ENVIRONMENTAL ANALYSIS OF THE BOUNDED LUNAR EXOSPHERE (ENABLE): ANALYTICAL CHEMISTRY IN EXTREME HIGH VACUUM (XHV).
E. L. Patrick[1] and R. L. Blase[1], [1]Space Science & Engineering Division, Southwest Research Institute®, 6220 Culebra Rd., San Antonio, TX 78238 (epatrick@swri.edu).

Introduction: The difference in scale between terrestrial sea level atmospheric pressure of our everyday experience and that at the lunar equator at local Midnight is approximately the same as the difference between the width of a microwave oven and the radius of a proton. From the opposite perspective, the difference in scale between pressure at the lunar equator at local Midnight and that at the seashore is about the same as that between the length of a school bus and the distance to Alpha Centauri.

Beneath the extreme high vacuum (XHV) of the lunar surface bounded exosphere (SBE)[1] are unexplored local and regional traps for native volatiles. During the coming prospecting and processing efforts for in situ resource utilization (ISRU), artificial contamination will unavoidably result from robotic and human operations at the lunar surface. It is therefore essential that signatures of contaminants be distinguished from those of important native volatiles through appropriate analytical techniques.

Pressure at the Lunar Surface: Quantitative pressure detection began at the lunar surface in November 1972 with the deployment of the Cold Cathode Gauge Experiment (CCGE) by the Apollo 12 (A12) astronauts[2]. Deployed and operating during lunar daylight, the CCGE successfully detected elevated background pressures at the lunar landing site due to artificial contamination, human activities that included depressurization (“depress”) of the A12 Lunar Module cabin, and a pressure saturation condition produced by the backpack of Commander “Pete” Conrad walking away from the sensor[3].

Lunar Mass Spectrometry: Mass spectrometry from the lunar surface began in December 1972 with deployment of the Lunar Atmospheric Composition Experiment (LACE) during Apollo 17[4]. Among its results, LACE successfully detected He, Ne and Ar in the lunar exosphere.

ENABLE: The Environmental Analysis of the Bounded Lunar Exosphere (ENABLE) project seeks to produce a prototype flightworthy mass spectrometer for use at the lunar surface. For this purpose we have selected a commercial off-the-shelf (COTS) quadrupole mass spectrometer (QMS) residual gas analyzer (RGA) as the basis for our prototype design.

The COTS unit is capable of pressure measurement over the nearly 15 order of magnitude range from terrestrial atmosphere to $1x10^{-12}$ Torr. These pressure detection features include an integral Pirani gauge ($\geq 1x10^{-3}$ Torr) and Bayard-Alpert ion gauge ($\leq 1x10^{-2}$ Torr). Partial pressure detection by mass spectrometry is conducted with a Faraday cup at pressures below $5x10^{-4}$ Torr with a lower sensitivity limit of $5x10^{-12}$ Torr and a multiplier that can operate from $5x10^{-6}$ Torr to $5x10^{-14}$ Torr, thus covering over 15 orders of magnitude in pressure. Mass scanning can be conducted in 0.1 Da steps from 1 to 300 Da.

The instrument is capable of producing electron bombardment (EB) energies spanning a wide range (11 - 150 eV). Traditional EB energy used is 70 eV, but lower energies can be utilized to emphasize trace gas species over dominant majority gas species of lower mass that require significantly higher impact energies.

Data will be presented on the operation of the COTS QMS and how mass peaks of organic molecules can be amplified against those of major gas species. We will also cover the various mission platforms and lunar environment scenarios envisioned for ENABLE operations (Fig. 1), including as a detector for leaks, micrometeoroid swarms, overflying spacecraft, or for triangulation—along with a network of other MS instruments—to identify and analyze gas plumes from landing spacecraft, impactors, or surface vents.

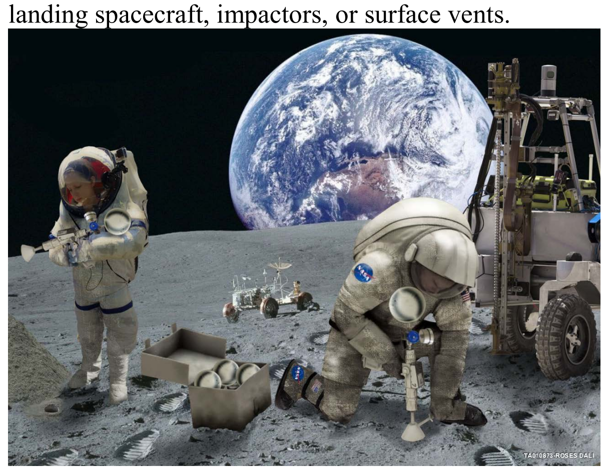

Fig. 1. *A future astronaut adjusts her ENABLE mass spectrometer as a colleague obtains a gas sample.*

Acknowledgment: ENABLE is supported by NASA ROSES DALI Grant #80NSSC21K0744.

References: [1] Stern, (1999) *Rev. Geophys*. 37, [2] Johnson F. S. et al. (1970) *A12 PSR*, 93-97. [3] Patrick E. L. and Mandt K. E., *LPSC 47*, 2649. [4] Hoffman et al. (1973) *LPS 4*, 2865.