Science Analysis and Briefing

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TEAM MOUNTAINEERS
UNIVERSITY ROVER CHALLENGE

Presentation Overview

- Mission Statement
- Mission Approach
- Surface Collection Sites
- Subsurface Results
- Stratigraphic Profile
- Conclusions

<u>Appendix</u>

- Spectroscopy
- Baeyer's Reagent
- HCl
- Covariance
- GPS Altitude
- Measuring Soil Conductivity
- Open Source

Mission Statement

- Our goal is to observe signs of existing life…
    - Organic molecules
- …and identify potential conditions for habitability
    - Temperature
    - Moisture and Signs of Water

Mission Statement

- To observe organic molecules, we have devised three experiments:
  - Colorimetry to identify organic pigments
  - Baeyer's Reagent to confirm colorimetry results and provide a wider scope of identifiable organic molecules
  - HCl solution to identify the presence of calcium carbonate

Mission Approach

- To observe conditions for habitability and find signs of life, we will be picking sites based on signs of water
    - Depositional environment
    - Identify sites
    - Confirm signs of water at site

Fluvial pebble fields; dried streams and mudcracks [1]

[1] MDRS EXPEDITION GUIDE

Mission Approach

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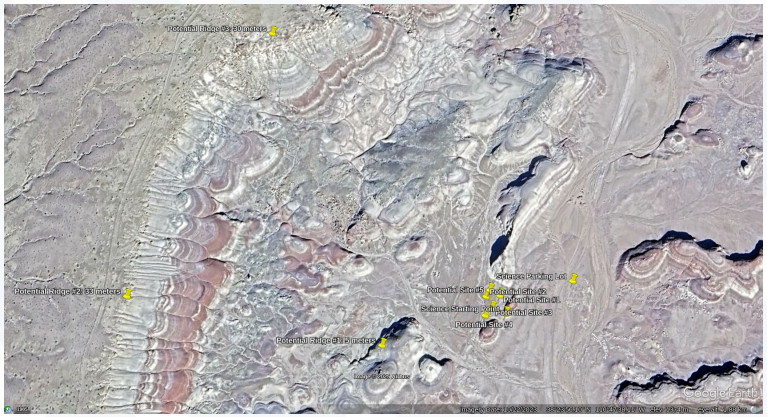

Potential Sites identified on Google Earth Pro

Mission Approach

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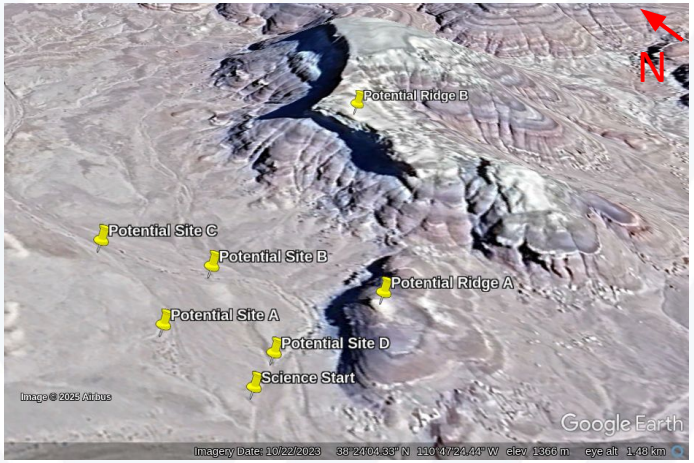


Potential Sites identified on Google Earth Pro

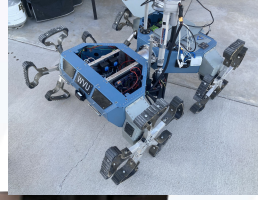
Mission Approach

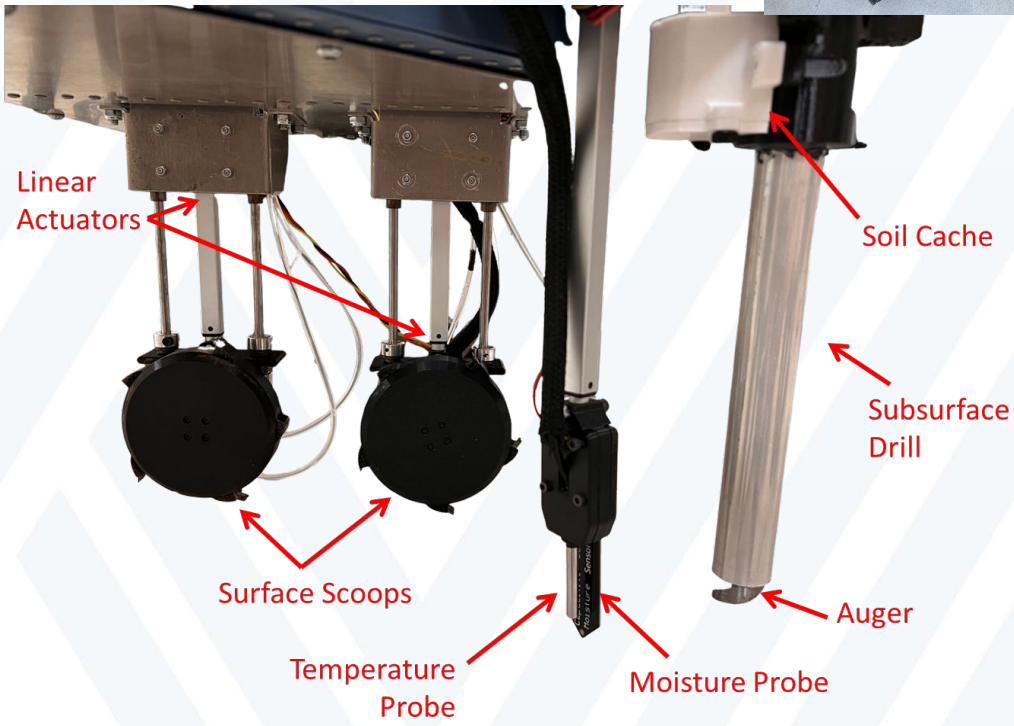
- To observe conditions for habitability and find signs of life, we will be picking sites based on signs of water
    - Depositional environment
    - Identify sites
    - Confirm signs of water at site

Closer view of sample sites

Mission Approach

- To investigate the MDRS region, we have equipped our rover with the following:
  - Surface collector
  - Pump to carousel
  - Spectrometer
  - Subsurface drill
  - Probe for moisture, temperature
  - 10 Cameras, including gimbal





