

***Geomorphology Lab:  
Rocks, Weathering and Erosional Landscapes***

***author***

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**Audience:** Undergraduates—Sophomore geology majors

**This lab is designed to help students transport basic skills acquired in the introductory physically geology course and apply them to geomorphology.**

## ***Geomorphology Lab: Rocks, Weathering and Erosional Landscapes***

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**Goal:** You will understand the role of lithology and weathering in the development of erosional landscapes.

**Content/concept goals:** At the end of this lab you will be able to:

1. identify principal rock forming silicate minerals and distinguish their relative stability when exposed to weathering.
2. identify sedimentary, igneous and metamorphic rocks and deduce the relative resistance based on mineral composition and texture.
3. relate erosional landscapes to the differential weathering and erosion of rocks of varying strengths.

**Supplies:** Plain and colored Pencils, drafting eraser, previous labs from physical geology

### **Introduction:**

*Rocks support the resistant framework from which erosional landscapes are carved. Cohesive and chemically resistant rocks form steep cliffs, monoliths and ridges while less resistant rocks form basins, swales, and gently slopes. Understanding lithology is the first step in deciphering landscape. Variables influencing stability are both internal (intrinsic) and external (extrinsic). Composition, texture, bedding style, fissility and cleavage are examples of intrinsic factors. In a sandstone, variations in clast composition and in the solubility of cementing agents can make one sandstone inherently stronger than the other. Cleavage in a slate will add pathways for water that are lacking in a hornfels. Granites with abundant biotite or having large variations in crystal size can disintegrate faster than those that don't. External factors such as climate, exposure, and proximity to the ocean will induce different weathering responses for the same lithology. For example, carbonate rocks are quite stable cliff formers in arid regions, but commonly underlie solution features in humid landscapes. This lab is both a review of rocks and minerals and an introduction to the role rocks play in shaping landscapes.*

### **Part I: Silicate Minerals:**

The composition, bonding and structure of silicate minerals determines their stability at the surface. Minerals, such as quartz, which have a low Si:O ratio (1:2) and the greatest number of covalent bonds, are the most stable; whereas minerals, such as olivine, which have a high Si:O ratio (1:4), are least stable. In 1939, Sam Goldich noted that relative rates of weathering are inversely related to Bowen's Reaction series, with minerals crystallizing first weathering first. A quantified version of the Goldich weathering series is shown in Table 1.

Table 1. Mean lifetime of select silicate minerals  
(Modified from Table 7-2, Bloom, 2004, from Lasaga et al., 1994)

Mineral	Lifetime in years of a 1mm Crystal (@ 25°C and pH5)
Quartz	34,000,000
(Kaolinite)	6,000,000
Muscovite	2,600,000
K-feldspar (microcline)	921,000
Na-feldspar (Albite)	575,000
Pyroxene (enstatite)	10,100
Olivine (fosterite)	2,300
Anorthite	112

**Exercise I:** You will have 6 minerals samples to identify. Use your lab book for reference.

Fill out the table using the following instructions:

- I. Neatly draw and color each sample. As with all your labs this is to be completed in pencil.
- II. Determine the hardness ( $>2.5$ ,  $2.5-5.5$ ,  $>5.5$ ) using your fingernail and a glass plate
- III. Breakage. Does the mineral fracture or cleave?
- IV. Other physical properties: habit, color, luster, solubility, etc.
- V. Minerals name: Identify the mineral. Mineral ID tables are in pp. 26-30 of your lab book.
- VI. Determine the mineral's lifetime from Table 1 and state its stability relative to other minerals identified. Estimate a range for any mineral sample not in the table.

Sample	I. Drawing	II. Hardness	III. Breakage	IV. Other physical properties	V. Mineral name	VI. Lifetime/Relative stability
1						
2						
3						
4						

Sample	I. Drawing	II. Hardness	III. Breakage	IV. Other physical properties	V. Mineral name	VI. Lifetime/Relative stability
5.						
6.						
7.						
8.						

**Part II. Rock Identification and relative stability.**

Chosen for you to identify are three igneous rocks (1-3), three metamorphic rocks (1-3) and four sedimentary rocks (1-4). Again use your Lab Manual to aid in identification. Fill out the identification table (next page) for each sample. On a scale of 1 (least stable) to 3 (most stable) estimate the relative stability of each rock and offer an explanation for your conclusion. Assume that these rocks are exposed in the eastern states.

**I. For igneous rocks** circle the appropriate color, texture, and mineralogy. Identify the rock and rate its relative stability relative to the other rocks in the same category. Once you've rated the rocks justify your rating in the explanation box.

**II. For metamorphic rocks** circle the appropriate texture and identify the 2 or three most abundant minerals. If the rock is microscopic the most abundant minerals are clay and sericite (mica).

