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 (H_2O_2) relative to iron-poor silicates (i.e. bytownite, labradorite) likely due to Fenton chemistry (OH* generation via H_2O_2 reacting with surficial Fe^{2+}).[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 (Fe^0) 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. 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] Fa_{50} generates the maximum OH* concentration (1.6 μM) while the endmembers, forsterite (Fo_{100}) and fayalite (Fa_{100}), 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 Fo_{100} and maximum reactivity at Fa_{100}. We are working to understand the aforementioned trends. To first order, these relationships in indicate that the OH* generation potential for lunar olivines (typically Fa_{20}-Fa_{70}) 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.

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