A Diluvial Interpretation of the Appalachian Provinces: Geology and Geomorphology

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Key Words: Appalachians, Blue Ridge Province, Central Atlantic Magmatic Province, coal rank, Deep River Basin, erosion, exotic terranes, Piedmont Province, rift basins, thrusts, Valley and Ridge Province

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Abstract

The physiographic provinces and general geology of the Appalachians and associated provinces are described. The Coastal Plain Province starts at the Fall Line and forms an increasingly thick wedge of sediment that continues offshore to thick margin sediments. It was deposited by paleocurrents flowing eastward. The Piedmont Province is an erosion surface with monadnocks and metamorphosed, except for sediments in the numerous rift valleys. It is thought to have formed from accreted exotic terranes from the east. West of the Piedmont are the Blue Ridge Mountains, the elevated, metamorphosed core of the Appalachians. The Valley and Ridge and the Appalachian Plateau Provinces are described with sediments of the Appalachian Basin that thicken southeast over 13,600 m. Overlying the eastern Piedmont is the Coastal Plain sediment wedge, extending offshore. Some are exposed; others lie under Coastal Plain sediments. The region is extremely complex. Uniformitarian theories center on orogenesis and plate tectonic cycles over hundreds of millions of years. Though intensively studied, problems and puzzles exist. We note several and offer a Biblical explanation for some major features. During the Flooding Stage, the Blue Ridge and Piedmont were thrust northwest as one massive unit. At the same time, large cratonic basins and rifts were developing to the west. The Retreating Stage saw great erosion of the Appalachians and Piedmont. Waning east-directed currents deposited the Coastal Plain sediment wedge and formed water and wind gaps late in the Genesis Flood.

Simple Summary

The Appalachian Mountains, which run 2,400 km along eastern North America, are divided into five main geographic areas, including the Coastal Plain, Piedmont, Blue Ridge Mountains, Valley and Ridge, and Appalachian Plateau. Conventional geologists explain this region's complexity through uniformitarian processes like continental and island arc collisions and plate tectonic cycles over hundreds of millions of years. However, this paper offers a Diluvial Interpretation based on the Biblical Genesis Flood. During the Flooding Stage, the Blue Ridge and Piedmont Provinces were thrust northwest as a massive unit, while deep basins formed to the west, accumulating sedimentary rock that may have reached up to 20,000 meters thick in the Appalachian Basin. The later Retreating Stage of the Flood caused immense erosion of the Appalachians and the Piedmont, forming widespread planation surfaces and depositing the thick Coastal Plain sediment wedge towards the east. This massive erosion, potentially removing several kilometers of rock (up to 6.5 km in some areas, based on coal rank), suggests the Appalachians were once significantly higher.

Introduction

The Appalachian Mountains of eastern North America run 2,400 km from central Alabama to Newfoundland (Figure 1). The region is broadly composed of five physiographic (geomorphological) provinces, defined by similar geomorphic features (Fenneman, 1938; Thornbury, 1965; Oard, 2011a) (Figure 2). These are: (1) the Coastal Plain, (2) the Piedmont, (3) the Blue Ridge Mountains, (4) the Valley and Ridge, and (5) the Appalachian Plateau provinces. The focus of this article is to describe the general geology and geomorphology of the Appalachians to provide a regional context for the Deep River Basin, a rift basin in central North Carolina, which will be published later.

The Blue Ridge and Valley and Ridge provinces are the core of thrusting and deformation, and together range from 160 to 500 km wide. The highest mountains today are the Great Smoky Mountains in the Blue Ridge of western North Carolina and eastern Tennessee. Mount Mitchell, 2,037 m asl, near Asheville, North Carolina, is the highest point east of the Mississippi River. Grandfather Mountain, about 64 km north of Mount Mitchell, tops out at 1,810 m asl (Figure 3). They were, at one time, presumably much higher.

Explaining the Appalachians has proven difficult, despite nearly two hundred years of uniformitarian research by secular geologists. Spotila and Prince (2022, p. 1) state: "Despite vast scientific inquiry, the evolution of Appalachian Mountain topography in eastern North America has yet to be robustly explained."

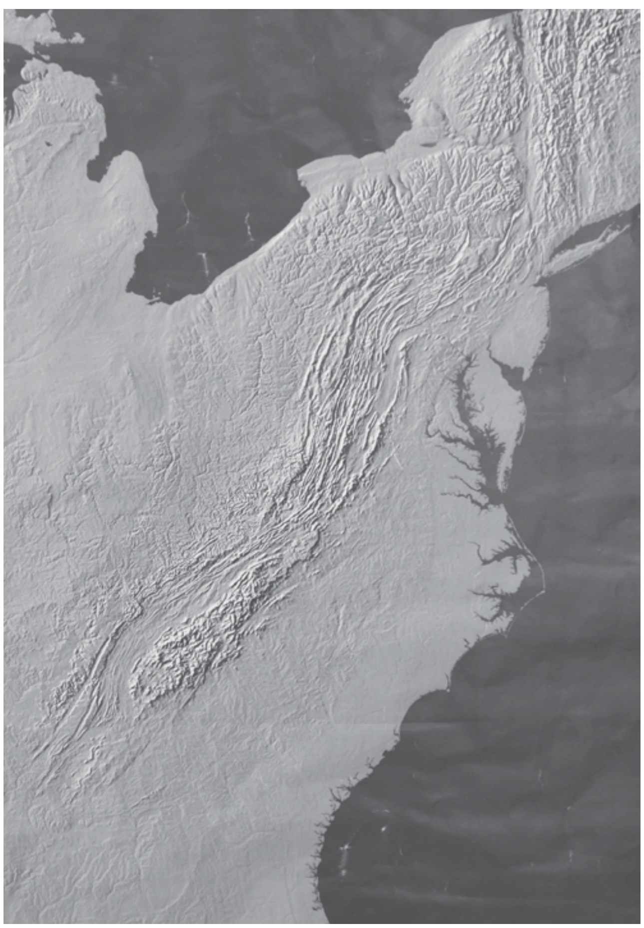

Figure 1. The distinctive geomorphology within the United States of the Appalachian Mountains, the Blue Ridge, and Valley and Ridge Provinces, as seen from space (from Landforms of the Conterminous United States).

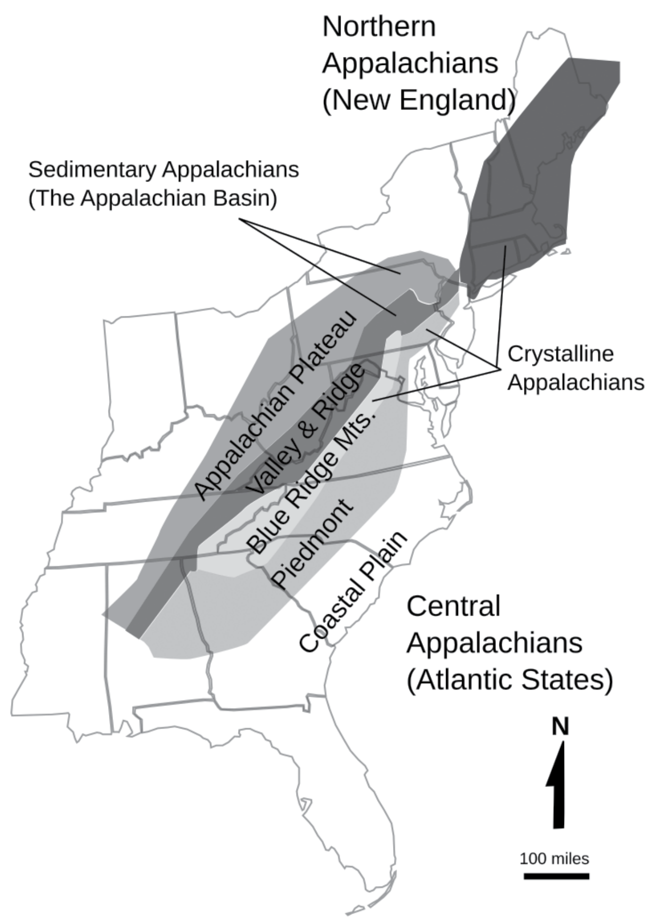

Figure 2. Map of the Appalachian provinces and the two provinces to the west (Jo, USGS, public domain).

Figure 3. Grandfather Mountain in the southern Blue Ridge Mountains at 1,810 m asl as seen from the Blue Ridge Parkway at 1,265 m asl.

