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NaCl-CO_2-bearing hydrothermal brine related to deep low frequency earthquake: origin and genesis

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Activity of deep low frequency earthquakes (DLE) in Japan have been monitored mainly by Hi-net for the last decade. Those earthquakes are well-determined for hypocenter having feature of very deep (20-40km depth) and thought to be related with hydrothermal fluids. Characteristic feature of spatial distribution of DLEs are; type-1) found along 1000 km of the SW Japan arc at about 35 km deep on the upper part of subducted Philippine Sea Plate, type-2) occur close to Quaternary volcanoes, and type-3) occur as non-volcanic clusters at depth from 20-45km. To get information of deep crustal hydrothermal fluids play roles on DLE, we investigated groundwater data close to areas just above hypocenter of DLE and summarized chemical and isotopic compositions of waters. In this study, we will show characteristics of deep crustal hydrothermal fluids and discuss their origin and genesis.
As for type-1 related fluids, the Arima-type thermal brines found along the Median tectonic line (MTL) through Shikoku-Kinki-Tokai district are likely the fluid concerned because most of them have a mixing end-member with isotopic composition of water similar to magmatic water, highly saline nature and free CO_2gas from deep sources. In spite that they have some magmatic signatures, the Arima-type brines found on MTL are likely originated from dehydrated water from altered basalts in the Philippine Sea slab since there are no mantle above the slab beneath the MTL. Type-2 DLEs occur close to most of the active Quaternary volcanoes. We recognized cases that saline hot springs containing free CO_2gas exist around volcanoes, but they are neutral to a little acidic in pH, and never be of low pH like the volcanic fluids degassed from shallow magmas. These neutral saline water tends to contain more ferrous ion less sulfur species than acidic magmatic water indicating that saline water come from reduced condition of state which generally attained at great depth. Sulfur species could be deposited as sulfide at depth and it is difficult to be transported to the surface. Furthermore, amounts of free $CO_2$with NaCl would never come from shallow degassing magmas but likely from fluids when basalts at lower crust solidified. Type-3 DLE clusters are found at non-volcanic areas especially in Chugoku-Kinki and Tohoku-Hokkaido regions. Some saline hot springs spouting with free $CO_2$are identified close to type-3 clusters. We think that these type-3 clusters are possibly related to solidifying basaltic magmas.
As indicated above, the representative saline hydrothermal fluids related to DLE is NaCl-CO_2-H_2O-type waters lacked sulfur and they are similar to each other on chemical and isotopic feature regardless of the type of DLEs. Isotopically, all these waters are mixture of local meteoric water and magmatic or Arima-type waters indicating that their ultimate origin is the same water, dehydrated from the slab. Our preliminary conclusion is that the type-1 water seems directly upwell through tectonic lines from dehydration places, and type-2 and -3 waters migrate in the wedge mantle then produce magmas, and at last released from solidified magmas at a lower crust.

Keywords: deep low frequency earthquake, distribution of hypocenter, Arima-type thermal brines, free CO2 gas, non-volcanic fluid