The Characteristics of Lead Isotope Compositions and Fluid Inclusions of Yutang Pb-Zn Deposit, Western Hunan Province, China and Their Geological Significance

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1 Geology of Ore Field and Ore Deposit and Sampling

The Yutang Pb–Zn deposit mainly dominated by lower Cambrian Qingxudong Formation limestone and located in southeastern margin of Yangtze block in regional structure, is part of the Huayuan Pb–Zn ore field situated in the western Hunan Province, China (WHPC). Orebodies are controlled by NE–trending Zhangjiajie–Huayuan and NNE–trending Malichang deep–faults and constrained by NE–trending Guzhang anticlinorium and Sangzhi synclinorium (Fig. 1). Many studies on Yutang Pb-Zn deposit have been done in terms of geology, isotope geochemistry, fluid inclusions and genesis for many years (Shu, 1985; Peng, 1986; Liu et al., 2000; Fu et al., 2006), however, the sources of Pb in ore minerals and ore-forming fluids is still controversial, thus Pb-Zn ore samples (comprising paragenetic sphalerite galena and calcite) characterized by disseminated and veinlet-disseminated structure were separated from major metallogenic stage hosted by algal-bearing limestone which is the main ore-bearing strata.

2 Samples Preparation and Analytic Results

The representative samples were selected from the major metallogenic stage of the Yutang Pb-Zn deposit and were crushed to 40-80 mesh in size. Sphalerite, galena and calcite were handpicked individually from ore samples under a binocular microscope, with purity level of single grain more than 99%. Sphalerite and paragenetic calcite were analyzed for fluid inclusions and galena was used to measure lead isotope compositions.

The $^{208}Pb/^{204}Pb$, $^{207}Pb/^{204}Pb$ and $^{206}Pb/^{204}Pb$ ratios of galena investigated here together with the published results range from 38.111 to 38.576, 15.659 to 15.770, and 18.028 to 18.235, respectively, showing a relatively restrained variation.

The fluid inclusions (L+V) of sphalerite and calcite are aqueous, two-phase inclusions, with a

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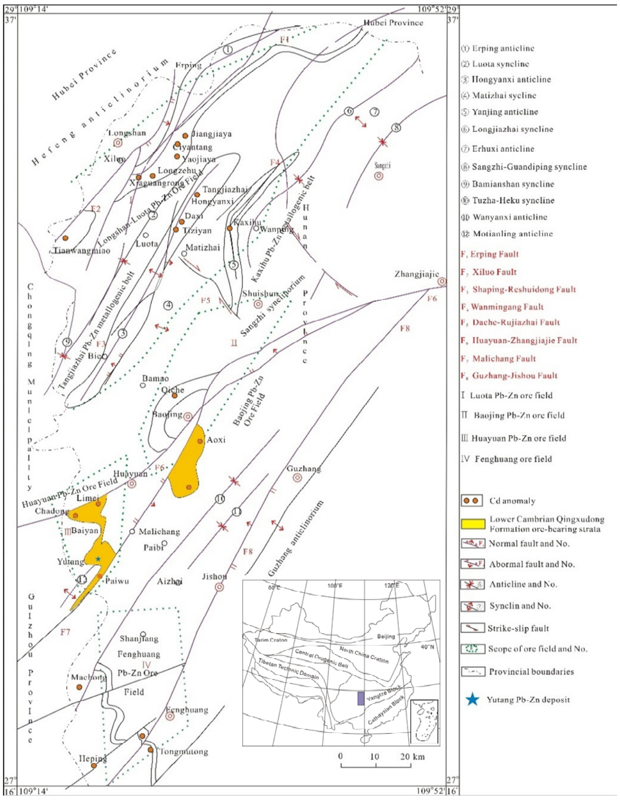

Fig. 1 Tectonic sketch map of the Pb-Zn ore fields in western Hunan Province, China (WHPC) (after Yang et al., 2007b).

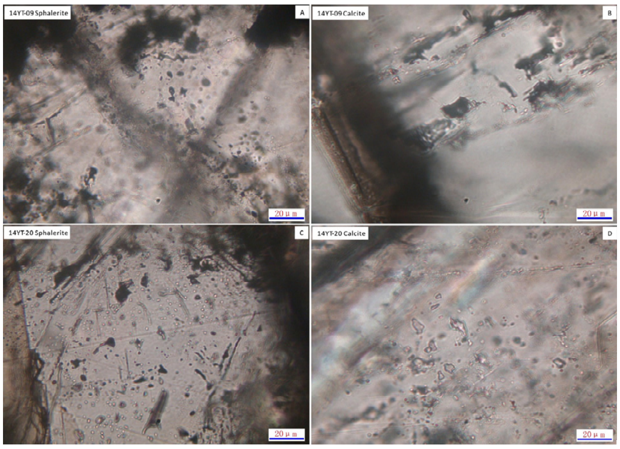

Fig. 2 Photomicrographs showing the fluid inclusions in sphalerite and calcite from the major metallogenic stage in the Yutang deposit

A and B: The fluid inclusions from disseminated ore sample with paragenetic sphalerite and calcite. C and D: The fluid inclusions from veinlet-disseminated ore sample with paragenetic sphalerite and calcite

vapor/liquid ratio of 5%~10 % and are relatively regular in shape in terms of petrography (Fig. 2). They have a high and narrow salinity range (16.53%~22.38%NaCl) and a wide range of homogenization temperature (80~125℃) with regard to microthermometry.