Appalachian Provinces

The Coastal Plain

The Coastal Plain Province is defined by both geomorphic and stratigraphic expression. On the Atlantic coast, it is a wedge of sedimentary rocks, thickening from the Fall Line, and dramatically so offshore. The "Fall Line" is a slight topographic drop. It was defined long ago by the upstream limit of shipping, because a slight escarpment created waterfalls and rapids in the coastal rivers. This is attributed to riverbeds dropping abruptly as they transitioned from hard Piedmont igneous and metamorphic rocks to the softer sediments of the Coastal Plain.

Coastal Plain sediments blanket a significant erosional surface. Eastward-flowing, late-Flood currents probably accomplished both the erosion and deposition, the two processes reflecting changes in flow energy. The true volume of this sediment is seen in its offshore thickening onto the continental shelf, slope, and rise (Figure 4). In the northern coastal plain, from New Jersey to Maryland, onshore sediments reach over 2,200 m, then over 9,000 m in offshore basins. In the central coastal plain, North Carolina and Virginia, they reach over 3,000 m onshore, before thickening to about 18,000 m in the Baltimore Canyon trough. In the southern coastal plain, onshore sediment thickness is below 1,500 m, but reaches more than 9,000 m in the Hatteras Basin (Straume et al., 2019).

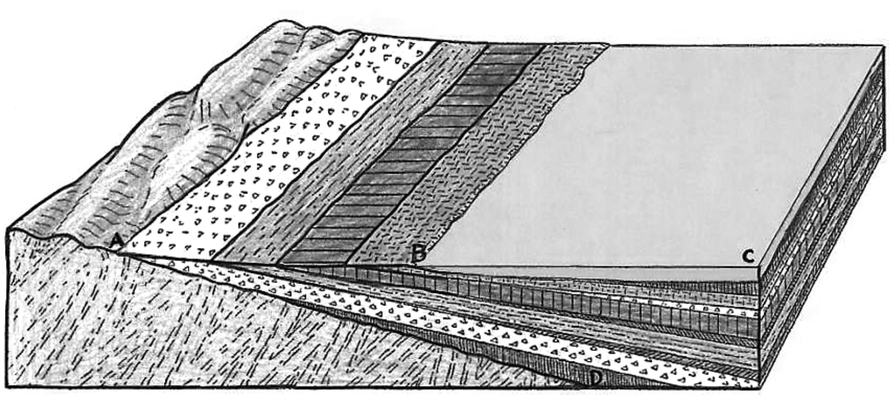

Figure 4. Schematic of coastal plain and offshore sediment wedge (drawn by Melanie Richard).

The Piedmont Province

The Piedmont Province extends northeastward from Alabama to the Hudson River (Figure 2), ranging up to 200 km wide. The Piedmont's elevation gradually rises westward from the Fall Line to the Blue Ridge Mountains. The Piedmont is composed of igneous and metamorphic crust that extends beneath the Coastal Plain to the continent margin. Its lithologic and structural complexity is great, and is currently explained by the accretion of exotic terranes onto eastern North America (Hatcher et al., 2007). The North Carolina interactive map of 2017 shows a number of these terranes (Figure 5).

Martin and Bosbyshell (2019, p. 1064) note: "Many names and shifting criteria have been used to categorize the metasedimentary rocks of the Piedmont Province in the central Appalachian Orogen over the past 130 years…" Previously, terranes were defined by geomorphology, but today, detrital zircon ages are more often used (Martin and Bosbyshell, 2019), which, in some cases, contradict the geomorphology. The designation of an exotic terrane can be difficult in the Piedmont, due to variable lithology and intense

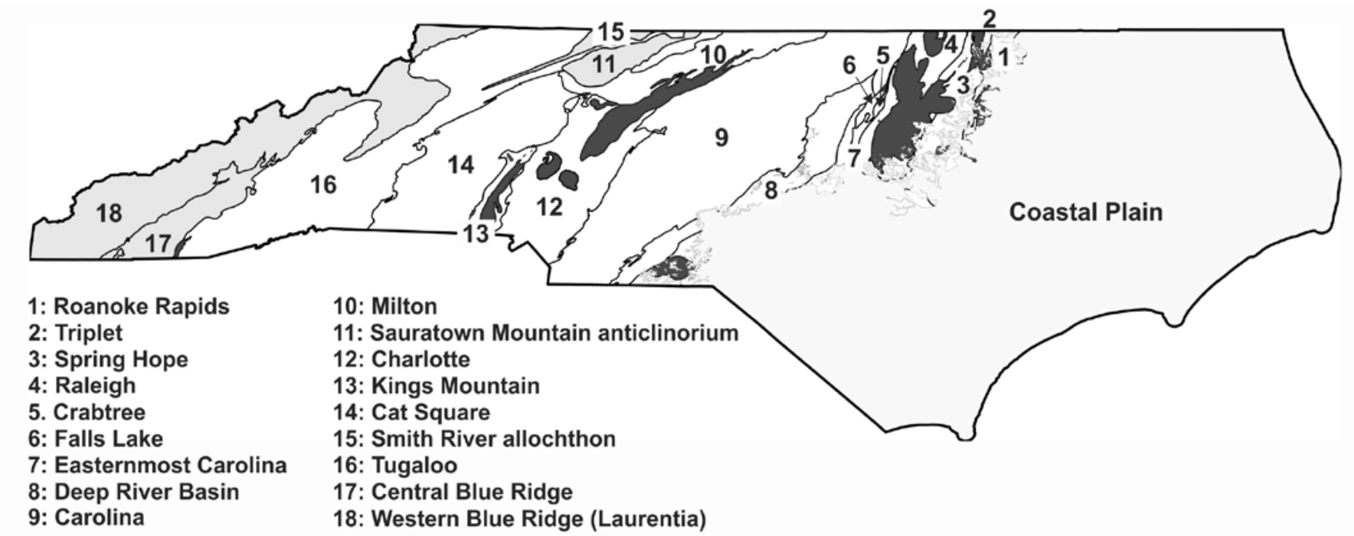

Figure 5. Terranes of the Blue Ridge and Piedmont of North Carolina. Medium gray areas are Blue Ridge terranes. Black areas are plutonic intrusions. The Deep River Basin lies at the eastern edge of the Carolina terrane. Note the increasing complexity near the Coastal Plain. From https://experience.arcgis.com/experience/8eaba8247a8c4347b47a38120a3f0570/.

metamorphism. The "Trenton Prong" in southeast Pennsylvania and west-central New Jersey was once considered an exotic terrane but is no longer (Volkert and Aleinikoff, 2021). Masis et al. (2024, p. 1) state the difficulty in interpreting terranes for New England:

> In contrast, the boundaries between the accreted terranes themselves… are more difficult to distinguish in New England due to their similar geologic characteristics, burial by post-accretion sediments, poor exposure, lack of a clear geophysical signature, and overprinting by post-accretion deformation…

The province has been *planed fairly flat* across its entire area (Figure 6), but exhibits numerous erosional remnants called monadnocks (Figure 7). Stone Mountain, Georgia, is probably the best known (Froede, 1995), rising 240 m above the surrounding terrain (Figure 8). The presence of rolling hills and monadnocks technically makes the Piedmont an erosion, rather than a planation surface (Neuendorf et al., 2005), but many kilometers of rock were eroded off the current surface.

The Piedmont has a large variety of rocks that have been heavily metamorphosed; metamorphic grade increases westward to the Blue Ridge (Marzen et al., 2019). It even contains some claimed mantle rocks (Miller et al., 2006).

Many rift valleys have formed that roughly parallel the northeast-southwest trend of the Blue Ridge Mountains, from Florida to near the Georges Bank (Figure 9). Some are exposed (e.g., the Newark Basin); others are buried beneath Coastal Plain sediments (Heffner, 2013: Post et al., 2015). In Florida, Georgia, and South Carolina, they are all buried under Coastal Plain sediments, although the Dunbarton Basin, near Augusta, Georgia, is very near the Fall Line (Marine and Siple, 1974). These basins are filled with predominantly unmetamorphosed terrestrial sediments and some basalt and diabase sills and dikes.

Figure 6. Lake on the Piedmont near Parkersville, South Carolina, showing the general flatness of the terrain.

Figure 7. Granitic monadnock on the Inner Piedmont, east of the Blue Ridge Mountains, close to Caesars Head State Park, South Carolina.

Figure 8. Stone Mountain, Georgia, monadnock (photo courtesy of Carl Froede).

The Newark Basin reaches depths of over 9,000 m, but most are shallower. The Deep River Basin, which we have especially studied, is thought to have obtained a depth of a little more than 2,500 m (Reid et al., 2010). Diabase sills were injected after the basins formed and prior to erosion.

