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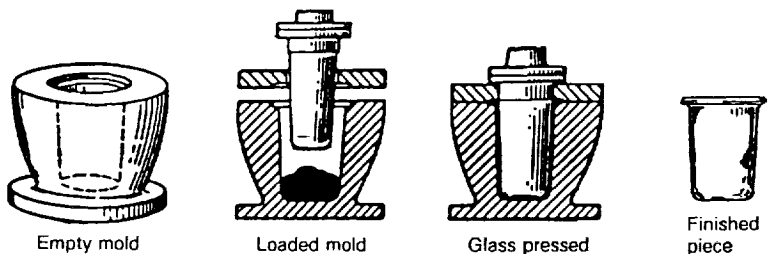
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Glass and Ceramics

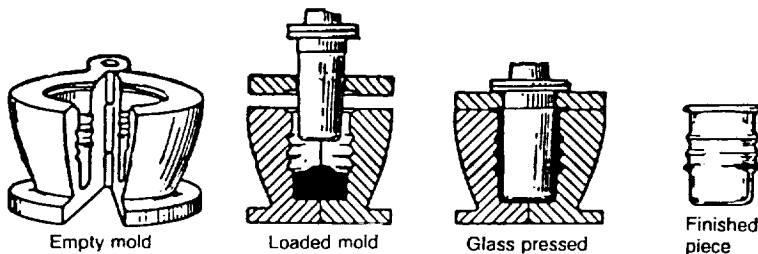
Larry A. Haskin

A variety of glasses and ceramics can be produced from bulk lunar materials or from separated components. Many glassy materials have been described in previous studies (Mackenzie and Claridge 1979, Criswell 1980). They include sintered (heated and pressed) regolith, quenched molten basalt, and transparent glass formed from fused plagioclase. No research has been carried out on

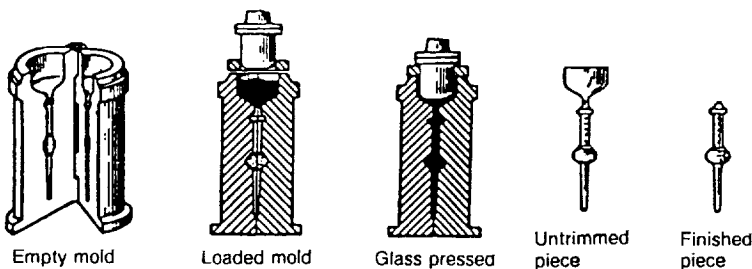
lunar material or close simulants, so properties are not known in detail; however, common glass technologies such as molding and spinning seem feasible (fig. 7). Uses of glass include structural applications (bricks, slabs, beams, windows) and specialty applications (fiber strengtheners, insulation, heat shields, cables, light pipes). See figures 8 and 9.



(a) Block mold



(b) Split mold



(c) Font mold

Figure 7

Glass Forming

The material on the lunar surface has a high silicate content. Some of these silicate materials could be the constituents of transparent glasses, which could have a variety of uses at a lunar base. Various processes are available for fabricating objects from glass. Here, molds are used for glass pressing. The liquid glass is poured into the mold, which is compressed. When the glass has cooled, the object is extracted from the mold.

From Shand 1958, p. 164.

Figure 8

Glass Drawing

When silicate glasses are melted, they are viscous and thus can readily be drawn by special machines into fibers or rods or tubes. Glass fiber textiles and mats, which are commonly used terrestrially as thermal and electrical insulators, could be used as construction materials in a space facility.

From Shand 1958, p. 385.

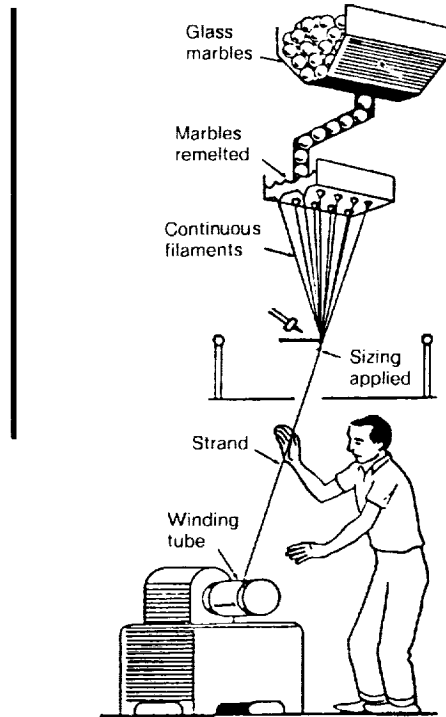
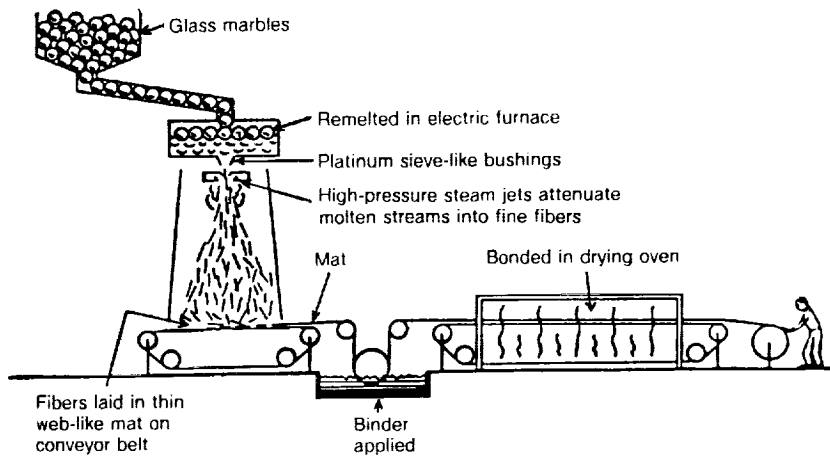


