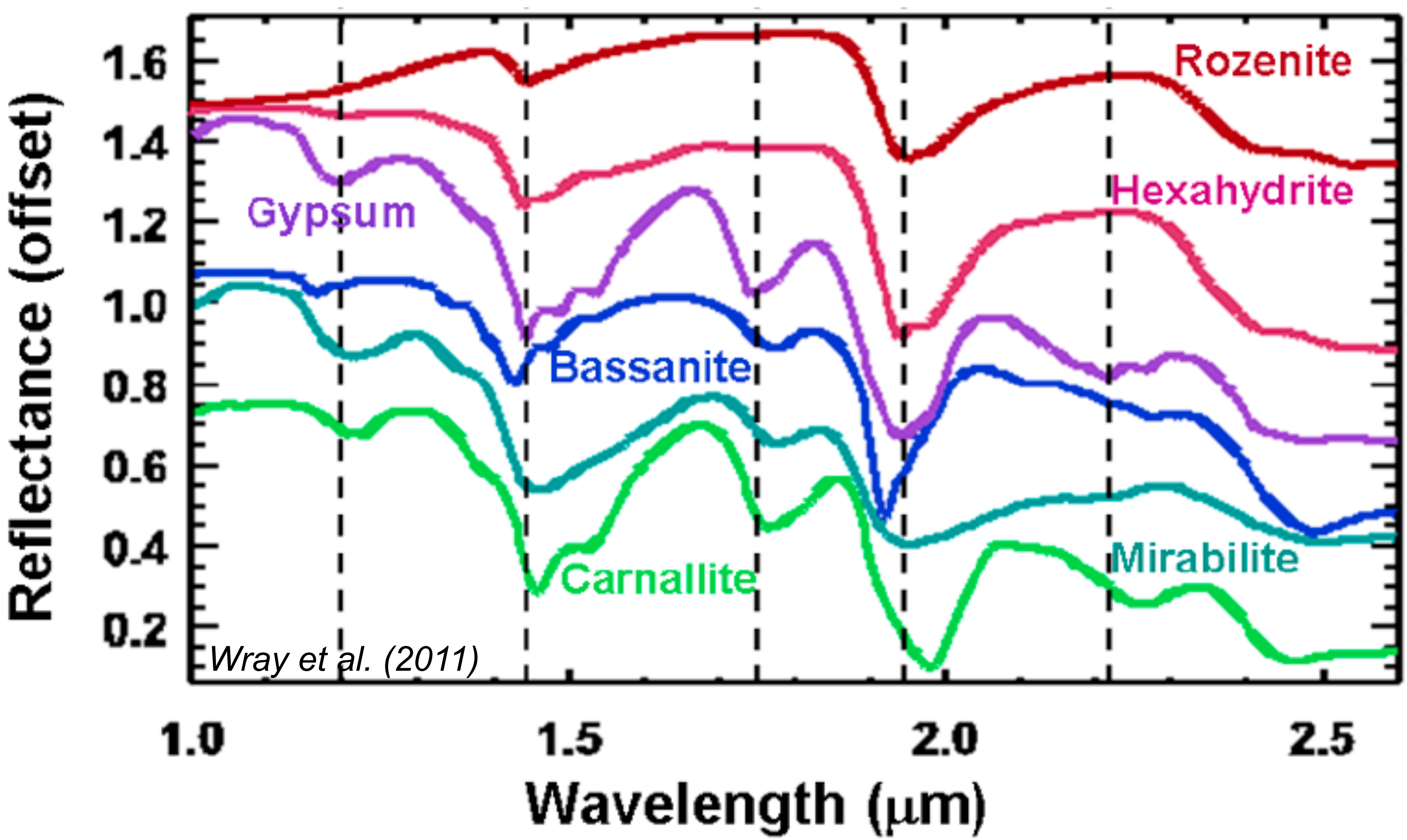
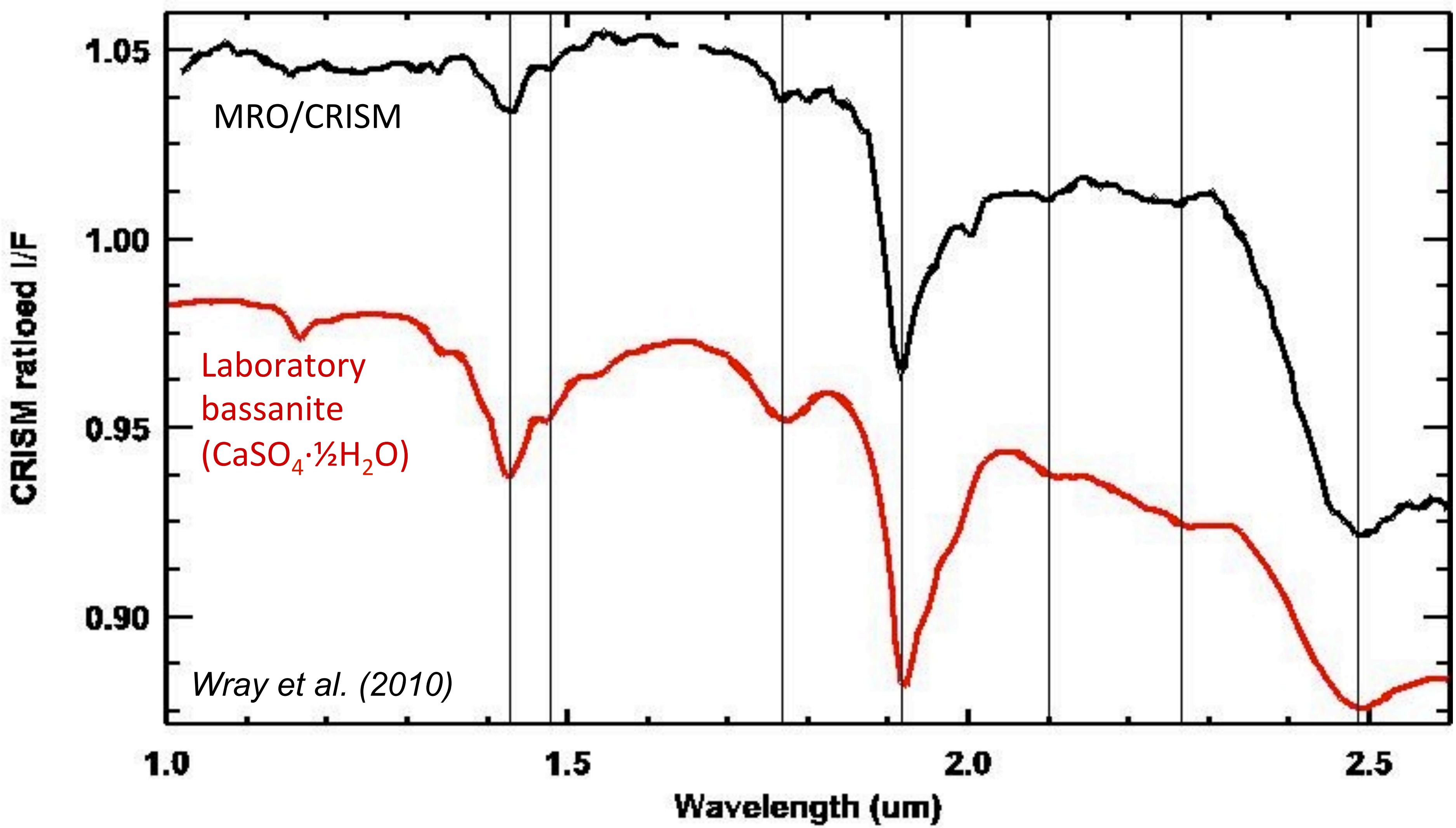
Hydrated salt spectra

