Goldschmidt 2024 Abstract
https://doi.org/10.46247/gold2024.21799

Solar System formation scenarios effect on ideal redox state of disk needed to produce Earth

GABRIEL NATHAN, HUNG NGUYEN AND SETH ANDREW JACOBSON

Michigan State University

Presenting Author: nathanga@msu.edu

Several competing formation scenarios can reproduce viable Solar Systems, including the Grand Tack [1,2], the early giant planet instability [3], inside-out growth [4], and narrow disk models [5,6]. Each of these models differ in their initial distribution of material, extent of radial mixing within the protoplanetary disk, and the timing of instabilities and giant impacts. Despite their varied initial conditions and evolutions, each model can successfully create Solar Systems that match the observed astrophysical properties of the inner planets. This is problematic because these models are mutually incompatible. Thus, we must turn to geophysical constraints such as the chemical and isotopic compositions of the terrestrial planets to further distinguish between these proposed early Solar System histories.

To do this, we use a combined astrophysical N-body accretion and geochemical core-mantle differentiation model (based on [7-9]) to determine the geochemical effects of various proposed formation scenarios. Our models vary the initial Fe and Si redox gradients in a simulated protoplanetary disk and use the major and trace element composition of Earth's mantle as a constraint. Here, we determine the initial redox state of the protoplanetary disk needed to reproduce the Earth in the aforementioned formation scenarios. We find trends between different suites of formation simulations that support and rule out broad features of various proposed early Solar System histories.

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