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Seasonal changes of physical and chemical properties in Mn-rich cold spring

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Hiramatsu cold spring contains about 2 mg/L of manganese and precipitates unconsolidated manganese oxide in its tanks and bathtub (Takashima et al., 2012). But, origin of Mn in the cold spring is not clear. This study identifies origin of Mn-rich cold spring and causes of seasonal changes in the water chemistry from a continuous observation for a year.

This spring is located at Saga city, Saga Prefecture. Depth of this spring source is very shallow, about 7.5 m, from the altitude of about 2 m. Jizou River flows about 150 m west from the spring. Geology of Saga plain on the basal granite consists of the Nakahara Formation, Takagise Formation, Aso-4, Mitagawa Formation including sands and gravels, Ariake Clay, sands and gravels?rich of the lower Hasuike Formation, clay-rich upper Hasuike lower formation, in ascending order (Miura et al., 1996). A continuous observation was performed from January 2012 to January 2013. Samples were collected from the spring source and Jizou River after measuring water temperature, pH and dissolved oxygen concentration (DO). Collected water samples were analyzed of alkalinity, water chemistries and stable oxygen isotope.

Results of the continuous observation indicate distinct seasonal changes of each parameter in the spring and the river water, especially in a period from June to August. The spring water temperature is stable at about 18 degree from January to May and increases to August, and then decrease to 18 degree from September to next January. On the other hand, the river water temperature increases continuously until August, and decreases during next winter. The spring water tends to be stable in slightly alkaline, but in July and August, it was neutral pH. DO concentration of the spring water is less 1.5 mg/L during winter, and keep high level (above 1.5 mg/L) during summer. Concentrations of Mg, Na, Cl, Mn clearly decreased in summer. Oxygen stable isotope values of the spring water show lighter values in summer.

Depth of the spring source is very shallow and probably comes out sand and gravel rich Hasuike lower formation located about -5 m below the sea level. Given shallow depth source and geology around the cold spring, meteoric water should be the origin of the cold spring water. But seasonal changes of the spring water temperature and dissolved component concentration cannot be explained by such a simple origin. The Mg-rich spring water does not consistent with Ca-HCO_3 type groundwater in granite area (Sasaki, 2008). Moreover, because the spring water temperature is very stable excepting for summer period, the spring water contains likely groundwater in aquifer. Candidate of an aquifer is the Ariake Clay lying below the lower Hasuike Formation, which contains much Mg and Mn. Therefore, the cold spring is consists of mineral-rich groundwater in the Ariake Clay and meteoric water.

Seasonal changes of each parameter in the cold spring during summer reflect dilution effect by meteoric water. During summer, meteoric water of high temperature and lower density flows above the Ariake Clay, and, the cold spring also becomes high temperature of lowered concentration of dissolved components. In contrast, during winter, fractions of mineral-rich groundwater increase due to raising the aquifer, because higher density meteoric water flows under the aquifer.

[References]

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