**III. For sedimentary rocks** circle the appropriate texture, mineralogy and fill out the other fields.

1. Igneous Rock	Name:
Drawing:	Color:
	Texture: aphanitic, phaneritic, vesicular glass
	Mineralogy: felsic, intermediate, or mafic assemblage, other state:
	Relative Stability (1-3)
	Explanation of stability rating:

2. Igneous Rock	Name:
Drawing:	Color:
	Texture: aphanitic, phaneritic, vesicular glass
	Mineralogy: felsic, intermediate, or mafic assemblage, other state:
	Relative Stability (1-3)
	Explanation of stability rating:

3. Igneous Rock	Name:
Drawing:	Color:
	Texture: aphanitic, phaneritic, vesicular glass
	Mineralogy: felsic, intermediate, or mafic assemblage, other state:
	Relative Stability (1-3)
	Explanation of stability rating:

1. Metamorphic	Name:
Drawing:	Color:
	Texture: slaty, phyllitic, schistose, gneissic, non-foliated
	Mineralogy: micas, quartz, amphibole, feldspar, calcite,
	Other (state):
	Relative Stability (1-3)
	Explanation of stability rating:
2. Metamorphic	Name:
Drawing:	Color:
	Texture: slaty, phyllitic, schistose, gneissic, non-foliated
	Mineralogy: micas, quartz, amphibole, feldspar, calcite,
	Other (state):
	Relative Stability (1-3)
	Explanation of stability rating:
3. Metamorphic	Name:
Drawing:	Color:
	slaty, phyllitic, schistose, gneissic, non-foliated
	Mineralogy: micas, quartz, amphibole, feldspar, calcite,
	Other (state):
	Relative Stability (1-3)
	Explanation of stability rating:

1. Sedimentary	Name:
Drawing:	Color:
	Texture: clastic (microscopic, sand, gravel), crystalline, fissile
	Mineralogy: quartz, arkosic, clay, lithic fragments, calcite
	Cement if applicable: calcite, quartz, iron oxide
	Relative Stability (1-3):
	Explanation of stability rating:

2. Sedimentary	Name:
Drawing:	Color:
	Texture: clastic (microscopic, sand, gravel), crystalline, fissile
	Mineralogy: quartz, arkosic, clay, lithic fragments, calcite
	Cement/chemical precipitate: calcite, quartz, halite
	Relative Stability (1-3):
	Explanation:

3. Sedimentary	Name:
Drawing:	Color:
	Texture: clastic (microscopic, sand, gravel), crystalline, fissile
	Mineralogy: quartz, arkosic, clay, lithic fragments, calcite
	Cement/chemical precipitate: calcite, quartz, halite
	Relative Stability (1-3)
	Explanation of stability rating:

4. Sedimentary	Name:
Drawing:	Color:
	Texture: (clastic 1/16-2mm)clastic (>2mm), clastic (fissile), crystalline
	Mineralogy: quartz, arkosic, clay, lithic fragments, calcite
	Cement/chemical precipitate: calcite, quartz, halite
	Relative Stability (1-3):
	Explanation of stability rating:

