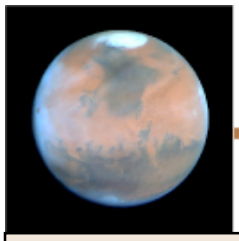

The Dirt on Mars

Grades 6-8

Lesson Summary

Students will explore density and water absorption properties of sand and two types of dry clays. After completing the activity students relate what they have learned to the Martian environment and the possibility of water hidden on Mars.

Prior Knowledge & Skills

- Basic experimentation
- Data collection
- Able to read a scale
- Able to use a graduated cylinder

AAAS Science Benchmarks

The Physical Setting

Structure of Matter

Habits of Mind

Computation and Estimation

Manipulation and Observation

NSES Science Standards

Science as Inquiry

Understandings About Scientific Inquiry

Physical Science

Properties and changes of Properties in Matter

NCTM Mathematics Standards

Measurement

Teaching Time: 2 - 50 minute periods

Materials (per group)

- 50 mL x 1 mL graduated cylinder
- 7- coffee filters (generic, basket-style works best)
- 6- wooden stir sticks
- 3- custard cups
- 6- 9 or 10 oz plastic beverage cups
- Wet erase marker
- 6- 3" or 3.5" x ¼" rubber bands
- 1- straight edge or ruler
- 1- rubber spatula
- 1- teaspoon
- 1- tablespoon
- 80 mL or 4 tablespoons plus 4 teaspoons of:
    - Kaolinite (or China) dry powdered clay
    - Montmorillonite (or Bentonite) dry powdered clay
    - Coarse quartz sand

Materials (to share with the class)

- Plastic wrap
- 1-3 scales accurate to 0.1 grams

Advanced Planning

Preparation Time: ~20 minutes

- Review the procedure and gather materials
- Clays and sand available at http://wardsci.com/

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The Dirt on Mars

Materials

Per Group
50 mL x 1 mL Graduated Cylinder
7-Coffee filters (generic, basket-style works best)
6-Wooden stir sticks
3- 6oz custard cups or bowls
6- 9 or 10 oz plastic beverage cups
Wet-erase marker
6 – 3” or 3.5” x ¼” rubber bands
1-Straight edge or ruler
1-Small spatula
1-Tablespoon
1-Teaspoon

80 mL or 4 tablespoons plus 4 teaspoons of:
Kaolinite (or China) dry powdered clay
Montmorillonite (or Bentonite) dry powdered clay
Coarse quartz sand

To share with class:
Plastic wrap
Sink or pitcher for water
1-3 scales accurate to 0.1 grams

Notes on Materials:
Clays and sands can be purchased at Ward’s Natural Science Store. 32 oz of coarse sand costs $4.15. 500 g of Kaolinite costs $9.95. 500 g of Montmorillonite costs $8.95. These amounts are enough for seven groups if no sand is wasted.
http://wardsci.com/

The Dirt on Mars

Student Directions
Pre-lab

In this experiment, you will be testing the water absorption properties of two types of clay and one type of sand.

Visually examine the two clays and sand.

1. How are the clays different from one another? Look at color. Feel the texture between your fingers.

2. How are the clays different from the sand? Are there any similarities?

3. Make a prediction about which substance or substances will hold the most water.

Procedure

Part I.

Density is the measurement of how tightly packed a material is in a given volume. For example, a cube of lead is denser than a cube of copper, regardless of the size of the cube. A given material always has the same density.

If you could measure the density of one grain of each of the materials, you would find that the density of each grain of a given material is the same. Unfortunately, the scales you are using aren't accurate enough to measure the mass of one grain, and it's tricky to find the volume of such a small particle. Instead, you will be measuring the density of a collection of grains. Measuring the density of loose material is more difficult than measuring the density of a solid cube, so your value might differ somewhat from your neighbor's.

An example of some of the materials you will need for this lab

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I.I. Gather your group's materials.

I.II. Using the wet-erase marker, mark one of the custard cups with an "S" for "sand." Before filling it with sand, place it on the scale and zero the mass.

I.III. Measure out 2 tablespoons and 2 teaspoons of sand and pour it in the cup. Remember to level each spoon with your straight edge before pouring. This is a volume of 40 cm^3.

I.IV. Record the mass of the sand in the "Density" table.

I.V. Compute the density of the sand. Density is equal to the mass divided by the volume. D = M ÷ V. Record the density in the "Density." Remember to include your units (g/cm^3), and round your answer to two digits.

Level each spoon using your straight edge

I.VI. Repeat this procedure using kaolinite, this time marking your bowl with a "K."

I.VII. Repeat this procedure using montmorillonite, this time marking your bowl with an "M."

I.VIII. On the board, record the value obtained for each density measurement. As a class, find the average density for each material. Record these average values in the "Density" table.

Part II

II.I. Use the table to record your group's findings. Note: 1mL = 1 cm^3

II.II. Take the filter paper and place one filter inside each of the plastic drinking cups. Overlap the top of the filters with the top of the drinking cups. Secure them with a rubber band.

II.III. Using the custard cups and material from Part I, pour 20 mL of water into each container and stir with a wooden stir stick until all the water is well mixed. Use a different stir stick for each bowl.

Place a filter inside the cup, overlapping the filter with the top of the cup. Secure with a rubber band.

II.IV. Label three of the plastic drinking cups: one with "S-20mL H_2O", one with "M-20mL H_2O", and one with "K-20mL H_2O".

