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Fluid Inclusion Study on the Talate Pb-Zn Deposit, Southern Altay, China

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1 Introduction

The Talate Pb-Zn deposit, located 20 km southeast to Altai (Fig. 1), Xinjiang, occurs in the Devonian Kelan vocanic-sedmentary basin, which strikes NW-SE along the south margin of Altay Mountains. The Talate Pb-Zn deposit was subjected to the regional metamorphism and metamorphic overprint, and the genesis of mineral deposit is in dispute as yet, such as skarn type (Li et al., 2012), VMS type (Yuan et al., 2011) and exhalation sedimentation-reformation type (Tiras., 2009). Here we present the result of fluid inclusions in the the Talate Pb-Zn deposit and new insights of the ore genesis.

2 Ore Geology

The Talate Pb-Zn deposit is hosted in the upper second lithological section of lower Devonian lower Kangbutiebao formation ($D_1k_1^2$) mainly composed of meta dacite, dacitic crystal tuff, biotite granulite, marble, biotite schist. And its disposition and occurrence are controlled by the regional NW fault—the Keyingong and the Abagong (Fig. 1).

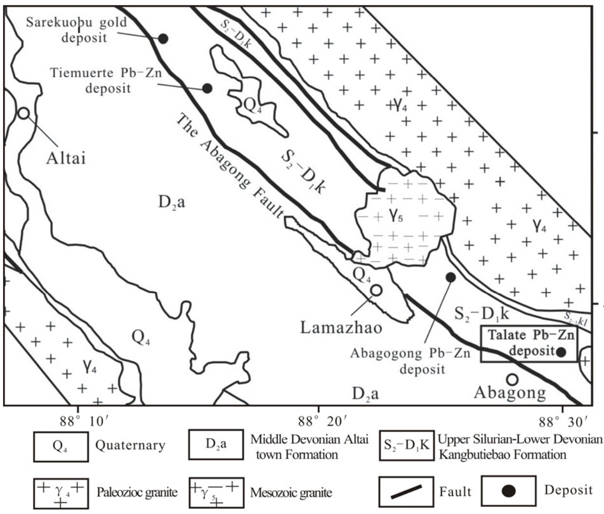

Fig. 1 Geological map showing the regional geology and distribution of deposits in the Kelan basin, Altay

The Pb-Zn ore bodies occur as stratabound deposit, with the overprints of late sulfide-quartz veins. The main ore minerals are sphalerite, gelenite, pyrite, magnetite and chalcopyrite, with gangue minerals including quartz, tremolite, chlorite, calcite and biotite. The wall rock alterations are mainly pyritization, silicification and skarn alteration. Ore textures mainly are euhedral-subhedral, replacement remnant and cataclastic, with ore structures mainly including block, banded, veinlet and disseminated.

There were two obvious mineralization periods based on ore occurrences that are submarine volcanic sedimentary exhalation and metamorphic hydrothermal superimposition. Considering mineral assemblages and crosscutting relations of veins (Fig. 2), metamorphic overprints could be divided into two stages (Q1 and Q2). In the early stage (Q1) bedding lentoid quartz veins distributed in the chlorite schist and the leptite of the ore-bearing horizon. The appearance of disseminated pyritization and the phenomenon that layered sphalerite were replaced by pyrite and chalcopyrite is obvious under the microscope. In the late stage (Q2), pyrite-chalcopyrite quartz veins cut chlorite schist and leptite or the massive Pb-Zn ores and sulfides are sparse and disseminated.

3 Fluid Inclusions

The four types of fluid inclusions in the quartz veins

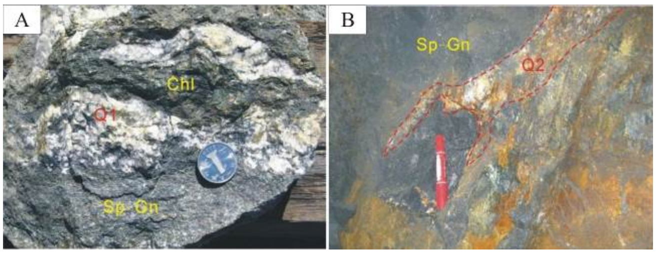

Fig. 2 Field outcrops of the Talate Pb-Zn deposit
A-Bedding quartz vein(Q1) occurring as lenses between banded Sphalerite-galena(Sp-Gn) and chlorite schist (Chl), 1040m level; B-Pyrite-quartz vein (Q2) cutting sphalerite-galena layer (Sp-Gn), 1040m level, 30m east of the 128 line

