Objective and Landing Site

Introduction: The surface of a strange planet can be a very hostile environment. Temperatures and winds can vary tremendously. Selecting an appropriate landing site is a key-determining factor between a successful or unsuccessful mission.

Goal: Students use a surface map of the SNP to determine an appropriate objective(s) and landing site for their mission.

Objectives: Students will...

- Determine an objective for their mission
- Use a compass rose to determine direction of movement in degrees
- Accurately measure the distance traveled between each selected landing site to their assigned testing site
- Use a scale to convert their measurement into actual surface distances
- Select their landing site

Materials (for a class of 20):

- 20 compass roses
- 20 metric rulers
- 20 Determining an Objective and Landing Site - Student Map
- 20 Determining an Objective and Landing Site- Student Sheet
- 20 Determining an Objective and Landing Site- Student Direction Sheet
- Students will need their TES images (color-coded maps) from the Ground Truthing activity.

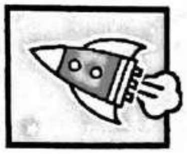
Time Required: One 45-60 minute period

Standards Met: S1, M1, M3, M12, M13

Procedure:

- Student should work in their Mission Teams.
- Give each student a copy of Determining an Objective and Landing Site- Student Sheet.
- Give each student a copy of Determining an Objective and Landing Site - Student Map
- Ask student groups to get out their TES maps they created during the Ground Truthing activity. They can use these maps to consider mineral content at each testing site.
- Using their TES maps and site maps, allow each group time to brainstorm some possible objective(s) in relation to the three possible test sites. Have teams share some of their possible scientific objectives.
- Teams should now answer questions 1 and 2 on the Determining an Objective and Landing Site- Student Sheet.

- Discuss with the students the factors on the surface of the SNP that might have adverse effects on a successful landing of their craft. Refer to the background information at the beginning of this lesson plan.
- Give each student a copy of Determining an Objective and Landing Site- Student Direction Sheet.
- Demonstrate how to correctly use a compass rose to determine direction of movement in degrees.
- Demonstrate the correct use of a metric ruler and how to measure accurately in millimeters.
- Discuss how to use a conversion scale.
- Have teams follow the directions on the Determining an Objective and Landing Site- Student Direction Sheet.
- Each student should answer the questions on Determining an Objective and Landing Site- Student Sheet
- Collect their student sheets.



Determining an Objective and Landing Site - Student Direction Sheet

Using your TES maps and site maps, brainstorm some possible objective(s) in relation to the three possible test sites.

Answer questions 1 & 2 on your student sheet.

Using the compass rose and a metric ruler, determine the direction of movement in degrees and distance in millimeter from each of the potential landing to your selected testing site (your team must avoid going over any topographical features such as canyons, riverbeds, volcanoes, etc.). Draw a line on your Student Map that represents your actual path of movement from all 3 landing sites (A, B, and C). Indicate direction in degrees and distance in millimeters for each segment of your movement (Landing sites A, B, and C). Write the degrees and distance measurements on the lines you drew on your Student Map.

Using the scale provided on the map, determine the actual distance that you traveled on the planet's surface.

Actual distance from Landing Site A:

Actual distance from Landing Site B:

Actual distance from Landing Site C:

Answer the questions on the Student Sheet.