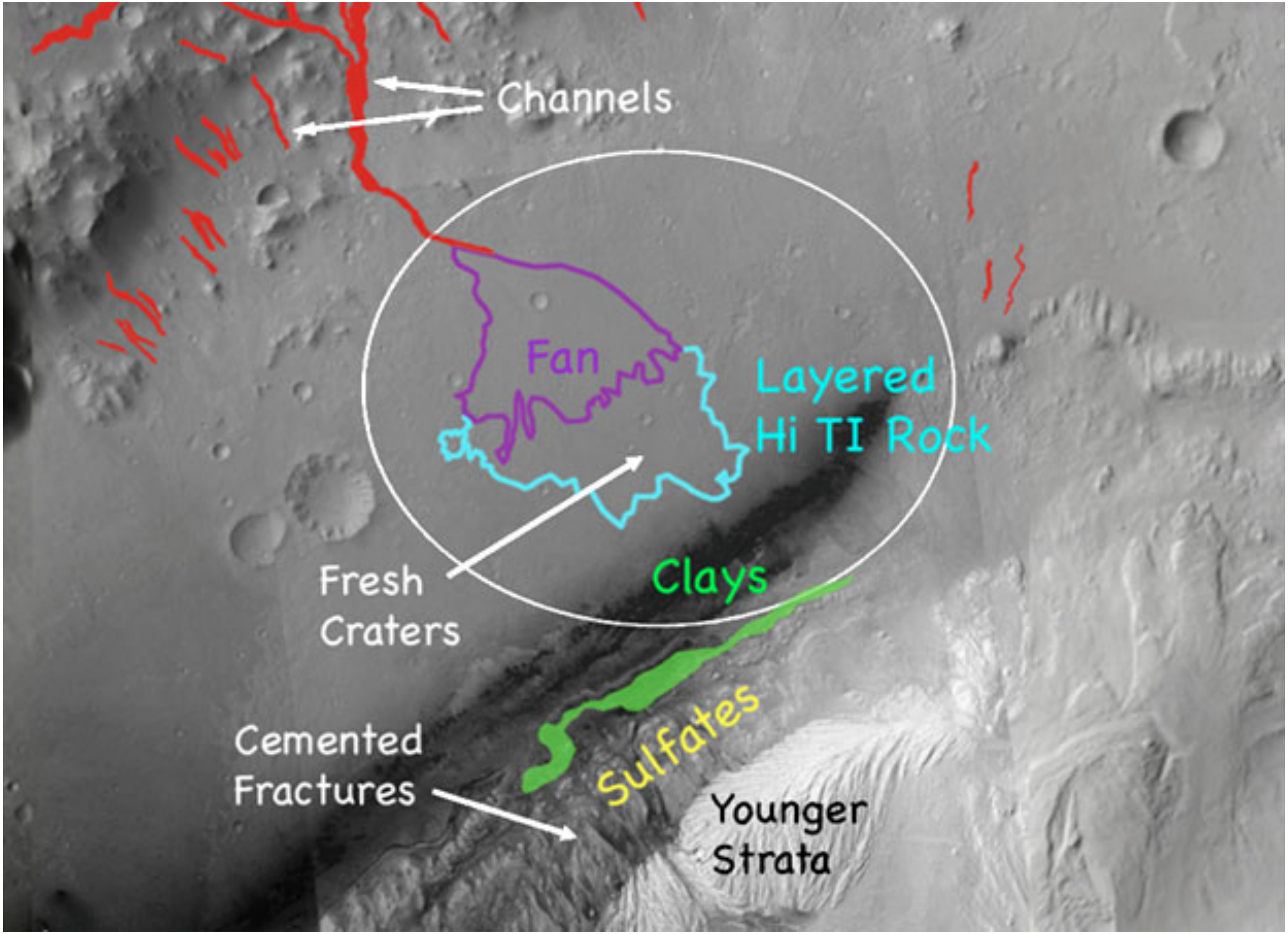


Essentially all features due to H_2O/OH vibrations

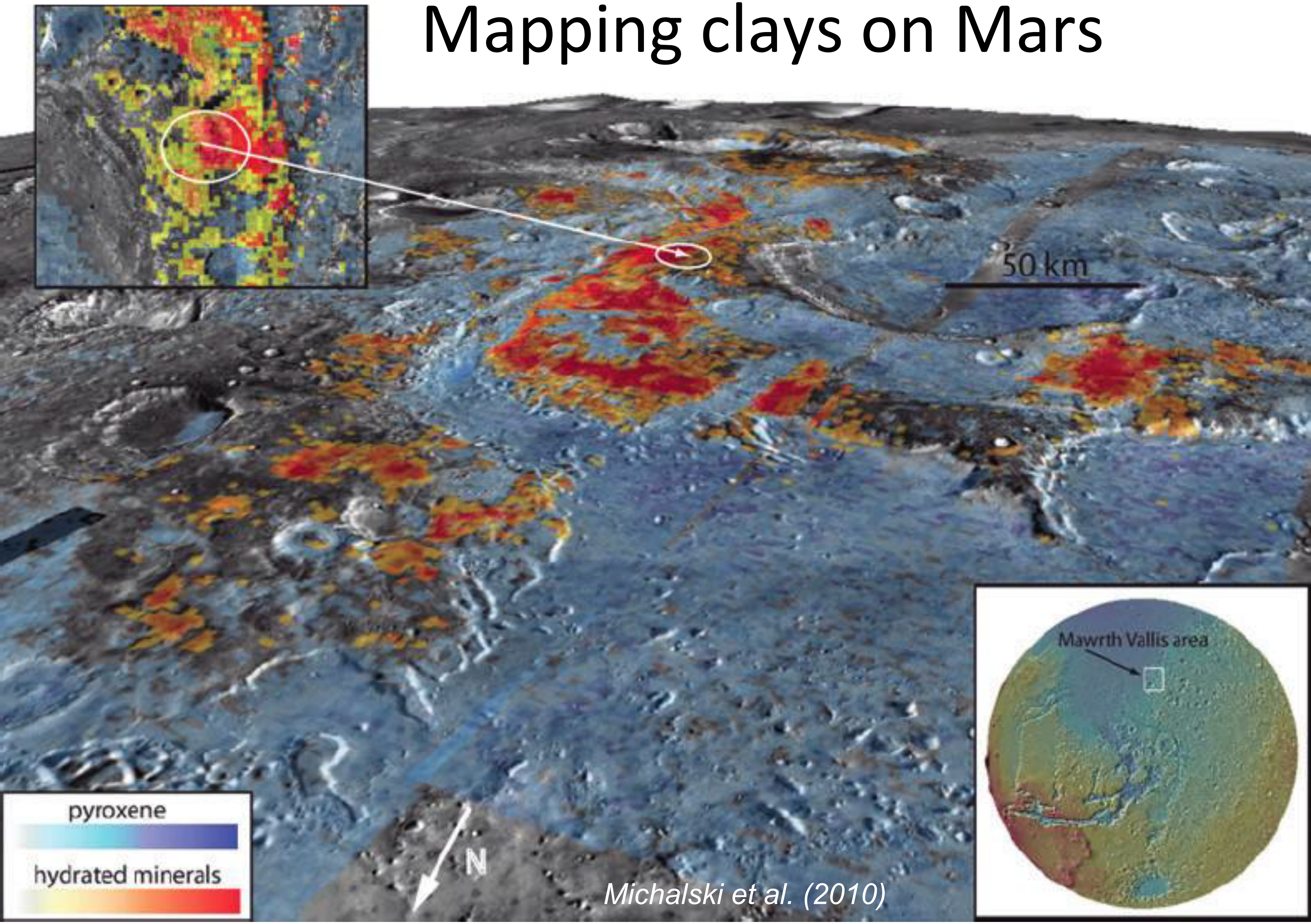
Hydrated salts on Mars: e.g., bassanite



Spectroscopy-guided roving

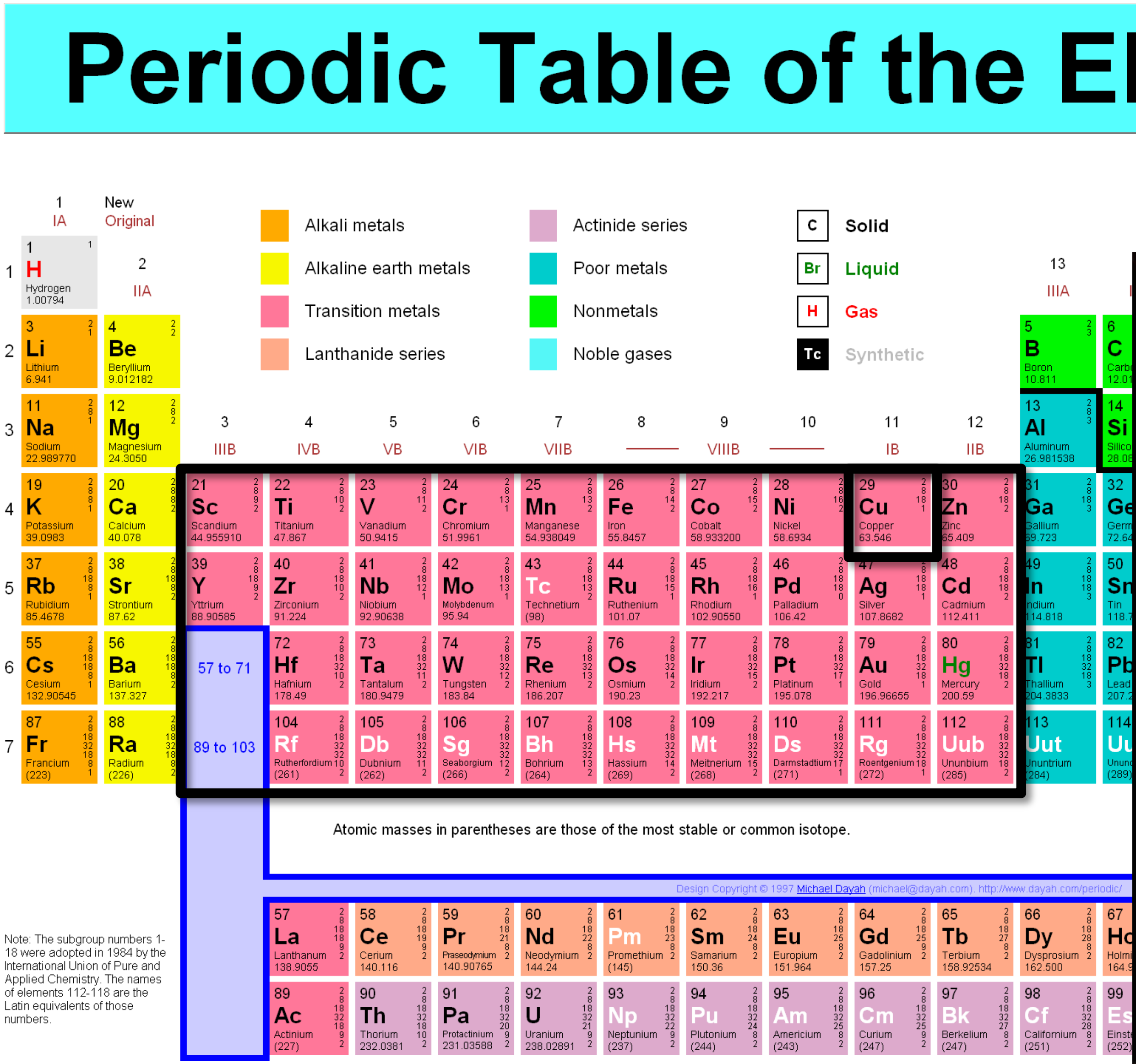


Mapping clays on Mars



Michalski et al. (2010)

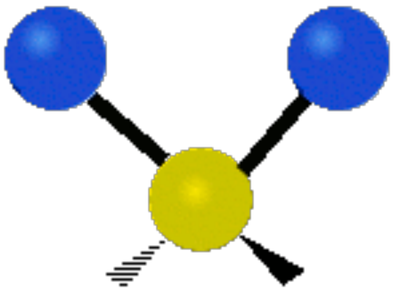
Unfilled *d* orbitals: the transition metals



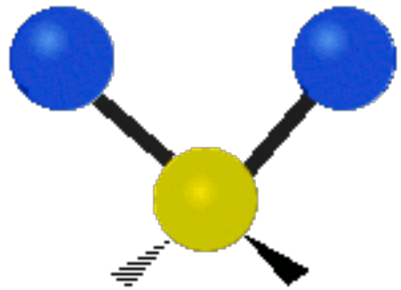
Iron is the most geologically abundant transition metal

