Earth's first Phanerozoic-style glaciation?

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Summary

The Ediacaran Period was a crucial transition interval for the Earth System which saw the emergence of ecosystems with complex macroscopic organisms between 580 Ma to 575 Ma[1]. There is good geological evidence for at least one major glaciation during the mid-Ediacaran[2-5] that appears to break the Cryogenian 'Snowball Earth' mould of globally distributed persistent low altitude ice[6]. We evaluated the temporal, spatial, and sedimentological evidence for a mid-Ediacaran glaciation (**Figs. 1, 2**), focused around the *c.* 580 Ma 'Gaskiers glaciation'.

Our results support a 10 Myr to 15 Myr (**Fig. 1**) icehouse interval with grounded ice at mid- to high-latitudes (**Fig. 2, 3**) that terminated at 580 Ma, followed by a gap in the glaciogenic record of 5 My to 10 My. The spatial distribution of geological evidence for glaciation in this interval is in good agreement with the extent of sea global sea ice estimated from general circulation model (GCM) simulations of global climate (**Fig. 3**).

Our analysis suggests that the Gaskiers glaciation was a multi-million-year icehouse interval, similar in spatial extent to later Phanerozoic ice ages, and that ended just before the emergence of complex macroscopic life.

The geological evidence for mid-Ediacaran glaciation

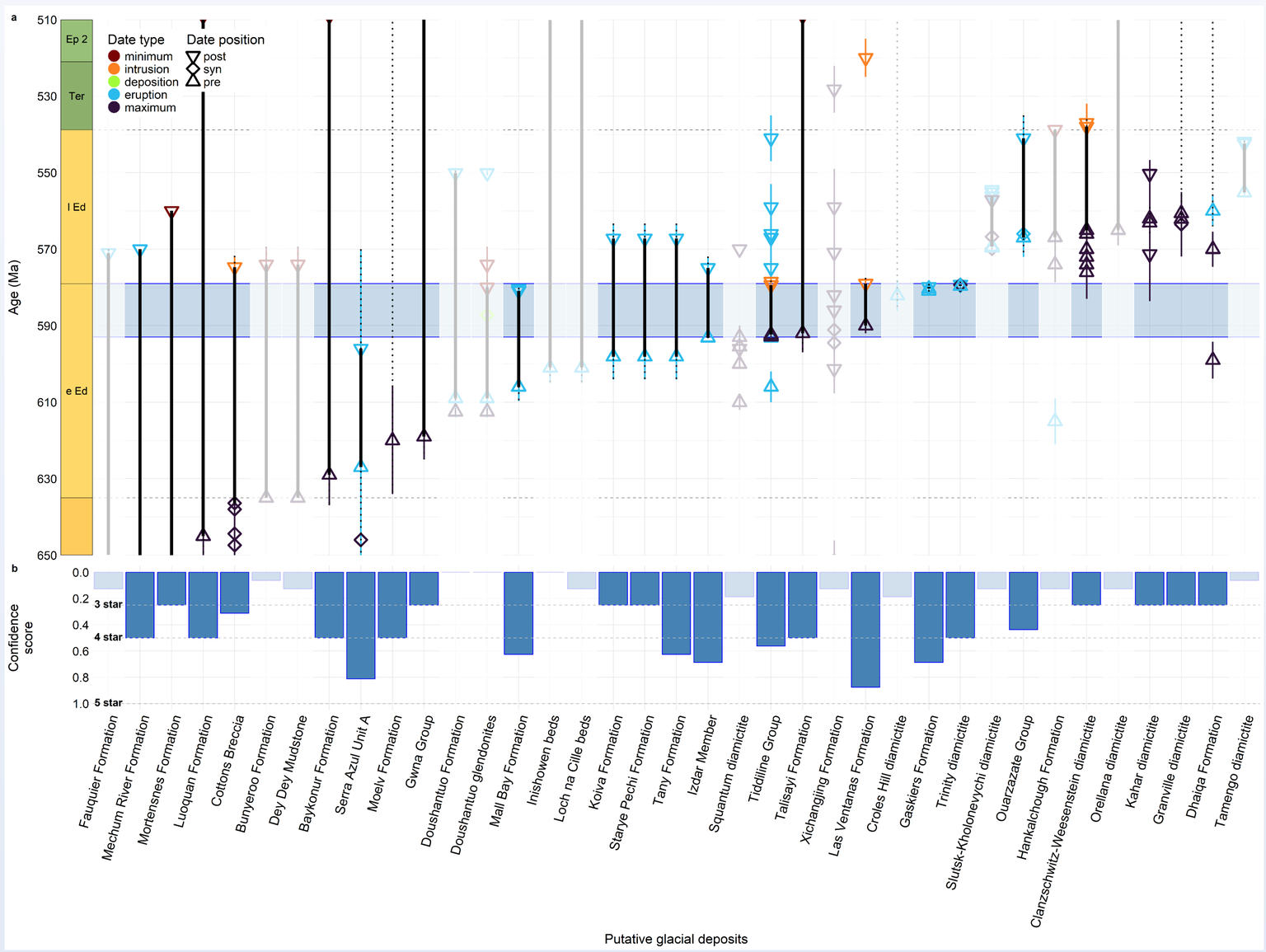


Fig. 1: (**a**) Radiometric, chemostratigraphic, and (Palaeozoic) biostratigraphic age constraints for deposits associated with the Gaskiers glaciation in the literature[2-5]. (**b**) Semi-quantitative glaciogenicity likelihood score adapted from Tindall's[4] logarithmic 0- to 5-star scheme; deposits rated less than 3 stars (score < 0.25) are shaded out.