Determining an Objective and Landing Site-Student Sheet

Name:____________________________________

1. What is your research question and hypothesis?

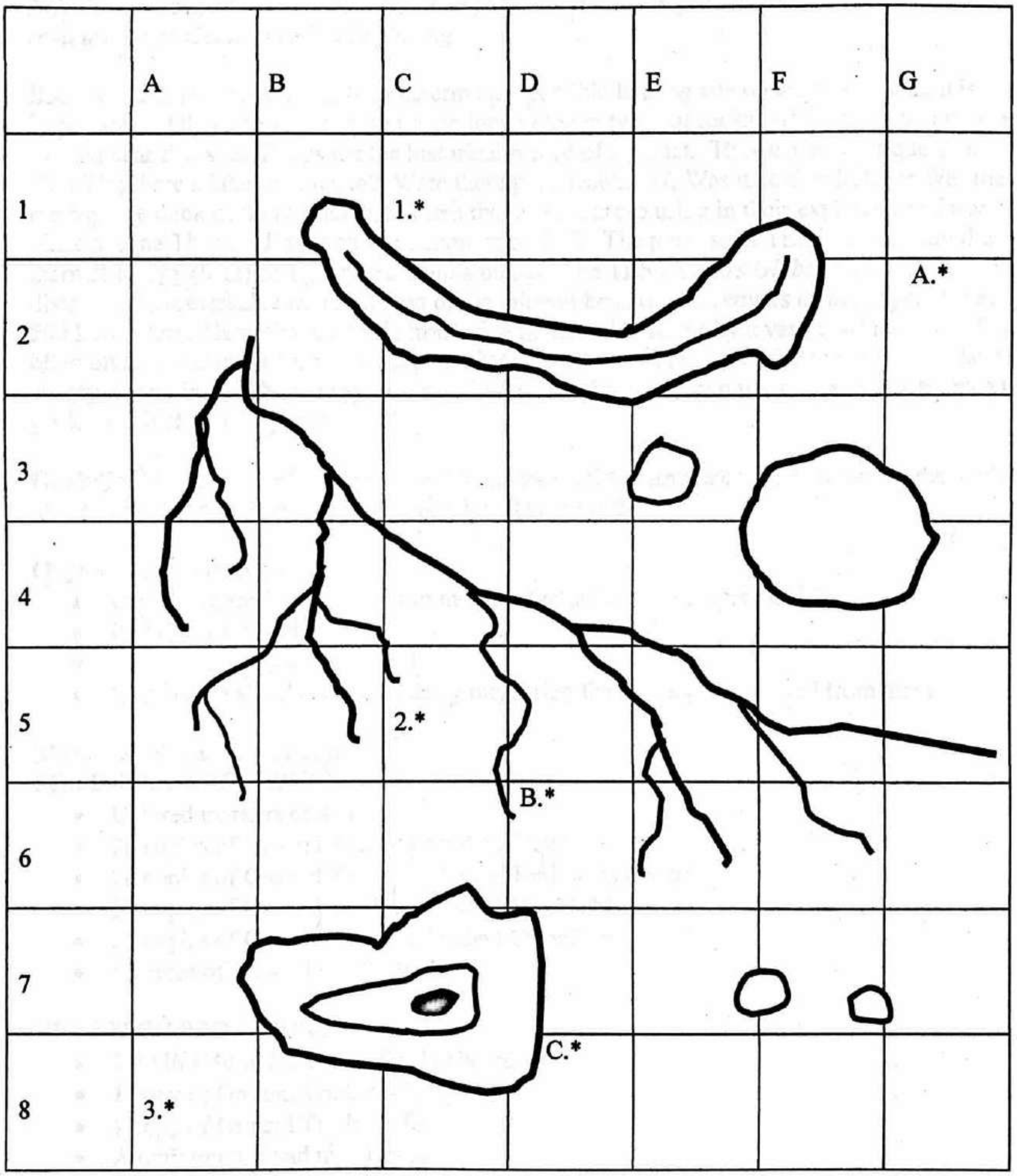
2. Based on your research question, what is the objective for your mission in relation to your selected testing site? Explain in detail.

3. Why is it necessary to avoid (navigate your rover around) topographic features such as riverbeds and canyons?

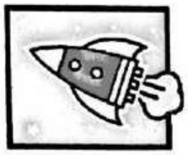
4. What site did you select for your landing site? Explain your decision.

