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Petrology, chemistry, and chronology of basaltic fragments in the chang'e-6 soil

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On June 25, 2024, the Chang' e-6 mission successfully completed the first sample return from the far side of the Moon, collecting 1935.3 grams of lunar soil. These samples provide a unique opportunity to investigate the geological history and evolution of the lunar far side. The Chang' e-6 landing site (41.6385°S, 153.9852°W) is located between the inner and outer rings of the Apollo Basin, within the South Pole-Aitken (SPA) Basin on the lunar far side. This area is characterized by a thin lunar crust and significant basaltic deposits. We studied basaltic fragments from the Chang'e-6 sample CE6C0100, selecting 33 basaltic fragments with a particle size larger than 500 microns from a 2g lunar soil sample. These fragments exhibit porphyritic, subophitic to poikilitic textures with some enriched in late-stage mesostasis. Bulk data classify the basalt as a low-Ti, low-K type, similar to many low-Ti basalts found on the lunar nearside. Using Secondary Ion Mass Spectrometry (SHRIMP II), we investigated the U-Pb isotopic systems of phosphate, zircon, zirconolite, and K-feldspar grains present in the fragments and determined the age of the Chang' e-6 basalt formation as 2.823±0.006 billion years. Based on lunar Pb evolution models and the basalt age, we calculated the μ-value ($^{238}U/^{204}Pb$ ratio) of the basalt source as 480±56. This μ-value is comparable to those obtained for Apollo 12 and Apollo 15 low-Ti basalts and might indicate the presence of a small (3-4%) proportion of KREEP component in the Chang'e-6 basalt source and the existence of a KREEP layer on the lunar far side. If true, the presence of a KREEP layer on the far side of the Moon supports the idea of a global-scale lunar magma ocean (LMO). However, the study indicates that the Pb isotopic evolution path recorded by the Chang'e-6 basalts differs from that of low-Ti basalts on the lunar nearside, suggesting regional variations in the post-LMO evolution of the Moon's mantle, probably related to the modification of upper mantle by basin forming events such as the SPA impact.