Constraining sedimentation rates with $^{231}Pa/^{230}Th$ ratios of marine sediments

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The determination of the sedimentation rates of carbonate-free, virtually organic-free marine sediments is notoriously difficult. Such sediments cover more than 30% of the surface of the Earth. Consequently, fluxes into these sediments may amount to significant proportions in global budgets, even if annual deposition seems very small, with sedimentation rates often on the order of micrometers per year.

The dating potential of the naturally occurring radioisotopes ^{230}Th and ^{231}Pa, which are produced in sea water in a well known ratio, has been recognized early. However, measurements revealed that the ratio found at the sediment surface usually deviates from the expected production ratio. Various effects have been found to affect the initial $^{231}Pa/^{230}Th$ ratio in marine sediments, in particular the effect of boundary scavenging, changes in ocean ventilation, and particle composition (^{231}Pa being preferentially adsorbed onto biogenic opal). Consequently, the application of excess $^{231}Pa/^{230}Th$ ratios for dating marine bulk sediments has been virtually discontinued, and the ratio of the isotopes is instead widely used to study past ocean circulation and particle fluxes in areas where independent age information is available, e.g. from carbonates.

Here, we re-evaluate the use of $^{231}Pa/^{230}Th$ ratios for the determination of sedimentation rates in pelagic sediments without independent age information, taking all known effects overprinting the production ratio into account. We conclude that $^{231}Pa/^{230}Th$ ratios can be an excellent tool to estimate sedimentation rates, even in the absence of any independent dating tool, and to determine bioturbation depths. We also re-assess the effect of regional variations in sedimentation rates on Pacific surface sediment $^{231}Pa/^{230}Th$ ratios.