The Blue Ridge Province

The Blue Ridge Province is the crystalline core of the Appalachians and exhibits the highest elevations. It includes a variety of severely deformed igneous and metamorphic rocks believed to have been thrust northwest (Hatcher, 1972; 1978). The amount of thrusting is difficult to estimate. Hatcher (1972) believed the maximum distance was 125 km. Bartholomew and Hatcher (2010) now think it is 150 to 300 km based on "paleostress indicators." Levine et al. (2025) claim 300 km.

On the southeast edge of the Blue Ridge Mountains, in the southern Appalachians, is an escarpment about 500 km long with a sharp change in elevation between 300 and 600 m. It is most abrupt in western North Carolina, where it rises nearly vertically for about 600 m (Figure 10). Spotila et al. (2004, p. 42) stated:

> In northern North Carolina and southern Virginia, the Blue Ridge highlands exhibit low relief, such that the escarpment is a striking boundary between two subdued surfaces, which we refer to as the Upland and Piedmont surfaces.

Along the eastern boundary of the Blue Ridge Province lies the Brevard Zone, a major 700 km-long, 1–3 km wide fault zone, dipping southeast, extending from Alabama into Virginia (Hatcher et al., 2007). It contains highly sheared and crushed rocks, including mylonite. The Brevard Zone has undergone intense study, with various interpretations that include a continental suture zone, strike-slip fault, and thrust fault (Hatcher, 1978). Parker et al. (2015) map the Brevard Zone as an overthrust contact. Levine et al. (2025) consider the Brevard Zone a strike-slip fault separating the Blue Ridge from the Piedmont Province.

The Valley and Ridge Province

The Valley and Ridge Province, west of the Blue Ridge, extends from Alabama to New York, and is composed of numerous parallel valleys and ridges (Figure 1), formed during late thin-skinned thrusting, involving primarily sediments. Many of the valleys are eroded anticlines (Gore and Witherspoon, 2013) of softer rocks, with resistant rocks forming the ridges.

Its distinct appearance comes from it being a fold and thrust belt, verging northwest (the direction of thrusting). Thrusting is shown by "windows" eroded through the thrusts (Harris and Bayer, 1979).

Along the eastern edge of the province is the "Great Valley." It extends the full length of the Appalachians, from Alabama to the St. Lawrence Lowland of Canada, though low passes create segments. It varies from 3.5 km wide just north of Roanoke, Virginia, to 80 km at its southern end. It has many local names, such as Coosa, Shenandoah, Cumberland, Lebanon, Hudson, and Champlain. The sedimentary rocks underlying the Great Valley are deformed and folded like the rest of the Valley and Ridge, yet have been planed into long, narrow erosion surfaces (Perry, 1978). Many cities and towns were built in the Great Valley, and Interstate 81 runs almost its entire length.

Appalachian Plateau Province

The Appalachian Plateau Province is west of the Valley and Ridge. It includes the Allegheny Plateau in the north and the Cumberland in the south. The limestone layers of the Cumberland Plateau have one of the largest concentrations of caves in the world (Taylor, 2020). Farther west is the Interior Low Plateaus Province, which is not considered part of the Appalachians. Thick sedimentary rocks of the Appalachian Basin underlie the Appalachian Plateau and Valley and Ridge Provinces, thickening eastward.

Appalachian Basin sediments are deformed in the Valley and Ridge, but less so in the Appalachian Plateau Province. They thicken southeastward (Figure 11) and reach a depth of 7 to 10 km beneath West Virginia (Lebold and Wilkinson, 2018), and thicken to 12–13 km in Pennsylvania (Milici and de Witt, 1988; Way, 1999). The maximum thickness is over 13.7 km in the eastern

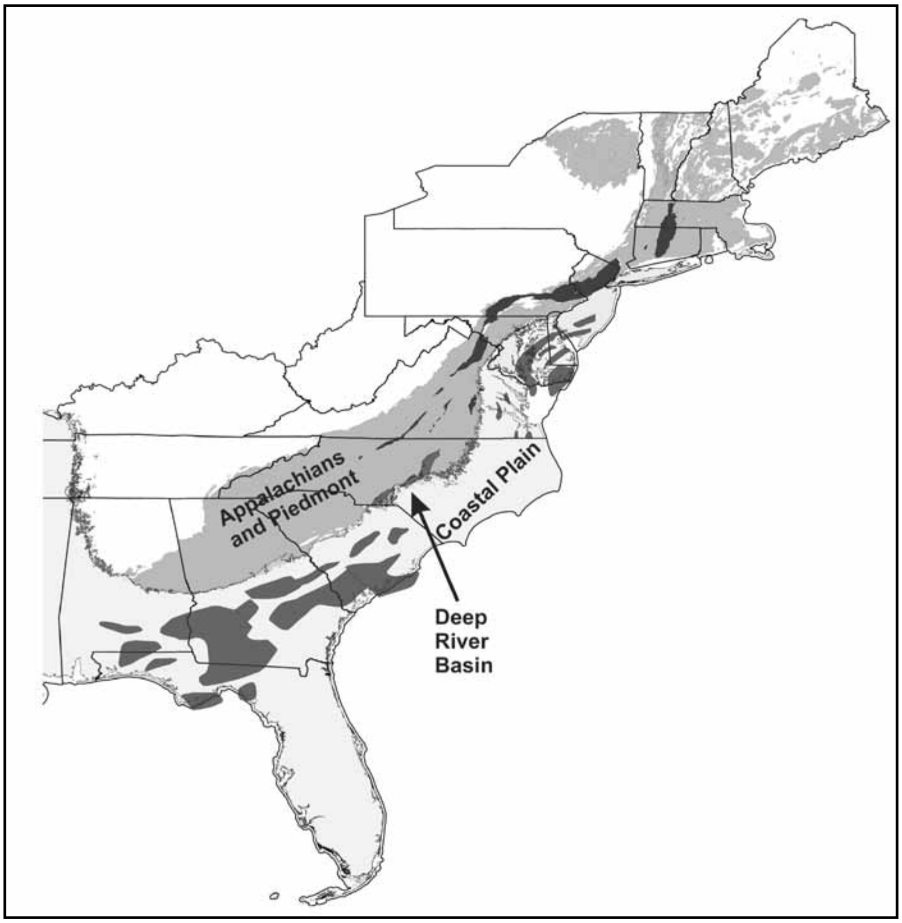

Figure 9. Rift basins occur within the Piedmont and Blue Ridge provinces (black); some are exposed and some are below Coastal Plain sediments (light gray). Basin locations and shapes from Heffner (2013), Post et al. (2015), and various state surveys.

Figure 10. Blue Ridge Escarpment, a 600 m cliff, at Caesars Head State Park, South Carolina (view southeast).

