

Virtual Geologic Mapping Exercise at McCauley, WV

This virtual mapping exercise focuses on a 7 square kilometer field area just east of the town of Baker in northeastern West Virginia (Figure 1; approximate latitude: 39.05°, longitude: -78.72°). The basic geology consists of a layered sequence of Silurian to Devonian clastic and carbonate rocks that are complexly folded. Virtual field investigations and construction of a geologic map will be facilitated by using the Google Earth virtual globe. The exercise works best with the web version of Google Earth, which can be accessed using the Chrome, Firefox, Opera, or Edge browsers at the URL below:

<https://earth.google.com/web/>

Note that the web version of Google Earth does not work with Safari or Internet Explorer. The exercise will work on the desktop version of Google Earth, but some of the GE tools are located in alternate places and work slightly differently.

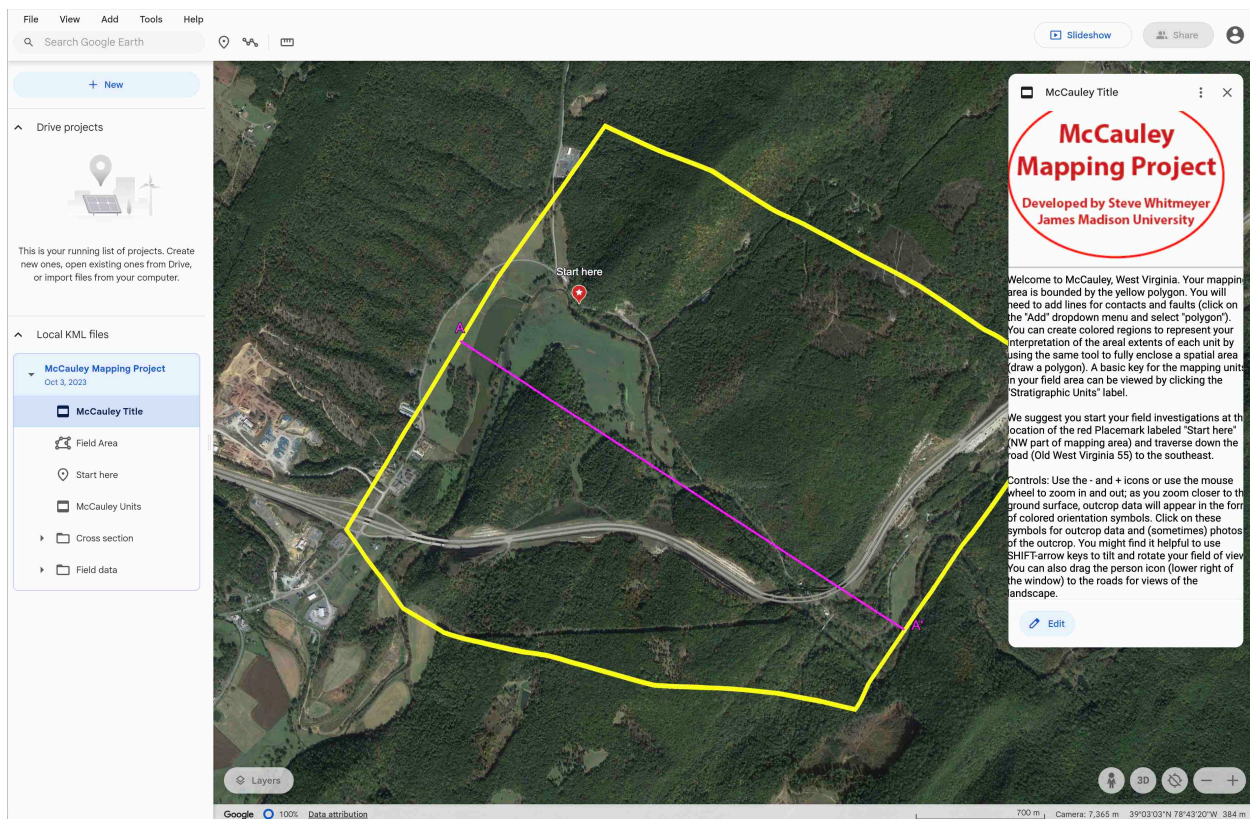


Figure 1: McCauley field area outlined by the yellow polygon and title with project information, as seen in web Google Earth