### PART III: Rocks and Landscapes

#### A. A landscape in the Valley and Ridge of Pennsylvania (Hollidaysburg, Central Pennsylvania)

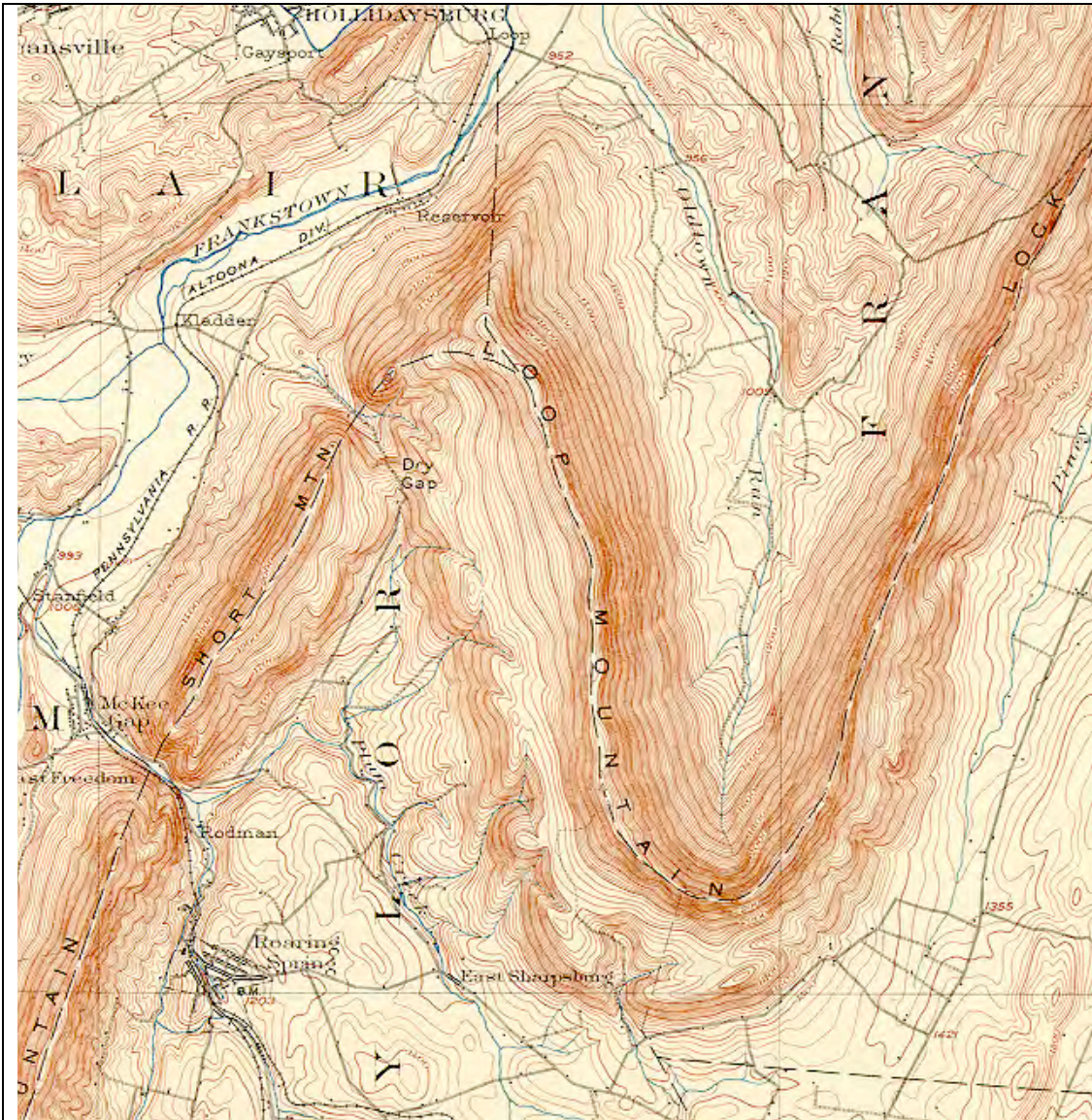


Figure 1. Topographic map of portions of the Hollidaysburg Quadrangle, PA.

This region, underlain by folded shales, sandstones, and limestones, is located in the Appalachian Valley and Ridge Province ([satellite image](#) Geology.com/ Wikimapia [Image](#)) of the United States. The climate is humid temperate.

Answer the following questions:

1. Of the three rock types mentioned above, which is the most resistant?
2. Which are the least resistant.
3. On what do you base your conclusions? Explain.



4. Refer to the map in Figure 1. Describe the topography.
5. Color red the areas you believe are underlain by sandstone. Color yellow the areas underlain by shale and limestone.
6. In regions underlain by sedimentary rocks, bedding orientation and fold patterns control the distribution of lithologies, which influences the grain of the topography. Review the chapter on structures in your physical geology text. Identify the structure exhibited in this quadrangle.
7. Explain why this region is called the Valley and Ridge.

Check your map with the:

Hollidaysburg panoramic movie (URL: [http://reynolds.asu.edu/geomap3d/gm3d\\_hollidaysburg\\_pano.mov](http://reynolds.asu.edu/geomap3d/gm3d_hollidaysburg_pano.mov)) by Stephen J Reynolds (Gallery URL: [http://reynolds.asu.edu/geomap3d/geomap3d\\_gallery.htm](http://reynolds.asu.edu/geomap3d/geomap3d_gallery.htm)).

**Key:**

Sandstones = Ordovician Oswego Sandstone (Oo) and Silurian Tuscarora Sandstone (St)

B. A metamorphic and igneous terrain of the New England Province (Barren Mountain West Quadrangle, Central Maine)

This region in central Maine is underlain by Devonian turbidites (Carrabassett Formation) that were regionally metamorphosed to slate. Following regional metamorphism, these slates were locally metamorphosed to hornfels where they were intruded by late Devonian plutons. The map area below is underlain the Carrabassett Formation and a gabbroic portion of the Onawa pluton, which intruded after regional metamorphism around 403 million years ago. (The hornfels is composed of quartz, feldspar, biotite, andalusite/sillimanite, and cordierite. Silimanite and andalusite are durable aluminosilicate polymorphs having a hardness of 7.5. The Onawa pluton is composed of biotite, hornblende, and plagioclase.)

1. Describe the topography.
2. Which rock underlies the lake and adjacent lowlands? Which rock underlies the mountains?
3. Give an approximate range for the width of the contact aureole in the southwest  $\frac{1}{4}$  of the map area. (Spacing between UTM gridlines = 1000 meters.)
4. Approximate the exposed area of the pluton.
5. The pluton extends northeast covering approximately  $20 \text{ km}^2$  outside the map area. Would this pluton be classified as a stock or batholith? Explain.