Mission Approach

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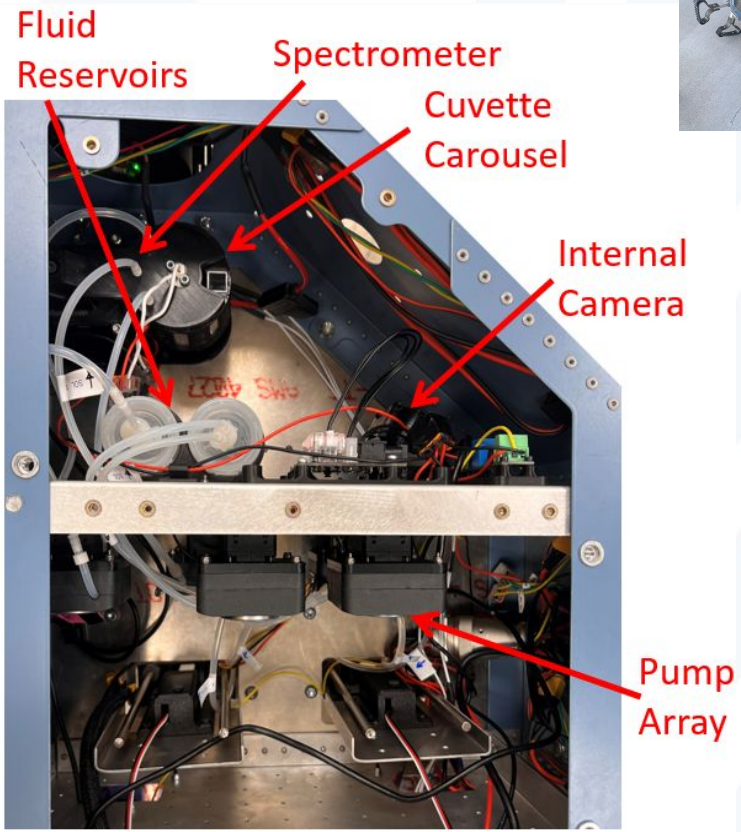
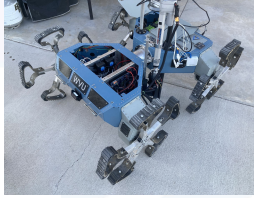


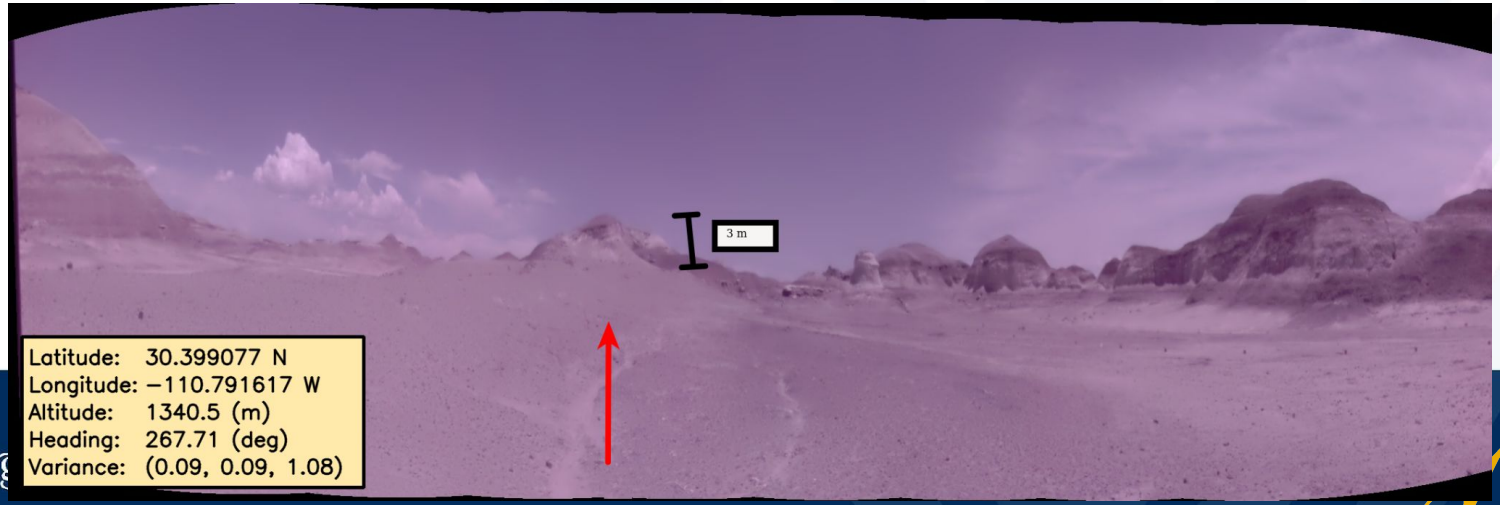


Rocks

Surface Collection Sites - Site 1

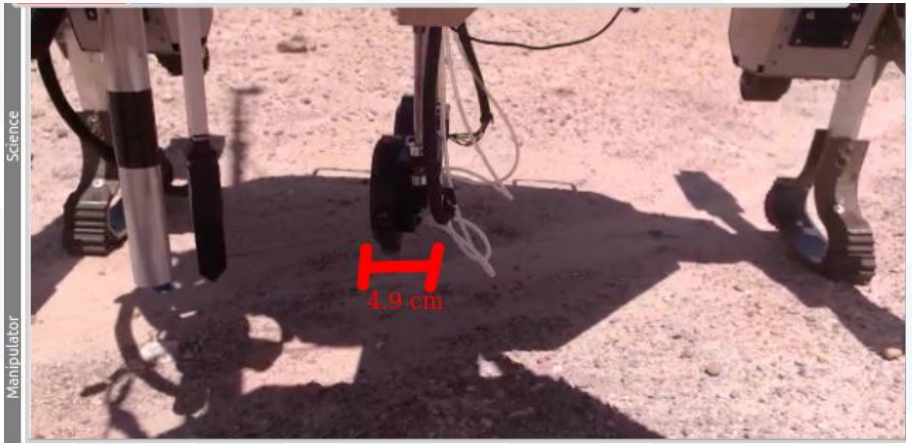
- Reasons for selection
  - Fluvial Pebble Field
  - Braided washes/channels

- What we expect to find
  - Cracking clays
  - Drainage structures
  - Small Smooth rocks



