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Geological, Isotopic and Geochronological Constraints on Hetaoping Distal Skarn-Type Zn-Pb-Ag-Cu Deposits in Baoshan Palaeozoic Massif, SW China

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Hetaoping Zn- Pb- Ag- Cu deposits has been discovered as a large polymetallic ore field in recent years (Xue et al., 2008). It is located at the northwestern margin of Baoshan Palaeozoic massif adjacent to Lancang River fault zone in western Yunnan, SW China. It lies in a structural compounding position, which is produced by the north plunging part of Baoshan- Shidian anticlinorium along the NNW- trending Chongshan fracture zone. Being the concealed magmatic granites not be revealed up to now, the ores genesis has remained enigmatic. In this paper, field observations, geological and geochemical study results indicated that the ore deposit formed by Cenozoic Indo-Asian continental collision processes, and produced a distal skarn- hosted magmatic hydrothermal metallogenic system.

1 Deposite Geology

The ore field composes of bioclastics (limestone and dolostone) interlayered with sandstone and shale in Upper Cambrain Hetaoping Formation to Jinchanghe Formation. The main structures consist of Baichonghe anticline that is the secondary anticline of SN- trending Baoshan- Shidian anticlinorium, and SN-, NNW-, NE- and EW- trending fractures. The majority diabase and diabase gabbro dikes (weak metamorphic) are small sizes with zircon SHRIMP U- Pb dating age of 195.0 ±5.3 Ma, and intruded earlier than the ore bodies forming exposed in this area (Xue et al., 2011). A few small size granites and quartz porphyry outcrops are developed in the eastern side of Hetaoping area along the Lancang River fault zone.

The ore field can be divided into Shangchang ore block, Xiachang ore block and Dachangao ore block. More than 16 ore- bodies scattered throughout the district vary in shapes such as stratiform, vein, lenticular and chamber. They are hosted in skarns and marbleization limestone, which is located in SN- and NNW- trending fracture zones in the core and eastern wing of the Hetaoping anticline. Usually, the ore bodies controlled by F1 and F2 fault are the largest ores with great metal reserves.

2 Alternation and Mineralization

The alteration developed very well along certain part of the ore- controlling faulted zone. It include skarnization, silicification, calcitization, dolomitization, pyritization, chloritization, and etc. The skarnization and silicification are relatively stronger in proximal ores, and hornfels couble are observed in local district.

The horizontal alternation zoning is skarnization-sphalerite-galena zone, skarnization-pyritization zone, carbonate- quartz- skarnization zone, carbonate-chloritization zone, and marble limestone zone from the centre of skarn outward. The vertical alternation zoning can be divided into tremolite skarn, actinolite- tremolite - epidote skarn, actinolite- epidote- tremolite skarn, epidote skarn and epidote- chlorite skarn from top of the ore bodies to bottom. Garnet skarn and diopside skarn can be observed in local area. Marble and skarnization is the positive relationship.

Ore occur in sparse to dense disseminated and massive structure, and a small amount of vein, stockwork and banded structure. The mineralization have no selective to strata, but the marble limestone, argillaceous limestone are more favorable to mineralization. The ore- bodies are dominated by Zn or Cu in local area in fractured zones. They are polymetallic symbiotic and associated with Pb, Ag, Au, and Cd. Mineralization types can be divided into skarn- magnetite Fe- Cu ores, skarn- magnetite Cu ores, skarn type vein Cu- Pb- Zn- Ag ores, hydrothermal vein Pb - Zn- Ag ores, marble disseminated Pb- Zn ores, calcareous mudstone disseminated Pb- Zn ores, and hydrothermal vein Au- Ag ores. Mineralization zoning is Fe- Cu zone, Cu- Zn

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(-Fe) zone, Pb- Zn (-Cu -Au -Ag) zone, and Au- Ag zone from the centre of ore bodies outward.

The ore- forming processes of hydrothermal fluid can be divided into six stages, which are anhydrous skarn stage (I), wet skarn stage with quartz and magnetite (II), hydrothermal skarn- quartz- pyrite- pyrrhotite- chalcopyrite - sphalerite- galena stage (III), quartz- carbonate- barite- sphalerite- galena stage (IV), quartz - carbonate- galena stage (V), and carbonate stage (VI). The III and IV stage are the main polymetallic mineralization period.

3 Fluid Inclusions

Skarn minerals, calcite, quartz and sphalerite contain abundant fluid inclusions. The fluid inclusions with the negative form, oval or irregular shape can be divided into four types, that is pure liquid- type, gas-liquid two-phase-type, pure gas phase- type, CO2 phase- type and intron-type inclusions. The former three types are dominated. The temperature of the fluid can be divided into high temperature (250- 350℃) and low temperature (100- 230℃). The cationic composition of the liquid phase mainly include Ca2+, Na+ and a small amount of Mg2+, and the anionic composition is Cl- and F-. Cu, Pb, and Zn are transport by chloride complexes in fluid. The gas phase composition is mainly H2O, CO2 and a little of CH4, C2H6 and N2, which is a fluid system rich in CO2– NaCl– CaCl2 – H2O. Fluid inclusions in late stage quartz with vein shape and early stage quartz with patch shape basically have the same gas phase composition, but the former contain higher C2H2+ C2H4, C2H6, CO and CO2 content than that of the latter. The fluid salinity is 3.87- 19.68wt% NaCleq., which can be divided into low salinity fluids (3.87- 10.11wt% NaC1eq.) and moderate salinity fluid (12.28- 19.68 wt% NaC1eq.). Calculation shows that sphalerite formed at shallow- seated environment (0.2- 2 km depth), 190- 220℃ and 7- 16 MPa.

