ENHANCED CHEMICAL REACTIVITY OF CRYSTALLINE QUARTZ BY MECHANICAL GRINDING.

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Introduction: The chemical reactivity of lunar regolith is one of the most important issues which impacts the human health and biological effects of lunar regolith. The constant micrometeorite bombardment of the lunar surface results in both comminution and shock melting of lunar regolith. In addition, radiation effects are likely to enhance the chemical reactivity of lunar regolith.

With respect to chemical reactivity issues, crystalline silica is probably the most important terrestrial analog of lunar regolith. The chemical reactivity of crystalline silica can be transiently increased by mechanical grinding, a process that increases its toxicity to the lungs. In extreme situations freshly fractured crystalline silica can lead to an accelerated form of silicosis which is rapidly fatal. A tragic example of this phenomenon occurred in the Hawk's Nest Tunnel disaster in which more than 400 workers died of exposure to freshly fractured crystalline silica [1].

Laboratory examinations of the potency of freshly fractured crystalline silica in biological systems have been described by Vallyathan and colleagues at the National Institue of Occupational Safety and Health (NIOSH) [2]. The equipment used in this study for generating freshly fractured crystalline silica, however, is no longer available. The focus of this short paper is the introduction of a new technique to enhance the chemical reactivity of crystalline silica by mechanical grinding. The goal is to develop a simple method for generating "freshly fractured silica" to serve as a control material for lunar dust chemical reactivity studies.

The Terephthalate Assay: At Ames Research Center and Johnson Space Center, we have been using a simple chemical assay to evaluate the chemical reactivity of lunar dust, crystalline silica, and other terrestrial reference materials [3]. The assay measures the potential for surface radicals on lunar dust to generate hydroxyl radicals upon exposure to water. The assay involves the conversion of terepthalate (non-fluorescent) to hydroxyterepthalate (fluorescent), in the presence of hydroxyl radicals. Hence, simple fluorescence detection systems can be used as an indicator of surface radicals on lunar dust. This assay provides us with a method for evaluating different techniques of lunar dust reactivation, as well as a method for characterizing the decay (passivation) of this reactivated state.

Grinding Technique: In order to reproducibly grind mineral specimens, we have been using a ball mill (Retsch MM400). The MM400 utilizes a horizontal oscillatory motion to cause repeated impacts of the balls with the top and bottom of the grinding jar in order to pulverize the material.

To adapt the technique for mechanical grinding of crystalline silica, we have studied the effects of grinding jar material (stainless steel vs. agate), quantity of material in the jar, duration of grinding, and the particle size of the starting material. We have been using the terephthalate assay as the primary endpoint for evaluating the effectiveness of grinding. In addition, we have examined the particle size distribution of the ground materials using a multi-laser light scattering instrument (Microtrac S3550).

Results: Our preliminary results indicate that stainless steel grinding jars and balls provide the most efficient fracturing of crystalline silica as assessed by the terephthalate assay. By comparison, the use of an agate jar with agate grinding balls showed minimal activation of crystalline silica. In initial experiments we did not observe a consistent correlation between degree of activation and reduction in particle size, as measured by the particle size analyzer. Continued evaluation of the relationship of particle size and chemical reactivity is underway. An important parameter which affects grinding efficiency, as judged by the terephthalate assay, is the amount of material loaded into the grinding jar at the start of the grinding procedure. Our preliminary results indicate that grinding efficiency drops off as larger amount of material are loaded into the grinding jar.

Summary: We have developed a technique for mechanically grinding crystalline silica which increases the chemical reactivity of the material as judged by the terephthalate assay. This technique uses a modern, commercially available ball mill. It provides a method for generating "fresh fractured" or "activated" silica to serve as a positive control for studies of lunar regolith chemical reactivity. The technique generates sufficient quantities of activated material (250 mg – 750 mg) to provide a ready source for biological and chemical studies. The technique may serve as a valuable method for applications with lunar regolith and other planetary materials which exhibit activation when mechanically ground [3].

References: [1] Chernick M. (1986) *The Hawk's Nest Incident.* [2] Vallyathan, V. et al. (1988) *Am. Rev. Respir. Dis.* 138, 1213. [3] Wallace W.T. et al. (2008) *Meteor. Planet. Sci.* Submitted.