The McCauley mapping exercise makes use of a KML file of field data, which can be downloaded from the URL below:

<https://educ.jmu.edu/~whitmesj/Fieldwork/McCauley/McCauleyMappingProject.kml>

Exercise Goals:

1. In Google Earth, virtually traverse the full field area, visiting outcrops (indicated by colored orientation symbols or dots) and collecting field data.
2. Build a geologic map in Google Earth by drawing contacts between lithologic units. Draw polygons, colored by unit, to represent the interpreted regions for each lithologic unit. Fold axes and/or faults should be indicated. Upon completion, the full mapping area, as denoted by the large yellow polygon, should be colored. Neatness counts!
3. Interpret the geology of the field area by writing detailed descriptions of the lithologic units, constructing a cross-section that interprets the geology of the area, and writing a memoir/summary of the geologic history of the field area.

To investigate the field area, start by opening Google Earth in your web browser, using this web address: <https://earth.google.com/web/>. Once you are in Google Earth click on the “File” dropdown menu at the upper left side of the window, select “Import KML / KMZ file”, and import the “McCauleyMappingProject.kml” file from your computer (see Figure 2.) If you haven’t downloaded the file to your computer yet, it is available here: <https://educ.jmu.edu/~whitmesj/Fieldwork/McCauley/McCauleyMappingProject.kml>.

Once the KML file is loaded, your window should look similar to Figure 1.

Now you can start investigating the field area; the boundaries of the field area are indicated by the yellow polygon. We suggest that you start at the location of the red Placemark, entitled “Start here” (northwest region of mapping area) and traverse down the road to the southeast. In Google Earth you can use the - and + icons (lower right in your window) or use your mouse wheel to zoom in and out. As you zoom closer to the ground surface, outcrop data will appear in the form of colored orientation symbols or dots. Click on these symbols for outcrop data and (sometimes) photos of the outcrop.

You might find it helpful to use <SHIFT>arrow keys to tilt and rotate your field of view; clicking on the 3D button in the bottom right will also tilt the view.

You can also drag the white person icon (lower right of the window) to the roads for StreetView imagery of the landscape.

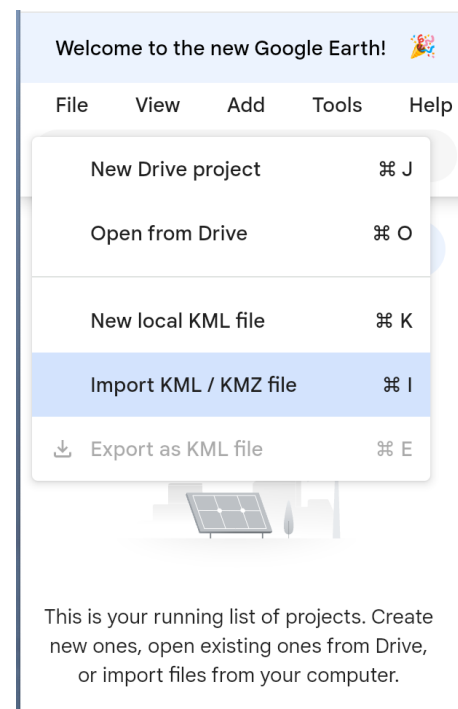


Figure 2. Loading a KML file in Google Earth

You will notice that the geologic field data only appears when you are zoomed close to the ground surface. A basic key for the mapping units in your field area can be viewed by clicking the "McCauley Units" label below the "McCauley Mapping Project" menu at the left (also see Figure 6). However, you will need to visit the virtual outcrops to get details on the features of the lithologic units in order to complete your lithologic descriptions (see Exercise Deliverable #2 below.)



Figure 3. Examples of Placemark, black contact lines, and colored polygons for unit areas.

