The impact of ocean circulation on the distribution and transport of ^{230}Th and ^{231}Pa produced by U decay in seawater: Modern and paleoceanographic applications

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Scavenging models neglecting advective and diffusive transport predict linear increases with depth in the seawater concentration of ^{230}Th and ^{231}Pa, two particle-reactive nuclides produced by decay of dissolved uranium. Such linear profiles, however, are rarely found. Instead, we typically find concave profiles with deep water concentrations lower than predicted by the scavenging models or convex profiles with mid-depth concentrations higher than predicted by the scavenging models. These deviations from linearity appear to be largely due to the redistribution and transport of the two nuclides by the meridional overturning circulation of the ocean. In areas of deep water formation, shallow water with relatively low ^{230}Th and ^{231}Pa concentrations sinks to greater depths, lowering deep water concentrations below model predictions. On the other hand, in areas of deep water upwelling, deeper water with high nuclide concentrations is brought to shallower depths, resulting in mid-depth concentrations exceeding model predictions.

The global overturning circulation of the ocean thus results in relatively low nuclide concentration in the deep waters of the Atlantic Ocean, particularly in the Deep Western Boundary Current. Under these circumstances, desorption of scavenged nuclides from sinking particles is favored over adsorption, resulting in a gradual increase in deep water nuclide concentration as deep water ages. This gradual increase in turn results in a net export of the nuclides down the “conveyor belt” pathway. The rate of increase is much faster and the extent of lateral export smaller for ^{230}Th, which has a higher affinity for particles than ^{231}Pa. In regions of deep water upwelling, such as the Southern Ocean and the North Pacific, high mid-depth concentrations favor adsorption, resulting in the scavenging of the laterally exported nuclides.

The redistribution and transport of the two nuclides by ocean circulation has the potential of providing information on deep water circulation on decadal to centennial timescales, which is difficult to obtain otherwise. In addition, because the two nuclides are eventually removed to the underlying sediment, they leave an imprint in the sedimentary record that provide useful information on changes in the pattern and rate of the mean global circulation during the Late Quaternary glacial/interglacial climatic cycles.

Radiogenic isotopes as tracers of sediment provenance and flux: Paleoceanography of the South Atlantic

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Deep sea sediment cores have been widely used to study changes in ocean circulation on glacial-interglacial timescales. Clay mineralogy, elemental and radiogenic isotope ratios can be sensitive tracers of sediment provenance, and have been interpreted in terms of changes in circulation patterns. Another tool that has recently become important for studying the past oceans is $^{230}Th^{o}_{xs}$. The excess ^{230}Th measured in the sediment is useful as a constant-flux proxy, and puts additional constraints on the lateral transport and redistribution of sediments. The combined measurements of sediment provenance and flux, therefore has great potential for determining sediment transport patterns, and how they have changed through time.

The southeast Atlantic is an important study site because it is a region where thermocline and intermediate waters are exchanged with the Indian Ocean by the “Agulhas Leakage”. This leakage is thought to be an important source of heat, salt and potential vorticity to the Atlantic Ocean, possibly acting as a positive feedback for the formation of North Atlantic Deep Water (NADW) and the intensity of global thermohaline circulation. Changes in the strength of NADW formation has been called upon as a major amplifier for climate change during the Pleistocene glacial cycles, with the hypothesis that NADW formation was weaker during the cold periods of the glacial cycles, particularly during the Last Glacial Maximum (LGM), approximately 18,000 years ago.

^{87}Sr/^{86}Sr, ε_{Nd} and ^{230}Th–normalized terrigenous flux measurements from Holocene and LGM sediment samples support the Agulhas Current as a major source of sediment to the Cape Basin drift deposit. The results are consistent with 3 endmember mixing between sediment carried by the Agulhas Current, the Antarctic Circumpolar Current (ACC) and a local source. A comparison of the two timeslices implies that a smaller proportion of sediment deposited in the Cape Basin is derived from the Agulhas Current during the LGM. The results are consistent with a reduced Agulhas leakage, and hence less interocean exchange during the LGM (Rutberg et al. 2002), or by a larger contribution from other sediment sources, such as the ACC.

Current research focuses on changes in the sediment provenance and flux under the path of the ACC in the South Atlantic.

References

Rutberg, R.L., Goldstein, S.L. and Hemming, S.R., (2002), *Geochimica et Cosmochimica Acta* 66, Suppl. 1, p. A658