Lunar ^{182}W excess: Implications for the origin of the Moon

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The Moon likely formed after a giant impactor hit the Earth [1]. Details regarding the origin of the Moon, however, are still under debate. Variations in the abundance of ^{182}W—the decay-product of short-lived ^{182}Hf ($t_{1/2}$~9 Myr)—are a tracer of different components that make up the bulk silicate Earth (BSE) and the Moon, may therefore provide a better understanding of the Moon-forming giant impact and Earth's accretion history. However, until now, no one has determined the lunar ^{182}W value precisely enough, mostly because of cosmogenic contributions to ^{182}W [2]. Here we re-assess the ^{182}W value of the Moon through analysis of KREEP-rich samples using improved techniques for high-precision W isotope measurements by MC-ICPMS and a new approach for quantifying cosmogenic ^{182}W variations using Hf isotopes [3].

We find that the Moon exhibits a 27±4 ppm ^{182}W excess over the modern BSE. This excess is consistent with the calculated ^{182}W change resulting from a 'late veneer' of primitive material added to the BSE after the end of core formation [4]. Thus, the pre-late-veneer BSE and the Moon had indistinguishable ε^{182}W, and the giant impact did not induce a ε^{182}W difference, consistent with the Earth–Moon isotopic homogeneity observed for other elements (e.g., [5]). This could reflect that impactor and proto-Earth accreted from a homogeneous inner disk reservoir [6] or that the Moon fully consists of proto-Earth mantle material [7] [8]. However, the giant impact itself should have led to a ^{182}W difference by (1) modifying the ε^{182}W of the proto-Earth mantle, and (2) by distributing W-rich but ^{182}W-depleted impactor core material to the lunar accretion disk. Consequently, the giant impact would have much more likely produced a ^{182}W anomaly in the Moon, than generating ppm-level Earth–Moon ^{182}W homogeneity which required extraordinarily fortuitous circumstances. Thus, our new findings appear to demand for a mechanism that post-dated the giant impact and which led to isotopic equilibration of BSE and the Moon.

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