**APPALACHIA 5**

1. Just like the Taconic, the Acadian Orogeny was over when the mountains had worn down and the foreland basins had filled with sediment.
2. Another period of orogenic calm followed. With the influx of clastic sediment for the Acadian Mountains finished, carbonates flourished in the clear, shallow Kaskaskia epicontinental sea.
3. For a time, the Mississippian reef builders are blissfully unaware of the tectonic catastrophe that will soon cause 87% of all fossil families to go extinct.
4. The carbonate salad days will end with the climactic orogeny of the Appalachian saga – the mighty Alleghenian! This was the last major orogenic event to affect the Mid-Atlantic region.
5. The orogeny occurred when northwest Africa, (part of the supercontinent Gondwana) collided with the eastern seaboard of North America closing the Proto-Atlantic and Rheic oceans. The collision resulted in several associated orogenies; the Mauritanide (the complementary orogeny on Africa opposite the Alleghenian), the Ouachita (South America striking the Gulf Coast region), and the Hercynian (Gondwana colliding with southern Europe). All of these orogenies sutured together the supercontinent Pangaea.
6. To understand how the Alleghenian orogeny affected the central Appalachians it’s helpful to review what the region was like just prior to the Alleghenian. To the east, the eroded stumps of the prior Taconic and Acadian orogenies lay bare and exposed at the surface. To the west, their respective foreland basins lay completely filled with mid-to-late Paleozoic clastic wedges and oblivious epicontinental carbonates – all of which cover early Paleozoic DCM sediments which in turn lay above the rifted Grenville basement rocks. Despite the two major collision orogenies, the pre-Alleghenian sedimentary rocks were left surprisingly unscathed. Almost no recognizable internal folding or faulting existed prior to the Alleghenian.
7. Unlike the two previous orogenies, the mighty Alleghenian orogeny caused intense folding and thrust faulting of all pre-Alleghenian rocks in the region and built a mountain range that was probably Himalayan in scale. Virtually all of the landforms, physiographic provinces, structures in road cuts, etc. seen today in the central Appalachians reflect this event. In the Alleghenian orogeny, the African portion of Gondwana became a hinterland - meaning it was thrust up and over the North American edge. The weight of Africa shoved the North American rocks down deep in the earth and metamorphosed them. None of Africa remains here, by the way. All of it was removed by erosion and transported westward as sediments into the foreland basins. The Alleghenian foreland basin developed farther west through Kentucky, West Virginia, western Pennsylvania, Ohio, and beyond.
8. Although all three Appalachian parks were affected by the Alleghenian orogeny, Great Smokey National Park shows off the Alleghenian structures best.
9. The Alleghenian thrust the hard Grenville crust up to form the Blue Ridge province, …
10. …but although the overturned anticline of Shenandoah was folded by the Alleghenian, the old crystalline rocks in the Blue Ridge lack the layering that really shows-off the Alleghenian folds.
11. Such folding is best seen in the compressed sediments of the Valley and Ridge province, where the ridges are formed of the more resistant sedimentary rocks …
12. … like at Sideling Hill, a beautiful syncline exposed in a road cut along I-68, about 60 miles NNW of Shenandoah National Park. Similar folds were produced throughout the Valley and Ridge Province by the Alleghenian Orogeny, but nowhere are they as beautifully exposed as they are here.
13. Nonetheless, because Great Smokey National Park includes a portion of the Valley and Ridge Province, similar structures do occur there.
14. In fact, the Alleghenian Orogeny was especially intense in the Great Smokey’s, …
15. … a fact witnessed by the much greater width of the Appalachians in the Smokey’s, …
16. … along with tighter folds and more closely spaced thrust faults compared to Shenandoah. This is not to downplay the affects of the Alleghenian Orogeny in Shenandoah, where not only did the orogeny form the overturned anticline, but it also thrust the Grenville basement some 150 miles westward. It’s just that the orogeny was even more intense in the Great Smoky Mountains where displacement along the Great Smoky thrust fault has been estimated by some accounts to be 200 to 300 miles!
17. With that kind of displacement the rocks along the Great Smokies Fault are obviously going to become highly disturbed – a fact underscored by the “outcrop from hell” description someone gave this road cut.
18. One of the more intriguing features often formed in association with thrust faults is a “thrust window”. Thrust faults always thrust older rocks up and over younger rocks along relatively low-angle reverse faults. If a portion of the overlying older rock is removed by erosion such that the underlying younger rock is exposed, the area of exposed younger rocks is called a thrust window.
19. Cades Cove is one of many such thrust windows in the Valley and Ridge province. Younger (Ordovician) DCM carbonates are exposed in the window which is surrounded by mountains of older (late Proterozoic) rocks which lie above the Great Smoky Thrust Fault.