The spatial extent of mid-Ediacaran glaciation

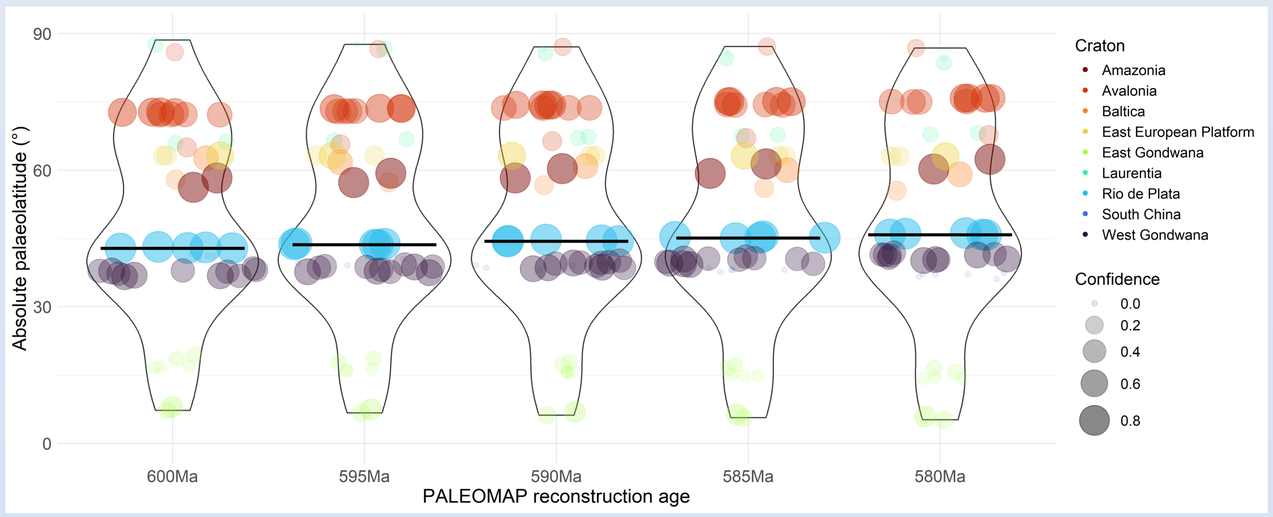
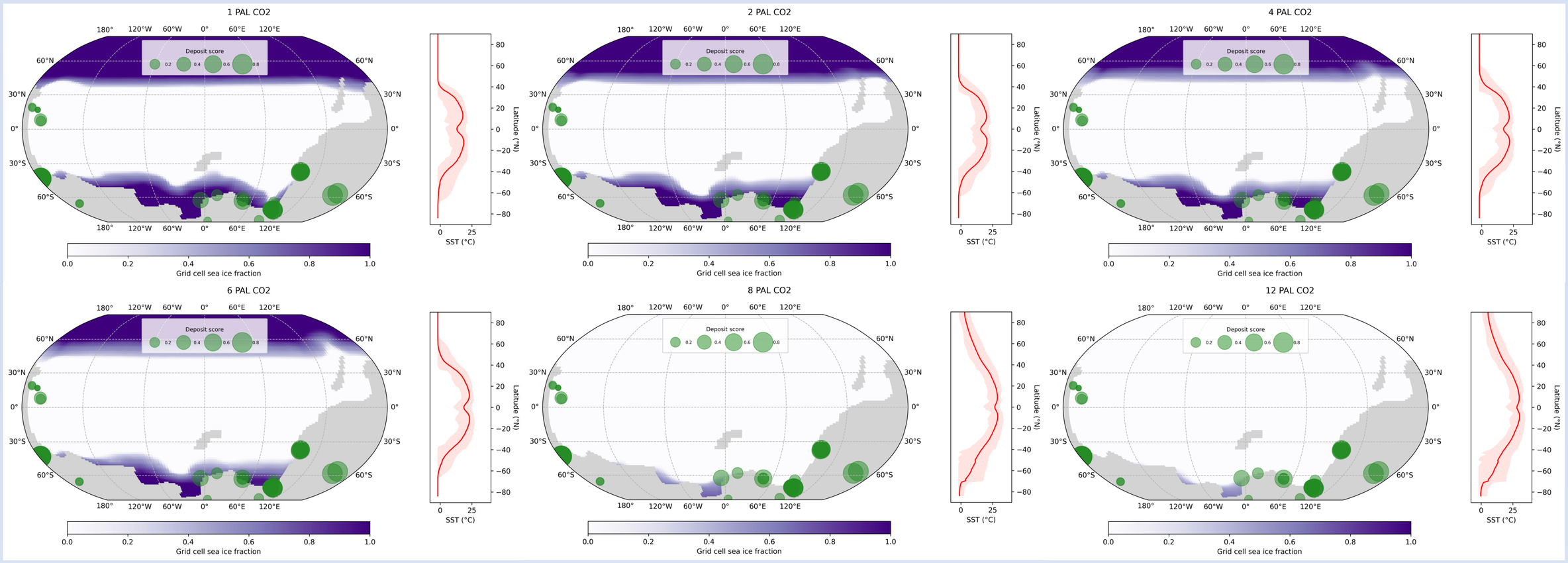


Fig. 2 (left): Absolute palaeolatitude distribution of potential Gaskiers-age (maximum age > 570 Ma; minimum age < 635 Ma) deposits size- and transparency-scaled by glaciogenicity likelihood score, and coloured by craton.

Fig. 3 (below): Sea ice fraction simulated configuration using the Fast Ocean Atmosphere Model (FOAM)[7] GCM for six pCO_2 levels, with potential Gaskiers-age glaciogenic deposits plotted at their palaeo-rotated positions and scaled by glaciogenicity likelihood score. Continental configuration: 600 Ma PALEOMAP[8] reconstruction. PAL: preindustrial atmospheric level pCO_2 = 280 ppm.



References. [1]Xiao & Narbonne 2020, *in* Geologic Time Scale 2020. [2]Retallack 2022, *Australian Journal of Earth Sciences*. [3]Wang *et al*. 2023, *National Science Review*. [4]Tindal 2023, *PhD Thesis*, University of Cambridge. [5]Niu *et al*. 2024, *Earth-Science Reviews*. [6]Hoffman *et al*. 2017, *Science Advances*. [7]Jacob 1997, *PhD Thesis*, The University of Wisconsin – Madison. [8]Scotese 2016, *PALEOMAP Project*.

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