Records of hydrothermal activity in the Across-arc seamount chains of the Izu-Ogasawara arc -preliminary description-

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Abstract Various types of records of ancient hydrothermal activity were found on the across-arc seamount chains of the Izu-Ogasawara arc. They are mainly hydrothermal Mn-oxides and nontronite. Low temperature hydrothermal activity is supposed to have widely occurred associated with the volcanism on the across-arc seamount chains during Miocene to Pliocene.

Introduction

The Izu-Ogasawara arc is a suitable place for studying the tectonic control on the characteristics of hydrothermal activity, because hydrothermal activity in different tectonic settings (volcanic front and back-arc rift) were reported (e.g. Iizasa et al., 1992; Urabe and Kusakabe, 1990) and can be compared to each other. Furthermore, volcanic history of the back-arc region, especially of the back-arc seamount chains, is being revealed by systematic K-Ar and \(^{40}\)Ar/\(^{39}\)Ar dating (Ishizuka et al., submitted). Based on this volcanic history, understanding of characteristics of hydrothermal activity at various volcanic episodes including volcanism on the across-arc seamount chains, onset of back-arc rifting, eruption of back-arc basin basalt and volcanism on the present-day front will enables us to make clear the temporal variation of hydrothermal activity along with the change of tectonics in the oceanic island-arc setting. From this point of view, knowledge of hydrothermal activity on the across-arc seamount chains is quite important, though it had been quite limited except for a report on occurrence of hydrothermal Mn-oxides on the Ten’na seamount by Usui et al. (1986). MW9507 cruise in 1995 recovered large amount of hydrothermally altered rocks and precipitates from hydrothermal solution which show wide range of evidences of ancient hydrothermal activity on the across-arc seamount chains, although no modern hydrothermal activity has been found.

Hydrothermal Mn-oxides

Hydrothermal Mn-oxides were collected at almost all of the seamounts in the Enpo chain and some in the Manji and Kan’ei chains (Fig. 2). The hydrothermal Mn-oxides mainly exhibit three types of mode of occurrence: 1) dissemination in the host rocks. Host rocks are mainly porous hyaloclastite and volcanic sandstone. Mn-oxides often form network of veinlet and/or fill the interstices among the components of host rocks. Hydrothermal Mn-oxides layer is often observed between the disseminated host rocks and hydrogenetic Mn-oxides crust which covers the host rocks (Fig. 3). Microscopic observation of polished section of...
Fig. 2 Distribution of hydrothermal alteration on the back-arc seamount chains

Hydrothermal Mn-oxides and iron-rich clay (nontronite) were found in many places ranging from the westernmost part of the seamount chains to the knolls just west to the front volcanoes.
the layer revealed that the hydrothermal Mn-oxides grew downward using the hydrogenetic Mn-oxides crust as a substrate (Fig. 4). This occurrence indicates that hydrothermal solution which came up through the porous and permeable rocks (e.g., hyaloclastite and volcanic sandstone) was tapped beneath the less permeable hydrogenetic crust and precipitated Mn-oxides there. Hydrothermal activity is assumed to have occurred after the accumulation of hydrogenetic Mn-oxides crust to a certain thickness on host rocks. The host rocks are usually products of volcanism of the seamounts. Thus, hydrothermal activity is supposed to have taken place even long after the main activity of the seamount volcanism.

2) intercalation in Mn-oxides nodule (Fig. 5). In some cases, Mn-oxides nodules composed of both hydrogenetic Mn-oxides layer and hydrothermal Mn-oxides layer. This occurrence indicates that hydrothermal activity had several active period and continued during a long period which permitted the accumulation of a few centimeters of hydrogenetic Mn-oxides layer (probably longer than 1 m.y.).

3) replacement of limestone At a small knoll (Daigo Nishi-Sumisu Knoll) on the extension of the Genroku chain (Fig. 6), Mn-oxides replace limestone and form relatively compact and hard “ore”. Hydrothermal Mn-oxides replace calcareous fossils including foraminifera and bivalve. Overgrowth of Mn-oxides on the fossils are also widely observed. Mn-oxides usually show colloform and reniform texture. Euhedral calcite crystals occur in the voids of Mn-oxides. This occurrence suggests that calcite was dissolved and reprecipitated by the hydrothermal fluid.