Molecular vibrations

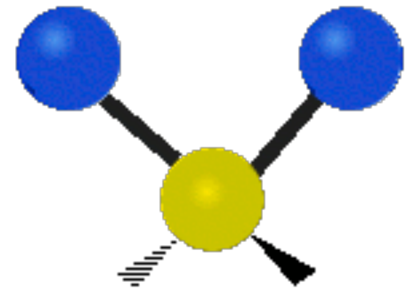
Symmetric stretch



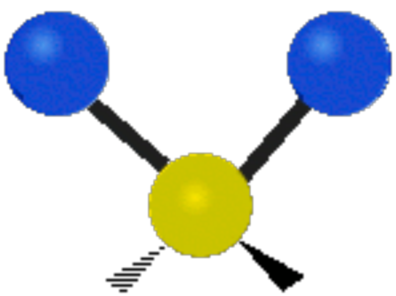
Asymmetric stretch



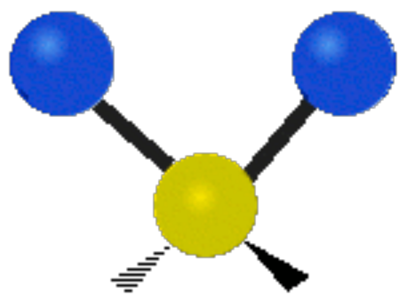
Scissor/bend



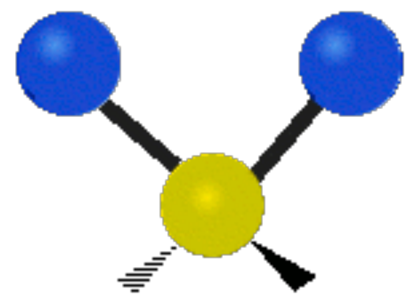
Rocking



Wagging



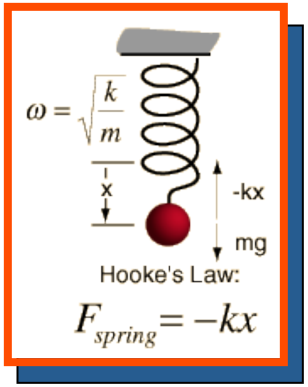
Twist



Vibrational Processes

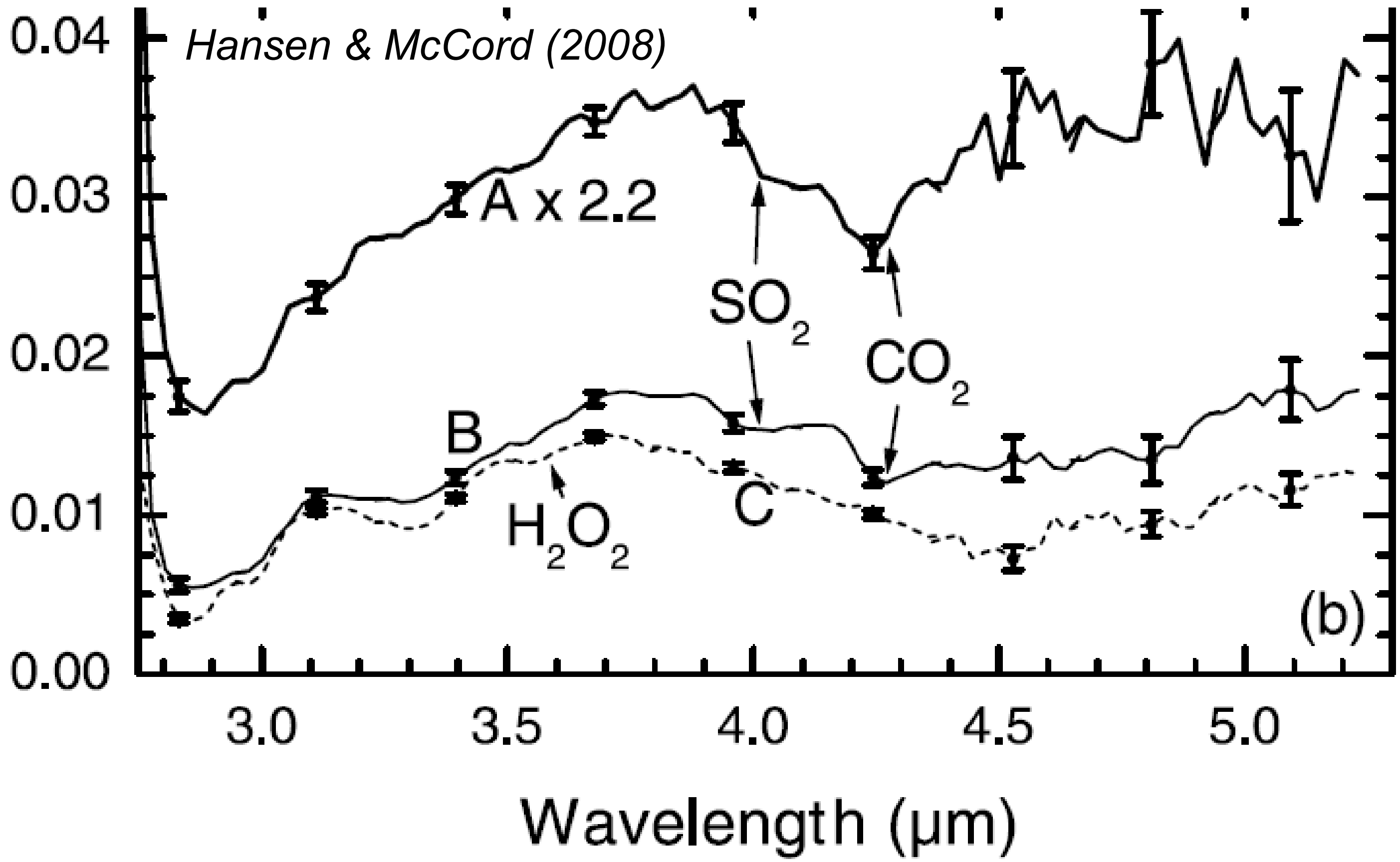
The bonds in a molecule or crystal lattice are like springs with attached weights: the whole system can vibrate. The frequency of vibration depends on the strength of each spring (the bond in a molecule) and their masses (the mass of each element in a molecule). For a molecule with N atoms, there are 3N-6 normal modes of vibrations called fundamentals.* Each vibration can also occur at multiples of the original fundamental frequency (overtones) or involve different modes of vibrations (combinations).

* In general, a molecule with N atoms has 3N-6 normal modes of vibration but *linear* molecules have only 3N-5 normal modes of vibration as rotation about its molecular axis cannot be observed.

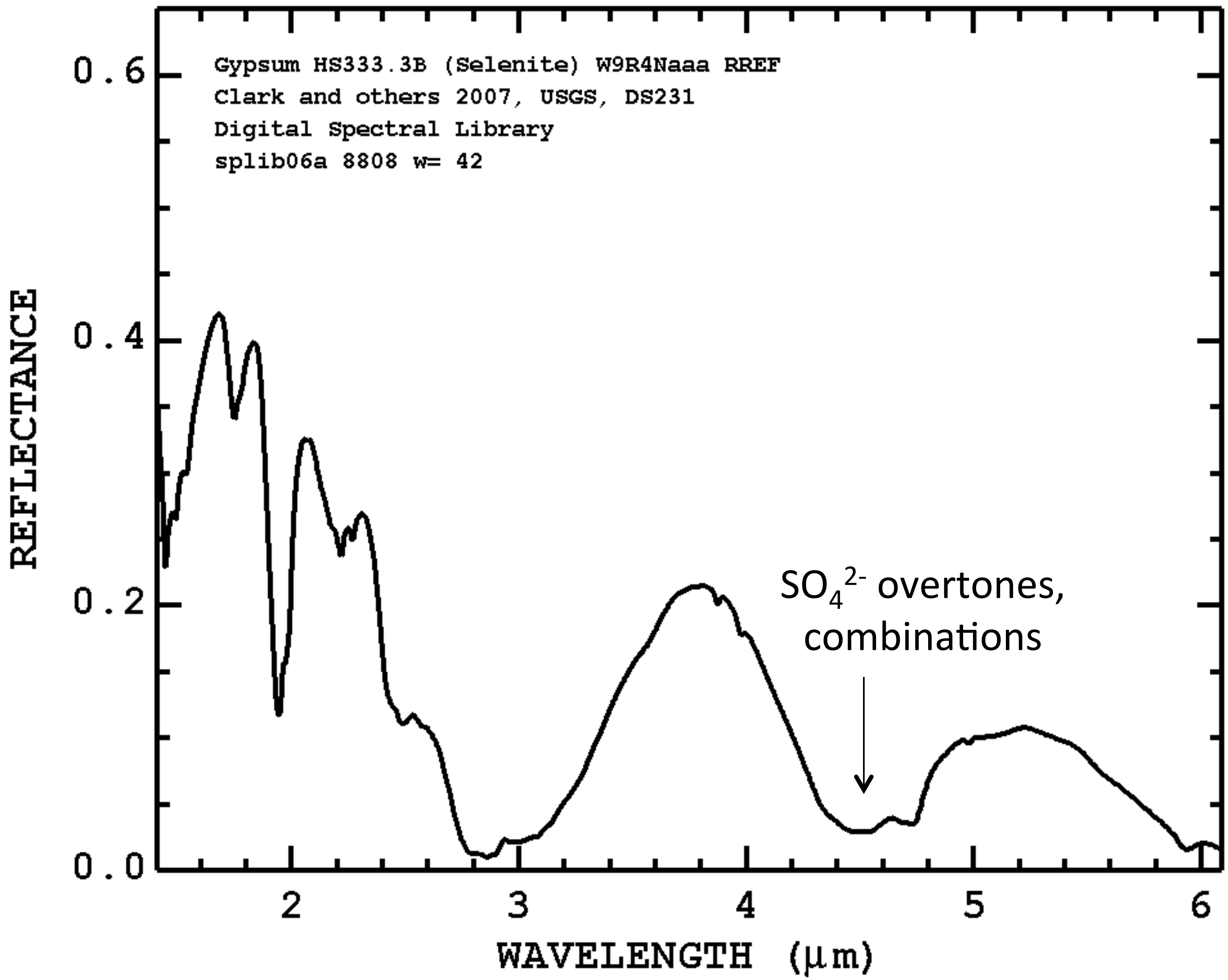


Peroxide, CO_2 and more on Europa

(and Ganymede, Callisto)



