Comment on bg-2021-112
Charles Wheat (Referee)

Referee comment on "Geochemical consequences of oxygen diffusion from the oceanic crust into overlying sediments and its significance for biogeochemical cycles based on sediments of the northeast Pacific" by Gerard J. M. Versteegh et al., Biogeosciences Discuss., https://doi.org/10.5194/bg-2021-112-RC1, 2021

This is a nice contribution that should be published. The interpretation is sound, but some of the wording that describes the interpretation should be changed to match the exact meaning. While I know what the authors are trying to convey, some of the wording isn’t exactly correct. There are some newer publications that should be examined especially those by D’Hondt and his collaborators. Even though there are a lot of suggested changes, most changes are related to word choice and if I didn't provide an accurate response, please change the sentence so that others will understand the point. I consider my suggestions to require minor modification and the manuscript should be published without the need to send it back to me. Geoff Wheat

21 This is especially the case where sediments are thin or in the proximity of faults. Also in the middle of gyres e.g. D’Hondt papers and IODP Exp. 329.

28 basement becomes a nitrate source. The basement is not a source of nitrate. The sediment is a source of nitrate to the basement but I understand that later in the paper you note that the nitrate in the basaltic formation fluid is higher than the concentration in pore waters. Nevertheless, this sentence needs to be fixed.

Abstract in general - first describe completely the oxic situation, then describe the suboxic condition. Currently the text goes back and forth.

40 Most of the ocean floor has cooled over long periods and conversely, most ventilation of the basaltic crust occurs at low temperatures. What are long periods? Crust that is 0.5 Ma is often very cool.

58 is available it becomes - replace it with dissolved oxygen

69 benthic consumption deeper into the sediment - needs a reference – Steve Emerson and or Jim Murray did a lot of this work decades ago.

77 add Orcutt et al. 2013. Why single out these two locations where as the central gyres are DO depleted (IODP Exp. 329)??

83 In this zone of upward diffusing oxygen, oxygen exposure time of OM decreases upward from the sediment-basement interface to the point of DO depletion; however, in the case of a completely oxic sediment column, oxic conditions have persisted since deposition.

86 - Need to rethink the minimal aspects as there has been a lot of work related to 329 and a similar study led by D’Hondt in the Atlantic gyre (post 329)

94 - I don’t think Ziebis hit basement and it was a piston/gravity coring expedition. Orcutt et al 2013 was drilling related in North Pond.

98 2018) thus ----- 2018), thus

99 sedimentation and seawater circulation within the upper basaltic crust that delivered dissolved oxygen to the overlying sediment which penetrated the entire sediment column or at least to the deepest sediment recovered.

101 long periods of oxidation
102 phenomenon in abyssal ocean deposits - again IODP Exp. 329 papers. Better to start here and go down the list. There are a lot of relevant papers related to the Pacific work and the more recent work in the Atlantic.

https://scholar.google.com/citations?hl=en&user=n57iAiYAAAAJ&view_op=list_works&sortby=pubdate

109 has been ---was

114 the current carbonate compensation

118 the basaltic crust – the oceanic crust is made up of basalt and the overlying sediment

128 Sediments have been - Sediment was

129 cores consist generally of stiff and compact brown clays with color depending on the MnO2 contents. For example, less MnO2 (< concentration) resulted in a lighter brown color and more MnO2 (> concentration) resulted in a darker color

142 pressure) and was calculate

154 have been - were – replace all and the have not been to were not

204 For most oceanic sediments oxygen is high at the sediment–water interface and steeply decreases to zero at depth (e.g., 205 Wenzhöfer and Gludd, 2002) due to mineralization of organic matter (OM - this reflects a portion of the ocean – the gyre are huge - you should re-think this statement.

209 consumption rates are low

221 with a suboxic zone with a second oxic zone
233 In the case where oxygen consumption exceeds supply

245-255 – too much emphasis is placed on the “measured” sediment thickness. The basaltic crust has hills and valleys at many different scales included at the scale that the sonar measurements were taken that interrogate a large footprint. Ship mounted sonars are insensitive to variations that one might consider for a basaltic mound or a depression.