Surface Collection Sites - Site 1

- Site Observations:
  - Mudcracking
  - Small, smooth pebbles
  - Wash



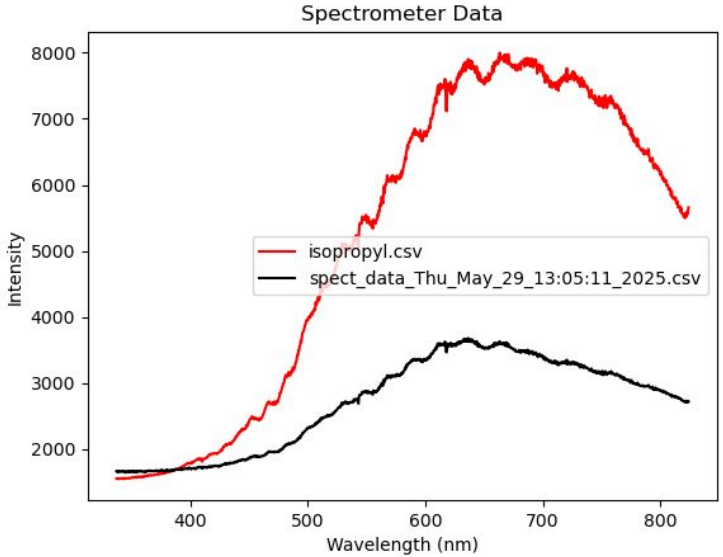
Surface Collection Sites - Site 2

- Site Observations:
  - Pebbles
  - Plant Life

Surface Collection Sites - Site 1

- Spectroscopy Results
  - No observed correlation to our reference spectra

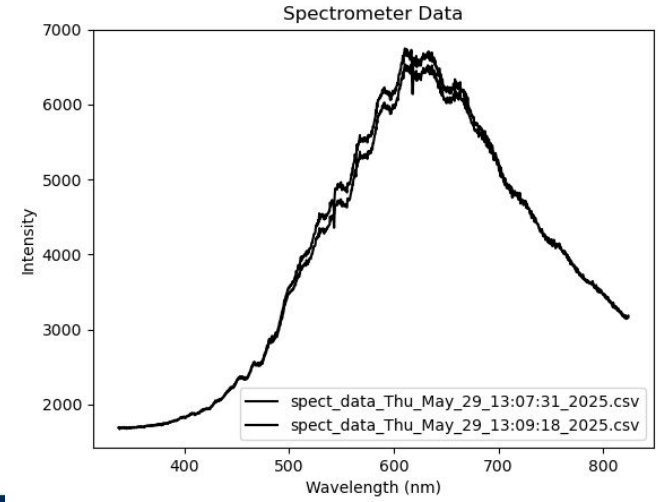
Sample Isopropyl



Surface Collection Sites - Site 1

- Baeyer's Reagent

  Observed Precipitate

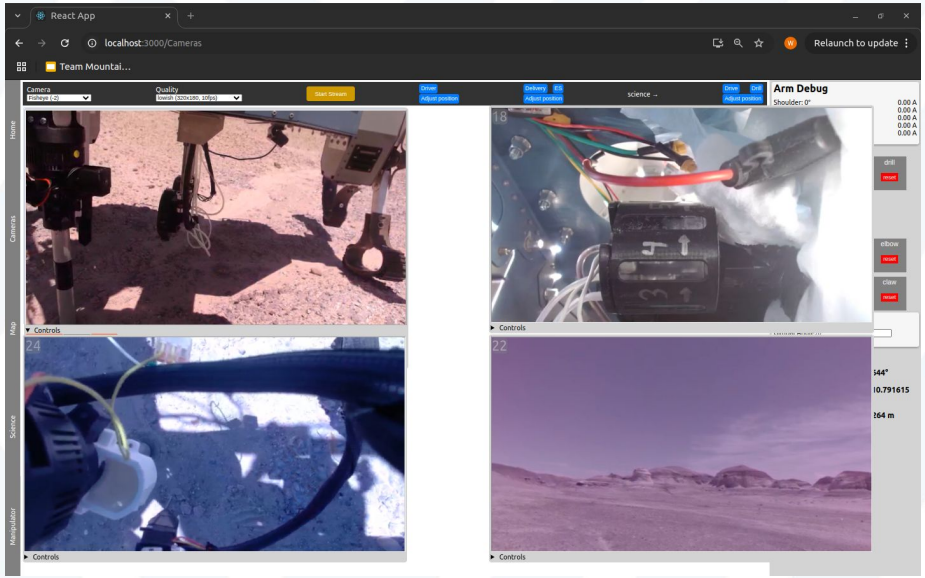


Surface Collection Sites - Site 1

- HCl
- No observed reaction

Subsurface Collection

- Collected at Site 1
- Reason for selection
    - Depositional environment
    - Further downstream
- Subsurface Temperature: 38.56 C
- Subsurface Humidity: 7%



Stratigraphic Profile

Morris Formation

Brushy Basin Member

Salt Wash Member

Stratigraphic Profile

Morris Formation

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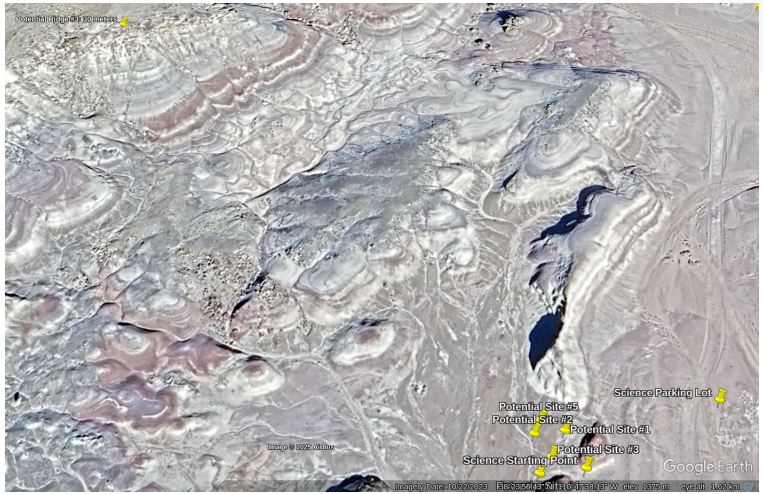
Salt Wash Member



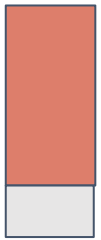
Stratigraphic Profile

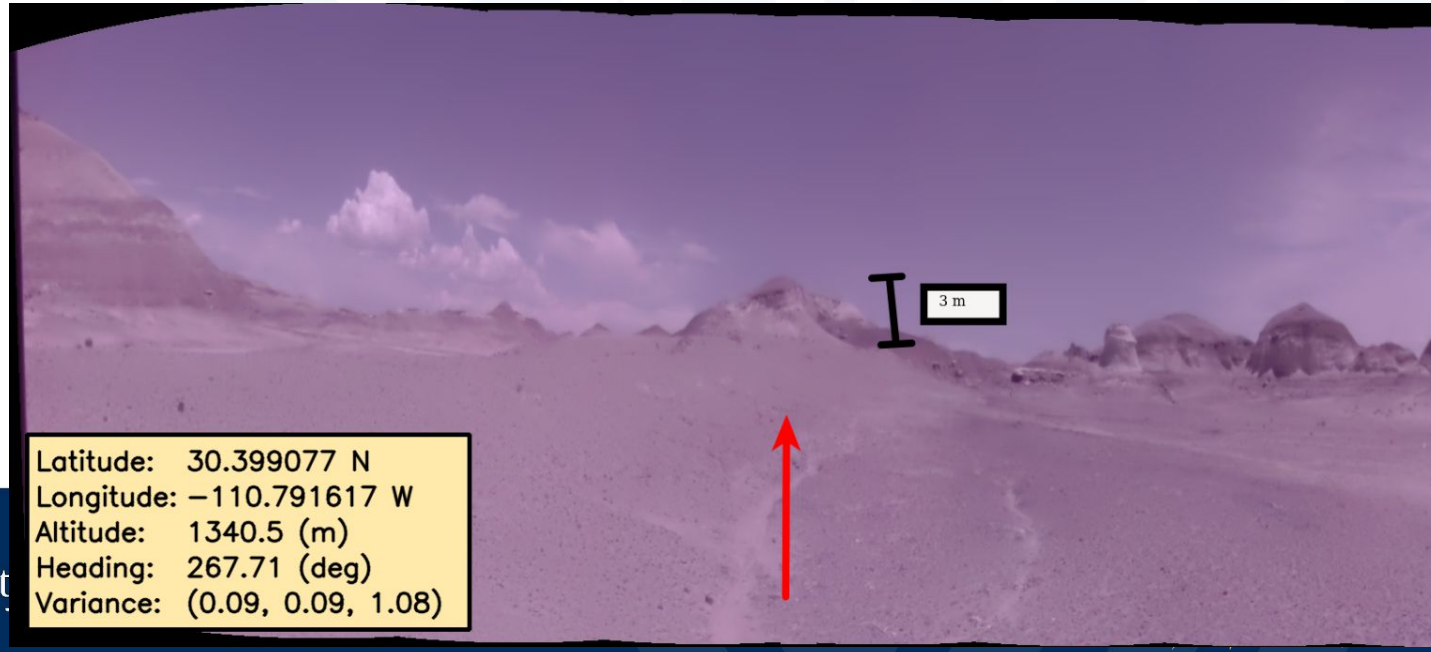
- Cracking clay slopes
- Potential skip Dakota, top is Mancos