Sulfate vibrational absorptions



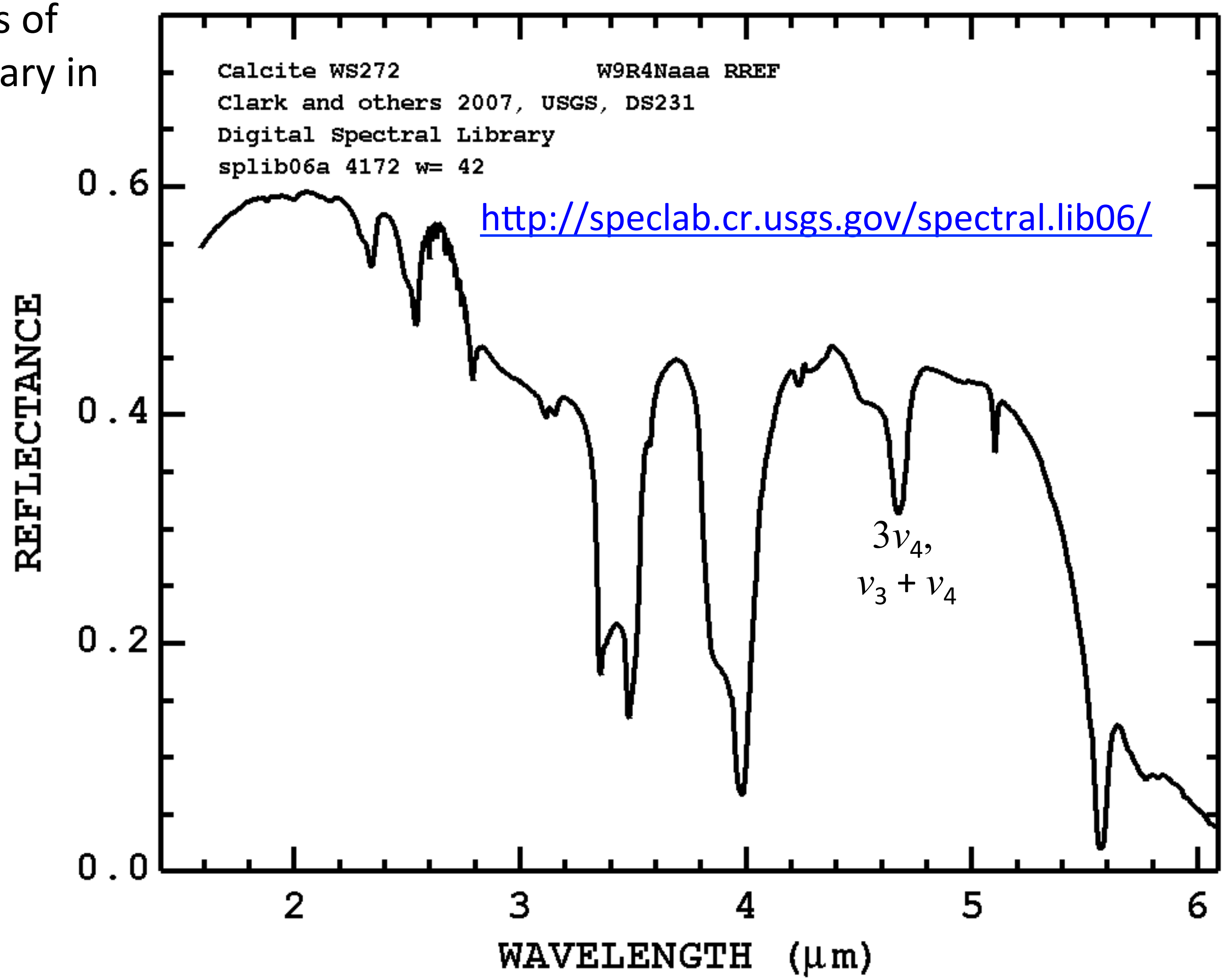
http://speclab.cr.usgs.gov/spectral.lib06/

Carbonate vibrational absorptions

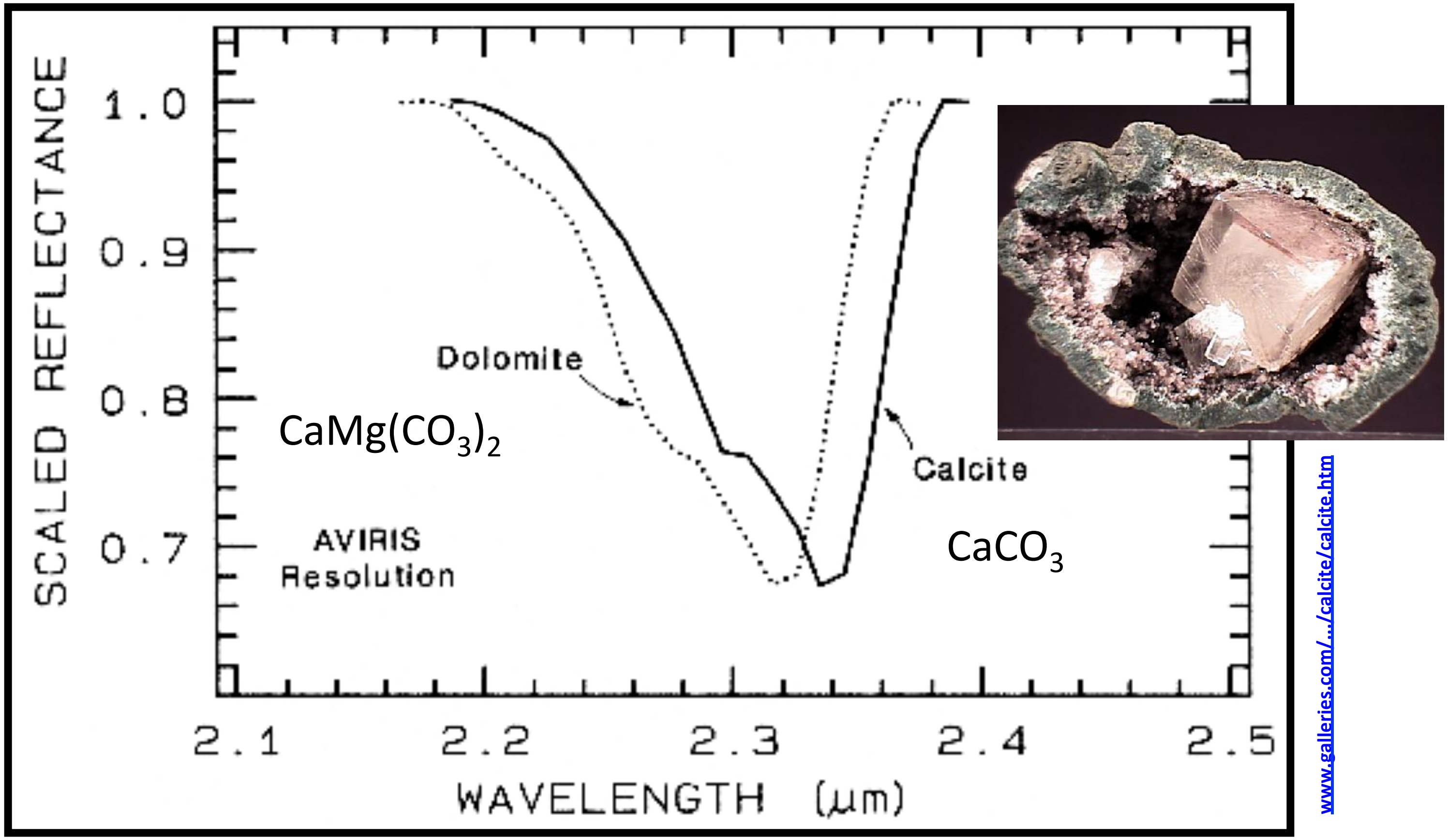
Fundamental modes of free CO_3^{2-} ion (will vary in minerals):

