The $^3He/^4He$ ratios in hot spring gases after the Iwate-Miyagi Nairiku earthquake in 2008

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On the basis of high density and sensitivity seismograph network progressed in recent years, geophysical studies indicates that aqueous fluids supplied by the slab reach shallow level effecting local contractive deformation and increasing the local crustal contraction rate in NE (northeastern) Japan (e.g. Hasegawa *et al*., 2005). However, the presence of aqueous liquid is estimated only by the seismic velocity anomalies and it seems difficult to detect a kind of upwelling aqueous liquid simply by geophysical studies.

The Iwate–Miyagi Nairiku Earthquake in 2008 occurred on 14 June 2008. The epicenter was 39°1.7'N 140°52.8'E with the magnitude M7.2 (outlined information released from JMA). A $^3He/^4He$ ratios could be a good tracer to identify the origin of the aqueous fluid, as the helium isotopic ratios in the mantle and crust are quite different each other. A 39–39.5°N area in NE Japan have ratios as low as 1 Ra, indicating the presence of crustal material under this region, which is also supported from the seismological underground structure (Horiguchi, 2008).

In a week and half a year after the earthquake, some water/gases samples were collected from hot springs near the epicenter, with the intention of studying the change of $^3He/^4He$ ratios after the event. We measured a $^3He/^4He$ ratio with He and Ne concentrations of the dissolved gases by using the noble gas mass spectrometer (VG 5400) installed at Osaka University.

The obtained results show that $^3He/^4He$ ratios increased in many hot springs in this region by 10-85% after a week. After half a year, $^3He/^4He$ ratios decreased at the nearest point of the main shock region. Meanwhile, the isotopic ratios further increased in the northwestern part of the main shock region. These results suggest that there was an uplift of the mantle material containing the primordial ^3He-containing fluid and this could be the cause of the earthquake.

We plan to compare these geochemical results with the geophysical data in this region.

Isotope fractionation of fluids under geologic conditions

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Isotopic properties of molecular fluids such as the reduced partition function ratios (RPFR) have traditionally been calculated by means of the well-established statistical mechanical approach, which implicitly assumes no significant intermolecular and solute-solvent interactions. However, recent several laboratory experimental studies [1, 2] clearly demonstrated that isotopic fractionation involving fluids changes measurably as a function of, not only temperature, but also pressure and fluid compositions. These results showed that the above assumption for molecular fluids is not valid under geologic conditions, underscoring the need of better understanding of the isotopic properties of 'real' geologic fluids.

Along with laboratory experiments, we have been developing theoretical and molecular-based simulation methods for investigating the isotopic properties of fluids (*i.e*., water, N_2, O_2, CO_2, CH_4) to high-pressures and temperatures. Our first method utilizes thermodynamic relationship to calcualte the effect of pressure (density) on the RPFR, using the equation-of-state of isotopologues, which is available from the literature or can be obtained from our novel corresponding-states priciple approach [3, 4]. A second approach is based on statistical-mechanical, molecular-based simulations, using the perturbation method [5, 6]. We present an overview of our efforts, along with literature data, on experimental, theoretical, and simulation results on the isotopic properties of fluids.

Sponsored by the Division of Chemical Sciences, Geosciences, and Biosciences, Office of Basic Energy Sciences, U.S. Department of Energy under contract DE-AC05-00OR22725, Oak Ridge National Laboratory, managed by UT-Battle, LLC.

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