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Revisiting ocean mixing timescale in the Precambrian

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Redox sensitive trace metals such as U, Cr and Mo and their isotopes are widely used as indicators of global oxygen level in early Earth's oceans. However, these tracers could have had a shorter residence time in anoxic Precambrian oceans. If ocean mixing timescale also differed due to variations in Earth's geophysical parameters and was similar to the tracers' residence time [1], then the tracers may not be recording a global signal and inferrences from such tracers would need to be reevaluated. This study assesses the consequences of evolving ocean circulation patterns on the current understanding of Earth's oxygenation by constraining the ocean mixing timescale and residence time of trace metal redox proxies in the Precambrian ocean.

We simulated ocean circulation with the cGENIE 3-D ocean model driven by wind fields from the PlaSim 3-D atmosphere model. We first tested the sensitivity of ocean mixing to 4 parameters: rotation rate, tidally-driven turbulent mixing, surface pressure and continentality [2], and then covaried them to approximate 5 historical scenarios: Paleoarchean, Neoarchean, Paleoproterozoic, Mid-proterozoic and Neoproterozoic. We examined the variation in residence time of U, Re, Cr and Mo in Precambrian oceans by integrating data compilation of trace metal enrichment in ancient marine sediments with a mass balance model modified from [3]. We find that the ocean mixing timescale is generally relatively weakly sensitive to the considered geophysical parameters, and probably did not differ by more than a factor of a few from the modern value of about 1000 years. However, tracer residence times in Precambrian oceans are consistently smaller than their modern values, and may even become shorter than the modern ocean mixing timescale when the model involves some nonlinearity. The implication that some of the paleoredox tracers may only have recorded a local signal may require reevaluation of existing global redox proxy records.

[1] Chen et al. (2021) *GCA* **300**, 164-191. [2] Olson, Jansen & Abbot (2020) *ApJ* **895**:19. [3] Reinhard et al. (2013a) *PNAS* **110**(14).