Chemical characteristics of the indium-polymetallic ores from the Toyoha mine, Hokkaido, Japan

Shunso Ishihara1,* and Hiroharu Matsueda2


Abstract: High-grade indium-polymetallic ores of the Toyoha deposits, Hokkaido, which mainly belong to the stage IV mineralization, were studied chemically at E-W trending Shinano-Izumo-Iwami Veins, WNW-ESE trending Soya Vein, and N-S-trending Sorachi-Nemuro Veins. The indium contents go up to 1.0 wt % in the ores (Sorachi, -430 mL). Averaged indium contents and 1000 In/Zn ratio are obtained as follows: Shinano Vein (n=29): 568 ppm and 9.0; Izumo Vein (n=7): 582 ppm and 1.9; Iwami Vein (n=17): 371 ppm and 6.4 (n=16, excluding the highest value of 444.6); Soya Vein (n=4) 1,467 ppm and 3.1; and Nemuro-Sorachi Vein (n=5): 4,050 ppm and 9.1. The whole average is 854 ppm (n=62) and 7.1 (n=61). These indium-rich ores occur in the southeastern part of the Toyoha deposit, where the hydrothermal ore solutions were considered flown out from the depth.

Indium contents of the ores are positively correlated with zinc contents on the Shinano Vein (correlation coefficient of 0.65), but unclear on the whole veins (correlation coefficient of 0.51). Positive correlation between indium and tin is only seen locally (e.g., Iwami Vein). Within available level of 500 meters, zinc content decreases but tin and arsenic contents increase with the depth. Distribution of indium has some similarity with that of tin and arsenic vertically. These chemical characteristics suggest that indium was closely associated with tin and arsenic, besides zinc and cadmium in the hydrothermal fluids. Comparing with similar indium-rich ore deposits in sedimentary terrains in Bolivia, indium-contents are similar in the two regions. Mafic components such as iron, copper, nickel, cobalt, arsenic, and silver are, however, richer in the Toyoha deposits than in the Bolivian deposits. Manganese, antimony, bismuth and tin are predominant in the Bolivian ore deposits. These chemical characteristics reflect general difference of the host rocks, juvenile mafic volcanics vs. sedimentary and felsic volcanics, of the two regions.

Keywords: Toyoha deposit, Miocene, mafic host rocks, vein type, lead-zinc, indium, tin

1. Introduction

There are two sources for industrial use of indium: one is submarine volcanogenic massive base-metal sulfides, while the other is vein-type base-metal sulfides. The massive sulfides such as Kidd Creek and Brunswick deposits, Canada, are large in the tonnage of base-metal but low in indium grade. The tin-polymetallic vein-type deposits such as Toyoha and Ikuno-Akenobe deposits in Japan, and many in Bolivian tin-polymetallic belt, are moderate to small in the base-metal size, but the indium grades are high in general. These ore deposits are also volcanogenic occurring mostly in terrestrial volcanic environment. The Toyoha deposit is the largest in Japan, containing ca. 5,000 tons of indium (Ishihara et al., 2006).

Toyoa lead-zinc pyrite ores were cropped out along the upper stream (Shirai river) of the Toyohira river, southwest of Sapporo (Fig. 1), which were discovered by geological survey of either by Ikutaro Asai or Koto- ra Jinbo during 1890-1891s. The property was acquired and developed by the Kuhara Mining Co. in 1914-1921. The Nippon Mining Co. was the successor and re-opened the mine in 1934, and continued the silver-lead-zinc mining up to 1950s. In 1950s, the mining license was shifted to the present owner of the Toyoha Mining Co. Ltd. (Toyoha Mining Co. Ltd., 1981), who developed most of polymetallic ores and ceased the mining on the 31st March, 2006.

Mineralogical studies were most advanced in indium-
bearing ore deposits of the early days in Japan, including Toyoha deposits (e.g., Kato and Shinohara, 1968; Shimizu et al., 1986; Shimizu and Kato, 1991; Ohta, 1989). Yoshie et al. (1986), however, tried to evaluate valuable trace components including Au, Cu, Zn, W, In and Co for the mining purpose of the Toyoha mine. Genetic model for the polymetallic deposits was proposed by Yajima et al. (1993). Extraction of these useful components during the dressing and smelting processes made the Toyoha ores the most valuable than any other lead-zinc ore deposit in the Japanese Islands and of the world (Ishihara, 2005).

