Why Are These Mountains Here?

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The mountains are calling! Yes, the mountains were one of the main reasons that I wanted to retire here in Connestee Falls after working as a geologist for over 40 years. I think we can all agree this is a wonderful community to live in, with a whole range of beautiful settings and natural resources. But have you ever wondered why these mountains are here? Were they always here? How old are they? Were they ever much higher? What kind of rocks am I seeing as I hike our more than 20 miles of trails? Are they the same rocks as those over along the Blue Ridge Parkway? Will these mountains be here forever? In this article I would like to briefly address many of these questions. Some issues may be covered in more detail in future geology articles or on my Geology 101 Walk & Talk events. Geology and geologic processes fundamentally shaped and affected nearly everything we see and enjoy in and around Connestee Falls.

Geology 101. First, a brief introduction to geology to get started. Geology is not simply the study of rocks as many people believe; it is more generally the <u>*study of the earth*</u>. As you can then imagine, geology is an extremely wide-ranging science: rocks (sedimentary, igneous, metamorphic), minerals (quartz, feldspar, mica, and so on), fossils (micro and macro), oceans and rivers, sedimentation and erosion, earthquakes, volcanoes, glaciers, mountain building, plate tectonics, to list some aspects. Many geologists do indeed specialize in one of these disciplines, but to be, let's say a micropaleontologist (as I am), you need to have a working knowledge of, or be involved with, many of the other often interrelated fields within geology. *(See Attachment at the end of this article.)*


Fig. 1

Brevard Fault Zone. When you get a chance, stop by the *Overlook* at the curve up the hill from the Main Gate. Here you are not only looking at a beautiful NW view, but also something of geologic importance! The valley (up to a mile wide in places) in front of these mountains (***Fig. 1***) reflects the linear surface-trace of a major thrust fault zone, that dips (slopes) with a shallow angle to the SE for a considerable distance deep underground where you are standing. (A thrust fault involves a large-scale section of typically older rock that breaks and slowly pushes up over younger rock in the sub-surface, often ultimately resulting in mountain ranges at the surface.) The rocks along this sliding thrust-faulting plane/zone have been stretched and ground up through time, and now when exposed at the earth's surface (as they are here in front of you) they are more easily eroded by streams and rivers, locally here by the French Broad River. This long series of valleys runs along mountain fronts for about 435 miles from AL and GA to the NC/VA border, and generally marks what is known as the <u>*Brevard Fault Zone*</u>. Large-scale NW movement of crustal rocks in the sub-surface and abovesurface (thick thrust fault sheets) may have occurred along this thrust fault zone during each of the mountain-building events we are about to cover. There may be no large earthquakes along the *Brevard Fault Zone* today, but in the distant past there certainly were! The high mountains of the past have all mostly eroded with their sediments ending up in oceans long gone.

Although the *Brevard Fault Zone* is generally considered to be the dividing line between the present-day Blue Ridge Mts and Piedmont physiographic regions along its 435 miles length, an interesting divergence occurs locally for us. We have mountains on both sides of the *Brevard Fault Zone*, which can be seen on the relief-style topographic map below (***Fig. 2***). The fault zone (**blue line**) generally traces this lineation of mountain fronts and valleys running along Rt. 280 from near the Asheville airport (**a**) SW through downtown Brevard (**B**), then continues along Rt. 64 near Rosman, and eventually into GA and AL. From the airport (**a**), south of Asheville (**A**), it heads generally NE towards Boone, and essentially ends by splitting into two other faults near the NC/VA border. To