Morris Formation

Brushy Basin Member

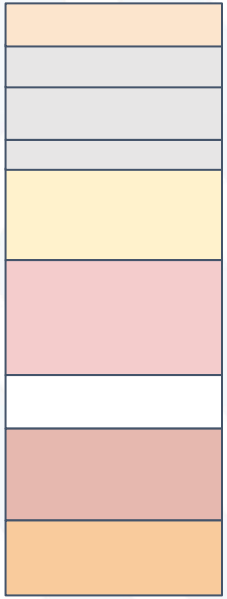
Salt Wash Member





Stratigraphic Profile

Formation	Member	Age	Lithology
Mancos Shale	Emery	Late Cretaceous	Yellow fluvial to marginal marine sand
	Blue Gate		Carbonaceous and pyritic marine shale
	Ferron		Yellow fluvial to marginal marine sand, local coal in upper part
	Tunuck		Carbonaceous and pyritic marine shale
Dakota		Late Cretaceous	Calcareous cross-bedded channel filling sandstone, conglomeratic sandstone, and conglomerate with local oyster reefs
Morrison		Late Jurassic	
	Brushy Basin		Red brown clays and shales with lesser white and green beds, minor green tuffs, red-brown sandstones, and anhydrite or carbonate cemented nodules
	Salt Wash		White, cross-bedded sandstone and conglomeratic sandstone
Curtis		Late Jurassic	Thin bedded red-brown shales with beds of nodular gypsum and cross cutting gypsum veins. Thin sandstone lenses towards top
Entrada		Early Jurassic	Thickly bedded cross-bedded brown sandstone with lesser interbedded brown shales



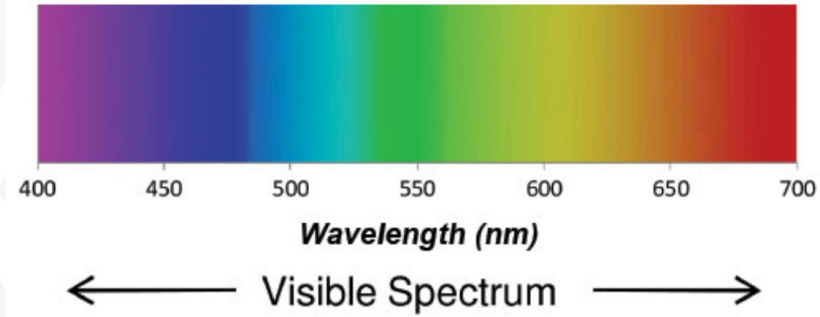
Conclusion

- We were unable to identify signs of life
- However, we were able to observe moisture in the soil below the surface and potassium in the sample
- This indicates signs of conditions necessary to support life

Appendix

Spectroscopy

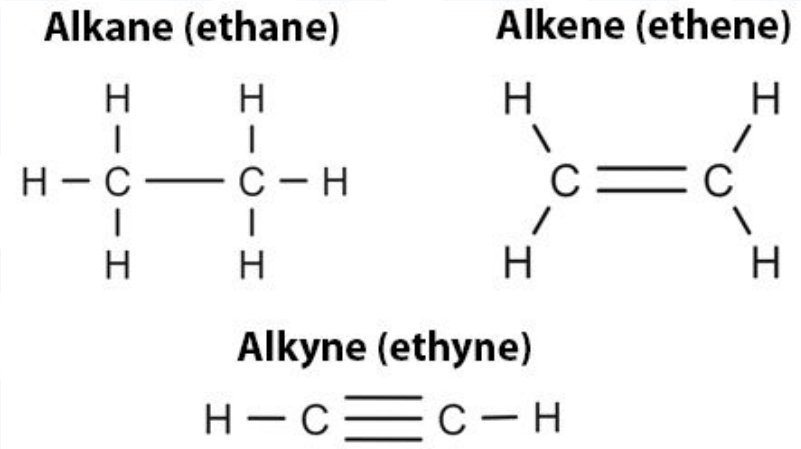
- Visible light consists of electromagnetic radiation in range wavelengths from 380 to 780 nm
- Emission of most radiation occurs when when atoms or molecules are excited by the absorption of energy from another source source as heat, electrical discharge etc.
- Energy excites the electrons in the molecules, causing them to jump from a lower excited state to a higher state
- The excited electrons move to the ground state and release energy in the form of photons
- The wavelength of the emitted photon corresponds to a specific wavelength that can be measured on the visible light spectrum
- Bier-Lambert: Path length and concentration are proportional to absorbance



Visible Light Wavelengths

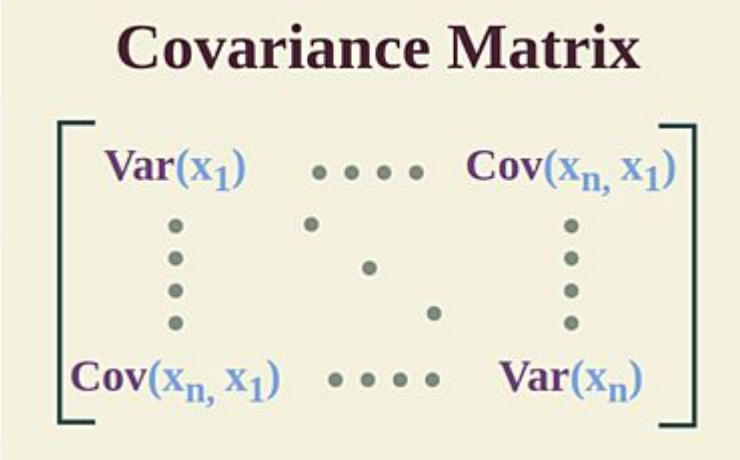
Baeyer's Reagent

- The pigments we are looking for with the spectrometer are long-chain carbons with alkenes/alkynes
- Alkenes/Alkynes are less saturated with hydrogen, instead having double- or triple-bonds
- Permanganate ion forms complex with the alkene/alkyne and changes from the natural purple color of the permanganate to clear
- Precipitate is formed in solution which can be observed as a brown sludge at the bottom



Covariance Matrix

- Mavros gives a covariance matrix for positional error.
- Variances are then taken from the main diagonal of this matrix because there is no covariance between each positional error term. (All covariance terms are measured as 0)



