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Radiogenic isotope systematics in lunar basaltic rocks

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Despite sixty years of investigation, the chemical evolution and composition of the proposed mantle sources explaining the major chemical types of lunar basalts (low- and high-Ti as well as KREEP, for high K, REE and P enriched) are still poorly constrained. This is related to: (1) the lack of precise and accurate dates for many lunar basalts and (2) as a consequence, an inability to constrain precise Sr-Nd-Pb radiogenic initial isotope systematics. Here we aimed to decipher the chemical characteristics of the mantle sources of lunar volcanism using precise Pb-Pb ages and Sr-Nd-Pb systematics.

Development of the secondary ion mass spectrometry (SIMS) approach to analyze Pb isotope compositions in lunar basalts was critical in: (1) assessing potential terrestrial contamination of the samples [1], (2) improving the accuracy of sample ages [1,2], (3) establishing Pb initial isotope compositions of the samples, and (4) determining more accurate initial Sr-Nd-Pb ratios from previously published or newly-acquired data.

Initial Pb compositions indicate the existence of systematic trends shown by both high- and low-Ti basalts that cannot be explained by time related ingrowth of radiogenic Pb in two separate (high- and low-Ti) mantle reservoirs. This can be interpreted as two-component mixing between an enriched (probably KREEP) and a depleted component. In the case of the low-Ti basalts, the latter is best represented by the YAM meteorites (e.g., Asuka 881757 [3]) that are characterized by relatively low $^{238}U/^{204}Pb$ values. Plotting the Sr-Pb initial ratios against age indicates a progressive increase in the enriched component in younger basalt sources (both high- and low-Ti), which is not related to their differentiation after formation. Nd initial isotope compositions indicate a more complex pattern that cannot be fully explained by a simple two-component mixing.

This gradual increase of KREEP contribution implies the possibility of sustained mantle convection. This process led to the gradual erosion of KREEP-rich material originally located under the lunar crust then providing enriched materials into deeper parts of the mantle.

References

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[2] Merle et al. (2020), *MAPS* 55, 1808-1832.

[3] Misawa et al. (1993), *GCA* 57, 4687-4702.