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A submarine caldera volcano as an incubator of mineral resource and subseafloor biosphere

Jun-ichiro Ishibashi (Kyushu University, Japan)
ishi@geo.kyushu-u.ac.jp
Toshiro Yamanaka (Okayama University, Japan)
toshiroy@cc.okayama-u.ac.jp

Volcanic calderas provide suitable environment for development of a hydrothermal fluid circulation system. Moreover, the hydrothermal system related with arc-backarc caldera volcano can be long-life, because the heat source magma would be regenerated several times. Submarine volcanoes are good target fields to study accumulation of mineral resources and development of rich and varied subseafloor biosphere, both would be related with such a long-life hydrothermal fluid circulation and with significant involvement of volatile species from a magma just below the caldera floor. Drillings provide opportunities to obtain subseafloor materials those are useful for geochemical and microbiological studies. These studies provide physical and chemical parameters to subseafloor environment that is supported by the fluid circulation and strong evidence for biogeochemical interactions within the subseafloor biosphere. Moreover, direct measurements using borehole observatory is important for these studies, because the hydrothermal system is dynamic. Interdisciplinary studies would enhance understanding mechanism of development of a hydrothermal system and its products.

Research focus

A caldera is a volcanic depression formed by evacuation and eruption of magma, which is often observed as a mode of felsic volcanic activity in plate convergent regions. Submarine calderas are often becomes large structures because collapse of volcanic piles by gravity is suppressed.

Calderas provide suitable environment for development of a hydrothermal fluid circulation system. Subsurface magma at rather shallow depth is a large source of heat to drive hydrothermal systems. Structural permeability afforded by caldera faults focuses hydrothermal fluid upflow. Accumulation of significant thickness of pyroclastic deposits within the caldera would cause stratigraphic permeability that can develop large volume of an aquifer. Moreover, a hydrothermal fluid circulation system related with arc-backarc volcanic activity can be long-life, because the heat source magma would be regenerated several times. Submarine volcanoes are good target fields to study accumulation of mineral resources and development of rich and varied subseafloor biosphere, both must be related with such a long-life hydrothermal activity.

Expected new outcomes

Drillings provide opportunities to obtain subseafloor materials those are useful for geochemical and microbiological studies, which enables qualitative discussions of understanding mechanism of development of a hydrothermal system and its products.

A size of fluid circulation cell of a caldera hydrothermal system would be as large as the caldera's size. By a case study of a semi-submerged caldera in the Kyushu Island, Japan, it is revealed that venting fluid from a submarine crater at 200 meters water depth partly originates from meteoric water based on the δD-$\delta^{18}O$-Cl systemtatics of pore fluids in the shallow sediment. This clearly indicates fluid circulation cell has a size of at least 10 km, because the venting site is located far from the shore lines which are flanged by the outer rim of the caldera. In the case of submarine calderas, recharged fluid might be entrained also from the outer part of the caldera, because the volcano body consists of lava flow and volcaniclastic material.

Evolution of the fluid geochemistry from the entrained seawater is caused by fluid interaction with volcaniclastic sediment during the fluid circulation. The fluid-sediment interaction would be enhanced by

involvement of magmatic volatiles that contributed from felsic magma. Mobility of elements between fluid and sediment would be revealed by geochemical studies of pore fluids and alteration minerals. Geochemical studies focusing on trace elements could provide the final answer for an important question whether ore metal elements are supplied by involvement of magmatic volatiles or leaching of crustal material.

Transportation of reductive chemical species by the hydrothermal fluid circulation supports subseafloor biosphere within the stratigraphic permeability. A submarine arc/backarc caldera could be an incubator for subseafloor biosphere, because large volume of habitat space is secured within porus volcaniclastics that sediments horizontally and plenty metabolic sources are supplied as magmatic volatiles. Moreover, microbial diversity might be expected, because steep temperature gradient is caused by shallow existence of the heat source.

Path to achieving the goals

Drillings provide opportunities to obtain subseafloor materials those are useful for geochemical and microbiological studies. These studies provide chemical parameters to describe subseafloor environment and strong evidence for biogeochemical interactions within the subseafloor biosphere.

Moreover, direct measurements using borehole observatory is important for these studies, because the hydrothermal system is dynamic. Such observatory would provide important data for hydrological, geochemical and microbiological discussions. Interdisciplinary studies would enhance understanding mechanism of development of a hydrothermal system and its products.