3 Discussion

3.1 Source of ore-forming metals constrained by Pb isotopes

Since there are very low contents of U and Th in sulfide minerals, their radiogenic lead growth can be ignorable (Zhang, 1988; Carr et al., 1995). However, the sedimentary rocks overlain by the Pb–Zn deposit need to be age–corrected because of the relatively high U and Th. The timing of the Pb–Zn deposit is about ~410 Ma (Duan et al., 2014), thus the age is used to correct the lead isotope compositions of Proterozoic basement rocks and lower Cambrian sedimentary strata. The initial lead isotopic ratios of sulfide minerals plotted in the $^{207}Pb/^{204}Pb$ versus $^{206}Pb/^{204}Pb$ diagram (Fig. 3) are distributed over the upper crust growth curve, suggesting Pb for the deposit may be sourced from upper crust. In addition, the ratios have the genetic relationship with Proterozoic basement rocks (Banxi Group) and lower Cambrian Qingxudong Formation carbonate rocks, and far from those of age–corrected lower Cambrian sedimentary

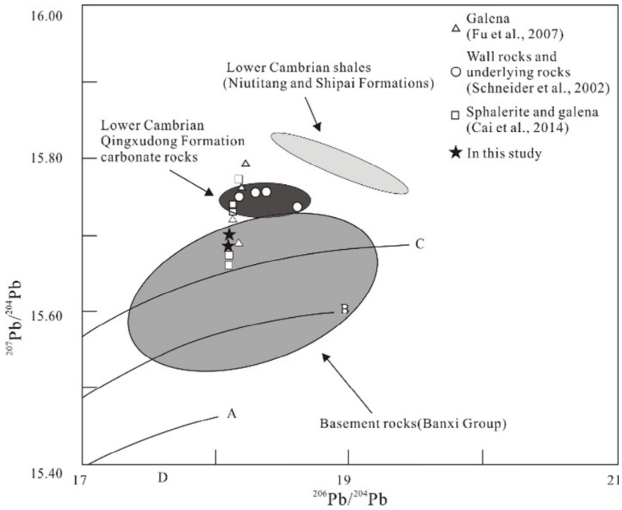

Fig. 3 Diragram of $^{207}Pb/^{204}Pb$ vs. ^{206}Pb–^{204}Pb for the Yutang Pb–Zn deposit

Trends for the upper crust (C), orogenic belt (B) and mantle (A) are taken from Zarman et al. (1981). Pb isotopic field of basement rocks (Banxi Group) and lower Cambrian rocks are taken from Liu Haichen et al. (1999) and Schneider et al. (2002). Pb isotope compositions of sulfide minerals are taken from Fu et al. (2006), Cai et al. (2014) and this study. Deeper grey field: Lower Cambrian Qingxudong Formation carbonate rock; Medium grey field: Basement rocks (Banxi Group); Lighter grey field: Lower Cambrian shales (Niutitang and Shipai Formations)

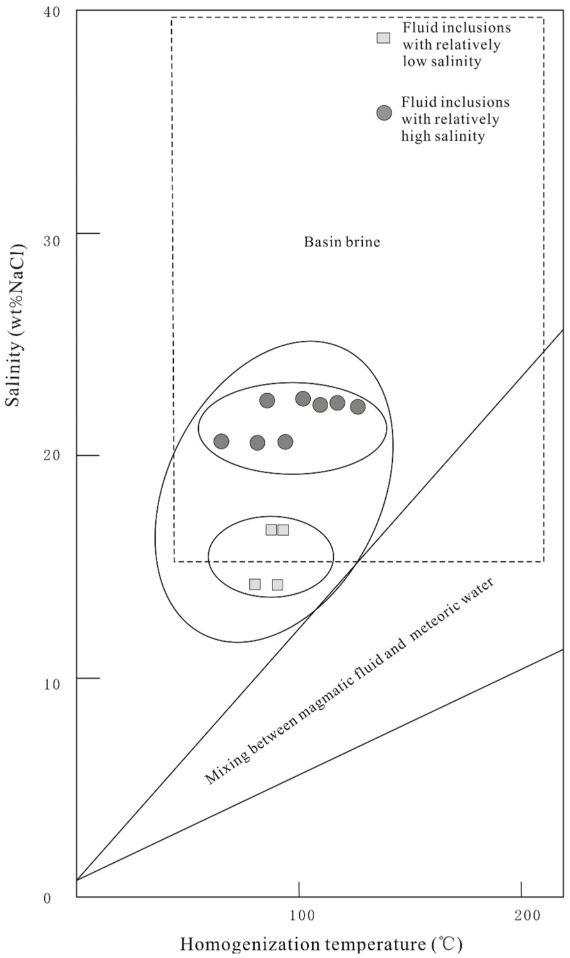

Fig. 4 Homogeneous temperatures (℃) versus salinities (wt% NaCl) of the fluid inclusions from disseminated and veinlet-disseminated ore samples of Yutang Pb–Zn deposit (modified after Beane, 1983)

strata in particular Niutitang and Shipai Formations shales overlain by the Pb–Zn orebodies, which indicates that the ore–forming metals derived from Proterozoic basement rocks and Qingxudong Formations carbonate rocks rather than Pb–enriched Niutitang and Shipai Formations shales.

3.2 Nature of the ore–forming fluid

Fluid inclusions contain important information about the evolution of ore-forming fluid. From the homogenization temperature–salinity diagram (Fig. 4), the data points mainly fall in the field of basin brine, which suggests that basin brine has close relationship with the ore–forming fluid. Moreover, the four points with relatively low salinity are closer to the mixed area (Fig. 4), indicating that meteoric water may be involved in mineralization because of no magmatic fluid in the ore field (Yang et al., 2007a). Therefore, the Pb–Zn ore mineralization is most likely derived from medium–low temperature and high salinity basin brine. However, the mineralization may be also influenced by later meteoric water.

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