Sediment and trap geochemical signatures along the NE Atlantic margin: excess Ba advective transport and export production estimation

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Particulate Ba fluxes have often been used for providing a quantitative palaeo-productivity proxy (François et al., 1995, Nurnberg, 1995, Sarthein et al., 1988). In continental margin environments, the flux of Ba has been proposed to trace labile organic matter exported from the euphotic zone because it turns out to be affected by input of more refractory carbon from continents (François et al., 1995). However previous trap studies in the Pacific Ocean (Dymond and Collier, 1996) have documented an increasing trend in the excess Ba fluxes in deep traps, suggesting either a formation of baryte within deep waters or an additional input by lateral transport. Working on the NE Atlantic margin, our aim is to verify the hypothesis of excess Ba advection and to estimate its influence on the export production estimation.

Material and methods

Major and trace elements (Zr, Ba, rare earth elements REE, and Th) were analysed on bulk sedimentary material collected along the NE Atlantic margin (OMEX project, Antia et al., 1995). Three sedimentary sites have been recovered: site 2 at the shelf break (1460 m), site 3 at the base of the slope (3650 m), and site 4 in the abyssal plain (4470 m). Sediment traps were deployed between July 1993 and September 1995 (Antia et al., 1995), in shallow (~600 m, site 2 and 3), intermediate (~1000−1400 m, site 2 and 3), and deep waters (>3000 m, site 3 and 4). The Si and Al were analysed by inductively coupled plasma atomic emission spectrometry (ICP-AES). The Ti, Mg, Mn, Ca and trace elements (i.e. Zr, Ba, REE, and Th) were measured with inductively coupled plasma mass spectrometry (ICP-MS). Accuracy was determined on artificial solutions and international standard reference rocks.

Results and discussion

The geochemical signatures of sediments remain close to the upper crust reference, with flat shale-normalized REE patterns and constant elementary ratios. The calculated biogenic fraction of Ba (or excess Ba) ranges between 20−25% at the shelf break and the abyssal sites and 45% at the slope site. Such values remain lower than the excess Ba record in trap material (80−99%). The correction taking into account the loss of baryte by dissolution at the seafloor and based on the mass accumulation rate (Dymond et al., 1992) is only consistent with the changes between the sediment and the trap records at the slope site. The strong detrital control, the level of redox conditions and winnowing or focussing by bottom currents preclude any accurate determination of the excess Ba at the shelf and at the abyssal sites.

The trap material displays a wide range of variation in its trace element content (e.g. Ba ~150−3000 ppm, Zr ~2−100 ppm), except for the abyssal site where its geochemical signature is constant. In the two other sites, all the trace element contents increase with water depth, showing pronounced seasonal changes at every water depth. The excess Ba also increases in the deepest traps. Although its yearly evolution mimics the change of the other analysed trace elements, it shows complex relationships with particulate organic carbon. In terms of fluxes, two periods of enhanced excess Ba fluxes are shown: (1) A winter enhancement of excess Ba with the detrital-like elements (Th, REE); (2) a spring increase of the excess Ba fluxes independent of the detrital-like elements. The origins of the first case are discussed, and a supply through lateral advection is proposed. Such transient input of significant excess Ba flux will have a great impact on the yearly averaged estimation of the export production:

(1) Only the spring excess Ba fluxes reflect a bloom in the biological productivity of the water column and must be taken into account in a mean calculation of the export production; (2) Normalization of the excess Ba by other trace elements (such as Th or *REE*) will help to discriminate between a real increase of the excess Ba due to local productivity change (high excess Ba % and high excess Ba/Th ratio) and inputs due to advection process (high excess Ba but low excess Ba/Th ratio).

Conclusion

Proper understanding of the behaviour of the Ba with regard with other trace elements appears a necessary preliminary step before any use of this element can be envisaged to calculate vertical export production, especially in the off-margin environment, where both advective processes and atmospheric-oceanic exchanges are important.

References

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