

## **PART III CONCLUSIONS AND RECOMMENDATIONS**

## Chapter 1 Conclusions

As the hydrothermal alteration zones exist widely in the Oruro-Uyuni region and also mineral showings exist, it is expected to host epithermal ore deposits at depth.

Considering the mineralization in the Altiplano and the Eastern Bolivian Andes, it was interpreted that the mineralization in the Western Bolivian Andes is similar to the Bolivian-type deposit and shows an epithermal type mineralization in the upper part, while it changes to a polymetallic mineralization in the lower part.

It is reported that the mineralized ages of Chilean porphyry type deposits have a tendency to become younger from west to east and the porphyry type deposits were expected.

Sixteen Districts were studied in three years.

After the surveys lots of matters about the mineralizations in the Oruro-Uyui region still remained unknown, nevertheless the following things became clear.

- 1) The satellite image analysis was proved to be useful for selection of alteration zones, as alteration zones selected by satellite image analysis in this survey well coincided with the results of the ground truth.
- 2) The area is underlain by volcanic rocks of early Miocene to Pleistocene, their ages, however, showed irregular distributions.
- 3) Alteration minerals in the volcanic rocks showed a zonation of cristobalite zone, quartz zone, quartz-sericite zone from the outer part to the center part. Quartz-sericite zone in the volcanic rocks of Late Miocene or younger, is generally absent or small if exists, while quartz-sericite zone in the volcanic rocks of the Middle Miocene or older is widespread.
- 4) The vein materials showed a variation of clay, clay-silica, silica and quartz from the outer part to the center part. Manganese oxide is shown inside of clay in some place. In either case, quartz zone is accompanied by ore minerals such as gold, silver, copper, lead and zinc.
- 5) Results of the chemical analysis of samples from the La Deseada vein exposed from the top to the bottom, values of (gold), (copper), lead, arsenic and antimony are higher in the upper part of the mineralization, and those of gold, silver, copper, lead, zinc and antimony increase in the lower part of mineralization. Combination of these factors and

vein character is a good indicator to consider the portion of a mineralized zone in the same area as Mendoza District.

- 6) Homogenization temperatures and salinities of fluid inclusions showed difference of ore solutions by each vein. Veins showing low temperatures like the La Deseada vein indicate the possibility of ore deposits underneath.
- 7) It is not cleared whether the quartz(calcedony)-barite vein changes to Bolivian-type? Polymetallic vein, as drilling survey was carried out only in the Chullcani. The reason why no sulfide vein was confirmed in the ore showings in the older volcanic rocks, some part of mineralization in the Western Andes and Altiplano is considered to be different from the bolivian-type mineralization in the east.
- 8) Positive showing suggesting the existence of the porphyry type deposit could not be confirmed.

Conclusions of principal districts are as follow.

#### **Turaquiri district**

Many veins mainly of manganese dioxide are confirmed northwest of Turaquiri Deposit.

Most of them, however, are less than 10 cm in width and mineralizations of network and dissemination types are not confirmed.

The observation in the field suggests that veins beneath the manganese dioxide might change to Ag- Pb- Zn- Cu veins, but their size is insufficient for a bulk mining operation.

#### **Chullcani district**

It is interpreted that Volcano Chullcani is a single stratovolcano and subsequent erosion denuded the center part of the volcanic body exposing the tip of diorite. A quartz-sericite alteration zone shows that diorite intrusive rock is the center of hydrothermal activity. Two drill holes were carried out in the diorite intrusive rock and at the slope where is inferred to be a local center of hydrothermal activity. After drilling dominant hydrothermal alteration zones were confirmed. However, significant mineralization was not intersected.

Possibilities remain for deposition of epithermal gold mineralization ore deposits in the southeastern part of the MJBO-2 drill hole related to intrusive activity in shallow parts.

However, the facts that Volcano Chullcani is interpreted as a stratovolcano and the gold geochemical anomaly on the surface is not dominant in the deeper parts suggest possibilities that

gold mineralization was weak in general.

### **Sonia - Susana district**

In Jankho Kkollu it is possible that the volcano was formed later than the time when the Carangas Formation was formed in Middle Miocene, instead of Upper Oligocene to Lower Miocene.

Many lead-zinc bearing barite-quartz veins are confirmed in areas south of the intrusive rock body. A limonite vein was confirmed north of the intrusive rock body.

The mineralization of this area is estimated to be epithermal Ag- Pb- Zn- Cu deposits related to a hypabyssal rock intrusion activity in a shallow place. However, ore veins in the south part are discontinuous and small in size. The veins in the north part are also very small. Therefore, ore deposits should not be expected to be large.

Geochemical anomaly of molybdenum shows that the porphyry type mineralization is expected for the Santa Catalina Prospect in the Sonia- Susana District. However, positive signs suggesting its existence are not confirmed.

### **Calorno district (Fig. I-4-2(5))**

The hydrothermal alteration zones widespread in the district are considered to situate at the topmost (outermost) parts of the alteration zones.

At the place where gossan, mainly of goethite, occurs along the Rio Agua Milagro, low sulfidation type epithermal ore deposit is considerable nearby.

