Formation timescales of pallasite meteorites inferred from the Mg isotope composition of olivine

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Early formed meteoritic materials with significantly sub-chondritic Al/Mg ratios are not influenced by in-growth of ^{26}Mg from the decay of ^{26}Al ($t_{1/2}$ ~ 0.73 Myr) and thus should record deficits in the mass-independent component of ^{26}Mg (μ^{26}Mg*) inherited from the source reservoir at the time of formation. This provides a means to define their formation timescales. Moreover, potential stable isotope variability in magnesium (μ^{25}Mg) can be used to track genetic relationships between early solar system reservoirs. Pallasite meteorites, consisting of large mm- to cm-sized olivine crystals (Al/Mg ~ 0) set in evolved iron–nickel metal, are ideally suited to constrain the timing of asteroidal accretion and differentiation in the early solar system. Using improved methods for high-precision Mg-isotope measurements [1], we have extended our search for deficits in pallasite meteorites [2] to diverse main group pallasites (PMGs), two pyroxene pallasites, the ungrouped Zinder and Milton pallasites and two pallasites from the Eagle Station grouplet (PESs), including 20 distinct olivine crystals from Eagle Station.

Apart from PESs, all pallasite meteorites studied here have μ^{25}Mg values that are identical to that of Earth's mantle. The PESs have μ^{25}Mg systematically lighter than PMGs and Earth's mantle; defining a weighted mean of -183 ± 23 ppm (relative to DSM-3). This composition is similar to that of the bulk Allende meteorite, supporting the view that PESs formed from a CV chondrite-like precursor [3]. Considerable variability is observed in μ^{26}Mg*, with PMGs, pyroxene pallasites and Zinder having consistently negative μ^{26}Mg* and PESs displaying positive μ^{26}Mg* values. Individual olivine grains from the Eagle Station pallasite have μ^{26}Mg* values ranging from +1.3 ± 1.5 ppm to +14.8 ± 2.0 ppm, plausibly related to igneous evolution on the Eagle Station parent body. Such excesses may record an evolutionary history of a magmatic reservoir with super-chondritic Al/Mg ratio while ^{26}Al was still extant. Model ^{26}Al-^{26}Mg ages constrain the differentiation of the parent bodies of PMGs, PESs, the Vermillion and Yamato8451 pyroxene pallasites as well as Zinder to <2 Myr after solar system formation.

[1] Bizzarro *et al*.. (2011). *J. Anal. At. Spectrom.* **26**, 565-577. [2] Baker *et al*.. (2012). *GCA*. **77**, 415-431. [3] Shukolyukov and Lugmair (2006). *EPSL*. **250**, 200-213.

Indispensable amino acids become dispensable via bacterial symbiosis in a generalist soil detritivore

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Detritus-feeders play a key role for stimulating microbial activity in arctic peatlands but their nutritional requirements are poorly understood. We investigated whether a dominant detritivore in arctic peatlands, the enchytraeid worm, can overcome amino acid limitations in their nutrient poor diets by supplementation from bacterial symbionts. With a new isotopic tool for identifying bacterial synthesis of indispensable amino acids (IAAs) *in situ*, we demonstrated that enchytraeids feeding on hardly digestible diets derived nearly all IAAs from symbiotic bacteria; however, it was considerably less for enchytraeids feeding on easily digestible diets. We also found evidence for substantial bacterial IAA supplementation among enchytraeids dwelling in arctic peatlands. Although symbiotic synthesis and subsidy of IAAs to hosts is well known in herbivore specialists, this study provides the first evidence for substantial symbiotic IAA supplementation among soil detritivores. Our findings suggest that digestibility and initial microbial degradation of soil litter rather than nutritional qualities such as IAA composition determine its suitability as a food resource for enchytraeids. Recent observations and climate change projections for northern high latitudes indicate wetter and warmer conditions, which would be likely to stimulate enchytraeid activity by longer seasons and increased access to older stocks of decomposing litter.

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