v_1 = 9.407 µm
v_2 = 11.4 µm
v_3 = 7.067 µm
v_4 = 14.7 µm

Combination / overtone bands are weaker



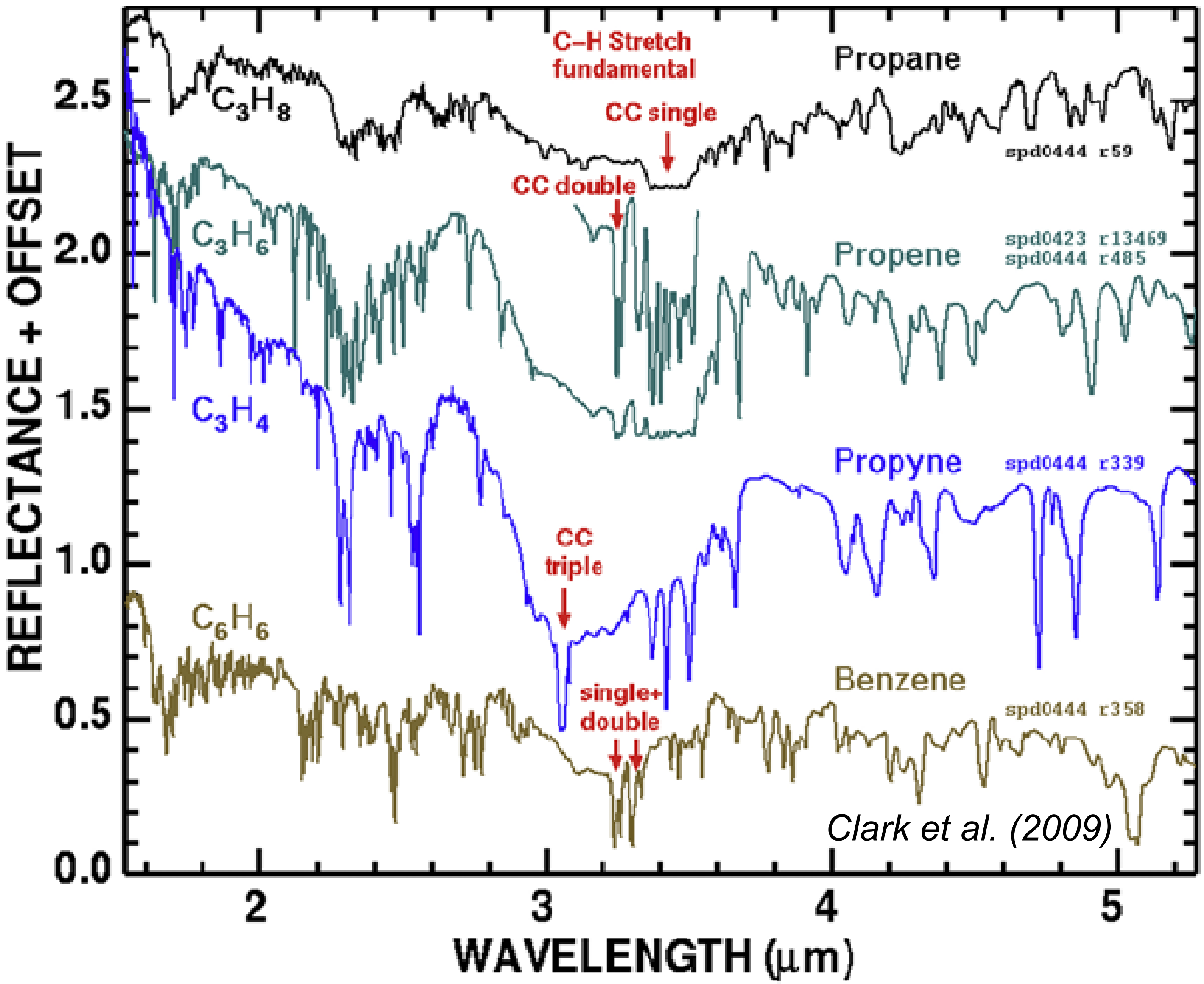
Band position in carbonate minerals shifts with composition



www.galleries.com/.../calcite/calcite.htm

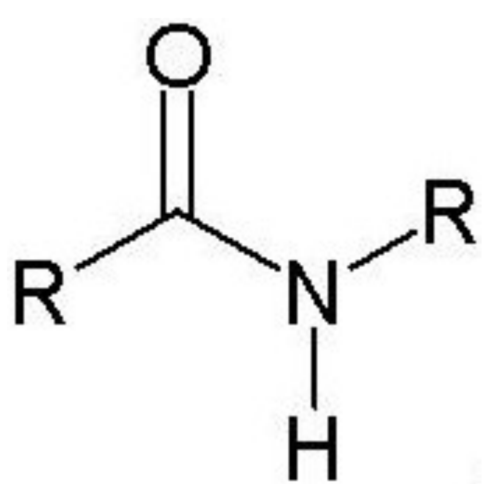
Organic molecules

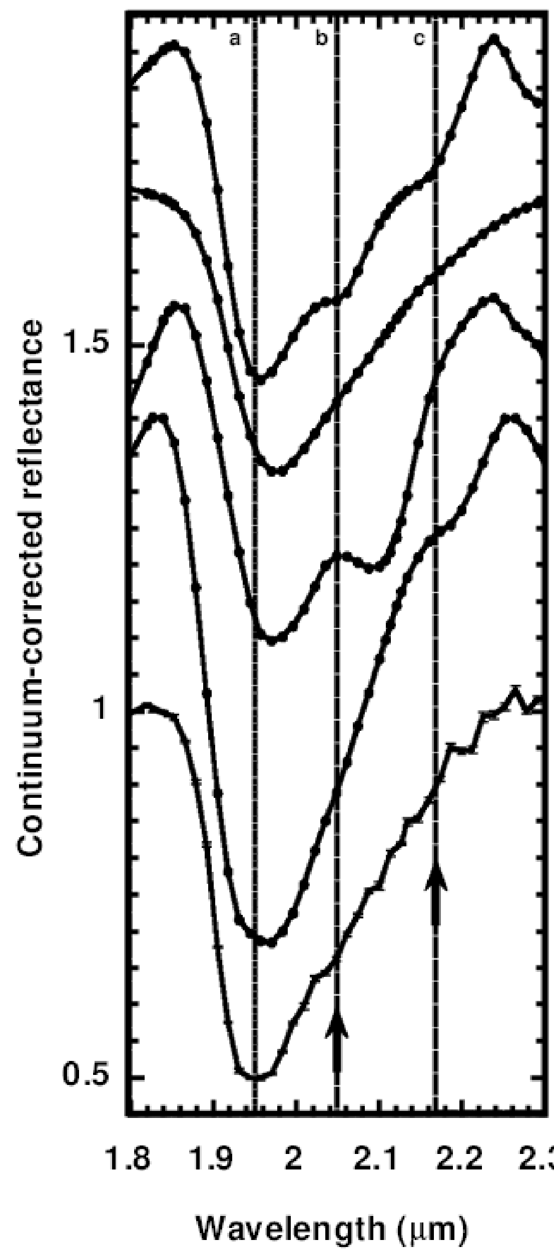
Identified on several moons of Jupiter and Saturn



Amides: Spectral biomarkers?

