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滇西红牛矽卡岩型铜矿床石榴子石特征

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摘要：

红牛矽卡岩型铜矿床是义敦岛弧南段格咱火山-岩浆弧新探明的铜矿床之一，目前探明铜金属资源量已达大型规模。与由侵入岩和大理岩直接接触形成的典型矽卡岩矿床不同，红牛铜矿床是隐伏岩体远程矽卡岩化的产物，其矽卡岩矿体与地层产状基本一致，通常相间排列，且距离岩体较远，大理岩中可见粗粒石榴子石和硅灰石，矽卡岩中常见大理岩捕掳体。根据矽卡岩矿物组合可将该矿床矽卡岩类型划分为石榴子石矽卡岩、石榴子石透辉石（或透辉石石榴子石）矽卡岩、透辉石矽卡岩、符山石-石榴子石矽卡岩、硅灰石-石榴子石矽卡岩、绿帘石-石榴子石矽卡岩、阳起石-绿帘石矽卡岩、硅灰石矽卡岩和绿帘石矽卡岩，其中以石榴子石矽卡岩、透辉石矽卡岩和硅灰石矽卡岩为主。石榴子石是最重要的矽卡岩矿物，分布广泛、颜色变化大，且石榴子石矽卡岩中黄铜矿、黄铁矿、磁黄铁矿化最好。本文通过对0ZK10、3ZK11和7ZK16钻孔岩芯的地质编录，查明石榴子石在红牛铜矿床的空间分布和矿化特征，采集该矿区新鲜的石榴子石矽卡岩、矽卡岩化大理岩和角岩磨制成光薄片，开展详细的显微镜下鉴定工作，观察石榴子石的颜色、粒度、结构、光性等岩相学特征，并通过电子探针分析其化学成分。红牛铜矿床石榴子石集中产出于矽卡岩中，少量产出于矽卡岩化大理岩和角岩中，具有明显的两期。早期石榴子石分布广泛，多呈褐色-红褐色，非均质性，异常干涉色，粒径一般在0.2~4mm之间，半自形-自形中细粒结构，韵律环带发育。SiO_2含量变化范围为35.18%~37.69%、CaO为33.34%~36.35%、Al_2O_3为3.64%~13.69%、FeO为11.90%~24.18%、MgO为0.00%~0.08%，FeO和Al_2O_3含量变化呈负相关，SiO_2和CaO含量变化整体呈正相关。石榴子石端员组分总体以钙铁榴石（36.88%~82.36%）为主，其次为钙铝榴石（16.59%~60.75%），还有少量的镁铝榴石、铁铝榴石和锰铝榴石，属于钙铁榴石-钙铝榴石系列（$And_{37-82}Gro_{17-61}Spe+Pyr+Alm_{0.33-3.71}$）。晚期石榴子石呈浅褐色-浅红色，多发育于矽卡岩化角岩和大理岩中，少量发育于矽卡岩中，半自形-他形粒状结构，均质性，全消光，常具有溶蚀结构。SiO_2含量变化范围为35.06%~36.27%、CaO为33.07%~33.77%、Al_2O_3为0.04%~1.05%、FeO为27.38%~28.18%、MgO为0.00%~0.04%，属于钙铁榴石（94.42%~98.46%）。早期石榴子石韵律环带发育，其主量元素含量变化显示出一定的规律性，由核部向边缘，SiO_2和CaO基本保持不变，FeO含量增加，Al_2O_3含量减少，钙铁榴石含量增加，钙铝榴石含量减少，反映在石榴子石形成早期，成岩环境为低氧逸度、酸性还原环境；形成过程中氧逸度增加，成矿溶液由酸性向弱碱性演化。黄铜矿、磁黄铁矿、辉钼矿等金属硫化物多呈他形充填于石榴子石颗粒之间，或在石榴子石的裂隙中形成细脉，或沿石榴子石生长环带面交代，表明石榴子石形成于矽卡岩早期、早于铜矿化，并为金属硫化物的沉淀富集提供了空间。