20. Pioneers found that the carbonates in Cades Cove were far more productive than the poorer mountain soils and so the valley was settled.
21. The pattern of settlement in areas underlain by carbonate rocks was repeated many, many times throughout the Valley and Ridge Province - a great example of how geology influences human culture.
22. On this bedrock and structure map of Cades Cove in Great Smoky Mountains National Park you can see the exposed carbonates in the thrust window in blue surrounded by various late Proterozoic rocks. On geologic maps thrust faults are always shown with a saw-toothed pattern and the teeth always point towards the rocks that lay above the fault.
23. If we place a similar symbol at the base of the Himalayas in India, the teeth would point away from India but toward Nepal and Mongolia which are thrust on top of India.
24. The Himalayas provide a modern analogue to the mountains built by the Late Paleozoic Alleghenian orogeny - the bulk of which would have been made of Africa, thrusting over the North American craton. One of the main differences in this uniformitarianism-based thought experiment is that relative sea level was higher during the Alleghenian orogeny and, so, much of North America was under water (the Absaroka epicontinental sea). During the climax of the Alleghenian orogeny (during the Late Pennsylvanian) the sediments eroding from the Allegheny mountains poured into the adjacent sea, building deltas and the coal swamps …
25. … which produced the vast quantities of Appalachian coal mined today.
26. The Alleghenian lasted for a long, long time. It started in the Late Mississippian and it wasn’t over until the Late Permian when the mountains had completely worn down and the foreland basins had been filled.
27. Thus the supercontinent cycle that began with the Late Proterozoic rifting of Pannotia (or Rodinia if you prefer) ends with the peneplanation of Pangaea some 320 million years later. All three of our Appalachian Parks were peneplaned, but none display particularly good records of the event. The massive supercontinent of Pangaea lasted about 50 million years, …
28. … until, like all supercontinents, it succumbs to the tensional forces associated with a newly initiated hot spot (mantle plume) and undergoes rifting about 200 million years ago.
29. Rift valleys opened along the entire length of the peneplaned Alleghenian mountains during the Late Triassic to Lower Jurassic.
30. … Although none of our three parks actually preserve any of the rift valley sediments, Shenandoah …
31. ... lies very close to one of the Triassic rift basins, which are mostly located in the Piedmont province. None of these rift basins extended to the point where oceanic crust was produced. That boundary lay well to the east of the current Atlantic shoreline in North America.
32. Thus rifting was not symmetrical. Like a lopsided divorce settlement, the union and subsequent separation of North America and Africa left North America with all the marriage-accumulated wealth – in this case, the terranes accreted by the Taconic and Acadian orogenies.
33. Or if you prefer a different analogy, North America got custody of the children – Tac and Avalonia. Poor Africa was not only left alone, but because it was thrust over North America during the Alleghenian, it bore the cost of peneplanation far greater than did North America and thus left the marriage with a sizeable chunk of its pre-marriage real estate missing.
34. North America even got the divorce records – the axial rift!
35. But life goes on after divorce and both divergent continental margins got on with the process of rebuilding. The old rifts are now completely covered by thick DCM sediments on the continental shelf and coastal plain. One day in the distant geologic future those sediments may be thrust upwards into majestic, collision-built mountains should North America and Africa rekindle their tectonic attractions and reunite. Although they’ve done it twice before, there’s no guarantee that North America will reunite with Africa. However, if the Wilson Cycle is true to its promise, both continents will remarry, just not necessarily to one another. They may find different super-continental partners once the Atlantic ocean floor which separates them has fully sunk back into the mantle. No matter who they hook up with, subduction always leads to orogeny.
36. But I’m getting ahead of the story. It turns out that more than just DCM sedimentation happened as the Atlantic widened.
37. That the Appalachian landscape has not been completely stable following the last period of peneplanation is evident in the distinctive pattern of long parallel ridges of nearly the same elevation separated by narrow valleys, and the narrow, steep sided “water gaps” that slash across those ridges. A little thought shows that the rivers flowing through the water gaps could not have cut those gaps *after* the mountains formed. To do so the water would have to flow uphill - and then erode down. The conclusion is that the rivers existed *before* the mountains.
38. Similarly, the near equal elevations of all the ridges seems to indicate that the rocks underlying all the ridges were at one time eroded down to the same elevation, and that they have all been lifted up at the same time. Both of these lines of evidence lead to the conclusion that sometime in the Cretaceous or Cenozoic all of Appalachia had been eroded down …
39. … to another peneplain, flat all the way down to sea level, crossed by rivers draining the continent to the *west.*
40. Furthermore, all this land then underwent gentle uplift (rejuvenation) allowing the streams and rivers to begin to erode and cut their way back down.
