Origin of fluid causing earthquake swarms at southeastern foot of Ontake volcano

Yoshiro Nishio[1]; Kei Okamura[2]; Yuji Sano[3]

[1] KOCHI/JAMSTEC; [2] Kochi Univ; [3] Ocean Res. Inst. Univ. Tokyo

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Region around Ontake volcano is a notable research field for the nature of deep-crustal fluid. Since 1978, earthquake swarms have been observed continuously at the southeastern (SE) flank of Ontake volcano in central Japan. Earthquakes bigger than M4 have been occurred one or two a year. In this earthquake swarm region, uplift of 3-6mm has been also detected in 2002-2004 (Kimata et al., 2004). The results of specific electric conductivity measurements have revealed that these crustal deformation activities were caused by deep-crustal fluid (Kasaya et al., 2002; 2004). The origin of the deep-crustal fluid causing crustal deformation at the SE flank of Ontake volcano, however, has been unknown. It has been difficult to get information about deep-crustal fluid from spring and well water samples, because the deep-crustal fluid was very diluted by surface water during ascending. Lithium (Li), the lightest alkali metal, is a fluid-mobile element having two stable isotopes, ^{7}Li and ^{6}Li, with abundances of 92.5% and 7.5%, respectively. Amount of Li leached from rock to fluid drastically increases with the temperature, and once leached Li is kept in fluid while decreasing temperature (cooling). These features indicate that non-traditional Li isotopic tracer has a great potential to provide new insight on the origin of deep-crustal fluid. Accordingly, to reveal the origin of the deep-crustal fluid causing crustal deformation at the SE flank of Ontake volcano, we analyzed ^{7}Li/^{6}Li ratios together with ^{87}Sr/^{86}Sr ratios and chemical compositions of filtrated spring and well water around Ontake volcano. Analyzed fluids have been sampled biennially since 2000.

The results reveal that several samples from the earthquake swarm region have significantly lower d^{7}Li values than the island arc volcanic rock value (+3 ˜+5 per mil), where d^{7}Li = [[^{7}Li/^{6}Li]$_{sample}$/[^{7}Li/^{6}Li]$_{L-SVEC standard}$ -1] x 1000. Temperature-dependent Li isotopic fractionation occurs between fluid and rock, whereas the fluidal d^{7}Li value is always higher than the rock d^{7}Li value. Thus, the low d^{7}Li fluid that causes crustal deformation of studied area cannot be explained by simple magmatic fluid.

The d^{7}Li values of the earthquake swarm region samples vary widely from year to year, while the d^{7}Li values of samples in same place are decreasing with ^{87}Sr/^{86}Sr ratios. These correlations can be explained by two components mixing: one is surface water characterized by high d^{7}Li and low ^{87}Sr/^{86}Sr ratio and the other is non-surface fluid characterized by low d^{7}Li and high ^{87}Sr/^{86}Sr values. Although Li and Sr isotope compositions of non-surface fluid end-members vary with the sampling sites, it is inferred that the Li-Sr isotope variation may be result of second order (non-surface fluid) two components mixing between upper crustal fluid (d^{7}Li= 0 per mil, ^{87}Sr/^{86}Sr ˜0.710) and deep-crustal fluid. In this model, further low d^{7}Li value (˜-5 per mil) is required as the deep-crustal fluid value.

Reference

Kasaya et al., 2002. EPS 54, 107-118.
Kasaya & Oshiman 2004. EPS 56, 547-552.
Kimata et al., 2004, EPS 56, E45-E4