英文摘要：

The Hongniu deposit is a newly discovered skarn type copper deposit in Geza volcanic-magmatic arc which is located in the southern part of Yidun island arc. Its copper reserves have reached the large size. Distinctly different from the typical skarn deposits, its skarn and hornfels usually arranged alternately, consisting with the attitude of stratum. Skarn is not in direct contact with the intrusive rocks but direct contact with the marble. There are coarse garnet and wollastonite visible in the marble. While, there also have marble xenoliths in the skarn. Therefore, the Hongniu copper deposit is the product of concealed intrusive rocks, belonging to the distal skarn type. According to the combination of skarn minerals, the skarn type can be divided into garnet skarn, garnet-diopside (or diopside-garnet) skarn, diopside skarn, idocrase-garnet skarn, wollastonite-garnet skarn, epidote-garnet skarn, actinolite-epidote skarn, wollastonite skarn and epidote skarn. Among these types, the garnet skarn, diopside skarn and wollastonite skarn are the most common. Garnet is the most important skarn mineral in the Hongniu deposit, and it is therefore significant to study characteristics of garnet due to its wide distribution, various colors and strong mineralization. Through systematic field work and the made-up of drill holes (0ZK10, 3ZK11 and 7ZK16), the paper summarizes the garnet distribution in spac

e and mineralized characteristics in Hongniu deposit, collecting some fresh garnet skarn and a small amount of skarnized marble to make thin sections, and carrying out detailed microscopic identification, to induce the characteristics of garnet including color, shape, structure, petrography, and analyzed its chemical composition by electron probe. Garnet has two obvious stages. Early garnets are widely distributed, brown-red to brown, hypidiomorphic-idiomorphic medium grained texture, with anomalous optical characteristics on the cross-polarized light, and their particle size is generally between 0.2~4mm, developing zonation patterns. Changes in the content scope of the SiO_2 is 35.18%~37.69%, CaO is 33.34%~36.35%, Al_2O_3 is 3.64%~13.69%, FeO is 11.90%~24.18%, MgO is 0.00%~0.08%, and there is a negative correlation between the content of FeO and Al_2O_3, while an overall positive correlation between the content of SiO_2 and CaO. The end members of garnet are mainly andradite (36.88%~82.36%), followed by grossular (16.59%~60.75%), and there are a small number of pyrope, almandine and spessartine, belonging to andradite-grossular series ($And_{37-82}Gro_{17-61}Spe+Pyr+Alm_{0.33-3.71}$). The garnets of later stage are brownish to light red, usually veinlike distributed in skarnized hornfels and marble, also can be seen in some kinds of skarn, with hypidiomorphic-xenomorphic granular structure. Changes in the content scope of the SiO_2 is 35.06%~36.27%, CaO is 33.07%~33.77%, Al_2O_3 is 0.04%~1.05%, FeO is 27.38%~28.18%, MgO is 0.00%~0.04%, the composition of end members belongs to andradite. Changes in contents of major elements in zoned garnet shows a certain regularity, from the core to the rim, the content of FeO increased, the content of Al_2O_3 decreased, the content of andradite increased, the content of grossular decreased, reflecting the diagenetic environment was acidic and reduced with low oxygen fugacity when the garnet began to form. During the process of the crystal formation, the oxygen fugacity increased, and the ore-forming solution shifted from acidic to weakly alkaline, causing the precipitation of metal sulfide. Chalcopyrite, pyrrhotite, molybdenite usually fill between garnet grains, or form veinlets in the cracks of crystal, or replace along the garnet growth zoning surface, showing that the garnets form prior to the mineralization of copper and can provide space for the precipitation and enrichment of metals.

关键词：石榴子石 钙铁-钙铝榴石 物理化学条件 红牛矽卡岩型铜矿床 滇西

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