GEO203 Fall 2009

**Lab 11**

**Geomorphology:**

**Were Earth-like river processes ever present on Mars?**

In this exercise, you will compare rivers on Earth to channel-like features on Mars, and consider whether Earth-like river processes were ever present on Mars.

The purposes of this exercise are to 1) become familiar with some geomorphologic features of rivers, 2) get introduced to ArcGIS and 3) learn about the “geo”logy of Mars.

In Part Ia of the lab, we use ArcVIew GIS to analyze characteristics of Stony Brook, the local stream that runs across bedrock geology that you have become familiar with during the Stony Brook field trip and the local geology field trips. In Part Ib, we graduate to major river systems in North America.

In Part II, we move on to Mars and use the same tools to compare characteristics of channel-like features on the surface of Mars, to river systems on Earth.

To get started, open up ArcView, then go to the View/Toolbars and check the following toolbars:

* Main Menu
* 3D Analyst
* Draw
* Editor
* Spatial Analyst
* Standard
* Tools

# Earth

# Stony Brook – our local stream

# In ArcView, open the *StonyBrook.mxd* file and, explore and become familiar with the software. For example, zoom in and out, pan, activate and explore the bedrock geology layer, etc. Note that distances in this file are in feet.

# What is the resolution of the topographic data for this ArcView project? (Zoom waaaaaaaaay in and use the measuring tool to determine the diagonal length of one pixel). one pixel = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

# Make and print out a stream profile for Stony Brook (see Appendix A)

# Why is the profile somewhat jagged and not smooth?

# On the stream profile printout, determine stream gradients for Stony Brook: the steep part, the shallow part, and an average.

# Show your work on the profile printout.

# Add the data to the class spreadsheet.

# Consider the underlying geology and discuss why the profile of the Stony Brook changes abruptly in a couple of places, instead of changing in a smooth manner.

# Using the figures provided, determine the highest stream order of the Stony Brook/Millstone/Raritan River system: \_\_\_\_\_\_\_\_\_\_\_ Record this value on the class spreadsheet.

# Other U.S. Rivers

# Load the *USRivers.mxd* file into ArcView and explore it by zooming in and out, panning, etc.

# What is the resolution of the topographic data for this ArcView project? (Zoom waaaaaaaaay in and use the measuring tool to determine the diagonal length of one pixel). one pixel = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

# Choose a river, then make and print the stream profile for your river (see Appendix A).

# Why is the profile jagged and not smooth?

# On the stream profile printout, determine the average stream gradient for your river:

# Show your work on the profile printout.

# Add the data to the class spreadsheet.

# Fill out the class spreadsheet for your river

# Break for brief class discussion of other characteristics of Earth river systems:

# Drainage density = the line length of all streams in a drainage basin divided by the area of the drainage basin. Typical values for Earth range from .07-0.2 km-1

# What feeds water into Earth’s river systems?

# Hypsometric curve for Earth (Appendix D)

# Mars

# Load the *Mars.mxd* file into ArcView and explore it. It includes 3 sets of data (see Appendix C describing MOLA, CTS and THEMIS data).

# *(If MOLA data is not shown in gradations of color: Right click MOLA, choose Properties, calculate statistics if asked, click the Symbology tab, click and then unclick “Invert,” and then click Apply.)*

# Relative dating of the area of interest – on a separate sheet of paper, describe the (relative) geologic history of the area, giving supporting evidence: for example, by printing out and annotating images of specific areas. You should include relationships between lava flows, channel systems and different generations of craters.

# Channels on Mars

# What is the resolution of the topographic data for this ArcView project? (Zoom waaaaaaaaay in and use the measuring tool to determine the diagonal length of one pixel). one pixel = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

# Pick a channel and trace it, then turn it into a graphic feature (Appendix B).

# Make and print out the profile of this channel (Appendix A).

# Why is the profile jagged and not smooth?

# On the channel profile printout, determine the average stream gradient for your channel:

# Show your work on the profile printout.

# Add the data to the class spreadsheet.

# Using the figures provided, determine the highest stream order of Martian channels in this area: \_\_\_\_\_\_\_\_\_\_\_ Record this value on the class spreadsheet.

