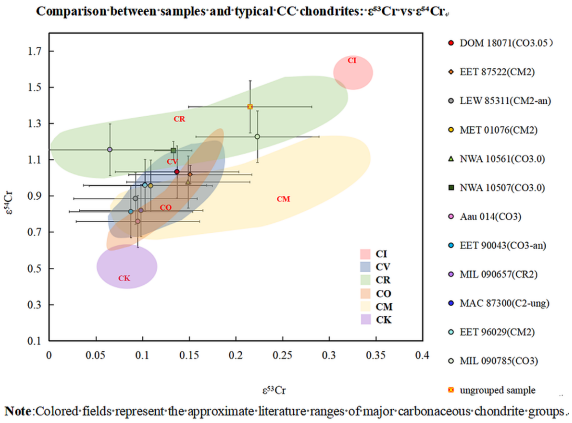
Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.37169

Uncovering diversity among anomalous carbonaceous chondrites using chromium isotope systematics

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Note: Colored fields represent the approximate literature ranges of major carbonaceous chondrite groups.

Carbonaceous chondrites (CCs) preserve isotopic fingerprints of early Solar System reservoirs, but an increasing number of anomalous and ungrouped CCs show petrographic and geochemical features that do not fit neatly within established classifications. Mass-independent variations in Cr and Ti isotopic compositions of nucleosynthetic origin serve as sensitive tracers of genetic affinity and parent-body heritage of extraterrestrial materials. Here we evaluate whether such anomalous CCs can be linked to existing CC clans using new $\varepsilon^{53}Cr$–$\varepsilon^{54}Cr$ results, or alternatively, whether they may define new CC sub-groups, and outline how these constraints motivate targeted integration with Ti and O isotopes for classification. We determined bulk elemental abundances and Cr isotopic compositions for 13 ungrouped CC samples, including several candidates for new unofficial CC types such as CT, CZ, and CX. Chromium was purified using a four-step ion-exchange procedure [1,2] and analyzed by TIMS with 3-line multi-static method. Accuracy and reproducibility were assessed via repeated analyses of Allende (CV3) and JP-1.

The key question is whether anomalous CC candidates could define a coherent subgroup. Notably, several meteorites that carry different current classifications in the Meteoritical Bulletin nevertheless display very similar $\varepsilon^{54}Cr$ values and closely matching elemental abundance patterns; for example, DOM 18071 (MB: CO3.05), EET 90043 (MB: CO3-an), and MAC 87300 (MB: C2-ung) fall within the same field for $\varepsilon^{54}Cr$ and show coherent elemental trends (Major and rare earth elements). This coherence suggests a potential shared affinity for a subset of samples and highlights that current classifications may not fully reflect their relationships.

In this study, our results show that Cr isotopes provide robust first-order constraints on genetic affinity (CM/CO/CV-like versus CR-like) but are insufficient for definitive taxonomy of anomalous CCs. Integrating Ti and O isotopes with petrographic context is part of our ongoing plan and will be essential to refine genetic affinities and classification, ultimately improving constraints on early Solar System mixing and parent-body evolution.

[1] Yokoyama, T. et al. (2023) GGR, 47, 415. [2] Xu, L.J. et al. (2023) At. Spectrosc, 44(3), 142-152..