Using Stable Isotope Geochemistry to Investigate the Source(s) of Volatiles in the Lunar Regolith

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1: Introduction:

- Previous laboratory analyses of lunar soil samples have documented a range of volatile species present within the regolith that blankets the lunar surface.
- Thermal gas release studies (heating soil samples at rates of 4 °C/min up to temperatures just exceeding their initial melting point) released solid gases, CH₄, CO, CO₂, H₂, H₂O, and halogen-bearing species (F, Cl, Br) at variable temperatures. In the present campaign, solar-wind-derived hydrogen and helium were released between 300–700 °C.[2]
- Most of the isotope ratio variations appear to be significantly larger than the range observed in the laboratory. Therefore, when mass 46 was detected, the isotope ratios varied by around 1000‰ (ppm).

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2: IonCam 2020 Gas Analysis Mass Spectrometer

- The IonCam 2020 mass spectrometer was purchased from Oxford Analytical (of Alabama, USA) in the autumn of 2012.
- It is a miniaturised, portable, non-invasive mass spectrometer allowing for simultaneous detection of all mass species present in a gas sample.
- The VarICD detector (Charge-Coupled Device) within the machine is described as pressure independent and highly linear, suggesting that it should function well with small amounts of gas (ideal for lunar soil sampling). A linear response here would mean that gas flow (measured as gas intensity at the detector) is proportional to pressure.

To investigate the instrument's capability for use with solar wind volatile samples, it was exposed to a continuous flow of reference gas (via the inlet capillary on the front of the machine).

3: Detection Limit

- In order to make reliable, precise isotope measurements, the response seen on the detector needs to be at least 20% of the time over a measurement (in this case, over 5 minutes).
- Given that δ⁴⁶/⁴⁴ values from previous studies of lunar soils range from -30‰ to +30‰, it is essential for a stable detector to maintain an output at a steady level for the entire measurement period with a constant error.
- The real-time count of mass 44, 45, and 46 from the “5K” function (whereby 250 frames of data from this mass range are collected every second) were then converted into isotope ratios (δ⁴⁶/⁴⁴) for each frame logged.

4: Stability

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5: Suitability

- Using these results to make sure that the instrument is capable of accurately measuring the range of δ⁴⁶/⁴⁴ values that are produced by the laboratory.” IonsCam instrument for isotopic analysis and for total chromatographic column, where the various volatiles are separated so that they can be detected and measured individually.
- The data collection was carried over several weeks, in both “raw” form (measured intensity in each pixel on the CCD detector) and converted into isotope ratios (δ⁴⁶/⁴⁴) for each frame logged.

6: Other Instrumentation

- There are several well-established instruments at the Open University that are capable of making highly precise isotopic measurements on small sample sizes, so these will be the next possibilities to explore.

7: References

- [3] Cepas, E., D. (2013) *A linear response here would mean that gas flow (measured as gas intensity at the detector) is proportional to pressure.
- [5] Cepas, E., D. (2013) *A linear response here would mean that gas flow (measured as gas intensity at the detector) is proportional to pressure.
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