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Precise measurement of $^{226}Ra/^{230}Th$ disequilibria in deep-sea sediments by high-sensitivity ICP-MS

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We describe a new method suitable for the precise and accurate determination of ^{226}Ra in porewater and sediment samples using a single-collector sector field ICP-MS (ThermoFisher Element XR) equipped with an Apex-Q desolvation device and a high-sensitivity Jet-X interface. In combination with ^{230}Th measurements in parallel sediment samples, this method allows precise and accurate quantification of the $^{226}Ra/^{230}Th$ disequilibria in surface sediment cores, thereby enabling the use of this isotope pair as a tracer of solute transfer across the sediment-water interface in the deep ocean. The method integrates a step of isotope dilution with ^{228}Ra as an internal spike, a pre-concentration of Ra and Ba by MnO_2 precipitation, and an efficient separation of Ra from other undesirable elements using a cation exchange resin and a Triskem Sr-spec resin. With the inclusion of one or two additional cation resin columns and the use of up to 16 bed-volumes of a lower molarity (1.7 M) HCl eluent, our procedure eliminates the complicated matrix effects persistently encountered in previous studies, and provides a highly purified solution suitable for ^{226}Ra measurement using an Element XR ICP-MS apparatus. Consequently, we are able to determine the activity of ^{226}Ra in ~20-50 ml of porewater or 100 mg of sediment with an internal precision of ~1.0% and an accuracy of ~99.2%. The precise measurements of porewater and solid phase ^{226}Ra in a sediment core from the North Pacific Ocean allowed the distribution coefficient (K_d) of ^{226}Ra to be constrained tightly within a range of 4700-11600 ml g^{-1}. Moreover, with the aid of a one-dimensional exchange model, the combination of the ^{226}Ra and ^{230}Th measurements allowed us to estimate a ^{226}Ra flux of 1140±20 dpm m^{-2} y^{-1} from the sediment core.