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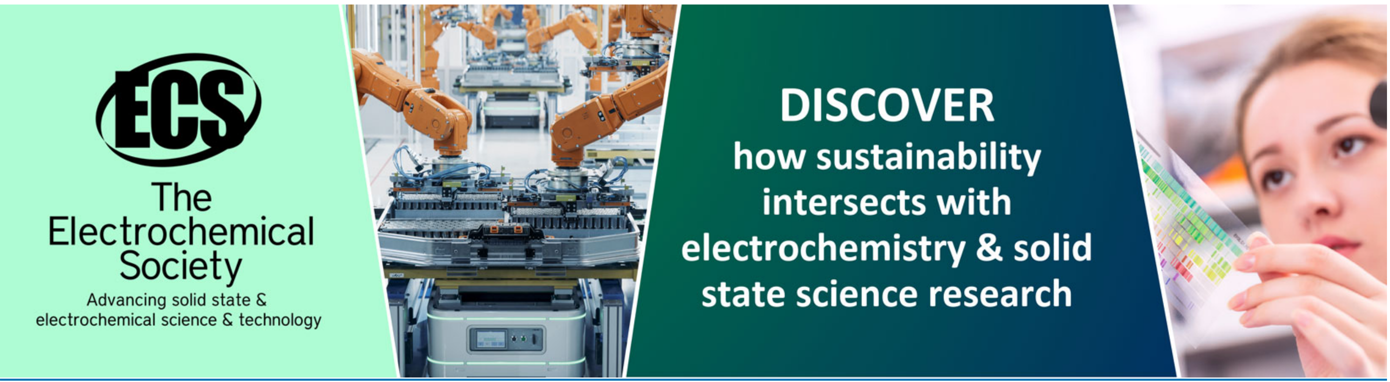

Shamai Tungsten Deposit, Inner Mongolia: Constraints from $^{40}Ar/^{39}Ar$ Age of hydrothermal Muscovite

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Abstract. The Shamai tungsten deposit in Inner Mongolia is located in the Xing'an Mongolia Orogenic Belt, east part of the Central Asian Orogenic Belt. Orebodies exist in the fault zone of the biotite monzogranite (porphyry), in the pegmatite and greisen forms. This paper presents precise 40Ar/39Ar ages of muscovite related to the mineralization by laser incremental 40Ar /39Ar analysis. Muscovite yielded a well-defined $^{40}Ar/^{39}Ar$ plateau age of (138.4 ± 0.84) Ma, with normal and inverse isochron ages being (137.32 ± 0.73) Ma and (137.35 ± 0.73) Ma. These ages can represent the formation age of the deposit and suggest that the Shamai deposit is related to the magmatic activities of Yanshanian period, which is in conformity with things of the regional metallogenic events. Combined with the previous studies of the geodynamic settings of South China, the authors consider that Shamai tungsten deposit might be formed in an intracontinental extensional setting following the collision.

1. Introduction

The Shamai tungsten deposit located in the Xing'an Mongolia Orogenic Belt is the largest proven tungsten deposit in Dongwuqi area. Predecessors have done some work on geology and geochemistry of the deposit, preliminarily identified the geological characteristics, ore body and mineralization characteristics of the deposit, and put forward a preliminary understanding of its genesis. However, due to the limitation of the test accuracy and the test object, the ore-forming age of the deposit is still controversial. Some scholars believe that the deposit was formed in the late Yanshanian period[1], while others believe that the formation of W (Mo) deposit in this area is related to the hydrothermal activity of Indosinian granitoid intrusion[2]. In order to accurately determine the metallogenic age of the Shamai tungsten deposit, based on the previous work, this paper, through $^{40}Ar/^{39}Ar$ isotopic dating of the hydrothermal muscovite in the mining area, further determines the time limit of the hydrothermal activity of the deposit, and provides chronological evidence for understanding the metallogenic process of the deposit.

