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Continental or hydrothermal dominance: insights from neodymium isotopic heterogeneity in the Archean oceans

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Large variations in the neodymium isotopic composition (ε_{Nd}) of similarly aged late Archean banded iron formations (BIFs) suggest that the late Archean oceans were inhomogeneous with respect to $^{143}Nd/^{144}Nd$ ratios [1-2]. Without constraints on Archean ocean mixing timescale and Nd residence time, it was hard to tell whether such heterogeneity was a global phenomenon or was confined to local depositional environments, or to understand which sources were more important in determining the seawater ε_{Nd} as recorded in BIFs. This study evaluates the contributing factors to the Nd isotopic heterogeneity in the Archean oceans by modelling the spatial distributions of Nd isotopes in Archean oceans whose mixing timescales are constrained in [3].

We simulate the Archean Nd cycle in the cGENIE ocean circulation model by estimating Nd source fluxes using similar scaling arguments as those used for iron by [4] and compiling the corresponding ε_{Nd} values from Precambrian sedimentary archives [5-7]. With the calculated global Nd residence time being similar to the mixing timescales in our modeled Archean oceans, we find that the observed extent of Nd isotopic variations in late Archean BIFs is difficult to reproduce even when endmember continental ε_{Nd} values are used. This indicates that the extreme heterogeneities probably existed in coastal environments at a scale not resolvable by our model, as expected when the oxide-facies BIFs scavenged Nd from seawater, leading to a local Nd residence time much shorter than the global average. Consequently, the ε_{Nd} values of late Archean BIFs were likely dominated by local continental runoff, with the high ε_{Nd} reflecting input from juvenile emerged crust instead of deep-sea hydrothermal sources as previously speculated.

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