## Virginia View Curriculum

<table>
<thead>
<tr>
<th>Lesson Plan</th>
<th>Geology of Virginia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade Level</td>
<td>High School, Earth Science</td>
</tr>
<tr>
<td>Applicable Virginia SOL</td>
<td>ES 1, 2, 3, 5, 6, 8, 10</td>
</tr>
<tr>
<td>Summary</td>
<td>This activity begins with students examining a map of Virginia's Provinces, then goes into more depth about the geologic history of Virginia.</td>
</tr>
<tr>
<td>Classroom Materials</td>
<td>This lesson requires computers with ArcGIS 9.3 or 10 and internet access. This lesson is very involved and will require more than one 45-minute class period.</td>
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<tr>
<td>Submitted by</td>
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</tbody>
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### Contact Information

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Teacher Guide

Applicable Virginia SOLs:

ES.1 The student will plan and conduct investigations

ES.2 The student will demonstrate scientific reasoning and logic

ES.3 The student will investigate and understand how to read and interpret maps, globes, models, charts, and imagery

ES.5 The student will investigate and understand how to identify major rock-forming and ore minerals based on physical and chemical properties.

ES.6 The student will investigate and understand the rock cycle as it relates to the origin and transformation of rock types and how to identify common rock types based on mineral composition and textures.

ES.8 The student will investigate and understand geologic processes including plate tectonics.

ES.10 The student will investigate and understand that many aspects of the history and evolution of the Earth and life can be inferred by studying rocks and fossils.

Teacher Preparation:

- Review the background material on Geology of Virginia with students.
- Set up your computer lab with the exercise data. Download Geology_Exercise_Data from the Virginia View website. Unzip the Geology_Exercise_Data folder and copy the folder to a network drive that the students can work from, or copy the folder to the hard drive (C: drive) on each lab computer. For question #5 on the student worksheet, you will need to point students to the correct directory and the Geology_Exercise_Data folder to find the mxd file (map file) to open.
- Print out the Student worksheet for each student or group of students. A key is attached at the end of the exercise.
- Follow the instructions listed in “Procedure: Students and Teacher” to complete the exercise.

A STEP FURTHER: Implement these ideas after going through the exercise on your own.

- A more advanced activity would be for students to copy and paste the attribute table into their own Excel spreadsheet. They could then rearrange the spreadsheet by chronological order and describe the geologic history of Virginia.
Another more advanced activity would be for students to conduct queries on the "Stops on Grand Tour of Virginia" layer. (i.e. select all the stops that have rocks of a certain age, or all the stops that have rocks of a certain type).

**Background Information:**

The geology of a region is a complicated topic. Clues such as types of rocks, geologic structures, ages of the rocks, fossils and topography can help a geologist to hypothesize the ancient environment and history of a region. Using basic concepts such as plate tectonics, Principle of Uniformitarianism, Law of Superposition, Law of Cross-cutting relationships, etc also help geologists to understand what when on in the past in a certain area.

The State of Virginia is composed of many types of rocks of various ages, but the location, direction and distribution of these strata are not random. If one examines these clues, along with others such as the topography, location and directions of faults, location and position of fossils a picture can be formed of Virginia's Geologic History.

This activity begins with students examining a map of Virginia's provinces, but then goes into more depth about the geologic history of Virginia as an additional map "Grand Tour of Virginia" is added.

A bit of history about the "Grand Tour of Virginia Map". I personally created this map from information I got while taking summer field school at Radford University in 1991. Dr. Chester (Skip) Watts and Dr. John Tso from the Geology Department at Radford University conducted the six week field school. A group of about 25 high school Earth Science teachers from all across the state of Virginia attended. Each day we would have a 1-2 hour lecture about a different geologic region in the state, then we would "head to the vans" for the next six hours. We would then travel to that region and examine the topography, take notes, rock samples and photographs. The culminating activity was the "Grand Tour of Virginia". We went all across the State of Virginia from the Appalachian Plateau to the Coastal Plain in 5 days. We had 30 "stops" or visits to different geologic features.

I used this information from the '91 Grand Tour to create my map that is used in this activity. I had collected rock samples at the 30 stops and taken slide pictures. To create my map I had to take digital images of all my rock samples and post them on the internet in Picasa. I had to turn my old Kodak slides into digital images and post them on the internet on Picasa. (Big thanks to Skip Watts for helping me do this!). I then had to turn all my notes on the geology of each stop into a "gigantic attribute table" in the map. This was not an easy endeavor, but I wanted to create an interactive map that could be used to study the geology of Virginia.

I would really like to thank Dr. Watts and Dr. Tso for all their time and patience recently helping me by consulting with me to verify my information, converting my slides into digital images, and for all their moral support 10 years after I took their class! Others were very helpful as well. Dr. John McGee from the Virginia Geospatial Extension Office helped me to
get my map published. My GIS instructor from Virginia Western Community College, Michael Nichols, was also a wonderful resource.

The Geologic Units Map is from the USGS web site: http://tin.er.usgs.gov/geology/state/state.php?state=VA

My hope is that others will find this information useful and can find ways to add their own information to this map. I hope that students will find this information useful in helping them to understand Virginia's geology and history, and that they learn to appreciate all the wonderful resources and geologic diversity that we have in our great State of Virginia!

