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胶东中生代金成矿系统

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摘要：

胶东是我国最重要的金矿集区，其内已发现金矿床150余处，探明金资源储量4000余吨。虽然其金矿床数量众多、资源储量巨大、分布地域广泛、产出空间各异、矿化类型多样，但它们的成矿地球动力学背景、赋矿围岩环境与产出条件及其成矿作用特征总体一致：（1）胶东是一个主要由前寒武纪基底岩石和超高压变质岩块组成、中生代构造-岩浆作用发育的内生热液金矿集区，约130~110Ma的金成矿事件比区域变质作用晚约2000Myr；（2）区域金成矿系统形成于早白垩世的陆缘伸展构造背景，大规模金成矿事件发生在区域NW向伸展转换为NE向伸展后的NEE向挤压变形作用过程中，对应于中国东部岩石圈大规模减薄、华北克拉通破坏和大陆裂谷作用的高峰；（3）金矿床群聚于NNE向玲珑、鹊山和昆嵛山变质核杂岩周边，主要沿前寒武纪变质岩与中生代花岗岩体接触带形成的区域NE-NNE向拆离断层带分布；（4）控矿断裂带经历了早期的韧-脆性变形和晚期的脆性变形构造叠加，在三维空间上呈舒缓波状延展，控制了金矿体的侧伏和分段富集；（5）矿化样式以破碎带蚀变（砾）岩型、（硫化物-）石英脉型和复合脉带型为主，矿石普遍发育压碎、晶粒状和填隙结构，浸染状、细脉浸染状、网脉状、脉状、团块状和块状构造，反映其形成于韧-脆性→脆性变形环境；（6）矿石中金属矿物以黄铁矿、黄铜矿、方铅矿和闪锌矿为主，非金属矿物以石英、绢云母、钾长石、斜长石和方解石为主；金矿物以银金矿和自然金为主、含少量金银矿，主要以可见金的形式赋存于黄铁矿和石英裂隙中、含少量晶隙金和包体金；热液蚀变主要为黄铁矿化、硅化、钾长石化、绢云母化和碳酸盐化；成矿元素为Au-Ag（-Cu-Pb-Zn）；呈现出中-低温蚀变矿化组合特征；（7）成矿流体为壳-幔混合来源，以壳源变质流体为主；成矿物质总体来源于中生代活化再造的前寒武纪变质基底岩石，并混入了少量浅部地壳和地幔组分。这种区域成矿特征的一致性，表明胶东金矿集区早白垩世大规模金成矿作用受控于统一的地质事件，属于后生的中-低温热液脉金成矿系统。这些金矿床具有明显的时空群聚分布特征，主要沿三个变质核杂岩周边的岩相接触带产出，且自西向东，金成矿作用年龄由老变新。据此，可划分为胶北隆起蚀变岩-石英脉型、苏鲁超高压变质带硫化物-石英脉型和胶莱盆地北缘蚀变砾岩型三个金成矿子系统。其矿化样式由浸染-细脉、细脉-网脉型和石英脉型→硫化物-石英脉型→蚀变（角）砾岩型变化，矿石结构、构造以细脉浸染状构造为主→环带结构与梳状构造→角砾状构造为特色，反映其成矿作用分别发生于脆-韧性转换带（约15km）→脆性张剪性断裂带→脆性角砾岩带（约5km）环境；矿化、蚀变规模和强度逐渐减弱，成矿物质中浅部壳源组分逐渐增多，可能与其矿床定位空间越来越远离源区有关；成矿温度和压力依次降低、成矿流体中大气降水和/或盆地卤水贡献逐渐增大，与其成矿深度越来越浅、成矿构造环境越来越偏张性的变化趋势一致。这种成矿特征的区域规律性变化反映至少在拆离断层韧-脆性转换带附近→脆性角砾岩带之间的地壳剖面中、在不同的垂向深度上连续成矿。胶东中生代金成矿系统的上述特征明显区别于典型的“与侵入岩有关的金矿”和“造山型金矿”，也不同于全球其它已知的金矿床类型，不能被已有成矿模式所涵盖。为合理解释胶东中生代金成矿系统独特的地质与成矿特征，我们提出新的“胶东型金矿”成矿模式，指出古太平洋Izanagi俯冲板片的回转作用可能是引起区域前寒武纪变质基底岩石中成矿物质大规模活化再造的主要驱动机制，成矿流体主体来源于俯冲板片变质脱水，金可能主要以$Au(HS)_2^-$络合物的形式在流体中沿拆离断层系输运，在韧-脆性转换带附近→脆性角砾岩带，由于构造空间急剧增大、成矿流体的温度和压力突然降低，CO_2、H_2S逸出和硫化作用导致$Au(HS)_2^-$等金络合物失稳分解，金大规模沉淀富集成矿。

