

Interactive comment on “Influence of intense scavenging on Pa-Th fractionation in the wake of Kerguelen Island (Southern Ocean)” by C. Venchiarutti et al.

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Received and published: 19 August 2011

We are very grateful to the anonymous Reviewer #1 for the constructive comments and corrections that have been helpful in the revision process of our manuscript.

Authors' response (AR) to the comment: “Is there any data of sediments to confirm the findings? If not, where would it be most valuable to collect and analyse sediment samples?”

AR: Unfortunately, there are no sediment data available for the analysis of Pa and Th for this study. However, sediment traps and sediment samples have been collected in some areas around the Kerguelen plateau during other expeditions (e.g. Dezileau et al.

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2000). Moreover, during the KEOPS II expedition, planned for autumn 2011, sediment and some water samples should be collected and analysed (J. Gherardi, pers. comm.). It would be interesting to sample sediments on the central Kerguelen plateau and along the eastern escarpment between the KEOPS stations C11 and A11 to see the impact of the intensive scavenging on the plateau on the Pa/Th sedimentary records and of the boundary scavenging along the eastern slope of the plateau (as studied by Dezileau et al., 2000). Then, we could use these data to test the validity of the new model to evaluate the flux of Th and Pa to the sediments in the Kerguelen wake.

Authors' reply (AR) to technical issues

page 4874 line 1 “along” use “throughout the water column” MODIFIED

page 4874 line 13 “mainly” use “not only” MODIFIED

Page 4877 lines 7-9. PF Trough, Northwest-Southeast Trough are not indicated on Map.

AR: The troughs are now indicated on the map (Figure 1).

Page 4877 line 17 “then” delete MODIFIED

Page 4878 line 8 “full” delete MODIFIED

Page 4878 line 25. “6 out of 9 stations”. Be consistent with tables and figures. I count 4 ISP stations out of 6. MODIFIED

Page 4879 line 22 “achieved” use “performed”/executed MODIFIED

Page 4880 line 12 “bar” delete MODIFIED

Page 4880 line 13 “yielded” use “require” MODIFIED

Page 4880 lines 14-22. please clarify the procedure. Mention here that Th analyses were reported in the 2008 paper. Were yield tracers added after leaching the filters? Was the 80/20% separation made of the filter or of the leach? Why were Th and Pa

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not analysed on the same filter leach? Especially line 21 is confusing. Is the Th/Pa separation described here also used to purify the Th fraction of the 80% aliquot? Then are the results consistent with those of the 20% aliquots?

AR: This paragraph is now clarified. Due to problems with the ^{233}Pa spike, the analysis of Pa was postponed and the particulate samples split to allow in the first instance the Th analysis. The chromatography method described in Venchiarutti et al., 2008 and Jeandel et al., 2011a was also applied to purify the Pa fractions/samples from the 80% aliquots for the particulate Pa analysis.

Page 4882 line 4 “samples” use “Pa fractions” MODIFIED

Page 4882 line 13. What is the ^{232}Th content of the ^{233}Pa spikes added? (not given in Table 2)

AR: In the second ^{233}Pa spike (obtained by milking of ^{237}Np at the AWI), the ^{232}Th content was estimated at about 60 pg per sample. This contribution was taken into account, in addition to the procedural blanks, for the estimation of the Th concentrations of the duplicated samples (dissolved and particulate), i.e. those spiked with this batch of ^{233}Pa (AWI).

Page 4883. Make line 4 consistent with line 14 MODIFIED

Page 4883 line 25. What chemical yield and what error were used for the Pa calculations of the stations analysed without Pa yield tracer?

AR: No chemical yield had been applied to the determination of the final Pa concentrations. Due to the uncertainty associated with these data (without Pa yield tracer), we decided to remove these Pa data from the revised manuscript, as suggested by the reviewer.

Page 4886 lines 21-24 redundant formulation. MODIFIED

Page 4887 line 9-14 rather speculative, would fit better in discussion part.

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AR: We deleted completely this paragraph about the Kerfix station/feature in the revised manuscript since the dissolved Pa data of the Kerfix station (without Pa yield tracer) are now removed from the manuscript.

Page 4887 line 23 “to” delete MODIFIED

Page 4887 24-25 reformulate, e.g.: “only in the upper 100m of the water column the particulate part of ^{231}Pa dominates”

AR: Modified according to reviewer’s suggestion.

Page 4887 line 27. There is a clear depth dependence in Fig. 4 (as mentioned below)

AR: MODIFIED. The particulate $^{231}\text{Pa}/^{230}\text{Th}$ ratios show indeed a marked dependence with depth, with decreasing ratios with increasing depth. This is now clearly stated in the text.

Page 4887 line 28 “except for a few maxima”.

AR: This sentence was modified to fit with the clear depth dependence of particulate $^{231}\text{Pa}/^{230}\text{Th}$ ratios.

