Essay:

"Where Is (and Was) Pennsylvania?"

W.E. Hamilton
D.Y. Sillman
Penn State University

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Pennsylvania is a pretty obvious place to us. It’s a rectangular, politically defined piece of the eastern United States with a wiggly eastern border that follows the Delaware River and three, very straight other borders on the north, west, and south that were laboriously marked off after a great deal of social and legal travail and even some violence. It’s a hilly to mountainous, river-rich place with forests and fields and cities. Its statistics are simple: it is about three hundred miles from east to west and a little less than one hundred and seventy miles from south to north. It comprises 46,058 square miles (although the number “45,308” shows up in some references). Its latitude range is thirty-nine degrees forty-three minutes N to forty-two degrees N, and its longitude range is seventy-four degrees and forty-three minutes W to eighty degrees thirty-one minutes W (Netstate 2008).

This Pennsylvania, though, hasn’t always been all of that. The great rectangle of Pennsylvania has been, through the geological history of the Earth, in the southern hemisphere, on the equator, and in a great many places in between. It has been oriented with its long, three hundred mile axis east to west and also with this long axis running south to north. It has been a sea floor, a coastal swamp, and part of one of the greatest mountain ranges ever to exist on Earth. It has had a wide range of types of vegetation and has even had its forests almost completely destroyed by human activity. These same forests, or one’s approaching varying degrees of similarity, anyway, then re-grew in a time period substantially less than a geological blink of an eye.

Let’s start at the beginning……

The Earth formed 4.5 to 5 billion years ago. The condensation of cosmic materials that had originated in the super nova death of one of the universe’s original stars formed our sun, and, eventually, via the collision and consolidation of much smaller “planetesimal” fragments, the sun’s set of planets including the Earth. The gravitational compression of the huge mass of the sun generated great heat and the subsequent release of massive amounts of energy (including heat and light) from the thermally triggered process of nuclear fusion. The gravitational compression of the much smaller mass of the earth also generated internal heat but the temperatures generated were not adequate to trigger fusion. They were enough, though, to cause the consolidated cosmic materials to eventually transform into rocks. The oldest rocks on Earth have been dated at 3.9 billion years of age, so this initial rock formation process took some 600 million to a billion years to occur (Windley 1995, Taylor 2004).

The pressures inside the Earth along with the accumulating heat from the radioactive decay of its heavy elements and the energy from more colliding planetesimals generated sufficiently high temperatures to melt the internal rocks (Windley 1995). The cool, thin, outer crust of rock began to “float” on an inner sea of semi-molten rock called the mantle. This crust is broken up into discrete masses which are called the “continental plates.” These great continental islands of cooled rock slide about on the warmer, more plastic rock of the mantle and crash into each other like a set of massive, geological bumper cars. Plates crashing into each other, sliding up and over one another, and pulling apart from each other generate the Earth’s mountains, volcanoes, and ocean beds. This active movement of crust and mantle materials was also critical in releasing gaseous materials from the Earth’s interior and, thus, formed, the first atmosphere of the Earth (Burke 2006, Windley 1995).

The water that fills in the lower places in between the great lumps of moving crustal rock (the systems that we call “the oceans”) probably also originated in the heated, inner retort of the earth’s rocks. This water was then released in volcanic eruptions and in the violent, crust tearing collisions of planetesimals which continued to hit the stabilizing Earth. Some of the ocean water may also have come to the Earth in and on the planetesimals themselves (Evertt 2002).

“Pennsylvania” is a small area that rides along on one of the continental plates. Its plate is typically, and very logically, called the “North American Plate,” but it also historically referred to as the “Laurentian Plate.” We want to pick up our “Pennsylvania” on the Earth’s surface some 1.2 billion years ago in the later stages of the Precambrian Era. A lot had gone on during the 3.5 to 4 billion years of this era: oceans and continents had formed, life had come in being, although it was still confined to the oceans, and an atmosphere containing molecular oxygen had formed (although the oxygen levels 1.2 billion years ago were probably only 20% of what we have today). But all of that is material for another book.

About 1.2 billion years ago the floating continental plates of the Earth were joined together in what would be in our modern geographic orientation the southern hemisphere to form the Supercontinent called “Rodinia.” Rodinia is a Russian word meaning “homeland.” While it is acknowledged that there had been previous supercontinents during the previous 3 or 4 billion years of Earth’s existence, Rodinia is the first continental coalescence about which we have substantial, geological evidence (Rogers and Santosh 2004, Blakey 2006, and Burke 2006).

The North American plate (and our modern area of Pennsylvania) was somewhere in the middle of the Rodinia supercontinent. Most of this plate including Pennsylvania was below sea level and existed as a shallow sea bed upon which sediments from the surrounding, eroding land masses accumulated and began their slow transformation into sedimentary rocks (which include sandstone, siltstone, and limestone) (Tagg 2000).

