Formation region of volatile-rich asteroids inferred from nucleosynthetic isotope variations in carbonaceous chondrites

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Describing the comprehensive evolutionary scenario for asteroids (i.e., meteorite parent bodies) is the key issue to explain the various physical processes of the Solar System, such as migration of giant planets and late accretion of volatile elements to rocky planets. In this study, we tried to determine the formation region of asteroids by utilizing the nucleosynthetic Cr isotopic variation ($^{54}Cr/^{52}Cr$) in bulk-scale carbonaceous chondrites (CCs) that possibly record the information of the protoplanetary disk. Numerical calculations are conducted to track the temporal evolution of isotopically different (solar and presolar) dusts and $^{54}Cr/^{52}Cr$ values for mixed materials with disk radius. Our results suggest that nucleosynthetic isotopic variations in CCs were predominantly caused by the spatial heterogeneities of dusts. The formation region of B-, Ch-, D-, and K-type asteroids could be determined using the profile of $^{54}Cr/^{52}Cr$ and the accretional ages of CCs. Among these asteroids, B-type asteroids formed in the outermost region, which is apparently inconsistent with the present population of asteroids showing that D-type asteroids are generally located beyond most of the C-complex asteroids. Both the initial and present orbits of asteroids can be explained by the scatter attributed to the inward–outward gas-drag migration of Jupiter and Saturn.

Keywords: asteroid, chondrite, isotopic heterogeneity

