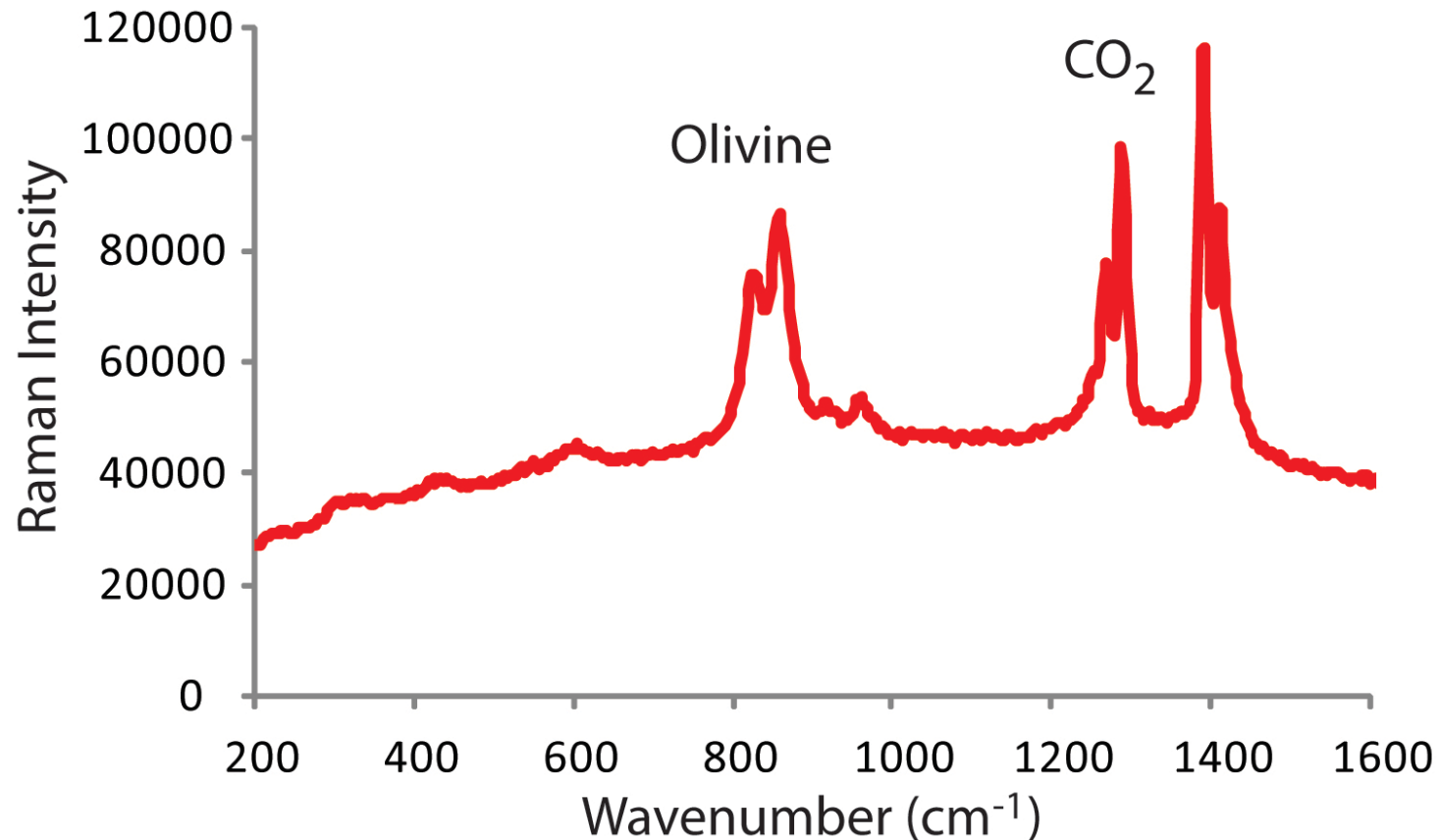


Raman + LIBS = mineralogy + chemistry!

