Pore-water diffusive fluxes of ^{224}Ra and CO_2 in Bedford Basin, Nova Scotia.

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Introduction and aim of the study

On the seafloor, chemical processes occurring within sediments create pore-waters highly enriched in various chemical constituents. Many of these processes are fuelled by particulate organic matter (POM), generated during primary production in the euphotic zone and settled onto the surface sediments. Biological transformations of POM in the surface sediments, aerobic or anaerobic, eventually increase pore-water concentrations of dissolved inorganic carbon (DIC), and depending on redox conditions, also alkalinity (A_T). Furthermore, the decay of radioactive elements in the sediments constitutes a further source of chemical species enriched in pore-waters, such as the decay of sediment-bound ^{228}Th ($t_{1/2}$=1.91y), which yields high concentrations of its shorter-lived daughter ^{224}Ra ($t_{1/2}$=3.66 d). We investigate the diffusive flux of three such constituents, the short-lived radium isotope ^{224}Ra, DIC and A_T, from pore-waters into the deep waters of Bedford basin (Nova Scotia, Canada), in order to shed light on both the biogeochemical behaviour of ^{224}Ra and on the return flow of DIC and A_T into the water column from POM respiration on the surface sediments.

Results and Discussion

We apply a 1-D diffusive mixing model (Moore, 2000) to near-bottom profiles of excess ^{224}Ra activity. The recurrence of sharp Ra gradients supports the assumption of a diffusion-dominated mixing regime. We yield vertical eddy-diffusion coefficients (K_Z), along with estimates of ^{224}Ra activity at the sediment-water interface, from which we derive ^{224}Ra fluxes per unit area of sediment. Subsequently, we apply K_Z values to the near-bottom gradients of DIC and A_T, in order to estimate benthic DIC and A_T fluxes from Bedford Basin sediments into the overlaying water column.

Integrating our findings over a full annual cycle, the benthic return flux of DIC constitutes as much as 50% of the annual primary production [2], suggesting substantial additional delivery of organic carbon to deep sediments in the basin. Input from nearby sewage outfalls, re-suspension and transport of sediments at shallower depths [3], and high retention levels within the basin [4] may provide the mechanisms required for this enhanced carbon delivery. Finally, we do not observe any significant release of A_T from the surface sediments to the overlaying water column, which can be seen as an indicator of primarily aerobic respiration of the settled POM, fuelled by sufficiently high dissolved oxygen levels. [5]

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Assessing global N cycling in subduction zones from data on metamorphic rocks: Implications for the evolution of N in Earth's reservoirs

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In order to evaluate the budget of nitrogen buried to the mantle in subduction environments, we performed quantitative and N isotopic analyses of Alpine metamorphic rocks subducted to different depths, and on their non-metamorphic analogues. The samples investigated represent a complete section of the oceanic lithosphere including from bottom to top, serpentinized peridotites, metagabbros, metabasalts and overlying metasediments.

A global annual flux of N subducted by metagabbros has been estimated at about 4.2 (± 2.0) $\times 10^{11}$ g/yr with an average δ^{15}N-value of 1.8 $\pm$ 0.8 ‰ (1σ). This flux is about half that of sedimentary rocks, which indicates that gabbros carry a significant portion of the subducted nitrogen. The net budget between subducted N and that outgassed at volcanic arcs indicates that ~80% of the subducted N is not recycled to the surface.

On a global scale, the total amount of N buried to the mantle via subduction zones is estimated to be 3 times higher (13.2 $\times 10^{11}$ g/yr) than that released from the mantle via mid-ocean ridges, arc and intraplate volcanoes and back-arc basins. This implies that N contained in Earth surface reservoirs, mainly in the atmosphere, has been progressively transferred and sequestered into the mantle, with a net flux of ~9.6 $\times 10^{11}$ g/yr. Assuming a constant flux of subducted N over the Earth's history suggests that an amount equivalent to the present atmospheric N may have been sequestered into the silicate Earth over a period of 4 billion years.

Considering a present day mantle value of ~ -5‰, an average δ^{15}N value of subducted nitrogen of about 3.4 $\pm$1.4 ‰ implies that the secular evolution of the mantle δ^{15}N value should have increased through time, whereas that of the crust and atmosphere should have decreased.