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Osmium and Strontium Isotope Tests of a Sturtian-Rapitan Snowball Earth

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The Snowball Earth hypothesis predicts that Cryogenian glaciations: 1) were globally synchronous; 2) had a duration on the order of 10 Myrs; 3) terminated with the build up of volcanogenic CO_2 and a flux of alkalinity to the oceans. Although there are many observations consistent with the hypothesis (c.f. Hoffman and Schrag, 2002), aside from confirmation of an extreme greenhouse in the aftermath of the Marinoan glaciation (Bao et al., 2008), definitive tests of the Snowball Earth hypothesis have been hampered by the paucity of reliable geochronological constraints and the limitations of Sr isotopes as an independent weathering proxy. Osmium isotope stratigraphy provides a complementary window into silicate weathering that can be time calibrated with Re-Os organic-rich rock (ORR) geochronometry. When applied to organic-rich Cryogenian successions in NW Canada and Mongolia that have independent U-Pb zircon geochronological constraints, these data suggest that the Sturtian-Rapitan glaciation lasted >50 Ma that deglaciation was global and synchronous. Moreover, osmium and strontium isotope values in marine sediments trend towards more unradiogenic values going into the Sturtian-Rapitan glaciation and rapidly become more radiogenic in the overlying deglacial transgressive sequence, consistent with increased CO_2 consumption via weathering continental flood basalts as an initiation mechanism (Godderis et al., 2003) and increased silicate weathering during a post-glacial super-greenhouse. The lack of a trend to unradiogenic Sr isotope values across Cryogenian glacial deposits has been used as an argument against the Snowball Earth hypothesis (Jacobson and Kaufman, 1999; Kennedy et al., 2001). However, carbonate weathering in the high CO_2 environment necessary for deglaciation may increase the residence time of Sr and buffer the system to change (Higgins and Schrag, 2003). This is not an issue for Os isotope data.

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