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Research Status of the Enrichment Regularity of Dispersed Element Indium

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Indium is a rare metal element, which is also a strategic metal, but its content in the crust is very low. Indium possesses very unique physical and chemical properties, such as low melting point, high boiling point and good conductivity. Indium, therefore, is widely used in electronic computer, energy, electronics, photo-electricity, national defense military, aerospace, nuclear industry, the modern information industry and other high-tech fields. It has become increasingly important in the national economy, and is considered as one of the most important supportive materials to modern electronic industry (Liu et al., 2005). At present, indium is mainly used for indium-tin oxide (ITO) target materials in liquid crystal display industry; copper-indium-selenium solar cells are considered to be one of the most important ways to replace traditional energy supply and have gained high attention from the government. Intel has released standard of next generation of computer central processing unit (CPU), with indium antimony alloy (SbIn) to become the raw material of semiconductor chips. Obviously, with the rapid development of electronic technology and other high technology, the use of indium is also expanding.

Research on indium began in the 1950s, mainly focused on geochemistry, output state, thermal dynamics, etc. According to previous studies, enrichment of indium is limited to a specialization of certain deposit types and mineral types. In Zn-Sn deposits, indium shows an obvious enrichment trend. In China, indium-rich deposits mainly consist of cassiterite-sulfide deposits and tin-rich Pb-Zn deposits.

China has the largest indium geological reserves, and is also currently the largest native indium producer and exporter, but the distribution of proven reserves is not uniform, mainly clustered in the fold belts of south China and Archean parts of Asia, such as Guangxi, Yunnan, Inner Mongolia, Guangdong, Qinghai, Hunan, Jiangxi, Guizhou and Sichuan. Yet, about 80% of reserves are produced in Guangxi, Yunnan, Inner Mongolia and Guangdong (Li et al., 2007). The reserve of Dachang exceeds 5000 t, ranking it the first in the world, followed by Yunnan (about 4400 t) and Inner Mongolia (about 600 t), however, the global total reserves are not more than 19000 t (Liu et al., 2005).

For a long time, the study of indium has made certain progress, but still many scientific problems remain unresolved. The need of new breakthrough, of understanding of its enrichment, the provision of improved scientific basis for exploration, are essential. Tu (2003) thought that the low temperature metallogenic region in China's southwest area is favorable to indium enrichment. Foreign countries including Japan, Sweden, France, Canada, the United States, Russia, Bulgaria, Mexico and others also have made discoveries. As the balance between supply and demand of indium is increasingly disturbed, the consumer prices are also rising. Currently, evolving technology and financial support that have been invested in indium industry help to meet the increasing demand of economic development. But broadly speaking, geological work that is focused on indium is gravely insufficient, and new proven reserves lag behind the consumption growth, so it is quite necessary to strengthen geological work, find new resources, and guarantee the demands for sustainable development of the world economy (Li et al., 2007).

According to the current knowledge of indium-rich deposits, the cassiterite sulfide and tin-rich Pb-Zn deposits have the highest content of indium, such as Guangxi Dachang, Yunnan Gejiu and Dulong, Hunan Qibaoshan and Inner Mongolia Meng'entaolegai. Yet, the most obvious difference between Meng'entaolegai deposit that

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is located in the northern margin of north China and other Pb-Zn deposits is the containment of more than 2000 tons of comprehensively recyclable tin, and this area shows high geochemical background value of indium, which is expected to become another large indium deposit in the future. Indium and tin have a relationship of synchronous growth in different types of ore deposits, and the indium-rich deposits in other countries are also tin-rich to some degree.

In general, indium enrichment only happens in hydrothermal sulfide mineralization, and the main carrier is sphalerite. It is necessary to further the study of the enrichment of indium in gold deposits, those with few sulfides and rare sphalerite. In the light of the comparative study of different types of gold ore, or content of indium in the same type of gold deposits, the enrichment of indium may be associated with marcasite. However, the factors causing indium enrichment and the relationship with gold mineralization are still not very explicit.

It is generally accepted that tin possibly plays an important role to indium enrichment, yet quite obscured. In indium-rich deposits, significant indium incorporation into cassiterite can be excluded. Indium-rich deposits are always tin-rich deposits at the same time; the content of indium in sphalerite of the pure Pb-Zn deposit is very low. In indium-rich deposits, indium enrichment shows a certain regularity, namely plenty of indium enriches in sphalerite, while other minerals contain little indium, this regularity can be called the specialization of the mineral type. Therefore, in the tin-containing sulfide deposits, only when abundant of sphalerite, large scale of indium enrichment is more likely to happen, and with result of coexisted indium deposit. In the process of mineralization of indium, it enters into the lattice of indium-rich minerals in the form of ion substitution.

Obviously, the important problem, which is closely related to the dispersed element indium specialization characteristics, is the sustainable development of indium resources. Indium deposits, especially those of great industrial significance are found in cassiterite sulfide deposits. In cassiterite sulfide polymetallic deposits, more than 80% of indium is concentrated in sphalerite. In the ore deposits mentioned above, the sections where sphalerite is enriched or Pb-Zn orebodies prevail, are the main object to exploration of indium. Therefore, it is vital to further analysis of specialization characteristics that can provide important clues to deepen the theory of indium enrichment in deposits or indium-independent deposits, and to accelerate the exploration discovery.

Nowadays, a pure indium deposit or indium-dominant deposit has not been found; the geological research on indium is still very weak, and even many accepted facts or phenomenon are still lack of theoretical evidence. Therefore, it is necessary to provide important technical support for the sustainable development of indium resources and its further research.

Generally, geological work related to indium is limited, especially focused on indium metallogeny and metallogenic mechanism, and the research of ore-forming fluid of indium is just starting. The fluid mineralization of cassiterite sulfide deposits is particularly weak, only a few scholars have carried out some research, which should be one of the important directions that need further study in the future.

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