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Geochemical studies of hot springs in Tokara Islands

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Tokara Islands include several volcanic islands which is southwestern extensions to volcanoes in Kyushu. A previous systematic geologic study (Yokose et al., 2010) demonstrated three huge submarine calderas which were formed by Quaternary volcanic activity in this region. It is well known that formation of volcanic massive sulfide ore deposit is often strongly related with hydrothermal activity within submarine caldera structure. We studied geochemistry of hot spring waters collected from some islands in the Tokara Islands, with a view to explore possible hydrothermal activities at the seafloor of the submarine calderas. Hot spring water samples were collected in December 2009, from hot springs in the Kuchi-no-Shima which is the outer rim of the Kuchi-no-Shima Submarine Caldera and in the Ko-Takara Shima which is in adjacent to the Takara Shima Submarine Caldera. Chemical analysis of major elements composition was conducted by conventional methods (ICP-AES, AAS, IC and so on).
The hot spring waters from Kuchi-no-Shima (T=65.9 degC, pH=6.03-6.51) showed low SO4 and Cl concentrations, which molar ratio (SO4/Cl = 3.8) was distinctive from that of seawater but similar to the reported value for the volcanic gas collected from the Kuchi-no-Erabu that is located at about 50km northeast. Cation composition of the hot spring waters showed similar pattern to the reported bulk chemical composition of acidic rocks collected from the Kuchi-no-Shima. The hot spring water chemistry would be explained by a conventional model for acid sulfate hot spring water formation; an acidic hot spring is formed by involvement of magmatic volatiles into the meteoric water and then leaches cations from volcanic rocks during the fluid-rock interaction. As the previous exploration (Yokose et al., 2009) reported evidence for hydrothermal alteration such as clay minerals and sulfides in the Kuchi-no-Shima Caldera, emanation of acidic hydrothermal fluid might be found as well as subaerial hot springs.
The hot spring waters from the Ko-Takara Shima showed a range from high temperature waters (T=86.8-88.5 degC, pH=5.04-5.06) to a strong acidic water (T=51.5 degC, pH=2.72). All of the spring waters showed high Na and Cl concentrations with the ratio of Na/Cl =0.88 close to that of seawater. Although both Na and Cl concentrations are higher than that of seawater, Mg and SO4 are depleted in the hot spring waters. The hot spring water chemistry would be explained by a conventional model for brine-rich submarine hydrothermal fluid formation; After Mg and SO4 removal from the seawater due to high temperature (>200 degC) fluid-rock interactions, phase separation causes Na and Cl enrichment. Fluid temperature of the interactions could be estimated by the alkali geothermometer as around 280 degC, which is close to the boiling point at 600 to 700 meters water depth. The hot springs in the Ko-Takara Shima could be one of discharge vents of a submarine hydrothermal system.
More strong evidence would be expected from ongoing isotopic studies of hot spring waters.

Yokose et al. (2009) Evidence of recent hydrothermal activity in the Amami caldera: discovery of Fe-Mn crusts enriched in As and Mo. Gekkan Chikyu.
Yokose et al. (2010) Mid-Pleistocene submarine acidic volcanism of the Tokara Islands, Japan. Journal of Geography, 119, in press.

Keywords: submarine huge caldera, submarine hydrothermal system, Kuchi-no-Shima,
Ko-Takara Shima