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胶西北新城金矿床硫同位素地球化学

作者	单位
张潮	中国地质大学地质过程与矿产资源国家重点实验室, 北京 100083
刘育	中国地质大学地质过程与矿产资源国家重点实验室, 北京 100083
刘向东	中国地质大学地质过程与矿产资源国家重点实验室, 北京 100083
冯建秋	中国地质大学地质过程与矿产资源国家重点实验室, 北京 100083
黄涛	中国地质大学地质过程与矿产资源国家重点实验室, 北京 100083
张庆	山东黄金矿业股份有限公司新城金矿, 莱州 261438
王旭东	山东黄金矿业股份有限公司新城金矿, 莱州 261438

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摘要：

新城金矿床是胶西北金矿集区中典型的破碎带蚀变岩型金矿床，其热液成矿作用可划分为四个阶段：黄铁矿-石英-绢云母阶段（Ⅰ）、石英-黄铁矿阶段（Ⅱ）、石英-多金属硫化物阶段（Ⅲ）和石英-方解石阶段（Ⅳ），其中金主要赋存于Ⅱ和Ⅲ阶段的黄铁矿内。该矿床赋矿围岩为郭家岭岩体，岩性为石英二长岩和二长花岗岩，主要为胶东群变质基底经部分熔融形成。胶东群变粒岩硫同位素较为均一（δ^{34}S值介于6.9‰~9.4‰，均值为8.0‰）；郭家岭岩体的δ^{34}S值介于6.0‰~16.0‰，均值为8.6‰，反映了其硫同位素组成总体上继承了变粒岩的硫同位素特征；长英质脉岩的δ^{34}S值变化范围为0.8‰~8.5‰（均值为6.7‰），其中4件样品的δ^{34}S值变化范围为7.4‰~8.5‰，反映了其硫主要源自于郭家岭岩体，变粒岩可能提供了部分硫源；而其中1件样品的δ^{34}S值仅为0.8‰，符合岩浆硫来源特征，表明深部岩浆可能也提供了部分硫源。新城金矿床矿石中硫化物δ^{34}S值变化范围较大（4.3‰~10.6‰，均值为8.3‰），表明矿石硫可能源于郭家岭岩体、变粒岩和长英质脉岩，最终主要来源于胶东群变质基底。Ⅰ阶段黄铁矿颗粒较小（5~600μm），晶形主要为立方体，反映其处于温度较高（300~350℃）、成矿流体的过饱和度较低、低氧逸度和硫逸度、冷却快速、物质供应不足的成矿环境；黄铁矿δ^{34}S值变化范围为8.4‰~10.6‰，均值为9.7‰，反映了矿石硫可能源自于δ^{34}S值较高的郭家岭岩体和变粒岩。Ⅱ和Ⅲ阶段黄铁矿粒径变化较大（3μm~2.5mm），晶形主要为五角十二面体，反映其处于中-低温度（200~300℃）、成矿流体过饱和度高、高氧逸度和硫逸度、缓慢冷却同时物质供应充分的成矿环境。其中，Ⅱ阶段黄铁矿δ^{34}S值变化范围为7.7‰~9.7‰，均值为8.7‰，表明矿石硫源除郭家岭岩体和变粒岩外，δ^{34}S值较低的长英质脉岩可能也提供了部分硫源。Ⅲ阶段硫化物δ^{34}S值变化范围较大（4.3‰~9.4‰，均值为7.1‰），闪锌矿-方铅矿硫同位素热力学平衡温度范围为180~282℃，氧逸度约为$10^{-37.3}$~$10^{-36.8}$，反映了矿石硫源自于郭家岭岩体、变粒岩和长英质脉岩，硫化物δ^{34}S值变化范围较大可能是硫同位素分馏达到平衡的结果。Ⅳ阶段黄铁矿粒径最小（1~5μm），为晶形完好、表面光滑的立方体晶形，表明其处于较低温度（<200℃），成矿流体的过饱和度较低、氧逸度和硫逸度较低、物质供应不足的成矿环境。