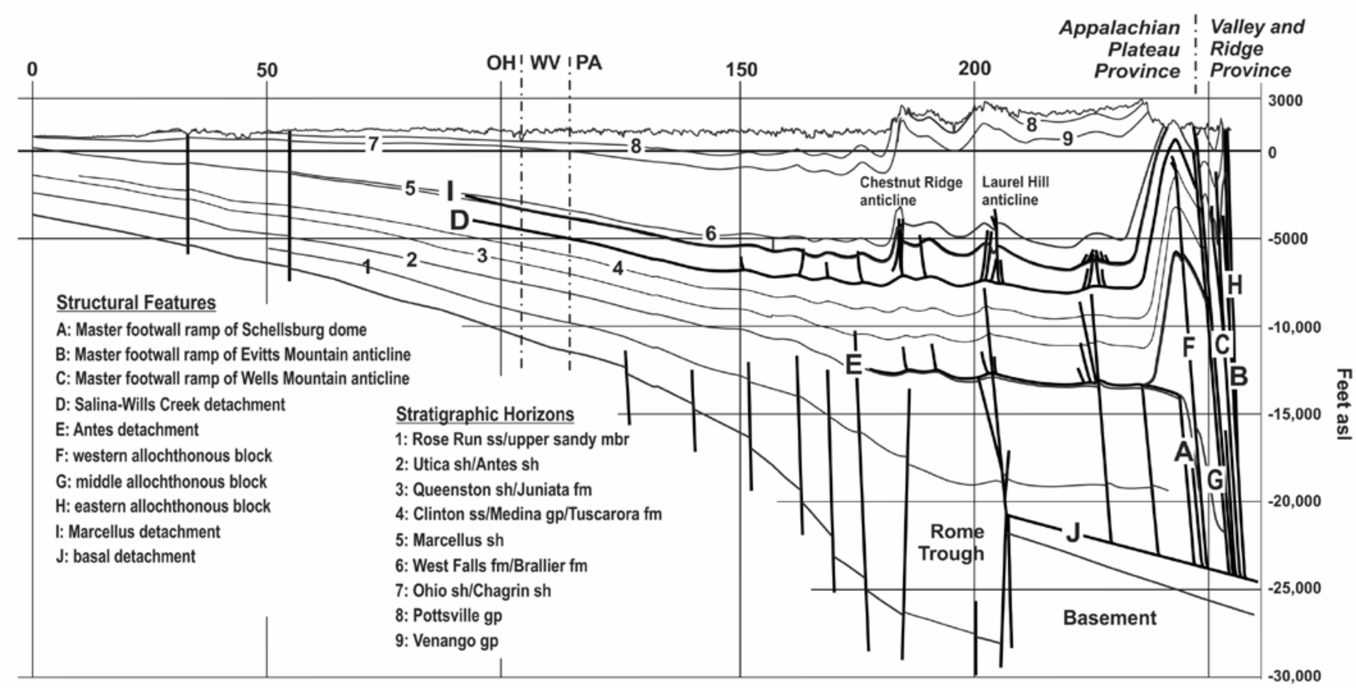

Figure 11. Schematic of USGS Cross-Section C-C′ (Ryder et al., 2012), showing the structural deformation of Appalachian thrusting over the eastern Appalachian Basin. Key stratigraphic horizons are shown to illustrate the thickening into the basin and subsequent deformation in the Valley and Ridge.

part of the Appalachian Basin (Martins et al., 2022).

The Cumberland Mountains are a narrow band of low hills between the Cumberland Plateau and Valley and Ridge in the Central Appalachians (Figure 12). The Allegheny Mountains are a continuation of the Cumberland Mountains into Pennsylvania along the eastern edge of the Allegheny Plateau. In both plateaus, elevation is relatively low in the west, but increases sharply on the eastern, deformed edges.

Uniformitarian Theories

Conventional scientists think the Appalachians were formed by continental collisions between North America and Europe/Africa from the Neoproterozoic to the late Paleozoic (Hatcher, 1989; Plummer and McGeary, 1996; Hatcher et al., 2007). They claim the assembly of Rodinia in the Mesoproterozoic (1.3–0.9 Ga) formed the Grenville Mountains, supposedly among the largest in history (Krabbendam et al., 2017). They are believed to have eroded over millions of years, with transcontinental rivers spreading sediments into western North America (Blum and Pecha, 2014; Mulder et al., 2017; Rainbird et al., 2017; Oard, 2019). Conventional geologists claim Rodinia broke apart in the Neoproterozoic (0.75–0.55 Ga), and in the Late Paleozoic, Pangea formed. Throughout the Paleozoic, thick sedimentary rocks accumulated in the Appalachian Basin foreland.

Furthermore, secular scientists believe the East Coast experienced smaller collisions that welded exotic terranes onto North America and caused the classical Appalachian orogenies: the Taconic (Ordovician-Silurian), the Acadian (Devonian), and the Neoacadian (Devonian-Mississippian), followed by the Alleghenian (Pennsylvanian-Permian) (Marzen et al., 2019). These exotic terranes have had a variety of names. In the Southeast, these include the Charleston/Brunswick and Suwannee Terranes (Marzen et al., 2019). North Carolina's geological survey divided the Piedmont and Appalachians into many smaller terranes (Figure 5). In the northern Appalachians, the terranes have different names (Mohaver and Darbyshire, 2022). Gore and Witherspoon (2013, p. 181) say: "Recognizing terranes and their boundaries is not easy because these tectonic collisions happened over a very long period of time, during which many types of rocks were forming." Levine et al. (2025) claim that the Neoacadian and Alleghenian collisions were one orogeny.

Thus, "Many questions remain about the style of orogenesis in ancient

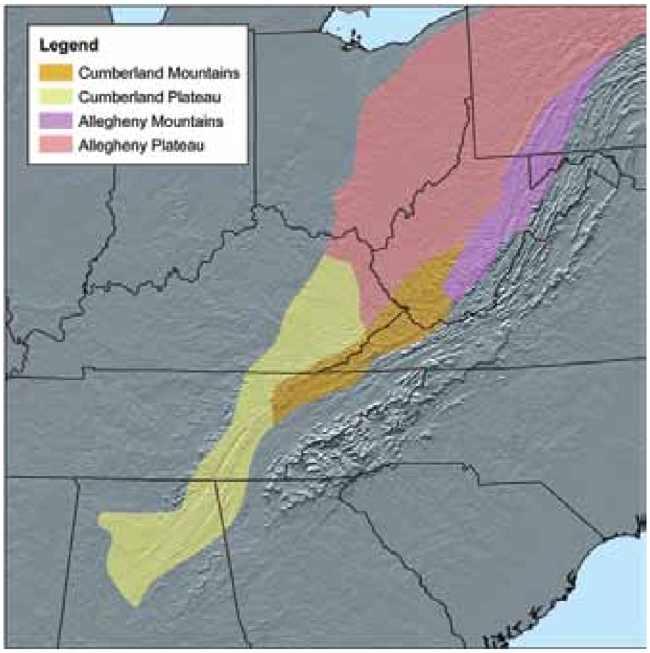

Figure 12. Map showing the Cumberland Plateau and Mountains and the Allegheny Plateau and Mountains (Kmusser, Wikimedia Commons CC-BY-SA-2.5).

Figure 13. Location of large residual elements of the Central Atlantic Magmatic Province (Williamborg, Wikimedia Commons CC-BY-SA-3.0).

orogens and the effects of orogenic structures on later tectonic events" (Marzen et al., 2019, p. 6625). After these orogenies, the Piedmont is believed to have moved southwest by strike-slip motion along the Brevard Zone (Gore and Witherspoon, 2013).

Therefore, uniformitarian scientists believe orogenesis was ongoing from the late Proterozoic through the Paleozoic. During that time, the core of the Appalachians is believed to have formed by repeated northwest thrusting up to several hundred kms (Perry, 1978; Simmons, 1983; Hatcher, 1989, 2010; Levine et al., 2025). Some involved crystalline basement, but some did not, hence the terms 'thick-skinned' and 'thin-skinned' tectonics, respectively. This thrusting is associated with intrusions of mostly granitic rocks (Misra and Keller, 1978; Miller et al., 2006) throughout the Appalachians. During these collisions, the Appalachians were believed to have pushed up as high as the modern Himalayas (Karle, 2009). The mechanism and energy source for this overthrusting and mountain building are not known, but conventional scientists assume it is because of exotic terrane or continental collisions.

During the Mesozoic (200–100 Ma), Pangea split. Early rifting saw basalt flows across the Piedmont and the Coastal Plain (McHone, nd), part of the Central Atlantic Magmatic Province (CAMP), believed to have covered 11 million km^2 in North America, South America, Africa, and Europe. Like other Large Igneous Provinces (LIPs), a large volume was quickly emplaced in less than one million years (Marzen et al., 2019). This basalt has been almost completely eroded (Figure 13) and is absent on the continental shelf (Marzoli et al., 2011). Basalt has been preserved in some rift basins, generally conformably layered with sedimentary rocks (Schlische and Ackermann, 1995; Withjack et al., 2009; Marzoli et al., 2011). Basin sediments are Triassic to Jurassic, and the basalts are Jurassic.

The CAMP basalts extend along the entire continental margin and are believed to be up to 20–25 km thick (Holbrook and Kelemen, 1993), and are likely the cause of the Brunswick and East Coast magnetic anomalies (Oh et al., 1995).

The CAMP basalts are considered independent of the younger Cenozoic basalts (Storey et al., 2007) of the North Atlantic Magmatic Province. This younger basalt is believed to have formed a large plateau that was later broken up during spreading. Remnants are found in eastern Greenland, Northern Ireland, western Scotland, northwest Iceland, the Faroe Islands, and many other islands of the northeast North Atlantic Ocean. Although the North Atlantic Magmatic Province is considered distinct from the CAMP basalts, they are all thought to be the result of rifting.

The origin of the volcanism is unknown (Marzen et al., 2019) but, generally, attributed to continental separation. This is also the time when the Piedmont rift basins formed (Lang et al., 2024). The basalt is believed to have originated in the upper mantle from the uplift of the hot asthenosphere and decompression melting (Lang et al., 2024).