About 700 million years ago, under the pressure of the Earth’s internal heat, Rodinia broke up into two smaller, but still incredibly large, continental masses: Proto-Laurasia (which included North America and our Pennsylvania rectangle along with Northern Europe, Siberia, South America, and Western Africa) and Proto-Gondwana (which included most of Africa, Antarctica, India, Arabia, Australia, and South and North China). Proto-Laurasia drifted north and west, passed through the region of the South Pole and ended up on the opposite side of the Earth from Proto-Gondwana. Proto-Laurasia also broke up into its respective continental masses as it drifted along (Windley 1995, Blakey 2006, Burke 2006).

At the transition between the Precambrian Era and the Paleozoic (“early life”) Era, the North American plate was in the Southern Hemisphere and was rotated about 90 degrees clockwise from its modern day orientation. So, its present day eastern coast was to the south and its northern sections were to the east. The rectangular area that would become Pennsylvania was likewise rotated 90 degrees, and its present day eastern boundary pointed south. The Pennsylvania part of the North American plate was above sea level, though, and there were mountainous up-thrusts far to its south (Blakey 2006).

By the late Cambrian Period (the end of the first period of the Paleozoic Era), about 500 million years ago, the North American plate and the future Pennsylvania were in the same orientation but had moved further to the north. The continental plate now straddled the equator and its southern sections (which were still in the southern hemisphere and which included our future Pennsylvania) were back below sea level. Pennsylvania, then, was the sea bed of a shallow, coastal ocean. Erosion materials from the surrounding land masses poured into the sea bed and began the process of sedimentary rock formation (Tagg 2000, Burke 2006).

This location of the future Pennsylvania in a 90 degree, clockwise rotation from present day, near the equator, and below sea level would continue for several hundred million years. Surrounding land masses would continue to erode and their abundant sediments would accumulate in the Pennsylvania sea bed and help to provide the materials for the sedimentary rock layers that underlay the state. Great mountain ranges on these surrounding land masses would be lifted up by the collision of the North American plate with surrounding continental plates, and these mountains would almost immediately begin to erode into the Pennsylvania sea bed (Burke 2006). These continental collisions also sent ripples of folds and bends through the forming sedimentary rocks of Pennsylvania much like an automobile collision sends ripples through the metal of a car fender or hood. These collision ripples are visible in long north-south ridges that dominate the central parts of the state and also in broadly rolling sedimentary rocks layers (the "anticlines" (upward folds) and "synclines" (downward folds)) of the west (Barnes and Sevon 2002).

In the Ordovician Period of the Paleozoic Era, 440 million years ago, the North American plate collided with the Northern European plate, the Greenland plate and the Northern Asian plate forming the Laurasia supercontinent (Rogers and Santosh 2004). This collision also lifted a range of mountains far to the south of still submerged Pennsylvania. Erosion of these mountains (which were called the Taconic Mountains) sent even more material into the shallow, Pennsylvania ocean basin, and more and more sedimentary rock formed (Van Diver 1990).

Marine life abounded in the warm, equatorial ocean that overlay Pennsylvania. Through countless life spans ancient shelled organisms deposited great masses of calcium carbonates into the forming sediments. These sediments slowly "grew" into limestone which was subsequently encased by depositional layers of sandstones and siltstones that formed from the debris that kept arriving from the on-going erosion of the surrounding mountains (Barnes and Sevon 2002).

Then, in the Devonian Period of the Paleozoic, some 385 million years ago, under the force of the approaching continental mass of Gondwana which was sliding under the South Pole on its trip from the other side of the globe, Laurasia was pushed further and further to the north. Continued collisions over the next 50 million years between the North American plate and the Northern European plate aided by the on-going Gondwana collision raised another set of mountains (the Acadian Mountains) off of the future eastern shore (which was still oriented to the south!) of North America. These mountains also eroded and added more and more material to the shallow ocean sediments over Pennsylvania.

Fifty million years later, in the Permian Period of the Mesozoic ("middle life") Era, Laurasia collided with the African plate portion of Gondwana . This great collision joined all of the Earth's land masses into single supercontinent called "Pangea" (Van Diver 1990, Windley 1995, Rogers and Santosh 2004). This collision lifted the Pennsylvania sea bed above sea level where it would remain thus stopping the hundreds of millions of years of sediment accumulation and sedimentary rock formation.

The collision that made Pangea also caused more mountains to grow. These were the Allegheny Mountains. These ancient Alleghenies (and there is a present day "Allegheny Mountain" range that is not the same set of mountains at all) were thousands of miles long and higher than the present day Himalayas. They were some of the greatest mountains ever to exist of Earth! These mountains, too, though, began to erode even as they were being formed (Van Diver 1990).

