Early Solar System chronometry and the ^{26}Al-^{26}Mg clock

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The short-lived ^{26}Al-to-^{26}Mg isotopic system ($t_{1/2}$ = 0.73 Myr) is potentially the most powerful chronometer to study early Solar System timescales. This reflects: a. the short half-life of ^{26}Al and large Al/Mg fractionations induced by nebula and planetary processes, coupled with precisely determined initial ^{26}Al abundance of CAIs, which make it the only isotopic system that allows ‘relative age determinations on meteorites to be made with a resolution ≤ ±0.2 Myr; b. that it is possible to test with some rigour the assumption that the short-lived parent nuclide (^{26}Al) was homogeneously distributed in the inner Solar System.

A high-precision ^{26}Al-^{26}Mg isochron for CAIs yields an initial ^{26}Mg abundance 0.032‰ lower than the present-day Mg isotope composition of reference Solar System materials (chondrites, Earth, Moon and Mars). This is consistent with ^{26}Al being distributed throughout the inner Solar System at levels broadly comparable to CAIs and provides the basis for dating of meteoritic material with Al/Mg = 0 that formed in the first two million years of the Solar System. In such cases, the meteorite material will have small (up to ca. 0.04‰) but resolvable ^{26}Mg deficits compared to inner Solar System reference materials.

We have measured to high-precision Mg isotope ratios in meteoritic material from differentiated planetesimals (aubrites, pallasite olivine, and ureilites) with Al/Mg = 0 by MC-ICPMS. These materials are characterised by ^{26}Mg deficits and if these do not represent analytical artefacts, cosmogenic irradiation effects or ^{26}Al-Mg isotope heterogeneity in the young Solar System, they yield model ages that date planetary differentiation to the first million years (±0.2 Myr) of the Solar System and, in some cases, overlap with CAI formation. Given the mounting evidence that differentiated planetesimals accreted and melted before accretion of chondritic material it seems that collisions between molten bodies could have been an important chondrule forming process. Further, thermal modelling of a heating asteroid suggests that some of these differentiated planetesimals perhaps even pre-dated CAI formation. Given this, we suggest that conventionally accepted models for CAI formation may need to be reconsidered.