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(Q1 and Q2) can be identified: 1) CO_2-rich fluid inclusions (L_{CO2}-L_{H2O} type) (Fig. 3), that are the main type of fluid inclusion in the quartz veins from the Talate Pb-Zn deposit, comprised of a liquid CO_2 and a liquid H_2O phases, with CO_2/H_2O volume ratio from 30% to 90%, even up to 95%, and 4~46 μm of sizes, mostly in crowds or in zonal distribute in Q1 and Q2 with different shapes such as ellipticity, elongation, or irregular shape. Only a spot of homogenization temperature are acquired since the fluid inclusions burst as the pressure increased in the process of microthermometry; 2) Carbonic fluid inclusions ($L_{CO2\pm CH4\pm N2}$ type) (Fig.3), usually occurring as single phase at room temperatures, having 6~40 μm of sizes, mostly distributing separately or in crowds; 3) Aqueous fluid inclusions (L_{H2O}-V_{H2O} type), composed of a vapour and a liquid phase with 5% to 30% of *V*/*L* ratios and 4~29 μm of sizes. Most of them are secondary; 4) Daughter mineral bearing fluid inclusions (L-V-S), only existing in the early quartz veins (Q1).

Fluid inclusions in sphalerite (Fig. 3) of the submarine volcanic sedimentary exhalation contain residual aqueous inclusions, secondary aqueous fluid inclusions and a spot of CO_2-rich fluid inclusions trapped in tiny fissures. Secondary aqueous fluid inclusions have $T_{h,tot}$= 267~334 ℃, and secondary CO_2-rich fluid inclusions have $T_{m,CO2}$= -61.2~ -60.2 ℃ and $T_{h,CO2}$= 6.5~11.0 ℃.

Fluid inclusions in early vein quartz of metamorphic period consist of a great number of CO_2-rich fluid inclusions, carbonic fluid inclusions and a few aqueous fluid inclusions. CO_2-rich fluid inclusions have $T_{m,CO2}$= -62.6~ -60.5 ℃ and $T_{h,CO2}$= 7.7~29.5 ℃ (Fig. 4), with X_{CH4}= 0.18~0.26, ρ= 0.55~0.93 g/cm^3 and salinities of 5.5%~7.4% $NaCl_{eqv}$ on the basis of *V*-*X* phase diagram, ρ-X_{CH4}-T_h diagram in the CO_2-CH_4 system as well as the relationship between $T_{m,cla}$ and salinity. The $T_{h,tot}$s' are 294~368℃ (only a few data acquired). Aqueous fluid inclusions have $T_{m,ice}$=-5.1~-3.8℃ and $T_{h,tot}$= 346~386℃, with salinities of 6.2%~8.0% $NaCl_{eqv}$ and ρ= 0.61~0.68 g/cm^3. There is no data about carbonic fluid inclusions can be acquired in this stage. Fluid inclusions in late pyrite-chalcopyrite quartz veins consist of a great number of CO_2-rich fluid inclusions, carbonic fluid inclusions, and secondary aqueous fluid inclusions. CO_2-rich fluid inclusions have $T_{m,CO2}$=-66.0~ -56.6 ℃ and $T_{h,CO2}$= -6.0~29.4 ℃ (Fig. 4), with X_{CH4}= 0.02~0.33, ρ= 0.56~0.91 g/cm^3 and salinities of 2.4%~16.5% $NaCl_{eqv}$. The $T_{h,tot}$s' are 142~360℃(only a few data acquired). Aqueous fluid inclusions have $T_{m,ice}$=-5.1~ -0.5℃ and $T_{h,tot}$= 205~412℃, with salinities of 0.9%~13.9% $NaCl_{eqv}$ and ρ= 0.70~0.93 g/cm^3. Carbonic fluid inclusions have $T_{m,CO2}$= -61.5~ -58.0 ℃ and $T_{h,CO2}$=-27.0~ -14.5℃ and 27.1~28.7 ℃, with X_{CH4}= 0.26~0.56 and ρ= 0.82~0.92 g/cm^3.