To complete your geologic map of the field area you will need to add lines for contacts and faults (click on the "Add" dropdown menu and select "Polygon"). You can create colored regions to represent your interpretation of the areal extents of each unit by using the same tool to fully enclose a spatial area (draw a polygon.) Note that you can mark key locations for use when drawing your geologic map by adding a Placemark from the same "Add" menu; see Figure 3 for examples. Note that all of the new features that you add will be viewable from any zoom extent. Thus, you can zoom in to draw your features or mark points with Placemarks and then zoom out to see how your map interpretation looks. Features can be edited by clicking on the feature and then clicking on the pencil "Edit" button in the pop-up balloon. Features can be deleted by clicking on the 3 vertical dots in the popup balloon, and then selecting "Delete".

Remember that a completed geologic map will have the full mapping area marked by contacts and faults that bound colored regions which represent your interpretation of the areal extent for each unit. There should be no blank space within the yellow boundary polygon once your map is completed.

Draft and final versions of your geologic map can be saved as KML files on your computer by clicking on the "File" dropdown menu and then selecting "Export as KML file" (see Figure 4). We suggest that you iteratively save multiple versions of your draft geologic map to back up your work. The final version of the KML file is what you will turn in as Deliverable #1.

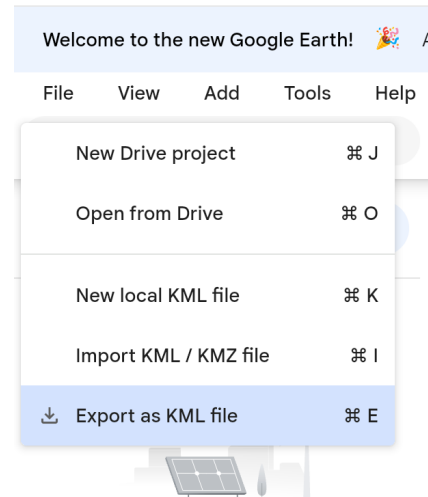


Figure 4. Example of how to save your geologic map as a KML file on your computer by clicking on the "File" dropdown menu and selecting "Export as KML file".

This is your running list of projects. Create new ones, open existing ones from Drive, or import files from your computer.

If you are not satisfied with the native background Google Earth imagery, you can download a KMZ file that has alternative basemaps (a USGS 1m shaded relief image, and a section of a 1999 USGS topo map) that you can use. These alternate basemaps can be downloaded from here:

<https://educ.jmu.edu/~whitmesj/Fieldwork/McCauley/McCauleyBasemaps.kmz>.

Load this file in Google Earth from the “File” dropdown menu the same way as you loaded the McCauleyMappingProject file (see Figure 2). Then select the background map you want to use by clicking on the eye symbol for that map. That will fix the chosen basemap to the Google Earth ground surface, after which you can go back to the McCauleyMappingProject file to work on your geologic map.

Once you have completed your geologic map, you will need to draw a vertical cross section interpretation of the subsurface geology. At the left side of your Google Earth window, there is a label entitled “cross section”, and if you click on the “eye” symbol, a purple cross section line will appear trending from northeast to southwest across the middle of the field area. You can use the blank cross section box included with this packet to draft your cross section, by loading the box into a drawing program like Illustrator, PowerPoint, or Google Slides. You can rotate the Google Earth view of the cross section line in the field area to horizontal on your screen and then zoom to match the length of the cross-section line to the width of the cross section box (see Figure 5.) That will help you to accurately transfer your contacts and unit areas from the Google Earth geologic map to the surface topographic trace (the squiggly line in the box in Figure 5) in your cross section box. If you are unclear on how to draw an accurate cross section that best represents the geology of your field area, please talk to your instructor.

