Biogeosciences Discuss., 8, C4036–C4041, 2011
www.biogeosciences-discuss.net/8/C4036/2011/

Biogeosciences Discussions

Interactive comment on "Latitudinal differences in the amplitude of the OAE-2 carbon isotopic excursion: *p*CO_2 and paleoproductivity" *by* E. C. van Bentum et al.

E. C. van Bentum et al.

bentum@geo.uu.nl

Received and published: 31 October 2011

Reaction to C2676–C2678 S. Voigt (Referee)

S. Voigt (Referee):" (1) The main result of this study rests on the discrimination of the magnitude of carbon isotopic fractionation between a global component that represents enhanced rates of organic carbon burial and a regional productivity-related component. The contribution of organic carbon burial is estimated to have been 2.5 ‰ based on inorganic carbon δ^{13}C-records. Although this value is widely accepted in the scientific community, it is founded on analyses of chalk and limestone which all experienced a certain degree of burial diagenesis. Here, I want to make aware that the only pristine

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

inorganic OAE-2 $\delta^{13}C$ -record we know to date has a magnitude of 4 ‰ (Voigt et al., 2004). This higher magnitude is identical with values derived from terrestrial organic matter that reflect changes in the isotopic composition of the atmosphere and therefore the global component of the OAE-2 excursion (Barclay et al., 2010). A higher magnitude of the global OAE-2 excursion would have significant influence on the calculation provided in this study."

We appreciate this comment. Indeed, 2.5 ‰ is the generally accepted positive isotope excursion during OAE-2 based on many carbonate records although one could wonder how diagenesis has affected this assessment. However, the record published by Voigt et al. (2004; Figure 2) shows quite some scatter and when a running mean is taken a clear 2.5 ‰ excursion is evident. Therefore, we feel we should stick to the generally accepted 2.5 ‰ . We followed the suggestion of the referee and redid our calculations using the 4 ‰ excursion. During OAE-2 this leads to an approximately 1500 ppm larger increase in pCO_2 values. Although the $[CO_2(aq)]$ values change for the three different scenarios, the conclusion about the changes in productivity among the four sites remain the same. We feel that it would make the manuscript unnecessarily long when adding these calculations.

S. Voigt (Referee):" (2) The temporal relationship between atmospheric CO_2 reduction and surface water cooling as feedback of CO_2 sequestration is not as well constrained as the authors have stated it. This becomes especially evident from the data presented for Site 1260 in Figure 6 (We assume the referee meant Figure 7 or 8). *The initial CO_2 rise occurred in pre-OAE-2 times while the rise in SST that should be associated, is related to the initial phase of OAE-2. A similar temporal offset is evident for the proposed relation between declining atmospheric CO_2 values and SST. While the CO_2 reduction is related to the initial OAE-2, the SST cooling is significantly delayed. According to the available astronomical age models of OAE-2 (Sageman et al., 2006; Voigt et al., 2008) these temporal offsets are in the order of 10s to 100 kyr. Such long time spans are not consistent with the response time of the ocean-climate system today and are also not* *supported by results OAE-2 ocean-climate modeling (Flögel et al., 2011).”*

We agree that currently the direct link between pCO_2 and temperature during OAE-2 still needs to be better developed. In our view this is predominantly because we lack accurate proxies for pCO_2 and because we are comparing local temperature records (i.e. SST) that are definitely affected by additional factors than the atmospheric CO_2 concentration with global CO_2 (reconstructed) signals. Nevertheless we feel that there are clear indications that higher CO_2 levels are inducing higher SSTs (e.g. during volcanic outgassing) and that lower CO_2 levels (due to burial of OM) results in lower SSTs. We will carefully rephrase this section, accommodating the concerns of the referee.

S. Voigt (Referee):” (3) Another question that arises from the proposed relation between productivity, organic carbon burial and atmospheric CO_2 reduction is, why is the cold event such a brief pulse, while high organic carbon burial rates and low atmospheric CO_2 concentrations persisted through the entire OAE-2 interval? Are there additional mechanisms involved?”

Our pCO_2 record does not cover the stratigraphic interval following directly to the cold event at Site 1260, thus, it is not evident from our data that pCO_2 indeed stayed low throughout most of phase B. Work by Jarvis et al. (2011) reveals that reconstructed pCO_2 values re-increase just after a minimum that roughly coincides with the paleotemperature minimum. Furthermore, the atmospheric CO_2 concentration is not only affected by burial of OM and enhanced weathering during OAE-2 but also by substantially increased volcanic activity, releasing CO_2 to the atmosphere. So, although we observe an episode of cooling during OAE-2, this is counterbalanced by an increase in volcanic activity (see Turgeon and Creaser, 2008; van Bentum et al., 2009; Snow et al., 2005). We already mention this on page 6207, line 6 onwards, but will elaborate a little bit more at this point.

S. Voigt (Referee):” (4) Site 1260 is the most condensed OAE-2 succession among

BGD

8, C4036–C4041, 2011

Interactive Comment

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

all sites along the Demerara Rise transect (Hardas and Mutterlose, 2006; Erbacher et al., 2005). The probability that the OAE-2 interval is completely recorded, as stated in paper, is rather low."

