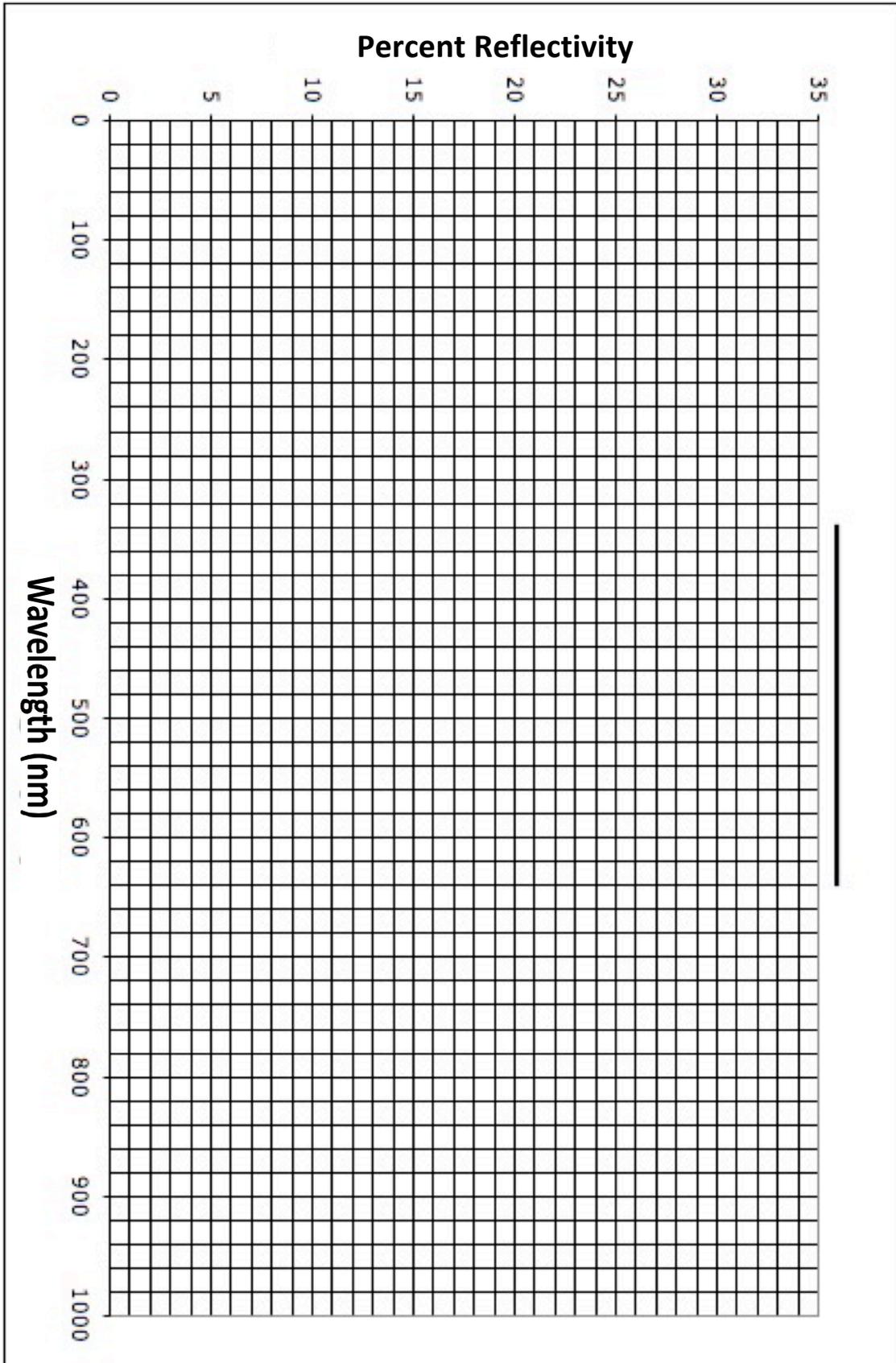


Student Graph Paper



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## **Student Handout**

It is the year 2032. Humans have established a base camp in the Martian northern hemisphere in a region called Mawrth Vallis. The team collected and made measurements of some soil from a region near the camp, but wanted to confirm their measurements. In an ambitious mission, the scientists in the Mawrth Vallis base camp built a rocket to return a soil sample to Earth for analysis. Your class was selected to participate in the analysis of the sample. Your job is to determine the major components of the soil and send your results back to the Martian team using an ALTA II reflectometer, a tool similar to the one the scientists have. The scientists hope you can confirm some of the minerals that could be used at their camp and what the potential uses are. The scientists think there may be silicon dioxide, calcium sulfate, ferric oxide, and cupric sulfate in the soil, but are not completely sure because their equipment has not recently been calibrated and was recently exposed to harmful solar radiation.