5. Will the best landing site always be the closet one to your test site? Explain your answer.

Determining an Objective and Landing Site - Student Map



Scale: 1mm=10m (exact location of site is indicated by the star)



Ground Truthing

NOTE: *There are two procedural choices for this activity: high-tech and low-tech. Please review both procedures before beginning.*

Background: Before scientists can determine a possible landing site on the new planet, it is important that they can make some predictions as to the types of rocks and minerals that may be located near that site. Rocks are the historical record of a planet. They can answer questions like: Was there a lake or volcano?, Were there plate tectonics?, Was it cold or hot?, or Was the atmosphere thick or thin? One instrument that scientists are using in their exploration of new planets is the Thermal Emission Spectrometer or TES. The purpose of TES is to measure the thermal energy (heat) being emitted from a planet. The TES on *Mars Global Surveyor* discovered a remarkable accumulation of the mineral hematite that covers an area approximately 500 kilometers. Hematite is a ferric iron oxide mineral that forms by a variety of processes that often involve water. Different rocks and minerals absorb and reflect different amounts of heat energy depending on their composition and structure. Scientists can use this property to trace the geological history of a planet.

Goal: Students use an infrared thermometer to measure the simulated temperature on the surface of the new planet to determine possible mineral composition.

Objectives: Students will…

- Use an infrared thermometer to measure temperature in degrees Celsius
- Plot data on a grid
- Interpret data by using a chart
- Identify the simulated minerals by measuring the heat that is radiated from them

Materials (for a class of 20):
FOR EITHER PROCEDURE

- Colored markers or pencils
- 20 copies of Ground Truthing-Student Sheet
- 20 copies of Ground Truthing-Mineral Emissions Chart
- 20 copies of Ground Truthing-Student Data Table
- 20 copies of Ground Truthing-Student Directions
- 5 copies of Mineral Guide Book

HIGH TECH PROCEDURE

- 1 20 in x 30 in foam core display board
- 1 copy of Ground Truthing-Template 1
- 1 copy of Ground Truthing-Template 2
- Aluminum foil and metal tacks
- 2 pieces 8½" x 11" black construction paper
- 1 infrared heat lamp and socket clamp
- 1 support rod to hold lamp

- 1 hand held infrared thermometer (simulates TES --can be purchased from companies such as, Arbor Scientific, Product ID, 68-6500, $29.00, http://www.arborsci.com/SearchResult.aspx

LOW TECH PROCEDURE
- 1 20 in. x 30 in foam core display board
- 1 pad of Post-it® Notes
- 1 copy of Ground Truthing-Low Tech Template
- 1 marker

OPTIONAL INTRODUCTION:
- "When You're Hot, You're Hot" song by Jerry Reed (from the Super Hits CD)
- Player to play the music
- 1-2 Packages of Hand Warmers™ available at local outdoor stores or at www.grabberwarmers.com for approximately $2.00/pack of two.
- 20 copies of Ground Truthing-When You're Hot, You're Hot Data Table

Time Required: 45-60 minute period

Standards Met: S1, S2, S3, S5, S6, M4, M6, M12, M13, M16

Procedure:
HIGH-TECH OPTION
OPTIONAL INTRODUCTION
If you want to set the mood for this lab, have "When You're Hot, You're Hot" playing as the students are entering the room. Tell the students that you have discovered a device that can measure how "Hot" each of them are.
- Before class begins, tape some Hand Warmers™ packets to your chest. Make sure that they cannot be seen through your shirt.
- Explain how an infrared thermometer works.
- Pick one student at a time and have them stand facing you.
- Point the infrared thermometer at their chest.
- Record the temperature of each student's chest in Ground Truthing-When You're Hot, You're Hot Data Table
- Ask a student to measure the temperature of your chest with the infrared thermometer and record the temperature.
- Discuss what variables could affect the readings from the thermometer.

PREP
- Draw (in black marker) planetary geological features (valleys, craters, volcanoes, etc.) on the foam display board, a template (Template 1) is provided.
- Copy the grid lines over the geological features using a different colored marker.
- Label the three landing sites (A, B, and C) and three test sites (1, 2, and 3).
- Using a second template (Template 2), draw grid lines on the backside of the foam board and label according to the template.

- **Use tacks to attach the aluminum foil and black construction paper to the back of the foam board in the areas designated.**

- Set up the foam board similar to the Diagram 1 shown below.

