Experimental study for noble gas release and age reset under high-speed frictional melting

Keiko Sato[1]; Takehiro Hirose[2]; Hidenori Kumagai[2]; Hajimu Tamura[3]; Kazuo Mizoguchi[4]; Toshihiko Shimamoto[5]

[1] JAMSTEC, IFREE; [2] JAMSTEC; [3] IFREE, JAMSTEC; [4] NIED; [5] Graduate School of Science, Hiroshima Univ.

Isotope ratios of noble gas in certain minerals are believed to be modified easily by their ambient reservoirs when the minerals reach higher temperatures than their closure temperature. The thermal history of a rock or a geologic event, even a fault movement, can therefore be determined quantitatively by applying radiometric dating methods to a set of different minerals. However, neither traditional K-Ar nor Ar-Ar dating methods can be applied easily to faulted rocks because, in the case of faulting, it is difficult to prove that the temperature of an event was greater than the closure temperatures of minerals.

Frictional melting experiments performed on fine grain homogeneous gabbros with high temperatures induced by frictional heating using a high-velocity friction apparatus were used to test whether rapid fault movement can reset the noble gas isotope ratio of fault rocks. The temperature on the artificial fault plane is well above the closure temperature of the K-Ar system, as expected from the calculated cooling age. The anticipated rapid equilibration of volatiles during the frictional melting of rocks implies that the noble gas isotope composition/ratio was reset to an atmospheric value during this experiment.

We measured noble gas isotopes in a gabbro sample using laser fusion analysis. The resetting of noble gases is only observed in glass that had melted completely. Rejuvenation and/or apparent increases in the K-Ar ages were only observed in a narrow, 3-mm-wide zone around the fault plane that appears thermally altered and mechanically fractured in thin sections. Such glassy materials, formed by complete melting of rocks by frictional heating, sometimes observed along at the fault plane in natural faults, are called pseudotachylytes. Gases released by the sample were collected in a small aluminum tube in a nitrogen atmosphere before and after the frictional melting experiment. The gas comprised carbon dioxide, water vapor, hydrogen, helium, and other noble gases.