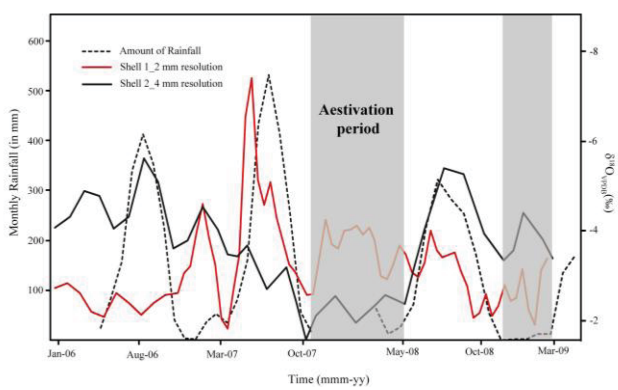
Reconstruction of the Indian Summer Monsoon at weekly to sub-weekly resolution using terrestrial Giant African Snail *Lissachatina fulica* from northern India.

RAVI RANGARAJAN[1*], PROSENJIT GHOSH[1]

[1]Centre for Earth Sciences, Indian Institute of Science, Bangalore, India. *ravi@ceas.iisc.ernet.in., pghosh@ceas.iisc.ernet.in. (*presenting author),

Reconstruction of the ISM (Indian Summer Monsoon) at weekly to sub-weekly scales using terrestrial land snails is attempted here. Terrestrial mollusc *Lissachatina fulica* belonging to the Giant African Land Snails (GAL's) are endemic to the African sub-continent and have become an invasive species in most parts of the world. In this study, the stable isotopes of oxygen from the carbonate shells of *L.fulica* are used as a proxy to infer the variation in the ISM during the time period at the beginning of the last century. To establish and validate the suitability of the proxy for monsoon reconstruction, *in vitro* growth rate monitoring and present day comparison of precipitation and shell oxygen isotope has been carried out. The in vitro growth rate experiments showed a high growth rate (2.5 mm/week). Further, the dormancy/aestivation periods associated with non-monsoon time were also defined to explore the possibility for weekly reconstruction of ISM precipitation. The $\delta^{18}O$ of present day shells collected from Kolkata were compared with the already available precipitation isotopic data [1]. The $\delta^{18}O$ values ranged from -2 to -6‰ across the growth period of 3 years with marked cyclicity (Figure 1). The approach was then tested with museum specimens that were collected in the year 1918 from the same region. The $\delta^{18}O$ profile of the archived shells showed a higher depletion of ~1 to 2 ‰ than the present day shells, confirming the variation in the amount of precipitation.

Figure 1: Comparative $\delta^{18}O$ plot of the snail shell carbonates of two individual shell specimens along with the cumulative rainfall data of the region.



Reference

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Fractional crystallization of the Lunar Magma Ocean

JENNIFER F. RAPP[1,2*], DAVID S. DRAPER[2]

[1]Lunar and Planetary Institute, Houston, TX, USA, jennifer.f.rapp@nasa.gov (* presenting author)
[2]Astromaterials Research Office, ARES Directorate, NASA Johnson Space Center, Houston, TX, USA, david.draper@nasa.gov

The current paradigm for lunar evolution is that of the crystallization and differentiation of a Lunar Magma Ocean (LMO) [1]. In this model, the crystallization of the LMO gave rise to the plagioclase-rich ferroan anorthosite highlands crust, due to flotation of less dense plagioclase in the mafic magma ocean; and to mafic cumulates rich in olivine and pyroxene, which were later re-melted to produce basaltic magmas such as mare basalts and picritic pyroclastic glasses. LMO crystallization also produced KREEP, which represents the very late-stage incompatible element enriched liquid resulting from magma ocean crystallization, and is thought to have later hybridized with the ascending basaltic magmas (or their source rocks) resulting in specific minor and trace element enrichments seen in lunar basalts.

Numerical simulations have been used to predict the crystallization sequence of the LMO, the extent of fractional crystallization versus bulk crystallization [2], and the density profile of the resultant cumulate pile [3]. However these models, on which a large portion of lunar petrological research is predicated, remain largely untested experimentally. The Snyder model [2] features crystal suspension in the magma ocean due to vigorous convection, and equilibrium crystallization for the majority of LMO crystallization followed by fractional crystallization of the residual magma ocean. This model has been tested experimentally [4], and found to produce a different cumulate assemblage from that predicted by Snyder. We are experimentally simulating fractional crystallization from the outset of LMO solidification, as an alternative end-member model of lunar differentiation. We find that fractional crystallization of the lower portion of the LMO produces a divergence of residual liquid compositions from that of the equilibrium crystallization process, with liquids being somewhat more orthopyroxene-normative, and trending strongly towards plagioclase after approx. 50 volume % of the magma ocean has crystallized. We also find that spinel crystallizes, in small but significant quantities, in our cumulate pile deeper than predicted by previous models [2-4]. These differences are likely to be more pronounced as fractional crystallization proceeds, leading to concomitant differences in crystallizing assemblages including a lack of garnet in the lunar interior, which has implications for the potential thickness of the anorthosite crust. It remains to be seen whether this melt composition will evolve to produce sufficient plagioclase to account for the lunar crust, with a residuum representing KREEP. The outcome of this experimental investigation will enable us to put further constraints on the mechanisms by which the Moon evolved, in particular the extent, if any, to which equilibrium crystallization played an active role in LMO crystallization.

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