- Alison Goforth
Procedure: (For Teacher and Students)

1. Make sure your CPU’s are loaded with ArcEditor or ArcMap.
2. Open up ArcMap with an empty map.
3. Click on (+) or go under File; add data
4. In the pop up window "Look in", click on the drop down arrow/menu and choose "GIS Servers" * it may be down at the bottom of the list, so keep looking, then Click Add
   *If using ArcGIS 10, in catalog click on drop down menu to "GIS Servers". In window in catalog expand folder GIS Servers, double click Add ArcGIS Server. On the first window, select “Use GIS Services.” Follow the directions in the wizard (see steps 7-9 below)
5. In the next window, select: "Add ArcGIS Server", Click add, a new pop up window "Add ArcGIS Server" appears.
6. Select "use GIS services", click next
7. A new pop up window "General" appears
   Select "internet" and type or paste URL in window: [http://arc.gis.vt.edu/arcgis/services](http://arc.gis.vt.edu/arcgis/services)
8. Leave Authentication (optional) info blank, click "finish"
9. You will see the name arcgis on arc.gis.vt.edu as a listing/choice in the "Add Data" pop up window
10. Close the "General" window
11. In the "Add Data window, click on arcgis on arc.gis.vt.edu and make sure in the name field it says "arcgis on arc.gis.vt.edu", and the Show of type says "Datasets and layers (.lyr)", Click  ADD
12. In the new "Add Data window", click/select the folder "VA View", then ADD
13. Select : "Physiographic_Provinces" to add the physiographic provinces in Virginia, data layer.
14. Click on the layer name so it is highlighted : "Physiographic_Provinces" and then right click and ZOOM TO LAYER.  You may have to keep zooming until you see the state of Virginia full screen on your map. Use the (+) magnifier, click and drag a box around the state of Virginia. Wait for the map to reload.
15. Expand all the data layers (click on the + box next to each name).  You should get the following:
16. Be sure to name (no spaces between names, use _, if you need to space out words) and save your map frequently on your C drive in a designated folder. Under File-Click on Map Document Properties- Under the General Tab, make sure that the box near "Pathnames" is checked to "Store Relative pathnames to data sources" is selected.

Zoom into the state of Virginia so it fills your map page! (hint: use the (+) magnifier and click and drag a box around the state of Virginia! You might need to do this more than once. Remember if the globe/world is spinning the program is redrawing the map. PLEASE be patient and let it redraw before you zoom in again!
Student Worksheet

Geology of Virginia

Name _____________________________  Partner's Name _____________________

1. List the physiographic provinces in Virginia from **West to East**

______________________________________________________________________________

______________________________________________________________________________

2. Make sure you have expanded the menu in "Physiographic_Provinces" so you can see the various colors and names of the provinces in Virginia. (Ex: Appalachian Plateau = yellow, Blue Ridge = purple, etc) List the physiographic provinces of Virginia and their assigned color going from **East to West**.

______________________________________________________________________________

______________________________________________________________________________


4. Why is Virginia divided this way? In other words, what are the criteria that make up a physiographic province?

______________________________________________________________________________

______________________________________________________________________________

(Don't worry if you do not know. After this activity you will know the answer to this question!)
5. Close the "Physiographic_Provinces" map in ArcMap and follow the directions given by your teacher to open the Geology_GrandTour.mxd map file. **Zoom to Layer** (Right click layer name-drag to "zoom to layer") and **Zoom to Virginia** (Use + magnifier, click and drag a box around Virginia. Wait patiently for map to load. As long as world/globe icon is spinning, map is loading)

6. We are going to add some base data to our map to give us a better idea of the areas we will be exploring. In ArcMap go under File; **"Add Data from ArcGis online"**. In the “search” box, enter US topo Maps. Add the USA Topographic Maps map service by ESRI to your map. **In ArcGIS 10, Go to File, Add Data, Basemap. Select USA Topo Maps.** Right click "USA_Topo_Maps" and click on **Properties.** Click on the display tab and set the transparency to 50%. You may also want to add an “Imagery” layer in the same manner. **Note: In ArcGIS 10, the addition of Base Map data from ESRI seems to cause the program to crash more often. If this is an issue, do not add the US Topo Maps layer or Imagery layer. Another option is to zoom in to a small area (scale 1:100,000 or larger) and then add one of these base map layers.**

7. Click and drag the USA_Topo_Maps layer below the Stops layer and above the Geologic Unit Boundaries layer in the Table of Contents.

8. Expand all the menu items (click on the + symbols in front of each layer).

9. How many layers make up the Geology of Virginia Map? ________________

10. How many stops were on the Grand Tour? ________________________ (Don't worry about the same number appearing more than once, just count to the highest number stop shown!)

You can see that this map is made up of many layers. Remember in ArcMap you can click and drag a layer's name to the top to make it show up "ON TOP OF" another layer. Be patient while the map reloads (world spins)!

11. Right click on the "Geologic Units-Stratigraphy" layer and select "properties". Click on the "Source" tab and look at the information in the "data" section. What is the geographic coordinate
system used in this map?

Close the window for Geologic Units-Stratigraphy.

12. Right click on the "Stops on the Grand Tour of Virginia" layer and click on "Open Attribute Table". Expand the table and take some time to read the column headings from left to right.

You can see that there is a lot of information in the table.

13. We can use the attribute table to help us navigate the stops on the Tour. The attribute field named “stop_num” is the Stop Number on the tour. **Select stop number 1 by clicking on that row in the table**, it will also select stop number 1 on the map. You may need to re-size the attribute table to see both the map and the table at the same time.
14. Now let's visit some stops. Zoom into the area with stop #1 that you just selected (Star 1).

15. Click on the identify tool (i) and then on the Star 1. Where was the first stop on our Grand Tour? ________________

(hint: You could have also found out this information when you had the attribute table open earlier). Often in ArcMap there is more than one way to the same information.

16. Notice when you have the identify window open for Stop 1, you see a link for "rock_pic". Click on that link. It should take you to a picture of a rock posted on a Picasa website. This is the type of rock found at Stop 1.
Notice that all the information in the attribute table is shown in the identify window. ArcMap 10 allows you to position your windows. When you click on the identify window a blue cross appears on the middle of the old map. If you drag your mouse to one of the arrows (Up, Down, Right or Left) then release. ArcMap 10 will place the new window in that location, while still keeping the old window (map) showing.

