Oxygen minimum zones in the early Cambrian ocean

ROMAIN GUILBAUD[1*], BEN J. SLATER[1], SIMON W. POULTON[2], THOMAS H.P. HARVEY[3], JOCHEN J. BROCKS[4], BENJAMIN J. NETTERSHEIM[4], NICHOLAS J.BUTTERFIELD[1]

[1] Department of Earth Sciences, University of Cambridge, Cambridge CB2 3EQ, UK, r.guilbaud@cantab.net
[2] School of Earth and Environment, University of Leeds, Leeds LS2 9JT, UK
[3] Department of Geology, University of Leicester, Leicester LE1 7RH, UK
[4] Research School of Earth Sciences, The Australian National University, ACT 2601, AU

The relationship between the emergence of early animal communities around 630 million years ago (Ma) and the oxygenation of Earth's environment is the scene of ongoing controversy [1-3]. Several lines of evidence point towards progressive ocean oxygenation in the late Neoproterozoic, but reconstructions of redox conditions during the early Cambrian are equivocal. In particular, conflicting datasets from deeper marine settings suggest either ocean anoxia or fully oxygenated conditions. To evaluate links between the preserved fossil archives and the evolving environment, we have studied an exceptionally well defined succession of early Cambrian strata from the Baltic Basin, coupling inorganic geochemical palaeoredox proxies, biomarkers and the record of small carbonaceous fossils. Our results reveal that both inner- and outer-shelf environments were pervasively oxygenated, whereas mid-depth settings were characterized by spatially oscillating anoxia, comparable to the expression of modern oxygen minimum zones (OMZs). As such, the conflicting redox signatures recovered from individual study sites most likely derive from local sampling bias, whereby anoxic conditions represent mid-shelf environments characterized by high productivity and correspondingly high oxygen demand. Recognition of a wedge-shaped, OMZ-like profile in the Cambrian Baltic Basin contrasts with prevailing models of globally stratified oceans, offering a more nuanced and realistic account of the Proterozoic-Phanerozoic ocean transition, which bears importantly on models of early Earth oxygenation.

[1] Canfield, D. E. *et al. Science* **315,** 92–95 (2007). [2] Butterfield, N. J. *Geobiology* **7,** 1–7 (2009). [3] Planavsky, N. J. *et al. Science* **346,** 635–638 (2014).