



## Corrigendum

**Corrigendum to “Basin-scale controls on the molybdenum-isotope composition of seawater during Oceanic Anoxic Event 2 (Late Cretaceous)” [Geochim. Cosmochim. Acta 178 (2016) 291–306]****Abstract**

A recent molybdenum-isotope estimate of the extent of anoxic and euxinic conditions in the world ocean during Oceanic Anoxic Event 2 (~94 Ma) concluded by discussing a contrast between the new results with existing estimates of marine euxinia based on sulphur isotopes. This suggested contrast was erroneous; when areal extents of marine anoxia and euxinia are calculated for both isotopic proxies, the agreement is actually striking, and highlights the fact that large areas of the global ocean probably remained well ventilated during this event.

**Text**

Our recent study of the molybdenum-isotope composition (expressed as  $\delta^{98/95}\text{Mo}$  relative to NIST 3134) of marine sediments deposited during Oceanic Anoxic Event 2 (~94 Ma) concluded that the global seawater composition during this event was  $\sim 1.2\text{‰}$  (Dickson et al., 2016), in agreement with a previous estimate (Westermann et al., 2014). This composition is significantly lower than the present-day seawater  $\delta^{98/95}\text{Mo}$  of  $\sim 2.1\text{‰}$  (Nakagawa et al., 2012), which can be explained by a comparatively higher removal flux of Mo into sulphide-rich sediments deposited in anoxic and euxinic settings during OAE-2.

In our concluding paragraph, it was stated that the removal flux of Mo into anoxic and euxinic environments during OAE-2 was 60–125% greater than at present, which was highlighted as being significantly different from the 15–30 fold increase in euxinic seafloor area estimated using the isotope composition of sulphur bound within carbonates ( $\delta^{34}\text{S}$ ) deposited during the same event (Owens et al., 2013). In fact, the Owens et al. estimate equates to  $\sim 2\text{--}5\%$  of the OAE-2 seafloor being covered by euxinic waters, which is a maximum estimate given that  $\delta^{34}\text{S}$  is unable to differentiate between pyrite formed within a sulphidic water column and pyrite formed within sulphidic sediment pore-waters. The increase in Mo-removal fluxes into anoxic and euxinic sediments for OAE-2 calculated by Dickson et al. (2016) can be converted to approximate seafloor area by calculating a scaling constant from the proportional Mo flux into these environments (covering  $\sim 0.15\%$  of the global seafloor) in the modern ocean; and then applying this scaling to the range of proportional fluxes into anoxic and euxinic environments estimated by Dickson et al. (2016) for OAE-2 (c.f. Ling et al., 2005). These calculations limit the extent of anoxic and euxinic water masses to  $< \sim 2\%$  of the global seafloor during OAE-2, a value that is extremely close to the lower bound of the estimates (2–5%) based on  $\delta^{34}\text{S}$  (Owens et al., 2013). Note that the value of  $< \sim 10\%$  quoted by Dickson et al. (2016) was a conservative estimate. Estimates of seafloor euxinia using both Mo- and S-isotopes contain a number of uncertainties, but can provide order-of-magnitudes assessments of the extent of deoxygenated water masses in the world oceans. The similar range of estimates using both methods is therefore an important observation.

DOI of original article: [10.1016/j.gca.2015.12.036](https://doi.org/10.1016/j.gca.2015.12.036).

<http://dx.doi.org/10.1016/j.gca.2016.06.025>

0016-7037/© 2016 The Author(s). Published by Elsevier Ltd. All rights reserved.

The statement in the concluding paragraph of Dickson et al. (2016) that assessments of the extent of seafloor redox using the Mo- and S-isotope proxies were in disagreement for OAE-2 is not correct; in fact, the agreement between them is striking, and establishes that seafloor anoxia and euxinia, albeit expanded compared with the present day, did not affect the global ocean in as dramatic a manner as envisaged by some numerical models (e.g. Monteiro et al., 2012). The similarity in the results from the two proxies highlights the value of multi-isotopic approaches for reconciling the impact of oxygen depletion in the world ocean and, in turn, for assessing the likely impact of future deoxygenation on marine ecosystems and geochemical cycling of bio-essential nutrients and trace metals.

### Acknowledgements

We thank Shell International B.V. for funding the original paper, and Associate Editor Tim Lyons for input.

### References

- Dickson A.J., Jenkyns H.C., Porcelli D., van den Boorn S. and Idiz E. (2016) Basin-scale controls on the molybdenum-isotope composition of seawater during Oceanic Anoxic Event 2 (Late Cretaceous). *Geochim. Cosmochim. Acta* **178**, 291–306.
- Ling H.-F., Gao J.-F., Zhao K.-D., Jiang S.-Y. and Ma D.-S. (2005) Comment on “Molybdenum isotope evidence for widespread anoxia in Mid-Proterozoic oceans”. *Science* **309**, 1017.
- Monteiro F.M., Pancost R.D., Ridgwell A. and Donnadiou Y. (2012) Nutrients as the dominant control on the spread of anoxia and euxinia across the Cenomanian-Turonian oceanic anoxic event [OAE2]: model-data comparison. *Paleoceanography* **27**, PA4209. <http://dx.doi.org/10.1029/2012PA002351>.
- Nakagawa Y., Takano S., Lutfi Firdaus M., Norisuye K., Hirata T., Vance D. and Sohrin Y. (2012) The molybdenum isotope composition of the modern ocean. *Geochem. J.* **46**, 131–141.
- Owens J.D., Gill B.C., Jenkyns H.C., Bates S.M., Severmann S., Kuypers M.M.M., Woodfine R.G. and Lyons T.W. (2013) Sulfur isotopes track the global extent and dynamics of euxinia during Cretaceous Oceanic Anoxic Event 2. *PNAS* **110**, 18407–18412.
- Westermann S., Vance D., Cameron V., Archer C. and Robinson S.A. (2014) Heterogeneous oxygenation states in the Atlantic and Tethys oceans during Oceanic Anoxic Event 2. *Earth Planet. Sci. Lett.* **404**, 178–189.

Alexander J. Dickson	Department of Earth Sciences, University of Oxford, South Parks Road, Oxford OX1 3AN, UK
Hugh C. Jenkyns	Department of Earth Sciences, University of Oxford, South Parks Road, Oxford OX1 3AN, UK
Donald Porcelli	Department of Earth Sciences, University of Oxford, South Parks Road, Oxford OX1 3AN, UK
Sander van den Boorn	Shell Projects and Technology, Kessler Park 1, 2288 GS Rijswijk, The Netherlands
Erdem Idiz	Department of Earth Sciences, University of Oxford, South Parks Road, Oxford OX1 3AN, UK
Jeremy D. Owens	Department of Earth, Ocean and Atmospheric Science, Florida State University, Tallahassee, FL 32306-4520, USA