

# Lesson 8: Rock Evolution & Change

## Summary

Students will be exposed to the processes of metamorphism and diagenesis on Earth and determine which processes are dominant on Mars. Are diagenetic processes on Earth mirrored on Mars?

## Learning Goals

### Students will be able to:

- Observe and understand the diagenetic alteration of goethite to hematite,
- Test different variables through experimentation to understand diagenetic environment thresholds of alteration.

## Context for Use:

This module is meant for adaptation in an earth science course where sedimentary rock lithology and processes of formation are already familiar to students.

Background materials for rock types and classification include:

[http://www.youtube.com/watch?v=pg\\_jKJFbA2A](http://www.youtube.com/watch?v=pg_jKJFbA2A) (This is a classification using a cooking kitchen analogy)

## Description and Teaching Materials

### *In-Class Activity:*

In-Class Activity 1: Cooking Rocks - Did the experiment work? - After the students have tried the homework (they may need several days to complete it), a later follow-up activity includes discussing whether the experiment worked for people and why/why not?

### *Homework/Lab*

Homework 1: Cooking Rocks- Diagenesis

## Teaching Notes and Tips

- In Homework 1: students will need samples of southern Utah picturestone.

## Assessment

Methods of assessment are within each individual *In-Class Activity* and *Homework*.

## Mars for Earthlings

## References and Resources

1. Image File: [Rock Evolution and Change](#)
2. Potential picturestone vendor- Kanab, UT:  
<http://www.westernhills.com/index.html?shopper=cb6311c803426cebbc922d135f10e356>
3. Rainbow Bridge Image:  
[http://nature.nps.gov/geology/geologic\\_wonders/images/rainbow.jpg](http://nature.nps.gov/geology/geologic_wonders/images/rainbow.jpg)
4. Gold stone Image:  
[http://rayerminerals.homestead.com/Verkoop\\_mineralen\\_6.html#](http://rayerminerals.homestead.com/Verkoop_mineralen_6.html#)
5. Published paper on the exercise: Chan, M. A., and Kahmann-Robinson, J., 2015, Cooking Rocks: Teaching About Diagenesis on Earth and Mars. Journal of Geoscience Education v. 63, p. 57-65.



## Mars for Earthlings

### ***In-Class Activity 1***

How Rocks Change on Mars\_MFE

*Cooking Rocks: Did the experiment work?*

**Preparation:** In this case students should do the homework before this activity. The students will need several days to do the homework at home. For this activity, make sure students have completed their “Cooking Rocks” homework.

### **Engage**

#### **What do the students think?**

1. What holds sand grains together in a sandstone?
2. How does the cementing mineral form?
3. Can some of these minerals change?
4. Do similar minerals occur on Mars?
5. What might happen when you “cook” a rock with minerals containing water?

Have students think about the fact that minerals can change under certain conditions. For example: graphite and diamond are c-based minerals.

Movie showing conversion of synthetic diamonds to graphite

<http://www.youtube.com/watch?v=7L7BV3IBfFA>

For the homework experiment:

Observe the following experimental results (left side examples are “before” and right side examples are “after”). Why are they different colors?



## Mars for Earthlings



Credit: Marjorie Chan

### Explore

1. Do the students consider their experiment successful? Why or why not?
2. If any failures or issues presented themselves, why did they occur? How could the students mitigate them?

### Explain

1. As students discuss their experiment, particularly the results, explain what success in experimentation really means. Success isn't always equated to "the test worked". Sometimes there is much to be learned in what may appear as failure.
2. If students experienced "failure" help them to determine the parameters that can be changed, or ascertain from the students what they think prevented them from a successful experiment.

