PERSISTENT CHEMICAL REACTIVITY OF QUARTZ GENERATED BY MECHANICAL GRINDING RELEVANT TO LUNAR DUST ACTIVATION AND TOXICITY STUDIES. J. C. Rask1, C. G. McCrossin1, E. Tranfield1, D. J. Loftus1. 1Lunar Dust Biological Effects Laboratory, Space Biosciences Division, NASA Ames Research Center, Moffett Field, CA 94035 (jon.c.rask@nasa.gov)

Introduction: While the basic structure and composition of lunar dust has been well described, very little is known about the in situ chemical reactivity of lunar dust, which could have significant impacts on in situ resource utilization, spacecraft design, and astronaut health [1]. All three major features of the unique radiation environment of the Moon—keV energy protons and helium ions of the solar wind, MeV energy protons from solar particle events, and UV radiation, down to the Lyman alpha-line—have potential to affect the mineral structure and chemistry of lunar dust, especially in the deep vacuum of the Moon. Once lunar dust is brought into a lunar habitat, where it will be exposed to oxygen and water vapor, it is assumed that the chemical reactivity of lunar dust will decay, over a time course of hours to days. Once passivated, lunar dust is likely to be less toxic, and may be less reactive with materials found inside the habitat. The nature of lunar dust chemically reactive states and the time course of passivation both must be understood in order to prepare for long-duration manned missions to the Moon.

Background: On Earth, one of the best understood minerals from the standpoint of chemical reactivity and toxicity is crystalline silica (quartz). While most silicon based oxides in lunar dust are non-crystalline, an understanding of the chemical reactivity of quartz and the biological implications of this chemical reactivity serve as a foundation for studies of lunar dust. A key feature of quartz is the fact that its chemical reactivity can be increased by mechanical grinding, a process that has been shown to generate mineral radicals (measurable by Electron Spin Resonance, ESR). Mechanically ground (freshly-fractured) quartz is more toxic than unground or ground-then-aged quartz [5]. On exposure to laboratory air (ambient oxygen levels and humidity), the chemical reactivity of freshly-fractured quartz decays with a half-life of about 30 hours, although some residual long-lived chemical reactivity is also evident [3][4]. Although definitive studies of lunar dust will involve exposing lunar dust to Moon-relevant radiation, mechanical generation of chemical reactivity may be a reasonable surrogate, as both strategies probably involve generation of unpaired electrons (mineral radicals) [6].

Methods: In this study, we investigated two grinding techniques, and the effect it had on quartz chemical reactivity. For grinding of quartz specimens, we used a mixer mill (Retsch, MM400). OK-75 crystalline quartz (U.S. Silica) was ground for 100 minutes in a zirconium oxide jar, and a sample of OK-75 crystalline quartz was also ground in an agate jar. For passivation studies, the specimens were placed in a fume hood to permit continuous exposure to ambient air (approximate humidity 40%). Seven weeks later, this same grinding procedure was repeated on two new samples of OK-75, and all four samples were analyzed for chemical reactivity by ESR and the TA. A particle size distribution analysis of all samples was carried out for all ground specimens.

Results: ESR data indicate that grinding quartz in a zirconium oxide jar was highly effective at generating radicals (Figure 1). At most, about 5% decay in the ESR signal was seen after exposure of a companion specimen to ambient air for 7 weeks (Figure 2). Persistence of free radicals was confirmed by the TA. Grinding of quartz in agate vials was completely ineffective at generating radicals (Figure 3 and 4), also confirmed by the TA. Both materials, however, were equivalently “size-reduced,” as judged by particle size distribution analysis.

Figure 1. Quartz ground in Zirconium and analyzed immediately after grinding showed a strong ESR signal.
**Summary:** Mechanical grinding of quartz in a zirconium oxide vial generates a strong ESR signal, indicating formation of abundant mineral radicals. In contrast, agate-ground quartz yielded no radicals. For the Zirconium-ground specimens, the radicals persist for many weeks, as measured by both ESR and a fluorescence assay (TA). These findings are in contrast to previous reports of quartz-radical passivation in ambient air with a half-life of 30 hours. These findings may provide insight into the mechanisms of mineral-based radical generation pertinent to lunar dust toxicity studies.

**References:**


