

CHEMICAL REACTIVITY AND POTENTIAL TOXICITY OF LUNAR SOILS: A STUDY OF THE OLIVINE SOLID SOLUTION SERIES

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Introduction. Lunar activities by humans such as mining, exploration, energy production, etc. will become more commonplace in time and will inevitably expose future astronauts to potentially hazardous lunar dust. Past studies, in an attempt to understand potential hazards of lunar dust exposure, have assessed the reactivity of various terrestrial materials including pure mineral phases and lunar simulants.¹⁻⁴ Results indicated that iron-rich silicates (i.e. olivine, pyroxene) generated the largest quantities of hydroxyl radical (OH^{*}) and hydrogen peroxide (H₂O₂) relative to iron-poor silicates (i.e. bytownite, labradorite) likely due to Fenton chemistry (OH^{*} generation via H₂O₂ reacting with surficial Fe²⁺).¹⁻⁴ These results imply that highly reactive iron-rich mineral phases are possibly most hazardous to human health. Caveats of these studies that must be taken into account include the fact that terrestrial rocks and minerals lack metallic iron (Fe⁰) which is abundant in lunar dust due to space weathering.⁵ Past work has involved the assessment of reactivity of more “lunar-like” lunar simulants that have been reduced to include metallic iron (see Nekvasil et al. this conference). In this work, we present initial results of an investigation into the OH^{*} generation potential of the olivine solid solution series to assess the role that iron plays in promoting OH^{*} generation through Fenton chemistry. Assessing reactivity of the olivine solution series will allow us to better understand the underlying mechanisms of Fenton chemistry. Olivine is a mineral associated with mare basalts and present in the lunar regolith.⁶

Methods. Olivine phases were synthesized with the following compositions Fo₁₀₀, Fa₁₅, Fa₅₀, Fa₆₀, Fa₈₅, and Fa₁₀₀. Olivine samples were synthesized by sub-solidus reaction of oxide components, SiO₂, MgO, Fe₂O₃, and Fe⁰, wrapped in silver foil in an evacuated silica tube at 900 °C for two weeks. The resulting olivine was ground for one hour in an automatic mortar. Olivine powders were left exposed to air for a minimum of two weeks to diminish any reactivity as a result of grinding in the automatic mortar prior to testing for OH^{*} generation.

Two (200 mg) aliquots of olivine were hand-ground in an agate mortar and pestle for 10 min which was then subsequently incubated in the dark for 15 min in an 88.4 mM solution of the spin-trap compound known as DMPO. The resulting slurries were filtered using a 0.2 μm syringe filter. The filtrate was pipetted into a 50 μL glass capillary tube which was then sealed with Cri-

toseal® and placed into an X-band electron paramagnetic resonance (EPR) spectrometer. OH^{*} generation was measured using the EPR calibration standard known as TEMPOL.

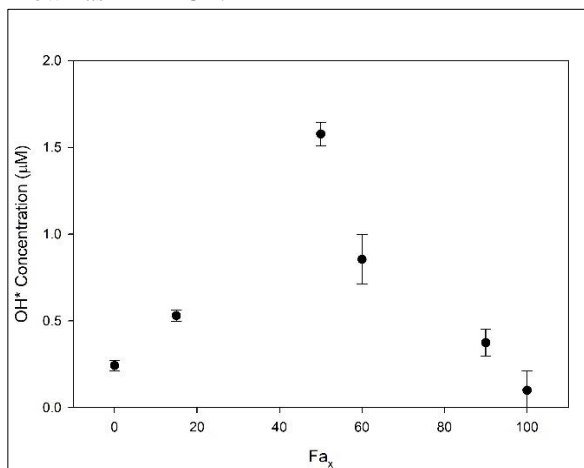


Fig 1. OH^{*} (μM) vs. olivine phase composition. All experiments ran in duplicate.

As shown in Figure 1, Fa₅₀ generates the maximum OH^{*} concentration (1.6 μM) while the endmembers, forsterite (Fo₁₀₀) and fayalite (Fa₁₀₀), generated the least amount of OH^{*}. This contradicts previous results which demonstrated a strong relationship between FeO abundance in silicates and OH^{*} generation.¹ If that relationship held for the olivine series then we would have observed a linear relationship with minimal reactivity at Fo₁₀₀ and maximum reactivity at Fa₁₀₀. We are working to understand the observed trend in Figure 1. To first order, the relationships in Figure 1 indicate that the OH^{*} generation potential for lunar olivines (typically Fa₂₀-Fa₇₀) is higher relative to that of forsteritic terrestrial olivines that are typically used in reactivity studies.⁶ Future work will include the study of reactivity within the pyroxene and plagioclase solid solution series.

References. [1] Hendrix, D.A. & Hurowitz, J.A. (2019), *GeoHealth*, 3, 28-42. [2] Hurowitz, J. A. et al. (2007), *Earth Planet. Sci. Lett.* 255, 41-52. [3] Turci, F. et al. (2015), *Astrobiology* 15, 371-380. [4] Kaur, J. et al. (2016), *Acta. Astronautica* 122, 196-208. [5] Hill, E. (2007), *J. Geophys. Res. Planets* 112, 1-11. [6] Heiken et al. (1991), *Lunar Sourcebook*, Cambridge University Press, 753 p.