

The biological pump and evolution of marine animal ecosystems

K.M. MEYER^{1*}, A. RIDGWELL² AND J.L. PAYNE¹

¹Department of Geological and Environmental Sciences, Stanford University, Stanford, CA 94305, USA (*correspondence: meyerk@stanford.edu)

²School of Geographical Sciences, University of Bristol, Bristol, BS8 1SS, UK (andy@seao2.org)

The export of organic matter from the surface ocean and its respiration at depth creates gradients in nutrient and oxygen availability that influence the structure and distribution of marine ecosystems. Today the strength of the biological pump is strongly influenced by mineral-ballasted phytoplankton. In Earth's past, however, mineralized phytoplankton were less common and, consequently, the biological pump was likely weaker. Here we use the GENIE model to explore the impact of a changing biological pump on marine chemistry and ecosystem structure. We find that under a weaker biological pump likely typical of the Paleozoic and early Mesozoic, the position of the oxygen minimum zone shallows and anoxia is more prevalent near the surface. In this scenario, less oxygen is available to benthic ecosystems on shelf environments. If so, these results imply that the mid-Mesozoic radiation of phytoplankton with mineralized tests spread oxygen demand more evenly through the oceans and reduced the spatial extent of anoxic regions. Thus, we hypothesize that the Phanerozoic trend toward greater animal abundance and metabolic demand was driven more by increased oxygen availability than by greater food availability. In fact, a reduction in productivity may have been required to generate sufficient oxygen availability in the shallow oceans to make the oceans more habitable for animals.

Preliminary U-series dating results from the GISP2 ice core

K.W. MEYER AND S.M. ACIEGO

University of Michigan, Ann Arbor, MI 48109-1005, USA (*correspondence: meyerkw@umich.edu)

Ice core climate proxy records often lack precise age constraints on the geochemical variations they record in trapped gases and/or dust inclusions. Currently, few geochronological methods exist to determine the age of the disturbed sections of deep and basal ice. Recent work on material from the Antarctic EPICA Dome C core has demonstrated advances in a radiometric dating method based on $^{234}\text{U}/^{238}\text{U}$ measurements and dust surface area [1]. Our work has focused on applying these same methods to ice samples from the Greenland Ice Sheet Project (GISP2) drill core. Given that the bottom 10% of the GISP2 core consists of disturbed deep ice argued to be 240 ka or older, external dating methods are necessary for confirming the absolute age of these samples and to further extend Northern Hemisphere climate reconstructions [2].

The U-series method depends on determining three variables: (1) the initial concentration of ^{234}U in the soluble fraction of the ice, (2) the parent concentration (^{238}U) in the dust and (3) the precise surface area of the dust grains to account for the loss of ^{234}U from the grain by α -recoil.

One of the critical assumptions of the dating method is that the dust is of marine origin, possessing an initial $^{234}\text{U}/^{238}\text{U}$ activity ratio of 1.14 ± 0.01 [3]. Other studies have determined that there is a significant presence of soluble dust from sea salt deposition on the Greenland Ice Sheet by $^{87}\text{Sr}/^{86}\text{Sr}$, $^{234}\text{U}/^{238}\text{U}$, and ϵ_{Nd} measurements [4]. Our initial measurements yielded $^{87}\text{Sr}/^{86}\text{Sr}$ values ranging between 0.709439 ± 0.00002 and 0.711007 ± 0.00003 . These values are in agreement with the average global $^{87}\text{Sr}/^{86}\text{Sr}$ composition of seawater, given possible interaction with the insoluble fraction. Therefore, our underlying assumption for the source of the soluble dust fraction is plausible. Initial $^{234}\text{U}/^{238}\text{U}$ activity ratios for the soluble fraction increase from 1.178 to 1.229 with depth, suggesting that the daughter excess of ^{234}U correspond to resolvable ages. Surface area and ^{238}U measurements of the insoluble fraction will be presented in the context of the uranium age equation.

[1] Aciego et al. (2011) *Quaternary Science Reviews* **30**, 2389–2397. [2] Suwa et al. (2006) *Journal of Geophysical Research* **111**, D02101. [3] Henderson (2002) *Earth and Planetary Science Letters* **199**, 97–110. [4] Lupker et al. (2010) *Earth and Planetary Science Letters* **295**, 277–286.