Solving the Early Earth - Moon Tungsten Riddle

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Many lunar basalts and Archean rocks on Earth exhibit ^{182}W anomalies, which are typically excesses. Two endmember models can explain these isotope anomalies: (1) missing late veneer contributions and (2) early silicate differentiation, possibly during the magma ocean stage. We evaluate these endmember models with respect to recently available W and Ru isotope data for terrestrial rocks, and elemental W systematics of lunar and early Archean rocks. As a first order observation, a compilation of available data for Archean assemblages show that combined ^{182}W and HSE patterns of many Archean assemblages do not overlap a missing late veneer array, as defined by the most plausible delivery agents for Earth's characteristic volatile inventory, CI and CM chondrites [1]. Combining recently reported ^{100}Ru excesses with HSE patterns in Archean mantle rocks from SW Greenland [2] requires a scenario, where at least 60% of late veneer material was already added. Such quantities of late veneer, however, only contribute a third of the measured ^{182}W excess (ca. +12 ppm). Thus, early silicate differentiation is required to explain at least 2/3 of the ^{182}W excess, consistent with ^{142}Nd excesses found in rocks from SW Greenland and new ^{182}W-^{142}Nd data for the Kaapvaal craton [3,4]. Similar to the early Archean rocks on Earth, on the Moon only ca. 50% of the ca. +26 ppm ^{182}W excess can be explained by missing late veneer. A key parameter is also the lower W/Th of the lunar mantle that requires lunar core formation to have fractionated Hf/W on the Moon. Core formation therefore provides the most plausible explanation for at least 50% of the lunar ^{182}W excess. Consequently, the Moon must have formed within the first 70 Myrs of the solar system [e.g., 5].

[1] Braukmüller *et al.* (2019) Nat. Geosc. **12**, 564-568. [2] Fischer Gödde *et al.* (2020) Nature, in press. [3] Tusch et al. (2020) this meeting. [4] Schneider et al. 2019 Chem. Geol 511, 152-177. [5] Thiemens *et al.* (2019) Nat. Geosc. **12**, 696-700.