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Interactive Comment

Interactive comment on "Sources and transport of dissolved iron and manganese along the continental margin of the Bay of Biscay" *by* A. Laës et al.

A. Laës et al.

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Response to 1st comment:

These different issues are discussed below and the text was modified accordingly.

Seasonality of benthic flux, availability of reactive Fe and Mn:

Ocean margins are generally characterized by intensive vertical mixing at the shelf slope break which may strongly enhance primary production (Wollast and Chou, 2001). After the bloom ending, relatively high rates of particle deposition along the continental margins are usually observed (Wollast et al. 1990, Walsh 1991), leading to intensified biogeochemical processes in the underlying sediments. The diagenesis is

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mostly driven by the biological activity of the micro organisms present in the sediments. Bioturbation can also enhance this process. Mc Cave et al. (2001) suggested that greater erosion is possible during periods of high productivity because increased benthic macrofauna activity reduces the threshold stress for sediment erosion. Even if the availability of Fe and Mn in coastal shelf sediments in the Bay of Biscay is not well studied (see answer N$^\circ$ 2), we would have observed higher dissolved concentrations of metals in the bottom waters if our study was conducted later in the year.

Advective transport, upwelling intensity

In a recent publication, McPhee-Shaw, (2006) reports that internal wave breaking is a viable mechanism for offshore dispersal of boundary layer fluid, but that very little is known about its spatial and seasonal variability and the intensity of lateral transport of dissolved and particulate chemical constituents associated to it. She also highlights that no process study exists to document near-boundary mixing and to quantify the associated offshore flux of boundary layer water. As correctly pointed out, one of the reason why we did not observe a more pronounced influence of the shelf sediments on the abundance of trace metals in the surface waters off-shore was because benthic metals fluxes at that time of year were probably relatively low. But it could also be caused by non optimal conditions of lateral transport (low intensity, short term) observed at this period in our sampling site.

To avoid any confusion we changed the conclusion into: “The influence of continental margin on the distribution of trace metals for this particular period of the year seems to be confined to this region. Long distance transfer of the metals into the open ocean was not observed.” And we added some explanations in the text : “One of the reasons why we did not observe a more pronounced influence of the shelf sediments on the abundance of trace metals in the surface waters off-shore was because benthic metals fluxes at that time of year are probably relatively low. It could also be caused by low intensity and short term advective transport at this period of the study.”

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Wollast, R., 1990. The coastal org. C cycle: fluxes, sources and sinks. In: Mantoura, R.F.C., Martin, J.M., Wollast, R. (Eds.), Ocean Margin Processes in Global Change. Wiley, New York, pp. 365}381. Wollast R. and Chou, L. 2001, The carbon cycle at the ocean margin in the northern Gulf of Biscay, DSR part II, 48, 3265-3293 Walsh, J., 1991. Importance of continental margins in the marine biogeochemical cycling of carbon and nitrogen. Nature 350, 53}55. McCave, I. N., Hall, I. R., Antia, A. N., Chou, L., Dehairs, F., Lampitt, R. S., Thomsen, L., Van Weering, T. C. E., and Wollast, R.: Distribution, composition and flux of particulate 5 material over the European margin at 47_-50_ N, Deep-Sea Res. Part II, 48, 3107-3139, 2001. McPhee-Shaw, E. 2001, Boundary-interior exchange: Reviewing the idea that internal-wave mixing enhances lateral dispersal near continental margins, Deep Sea Research Part II, 53, 42-59

Response to 2nd comment

We misinterpreted the values published from Hyacinthe et al. (2001). They were not benthic metal fluxes but pore water metal fluxes to the 10 cm upper core of sediments. So these values can not be compared to the Berelson's estimations. The portion of text : "but Hyacinthe et al. (2001) indicated that for a shallow station over the Aquitaine margin fluxes of Fe (II) and Mn (II) at the sediment-seawater interface are in the order of respectively 41 and 140 μM m-2 day-1, nearly 10 times the estimation of Berelson et al. (2003): Fe(II) fluxes of 5.18 and Mn(II) fluxes of 9.76 and μM m-2 day-1 for a shallow station (99m) in the Monterey Bay." was cancelled from the paper. There are very few studies showing results of iron and manganese benthic fluxes, and none in the case of the Bay of Biscay so it is difficult to compared them.