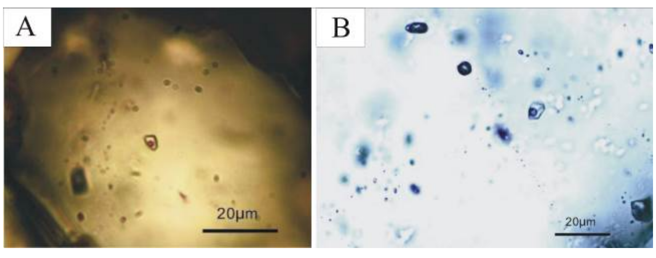

Fig. 3 The characteristics of fluid inclusions from the Talate Pb-Zn deposit

A-Primary aqueous fluid inclusions in sphalerite from banding Pb-Zn ore, TL1102; B-Primary CO_2–rich fluid inclusions and associated carbonic inclusions within quartz grains of the bedding quartz vein(Q1), TL339

Raman spectra analysis of fluid inclusions shows that carbonic fluid inclusions of Q2 mainly contain CO_2, with a spot of N_2. The secondary CO_2-rich inclusion mainly containing CO_2 as well as a spot of CH_4 in the sphalerite. The results of Raman analysis are consistent with those of microthermometry.

4 Trapping *P-T* conditions of fluid inclusions

The trapping pressures of CO_2-rich fluid could be acquired by the $T_{h,CO2}$ from the carbonic fluid inclusions as well as $T_{h,tot}$ from the CO_2-rich fluid inclusions in the same sample (Van den Kerkhof and Thiery, 2001). The results show that the minimum trapping pressures of CO_2-rich metamorphic fluid in the Talate Pb-Zn deposit vary from 100 to 370 MPa. These data are similar to the pressures for the Altai orogeny during ductile and drittle tectonic deformation (250 to 400 MPa, Zang et al., 2007) and the minimum trapping pressures of carbonic fluid inclusions in metamorphic sulfide quartz veins of the Tiemuerte and

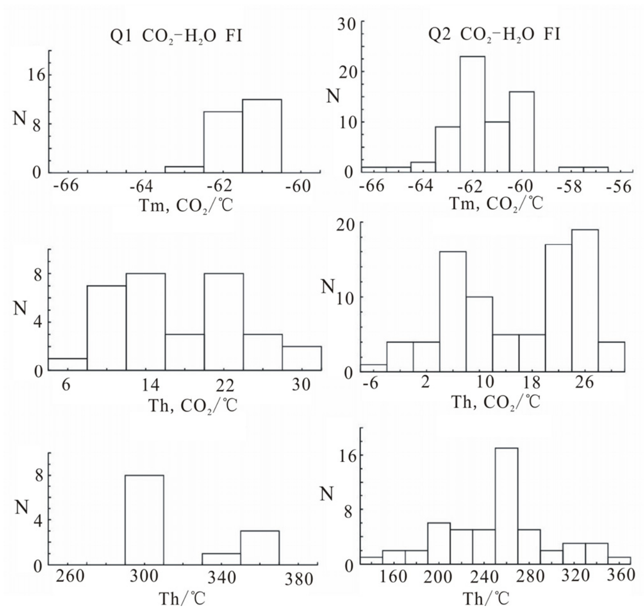

Fig. 4 Microthermometry of CO_2-rich fluid inclusions from the Talate Pb-Zn deposit

Dadonggou Pb-Zn(Cu) deposits (120~340 MPa, Xu et al., 2011).

5 Conclusions

Two obvious mineralization periods can be identified based on ore occurrences that are submarine volcanic sedimentary exhalation and metamorphic hydrothermal superimposition, and metamorphic overprints could be divided into two stages (bedding and crosscutting quartz veins). Deformed and metasomatic textures of ore in the Talate deposit and the characteristics of CO_2-rich fluids may explain that metamorphic fluids participate in the superimposed reformation and possess characteristic of multi-stage. The *P-T* trapping conditions of CO_2-rich fluids (100~370 MPa) coincide with those of late or post regional metamorphism.

Acknowledgements

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