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Magmatic-Fluid-Metallogenic System of the Anqing Skarn Cu-Fe Deposit, Anhui Province, China

YANG Guangshu¹, WEN Hanjie², YAN Yongfeng¹, FENG Pengyu¹ and ZHANG Junwei¹

¹ Kunming University of Science and Technology, Kunming 650093, China

² Institute of Geochemistry, Chinese Academy of Science, Guiyang 550002, China

1 Introduction

The Anqing skarn-type Cu-Fe deposit is an important part of Tongling-Anqing iron-copper mineralization concentration field. Over the last few decades, several metallogenic models have been proposed (Zhou et al., 2007; Yang, et al., 2008). However, the source of ore-forming materials and the fluid system of mineralization are controversial (Zhang et al., 2012). This paper represents the characteristics of ore-forming fluid and C-O isotope compositions in the Anqing Cu-Fe deposit, and tries to use these data to discuss and understand the magmatic- fluid-metallogenic system of this deposit.

2 Geology of the Anqing Deposit

Anqing Cu-Fe deposit contains three main ore bodies, which are located within the contact zones between the

northeastern branch of early Yanshanian Yueshan diorites and Middle to Lower Triassic marbles. The occurrence of ore bodies are controlled by fault and the shape of contact zone. The mineralization zoning is clear, characterized by the andradite-rich skarns and copper-bearing magnetite ore bodies mainly occur in the external contact zone near marbles, and the diopside- (scapolite-) and chalcopyrite-bearing endoskarns and altered diorite-type ores occur within the diorites (Fig. 1).

The Anqing Cu-Fe deposit is formed after two epochs with five stages of mineralization process (Tab. 1).

3 Ore-Forming Fluid Feature

Fig. 2 shows the result of fluid inclusion studies on the Anqing Cu-Fe deposit. The fluid inclusions of early skarn period are characterized by high homogeneous temperatures (above 400°C) and salinities (above 40 wt.%,

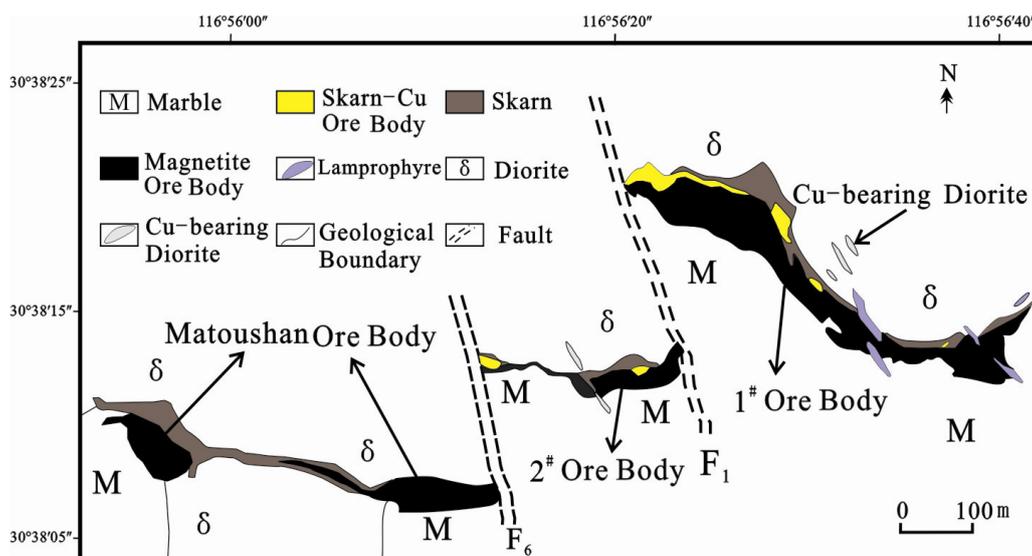


Fig. 1. Distribution of ore bodies in the -400m level in the Anqing Cu-Fe deposit

* Corresponding author. E-mail: 13049706@qq.com

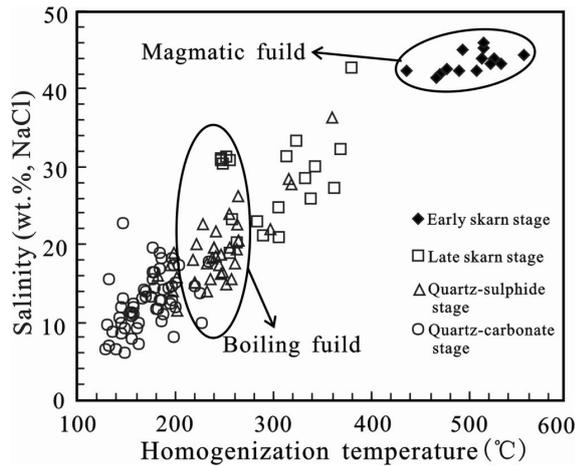


Fig.2. Homogenization temperature vs. salinity plot of fluid inclusions from the Anqing Cu-Fe deposit

increases in the later hydrothermal stages, boiling and mixing of different fluids are widely developed at quartz-sulfide stage, and ultimately lead to the precipitation of metal sulfides.