17. What type of rock is found at Stop 1?
_________________________________________________ (hint: use the identify window or the attribute table)

18. What physiographic province is Stop 1?
_____________________________________________

19. What age is the rock? _______________ What Era is it from? _____________________


21. Where is Stop 2 located?
___________________________________________
22. What was the latitude and longitude of Stop 2? latitude = ________________,
longitude=____________________

23. Take a look at the rock picture from Stop 2. What type of rock is found here?
____________________

24. What is the ancient environment at Stop 2 (hint: look at the identify window headings or the
headings in the attribute table)?
____________________________________________________________________________

25. What province is Stop 2 located? ________________________________

26. Click on the link "slide_address" to see a picture of the Stop 2. Did Tom get his feet wet?
___________

27. What was the orogenic (mountain building) event at Stop 2?

28. Was the Roanoke area under an ocean at one time in its history? __________ How long ago
was that? __________ How do we know that? What is the evidence?

Close the identify window for Stop 2. and Zoom Out and find Stop 3.

29. What county is Stop 3 located in (answer only if you have base data loaded in your map)?
____________________________________

30. Are the rocks at Stop 3 older or younger than Stops 1 & 2? ______________________.
What is the age of Rock 3?________________________________

31. What was the ancient environment at Stop 3?
32. Open the picture for Rock 3. Are the crystals large (bigger than sand-sized), medium (sand-sized) or small (smaller than sand-sized)? __________________________________________
   What is in the picture to help you get the scale of the crystals?
   __________________________________________

33. What was the orogenic event at Stop 3?
   _________________________________

34. What province is Stop 3 located in? _________________________________

35. What formation are the rocks at Stop 3 a part of?
   ______________________________________

36. What type of rocks are found here (igneous, sedimentary or metamorphic)?
   __________________________

37. How are these types of rocks formed?
   ______________________________________

Close the identify window for Stop 3. Open it for Stop 4.

38. Open the rock picture for Stop 4. Are the crystals large, medium or small?
   _________________________________

39. How can you tell?
   ______________________________________

40. What is the name of the rock? __________________________________________

41. Look in the identify window. What is the mineralogy of the rock?

42. What type of rock is this (igneous, metamorphic or sedimentary)? Circle one

43. What province is rock 4 located in? _______________________________________
45. What is the age of rock 4? ________________________________

46. What was the orogenic event?

47. Open the slide picture for stop 4. Do these rocks look like they have undergone a lot of stress? ________

Explain:

48. Close the identify window for Stop 4. Open the Attribute Table for the layer "Stops on the Grand Tour of Virginia". Scroll to Stop 5- South of Lynchburg, VA. Notice there are two rocks for Stop 5-Rock 5.1 and Rock 5.2. That is why there are two 5's on the map around the star for Stop 5. Both of these rocks are metamorphic, but rock 5.1 is a __________________________(name rock type), where as rock 5.2 is a _______________________(name the rock type.)

49. Have we changed physiographic provinces yet? ________ What province are we in at Stop 5? ____________________________

50. What was the ancient environment at Stop 5?

_________________________________________________

Take a look at the rock picture and slides for Stop 5.

51. Close the identify window for Stop 5 and open it for Stop 6. What is the name of the formation at Stop 6?

52. Look at the rock picture and the slide for Stop 6. Do the rocks look muddy? ______________

What was the protolith (original rock before being metamorphosed)? (hint: look at rock_type)
53. What was the ancient environment?
___________________________________________________

54. Close the identify window for Stop 6 and open it for Stop 7. Look at the slide picture. Do the rocks look like they have been under a lot of stress? _______________ What type of rocks are found at Stop 7? __________

55. What physiographic province are we in at Stop 7? ________________________________

56. What is the formation of the rocks at Stop 7? ________________________________

57. Close the identify window for Stop 7 and open it for Stop 8. What physiographic province are we in at Stop 8?_______________________________.

58. What type of rocks are found here? ________________________________ Age? ________________

59. What physiographic province is Stop 9 located in ? ________________________________

60. Open the identify window for Stop 10. Notice there are several rock samples for Stop 10-Willis Mountain. Take a moment to look at all the different rock pictures and the slides for Stop 10 (Hint: To access all the slide pics and rock pics, click on a different line/name in the top of the identify window. It will open the different rock and slide samples). Willis Mountain is a very special feature. It is a monadnock. What is a Monadnock? (hint: look at ancient_environment) _____________________________________________________________________________

61. Why do they mine Willis Mountain?
_________________________________________________________________________________

62. What are the industrial uses for the kyanite?
_________________________________________________________________________________
63. Close the identify window for Stop 10 and Open it for Stop 11. What valuable mineral resource is found here at Stop 11? ________________________________

64. What type of rock is found at Stop 11? (igneous, metamorphic or sedimentary) Circle one.

65. Examine the rock pictures? Are the rocks large, medium or fine-grained? Circle one

66. Examine the slides. What are the commercial uses for the rocks found here?

67. What type of cleavage does the rocks at Stop 11 show?
____________________________

68. How old are the rocks at Stop 11? ________________

69. What was the ancient environment?

70. Have we changed physiographic provinces yet? ___________. Explain

71. Close the identify window for Stop 11 and open it for Stop 12. What county is stop 12 (only if you have base map data loaded in your map)?

72. What is the mineralogy of the rock 12.3 at Stop 12? What are the large dark spots?

73. What is the ancient environment?

74. Look at the slide for rock 12.3. What are the 3 red dots in the upper portion of the rock? How did they form?
75. Is this rock foliated? Explain

76. What is the orogenic event for rock 12.3?

77. Close the identify window for Stop 12 and open it for Stop 13. Look at the slide picture. This slide shows an excellent example of what weathering process? (hint: read rock_type)

78. What type of rock is at Stop 13 (igneous, metamorphic or sedimentary)? Circle one.

79. What physiographic province are we located at Stop 13? _________________

80. What was the ancient environment?

81. What Era are the original rocks at Stop 13 from? ______________________

82. Close the identify window for Stop 13 and open Stop 14. How is the rock 14.1 at Stop 14 related to the rock 4 at Stop 4? (hint: look at the formation)

83. Look at the picture for rock 14.2. Are the crystals (large, medium or small)? Circle one.

84. What is a pegmatite? (hint look at rock_type)

85. What was the ancient environment for rock 14.2?

86. Look at the picture for rock 14.3 and the slide for 14.3 (That's Dr. Tso in the slide). Is rock 14.3 foliated? ______ What could cause that to happen?
87. How old is the rock 14.3? _______________________

