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Final Report

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Studies on the Processing Methods for Extraterrestrial Materials

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FINAL REPORT

Introduction

The use of vacuum vaporization as a means of separating elements and compounds from lunar or other extraterrestrial materials shows great promise. It is unfortunate that little scientific information exists concerning selective vaporization of complex mineral systems.

This report covers the first year of a research program on the processing of extraterrestrial materials by high-temperature vacuum vaporization. The original program was to be a multiyear effort, and the goals of the program were predicated on that basis. Due to the untimely termination of the project, the short term goals were modified late in the year in the hope that program progress could be maintained until other sources of funds could be obtained. The overall goals, however, remain unchanged.

Project Goals

1. Identification of the neutral vapor species produced by the extraterrestrial materials.
2. Determination of material release profiles (i.e. vaporization rates) as a function of time and temperature.
3. Investigation of means by which the release kinetics of the various chemical constituents might be altered.
4. Formulation of models by which process predictions could be made.

Progress

1. Literature Search

Mass spectrometric investigations of the vaporization of oxide systems at high temperatures are time-consuming and difficult. Much time can be saved if data from the published literature are used to a maximum. Accordingly, a search was made of the high-temperature mass spectrometric research literature on single oxides, complex oxide systems and minerals. The literature was shown to be extremely spotty, as anticipated, but valuable nevetheless.

2. Data Acquisition System

Conventional high temperature mass spectrometry involves the study of equilibrium systems. In these systems, ion intensities vary only slowly with time, and manual control of data acquisition is satisfactory. Virtually all extraterrestrial materials constitute non-equilibrium systems in which the partial pressure of the vapor species will vary with time and temperature. To study the complex systems, modification of the data acquisition components was required.

An obsolete vibrating capacitor electrometer was replaced with a Keithley model 642 digital electrometer. The model 642 was necessary since no other electrometer had a remote capability. To incorporate the model 642 into existing equipment, a modified electrometer coupler and support were designed and built.

The precision 10V output is used for the source signal from the electrometer. The existing equipment employed a 1V analog signal: thus, a new V-F converter was designed to accomodate the 10V signal, ±10V reference voltage, and a 10 mV offset reference for zeroing. The unit has been built, tested, and incorporated into the mass spectrometer.

The output from the V-F converter is connected to an ORTEC model 874 quad counter which is connected, in turn, via an IEEE-488 bus to the Apple II + computer supplied by the Chemistry Department. The ORTEC 874 was chosen for its precision time base and remote programming capability.

Development of software for the IEEE-488 Apple-ORTEC interface required substantially more development time than originally anticipated. This was due in large part to poor documentation of the IEEE control statements for the ORTEC unit and poor Apple documentation of the bus. A defective IEEE-488 bus added to the difficulty. The problems were resolved, and a seres of menu-based programs are now operational which:

(1) Test the ORTEC counter and interface;

(2) Permit calibration of the V-F converter;

(3) Permit adjustment of mass spectrometer parameters;

(4) Provide a computer based operating routine for the mass spectrometer.

3. High Temperature Furnace and Controller

Preliminary investigations at temperatures up to 1000°C showed the potential usefulness of these investigations. It is also apparent both from the experimental evidence and the estimates of Steuer (JPL Publ. 83-36) that temperatures substantially in excess of 1000°C will be required to effect meaningful separations.

The resistance furnace and controller currently in use on the mass spectrometer were designed for operation at temperatures up to 1000°C. Earlier, it was thought that we might be able to extend the range to 1200°C by modification of existing equipment. Attempts at this were unsuccessful. Experimental design information from the 1000°C furnace was then used in conjunction with heat transfer calculations to develop the basic furnace design for the higher temperature furnace. The requirements of the temperature controller and power supply were also obtained from these data. The 1600°C furnace controller has been designed and built. Critical design of the 1600°C furnace has been completed, and most of the commercial components have been received.

<u>Plans for Continued Work</u>

1. Construction of 1600°C Furnace

Work is about to start on the assembly drawings of the furnace. The Chemistry Department has provided funds for the machine shop work necessary to fabricate the non-commercial components of the furance. The 1600°C temperature controller will be used with the existing power supply for studies up to 1200°C. The power supply necessary for the 1600°C temperature could not be purchased due to a lack of funds. For the time being, funding constraints will limit the range of study.

2. Materials Studies

Prof. Grimley will investigate the materials planned at temperatures up to 1200°C with the hope that additional funds might be obtained which would allow the more productive temperature regions to be investigated.

3. Software Development

Some additional developments of files is required for storage of experimental data.

4. Long Term Studies

More extensive high temperature studies will be undertaken when additional funds are found.

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