2. Geological setting

Dongwuqi area in Inner Mongolia is located in the southern part of Daxinganling metallogenic belt, which belongs to the middle part of Xingmeng orogenic belt. Most of this area belongs to grassland covered area, mainly covered by Tertiary and Quaternary sandy soil. The main exposed strata in the area are lower Cambrian, Ordovician, Silurian, Devonian, Carboniferous, Permian, Jurassic and Cretaceous of Early Paleozoic (Fig. 1).

The NW-trending faults are crosscut by NNE- to NE-trending faults in the Dongwuqi area. Most of the Intrusions in the Dongwuqi area are formed in the Hercynian and Yanshanian (Fig. 1), which widely developed along the NW- and NE-trending faults or at their intersections, consisting of intermediate to felsic granitoid plutons, with volcanic rocks and mafic or ultramafic intrusions.

The multi-stage magmatic intrusion is accompanied by the formation of a large number of non-ferrous metal minerals in the area. The scale of the deposits is mainly large and medium, and the types of deposits are diverse, including porphyry type, skarn type, hydrothermal vein type, etc.

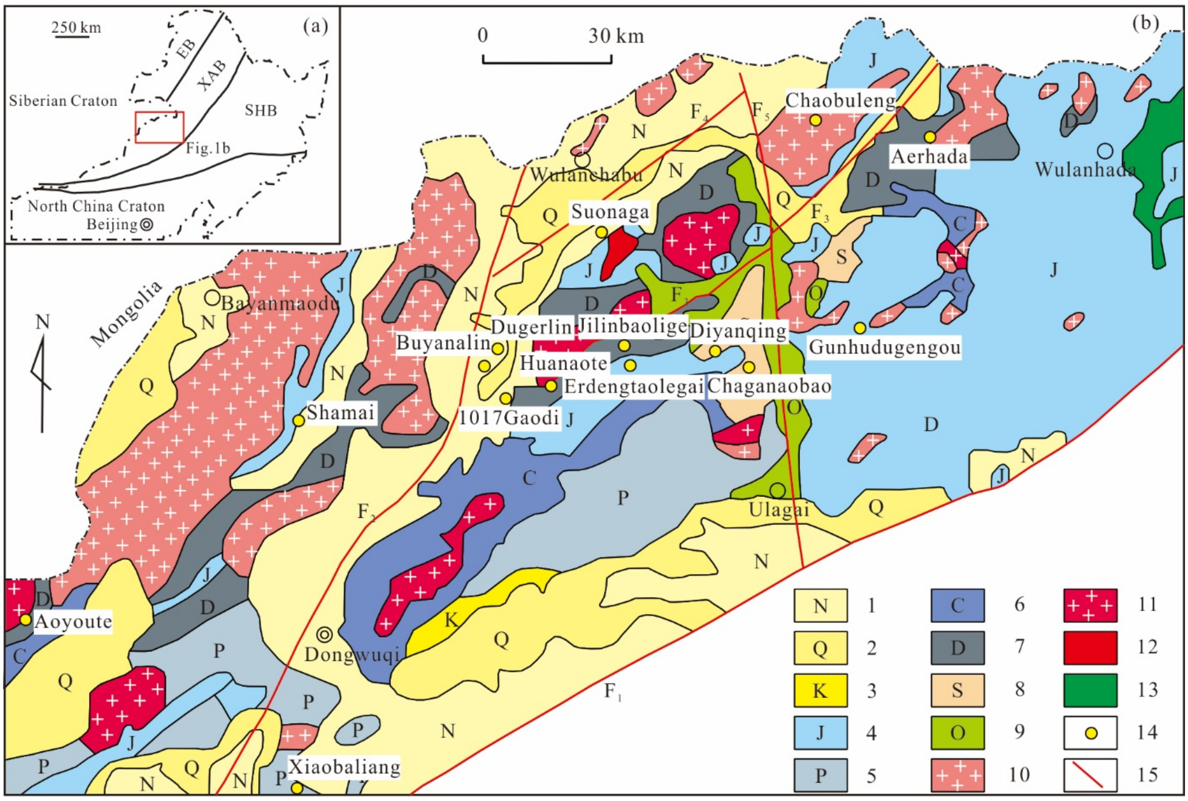

Figure 1. Regional tectonic framework of the Great Xing'an Range and adjacent areas in northeast China (a, based on Ref. [3]) and Simplified geological map of the Dongwuzhumuqinqi area (b, based on Ref. [4])

