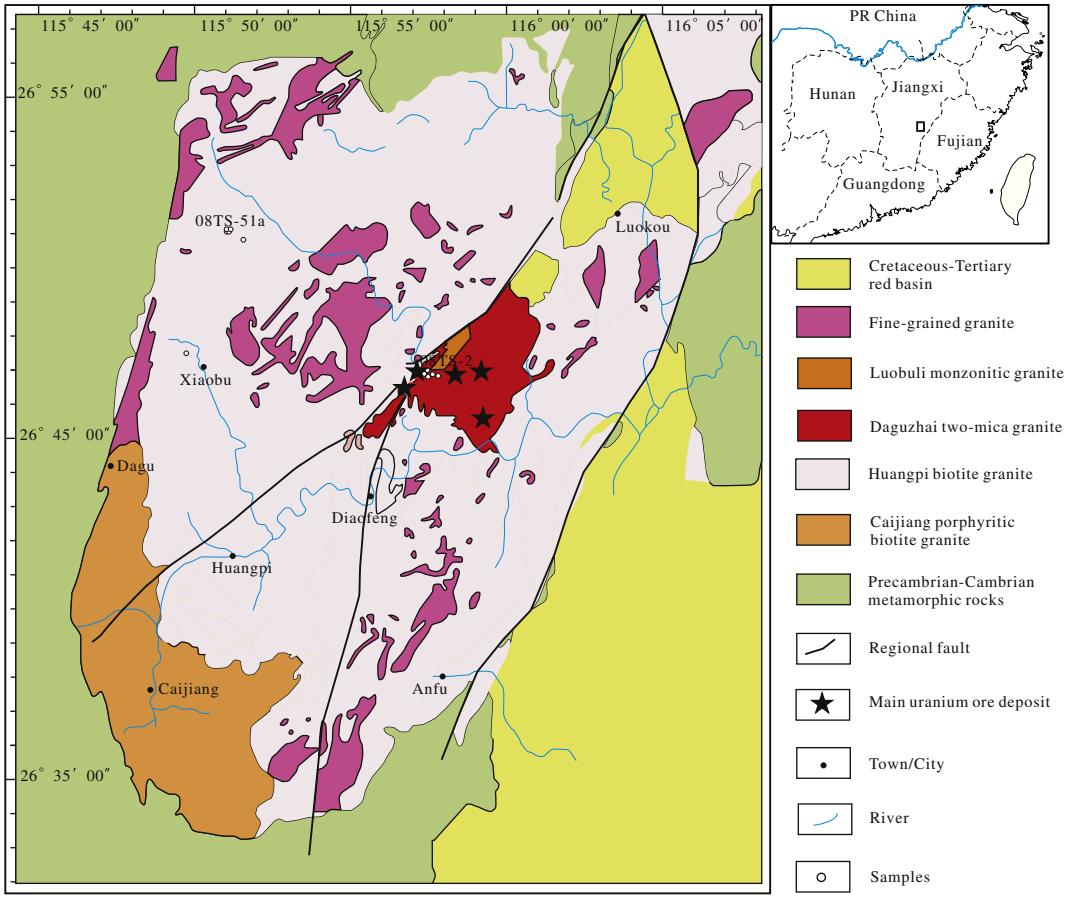

Fig. 1. Simplified geological map of the Taoshan Complex in Jiangxi Province, South China.