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Oxygen fugacity of the young mare basalts returned by Chang’e-5 mission

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Oxygen fugacity exerts an important control on the chemical differentiation and evolution of terrestrial planets. For the Moon, basalts returned by the Apollo mission have been extensively studied to suggest that the oxygen fugacity ranges between iron-wüstite (IW) buffer and ~1 log unit below it, more oxidized than small bodies but more reduced than other terrestrial planets in the Solar system. However, all of the Apollo samples are older than 2.9-2.8 Ga and provide an incomplete picture of the redox evolution of the lunar mantle. The Lunar samples recently returned by China’s Chang’e-5 mission have been dated to be ~2.0 Ga and represent the youngest returned lunar mare basalts. Here, we use the redox-sensitive behavior of vanadium (V) in equilibrated olivine-clinopyroxene mineral pairs to reconstruct the oxygen fugacity of the young mare basalts returned by Chang'e-5.

We find that the oxygen fugacity increases from ~IW-1 to >IW+1 with magmatic differentiation. Two possible explanations may account for this observed oxidation during magmatic differentiation. First, degassing may release large amounts of reduced gas, such as CO, H_2, and H_2S, leaving the remaining magma more oxidized. Second, ferric iron became more enriched in the melt due to its incompatibility in the olivine and clinopyroxene. The oxygen fugacity recorded by the most primitive olivine-clinopyroxene pairs is close to IW-1, within the oxygen fugacity range of the mare basalts returned by the Apollo missions. Our findings suggest that the oxygen fugacity of the Lunar mantle may have remained near constant during secular evolution. This hypothesis will be further tested when more primitive samples become available.