### **PART 1**

#### Directions

1. Collect an ALTA II reflectometer for your group.
2. When the lights are off, turn on the ALTA II and lightly press it against a hard surface. Without pressing any buttons, observe the value on the display. This is your dark voltage. Record this value on every data sheet in the dark voltage space. Later, once all measurements have been recorded, you will subtract your dark voltage reading from each measurement.
3. You and your group will go to one of the stations set up around the room.
4. Find the white paper at the first station you visit. Turn on the spectrometer and place it flat on top of the white paper. Now, press each wavelength button one at a time and record your measurements on the data sheet provided.
5. Before taking measurements, look at each sample (do not touch). Write down some observations: What overall color is it? Does it appear to have more than one color in it? What type of texture does it have? Does it look like sand, clay, or dirt? Is it clumpy or smooth?
6. Predict whether *you think* the sample is or is not a component of the Mars soil simulant.
7. Next, measure the reflectance of the sample. Start by placing the ALTA II on top of the box. Without pushing any buttons, check to make sure the dark voltage is close to the value you recorded for dark voltage in step 2. If not, some light is leaking into the ALTA II and it should be moved until the dark voltage is similar to your measurement.
8. Push down each button for each of the wavelengths and record these values in the tables provided.
9. Move to another station, and repeat steps 5-8.



# Marvelous Martian Minerology

**DATA SHEETS**

Names: \_\_\_\_\_

Dark Voltage Reading \_\_\_\_\_

**WHITE PAPER**

| Color    | Wavelength (nanometers, nm) | White Paper Reading | White paper – dark voltage (A) |
|----------|-----------------------------|---------------------|--------------------------------|
| Blue     | 470                         |                     |                                |
| Cyan     | 525                         |                     |                                |
| Green    | 560                         |                     |                                |
| Yellow   | 585                         |                     |                                |
| Orange   | 600                         |                     |                                |
| Red      | 645                         |                     |                                |
| Deep Red | 7000                        |                     |                                |
| IR 1     | 735                         |                     |                                |
| IR 2     | 810                         |                     |                                |
| IR 3     | 880                         |                     |                                |
| IR 4     | 940                         |                     |                                |

SAMPLE NAME \_\_\_\_\_

Visual observations:

Prediction:

| Color    | Wavelength (nanometers, nm) | Sample reading | Sample reading – dark voltage (B) |
|----------|-----------------------------|----------------|-----------------------------------|
| Blue     | 470                         |                |                                   |
| Cyan     | 525                         |                |                                   |
| Green    | 560                         |                |                                   |
| Yellow   | 585                         |                |                                   |
| Orange   | 600                         |                |                                   |
| Red      | 645                         |                |                                   |
| Deep Red | 7000                        |                |                                   |
| IR 1     | 735                         |                |                                   |
| IR 2     | 810                         |                |                                   |
| IR 3     | 880                         |                |                                   |
| IR 4     | 940                         |                |                                   |



# Marvelous Martian Minerology

SAMPLE NAME: \_\_\_\_\_

Dark Voltage Reading: \_\_\_\_\_

Visual observations:

Prediction:

| Color    | Wavelength (nanometers, nm) | Sample reading | Sample reading – dark voltage (B) |
|----------|-----------------------------|----------------|-----------------------------------|
| Blue     | 470                         |                |                                   |
| Cyan     | 525                         |                |                                   |
| Green    | 560                         |                |                                   |
| Yellow   | 585                         |                |                                   |
| Orange   | 600                         |                |                                   |
| Red      | 645                         |                |                                   |
| Deep Red | 7000                        |                |                                   |
| IR 1     | 735                         |                |                                   |
| IR2      | 810                         |                |                                   |
| IR 3     | 880                         |                |                                   |
| IR4      | 940                         |                |                                   |

SAMPLE NAME \_\_\_\_\_

Visual observations:

Prediction:

| Color    | Wavelength (nanometers, nm) | Sample reading | Sample reading – dark voltage (B) |
|----------|-----------------------------|----------------|-----------------------------------|
| Blue     | 470                         |                |                                   |
| Cyan     | 525                         |                |                                   |
| Green    | 560                         |                |                                   |
| Yellow   | 585                         |                |                                   |
| Orange   | 600                         |                |                                   |
| Red      | 645                         |                |                                   |
| Deep Red | 7000                        |                |                                   |
| IR 1     | 735                         |                |                                   |
| IR 2     | 810                         |                |                                   |
| IR 3     | 880                         |                |                                   |
| IR 4     | 940                         |                |                                   |



