The Age of Submarine Hydrothermal Plumes – A Radium Isotope Approach

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The four naturally occurring isotopes of radium (Ra) cover a wide timespan with half lifes ranging from 3.7d to 1,600a. Ra is enriched in hydrothermal fluids and thus may be an ideal tracer to estimate mixing rates, ages of hydrothermal plumes and submarine hydrothermal discharge (SHD) in analogy to the well proven application in coastal submarine groundwater discharge (SGD) research. Ra can be extracted from water samples via adsorption onto MnO_2 coated fibers and on board RaDeCC measurements provide an immediate sample strategy feedback.

To our knowledge this study represents the first approach of using short-lived Ra isotopes as tracers to determine the time since the hydrothermal fluids have left the vents (residence time). By sampling hot fluid as end member samples apparent Ra ages of discrete plume samples can be calculated due to differences in decay constants.

The method was demonstrated at three hydrothermal systems within the Kermadec arc (SW Pacific), namely Macauley, Haungaroa and Brothers (400-1600m depth). Sampling was done during SO 253 cruise (Dec '16 – Jan '17) using titanium and Niskin samplers attached to a ROV and in-situ pumps or rosette samplers for high volume (15-400 L) samples. It can be shown that the pure hydrothermal fluid used as end member, is highly enriched in Ra isotopes, both short- and long-lived, with up to 2600 dpm/100L excess ^{224}Ra not supported by ^{228}Th. Initial ^{224}Ra/^{223}Ra activity ratios (AR) of hot fluids range between 22, 25 and 43 for Macauley, Haungaroa and Brothers, respectively, indicating different Th/U ratios of the volcanic source rocks. Calculated ages after Moore [1] using the initial vent field-specific AR range between <1d (close to the vents) and 35 days (6 km distance) depending on the sampling position in the hydrothermal plume. Our data indicate that a fraction of the discharging hot fluids stays within the caldera at Brothers for some time period before leaving it.

The goal of our study is to provide a method for calculating fluxes of dissolved compounds from submarine volcanism to evaluate the impact of hydrothermal activity on biogeochemical cycles in the ocean (e.g. Fe).

[1] Moore, W.S. (2000), J. Geophys. Res. 105, 117-122