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Nucleosynthetic Ti isotope compositions of planetary bodies indicate secondary sub-structures in the solar protoplanetary disk

MIRIAM RÜFENACHT[1], PRÉCILLIA MORINO[1], YI-JEN LAI[2], MANUELA A. FEHR[3], MAKIKO K. HABA[4] AND **MARIA SCHÖNBÄCHLER**[5]

[1]Institute of Geochemistry and Petrology, ETH Zürich
[2]Macquarie University
[3]ETH Zurich
[4]Tokyo Institute of Technology
[5]ETH Zürich

Presenting Author: mariasc@ethz.ch

Nucleosynthetic isotope variations in bulk meteorites are powerful tracers to assess the early evolution of the solar system, including mixing and reservoir formation in the protoplanetary disk. These variations reflect the heterogeneous distribution of isotopically distinct dust in the disk. Parent bodies of meteorites formed from isotopically distinct dust reservoirs, preserving local isotopic compositions. ALMA telescope observations demonstrate that gaps and ring-like dust structures are common features in primordial disks [1]. It remains an open question, how strongly such features influenced the composition of asteroids and planets observed in our solar system today.

To this end, we report high-precision Ti isotope data for 45 bulk meteorites covering a wide range of meteorite groups. Our Ti isotope data confirm the first order dichotomy between carbonaceous chondrites (CC) and non-carbonaceous (NC) meteorite groups [2-4]. The Ti isotope data, when combined with nucleosynthetic data from other elements, indicate that the inner disk (NC reservoir) was isotopically heterogeneous and can be further divided into two (or more) sub-reservoirs. Two clusters identified are (i) the *Vesta-like* howardites-eucrites-diogenites (HEDs), mesosiderites, angrites, brachinites, acapulcoites and lodranites; (ii) the *Earth-Mars-like* ordinary chondrites, aubrites, enstatite chondrites, winonaites, IAB silicates, Martian and terrestrial samples. These clusters likely correspond to disk substructures such as secondary gaps and ring-structures in the protoplanetary disk. These can be created e.g., by spiral arms emitted from the growing Jupiter and/or Saturn. The denser rings were then sampled by forming planetesimals. A Proto-Jupiter of 10-20 Earth masses will open a primary gap and hinders the inward transport of particles, but not the gas [5]. Such gaps, primary or secondary, act as dust filters, allowing the passage of gas and small dust grains <300µm e.g., [6]. This allows for an isotopic evolution of these reservoirs with time and location, until dust is captured by a planetary body.

[1] ALMA Partnership et al. (2015) *ApJ Letter* 808, 1-10. [2] Leya et al. (2008) *EPSL* 266, 233-244. [3] Trinquier et al. (2009) *Science* 374, 374-376. [4] Rüfenacht et al. (2023) *GCA*, submitted. [5] Alibert et al. (2018) *Nat. Astron*. 2, 873-877. [6] Weber et al. (2018) *ApJ* 854, 1-14.