Vapor and Plasma Phase Pyrolysis; A Key to Lunar Industrialization

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In the 20th century NASA researched many methods for the production of oxygen, and some for metals, from the ubiquitous metal oxides that make up the bulk of the Moon. However, the vast majority, as is recorded in summary form in the NASA publication SP-509, were based on chemical processing, requiring toxic and corrosive reagents requiring complex machinery and periodic replenishment from the Earth. Two processes, by NASA JPL's Wolfgang Steurer, mentioned in NASA SP 509, were based on simple thermal methods, Vapor Phase and Plasma Phase Pyrolysis. These processes are related, and the work of Steurer focused on oxygen production via Vapor Phase Pyrolysis and oxygen and metals via plasma phase pyrolysis. The difference between the two processes is the temperature required for the disassociation of metals and oxygen for lunar metal oxides. In the past, the temperatures required were too high for available crucible materials (over 3,000 degrees c) and energy requirements were also excessive. The research presented here will survey and present experimental evidence from industry that ultra-high levels of vacuum such as exists on the Moon, dramatically reduces the temperature required for molecular disassociation of lunar metal oxides. These temperature reductions are sufficient to enable existing industrial crucibles of tungsten or Iridium to be used, and additionally lower electrical power requirements. Adding vacuum electromagnetic separation or zonal distillation enables the capture of oxygen and the capture and purification of metals to be used as inputs into industrial processes. It is estimated that this process could recover in excess of 95% of the oxygen and metals from the input metal oxides. Discussion of the design of an experimental apparatus and campaign will be presented that will validate materials selections, energy requirements, and determine yields using lunar analog materials of both highlands and mare varieties.

When the discussion of the Moon that goes beyond science to activities pertaining to In Situ Resource Utilization (ISRU), the vast majority of the discussion, since the confirmation by remote sensing and the LCROSS impactor, has centered around obtaining, processing, and using water. Water is an absolutely necessary component of an industrial economy utilization lunar resources. However, though necessary, water is not sufficient for an economic system that supports the opening of the solar system for the advance of humanity. Validation of the ability to separate metals and oxygen from metal oxides would be a major advance toward true lunar industrialization.