PLANETARY SCIENCE

Water and the lunar dynamo

On Earth, water drives an active hydrologic cycle between the surface, subsurface and atmosphere. Water is, however, also stored deep within the mantle, where it plays a key role in geologic processes such as mantle convection, the melting behaviour of minerals, subduction, volcanism and earthquake generation. The Moon, by contrast, was long thought to have retained little water or other volatile material, partly as a result of its low gravity and partly because it is believed to originate from the hot debris of a giant impact into a proto-Earth about 4.5 billion years ago. Thus, water was assumed to not have meddled with the geologic evolution of the lunar interior like it has for the Earth. But the Moon, it turns out, is not dry.

Geochemical analyses of samples from the Apollo missions have uncovered evidence for water in at least some regions of the lunar interior. If the Moon contained water when its interior solidified, then the lunar mantle would be expected to preserve a deep reservoir that is enriched in water. If so, water in the Moon's lower mantle ought to have influenced the thermochemical evolution of the Moon and could have facilitated a long-lived lunar dynamo, suggest Alexander Evans and colleagues (*J. Geophys. Res.* http://doi.org/sp2; 2014).

Analyses of the magnetization of lunar samples have indicated that the ancient

Moon had a core dynamo until at least about 3.5 billion years ago. This has puzzled lunar scientists, as convection models of the thermal evolution of the lunar interior generally do not predict sufficient heat flux across the core–mantle boundary to drive a dynamo for an extended period of time. However, these studies assume an early lunar interior that is homogeneous in water content and relatively dry. Water in the deep mantle is expected to reduce the viscosity and increase the heat flux across the core–mantle boundary.

Evans and colleagues explore the influence of water on the evolution of the Moon and its ancient dynamo with a finite-element numerical model. Their simulations yield estimates of the heat flux across the core–mantle boundary in the presence of varying amounts of water, which can then be used to constrain the lifetime and nature of the lunar core dynamo.

Because the density structure, chemical composition and temperature profile of the Moon's interior are uncertain, the researchers explore a range of model scenarios that are within the constraints currently available for the properties of the lunar interior. Although the details differ depending on the starting conditions, enrichment of water in the lower mantle of the Moon leads to a longer-lasting and more vigorous lunar dynamo in the simulations. The models suggest that heat flow across the core–mantle boundary may have been sufficiently high and prolonged to sustain a lunar dynamo as late as 2.5 billion years ago — a billion years beyond the record provided by the lunar sample collection.

Water in the Moon thus turns out to be an added complication in our understanding of the geological evolution of the lunar interior. As we attempt to unravel the distribution and abundance of water in the Moon (page 401), magnetic anomalies on the Moon add further support for a long-lived and complex lunar dynamo (page 409). The discovery that the Earth's lone satellite is not dry will have repercussions throughout lunar science, to the very core of the Moon.

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