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Negligible KREEP contribution in Chang'e 5 basalts constrained by high precision high field strength element measurements

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In 2021, the Chang'e 5 mission returned lunar mare basalts from the Oceanus Procellarum region. These samples expanded the age range of lunar mare volcanism to as young as 2.0 Ga [1,2]. Subsequent measurements of trace elements and radiogenic isotope compositions led to controversial models concerning the mantle sources of these mare basalts [3,4,5]. While the strong enrichment of incompatible elements was interpreted to mirror KREEP-rich sources [4], radiogenic Hf-Nd and unradiogenic Sr isotope compositions in these samples were used to argue in favour of trace element depleted cumulate sources in the lower lunar mantle [3,5]. To resolve this controversy, we performed combined trace element and radiogenic isotope measurements on Chang'e 5 soil samples and basaltic clasts, using the same sample splits. The measurements also included high-precision measurements of HFSEs (W-Nb-Ta-Zr-Hf) and Sm-Nd-Lu-U-Th, employing an isotope dilution approach [6]. HFSE systematics in lunar rocks allow to discriminate between different lunar mantle reservoirs and are a particularly sensitive tool to identify KREEP components and ilmenite-rich cumulate sources.

Measured radiogenic isotope compositions of Sr, Nd, and Hf are similarly depleted as those reported in previous studies [3,5]. Notably, ratios of Nb/Ta (16-19) and Zr/Hf (34.0-35.5) in the Chang'e 5 samples clearly rule out a significant involvement of KREEP components in their sources, rather overlapping compositions of low-Ti mare basalts. Compositions of Hf/W (26.5-31) and Ta/W (3.3-3.9) corroborate this conclusion and can also rule out significant involvement of ilmenite-rich cumulate in the lunar mantle source, although TiO_2 contents in Chang'e 5 samples are elevated (>5 wt. %). Hence, some of the trace element and TiO_2 enrichment may be caused by fractional crystallisation. However, trace element ratios of Chang'e 5 samples (including HFSEs) that are not sensitive to fractional crystallisation still plot at the enriched end of typical low-Ti mare basalt compositions, arguing for a near primitive, previously unsampled lunar mantle reservoir.

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