4 C-O Isotope Compositions

Fig. 3 shows the results of the C-O isotope compositions of calcites and marbles in the Anqing Cu-Fe deposit. The $\delta^{13}C_{PDB}$ values increase gradually from ore body (average -3.30‰) to near-ore altered marbles (average -0.40‰), then to far-ore unaltered carbonate rocks (average 1.50‰). In Fig. 3, the carbon of calcites of ore-bodies and skarns show mixed genetic features of magma and sedimentary rocks by pyrometasomatism and alteration.

Table 1 Physicochemical parameters of the ore-forming fluid from Anqing Fe-Cu deposit

Mineralization stage	Temperature (°C)	Salinity (wt.% NaCl)	Pressure ($\times 10^7$ Pa)	Density (g/cm ³)	Oxygen fugacity (lg fO_2)	pH value
Early skarn stage	465 ~ 570	40 ~ 46	8 ~ 8.5	0.64 ~ 1.10	-18 ~ -25	
Magnetite stage	415 ~ 562	40 ~ 45	8 ~ 8.5	0.76 ~ 0.98	-16 ~ -28	
Late skarn stage	258 ~ 435	21 ~ 42	8	0.88 ~ 0.99	-26 ~ -31	
Quartz-sulphide stage	183 ~ 366	8 ~ 36	6 ~ 8	0.85 ~ 1.04	-23 ~ -35	5.1 ~ 6.7
Quartz-carbonate stage	124 ~ 234	6 ~ 22	6	0.92 ~ 0.96		

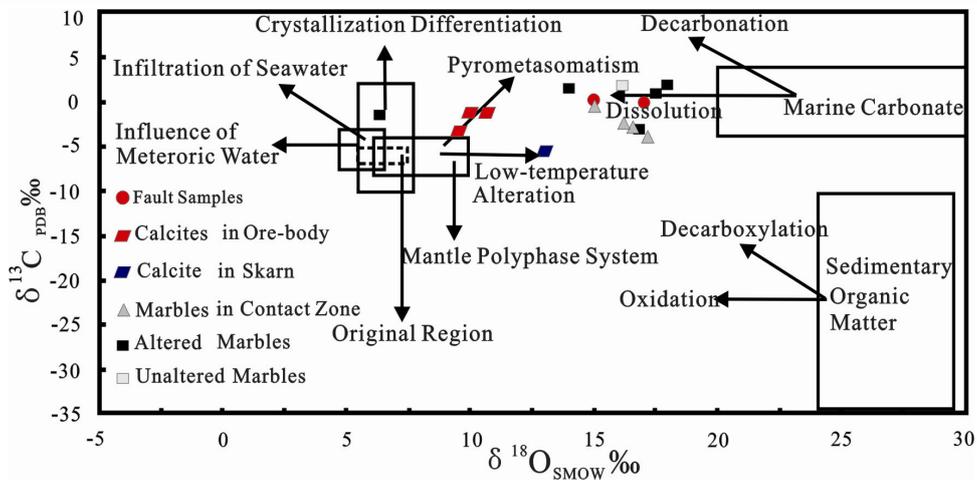


Fig.3. Diagram of $\delta^{18}O_{SMOW}$ vs. $\delta^{13}C_{PDB}$ from the Anqing Cu-Fe deposit

NaCl), all of them fall into the top-right isolated area in Fig. 2, have distinct difference from other stages, which indicates the ore-forming fluid of early skarn stage is probably magmatic fluid, the andradite-rich skarns and magnetite ore bodies are mainly formed at this stage. Homogeneous temperatures and salinities of the fluid inclusions decrease continually from late skarn stage to quartz-carbonate stage (Tab. 1), and many different kinds of fluid inclusions coexist in one quartz crystal at the quartz-sulfide stage, with similar homogeneous temperatures. This indicates that the proportion of meteoric water

The average values of $\delta^{18}O_{SMOW}$ from diorites to wall rocks are 8.25‰ (for diorite) \rightarrow 10.85‰ (for altered diorite) \rightarrow 9.80‰ (for diopside skarn) \rightarrow 7.00‰ (for andradite skarn) \rightarrow 4.20‰ (for magnetite) \rightarrow 14.80‰ (for marbles near the ore body) \rightarrow 17.24‰ (for Triassic carbonate rocks) (Zhou et al., 2007), respectively. The $\delta^{18}O_{SMOW}$ values of magnetite and early skarns are lower than that of diorites and wall rocks.

The isotopic features indicate that the carbon and oxygen isotopic exchanges were commonly occurred among ore-forming fluids, diorites, and wall rocks in the

mineralization process. The ore-forming metals are probably derived from magmatic fluid with low $\delta^{18}\text{O}$, which is separated from the dioritic magma by immiscibility in shallow magma chamber (Zhang, et al., 2012).

5 Magmatic-Fluid-Metallogenic System

Comprehensive studies of ore body geology and geochemistry support the ore-forming fluid system as follows. The immiscibility in shallow magma chamber led to the formation of primary magmatic ore-forming fluid (ore pulp); the pulp migrated upwards along the deep faults, and exchanged components with the wall rocks by assimilation, which resulted in the formation of early skarn and magnetite ore bodies at the exocontact zone. With the mixing of meteoric water, boiling and mixing of the rest fluids led to the deposition of metal sulfides, made up the skarn-type Cu-Fe deposit.

Acknowledgements

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