#

# Drainage density

# Hypsometric curve (Appendix D)

# Lab report - compile the following, in the order below:

* This completed handout.
* Your Stony Brook topographic profile, with worked-out gradients (item I.a.v.)
* Your US River topographic profile, with worked-out gradient (item I.b.v.)
* Your Mars channel topographic profile, with worked-out gradient (item II.c.v.)
* The class spreadsheet.
* Response to relative dating of Mars geologic events (item II.b)
* A 1-2 page discussion of evidence for Earth-like river systems on Mars, at some time in the past, referring to data and images produced in this lab.

**Appendix A: Making a stream/channel profile with ArcView**

1. On the main toolbar, click the “Clear Selected Features” tool.
2. On the Table of Contents, click the box for the river or channel for which you want to make a profile. Unclick all the other rivers or channels.
3. On the Table of Contents, select (highlight) the river or channel for which you want to make a profile
4. On the main toolbar, click on the “Select Features” tool and then on the map, select (click) on the river or channel for which you want to make a profile (it will become highlighted in a light blue color).
5. On the 3D analyst toolbar, click the down-drop menu and choose “Convert”, then “Features to 3D”.
6. In the dialog box that comes up, carefully specify the appropriate a) input features, b) Raster or TIN surface, and c) output features (you might call it Delaware3D, for example). Then click OK. A new item (named whatever you specified in “output features”) will appear in the Table of Contents.
7. On the main toolbar, click the “Clear Selected Features” tool.
8. On the Table of Contents, unclick the box for the original river or channel, and click the box for the new item.
9. On the Table of Contents, select (highlight) the new item.
10. On the main toolbar, click on the “Select Features” tool and then select (click) on the river or channel in question (so that it becomes highlighted in a light blue color).
11. ON the 3D Analyst toolbar, click the “Create Profile Graph” tool.
12. Double-click on the graph that is produced, and add an appropriate title.
13. Drag the corners of the graph to enlarge it, then right click and you’ll get a Print Preview dialog box. Close it if you are not satisfied with the Print Preview, and adjust the size of the graph again.
14. When satisfied with the Print Preview, specify the appropriate printer and click Print.

**Appendix B: Drawing a channel and converting it to a graphic feature**

1. On the map, zoom into one end of the channel that you want to draw.
2. On the Drawing toolbar, click the appropriate down-down menu (there are several) and choose the “New Line” tool.
3. On the map, start clicking along the channel. Use the keyboard arrow keys to move the map around, and the mouse wheel to zoom in and out as you draw.
4. When you get to the end of the channel, double-click to end the line. ArcView puts a dashed rectangle around the feature.
5. Go back to the Drawing toolbar, click the appropriate drop-down menu (there are several) and chose “Convert Graphic to Feature”.
6. In the dialog box that appears:
* Input an appropriate name in the “Output shapefile or feature class” box.
* And click the box for “Automatically delete graphics after conversion.
* Then click OK.
1. In the next dialog box that appears, click “Yes” in response to “Do you want to add the exported data to the map as a layer”. ArcView then adds the item to the Table of Contents.
2. To change the color or line-width of the line you have drawn, in the Table of Contents, double-click on the name of the item.
3. In the dialog box that appears, click the Symbology tab, then double-click the “Symbol” box to bring up a dialog box to change the color, line width, etc. When satisfied, click Apply, then OK.

**Appendix C: Sources of Mars Data**

**MOLA (Mars Orbiter Laser Altimeter)** *on the Mars Global Surveyor*

 The Mars Global Surveyor (MGS) launched on November 7, 1996. It traveled towards Mars for 309 days, entering orbit on September 12, 1997…Starting in March, 1998, MGS started making pole-to-pole observations of the planet. Its goal is to map the entire Martian globe, laying the foundation for 10 more years of NASA missions. Global Surveyor's role is to determine the geology and perhaps the past history of Mars and its climate. It is designed to compile global maps of Mars and collect data on its atmosphere, surface composition, interior and evolution.

