MINERAL BENEFICIATION STUDIES USING APOLLO ROCKS AND SOILS

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Introduction: The success of a lunar settlement will be largely dependent upon the efficiency with which the indigenous rocks, minerals, and soils are utilized. However, a thorough knowledge of the complexities and uniqueness of these lunar resources must be appreciated, before any effective mineral liberation and beneficiation endeavors are proposed. This will necessitate the development of lunar simulants that are based upon the soil characteristics needed for studies. It is paramount that a lunar rock and soil expert be consulted continuously during the planning and implementation of the production of this simulant. Recall that during Apollo times, we used sand from League City mixed with montmorillonite clay to best simulate the lunar soil geotechnical properties for drill testing and rover trafficability. Trying to make lunar simulants that have multiple uses has led to numerous problems, not generally appreciated by the engineers using the simulants.

Beneficiation: The beneficiation of ilmenite from lunar rocks and soils is a case-in-point. Terrestrial ilmenite virtually always contains some Fe^{3+}, typically in the form of exsolved magnetite, giving the ilmenite a high magnetic susceptibility. Our detailed studies of the magnetic susceptibilities (MS) of the mineral and glass components of lunar soils and rocks [1-2] demonstrated the unusual behavior of these lunar minerals. Lunar ilmenite has a low MS, about the same as pyroxene, not anything like terrestrial. Using terrestrial ilmenite for magnetic and electrostatic beneficiation studies is purely wrong. Secondly when a rock weathers and releases its minerals, the pieces do not break apart so that they are each separate minerals – indeed, intergrowths are more common. Making a simulant from separates of several minerals may be entirely unrealistic. A preliminary crushing of a soil may be necessary to further release the individual minerals. Lastly, it would seem intoitive to use a mature soil for beneficiation of its minerals. This is not the case with lunar soils, where it is better to use an immature soil [3]. Continued maturation of lunar soil by micrometeorite bombardment comminutes (i.e., crushes) the particles, BUT these impacts melt a larger & larger portion of the soil that quenches to glass. Indeed the amount of such impact-produced glass in typical mature lunar soil = ~40 %.

High-Ti lunar rocks were studied [4-6] in order to evaluate how crushing would facilitate the separation of ilmenite. An obvious factor to consider is the size and texture of the ilmenite versus the host minerals of the rock. E.g., fine-grained ilmenite inter-grown with coarse pyroxene reacts entirely differently to crushing than does a rock with coarse-grained ilmenite. Mineral liberation graphs, used in our studies [4], illustrated their use for mineral liberation and beneficiation of various lunar rocks. Some of these graphs will be discussed in the talk.

Summary: As shown by these several studies using Apollo lunar samples, mineral beneficiation of lunar rocks and soil is much more complicated that our terrestrial experiences might imagine. Indeed, making suitable simulants may not be feasible for certain purposes. Bottom line to such studies is that a lunar expert must be a working member of your team in order to assure that the studies are realistic and meaningful.

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