We collected various ores from drilling cores for exploration of major veins of the southeastern part of the Toyoha mine, and analyzed major and trace elements by ICP/MS methods paying special attention to the indium contents. This mine has had largest indium production in the past, over 5,000 tons metal, among major indium-bearing tin-polymetallic ore deposits of Ikuno, Akenobe and Ashio mines in the Japanese Islands (Ishihara et al., 2006). This paper reveals chemical characteristics of trace and some major elements of this largest indium-bearing ore deposit in Japan and compare them to similar Miocene tin-polymetallic ores in Bolivia.

2. Geology and mineralization stages

Toyoha mine is situated in Miocene volcano-sedimentary area in the southwestern part of Hokkaido (Fig. 1), and is located very close to Quaternary volcanic front. The famed Jozankei hot spring occurs about 10 km east of this mine and dormant volcano of Muine-yama (1,461m) and Nagao-yama (1,211m) are seen 5 km to the south. Because of the young and active volcanic circumstance, the mining tunnels of the southeastern corner of the Toyoha mine was very hot to the limit of dynamite blasting (170°C) on the wall rocks, and over 40°C in the air temperature.

According to Yoshie et al. (1986), the mine area is underlain by Miocene volcanic and sedimentary rocks of three units. The lowest Koyanagizawa Formation is composed of the lowest andesite lava, middle basaltic lava and upper dacite lava and its pyroclastics with very local intercalation of conglomerate and mudstone. Motoyama Formation overlies unconformably the Koyanagizawa Formation and consists of alternative conglomerate, sandstone and mudstone. Motoyama Formation overlies unconformably the Koyanagizawa Formation and consists of alternative conglomerate, sandstone and mudstone. The uppermost

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Fig. 1 Location and vein system of the Toyoha mine showing the indium polymetallic zone, base metal zone and manganese zone from the southeast to northwest (originally from Yajima et al., 1993).
Nagato Formation, composed of lower fine tuffs and upper andesite lava and its tuff breccia, overlies conformably on the Motoyama Formation. All of these rocks host the ore veins. No large Miocene intrusions have been observed, but small Miocene felsic dikes ("quartz porphyry", 12.8 Ma U-Pb age on zircon, Ishihara et al., 2010a) intrude into these host rocks, which is considered branched dikes of the main quartz porphyry (E-W 4 km and N-S 4 km) located in the Jozankei township with the satellitic bodies southward.

The ore deposits are vein type with more than 50 named and un-named veins. Major veins are E-W trending Oshima footwall-Tajima-Harima Vein and Iwami-Izumo-Shinano Veins, WNW-SEE trending Soya Vein, and N-S trending Sorachi Vein (Fig. 1). The mineralizations occurred more than 700 m vertically in blind condition (Fig. 2), which made the Toyoha mine large in production. Vein-type deposits of the Toyoha mine are composed of silver-lead-sphalerite-rhodochrosite ores in the northwestern area, where a part of the ores was cropped out. Moving toward southeastern corner, these ores became polymetallic containing tin, tungsten and indium in the base metal ores. For example, cassiterite and stannite and a new mineral of sakuraiite (Cu, Zn, Fe)\(_3\)(In, Sn)\(_4\)S\(_{10}\) were discovered in the Giant Shinano Vein (Yajima, 1977). Zinc-indium mineral of Cu(Zn, Fe)\(_2\)InS\(_4\) and silver-indium mineral of AgInS\(_2\) were reported from Izumo and Sorachi Veins (Ohta, 1980).

These veins were originally classified into the first stage of silver-bearing galena-sphalerite assemblage and the second stage of chalcopyrite-pyrite assemblage, both intruded by the latest rhodochrosite-calcite-silver quartz veins (Akome and Haraguchi, 1963). The two-stage classification was modified by Yajima and Ohta (1979) who pointed out the characteristic minerals of the first stage as sphalerite, galena, pyrite, arsenopyrite and hematite, and those of the second stage as pyrrhotite, graphite, tin and tungsten minerals, besides sphalerite, galena and pyrite. Thus, both the oxygen fugacity and temperature during the formation are quite different between two stages.

Yoshie et al. (1986) and Narui et al. (1988) classified crystallization history of the ore minerals into seven stages, which are slightly modified by Sanga et al. (1992). They showed the geographic distribution of the stage I and II mineralizations in the E-W veins of the northwestern part, and the main polymetallic veins of the stage III to V in all the NW-SE and N-S veins of the southeastern part. The stage VI and VII veins are seen along NW-SE striking veins as the whole but mainly in the northern area.