GPS Altitude

- GPS altitude may differ significantly from a standard altimeter.
- GPS works by having its satellites send a timecode to the receiver device.
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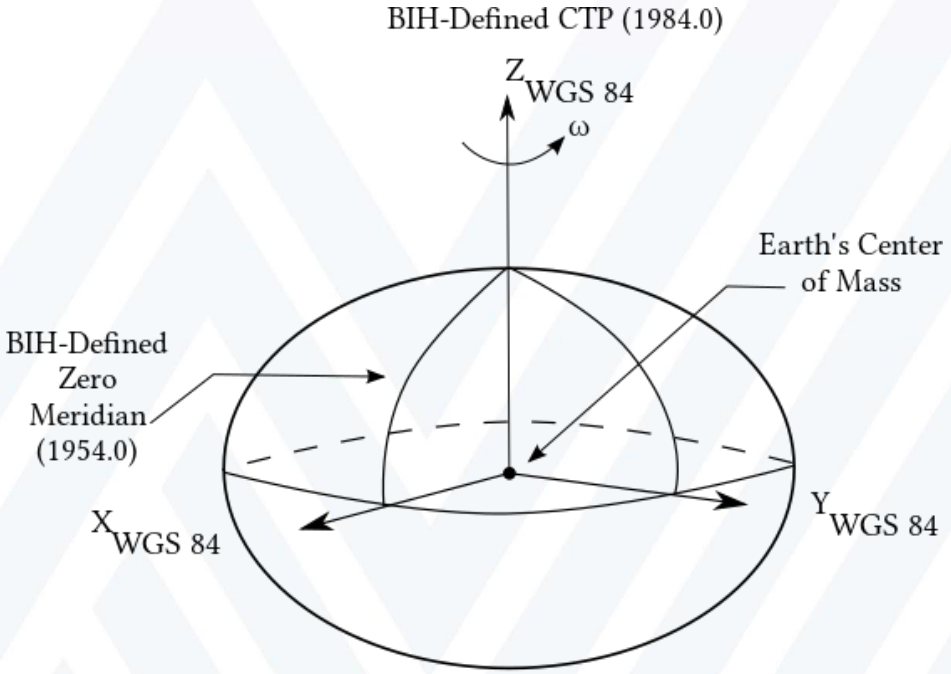

Figure 1.1 WGS 84 Reference Frame

Measuring Soil Conductance

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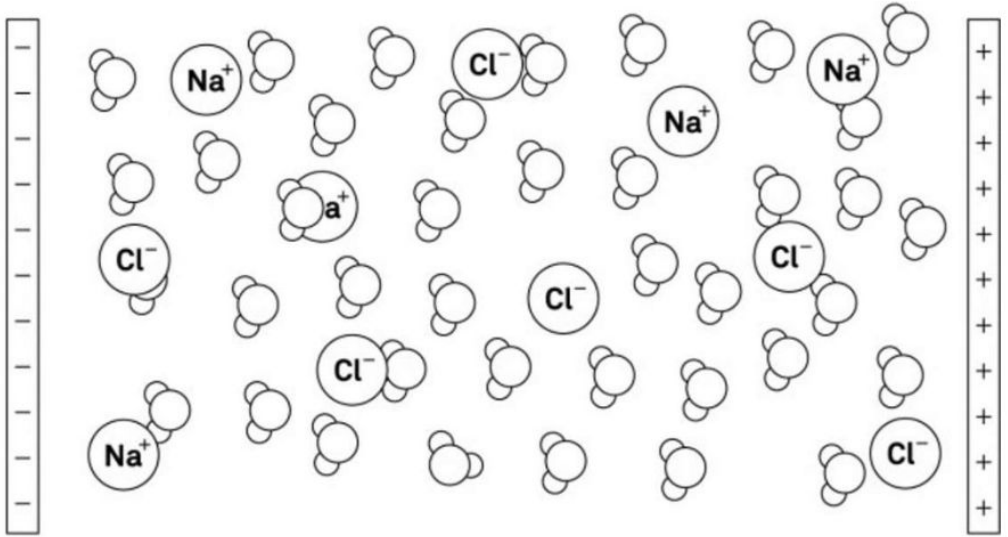

Measuring Soil Conductance

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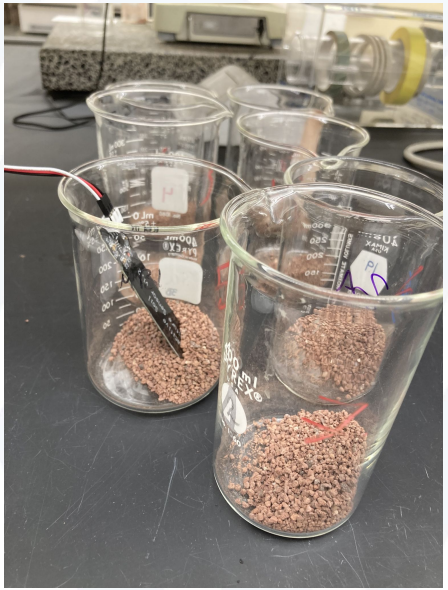