The Appalachians present many challenges. One often not considered is the paucity of outcrops because of such well-vegetated areas. Another is that paleocurrent directions indicate westward flow in the Appalachian Basin, for the most part (Whitaker, 1955; Nichelsen, 1958; Pelletier, 1958; Yeakel, 1962; Schlee, 1963; Pettijohn, 1970). This indicates an eastern source, possibly the Blue Ridge Mountains or the Piedmont. Following the Paleozoic, there was apparently a paleocurrent reversal that indicates flow toward the southeast, accompanied by significant erosion. The reason for this reversal remains controversial (Kaktins and Delano, 1999).

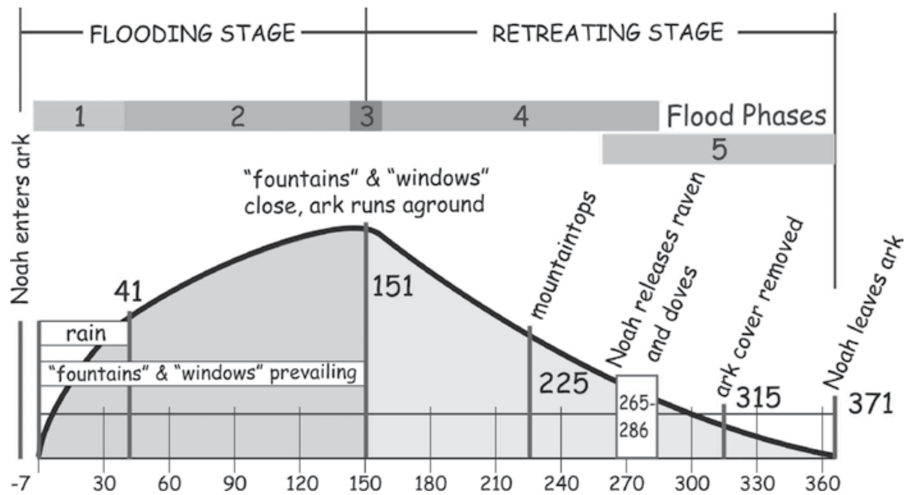

Figure 14. The stages and phases of Noah's Flood and key Biblical events from Walker (1994); drawn by John Reed.

Methods: Placing the Appalachians in Biblical Earth History

It is a challenge to reorient all of the intense study of the Appalachians into a Biblical perspective. To begin, we refer to Walker's (1994) model (Figure 14). Like any flood, the water rose to a peak during the Flooding Stage, then receded during the Retreating Stage to the current sea level. Unlike small floods, Noah's Flood included profound geological events. We suggest five phases for the Appalachian region.

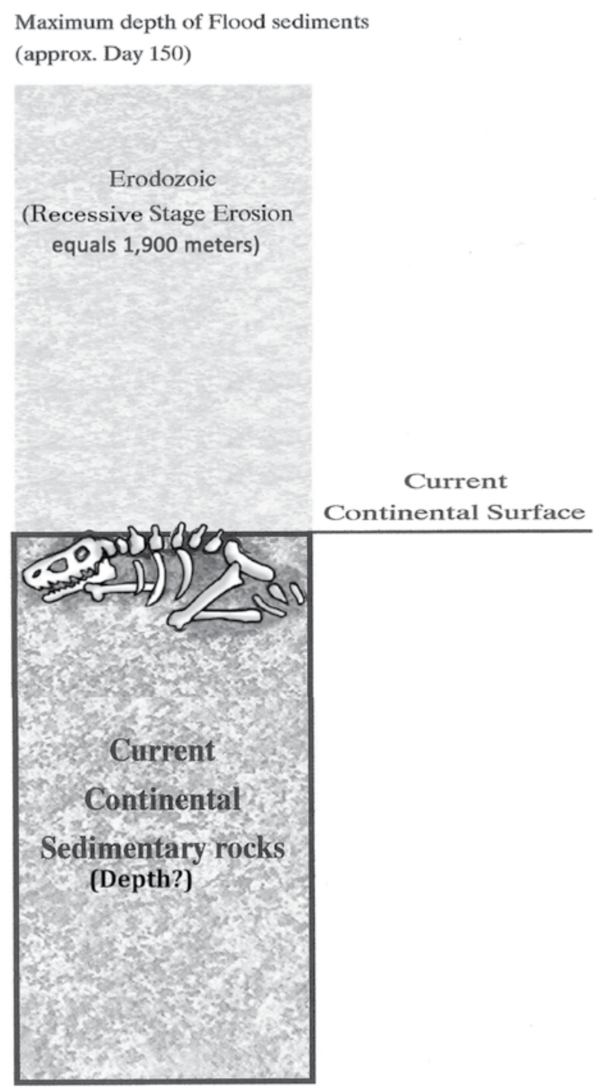

Figure 15 *(right)*. Block diagram showing the maximum amount of sediment on the continents at the peak of the Flood, with 1,900 eroded during the Recessional Stage and an unknown depth of sedimentary rock remaining on the continents. For the mid-continent region, the remaining sediment thickness is approximately 1,800 m (drawn by Melanie Richard).

To help tie the stages and phases of Figure 14 to empirical geology, we initiated the Flood Sediments Research Project (FSRP) (Reed et al. 2022, 2024, 2025; Oard et al., 2023a,b).

The initial purpose of the FSRP is to determine the volume and distribution of all diluvial sediment. Based on the volume of upper Mesozoic and Cenozoic continental margin sediment, we determined that an average of around 1,900 m was eroded from all the continents during the Retreating Stage of the Flood, creating much of the sediments of the Atlantic margin and the Gulf of America (formerly, Gulf of Mexico) (Reed et al. 2022; Oard et al. 2023a). This implies that the volume of diluvial sediment in the central and eastern U.S. was once much greater. The present average thickness in the midcontinent region is about 1,800 m (Reed et al., 2024). If we add back 1,900 m, then an average of 3,700 m of sediment was present there at the peak of the Flood (Figure 15).

As verification of the Retreating Stage erosion, the coal indicates tremendous erosion of the Appalachians. Coal is common in the Valley and Ridge and Appalachian Plateaus provinces. There are 62 mineable coal beds in West Virginia alone (Lebold and Wilkinson, 2018). Coal rank generally increases to the southeast up to high-rank anthracite (Hower and Rimmer, 1991). Assuming rank was a result of heat and pressure from burial, the coal rank implies many kilometers of eroded sedimentary rock, especially where coal is found near the surface. The inferred thickness of eroded overburden varies with other factors, such as geothermal gradient. But if the temperature of the eroded sediment was warmer than expected, the amount of overburden would be less.

Erosion off the Catskill Mountains of New York, by this method, was estimated at about 6 km (Friedman and Sanders, 1982), assuming a normal geothermal gradient and no local heat sources. A higher gradient or past thermal process would reduce the estimate (Hower and Rimmer, 1991). Lower rank bituminous coal has many subdivisions, ranging from sub-bituminous C (1.7 km of removed overburden) to low volatile bituminous A (a little more than 6 km) (Thomas, 2013).

This method is equally valid in the Valley and Ridge. Assuming no other heat sources and a normal geothermal gradient, 4.0–6.5 km of rock was eroded from the Valley and Ridge. Coal in the Deep River Basin indicates up to 6 km of erosion from the Piedmont.

This simple method, if valid, implies that the Appalachians were once higher than today's Rocky Mountains! Detritus from their erosion was transported east, west, and south, depending on the topography and flow direction at the time. Some is thought to have made it as far west as the Colorado Plateau (Froede, 2004; Oard, 2009) based on uranium-lead ratios in zircon crystals.

A diluvial sediment isopach map of the midcontinent region also shows the large-scale rifting at the onset of the Flood (Figure 16) (Reed et al., 2025). At the same time, major parts of the basement were being heavily eroded, as shown by pinnacles in the Kansas basement (Cole, 1976), which we interpret as erosional remnants (Figure 17). Both of these events occurred prior to deposition of the Sauk Megasequence.

Determining the Genesis Flood sediment volume and distribution requires mapping the base of diluvial sediments, as we did for the midcontinent region. However, some uncertainties arise where the base of diluvial sedimentation is unclear, as in the Midcontinent Rift, and must be assumed (Figure 16). Nonetheless, the upper surface was either a DEM or the base of Ice Age sediments. When done elsewhere, volume can be calculated for any geographical area. This constrains hypotheses about sediment source, transport, and deposition, allowing more realistic estimates about diluvial geology. So far, we have surmised that sediments along the Gulf and Atlantic margins came from the North American craton during Phases 4 and 5 (Figure 14), and that much diluvial sediment on the craton largely originated from the cratonic basement, especially the Canadian Shield, helping to create the Great Unconformity. These eroded diluvial sediments (not including the rifts) were later deposited on the Great Unconformity (Sengör et al., 2022).

