Modelling bioturbation's impact on qualitative differences between the Neoproterozoic and Cambrian $\delta^{13}C$ records

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Mixing of sediments by moving animals becomes apparent in the trace fossil record from about 550 million years ago (Ma), loosely overlapping with the tail end of the extreme carbonate carbon isotope ($\delta^{13}C$) fluctuations that qualitatively distinguish the Proterozoic geochemical record from that of the Phanerozoic. We note that several previous (independent) hypotheses explain high amplitude $\delta^{13}C$ fluctuations via a build-up of isotopicially light carbon, through mechanisms (e.g. authigenic carbonate precipitation or methanogenesis) that are ultimately contingent upon extensive anoxia in marine sediments. We hypothesize that the rise of bioturbation qualitatively reduced marine sediment anoxia by exposing sediments to oxygenated overlying waters- thereby decreasing the carbon cycle's subsequent susceptibility to Precambrian-scale $\delta^{13}C$ fluctuations. We conduct a comparative modelling exercise in which we introduce bioturbation to existing model scenarios; expressing both the anoxic fraction of marine sediments, and the global organic carbon burial efficiency, as a decreasing function of bioturbation. We illustrate how bioturbation's oxygenating impact on sediments has the capacity to prevent $\delta^{13}C$ fluctuations caused by authigenic carbonate precipitation or methanogenesis. More tentatively, we argue that bioturbation may also have reduced the quantity of (isotopically light) organic-derived carbon feeding into any isotopically influential ocean crust carbonatization flux. (Bioturbation's impact on the *f*-ratio via remineralization is partially offset by liberation of organic phosphate, some of which feeds back into new production). With the proviso that this work is ultimately semi-quantitative in nature, we conclude that it is entirely plausible that bioturbation made a decisive contribution to the enigmatic directionality in the $\delta^{13}C$ record, from the Neoproterozoic–Cambrian boundary onwards.