Geophysical Research Abstracts
Vol. 21, EGU2019-11035-1, 2019
EGU General Assembly 2019

Tides on a snowball: an Earth Science whodunit?

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The Cryogenian (720 – 635 million years (Ma) ago) was a period in Earth's history of prolonged and severe glaciations, known as "Snowball Earth". The two main glaciations were probably near-global in extent, and the first of these (the Sturtian glaciation) lasted over 55 Ma, from about 715-660 Ma. The second, the Marinoan, "only" lasted 15 Ma, between 650-635 Ma. Recent results on the deep time history of Earth's tides, especially the discovery of a supertidal cycle linked to the tectonic supercontinent cycle, show that the tides are weak during a supercontinent arrangement because the ocean basins are not in tidal resonance due to their size. The Cryogenian was a period of a slow breakup of the supercontinent Rodinia between 750-633 Ma, and most of the period was spent with the continents only weakly scattered. Furthermore, the presences of nearly 1 km of ice may effectively have dampened out the tide. We can therefore expect the tides to be weak during the Cryogenian, but how weak? Did Snowball Earth kill the tides?

Using an established a well-constrained numerical tidal model and the latest reconstructions of the tectonic configurations for the period, we show that the tides were indeed very weak throughout the Cryogenian. This is especially true during the glaciations, when a lowstand in sea-level of about 800m led to significantly reduced tides compared to an ice-free Earth with the same continental and orbital configuration. The 150 Ma simulated here are the most tidally quiescent of the 1 Byr now simulated, and they further support the idea of a supertidal cycle linked to the supercontinent cycle. The results further show that the tides were more energetic before the onset of the glaciations, and that they rapidly increased at the end of the Marinoan. We therefore conclude that the extensive glaciations did dampen the tides to very low levels due to changes in sea-level, with consequences for the Earth system at the time. The snowball did indeed kill the tides, with a sea level low stand during a supercontinent.