An example of rock volume eroded from the Canadian Shield is at the claimed Sudbury impact site. Erosion there has been estimated at about 5 km (Senft and Stewart, 2009), and the rest of the southern Canadian Shield is believed to have eroded anywhere from 2–11 km, based on igneous and metamorphic pressure estimates of surface rocks (Figure 18) (Sengör et al., 2022). The highest value mirrors Senft and Stewart's (2009) erosion estimate from the Vredefort Impact Structure on the Kaapvaal Craton of southeast Africa. So, it is difficult to determine the antediluvian topography of North America, although it is likely that erosional estimates based on metamorphic grade are exaggerated and could have been affected by early diluvial catastrophism. Regardless, it is safe to say that significant amounts of rock were removed from the Canadian Shield at some point in the Flood Year, but especially early in the Flood.

Moreover, significant volumes of rock were eroded across the United States, as seen in the extent of the Great Unconformity on the craton (Figure 19). The eroded sediment was transported to other areas of North America. Significant subsequent deformation is demonstrated by the fact that while the Great Unconformity is near the base of the Grand Canyon in northern

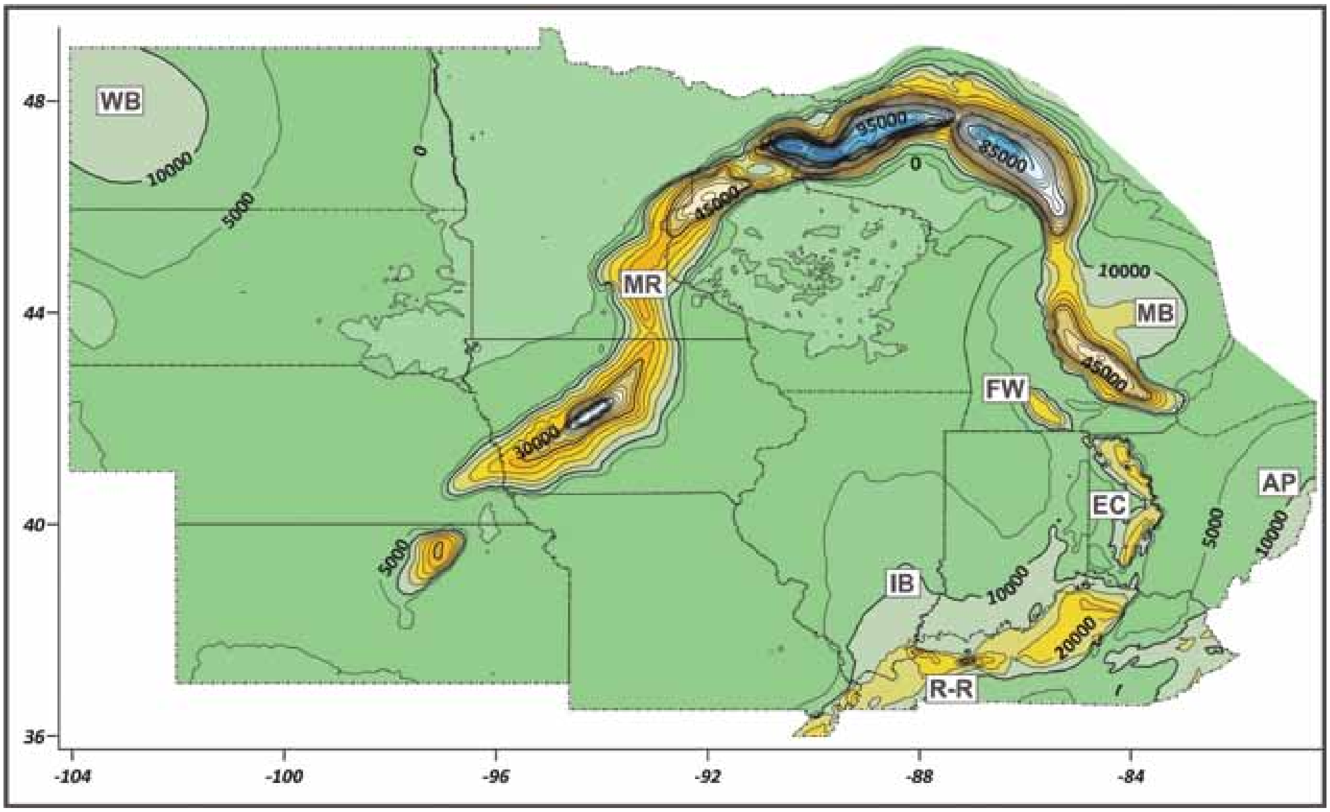

Figure 16. Isopach map from the ground surface to the diluvial basement in the north-central United States in feet. The contour interval is 5,000 ft. MR is the Midcontinent Rift, WB is the Williston Basin, IB is the Illinois Basin, MB is the Michigan Basin, AP is the Appalachian Basin, EC is the East Continent Basin, and RR is the Reelfoot/Rough Creek/Rome Rifts.

Arizona, it is found atop mountains in southern Montana and Wyoming.

Discussion: Earth History of the Appalachians—*The Flooding Stage*

The Flooding Stage begins with Phase 1 on Figure 14. Numerous sudden catastrophes were occurring simultaneously, including volcanism, meteorite impacts, vertical tectonics, tsunamis, and global heavy rain for 40 days, etc. Their significance is seen in the rifts of Figure 16 and a few of the large Precambrian impacts (Oard and Reed, 2017; Oard and Carter, 2021; Reed et al., 2025). Sedimentation occurred in deep rifts and basins. Many of these are

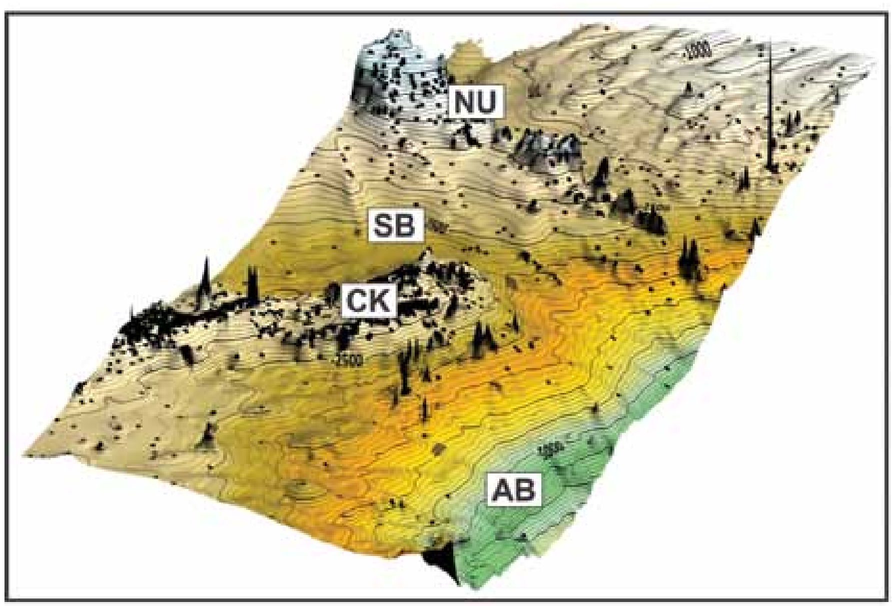

Figure 17. Erosional remnants on the Kansas basement surface, as mapped by Cole (1976), and with significant vertical exaggeration, looking east from Colorado. The erosional remnants are controlled by multiple wells (black dots).

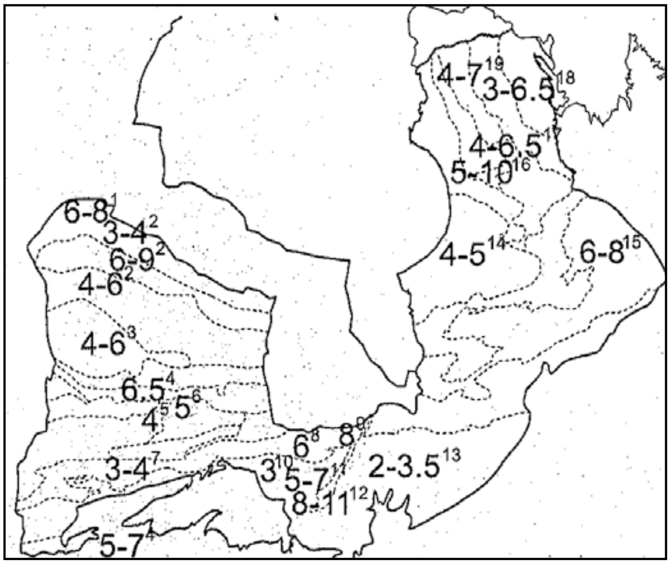

Figure 18. The amount of erosion of the Superior Province, southern Canadian Shield, based on igneous and metamorphic pressure estimates on the surface (from Sengör et al., 2022, Figure 8).