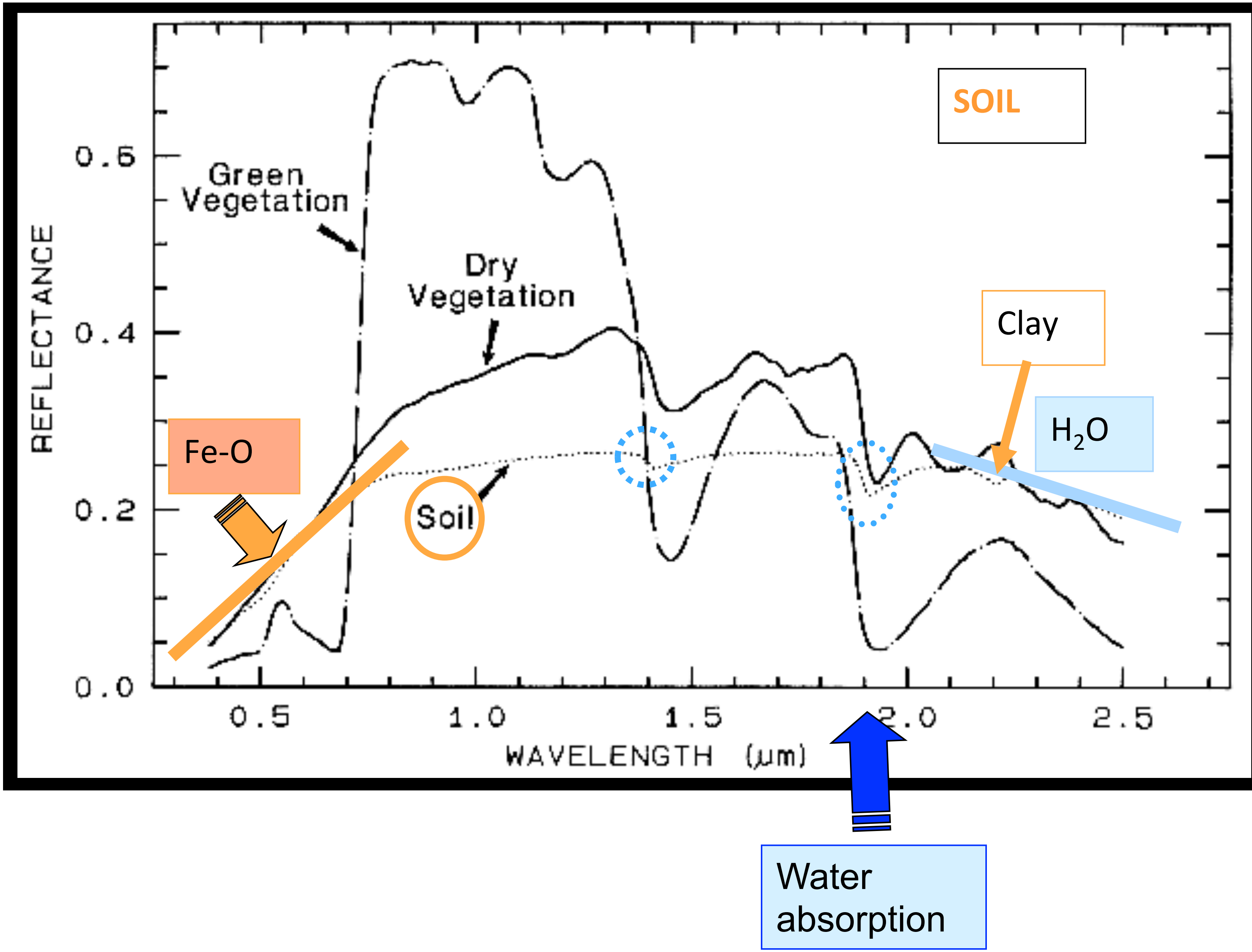
- Link amino acids in proteins, with distinct IR signature → *biomarker*
- NIR bands ambiguous; stronger fundamental bands at ~6 μm



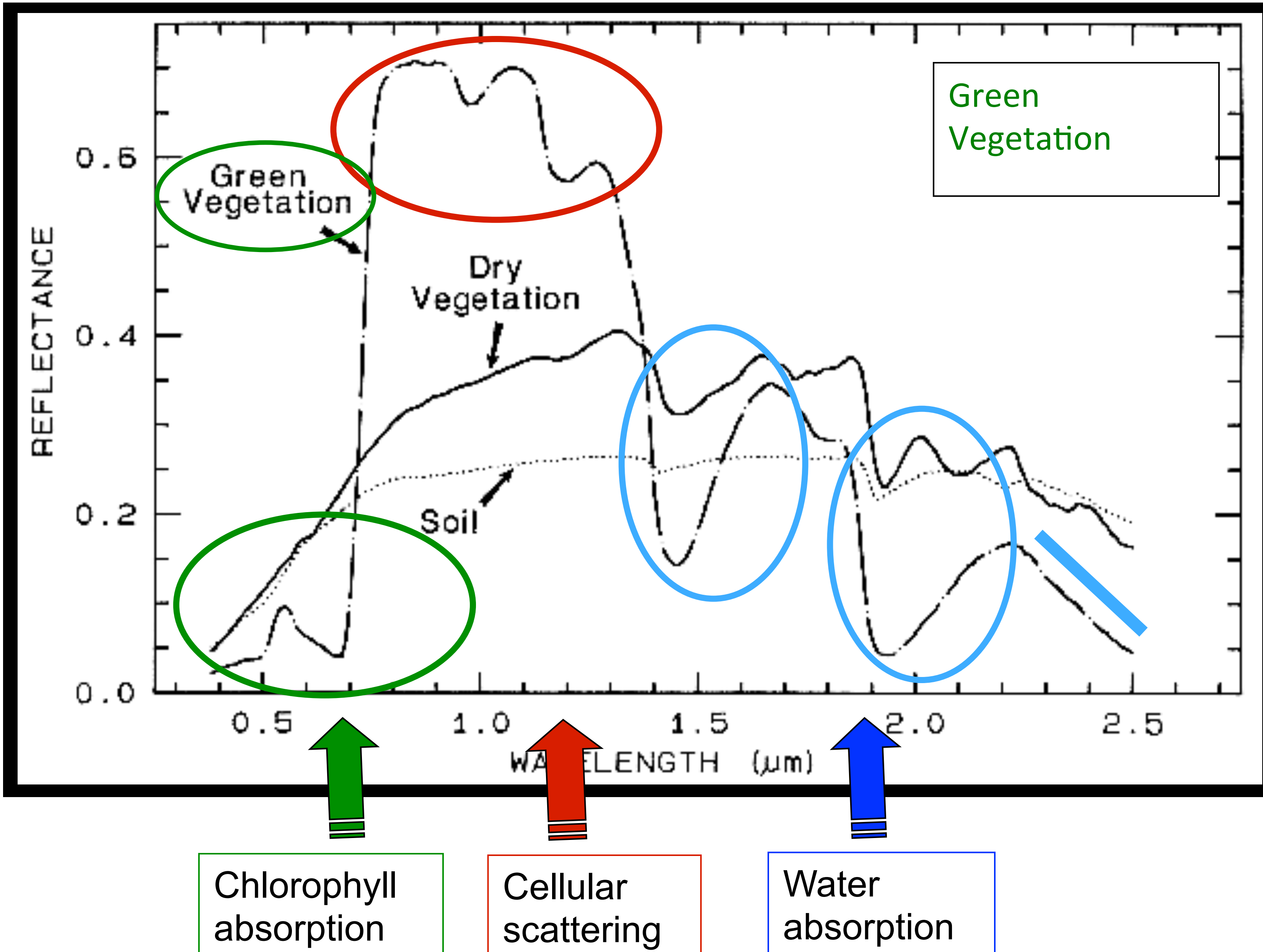


Dalton et al. (2003)

