ZIRCON FORMATION IN IMPACT MELTS: COMPLICATIONS FOR DECIPHERING PLANETARY IMPACT HISTORIES. M. M. Wielicki and T. M. Harrison, 1 Earth, Planetary, and Space Sciences, UCLA, 595 Charles Young Drive East, Los Angeles, CA 90095.

Introduction: The impact history of the solar system remains controversial. Early investigation of lunar samples, returned by Apollo astronauts, led to the 'Late Heavy Bombardment' (LHB) concept [1,2] which hypothesized a sharp increase in bolide flux centered around ~3.9 Ga. Evidence for this cataclysm was first derived from whole-rock U-Pb and Rb-Sr ages [2] but subsequently more on 40Ar-39Ar data [3,4]. However, interpretations of lunar 40Ar-39Ar geochronology can be problematic [5]. Recent studies [6,7] have focused on using U-Pb dating of zircon as a new tool with which to identify ancient large-scale impact events, such as the LHB, on the Earth-Moon system.

Background: Poikilitic zircon, which appears as branching, interstitial networks of zircon enclosing other phases, within the melt matrix from lunar meteorite SaU 169 and Apollo 12 samples, have been interpreted [6–8] as growing during equilibrium crystallization of impact melts. U-Pb geochronology of such grains have been used to constrain the age of the Imbrium basin and as such would introduce an important new means with which to probe planetary impact histories [7,8]. Although poikilitic textures are observed in zircon and other phases [10], they are rare in terrestrial environments.

Recently, Hadean zircons from Western Australia have been proposed to form from large scale melting of the Hadean crust by impacts [7]. If so, the age distribution of this population may provide insights into the bolide flux on early Earth. However, identifying zircons that formed in impact melts can be challenging.

Here we evaluate the formation conditions and inheritance probability of zircon in impact melts and the implications of using zircon geochronology to investigate planetary impact histories. Specifically we examine the likelihood of zircon crystallization within simulated lunar impact events, such as the formation of poikilitic zircon within lunar meteorite SaU169, and report SIMS U-Pb geochronology of similar textured zircons found within the melt matrix of the largest terrestrial impact (Vredefort, South Africa) to test the hypothesis that such grains crystallized within an impact melt. We also model the occurrence and crystallization temperature spectrum for zircon in simulated impact melts on an ancient terrestrial surface to assess the role of impacts in the formation of the Hadean zircons from Western Australia and their use in identifying the impact flux on early Earth.

Results: Modeled crystallization temperature spectra for zircon growth in lunar impact melts indicate that zircon crystallizes in only ~2% of the simulations, reflecting the high [Zr] necessary to nucleate zircon in predominantly mafic lunar compositions [11]. Interestingly, model temperatures, which range from ~850-1050°C, are typically ~100-200°C higher than those reported by [12] for terrestrial impacts, presumably reflecting the anhydrous nature of lunar melts. Modeled temperatures are significantly lower than Ti-in-zircon crystallization temperatures reported for lunar grains [12,13]. A modeled result for an ancient terrestrial surface predicts a crystallization temperature spectrum significantly above that seen in the Hadean zircon population [15].

Zircons isolated from the granophyre unit of the Vredefort impact show an intimate relationship with Mg-rich pyroxene (i.e. poikilitic texture) similar to that discovered in lunar meteorite SaU 169 [16]. Twelve of twenty isolated grains were analyzed, as the others were so inter-grown that no continuous surface was available to place the ion beam without excessive common Pb contamination. One grain was rejected due to high common Pb presumably contributed from contaminated areas or from the inter-grown pyroxene. Results indicate that all the grains were inherited from the Archean target, with a crystallization age of 3077±74 Ma, and a lower intercept of 1984±150 Ma (MSWD = 2.6), consistent with the impact age. No grains appear to have grown or been 'reset' within the impact melt.

Discussion: Modeled crystallization temperatures appear to argue against most lunar zircons forming in response to impact melting. Dissolution and growth of zircon in an impact melt is a function of: 1) the solubility of Zr, which itself is a function of composition (i.e. cation ratio 'M' = (Na+K+2Ca) / (Al+Si)); 2) the diffusivity of Zr; and 3) the temperature and rate of cooling [15–17]. For lunar zircons incorporated within predominantly mafic melts (SaU 169 M = 3.32), a high degree of resorption is likely given the propensity of high 'M' magmas (e.g., M ≈ 3.0), to dissolve zircon. For the composition of SaU 169, growth of zircon would require twenty times higher [Zr] (50,000 ppm) than that reported by [6], essentially ruling out the possibility of this grain growing in equilibrium with the impact melt. Our observation of Vredefort zircon with inherited U-Pb systematics and apparent poikilitic textures further supports our conclusion that poikilitic
grains from Apollo samples and lunar meteorite SaU 169 [7,8] are likely inherited from target rocks and are not primary zircons grown in impact melts [9]. Thus, such grains should be interpreted with caution when investigating impact chronologies for terrestrial and extraterrestrial samples.

Furthermore, modeled crystallization temperature spectrum results for impacts on early Earth suggest formation temperatures significantly higher [12] than reported for the Hadean population [15]. Thus, we conclude that impacts were not a dominant source for the Hadean zircons and their age distribution does not provide a constraint for impacts on early Earth [7].

**Conclusion:** Given fewer inherent complications than commonly used $^{40}$Ar-$^{39}$Ar method, U-Pb dating of zircon may become an important new tool to probe planetary impact histories. However, a better understanding of zircon crystallization in response to impact shock and heating is required. Specifically, being able to discriminate inherited zircons grown in endogenic environments as opposed to impact melts is important for their use in establishing impact histories. Only in the case of small parent bodies without the thermal capacity for prolonged endogenic magmatism can zircon age and geochemistry currently be used to conclusively identify an impact. Lastly, the terrestrial Hadean zircon population is quite inconsistent with formation in impact environments.

**References:**