Supplementary Information for:

Plate motion drives variability in ocean oxygenation through the Phanerozoic

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Supplementary Discussion

Most of the simulations in Extended Data Figs. 5 and 6 show that the ocean dynamics eventually settles to a stable steady-state solution. However, amongst these are cases where the system overshoots (for example, compare panels a and g of Extended Data Fig. 5) before approaching a steady-state solution. This implies the presence of an oscillatory mode, in agreement with the linear stability analysis of low-resolution GCM steady states under present-day conditions[47,48]. The simulations in Extended Data Figs. 5 and 6 reveal that, depending on changes to continental configuration, the steady-state solutions can lose stability, resulting in stable oscillations. It is known that, under certain climate conditions, advective feedbacks in the ocean circulation can destabilize the steady-state[49]. Extended Data Figs. 5bb and 6z are cases of steady-state solutions with oscillatory modes that are linearly stable, but only weakly stable, resulting in clear examples of damped oscillations. Since the frequencies of the damped and self-sustained oscillations of Extended Data Figs. 6z and 6aa, respectively, are very similar, the transition could represent a Hopf bifurcation, resulting in self-sustained oscillations around an unstable steady state.

The precise conditions that allow not only the destabilization of the steady state, but also the existence of *stable* oscillations, as well as the precise bifurcation structure associated with the oscillations, is the subject of ongoing work with idealized continental configurations.

Supplementary References

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