Distribution of ^{54}Cr Isotope Anomalies in Asteroid Belt

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Isotope Anomalies of ^{54}Cr in Various Meteorites: The degree of ^{54}Cr anomalies in various meteorites was shown to have a good correlation with the evaluated formation ages of their parent bodies [1], except for CAIs [2]. A possibility that the correlation is caused by an input of ^{54}Cr-rich grains ejected from a nearby supernova was proposed [1]. In the model, the input material was assumed to land on a certain ring of the solar nebula at the certain time. Then, the model may reproduce the increase of the ^{54}Cr content, but a spike of ^{54}Cr anomaly contained in CAIs cannot be reproduced by the model. Here, we look for the other process. Inside a molecular cloud core that would form a star and a protoplanetary disk system could be inhomogeneous [3]. This suggests that the isotope anomalies seen in meteorites today may be caused by the isotopic heterogeneity in the molecular cloud core.
In this study, a model that may reproduce the observed anomalies of 54Cr starting from the inhomogeneous molecular cloud core is examined.

Model: It is assumed that isotopically heterogeneous dust grains are inhomogeneously distributed in the initial molecular cloud core; especially, ^{54}Cr-rich grains are concentrated in the central part of the cloud core. Then, the concentration of ^{54}Cr-rich grains is calculated numerically as a function of the time and the place in the solar nebula. Model parameters are the initial angular velocity of the molecular cloud core omega, which determines the size of growing solar nebula, and the strength of the gas turbulence in the solar nebula alpha, which controls the radial flow of the gas and the diffusive motion of dust grains. The mass infall from the molecular cloud core lasts 0.4 Myr.

Results: A typical result is as follows. When omega = 3×10^{-15} s^{-1} and alpha = 10^{-4}, in the early phase (< 0.4 Myr), the concentration decreases as time because the infall of new dust grains from the cloud core dilutes the concentration of ^{54}Cr rich dust grains. Later (> 0.4 Myr), the concentration increases because of the diffusive motion in the nebula. These features are consistent with observations [1, 2].

Summary: We examined the possibility that an inhomogeneous molecular cloud core could generate the inhomogeneous and time dependent distribution of ^{54}Cr-rich dust grains in the asteroid belt. We found that indeed the mechanism may work. The isotope anomalies may be caused by the inhomogeneous initial molecular cloud and by the incomplete mixing of dust grains in the solar nebula.

References: [1] Sugiura and Fujiya (2014) *Meteorit. and Planet. Sci.* **49**, 772-787. [2] Trinquier *et al.* (2009) *Science* **324**, 374-376. [3] Kuffmeier, M. *et al.* (2016), *Astrophysical Journal* **826**, id. 22.

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