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Metallogenic Epoch of Longqiao Iron Deposit in Lujiang-Zongyang Ore Concentrated Area, Middle and Lower Reaches of Yangtze River, China

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1 Introduction

Lujiang-Zongyang ore concentrated area is one iron-copper concentrated area in Middle and Lower Reaches of Yangtze River, and characteristics with porphyrite iron deposit and stratabound-hydrothermal superimposed pyrite deposits(Chang et al.,1991; Zhai et al.,1992).The Longqiao iron deposit is located in the northern edge of Lujiang-Zongyang ore concentrated area. The geological feature, ore-controlling condition,metallogenic stratohorizon,ore genesis of the deposit had already been discussed(Hu et al.,1991;Ni et al.,1994;Wei et al.,1997,1999),the focus of contention were metallogenic time and metallogenic stratohorizon.At present, there existed three primary viewpoints, they have been mentioned as follows:

(1)Ren et al.(1991)considered that the metallogenic stratohorizon had been the Luoling Formation in middle Jurassic, and the ore deposit had formed in volcanic magma in middle Jurassic;(2)Ni et al.(1994) deemed that the metallogenic stratohorizon had come from ferriferous sedimentary source bed of Dong Ma'anshan Formation in middle Triassic, and reformed by thermal metamorphism and hydrothermal superimposition of Yanshanian magmatism; (3)Wei et al.(1997,1999) believed that the metallogenic stratohorizon had been Longqiao Formation. Therefore,the metallogenic epoch of the Longqiao deposit was inconsistent. In this paper, the authors collected syngenetic biotite of magnetite body and alteration biotite in trachyandensite of Longmenyuan Formation, and discussed the metallogenic epoch of the Longqiao iron deposit according to Ar-Ar isotope dating.

2 Geological features and sampling location

In the deposit, the main orebody is hosted in argillaceous sandstone and carbonate between the trachyandensite of Longmenyuan Formatoin and the quartz syenite and monzonite of Yanshanian intrusive rocks. The main orebody has stratiform structure and trend surface of hanging wall and footwall have southwest dip direction (Ma et al., 2009). The local orebodies intersperse in taffaceous sandstone, amphibole trachyandensite and quartz syennite. The sampling location is situated in exploration line 5-7,370m Midpiece of Longqiao iron deposit. The sample of Lz370-1 is the biotite with crystal form of flakes, which picked out intergrowth with magnetite, calcite and pyrite. The sample of Lz370-2 is the biotite with crystal form of flakes, which selected in gray black trachyandensite from wall rocks of hanging wall, coexistence with magnetite and pyrite.

3 Sample processing

All the samples had weathered rim removed and were crushed to millimeter-scale grains. The required minerals were carefully handpicked under a magnifier. Only fresh mineral grains of 60~80 mesh grain-size were selected. A mineral purity of 99% was achieved. The selected mineral concentrates were individually wrapped in Al-foil packets, encapsulated in sealed Gd-foil, and irradiated for 3008 min at the central thimble position of the nuclear reactor (1000 kW) at the Chinese Academy of Atomic Energy Science. The instantaneous neutron flux was 2.65×10^{13} n / cm^2s and the integrated neutron flux was 4.78×10^{18} n/cm. The internal standard Biotite ZBH-25 had been used, which the age was 132.7 ± 1.2 Ma,the Potassium content was 7.6%.

The samples were progressively heated and each heating step was maintained for 30 minutes. Experiments were started at a temperature range of 400~430℃ and ended at 1420~1450℃. At each extraction temperature, the impure gas released was in turn purified through a 5Å molecular griddle, Cu–CuO (550℃), a spongy Ti container (850℃) and a Ti evaporated pump. Purified argon was finally collected using a Zr–Al getter pump, and subsequently analyzed using gas source mass-spectrometers operated in the static mode MM-1200B mass analyzer at the Institute of Geology, Chinese Academy of Geological Sciences. Measured isotopic ratios were corrected for the effects of mass discrimination and interfering isotopes, using the factors, $(^{38}Ar/^{36}Ar)_{Ca} = 0.1869$, $(^{38}Ar/^{37}Ar)_{Ca} = 3.81\times10^{-5}$,$(^{36}Ar/^{37}Ar)_{Ca} = 2.64\times10^{-4}$, $(^{39}Ar/^{37}Ar)_{Ca} = 6.87\times10^{-4}$, $(^{40}Ar/^{39}K)_k = 0.01$.The blank atmospheric argon $^{40}Ar/^{36}Ar$ ratio is 294.2 for this group of experiments. Total uncertainties in each apparent age (1σ) have been calculated using the methods outlined by Dalrymple and

