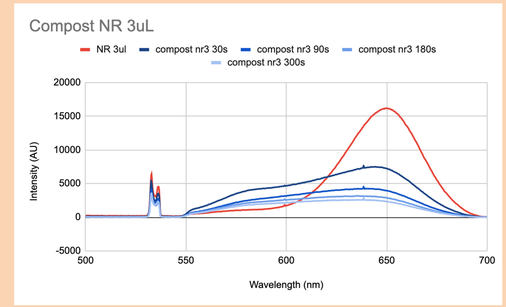
Wet Lab Fluorescence Spectroscopy for Detection of Life in Martian Soil

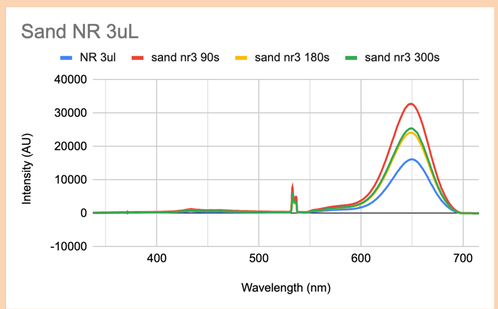
Patil, Nupoor[1]; Johnson, Karl[1]; Jayamohan, Ashish[1]; O' Malley, Breila[1]; Muruhathasan, Vikash[1]

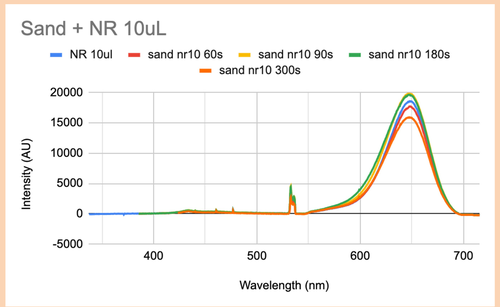
[1]Yonder Dynamics, University of California San Diego

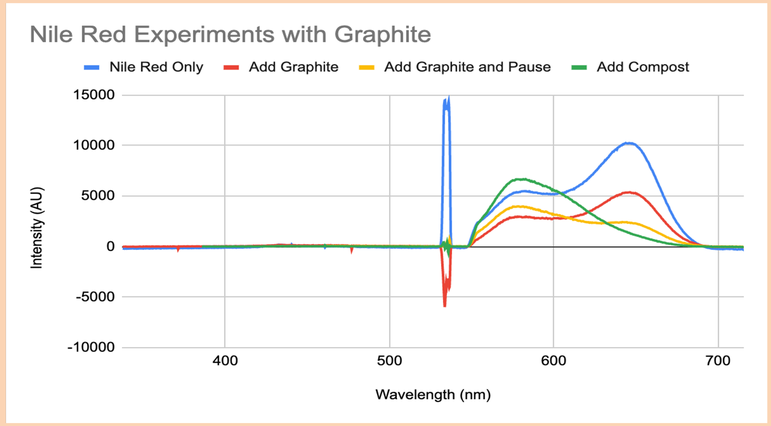
Research Objective & Background

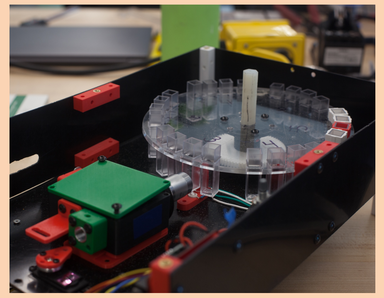
- Only two of all the Mars Missions have used wet lab techniques to detect biosignatures, Viking I and II, and Curiosity.
- Almost all of them used spectrometers to analyze soil and rock samples.
- Use of spectrometry alone results in data that requires extensive processing to extract relevant information.
- Fluorescence spectroscopy, which uses fluorescent stains in conjunction with spectrometers, produces results that are easily analyzable.
- We used this method to detect biosignatures, by looking for solvatochromism shifts.
- Solvatochromism, the change in absorption and emission spectra due to the polarity of solvents, can cause a detectable change in the emission spectra.









