Lunar Zircons

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Zircons are rare, but widely distributed in lunar regolith and rocks. Regolith zircons represent a relatively unexplored resource for study of the Moon. Combined $\delta^{18}O$ and [Ti] provide a signature of zircons from the Moon[1,2]. [Ti] is higher in undisturbed zircons from the Moon than on Earth and varies from 36 to 260 ppm[1-4]. Lunar zircons are remarkably constant and unexpectedly higher in $\delta^{18}O$ (5.61 ±0.07‰ VSMOW) than zircons from Earth's oceanic crust (5.20 ±0.03‰) even though mare-basalt (WR) is nearly the same in $\delta^{18}O$ as oceanic basalts on Earth (~5.6‰)[1,2,5]. The average fractionation between primitive basalt and zircon is smaller on the Moon ($\Delta^{18}O$(WR-Zrc) = 0.08 ±0.09‰) than on Earth (0.37 ±0.04‰), suggesting higher T of zircon crystallization in lunar magmas; consistent with higher [Ti] in lunar zircons and phase equilibria. REEs in lunar zircon are HREE-enriched with prominent-negative-Eu and muted-positive-Ce anomalies. Values of Ce/Ce* suggest LogfO_2 values of iron-wustite -0.5 ±1.5[2,6] at time of zircon crystallization, in agreement with petrological measurements of lunar basalts and the stability of Fe metal[7]. The systematic O and Ti data for lunar zircons suggest the following model. Many analyzed lunar zircons formed in evolved differentiates from KREEP-Zr-rich magmas that concentrated any water[8]. Such late igneous zircons would form at significantly lower temperatures in evolved hydrous melt than in evolved dry melt. Although lunar basalts could readily lose H_2 to space during eruption, lowering water fugacity, it is likely that H_2 degassed early[9]. Furthermore, the morphology, large size, and presence in plutonic rocks suggest that many zircons crystallized at depths that retarded degassing. In either case, the crystallization temperatures of zircons are a sensitive monitor of the water content of the parental magma. The smaller $\Delta^{18}O$(Zrc-mare basalt) values suggest that even highly evolved zircon-forming magmas on the Moon crystallized at higher temperature than similar magmas on Earth and that parent magmas were generally drier on the Moon.

[1] Valley *et al* 2014, *CMP* [2] Spicuzza *et al* 2011 *LPSC* [3] Taylor *et al* 2009 *EPSL* [4] Grange *et al* 2009 *GCA* [5] Whitehouse & Nemchin 2009 Chem Geol [6] Trail *et al* 2011 Nature, 2012 *GCA* [7] Wieczorek *et al* 2006 *RIMG*: 60 [8] Elkins-Tanton & Grove 2011 *EPSL* [9] Sharp *et al* 2013 *EPSL*