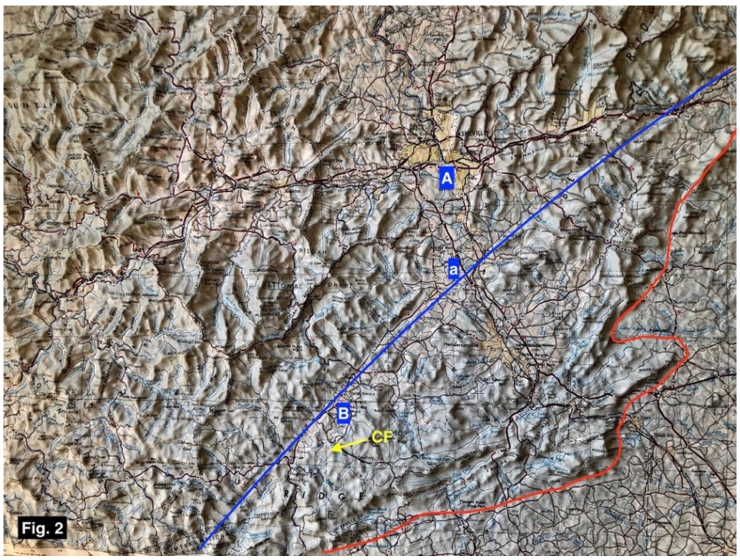

Fig. 2

complicate things a bit, there is a regional erosional feature, called the *Blue Ridge Escarpment* (**red line**), that generally follows the *Brevard Fault Zone* for a considerable distance, but in our area it does not. This segment of the Piedmont, on which Connestee Falls (CF-**yellow arrow**) is located, has not yet eroded back to the *Brevard Fault Zone*, but it will likely in the next few million years or so. *Good-bye, Connestee Falls!* If you go up to Caesar's Head State Park and stand on the cliff edge, you are looking out over the Piedmont physiographic province, where the drop at this erosional escarpment is almost 2000 ft.!

Tectonic plates on the move. The modern earth is divided into about 12 large (and additional smaller) plates carrying both continents and oceans that are still moving, usually up to about 1 or 2 inches a year. The numbers and configurations of these tectonic plates on the earth changed through time. This process is called ***plate tectonics***, powered by convection systems deep in the earth's mantle (large thermal loops), and helped along by gravity movement (pull) associated with the moving plates subducting (sinking and diving) into deep oceanic trenches and the mantle.

Let's now go back a long time...about one billion years ago, in what geologists call the Proterozoic! *(see Attachment of Geologic Time Scale at end of this article to follow along).* Parts of what are the present-day Carolinas would have been in the middle of a gigantic supercontinent we call ***Rodinia***. Near the town of Toxaway, NC, I collected a sample of Toxaway Gneiss (radiometrically dated at 1.2 billion yrs old). This gneiss was once a granite that formed in a volcanic magma chamber when Connestee Falls was part of *Rodinia*. Then from about 700 to 600 million yrs ago, *Rodinia* began to break up into a number of tectonic plates, including Gondwana (Africa and South America), Laurentia (North America), and Baltica (Europe), separated by what we call the Iapetus Ocean. As this break up continued, down-dropped rift (pull-apart) basins formed into which sediments were deposited that became sedimentary rocks. They were later buried more deeply and transformed into what are now known as the *Ashe Metamorphic Suite* of rocks. We can see some of these rocks (gneisses and schists) across the valley in the mountains on the NW side of the *Brevard Fault Zone,* as observed from the Connestee Falls *Overlook*.

Like a kind of geo-conveyor belt, over the next couple hundred million years, plate tectonics carried both oceans and landmasses, some that broke off Gondwana, generally in a NW direction towards, and then eventually collided with, Laurentia. Most of this occurred south of the equator. The *Brevard Fault Zone*, part of a much larger fault system, generally marks the surface expression today of one or more of these sub-surface thrust faults involved with the SW-NE alignment of these collisions of continental landmasses riding on the tectonic plates. Each of these collisions produced a mountain building event (called an orogeny). For example, during the Taconic Orogeny beginning in the Middle Ordovician (*refer back to the Geologic Time Scale)* about 475 million yrs ago, one or more landmasses referred to as *Piedmont Terrane (**P**)* type, slowly collided with Laurentia resulting in mountains we refer to as the Ancestral Appalachian Mts. (***Fig. 3A***). It should be noted that only the ***westernmost*** part of the Carolinas as we know them today (NC/SC location shown on Laurentia) would have existed during this time. *Piedmont (**P**)* type terrane that was accreted (added on) to NC and SC during this collision can be identified today generally paralleling the Blue Ridge Mts. The granite that was once part of gigantic volcanic magma chambers 10 or more miles deep was later

