MARS 2007 PHOENIX SCOUT MISSION ORGANIC FREE BLANK: METHOD TO DISTINQUISH MARS ORGANICS FROM TERRESTRIAL ORGANICS. D.W. Ming[1], R.V. Morris[1], R. Woida[2], B. Sutter[3], H.V. Lauer[3], C. Shinohara[2], D.C. Golden[3], W.V. Boynton[2], R.E. Arvidson[4], R.L. Stewart[5], L.K. Tamppari[6], M. Gross[6], P. Smith[2], and the Phoenix Science Team. [1]ARES, NASA Johnson Space Center, Mail Code KX, Houston, TX 77058 (douglas.w.ming@nasa.gov), [2]Lunar & Planetary Laboratory, University of Arizona, Tucson, AZ, [3]Jacobs Engineering, ESCG, Houston, TX, [4]Dept. Earth and Planetary Sciences, Washington University, St. Louis, MO, [5]Corning Incorporated, Corning, NY, [6]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA.

Introduction: The Mars 2007 Phoenix Scout Mission successfully launched on August 4, 2007, for a 10-month journey to Mars. The Phoenix spacecraft is scheduled to land on May 25, 2008. The primary mission objective is to study the history of water and evaluate the potential for past and present habitability in Martian arctic ice-rich soil [1]. Phoenix will land near 68° N latitude on polygonal terrain presumably created by ice layers that are expected to be a few centimeters under loose soil materials [2,3]. The Phoenix Mission will assess the potential for habitability by searching for organic molecules in ice or icy soils at the landing site. Organic molecules are necessary building blocks for life, although their presence in the ice or soil does not indicate life itself. Phoenix will search for organic molecules by heating soil/ice samples in the Thermal and Evolved-Gas Analyzer (TEGA, [4]). TEGA consists of 8 differential scanning calorimeter (DSC) ovens integrated with a magnetic-sector mass spectrometer with a mass range of 2-140 daltons [4]. Endothermic and exothermic reactions are recorded by the TEGA DSC as samples are heated from ambient to ~1000°C. Evolved gases, including organic molecules and fragments if present, are simultaneously measured by the mass spectrometer during heating.

The spacecraft will undoubtedly take organic contaminants to Mars, although elaborate precautions were taken to minimize contamination during spacecraft assembly, test, and launch activities. Critical to the success of the mission is the capability to distinguish Mars organics from terrestrial organic contamination once TEGA begins Martian surface opertions. The Organic Free Blank (OFB) was designed, built, tested, and mounted on the Phoenix spacecraft to provide a carbon blank to distinguish Martian from terrestrial organics that traveled with the spacecraft to Mars. Use of a blank is standard procedure in analytical labs. The objective of this paper is to provide an overview of the design, fabrication, testing, and spacecraft assembly for the Phoenix OFB.

OFB Requirements, Design, and Fabrication: Major OFB requirements are an organic carbon content of ≤10 ng C g^{-1} of sample, a non-porous structure, and sufficient strength to pass shock and vibration testing within the constraint of being machineable by the Robotic Arm (RA) Icy Soil Acquisition Device (ISAD). A specially fabricated form of commercial Macor™ (a machineable glass-ceramic), made with nitrate salts replacing carbonate salts, was selected as the OFB material. Macor™ is fabricated by Corning Incorporated (Corning, NY). The bulk chemical composition is nominally 46 wt. % SiO_2, 17 wt. % MgO, 16 wt. % Al_2O_3, 10 wt. % K_2O, 7 wt. % B_2O_3, and 4 wt. % F, and the bulk mineralogical composition is 55% fluorophlogopite and 45% amorphous borosilicate glass. The total C content of commercial Macor™ is ~295 µg C g^{-1} of sample. This number is a factor of ~30,000 higher than the design requirement set for organic C in the OFB (<10 ng organic C g^{-1} of sample). The high C content of commercial Macor™ was attributed to residual C from the carbonate-bearing starting materials that were used to produce the melts during fabrication. Atmospheric carbon dioxide might also be entrapped in commercial Macor™ during cooling of the melt and subsequent ceramming. To reduce potential C contamination, Corning produced a special batch of Macor™ (NO_3-Macor) from nitrate-bearing starting materials and a $N_2/Ar/O_2$ process gas atmosphere to reduce potential C contamination. Total C in the NO_3-Macor™ was further removed by several cleaning processes described below.

The OFB Flight Model (FM) consists of three components: (1) OFB block unit; (2) spacecraft mounting feet; and (3) integration hardware to attach the OFB block to the mounting feet. The dimensions of the OFB FM are 71.1 x 67.0 x 17.5 mm. Channels on the bottom of the OFB allowed the attachment of the block to four Al 7075 mounting feet that are attached to the RA baseplate (Fig. 1). Stainless steel rods and compression fittings were used to hold the OFB in place. Two witness blocks (5 x 2 x 2 cm) were also milled from the same Macor block that were used to fabricate the OFB FM block. Witness blocks accompanied the OFB FM throughout the entire fabrication and cleaning process. Because the OFB FM could not be characterized for total C, witness blocks were analyzed for total C prior to shipping the OFB FM for spacecraft integration. Three identical OFB FMs were fabricated and tested for possible integration onto the Phoenix payload. All three FMs successfully passed shock and vibration (S&V) environmental testing.

