Origin of deep thermal water from hot spring wells in Oita plain, eastern Kyushu, Japan

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Chemical and isotopic compositions (concentrations of major dissolved constituents, dD and d18O of water and d13C of dissolved inorganic carbon) were determined for 11 hot and cold spring waters of Na-Cl,HCO3 type especially which have high salinity collected from deep wells and natural springs in the Oita plain, eastern Kyushu, Japan. On d18O and dD diagram, most data points of the sampled hot and cold spring waters are plotted near local meteoric water line and this shows that these waters come from local precipitation. However, two of them with very high Cl concentration (24000mg/L and 19000 mg/L) have extremely high dD and d18O values (-22.2 per mil, -27.1 per mil and +2.7 per mil, +1.9 per mil, respectively) and it can be classified into the Arima-type deep thermal water. We thought that such high values in water isotope composition imply that these saline waters are originated from andesitic magmatic steam or metamorphic water. Linear relationship between reciprocal of concentration and stable carbon isotope ratio (d13C) of dissolved inorganic carbon (DIC) of the sampled waters shows that DIC in the hot and cold spring waters laid under the Oita plain is the mixture of soil CO2 and magmatic or mantle-derived CO2. Concentration and d13C of DIC in the foregoing heavy waters are 24000mg/L, 19000mg/L and -3.8 per mil, -3.2 per mil, respectively and these accord with the deep-originated end-member of the mixing relation as shown before. Therefore, it is appropriate that the Arima-type deep thermal water found in the Oita plain this time is derived from the Earth's interior. Furthermore, formation of this deep-originated thermal water should have no relation to magma generation, because the Oita plain is located in fore-arc region. Linear relationships between dD versus Li concentration and dD vs. B concentration of the sampled hot and cold spring waters also show that these waters are a mixture of two end-members: one is subsurface water of meteoric origin having low dD and low Li and B concentrations and the other is deep-originated thermal water having high dD and high Li and B concentrations. The latter would be the fluid devolatilized from the subducting oceanic plate. In addition, good liner relations between Li and Cl concentration and B and Cl concentrations of the sampled hot and cold spring waters suggest that Cl as major constituent of these waters of Na-Cl,HCO3 type in the Oita plain is also derived from the devolatilized fluid of the slab.