88. Where have we seen rocks that old before in Virginia?
______________________________

89. What was the ancient environment?

90. Open the identify window for Stop 15? Where is stop 15 located?
______________________________

91. Are we still in the piedmont physiographic province? Explain

92. Open the slide for Rock 15. What is in the picture? _______________________________
Do you see any changes of elevation in the picture? ________________________

93. Why is Richmond on the "fall-line"? What does that mean?

94. Take a look at all the slides for Stop 15. In the last slide is an very interesting feature, what is it?

____________________________________

95. Open the identify window for Stop 16. The Amelia Pegmatite mine is a very interesting place to visit. Take a look at all the rock pictures and slides for Stop 16. What semi-precious gem stones can be found at the Amelia Pegmatite mine?

96. What is the turquoise colored rock that can be found here?

_______________________________________
97. What is a pegmatite?

98. What mineral do we find in the Amelia Pegmatite mine that we saw at Willis Mountain?

99. What physiographic province is the Amelia Pegmatite mine located in?

Take a look at the slides at the mine. Dr Skip Watts is in Slide 1 sitting on the rock.

100. Zoom out to the whole State of Virginia Extent. Find Stop 17 and open the identify window. Where are we now in the State of Virginia?

101. What physiographic province are we in now?

102. What Era are the rocks at Stop 17?

103. What are the rocks at Stop 17?

104. Open the identify window for Stop 18. What was the ancient environment?

105. What physiographic province is Stop 19 located in?

106. How old are the rocks at Stop 19?

107. Where are the youngest rocks in Virginia found?

108. Take a look at the imagery (picture on map) of Stop 20. Stop 20 is Willoughby Spit off of Virginia Beach.
What is a spit? (use your textbook to look it up)

109. Zoom in close to Stop 20. (Do this only if you have Imagery base map data loaded in your map). Are there any people living on Willoughby Spit? Explain.

110. Open the identify window for Stop 21. Open the rock picture. What do you see?

111. What kind of environment was in this area at Stop 21 in the past, based on the rocks?

112. What Era and Period are these fossils from?

113. Open the identify window for Stop 22. Hicks Borrow Pit. What was the ancient environment?

114. What age are the rocks 22.1?

115. What type of rocks are they? (igneous, metamorphic, sedimentary) Circle one.

116. Take a look at all the pictures of the rocks. Why do the rocks look rounded?

117. Open the identify window for Stop 23. What physiographic province is Stop 23 located in?

118. What is the era of the rocks from Stop 23?

119. What was the orogenic event going on at Stop 23?
120. Open the identify window for Stop 24. Where is Stop 24?

____________________________________

121. What type of rock is found there? (igneous, metamorphic or sedimentary) Circle one.

122. What physiographic region is Stop 24 located?

____________________________________

123. Set your extent to be 1:4,305 (hint: type that ratio in the space in the toolbar, right next to the + add data button. Wait for the map to reload. What do you notice about the Potomac River at this location (you will need imagery loaded to answer this question)?

______________________________________________________________________________

124. Does this make sense given the physiographic province we are in here?

125. Turn off the imagery layer. Click on the world in the upper left of the toolbar, next to the pan (hand) tool. Then use the + magnifier to draw a box around Virginia in the map. Wait for the map to reload. Keep zooming in (using the + magnifier) until you see Stop 25. (hint: This method is often faster to get back to where you want to be). Another way to get "back to where you were on the previous screen" is to click on the blue left arrow on toolbar. Remember there is more than one way to get to the same place in ArcMap.

Open the identify window for Stop 25. What was the orogenic event?

____________________________________

126. How old is the rock from this stop? ________________________________

127. What era and system is the rock from here?

____________________________________

128. What physiographic region is Stop 25? ________________________________

129. What was the ancient environment?

_______________________________________________
130. Click on the identify for Stop 26. Open the picture of the rock. What color is the rock? _________

131. Is the rock coarse-grained, medium-grained or fine-grained? Circle one

132. What physiographic region are we in now? ________________________________

133. Take a look at the slide pictures. Do you see the mud cracks and footprints. What type of ancient environment was here in the Jurassic? ________________________________

134. Open the identify window for Stop 27. What is the mineralogy of the rocks?

135. Take a look at all the slides. Why is there a big pit in this area? ________________________________

What are they quarrying for at Stop 27?
__________________________________________________

136. What type of dinosaur tracks are found in this Mesozoic Basin?

137. What was going on with Pangaea in this area when the dinosaurs were walking around?

138. What is the name of the formation? ________________________________

139. What type of pattern do the dino footprints show?

140. Open the identify window for Stop 28. What physiographic region are we in now? ________________
141. What is the formation? ________________________________

142. Where are we in Virginia at Stop 28?
____________________________

143. What was the ancient environment?
______________________________

144. What was the orogenic event?
______________________________

145. Why are there so many landslides in this area on I-64?

146. Open the identify window for Stop 29. What physiographic region is Stop 29?
________________________

147. What type of rock is at Stop 29? (igneous, metamorphic or sedimentary) Circle one.

148. What era is the rock from Stop 29? ________________________________

149. Why is there a hole at this location?
______________________________

150. Why did people throw trash in this hole?

151. What effect will this have on the groundwater?
______________________________

152. Open the identify window for Stop 30. What physiographic region is Stop 30?
________________________

153. What era are the rocks from in Stop 30?
______________________________
154. Would the rocks in this area be tilted or overturned? Explain

YOU HAVE NOW VISITED ALL THE PHYSIOGRAPHIC PROVINCES IN VIRGINIA

Conclusion: Now can you explain why the physiographic provinces are located where they are located? How do we know when we would change from one province to another? What kind of clues do the geologists use to distinguish one province from another?
Student Worksheet

Geology of Virginia (key)