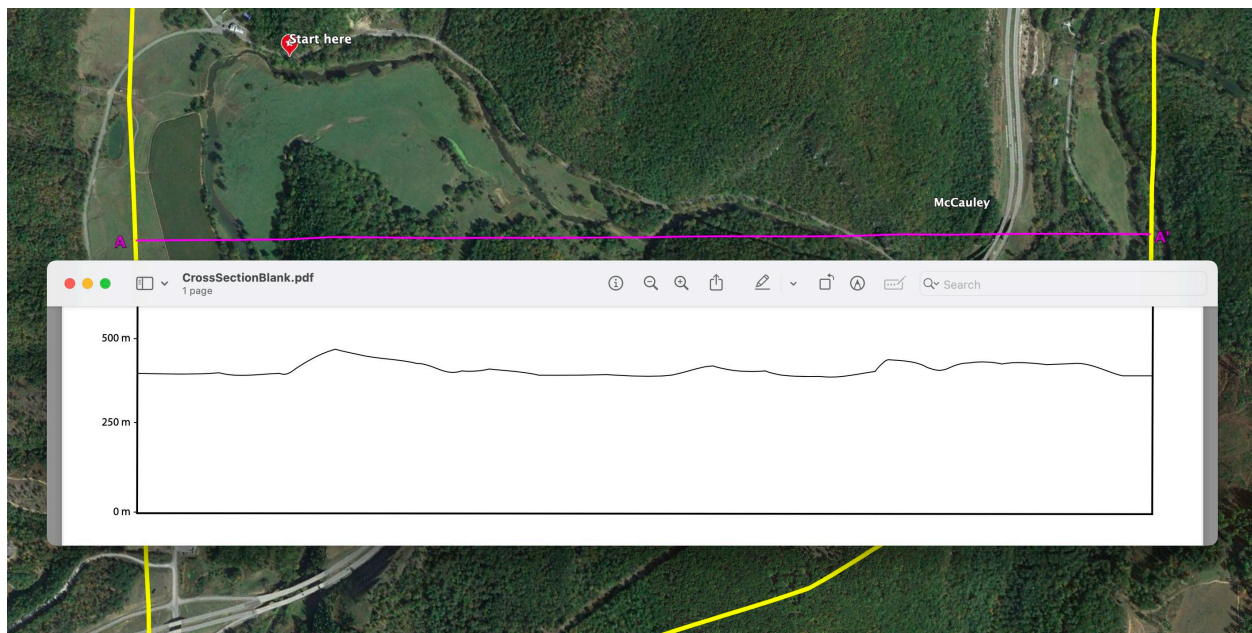


Figure 5. Example of aligning the blank cross section box PDF image with the purple cross section line in Google Earth.

Exercise Deliverables:

- 1) The KML file of your completed geologic map of the McCauley field area.
- 2) Descriptions of the lithologic units in the field area. These descriptions will use data from the field area and expand on the basic descriptions in Figure 6.
- 3) A cross section from A (northwest) to A' (southeast) across the field area; you can use the blank cross section box included in this packet and load it into a drawing program (like PowerPoint, Illustrator, or Google Slides) to draw your geologic interpretation.
- 4) A neat and legible memoir/summary of the geology of your mapping area. Good memoirs start with the location and characteristics of a field area, present the field data and observations, and then discuss/interpret that data in a regional tectonic context.