英文摘要：

Jiaodong Peninsula is the most important gold concentration area of China, more than 150 gold deposits within it have been found and the proven gold reserves add up to 4000 tons. The amount of gold deposits and gold resource are huge, gold occurrence and mineralization type vary with the widely distributed gold deposits, however, the metallogenic geodynamics background, ore-host rock environment, gold occurrence conditions and metallogenic characteristics are identical as a whole: (1) Jiaodong area is an endogenic hydrothermal gold concentration area consisting of Precambrian base rocks and ultra-high pressure (UHP) metamorphic rocks, tectonism and magmatism happened frequently in Mesozoic, 130~110Ma gold metallogenic events occurred 2000Myr or so later than the regional metamorphism; (2) regional gold metallogenic system formed in the Early Cretaceous continental-margin extension tectonic backgrou

nd, large-scale gold metallogenic events happened in the process of regional NW extension changing to NE extension followed by the NEE compression, which corresponded to the lithosphere reduction in East China, North China craton destruction and the peak of continental rifting; (3) gold deposits clustered around the NNE Linglong, Queshan and Kunyushan metamorphic core complexes, mainly along the regional NE-NNE detachment faults developing along the contact zone of Precambrian metamorphic rocks and Mesozoic granites; (4) the ore-controlling fault belts went through the early ductile-brittle deformation and late brittle deformation structure superposition, extended in smooth-out wave forms in 3D space and controlled the lateral trending and subsection enrichment of gold orebodies; (5) the mineralization types mainly include clastic altered (breccia) rock type, (sulfide-) quartz vein type and compound vein-belt type, textures like the crush texture, crystalline-granular texture, interstitial texture and structures like the disseminated structure, vein structure, massive structure, crumby structure are abundant in the ore rocks, which indicates the ore-forming environment changed from ductile-brittle conditions to brittle conditions; (6) metallic minerals mainly include pyrite, chalcopyrite, galena and sphalerite, non-metallic minerals mainly include quartz, sericite, potash-feldspar and calcite; gold minerals mainly include the electrum, natural gold and a small amount of küstelite, which mainly occur in the fractures of pyrites and quartz in the form of visible gold, lesser in crystal gap and as inclusions; hydrothermal alteration types mainly include pyritization, silicification, sericitization and carbonatation; ore-forming elements mainly consist of the Au-Ag(-Cu-Pb-Zn) assemblage; the alteration and mineralization assemblage mentioned above show the characterisics of mesothermal-epithermal assemblage; (7) ore-forming fluids came from both the crust and mantle and are mainly the crust source metamorphic fluids; metallogenic materials derived from the Precambrian metamorphic basement rock mass which reactivated in the Mesozoic, mingling with a small amount of the shallow crustal and mantle components. The consistency of regional metallogenic characteristics indicate that the Early Cretaceous large-scale gold metallogenesis in Jiaodong gold concentration area is controlled by the uniform geological events, and the gold metallogenesis belongs to an epigenetic mesothermal-epithermal hydrothermal vein gold metallogenic system. These gold deposits have obvious characteristic of spatio-temporal cluster distribution and lie mainly along the contact zones of different lithofacies around three metamorphic core complexes. From west to east, the gold mineralization age changes from older to newer. Therefore, three gold subsystems can be divided, which are the altered rock-quartz vein type in Jiaobei Uplift, the sulfide-quartz vein type in Sulu UHP metamorphic belt and the altered breccia type in north margin of Jiaolai Basin. The mineralization style changes from disseminated-veinlet, veinlet-stockwork and quartz vein type, to sulfide-quartz vein type, to altered breccia type. The texture and structure of ores are characterized by veinlet-disseminated structure dominated, to band structure and comb structure, and then to breccia structure, indicating mineralization occurred respectively in brittle-ductile transformation zone (ca. 15km deep), a brittle extension-shear fault zone, and a brittle breccia zone (ca. 5km deep). The decrease of the size and strength of alteration and mineralization, and the increase of shallow crustal components in metallogenic materials, may be related to the deposits' location which is more and more far away from the source area. The ore-forming *P-T* conditions gradually decreased and the meteoric water and/or basin brine ratio in the ore-forming fluid gradually increased, respectively, which corresponds to the shallower metallogenic depth and more and more extended trending mineralization tectonic environment. All the regional regular changes of metallogenic characteristics reflect a crustal continuum metallogenic in different vertical depth of crust, between the detachment fault ductile-brittle transition zone and the brittle breccia zone. Mesozoic gold metallogenic system of the Jiaodong gold province is distinct from typical "intrusion-related gold deposit", "orogenic gold deposit" or other known gold deposit type around the globe, and can't be classified into the known metallogenic model. To reasonably explain the unique geodynamic background, environment of ore-host rock and mineralization characteristics, we put forward the new understanding of the "Jiaodong type" gold deposit and metallogenic model. We conclude that the rollback of ancient Pacific Izanagi subduction plate may be the main drive mechanism leading to large-scale revitalizing of the metallogenic materials in regional Precambrian metamorphic basement rock mass, and ore-forming fluids mainly came from metamorphic dehydration of the subducting plate. Gold is mainly in $Au(HS)_2^-$ complex and transported along detachment fault system in ore fluids. The tectonic space increases sharply as well as the metallogenic temperature and pressure decreases suddenly around the brittle-ductile transformation zone of detachment fault system and brittle breccia zone. Therefore, CO_2 and H_2S lossing from the ore fluids and sulfidation leads to a stability decreasing of $Au(HS)_2^-$ and other gold complexes, and subsequent large-scale gold precipitation.

关键词：陆缘伸展 断裂构造复活 地壳连续成矿模式 金矿系统 胶东

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