

Compositional and geochronological constraints on the lunar cataclysm

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Radiometric dating and compositional clustering of lunar impact-melt rocks form the backbone of the lunar cataclysm hypothesis. Precise age determinations of Apollo and Luna impact-melt rocks (e.g. [1-2]) (Fig. 1) define the classic formulation of the cataclysm: a sharp peak at 3.9 Ga, a steep decline after 3.9 Ga perhaps only 20-200 Myr long, and few, if any, positively identified rocks of impact origin prior to ~4.0 Ga. Lunar meteorites represent a more random sampling of the lunar surface, but impact-melt clasts in these rocks show the same apparent age cutoff at 4.0 Ga (e.g. [3]) (though their ages extend ~500 Myr later). Glass spherules and glass fragments in lunar soil may be formed by impacts of all sizes throughout lunar history, but even these samples do not predate 4.0 Ga [4-6]. Geological associations between compositional groups of impact-melt rocks and specific impact basins imply that five large basins formed on the Moon within 200 Myr [7] but a counterargument postulates they are all products of the Imbrium basin-forming impact [8]; it is not yet proven whether groups of impact melt that are resolvable from each other in age and in trace-element composition represent multiple impacts. The 3.9 Ga age peak and subsequent steep decline are not well mirrored in meteorite data. Radiometric ages in ordinary chondrites and HED meteorites peak around 3.9 Ga but ages older and younger than 3.9 Ga are common [9]. Among Martian meteorites, there is a single impact-related age: ALH 84001 was shocked at 3.92 ± 0.04 Ga [10]. Differences in relative impact velocity, impact-melt production, and sampling rate could explain differences between the meteorite and lunar records. One way to anchor the early end of the lunar flux would be to directly sample the impact-melt sheet of a large lunar basin distant from Imbrium, such as the South Pole-Aitken basin, where a large amount of melt probably still resides on the basin floor and could be directly sampled by a human or robotic mission

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Dynamics of water in aqueous solutions confined in silica matrices determined from neutron scattering

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Backscattering neutron spectroscopy (High Flux Backscatter Spectrometer, HFBS, NIST) was used to probe the dynamics of water molecules in LiCl and CaCl₂ aqueous solutions confined in 2.7, 1.9, and 1.4 nm diameter pores of various silica matrices. The pore size of 2.7 nm (standard MCM41 silica) was found to be sufficiently large for the confined liquids to exhibit characteristic traits of bulk behavior, such as a freezing-melting transition and a phase separation. On the other hand, none of the fluids in the 1.4 nm pores (SBA15 silica) exhibited a clear freezing-melting transition; instead, their dynamics at low temperatures gradually became too slow for the nanosecond resolution of the experiment. The greatest suppression of water mobility was observed in the CaCl₂ solutions, which suggests that cation charge and perhaps the cation hydration environment have a profound influence on the dynamics of the water molecules. Quasielastic neutron scattering measurements of pure H₂O and 1 m LiCl-H₂O solution confined in 1.9 nm pores (modified MCM41 silica using atomic layer deposition) revealed a dynamic transition in both liquids at practically the same temperature of 225-226 K, even though the dynamics of the solution at room temperature appeared to slow down by more than an order of magnitude compared to the pure water. The observation of the dynamic transition in the solution suggests that this transition may be a universal feature of water governed by processes acting on the local scale, such as a change in the hydrogen bonding. Molecular dynamics (MD) simulations are being carried out to investigate the dynamic properties of the system and compare them against QENS experiments.