Figure 19. The North American craton (USGS public domain).

designated as Precambrian sedimentary rocks and volcanic rocks (Oard et al., 2023b).

Continental-scale marine transgression eventually covered the land by the maximum of the Flood, believed to be about Day 150 (Boyd and Snelling, 2014). Whitcomb and Morris (1961) called this second phase the "prevailing" of the Flood. As currents and turbulence slowed, the "Great Deposition" would occur, in which massive sediment was laid down, often with minimal deformation. The sequence in Grand Canyon and the

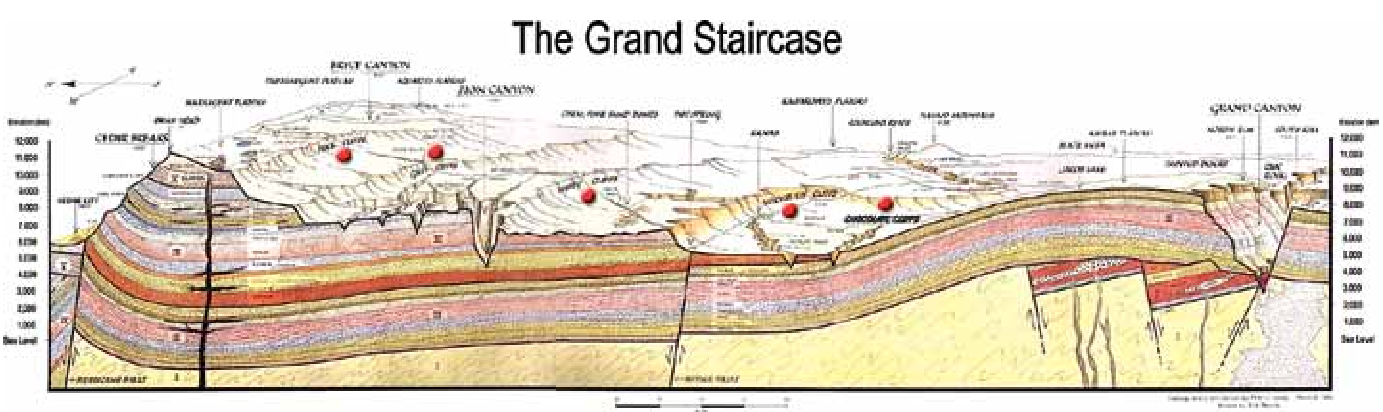

Figure 20. The Grand Staircase and the Grand Canyon. Red dots from left to right: Pink Cliffs, Grey Cliffs, White Cliffs, Vermilion Cliffs, Chocolate Cliffs (National Park Service, public domain).

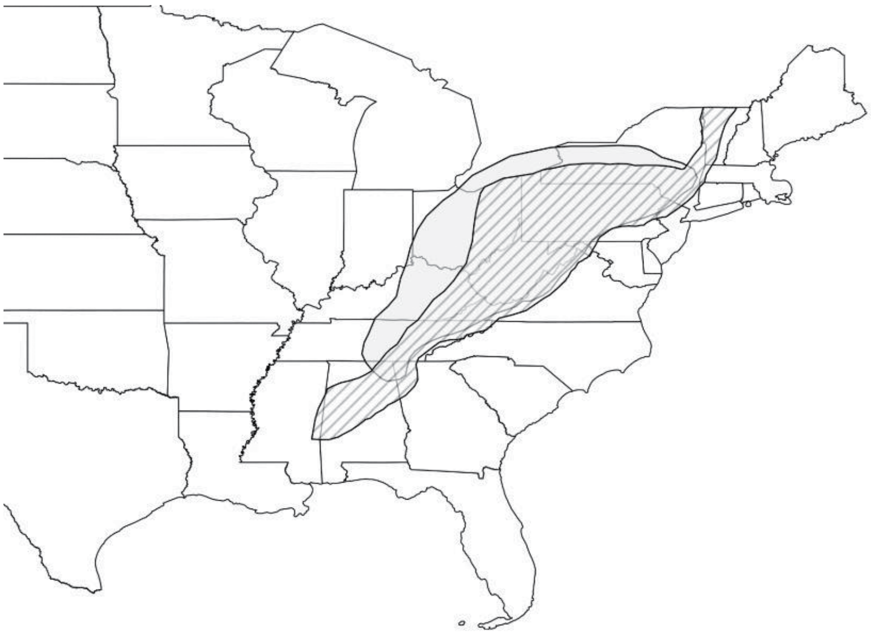

Figure 21. The Appalachian Basin. The solid gray is from Evenick (2021), and the cross-hatched is from Coleman and Cahan (2012).

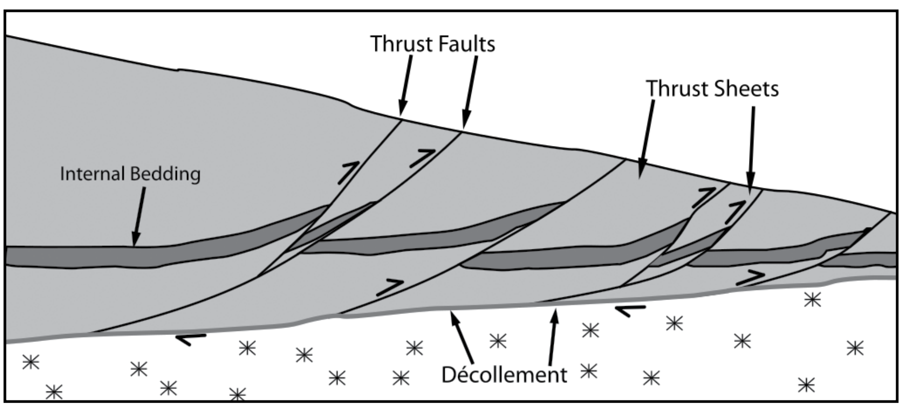

Figure 22. Schematic of multiple imbricate thrusts above a décollement (Tberli3, Wikimedia Commons CC-BY-SA-3.0).

Grand Staircase to the north (Figure 20) is a case in point: 3,000–5,000 m of sediment was laid down with little faulting and folding, even later. Of course, on a global scale, local conditions would determine the amount of deformation, the Appalachians and Piedmont being examples of intense deformation and metamorphism. Significant thrusting was occurring there during the deposition of the sediments in the Appalachian Basin.

During Phase 2, 13,700 m of sediment, plus the sediment eroded during the Retreating Stage, accumulated on the west side of the Appalachians (Figure 21). The eroded sediment could have reached 6,000 m based on coal rank and the volume of sediments on the continental margins (Oard, 2011a). If so, the basin contained up to 20,000 m at the peak of the Noahic Flood.

It is uncertain how much sediment accumulated east of the Appalachian orogen. At present, there is very little known. There are metasediments and metavolcanics in the Piedmont, but their stratigraphic position in the Deluge is unclear. We could label them antediluvial (pre-Flood), except for the sparse presence of Ediacaran fossils in the Carolina Terrane of North Carolina (Weaver et al., 2008; Hibbard et al., 2009). So, it is unclear if they are the earliest Flood or pre-Flood.

Westward-directed paleocurrents in the Appalachian Basin are also perplexing. It is possible the source was Europe and Africa prior to separation late in Phase 2 (see below), which is contrary to the belief of conventional geologists, who do not believe continents existed to the east during most of the Paleozoic. Another possible source is the ancestral Appalachians, since there are few claimed Paleozoic sediments east of the Appalachians. Furthermore, U/Pb dates in zircons in sediments of the American Southwest indicate they originated in the Appalachians (Goddard et al., 2025). Mainstream scientists believe that the Blue Ridge and Piedmont Provinces rose from mid-crustal depths, based on their present metamorphic grade. These could be exaggerated since metamorphism also depends on temperature. For example, if the area was hotter, the rock need not have risen as much. Indications of regional higher heat are provided by the numerous granitic plutons in the provinces, and even some exposed mantle rocks (Misra and Keller, 1978; Miller et al., 2006). The Blue Ridge and Piedmont Provinces certainly moved upward, but maybe not from mid-crustal depths.

Figure 23. Aerial view of multiple overthrusts (ridges) along the Rocky Mountain Front (Bobak Ha'Eri, Wikimedia Commons CC-BY-3.0), looking north across the Sun River Canyon. The lake is the Gibson Reservoir, west of Augusta, Montana, USA, and is formed by a dam on the Sun River. The Lewis Overthrust is just out of the figure to the left, west of the wide north-south valley of the Middle Fork of the Sun River.