# Marvelous Martian Mineralogy

SAMPLE NAME: \_\_\_\_\_

Dark Voltage Reading: \_\_\_\_\_

Visual observations:

Prediction:

| Color    | Wavelength (nanometers, nm) | Sample reading | Sample reading – dark voltage (B) |
|----------|-----------------------------|----------------|-----------------------------------|
| Blue     | 470                         |                |                                   |
| Cyan     | 525                         |                |                                   |
| Green    | 560                         |                |                                   |
| Yellow   | 585                         |                |                                   |
| Orange   | 600                         |                |                                   |
| Red      | 645                         |                |                                   |
| Deep Red | 7000                        |                |                                   |
| IR 1     | 735                         |                |                                   |
| IR2      | 810                         |                |                                   |
| IR 3     | 880                         |                |                                   |
| IR4      | 940                         |                |                                   |

SAMPLE NAME \_\_\_\_\_

Visual observations:

Prediction:

| Color    | Wavelength (nanometers, nm) | Sample reading | Sample reading – dark voltage (B) |
|----------|-----------------------------|----------------|-----------------------------------|
| Blue     | 470                         |                |                                   |
| Cyan     | 525                         |                |                                   |
| Green    | 560                         |                |                                   |
| Yellow   | 585                         |                |                                   |
| Orange   | 600                         |                |                                   |
| Red      | 645                         |                |                                   |
| Deep Red | 7000                        |                |                                   |
| IR 1     | 735                         |                |                                   |
| IR 2     | 810                         |                |                                   |
| IR 3     | 880                         |                |                                   |
| IR 4     | 940                         |                |                                   |



# Marvelous Martian Mineralogy

## PART 2

Earlier you made measurements of each sample. Your group subtracted the dark voltage from each measurement. Dark voltage is the number the ALTA II records without any buttons being pressed. This is called “noise.” Scientists subtract noise because it is not part of the real measurement of the instrument.

The ALTA II collects light to make a measurement. When all of the lights are off and it is pressed against a surface, no light should be collected, but the ALTA II still records a number. That number *should* be zero, but it’s not because the electronics inside make the ALTA II think that light is being collected. It’s like if your bathroom scale were set to 10 pounds before you stepped on it— You’d want to subtract that, right? We subtract the dark voltage number to find the real measurement.

You also measured the reflectivity of the white paper. Think of the white paper as being the most reflective surface, or the maximum, the ALTA II can measure. We can express all of the other measurements as a ratio of the white paper measurements. Then, we can compute how reflective the samples are compared to the white paper. This is something called percent reflectivity (%Reflectivity). If you got an 8 out of 10 on an assignment, the ratio would be 8/10 or 0.8. If we convert that to a percentage, we would multiply  $0.8 \times 100 = 80\%$ . This is basically the same thing:

White paper - dark voltage = A

Sample - dark voltage = B

% Reflectivity = R

$$R = (B/A) \times 100$$

OR

$$\% \text{ Reflectivity} = \frac{\text{Sample - Dark voltage}}{\text{White reading - Dark voltage}} \times 100$$



# Marvelous Martian Minerology

**Directions:**

On the tables provided, compute the %Reflectivity (R) for each sample. Import the values for the White Paper table, and from the Sample tables. Use a calculator.

Mars Soil Sample

| Color    | Wavelength (nanometers, nm) | White paper – dark voltage (A) | Sample reading – dark voltage (B) | %Reflectivity<br>$R = \frac{B}{A} \times 100$ |
|----------|-----------------------------|--------------------------------|-----------------------------------|---|
| Blue     | 470                         |                                |                                   |   |
| Cyan     | 525                         |                                |                                   |   |
| Green    | 560                         |                                |                                   |   |
| Yellow   | 585                         |                                |                                   |   |
| Orange   | 600                         |                                |                                   |   |
| Red      | 645                         |                                |                                   |   |
| Deep Red | 700                         |                                |                                   |   |
| IR 1     | 735                         |                                |                                   |   |
| IR2      | 810                         |                                |                                   |   |
| IR 3     | 880                         |                                |                                   |   |
| IR4      | 940                         |                                |                                   |   |

