Identification of mechanically induced radical species and hydroxyl radicals via electron paramagnetic resonance

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As we move on into the 21st century, humans will conduct missions throughout our solar system. The Moon, being so close, is most likely where we will go to in the near future. It has been reported that lunar dust has potential detrimental effects on human health.[1] Inhalation of lunar dust and micron-sized mineral grains have the capability of producing reactive species containing oxygen in the lungs. These reactive oxygen species are capable of destroying DNA and inducing cell apoptosis (cell death).[2] Hydroxyl radicals, which consist of a hydrogen bonded to an oxygen with an extra unpaired electron, are the most commonly generated species. EPR (electron paramagnetic resonance) spectroscopy is a technique that can detect unpaired electrons in solids, liquids, and gasses. The production of hydroxyl radicals has been detected by the incubation of pulverized minerals in solution. Currently we are working with five different minerals including quartz, albite, forsterite, diposide, and augite. Diopside, augite, and forsterite have been detected in the lunar mare so these are good analogs to study.[3] Although the lunar highlands are composed of highly calcic plagioclase; albite is currently the only feldspathic mineral available for testing. Future testing with labradorite and bytownite (Ca-rich feldspars) are planned. All minerals were pulverized for 5, 15, and 30 min in a Retsch agate ball mill grinder. Approximately 0.2 g of each pulverized mineral samples were incubated for 5, 15, and 30 min in a 50 μM DMPO (5,5-dimethylpryrroline-N-oxide) solution. The resulting mineral slurries were then filtered with a 0.45 μm syringe and the filtrate was transferred to a 50 μL capillary tube. The capillary tube was inserted into an EPR sample tube, and the sample was tested with a Magnettech X-band EPR spectrometer. All mineral samples generated various amounts of DMPO-OH radicals with the exception of albite. Forsterite, augite, and diopside generated the largest quantities of hydroxyl radical, with forsterite being the highest. Quartz generated small amounts of hydroxyl radicals compared to the aforementioned minerals. One known mechanism for the generation of hydroxyl radicals is the Fenton reaction. The Fenton reaction involves the oxidation of ferrous iron to ferric iron and subsequent generation of hydroxyl radicals. The Mg/Fe ratio has not been evaluated for forsterite but it is suspected that there is enough iron to generate relatively large quantities of hydroxyl radical. Augite is the second largest generator of hydroxyl radicals followed by diopside. Augite may contain iron that undergoes Fenton reaction. Diopside contains mostly calcium and magnesium, which means that either Ca or Mg also is able to undergo Fenton reaction (they are divalent just like ferrous iron) or they contain defect sites in which they themselves generate hydroxyl radical. Future tests with X-ray fluorescence would enable the quantitative measurements of potential hydroxyl radical generators. Quartz generated significantly less hydroxyl radicals compared to forsterite, augite, and diopside. The only possible mechanism for hydroxyl radical generation via pulverized quartz is through defect sites or other divalent cation impurities. Albite did not generate any hydroxyl radical which is most likely due to the absence of ferrous iron or any other defect sites.

(1)Khan-Mayberry, N., (2008), *Acta. Astronaut* (2)Harrington et al., (2012), *Geochem Trans.*
(3)Rosso, J.J. et al., (2006), *The Mineralogical Society of America*