These modes of occurrence of hydrothermal Mn-oxides imply that relatively low temperature hydrothermal activity took place in many places on the across-arc seamount chains. The activity is supposed to be related to the volcanism on the seamount chains, however, it seems to have continued long after the main activity of volcanism.

Hydrothermal nontronite

Nontronite of hydrothermal origin also occurs mainly in hydrothermally altered hyaloclastite and volcaniclastic rocks. Nontronite also occurred intimately associated with hydrothermal Mn-oxides or network of quartz veinlet. Composition of nontronite is shown in Table 1, which indicate the similarity of chemical composition of nontronite from the seamount chains to those from active seafloor hydrothermal system. Nontronite sometimes contains remains of various kinds of bacteria (Fig. 6). These bacteria probably flourished in the low temperature hydrothermal environment. In some cases, so-called “filamentous texture”, which is formed by overgrowth of nontronite on remains of bacteria, is observed. Iron content of nontronite is much

### Table 1 Chemical composition of hydrothermal nontronite
from the Daigo Nishi-Sumisu Knoll

<table>
<thead>
<tr>
<th></th>
<th>This study</th>
<th>Woodlark</th>
<th>Lau</th>
<th>Galapagos</th>
<th>Loihi</th>
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<tr>
<td>Fe₂O₃</td>
<td>36.13</td>
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<td>0.36</td>
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<tr>
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<tr>
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<td>0.00</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Cr₂O₃</td>
<td>0.00</td>
<td>0.02</td>
<td></td>
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<tr>
<td>Total</td>
<td>87.09</td>
<td>90.62</td>
<td></td>
<td>96.72</td>
<td>79.14</td>
</tr>
</tbody>
</table>

(determined by EPMA)

Woodlark basin (Binns et al., 1993); Galapagos Mounds (Moorby, 1983)
Lau basin (Stoffers et al., 1990); Loihi Seamount (De Carlo et al., 1983)
higher near the fossilized bacterial remains than other part. This implies that some kinds of bacteria concentrated iron selectively around their body and promoted the precipitation of iron-containing minerals.

Summary

1. Hydrothermal Mn-oxides were found in many seamounts belonging to the across-arc seamount chains in the back-arc region of the Izu-Ogasawara arc. They were formed by hydrothermal activity associated with the volcanism of the seamounts during Miocene to Pliocene.
2. The hydrothermal activity related to the formation of hydrothermal Mn-oxides is supposed to have long duration (probably longer than 1 Ma). The activity seems to have had several period of high activity.
3. Nontronite which is supposed to have hydrothermal origin is observed in several seamounts on the across-arc seamount chain. Nontronite is characteristically associated with bacterial remains. This implies that some kinds of bacteria concentrated iron selectively around their body.

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References


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3A. Hydrothermal Mn-oxides from the Ten'na seamount on the Enpo chain. Hydrothermal Mn-oxides fill the interstices of hyaloclastite. Photomicrograph (reflected light) of the boundary of hydrogenetic and hydrothermal Mn-oxides.

3B. Hydrothermal Mn-oxides (lower part) grow downward on the substrate of hydrogenetic Mn-oxides (upper part).

Fig. 3A, B  3A. Hydrothermal Mn-oxides from the Ten'na seamount on the Enpo chain. Hydrothermal Mn-oxides fill the interstices of hyaloclastite. Photomicrograph (reflected light) of the boundary of hydrogenetic and hydrothermal Mn-oxides.

3B. Hydrothermal Mn-oxides (lower part) grow downward on the substrate of hydrogenetic Mn-oxides (upper part).

Fig. 4 Mn-oxides nodule from the unnamed seamount on the Manji chain
Alternation of layers of hydrogenetic (dark part) and hydrothermal Mn-oxides (lighter and metallic part) is observed. This texture implies that hydrothermal activity continued intermittently for a certain period (Growth rate of hydrogenetic Mn-oxides is estimated to be around 1cm/1Ma in this area. (Usui, pers. comm.)).
Fig. 5 Hydrothermal Mn-oxides ore replacing limestone from the Daigo Nisi-Sumisu knoll. Hydrothermal Mn-oxides partly replace the fossils including foraminifera. Overgrowth textures of Mn-oxides on the fossils are also common.

Fig. 6 Bacteria-like fossils in nontronite from the Daigo Nisi-Sumisu knoll. Cellular texture is clearly observed.