1st Space Exploration Conference: Continuing the Voyage of Discovery
30 January - 1 February 2005, Orlando, Florida

AIAA 2005-2510

The Lunar Dust Problem: From Liability to Asset

Lawrence A. Taylor[1] (lataylor@utk.edu)
Planetary Geosciences Institute, University of Tennessee, Knoxville, TN 37996

Harrison H. Schmitt[2]
Engineering Research Bldg., University of Wisconsin, Madison, WI, 53706

W. David Carrier, III[3]
Lunar Geotechnical Institute, P.O. Box 5056, Lakeland, FL 33807

And

Masami Nakagawa[4]
Division of Engineering, Colorado School of Mines, Golden, CO 80401

ABSTRACT

In-Situ Resource Utilization (ISRU) of lunar materials for the establishment of an extra-terrestrial human base or settlement will involve guarding against, as well as utilizing, the ever-present, clinging, penetrating, abrasive, resource-rich, fine-grained lunar dust. The properties of the fine portion of the lunar soil (<50 μm), its dust, must be adequately addressed before any sustained presence on the Moon can be fully realized; these include: 1) *abrasiveness*, with regards to friction-bearing surfaces; 2) *pervasive nature* as coatings, on seals, gaskets, optical lens, windows, etc., 3) *gravitational settling* on all thermal and optical surfaces, such as solar cells; and 4) *physiological effects* on the tissue in human lungs. The chemical and physical properties of the fine fraction of lunar soil is at the root of the unusual properties of the dust that contribute to its deleterious effects – its *"liability".* Recent discoveries of the unique magnetic properties of lunar mare and highland soils by the senior author's Tennessee group have led to suggested solutions to the liability of the lunar dust. The soil fragments and dust grains contain myriads of adhering nano-sized (3-30 nm) Fe^0 particles, iron in its elemental form, concentrated especially in the fine, dusty fraction. The presence of this ferromagnetic Fe^0 on and in almost every grain of the fine dust-sized particles imparts an unusually high magnetic susceptibility to the particles, such that they are easily captures by a magnet. Furthermore, the presence of these nanophase Fe^0 grains imparts an unusual property to the soil for microwave energy. The microwaves couple strongly with the Fe^0 to such a degree that a sample of Apollo soil placed in an ordinary 2.45 MHz kitchen microwave will literally begin to melt before your tea-water boils. Further considerations of the properties of the fine soil are the basis for the microwave sintering/melting, hot-pressing, and extrusion of the soil to form various construction materials, in order to realize some of the *"assets"* of the soil

I. Introduction

The economic and societal rewards from exporting resource commodities from the Moon to LEO and to Earth, and potentially to Mars, as well as for use at a lunar base or settlement, would appear to be very great if not limitless. In fact, resources from the Moon can have a direct bearing on potentially reducing the cost and extending the longevity of the International Space Station (ISS) or future such stations. The ISS consumption of hydrogen, oxygen, and water can be satisfied by production of these commodities from lunar soil. For example, the production of liquid lunar oxygen (LLOX), liquid lunar hydrogen (LLH), and water involve relatively uncomplicated, well-characterized and researched processes on the Moon[1-5]. The beaming of electrical power from lunar solar cells to LEO and Earth has been examined in detail by Dave Criswell[6]. The potential of a D-^{3}He energy reactor being created and capable of using lunar ^{3}He becomes closer to reality each year, largely through the research of G.L. Kulcinski's team[7-10] at the Fusion Technology Institute (University of Wisconsin-Madison. Even placing astronomy instrumentation on the Moon and the establishment of human habitats are areas of open discussion and planning in many NASA and private circles. But, what do all of these apparent dissimilar activities have in common? *Lunar Dust.*