The Blue Ridge and Piedmont

As noted earlier, the Blue Ridge and Piedmont were overthrust to the northwest. Erosion during uplift could have exposed the metamorphic rocks, which may be altered Creation Week crust. This transport is believed to be well over 100 km and to have occurred on a décollement at depth, but it is difficult to detect (see below). The contact of the Blue Ridge Province with the Valley and Ridge Province does not show much overthrusting (see Figure 11).

A Biblical model must reexamine the conventional terranes and orogenies. A major difference between Biblical and secular natural history is the fiat creation of the antediluvian crust, rather than its evolution over several billion years and multiple Wilson cycles. We suspect that much of the deformed igneous and metamorphic basement of the Piedmont and Appalachians was Creation Week crust.

Northwest thrusting of the Piedmont, as postulated, requires a deep master detachment surface, or décollement (Figure 22). However, this feature is elusive on seismic data: "One of the most elusive tectonic features in the southern Appalachians is the AD [Appalachians décollement]" (Frothingham et al., 2022, p. 1,306). Although it is difficult to image a décollement on seismic charts, it is possible that it does not exist. This would suggest a more vertical component, with less net horizontal movement.

Also, the various terranes, if accreted, are too homogeneous. The terranes are said to be island arcs and continental slivers. But geophysical velocity transects for the crust in the southern Appalachians show little variation, as if such convergence never happened:

> The crustal velocity structure required to fit the data is surprisingly simple considering that this crust experienced multiple terrane events during the Appalachian orogeny, CAMP magmatism, and extension during the breakup of Pangea" (Marzen et al., 2019, p. 6,637).

However, conventional geologists claim that there is at least one Moho offset in the northern Appalachians (Hillenbrand et al., 2021). Below the Moho, tomographic images of the eastern United States do not indicate any terrane boundaries. However, there is a mysterious high-velocity anomaly west of the Appalachian Basin that extends vertically down to 800 km and then slants eastward with depth below 800 km (Schmandt and Lin, 2014). It is unknown what is the meaning of this high-velocity region is, but Schmandt and Lin (2014) believe it is a remnant of the Farallon Plate subducted from the west, but this is contrary to previous beliefs, in which the remnant Farallon Plate is much deeper. The near-vertical high velocity mantle is certainly not related to any proposed terrane or continental collisions from the east.

Thrusting in the Valley and Ridge Province

The thrusting of the Blue Ridge and Piedmont compressed the eastern side of the Appalachian Basin in the Valley and Ridge (Figure 11). Evidence suggests that these thrusts could have formed by gravity spreading. Uplift of the Blue Ridge and Piedmont Province would have provided abundant potential energy for the Valley and Ridge thrusting. Uplift adjacent to the eastern Appalachian Basin could have caused sheets to slide downward and northwest, causing the fold and

Figure 24. A three-toed dinosaur track from the Culpeper Basin, Virginia (Smokeybjb, Wikimedia Commons CC-BY-SA-3.0).

thrust belt. As shown in Figure 11, thrusting attenuated quickly into the Appalachian Basin, resulting in the relatively undeformed Appalachian Plateau Province, but causing uplift of the Cumberland and Allegheny Mountains on their eastern margin.

Fold and thrust belts from gravity spreading are seen elsewhere. The imbricate overthrusts along the eastern edge of the Rocky Mountain front in central Montana (Figure 23) (Mudge, 1972; Oard and Klevberg, 2015) provide a possible analog. Secular geologists have mapped at least nine major stacked thrusts, and dozens of minor ones, in the region just east of the continental divide. These overthrusts likely were caused by the potential energy of uplift of the Rocky Mountains.

Piedmont Rifts Late in the Inundatory Stage

We can estimate the timing of the Piedmont Rifts in the Flood Year (Figure 9). The sedimentary rocks of these rifts are *not* metamorphosed and must have been deposited after the main erosion of the Blue Ridge and Piedmont Provinces. Dinosaur tracks found in these sediments (Figure 24) likely place the rifts in Phase 2 of Figure 14.

Earth History of the Appalachians—*The Recessional Stage*

The Recessional Stage was marked by the formation of new ocean basins and the regression of Floodwater off the continents and into them. It was marked by erosion (Oard, 2013). As discussed above, the exposed coal rank indicates that possibly up to 6.5 km of rock was removed from the region. This fits Phase 4 (Figure 14) of the Retreating Stage. The erosion produced geomorphological features that cannot be explained by conventional geologists.

Erosion and Planation Surfaces

The initiation of late-Flood regression likely saw wide currents eroding the Appalachians, the Piedmont, and the Appalachian Basin. A widespread erosion surface formed on the Piedmont by eastward-flowing currents (Oard, 2011b). Another large planation surface formed on the Appalachian Plateau by westward-flowing currents.

Lithologic variations suggest that uniformitarian erosion would have created a more rugged surface, with hard rocks eroded less than soft rocks. In other words, harder rocks should be mountains and softer rocks, deep valleys. But in the Appalachians, both hard and soft rocks were planed by the same erosion event. Fenneman (1938, p. 122) stated:

> At a much later time, the older belt became two physiographic provinces by the reduction of its seaward side of a relatively late peneplain [planation surface] (Piedmont Province), while the higher belt on its western side (Blue Ridge Province) was not destroyed.

Thick Continental Margin Sediments Accumulated as a Sheet

Sediment from this erosion formed the clastic wedge along the continental margin. Material from the western Appalachians and Appalachian Basin was transported to the Gulf Coastal Plain. Rifts occurred off the East Coast when the Atlantic seafloor sank relative to North America. Poag and Sevon (1989, p. 119) stated: "The primary forcing mechanisms considered have been tectonic and isostatic uplift and subsidence…" Tectonic uplift of the eastern United States is believed to have caused the erosion, while the total amount of subsidence along the continental margin is believed to have been 14 km (Poag and Sevon, 1989; Poag, 1992)!

Lang et al. (2024) reinforce this vertical component, with a deepening margin during continental uplift. Thick sediments accumulated offshore. In the Baltimore Canyon Trough, which extends some 400 km from Cape Hatteras to Long Island (Pickering et al., 1989), there is a maximum fill thickness of 18 km (Pazzaglia and Gardner, 2000). Its total area is 200,000 km^2. Similar troughs and rifts occur offshore (Straume et al., 2019). These are likely independent of the Piedmont rifts. The sediment along the continental margin was deposited as a continuous sheet during Phase 4, as shown by seismic profiles parallel to the coast (Lang et al., 2024). These thick and extensive sedimentary wedges are best explained by massive sheet flow off the continents.

Phase 5 Channelized Flow Eroded Linear Features

As the base level dropped, the runoff was likely forced around emerging obstacles and channelized during Phase 5 (Figure 14), forming spectacular water and wind gaps in the Blue Ridge and

Valley and Ridge Provinces (Oard, 2012; Lee, 2013). The Great Valley could have been eroded by southwest/northeast currents caused by the emergence of the Blue Ridge Mountains. On the Appalachian Plateau, the planation surface was dissected by these channelized currents. Offshore, submarine canyons, like the Hudson Canyon, possibly formed during accelerated channelized runoff (Oard, 2013). The end result of the greatly diminished channelized erosion at the end of the erosion phase was the modern drainage system.

Conclusion

Conventional geologists have attempted to explain the Appalachians within their paradigm. However, the region is incredibly complex, and there are still many unresolved issues. They believe multiple orogenies were caused by repeated collisions during the Rodinia-Pangea cycles. This resulted in the accretion of what are called 'exotic terranes' of the Piedmont. Several geological and geomorphological features seem contrary to this interpretation. For example, thrusting in the Appalachians was well inland from these collisions. Why was the force transmitted that distance, instead of causing deformation at the continental boundary? As seen in the Appalachian Basin, deformation can also end abruptly. It is possible that the Appalachians formed by Cordilleran-like uplift and thrusting, with gravity spreading causing the Valley and Ridge Province.

Whatever the explanation, the region experienced severe deformation and metamorphism. Tectonic activity likely caused the numerous Piedmont rift basins that filled with sediment and the CAMP volcanics.

The Flooding Stage transitioned into the Retreating Stage, and the Appalachians underwent massive erosion, forming erosion, planation surfaces, and water and wind gaps. This tentative model seems to explain the broad features of the Appalachians. In Part II, we will focus on one of the rift basins, the Deep River Basin, for a more detailed analysis within Biblical Earth history.

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