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Interactive comment on "Cenomanian to Coniacian Water-mass Evolution in the Cretaceous Western Interior Seaway of North America and Equatorial Atlantic" *by* James S. Eldrett et al.

James S. Eldrett et al.

james.eldrett@shell.com

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The authors would like to thank Anonymous Referee #1 for the review. Many of the comments have already been incorporated into the revised manuscript, which we believe strengthens the contribution. Below are the specific comments (numbered) from Anonymous Referee #1 and the author response (R..). We are currently revising the text and look forward to additional review and comments from peers to improve the publication.

1. âËŸA ′c p.4 ligne 36 : change "paleonenvironmental" by paleoenvironmental R1. Thankyou for pointing this error, it is now corrected

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Discussion paper

2. âËŸA ′c p.5 ligne 25 : “previously published organic and inorganic geochemical analyses” put bibliographic references

R2. We have inserted the appropriate bibliographic references as suggested.

3. âËŸA ′c 2. Material and Method; In the supplementary data there is a lack of discussion on the authigenic origin of the trace metals used. To validate their types of source, the major and trace element abundances have to cross-correlated with Al abundances (indicators of detrital influx). See for example Lebedel et al., 2013 (Pal, Pal., Pal.)

R3. We had not included a discussion on the authigenic origin of the trace metals as we felt this had been addressed in previous publications. We refer the reviewer to Eldrett et al. 2015b, Earth Planetary Science Letters 423, 98-113, in particular Figure 5 and discussion in section 3.3. The relevant trace metals and associated litho-facies are cross-correlated with Al and discussed in that paper. We have inserted a sentence into the supplementary information referring the readers to Eldrett et al. 2015b and have provided all data in the supplementary datafile where the data can be cross-plotted and interrogated.

4. You can also distinguish between redox proxies, Mo, V, U (Calvert and Pedersen, 1993) and palaeoproductivity proxies, Zn, Ni (Hatch and Leventhal, 1992).

R4. We do not believe that Zn and Ni can be distinguished from redox control and used solely as palaeo-productivity proxies. See also reply R11.

5. Finally, there is no Measurement accuracy.

R5. Measurement accuracy table added to the supplemental.

6. âËŸA ′c 3.1 Organic carbon-isotope Stratigraphy; In this section I think it is important to confront geochemical correlations with biostratigraphic correlations. This section seems to suggest that the identification of the Middle Cenomanian event and the Cenomanian-Turonian CIE is not based on age, but only on the magnitude of _13

Corg positive excursion.

R6. Clarification statement added. Carbon isotope stratigraphy is not just based on magnitude of the positive excursions, but also constrained by biostratigraphy (nannofossils, foraminifera, palynology), geochronology and astrochronologic calibration. These details were presented in Eldrett et al. 2015a and a clarification statement referring the readers to that publication for detailed discussion is inserted.

7. âËŸA ′c 3.2 Geochemistry p.6; It is necessary to re-organize this section. Use chronostratigraphic subdivision instead of lithostratigraphic subdivision. It lacks a description of the diverse sedimentary series that is the description of the main facies because the paleoenvironmental perturbations are recorded in the litho and biofacies. Are there cherts in these series?

R7. Re-organizing this section according to chronostratigraphy would in the authors opinion create unnecessary complexity and confusion. The results and majority of the text is presented in lithostratigraphic units and in depth as a presentation of results per core/outcrop section. Most of the geochemical and environmental signals are reflected in the deposition of lithology, not age. Therefore, presenting in chronostratigraphy, particularly the PCA results would be entirely confusing as the main lithological trends would be obscured. The extra interpretative step of regional trends in the discussion of water-masses is presented in chronostratigraphic age as an attempt at synthesis of the regionally important trends. To help clarify, age assigments are provided next to the associated depth in core (in parenthesis) so that the reader can orientate themselves in age as well as depth; also being consistent with the figures. We feel the main lithologic units are adequately presented in this contribution with focus on larger scale trends. Detailed environmental trends related to lithofacies (limestone-marlstone and bentonites) is presented by Eldrett et al. 2015b (Earth Planetary Science Letters 423, 98-113).bed-scale lithofacies descriptions are beyond the scope and is presented by Minisini et al. (Sedimentology, in review).

