The Great Ordovician Biodiversification Event was promoted by persistent deep oceanic anoxia

FEIFEI ZHANG[1*], RICHARD STOCKEY[2], NOAH PLANAVSKY[3], JUNXUAN FAN[1], NA LI[4], SETH FINNEGAN[5], COLE EDWARDS[6], SAM GOLDBERG[7], MATTHEW SALTZMAN[8], TAIS DAHL[9], KRISTIN BERGMANN[7], ERIC SPERLING[2], XIANGDONG WANG[1], SHU-ZHONG SHEN[1]

[1] School of Earth Sciences and Engineering, Nanjing University, China (*correspondence: fzhang@nju.edu.cn)
[2] Stanford University, Stanford, CA, USA
[3] Yale University, New Haven, CT, USA
[4] China University of Geosciences, Wuhan, China
[5] University of California, Berkeley, California, USA
[6] Appalachian State University, Boone, NC, USA
[7] Massachusetts Institute of Technology, Cambridge, USA
[8] The Ohio State University, Columbus, OH, USA
[9] University of Copenhagen, København K, Denmark

The Great Ordovician Biodiversification Event (GOBE) is one of the most important increases in marine biodiversity in Earth's history. The cause(s) of the GOBE remain poorly understood and may include profound changes in external environmental conditions. Given that the GOBE occurred in the oceans, any changes in marine O_2 levels would have played a critical role in shaping the biological evolution. Here, we provide the first quantitative analyses of the extent of global marine redox changes in the Early-Middle Ordovician oceans using $\delta^{238}U$ of marine carbonates. The $\delta^{238}U$ trends from three widely spaced carbonate sections are remarkably similar, yielding a mean value of –0.49‰. The nearly invariant and low $\delta^{238}U$ values over ~15 Myr indicate persistent oceanic anoxia in the Early-Middle Ordovician oceans. A U isotope mass balance model combined with a Monte Carlo framework suggests 3–30% of seafloor areas were overlain by euxinic bottom water, covering the majority of continental shelf areas. With the favor of an intermediate complex Earth system model (cGENIE), we suggest that abundant nutrient supplies and high primary productivity were the immediate cause of the persistent oceanic anoxia. By comparing quantitative paleoredox data derived from our $\delta^{238}U$ records with global biodiversity curves of planktonic faunas and benthic faunas, we find that deep oceanic anoxia in the Early-Middle Ordovician oceans did not change the diversity of benthic faunas which mainly developed during the Cambrian explosion; whereas abundant nutrient supplies in the surface oceans facilitated the radiations of planktonic faunas that represent the GOBE.