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Ore Deposit Types and Mineralization Sequence of Tianbaoshan Metallogenic Region In Yanbian Area , Northeastern (NE) China

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The Tianbaoshan polymetallic metallogenic region in Yanbian area is characterized by long history of mining, complex mineral deposit types, abundant non-ferrous and precious metal mineral resources. In recent years, it has been paid close attention for genesis types, ore-forming mechanism, metallogenic epochs of different deposits and some key scientific questions which are closely related to geological prospecting.

1 Geological Setting of the Metallogenic Region

According to the newest division of geotectonic units of NE China, Yanbian area located among with Khanka Block，Jiamusi Block and North China Block. It has experienced the evolution and transformation of the Paleozoic Paleo-Asian Ocean tectonic domain and the Mesozoic circum-Pacific tectonic domain successively, frequent and strong tectonic magmatic activity provided favourable geological conditions for the formation of endogenetic metallic deposits in this area. The Tianbaoshan metallogenic region lies in eastern Yanbian. The mainly strata occur in this region include carboniferous Shanxiuling Formation, Permian Miaoling Formation, Kedao Formation, Qinglongcun Formation, Jurassic Mingyuegou Formation and Neogene Chuandishan Formation. There mainly occurs NNE, NE and nearly NW-trending faults and some secondary structures. Hercynian granodiorite, diorite and biotite quartz diorite，Indosinian granodiorite, monzonitic granite, rhyolite, dacite and volcaniclastic rock，Yanshanian granodiorite, granite porphyry are closely associated with metallic mineralization.

2 Genetic Types and Ages of Ore Deposits

2.1 Lishan Pb-Zn deposit

The orebodies in LIshan occurs in the contact zone of Permain Miaoling Formation marble and granodiorite and granite porphyry. The ore minerals such as galena and sphalerite in the deposit has automorphic–subhedral granular, metasomatic relict and separation of the solid solution textures and the ore is commonly featured by disseminated, massive and veins structures. The wall rock alterations include garnetization, diopsidization, scapolitization, tremolitization, chloritization and epidotization, which indicates that the Lishan deposit belongs to skarn one.

The weighted mean age of the zircons in metallogenic granodiorite is 261.0±7.0Ma by the zircon LA-ICP-MS U-Pb dating (Ju.et al. 2013). It can be concluded that the diagenesis and mineralization of the Lishan skarn deposit took place in the mid-Permian. It's indicted that the granodiorite formed in the Permian intruded into marble of the Permian Miaoling Formation, and the contact metasomatism occurred at the contact zone and formed the skarn polymetallic deposit.

2.2 Dongfengnanshan copper polymetallic deposit

One group of the orebody occurs in the zone of andesitic tuff - hornfels segment in Miaoling Formation, which shaped as Lenticular and stratoid. Other occur in the contact zone of the Carbonate of Shanxiuling Formation and diorite, and charactered by veins and veinlet mineralization. In addition, the deposit is reconstructed by epigenetic hydrothermal fluids. Ore minerals consist of galena, sphalerite and chalcopyrite. The wall-rock alterations develops skarnation, silicification, chloritization, epidotization, sericitization and carbonatization etc. Studies indicate that the Dongfengnanshan deposit belong to sedimentary metamorphic and hydrothermal transformation type, and the contact metasomatic deposits near the contact zone of

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the limestone and the diorite.

Zircons from the ore-bearing diorite rock sample yield excellent concordant results with a weighted mean $^{206}Pb/^{238}U$ age of 255.0±4.3Ma, suggesting the ore-bearing rock formed in the late Hercynian, so orebody produced in the contact zone of carbonate rock with diorite and the sedimentary-metamophic transformation type lead-zinc mineralization were formed in this period, and post-mineralization was superimposed by Indo-Yanshanian magmatic hydrothermal alteration.

2.3 Dongfengbeishan Mo deposit

The orebodies in Dongfengbeishan occurs near the contact zone of the granodiorite, alkali-feldspar granite and quartz diorite. Almost all orebodies are controlled by faults and fractures in biotite quartz diorite, and charactered by veins and veinlets. Ore minerals in the deposit are mainly molybdenite. The ores have euhedral-subhedral granular texture, metasomatic relict texture, as well as disseminated,and veinlet structures. The wall-rock alterations include biotitization, silicification, chloritization, epidotization, sericitization and carbonatization etc. This suggests that the Dongfengbeishan deposit has characteristics of porphyry molybdenum mineralization.

Re-Os isotopic isochron age of molybdenite from quartz veins is 192.0±3.1Ma, which is consistent with that reported by Zhang et al. (2012). It is indicated that the Dongfengbeishan molybdenum deposit was formed in the early Yanshanian period.

2.4 Xinxing Pb-Zn-Ag(Cu) deposit

The crypto-explosive breccia in Toudaogou occurs in the granodiorite rock and controlled by breccia pipe, the ore bodies almost have the same attitude as breccia pipe. The ore structures include ring-shaped, breciated, packing and veins. The composition of breccia, with different size and mostly subangulr, angular, little half round shape, is mainly granodiorite, hornstone dacite and rhyolite. Galen and sphalerite are the mainly metallic minerals, and there develop such wall-rock alterations as silication ,epidotization, sericitization, carbonatation and propylitization.

The muscovite K-Ar age of 224 Ma in Xinxing crypto-explosive rock mass got by Peng et al. (2009), which shows that it is a production by magmatism in Triassic, while the lead, zinc, silver (copper) mineralization probable were in Indosinian to Yanshanian, and there may exist porphyry mineralization in the deep of the Xinxing breccia pipe.

3 Metallogenic Sequence in Tianbaoshan Metallogenic Region

According to present data, the Hercynian, Indosinian and Yanshanian magmatic metallogenic events successively happened in Tianbaoshan metallogenic region. The rock mass is mostly granodiorite and biotite quartz diorite in late Hercynian period, and the granodiorite intruded to carbonatite strata of Miaoling formation in Permain or near to the contact zone, at where formed the Lishan and Dongfengnanshan large scale contact metasomatic type deposit as well as the ore-bedring rock of Dongfengbeishan molybdenum mineralization and Dongfengnanshan lead and zinc mineralization. The early mineralization of Xinxing is formed by the formation of the Xinxing crypto-explosion breccia body in Indosinian. The addition of intense magmatic activity in Hercynian keep the mineralization enrichment to the peak,and formed the Dongfengbeishan molybdenum deposits. Zhang et al. (2011) reached positive and negative isochron $^{39}Ar/^{40}Ar$ age 179±11 Ma and 179.1±9.8Ma in fluid inclusion contained in Tianbaoshan polymetallic deposit minerals .The age represent the metalogenetic epoch of the Tianbaoshan polymetallic region and show metallogenic peak occured in early Yanshanian. Three major magmatic activity successively superposed consist of various minerals and complex deposits genesis in Tianbaoshan ore concentration area. The difference period of metallogenetic epoch and associated ore-bearing rock have important implications to guide the prospecting in Tianbaoshan metallogenic region.

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