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Introduction: While there are many examples in the literature that illustrate or calculate the low wavenumber transitions for various materials of geological interest [1-4], most have limited data available down below 200 cm⁻¹. This gap in information occurs because traditional Raman spectroscopy systems that are commonly used are limited to measurements of molecular vibrational energy transitions in the 200-4000 cm⁻¹ region corresponding to sub-molecular stretching or bending transitions. This region is often referred to as the chemical fingerprint for its ability to distinguish the chemical composition of the material. Vibrational energy transitions below 200 cm⁻¹ correspond to structural vibrations of the entire molecule or crystal lattice unit cell [5-6]. This region has historically been much more difficult to measure, requiring multi-stage spectrometers or terahertz spectrometers that are bulky, expensive, inefficient and difficult to use outside of the laboratory. Measurements of these crystal lattice modes can yield valuable information about the physical structure of the crystal or the presence of any contaminants/defects that would impact these vibrational modes. We present a new, commercially available tool for simultaneously measuring both these low wavenumber/terahertz signals and the traditional chemical fingerprint region that is both compact and affordable with no special sample preparation required, for use in a variety of environments.

Ondax SureBlock™ XLF THz-Raman® spectroscopy systems use ultra narrow-band volume holographic grating (VHG) based notch filters to block the Rayleigh scattered light from the sample. Their ultra-narrow transition width with high optical density (OD >4) enable both Stokes and anti-Stokes measurements down to ~5 cm⁻¹. When combined with a conventional spectrometer and a wavelength stabilized visible or NIR laser, the system is a powerful, compact, easy to use and economical means of measuring low energy transitions. The system incorporating the laser and filters with fiber coupled output that can be connected to virtually any commercially available spectrometer has a footprint of 8.5" × 11", corresponding to a sheet of U.S. sized letter paper. An alternate form of the system can be mounted directly to any scientific grade microscope to easily map out the properties of the sample under test.

An example of the spectra that can be obtained with a THz-Raman® system is shown in Figure 1 for wulfenite. Wulfenite is part of a series of molybdate bearing minerals including wulfenite, powellite, lindgrenite and iriginite that have been demonstrated in the literature [3] to exhibit these low wavenumber signals. Measurements were taken at 785nm with seconds of integration time. Since notch filters are used to block the Rayleigh scattered light from the sample, both the

![Figure 1. Low wavenumber spectrum of wulfenite measured at 785nm with an Ondax SureBlock XLF-CLM system.](image-url)
Stokes and anti-Stokes signals can be captured simultaneously by the spectrometer, giving a symmetric spectral profile about the Rayleigh line that is inherent to the material under test and can be used as a self-calibration reference of the instrument. In addition to wulfenite, spectra from several other materials of geological significance will be presented to highlight the versatility and ease of data collection from this system.