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Sequencing Terrestrial Planet Formation Stages with Isotopic Clocks

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The standard model of planet formation predicts the following evolutionary stages in the protoplanetary disk. (1) Coagulation of dust to km-sized planetesimals (10^2-10^4 yrs at 1 AU), probably aided by the Goldreich-Ward gravitational instability. (2) Rapid runaway growth that is followed by decreased rate of oligarchic growth phase (limited by depletion of supplies) from planetesimals to planetary embryos (~20 oligarchs), which takes 10^5-10^6 yrs at 1AU. As observationally inferred disk depletion timescales are 10^6-10^7 yr, oligarchic growth would proceed before the disk gas dissipates. (3). In the late stage, the planetary embryos perturb each other into crossing orbits leading to giant impacts, the result of which is the formation of full-sized planets (10^7-10^8 yr). Thus, the formation of the Moon via a giant impact is an integral part of the protoplanetary disk evolution. In this talk, I will review recent progresses in using multiple isotopic clocks to constrain all these processes. For example, using core formation as a tool to monitor the rate of accretion, the date by the 182Hf-182W chronometer constrains the end of stage 3 of planet formation. Copious amount of debris disk would accompany the stage 3 (giant impact stage). Geochemical consequences of re-accreting these materials during and/or post giant impact phase will also be discussed.

Keywords: Solar System, Planet Formation, Chronometers, Earth, Moon, Giant Impact