259 Especially in combination with extension, pore volumes may increase, so that it is conceivable that faults increase sediment permeability – there are no data to make this assertion or references. Even if the permeability is slightly increased this does not affect the diffusion of oxygen. Diffusion of DO is affected by porosity and tortuosity but you have no measurements and no data to suggest this permeability statement as fact. Odds are that the seafloor is not flat and the core was taken near a topographic high that was not identified in the sonar data that encounters a wide swath and does poorly in rough terrain and against seamounts.

271 Over time, the reactivity of the basement decreases as does temperature – not necessarily so. Reactivity could likely increase with age because of cracking and temperature increases with age and because sediment thickness increases with age and acts like a blanket, warming the basaltic crust.

275 As such it is conceivable that lateral oxygen diffusion, perpendicular to this venting, contributes to the upward oxygen profile for 69SL resulting in sediment columns in proximity of these venting systems that may be entirely oxic, possibly overruling the effect of sediment thickness. I don't see it. 69SL looks perfectly diffusional without any lateral interaction. While the data are not as monotonic as other profiles, the idea of invoking lateral flow means that you have lost. You have just introduced multiple degrees of freedom in a one-dimensional data set (barring figure 8). Also consider diffusion does not necessarily result in a linear concentration especially if there are changes in tortuosity or porosity. In addition, lateral diffusion would not be point source; however, the slight deviations would require a point source if diffusion or advection was the driving force. Also there is no force that would drive lateral advection. Thus I don't see the need to invoke lateral forces unless you can physically/mathematically prove it.

283 to see this – to observe this

286 We find this back in the .. This result was observed in the multi core data

289 OM mineralization slows down with
297 have a relatively constant nitrate concentration – constant to what??

298 It also implies that the seismic–based estimates of sediment thicknesses must be relatively accurate.

300 This stability of nitrate concentrations at the sediment–basement interface contrasts with the variability of inferred oxygen concentrations at this interface suggesting very different dynamics such as a much stronger influence of processes in the basement on oxygen concentrations. - This could be true or it could be a result of the gradients and the higher diffusion coefficient for DO than nitrate. You will have to calculate the flux.

317 edit

335 the Wheat and Fisher paper is a little out of date given a better analysis in the Wheat et al EPSL paper in 2017. Cool seafloor hydrothermal springs reveal global geochemical fluxes that shows that the nitrate is the same as bottom seawater. However, this paper suggests that the nitrate concentration is the same as bottom seawater. Note that the Wheat et al 2020 paper in G-cubed (North Pond) shows a higher nitrate concentration in basaltic formation fluids than bottom seawater. This one is more appropriate to your statement.


341 – this is the same as the pore waters drilled on IODP Exp 336, in which there is one profile with measurement Mn and none with Fe.

362 water oxygen content – not correct in the sense that the crustal fluid is bottom seawater that is slightly aged (thousands of years) and deep-water DO changes on much longer time scales than a few thousand years.

372 movement -- diffusion

374 – would help to incorporate thoughts from D’Hondts work in the comparison.
376 reaction time is long and may equal sediment age - need to reword

376 Here, not oxygen exposure time is limiting the ... Here, oxygen exposure time is not limiting the

384 Considering the large amount of time available, --while I agree the rest of the sentence, I don't follow the time statement. New DO is constantly be fluxed into basal sediment. The OC in basal sediment is refractory resulting in slow rates of reaction. I know what you are saying, but there must be a better way to say it.

Line 395 equal flux - No flux????

Section 4.6 - Introduce figure 8 in this section.

411 organic carbon mineralization is exhaustive – OM is not exhausted. There is some there. Only the more refractory compounds remain.

412 Nitrate production is larger than nitrate removal via denitrification – With ample DO why would there be denitrification?

419 (see conclusion 4). -- add .... in the sampled region.

Conclusions – Much of the conclusions are a re-hash of the paper. The first 7 items should be shortened to get to the main point but with a broader brush as to how this work will be applicable to other areas and with how we think of global systems. The last two items #8 and #9 are good in that these statements go beyond the immediate data and area of study. Think big.

Fig 2 and 3 - It would be nice to list the estimated sediment thickness for each core