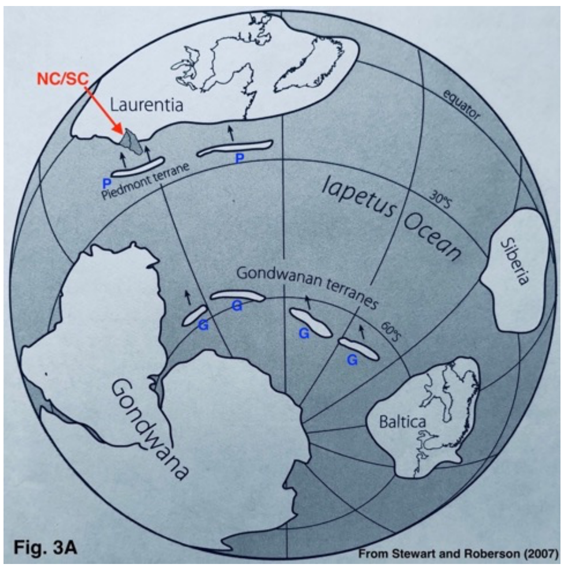

Fig. 3A

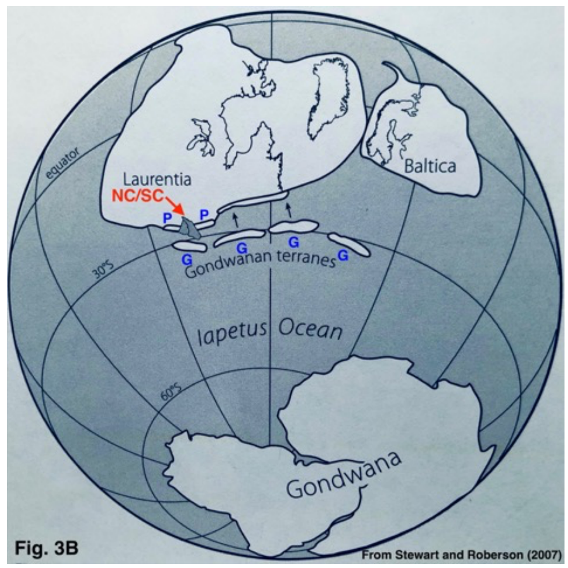

Fig. 3B

metamorphosed into the granitic gneiss we see today here at Connestee Falls (***as Henderson Gneiss***), and as related rocks at Caesar's Head and Table Rock. Then from about 420 to 370 million yrs ago in the Devonian, the Acadian Orogeny occurred with the collisions of landmasses moving N-NW referred to as *Gondwana Terrane (**G**)* type (***Fig. 3B***). These ***G*** type terranes (likely derived from the Gondwana landmass) also accreted onto NC and SC, and are identified today as Charlotte, Carolina, Kings Mt., and other Subterranes or Belts; they also mostly run parallel to the Blue Ridge Mts. *(Please note that Piedmont and Gondwana terrane type **shapes** and **movements** are shown on the maps for **diagrammatic** purposes only.)* Importantly, what we see today are the deep cores (roots) of these eroded mountain systems in our present-day Blue Ridge Mts. It must also be emphasized that the gentle, rolling hills of our Piedmont that you can view for many miles from Caesar's Head today hide severely eroded, very complex folded and faulted geologic structures of long-ago mountains and added terranes from far-away places in its sub-surface.

Are you ready for the big one? During what is called the Alleghanian (or Appalachian) Orogeny beginning in Carboniferous (Late Mississippian) time, about 330 million yrs ago, the large Gondwana landmass began colliding with Laurentia and Baltica/Eurasia, creating a gigantic supercontinent called ***Pangea*** (***Fig. 4***). Note where the Carolinas (only western parts) would have been. The resulting complex of huge thrust faults produced the *Central Pangean Mts*. in this continent-continent collision, near the equator, likely snow-capped, and probably of present-day Himalayan heights. Today we call the remnants of this mountain system, probably re-uplifted at times during the Miocene 20 to 5 million yrs. ago, the *Appalachian Mts*. in the US from Alabama to New England. Similar mountain remnants, also part of this large mountain system, are present in Newfoundland and Greenland, as well as in Great Britain (Scottish Highlands), Scandinavia and other parts of Europe (Variscan Mts.), and Morocco in Africa (Atlas Mts.).

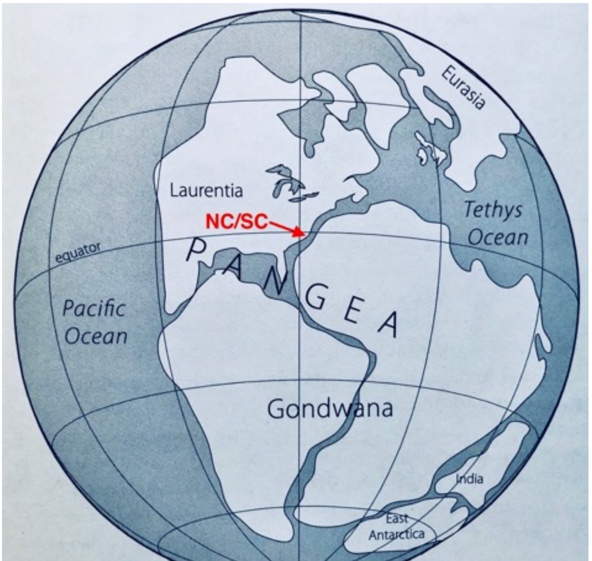

Fig. 4 From Stewart and Roberson (2007)