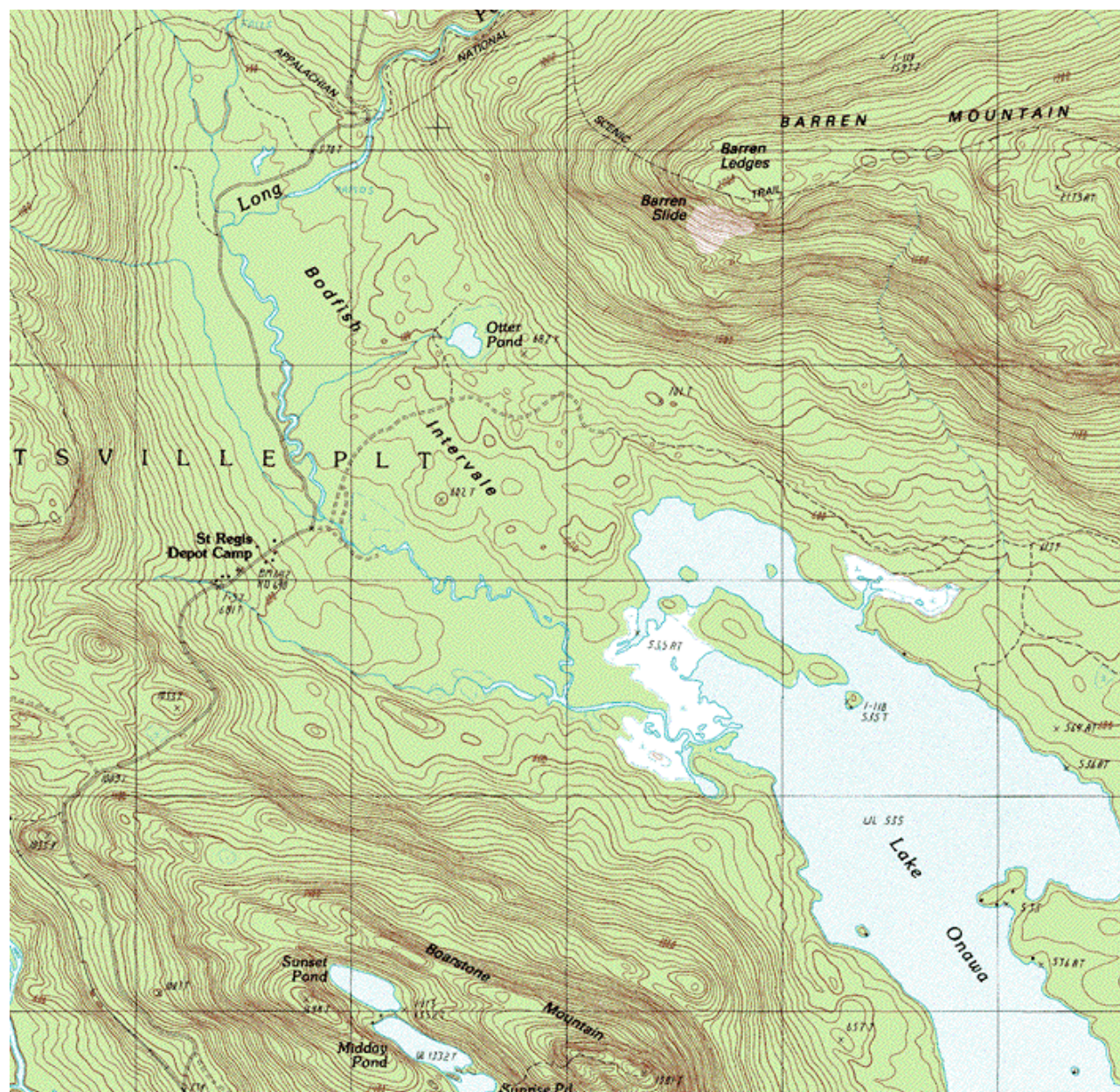


Figure 2. Portion of the Barren Mountain West Quadrangle, Central Maine Appalachians.

Summary:

In the space below summarize what you learned from this lab:

This image shows a single sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

## References

- Bloom, A. L. Geomorphology, a systematic Analysis of Late Cenozoic Landforms (3<sup>rd</sup> Edition): Waveland Press, Inc, Long Grove, Ill.  
Goldich, S.S., 1938, A study in rock-weathering: *Journal of Geology* 46: 17-58.  
Lasaga A.C., Soler J.M., Ganor J. et al. 1994, Chemical weathering rate laws and global geochemical cycles: *Geochim. et cosmochim. acta*. V. 58. № 10. P. 2361–2386.