1-Tertiary; 2-Quaternary; 3-Cretaceous; 4-Jurassic; 5-Permian; 6-Carboniferous; 7-Devonian; 8-Silurian; 9-Ordovician; 10-Yanshanian granite; 11-Hercynian granite; 12-quartz porphyry; 13-basalt; 14-deposit; 15-fault; F1-Erlian–Hegenshan fault-zone; F2-Dongwuqi–Yihebashaer fault; F3-Baiyunhubuer–Mandubaolige fault; F4-Barunshabaer–Chaobuleng fault; F5-Chaobuleng–Wulagai fault; EB=Erguna block, XAB=Xing'an–Airgin Sumblock, SHB=Songliao–Hunshandake block.

3. Local and ore geology

The outcrops of the inner strata in Shamai deposit are relatively single, mainly Devonian epimetamorphic rocks and Jurassic volcanic sedimentary rocks. The whole Shamai deposit is located in the axis of NE-trending Dongwuqi anticline, and the basic structural pattern is controlled by multi-stage tectonic activities in NW and NE directions. NW-trending faults are well developed, which strictly control the distribution of tungsten veins in the mining area and are the main ore hosting structures in this area. Medium-fine grained biotite monzogranite is exposed in the area of Shamai deposit, and biotite monzogranite porphyry is concealed under the surface. Quartz syenite porphyry, fine-grained granite, fine-grained rock and felsic pegmatite are also found in the biotite monzogranite.

Most of the tungsten mineralization in the Shamai deposit occurs in the intrusive body of the Shamai granitoid as veinlets or veins. More than 550 ore bearing veins have been found and delineated in the Shamai tungsten mining area, which can be roughly divided into five main vein zones, approximately parallel, ranging in length from several meters to hundreds of meters. In terms of spatial distribution characteristics, tungsten veins are mainly distributed in NW direction, and the distance between vein belts is roughly the same.

The main mineralization types of the Shamai tungsten deposit are quartz-vein type (or pegmatite type) and greisen type, the former is of high grade. In addition to wolframite, there are molybdenite, scheelite, and a small amount of sphalerite, galena, chalcopyrite, malachite, limonite, etc. Gangue minerals mainly include quartz, muscovite, fluorite, potash feldspar, plagioclase and a small amount of biotite and topaz. The ore structure is mainly pegmatite and coarse-grained, and the ore structure is mainly massive, vein, net vein, comb and cave. Hydrothermal alteration is well developed in Shamai deposit, mainly including pegmatization, greisenization, silicification, muscovitization, fluoritization and pyritization.

4. Results

Muscovite samples for ^{40}Ar/^{39}Ar dating were collected from pegmatite dikes with wolframite. The muscovite samples were analyzed by ^{40}Ar/^{39}Ar experimental laser heating in 10 stages. The temperature was gradually raised from 700℃ to 1300℃, forming a basically undisturbed age spectrum (Fig. 2). In this experiment, the surface ages of 10 heating stages constitute a relatively flat age plateau. Most of the ^{39}Ar precipitated in the heating stage are in accordance with the plateau forming conditions, and the correlation is excellent, indicating that the argon isotope composition in the mineral is relatively stable, and it is basically not disturbed by the later thermal events. The samples yielded a well-defined age spectrum with a plateau age of 138.4±0.94 Ma, which is consistent with the inverse isochron age (137.32±0.73 Ma), showing that the ^{40}Ar-^{39}Ar age data of Muscovite is true and reliable.