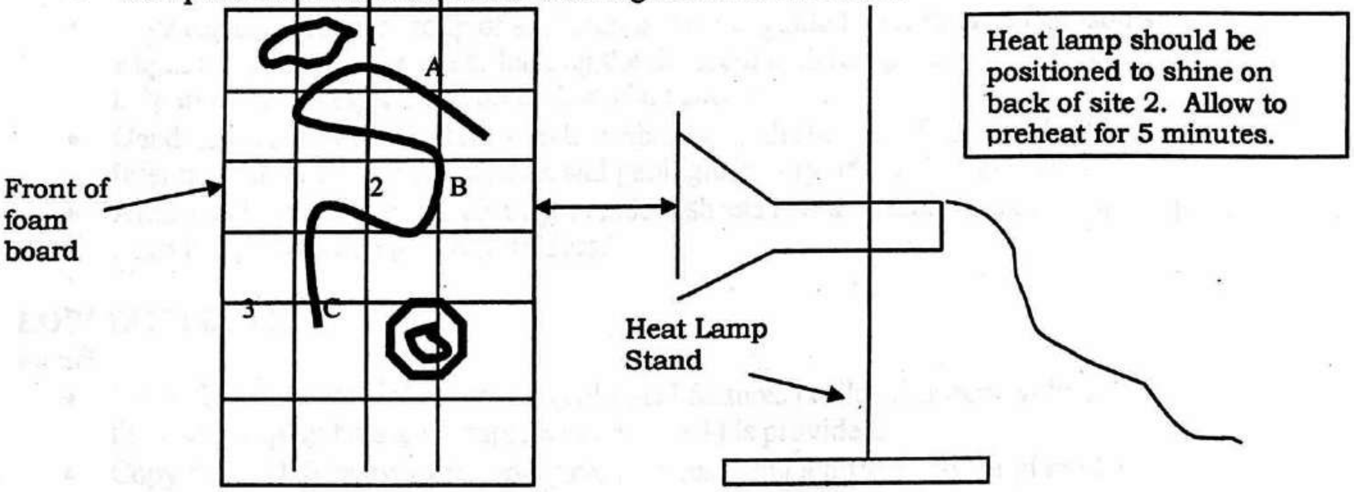


Diagram 1: Setup showing heat lamp and foam board with potential test and landing sites

Safety Note: The infrared heat lamp can cause severe burns if touched and should be kept away from all combustible materials. It should not be aimed directly at an individual. The infrared thermometer emits a low energy laser beam for aiming and should never be pointed into anyone's eyes.

IN CLASS

- Explain TES and the data collection and information it can provide about the planet.
- Explain that students will be looking for temperature variations on a simulated map/section of the planet's surface. They will keep track of temperature differences on their own maps.
- Hand out Ground Truthing-Student Data Table and the Ground Truthing-Student Direction Sheet to each student. Review the directions and how to fill in the data table.
- Ask a student to point the infrared thermometer at the top row. The student should press the button on the thermometer while pointing the laser in one of the squares. They must then read off the temperature from the thermometer.
- Students should then record information on their data table.
- Ask a different student to point the infrared thermometer at the next square in the top row. Students should record the temperature. Repeat this process until the entire grid has been mapped.
- Then, ask students to design a color key based on temperature and color code their maps according to temperature.
- Use color code and temperatures to shade in their data tables accordingly. The end product should be a colored map showing the temperature variations on the map.
- Give each student the Ground Truthing-Mineral Heat Emissions Chart.

- Use the Ground Truthing-Mineral Heat Emissions Chart to determine what type of minerals could be present on various places on the map.
- Give each student (or group of students) a mineral guide book, such as Peterson's. Explain that they will need to look up the different minerals present on their maps for help in answering questions on their student sheets.
- Hand out the Ground Truthing-Student Sheet to each student. They will be making inferences on mineral composition and geologic history of the sites on their map.
- After you have reviewed their maps, student sheets and data tables, ask students to place them in their mission portfolio folders.

LOW TECH OPTION

PREP

- Draw (in black marker) planetary geological features (valleys, craters, volcanoes, etc.) on the foam display board, a template (Template 1) is provided.
- Copy the grid lines over the geological features using a different colored marker.
- Label the three landing sites (A, B, and C) and three test sites (1, 2, and 3).
- For each square, create a Post-it® Note that covers the square. On the backside of the note, write the temperature for the square. Refer to the Ground Truthing-Low Tech Template for the key.