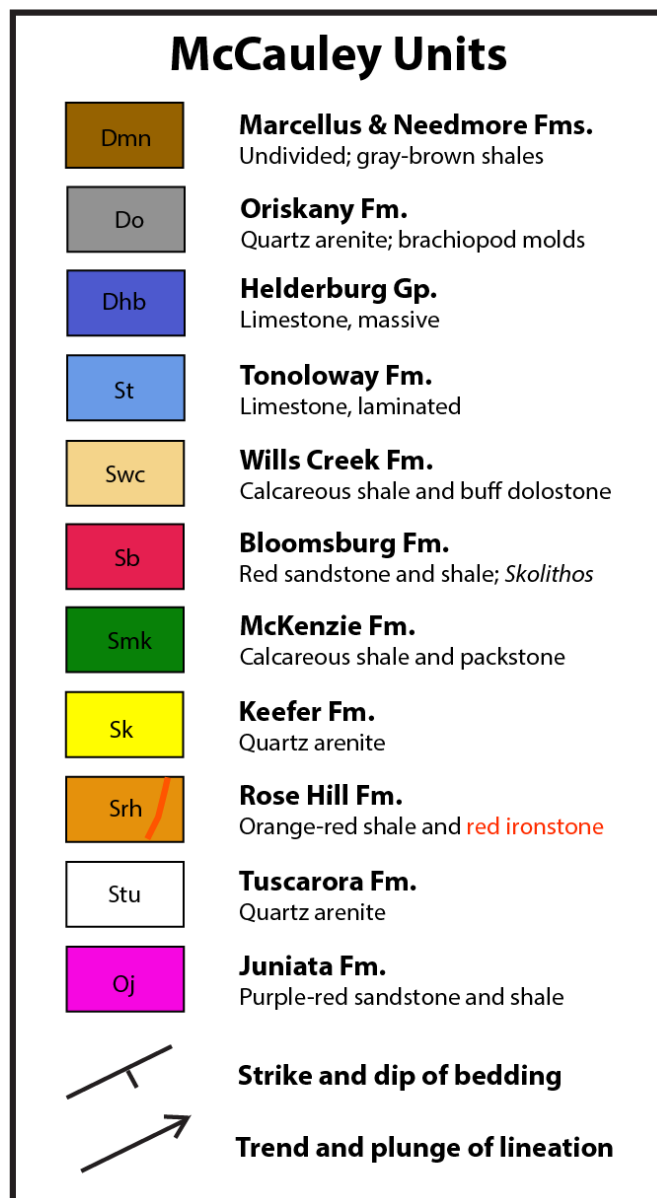


Figure 6: Lithologic units and symbology in the McCauley field area.

Selected References:

Bocan, J.M. and Bentley, C., 2017, West Virginia Geologic Transect: West Virginia Geological and Economic Survey,

URL: http://www.wvgs.wvnet.edu/www/geology/geologic_transect.html.

Hunt, P.J., McDowell, R.R., Blake, Jr., B.M., Toro, J., and Dinterman, P.A. 2017. What the H!? Paleozoic Stratigraphy Exposed, Pre-Meeting Field Trip Guide for the 46th Annual Meeting, Eastern Section of the American Association of Petroleum Geologists (ESAAPG), Morgantown, West Virginia, September 24 and 25, 2017: West Virginia Geological and Economic Survey, Field Trip Guide FTG-9, 87 p.

Haynes, J.T., Pitts, A.D., Doctor, D.H., Diecchio, R.J., and Blake, B.M. 2018. Appalachian Basin Stratigraphy, Tectonics, and Eustasy from the Blue Ridge to the Allegheny Front, Virginia and West Virginia, West Virginia Geological and Economic Survey, FTG-10, 86 p.

United States Geological Survey. 2021. United States Geological Survey 3D Elevation Program 1 meter Digital Elevation Model, distributed by OpenTopography, <https://doi.org/10.5069/G98K778D>. Accessed 2024-02-09.

Tilton, J.L., Prouty, W.F., Tucker, R.C., and Price, P.H. 1927. Hampshire and Hardy Counties. West Virginia Geological Survey, County Geologic Report CGR-8, Morgantown, West Virginia.

Woodward H. P. 1941. Silurian System of West Virginia, West Virginia Geological Survey, Report XIV, 326 p.

Woodward, H.P., 1943, Devonian System of West Virginia: West Virginia Geological Survey, Report XV, 655 p.

Supplemental Data:

The next two pages consist of supplemental data that summarize measured sections from the McCauley field area, as reported in Tilton et al. (1927), Woodward (1941), and Woodward (1943.) These measured sections can be consulted for reference when considering the relative thicknesses of lithologic units in the field area.