Silicon Dioxide

| Color    | Wavelength (nanometers, nm) | White paper – dark voltage (A) | Sample reading – dark voltage (B) | %Reflectivity<br>$R = \frac{B}{A} \times 100$ |
|----------|-----------------------------|--------------------------------|-----------------------------------|---|
| Blue     | 470                         |                                |                                   |   |
| Cyan     | 525                         |                                |                                   |   |
| Green    | 560                         |                                |                                   |   |
| Yellow   | 585                         |                                |                                   |   |
| Orange   | 600                         |                                |                                   |   |
| Red      | 645                         |                                |                                   |   |
| Deep Red | 700                         |                                |                                   |   |
| IR 1     | 735                         |                                |                                   |   |
| IR2      | 810                         |                                |                                   |   |
| IR 3     | 880                         |                                |                                   |   |
| IR4      | 940                         |                                |                                   |   |



# Marvelous Martian Mineralogy

## Calcium Sulfate

| Color    | Wavelength (nanometers, nm) | White paper – dark voltage (A) | Sample reading – dark voltage (B) | %Reflectivity<br>$R = \frac{B}{A} \times 100$ |
|----------|-----------------------------|--------------------------------|-----------------------------------|---|
| Blue     | 470                         |                                |                                   |   |
| Cyan     | 525                         |                                |                                   |   |
| Green    | 560                         |                                |                                   |   |
| Yellow   | 585                         |                                |                                   |   |
| Orange   | 600                         |                                |                                   |   |
| Red      | 645                         |                                |                                   |   |
| Deep Red | 700                         |                                |                                   |   |
| IR 1     | 735                         |                                |                                   |   |
| IR2      | 810                         |                                |                                   |   |
| IR 3     | 880                         |                                |                                   |   |
| IR4      | 940                         |                                |                                   |   |

## Ferric Oxide

| Color    | Wavelength (nanometers, nm) | White paper – dark voltage (A) | Sample reading – dark voltage (B) | %Reflectivity<br>$R = \frac{B}{A} \times 100$ |
|----------|-----------------------------|--------------------------------|-----------------------------------|---|
| Blue     | 470                         |                                |                                   |   |
| Cyan     | 525                         |                                |                                   |   |
| Green    | 560                         |                                |                                   |   |
| Yellow   | 585                         |                                |                                   |   |
| Orange   | 600                         |                                |                                   |   |
| Red      | 645                         |                                |                                   |   |
| Deep Red | 700                         |                                |                                   |   |
| IR 1     | 735                         |                                |                                   |   |
| IR2      | 810                         |                                |                                   |   |
| IR 3     | 880                         |                                |                                   |   |
| IR4      | 940                         |                                |                                   |   |



# Marvelous Martian Mineralogy

## Cupric Sulfate

| Color    | Wavelength<br>(nanometers,<br>nm) | White paper<br>– dark<br>voltage (A) | Sample reading<br>– dark voltage<br>(B) | %Reflectivity<br>$R = \frac{B}{A} \times 100$ |
|----------|-----------------------------------|--------------------------------------|---|---|
| Blue     | 470                               |                                      |   |   |
| Cyan     | 525                               |                                      |   |   |
| Green    | 560                               |                                      |   |   |
| Yellow   | 585                               |                                      |   |   |
| Orange   | 600                               |                                      |   |   |
| Red      | 645                               |                                      |   |   |
| Deep Red | 700                               |                                      |   |   |
| IR 1     | 735                               |                                      |   |   |
| IR2      | 810                               |                                      |   |   |
| IR 3     | 880                               |                                      |   |   |
| IR4      | 940                               |                                      |   |   |

### Part 3

#### Directions:

- 1) Using a wet-erase marker and the transparency graph paper provided by your teacher, graph Wavelength vs. %Reflectivity for the Mars soil sample. Wavelength is the X-axis and %Reflectivity is the Y-axis. This is the reflection spectrum for the Mars soil.
- 2) Plot Wavelength vs. %Reflectivity on the graph paper provided for all of the other samples.
- 3) Place the Mars soil reflection spectrum (transparency graph) over each of the other spectra and compare the dips and peaks. Be very careful because some may be close to each other but not exactly at the same wavelength. Try to decide which chemicals are in the Martian soil simulant and which are not! Write down your results.
- 4) As a class, discuss your results. Did everyone come to the same conclusions?
- 5) Research one of the components of your Martian soil. Can the scientists use the soil to make useful things on their Martian base? Assume they have the necessary equipment. Write 2-3 paragraphs about what they might make and how it could be used on the base.