ISOTOPIC CONSTRAINTS ON THE ORIGIN OF THE MOON. T. Kleine[1], T. S. Kruijer[1] and C. Burkhardt[1], [1]Institut für Planetologie, University of Münster, 48149 Münster, Germany (thorsten.kleine@wwu.de).

Introduction: The Earth and Moon exhibit a surprising isotopic similarity for several elements that otherwise show large variations among solar system objects [1]. This isotopic similarity is surprising, because the giant impact model typically predicts a significant fraction of impactor material in the Moon. Thus, if the isotopic heterogeneity seen among meteorites extends to the Moon-forming impactor, then the Moon should *not* be isotopically identical to the Earth. Several solutions to this problem have been proposed: (*i*) post-giant impact Earth-Moon equilibration [2]; (*ii*) 'new' giant impact models in which the Moon largely consists of proto-Earth material [3, 4]; (*iii*) formation of Earth and impactor from the same homogeneous inner disk reservoir [1]. In this case no isotopic anomaly is expected for the Moon, regardless of how much impactor material was incorporated into the Moon.

While all these models provide potential solutions for the isotopic similarity of the Earth and Moon for most elements, they cannot easily account for the similar ^{182}W compositions of the Earth and Moon [5, 6]. This is because, unlike genetically relevant isotope variations in elements like O or Ti, ^{182}W compositions reflect the distinct accretion and core formation histories of the Earth and the impactor. As such, the proto-Earth's mantle as well as the impactor mantle and core must have had different ^{182}W compositions. Because during the giant impact, these components were mixed, the Moon should exhibit a ^{182}W anomaly compared to Earth's mantle.

***Expected* $\varepsilon^{182}W$ of the Moon:** We calculated the *expected* ^{182}W composition of the Moon in various giant impact scenarios. The main purpose of these calculations is to assess the *likelihood* of producing nearly identical ^{182}W compositions for the Earth's mantle and the Moon. The results of these calculations show that the probability to obtain nearly identical ^{182}W compositions of the Earth and Moon is only ~5% if the Moon predominantly consists of proto-Earth material, and is reduced to ~1% if the Moon largely derives from the impactor (Fig. 1).

Implications for the origin of the Moon: Altbough the nearly identical ^{182}W compositions of the Moon and the Earth's mantle could be coincidence, the probability of this is uncomfortably low. Thus, additional processes might have been important. It has recently been proposed that the Procellarum basin on the Moon formed by a giant impact [7]. Mass balance calculations show that this impact might have lowered the ^{182}W composition of a significant portion of the lunar mantle by up to ~1 $\varepsilon^{182}W$. If the lunar samples analyzed to date would all derive from this modified area, then the Moon might initially have had a larger ^{182}W anomaly, as predicted by our calculations.

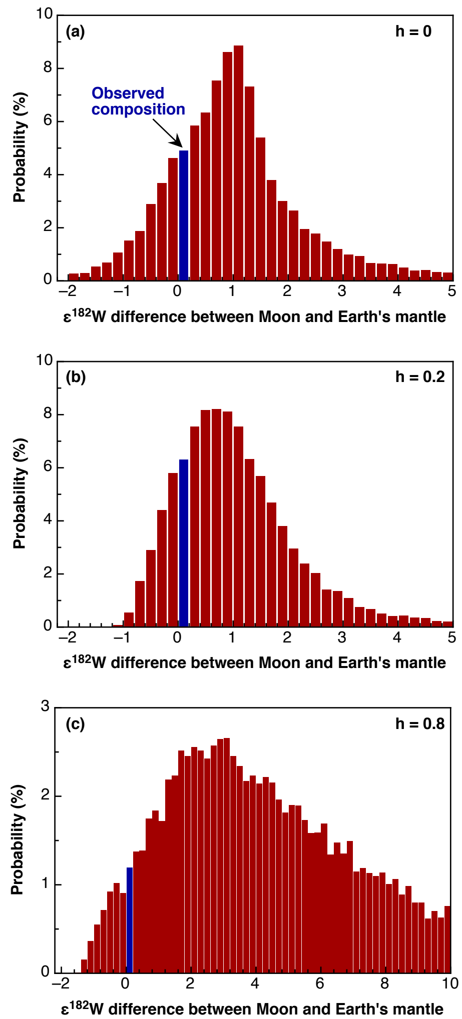

Fig. 1: Histogram showing the expected $\varepsilon^{182}W$ difference between the Moon and Earth's mantle. h = mass fraction of impactor material in the Moon.

References: [1] Dauphas, N. et al. (2014) *PTRS A*, *372, 20130244*. [2] Pahlevan, K. and D.J. Stevenson (2007) *EPSL*, *262, 438-449*. [3] Canup, R.M. (2012) *Science*, *338, 1052-1055*. [4] Cuk, M. and S.T. Stewart (2012) *Science*, *338, 1047-1052*. [5] Kruijer, T.S. et al. (2015) *Nature*, *520, 534-537*. [6] Touboul, M. et al. (2015) *Nature*, *520, 530-533*. [7] Zhu, M.H. et al. (2017) *LPSC*, #1851.