英文摘要：

The Xincheng gold deposit, located at the Zhaoyuan-Laizhou goldfield in the northwestern Jiaodong, is one of the most typical altered-type gold deposits. Four stages of mineralization were identified, which are pyrite-quartz-sericite stage (stage Ⅰ), quartz-pyrite stage (stage Ⅱ), quartz-polysulfide stage (stage Ⅲ) and quartz-carbonate stage (stage Ⅳ). While, the precipitation of gold mainly occurs in pyrites from the stages Ⅱ and Ⅲ. The wall rocks of the deposit are the Guojialing granodiorite, comprising the quartz monzonite and monzogranite, which are generated by partial melting of the metamorphosed basement rocks of Jiaodong Group. The granulite, one of metamorphic rocks hosted in the Jiaodong Group, has a narrow δ^{34}S range of 6.9‰ to 9.4‰ with an average of 8.0‰, whereas the δ^{34}S value of Guojialing granodiorite varies in a wider range (6.0‰~16.0‰, average 8.6‰), indicating sulfur mainly derived from the granulite. The felsic dikes have a δ^{34}S range varying from 0.8‰ to 8.5‰ (average 6.7‰). Among them, four δ^{34}S values range from 7.4‰ to 8.5‰, showing that the sulfur of felsic dikes came from the Guojialing granodiorite and the granulite. And the left δ^{34}S value, 0.8‰, showing certain features of magmatic origin, indicates that besides the granulite and the Guojialing granodiorite origins, the magma also provided certain portion of sulfur. The δ^{34}S value of sulfide minerals ranges from 4.3‰ to 10.6‰ with an average of 8.3‰, indicating the ore sulfur may come from the Guojialing granodiorite, the granulite, and the felsic dike, and eventually derive from the metamorphosed basement rocks of Jiaodong Group. Pyrites in stage I are usually small (5~600μm) and cubic, which suggests a steady metallogenic environment at a relative higher temperature (300~350℃), low degree supersaturation of ore-forming fluid, fast cooling down, low oxygen fugacity, low sulfur fugacity and insufficient material supplies. The δ^{34}S value of pyrites at the stage I has a spectrum of 8.4‰ to 10.6‰ (average 9.7‰), indicating that the sulfur came from not only the Guojialing granodiorite, b ut also the granulite with a higher $\delta^{34}S$ value. Significantly, the size of pyrites in the stages Ⅱ and Ⅲ varies from 3μm to 2.5mm, and the main crystal habit is pyritohedron, which represents an ore-forming environment of medium-low temperature (200~300℃), high degree supersaturation of ore-forming fluid, slow cooling down, high oxygen fugacity, high sulfur fugacity and sufficient material supplies. The range of $\delta^{34}S$ value of pyrites from the stage Ⅱ is 7.7‰ to 9.7‰ (average 8.7‰), indicating apart from the Guojialing granodiorite and the granulite, the felsic dikes having a lower $\delta^{34}S$ value also provided certain portion of sulfur origins. The $\delta^{34}S$ value of sulfide in the stage Ⅲ has a wider range (4.3‰~9.4‰, average 7.1‰), in which the temperature has a range of 180~282℃ according to sphalerite-galena sulfur isotopic thermodynamic equilibrium, and the oxygen fugacity is about $10^{-37.3}$~$10^{-36.8}$, indicating that the sulfur came from the Guojialing granodiorite, the granulite, and the felsic dikes. The wide range of sulfide $\delta^{34}S$ value is the outcome of sulfur isotopic thermodynamic equilibrium fractionation. The pyrites at the stage Ⅳ are smallest (1~5μm) and integral cubic, representing a steady metallogenic environment with lower temperature (<200℃), lower degree supersaturation of ore-forming fluids, lower oxygen fugacity, lower sulfur fugacity and insufficient material supplies.

关键词：硫同位素 黄铁矿晶形 成矿物质来源 成矿物理化学条件 新城金矿床 胶东

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单位地址：北京9825信箱/北京朝阳区北土城西路19号