## Mars for Earthlings

### Elaborate

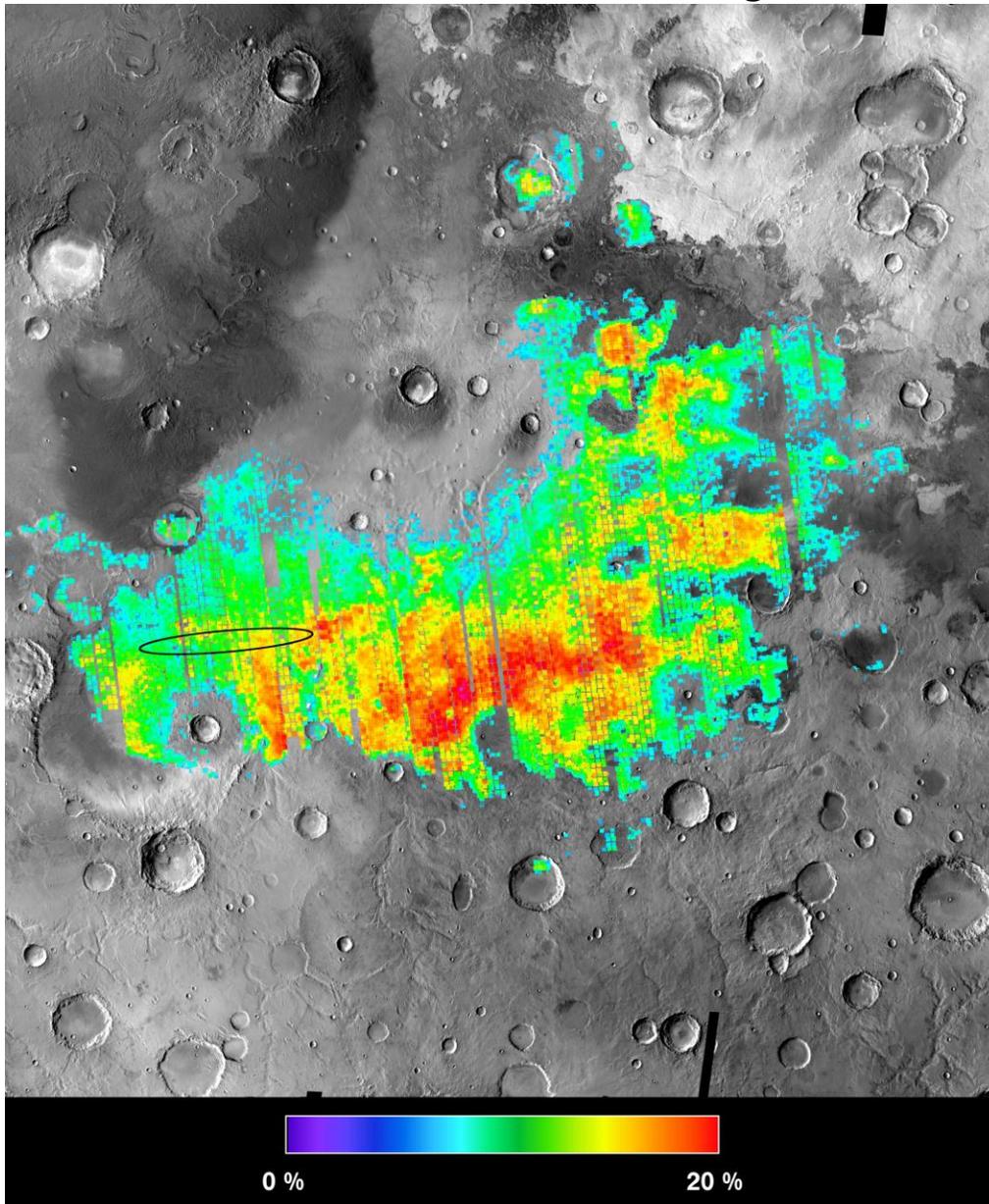
1. Have students in their own words, define the term diagenesis:
2. How do goethite and hematite differ?
3. How did “cooking” the rock facilitate a change in mineral composition?
4. Would adding water into/onto the “after” sample change the mineralogy? Why or why not?

### Evaluate

1. Are there diagenetic minerals on Mars? Why would one be more common than another?
2. What is the origin of the hematite in the Thermal Emission Spectroscopy (TES) imagery?



## Mars for Earthlings



**Figure 1:** Meridiani Planum; Image credit: NASA/JPL/Arizona State University.

Image from: [http://www.nasa.gov/mission\\_pages/mgs/20061121-imagesb.html](http://www.nasa.gov/mission_pages/mgs/20061121-imagesb.html)

Note: On the relative abundance bar at the bottom, hematite abundances range from 5 % (blue) to 20 % (red). Hematite often forms in the presence of liquid water.