At some place in the northern part of the survey area, it is interpreted that a hydrothermal alteration zone was formed from strong acid solution of magma origin, high sulfidation type epithermal deposit or epithermal Au-Ag-Pb-Zn deposit related to volcanic activity are expected.

Although large deposits are expected because of the existence of wide area of hydrothermal breccia, it is probable that the mineralization is weak or deep-seated, because geochemical anomaly is not remarkable

### **Mendoza district**

The presence of epithermal Au- Ag- Pb- Zn deposit related to shallow volcanic activity is presumed in Co. Kancha. The result of K-Ar dating of the alteration minerals suggests that the

hydrothermal alteration took place at least twice in the area. The mineralization, however, is probably weak or deep-seated, as the geochemical anomalies are weak and scattered.

The ore deposit of the La Deseada mine is an epithermal Au- Ag- Pb- Zn deposit related to shallow volcanic activity.

The existence of the similar ore deposit to La Deseada ore deposit is expected beneath the geochemical anomaly of Co. Mokho. Besides, as the alteration zone of Co. Mokho is continuously extended to La Deseada mine, the mineralization of two areas is probably connected.

Enargite collected from the waste dump at the portal of the Guadalupe mine suggest that there is a high sulfidation type epithermal mineralization. As the ore of enargite and pyrite is brecciated, two stages of mineralization have probably taken place.

A large number of lead-zinc-bearing veins are confirmed in propylitic rock in the Iranuta section. The mineralization in the Iranuta section is believed to be epithermal Pb- Zn mineralization associated to hypabyssal activity caused by rhyolite intrusive rock in the north and that the mineralization is different from Mt. Choroka.

Veins at Iranuta are believed to be exposed relatively deeper parts as epithermal ore deposit and large-scale ore deposits are not expected.

At the upper part of the northern slope of Mt. Choroka where acidic alteration zones are spotted, a high sulfidation type Au-Cu mineralization is expected.

Considering strong hydrothermal activity, intrusive rock are estimated below the Mt. Choroka.

Epithermal gold and silver deposits related to hypabyssal intrusive activity in shallow places are expected. The size of mineralization, however, may be small because Mt. Choroka is interpreted as a single stratovolcano.

### **Panizo district**

In Panizo prospect of Panizo district, the mineralization of northern and southwestern parts of the area is expected an epithermal type Au- Ag- Pb- Zn mineralization, and in the central part high sulfidation type Au- Ag- Cu mineralization is expected.

In the southwestern part, mineralization of high sulfidation type epithermal deposit could be overlapped.

As the K-Ar dating of the alteration mineral showed late of Middle Miocene, erosion has been considerably advanced. As the geochemical anomalies are rather intense, if exists, its level is

not so deep from the surface,.

### **Sailica district**

The mineralization of Plasmar mine correspond to epithermal Au- Ag- Pb- Zn deposit related to shallow volcanic activity, based on the previous data and result of geochemical survey. And there is a possibility of overlapping of high sulfidation type Au- Ag- Cu mineralization. As there is an extensive alteration zone and remarkable geochemical anomalies, the possibility of existence of ore deposits in underground seems to be high.

## Chapter 2 Recommendations for the future

There are no strong reasons for further exploration can be suggested as the result of the project, although the third phase of the survey revealed detailed and information for the geology and mineralization of the area.

However, the recommendations for further explorations are summarized as follows, for in case of re-evaluating the potentiality of the Oruro - Uyuni Area and the adjacent Western Andes Region.

### (1) Recommendations for exploration of epithermal type mineralization

The analysis of remote sensing data is a useful tool for selecting a hydrothermal alteration zone from a wide area. The potential mineralized zone should be selected by geochemical investigations. Further detailed geological investigations should be mentioned with the following viewpoints.

- i) Existence of ore bringers (domes and intrusive rocks).
- ii) Existence of hydrothermal fluid paths (mineralized solution).
- iii) Repetitive supply of hydrothermal fluids (overlap of igneous activities).

The analytical study should be mentioned for the following viewpoints.

- a) Dissection degree of volcano: distribution of igneous rock age, homogenization temperature of fluid inclusions, geochemical anomalies and alteration minerals, etc.)
- b) Evaluation of the vertical position in mineralization: distribution of alteration minerals, geochemical anomalies and gangue minerals.

Those districts with high potential that are narrowed down in this detailed geological survey should preferably conduct geophysical exploration and drilling exploration to reveal the deep geological structures and mineralization.

### (2) Recommendations for exploration of porphyry type mineralization

The mineralized age of Chilean porphyry copper deposits have a tendency to become younger from west to east. It shows the potentiality of this type mineralization in the volcanic region of the Western Bolivian Andes. But at the younger volcanoes, the porphyry type mineralization would be located quite deep underground if it exists.

Therefore it is desirable for a detailed investigation of volcanic stratigraphy (especially in dating the age of volcanic rocks) of the Western Andes Region as basic information for the explorations. It also should be important information for the exploration of the epithermal type

mineralization mentioned above.