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The Role of Paleogeography and Lithology in Triggering Extreme Climate Change

Over geological time scales, the silicate weathering feedback controls atmospheric CO$_2$ levels, and hence global climate. The CO$_2$ set point is determined by many factors, including, solar luminosity, paleography, topography, vegetation, and exposed lithologies on the continents. Here I argue that the unique middle Neoproterozoic (ca. 720 Ma) paleogeography of a rifting supercontinent in the low latitudes, combined with abundant fresh continental flood basalt in the tropics, triggered the onset of Cryogenian glaciation, culminating in global ice cover that lasted for 10s of millions of years. Basalt weathering during the middle Neoproterozoic would also have strongly influenced the fluxes of biogeochemically important elements, such as P, S, and Fe, from the continents to the oceans. Indeed, a sustained interval of intense basalt weathering leading into the Cryogenian likely helped sustain high organic carbon burial rates, and hence the high d$_{13}$C of the oceans that characterizes this time interval. At the same time, oxidative weathering of ferrous minerals in basalts would have slowed accumulation of atmospheric O$_2$ and contributed to a reprise of deposition of banded iron formation during the first Cryogenian glaciation. Continental flood basalt weathering also seems to have been an important factor in several global paleoenvironmental perturbations during the Phanerozoic, including the onset of Antarctic glaciation at the Eocene-Oligocene boundary.