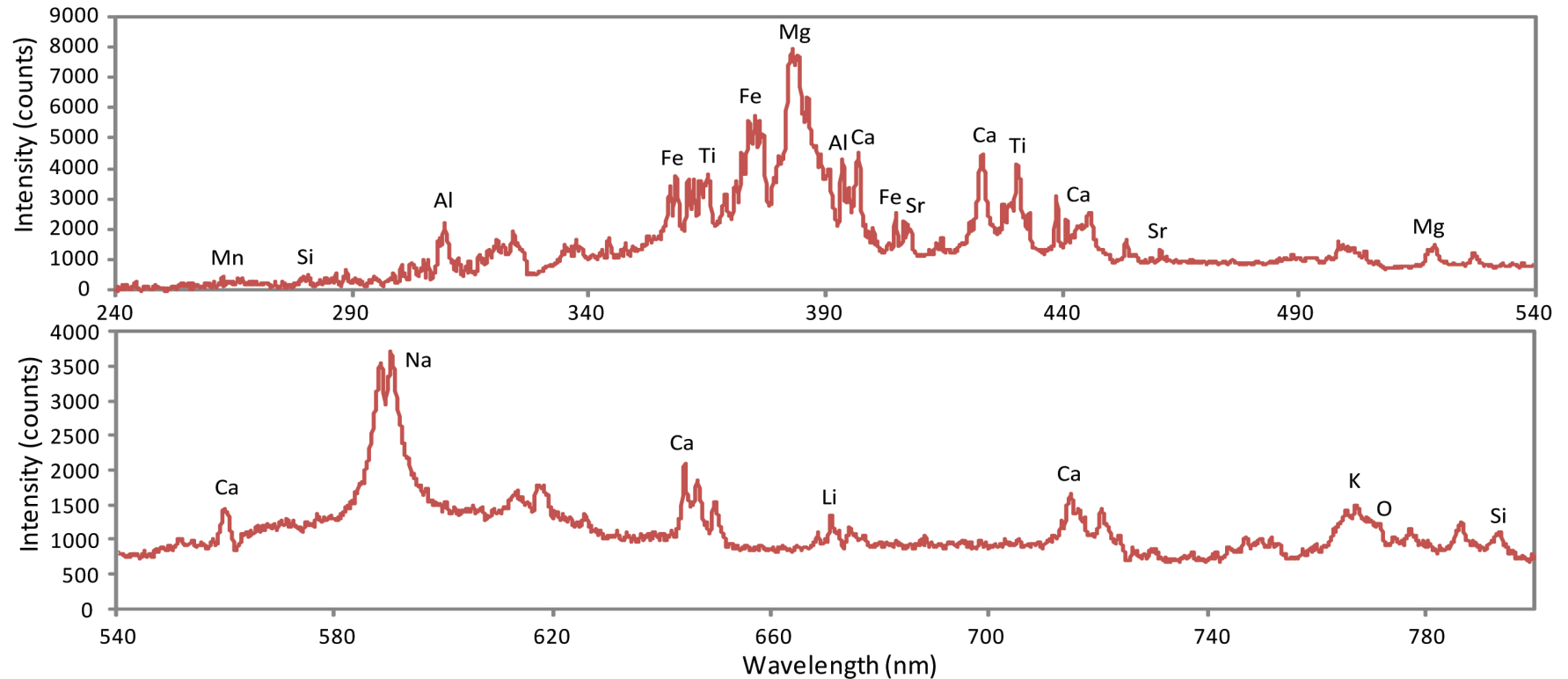
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Raman	LIBS
533.5-nm laser generates molecular and lattice vibrational-mode spectral fingerprints characteristics of specific minerals and compounds	Nd:KGW 1067-nm laser generates expanding plasma of electronically-excited species that emit light at characteristic wavelengths
Mineralogies obtained via comparisons with known mineral spectral databases (RRUFF)	Elemental LIBS emission lines well-known for all elements (NIST database) and calibrated using standards
Insensitive to surface pressure	Pressure within the LIBS plasma (~1000 bars) >> 92-bars, though atmospheric correction has been determined
Lines sharp and well-defined at temperatures up to 970 K (697°C)	Insensitive to 735K Venus surface temperature because plasma >5000 K
Blackbody radiation and fluorescence from the 735 K surface can be effectively removed by the gated detector	Can use high-powered laser pulses to remove dust or penetrate thin weathering rinds.
Atmospheric CO ₂ does not interfere with the spectral signatures of surface minerals	