We call our part of the Appalachians the Blue Ridge Mts., what you see at the Connestee Falls *Overlook* looking NW. Recall that the presence of the *Brevard Fault Zone* is reflected in the valley and up to the base of the mountains, part of it running right through the town of Brevard, and extending hundreds of miles north and south from this view. For millions of years the meandering French Broad River has been flowing at the surface, eroding and re-depositing the mylonitic (crushed/softer) rocks of this sub-surface thrust fault zone, a gently SE dipping (sloping) complex of rocks deep in the earth under the *Overlook*. Tectonic movement (thrust faulting) likely occurred northwestward on the *Brevard Fault Zone* during parts or most of the mountain building events just discussed. The high, snow-capped Andes-type and Himalaya-type mountains associated with these events have long eroded away, just as the mountain core remnants of our Blue Ridge Mts. will do some day. When those extremely high mountains were here during Pangea time, there were no true mammals and no birds! They did not yet exist on the earth. No plants with flowers. Not even dinosaurs! They were all to come later. And the Atlantic Ocean had not yet formed.

What happened to the high mountains? During and between these major orogenies, the uplifted high mountains and accreted terranes were continuously eroded, with most of the sediments ending up in ancient oceans that are long gone. However, in the Middle Jurassic (over 170 million yrs ago) the Atlantic Ocean began to open, as the long, sub-surface Mid Atlantic Ridge down the middle of the North Atlantic and South Atlantic started spreading basaltic ocean floor very slowly eastward and westward. The Appalachian Mts. and the accreted terranes of the Piedmont along the eastern coast of Laurentia (North America) began eroding and shedding sediments down the streams and rivers toward the newly-forming Atlantic Ocean. As sea level rose and fell intermittently through time, with the shoreline moving back and forth, sediments derived from the mountains and terranes were eventually deposited over parts of the Piedmont and then began to build out as a thick sedimentary wedge into the Atlantic Ocean to the east. This covered geologic periods we call Jurassic, Cretaceous, Paleogene, Neogene, and Quaternary to the Present (see *Geologic Time Scale*), resulting in what we know today as the Coastal Plain physiographic region. At the coastline today, this sub-surface rock wedge of sedimentary rocks is over 10,000 ft thick; offshore it thickens to over

30,000 ft thick. It is interesting to note that sea level may have been over 700 vertical feet higher than present day oceans in the Cretaceous around 90 million yrs ago! This would have pushed the shoreline back to near where Greenville, SC is located today. Get out the beach chairs!

At some point, eroded sediments from parts of the mountains also began travelling down rivers, like the French Broad, on their way toward the Gulf of Mexico, as they do today from Connestee Falls, which happens to be on the western side of the **U. S. Eastern Continental Divide** (near Caesar's Head State Park). Eroded sediments on the eastern side of the Divide ended up in rivers heading toward the Atlantic Ocean. It's still that way today.

Geologic future. What does the future hold for eastern North America, including the Carolinas and Connestee Falls? The North American tectonic plate, on which we are riding W/SW, originates in the middle of the Atlantic Ocean along the Mid Atlantic Ridge. Here, magma moves up from the mantle and hardens into basalt moving out both eastward and westward on the seafloor up to about 1 in. per year (similar to the rate of your fingernail growth). Our North American plate, which terminates along western North America in complex faulting configurations, is getting way too large and way too old! Oceanic crustal basalt off the Carolina coast exceeds 200 million years in age; very little oceanic basalt on earth today is older than this. It is likely that in the next 10 to 20 million years, this very old and very dense basaltic oceanic crust off our coast will begin to break somewhere out from our shoreline or continental shelf or slope, and start to subduct (dip) under the less dense continental crust of North America. The tectonic subduction will result in a new mountain range, perhaps similar to the Andes Mts of today, with lots of volcanoes and huge earthquakes! It's extremely unlikely that any *Homo sapiens* will be here to see this happen!