Woodward (1941, 1943) measured sections of Baker Quarry area

Marcellus shale	475 ft. (estimated)
Needmore shale	75 ft. (estimated)
Oriskany (Ridgeley) sandstone	250 ft. (estimated)
Helderberg interval	137 ft.
Mostly concealed; 27ft. of cherty Port Ewen at base; interval probably contains Coeymans, New Scotland, Port Ewan, and Port Jervis Formations	
Keyser limestone	69+ ft.
Upper Keyser limestone (incomplete?)	20+ ft.
1. Thin-bedded nodular shaly limestone, top concealed (10+ ft.)	
2. Massive impure semicrystalline knobby limestone (10 ft.)	
Big Mountain shale	19 ft.
3. Shale (interval may be telescoped) (6 ft.)	
4. Hard semicrystalline blue limestone (3 ft.)	
5. Concealed; shaley (10 ft.)	
Lower Keyser limestone	30 ft.
6. Cross-laminated irregular limestone (11 ft.)	
7. Dense medium-bedded blue limestone (8 ft.)	
8. Finely rubbly impure limestone (6 ft.)	
9. Very thin-bedded irregular nodular limestone (5 ft.)	
Tonoloway limestone	443 ft.
Upper Tonoloway	228 ft.
1. Thin-bedded shaly limestone and calcareous shale, ribbony; faulted? (40 ft.)	
2. Blue-gray thin-bedded thin-laminated limestone (65 ft.)	
3. Covered; dip changes? (32 ft.)	
4. Poorly bedded thin-laminated limestone (91 ft.)	
Middle Tonoloway	89 ft.
5. Quite tough massive thin-bedded blue limestone (26 ft.)	
6. Shaly (4 ft.)	
7. Irregularly bedded dark limestone; forms crag (21 ft.)	
8. Same, more deeply weathered (35 ft.)	
9. Brown-weathering cherty laminated limestone; Stromatopora? (3 ft.)	
Lower Tonoloway	126 ft.
10. Covered (8 ft.)	
11. Quite massive thin-laminated blue limestone (36 ft.)	
12. Massive dark limestone; Stromatopora (6 ft.)	
13. Fairly massive thin-bedded laminated limestone (33 ft.)	
14. Rubbly limestone, like Keyser (3 ft.)	
15. Medium-bedded dark-blue thin-laminated limestone (18 ft.)	
16. Medium- to thin-bedded argillaceous laminated limestone (15 ft.)	
17. Rather massive laminated limestone (4 ft.)	
18. Brown dense fairly coarse sandstone (3 ft.)	

Prouty (1927), Woodward (1941) measured sections at McCauley

Wills Creek limestone	458 ft.
1. Concealed, probably shale (83 ft.)	
2. Buff to gray-weathering calcareous shale and argillaceous limestone (220 ft.)	
3. Thin interbedded shales and sandstone (38 ft.)	
4. Coarse gray and buff sandstone (9 ft.)	
5. Sandstone and shale (25 ft.)	
6. Thin-bedded limestone and shale (58 ft.)	
7. Gray thin-bedded sun-cracked sandy shale (25 ft.)	
Bloomsburg red-bed facies	33 ft.
8. Thick-bedded brownish-red to buff sandstone (33 ft.)	
McKenzie formation	244 ft.
9. Buff-weathering sandy and argillaceous shale; thin-bedded argillaceous and calcareous sandstones in 1- to 3-inch bands (210 ft.)	
10. Thin-bedded hard buff-weathering sandstone and arenaceous buff shale; mostly sandstone (4 ft.)	
11. Dark argillaceous and arenaceous shale; weathers buff to gray (15 ft.)	
12. Concealed; probably shale (15 ft.)	
Rochester shale	20 ft.
13. Concealed; dark shale (20 ft.)	
Keefer sandstone	41 ft.
14. Massive gray to white quartzitic sandstone (30 ft.)	
15. Concealed; probably shale (4 ft.)	
16. Thin-bedded quartzitic sandstone (7 ft.)	
Rose Hill formation	410 ft.
17. Olive to gray thin-bedded shale and thin green-gray sandstones, somewhat calcareous and ferruginous at the top; <i>Tentaculites minutus</i> (60 ft.)	
18. Deep-red ferruginous sandstone (ironstone) (12 ft.)	
19. Olive-gray arenaceous shales and argillaceous sandstone (190 ft.)	
20. Same; sandy beds more prominent (15 ft.)	
21. Same; shales predominant (12 ft.)	
22. Mostly hard olive to gray sandstones (10 ft.)	
23. Olive to gray shales with gray interbedded sandstones (111 ft.)	
Tuscarora (White Medina) sandstone	256 ft.
Juniata (Red Medina); top 150 ft. exposed	150+ ft.