Nitrogen cycle and climate dynamics during the Late Cretaceous: evidence for Greenhouse icesheets?

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Oxygen isotope data from mid-Turonian (~91.2 Ma) black shales at Demerara Rise (ODP Site 1259) may indicate a transient ~200 ka glaciation during the Cretaceous greenhouse [1]. Here we evaluate marine nitrogen cycle dynamics during the purported glaciation, to test for linkages that have been established for Pleistocene glacial/interglacial cycles. New N-isotope measurements from Site 1259A reveal $\delta^{15}N$ values that range from +0.2‰ to -3.5‰. ^{15}N-depletion is typical of Cretaceous black shales at Demerara Rise [2] and consistent with a nitrogen-fixation source for nutrient nitrogen, and upwelling and isotopic partitioning of ammonium from a shallow chemocline [3]. To provide a temporal framework for the $\delta^{15}N$ data, an astronomical timescale was developed using the average spectral misfit method and frequency domain minimal tuning [4]. Astronomically tuned wt.% $CaCO_3$ and wt.% TOC data reveal a dominant ~400 ka cycle, while the $\delta^{15}N$ data has a strong ~100 ka cycle and little variance at ~400 ka. The highest $\delta^{15}N$ values, and the largest amplitude ~100 ka cycles, are found within putative glacial interval. The $\delta^{15}N$ maxima are readily explained by enhanced oxygen minimum zone ventilation during times of cooling as indicated by TEX_{86} paleotemperatures. Applying the late Pleistocene model for the marine nitrogen cycle, denitrification was reduced during glacial times due to enhanced oxygen solubility and stronger thermocline ventilation [5]. The N-cycle response in the anoxic/euxinic Demerara Rise water column is opposite to that found during the Pleistocene, because advection of oxygen and ventilation promote, rather than inhibit, denitrification and isotopic partitioning of ammonium. The persistence of a ~100 ka $\delta^{15}N$ cycle prior to and following the proposed glaciation event suggests that ice sheet linked climate dynamics may be more important than previously recognized in modulating biogeochemistry and basinal hydrography during the Turonian greenhouse.

[1] Bornemann *et al* (2008) *Science*, **319** 189-192 [2] Junium & Arthur, (2007) *G³*, **8** 1-18 [3] Higgins *et al* (2012) *PNAS*, **109** 2269-2274 [4] Meyers (2012) *Paleocean.* **27** [5] Galbraith *et al* (2004) *Paleocean.* **19**