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Did early eukaryotes thrive in ancient lakes? New evidence from the Torridonian Supergroup, NW Scotland

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Non-marine habitats may have been important niches for early life, because they offered unique environmental conditions and nutrient inventories that may have facilitated the evolution or radiation of metabolic pathways. In support of this hypothesis, recent studies have documented unusually large sulfur isotopic fractionations [1] and molybdenum enrichments [2] in putative lake sediments of the Poll a'Mhuilt Member in the late Mesoproterozoic Stoer Group (1.2 Gyr), northwestern Scotland [3]. These data were interpreted as evidence of relatively more oxygenated conditions and a high nutrient inventory compared to the contemporaneous ocean. If so, then non-marine environments may have been particularly suited for the origin and evolution of eukaryotic life. However, the non-marine interpretation of this stratigraphic unit is based on contestable lines of evidence, including mild boron enrichments and close associations with fluvial sandstones [4], which cannot rule out a marine influence. Here we revisited the Poll a'Mhuilt Member with more detailed sedimentological observations and new geochemical tools. We found $\delta^{98/95}$Mo values up to +1.2‰ in euxinic shales and carbonate-bound $^{87}Sr/^{86}Sr$ ratios of <0.707-0.710 that agree well with constraints on the composition of Mesoproterozoic seawater [5, 6]. These data were measured in horizons that display herringbone cross-bedding and wave ripples indicative of tidal activity. We therefore conclude that these sediments were most likely deposited during a marine incursion into an estuarine environment, and that the high molybdenum concentrations and sulfur isotopic fractions are the results of evapo-concentration of seawater. Whether or not non-marine environments were important habitats for early life therefore remains unresolved.

References:

[1] Parnell J, et al. (2010) Nature 468: 290-293.
[2] Parnell J.et al. (2015) Nature Communications 6: doi:10.1038/ncomms7996.
[3] Steward AD (2002), The later Proterozoic Torridonian rocks of Scotland: Their sedimentology, geochemistry and origin: Bath, UK, Geological Society.
[4] Stewart AD and Parker A (1979) Sedimentary Geology 22: 229-241.
[5] Kendall B. et al. (2009) Geochimica et Cosmochimica Acta 73: 2534-2558.
[6] Kuznetsov AB (2014) Stratigraphy and Geological Correlation 22: 553-575.