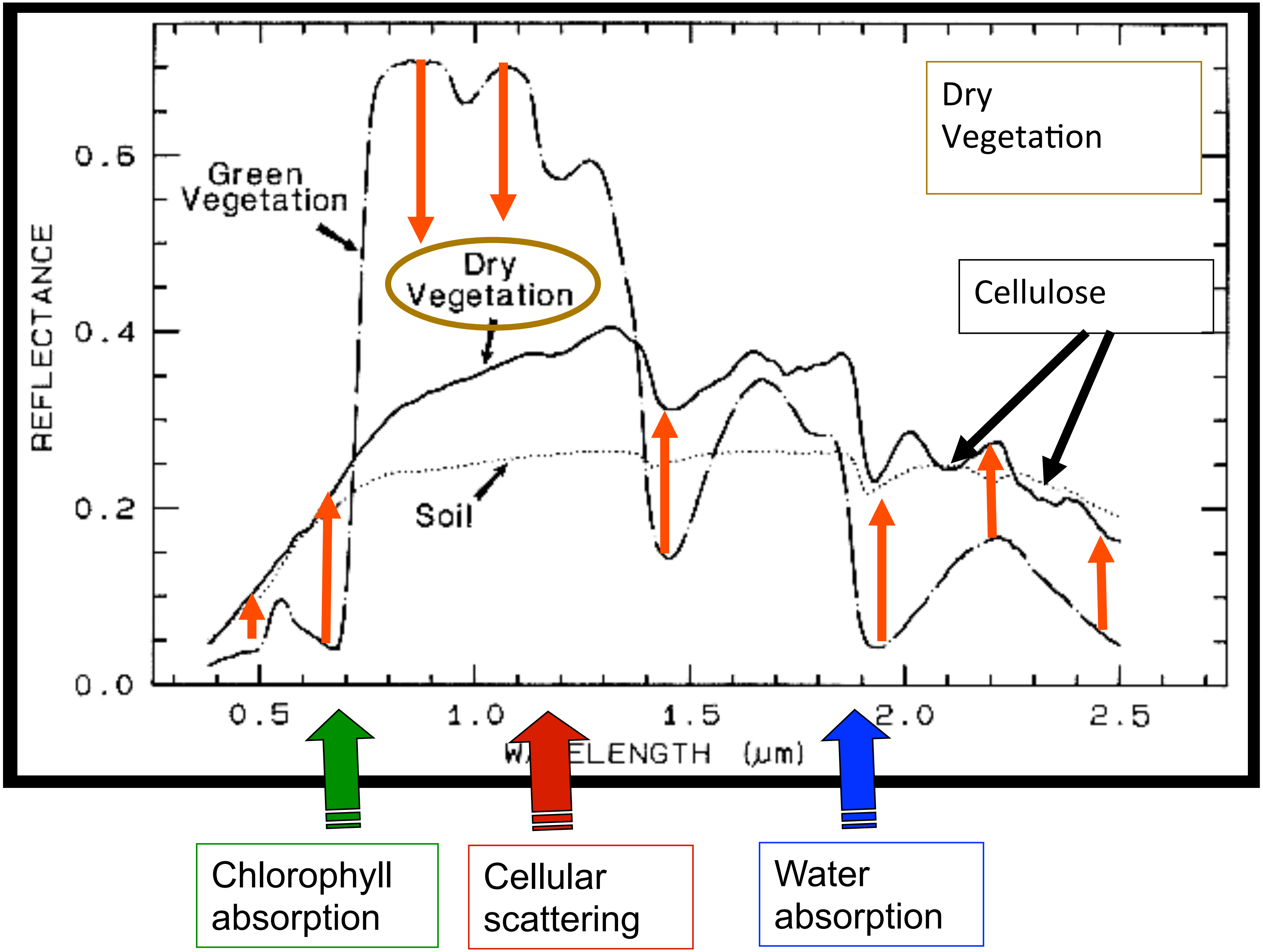
Spectra of common Earth-surface materials



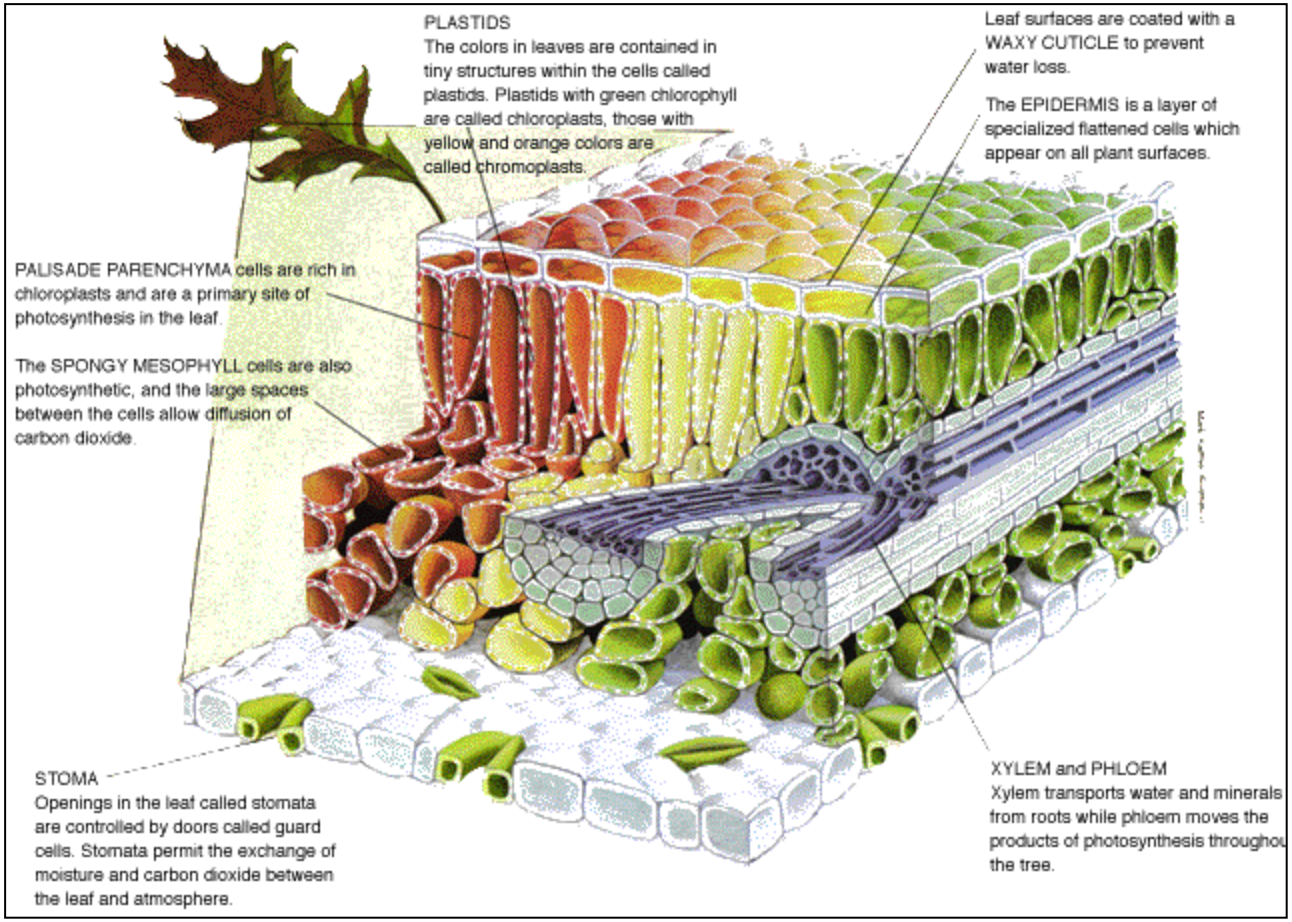
Spectra of common Earth-surface materials



Spectra of common Earth-surface materials



Leaf structure and its relation to spectra



Absorption band in red: chlorophyll pigment
Reflective NIR: scattering in the prismatic leaf cells
SWIR absorption: absorption by leaf water