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Acid Weathering, Clay Transport and Enhanced Phosphate Supply to Early Paleoproterozoic Oceans Following the Great Oxidation Event

Kurt Konhauser, Weiduo Hao, and Daniel Alessi
Department of Earth and Atmospheric Sciences, University of Alberta, Edmonton, Canada (kurtk@ualberta.ca)

It was previously hypothesized that following the Great Oxidation Event at ca. 2.5 billion years ago, oxygenation of the atmosphere led to increased rates of chemical weathering, unprecedented acid production from the oxidation of crustal pyrite, and enhanced levels of nutrient transport to the oceans (Konhauser et al., 2011). Higher levels of terrestrial phosphate supply would then have facilitated marine primary production, the burial of more organic carbon than any previous time in Earth's history, a rise in atmospheric oxygen, and a large increase in the 13C value of marine carbonates; these events are collectively known as the Lomagundi Event (LE) between ca. 2.22 and 2.06 Ga. The LE also witnessed the deposition of the first commercially important phosphorite ore (Bekker and Holland, 2012). Although phosphate was initially sourced from acidic soil pore- and ground-waters, increasing the dissolution of crustal apatite, the mechanisms by which the phosphate was transported to the oceans and then concentrated into P-rich deposits is unclear. Here we show that phosphate is readily adsorbed onto clay particles at freshwater conditions (pH 6, ionic strength=0.01 M) but that phosphate is released in marine aquatic environments (pH 8, ionic strength=0.56 M). We then suggest that during terrestrial weathering, P was carried by suspended clay particles to estuarine environments, where P was desorbed, released into seawater as ionic phosphate species and then utilized by photosynthetic plankton. Upon the death of the plankton, shoaling would have concentrated the biomass, leading to phosphorite deposition. Our research provides new perspectives on the mechanisms that link the rise in atmospheric O_2 and the LE.

Bekker, A. and Holland, H.D., 2012. Oxygen overshoot and recovery during the early Paleoproterozoic. Earth and Planetary Science Letters. 317:295-304.
Konhauser, K.O. et al. 2011. Chromium enrichment in iron formations record Earth's first acid rock drainage during the Great Oxidation Event. Nature, 478:369-373.