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Hydrogeochemical characteristics of mineral and thermal waters

title: **Hydrogeochemistry and noble gas geochemistry of geothermal waters from the Chungcheong province, central South Korea**

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An investigation of geothermal chemistry in South Korea has given insight into the degassing and circulation of volatile elements in this tectonic transition zone between island arc and continent. Fifteen geothermal water and gas samples from eight hot spa sites and one deep well test site were obtained from the Chungcheong Province of South Korea.

We measured chemical composition as well as the stable and noble gas isotopic ratios of the samples and found composition varied according to tectonic location. Water temperatures at the sample sites range from 21.4 to 47.0°C. All waters are alkaline (pH 7.6–9.8) with electrical conductivity of 224–495 μS/cm, the one exception being the CO_2–rich Neungam sample, whose waters are weakly acidic (pH 6.3) with very high electrical conductivity (2,780 μS/cm), high P_{CO2} (0.998 atm) and the highest $^3He/^4He$ ratio (1.76×10^{-6}) observed amongst our samples. The Chungcheong geothermal waters can be grouped into three chemical types related to temperature: Ca–HCO_3, Ca(Na)–HCO_3 and Na–HCO_3 (Fig. 1a). $\delta^{18}O$ and δD values range from –10.4 to –7.9‰ and from –77.9 to –58.8‰, respectively, and plot below the meteoric water line.

A wide range of $^3He/^4He$ ratios is observed (0.036 to 1.76 ($\times10^{-6}$)), showing evidence that while radiogenic ^4He is dominant in these samples, He of mantle-origin is also supplied to these waters. $^{40}Ar/^{36}Ar$ ratios are close to or slightly higher than the atmospheric value. Concentrations of ^3He and $^4He/^{20}Ne$ ratios increase with increasing water temperature within a single hot spa area, which may be explained by local groundwater mixing by mantle-derived He found in the high temperature waters (Fig. 1b). The concentration and isotopic composition of other noble gases (Ne, Ar, Kr and Xe) measured from the samples indicate that they are atmospheric in origin.

a) b)

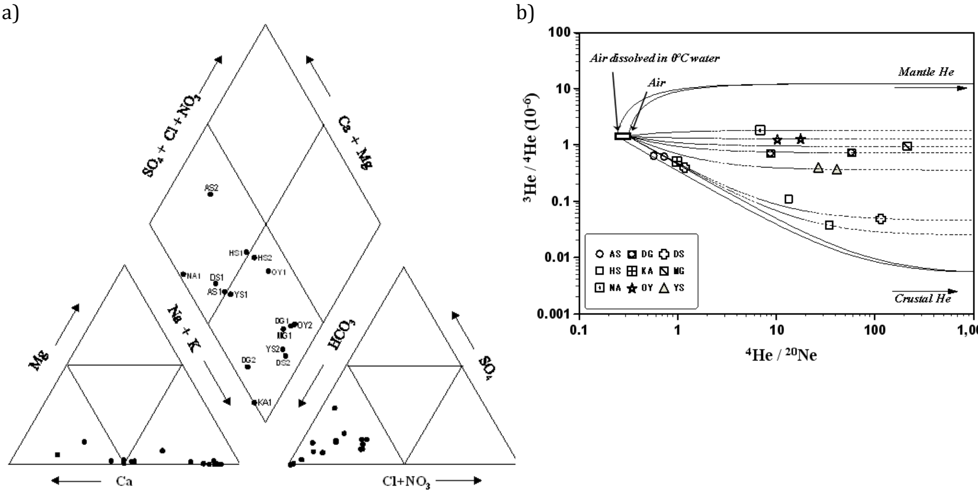

Figure 1. Trilinear Piper diagram of major ion compositions of geothermal water Samales (a), and plot of $^3He/^4He$ versus $^4He/^{20}Ne$ ratios for waters and gases (b).

From a broad geographical view point, the observation that the maximum $^3He/^4He$ ratio for our samples is lower than those observed for volcanics from the Japanese Islands is consistent with the increasing depth of the subducted oceanic plate beneath the Korean Peninsula (Zhao et al., 2004, 2007). The observed mantle He signatures show no relationship with basement rock type such as granitoid, high-grade gneiss or schist, temperature of waters and/or location of geothermal water site. The discharge rate of mantle He might be controlled by underground structures such as deep-seated faults. We speculate that a deep-seated fault system and a stagnant subducting plate beneath the Korean Peninsula play an important role in the release of mantle volatiles in a transitional tectonic setting.

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