5. Discussion

5.1 Timing of mineralization

The ^{40}Ar/^{39}Ar plateau age (138.4 ± 0.84 Ma) of muscovite can represent the metallogenic age of the Shamai tungsten deposit. The age is slightly later than the intrusive age of the biotite monzonitic granite (139.1 ± 0.93 Ma[5]), and is consistent with the Sm-Nd isotopic age of wolframite (137.9 ± 1.7 Ma[5]) and molybdenite Re-Os isotopic ages (137 ± 2 Ma[1]), indicating that the main tectonic magmatic activity and related thermal events occurred in the early Cretaceous of late Yanshanian. It also shows that the mineralization took place in the process of post magmatic hydrothermal events.

In recent years, a large number of diagenetic and metallogenic age data of polymetallic deposits related to intermediate acid intrusive magmatic rocks have been obtained in Dongwuqi area. The data show that except for 1017 Gaodi silver polymetallic deposit formed in the middle Hercynian period, all other hydrothermal deposits related to magmatic intrusion with reported metallogenic age formed in the Yanshanian period. For example, the Chaobuleng skarn type iron polymetallic deposit was formed at 138~140 Ma[6]; Oyute continental volcanic-subvolcanic copper deposit was formed in 187.11 ± 3.50 Ma[7]; The Diyanqinamu and Sonaga porphyry molybdenum polymetallic deposits were formed at 156~159 Ma[8] and 166.9 ± 2.3 Ma[9], respectively. The results show that Dongwuqi area, located in the west slope of Daxinganling Mountains, is also mainly affected by the Mesozoic Yanshanian tectonic magmatic metallogenesis, which also implies that the metallogenic events of Mo, W, Cu, Fe, Pb, Zn and Ag in this period are closely related in origin and have a unified geodynamic background.

5.2 Regional metallogenic geodynamic background

The Shamai tungsten deposit is located in the middle part of the Xing-Meng orogenic belt, where the tectonic evolution history is complex. During the Paleozoic, influenced by the Paleo-Asian Ocean tectonic domain, many micro landmasses were formed between the North China craton and the Siberian craton. During the Mesozoic, the Paleo-Asian Ocean was closed, and the micro landmasses closed to form a unified land. The region began to be affected by the superposition of Mongolia-

Okhotsk Ocean tectonic domain and Circum Pacific tectonic domain, and entered the stage of tectonic evolution dominated by extension after the collision. The magmatic activities are frequent and intense, and there are a lot of Yanshanian magmatic metal mineralization events.

