A sulfidic driver for the Late Ordovician extinction

E.U. HAMMARLUND[1,2]*, T.W. DAHL[1], D.A.T. HARPER[3], D.P.G. BOND[4], C.J. BJERRUM[5] AND D.E. CANFIELD[1]

[1]Nordic Center for Earth Evolution (NordCEE) and Institute of Biology, University of Southern Denmark, 5230 Odense M, Denmark (*correspondence: emma@biology.sdu.dk)
[2]Department of Palaeozoology, Swedish Museum of Natural History, Box 50007, 104 05 Stockholm, Sweden
[3]Natural History Museum of Denmark, Øster Voldgade 3-5, 1350 Copenhagen K, Denmark
[4]School of Earth and Environment, University of Leeds, LS2 9JT, UK
[5]Institute of Geography and Geology, Copenhagen University, Øster Voldgade 10, 1350 Copenhagen K, Denmark

The first of three major Phanerozoic extinctions occurred during the late Ordovician Hirnantian stage when 86% of marine species and up to 24% of families perished in two phases. The extinction has been linked to cooling, glaciation and transgression but the exact kill mechanism(s) remain enigmatic because the timing of events and environmental changes are unclear. We analyzed sediments from the Dobs Linn (Scotland), the Billegrav (Denmark), and the Carnic Alps (Austria). These record a positive excursion in the isotopic composition of pyrite sulfur of up to 40‰ during the early to mid-Hirnantian, with maximum $\delta^{34}S$ values close to those of modern rivers. Similar excursions have previously been noted from the Hirnantian of China. The positive $\delta^{34}S$ shift is interpreted to reflect a drop in seawater sulfate concentration promoted by enhanced pyrite burial during expanded global ocean euxinia.

We examined changes in local depositional environments during the late Ordovician extinctions using multiple redox indicators: reactive iron, molybdenum, organic nitrogen and carbon isotopes, and pyrite framboid size distributions. The emerging picture is of deep ocean euxinia, prevailing before the initiation of the first phase of Hirnantian extinction. We argue that both phases of the extinction, and especially the second, were linked to marine euxinia.

During the first phase of extinction, a sea level fall of up to 150 meters decreased shelf area and accompanying euxinia further compressed the habitable oxic zone of the upper ocean, foremost affecting nektonic species. The second phase occurred in the aftermath of the Hirnantian glaciation when ice caps retreated, leading to transgression and the invasion of shelves by deep sulfidic waters, killing mid and shallow water fauna.

Bench scale experiments modeling the effects of a phytostabilization strategy for arsenic and lead containing mine tailings in the semi-arid Southwestern United States

CORIN M. HAMMOND*, ROBERT A. ROOT, SCOTT WHITE, RAINA M. MAIER AND JON CHOROVER

Department of Soil, Water, and Environmental Science, University of Arizona, Tucson, AZ 85721, USA (*correspondance: schowalt@email.arizona.edu)

The Iron King Mine-Humboldt Smelter Site in Dewey-Humboldt, Arizona, U.S.A. is characterized by high iron oxyhydroxide content, acidic pH, and concentrations of arsenic and lead in the top 35 cm averaging about 4,010 mg kg^{-1} and 2,390 mg kg^{-1}, respectively. In the semi-arid climate, human exposure to contaminated tailings particulate matter occurs primarily by aeolian dispersion and water erosion. Consequently, the site was added to the National Priorities (*Superfund*) List by the United States Environmental Protection Agency (EPA) in 2008.

The overall research goal is to develop a cost effective phytostabilization strategy to remediate the Iron King Mine tailings by amending the tailings with compost, lime, mycorrhizal fungi, irrigation, tilling, and seed of native halotolerant plant species. ICP-MS analysis reveals variation in contaminant "solubility" (defined here as <0.2 μm diameter) as a function of dissolved organic matter (DOM) from dairy compost additions. Both arsenic and iron exhibited significant reductions in concentrations in the aqueous phase with increased DOM (Figure 1). This trend is attributed to decreased surface charge of suspended oxyhydroxide colloids with sorbed DOM enhancing flocculation. The colloids (<200 nm) were further investigated with synchrotron XAS and the arsenic species was shown to be As(V) associated with ferric hydroxides.

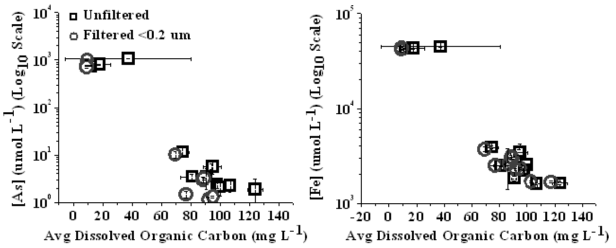

Figure 1: Arsenic (left) and iron (right) supernatant concentrations from batch experiments show similar trends with respect to dissolved organic carbon concentration.