Lab 11: Using Google Earth to interpret landforms on Mars and Earth

EPSC 240, Geology in the Field

Nov 14, 2018

Due date: Wednesday Nov 21

Meet: 1:35 pm in FDA 348

Bring: Laptop with Google Earth Pro already installed

Wear: Your choice

Instructions: Turn in answers to all **bold** questions.

Open Google Earth or Google Earth Pro. Find the little planet button on the toolbar. Select Mars. Enter "Olympus Mons" in the toolbar and Google will fly you to Olympus Mons! You will have to zoom out to see the whole thing, because it is so big (largest mountain in the solar system).

1. **Give the lat/long of the highest point on Olympus Mons**. Note that since there is no "sea level" on Mars, the 0 m elevation used by Google Mars is the Mars Global Datum.
2. Click the ruler button, and select Circle. Click on the centre of the mountain and drag to expand a circle to measure the area of Olympus Mons. **What is the area?**
3. The summit of Olympus Mons is marked by 6 nested calderas (circular collapse features formed when a magma chamber is emptied below the surface). The volume of the calderas provides an estimate of the volume of magma extruded in an eruption. **What is the total volume of the caldera complex?**
4. Navigate just south of the summit calderas to Pangboche Crater, an impact crater, where you will see a strip of higher-resolution imagery which crosses the east side of the crater (gray strip; from the HiRISE High Resolution Imaging Science Experiment, the "best camera ever sent to another planet"). Imagine as a planetary geologist, you want to know what it would look like to stand inside Pangboche Crater and look up at the walls.
   - Zoom around the edge of the crater and find a place where you can see the layering (lava flows) in the crater walls. This will probably be near the top of the crater, where the walls aren't covered with debris/talus.
   - Rotate your view by grabbing the N on the compass at the upper right corner of the map, and pulling it around until your perspective is lava layers at the top of your view, with your back (bottom of screen) toward the centre of the crater.
   - Click and hold on the arrows around the eye in the middle of the compass to change the plunge of your view from the default (looking straight down) to look toward the horizon to the south (use up arrow) until you can see the rocky ridges extending into the crater. If at any time you get lost, press R and the compass will spin back to north and the view will rotate back to straight down.
   - Use the arrows around the hand (below compass) to pull yourself closer to the ridges until you can see some stratigraphic layers. These show the layers of lava flows which successively built the huge edifice of Olympus Mons. They are of similar thickness to lava flows in some areas on Earth. **Use the Ruler > 3D Path tool to estimate the average thickness of the lava flows.**
   - When you are done, press the R key on the keyboard to return to a N-up, downward facing view.

   Enter the coordinates 33.116, -108.847 into the search box. This should bring you to an area of interesting topography, with wavy faults running ~NNE-SSW across the landscape. Zoom out to an eye altitude of about 80 km. Using Ruler>Path, draw a path perpendicular to the faults. Click the box to "Show Elevation Profile". **What is the average height of the fault scarps** (scarp = the topographic expression of the throw (vertical offset)) **of the Martian faults?** Since there is no erosion on Mars, we can assume that the height of a scarp is equivalent to the throw on the fault.

5. **What is the average spacing of the faults?** (in map view, measured perpendicular to the strike direction)
6. There are some smaller craters in the area - **Are they older or younger than the faults?**
7. Based on the shape, size, proportion and location of these craters, **are they volcanic or impact craters? Explain your answer.**

Now let's visit some similar features on Earth, where the landforms are also effected by erosion, wind, weathering, plant growth, and human modification. Use the little planet button to get back to your home planet. Search for Ubehebe Crater. The name Ubehebe means "Big basket in the rock". This feature formed about 600 years ago due to a steam-driven explosion when magma met ground water (a *maar*). The magma fragmented into pumice and ash and forms the black layers of *pyroclastic ejecta* covering the landscape all around Ubehebe. Before the eruption and maar formation, the valley was full of Pleistocene lake silts (tan coloured) which overly Miocene conglomerates (reddish).

8. Part of the crater wall is covered with black ejecta, and the individual layers represent pulses of volcanic eruption. **How thick are these layers? How do they compare to the volcanic layers on Olympus Mons?**
9. On the north and east crater walls, a fault visible between the Pleistocene lake sediments and the Miocene conglomerates. **What is the orientation of the fault? Is it a normal fault, reverse fault, or strike-slip fault? Use Ruler > Line to find the length and bearing of straight lines. Check the bedding along the fault for any drag features which might help confirm your answer.**
10. **How large is the area still covered by ejecta from the Ubehebe eruption (in km^2)?**

Now search for the town of Tulelake, in northern California. Zoom out until you can get a clear view of the landscape to the north and east of the town. Although the land surface has been affected by erosion, soil development, forestry and agriculture, you may be able to discern fault scarps similar to those on Mars. To search through images taken at different times (different seasons can be helpful!) click the button at the top of the screen which has an icon of a clock with a counterclockwise arrow going around it.

