The meteorite dichotomy and its implications for early Solar System evolution

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Isotopic studies of meteorites can help to reconstruct the earliest evolution of the Solar System and provide crucial insights into the processes of planetary growth. A recent key discovery is that meteorites exhibit a fundamental dichotomy in their genetic heritage with separate carbonaceous (NC) and non-carbonaceous (NC) solar disk reservoirs [1]. Here I will review the isotopic evidence for this NC-CC dichotomy and highlight its implications for the large-scale dynamics and structure of the solar accretion disk. The NC-CC dichotomy was first discovered based on Cr, Ti and O isotope anomalies in meteorites which define two separate clusters [1], implying a lack of mixing between two solar disk reservoirs. Subsequent work revealed that this NC-CC dichotomy also exists for other elements (e.g. Mo, Ni, Ru) and extends to iron meteorites [2-4]. The ages and genetics of iron meteorite and chondrites mandate an early and protracted spatial separation of inner (NC) and outer (CC) disk reservoirs, lasting between ~1 and ~4 million years (Ma) after the first solids [3]. This effective spatial separation is most easily reconciled with the early growth of Jupiter's core, inhibiting significant exchange of material within the disk. These findings are in good agreement with recent accretion models promoting rapid growth of protoplanetary bodies and gas giant cores [5], as well as with giant planet migration scenarios, which may explain the scattering of CC asteroids from the outer disk into the main asteroid belt [6]. Although its exact origin is still being investigated, the NC-CC dichotomy is consistent with a higher fraction of presolar carrier phases containing nuclides produced in neutron-rich stellar environments in the CC over the NC reservoir [2,4,7]. This is most readily accounted for by an isotopic change in the composition of the infalling material from the Solar System's parental molecular cloud [7], resulting in the formation of distinct inner (NC) and outer disk (CC) reservoirs which were then preserved for several Ma by the Jupiter barrier.

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