

# Lesson 12: Surface Sculpting Waters on Mars

## Summary

This learning module and related laboratory exercise exposes students to surface water erosion due to rivers and deltas and their evidence on the Martian landscape. Students will use modern analogs to assess the hypothesis that both rivers and deltas existed on Mars.

## Learning Goals

### Students will be able to:

- Demonstrate comprehension of fluvial styles and processes as well as delta formation through comparison of Earth-analog environments and Mars imaging.
- Gain experience with contour maps on both Earth & Mars.

## Context for Use

This learning module is meant for adaptation in an introductory Earth science course and/or planetary science course. If you desire to use the *In-Class Activity 1: Stream Table and Mars*, provide exposure to fluvial processes and styles prior to the activity.

## Description and Teaching Materials

### *In-Class Activity*

In-Class Activity 1: Carving Mars:  
Rivers

In-Class Activity 2: Eberswalde Delta  
Mars

### *Homework/Lab*

Homework 1: Mars Fluvial Channels:  
Contour Maps

## Teaching Notes and Tips

1. If you have access to a stream table conduct the “Stream Table and Mars” *In-Class Activity* in the stream table lab.

2. For larger classes (>20 students) in the “Stream Table and Mars” *In-Class Activity* use the video link provided in References and Resources and ask for volunteers to sketch out fluvial events on the board for others to explain and discuss. Encourage all students to participate and turn in their sketches for a participation grade.
3. All images required for activities/homework are available in the References and Resources in PowerPoint format.
4. Acquire red/blue glasses to view HIRISE red-blue anaglyph images.

## Assessment

Each *In-Class Activity* and *Homework* has its own measure of Assessment.

## Mars for Earthlings

### References and Resources

1. Image File: [Surface Sculpting Waters](#)
2. Stream Table: meandering river-  
<http://www.youtube.com/watch?v=YsQ7hW2fAEs&feature=related>
3. Boggs, S., 2001. Principles of Sedimentology and Stratigraphy, 3<sup>rd</sup> ed. Prentice Hall, ISBN: 0-13-099696-3, 726p.
4. Mars Global Surveyor image & Video of Martian delta:  
[http://www.nasa.gov/multimedia/imagegallery/image\\_feature\\_98.html](http://www.nasa.gov/multimedia/imagegallery/image_feature_98.html)
5. Red-blue glass anaglyph glasses example from Amazon: <http://www.amazon.com/Red-Blue-Anaglyphic-Glasses-Paper/dp/B002MXP42W>
6. Ehlmann B., et al. 2008. Clay minerals in delta deposits and organic preservation potential on Mars, Nature Geoscience, doi:10.1038/ngeo207.
7. Bhattacharya, J., and Giosan, L., 2003. Wave-influenced deltas: geomorphological implications for facies reconstruction, Sedimentology, v. 50, p. 187-210.
8. Water flows on Mars presented by Alfred McEwen (choose the video under “Possible Water Flows on Mars”): <http://mars.jpl.nasa.gov/mro/multimedia/videoarchive/>





## Mars for Earthlings

### Explore

1. Have students observe the Davidson Geology stream table experiment:  
<http://www.youtube.com/watch?v=YsQ7hW2fAEs&feature=related>
  - a. Students should sketch and label the timestamp associated with the following fluvial events:
    - i. Formation of a cut bank
    - ii. Formation of a point bar
    - iii. Stream avulsion
    - iv. Formation of multiple channels (at least more than 1)
  - b. For each of the sketches have students describe why they occurred.
    - i. Cut bank
    - ii. Point Bar
    - iii. Stream Avulsion
    - iv. Multiple channels
  - c. As students progress through the Exploration portion of the exercise discuss the terms and concepts:
    - i. Cut bank
    - ii. Point Bar
    - iii. Meandering vs. braided
2. Explore the HIRSE anaglyph image, using red-blue glasses (blue filter over right eye), of the Eberswalde region of Mars:  
<http://hirise.lpl.arizona.edu/images/2007/details/cut/Eberswalde-delta-3x.jpg>
  - a. Ask the students if any of their stream table sketches are similar to what they observe on Mars? Which one, if any?
  - b. Explain the circumstances in which this surface geomorphology on Mars might have formed.