Main vein-forming minerals of each stage are seen as follows (Yoshie et al., 1986). They also showed average and range of indium contents of the vein width of each stage as follows:

Stage I: Large amounts of quartz containing galena, sphalerite, pyrite, rhodochrosite, hematite, magnetite replacing hematite and argentite. Average indium contents vary from 10 to 60 ppm In in this stage, but the indium-bearing minerals have not been identified yet.

Stage II: Mainly rhodochrosite and Mn-calcite, together with small amounts of quartz, Mn-silicates, and pyrrhotite-containing pyrite. Indium content of this stage is as low as below 10 ppm.

Stage III: Mainly quartz and pyrite, with small amount of hematite. Indium contents are also as low as
Minerals associated with the stage of sphalerites and other indium-bearing minerals of the Toyoha mine occur associated with pyrite, arsenopyrite and stannite. The indium contents of this stage are very high, having generally much higher than that of the Stage I.

Stage VI: This is only seen in the Soya Vein, as an early quartz-chlorite vein and later galena-sphalerite-chalcopyrite vein. The indium contents are below the detection limit (<10 ppm).

Stage VII: Mainly Mn carbonates, associated with quartz, pyrite and Mn-silicates. The latest stage is characterized by Sb-minerals such as jasomonte and stibnite (Narui et al., 1988). The indium contents are below the detection limit (<10 ppm).

3. Analyzed samples, method and results

The analyzed samples were taken from drill cores for the underground exploration. They belong to the stage IV ores of the E-W and/or WNW-ESE striking veins of Shinano Vein at -300 mL to -600 mL (n=29), Izumo
Vein at -150 mL to -550 mL (n=7), Iwami Vein at -150 mL to -600 mL (n=17), and Soya Vein at -400 mL to -500 mL (n=4) from the east to west. From N-series veins, the analyzed samples are obtained from Sorachi Vein at -365 mL to -450 mL (n=4) and Nemo UrVein at -150 mL (n=1). These veins are shown in Fig. 1 and depth of the sample location is shown in Table 1.

3.1 Results on the ores and tailings

The chemical analyses were performed at Actlabs (Ancaster, Canada) and all by TD-MS (Total Digestion-Mass Spectrometry). High-grade Pb ores (>5000 ppm Pb) are, however, analyzed separately by ICP-OES (Inductively Coupled Plasma-Optical Emission Spectrometry). High-grade Ag values (>100 ppm) are also re-examined by chemical method after dissolving only sulfide elements. Their detection limits and obtained values are shown in Table 1. Averaged chemical compositions of all the analyses are shown at the bottom of Table 1. Chemical composition of two tailing samples from the Oshidori-sawa second covering point in the center and north margin is also supplemented.

The whole averaged value of our study is compared with the average composition of the produced ores in 2004, which was provided by the Toyohra mine and given in parenthesis as follows: In 854 ppm (309 g/t), Ag 563 ppm (305g/t), Cu 1.84 % (0.61 %), Pb 3.52% (2.17%), and Zn 24.65% (11.24%). Comparing with the mine’s data, the average of our studied samples are higher in all economic elements, such as In (x 2.8), Ag (x1.9), Cu (x 3.0), Pb (x 1.6) and Zn (x 2.2), implying that we selected higher grade ores than the produced ores. The iron content of our studied ores is
16.0%. These results agree to the fact that the studied ores were mostly selected from the later-stage high-grade veins containing much pyrrhotite and Fe-rich sphalerites, besides pyrite.

Indium contents of the studied ores vary from 11 ppm to 10,400 ppm, except for one (1 ppm) with very low content of the ore minerals but iron sulfides. Averaged values for major E-W veins are as follows: 568 ppm In for the Shinano Vein (n=29), 582 ppm In for the Izumo Vein (n=7), and 371 ppm In for the Iwami Vein (n=17). The whole samples (n=62) are 854 ppm in the average. The Soya and Nemuro-Sorachi Veins are very high, 1,467 ppm In (n=4) and 4,050 ppm In (n=5), respectively. Another way to evaluate indium anomaly of one given

Fig. 3  Binary diagrams for four pairs with the high correlation coefficients in the log-scale, as Cd-Zn 0.95, Bi-Cu 0.75, Ni-Co 0.73 and Sn-Cu 0.71.
Table. 2 Distribution coefficient among the analyzed ores from the Toyoha mine (n=62), excluding Zn concentrates and tailings, and ores from Hosin Inclined Shaft.

