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Early Solar System Evolution Recorded by Short-Lived Chronometers

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Absolute age constraints on early solar system processes and events can be derived from meteorites and their components using radioisotope systems. Due to the short time interval from the first formation of solids in the solar nebula to the accretion and differentiation of planetesimals and some planets, a high temporal resolution of the chronometers is essential and can be obtained in most cases only with short-lived isotope systems, particularly the decay schemes ^{26}Al-^{26}Mg, ^{182}Hf-^{182}W and ^{53}Mn-^{53}Cr. These chronometers provide highly resolved age constraints for the formation of the first solids (Ca-Al-rich inclusions, CAIs), chondrules, and planetary cores, for the accretion and differentiation of planetesimals and hydrous alteration. Formation of CAIs was restricted to the inner solar system and to a short time interval of $\ll$1 Ma, and marks the "beginning of the solar system". It was immediately followed by planetesimal formation. The oldest planetesimals accreted and differentiated into a metallic core and a silicate mantle within a few 10^5 a after the formation of CAIs. The accretion of planetesimals and their subsequent differentiation was a continuous process that occurred at different times in different locations of the solar nebula and extended over a time interval of at least ~4 Ma. The accretion of early planetary bodies was a condition for the formation of silicate chondrules in a narrow time interval from 1.5-3 Ma. The chondrule forming interval was immediately followed by the accretion of the chondrite parent bodies, which did not differentiate due to their late accretion when most of the heat-producing ^{26}Al had already decayed. Thus, the chondrite parent bodies are a second generation of planetesimals, but chemically they are the most primitive material preserved from the early solar system. Aqueous alteration of volatile-rich planetesimals started at ~3.5 Ma and coincided with metamorphism recorded in ordinary chondrite parent bodies. The compilation of ages from different meteorites and their components demonstrates the accretion of matter into planetesimals was a local phenomenon with stochastic spatial distribution. The spatial distribution of accretion processes operating in the early solar system appears to be similar to those in some directly observable nascent exo-planetary systems.