Redox- and bio-productivity changes in the Trans-Saharan epicontinental seaway during and after the Cenomanian-Turonian anoxic event (OAE2): insights from stable isotopes and trace metals

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1 Introduction

- First integrated geochemical dataset from the Ashaka quarry in the Upper Benue Trough (UBT), a basin flooded by the Trans-Saharan epicontinental seaway (TSSW)
- TSSW evolved during the Cretaceous due to the drifting of Gondwana (*Roney, 2013*) and connected the Tethys Sea with the South Atlantic Ocean through the UBT via a global marine transgression during the Cenomanian- Turonian
- The aim of the study is to determine the possible position of the OAE2 within this strata and reconstruct local variations in redox and bio-productivity systematics

2 Geological Setting and Stratigraphy

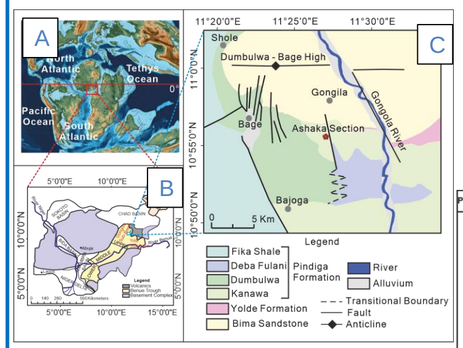
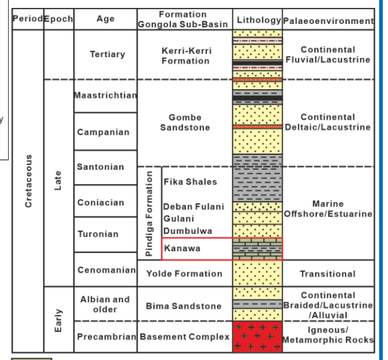


Fig. 1. A) 96.6 Ma paleogeographic map showing the location of the TSSW (*Scotese, 2014*); B) Map of Nigeria showing the location of the UBT (*Abubakar 2006*); C) Location of Ashaka Section (*Zaborski et al. 1997*)

Fig. 2. Stratigraphy of the Gongola Sub-basin of the UBT (*Abubakar et al., 2006*)



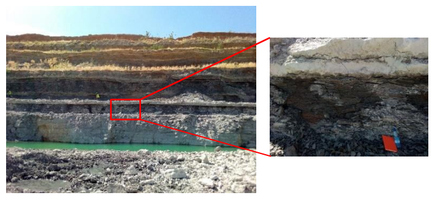


Fig. 3. Photograph of the Ashaka quarry with close-up of TOC rich potential OAE2 horizon

3 Methodology

- 20 samples (11 black shales, five grey shales, and four limestones), and GSD-9, SDO-1, and JDO-1 geologic RMs.
- $\delta^{13}C_{org}$ and TOC were obtained by treating the samples with 1M HCl
- Trace metals were obtained in iAR and 1M acetic acid carbonate leachates
- Trace metal analysis was conducted using an Agilent 7900 ICP-MS at the State Key Laboratory of Marine Geology, Tongji University, Shanghai.
- U isotope compositions were obtained using a ^{236}U-^{233}U double-spike followed by measurement in standard bracketing mode on a Thermo-Scientific NEPTUNE MC-ICP-MS at the Institut für Mineralogie, Leibniz Universität Hannover, Germany

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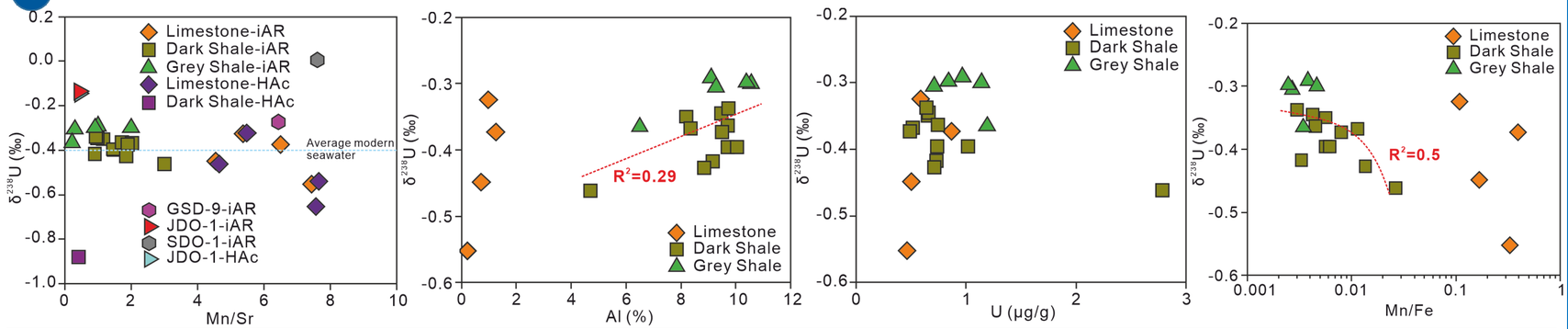
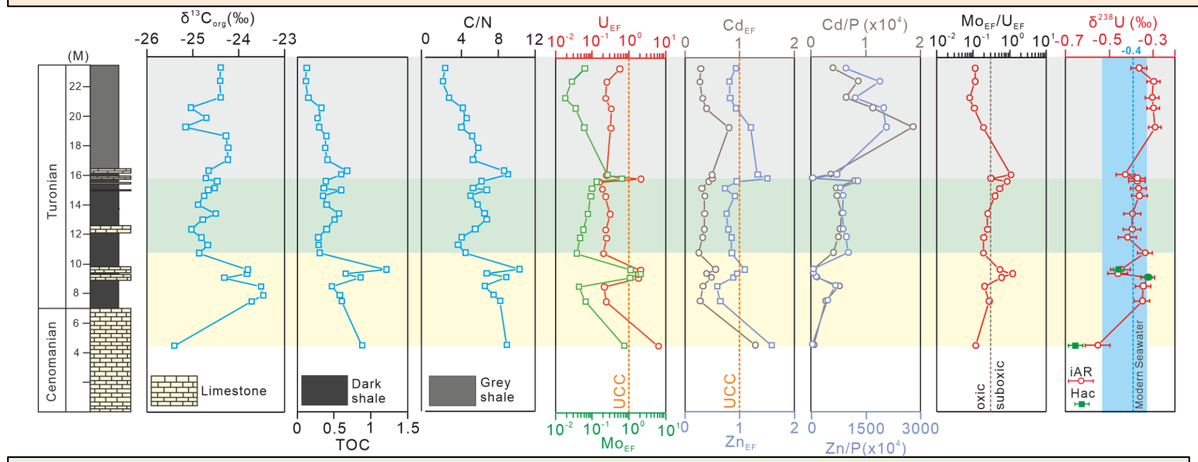
4 Results and discussion



