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## Metallogenic Processes: Evidences from Zoning Patterns of Mineralization and alteration and fluid inclusion geochemistry in the Lehong Zn-Pb Deposit in Northeastern Yunnan, China

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### 1 Introduction

The large clusters of Zn-Pb deposits in northeastern Yunnan, located in the southwestern margin of the Yangtze Block, are an important part of the Sichuan—Yunnan—Guizhou Pb-Zn Poly-metallic Metallogenic Triangle Area (SYGT). The area is surrounded by NE-trending Mile-Shizong fault zone, SN-trending Xiaojiang fault zone and NW-trending Ziyun—Yadu fault zone (Han et al, 2007, 2012). Approximately 440 Zn—Pb deposits and mineralization spots had been reported in the SYGT Area (Liu and Lin, 1999). The Lehong large-sized Pb-Zn deposit is one of the typical deposits in Northeastern Yunnan Lead-zinc Deposit Concentrated District. On the basis of summarizing the mineralization and alteration and fluid inclusion geochemistry, the ore-forming processes of the deposit have been discussed.

### 2 Zoning Patterns of Mineralization and alteration

The Lehong large-sized Pb-Zn deposit is located at the platform fold zone in eastern Yunnan. Main mineralization is sphalerite and galena. The alteration types are: hydrothermal dolomitization, calcilization, silicification and pyritization. According to the intercalated relationships between mineral veins, different alteration characteristics and mineral assemblage, ore structure and other features, the metallogenic stages of the deposit are divided into four stages: barite stage, dolomite—pyrite—quartz stage, sphalerite—galena—pyrite stage

and calcite—barite stage. Due to the multi-period tectonic activities and hydrothermal fluid activity, the alteration and mineralization were formed by the continuous evolution of ore-bearing fluid.

The boundary between mineralization and alteration zone shows gradual transition or superposition. Ore-bodies and alteration in the adits of level 1290m are characterized by the horizontal zoning. From surrounding rocks to the center of the ore-body which hosted near the main fault zone, the altered mineral assemblage and the alteration intensity are gradually increasing. Based on the mineralization and alteration facies mapping, the zoning patterns of alteration and mineralization have been established: marginal mineralization zone, transitional mineralization zone and central mineralization zone. And the corresponding mineral associations are Dol+Cal+Py, Dol+Cal+Py+Qt+Sp and Dol+Cal+Py+Qt+Sp+Gn, respectively. These patterns are important to predict deposits or ore-bodies among similar deposits in the Sichuan—Yunnan—Guizhou Pb-Zn Poly-metallic Metallogenic Area and its peripheral area.

### 3 Fluid inclusion geochemistry

According to the fluid-inclusion petrography, laser Raman microspectroscopic and micro-thermometry of fluid inclusions, which are discovered in sphalerite, quartz, barite and calcite from the different mineralization stages, the origin, property and evolution of ore-forming fluid and the metallogenic processes have been expounded. There are four types of fluid inclusions, including pure gaseous-type (I), gas-aqueous-type (II) which are composed of aqueous-rich gas—aqueous-

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type inclusions (II a), gas-rich gas – aqueous-type inclusions (II b) and pure liquid-type inclusions (II c),  $V_{CO_2+L_{CO_2}+L_{H_2O}}$  three-phase inclusions (III), and three-phase inclusions containing a daughter (IV), respectively. Research results show as follow:

1) The homogenization temperature in the barite stage is between 240.3°C and 319.3°C, the salinity is between 2.24wt% NaCleqv. and 10.73wt% NaCleqv., and it is shown that the fluid occurs in medium-high temperature and low-middle salinity.

2) The dolomite – pyrite – quartz stage occurs in middle-high temperature (219.8~310.1°C) and medium-low salinity (7.02%~17.61% NaCleqv.).

3) Ore-forming fluid in the sphalerite – galena – pyrite stage shows that the sphalerite of first generation (S1) formed in medium temperature (217.8~292.2°C) and medium salinity (8.81%~16.71% NaCleqv.). The sphalerite of second generation (S2) formed in medium-low temperature (180.2~241.3°C) and medium salinity (7.73%~18.47% NaCleqv.). The sphalerite of third generation (S3) formed in medium-low temperature (140.4~227.4°C) and medium-low salinity (0.35%~19.21% NaCleqv.). By three-phase inclusions with  $CO_2$  in S3, it is estimated that the pressure and depth of mineralization are 45~74.9 MPa (average 58.2 MPa) and 1.7~2.8 Km, respectively.

4) In the calcite stage, the homogenization temperature is 165.3°C, and the salinity is 11.28% NaCleqv.. In this stage the ore-forming fluid has low temperature and medium salinity.

The homogenization temperatures of different stages can roughly indicate the evolutionary process of the ore-forming fluid from early stage to late stage. The temperature appears in evolutionary trend of medium-high temperature and medium-low salinity → medium temperature and medium salinity → medium-low temperature and medium and low salinity.

#### 4. Discussion of metallogenic processes

Combining with isotope geochemistry, the origin and evolution of ore-forming fluid can be revealed. With the tectonic dynamic and thermodynamic processes, the deep-sourced fluid of high temperature and low salinity of the early stage migrated on a large scale.

The fluid in the early stage decompressed and boiled by structural stress, and mixed with meteoric water at the same time. Hydrothermal fluid migrated upward along the Lehong fault from the depth, and injected into the faults in the surrounding rocks. When the physical-chemical conditions of ore-forming fluid changed, the ore-forming materials in the fluid precipitated in second faults or cracks near the Lehong fault, and formed the Lehong lead-zinc deposit. Meanwhile, strong dolomitization, pyritization and silicification, etc. alterations occur near the edges of fault zones. This discussion about metallogenic process is not provides important evidences to further the metallogenic model of "tectonic-fluid 'injection'", but also has important significances in predicting the location of the ore-bodies.

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