41. The ridges are the hard rocks resisting erosion …
42. and the valleys softer rock eroding away.
43. The ridges run parallel to each other because they were all folded and faulted the same way during the Alleghenian orogeny.
44. Thus, what we are seeing are the final stages of uplift of the Alleghenian mountains, as the east coast of North America settles into greater and greater tectonic stability. Mechanisms hypothesized to account for this period of rejuvenation include continuous buoyant uplift of thickened crust and Tertiary to recent arching - perhaps associated with mantle migration away from the region depressed by the loading of DCM sediments.
45. At any rate one of the interesting consequences of rejuvenation in the Valley and Ridge province is stream capture. As rejuvenation uplifted the land, streams down cut into their valleys and extended their courses by headward erosion. This process happened faster for larger streams like the Shenandoah and Potomac Rivers than it did for smaller streams like Beaverdam, Gap Run and Goose Creeks.
46. Eventually headward erosion of the Shenandoah River (following the trend of more easily eroded rock) intersected the headwaters of Beaverdam Creek. Since the larger Shenandoah/Potomac River system had eroded its valley to a lower elevation than did the smaller creeks, all portions of Beaverdam Creek that where higher than the Shenandoah River at the intersection point drained into the Shenandoah. The added discharge only accelerated the down cutting and headward erosion of the Shenandoah River …
47. … such that it went on to capture the headwaters of Gap Run Creek …
48. … and Goose Creek as well. With their headwaters captured, the three creeks had far less discharge and could not muster enough down cutting to keep place with the uplift of the ridges. Their old water gaps through the ridges where eventually abandoned and replaced with “wind gaps” through which now only wind flows.
49. Well we have just a couple of finishing touches on the whole Appalachian saga to go over and we’re done! By virtue of its northerly and coastal positioning, Acadia National Park will have the honors of telling the last part of story about Quaternary glacial and coastal processes.
50. The glaciers that eroded Acadia National Park in the Pleistocene were of the continental variety and were part of the vast Laurentide Ice Sheet that advanced and retreated many times across northern North America beginning about 1.7 million years ago.
51. As is typical of areas affected by continental glaciation, the land was eroded nearly flat except for the most resistant rocks like the Granite of Cadillac Mountain.
52. Most of the rocks that resisted the erosion of the continental ice sheets like “The Bubbles” here were sculpted into Roche Moutonnees. Can you tell which way the glaciers moved?
53. The Porcupine Islands off Bar Harbor are also Roche Moutonnees and nicely show the direction of ice movement from left to right.
54. Glaciation influenced coastal processes by affecting both sea and land levels.
55. During periods when ice accumulated on land more sea water was evaporated from the ocean than returned via runoff and precipitation so the sea level lowered.
56. But the weight of the ice pressed the continental lithosphere beneath it into the soft asthenosphere.
57. Now when the ice melts, both sea level and the continental lithosphere rise, but importantly, the continent rises more, because the water added to the ocean from melting ice must be shared with all the world’s oceans and the buoyancy adjustments are confined to only the areas formerly under the weight of ice. Furthermore, a significant amount of ice still exists on places like Greenland and Antarctica, so not all of the glacial water has returned to the ocean. It was during this period that rivers carved valleys down to sea level along former glacial troughs. These valleys where submerged as ice melted in other areas …
58. … causing sea level to rise relative to Acadia because most of the buoyancy adjustments had already taken place. This rise in sea level is still happening in Acadia and explains …
59. … the heavily embayed coast here as former river valleys became submerged.
60. Although numerous glacial troughs have been gouged out along areas of softer and/or fractured rocks, …
61. … only Somes Sound connects with the ocean.
62. Somes Sound is therefore a fjord and the only true fjord on the eastern seaboard of the United States. Unlike the numerous embayments that punctuate the coastline which get deeper at their mouths because they were at least partly carved by rivers, Somes Sound gets shallower at its mouth. Obviously it could not have been carved by a river. The rising sea level combined with …
63. … heavy surf …
64. … and durable granite have sculpted one of the most beautiful coastlines in America.
65. The granite is so durable that virtually all coastal erosion is confined to softer areas such as where joints or dikes cut the granite.
66. The softer areas widen into slot-like inlets through which the waves slosh.
67. The most famous of these is Thunder Hole,
68. … where, under the right tide and wave conditions, a thunderous booming sound can be heard as waves smack up against a small cave at the base of the eroded joint system here. More often, the hole produces an thrilling splash that equally delights park visitors.