# The Hf-W isotopic system and the origin of the Earth and Moon

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The Earth has a radiogenic W-isotopic composition compared to chondrites, demonstrating that it formed while $^{182}$Hf (half-life 9 Myr) was extant in the Earth and decaying to $^{182}$W. This implies that the Earth underwent early and rapid accretion and core formation, with most of the accumulation occurring in ~10 Myr, and concluding about 30 Myr after the origin of the solar system. The Hf-W data for lunar samples can be reconciled with a major Moon-forming impact which terminated the terrestrial accretion process ~30 Myr after the origin of the solar system. The suggestion that the proto-Earth to impactor mass ratio was 7:3 and occurred during accretion is inconsistent with the W isotope data. The W isotope data is satisfactorily modeled with a Mars-sized impactor on proto-Earth (proto-Earth to impactor ratio of 9:1) to form the Moon at ~30 Myr.

# Magnesium isotope composition of chondrites, achondrites and the Earth-Moon system

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We have measured $^{24}$Mg, $^{25}$Mg, and $^{26}$Mg abundances of chondrites, achondrites, lunar and terrestrial rocks and minerals using Nu1700 a high mass resolution MC-ICPMS. Mg-isotopes of terrestrial and meteorite samples fall on a single mass dependent fractionation line. This provides evidence that inner solar system objects were derived from a well mixed reservoir. In contrast to Fe isotopes [1], Mg isotopes show very limited mass-dependent variation. The Mg isotopic composition ($\delta^{26}$Mg) of mantle olivines, enstatites and Cr-diopsides average at -0.07±0.02‰, -0.08 ±0.11‰, and +0.05±0.02‰ (2 s.d.) relative to DSM3, respectively. Based on these data we estimate a $\delta^{26}$Mg between -0.1‰ and 0.0‰ for Earth. Terrestrial volcanic rocks average at $\delta^{26}$Mg=-0.15±0.14‰. Eucrites (n=9) and Martian meteorites (n=4) have a mean of –0.06±0.14‰ and -0.12±0.11‰ respectively, overlapping with terrestrial mantle minerals and volcanic rocks. In contrast, 12 analyses of 7 carbonaceous and ordinary chondrites yield an average of -0.35±0.08‰ (2s.d.). Preliminary data for lunar rocks and minerals vary between chondritic values and DSM3 and are therefore slightly heavy relative to terrestrial values. The overall range of $\delta^{26}$Mg for planetary bodies in the inner solar system is <0.5‰. The homogeneity among chondritic meteorites is surprising because large isotopic variations have been reported for Ca,Al-rich inclusions and to a lesser extent chondrules e.g. [2,3]. The small $\delta^{26}$Mg range requires that, whatever produces the oxygen isotope heterogeneity in chondrites involves processes that cause little mass-dependent Mg isotope fractionation. This is consistent with a recently published model of mass-independent fractionation of oxygen at mineral surfaces during condensation of the solar nebula [4] but seems to be in conflict with the self-shielding model [5].

## References

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