- Mn/Sr of all samples treated with both iAR and HAc were <10, with black and grey shales <3; pure dolomite RM (JDO-1) and three limestone samples treated with iAR and HAc yield similar $\delta^{238}U$ values, indicating that the iAR only attacked authigenic components but no detrital silicate impurities
- One shale sample shows an offset of -0.17 ‰ between iAR and HAc, indicating the incomplete dissolution of authigenic phases by HAc; Al (wt.%) vs. $\delta^{238}U$(‰) shows two end members within the shales (R^2 *=0.29*)
- $\delta^{238}U$ ranges from –0.55 ±0.001 ‰ to -0.29 ±0.02 ‰; No correlation between $\delta^{238}U$(‰) and U concentrations
- $\delta^{238}U$(‰) vs. Mn/Fe show a weak negative correlation (R^2 *=0.5*) for the shale samples and there is no correlation within the limestones
- $\delta^{238}U$(‰) falls into the range of modern seawater compositions, with grey shales at the top plotting at heavier values possibly indicating increasing riverine flux into the UBT



Post OAE2

- After the OAE2, the middle part of the Ashaka section records primarily oxic conditions supported by very low TOC and $\delta^{238}U$ values similar to the modern ocean
- The top of the section exhibits highly depleted redox-sensitive metals and elevated micro-over macronutrient ratios, indicating a rebound to fully open marine conditions characterized by high productivity, upwelling, concurrent with a slight positive shift in $\delta^{238}U$ (-0.37 to -0.29 ‰) potentially indicating riverine influx

During OAE-2

- $\delta^{13}C_{org}$ displays a positive excursion of ~2 ‰ (-25.5 ‰ to -23.5 ‰) at the base of the section, indicating the occurrence of an OAE
- Relatively low TOC values (0.3-1.2 wt.%), indicate low burial rates at a potentially increasing influx of terrigenous organic matter => increasing C/N ratios from 4.4 to 10.3
- U and Mo Enrichment Factors (EF) exhibit depletion, enrichment, and subsequent depletion at the beginning, middle, and end of the OAE2 correlating with TOC
- Cd_{EF} and Zn_{EF} consistently show depletions throughout the OAE2 and display low ratios of micro- to macronutrients (Cd/P and Zn/P).
- The $\delta^{238}U$ of OAE2 at this locale (-0.46 to -0.32 ‰) overlap modern seawater (-0.4 ‰)
- While EFs suggest fluctuations from oxic to sub-oxic redox conditions and a reduced element shuttle at possibly suppressed paleo-productivity, U isotopes indicate oxidising conditions (except one sample at the base)

5 Conclusion

- This study demonstrates partly oxygenated conditions during the OAE2 in the epicontinental Trans-Sahara Seaway as reported in the epicontinental Western Interior Seaway (*Eldrett et al. 2014*). The low TOC values (0.3-1.2 wt.%) recorded during OAE2 in the Ashaka section correspond to the low TOC values from OAE2 section in paleo-South Pacific Ocean (0.13 to 0.65 wt.%) and proto-North Atlantic basin (avg. ~0.6 wt.%)
- The $\delta^{238}U$ negative excursion recorded during the onset of OAE2 from other sections, such as the Western Interior Seaway (1.4 ‰), Eastbourne (0.3‰), and Demerara Rise (0.15‰), is not observed in the Ashaka section. Instead, the $\delta^{238}U$ shows a positive shift of 0.2 ‰ during the onset of OAE2. However, a negative shift of 0.12 ‰ is observed in the middle of the OAE2

6 Funding

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