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Origin of the CC-NC isotopic dichotomy in early planetesimals (iron meteorite parent bodies)

ALESSANDRO MORBIDELLI[1], KEVIN BAILLIÉ[2], KONSTANTIN BATYGIN[3], SEBASTIEN CHARNOZ[4], TRISTAN GUILLOT[5], DAVID RUBIE[6] AND THORSTEN KLEINE[7]

[1]Observatoire de la Cote d'Azur
[2]Observatoire de Paris
[3]Caltech
[4]Université de Paris / IPGP/ CNRS / UMR 7154
[5]CNRS
[6]Universität Bayreuth
[7]Max Planck Institute for Solar System Research

Presenting Author: morby@oca.eu

The isotopic dichotomy between carbonaceous (CC) and non-carbonaceous (NC) chondrites has been shown to exist also among iron meteorites[1], whose parent bodies are the first planetesimals that formed in the Solar System, within 1 My of CAIs. The distinct highly-siderophile-element concentration in CC and NC iron meteorites indicates that the parent bodies of the former were significantly more oxidized than those of the latter. The isotopic and oxidation dichotomies suggest that the earliest planetesimals in the solar system formed at two distinct sites, one of which richer in water than the other. In this work[2], by modeling the evolution of a disk with ongoing accretion of material from the collapsing molecular cloud, we show that planetesimal formation via the streaming instability may have been triggered within the first 0.5 million years by dust pile-up at both the snowline (at ~5 au) and the silicate sublimation line (at ~1 au). Particle concentration at ~1 au is due to the early outward radial motion of gas and is assisted by the sublimation and recondensation of silicates. Our results indicate that, although the planetesimals at the two locations formed about contemporaneously, those at the snowline accreted a large fraction of their mass (~60%) from materials delivered to the disk in the first few 10^4 yr, whereas this fraction is only 30% for the planetesimals formed at the silicate line. Thus, provided that the isotopic composition of the delivered material changed with time, as proposed in[3], these two planetesimal populations should have distinct isotopic compositions, consistent with observations. The isotopic dichotomy in iron meteorites does not require the Jupiter's barrier: it is simply the consequence of planetesimal formation at distinct locations in a disk with an isotopic gradient. However, the preservation of the difference in isotopic composition between the inner and the outer disk at the time of chondrite formation requires that a barrier against the radial drift of dust is established within ~0.5 My.

[1] Kruijer, T.S., et al. 2017. PNAS 114, 6712–6716
[2] Morbidelli, A. et al. 2022. NatAs, 6, 72.
[3] Nanne, J.A.M. et al. 2019. EPSL 511, 44–54