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deposit is 1000In/Zn ratio, which is also shown in Table 1. At the Toyoha mine, the 1000In/Zn of the whole measurement is 7.1, excluding unusually low zinc and high copper ore of KO195.

The 1000In/Zn of zinc concentrates is 2.1, but that of the whole average of our studied result is 7.1. These figures imply that indium occurs not only in the sphalerites but also in many other minerals, such as tin, copper, silver and antimony sulfides and sulphosalts, in the Toyoha ore deposits. There is an extremely high copper ore of KO195.

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3.2 Correlation coefficient among ore metals

Correlation coefficient among the selected analyzed components of the ores, excluding those from the Hosin Inclined Shaft and zinc concentrates and tailings, are shown by log unit in Table 2. The total number is 62. The highest five values are obtained on the following pairs: Cd-Zn=0.95, Bi-Cu=0.75, Co-Ni=0.73, Bi-Co=0.72 and Cu-Sn=0.71; which are shown also in their binary diagrams, except for the Bi-Co pair (Fig. 3 A–D). Cd and Zn relationship is usually most beautiful in all the studied sphalerite-bearing ore deposits (e.g., Ishihara et al., 2006). The highest correlation coefficient on the Cd-Zn indicates cadmium substituting Fe and Zn in sphalerite. Co-As pair has also high value of 0.69, because cobalt is often substituted in arsenopyrite (Ishihara, 2011). Related to In, high values are obtained with Cd(0.66), Ga(0.56), Zn(0.51) and Sn(0.48).

On the individual veins, which are not shown here, the Shinano and Iwami Veins are mentioned here, because large numbers of the chemical analyses and the Shinano Vein formed closest to the supposed feeder of the ore solution (Fig. 1), while the Iwami Vein representing its western margin. Shinano Vein (n=29) has only seven pairs with the correlation coefficients higher than 0.80, such as Cd-Zn=0.98, As-Ni (0.87), As-Co (0.84), Co-Ni (0.84), Bi-Co (0.82), Cu-Ni (0.81) and Cd-V (0.80). On the other hand, the Iwami Vein (n=17) has only two pairs higher than 0.80, as Cd-Zn (0.92) and Co-Ga (0.80), implying that the Shinano ores were precipitated close to the conduit of the ore solutions.
3.3 Variation diagrams including indium

Indium was first found in stannite and Ag-bearing tin-sulfides by Yajima (1977). Binary diagram of indium vs. tin is given in Fig. 4A. The studied ores are plotted in the In/Sn ratio varying from 0.01 to 10, and there is a weak positive correlation between two elements as a whole, although the correlation coefficient in the log scale is 0.48. The ores from the Shinano Vein are widely scattered, while those of the Izumo Vein tend to have high In/Sn ratio. Indium contents of the Soya, Sorachi and Nemuro Veins show larger vertical variation than those of tin.

Indium is positively correlated with zinc in the In-Zn diagram, especially on the Shinano ores (Fig. 4B). The ores of the Iwami Vein are widely scattered, particularly to the low indium side. Correlation coefficient of the whole analyses is 0.51. In/Zn ratio varies from 0.0001 to 0.05, but two of the Iwami Vein exceed 0.05, in which indium minerals may be expected (KO195 and KO196-2). Again, ores of the Soya, Sorachi and Nemuro Veins, have large variation of indium in the high-grade sphalerite ores. Thus, mode of occurrence of

![Fig. 4 Binary diagrams for In-Sn, In-Zn, In-Ag and In-Sb of the studied ores from the Toyoha mine.](image-url)
indium in these N-S veins would be different from that of the E-W veins.

Indium is most positively correlated with silver around the \( \text{In}/\text{Ag} = 1 \) (Fig. 4C). Their correlation coefficient is 0.37 (Table 2), which is lower than that of In-Zn. Indium is similarly distributed with antimony (Fig. 4D) but their correlation coefficient is only 0.13 (Table 2).

3.4 Vertical variation of the ore components

Fig. 5 is vertical plotting of average contents of each vein width for In, Zn, Sn, As and In/Zn used for ore reserve calculation at the Toyoha mine (T. Yoshie, personal communication), which is channel sampling done at mining face in the 1990s. For In (Fig. 5A), the content increases with depth on the Izumo-Shinano ores, except for one plotting. Similar interpretation may be said on the Sorachi ores, except for two plottings. In/Zn pattern is similar to the In plotting (Fig. 5B). However, the Zn contents are completely different, in decreasing with the depth (Fig. 5C). On the other hand, the Sn and As contents increase with the depth or highest around 500 mL (Figs 5D, E).