4 C-H-O-Sr-Si-S-Pb Isotopes

The oxygen isotopic compositions of quartz in ores range from 6.1‰ to 7.6‰ with average value of 6.7‰, and the hydrogen isotopic compositions of quartz range from -100‰ to -108‰ with average value of -104‰. The carbon and oxygen isotopic compositions of calcite range from 6.6‰ to 5.9‰ and from 5.0‰ to 5.2‰ respectively. The 87Sr/86Sr ratio of quartz is 0.71393- 0.72100 and the average value of 0.71726, and that of sphalerite is 0.71396- 0.71940 and the average value of 0.71630, is much higher than the 87Sr/86Sr ratio of the Upper Cambrian strata, but little lower than that of the silicon- aluminum rocks. Sulfur, silicon and lead isotopes are also similar to those in magmatic hydrothermal solutions or mantle fluids, and likely mixed with crust- derived matter during the ore-forming processes.

5 Geochronology

Zircon SHRIMP U-Pb dating shows that the skarn with Pb- Zn mineralization is 63.4 ±1.7 Ma. 40Ar /39Ar plateau age of plagioclase in altered diabase located around the No. V1 orebody is 64.5± 0.7 Ma. Zhonghe Fe- Cu- Pb- Zn orebody hosted by fault zone in Middle Jurassic clastic sediments lied in 12km eastern side of Hetaoping deposit area, and zircon SHRIMP U- Pb age of adjacent granites is 35.3±0.7 Ma. Zircon LA- ICP- MS U-Pb age of concealed granite in Jinchanghe Pb-Zn deposit located in 10 km southeastern side of Hetaoping deposit area is 39 Ma (Chen et al., 2009), and LA- ICP- MS U- Pb age of the ziron came from concealed granite in Qingshuihe Pb- Zn deposit lied about 20km northward of this study area is 36 Ma (Huang et al., 2011).

6 Genesis and Exploration Implications

The characteristics of fluid inclusions in quartz, calcite and epidote indicated the mixing of low salinity fluids and moderate salinity fluids. The homogenization temperature, salinity and density show a trend of gradual decline from early skarn diagenetic stage to late carbonate stage. Calculation results show that sphalerite form at environment of 0.2- 2km depth, 190- 220℃ and 7- 16 MPa. The isotopic compositions show that ore- forming fluids mainly originated from magmatic hydrothermal fluid system through fault zone, metasomatic reaction happened locally between hydrothermal fluids with hosted rocks, the metallogenic elements were carried by the skarn fluids from magma. All event occurred in a closed system and undergone a homogeneous evolution processes, and were most likely driven and controlled constantly by some deep factors. Geochronology evidences indicate that the Hetaoping polymetallic deposits should be formed during the Palaeocene- Eocene epoch with the isotopic age from 65 Ma to 35 Ma, and the ore- forming had experienced a complicated processes successively.

All evidences support that the Hetaoping distal skarn-type base metal deposit is dominantly produced by the ore-bearing fluids from deep concealed magmatic metataxised processes , and has the same dynamic setting as Gangdes metallogenetic belt under the Himalaya Indo- Asian continental collision condition during Palaeocene- Eocene epoch (65- 35 Ma) (Hou et al., 2007). It is the important part of distal skarn- hydrothermal vein type Pb- Zn- Cu- Ag polymetallic metallogenic system controlled by tectonic and deep source magma fluid. At present, the deposits exposed in this district are still belong to the distal hydrothermal vein type deposits. It is believed that tectonic fracture zone on the top of deep concealed rock mass and the contract zone between rock mass and carbonate are the important sites for prospecting the contact skarn type ore deposits (orebodies). As well as there is not unlikely the potential for porphyry- type deposits (bodies) in the deep area. Meanwhile, there may be more superlarge Pb- Zn- Cu - Ag polymetallic deposits in the Baoshan massif, as well in other parts of the "Three River" region in southeastern margin of Tibetan Plateau.

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References

Chen YQ, Huang JN, Zhai XM, et al., 2009. Zircon U - Pb age and geochemistry of granitoids within Jinla Pb - Zn - Ag polymetallic ore field across China and Myanmar. Earth Science Frontiers 16: 344 - 362(in Chinese).

Hou ZQ, Zaw K, Pan GT, et al., 2007. Sanjiang Tethyan metallogenesis in SW China: Tectonic setting, metallogenic epochs and deposit types. Ore Geol. Rev. 31: 48- 87.

Huang JN, Chen YQ, Zhai XM, et al., 2011. Zircon SHRIMP U-Pb geochronology, geochemistry, and petrogenesis of the upper Eocene Shuangmaidi peraluminous granite in Baoshan Block, western Yunnan Terrain, southwestern China. Science China(Earth Science) 41: 452- 467(in Chinese).

Xue CD, Han RS, Yang HL, et al., 2008. Isotope geochemical evidence for ore-forming fluid resources in Hetaoping Pb- Zn deposit, Baoshan, northwestern Yunnan. Mineral Deposits 27: 243- 252 (in Chinese).

Xue CD, Han YW, Huang QH, et al., 2011. Metallogenesis and geochronology of Hetaoping Pb- Zn deposit in Baoshan county, western Yunnan province: A distal skarn- hosted hydrothermal deposit. Acta Mineralogica Sinica 31: 415- 418 (in Chinese).