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Neoproterozoic ice patch Earth: The paradox of low latitude sea level glaciation coeval with regions of open ocean

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Climate models show that if ice advanced from the Earth's poles to low latitudes the consequential rise in the Earth's albedo due to the increase in ice cover would inevitably result in a run-away glaciation of the whole planet (Budyko 1969; Chylek and Coakley 1975). Worldwide sedimentary and geochemical evidence for low latitude glaciations in the Neoproterzoic period has been interpreted by some as evidence for such global glaciations. The "Snowball Earth" model suggest 2 or more separate global glaciations occurred during the late Neoproterozoic (e.g., Hoffman et al. 1998a,b). A unique element of the Snowball Earth model is that it proposes an escape mechanism from global glaciation; namely closing down the carbon cycle that allows an uncontrolled rise in atmospheric CO_2 from volcanic out gassing to cause run-away global warming (Kirschvink 1992). However, there is strong sedimentary evidence that regions of the ocean remained ice free during periods when low latitude sea level ice existed (e.g., Christie-Blick et al. 1999, Deynoux 1982; Dobrzinski and Bahlburg 2006, Embelton and Williams 1986; Williams 1996; William and Tonkins 1985; Young and Gostin 1989, 1991; Young 2001) and for advance and retreat of wet based glaciers (e.g., Allen et al. 2004, Condon et al. 2002; Leather et al. 2002). These observations contradict the predictions of existing climate models and are incompatible with the CO_2 escape mechanism of the Snowball Earth model. They necessitate an alternative to the Snowball Earth's explanation for -ve δ^{13}C excursions. We address the apparent climatic paradox of coeval low latitude sea level ice and regions of open ocean. Data is presented from the Late Neoproterozoic Ghaub Fm glaciation exposed

in NE Namibia. An “Ice Patch” Earth model is proposed characterised by the advance and retreat of polar glaciers regionally along an irregular latitudinal front, which in places crossed into low latitudes, generating a lower magnitude increase in albedo. Regional advance and retreat of glaciers might reflect small magnitude local changes in ocean surface temperature due to changes to ocean circulation patterns, in a global ocean with a low ambient sea surface temperature.

(1) Evidence for low latitude glaciations: Glacial diamictites vs debris flow deposits

The principle evidence for low latitude glaciations are globally distributed diamictites interpreted as glacial in origin. However, diamictites have alternatively been interpreted as debris flow deposits e.g., Eyles and Januszczak, 2007. Dropstones in the Maieberg cap carbonate *overlying* the Ghaub diamictite support a glacial origin.

(2) Snowball vs. Ice Patch Earth: Were low latitude glaciations regional or global?

The correlation of diamictites to a few global events is based on chemostratigraphic correlation of -ve δ^{13}C excursions. Data is presented questioning the Snowball Earth’s interpretation of –ve δ^{13}C stages as recording collapse in organic productivity caused by the global ocean totally freezing over. Glaciations may be diachronous.

(3) Relative sea-level fluctuations during Maieberg cap carbonate deposition.

The Snowball Earth model interprets cap carbonates as precipitates deposited during a huge alkali influx into the ocean as ultra-greenhouse conditions caused massive continental weathering and a major marine trangression at the end of global glaciation. Organofacies evidence for relative sea-level fluctuations during Maieberg cap carbonate deposition is presented challenging this interpretation.