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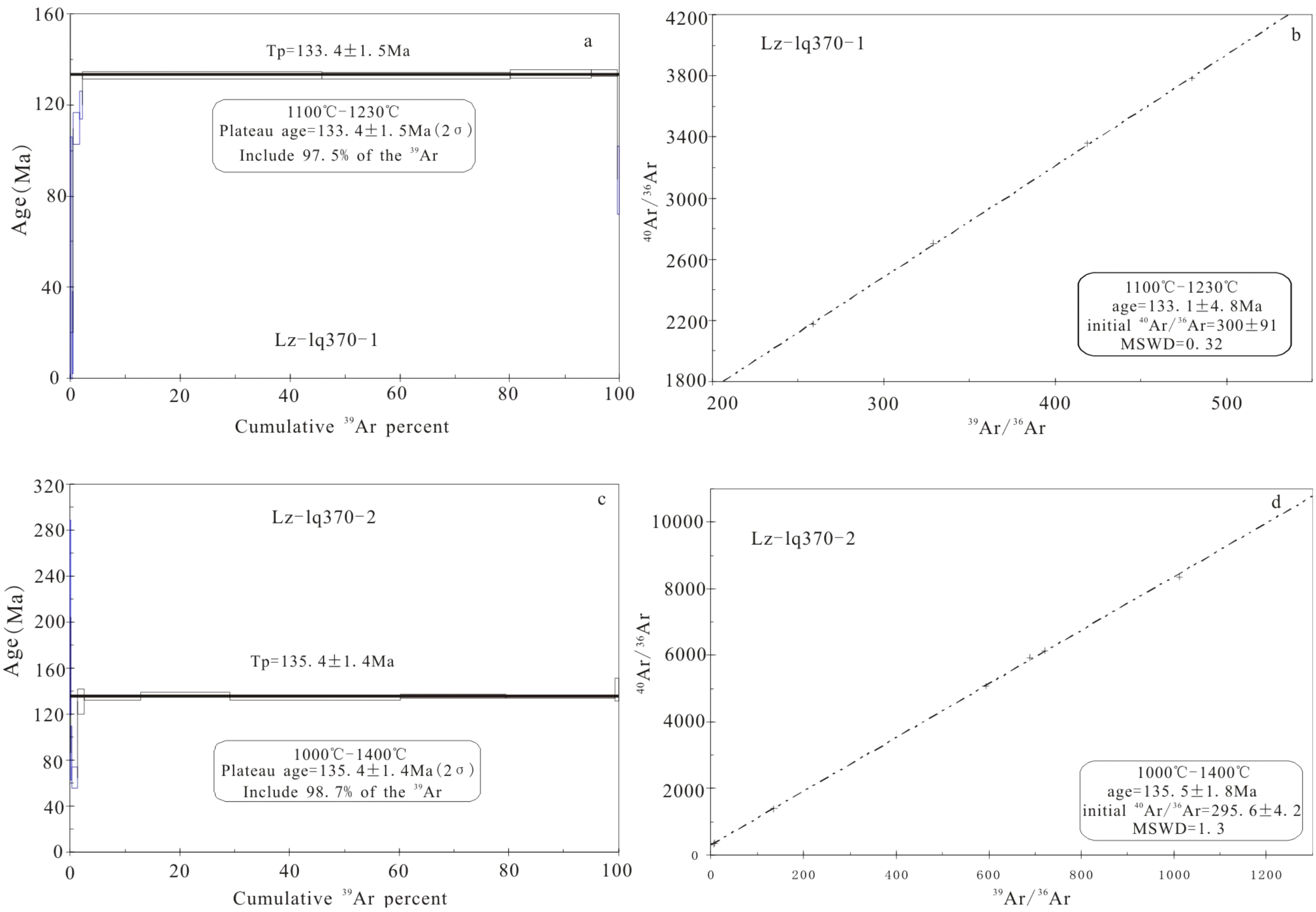

Fig.1 The ^{40}Ar-^{39}Ar spectrum and isochronal age diagram of biotite in the Longqiao iron deposit

Lanphere (1971). Plateau age, positive and inverse isochrones were processed by program ISOPLOT (Ludwig, v2.49, 2001). The error of plateau age was given 2σ. The relevant process can be seen in related articles (Chen et al., 2006; Zhang et al., 2006).

3 Results

The ^{40}Ar-^{39}Ar stage heating age of sample Lz370-1 has nine heating stages, the temperature ranges from 700℃ to 1300℃, plateau age spectrum shows in Fig.1-a, the relevant isochron diagram of $^{40}Ar/^{36}Ar$-$^{39}Ar/^{36}Ar$ displays in Fig.1-b. The apparent age comparatively concentrates on 900~1230℃ from three to eight stepwise heating. The released Argon reaches 97.5%. Plateau age is 133.4±1.5Ma(2σ) in a weighted average(Fig.1-a). The isochrone age of liner regression is 133.1 ± 4.8Ma (MSWD=0.32). The isochron age, coincides with plateau age, is within experimental error. The initial ratio $^{40}Ar/^{36}Ar$ is 300±91, the excess Argon may be contained in sample and lead to significant errors. Whereas, it coincides with atmospheric Argon within error($^{40}Ar/^{36}Ar$ =295.5±5).

