Impacts and Volcanism on the Moon: The View from Lunar Regolith Glasses

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Although not strictly minerals, silicate glasses found in the lunar regolith carry unique information about the timing of impact events and volcanic eruptions on the Moon, and the compositions of crustal and mantle source regions, including volatile-enriched regions in the lunar mantle. Developments in sample handling and a variety of analytical approaches have made it possible to obtain major element, trace element, and a range of isotopic data from individual glass particles from the lunar regolith.

The typically small size of lunar regolith glasses (≤0.1 mm) makes determination of their formation ages a challenging task, especially if major and trace element compositions are also desired in order to distinguish volcanic from impact glasses or assess compositional groupings. For example, does compositional clustering of impact glasses indicate formation of multiple particles in a single event or numerous impacts into a common crustal source that is sampled repeatedly through time? Distinguishing between these scenarios could have significant implications for interpretations of lunar impact history. How large were the impact events that formed the regolith glasses, and how do they relate to the crystalline lunar impact melt breccias and questions about the late heavy bombardment, collisional evolution of the asteroid belt, and biological and geodynamic events on the Earth? How do volcanic glasses differ in their compositions and ages from crystalline mare basalts, and what does this say about lunar mantle source regions?

A relatively small number of studies so far have presented both geochemical and age data for individual lunar regolith glasses, with the ages constrained by either ^{40}Ar-^{39}Ar or U-Pb isotopic data. Compositional regionality and a predominance of relatively young (≤1 Ga) ages suggest that most of the impact glasses formed by small events (<1-10 km diameter craters?), and therefore provide a different view of lunar impact history than the crystalline melt breccias which are mainly products of the late heavy bombardment at ~3.9 Ga. There does not appear to be a strong correlation between age and composition of these impact glasses, suggesting production in multiple events. The abundance of young ages may imply a period of enhanced impact flux, although more information about lunar regolith dynamics is needed.