8. âĚŸA ′c 3.3 Palynology p.7; In order to help the reader, it's better to present the meaning of the different parameters studied and presented in figures 4-10 (for example T/M ratio, Dinocyst P/G ratio, Shannon-Wiener diversity and Simpson Hunter Diversity). This information should not only appear in the supplementary data.

R8. The meaning of the parameters are now presented in the methods (page 5)

9. âĚŸA ′c 4.1 Â′n Principal Component Analyses ÂĚŹz (p. 8), Use chronostratigraphic subdivision instead of lithostratigraphic subdivision (same subdivision as geochemistry section).

R9. The authors see this would add complexity and confusion obscuring the main environmental signals. These are results and not presented in an interpreted chronostratigraphbic context. We have amended the text from 'stratigraphically' to 'lithostratigraphically'; ln. 25, and inserted, "The groups are discussed in a chronostratigraphic context in Section 4.2."

10. âĚŸA ′c p.8 line 19 "Gallium (Ga)-Al2O3 [kaolinite]" I don't understand the direct link between Al2O3 and Kaolinite. Illite also contains Al2O3

R10. Gallium is generally associated with Al2O3 associated with detrital clays and agree that the direct link with kaolinite is difficult to establish. We have ammended this section to read " high positive scores correspond with high values of elements enriched in heavy minerals (Zirconium-Hafnium; Zr-Hf), silicates (quartz, feldspar), phyllosilicates/clay minerals (Gallium-Potassium Oxide-Rubidium-Titanium; Ga-K2O-Rb-Ti [eg., illite, biotite, smectite, kaolinite], and increased terrigenous contributions (T:M ratio) locally corresponding with the clastics of the Dakota Sandstone Gr. The high positive score along axis 1 may not solely represent terrestrial/detrital riverine dilution, but may also reflect diagenetic alteration of the abundant volcanic ash from atmospheric fallout of western Cordillera plinian eruptions (SiO2, Al2O3, TiO2, heavy minerals) that were transformed into smectite–illite-Fe-Ti oxides (see Eldrett et al. 2015b). Therefore, the clustering of the environmental variables along the Axis/Eigen score 1 is interpreted as representing the carbonate - non carbonate/volcaniclastic mixing trend".

11. âËŸA ′c p. 8 line 27 Â′n redox sensitive trace metal concentrations ÂËŹz. Zn and Ni are also paleoproductivity proxies

R11. Although we agree with the reviewer in part, the main paleo-productivity elemental proxies are Barium and Phosphorus which have only one oxidation state. Zn, Cu, Ni are redox sensitive elements that are thought to be delivered to the sediment-water interface through the sinking of organic matter and could be used as proxies of organic matter flux. However, solubility and oxidation state of these elements are still a function of redox state and thus not solely an organic matter flux proxy. The delivery mechanisms and the calibration to surface water productivity are debated, so due to these uncertainties we have not split the element preferences from the primary category of redox sensitive. We retain the use of redox sensitive as it encompasses the main elements discussed in the paper (i.e. Mo, V, U).

12. âËŸA ′c p.8 line 35 change "paleonenvironmental" by paleoenvironmental

R12. We do not see this typo in the text?

