Risk of heavy metal and arsenic contaminations and its effect on marine phytoplankton during seafloor mining

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[Introduction]
Hydrothermal ore deposits are important as a metallic mineral sources. Many sulfide deposits containing Cu, As, Ag, Pb and Zn were found in the Exclusive Economic Zone of Japan. Recently, development of seafloor mining technology is advanced to use commercially those minerals. Environmental impact assessment is required because the seafloor mining could lead to marine environmental problems. For example, heavy metals and arsenic might be released from waste ore minerals during transfer of those from seafloor to vessel.
Here, we discuss about the possibility of heavy metal and arsenic contaminations and its effect on the primary production of marine phytoplankton during seafloor mining.
[Experimental]
Five types of chimney samples (G03, G04, G05, G06, and R04) which collected from hydrothermal fields of Iheya North Knoll and Izena Hole during the NT11-15 (Aug. 2011, R/V Natsushima) and NT12-06 (Mar. 2016) cruises with provided from JAMSSTEC. In the laboratory, the chimneys were powdered manually and sieved with a 1/16 mm mesh. Approximately 3.0 g of the powdered chimney was stirred into 30 mL of ultrapure water or artificial seawater (Daigo SP) in a Teflon centrifuge tube (50 cm^3), and then the tube was shaken at room temperature for 6 h. The solid phase was separated by centrifugation and filtration (0.2 μm). The metals dissolving in the solution were quantified by ICP-AES and ICP-MS.
Marine phytoplankton was incubated to evaluate the toxicity of the metals released from the chimney to the phytoplankton. Seawater was collected from subsurface chlorophyll maximum layer at hydrothermal fields of Iheya North Knoll and Bayonnaise Knoll during the KR15-17 (Nov. 2015, R/V Kairei) and KR15-20 (Dec. 2015), respectively. The solution reacted with the chimney G06 was added to the seawater and incubated for 18 h on the board. The chlorophyll fluorescence (F0) of the sample solution was determined by a pulse amplitude modulated (PAM) fluorometer.
[Results and Discussion]
Heavy metals such as Zn, Pb, Mn, Cd, and Cu and As were released from the chimney into the solution after the shaking with ultrapure water. The concentrations of Zn dissolving in the solution were between 41.7–1026.0 ppm. Arsenic (43.1 ppm) was the most abundant in the solution reacted with the chimney G05. Copper (61.6 ppm) was highly released from the chimney G06, whereas it was undetected from the other samples. The compositions of metals dissolving in the solutions were different from those of the chimneys. When the chimney was reacted with artificial seawater, the concentrations of heavy metals and arsenic dissolving in the solution were similar to ultrapure water. These results suggest that heavy metals and arsenic could be released from ore minerals to ocean during seafloor mining.
The chlorophyll fluorescence of seawater gradually decreased with time without addition of the solution reacted with the chimney G06. Marine phytoplankton living in the seawater collected from the subsurface chlorophyll maximum layers would be unvigorous. When the solution reacted with the chimney G06 was added to the seawater (0.2 %), the chlorophyll fluorescence rapidly decreased with time. Therefore, the primary production of marine phytoplankton would be limited by heavy metals

and arsenic released from ore minerals.

Keywords: seafloor mining, marine phytoplankton, heavy metal contamination

