TESTING PORTABLE RAMAN SPECTROMETRY FOR ASTROBIOLOGY. S. M. Som1, B. H. Foing2 and ExoGeoLab Team, 1Department of Earth and Space Sciences and Astrobiology Program, University of Washington, Seattle, WA 98105 – USA sanjoy@u.washington.edu, 2ESA/ESTEC SRE-S, Noordwijk, The Netherlands.

Introduction: Portable Raman spectrometry is seen as an important tool for future planetary exploration missions. With no moving parts and robust spectral signatures and libraries, Raman spectrometry is a practical instrument for in-the-field deployment. Here, we report on results of mineralogical, petrological and biological samples using a 785nm DeltaNu Rockhound portable Raman spectrometer.

Background: Raman spectrometry has been successfully applied in biology [1], microbiology [2-3], in extreme terrestrial environments [4-5] and in an astrobiological context [6-7]. Efforts here are applied to the ESTEC project 'ExoGeoLab' to gain insights into the applied capabilities of the device prior to its deployment on planetary exploration simulation platforms. Portable devices typically do not have the same capabilities as corresponding laboratory instruments due to limitations in mass, volume and energy consumption [8]. As such, assessing their capabilities independent of "laboratory settings" is vital.

ExoGeoLab: ExoGeoLab [9] is an ESTEC Skunk works pilot project with a testbench for instruments, landers and rovers for future exploration, to optimize scientific output at a putative lunar or planetary landing site. ExoGeoLab is used in parallel with the Exo-Hab project to study the interactions between human outposts, astronauts and instrumented equipment. ExoGeoLab operates with support from ESA, ILEWG (International Lunar Exploration Working Group), various European institutes and universities, international collaborators and some innovative small companies. It is focused on developing a research test bench for robotic landers, rovers, and instruments in extreme Earth and planetary environments.

Principles of Raman Spectrometry: Raman spectrometry relies on the inherent characteristic of molecular structures to interact with incident light. Typically, light is either scattered away (termed ‘elastic scattering’) or absorbed, but a very small fraction is scattered at a frequency different that the frequency of incident light, due to quantized energy transfers between the incident light and the vibrational, rotational or electronic modes of a molecular structure (this is called ‘inelastic scattering’; and is dominantly associated with vibrational coupling). Because energy and wavelength are linearly related through E=\hbar\nu, where E is the energy, \hbar is Planck’s constant and \nu is the frequency, a change in energy will be reflected by a change in frequency of the scattered light. Scattering in Raman spectroscopy is typically associated with energy gained by the scattered light (Stokes scattering), since the amplitude of the signal is higher than for energy lost (Anti-Stokes scattering).

Experiments: We conducted experiments on astrobiologically relevant minerals and rocks, a lunar meteorite and lichens. A major focus was creating an astrobiologically focused Raman database useable in the field.

Results: We find that bio-signatures are often of much less spectral intensity than their mineralogical counterpart. Raman activity > 1100 cm\(^{-1}\) is typically associated with biomolecules (and degraded carbonaceous geomolecules) rather than minerals (which typically have Raman peaks < 1100 cm\(^{-1}\)). When the groundmass of the rock is invisible to the naked eye (aphanitic), then the spectral signal is much reduced. Because biological degradation occurs at medium and higher power levels (Fig. 1), such samples must thus be analyzed at low power level. With the portable instrument, we successfully detected chlorophyll, betacarotene, rhizocarpic acid and parietin as biosignatures in lichens. Some biological samples can handle higher power level, but long integration times can cause signal degradation, likely by invisible thermal degradation of the excited molecules.

Fig 1: Thermal degradation of lichen exposed to five 5sec laser pulses at 31mW.