Behavior of iron hydroxides in Nagahama Bay, Iwo-Jima Island, Kagoshima, Japan

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Iron-rich sediments are now known to be bog iron and iron formations found only in limited areas such as mine drainage, wetlands, and seafloor where low-temperature hydrothermal waters circulate, where redox changes are abrupt (eg. Afify et al., 2015). The most widespread banded iron formations were formed at limited times around 2.5 billion, 1.8 billion, and 700 million years ago, and their sedimentation is considered to be indicators of the Earth's surface conditions during the Precambrian era (eg. Becker et al., 2014). However, the behavior of iron colloids leading to the precipitation and precipitation of iron hydroxide in water during the formation of these sediments remains unclear.

In Nagahama Bay, Satsuma Iwo-jima island, the seawater is always filled with orange-colored iron hydroxide in colloidal form, and thick iron hydroxide precipitates on the seafloor in the bay (Kiyokawa and Ueshiba, 2015). The hydrothermal water from the coastline contains high concentrations of iron (Fe^{2+} :191 ppm; Shikaura and Tasaki, 2001), which is oxidized by mixing with open seawater to produce iron hydroxides (Ninomiya and Kiyokawa, 2009). In this study, we measured the properties of seawater (temperature, turbidity, pH, ORP, and electrical conductivity) at different depths in the bay using a Horiba U-52. Then, the state of the seawater cross-section in the bay and the movement speed of the hydrothermal water and the behavior of iron hydroxide were investigated.

Method) Surface layer of Nagahama Bay: The flow of hydrothermal water on the surface of the sea was observed by a drone with temperature sensor at the Nagahama Bay landing site (E-site), and the flow of hydrothermal water on the surface of the sea from the hydrothermal water outflow area to the south was revealed.

Seawater cross-section: The seawater cross-section of 40m north-south and 3-7m depth at the Nagahama Bay landing site (E-site) was measured. A rope was stretched north-south from the inflow source to the bay, and measurement were taken from the surface to the seafloor at 20-50cm intervals in the depth direction at points (0m, 1m, 3m, 9m, 16m, 23m, 30m) from the boat using the outflow source as a reference point. The data were analyzed using Python3 to produce a north-south cross section showing continuous changes.

Date and time of water quality measurement: Measurements were taken at five different times eduring the period November 9, 2020- November 11, 2020: high tide, high tide, low tide, high tide and low tide, taking about one hour per measurement line.

Results) Surface water temperature observation by drone: Hydrothermal water upwelling was observed directly under the embankment and at the beach. In the E-site, a large amount of hydrothermal water upwelling was observed between the breakwater blocks, and the hydrothermal water is rising to the surface in the form of a plume.

Water quality measurement at seawater cross section: The pH in the surface layer (especially at a depth of 0-1 m) increases from the outflow source to the open sea, while the pH at the sea bottom is generally high and remains constant at about 8.0. The water temperature decreases from the outflow source (25.6℃) to the open sea (25℃), and remains almost constant at the sea bottom (24.5℃). Turbidity was found to be low at the sea bottom (constant at 20-30 NTU) and high at the surface (over 70 NTU) from the middle to the open sea. The turbidity was low (40-50 NTU) at the outflow source side, and the range to the point where the turbidity became high was 5-10 m at the low tide and 0-5 m at the high tide. The difference by tide level showed that the open sea water flowed quietly into the sea bottom at the high tide, and the

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effect of the high tide level was observed in all properties of seawater. The transparent part about 5 m from the outflow source was visible at high tide.
(Discussion) It was clarified that the hydrothermal water rises to the surface and flows out to the open sea, and the depth of the water affected by the rising hydrothermal water is 0-1m from the surface. The other indices show continuous changes, but only turbidity has a transparent part about 5 m from the outflow area (at high tide). This indicates the time it takes for the divalent iron ions in the hydrothermal water to be oxidized and precipitated as iron hydroxide colloids after gushing out. From the drone images, the velocity of the hydrothermal water flowing through the surface layer was estimated to be about 10.7 cm/s. Assuming that the amount of hydrothermal water flowing out and the speed of movement were constant, it took about 47 s for the hydrothermal water to change to iron hydroxide colloids.

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