Lunar Zircons: Probing the Moon's Early History

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Without resurfacing processes such as plate tectonics and erosion, the lunar surface retains rocks older than 3.9 billion years. At this early stage, the Solar System was witness to major events such as the proposed "late heavy bombardment." Samples returned from the Moon by the Apollo missions therefore provide a unique window into a key period of solar system history not accessible in the terrestrial rock record.

The ability of lunar zircons to record signatures of primary crystallization as well as secondary, impact modification, paired with their >3.9 Ga crystallization ages, makes them ideal for investigating both the early magmatic and impact histories of the Moon [e.g. 1]. We have conducted a coordinated geochronologic, trace element, and microstructural survey of 155 zircons separated from Apollo 14, 15, and 17 samples [1]. The findings of this study can be generally summarized by the following. (1) The distributions of ^{207}Pb-^{206}Pb ages for lunar zircons reveal that the vast majority of grains crystallized prior to 4.1 Ga, which suggests a protracted durantion of KREEP magmatism. (2) The trace element abundances can be characterized by one rare earth element pattern and are consistent with formation in an anhydrous, reducing environment after fractional crystallization of plagioclase. (3) Although most lunar zircons contain some textures indicative of impact modification, only a few grains show evidence of recrystallization in an impact environment. (4) The ages of these few zircons [1-8] and the ^{207}Pb-^{206}Pb age histograms suggest multiple pre-3.9 Ga impact events and show no evidence of a "late heavy bombardment" at 3.9 Ga.

[1] Grange *et al.* (2013) *GCA* **101**, 112-132. [2] Crow *et al.* (2017) *GCA* **202**, 264-284. [3] Smith *et al.* (1986) *LPSC XIIB*, 984-986. [4] Pidgeon *et al.* (2007) *GCA* **71**, 1370-1381. [5] Grange *et al.* (2009) *GCA* **73**, 3093-3107. [6] Liu *et al.* (2012) *EPSL* **319-320**, 277-286. [7] Norman and Nemching (2014) *EPSL* **388**, 387-398. [8] Hopkins and Mojzsis (2015) *Con. Min. Pet.* **169**, 30. [9] Bellucci *et al.* (2016) *Chem. Geol.* **438**, 122-122.