II.V. Have one teammate hold the bottom of the plastic drinking cup labeled "S-20mL" as another teammate pours the sand onto the filter paper using the spatula if needed. Rinse off spatula.

II.VI. Repeat step II.V with the montmorillonite, using the plastic drinking cup labeled "M-20ml H_2O".

II.VII. Repeat step II.V with the kaolinite, using the plastic drinking cup labeled "K-20mL H_2O".

II.VIII. Cover each plastic drinking cup containing filter and material with plastic wrap so the water does not evaporate.

II.IX. Rinse and thoroughly dry the three custard cups. Re-label them with either an "S", "M", or "K".

II.X. As in Part I, add 40mL of sand to the custard cup marked with an "S". Repeat for montmorillonite (placing in the cup marked "M") and kaolin (placing in the cup marked "K").

II.XI. Repeat steps II.III-II.VI, this time using 45mL of water.

II.XII. Place all of the plastic drinking cups aside and let them drain overnight.

Part III

III.I. Remove the plastic wrap from each of the plastic drinking cups.

III.II. Carefully, without spilling the material into the cup, remove the filter and material from the cup labeled "S-20mL H_2O."

III.III. Pour the water into the graduated cylinder and record the amount of water drained in the "Experiment Data" data table provided.

III.IV. Rinse and dry the graduated cylinder.

III.V. Notice the filter absorbed some of the water. Empty as much of the sand off of the filter as possible.

III.VI. Using the scale, weigh an unused, dry filter. Record this value on the "Filter Measurements" table.

III.VII. Now, take the damp filter and weigh it on the scale. Record this value on the "Filter Measurements" table.

III.VIII. The difference between the weight of the dry filter and damp filter gives you the mass of water the filter absorbed. Record this on the "Filter Measurements" table.

III.IX. We can assume the filters absorbed about the same amount of water . The density of water is $1 g/cm^3$. Find the volume of water the filter absorbed using the equation: Volume = Mass ÷ Density. Record this value on the "Filter Measurements" table and fill in this amount in the "Experiment Data" table in the appropriate column.

III.X. Repeat steps III.I-III.IX for the cup labeled "S-45mL H_2O."

III.XI. Repeat steps III.I-III.IV for each of the remaining cups, making sure to record all values in the table.

III.XII. Add the volume of water absorbed by the filter to the volume of water drained from each of the materials. Record this in the "Volume of Water Not Absorbed" column of the "Experiment Data" table.

III.XIII. Subtract the "Volume of Water Not Absorbed" from the initial volume of the water added for each material. This is the amount the material *absorbed*. Record these values in the table.

Experiment Questions

4. Review your prediction. Did you correctly predict which substance would absorb the most water? Explain any differences in your prediction versus your result.

5. Describe the appearance of the montmorillonite after adding 20 mL and 45 mL.

6. Describe the appearance of the kaolinite after adding 20 mL and 45 mL.

7. Suppose you added 50 mL of water to the montmorillonite. What do you think would happen?

8. What would happen to the kaolinite if you added 50 mL of water?

9. Based on your observations, how were the absorption properties of the clays different from the sand?

10. Compare the amount of water absorbed to the density measurements made in Part I. Do you think there is any relationship between density and water absorption? Explain your reasoning.

11. Which substance tested had the highest amount of water absorption?

12. Which substance tested had the lowest amount of water absorption?

13. Write 1-3 paragraphs about your experiences during the lab. Include any surprising results, further questions for exploration, and any thoughts or ideas pertaining to the lab.

Mars Questions

This image shows water ice on the floor of a crater at Vastitas Borealis on Mars. The image is courtesy of ESA/DLR/FU Berlin.

14. Consider what you have learned about the Martian surface and in this experiment. Do you think there is a possibility that liquid water could exist on Mars? Explain.

15. If clay and water existed on Mars, what assumption would you make about the ability of the clay to absorb water? Explain your answer based on what you know about the Martian surface.

16. The photo above shows water ice in the bottom of a crater. It appears as if no liquid water is present. Could liquid water actually be present? Why/why not? Explain your reasoning.

17. An astronaut visits Mars and brings a sample of the Mars surface in a jar back to Earth. The 100 mL jar contains 97 g of material. Remember: 1mL equals 1 cm^3. *Note: This is a hypothetical scenario. The Martian surface may or may not actually have the materials studied in this lab.*

    a. What is the density of the material?

    b. Which of the three materials studied in this lab (montmorillonite, kaolinite, sand) most closely match the Mars surface sample?

18. Write a 1-paragraph argument about the existence of life on Mars based on what you have learned throughout all of the Mars activities.

Data Tables

Density

Material	Mass of bowl	Mass of bowl and material	Mass of material	Volume of material	Density of material D=M÷V	Class average density
Sand				40 cm^3		
Kaolinite				40 cm^3		
Montmorillonite				40 cm^3		

Filter Measurements

Amount of water initially added to sand	20 mL	45 mL
Mass Dry Filter		
Mass Wet Filter		
Mass of Water Absorbed by Filter		
Volume of H_2O absorbed by filter: $V=M \div D$ $D=1\ g/cm^3$		

Experimental Data

Material	Initial Volume of H_2O added (mL)	Description of Material after H_2O added	Volume of H_2O drained	Volume of water absorbed by filter*	Volume of H_2O *Not* Absorbed by Material	Total Volume of H_2O absorbed by Material
Sand	20					
	45					
Montmorillonite	20					
	45					
Kaolinite	20					
	45					

*Amount of water absorbed by the filters for Montmorillonite is negligible