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PROCESSING LUNAR SOIL FOR STRUCTURAL MATERIALS; Philomena Grodzka, Lockheed Missiles and Space Company, P. O. Box 1103, Huntsville, Alabama 35807.

Since a previous assessment of the prospects of processing lunar soil for structural materials (1), more information has been gathered on the subject. The new information is indicated under the following material categories.

Metals: Numerous articles and patents continue to appear on methods of extracting aluminum or titanium from earth materials similar to those that are present on the moon, i.e., anorthosite for aluminum and ilmenite for titanium. Reported work, however, is aimed at developing earth based technologies for the lower grade ores. As a result, most of the methods utilize alkali or acid bleach processes which involve copious amounts of water and complex processing operations. Although it is understood that a study conducted by a group at Ames in the summer of 1975 recommended an acid bleach process for the extraction of aluminum on the moon, it is still the opinion of others that more direct routes must be sought for moon based extractive technologies. Electrolysis of molten silicate melts was one means suggested earlier (1). Since then a couple of other possible approaches suggested themselves. One possibility might be to explore further the chemistry of molten silicate melts. For example, it is reported (2) that when an aluminosilicate is fused with cryolite or fluorspar and sodium chloride, the mass forms two layers. The upper layer contains sodium chloride and aluminum fluoride, and the lower layer sodium and calcium aluminosilicate. Theoretically, the upper layer could be electrolyzed to give aluminum.

An intriguing thought is what would be the result of adding magnesium to a molten aluminosilicate mass. Magnesium oxide has a larger standard free energy of formation than does aluminum oxide (3). Magnesium, therefore, should reduce aluminum oxide at temperatures below about 1500°C. The free energy relationships, however, are such that magnesium can also reduce silicon dioxide. It would thus be interesting to see if any aluminum could be produced by adding magnesium to aluminosilicate melt. Such an approach is attractive because magnesium can probably be readily produced on the moon by some variant of the following vacuum retort reaction (4):

$$2\ CaO + MgO + Fe_xSi \rightarrow 2\ Mg(g) + (CaO)_2\ SiO_2 + x\ Fe$$

The reaction goes to the right because the pressure of magnesium gas at 1200°C is only about 34 mm Hg, i.e., a vacuum drives the reaction to the right. Magnesium gas is subsequently condensed to give a metal product that is purer than ordinary electrolytic magnesium. Magnesium production on the moon may also be desirable as a step in the production of titanium. The Kroll process for titanium production is based on the following reaction:

$$TiCl_4(g) + 2\ Mg(l) \rightarrow Ti(c) + 2\ MgCl_2(l)$$

Glasses and Ceramics: The relatively large number of recent papers on the production of glasses and ceramics from anorthosite, anorthite, various feldspars, and basalt indicate that such raw materials will soon be routinely used in many glass and ceramic industries. It is interesting to note that the Europeans and the Russians appear to be particularly active in this area. Interesting highlights from these papers are the following:

- Cylinders of basalt/sulfur concrete exhibited average strengths of 3,348 psi to 10,398 psi in compression (5).
- Basalt fibers have high thermal and electrical insulation properties and are extremely strong (6).
- Glass fiber reinforced cement make possible lightweight cement based sheets for cladding of large buildings. The composite has a high impact strength together with an associated pseudoductility during the early part of its life. More research is indicated, however, before the composite is considered for load bearing purposes. Wet conditions seem to hasten the aging (7).

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