OFB cleaning and C content: All three OFB FMs were heat treated two times in a tube furnace with a dry N_2 purge (0.25 L min^{-1}) from boil-off of LN_2 and then with purified O_2 to remove all organics. Cleaned OFB FMs and witness blocks were transferred in a controlled environmental glove box to a stainless steel glovebox for final processing and loading into a specially fabricated container (Contamination Free Transport Container) for transport from NASA Johnson Space Center (JSC) to the spacecraft assembly facility at Lockheed Martin Company in Littleton, Colorado.

The technique used to measure total C in Macor™ was developed to mimic the measurement process of the Phoenix TEGA instrument. The TEGA Testbed, assembled at JSC, consists of a pyrolysis/combustion oven integrated with a high-precision quadrupole mass spectrometer (QMS). The testbed can operate under TEGA like conditions on the surface of Mars and under Earth ambient conditions using various carrier gases (e.g., N_2, O_2). The TEGA Testbed does not have the detection limits of Phoenix TEGA because of the QMS limitations, although the system has the capability to detect total carbon down to 100 ppb C. The OFB FM has a total inorganic carbon content of ~1.6 µg C g^{-1} after fabrication, cleaning, and heat treatment in oxygen gas at 550°C. The detection limit for organic carbon is ~100 ng C g^{-1} of sample, or about a factor of 10 higher than the design goal. Details on the cleaning process and C measurements are provided in [5].

Conclusions: The Phoenix OFB will provide a check material for TEGA during its search for organic molecules on Mars. Although the total C content of the OFB FM is higher than the design requirement for organic C, it does not have measurable organic C residing within the OFB FM block within detection limits (100 ng C g^{-1} of sample). The C in the OFB probably results from trace levels of occluded CO_2 and carbonates. Although the total C content within the OFB FM is known, the amount of organic C that adheres to the non-porous surfaces of the OFB is unknown. The OFB FM was subjected to environmental conditions during spacecraft assembly that may contribute to surface organics on the OFB. These organics (if they exist) will be sampled by the RA ISAD on Mars and contribute to the overall C content and organic content of the material. Possible contaminants are being characterized with TEGA Testbed using TEGA-like operating conditions to mitigate this possibility.

The Phoenix OFB will be used only if organic C is detected on Mars by TEGA. The OFB will then be sampled and analyzed, and results will be compared to the organic signatures released by the Martian sample. After OFB analysis, a TEGA run will be conducted on a second sample of the putative organic-containing material to validate the first analysis. High concentrations of organic molecules and possibly organic fragmentation patterns not in the OFB will also contribute to a credible positive identification of organic molecules indigenous to Mars. The high total carbon content in the OFB FM (1.6 µg C g^{-1} of sample) may require that the total C content in the Martian materials substantially exceed this number, perhaps as much as 10 µg C g^{-1} of sample before a positive detection of organic molecules on Mars is credible.

References: [1] Smith, P., *et al.* (2008) *JGR* (submitted). [2] Arvidson, R.E., *et al.* (2008) *JGR* (submitted). [3] Mellon, M.T., *et al.* (2008) *JGR* (submitted). [4] Boynton, W.V., *et al.* (2008) *JGR* (submitted). [5] Ming, D.W., *et al.* (2008) *JGR* (submitted).

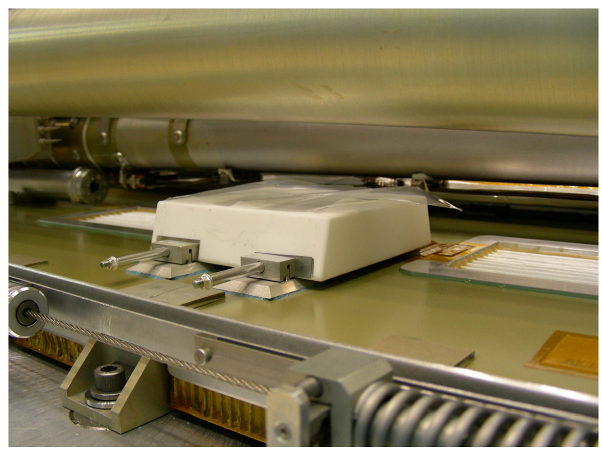

Figure 1. Installation of the OFB Flight Model on the baseplate of the Robotic Arm (RA). OFB mounting feet are attached to the RA baseplate with an adhesive and then tested to ensure the adhesive will survive spacecraft launch and landing. OFB FM is attached to the mounting feet. The entire RA, RA baseplate, and OFB FM are protected from organic organisms and organics during spacecraft assembly, launch, cruise, and landing by a biobarrier bag.