U-PB CHRONOLOGY OF TWO LUNAR IMPACT MELT BRECCIAS

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Introduction: Current understanding of lunar impact history is largely based on Ar-Ar studies of impact breccias and glass spherules from the Apollo lunar samples, and more recently from lunar meteorites, which have been interpreted to show a dearth of >4 Ga ages (e.g., [1, 2]). This has led to the hypothesis of a late heavy bombardment (LHB) in the inner Solar System at 3.9±0.1 Ga. However, recent Ar-Ar and U-Pb studies of impact melts from Apollo samples and meteorites have yielded ages >4.0 Ga (e.g., [3-5]), calling into question the LHB hypothesis. Large-scale impacts such as the Imbrium event could be responsible for resetting the isotope systematics of various radiometric chronometers to different degrees in samples from different locations on the Moon. Since Ar has a lower (~700K) blocking temperature than Pb (~1300K) in silicates [6, 7], the U-Pb chronometer may be able to provide more robust "primary" impact melt ages. Therefore, we present here the U-Pb chronology of two feldspathic impact melt breccias: 65015,60 (from the Apollo 16 Descartes landing site) and Shişr 166 (a lunar meteorite).

Results: One bulk-rock sample (~20mg) for 65015 and four mineral separates (~10-40 mg each) for 65015 and Shişr 166 were processed for U-Pb dating. Leaching (3 steps for 65015 and 5-7 steps for Shişr 166), dissolution, and Pb extraction methods were similar to [8]. Pb isotopic compositions and U/Pb of 65015 mineral residues were analyzed by MC-ICPMS and quadrupole ICPMS respectively at ASU. The 65015 residues have corrected $^{206}Pb/^{204}Pb$≈9,351-43,501. We obtain a U-Pb Concordia upper intercept age of 3,929±11 Ma (MSWD=3) and a consistent, but more precise, Pb-Pb isochron age of 3,935±2 Ma (MSWD=12), using $^{238}U/^{235}U$=137.84. The Shişr 166 residues have $^{206}Pb/^{204}Pb$ ≈60-250 and give a Pb-Pb isochron age of 3567±5 Ma (MSWD=0.05).

Discussion: The 3,935 Ma age for 65015 is consistent with, but more precise than, previous estimates using the Ar-Ar and Rb-Sr systems [9], but younger than a previously reported ~3.99 Ga Pb-Pb age [10]. Based on geochemistry and Ar-Ar chronometry, it was recently suggested that the Descartes terrains could be ~3.87 Ga ejecta from Imbrium instead of Nectaris basins [11]. The age of the 65015 breccia is older and may suggest that either it formed during a different event or the Imbrium impact event is older than previously thought (i.e. ~3.9 Ga based Ar-Ar chronometry of Apollo 15 and 16 breccias [1, 11]). The younger ~3.57 Ga age of Shişr 166 is recognized in other lunar meteorites by Ar-Ar chronometry [3] and suggests a protracted history for the formation of impact melt breccias on the surface of the Moon.

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