4. Comparison with Bolivian deposits

Both the Toyoha and Bolivian indium-bearing base metal regions are volcanogenic. Yet there are similarities and unsimilarities between the two regions. Basement terrains of the two regions are essentially accreted marine sediments of Cretaceous age in the Toyoha mine area, and of the middle Paleozoic in the

![Fig. 5 Vertical variation of indium in the major veins (original data, personal communication of T. Yoshie).](image-url)
Table 3. Comparison between averaged ores and concentrates of the Toyoha and some Bolivian ore deposits. The Bolivian data from Ishihara et al. (2010c).

<table>
<thead>
<tr>
<th></th>
<th>In/Zn</th>
<th>Cd/Zn</th>
<th>ppm</th>
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<tr>
<td>Toyoha mine (n=62)</td>
<td>3.5</td>
<td>7.1</td>
<td>854</td>
<td>1503</td>
<td>1396</td>
<td>246505</td>
<td>35231</td>
<td>18362</td>
<td>16.01</td>
<td>418</td>
<td>30</td>
<td>314</td>
<td>45</td>
<td>83.2</td>
<td>7.1</td>
<td>9079</td>
<td>64</td>
<td>563</td>
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<td>35</td>
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<td>Bolivar mine (n=46)</td>
<td>5.3</td>
<td>5.7</td>
<td>768</td>
<td>2284</td>
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<td><strong>Zinc concentrates</strong></td>
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<td>13.0</td>
<td>1930</td>
<td>474</td>
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<td>1030</td>
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<td>2650</td>
<td>2640</td>
<td>343000</td>
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<td>3300</td>
<td>8.88</td>
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<td>11</td>
<td>199</td>
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<td>0.7</td>
<td>1360</td>
<td>474</td>
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<tr>
<td>Porco mine</td>
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<td>3.9</td>
<td>498</td>
<td>1320</td>
<td>1600</td>
<td>406000</td>
<td>1503</td>
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Bolivian tin belt. Both the regions were involved in Miocene volcanism but with the mafic magnetite series of juvenile type (e.g., low Sr0) in the Toyoha mine area, and ilmenite-series rhyno-dacitic volcanism of recycled type in the Bolivian tin belt (Sugaki et al., 1988), as best observed at the Porco mine and Potosi mine.

In Table 3, an average composition of all the samples from the Toyoha deposit (n=62) is compared with an average composition of all the studied deposits in Bolivia (n=46, Ishihara et al., 2010b). Zinc concentrates from three representative mines are also supplemented. Indium contents are slightly higher in the Toyoha deposits (854 ppm) than in the Bolivian deposits (768 ppm), and the 1000 In/Zn ratio is also higher in the Toyoha deposit (7.1, n=61) than in Bolivian deposits (5.3, n=46). The tin contents are lower in the Toyoha deposits than in the Bolivian deposits as 1503 vs. 2284 ppm. The Toyoha ores are higher in silver (3.9 times), copper (3.5 times), nickel (3 times), cobalt (5.3 times), arsenic (2.3 times), lead (2.2 times) and iron (1.3 times) than the Bolivian averages among the major ore components. Antimony is distinctly higher in the Bolivian ores (11.3 times), which appear to be related to antimony mineralization occurring often around the indium-polymetallic deposits in Bolivia. Manganese and bismuth are higher in the Bolivian side, whose reasoning has not been known.

**Zinc concentrates from these mines are also listed in Table 3. Both indium-content and 1000 In/Zn ratio are higher in the Toyoha mine than those of the Porco and Bolivar mines in Bolivia; the Toyoha concentrates seem to contain the highest indium in this world. Cadmium contents are similar having the 1000 Cd/Zn ratio of 5.7 for the Toyoha mine, 7.7 for the Bolivar mine and 3.9 for the Porco mine. Arsenic contents are higher in the Toyoha concentrates than the Bolivar and Porco concentrates. Both antimony and bismuth are much dominant in the Bolivar concentrates than the other concentrates.**

The chemical characteristics between Toyoha and Bolivian deposits reflect general difference of the host rocks between the two regions as described before. If the iron is all contained within sphalerites in the zinc concentrates, iron percentage replacing zinc in sphalerites are calculated to be 11.8 wt.% for the Toyoha mine, 25.9 wt % for the Bolivar mine, and 24.0 wt.% for the Porco mine. The iron content in sphalerite is largely a function of oxygen fugacity during the crystallization (Tsukimura et al., 1987), implying that the Bolivian sphalerites were crystallized under much lower oxygen fugacity than the Toyoha sphalerites.