Page 4888 line 1 use fewer digits MODIFIED

Page 4888 line 14-18 gives a qualitative and hard to judge comparison between Pa/Th ratios and BSi, asking for a more rigorous property property plot. Such a plot is presented later as figure, which should be moved up here.

AR: Figures 6 and 8 were removed from the revised manuscript, since they did not show a satisfying and obvious relationship between KPa (or Pa/Th ratios) and BSi (results from Mosseri et al., 2008). However, the KPa and BSi relationship is now demonstrated in the text by comparing KEOPS data (KPa –this study- and BSi –from Mosseri et al., 2008) with values of KPa and BSi from the literature in diatom-poor areas (e.g; comparison with KPa values of ~ 0.01 - 0.04 in the Equatorial Pacific and in the South-East Atlantic (Anderson et al., 1983a; Scholten et al., 2008 respectively)

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and corresponding low BSi concentrations $< 0.5 \mu\text{mol.L}^{-1}$ (Leynaert et al., 2001; Bishop et al., 1978)).

Page 4888 line 22 “surface values” add: (0 and 50m) This paragraph is very weak and better deleted. Tell precisely at what depth you find Si release and Pa/Th fractionation. Normally Si is taken up in surface waters with corresponding isotope effects. It is highly unlikely that opal dissolution at the base of the mixed layer would give an opal dissolution signal in the surface water above that would (more than) cancel the opposite Si uptake signal there.

AR: We agreed with the reviewer’s comment and therefore deleted this paragraph.

Page 4890 line 1. “excellent” avoid this word to qualify the correlation of a so clearly non-normal distribution.

AR: Both reviewers #1 and #2 made constructive critics on the Figure 8 that intended to show the possible relationship between KPa and BSi for two stations Kerfix and C11. Their comments on the poor resolution of the data and the big uncertainty associated with these values suggested that it was not possible to establish an obvious relationship between KPa and BSi. Therefore, we decided to remove this Figure from the manuscript and changed the text (see above answer for comment “Page 4888 line 14-18” as well).

Page 4890 line 8-10. The reference refers to a depth range of 1000m and would be appropriate here if over that depth range the falling particles would come across a different water mass.

AR: We agreed with the reviewer and modified the sentence. It is now mentioned in the text that the FTh/Pa in the surface waters and hence its integration/average over the whole water column require cautious interpretation, since for instance, there are different processes taking place in surface waters with respect to deep waters.

Page 4891 “irreversible” why should this be irreversible?

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AR: The term “irreversible” is now deleted from the text and replaced by the following explanation is now reads in the text: “If there is a reversible equilibrium between dissolved and particulate Pa when particles fall through the water column, re-suspended particles should be at equilibrium with bottom waters and hence particle re-suspension should not produce further Pa scavenging. Therefore irreversible processes may be at work, since there are high particulate Th and Pa concentrations while dissolved concentrations are decreasing or constant close to the seafloor”.

Page 4891 “Nd concentration” is Nd also scavenged or is there merely isotope exchange?

AR: Nd is efficiently scavenged along the eastern escarpment plateau and the results were extensively communicated and are summarized in Jeandel et al., 2011b. This is now mentioned in the text.

Page 4892 line 11 “dpm m⁻²” use “dpm m⁻⁴” modified Page 4893 line 4,8 reduce # digits MODIFIED

Page 4894 “until now” but apparently not since Chever 2010 MODIFIED

Page 4895 line7 “conspicuous” clear? MODIFIED

Page 4895 line 21 “in future reversible-scavenging models” delete. MODIFIED

Page 4903 note “ there are no” use “we did not determine” MODIFIED

Page 4904 to which line belongs “insignificant contribution”? MODIFIED

Page 4906 pis 002 2000m Are these results and their error estimates realistic, realizing that there is significant particulate ²³⁰Th at this depth?

AR: These values were deleted following the reviewer’s suggestion.

Page 4908 Figure 1. Delete stations that were not sampled or highlight stations that were sampled for Pa/Th

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AR: The stations analysed for Pa (this study) are now highlighted on Figure 1.

Page 4912 Figure 5. Is this representation as function of density really used in the text?

AR: In the authors' opinion, the figure representing the Pa and Th concentrations as function of density is useful to distinguish the different water masses and their associated Th and Pa concentrations. The figure is discussed in the context of the boundary scavenging along the eastern escarpment plateau. These figures were improved in revised manuscript.

Page 4913 Figure 6. I am not sure this figure is required here. Most important is a proper analysis of the relationship between fractionation and BSi, especially if this could be given as percentage of the particulate fraction.

AR: Figure 6 was deleted. We did not have any particle mass for the KEOPS cruise and therefore the calculation suggested by the reviewer was not possible.

Page 4915 Figure 8. It would be more logical to exchange the axes to put KPa as the dependent variable. "the error bar at 100m" is not a useful description here

AR: Figure 8 was removed from the revised manuscript.

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