Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

AHW26-P22 Room:Convention Hall Time:May 24 17:15-18:30

Comparison between volcanic and non-volcanic thermal waters using the chloride type thermal waters in Kanagawa Pref.

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The sodium-chloride type thermal waters which are discharged in the Hakone volcano, located in the west margin of Kanagawa Prefecture, central Japane, are widely known as the typical volcanic thermal water originated from magma, that is, slab-derived fluid (Oki and Hirano, 1970). Recently, the sodium or calcium-chloride type saline waters and brines have been obtained from deep wells installed in the Kanto sedimentary basin of the eastern Kanagawa Prefecture. Itadera et al. (2011) suggests that these deep well saline waters are probably originated from modern or fossil seawaters. The purpose of this study is to understand the difference of the geochemical features between volcanic and non-volcanic chloride type thermal waters discharged in adjacent regions.

The sources of the deep well waters in Kanagawa Prefecture were divided into three groups, (1) modern seawater, (2) fossil seawater and (3) meteoric water, on the basis of the relationship between Cl^- and $SO_4{}^{2-}$ concentrations (Itadera et al., 2011). On delta-diagram the saline waters of group 1 are plotted along the mixing line between meteoric water (group 3) and V-SMOW (modern seawater), while those of group 2 are plotted below the mixing line (type A) or on the meteoric water line (type B). Almost all the saline waters of type A are discharging from Kazusa formation (Pliocene to Pleistocene), having higher Br/Cl ratio ($4.0x10^{-3}$) than that of modern seawater with natural gas as well as the natural gas brine in the Minami-kanto natural gas field (Maekawa et al., 2006). The source water of type A seems to be interstatial water of marine deposits, since the depletion of ^{18}O and Mg^{2+} perhaps produced by alternation of volcanic materials in sediments are found as well as pore water from sediments in oceanic crust (Lawrence and Gieskes, 1981). The saline waters of type B are discharging from Hayama formation (Miocene) which is lower than Kazusa one. On the figure of $d^{18}O$ vs. Cl^- concentration, the most saline waters of type B are plotted on the left-hand side of mixing line between meteoric water and modern seawater, namely the chloride ion is depleted and ^{18}O enriched in seawater. Similar saline water samples are produced from deep wells drilled in Miocene sedimentary rocks at Niigata and Miyazaki Plain. These saline waters seem to be diagenetic water originated from dehydrated interlayer water in smectite. (Ito et al., 2004 and Ohsawa et al., 2010).

The sodium-chloride thermal waters in Hakone volcano are discharging in Gora area, located on the flank of central cones in the caldera, and Hakone-Yumoto, located in the eastern margin of the caldera along valleys which is deeply dissected by Hayakawa and Sukumogawa rivers. Chloride concentration (below 3500m/L) of thermal waters is less than that of the deep well saline waters in the Kanto sedimentary basin. Though the isotopic shift is a little, the thermal waters in Hakone volcano are linearly plotted form meteoric water and high temperature volcanic steam (Matsuo et al., 1985). However, the Li/Cl ratios of thermal waters, which are useful value when seawater and slab-derived fluid are distinguished, differ between Gora and Hakone-Yumoto areas. Most thermal waters of Gora area have higher value ($0.5\tilde{}1.0x10^{-3}$) than those of Hakone-Yumoto ($0.25\tilde{}0.1x10^{-3}$) with closer value of seawater. The Br/Cl ratio of Gora area is inversely lower value ($1.5\tilde{}2.5x10^{-3}$) than that of Hakone-Yumoto area (around $3.0x10^{-3}$) in relation to the Br/Cl ratio of seawater is $3.46x10^{-3}$. These characteristics of thermal water in both areas seem to be attributed to the effect of the common source water (provably high temperature volcanic steam) and different geological settings and sources of dissolved components.

Keywords: deep hot spring water, Hakone hot springs, interstitial water, diagenetic fluid, volcanic fluid