### 5. Conclusions

1) Chemical analyses of indium-polymetallic ores of the Toyoha deposits, which mainly belong to the stage IV mineralization, show variable indium contents among the ore veins: E-W trending Shinano-Izumo-Iwami Veins, WNW-ENE trending Soya Vein, and N-S trending Sorachi-Nemuro Veins. High-grade indium ores tend to occur southeast of the ore deposits; indium contents are locally high as 1.0 wt.% at Sorachi Vein. Average indium contents and 1000ln/Zn ratio are 568 ppm and 9.0 (Shinano, n=29), 582 ppm and 1.9 (Izumo, n=7), 371 ppm and 6.4 (Iwami, n=16), 1,467 ppm and 3.1 (Soya, n=4), and 4,050 ppm and 9.1 (Nemuro-Sorachi, n=5). The whole average is 854 ppm (n=62) and 7.1 (n=61).

2) Indium contents are positively correlated with zinc contents on the Shinano Vein. On the whole veins, indium contents are most positively correlated with cadmium and zinc with the correlation coefficient of 0.66 and 0.51, respectively, although the indium contents are correlated only locally with tin contents (0.48). Within available mine’s level of 500 meters, zinc contents decrease but indium, tin and arsenic contents increase with the depth. These chemical characteristics suggest that indium was intimately associated with zinc, cadmium, tin and arsenic in the ore fluids.

3) Indium contents of the ores are similar between Toyoha and Bolivar ore deposits. The Toyoha ores, however, are richer in iron, copper, arsenic, nickel and cobalt, while the Bolivar ores are richer in manganese, antimony, bismuth and tin. These chemical characteristics are considered to reflect a juvenile igneous character for the Toyoha deposits, and terrestrial sedimentary and felsic igneous environment for the Bolivar deposit.
Acknowledgment: The authors acknowledge greatly the mine geologists especially of E. Narui, T. Yoshie, M. Katayama and K. Shinagawa for their help during the sampling of ores and providing some statistics of the mining stage. Valuable comments given by one of the reviewers, T. Shimizu, is greatly acknowledged.

References


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北海道、豊羽鉱床産インジウム多金属鉱石の化学的特徴

石原舜三・松枝大治

要 旨

豊羽鉱床の第IVステージに属するインジウム高品位多金属鉱石の化学的性質を、東西系の信濃－出雲－石見脈、西北西系の宗谷脈、南-北系の空知－根室脈について検討した。インジウム含有量は最高1%（空知脈,-430 m L）に達するほど多く含まれるが、平均値では分析例が少ない根室 - 空知脈 (4.050 ppm, 1000In/Zn=9.1, n=5), 宗谷 (1.467 ppm, 1000In/Zn=3.1, n=4) では少し高く、分析例が多い出雲脈 (582 ppm, 1000In/Zn=1.9 ppm, n=7), 信濃脈 (568 ppm, 1000In/Zn=9.0, n=29), 石見脈 (371 ppm, n=17, 1000In/Zn=6.4 (n=16, 異常に高い1個を除く, n=16) では一桁低下する。全平均値は 854 ppm(n=62), 1000In/Zn=7.1(n=61) である。これらのインジウム多金属鉱石は鉱液の供給口と考えられている南東部で多く観られる。

インジウム含有量は鉱石の亜鉛含有量と信濃脈では正相関 (相関係数 0.65) するが、この相関係数は全体としては 0.51に低下する。インジウムと錫との正相関性は、石見脈 (0.71) などで局的に高い。上下 500 m 間の垂直変化では、深部へ向けて亜鉛含有量は減少するが、錫と砒素、インジウム含有量は増加の傾向を示す。これらの化学的特徴は熱水鉱液中にインジウムが錫および砒素を親密に伴っていたことを示唆する。ボリビアの堆積岩地域に産出する同様なインジウム含有鉱石と比較すると、豊羽鉱床はインジウム含有量では類似するが、鉄・錫・砒素・ニッケル・コバルト・銀などに富んでいる傾向がある。他方、ボリビア産の鉱石はマンガン・アンチモン・ビスマス・錫などに富む傾向が見られる。これらの傾向はそれぞれの鉱床母岩が、豊羽鉱床で苦鉄質火山岩類、ボリビアで堆積岩・珪長質火成岩類が卓越することは関係していると考えられる。