Name _____________________________  Partner's Name _____________________

1. List the physiographic provinces in Virginia from **West to East Appalachian Plateaus, Valley and Ridge, Blue Ridge, Piedmont and Coastal Plain**

2. Make sure you have expanded the menu in "Physiographic Provinces" so you can see the various colors and names of the provinces in Virginia. (Ex: Appalachian Plateau = yellow, Blue Ridge = purple, etc) List the physiographic provinces of Virginia and their assigned color going from **East to West. Coastal Plain = Blue, Piedmont = Brown, Blue Ridge = Purple, Valley and Ridge = Green, Appalachian Plateau = Yellow**

3. What physiographic province do you live in? **Answers will vary**

4. Why is Virginia divided this way? In other words, what are the criteria that make up a physiographic province? **It is alright if students do not have a clear understanding of these divisions. Some may know that the provinces are based on the topography. They may not know that the divisions are also based on the geology as well. The rest of the lab will help them to understand the reason.**

(Don't worry if you do not know. After this activity you will know the answer to this question!)
9. How many layers make up the Geology of Virginia Map? 5 (depends on if base map data can be loaded)

8. Let's examine some of these layers. Turn off (un-check the box in front of the name) the

10. Turn off the Geologic Unit Boundaries and the Geologic Units-Stratigraphy layers. What is showing now? **Only the Stops on Grand Tour of Virginia layer** How many stops were on the Grand Tour? 30 (Don't worry about the same number appearing more than once, just count to the highest number stop shown!)

You can see that this map is made up of many layers. Remember in ArcMap you can click and drag a layer's name to the top to make it show up "ON TOP OF" another layer. Be patient while the map reloads (world spins!)

13. Right click on the "Geologic Units-Stratigraphy" layer and select "properties". Notice there are a lot more tabs now. Click on the "Source" tab and look at the information in the "data" section. What is the geographic coordinate system used in this map? **GCS_North_American_1927** Close the window for Geologic Units-Stratigraphy.

14. Right click on the "Stops on the Grand Tour of Virginia" layer and click on "Open Attribute Table". Expand the table and take some time to read the column headings from left to right.

15. Now let's visit some stops. Zoom into the Roanoke, VA area until you see stop #1 (Star 1). Click on the identify tool (i) and then on the Star 1. Where was the first stop on our Grand Tour? **Mill Mtn, Roanoke VA**

(hint: You could have also found out this information when you had the attribute table open earlier). Often in ArcMap there is more than one way to the same information.
17. What type of rock is found at Stop 1? (hint: use the identify window or the attribute table)
   metamorphic-clean white sandstone, quartzite, pinkish cast, greater or equal to 90% quartz

18. What physiographic province is Stop 1? western blue ridge

19. What age is the rock? 550 m.y.o. (million years old) What Era is it from? Paleozoic


21. Where was Stop 2 located? Roanoke Mtn, Roanoke, VA

22. What was the latitude and longitude of Stop 2? latitude = 37.191339 N, longitude=- 79.936525 W

23. Take a look at the rock picture from Stop 2. What type of rock is found here? sedimentary-
silty sandstone, cleavage goes against bedding, disk shape, axial plain cleavage, semi-meta,
dark and light gray banding, MAJOR FOLDS

24. What is the ancient environment at Stop 2 (hint: look at the identify window headings or the headings in the attribute table)? beach, inland sea, erosion of Grenville Mtns

25. What province is Stop 2 located? western blue ridge

26. Click on the link "slide_address" to see a picture of the Stop 2. Did Tom get his feet wet? Yes, he was in the creek!

27. What was the orogenic (mountain building) event at Stop 2? Grenville Mountains eroding

28. Was the Roanoke area under and ocean at one time in its history? yes. How long ago was that? 550 m.y.o. How do we know that? What is the evidence? The rock type is sedimentary silty sandstone that would have formed along a beach of an inland sea.

Close the identify window for Stop 2. and Zoom Out and find Stop 3.

29. What county is Stop 3 located in? Franklin County
30. Are the rocks at Stop 3 older or younger than Stops 1 & 2? **Older**, What is the age of Rock 3? **1100 m.y.o.**

31. What was the ancient environment at Stop 3? **Base**ment rocks of Grenville Mtns,(Supercontinent Laurentia formed 1100 m.y.o), later an igneous intrusion into these rocks during the Acadian Orogeny formed gneiss

32. Open the picture for Rock 3. Are the crystals large (bigger than sand-sized), medium (sand-sized) or small (smaller than sand-sized)? **large**  What is in the picture to help you get the scale of the crystals? **The penny next to the rock gives you a scale to compare.**

33. What was the orogenic event at Stop 3? **Grenville Mountains were formed as supercontinent Laurentia formed, 1100 m.y.o.**

34. What province is Stop 3 located in? **eastern blue ridge-crossed Rockfish Valley/Fries Fault**

35. What formation are the rocks at Stop 3 a part of? **Stage road layered gneiss**

36. What type of rocks are found here (igneous, sedimentary or metamorphic)? **metamorphic, gneiss**

37. How are these types of rocks formed? **metamorphic rocks are formed by tremendous heat and pressure**

Close the identify window for Stop 3. Open it for Stop 4.

38. Open the rock picture for Stop 4. Are the crystals large, medium or small? **Large** 39. How can you tell? **Compare crystal size with penny. Crystals are larger than sand-sized**

40. What is the name of the rock? **Sabot**

41. Look in the identify window. What is the mineralogy of the rock? **metamorphic-chlorite, actinolite(needle like amphibole/green), talc, Mg rich, low in Si, ultramafic, dense, Ophiolite= ultramafic surrounded by deep water sediments, metagraywacky, deep water/anaerobic**
42. What type of rock is this (igneous, **metamorphic** or sedimentary)? Circle one

43. What province is rock 4 located in? **eastern blue ridge**

45. What is the age of rock 4? **700 m.y.o.**

46. What was the orogenic event? Rifting of Laurentia, opening of Iapetus Ocean

47. Open the slide picture for stop 4. Do these rocks look like they have undergone a lot of stress? **yes**

   Explain: **The rock are tilted, bent, wavy, metamorphosed.**

48. Close the identify window for Stop 4. Open the Attribute Table for the layer "Stops on the Grand Tour of Virginia". Scroll to Stop 5- South of Lynchburg, VA. Notice there are two rocks for Stop 5-Rock 5.1 and Rock 5.2. That is why there are two 5's on the map around the star for Stop 5. Both of these rocks are metamorphic, but rock 5.1 is a **amphibolite schist** (name rock type), where as rock 5.2 is a **hornblende schist** (name the rock type.)