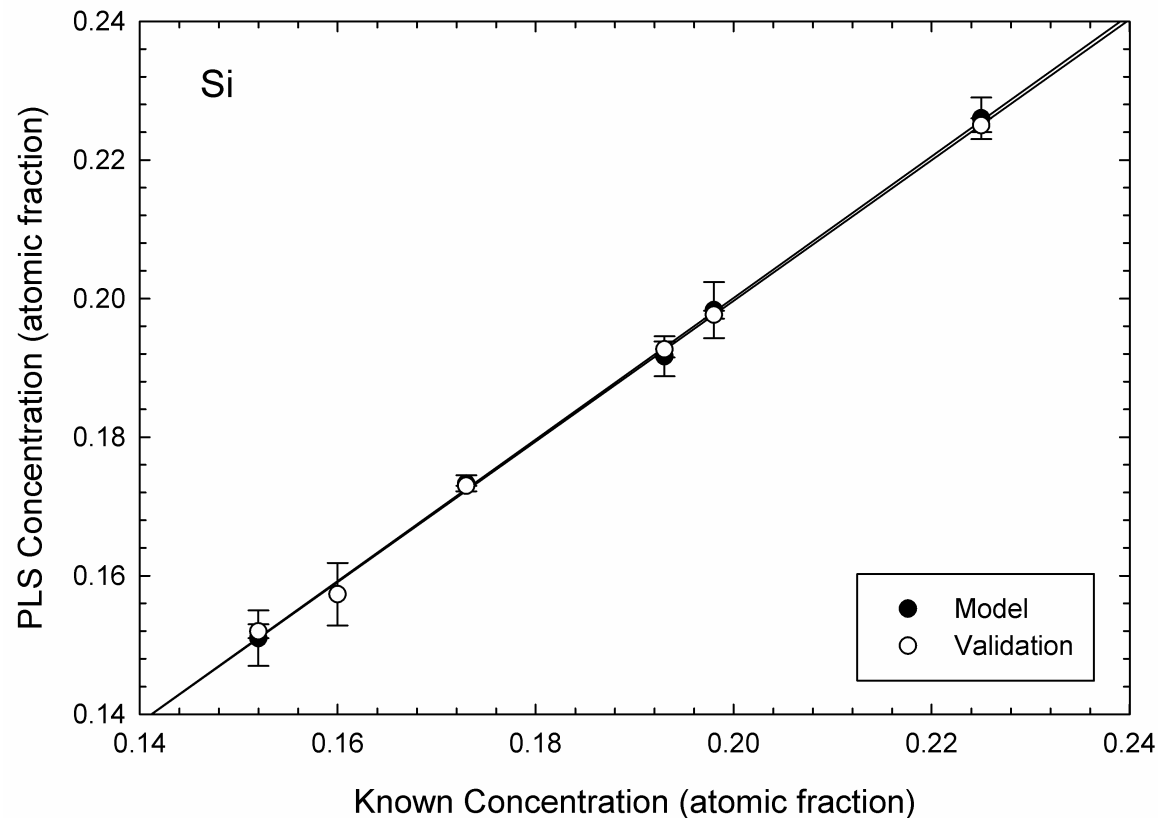
92-bar 735K Raman spectrum showing the characteristic fingerprint of peridotitic olivine (forsterite). The spectrum not only identifies olivine (peaks at ~ 820 and ~ 850 cm^{-1}), but also correctly predicts its composition of Fo_{75} . CO_2 peaks in the Venusian atmosphere at ~ 1280 cm^{-1} and ~ 1390 cm^{-1} do not overlap the critical region at lower wavenumbers used for mineral identification.



Detects minerals and derives compositions at concentrations as low as 1–3%, depending on Raman scattering cross sections.



92-bar, 735 K LIBS spectrum of an alkali-rich rock showing a rich array of elemental emission lines under Venus conditions. Peaks for all required major, minor, and trace elements are well above the noise floor and can be readily detected. Some of the spectral lines corresponding to major (e.g., Si and Al), minor (e.g., Mn and Ti), and trace (e.g., Mn and Li) elements are labeled. Peak intensities and areas of the emission lines yield elemental composition through comparisons with spectra from the calibration targets.



- LIBS experiments have been completed at 92 bars and 150°C at LANL, focusing on a series of basalt, andesite, dacite, and olivine standards.
- Data are nearly indistinguishable from the 92 bar, 735K data collected on one of the same samples in the JPL chamber.
- Chemistries of these standards used to build a partial least-squares (PLS) calibration model to predict elemental concentrations and assess the detection limits, precision, and accuracy of the technique under Venus conditions.
- Figure shows the validation plot for predict Si concentrations.