13. âËŸA ′c p. 9 lines 19- 23 "In addition, it is interesting to note that although phytoclasts plot negatively along eigen axis 2 and may represent a reduced masking effect of AOM during oxygenated conditions (Tyson, 1995); they also plot positively along Eigen score 1 (noncarbonate/ volcaniclastic trend) alongside freshwater algae and Areoligeracean dinocysts suggestive of a more nearshore environment (Brinkhuis and Zachariasse 1988; Harker et al. 1990; Li and Habib 1996)". This last interpretation must be confirmed by the calculation of a correlation coefficient which, in my opinion, will not show a correlation. Here, you do only a suggestion but not a real interpretation because the position of the phytoclasts is not at all correlated to the axis 1

R13. We agree with the reviewer. The suggestion was that freshwater algae and areoligeracean dinocysts are suggestive of a more nearshore environment by Brinkhuis and Zachariasse, 1988, Harker et al. 1990 and Li and Habib, 1996 rather than the relationship solely with axis 1. The statement has been amended to clarify the suggestion. It remains a suggestion as we state and believe other factors that we state (such as the masking effect and potential recycling) as discussed would complicate the relationship along axis 1 and reduce any correlation co-efficient.

14. âËŸA ′c p. 9 line 25 change “Figures 4-11” by Figures 4-6, 8-10

R14. Done, thankyou for the observation.

15. âËŸA ′c p.9 “Paleoenvironment Interpretation” Use the same chronostratigraphic subdivision as geochemistry section (3.2); If the sequence stratigraphy interpretation was not published before it's important to explain it.

R15. Chronostratigraphic age assignment for each of the main lithostratigraphic units presented and discussed in the text is provided in parentheses and we believe this as the optimal structure of the text. The sequence stratigraphic interpretation has not been previously published and is now included in the supplemental information.

16. âËŸA ′c p.11, line 16-19 “The sporomorph assemblages during OAE-2 mainly record a relative increase in gymnosperms, in particular during the PCE interval, and thus any increase in T:M ratio may reflect transition from mega-thermal to meso-thermal vegetation (perhaps also reflecting increased pollen production by wind dispersed gymnosperms) in response to climate cooling episode rather than increased hydrologic cycle”. Ti/Al can be used as a proxy for eolian versus fluvial input. What does this proxy show?

R16. The Ti/Al ratio shows an increase during the Plenus Marl event corresponding with recorded increase in gymnosperms. However, during this interval there is also an increase in mafic trace metal abundances, REE and Eu anomaly perhaps reflecting an igneous source, such as the High Arctic Large Igneous Province (see Eldrett et al. 2014; and supplemental figures). The increase in Ti/Al may reflect the emplacement and weathering of a LIP as well as alteration of biotite from the ubiquitous felsic volcanic ash beds rather than solely eolian versus fluvial inputs. We have included a sentence to discuss these uncertainties in Ti/Al as a proxy in the text and the potential relationship with increased gymnosperms and the PCE.

17. âËŸA ′c P.11 "Regional water-mass evolution"; "In this study we infer three main water-mass properties: i) a restricted suboxic-anoxic marine water-mass characterized by low diversity dinocyst assemblages interpreted to represent a tethyan source; ii) an unrestricted/open marine oxygenated water-mass characterized by high diversity dinocyst assemblages interpreted to represent a boreal source and iii) a partially restricted dysoxic water-mass interpreted to represent a more local central KWIS source." It's too direct, you have to explain!! Why do you talk about a tethyan source and not an Atlantic-tethyan source? You specify Â′n a restricted suboxic-anoxic marine watermass of tethyan source" before and after CIE. However Tethyan marine waters are generally well-oxygenated during these time intervals which are not the case of the Atlantic marine waters (see ref Monteiro et al., 2012 Paleoceanography for example: : :)". It would be better to write water mass of Atlantic-Tethyan source. Section organization: use the same chronostratigraphic subdivision than previously.