49. Have we changed physiographic provinces yet? **Not really**  What province are we in at Stop 5? **piedmont/blue ridge**

50. What was the ancient environment at Stop 5? **Old pillow lava, volcanic island arc off shore, deep water sediments in rift blocks, protolith basalt extrusive**

   Take a look at the rock picture and slides for Stop 5.

51. Close the identify window for Stop 5 and open it for Stop 6. What is the name of the formation at Stop 6? **Lynchburg-Alligator Back**

52. Look at the rock picture and the slide for Stop 6. Do the rocks look muddy? **yes**

   What was the protolith (original rock before being metamorphosed)? (hint: look at rock_type) **muddy shale/ turned to muddy slate/ turned to schist**
53. What was the ancient environment? **deep water, anaerobic, organic rich mud, sediment from Grenville basement originally.**

54. Close the identify window for Stop 6 and open it for Stop 7. Look at the slide picture. Do the rocks look like they have been under a lot of stress? **yes** What type of rocks are found at Stop 7? **metamorphic-meta-greywacke, protolith dirty sandstone, sericite (fine grained muscovite), chlorite, quartz, gritty/waxy texture, mica schist and phyllite, talc, similar to Chilhowee**

55. What physiographic province are we in at Stop 7? **piedmont/blue ridge**

56. What is the formation of the rocks at Stop 7? **Candler**

57. Close the identify window for Stop 7 and open it for Stop 8. What physiographic province are we in at Stop 8? **piedmont/blue ridge**

58. What type of rocks are found here? **metamorphic-Pelier schist, primarily biotite** Age? **700 m.y.o**

59. What physiographic province is Stop 9 located in ? **piedmont/blue ridge**

60. Open the identify window for Stop 10. Notice there are several rock samples for Stop 10-Willis Mountain. Take a moment to look at all the different rock pictures and the slides for Stop 10 (Hint: To access all the slide pics and rock pics, click on a different line/name in the top of the identify window. It will open the different rock and slide samples). Willis Mountain is a very special feature. It is a monadnock. What is a Monadnock? (hint: look at ancient_environment) **Willis Mtn is a Monadnock ( dike/Ig intrusion) in the surrounding Arvonia Slate. Island Arc is eroding into Iapetus Ocean creating muds that became Arvonia slate**

61. Why do they mine Willis Mountain? **To get the Kyanite**

62. What are the industrial uses for the kyanite? **Kyanite-alumino silicate (formed under medium/high pressure/temp), quartzite matrix, contains pyrite, micas and iron, protolith = clay rich mud, kyanite quarry-used in spark plugs, dentures and ceramic space shuttle tiles.**
63. Close the identify window for Stop 10 and Open it for Stop 11. What valuable mineral resource is found here at Stop 11? **Slate**

64. What type of rock is found at Stop 11? (igneous, **metamorphic** or sedimentary) Circle one.

65. Examine the rock pictures? Are the rocks large, medium or **fine-grained**? Circle one

66. Examine the slides. What are the commercial uses for the rocks found here? **Slate is used for patio's, roofs, chalkboards and other decorative stone uses.**

67. What type of cleavage does the rocks at Stop 11 show? **one directional, good for splitting into flat sheets!**

68. How old are the rocks at Stop 11? **430 m.y.o.**

69. What was the ancient environment? **Arvonian Syncline - Island Arcs eroding - accreting as Iapetus Ocean closing, Taconic Mtns Form**

70. Have we changed physiographic provinces yet? **no**. Explain **We are still in the piedmont/blue ridge**

71. Close the identify window for Stop 11 and open it for Stop 12. What county is stop 12? **Fluvanna County**

72. What is the mineralogy of the rock 12.3 at Stop 12? What are the large dark spots? **metamorphic-muscovite schist-meta-felsic intermediate, volcanic garnet, quartz and plagioclase in layers, first time muscovite is seen in the Chopawasmic belt, The dark spots are weathered garnets.**

73. What is the ancient environment? **Clay and mud eroded off Island Arc deposited in syncline in deep ocean, then metamorphosed as Islands are accreted in Taconic Orogeny**

74. Look at the slide for rock 12.3. What are the 3 red dots in the upper portion of the rock? How did they form?
The 3 red dots are weathered garnets. They formed as the rock was partially melted and the minerals crystallized to form the garnets (which are now very weathered).

75. Is this rock foliated? Explain **Yes, you can see bands of white and grey.**

76. What is the orogenic event for rock 12.3? **The Taconic Mountains were forming.**

77. Close the identify window for Stop 12 and open it for Stop 13. Look at the slide picture. This slide shows and excellent example of what weathering process? (hint: read rock_type) **exfoliation**

78. What type of rock is at Stop 13 (igneous, metamorphic or sedimentary)? Circle one.

79. What physiographic province are we located at Stop 13? **Piedmont**

80. What was the ancient environment? **Igneous intrusion in the Chopawasmic. Plagioclase weathers to clay, clay expands as it absorbs moisture and weathers along foliated planes**

81. What Era are the original rocks at Stop 13 from? **Paleozoic**

82. Close the identify window for Stop 13 and open Stop 14. How is the rock 14.1 at Stop 14 related to the rock 4 at Stop 4? (hint: look at the formation) **The rock 14.1 is from the State Farm Gneiss- Sabot Amphibolite the rock at Stop 4 was Sabot Amphibolite as well.**

83. Look at the picture for rock 14.2. Are the crystals **large, medium or small)? Circle one.**

84. What is a pegmatite? (hint look at rock_type) **pegmatite-igneous intrusion with large grains, K feldspar, quartz and plagioclase**

85. What was the ancient environment for rock 14.2? **Igneous intrusion during the Taconic Orogeny**

86. Look at the picture for rock 14.3 and the slide for 14.3 (That's Dr. Tso in the slide). Is rock 14.3 foliated? **yes.** What could cause that to happen? **During the Taconic Orogeny**
tremendous heat and pressure built up and the minerals partially melted then recrystallized.