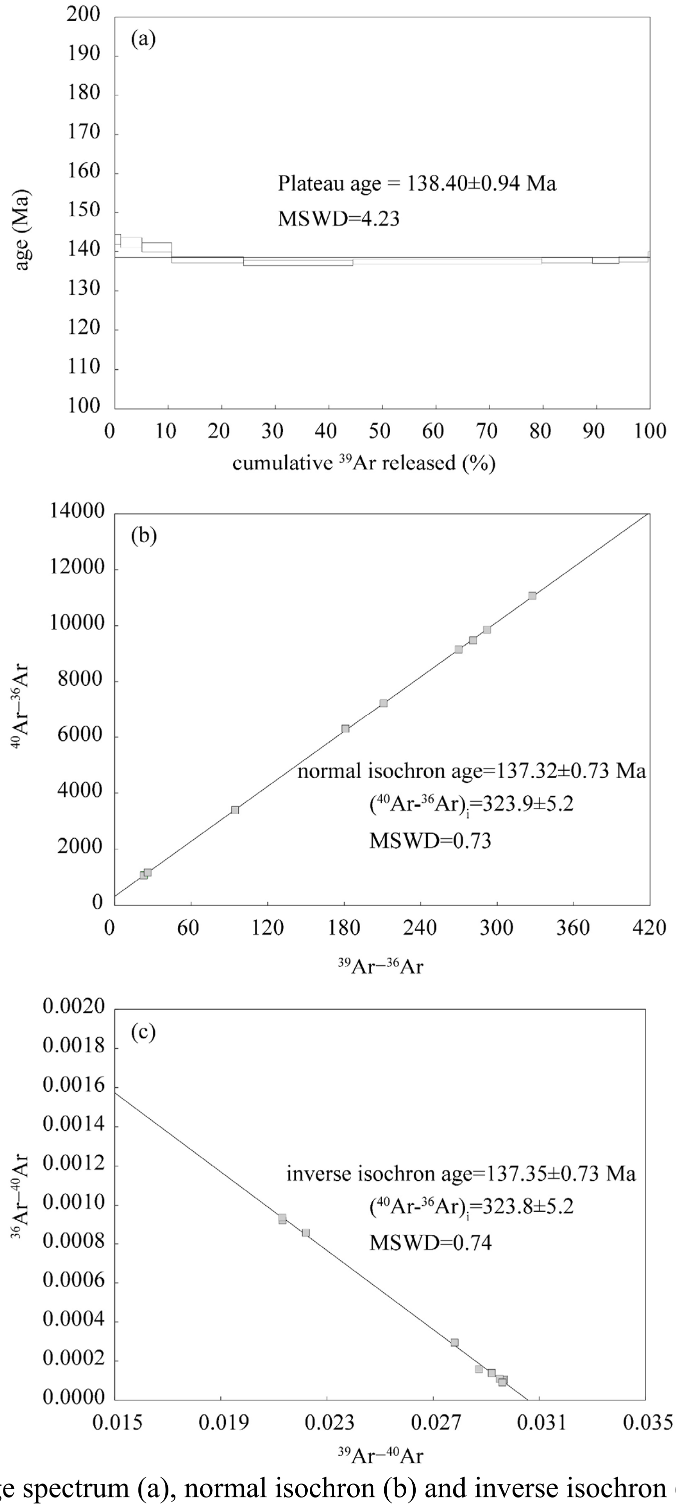

Figure 2. ^{40}Ar-^{39}Ar age spectrum (a), normal isochron (b) and inverse isochron (c) for muscovite from the Shamai tungsten deposit

Previous studies have shown that large-scale lithospheric thinning occurred in eastern China during the Yanshanian period of 160~110 Ma[10], accompanied by strong tectono-magmatic activities and large-scale metallogenic events. Since Mesozoic, under the influence of Paleo Pacific subduction, the tectonic framework of eastern China has been transformed from EW-trending to NE-NNE-trending, and the North China craton and its adjacent areas have been subjected to lithospheric thinning and strong extension.

Deep and large faults caused by crustal extension provide migration channels for ore bearing magma emplacement. Magmatic intrusions bring and extract ore-forming materials from deep crust, and release hydrothermal solution rich in ore-forming elements in the process of differentiation and evolution. With the change of physicochemical properties, ore bearing fluid fills a series of fault systems in biotite monzonitic granite (porphyry) in the Shamai deposit. The pegmatite type tungsten ore body is formed in the open space, while the disseminated greisen type tungsten mineralization is formed in the intrusive body or edge.

6. Conclusions

(1). The $^{40}Ar/^{39}Ar$ plateau age of muscovite is (138.4 ± 0.84) Ma, with normal and inverse isochron ages being (137.32 ± 0.73) Ma and (137.35 ± 0.73) Ma, which can represent the mineralization age. It suggest that the Shamai deposit is related to the magmatic activities of Yanshanian period, which is in conformity with things of the regional metallogenic events.

(2). The Shamai tungsten deposit is a hydrothermal tungsten polymetallic deposit related to granitic magma and might be formed in an intracontinental extensional setting following the collision, which is the product of large-scale metallogenic events in eastern China.

Acknowledgments

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