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Co-seismic fluid-rock interactions in fault zones

Tsuyoshi Ishikawa[1*], Tetsuro Hirono[2], Yohei Hamada[2], Go Honda[2]

[1]Kochi Inst. Core Sample Res., JAMSTEC, [2]Osaka Univ.

It is well known that fluid-rock interactions at high temperatures result in dramatic change of trace element and isotope compositions in solid phases. Trace element compositions of rocks after the interaction with fluid roughly depend on fluid/rock mass ratio and solid/fluid bulk distribution coefficients of elements, which vary as a function of temperature, if the initial compositions of rocks and fluids are constant. Thus theoretically it is possible to estimate the effects from fluid-rock interactions in fault zones on the basis of changes in trace element and isotope compositions of fault rocks.
In the Chelungpu fault in Taiwan, the black gouges recovered from three active fault zones exhibit marked increases of Sr and decreases of Li, Rb, Cs and 87Sr/86Sr relative to adjacent gray gouges, fault breccias, and undamaged sediments. Sr, Cs, Rb and Li are generally known to be fluid-mobile elements, and the observed chemical characteristics of the black gouges are consistent with results of hydrothermal experiments using hemipelagic sediments reported so far. Model calculations show that these trace element and isotope spectra of the black gouges are successfully reproduced by fluid-rock interactions at >350 deg. C, which is consistent with thermal pressurization during the seismic events. Similar chemical characteristics are observed in fault rocks recovered from the Emi Group and the Shimanto Group, Cretaceous-Tertiary accretionary complexes in Japan, and the trace element spectra are also consistent with fluid-rock interactions at >350 deg. C. These results indicate that co-seismic fluid-rock interactions at the temperatures of >300 deg. C widely occur within seismic faults and trace element and isotope compositions of fault rocks are useful indicators for such fluid-rock interactions.

Keywords: fluid-rock interactions, earthquake, fault, geochemistry, trace elements, isotopes