Environmental Influences on Neoproterozoic Carbon Isotope Excursions

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Neoproterozoic carbonates host some of the largest carbon isotope excursions in the geologic record. There has been much debate over the origin of these signals, and whether they reflect local or global conditions. Recently, Schrag et al. [1] suggested that precipitation of authigenic carbonates, whose isotopic composition may be either enriched or depleted relative to seawater, may play an important role in controlling the isotopic composition of the global ocean as recorded in primary marine carbonates. Using a diffusion-reaction model, we show that oscillations in sulfate reduction rates can drive large variations in the $\delta^{13}C$ of authigenic carbonates, forcing abrupt changes in the isotopic composition of average seawater. We suggest that sulfate reduction rates were unusually sensitive to geochemical perturbations during the early Neoproterozoic due to low sulfate concentrations at that time. Furthermore, low-oxygen conditions require that primary productivity was small and distributed primarily along the coasts; the resulting flux of organic carbon to sediments is shown to be very sensitive to geochemical perturbations. The combination of these factors may explain why sulfate reduction rates, and ultimately the $\delta^{13}C$ of seawater, were unusually prone to large excursions during the Neoproterozoic.

[1] Schrag, Higgins, Macdonald & Johnston (2013), Science 339, 540-543.