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The isotopic variations in bulk-scale carbonaceous chondrites and the possible targets in the next sample return mission

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The formation process of planetesimals is key to understand the history of the early solar system. The solar nebula is considered to have heterogeneous isotopic compositions for various elements due to the incomplete mixing of presolar materials, especially in its very early stage. The isotopic variations recorded in bulk-scale meteorites would provide important constraints on the temporal and spatial evolution of chemical and isotopic compositions in the early solar system materials.

Recent findings on bulk-scale isotopic compositions in meteorites indicate that the rocky materials in the early solar system can be classified into two groups; carbonaceous (CC) and non-carbonaceous (NC) meteorites [1]. Bulk-scale CC meteorites possibly record the primordial information associated with the formation process of their parent bodies. The compositional variations in CC meteorites could be associated with the diversity of volatile-rich asteroids, such as C-complex, P-, and D-types. In this study, we assessed the isotopic variations in CC meteorites using the data newly obtained and compiled by previous studies [2, 3].

Figure 1 shows relative isotopic deviations from CI chondrites for various elements in CC meteorites. Despite the different nucleosynthetic origins, the isotopic variations in CC meteorites have several features summarized below. First, CI chondrites are of end-member components among bulk-scale CC meteorites for all elements. Second, Tagish Lake has intermediate isotopic compositions between CI and the other CC meteorites. These trends in CC meteorites suggest the temporal and spatial heterogeneities in CC meteorite reservoir. Tagish Lake and the other CC parent bodies could be initially located inside the orbit of CI parent bodies [4] and incorporated the refractory materials from the inner solar system. For the next sample return mission, it is important to consider how to collect primitive and common materials in terms of the planetesimal formation process.

[1] Kruijer et al. (2017) *PNAS*, **114**, 6712. [2] Alexander (2019) *GCA*, **254**, 277. [3] Burkhardt et al. (2019) *GCA*, **261**, 145. [4] Fukai and Arakawa (2021) *ApJ*, **908**, 64.

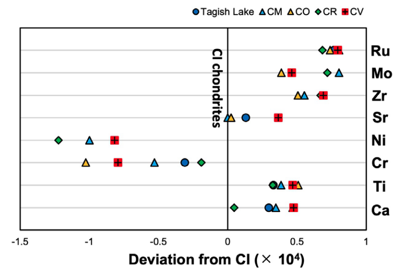

Fig. 1: The nucleosynthetic isotopic deviation from CI chondrites in various elements. The isotopic anomalies for $\varepsilon^{48}Ca$, $\varepsilon^{50}Ti$, $\varepsilon^{54}Cr$, $\varepsilon^{62}Ni$, $\varepsilon^{84}Sr$, $\varepsilon^{96}Zr$, $\varepsilon^{94}Mo$, and $\varepsilon^{100}Ru$ are used. The plotted data are the average value of each chondrite class. Data are normalized with the isotopic anomalies (deviation from the Earth) of CIs.