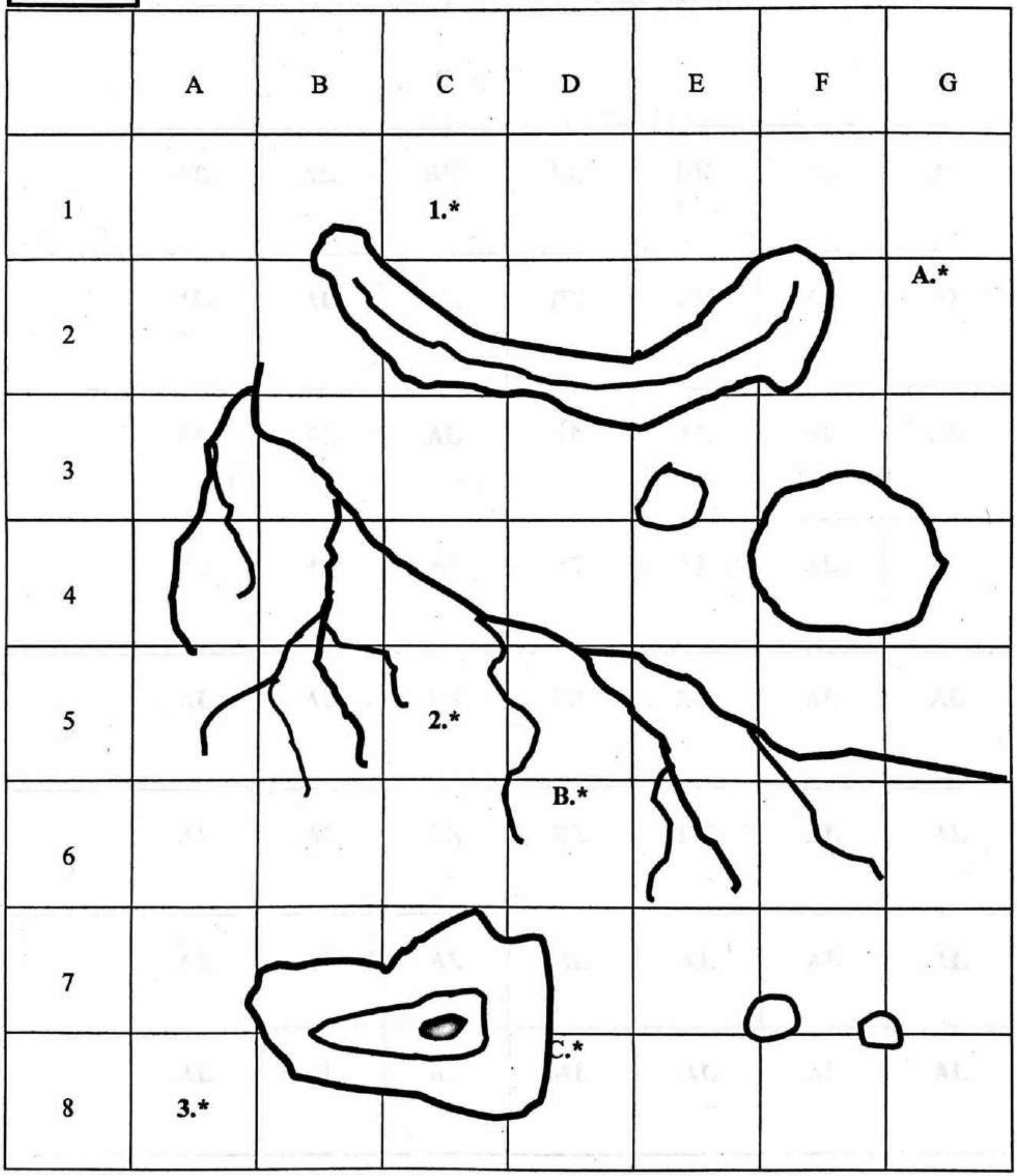
IN CLASS

- Follow the procedures for the High Tech Option. When the infrared thermometer is used, ask students instead to choose a square and manually reveal the temperature by looking on the back of the Post-it® Note. The student then shares the information with the rest of the class.
- Continue with this procedure until all squares have been revealed.