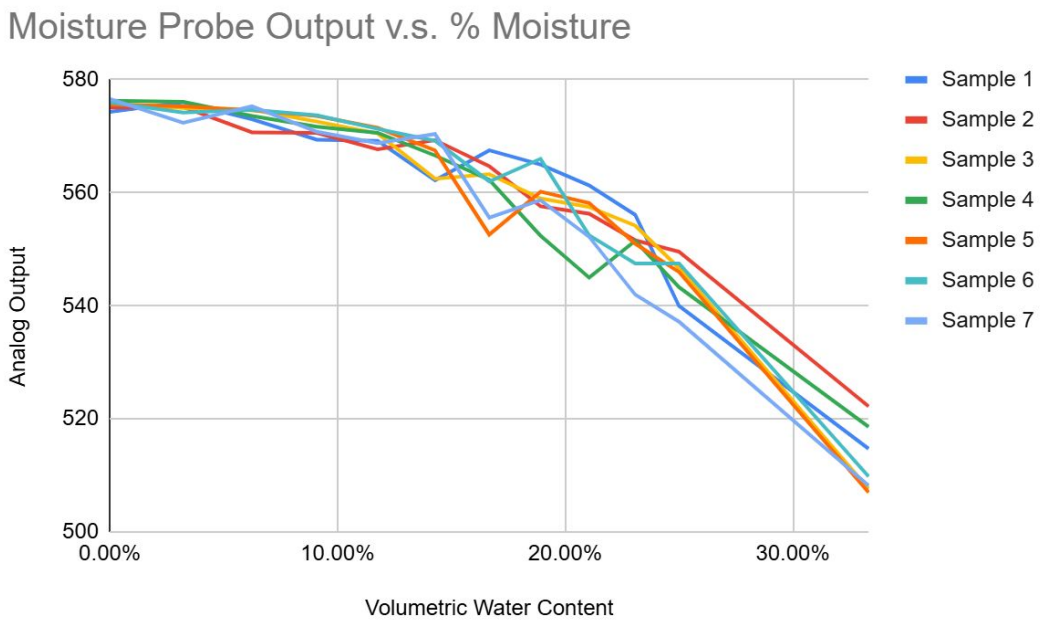
Measuring Soil Conductance

-

Medium Regolith		Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7
	g	30.1	29.9	30.1	29.8	29.8	30.2	29.7
Ambient conductanc	572							
WITH V1.2		Analog Input						
Added Volume	% Moisture	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7
0	0.00%	574.3	575.1	575.8	576.3	575.6	576.0	576.6
1	3.23%	576	575.2	575	576.1	575.3	574.2	572.4
2	6.25%	573	570.7	574.7	573.6	574.6	574.7	575.3
3	9.09%	569.4	570.6	572.6	571.7	573.6	573.7	570.8
4	11.76%	569.2	567.7	570.5	570.6	571.5	571.3	568.8
5	14.29%	562.2	569.3	562.5	566.6	567.5	569.2	570.4
6	16.67%	567.5	564.7	563.3	562.3	552.6	562	555.6
7	18.92%	565	557.6	559	552.4	560.2	566	558.7
8	21.05%	561.3	556.3	557.5	545	558.2	552.5	552.2
9	23.08%	556.1	551.6	554.2	551.5	551	547.5	542
10	25.00%	540	549.6	546.7	543.3	546	547.5	537.2
15	33.33%	514.7	522.2	507.6	518.6	507	509.8	508.2

Measuring Soil Conductance

-



Open Source!

- We release our documentation each year, including designs, code, and our Science Plan.
- 2025 documentation to be released in June

urc.orgs.wvu.edu

System Overview

- Cameras
  - 1 - HD 1080p
  - 9 - 480p (# of perspectives)
- Scoops rotate and deposit soil in to vessel inside scoop.
- STS-VIS miniature spectrometer
  - Detect common carotenoids, chlorophyll, and minerals
- Biuret Colorimetric test
  - Detect presence of proteins in soil above 0.8 mg/mL
- Subsurface drill reaches depth upto 20 cm.
- Probes reach depth upto 16 cm.
- Temperature Sensor: -55 to 125℃ with ±0.5℃ Accuracy
- Capacitive Soil Moisture Sensor: ADC values to track chane in moisture content

Heimdall's Sample Collection System

Exploration Approach

Site Selection
- Identify geological areas exhibiting history of water

Surface Analysis
- Photographic documentation
- Collect samples and analyze

Subsurface collection and Analysis
- Cached Sample
- Temperature and Humidity Sensors

Fluvial pebble fields [1]

Dried Streams and mudcracks [1]

[1] MDRS EXPEDITION GUIDE

Surface Collection Sites

Site 1

Site 1 Panoramic Image

Reasons for selection

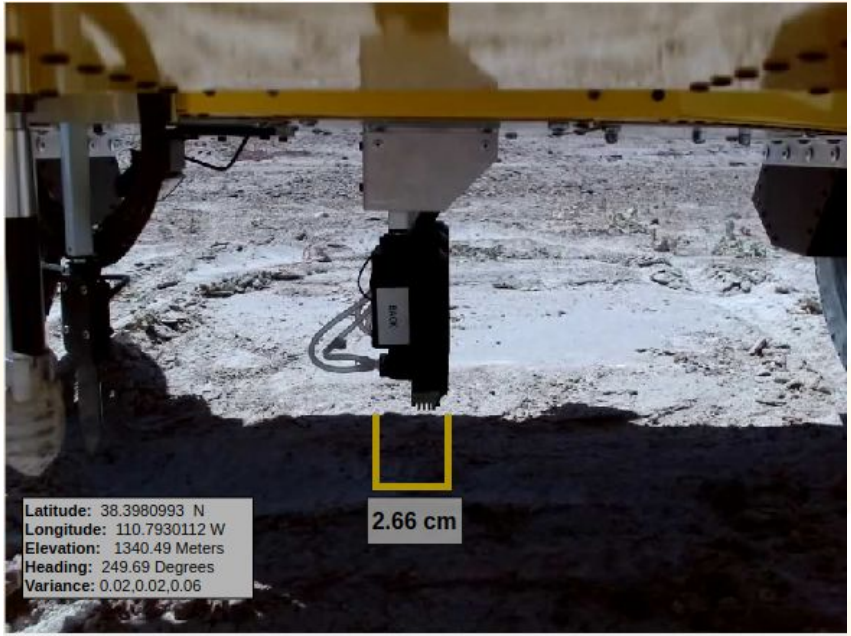
Fluvial Pebble Field

What we expect to Find

- Moist soil at base of the hill side
- Drainage structures
- Small Smooth rocks

Site 1

- What was found
  - Smooth mud
  - Mudcracks
  - Ripples



Site 1 Close Up Image

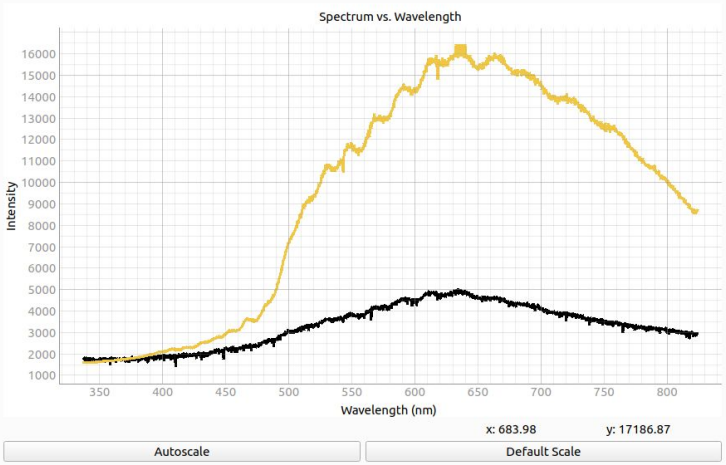
Sample Site 1 – Spectroscopy Results

Peak wavelength at: 650nm
- Similar peak wavelength for egg yolk
  - Indicates a presence of protein

Conclusions Drawn:
- Active biological life is supported

Sample

Egg Yolk



Spectroscopy Results

Sample Site 1 – Biuret Colorimetric Test Results

Color change not detected

Indicating:

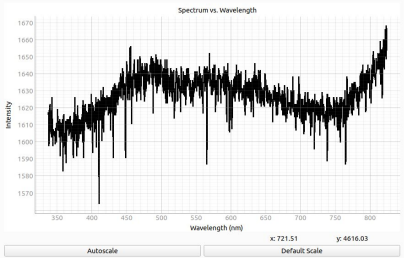
- Sample doesn't contain a concentration of proteins above 0.8 mg/mL.

Conclusions Drawn:

- There may be life below our detection capabilities.

