

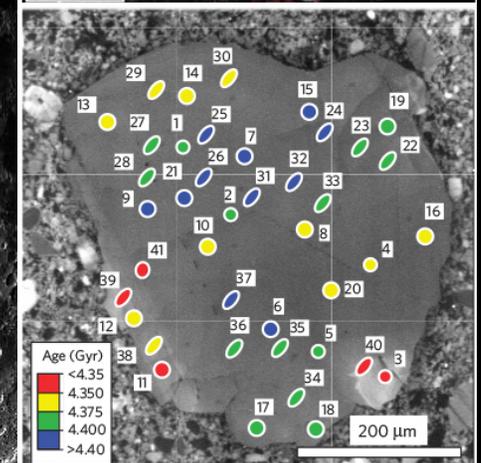
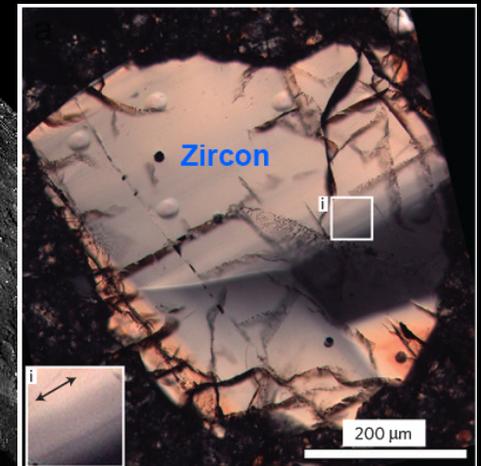
Crystallization of the Lunar Magma Ocean

W-Hf model of magma ocean crystallization must occur in less than 40 million years. Shearer C.K. and Newsom H.E. (2000) W-Hf isotope abundances and the early origin and evolution of the Earth-Moon system. *Geochim. Cosmochim. Acta* 64, 3599-3613.

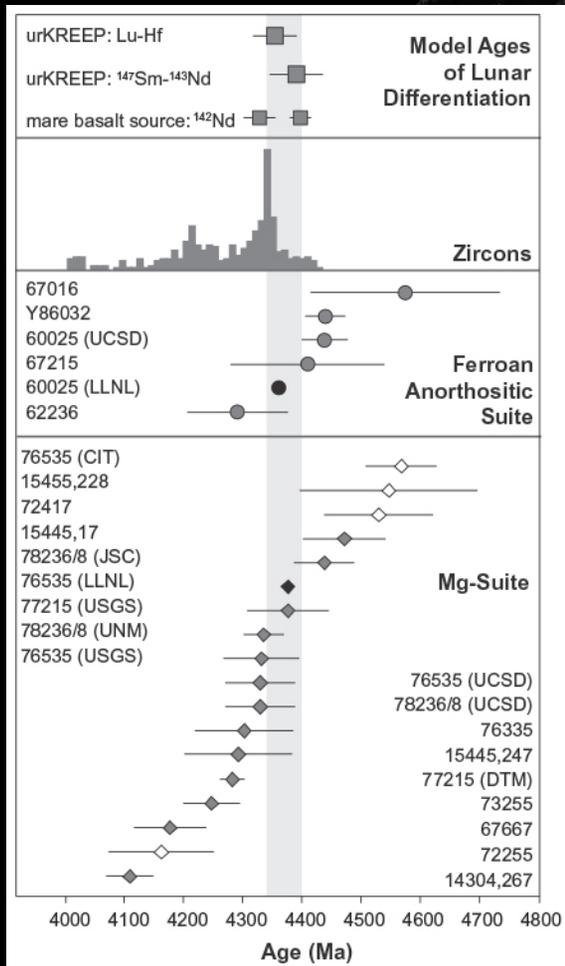
Zircon age of 4,4176 million years provides a precise younger age limit for the solidification of the lunar magma ocean.

Nemchin A. et al. (2009) Timing of crystallization of the lunar magma ocean constrained by the oldest zircon. *Nature Geosci.* 2, 133-136.

The Moon formed from a high Sm/Nd terrestrial mantle prior to 4.45 Ga. The LMO completely crystallized by ~ 4.44 Ga, and the sources of the high-Mg crustal rocks, KREEP and perhaps the low-Ti basalts were present in the lunar interior. Boyet & Carlson (2007) A highly depleted moon or a non-magma ocean origin for the lunar crust? *EPSL* 262, 505-516.



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FAN age (60025) of 4,360 +/- 3 million years requires that either the Moon solidified significantly later than most previous estimates or the long-held assumption that FANs are flotation cumulates of a primordial magma ocean is incorrect.

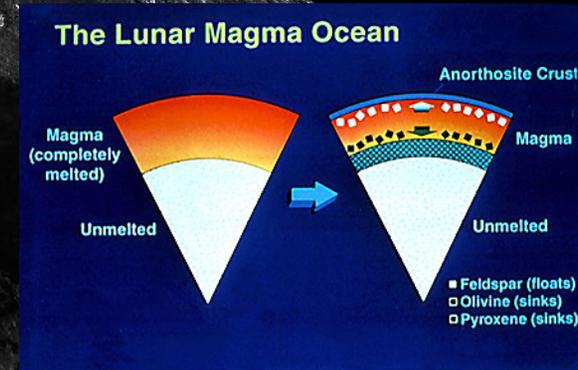
Borg L.E. et al. (2011) Chronological evidence that the Moon is either young or did not have a global magma ocean. *Nature* 477, 70-72.

The ^{176}Lu - ^{176}Hf urKREEP model age = 4353 ± 37 Ma, which is concordant with the re-calculated Sm-Nd urKREEP model age of 4389 ± 45 Ma. The average of these ages, 4368 ± 29 Ma, represents the time at which urKREEP formed.

Gaffney & Borg (2014) A young solidification age for the lunar magma ocean. *GCA* 140, 227-140

Modeling of Magma Ocean Crystallization

New modeling techniques and approaches to the crystallization of the lunar magma ocean.



Elkins-Tanton et al. (2002) Re-examination of the lunar magma ocean cumulate overturn hypothesis: melting or mixing is required. *EPSL* **196**, 239-249

Elkins-Tanton et al. (2011) The lunar magma ocean: Reconciling the solidification process with lunar petrology and geochronology. *EPSL* **304**, 326-336.

Elkins-Tanton & Grove (2011) Water (hydrogen) in the lunar mantle: Results from petrology and magma ocean modeling. *EPSL* **307**, 173-179.

Namur et al. (2011) Anorthosite formation by plagioclase flotation in ferrobasalt and implications for the lunar crust. *GCA* **75**, 4998-5018.

Elardo et al. (2011) Lunar Magma Ocean crystallization revisited: Bulk composition, early cumulate mineralogy, and the source regions of the highlands Mg-suite. *GCA* **75**, 3024-3045