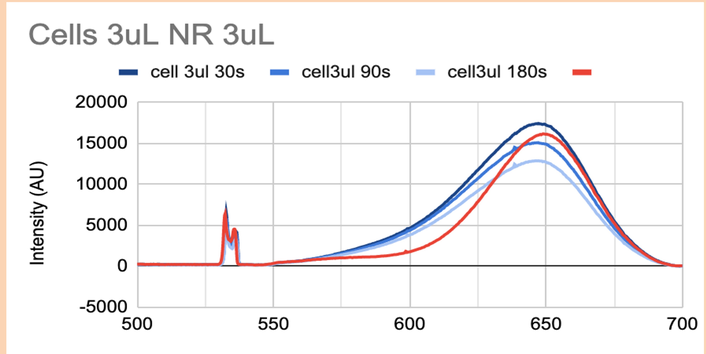


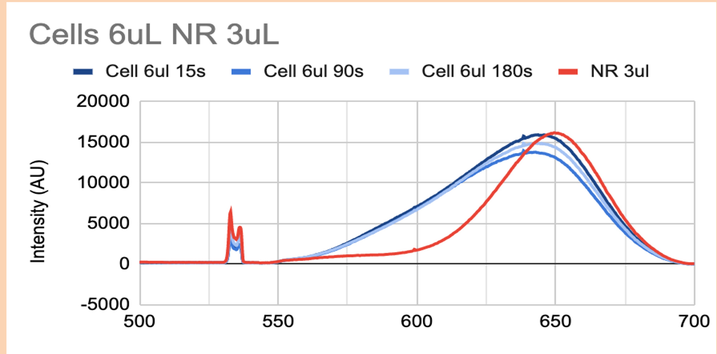
Methodology

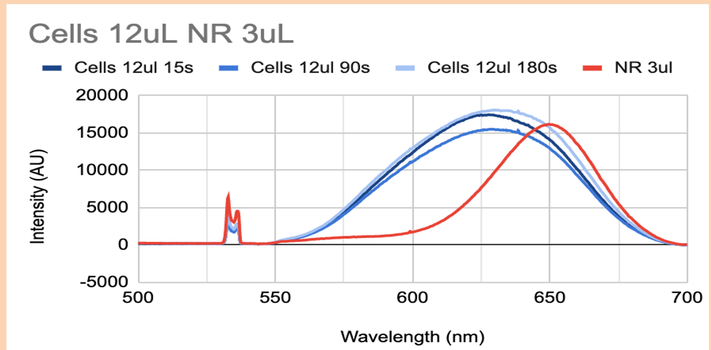
- We developed a protocol which helped bypass the washing of stains off the sample.
- Nile Red (NR) solution of concentration 30uM was added to the sample and the spectra was measured at 0s, 15s, 30s, 60s, 90s, and 180s. This formed the control.
- Live cells were added, and readings were taken at similar intervals as the control. This was the positive control.
- The amount of cells added were 22uL, 12uL, 6uL, and 3uL. The spectra were measured after each addition.
- Compost was added and measurements taken to simulate soil conditions.
- Similar tests were repeated after adding sand particles.
- The tests will also be conducted at the Mars Desert Research Station on board a rover in 1 weeks.

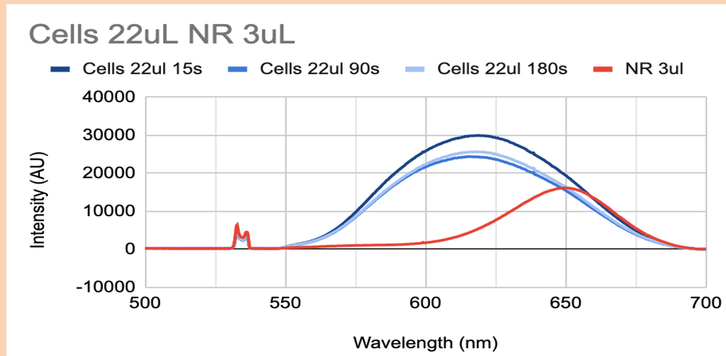
Materials

- Analog soil sample
- Fiber coupled CCD spectrometer
- Nile Red stain
- DAPI stain









Results

- We observed solvatochromism shifts after addition of each of the amounts of cells with the greatest shift with 22uL and the least with 3uL cells.
- Though the measurement was set to be done at 90 second mark the shift had already appeared by 15 seconds and continued for the full 3 minutes that the sample was tested.
- The compost sample demonstrated negative solvatochromism shift and we saw a flattened graph.
- The sand sample exhibited no solvatochromism shift.

Conclusion

- Fluorescence can test for a broad range of molecules and be easily measured via a spectrometer.
- Furthermore, spectrometers are easily incorporated onto a Mars rover because they don’t take up much space, and their data is retrievable from Earth.
- This experiment looked specifically at Nile Red and DAPI dyes as possible tests for life. Nile Red shows a very clear negative solvatochromism shift in the presence of lipids.
- Experimental testing has shown consistent and reliable results with Nile Red.
- DAPI binds to DNA causing a 20-fold increase in fluorescence, however, no positive result has been observed in testing.
- It’s possible that the LED is not appropriate for DAPI excitation.
- Also noteworthy, the spectrometer does not go into the UV range. A full UV spectrum might give better results.
- Fluorescence spectroscopy is a promising way to detect biosignatures on Mars. The setup is practical to put on a rover and yields easily interpretable results.

Acknowledgement

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