87. How old is the rock 14.3? **1100 m.y.o.**

88. Where have we seen rocks that old before in Virginia? **At Stop 3 near Boones Mill, VA, Stage Road Layered Gneiss**

89. What was the ancient environment? **Grenville mtns basement rock is metamorphosed as an igneous intrusion forms during the Taconic Orogeny, gradual contact with Sabot**

90. Open the identify window for Stop 15? Where is stop 15 located? **James River Park, near Richmond, VA**

91. Are we still in the piedmont physiographic province? Explain **No, now we are on the fall line, the boundary between the piedmont and the coastal plain**

92. Open the slide for Rock 15. What is in the picture? **The James River** Do you see any changes of elevation in the picture? **yes, there are rapids and waterfalls as the river drops lower**

93. Why is Richmond on the "fall-line"? What does that mean? **The fall line is the boundary between the piedmont and coastal plain provinces. It is called the fall line because that is where there is a change in topography/elevation causing waterfalls and ledges/rapids in the rivers. It was an early barrier to settlers exploring Virginia.**

94. Take a look at all the slides for Stop 15. In the last slide is an very interesting feature, what is it? **A dike, a vertical igneous intrusion in the existing rocks.**

95. Open the identify window for Stop 16. The Amelia Pegmatite mine is a very interesting place to visit. Take a look at all the rock pictures and slides for Stop 16. What semi-precious gem stones can be found at the Amelia Pegmatite mine? **Amelia Pegmatite Mine (Amelia Courthouse Quad). Min & rocks: Amazonite, Muscovite, Mica, beryl, quartz, Amethyst, Garnet, Topaz, Zenwaldenite, tourmaline, cassiterite, columbite, ENVIR: Intrusion into Maiden Gneiss of Goochland Terrain**
96. What is the turquoise colored rock that can be found here? **Amazonite**

97. What is a pegmatite? **Where an igneous intrusion partially melts existing rocks it contacts and the minerals re-crystallize, often into semi-precious gems**

98. What mineral do we find in the Amelia Pegmatite mine that we saw at Willis Mountain? **Kyanite**

99. What physiographic province is the Amelia Pegmatite mine located in? **Piedmont**

Take a look at the slides at the mine. Dr Skip Watts is in Slide 1 sitting on the rock.

100. Zoom out to the whole State of Virginia Extent. Find Stop 17 and open the identify window. Where are we now in the State of Virginia? **Near Virginia Beach, Seashore State Park**

101. What physiographic province are we in now? **The Coastal Plain**

102. What Era are the rocks at Stop 17? **Cenozoic**

103. What are the rocks at Stop 17? **Sand and alluvium, marsh and beach deposits**

104. Open the identify window for Stop 18. What was the ancient environment? **Erosion of Appalachian Mtns**

105. What physiographic province is Stop 19 located in? **Coastal Plain**

106. How old are the rocks at Stop 19? **0.01 m.y.o., Quaternary**

107. Where are the youngest rocks in Virginia found? **On the Coastal Plain**

108. Take a look at the imagery (picture on map) of Stop 20. Stop 20 is Willoughby Spit off of Virginia Beach.

What is a spit? (use your textbook to look it up) **A spit is where a sandbar connects to the shoreline.**
109. Zoom in close to Stop 20. Are there any people living on Willoughby Spit? yes. Explain You can see houses and streets on the imagery.

110. Open the identify window for Stop 21. Open the rock picture. What do you see? Teeth, shark's teeth, bones all fossilized.

111. What kind of environment was in this area at Stop 21 in the past, based on the rocks? It must have been an ocean environment to have shark's teeth, whale bones and manatees.

112. What Era and Period are these fossils from? Cenozoic Era, Tertiary Period.

113. Open the identify window for Stop 22. Hicks Borrow Pit. What was the ancient environment? Erosion of Appalachian Mtns.

114. What age are the rocks 22.1? 2.1 m.y.o.

115. What type of rocks are they? (igneous, metamorphic, sedimentary) Circle one.

116. Take a look at all the pictures of the rocks. Why do the rocks look rounded? The rocks are rounded because they have been eroded from the Appalachian Mountains to the west and the stream actions rounded them.

117. Open the identify window for Stop 23. What physiographic province is Stop 23 located in? Fall line.

118. What is the era of the rocks from Stop 23? Mesozoic.

119. What was the orogenic event going on at Stop 23? Erosion of Appalachian Mtns to the west.

120. Open the identify window for Stop 24. Where is Stop 24? Great Falls Park, Northern VA.

121. What type of rock is found there? (igneous, metamorphic or sedimentary) Circle one.

122. What physiographic region is Stop 24 located? Fall line.
123. Set your extent to be 1:4,305 (hint: type that ratio in the space in the toolbar, right next to the + add data button. Wait for the map to reload. What do you notice about the Potomac River at this location? **There are lots of rapids and waterfalls**

124. Does this make sense given the physiographic province we are in here? **Yes, the Fall Line is the boundary between the piedmont and the coastal plain. It is where the elevation drops and there are waterfalls and rapids on the rivers.**

125. Click on the world in the upper left of the toolbar, next to the pan (hand) tool. Then use the + magnifier to draw a box around Virginia in the map. Wait for the map to reload. Keep zooming in (using the + magnifier) until you see Stop 25. (hint: This method is often faster to get back to where you want to be). Another way to get "back to where you were on the previous screen" is to click on the blue left arrow on toolbar. Remember there is more than one way to get to the same place in ArcMap.