MOLA, the Mars Orbiter Laser Altimeter, is an instrument on the Mars Global Surveyor spacecraft. It collected altimetry data about the height of surface features on Mars until June 30, 2001.

 The altitude determination process used by MOLA works by measuring the time that a pulse of light takes to leave the spacecraft, reflect off of the surface of Mars, and return to MOLA's collecting mirror. By multiplying the reflection time by the speed of light, scientists can calculate Surveyor's altitude above the local terrain to within 30 meters (98 feet) or better.

*http://mola.gsfc.nasa.gov/about.html*

**THEMIS (**Thermal Emission Imaging System**)** *on the Mars Odyssey spacecraft*

 2001 Mars Odyssey is part of NASA's Mars Exploration Program, a long-term effort of robotic exploration of the red planet. The opportunity to go to Mars comes around every 26 months, when the alignment of Earth and Mars in their orbits around the sun allows spacecraft to travel between the two planets with the least amount of energy… The orbiter launched from Kennedy Space Center on April 7, 2001 and arrived at Mars on October 24, 2001. The orbiter spent the next several months achieving a circular mapping orbit by aerobraking (dipping into the atmosphere to slow and shrink the orbit). Aerobraking concluded in early February 2002, and primary mapping operations began a few weeks later.

 …The Odyssey orbiter has also provided a communications relay for the Mars Exploration Rovers, Spirit and Opportunity, transmitting 85% of the data from the rovers to Earth. Odyssey will continue to support the rovers and future landed missions to Mars throughout its extended mission. Scientists and engineers will also use Odyssey images and data to identify potential landing sites for future Mars missions as it did for the 2003 rovers.

 Mars Odyssey carries three main science instruments: The [Gamma Ray Spectrometer (GRS)](http://grs.lpl.arizona.edu/), the Thermal Emission Imaging System (THEMIS), and the [Mars Radiation Environment Experiment (MARIE)](http://marsprogram.jpl.nasa.gov/odyssey/technology/marie.html)…The Thermal Emission Imaging System (THEMIS) combines a 5-wavelength visual imaging system with a 9-wavelength infrared imaging system… The instrument's multi-spectral approach … enables 100-meter (328-feet) images of martian terrain to be captured in each pixel, or single point, of every image.

[*http://marsprogram.jpl.nasa.gov/odyssey/overview/*](http://marsprogram.jpl.nasa.gov/odyssey/overview/)

**CTX (Context Camera)** *on the Mars Reconnaissance Orbiter spacecraft*

 NASA's Mars Reconnaissance Orbiter (MRO) [blasted off](http://mars.jpl.nasa.gov/mro/mission/tl_launch.html) from Cape Canaveral in 2005, on a search for evidence that water persisted on the surface of Mars for a long period of time. …After a seven-month [cruise](http://mars.jpl.nasa.gov/mro/mission/tl_cruise.html) to Mars and six months of [aerobraking](http://mars.jpl.nasa.gov/mro/mission/tl_aerobraking.html) to reach its science orbit, Mars Reconnaissance Orbiter began seeking out the history of water on Mars with its [science instruments](http://mars.jpl.nasa.gov/mro/mission/sc_instru.html). The instruments zoom in for extreme close-up photography of the martian surface, analyze minerals, look for subsurface water, trace how much dust and water are distributed in the atmosphere, and monitor daily global weather…The Context Camera (CTX) on the MRO is designed to obtain grayscale (black & white) images of Mars at 6 meters per pixel scale over a swath 30 kilometers wide.

 In its survey of the red planet, the Mars Reconnaissance Orbiter is increasing tenfold the number of spots surveyed close-up. One of the orbiter's cameras is the largest ever flown on a planetary mission. Though previous cameras on other Mars orbiters could identify objects no smaller than a school bus, this camera can spot something as small as a dinner table. That capability has allowed the orbiter to identify obstacles such as large rocks that could jeopardize the safety of future landers and rovers, including the Phoenix mission. Its imaging spectrometer looks at small-scale areas about five times smaller than a football field, a scale perfect for identifying any hot springs or other small water features.

**Appendix D**