Assessment:

- Completed data table
- Completed student sheet
- Completed color-coded map

Ground Truthing-Template 1 (front)

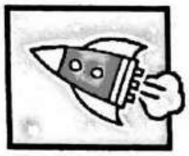


Scale: 1mm=10m (exact location of site is indicated by the star)

Ground Truthing-Template 2 (back)

	A	B	C	D	E	F	G
1	**AL**	**AL**	**BK**	**BK**	**BK**	**AL**	**AL**
2	**AL**	**AL**	**BK**	**BK**	**BK**	**AL**	**AL**
3	**AL**	**AL**	**AL**	**AL**	**AL**	**AL**	**AL**
4	**AL**	**AL**	**AL**	**AL**	**AL**	**AL**	**AL**
5	**AL**	**AL**	**BK**	**BK**	**BK**	**AL**	**AL**
6	**AL**	**AL**	**BK**	**BK**	**BK**	**AL**	**AL**
7	**AL**	**AL**	**AL**	**AL**	**AL**	**AL**	**AL**
8	**AL**	**AL**	**AL**	**AL**	**AL**	**AL**	**AL**

AL = Aluminum foil, BK = Black construction paper



Ground Truthing-Low Tech Template

Numbers below represent degrees Celsius.

	A	B	C	D	E	F	G
1	**23**	**24**	**25**	**24**	**23**	**22**	**21**
2	**23**	**24**	**25**	**24**	**23**	**22**	**21**
3	**25**	**30**	**34**	**31**	**30**	**23**	**22**
4	**30**	**35**	**42**	**40**	**34**	**28**	**23**
5	**37**	**41**	**45**	**42**	**38**	**32**	**24**
6	**35**	**40**	**43**	**40**	**36**	**30**	**22**
7	**24**	**26**	**30**	**27**	**22**	**21**	**21**
8	**17**	**17**	**18**	**19**	**22**	**21**	**21**

Ground Truthing-Teacher Key

Name: KEY Date: ____________

1. What is the correlation between the minerals you identified and the geological history of the planet? For example, are there minerals formed by a volcano, water…? *Answers will vary, but should correlate with the information found in the Mineral Heat Emissions Chart. For example, if they identified mineral E (30-50 degrees Celsius), they could assume that the planet may at one time had water on its surface.*

2. Using the data that you collected from this activity, which landing site would you select if you were trying to prove that life existed on the planet at one time? Explain your answer. *Answers will vary. However, sites that have minerals C, D, and E would represent the highest probability for finding evidence of life (past or present).*

3. Using the data that you collected from this activity, which landing site would you select if you were trying to prove that there might be water on the planet? Explain your answer. *Any landing site that has the presence of mineral E would be a high probability site for finding proof that water may be present on the planet.*

4. From the area that TES scanned in this activity, would you say that there was a great deal of volcanic activity at one time on the planet? Explain your answer. *If their TES scan discovered mineral G, there would be possible evidence that volcanic activity occurred on the planet.*

5. In this simulated activity of scanning the surface of the planet, what similarities and what differences does the infrared thermometer have with an actual TES? *Both are measuring reflected (infrared) heat. TES's data is computer correlated to actual minerals found on earth, the infrared thermometer was measuring simulated minerals from heat emitted by a piece of display board with a heat lamp behind it.*

6. Using the Ground Truthing-Mineral Heat Emissions Chart, list an actual mineral that matches the characteristics for each simulated mineral you have identified. *Answers will vary. Minerals are formed under a variety of environments, for example: Igneous (volcanic) environments – In rocks which have formed slowly during the principal stage of crystallization of a body of molten rock (magma), silicates are commonly found*

(olivine, pyroxene, amphibole, mica, felspars, quartz, and zircon), as are phosphates (apatites), sulfides (pyrite, pyrrhotite), oxides (magnetite, chromite) and a few native elements (platinum, diamond).