Biuret Control

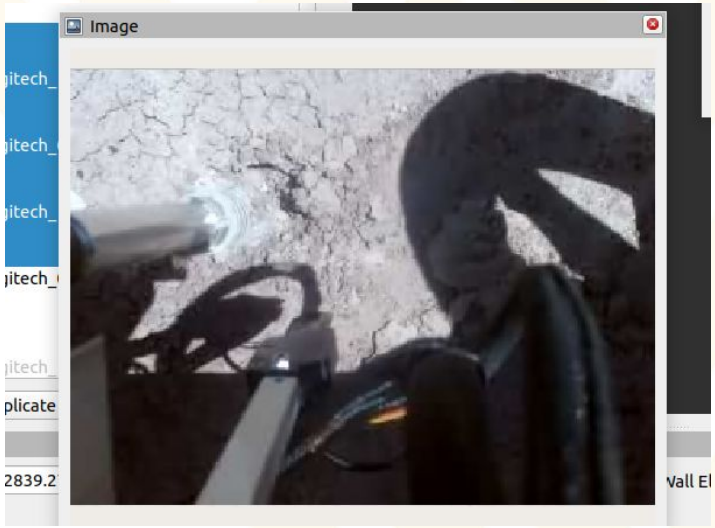
Tested Sample



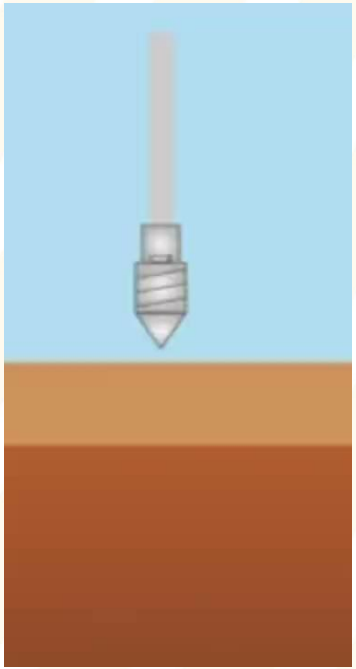
Spectroscopy Results

Subsurface Analysis

- Collected at Site 1
- Reason for selection
  - The indication of water
- Total Sample Collected:
- Subsurface Temperature: Invalid reading
- Subsurface Humidity: Invalid Data

