Shandong’s Zhaoyuan area is characterized by enormous gold reserves and limited gold mineralization duration (115±5Ma). The gold deposits are mainly distributed along the fracturing zones of Sanshandao, Jiaojia and Zhao-ping in which the Jiaojia altered rock type gold deposit and Linglong quartz vein type gold deposit are dominant ones. Many geologists have made considerable progress on the scientific research and exploration of gold deposits (Mao Jinwen et al, 2005; Deng Jun et al, 2005). Guojiadian gold deposits is one of the large gold deposit in Zhao-Ping fault belt. However, there still exist great disagreements about the metallogenesis of Jiaojia type gold deposits and Linglong type gold deposits.

1 Distribution Characteristics of Guojiadian Mantle Branch Structure

Mantle branch structure is the third level structural unit of the multiple evolution of mantle plume, and it is the comprehensive performance of mantle plume in the shallow crust. The metallogenesis of gold deposits in the mineralization concentration area of northwestern Jiaodong Peninsula is obviously controlled by the Guojiadian mantle branch. Niu Shuyin discussed the deep process of the mineralization concentration area in northwestern Jiaodong peninsula through analyzing the formation and evolution of Laiyang-Laixi sub-mantle plume and the Guojiadian, Qishan and Panshidian mantle branches around it. This study is designed to discuss the metallogenesis of Jiaojia and Linglong gold deposits from the viewpoint of the ore-controlling character of mantle branch.

Three regional fracturing zones of Sanshandao, Jiaojia and Zhao-ping are developed around the Guojiadian uplift in the northwest of the Jiaodong Peninsula. They control the mineralization of a series of middle, large and super-large gold deposits. The mineralization density and resource reserves are rare in the world. The mineralization includes Jiaojia altered rock type and Linglong quartz vein type. What is the difference for the ore-controlling structures of two types of deposits? And what is the difference for the metallogenesis of them? These are key issues on which are focused by most geologists.

2 Ore-Controlling of Guojiadian Mantle Branch Structure

Guojialing mantle branch is an important ore-forming and ore controlling structure in northwestern Jiaodong peninsula. It takes Guojiadian as center, extends north to Daqingjia of Zhaoyuan, south to Nanzhao, east to Zhaoyuan-Pingdu fracturing belt, and west to Xincheng-Jiaojia fracturing belt. On the whole, it is presented as a northeast extended elliptical uplift which takes Linglong complex as center. The Zhaoping and Jiaojia fracturing zones adjacent to the mantle branch are detachment zones of the mantle branch, and Sanshandao fault is a listric fault related to Jiaojia detachment zone.

It is the large scale of magmatism, especially the intrusion of intermediate-acid magma, that results in the intensive uplifting of igneous and metamorphic rocks. The cap rocks were greatly detached and slipped, which resulted in the top exposing of magmatic and metamorphic complex. The cap rocks were detached out up to Longkou and Changshan islands, which resulted in an intensively denudated Guojiadian mantle branch.

The research thinks that metallogenetic material is mainly derived from the deep mantle, even from the
supercritical layer between mantle and core. Through multiple evolution of mantle plume, the metallogenetic material sequentially transported and accumulated as a process of mantle plume®sub-mantle plume®mantle branch®favorable structural expending zones®ore fields®deposits®ore bodies. This possesses the nature of metallogenetic system of source®transportation passage®accumulation sites for ore-forming materials. So a series of large or super large gold deposits can be formed along major faults.

Gold mineralization mainly is the injection of ore-bearing hydrothermal fluid in which is dominated by deep-derived, but with subordinate countryrock-extracted ore-bearing fluid. The extraction and concentration of ore-forming material are influenced by the physical and chemical factors such as temperature and pressure, and the temperature and pressure decrease from the deep to shallow. For the Guojiadian mantle branch, the ore-bearing hydrothermal fluid mainly migrated up (or to outside) from the core of the mantle branch. However, if the core of mantle branch was over heated, the hydrothermal fluid could not satisfy the crystallization or precipitation temperature of metallogenetic material, and then the hydrothermal fluid would continue to migrate out. The migrated materials might be transformed from gaseous state to ore-bearing fluid state; finally it migrated to the brittle-ductile or ductile-brittle shearing zones, the internal and external contact zones of intrusions, dense fracturing zones and the contact zones between dikes and country rocks, then they accumulated as deposits. So, regionally the metallogenesis is more concentrated in the peripheral detachment zones (fracturing zones) of the mantle branch (Fig. 1).

As for the types of gold mineralization, they are closely related to the nature of structural localities. If the ore-forming hydrothermal fluid penetrated into the preexist ductile-brittle detachment slipping zones, it was easy to penetrate into the zones and form rock-altered type of gold deposits (Jiaojia type gold deposits, which is much like cement and stones in concrete) because there exist structural breccias and structural expending zones formed by early compresso-shearing or tenso-shearing activities. If the ore-forming hydrothermal fluid penetrated into the fractures formed by the uplifting of the mantle branch, the ore-forming material would crystallize or precipitate as gold-bearing potassic-silisic lode deposits (Linlong gold deposits, because the country rocks are complete, only a narrow altered zone was formed in both sides of ore vein).
Moreover, around the Laiwu basin (Laiyang-Laixi sub-mantle plume), a series of detached slipping belts that dip toward the basin were formed between the mantle branch and the basin. Some extensile zones in the slipping belts constitute favorable expending zones for mineralization, forming detachment zone type gold deposits (as in Pengjiakuang or Dujiaya). Certainly, the enormous metallogenetic material supply and favorable expending spaces for mineralization are important factors for the formation of gold deposits. Moreover, except for above mentioned types of mineralization, other transitional types of gold mineralization also might exist.

3 Conclusions

(1) Because the migration of hydrothermal fluid is constrained by geophysical and geochemical conditions (such as temperature and pressure) and migration channels, gold mineralization usually concentrates in the detachment zones, faults or fractures around the mantle branch.

(2) The deep-derived hydrothermal fluid, driven by P-T variation, migrates to the different structural expending zones of mantle branch. Due to the different nature of structural expending zones and country rocks, they have different types of gold mineralization, such as the rock-altered rock type in detachment zone and the quartz vein type in faults or fractures.

Acknowledgements

This study was financially supported jointly by “Key Laboratory of Gold Mineralization Processes and Resource Utilization Subordinated to the Ministry of Land and Resources (2013001)”, “Key Laboratory of Metallogenic Geological Process and Resources Utilization in Shandong Province (2013001)” and “the Scientific Base Research Program of China’s Typical Metallic Ore Deposits (200911007)”.

References
