What did Earth's earliest tides look like? Examining the tide in the Archaean (3.9 Ga) and Proterozoic (2.5 Ga) with a conceptual tidal model

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Introduction

It is known that the present day Atlantic tide is larger than the historical average because it is near half wavelength resonance for the M_2 tide (Green et al., 2017). We have hypothesised that these periods of enhanced global tidal dissipation will occur in the future as oceans form, open and close as part of their Wilson cycles, which is intrinsically linked to the Supercontinent cycle (Davies et al., 2020). Does this relationship exist for the whole history of the Earth-Moon system? Or is it a product of more recent tectonics?

Motivation

From previous work (Davies et al., 2020) we have established that the tides follow a general trend of strengthening between supercontinents and weakening as supercontinents form (fig 1). We now plan on analysing that relationship in the deep past.

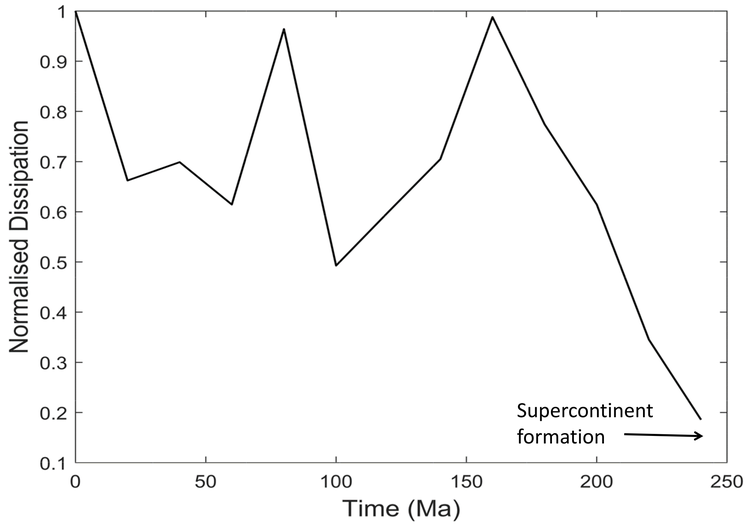

Fig 1. Averaged total global tidal dissipation (normalised to the present day global total dissipation) from Present day (0 Ma) to the next 250 Myr of Earth's future. The graph shows peaks and troughs as the Earth moves in and out of "Super-tidal" periods as the supercontinent cycle progresses (Davies et al., 2020).

Research approach

In the Archaean (3.9 Ga) and Proterozoic (2.5 Ga) the Moon was far closer and the tides were much stronger (table 1), we hypothesise this will strongly affect the tidal signal.

Table 1 (right). Day length, tidal period and strength, and lunar distance for the Present day, Proterozoic (2.5 Ga), and the Archaean (3.9 Ga)

Time period	Day Length (h)	M_2 Tidal period (h)	Equilibrium tidal height (m)	Lunar distance (km)
Present day	24	12.42	0.24	384402
2.5 Ga	17.1	8.83	0.45	322000
3.9 Ga	13.1	6.78	0.84	263000

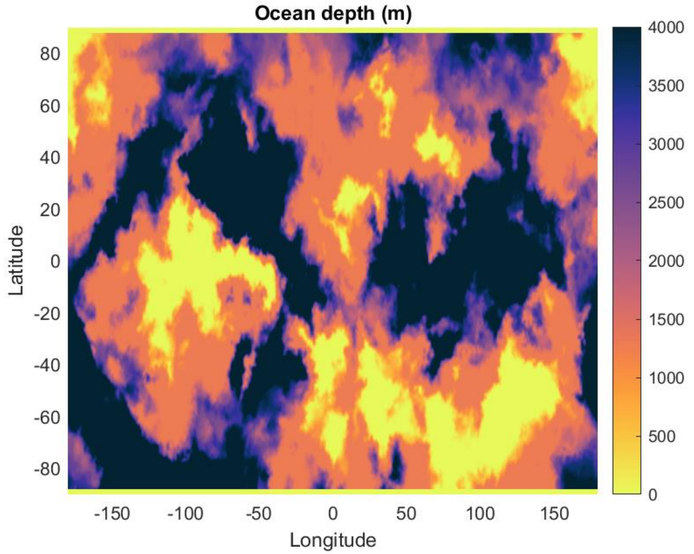

Fig 2. A bathymetry map of one of the 110 random maps used in this study.

Model Design

Archaean and Proterozoic tectonic reconstructions in the detail required for tidal modelling at this resolution (1/4°) do not exist, therefore we used 110 randomised planetary bathymetries with 5 – 15% land coverage by area. This creates a statistically significant estimation of an Archaean and Proterozoic Earth.

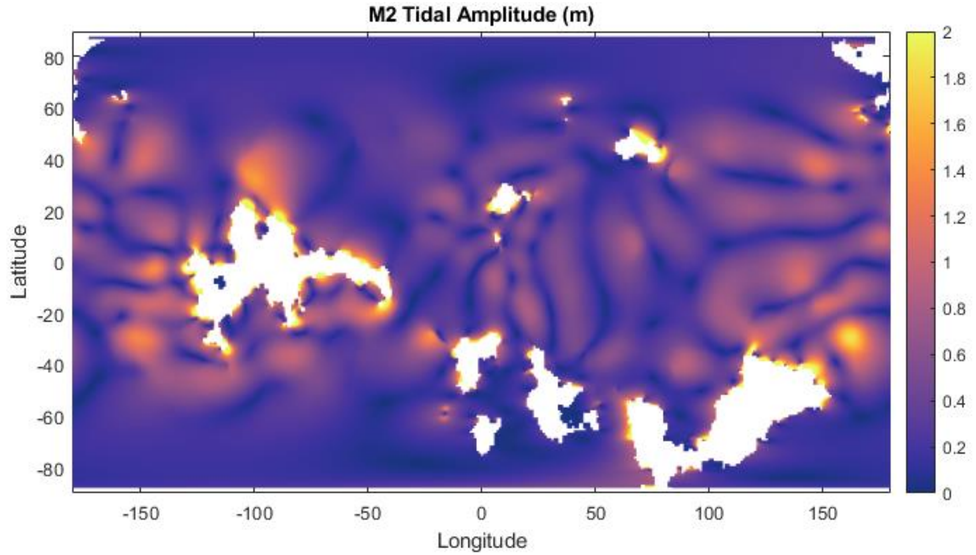

Fig 3. The same map as figure 2 displaying M_2 tidal amplitude. The scale saturates at 2 m.