Lunar Regolith Simulant Mineral Processing and Characterization. W. M. Cross[1], [1]Department of Materials and Metallurgical Engineering, South Dakota School of Mines and Technology, 501 E. St. Joseph St., Rapid City, SD 57701. William.cross@sdsmt.edu; (605) 394-2485.

Introduction: This work was performed to help develop mineral processing techniques for making lunar regolith simulant. As few locations on Earth have the correct composition and concentration of minerals as the lunar surface, and the lunar surface itself varies from site to site, methods are needed to produce mineral separates of the lunar regolith simulant materials. These separates can then be combined to simulate any lunar site. This work aims to develop appropriate separation techniques.

Procedure: Several standard mineral processing techniques were evaluated for their ability to separate terrestrial mineral analogs for lunar regolith. Mineral samples from the Stillwater Mine in Montana were obtained frm the United States Geological Survey in Denver. Two types of samples were obtained. One from the previously processed mill sands (called mill sands (hereafter) and one from a nearby road area (hereafter called road norite). The most promising techniques were then used to separate these mineral samples.

Results: Separations based on density, breakage, surface chemistry, magnetic and electrostatic properties were considered. The goal of these separations was to produce mineral concentrates having a grade in excess of 80% of the mineral to be concentrated. One of the main keys to producing concentrates of high grade is the liberation of the minerals. Liberation is the term used to describe whether each individual rock grain is composed of only one type of mineral or several mineral types. Liberation is achieved through crushing and grinding. The terrestrial mineral family members that are analogs for lunar regolith and present in the Stillwater ore body are plagioclase $(Na,Ca)(Al,Si)_4O_8$, orthopyroxene $(Mg,Fe)_2Si_2O_6$, and clinopyroxene $Ca(Mg,Fe)Si_2O_6$. Examination of the separation characteristic of these mineral families showed that, under the assumption of perfect liberation, nearly every method could be used to separate plagioclase from the pyroxenes. Lightly tapping uncrushed road norite samples with a hammer was sufficient to fracture the bonds between the plagioclase and the pyroxenes indicating that a high degree of liberation of the plagioclase should be. Bench-scale testing of magnetic separation using a Frantz Isodynamic Separator proved that this separation technique worked well for a variety of different size ranges. Thus, this technique was used to separate plagioclase from the pyroxenes. Pacer Corporation, a local South Dakota company that had a laboratory scale high intensity magnetic separator, was utilized to help with the separations

Magnetic separation. The road norite material was easily separated magnetically. Four size fractions (595-297 μm, 297-177 μm, 105-74 μm and -37 μm. For all size fractions, the non-magnetic fraction was more than 95% plagioclase, with the remainder calcite. For the three larger size fractions, the magnetic fraction grade was greater than 80% orthopyroxene. The clinopyroxene minerals became a greater fraction of the total as the size decreased. In addition, a small amount (2-5 wt%) of talc ($Mg_3Si_4O_{10}(OH)_2$) was also present in the magnetic fraction. Talc occurs due to hydrothermal alteration of the orthopyroxene.

For the mill sand sample, initial measurements indicated that the sample obtained was composed of plagioclase with a small amount of quartz. Scanning electron microscopy revealed the presence of considerable quantities of glass-like material. Discussions with frmer mill personnel indicated that the mill often added smelter slag from the prvious processing operations.. The glass materials were of two main types: one being a calcium-aluminum containing glass, while the other most resembled an olivine $(Mg,Fe)_2SiO_4$) composition glass material. The two types of glass often were unliberated making separation of thiese materials much more difficult.

Electrostatic separation. Separation of the pyroxene minerals is difficult to achieve with most eparation methods. One possible method is the use of free-fall electrostatic separator. A prototype of an electrostatic separator has been manufactured and is currently beign used to attempt pyroxene separation. The key issues are liberation of the minerals, and the electric field potential compared to the particle mass.

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