In between these last two mountain growing periods, specifically during the 60 million years or so of the Carboniferous Period of the Paleozoic (359 to 251 million years ago), great, alluvial plains formed over the just-above sea level Pennsylvania. These plains were covered with wet, plant-rich swamps that were densely vegetated with lycophytes and fern trees. These plants grew to great sizes possibly thriving in the carbon dioxide rich air of the time period. When the plants died, they fell into the poorly oxygenated waters of the swamps and formed thick deposits of peat. The peat was then periodically inundated by the fluctuating shallow sea and then covered by the sands and silts from the eroding, eastern mountains. The decomposable organic materials of the peat were thus sealed away and removed from the great biogeochemical cycling of carbon. This cycle of plant growth, peat formation, sedimentation, and sequestration was repeated over and over as the coastline of the shallow ocean ebbed and rose and the swampy regions around it lifted and fell (Barnes and Sevon 2002).

These sealed away peat layers formed the coal seams that underlay a large portion of Western Pennsylvania. These peat layers also were the starting organic materials that formed the oil and natural gas deposits of the region. This period of geological history is named to emphasize the incredible importance of these events happening not only over our state but all over the world. The Carboniferous Period is often referred to as the "Pennsylvanian Period" of the Paleozoic Era. It is the time when most of our "fossil fuel" (coal, oil, and natural gas) deposits were formed.

A remnant of the ancient Alleghenies, just their roots actually, persists today as our Appalachian Mountains. Most of the mass of these ancient Alleghenies eroded down into sediments and grew into layers of sandstone and siltstone. Great pieces of these ancient mountains, though, broke away when Pangea broke up 200 million years ago. These mountainous fragments of the ancient Alleghenies can be found in far away countries that were once connected in the Pangea supercontinent. Mountains in Britain, Greenland, Scandinavia, Western Europe, and Northern Africa have been shown to be parts of the old Allegheny Mountain range (Van Diver 1990).

I am standing on the pool patio of the Summit Inn on the northwestern edge of Chestnut Ridge. This ridge is the western-most fold of the ridge and valley topography that dominates Central Pennsylvania. These ridges are the ripples formed by the same tectonic plate collisions that lifted the mountains far to our present day east. Millions of years of erosion have carved these ridges into their preset day configuration.

Looking at a satellite map of Western Pennsylvania you see that on a large scale, with sufficient distance between the observer and the object, this portion of the state is flat. That's a very difficult thing to believe when your legs are wobbly after a long trek up a steep hillside, or when your knees are aching after a hard descent into a deep valley, but, it is true. Looking at the rocks of Western Pennsylvania you can see the overall flatness and the extended, gently rolling pattern of anticlines and synclines of the vast Allegheny Plateau that stretches out west from the central ridges of the state.

So, if the area is flat, where did all of these hills come from?

An old geology joke (and there are to my knowledge very few of those) states that there are no hills in Western Pennsylvania, only valleys. These valleys have been caused by rivers eroding down through the very regular, very gently undulating rocks. Some of these water cuts were huge and occurred in the not so recent past. The glaciers of the last Ice Age just touched the northern parts of the state. The rivers that arose from their melting and retreat, though, poured down through great, growing gashes in the "flat" rocks to the south. Along the steep ridges that line the Allegheny River and many of its larger, northern tributaries are terraces that were cut by the banks of these swollen river systems of the late Ice Age (Van Diver 1990). These terraces are filled with gravels and sands and other coarse, water borne deposits and have soils that are very well drained and that tend to become quite dry. These terraces were perfect sites for trees and other plants that thrived on dry soils or that needed periodic fires in order to re-establish their pure stands

I am looking out over a great plain that sweeps off to the north and west. This is the view that filled Mason and Dixon some 240 years ago and some 8 miles south of here with such joy. It is a view of land that could conform to the needs of farmers. It is a land much kinder for travel and exploration that the rugged ridges and ravines to the east over which they had so laboriously traveled. Uniontown is in the near foreground and beyond that, Connellsville. The bed of the Youghiogheny River leaving its rocky canyon formed by its cut through the ridge is there for the imagining, too.

The plain below has rolling bedrock layers but is flat enough to suggest the ancient sea bed and the flat, extended shoreline that defined this place hundreds of millions of years ago. The ridge I am standing on was once part of a sea bed, too. The rocks below my feet originated in mountains that have long ago disappeared from the face of the Earth and which never physically existed in any human memory. Now, thousands of feet of sediment latter, thousands of millions of tons of sea shells and algae encrustations later, thousands and thousands more of millions of tons of plants that fell into swamp sediments and were sealed away from the re-cycling flow of the earth later, and hundreds of millions of years later, I stand here seeing a great deal but not seeing it all that clearly.

This vista represents not a static reality but a momentary pause. A human lifetime is far too short to easily grasp what this site represents. We live and die far too quickly to have a deep sense of the long cycles of rocks. We have to use our intellects and our imaginations to set this apparently immovable land and rock into motion. We have to use different eyes to watch the ebb and flow of mountains, and continents, and oceans. We have to piece this story together carefully and then reflect upon not just its great usefulness, but its meaning and value for perspective and a sense of place.

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