

Interactive comment on “A cobalt plume in the oxygen minimum zone of the Eastern Tropical South Pacific” by N. J. Hawco et al.

Anonymous Referee #2

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Hawco and colleagues present a comprehensive and exciting data set for cobalt (Co) and ancillary parameters along the US GEOTRACES transect in the South Pacific Ocean. This manuscript will contribute substantially to our understanding of Co biogeochemical cycling in the ocean and I am looking forward to seeing it published in Biogeosciences.

I agree with most of the authors' interpretations (see one exception below) and my comments are largely editorial. Due to the comprehensive character of the data set, the manuscript is quite long and in places difficult to follow. Even after my second reading I could not quite figure out the logic behind the order of the different sections. The first section of the discussion discusses basin-wide cobalt-oxygen covariation. The second section deals with cobalt-phosphorus covariation, nutrient uptake and export. Then different redox-sensitive Co sources (oxygen minimum zone sediments; hydrothermal

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venting followed by scavenging) are discussed and the final section revisits the role of Co in limiting phytoplankton communities in the surface ocean. I understand that all these aspects and processes are coupled (and therefore difficult to structure) but there may still be a way to bring these things in a more consistent order. Many references to figures are missing or wrong and the overall order of figure appearance does not correspond to the figure numbering (Figure 9 appears before Figure 7 and 8, etc.) which also contributed to my confusion.

I have one important comment regarding the interpretation of sedimentary Co sources within the Peruvian oxygen minimum zone. The authors argue that most of the Co and manganese (Mn) in the oxygen minimum zone water derive from sedimentary sources. However, previous work on Co off the coast of Peru (Böning et al., 2004, GCA; cited in the manuscript) has shown that sediments are depleted in Co and Mn relative to the regional lithogenic background, even at the very sediment surface. Based on this observation, Böning et al. (2004) concluded that most of the Co and Mn delivered from terrigenous sources is not dissolved in the sediment but rather in the water column prior to deposition. The water column Co and Mn profiles in Figure 10 do not provide unequivocal evidence for either sediment or (lower) water column dissolution.

In the case of Mn, previously published data for sediments and pore waters by Scholz et al. (GCA 75, 7257-7276) can be used to differentiate sediment and water column sources. Dissolved benthic Mn fluxes on the Peru shelf range between 10 and 40 nmol/cm²yr. Peru margin sediments have average Mn/Al ratios of 0.0052 (g/kg / g/kg). The average Mn/Al in Andesite (0.0123), the regional lithogenic background, can be used to calculate a MnXS of -0.38 g/kg. That is, 0.38 g Mn is lost per kg of sediment accumulating. Multiplying this MnXS with the sediment mass accumulation rate for shelf sediments off Peru (2.8×10^{-5} kg/cm²yr) yields a Mn loss flux of -10.6 μg/cm²yr or -192 nmol/cm²yr. This calculation demonstrates that only 5 to 20 % of the Mn is dissolved in the sediments whereas the remainder must be dissolved in the water column prior to deposition. Given the close coupling of Co and Mn in oxygen minimum

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zone sediments (Böning et al., 2004) and waters (see present manuscript) I suggest the authors modify the discussion accordingly.

Minor comments:

Title: The paper contains many more interesting observations (and corresponding interpretations) than just the Co plume in the oxygen minimum zone. Consider a more general title that fully captures the comprehensive character of the presented data set.

Line 47, abstract: Add 'in' before 'oligotrophic regions'.

Line 72: It would be useful to define labile Co and the abbreviation LCo here.

Line 75: Does it matter whether the Mn oxides are formed by bacteria or abiotically? I assume they would be enriched in Co either way (see also Line 497).

Results section: The Results section would be easier to follow if it was divided into subsections, e.g., vertical Co profiles, lateral Co distribution, etc.

Line 293: Add number of gyre station so that it can be easily identified in Figure 3.

Line 299: 'overturning' (typo).

Line 313: Add reference to figure.

Line 321: Upwelling of P-rich and O-poor water 'results' in high dCo? Rephrase for clarity.

Line 329: Figure 13?

Line 340: Add figure reference.

Line 359: "On the GP16 transect . . .".

Line 417: I assume you mean "low O₂/high dCo water masses mix with high O₂/low dCo water masses". Rephrase for clarity.

Line 424: Is the LCo:O₂ trend shown in the figures? If yes, add figure reference; If no,

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add 'not shown'.

Line 433: What is meant with “double 0 μM intercept”? $2 \times 0 \mu\text{M}$? Rephrase for clarity.

Line 434: What exactly resembles “profiles of $\text{N}_2 \dots$ ”?

Line 444: The 50 m depth range is not shown with separate symbols in Figure 5c. Later in the text other depth ranges are discussed which are not shown either (Line 457). I suggest adding more color codes to Figure 5c to indicate all the depth ranges and corresponding covariation trends discussed in the text. Otherwise the discussion is difficult to follow.

Line 492: What is meant with ‘redox barrier’? Do you invoke a biological process or just that Mn oxides do not form at very low oxygen concentrations?

Line 499: Figure 7C does not show pCo.

Line 502: Remove ‘in’.

Line 518: Figure 14 is a summary figure which has not been introduced at this point of the discussion. I recommend referring to actual data here and to restrict references to Figure 14 to the Conclusions section. Section 4.3: See comment above on reductive Mn dissolution in the water column.

Line 545-549: The Peruvian shelf occasionally experiences oxidation events which also favor Mn deposition and burial (see discussion in Scholz et al., 2011).

Line 590: “oxidizing conditions \dots prevent reductive dissolution \dots ” is a misleading statement. The sediments at the western Pacific margin are certainly Mn-reducing in the shallow subsurface but the oxic surface sediments prevent diffusive escape of the pore water Co and Mn into the water column.

Line 594-Line 606: Because of low water exchange kinetics, Co is incorporated into pyrite and does not tend to form its own sulfide minerals (Morse & Luther, 1999, GCA 63, 3373-3378).

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Line 613: Does 'crust' refer to 'andesite' in this equation. It does not matter what you take but it should be consistent throughout the manuscript.

Conclusions: I really like Figure 14 and therefore recommend to introduce it more explicitly at the beginning of the Conclusions (something like: "the major pattern and underlying processes identified in this contribution are summarized in Figure 14"). The major finding can then be summarized by guiding the reader through Figure 14.

Caption Figure 1: What depth or potential density do the isolines correspond to?

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