We added in the text : "However it was reported that Fe and Mn pore water concentrations (0 and 5 cm in the sediments of the Aquitaine margin, 150 m depth) were in the range 0 -100 μM (Chaillou et al., 2003 and Hyacinthe et al., 2001). In Van der Zee et al. (2001) and Van der Zee et al. (2002), Fe and Mn pore water concentrations for stations over the Iberian continental margin (104 and 223 m depth), were in the range 0 - 70 and 0 - 400 μM, respectively. The oxygen concentrations in the bottom water, the oxygen penetration depth and the organic content of the sediments for the two areas are similar : Aquitaine margin (230 and 235 μM, 5 and 6 mm, 2 and 2.32% wt), Iberian continental margin (209 - 235 μM, 1 and 7.5 mm, 0.33 - 4,58% wt). We can then hypothesize that the manganese upward flux was close to the one obtained in the Iberian continental margin: 0.1 to 13.3 μmolm-2day-1. This is comparable to the Mn and Fe fluxes of 9.76 and 5.18 μmolm-2day-1 , respectively, reported by Berelson et al. (2003) at a 100m-depth station. Benthic Fe and Mn flux in the Bay of Biscay are likely to be of similar magnitude to fluxes for the Iberian continental margin and the California continental margin."

Chaillou, G., Schäfer, J., Anschutz, P., Lavaux, G., Blanc, G.: The behaviour of arsenic in muddy sediments of The Bay of Biscay (France), Geochim. Cosmochim. Acta, Vol. 67, No. 16, 2993-3003, doi:10.1016/S0016-7037(03)00204-7, 2003. van der Zee, C, van Raaphorst, W., Epping, E.: Absorbed Mn2+ and Mn redox cycling in Iberian continental margin sediments (northeast Atlantic Ocean), J. Mar. Res., 59, 133-166, 2001 van der Zee, C, van Raaphorst, W., Helder, W.: Fe redox cycling in Iberian continental margin sediments (NE Atlantic), J. Mar. Res., 60, 855-886, 2002 Hyacinthe, C., Anschutz, P., Carbonel, P., Jouanneau, J.M., Jorissen, F.J.: Early diagenetic processes in the muddy sediments of the Bay of Biscay, Mar. Geol., 177, 111-128, 2001.

Response to 3rd comment

Dissolved iron concentration alone is not sufficient to assess the importance of metal inputs from the continental margin. That is why we also coupled these values with the TDFe concentrations which gives us an estimation of iron concentrations in biogenic fractions and leachable mineral fractions. We also plotted the turbidity to link the enhanced dissolved metal concentration to occurrence of resuspended material or biogenic material. However a more comprehensive study including sediment composition, intensity of diagenesis and resuspension processes, nature of the transport and mixing of water masses above the slope would be required.

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We added in the text

“During our cruise, real-time data on the intensity and magnitude of the physical forces (internal wave breaking, along slope current, hydrological processes inducing resuspension) were not collected. Moreover the iron and manganese fluxes coming from the sediment were not measured. This has hampered quantitative discussion on the relative importance of the different sources and processes. As highlighted by McPhee-Shaw, (2006) there is a need for a physical oceanography coupled to biogeochemistry study to bring to light the dynamics causing dispersal of bottom boundary layer fluid into interior waters in order to quantify lateral transport of dissolved and particulate chemical constituents and to better understand feedbacks between supply of benthic iron and primary productivity on continental shelves. Our paper brings forward some hypothesis in the understanding of trace metal enrichment in the vicinity of a continental slope. Quantitative estimates will require further investigations concerning the sediment composition, the intensity of diagenesis and of resuspension processes, the nature of transport and the mixing of water masses ”

Responses to minor comments

Figure 2 and Figure 7 are enlarged. Figure 6 is splitted in two different panels: Figures 6.a and 6.b. TDFe: total dissolvable iron : unfiltered sample acidified to pH 2 for at least 6 months prior to analysis. This storage would allow dissolution of most biogenic fractions and surface oxyhydroxide coatings. Only iron included in the most refractory component of minerals would be excluded from the analysis. TDFe then represents the concentration of dissolved iron plus the most labile fraction of particulate iron (Löscher et al., 1997).

The following sentence was added to the text: “TDFe represents the concentration of dissolved iron plus the most labile fraction of particulate iron (Löscher et al., 1997).”

Interactive comment on Biogeosciences Discuss., 3, 1499, 2006.