The ^{40}Ar-^{39}Ar stage heating age of sample Lz370-2 has ten heating stages, the temperature ranges from 700℃ to 1400℃, plateau age shows in Fig.1-c. The relevant isochron diagram of $^{40}Ar/^{36}Ar$-$^{39}Ar/^{36}Ar$ displays in Fig. 1-d.The apparent age comparatively concentrates on 1000~1400℃ from four to ten stepwise heating, the released Argon is 98.7%. The plateau age is 135.4±1.5Ma (2σ) in a weighted average (Fig.1-c). Isochrone age of liner regression is 135.5±1.8Ma(MSWD=1.3) and coincides with plateau age within experimental error. The initial ratio of $^{40}Ar/^{36}Ar$ is 295.6±4.2. The excess Argon may be contained in sample and lead to significant errors. However, it almost coincides with atmospheric Argon within error($^{40}Ar/^{36}Ar$ is 295.5 ±5) (Fig.1-d).

The $^{40}Ar/^{39}Ar$ age usually represents cooling age of testing minerals and its closure temperature is 350~300℃ in Argon isotopic system of biotite(McDougall et al., 1988).Consequently, the plateau ages represents cooling age above 350~300℃ of the samples this time. The isochron age and plateau age of two samples are well consistent within error from Figure 1.Therefore, the test results are reliable. That is to say the $^{40}Ar/^{39}Ar$ cooling age of biotite from altered trachyandesites and the biotite symbiotic with pyrite, magnetite and calcite can be explained hydrothermal alteration age and metallization age of Longqiao iron deposit.

4 Discussions

The Middle and Lower Reaches of Yangtze River is a primary iron and copper polymetallic metallogenic belt(Chang et al.,1991; Zhai et al.,1992; Dong,2009). The magmatic activities and metallogeny were intense, and it's the production of magmatic explosion of Yanshan movement in Eastern China during Mesozoic (Hua et al., 1999). The time of regional magmatic activities was 126~145 Ma, and the iron and copper polymetallic metallogenic belt also formed in this period (Liu et al.,2002;

Zhang et al.,2003;Xie et al.,2008). The Ar-Ar isotopic ages, which obtained from this time, are ca.135~133 Ma.It's nearly same as the activity time of volcanic eruption and irruption, ca. 135~127Ma, in Lujiang-Zhongyang area(Zhou et al.,2007,2008; Xue et al.,2010). It demonstrates that the Longqiao iron deposit formed in early stage of volcanic activity was relative to shoshonite igneous magma. It identified that the metallogenetic epoch of the deposit was in early Cretaceous.

At the beginning of early Cretaceous, Tan-lu fault belt had happened pull-apart extension in translation fault system at southern end of it after a large scale sinistral movement of the Tan-lu fault in Middle and Lower Reaches of Yangtze River. On the settings of Northwest-Southeast extensional stress field, it happened pull-apart between Luohe fault and eastern edge fault of the basin. The Luohe fault is located at western side Lujiang-Zhongyang ore concentrated area and is parallel to Tan-lu fault. It cut through the crust, reached Moho,and turned on the channel of upward migration of mantle material and fluid, and controlled the deep metallogenesis of Lujiang-Zongyang area(Dong et al., 2009).

The polycyclic volcanic eruption and polyphase magmatic intrusion activities formed main part of Lujiang-Zongyang continental volcanic cycles. At the same time, deep metallogenic materials and hydrothermal emplaced in superficial or superimposed ferruginous sedimentary source bed(Ni et al.,1994). In regional, the sandstone of Luoling formation and Moshan formation of middle-lower Jurassic were involved in fold deformation of Yanshan period, but did not affect continental volcanic rocks of early Cretaceous. According to mining and borehole data of Longqiao iron deposit, the orebodies mainly existed in limestone between exploration line 10 and exploration line 26 in west mining area and occurred in sandstone and pelitic siltstone partly interpenetrating in trachyandesite and quartz syenite between exploration line 8 and exploration line 17 in east mining area.Therefore,the unconformity between continental volcanic basin and basement of it provided possible metallogenic space of Longqiao iron deposit.

Key words: Longqiao iron deposit;Metallogenic Epoch; Lujiang-Zongyang Ore Concentrated Area; Middle and Lower Reaches of Yangtze River

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