R17. This sentence is direct, but we feel appropriate. The reviewer is correct in that the definition of tethyan source was loosely applied here as part of the eastern Tethys was oxygenated during this time. As suggested we have amended the text and specifically refer to an equatorial-Atlantic tethyan source

18. âËŸA ′c p. 12 lines 8-12 "Lower Cenomanian sediments from the Equatorial Atlantic (ODP Site 1260) are interpreted as being deposited in a stratified suboxic-anoxic marine environment as indicated by laminated organic rich mudrock deposition and positive PCA-2 scores. This interpretation is consistent with a southern tethyan water-mass and a circulation controlled nutrient trap fuelling surface water productivity and anoxic depositional environment (Jiménez Berrocoso et al. 2010; Trabucho-Alexandre, 2010)". I don't understand why it's consistent with a southern tethyan water-mass.

According Trabucho-Alexandre et al., 2010, this zone is the seat of upwelling of deep waters coming from the Pacific, no southern tethyan water-mass is mentioned by these authors.

R18. We agree with the reviewer. Our findings are consistent with the depositional conditions presented by Trabucho-Alexandre, 2010 and Jiménez Berrocoso et al. 2010 and not necessarily linked with a southern tethyan water mass. We have amended the text accordingly.

19. âËŸA ′c p.12 line 17 : “with mixed dinocyst assemblages”. List of the genera

R19. We have amended the text to read: " In the Central KWIS (Portland-1 core), the early Cenomanian is characterized by relatively dysoxic depositional conditions, with frequent to common prasinophyte phycomata and mixed dinocyst assemblages, including taxa more typical of the northern and central KWIS such as Senoniasphaera microreticulata and Palaeoperidinium cretaceum, and the first consistent but mainly rare occurrence of Bosedinia cf. sp 1 & 3 which is common in coeval deposits at Demerara Rise; along with low diversity agglutinated benthic foraminfera (Figure 8) and the occasional occurrence of rare tethyan calcareous planktonic taxa, together suggestive of a mainly Western Interior Seaway source (Eicher and Diner, 1985)."

20. âËŸA ′c p.12, line 28 “In the Portland-1 core there is a clear shift from agglutinated to calcareous benthic foraminifera near the top of the MCE interval suggestive of a tethyan influence” why? Is there no agglutinated and calcareous benthic foraminifer in shallow water environment in the Atlantic and Pacific oceans?

R20. We agree with the comment of the reviewer and have clarified this sentence. The transition from agglutinated to calcareous foraminifera had been interpreted as reflecting the incursion of carbonate rich tethyan water into the KWIS, which in part is supported by occurrence planktonic foraminifera, ammonites, nannofossils of tethyan influence (see previous sentence). Detailed discussion of the foraminiferal assemblages we feel is beyond the scope of this contribution and have also inserted “for detailed discussion of tethyan-boreal foraminiferal distribution within Colorado, see Eicher and Diner, 1989)"

21. âĖŸA ′c p.13, lines 35-39. "Furthermore, at ODP Site 1261, the recorded shift towards a more diverse and open-marine dinocyst assemblage is also associated with an increase in the abundance of organic foraminiferal test linings; re-population by calcareous benthic foraminifera (Friedrich et al., 2011), which combined with a reduction in redox sensitive trace metals is indicative of an improvement in environmental conditions and a reduction on the oxygen minimum zone". Warning ! There are few samples analysed; 4 samples in 10 m, it's little. This interpretation does not seem really justified because the organic matter concentration is very high.

R21. Indeed there are only four samples, however trace metal data and palynological data (including foraminiferal test linings) are from the same samples which show correspondence. In addition, much higher resolution is available from Friedrich et al. (2011) who recorded re-population of benthic foraminifera. Therefore, we believe it reasonable to suggest improved environmental conditions. However, the wording may be too strong given some of the uncertainty and potential for high frequency variations not captured in the sampling resolution. We have therefore amended the text from "is indicative" to "may indicate" and also inserted "However it should be noted that organic matter concentration remains high".

22. âĖŸA ′c p.15 paragraph Â′n Global trace metal draw-down during OAE-2" line 3, "During the Cenomanian, sediments that have been influenced by tethyan waters" R22. Inserted "equatorial Atlantic"

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