meetabst\EGU03A.sam/doc Accepted for Session CL11.22 "Neoproterozoic Ice Ages" Convenors A.Nedelec, G.Ramstein, Y.Godderis & J.Laskar. EGS-EUG-AGU, Nice 6-11April 2003.

Joined into Session BG15: "From Snowball Earth to the Cambrian bioradiation: basins, ecosystems and geochemistry (co sponsored by CL) Convenors: H.Strauss, S.Bengtson, H.Bahlburg, and S.Bowring.

Published in CD-ROM Geophysical Research Abstracts Vol 5 2003, Abstr No 04765, where Ref .2 is unfortunately missing..

PLATE TECTONICS HIATI AS THE CAUSE OF GLOBAL GLACIATIONS: 1. EARLY PROTEROZOIC EVENTS AND THE RISE OF OXYGEN

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Plate tectonics is the main way in which the Earth's internal heat is brought to the surface and lost, so it seems that global tectonics should not stop and start. Consequently the long-standing fact that, globally, no orogenic granitoid or greenstone U-Pb ages have been found in the 2.45-2.22 Ga interval has been attributed to defective sampling. Here I argue that this interval was indeed a prolonged hiatus in plate tectonics, being the first of two. The other, but differently caused, was in the late Proterozoic and is the topic of Part 2. The feature common to both hiati, and relevant to global glaciation, is that mid-ocean ridges (MORs) die and subside, potentially lowering sea-level by several kilometres, causing loss of atmospheric CO_2 by weathering and an increase in planetary albedo.

For the origin of the first hiatus we must first go back to formation of the core. The current iron-percolation model is invalidated by the fact that its corollary, the arrival of a water- and siderophile-rich 'late veneer' at the end of percolation, would be required to arrive some 60 Ma after the Moon, which never had a late veneer, was already in Earth orbit. The available alternative [1] would have given the early Earth a wet and low-viscosity convecting mantle able to dispose of the early heat with high efficiency; so that by 2.8Ga MORs began to deepen, exposing cratons to massive weathering which lowered atmospheric CO_2. The well-documented late Archaean acceleration of crustal addition to cratons, or, more precisely, of TTG-granitoid intrusion of greenstone belts, is also, paradoxically, evidence of waning mantle heat. Such wide-belt intrusion, grouped into quasi-coeval 'events', are examples of post-subduction magmatism (PSM), marking interruption of flat-slab subduction under a greenstone belt when a microcraton arrived [2]. On each occasion the TTG, derived from the subducted and reheated oceanic crust, advected subducting-plate heat to the surface that would otherwise have been returned to the mantle heat budget. This worsened the heat-budget problem, finally precipitating a collapse of mantle convection and the ensuing Huronian global glaciations at ~2.35Ga.

The unparalleled deposition of banded iron-formation (BIF) during the early part of this hiatus supports this picture. Throughout the Archaean, Fe2+ had accumulated in the deep ocean, stabilized by acidic input from MORs, despite the efforts of oxygenic life (OL) in shallow water. Removal of this input enabled OL to 'win its battle', the BIF was deposited and the ocean largely oxygenated. $\delta^{13}C$ rose as OL really flowered at ~2.22Ga, when MORs resumed, patchily at first, and sea-level rose and flooded planated cratons.

[1] Osmaston, M.F. (Goldschmidt 2002) GCA 66 (15A) A571.

[2] Osmaston, M.F. (GSA Ann Mtg 2001) GSA Abstr. with Prog. 33 (6) A-145.