Open the identify window for Stop 25. What was the orogenic event? **Appalachian Orogeny**

126. How old is the rock from this stop? **180 m.y.o.**

127. What era and system is the rock from here? **Mesozoic Era, Jurassic or Triassic Period**

128. What physiographic region is Stop 25? **piedmont/Mesozoic Basin**

129. What was the ancient environment? **Opening of Atlantic, Pangaea is splitting apart. Igneous intrusion but cooled slowly at surface, big crystals**

130. Click on the identify for Stop 26. Open the picture of the rock. What color is the rock? **red brown**

131. Is the rock coarse-grained, medium-grained or **fine-grained?** Circle one

132. What physiographic region are we in now? **Mesozoic Basin**

133. Take a look at the slide pictures. Do you see the mud cracks and footprints. What type of ancient environment was here in the Jurassic? **A lake and marshy area**
134. Open the identify window for Stop 27. What is the mineralogy of the rocks? sedimentary-
Balls Bluff siltstone, red color, ripple marks, dino tracks (2000-3000 tracks)

135. Take a look at all the slides. Why is there a big pit in this area? There is a quarry here.
They are removing the rocks.

What are they quarrying for at Stop 27? The Balls Bluff Siltstone

136. What type of dinosaur tracks are found in this Mesozoic Basin? Aetosaur front foot and
back foot, Phytosaur-croc like dino, Eubrontes, Coelophysis tracks walking pattern

137. What was going on with Pangaea in this area when the dinosaurs were walking around?
Pangaea splitting, rifting of Atlantic ocean, Lake in Graben

138. What is the name of the formation? Balls Bluff Siltstone

139. What type of pattern does the dino footprints show? Dinosaurs going one way, then
changing direction. Maybe feeding or being chased.

140. Open the identify window for Stop 28. What physiographic region are we in now? Blue
Ridge

141. What is the formation? Catoctin Greenstone

142. Where are in Virginia at Stop 28? Afton Mountain on I-64 between Waynesboro and
Charlottesville, VA

143. What was the ancient environment? Deep water sediments in syncline off shore of island
arcs are metamorphosed as island arcs are accreted onto shoreline during Taconic
Orogeny. Foliation occurred during Taconic, positioning during the Alleghenian. The lava
basalt is Cambrian and metamorphosed.

144. What was the orogenic event? Taconic Mountains

145. Why are there so many landslides in this area on I-64? Because Interstate 64 cuts through
Afton Mountain which is composed of the Catoctin Greenstone. This is a fine-grained
metamorphic rock made from the muddy sediments in the syncline off shore of proto-North America. As the island Arcs were accreted (smashed) onto the continent, the mudstone metamorphosed. It is a fairly soft and weak rock and Afton Mountain is unstable, hence the frequent landslides.

146. Open the identify window for Stop 29. What physiographic region is Stop 29? **Valley and Ridge**

147. What type of rock is at Stop 29? (igneous, metamorphic or sedimentary) Circle one. **Sedimentary**

148. What era is the rock from Stop 29? **Paleozoic**

149. Why is there a hole at this location? **The limestone is eroded by the water. The area (Giles County) has lots of Karst topography and sinkholes. This is a sinkhole (a collapsed ceiling of a cave).**

150. Why did people throw trash in this hole? **It is now illegal to dump trash into sinkholes. In the past folks thought it was a good idea to "fill up the holes".**

151. What effect will this have on the groundwater? **Sinkholes are the collapsed ceilings of caves. Dumping trash into them will pollute the groundwater. When it rains, heavy metals, pesticides and toxins go directly into the ground water. They are not filtered and folks with nearby wells will be drinking contaminated water.**

152. Open the identify window for Stop 30. What physiographic region is Stop 30? **Appalachian Plateau**

153. What era are the rocks from Stop 30? **Paleozoic**

154. Would the rocks in this area be tilted or overturned? Explain **No, the rocks in the Appalachian Plateau are still in their horizontal position in which they were deposited. That is one of the differences between the Appalachian Plateau and the Valley and Ridge Region. The Valley and Ridge region rocks are tilted, folded into anticlines and synclines. The Appalachian Mountains were formed as proto-North America and proto-Africa collided to make the supercontinent Pangaea. The Appalachian Plateau rocks were up-**
lifted during the Appalachian Orogeny, but not folded or tilted like in the Valley and Ridge Region.

YOU HAVE NOW VISITED ALL THE PHYSIOGRAPHIC PROVINCES IN VIRGINIA

Conclusion: Now can you explain why the physiographic provinces are located where they are located? How do we know when we would change from one province to another? What kind of clues do the geologists use to distinguish one province from another? The physiographic provinces are based on the topography (changes in elevation), geology of a region (rock type, age) and geologic history. For example, the rocks underlying the Appalachian Plateau and Valley and Ridge are primarily Paleozoic in age and sedimentary. The Valley and Ridge rocks have been folded, tilted and faulted during the Appalachian Orogeny. The rocks underlying the Blue Ridge are primarily metamorphic and vary in age. The oldest rocks in Virginia are the rocks of the Grenville Mountains (1100 m.y.o.). They are exposed in several places in the Blue Ridge and Piedmont. The Piedmont (foothills) are composed primarily of erosional deposits from the weathering of the Appalachian mountains to the west. Metamorphic rocks underlay these deposits. In addition, there were a series of events in which island arcs were accreted to the continent (Taconic Orogeny, etc) prior to the Appalachian Orogeny. Many of these metamorphic rocks are found underlying the piedmont. The Mesozoic Basins are grabens (depressions) that formed from rifting, during the break up of Pangaea. The Coastal Plain is an inclined plain of primarily sedimentary rocks that were eroded from the Appalachian Mountains. The youngest rocks in Virginia can be found in the Coastal Plain. So the physiographic provinces are defined by topography and geology of the various areas.
Resources


A map-based resource designed for Virginia teachers. The Digital Atlas contains many different maps pertinent to Virginia in several accessible formats.


A Federal source of national-scale maps and geographic data of many different themes, including base maps.