Sedementary (fossils forming) environments – The minerals present in sedimentary rocks are largely the remains of preexisting rocks, only rarely derived from the transformation of these. We find in this category silicates (chrysocolla, hemimorphite), sulfates (anglesite), phosphates and vanadates (carnotite, vanadinite, pyromorphite), carbonates (malachite, azurite, cerussite, smithsonite), a few oxides (cuprite) and certain native elements (gold, silver, copper). Among the products of the evaporation of sea water, we have: sulfates (gypsum), carbonates (calcite, dolomite), borates (borax), nitrates (trona), and above all halites (rock salt or halite, sylvite).

Metamorphic (pressure and plate tectonics) environments – Here the minerals in question are formed by solid-state transformation, at temperatures and pressures often different than the original mineral-forming ones. Few are really typical. Among these are silicates (serpentines, chlorites, garnets, micas, kyanite, andalusite, sillimanite, amphiboles, staurolite, vesuvianite, scapolite), carbonates (magnesite), oxides (rutile, corundum, ilmenite, spinels), hydroxides (brucite), sulfides (pyrite and pyrrhotite), and the native element graphite.

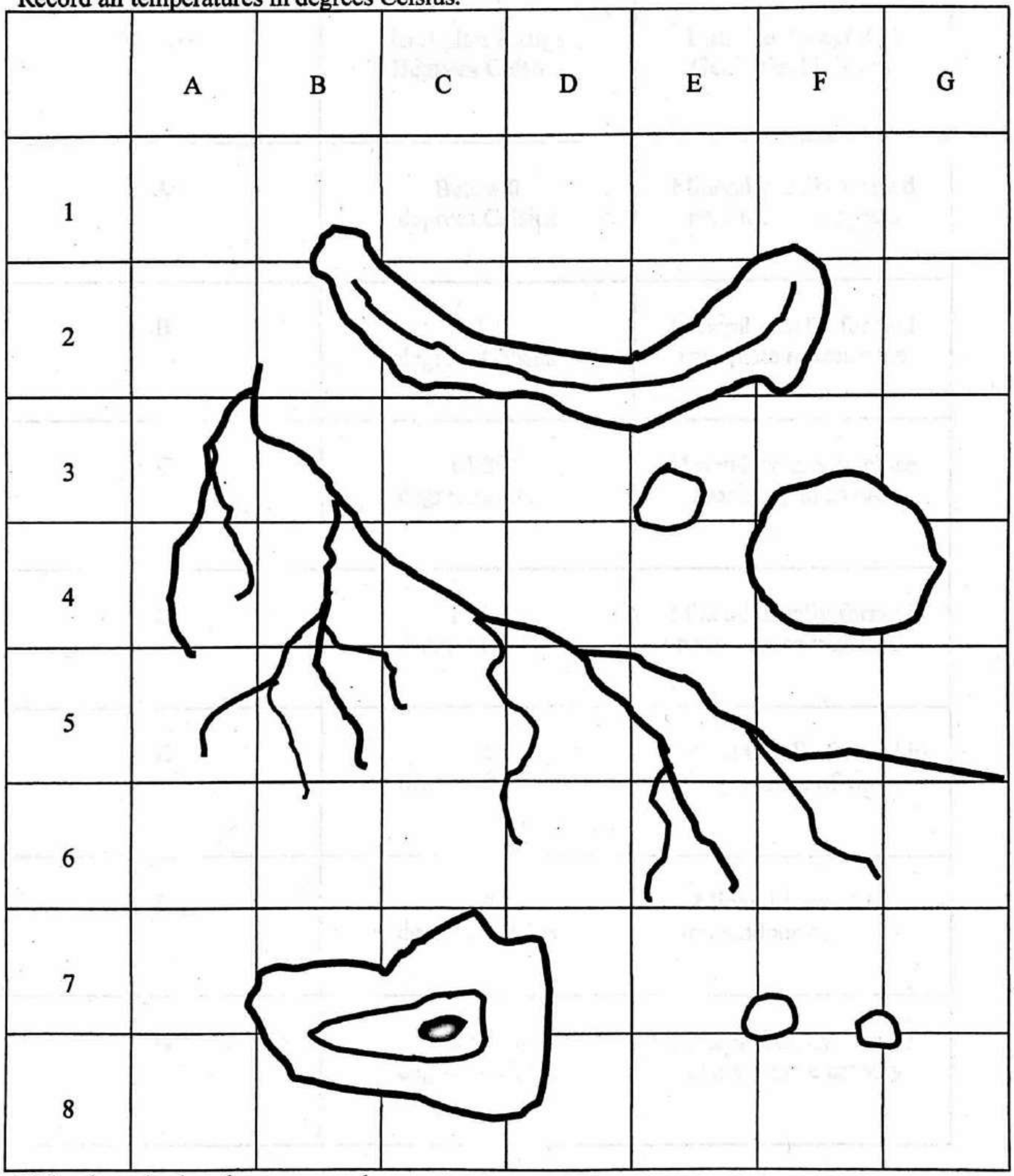
Ground Truthing-Student Direction Sheet

- Starting in the upper left-hand corner of the grid (A1), point the infrared thermometer so that the laser site is pointing to the center of the square.
- Record the temperature that the infrared thermometer measures in the table on the Ground Truthing-Student Data Table in the corresponding box.
- Move across the grid on the template using a similar procedure until all squares have been measured and recorded.
- Using the data obtained, shade or color in the table on the student data table with colors representing the different temperatures obtained. Design your own key to color code the temperatures and include it on the sheet somewhere.
- Using the Ground Truthing-Mineral Heat Emissions Chart, determine which type of minerals might be present at each site.
- Using the mineral guidebook, look up and identify what type of minerals may be present at each site.
- Answer the questions on the Ground Truthing–Student Sheet.

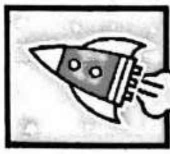
