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LETTER

Rhönite in Luna 24 pyroxenes: First find from the Moon, and implications for volatiles in planetary magmas

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ABSTRACT

Grains of rhönite have been discovered in magmatic inclusions in augite grains of the lunar regolith from Mare Crisium, returned to Earth by the Russian Luna 24 spacecraft. These rhönite grains are up to 8 μm long, pleochroic from tan to dark brown, and associated with ulvöspinel and silica-rich glass. Electron microprobe analysis gives a composition near end-member ferroan rhönite: $(Ca_{1.9}Mn_{0.0}Na_{0.1})(Fe^{2+}_{4.5}Mg_{0.1}Al_{0.3}Cr_{0.0})Ti_{1.0}(Si_{4.0}Al_{2.0})O_{20}$. The Raman spectrum of these grains is like those of terrestrial rhönites, and distinct from titanian amphiboles. Compositionally, rhönite plus silica plus water or halogens (F, Cl) is equivalent to titanian amphibole plus pyroxene, so the presence of rhönite in lunar basaltic rock is consistent with the known low abundance of volatiles in the Moon. When calibrated, mineral reactions involving rhönite and titanian amphibole may provide quantitative constraints on fugacities of water, F, and Cl in basaltic magmas from the Moon and other planetary bodies.

Keywords: Lunar and planetary studies, mare basalt, Luna 24, igneous petrology, moon, basalt, melt inclusion, petrography, rhönite