CONSTRAINTS ON THE AGE OF THE MOON FROM ^{182}W. T. Kleine, K. Mezger and C. Münker, ZLG, Institut für Mineralogie, Universität Münster, (tkleine@uni-muenster.de)

The decay of ^{182}Hf to ^{182}W ($t_{1/2}$ = 9 Myr) has been applied successfully as a chronometer to date accretion and subsequent chemical differentiation of planetary bodies [e.g., 1-6]. The recently determined W isotope composition of chondrites [4-6] provides new constraints on the age and origin of the Moon. As a result of early core formation Earth's mantle (BSE) shows a ^{182}W abundance of 1.9 ε units above the chondritic value [4-6]. For lunar samples strongly positive ε_W values have been reported [1], which in part are of cosmogenic origin [3]. For mare basalt 15555 the ^{182}W effects from neutron-flux are negligible and the ε_W of 1.3±0.4 may therefore be interpreted to have chronological significance [3]. This sample has a chondritic ^{142}Nd^{144}Nd [7] indicating the absence of early mantle differentiation in its source. The ε_W of 1.3, therefore, can be considered as the W isotope composition of the bulk lunar mantle.

The excess of ^{182}W in the lunar mantle can be due to ^{182}Hf decay within the Moon or may be inherited from the impactor. In the first case the 1.3 ε_W excess indicates that the Moon formed at 27±3 Myr and thus prior to Earth's core formation at 33±2 Myr (using the same Hf/W for the lunar mantle and BSE [8]). This interpretation requires that the lunar and terrestrial mantles started off with identical ^{182}W/^{184}W ratios after the Moon-forming impact. In this case the BSE value is lower, because radiogenic W was extracted into the Earth's core after formation of the Moon. Identical initial ^{182}W/^{184}W ratios might have been set by effective mixing of proto-Earth and impactor material. This, however, is unlikely given that many of the chemical differences between Earth and Moon seem to be inherited from the impactor [8]. Alternatively, the ^{182}W/^{184}W of the impactor mantle and BSE might have been similar. Since giant impacts can effectively homogenize the W isotopes [2] the ^{182}W/^{184}W ratio of the BSE was chondritic after formation of the Moon. Identical initial ^{182}W/^{184}W ratios, therefore, are only possible if the impactor mantle had a chondritic W isotope composition prior to its collision with proto-Earth, thus requiring a giant impact on the impactor just prior to that which produced the Moon itself [2].

If the ^{182}W excess of the lunar mantle is inherited from the impactor, the 1.3 ε_W of the lunar mantle can be used to estimate the ^{182}W/^{184}W ratio of the impactor's mantle. A contribution of 70 – 30 % from the impactor [e.g., 8,9] to the Moon implies ^{182}W/^{184}W ratios of the impactor mantle between 2 and 4 ε_W. Assuming that the Hf/W of the impactor mantle is similar to that of the lunar and terrestrial mantles, core formation ages of ~25 to ~18 Myr can be calculated.

In summary, W isotopes provide firm constraints that the Moon formed between 24 and 35 Myr. Formation of the Moon at 27±3 Myr, thus before core formation in Earth at 33±2 Myr, requires a giant impact on the impactor just prior to its collision with proto-Earth. If the Moon formation, however, is coeval with the final core-mantle equilibration in Earth, then core formation in the impactor can be constrained to 18 – 25 Myr. This age is similar to the core formation age on Mars [4] whose size is similar to that of the proposed impactor [9].

References: [1] Lee et al. (1997) *Science*, *278*, 1098-1103. [2] Halliday (2000) in *Origin of the Earth and Moon*, 45-62. [3] Lee et al. (2002) *EPSL*, *198*, 267-274. [4] Kleine et al. (2002) *Nature*, *418*, 952-955. [5] Yin et al. (2002) *Nature*, *418*, 949-952. [6] Schoenberg et al. (2002) *GCA*, *66*, 3151-3160. [7] Nyquist et al. (1995) *GCA*, *59*, 2817-2837. [8] Jones and Palme (2000) in *Origin of the Earth and Moon*, 197-216. [9] Canup and Asphaug (2001) *Nature*, *412*, 708-712.