Ground Truthing-Student Data Table

Name: ______________________________ Date: ___________________________

Record all temperatures in degrees Celsius.

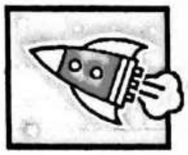


Write the color key for your map here:



Ground Truthing- Mineral Heat Emissions Chart

Mineral	Emission Range Degrees Celsius	Possible Associated Geological History
A	Below 0 degrees Celsius	Mineral usually formed near meteor impacts
B	0-10 degrees Celsius	Mineral usually formed near plate movements
C	10-20 degrees Celsius	Mineral usually in close proximity to fossils
D	20-30 degrees Celsius	Mineral usually formed near organic materials
E	30-50 degrees Celsius	Mineral usually formed in the presence of water
F	50–80 degrees Celsius	Mineral formed by tremendous pressures
G	Above 80 degrees Celsius	Mineral usually formed near volcanic activity



Ground Truthing-Student Sheet

Name: ________________________________ Date: ______________________

1. What is the correlation between the minerals you identified and the geological history of the planet? For example, are there minerals formed by a volcano, water…?

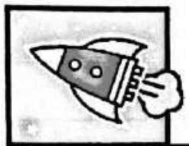
2. Using the data that you collected from this activity, which landing site would you select if you were trying to prove that life existed on the planet at one time? Explain your answer.

3. Using the data that you collected from this activity, which landing site would you select if you were trying to prove that there might be water on the planet? Explain your answer.

4. From the area that TES scanned in this activity, would you say that there was a great deal of volcanic activity at one time on the planet? Explain your answer.

5. In this simulated activity of scanning the surface of the planet, what similarities and what differences does the infrared thermometer have with an actual TES?

6. Using the Ground Truthing-Mineral Heat Emissions Chart, list an actual mineral that matches the characteristics for each simulated mineral you have identified.



Ground Truthing-
"When You're Hot, You're Hot" Data Table

Student's Name	Temperature (Celsius)	Student's Name	Temperature (Celsius)
1.		16.	
2.		17.	
3.		18.	
4.		19.	
5.		20.	
6.		21.	
7.		22.	
8.		23.	
9.		24	
10.		25.	
11.		26.	
12.		27.	
13.		28.	
14.		29.	
15.		30.	