### Explain

1. Students can use Google Earth to show continental areas on Earth (e.g. look in high mountainous areas) where multi-stacked channel styles are prevalent. Do the same for braided vs. meandering styles. In doing so, discuss the following concepts:
  - a. Channel gradient
  - b. Sediment input

### Elaborate

Make a Mars global map available for students to view digitally or hardcopy:

<http://www.google.com/mars/>

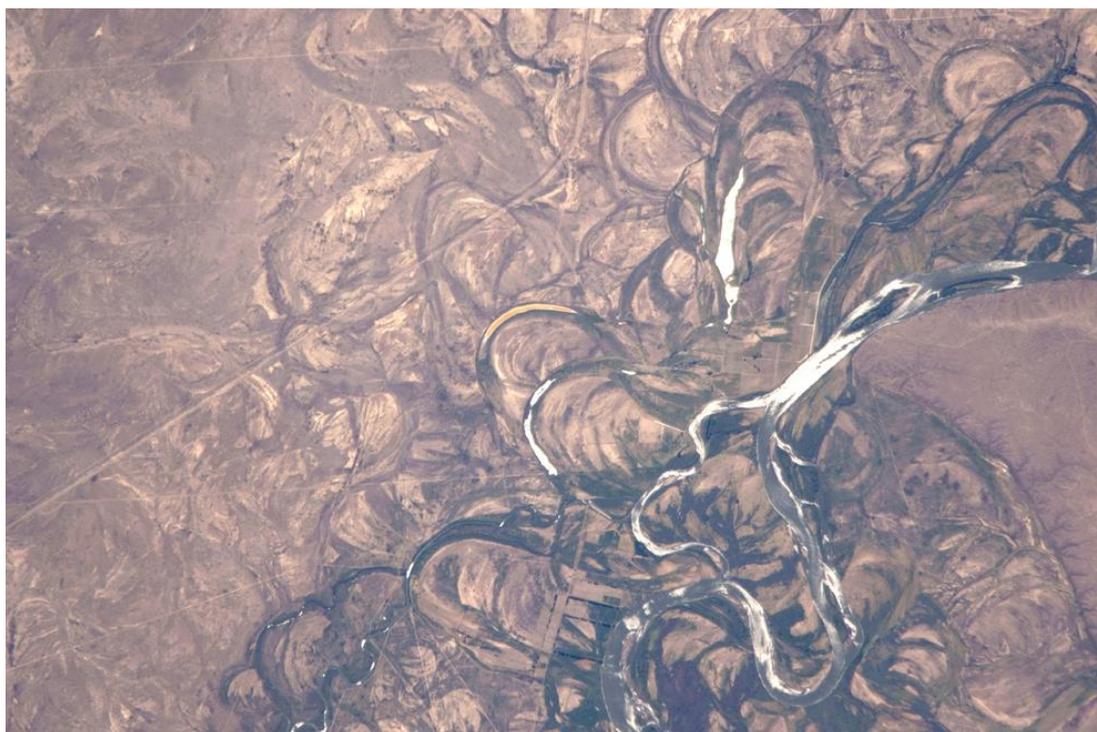
1. Consider the landscape of Mars. In what regions, could water have flowed as braided channels? Ask students to label a map or directly point out their response.
2. Would meandering or braided fluvial styles be more common on Mars? How does this differ from Earth, or does it?



## Mars for Earthlings

### Evaluate

1. In reference to figure 1 ask:
  - a. Where would it be safe to build a house?
  - b. Where is deposition occurring? What about erosion?
2. When students see the scars, ask the class:
  - a. What does this tell you about the meanders?
  - b. Can the students discern which meanders are older and which are younger?
  - c. Did they observe similar geomorphology on Mars?



**Figure 1:** RIO NEGRO, COLONEL JOSEFA AREA, FLOOD PLAIN

Center Point Latitude: -39.8 Center Point Longitude: -65.4

Credit NASA. (Image Source: [ftp://eol.jsc.nasa.gov/EFS\\_highres\\_ISS022\\_ISS022-E-19513.JPG](ftp://eol.jsc.nasa.gov/EFS_highres_ISS022_ISS022-E-19513.JPG). ISS/NASA)

## Mars for Earthlings

### ***In-Class Activity 2***

Surface Water\_MFE

*Eberswalde Delta Mars*

**Purpose:** Become acquainted with deltas on Earth and apply the principles of delta-formation to Mars images. Students will be able to create an informed hypothesis as to whether or not deltas are present on Mars.

### **Preparation**

1. Acquaint students with delta formation previous to this exercise or as a simultaneous component to your teaching.
2. Research and present deltas found here on Earth to serve as analog comparisons. The **Engagement** section will provide an opportunity, albeit small, for students to see an analog.