We are aware of the fact that the OAE-2 interval at Site 1260 appears rather condensed when compared to the OAE-intervals that were recovered from neighboring sites along the Demerara transect. However, since both the δ^{13}C phytane and the δ^{13}C bulk isotope record reveal all the important features which are characteristic for the event elsewhere (Forster et al., 2007), we are not worried that the record at Site 1260 is incomplete. In fact, it is not really of importance for our calculations of the three scenarios. For the scenarios we only use the largest amplitude of the excursion, it would therefore only influence our calculations if the excursion at Demerara Rise Site 1260 was even larger than it already is. However, this seems rather unlikely.

S. Voigt (Referee):" Figure 4: The latitudinal δ^{13}C gradient of recent organic matter (Rau et al., 1982) appears as a straight line. What is the data base for it? Does it reflect data from two single sites or represent it the linear regression of results from many sites? The different length of arrows needs to be explained in the figure caption."

The slope of the line taken from the Rau paper (1982) is the linear regression from many measurements of surface water plankton δ^{13}C. The arrows were mainly used for illustration, the dark grey arrows indicates the 2.5‰ of the OAE-2 excursion that has been interpreted as the result of enhanced global OM burial, the light grey arrow represents the amount of the excursion that is due to local variations. We will add this to the figure caption.

Page 6194, line 15 – Will be changed to: "the carbon isotope record used by Barclay et al. (2010) "

Page 6196, line 5 – Change sandy limestones to: foraminiferal packstones (Nederbragt et al., 2007).

References:

Barclay, R. S., McElwain, J. C., and Sageman, B. B.: Carbon Sequestration activated by a volcanic CO2 pulse during Oceanic Anoxic Event 2, Nature Geoscience, 3, 205-208, 2010.

Erbacher, J., Friedrich, O., Wilson, P. A., Birch, H., and Mutterlose, J.: Stable organic carbon isotope stratigraphy across Oceanic Anoxic Event 2 of Demerara Rise, western tropical Atlantic., Geochemistry Geophysics Geosystems, 6, Q06010, doi:10.1029/2004GC000850, 2005.

Flögel, S., Wallmann, K., Poulsen, C. J., Zhou, J., Oschlies, A., Voigt, S., and Kuhnt, W.: Simulating the biogeochemical effects of volcanic CO2 degassing on the oxygen-state of the deep ocean during the Cenomanian/Turonian Anoxic Event (OAE2), Earth and Planetary Science Letters, 305, 371-384, 10.1016/j.epsl.2011.03.018, 2011.

Forster, A., Schouten, S., Moriya, K., Wilson, P. A., and Sinninghe Damsté, J. S.: Tropical warming and intermittent cooling during the Cenomanian/Turonian oceanic anoxic event 2: Sea surface temperature records from the equatorial Atlantic, Paleoceanography, 22, PA1219, doi:1210.1029/2006PA001349, PA1219, doi:10.1029/2006PA001349, 2007.

Hardas, P., and Mutterlose, J.: Calcareous nannofossil biostratigraphy of the Cenomanian/Turonian boundary interval of ODP Leg 207 at the Demerara Rise, Revue de Micropaleontologie, 49, 165–179, 2006.

Nederbragt, A. J., Thurow, J., and Pearce, R.: Sediment composition and cyclicity in the mid-Cretaceous at Demerara Rise, ODP Leg 207., in: Proceedings of the Ocean Drilling Program, edited by: Mosher, D. C., Erbacher, J., and Malone, M. J., Scientific Results, Ocean Drilling Program, College Station, TX, 1-31, 2007.

Rau, G. H., Sweeney, R. E., and Kaplan, I. R.: Plankton 13C:12C ratio changes with latitude: differences between northern and southern oceans, Deep-Sea Research, 29 1935, 1982.

Sageman, B. B., Meyers, S. R., and Arthur, M. A.: Orbital time scale and new C-isotope record for Cenomanian-Turonian boundary stratotype, Geology, 34, 125–128, 2006.

BGD

8, C4036–C4041, 2011

Interactive Comment

Snow, L. J., Duncan, R. A., and Bralower, T. J.: Trace element abundances in the Rock Canyon Anticline, Pueblo, Colorado, marine sedimentary section and their relationship to Caribbean plateau construction and ocean anoxic event 2, Paleoceanography, 20, 1, 2005.

Turgeon, S. C., and Creaser, R. A.: Cretaceous oceanic anoxic event 2 triggered by a massive magmatic episode, Nature, 454, 323-326, 2008.

van Bentum, E. C., Hetzel, A., Brumsack, H.-J., Forster, A., Reichart, G.-J., and Sinninghe Damsté, J. S.: Reconstruction of water column anoxia in the equatorial Atlantic during the Cenomanian-Turonian oceanic anoxic event using biomarker and trace metal proxies, Palaeogeography, Palaeoclimatology, Palaeoecology, 280, 489-498, 2009.

Voigt, S., Gale, A. S., and Flögel, S.: Midlatitude shelf seas in the Cenomanian-Turonian greenhouse world: Temperature evolution and North Atlantic circulation, Paleoceanography, 19, PA4020, doi:4010.1029/2004PA001015, 2004.

Voigt, S., Erbacher, J., Mutterlose, J., Weiss, W., Westerhold, T., Wiese, F., Wilmsen, M., and Wonik, T.: The Cenomanian–Turonian of the Wunstorf section– (north Germany): Global stratigraphic reference section and new orbital time scale for oceanic anoxic event 2, Newsl. Stratigr, 43, 65-89, 10.1127/0078-0421/2008/0043-0065, 2008.

Interactive comment on Biogeosciences Discuss., 8, 6191, 2011.