The use of short-lived radium isotopes at submarine hydrothermal vents

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Radium (Ra) is low in seawater, whereas it is significantly enriched in hydrothermal fluids of submarine volcanoes. The four Ra isotopes cover a wide time span with half-lives from 3.7 d to 1,600 y. Thus, Ra isotopes can be used as time markers for hydrothermal plumes in the vicinity of the source region and further away. For the understanding of the transport and transformation of dissolved hydrothermal compounds (e.g. Fe, organic material) it is crucial to know the age of emanating plumes.

We evaluate the quality and suitability of Ra isotopes at two volcanoes within the Kermadec Arc, SW Pacific (1) to detect hydrothermal plume intensity, (2) to separate between direct and diffusive venting, (3) to determine end member acivities of hydrothermal fluids and (4) to calculate plume ages in an volcanic arc setting. Short-lived Ra isotopes can be measured on board and thus allow immediate sample strategy adaptation during a cruise. The Ra activity is compared with conventional plume proxies, like ^{3}He, turbidity and redox potential using multiple CTD tow-yo survey transects.

In our study we present results for near-field (<12 km) plume dispersion in vertical and horizontal direction at Brothers Volcano. Hydrothermal plume transport velocities were derived from plume ages that were calculated using short-lived Ra isotope and hot fluid end menber ratios. The resulting transport rates are in agreement with current ADCP measurements. Our data document slow transport (51 m/d) inside the caldera, faster transport (278 m/d) outside and a much slower vertical transport (8 m/d) above a vent.

A procedure based on Ra isotopes is presented to distinguish between hydrothermal plumes sourced by direct venting or dominated by diffusive flow. Modeling the volume of the hydrothermal plume in combination with our plume ages allows quantification of submarine hydrothermal discharge from volcanic areas.