$^{3}He/^{4}He$ ratios in pore fluids and bottom seawater around the Japan Trench

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Geochemical characteristics of pore fluids may be strongly related to tectonic settings and physical phenomenon at convergent plate boundaries such as fault-bending and great earthquakes. For investigation of fluid origins and cycles, ^{3}He is one of the most useful tracer because of its chemical inertness and high sensitivity of mantle-derived components.
In April 2011, one month after the 2011 Tohoku-oki earthquake, high excess ^{3}He ($^{3}He/^{4}He$ anomaly relative to air saturated water) was detected in bottom seawater nearby rupture zones close to the epicenter on the Okhotsk plate (Sano et al., 2014). They suggested that the excess ^{3}He was supplied by pore fluids with mantle-derived components which were released from the plate interface between the Okhotsk and the Pacific plates via faults during the earthquake period, and that high-pressure mantle fluids presented in the seismogenic zone may have triggered the great earthquake. In November 2016, Escobar et al. (2019) collected sweater and sediment samples nearby the same rupture zones, and detected less excess ^{3}He in the samples relative to those reported by Sano et al. (2014), which suggests dissipation of pore fluids with high $^{3}He/^{4}He$ ratios observed just after the earthquake in 2011. On the over-riding plate nearby the Japan Trench, He isotopic ratios in pore fluids may reflect addition of mantle-derived components associated with earthquake activity.
In order to investigate origin of fluids at outer rise regions of the Japan Trench, we collected sediment samples during KS-19-13 and KS-19-14 cruises onboard R/V Shinsei Maru. Sediment samples were collected from the seafloor using multi-corer and piston corer systems. The samples were immediately transferred into copper tubes and both ends were sealed by metal clamps on the ship in order to avoid air contamination. Subsequent sample preparation and analyses were conducted in Atmosphere and Ocean Research Institute, University of Tokyo. Pore fluids were extracted from the sediment by centrifugation. Then gases dissolved in the pore fluid samples were extracted and introduced into the vacuum line connected to a QMS and a noble gas mass spectrometer (Helix SFT). In the line, the sample gases were purified and $^{4}He/^{20}Ne$ ratios were measured with the QMS, and $^{3}He/^{4}He$ ratios were measured with Helix SFT. The obtained ratios were calibrated against those of atmosphere standard. In several sampling sites, vertical profiles of $^{3}He/^{4}He$ ratios indicated existence of deep fluid end-members with $^{3}He/^{4}He$ ratios apparently higher than atmosphere. This may reflect migration of mantle-derived or magmatic volatiles, which might be related to presence of petit-spot volcanism or pathways between the mantle and the ocean at the incoming Pacific plate, but the situation should be considered carefully also based on geophysical data.

(References)
Sano et al. (2014) Nature Communications 5, 3084.; Escobar et al. (2019) ACS Earth and Space Chemistry 3, 581-587.

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