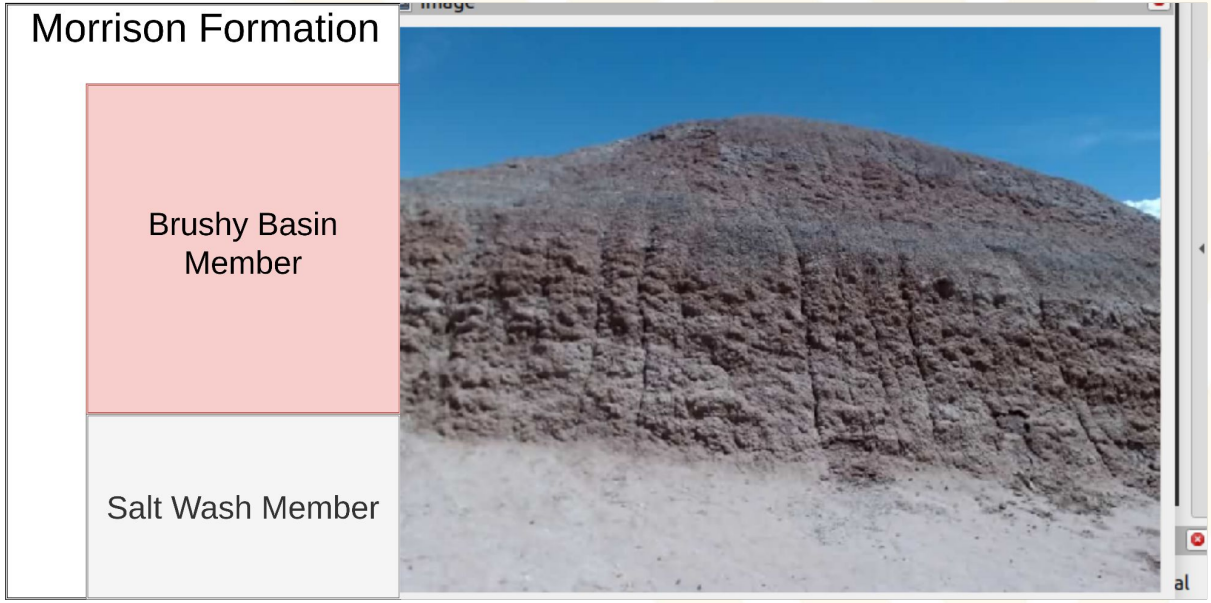


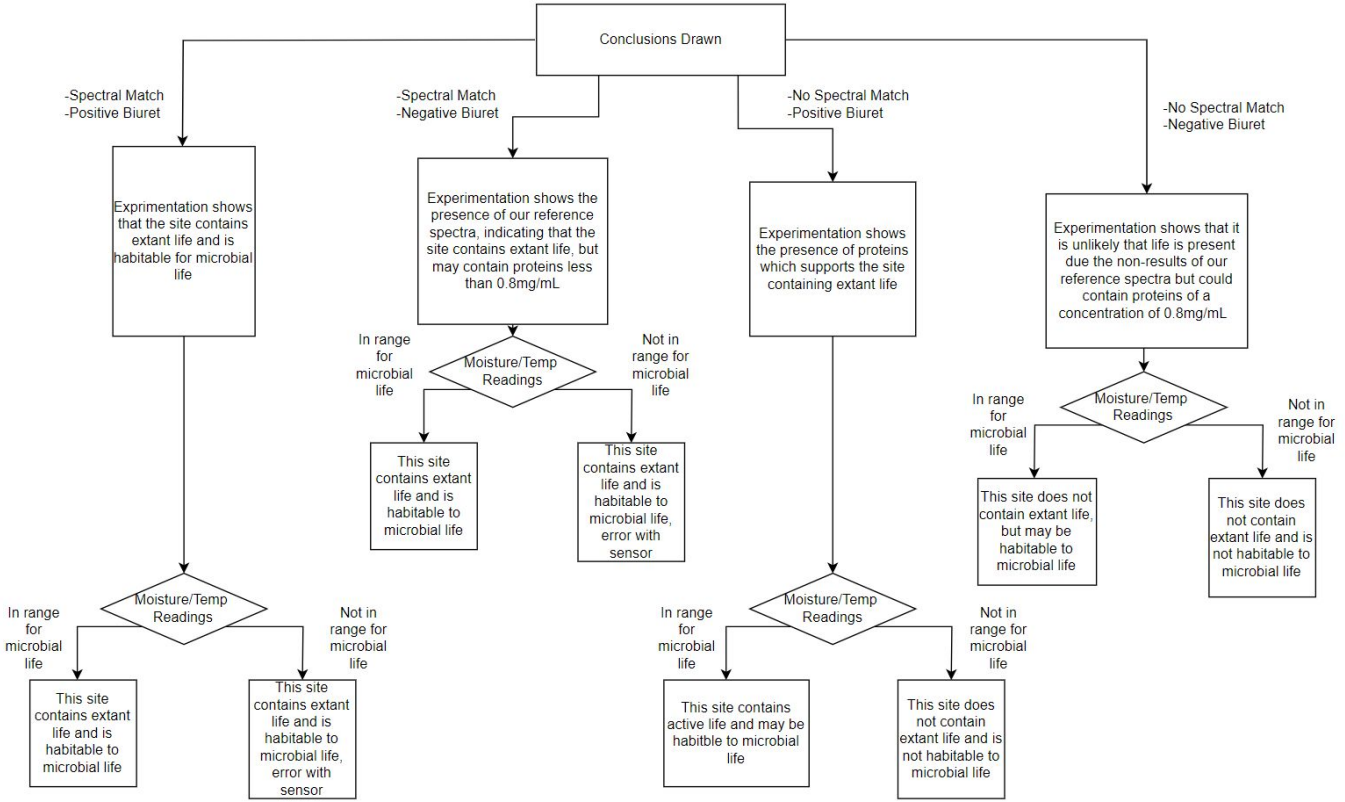
Drill Collecction



Collection Process

Stratigraphic Profile




Conclusions Drawn
-Spectral Match
-Positive Biuret
Exprimentation shows that the site contains extant life and is habitable for microbial life
Moisture/Temp Readings
In range for microbial life
Not in range for microbial life
This site contains extant life and is habitable to microbial life
This site contains extant life and is habitable to microbial life, error with sensor
-Spectral Match
-Negative Biuret
Experimentation shows the presence of our reference spectra, indicating that the site contains extant life, but may contain proteins less than 0.8mg/mL
Moisture/Temp Readings
In range for microbial life
Not in range for microbial life
This site contains extant life and is habitable to microbial life
This site contains extant life and is habitable to microbial life, error with sensor
-No Spectral Match
-Positive Biuret
Experimentation shows the presence of proteins which supports the site containing extant life
Moisture/Temp Readings
In range for microbial life
Not in range for microbial life
This site contains active life and may be habitble to microbial life
This site does not contain extant life and is not habitable to microbial life
-No Spectral Match
-Negative Biuret
Experimentation shows that it is unlikely that life is present due the non-results of our reference spectra but could contain proteins of a concentration of 0.8mg/mL
Moisture/Temp Readings
In range for microbial life
Not in range for microbial life
This site does not contain extant life, but may be habitable to microbial life
This site does not contain extant life and is not habitable to microbial life

Final Conclusions

Site 1

- Spectral results showed the presence of proteins
- The Biuret colorimetric test was negative.
- **It is believed that the site contains active life.**

Additional Information

Overview of Spectroscopy

- Visible light consists of electromagnetic radiation in range wavelengths from 380 to 780 nm
- Emission of most radiation occurs when when atoms or molecules are excited by the absorption of energy from another source source as heat, electrical discharge etc.
- Energy excites the electrons in the molecules, causing them to jump from a lower excited state to a higher state
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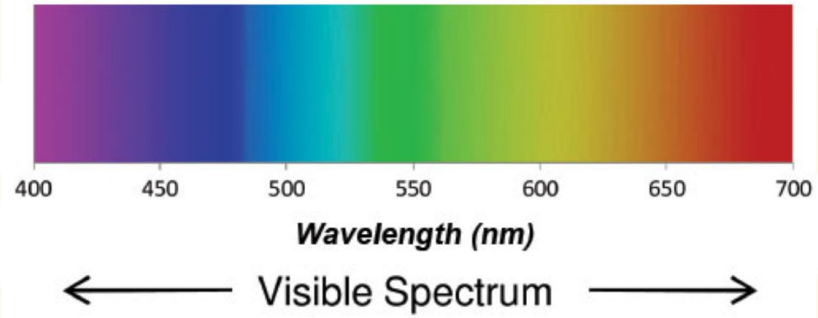
- The wavelength of the emitted photon corresponds to a specific wavelength that can be measured on the visible light spectrum



Visible Light Wavelengths

[1] "Visible spectroscopy," Visible Spectroscopy - an overview | ScienceDirect Topics, https://www.sciencedirect.com/topics/biochemistry-genetics-and-molecular-biology/visible-spectroscopy#:~:text=Visible%20spectroscopy%20and%20colorimetry%20are,quantitative%20information%20about%20a%20sample. (accessed May 29, 2024).

[2] Introduction: Visible light spectroscopy, http://www.chem.uiuc.edu/chem103/spectroscopy/introduction.htm

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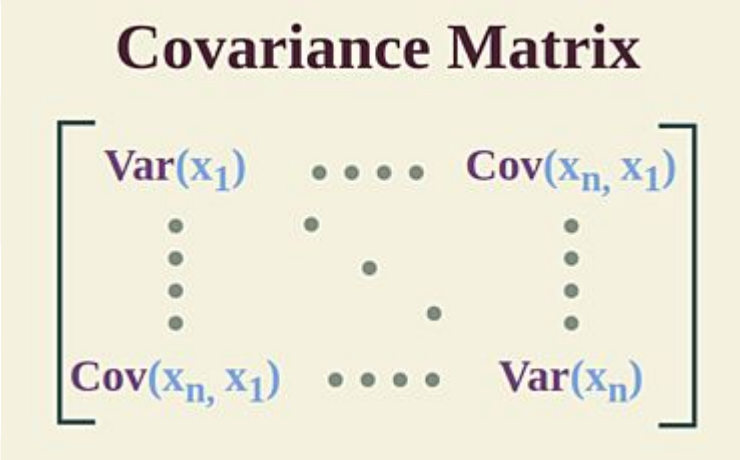

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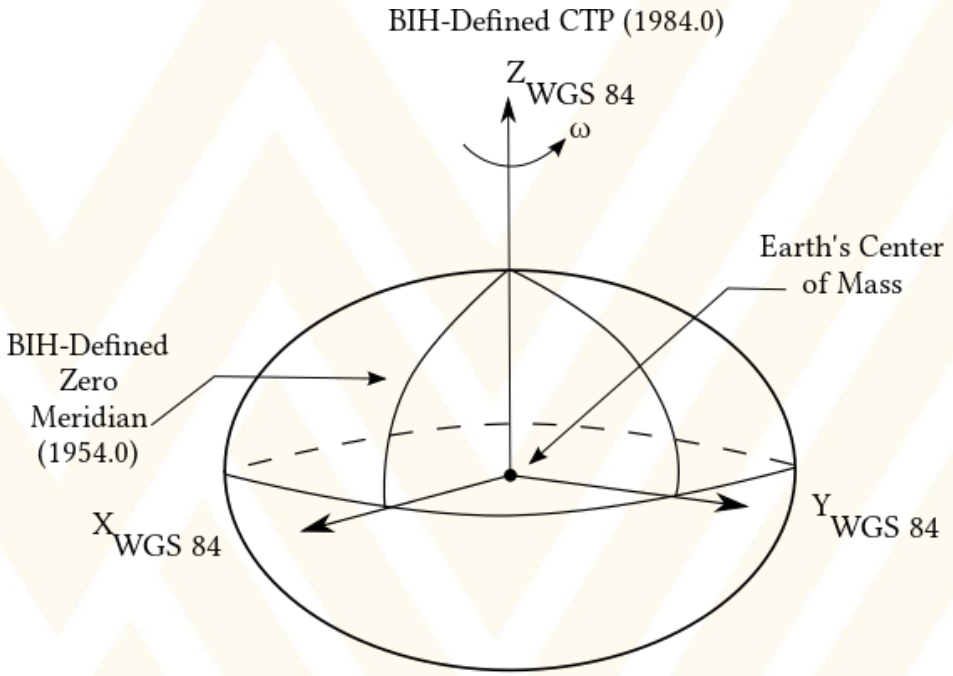

Figure 1.1 WGS 84 Reference Frame