The Impact of Snowball Earth Glaciation on Ocean Water $\delta^{18}O$ Values

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It has been long recognized that glacial episodes can affect the $\delta^{18}O$ value of ocean water, where preferential storage of ^{16}O in ice changes the $^{18}O/^{16}O$ ratio of the ocean. The Snowball Earth glaciations of the Cryogenian have the potential to cause very large (perhaps permanent) changes in ocean water $\delta^{18}O$ values due to their increased ice volume and long duration. Here, I use a numerical box model to investigate ocean water $\delta^{18}O$ values over the Proterozoic and Phanerozoic. The model simulates various temperature and tectonics dependant fluxes of ^{18}O, while also incorporating a zero-dimensional climate model and ice volume component to model glacial cycles. Monte Carlo simulations of the Sturtian and Marinoan glaciations reveal that these had the potential to alter ocean water $\delta^{18}O$ values for hundreds of millions of years after the termination of glaciation, providing a mechanism for secular change in the $\delta^{18}O$ value of ocean water. This occurs as a very large volume of ice (presumably, but not necessarily ^{18}O depleted) is sequestered from the ocean, causing the ocean to become enriched enough in ^{18}O for exchange at mid-ocean ridges to remove ^{18}O from the ocean and slowly change the overall ocean water $\delta^{18}O$ value. However, it is unlikely that the magnitude of this effect is large enough to explain the secular trend in $\delta^{18}O$ value seen in compilations of Phanerozoic carbonates. An additional finding of this work is that the duration of the Sturtian glaciation required a very low CO_2 degassing rate on the order of ~2 Tmol/year, significantly less than that estimated from riverine flux or other mass balance approaches for the Phanerozoic.