11. **Measure the scarp height and spacing of these faults. How do they differ from similar features on Mars?**
12. **Can the differences be explained by earth's erosion? Or are the fault systems fundamentally different (e.g., in length/height/spacing ratios?**

Now search for Mexican Hat, Utah. This is a beautiful region of the Colorado Plateau which is within the Navajo Nation. Just 3 km east of the town of Mexican Hat, there is a striking ridge of gray and red sedimentary rocks: The Raplee Anticline. Zoom in on this ridge.

13. Using the tools you have learned for measuring length and orientation of lines in Google Earth, follow the steps below to **measure the strike and dip of the sedimentary layers** near where the San Juan River bends close to the ridge.

- Study the sedimentary beds closely and pick out one bedding contact you can reliably follow for some distance across the landscape (at least 200 m).
- Go to Ruler>Line. Place the mouse very precisely on the bedding contact at someplace that is not too high and is not too low, make note of the elevation of that point (displayed at the

bottom right of the window) and click to place one end of the line. This is easiest to do if you are looking straight toward the ridge from the west, at a low elevation.

- Move the mouse some distance along strike (100-200 m away) and move the mouse along the contact until you find another point at the exact same elevation. Click again to end the line.
- Read the strike of the line from the "Heading" in the ruler window.
- Click Save and enter a name for your line. Go to the Altitude tab and experiment a bit. If your line is 'clamped to the ground', it will curve over topography - so this is not like a strike line, which is straight and goes right through the topography. Try 'absolute' to see your strike line in its true position.
- Rotate the map around, and change your elevation, so that you are looking straight on at the side of the ridge, to see your strike line in place.
- To find the dip, you need to measure the horizontal and vertical distance from your strike line to another point on the same sedimentary layer. Press 'R' to return your view to vertical.
- Go to Ruler>Line. Click on the strike line somewhere where it is not coincident with the earth's surface. Move your mouse carefully, watching the Heading, to make sure you are measuring in the dip direction (perpendicular to strike) and find the same bedding layer. Click to end your line, making note of the elevation, length, and heading.
- Use the horizontal length of this line, along with the change of elevation, to find the true dip.
- If at any time you need to return to this window for a saved line, right click (or control-click) on your line in the menu bar at the side, and choose 'Get Info'.

14. Go to mrdata.usgs.gov/geology/state and download the .kml file for the Utah geologic map. Load this in Google Earth. **What rock units make up the Raplee Anticline? How old are they?**

15. **What is the trend and plunge of the axis of Raplee Anticline?**

16. Raplee Monocline was formed when a thrust fault at depth caused deformation of the surface layers. **Based on the asymmetry of the fold, which way would you guess the fault dips?**

Go to http://www.mndm.gov.on.ca/en/mines-and-minerals/applications/ogsearth#simple-table-of-contents-4 and download the Surficial Geology map of Ontario and the Mineral Deposits Map of Ontario. Open both in Google Earth. First, have a look at the Bedrock map (uncheck the file for the Mineral Deposits map in "Temporary Places" if it is covering the Bedrock geology map.) Zoom out so you can see the whole province. If you mouse over or click on different areas of the map, geological information will pop up. You may find it useful to google a Geologic Timescale to help you understand the relative ages of the rocks, and look up definitions for any unfamiliar terminology.

17. Northwest Ontario is dominated by exposures of 'The Canadian Shield', which is a general name for the extremely old (Archean) rocks which make up the core of North America, but are mostly buried under younger rocks. These rocks are structurally complex, having been through many episodes of deformation. **What are the major lithologies (rock types) of the Canadian Shield?**

18. To the northeast, along the shore of Hudson Bay, the rocks change. **What type of contact divides the Archean rocks from the rocks along the shore of Hudson Bay? How old is this contact?**

19. Now turn off the bedrock geology layer, and look at the Google Earth satellite image of the landscape. **Describe any differences you see in the geomorphology between the two areas of different bedrock geology.**

20. Turn on the mineral deposits layer. **How does the distribution of mineral deposits relate to the bedrock geology patterns? Speculate on the cause of any relationships you find.**