Figure 9

Fiberglass

Another product that could be formed from lunar soil is fiberglass, which might find use as a structural material, perhaps combined with organic or metallic materials. On Earth, fiberglass tanks are commonly used for storage of fluids, such as in standard water heaters.

From Shand 1958, p. 384.



Among the high-leverage uses of fused silicate materials in the proposed utilization of nonterrestrial resources are the fabrication of heat shields for orbital transfer vehicles traveling from the Moon to Earth and the use of sintered or melted and sand-cast soil for structural support in unpressurized lunar shelters. The work of Blacic (1985) indicates that lunar glasses made under the anhydrous, hard-vacuum conditions on the Moon could have very high strengths and thus be quite applicable to structures in space. Prestressed beams made with sintered bricks, using fiberglass or iron bars as tendons, may find early application as structural members.

Ceramics like those used on Earth could be produced by chemical processing of raw lunar material; for example, fractional volatilization of plagioclase could lead to melts for ceramic applications. The recombination of plagioclase with the residue of the ilmenite reduction process (metallic iron and titanium dioxide) could yield cermets with interesting properties. Ceramics might find uses similar to those of glasses.

Alternative means of preparing glasses and ceramics appear to be direct heating using solar concentrators (Ho and Sobon 1979), electrical resistive heating,

and microwave heating. Direct use of waste heat from nuclear reactors used in space or on the Moon may also be practical but might require complex heat exchangers, heat pipes, and other devices for thermal control. The microwave heating concept is described in more detail in the first appendix to this part. It offers an efficient means of converting electrical energy into heat, delivered locally and in a controlled manner to the target to be heated. Additional work is necessary to define optimum thermal processing systems for glass and ceramic products and the properties of the heated lunar material. It will be desirable to have access to good simulants of lunar regolith or increased quantities of real lunar soil to further such necessary research.

The production of more complex ceramics, composites, and even semiconductors may prove desirable at some point during the development of a lunar base. Although perhaps not within the scope of most easily obtainable materials, semiconductors produced from lunar materials could have a major effect on the means of producing electricity on the Moon. Silicon-based photovoltaic devices could be constructed using silicon reduced from silicate minerals, covered with thin glass layers made from silicon

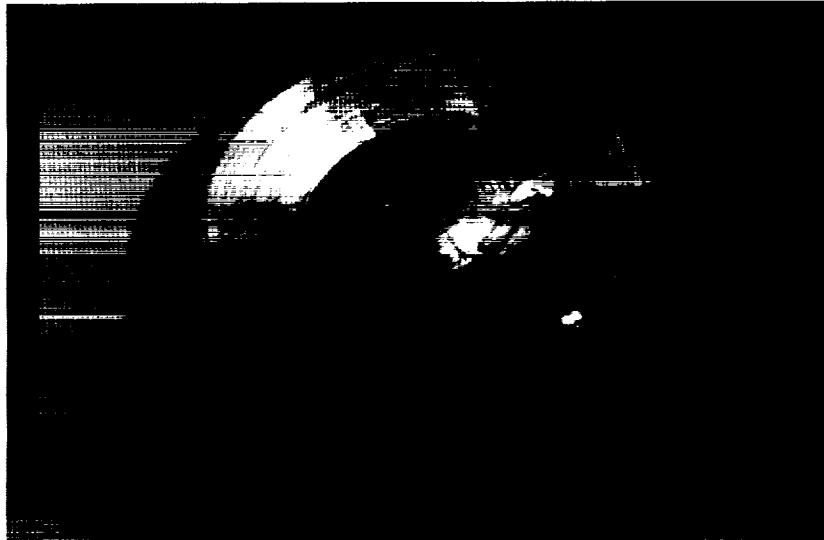
dioxide, supported by iron, aluminum, or glass structures, and supplied with iron wires to conduct currents. Lunar ilmenite has interesting semiconductor properties (see fig. 10) and might be usable in converting sunlight to electricity. The preparation of photovoltaic devices is now well known on Earth; however, adapting these processes to a lunar environment would be quite challenging.

Figure 10

Semiconductors

Lunar ilmenite is a natural semiconductor. Here, a "boule" of ilmenite of lunar composition has been fabricated in a furnace as a single crystal. Cut into thin wafers, provided with electrical leads, and exposed to the Sun, this semiconductor would cause an electrical current to flow. Although rather low in its efficiency of converting light to electricity, ilmenite is so abundant on the Moon that it may be an attractive alternative to photovoltaic devices brought from Earth.

Courtesy of R. K. Pandey, Electronic Materials Laboratory, Texas A&M University, College Station, TX



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