Helium isotope ratios in northeastern Japan and their comparison with the seismological data

KEIKA HORIGUCHI[1]*, NAOTO TAKAHATA[2], YUJI SANO[2], SADATO UEKI[1], TOMOMI OKADA[1], JUNICHI NAKAJIMA[1] AND AKIRA HASEGAWA[1]

[1]Research Center for Prediction of Earhthquakes and Volcaic Eruptons, Graduate School of Science, Tohoku University, Sendai, Japan (*correspondence: keika@aob.geophys.tohoku.ac.jp)

[2]Ocean Research Institute, The University of Tokyo, Tokyo, Japan (ysano@ori.u-tokyo.ac.jp)

A helium isotope ratio ($^3He/^4He$ ratio) is a good indicator to distinguish the origin of fluid as a carrier, because the ratios in the mantle and crust are quite different each other.

We have collected 42 samples of gases from hot springs, mineral springs, and deep wells, located mainly in the forearc region in northeastern Japan (Tohoku district). In addition, we also collected 24 samples of gases from hot springs and natural gas fields around the epicenter of the Niigataken Chuetsu-oki Earthquake in 2007 (M6.8) in central Japan.

The geographic distribution of helium isotope ratios ($^3He/^4He$ ratios) is characterized by high values of 4 to $8R_A$ (where R_A is the atmospheric $^3He/^4He$ ratio of 1.40×10^{-6}) along the volcanic front and in the back-arc region at northeastern Japan. In contrast forearc region shows low values less than $1R_A$. On the other hand, there is no clear contrast of the $^3He/^4He$ ratios except at the central Japan (e.g., Sano and Wakita, 1985). We decomposed the helium data in northeastern Japan into three components originated from the mantle, crust and atmosphere using $^3He/^4He$ ratios and $^4He/^{20}Ne$ ratios, and compared the geochemical data with the seismographic data. We also compare our $^3He/^4He$ ratios data with those obtained in the previous data before the earthquake.

Main features of our results for northeastern region are as follows: (1) The geographical distribution of $^3He/^4He$ ratios in northeastern Japan are characterized by low values in the forearc region and relatively high values along the volcanic front. These features agree with the seismotectonic data. (2) The regions around the epicenters of the Chuetsu-oki Earthquake in 2007 and the Chuetsu Earthquake in 2004 are characterized by high $^3He/^4He$ ratios and low-velocity zones between mid crust and uppermost mantle. The spacio-temporal changes in $^3He/^4He$ ratios in this region suggest the recent injection of fluid from mantle into the shallow part beneath the source region.

The dolomite problem: Oxygen isotope fractionation to elevated temperatures

JUSKE HORITA

Chemical Sciences Division, Oak Ridge National Laboratory, TN 37831-6110 (horitaj@ornl.gov)

Among many unresolved issues associated with the formation of dolomite in modern and ancient sedimentary environments (the so-called dolomite problem), our current understanding of isotopic fractionation involving dolomite is sketchy and controversial. At 25-80°C, Fritz and Smith [1] and Schmidt *et al*. [2] determined isotopic fractionation for mixtures of protodolomite (no superstructure peaks) and aragonite/amorphous carbonates that were precipitated from aqueous solutions. Vasconcelos *et al*. [3] conducted an isotopic study on microbial protodolomite and ordered dolomite that were formed at 25-45°C. While these low temperatures studies produce generally consistent results for (proto)dolomite, two experimental studies at elevated temperatures, Northrop and Clayton [4] at 300-510°C and Matthews and Katz [5] at 252-296°C, yielded quite different results (2‰ in magnitude).

We have conducted a series of laboratory experiments for determining the oxygen isotope fractionation of dolomite-water system over a wide range of temperature (80-300°C). Dolomite was synthesized by: (a) precipitation of protodolomite with the composition of slight Ca-excess (0.51) and a nanometer size from a mixed solution of Mg-Ca-Na-SO_4-NO_3-CO_3 at 80°C (similar to [2]), and (b) dolomitization of powder calcite or aragonite in Mg-Ca-Cl solutions between 100 and 300°C for durations up to 100 days (similar to [5]). Our new results on oxygen isotope fractionation are consistent with those of the low-temperature studies and closer to the dolomitization data [5], rather than to those of isotopic exchange [4].

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