Lunar spherule age distributions: Gardening or young spike?

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Age distributions for lunar impact spherules from the Apollo 12 [1] and 14 [2] sites show a spike in ≤400Ma ages but it is not clear whether the predominance of young spherules is due to regolith reworking or increased cratering rates. Here we present the first age distribution for spherule-producing impacts proximal to the Apollo 16 site from soil 66031, 65. Of the thirty spherules selected for $^{40}Ar/^{39}Ar$ dating, twenty-two gave statistically acceptable isochrons and step-heating plateaus with ages ranging from 276±63Ma to 4372±270Ma. One spherule yielded a total fusion age of 294±31Ma, and two others contained low abundance of $^{40}Ar^*$ and are inferred to be ~100-200 Ma. About a third of the spherules have ages ≤400 Ma; another third have ages between 400-2600 Ma and the final third are 3200-4400 Ma. Like [1] and [2], we observe a peak in ≤400Ma spherule ages but no cluster at ~800 Ma as proposed by [3]. The abundance of ≤400Ma spherules at three different sites and lunar terrains suggests a possible Moon-wide increase in the impact rate. This could relate to asteroid collision events as 7 of our spherules have ages that overlap with L-H chondrite impact ages (300-600Ma) [4, 5], and 2 of these have KREEPy compositions suggesting delivery by large events. Spherule age distributions could be distorted if multiple spherules produced in single impacts are treated as separate events. To avoid this issue we have, for the first time, integrated ages with major+trace element chemistry and found that the 25 dated spherules may only represent 13-17 unique impacts. All but three of these impacts occurred close to the Apollo 16 site based on spherule compositions. The peak in ≤400Ma ages still persists even with removal of duplicates. Higher impact rates could also lead to more rapid gardening of the lunar regolith, which could preferentially destroy old spherules. Abundant >3 Ga spherules at Apollo 14 and Apollo 16 suggest that destruction of spherules by gardening may be a secondary effect [1] but cosmic ray exposure ages of <600 Ma imply these older spherules were brought to the lunar surface relatively recently from a deep (>1 m) protected reservoir.

[1] Levine *et al*. (2005) *GRL* **32** L15201 [2] Culler *et al*. (2000) *Science* **287**, 1785-1788 [3] Zellner *et al*. (2009) *GCA* **73**, 4590-4597 [4] Bogard (1995) *MAPS* **30,** 244-268 [5] Swindle *et al*. (2009) *MAPS* **44**, 747-762.

Uptake and biotransformation of gold nanoparticles by a freshwater bivalve

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Biotransformation of Gold Nanoparticles

Our work has shown that protein-conjugated gold nanoparticles of varying size are readily accumulated by a filter-feeding bivalve, *Corbicula fluminea*, and that the rate of particle uptake by this organism is dependent on particle size. Micro-X-ray Spectroscopy results indicate that particles are primarily accumulated in the digestive tract and to a lesser extent, the digestive gland. Analysis of intact and digested fractions of egested fecal material by Transmission Electron Microscopy/Energy Dispersive X-Ray Spectroscopy and Inductively Coupled Plasma Emission Mass Spectroscopy confirm the presence of gold nanoparticles in feces and suggest that nanoparticles may undergo biotransformation processes that can alter their disposition in aquatic environments.

Discussion

Applications of gold nanoparticles in consumer products, particularly emerging nanopharmaceuticals, is rapidly increasing. Previous work has shown that nanoscale gold accumulates in filter-feeding invertebrates [1] and can be transferred from the water column to marine food webs [2]. Information remains limited, however, as to how these particles may be transformed through interactions with biota. The current work aims to improve understanding of uptake and biotransformation processes that will likely have important implications on the ultimate fate, transport, and toxicity of nanoscale particles released to aquatic environments.

[1] Renault *et al*. (2008) *Gold Bull*. **41**, 116-126. [2] Ferry *et al*. (2009) *Nature Nano*. **4**, 441-444.