THE UNIVERSITY OF WINNIPEG'S PLANETARY SPECTROPHOTOMETER FACILITY (aka HOSERLab): WHAT'S NEW.

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Introduction: The University of Winnipeg's Planetary Spectrophotometer Facility (PSF; aka HOSERLab) was established in 2003 to develop a state-of-the-art optical spectroscopy-focused facility to support planetary exploration by enabling laboratory- and field-based studies of the optical spectroscopic properties of planetary materials and terrestrial analogues.

The PSF has gradually expanded its capabilities and infrastructure over the intervening years, and here we provide a brief overview of the PSF, its current capabilities, and facilities and data available to the wider community.

Infrastructure: As mentioned, the PSF is focused on enabling laboratory- and field-based studies of the spectroscopic properties of planetary and terrestrial materials. Current capabilities include a number of lab and field-portable spectrometers that collectively span the range from the ultraviolet to the far-infrared. These instruments are configured to enable measurements of reflectance and transmission across a wide wavelength range. They include Ocean Optics Maya and S2000 spectrometers (~0.2-1.1 µm), an ASD FieldSpec Pro HR spectrometer (0.35-2.5 µm), a Jasco 370 dual beam spectrometer (~0.2-2.5 µm), a Designs and Prototypes 102F field-portable FTIR (2-16 µm), a Buck M5000 IR spectrometer (~2-16 µm), and a Bruker Vertex 70 FTIR spectrometer and Hyperion FTIR microscope (~0.4-50 µm). All but the Jasco and Bruker instruments are field-portable, and a number have also been custom-configured to enable interfacing with various planetary environment chambers (see below).

Complementary (non-spectroscopic) capabilities. Optical spectrometers are at the heart of the PSF, but to enable comprehensive sample characterization, our facility also has complementary (non-spectroscopic) analytical instruments, including:

- an Oxford Instruments X-MET3000 field-portable X-ray fluorescence spectrometer,
- a benchtop Carlo Erba 1100 light element (C,H,N,S) analyzer,
- an InXitu Terra field-portable XRF-XRD "suitcase" instrument,
- a Delta Nu 785 nm Rockhound field-portable Raman spectrometer
- a BWTek 532 nm iRaman field-portable Raman spectrometer
- a laboratory Bruker D-8 powder X-ray diffractometer

Planetary environment chambers. One of the primary goals of the PSF is to reproduce various planetary surface conditions in the lab to allow samples to be exposed to these conditions and to characterize sample spectral properties *in situ* without exposing the samples to the terrestrial environment. To enable this, the PSF has fabricated and acquired a suite of glove boxes and environment chambers that can simulate different surface environments, with a focus on simulating the martian surface. Capabilities in this area include:

- a small capacity (~500 cm^3) chamber ("mini-ME") with interchangeable windows (e.g., sapphire, ZnSe) that enables UV irradiation (via deuterium lamps) and spectral reflectance measurements from ~0.2 to ~16 µm. Chamber atmosphere can be controlled via inlet and outlet ports and few milliTorr pressures are routinely attainable. A standard sample holder allows up to ten 8 mm diameter samples to be exposed at any one time and sample temperature can be controlled via an aluminum pipe in thermal contact with the sample holder. Results of our first experiments runs were presented in [1,2].
- a larger capacity (~2' x 3' x 3') chamber ("big-ME"), also equipped with interchangeable 2" diameter windows for UV irradiation and spectral measurements. In its current configuration, the chamber can accommodate 32 1"-diameter sample cups arrayed in two turntables, one of which is equipped with a "racetrack" piping system to control sample temperatures. Atmospheric pressure and composition are also controllable. Access to the chamber interior is via two 8" diameter front-mounted windows. The chamber is also equipped with a variety of viewing ports. The large capacity of the chamber also enables large samples or instruments/systems to be exposed to various planetary surface conditions.
- two glove boxes that allow manipulation and characterization of samples in controlled environments - i.e., controllable atmospheric composition. The glove boxes have been used to manipulate and characterize humidity- and oxygen-sensitive planetary-relevant materials [3] and presumed pristine Apollo lunar samples [4].
- two vacuum ovens that allow samples to be heated to as high as 1100ºC in controlled environments -

i.e., controlled atmospheric composition and pressures as low as a few Torr.

One of the major characteristics of the mini-ME and Big-ME environment chambers is that they can be interfaced with a number of spectrometers, allowing samples to be spectrally characterized while they are held in controlled environments.

Spectral-compositional sample data: Prior to establishment of the PSF, the PI made extensive use of the NASA-supported RELAB facility at Brown University [5] for a variety of projects, and continues to make use of it. Between RELAB and the PSF, many thousands of reflectance spectra have been acquired by and for the PI. The vast majority of these samples have also been characterized by other techniques, such as XRF and wet chemistry and XRD, and a number by Raman or transmission spectroscopy.

The PSF and the wider planetary community: The PSF is dedicated to supporting the wider planetary exploration community. To enable this, the PSF employs a number of mechanisms:

- the PSF has a web site (http://psf.uwinnipeg.ca) to engage with the wider planetary community. The web site is currently undergoing a major upgrade (scheduled for release in spring 2015) and it serves to provide information concerning samples held at and available from the PSF (similar to the European ISAR project [6]) as well as providing downloadable associated compositional and spectral data. The sample information is aggregated into an ~1000 page MS Word document known informally as the "Mineral Bible"; the way in which samples are grouped reflects the evolution of PSF projects, and does not necessarily follow standard mineral/rock groupings. However, the document can be searched using standard MS Word search functions. The associated spectroscopic data are aggregated into MS Excel worksheets that follow the same groupings as the Mineral Bible. The PSF web site includes instructions for using and accessing the data bases.

The PSF's facilities are open to external users and collaborators on an as-available basis, and the current user/collaborator community is international in scope. As mentioned, characterized samples can be made available to the larger community if adequate reserves are on hand.

Future activities: The PSF is constantly expanding its capabilities depending on availability of funding. A number of facility upgrades are ongoing and planned:

- a new environment chamber ("X-ME") is under construction. It will be interfaced to our Bruker D-8 powder XRD and is equipped with a variety of windows/ports that will allow simultaneous sample characterization by XRD and reflectance, fluorescence, or Raman spectroscopy. This will enable spectral changes accompanying exposure to different conditions to be related to structural changes; a capability of importance to water-bearing minerals that may be present on Mars and whose stabilities may vary over short time scales [e.g., 7].
- a long-pathlength (White cell) chamber for dust transmission measurements. This chamber will be interfaced to our Bruker Vertex 70 FTIR spectrometer and provides path lengths up to ~80 metres, and can also be interfaced to our Ocean Optics Maya and ASD FieldSpec pro HR spectrometers and in-house light sources for transmission measurements down to 200 nm. It is intended for measuring transmission spectra of minerals and materials relevant to atmosphere-bearing planets such as Mars. The current chamber configuration only allows for transmission measurements at roughly ambient pressures but with control over atmospheric composition. Future upgrades include controllable atmospheric pressure.
- we are developing techniques for enabling acquisition of "reflectance-like" spectra of single mineral grains. This capability is relevant to non-destructive/non-contact analysis of returned or rare samples, such as Hayabusa samples from asteroid Itokawa [8], and OSIRIS-REx samples from asteroid Bennu [9].

Summary: The mandate of the PSF is to support planetary exploration, particularly in areas that involve optical spectroscopy. Our range of infrastructure and capabilities is supplemented by mechanisms designed to enable collaborations and making data available to the wider planetary community. Our intent is to maximize the value and utility of the PSF for planetary exploration.

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