Geochemical studies on the groundwater in SW Shimane Prefecture and NE Yamaguchi Prefecture, SW Japan

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Introduction The groundwater and mineral springs which contain high concentration of salt with carbon dioxide gas are erupting in SW Shimane Prefecture and NE Yamaguchi Prefecture, including the Shiogahara mineral spring in Tsuwano town, Shimane Prefecture. They are distributed along the Oharako-Yauneyamanishi fault system and are considered as deep crustal fluid. We investigate the origin of groundwater and gas and their flow path based on the geological and geochemical studies.

Geology, geological structure and gas eruption The location of the Shiogahara mineral spring is characterized by complex geology consisting of Paleozoic sedimentary rocks, Mesozoic accretional complex and metamorphic rocks which are bordered with faults each other. The other springs are distributed in the Cretaceous volcanic rock area. All springs are distributed along the Oharako-Yauneyamanishi fault system. Alternatively, CO_2 gas erupts intensively in the bed of the Tsuwano River near the Shiogahara mineral spring.

Geochemical properties of groundwater We measured the electrical conductivity (EC), oxidation-reduction potential (ORP), dD and $d^{18}O$ (vs. SMOW) of groundwater. ECs of the Shiogahara mineral spring are from 1.9 to 2.8 S/m, the highest value in the area. ECs of the Washibara spring, Kibetani and Kakinoki hot springs is from 0.9 to 1.3 S/m, are from 0.4 to 0.6 S/m, respectively. Other springs are from 0.1 to 0.3 S/m. Farther away from the Shiogahara Mineral Spring, lower EC of spring water. Water quality of the springs is characterized by NaCl type, excluding Yunoki Jisho Hot Spring ($NaHCO_3$ type). dD and $d^{18}O$ of groundwater erupted from Shiogahara, Washibara and Kibetani springs are plotted on the right side of meteoric water line in delta diagram.

Noble gas $^3He/^4He$ ratios of groundwater in the study region are from 3.63RA to 5.71RA, and indicate a high value with uniformity. $^4He/\ ^{20}Ne$ ratio of noble gases in the study area is similar in value each other, suggesting the same origin.

Dissolved Inorganic Carbon (DIC) and $d^{13}C$ $d^{13}C$ (vs. PDB) in CO_2 gas is from -9.0 to -7.2 permil and that in groundwater is from -7.8 to -3.3 permil, respectively. As a result of comparison of the $d^{13}C$ (vs. PDB) with dissolved total carbon, it is suggested that carbon which is not originated from soil gas is contained in the spring waters.

Discussion Origin of fluid: It is thought some of the fluid might be expelled from deep underground based on the following evidences,

1. dD and $d^{18}O$ of groundwater are plotted on the right side of meteoric water line
2. $^3He/^4He$ ratios of groundwater are higher than those of air composition

In addition, geochemical date obtained in the study area is similar to that in the Arima Hot Spring water, showing that they can be correlated with the Arima Type thermal Brine. As the result of dD and $d^{18}O$ measurements, the Shiogahara mineral spring is mostly influenced by the contribution of deep fluid without a meteoric water. On the other hand, relationship between $CO_2/^3He$ and $d^{13}C$ suggests that carbon in groundwater is mainly originated from marine carbonate such as limestone.

Ascending flow path and geological structure: Salinity of the groundwater decrease with being apart from the Shiogahara mineral spring progressively. On the other hand, concentration of $^3He/^4He$ ratios of noble gas in all springs is similar each other. This suggests that groundwater and gas are different in ascending behavior. The geochemical composition of noble gas, chloride concentration and the location of the springs suggest that deep crustal fluid ascends possibly in the spot area and finally erupts through the major fracture zones in the shallow underground.