It's a gneiss rock. Back here at the *Overlook*, we'll finish up on rock type. We live in a region here in western NC where many of the rocks are metamorphic, that is, they were once either igneous (like granite or basalt) or sedimentary (like sandstone or shale), and then buried deeply in the earth, and metamorphosed (changed in some way) by extreme pressure and temperature. As geologists, we not only specify a rock type, but also add a geographic or other identifying name. The rocks in and around Connestee Falls are part of what we call the *Henderson granitic augen gneiss*. *Henderson*, the geographic name, is named for the County where it was described. The rock type indicates that it is a metamorphic *gneiss* (German, for sparkling, because its minerals glitter in the light) that was once an igneous *granite* (crystallized magma) rock. *Augen* (German, for eye) suggests that the feldspar and quartz minerals look like eyes.

To see this gneiss, walk about 65 or 70 steps down the *Ogana Trail* from the *Overlook*, and check out the large rock to the left (***Fig. 5A,*** *view looking up the trail).* Note the *augen* stretched feldspar and quartz minerals (white) and biotite micas (black) that display foliation (banding) in the vertical rock face, as seen in this close-up photo (***Fig. 5B***).

Fig. 5A

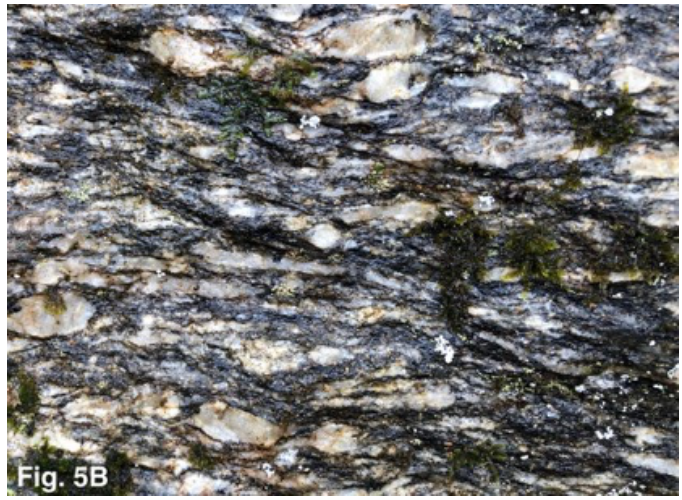

Fig. 5B

Look on top of this large rock and you can see how this gneiss, that formed over 450 million years ago over 10 miles underground, is now weathering (peeling) away here at the surface. The mountains are eroding right in front of you! Try to imagine how much geologic time it takes to erode whole mountain ranges that we have just discussed!!

For more geology related reading, including interesting geologic sites to visit in North and South Carolina, please check out *"Exploring the Geology of the Carolinas"*, by Kevin Stewart and Mary-Russell Roberson (UNC Press, Chapel Hill; 2007). This book is available at the Caesar's Head State Park visitors center, and Highlands Book Store in Brevard. Some of the material covered in my article was based on information and figures from this book, all with permission from the authors.

Please email me with any questions: rogerwitmer46@gmail.com If you are interested in learning more about the geology of Connestee Falls and the Blue Ridge Mts., consider attending one of my **GEOLOGY 101 Walk & Talk** sessions held in the Spring and/or Fall. Check out the Friday Flyer for details and sign-ups.

"Why Are These Mountains Here?" **Revised version (May, 2026)**

<u>GEOLOGY IS THE STUDY OF THE EARTH</u>!

For a child, grandchild, or relative or friend, who may say "I don't know what to be when I grow up."

GEOLOGY AND RELATED SPECIALITIES:

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-Structural geologist
-Field Geologist
-Petrologist [Igneous, Metamorphic, Sedimentary (Clastic or Carbonate) rocks]
-Geochronologist (radiometric rock dating)
-Sedimentologist
-Stratigrapher
-Sequence stratigrapher
-Biostratigrapher
-Paleontologist (micropaleontologist/macropaleontologist)
-Cyclostratigrapher
-Magnetostratigrapher
-Paleomagnetics geologist
-Mineralogist
-Crystallographer
-Gemologist
-Pedologist (Soil geologist)
-Geomorphologist
-Economic geologist/Mining geologist
-Petroleum geologist (Exploration/Reservoir/Production/Development geologists)
-Wellsite geologist
-Well-log analysist/Petrophysicist
-Petroleum engineer
-Environmental geologist
-Climate geologist (Climatologist/Paleoclimatologist)
-Glaciologist
-Hydrogeologist (Geohydrologist)
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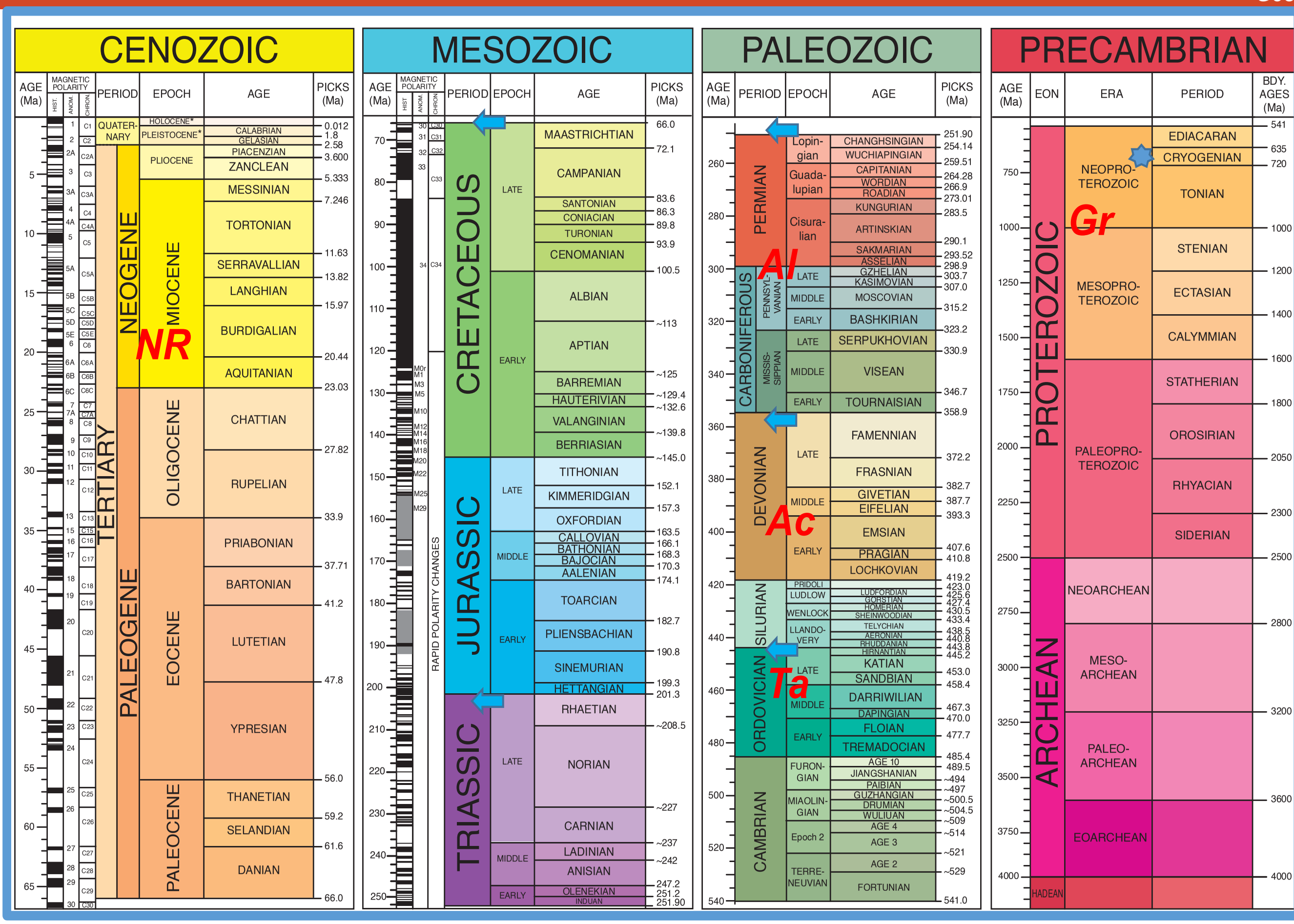
-Planetary geologist/Astrogeologist
-Geochemist (Organic/Petroleum geochemist; Inorganic geochemist)
-Geophysicist (Petroleum geophysicist/Seismic stratigrapher)
-Seismologist (Earthquake geophysicist)
-Volcanologist

Geologic Time Scale

Geological Society of America (GSA) ver. 6



MOUNTAIN BUILDING EPISODES:

NR=Neogene Re-Uplift
Al=Alleghanian
Ac=Acadian
Ta=Taconic
Gr=Grenville

Major Extinction Event

Major Snowball Earth