SUMMARY

This study aims to clarify the alteration zoning in the Hishikari deposit from the view of temperature at which host rocks reacted with hydrothermal solutions. The study of the western area of the Hishikari deposit is based on mineral determination by X-ray diffraction of 203 samples obtained from drill holes. Powdered bulk rock and oriented clay samples were examined to identify clay minerals. We distinguished three types of chlorite-hemimorphite mixed-layer minerals by the degree of the shift of basal reflections by ethylene glycol treatment. The clay mineral zoning indicates that favorable conditions for gold mineralization extend west of the present Hishikari deposit.

1. INTRODUCTION

The Hishikari epithermal vein-type gold deposit is located in southern Kyushu, Japan (Figure 1). It was discovered by Metal Mining Agency of Japan in 1981 (Izawa et al., 1990; Sillitoe, 1995) and developed by the Sumitomo Metal Mining Co., Ltd. and is known as one of the richest gold deposits in the world (Ibaraki and Suzuki, 1993).

This study aims to clarify the alteration zoning in the western part of the Hishikari deposit from the view of temperature at which host rocks reacted with hydrothermal fluid to interpret the ore fluid pathways.

2. GEOLOGIC SETTING

Geologically, the Hishikari deposit and the surrounding area consist mainly of basement sedimentary rocks of the Cretaceous Shimanto Super-group, Pliocene-Pleistocene volcanic rocks and alluvial deposits (Izawa et al., 1990) (Figure 2).

The Shimanto Supergroup consists of sandstone, shale and their alternations. The Honko-Sanjin area, the eastern part of the Hishikari deposit, rises to 120 m above sea level and hosts more than 60% of mineable veins (Izawa et al., 1990). The volcanic rocks, which unconformably cover the Shimanto Supergroup, are Hishikari Lower Andesites, Maeda Dacites, Shishimano Dacites, Hannyaji Welded Tuff and Ito Pyroclastic Flow Deposits, in ascending order. The Hishikari Lower Andesites are the host rock of about 40% of ore in the Honko-Sanjin area and of the entire veins in the Yamada area. (Figure 2).

Figure 1. Location map of the Hishikari deposit

Figure 2. Geological map of the Hishikari area and longitudinal section along A - A'. Modified from Ibaraki and Suzuki (1993) and Etoh et al., (2002).
3. METHODS AND MATERIALS

Hydrothermal alteration was studied between -100 m and 200 m above sea level in the north central and western areas of the Hishikari deposit using 203 samples from drill holes (Figure 3). The minimum sampling interval of drill cores is 20 m.

Hydrothermal minerals were identified using X-ray diffractometry for powdered bulk rocks and clay fractions collected by sedimentation. Oriented clay samples were prepared by pipetting clay suspensions onto glass slides. Air-dried and ethylene glycol treated samples were examined. Among the clay minerals identified in this study, smectite, chlorite and chlorite-smectite mixed layer minerals are examined in detail.

Triocahedral chlorite/smectite (C/S) mixed-layer minerals are common minerals of hydrothermally altered andesitic rocks under near-neutral pH condition. The smectite component (%) S decreases discontinuously with increasing temperatures from 80-100 % (smectite-rich C/S) through 40-50 % (corrensite) to 0-10 % (chlorite-rich C/S) (Inoue, 1995).

X-ray diffraction patterns for chlorite-smectite mixed-layer minerals are shown in Figure 4. Smectite-rich C/S resembles smectite in diffraction patterns of air-dried samples, but a slight difference is caused by ethylene glycol treatment. Whereas the peak of the pure smectite shifts from 14° to 17° by this treatment, the peak of the smectite-rich C/S moves to 16.8° or less. An ordered trioctahedral chlorite-smectite mixed-layer mineral, corrensite, is identified by a superlattice reflection with d = 29-30 Å. Chlorite-rich C/S resembles chlorite in diffraction patterns of air-dried samples, but slight layer expansion was caused by ethylene glycol treatment. Figure 4 shows the X-ray diffraction patterns of air-dried and glycolated samples for the chlorite/smectite mixed layer minerals from the Hishikari deposit.

4. RESULTS AND DISCUSSION

Least-altered andesitic volcanic rocks (the Hishikari Lower Andesites) consist of plagioclase, cristobalite, tridymite and small amounts of hypersthenite and augite. Quartz and K-feldspar occur in the Shishimano Dacites. Clay minerals (smectite, kaolinite, mixed-layer clay minerals, chlorite and illite), zeolite minerals (stilbite, mordenite and laumontite), adularia, calcite, gypsum and pyrite were formed by hydrothermal alteration.

Using assemblages of clay minerals with silica minerals, the hydrothermal alteration zones in the
Hishikari deposit is defined as follows; cristobalite and smectite for zone I, quartz and smectite for zone II, quartz and mixed layer minerals for zone III, and quartz and chlorite and/or illite for zone IV. This classification was defined by Izawa et al. (1990) and these alteration zones were considered to correspond to following temperature conditions: less than 100°C for zone I, 100-150°C for zone II, 150-220°C for zone III and higher than 220°C for zone IV (Ibaraki and Suzuki, 1993). However, the temperature of zone IV indicated by chlorite may be lower than 220°C judged from data on active geothermal fields and is about 200°C (e.g. Nakagawa et al., 1985; Inoue, 1995), although chlorite minerals provides somewhat ambiguous temperature information (Hulen and Nielson, 1986).

This study revealed that three types of chlorite-smectite mixed-layer minerals occur in the Hishikari deposit reflecting various temperature conditions. Figure 5 shows the alteration zoning and temperature conditions indicated by clay minerals.

As zone III exists above sea level in the sections C-C' and D-D', we conclude that hydrothermal fluid (>150°C) flowed through the western part of the Yamada area and that the favorable condition for gold mineralization exists on the western side of the Yamada area.

5. CONCLUSIONS

Clay minerals, in particular three types of chlorite-smectite mixed-layer minerals, show the temperature distribution during hydrothermal alteration in the Hishikari deposit.

Temperature conditions deduced by clay minerals range from 150°C to above 200°C in the Yamada area.

Corrensite and chlorite-rich mixed-layer minerals occur near quartz veins.
Figure 6. Vertical alteration zoning on A - A', B - B', C - C' and D - D' cross sections.

It is expected that the favorable condition for gold mineralization exist on the western side of the Yamada area.

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7. REFERENCES


