Evolution of bioturbation buffered Neoproterozoic oxygenation

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A range of geochemical evidence suggests a major oxygenation of the ocean (and by implication atmosphere) at the end of the Neoproterozoic – a change that may well have been necessary (although not sufficient) for the proliferation of the earliest animal life. However, indications of a localised reversion to more anoxic (and sulphidic) ocean conditions during the Cambrian raise the possibility of a subsequent drop in atmospheric oxygen. Furthermore, an explanation for why oxygen stopped rising during the Neoproterozoic remains elusive. Here we hypothesize that the efficiency of phosphorous removal from the ocean was significantly increased by the onset of large-scale sediment bioturbation and resultant ventilation - caused by the proliferation of macroscopic animals. This was due to (a) increased microbial P sequestration under oxic sedimentary conditions, and (b) greater net organic carbon oxidation reducing the C:P burial ratio[1,2]. The resulting reduction in the concentration of phosphorus in the ocean suppressed new production and organic carbon burial, reducing the long-term source of atmospheric oxygen and thereby buffering its concentration on a multi-million year timescale. We suggest that a plausible scenario for the integrated evolution of the Earth system at the end of the Neoproterozoic is therefore "increased marine P concentration via weathering of the land surface following terrestrial colonisation ⟶ increased marine production and organic carbon burial ⟶ increased atmospheric oxygen ⟶ drastic increase in biomass and motility of the (already multi-cellular and differentiated) animal biosphere ⟶ increased bioturbation ⟶ reduction in marine P reservoir size and stabilisation of global phosphate and oxygen cycles"[3,4]. We argue that these feedbacks and a trajectory along these lines can help explain why atmospheric O_2 and marine PO_4 fluctuations have been well buffered during the Phanerozoic.

References

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Lead-isotope geochemistry of the Bagirkacdere lead– zinc deposit, Biga Peninsula, NW Turkey

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The Biga Peninsula contains several base-metal skarn deposits associated with Oligo-Miocene age granitic intrusions. The Bagirkacdere lead-zinc deposit is a typical example of the skarn-type deposits occurring in the northern section of the Biga Peninsula (5.2 Mt at 3.8 % Pb, 2.18 % Zn). The mineralization developed within the Paleozoic meta-sedimentary (Torasan metamorphics) and meta-granitic rocks (Camlik meta-granitoids) as stratabound disseminations and thin veins in schists, marble and meta-granitoids of the skarn zone. Pyrite, sphalerite and galena are the main sulphide minerals and they are accompained by minor amounts of chalcopyrite, arsenopyrite and hematite. Limonite, malachite, smithsonite, anglesite and cerrusite are secondary alteration products. The skarn is dominated by garnet, calc-silicates, epidote, actinolite, diopsite, feldspar and quartz.

Lead isotope ratios for galena have mean values of $^{206}Pb/^{204}Pb$ 18.758, $^{207}Pb/^{204}Pb$ 15.698, and $^{208}Pb/^{204}Pb$ 38.958. . When the data are plotted on the model curves for average crustal Pb-isotope evolution [1], $^{207}Pb/^{204}Pb$ and $^{208}Pb/^{204}Pb$ ratios are close to or above the evolution curves and clearly indicate a crustal source. Possible Pb sources have been investigated using the plumbo-tectonic diagrams [2] and the $^{208}Pb/^{204}Pb$ vs. $^{206}Pb/^{204}Pb$ data points are distributed along a trend between the representative curves for the Lower and Upper Crust, but they are closer to the Orogenic and Upper Crustal curves. The isotope data has higher $^{206}Pb/^{204}Pb$ ratios that are close to the 0-age suggesting young (Cenozoic) Pb-model ages [1]. The Pb data for Bagirkacdere is similar to mineralization at Arapucandere and Koru, which are close to Bagirkacdere in the north part of peninsula, indicating that similar processes were operatring over a wide area.

The $\delta^{34}S$ values of galena and sphalerite from the Bagirkacdere deposit, which are close to 0 ‰, are consistant with dominantly magmatic sulphur reservoir [3]. The combined lead and sulfur isotope data indicate that the source of lead and other metals in the skarn is primarily derived from Tertiary granites.

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