### **Engage**

1. Ask students the following question to start off the activity: When you hear the word “delta” what do you think of?
  - a. List ideas on board
  - b. Discuss each one as it applies
2. To test current understanding share with them the following images and have them identify which is a “delta” (see the Image file in **References and Resources** for images).
  - a. Horseshoe Bend Colorado
  - b. Lake Powell
  - c. Amazon Delta
  - d. Congo River

### **Explore**

1. View the following video from NASA.gov- click on the “+ View Video” link in blue: [http://www.nasa.gov/multimedia/imagegallery/image\\_feature\\_98.html](http://www.nasa.gov/multimedia/imagegallery/image_feature_98.html)
2. As students view the video, ask them to write down the evidence cited by scientists that this is a delta on Mars.
3. Ask students to compare and contrast their Mars findings with Earth-based observations of the following deltas: Mississippi River and Colorado River (dry).
  - a. You may use a similar Table Format provided in this learning module if you plan to have students turn in their observations as a result of this *In-Class Activity*
  - b. See the Image file in **References and Resources** for images.



## Mars for Earthlings

Delta	Overall Geometry	What body is/was it emptying into? Evidence?
Eberswalde Crater, Mars		
Mississippi River, Earth		

**Explain**

1. As students complete the **Explore** activity, discuss concepts such as delta *lobe switching* and the *forces creating different delta geometries* (bird's foot vs. cusped).
2. As appropriate share the tripartite classification (consult Bhattacharya & Giosan, 2003 **References and Resources**) of deltas and which would be more applicable on Mars (Ehlmann et al., 2008 **References and Resources**), if any.

**Elaborate**

1. Search and discover other deltas on Earth via Google Image search or the like (HINT: search major river systems). Have students determine which delta on Earth is most similar to Eberswalde Delta on Mars. Are any a good match? Ask students to explain why or why not.
2. Ask students how they might conduct "tests" on Mars to determine whether or not a delta exists? (Hint: remember that deltas form where sediment is dispersed into a standing body or former standing body of water.)

**Evaluate**

1. If you use this activity as homework, have students submit the chart and associated questions and assess their answers.
2. If you use the Elaboration section, the tests students come up with should indicate their grasp of delta processes.



## Mars for Earthlings

### **Homework 1**

Surface Water\_MFE

*Mars Fluvial Channels: Contour Maps*

**Purpose:** Become familiar with contour maps and learn how to read them. Observe fluvial incised-channels on a contour map of Earth and compare to a contour map of Mars, and make predictions of potential fluvial activity on Mars.

### **Preparation:**

1. If not uploaded to the students' Google Earth application, load the USGS topographic maps layer to Google Earth using the following website and link:  
<http://www.gelib.com/ng-topo.htm>
2. Open the Mars contour map found here:  
[http://pubs.usgs.gov/imap/i2782/i2782\\_sh2.pdf](http://pubs.usgs.gov/imap/i2782/i2782_sh2.pdf)

### **Directions/Questions:**

*Earth Fluvial Channels*

1. Open Google Earth:
  - a. Have the students get their bearings on Earth by centering their map/viewer on the following coordinates:  $38^{\circ}27'N$ ,  $109^{\circ}41'W$ , near Pyramid Butte, UT.
  - b. What is the major river in the area?
  - c. Find Dripping Spring (southeast of Pyramid Butte). What is the flow direction from Dripping Spring to the nearby major river?

How do the contour lines indicate the flow direction? Sketch an example below of what the contour lines look like in relationship to the stream:

- d. If the students were to hike from Pyramid Butte to the nearby campground in the northeast, would they be hiking uphill or downhill? Have them explain their reasoning.



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- e. Follow the meanders of the major river channel. How are the contours drawn near the river? Do they follow the river? Cross the river? Explain the reason why the contours are drawn that way.
- f. Using the ruler tool, estimate the distance in miles from Pyramid Butte to Musselman Arch to the southwest.
- g. Zoom in on the Goosenecks of the major river. Zoom in enough to see the annotated hand-drawn sand bars of the river. Explain the origin of the sand bars and whether or not you could hike out of the Goosenecks easily.
- h. Is the white area where the words “Goosenecks” are written an area of relief or a depression? Have students explain their reasoning.

### *Mars Fluvial Channels*

2. Using the Mars contour map, find Valles Marineris. Look northeast of Valles Marineris, around the 330E/30W longitude line and the Martian equator.
  - a. What features stand out/are enhanced by the contour data (mountains, rivers, craters etc.)?
  - b. Are there any areas that are similar to a fluvial channel? If so, screen capture an image and paste here or have the students sketch what they see as evidence of a fluvial channel.

