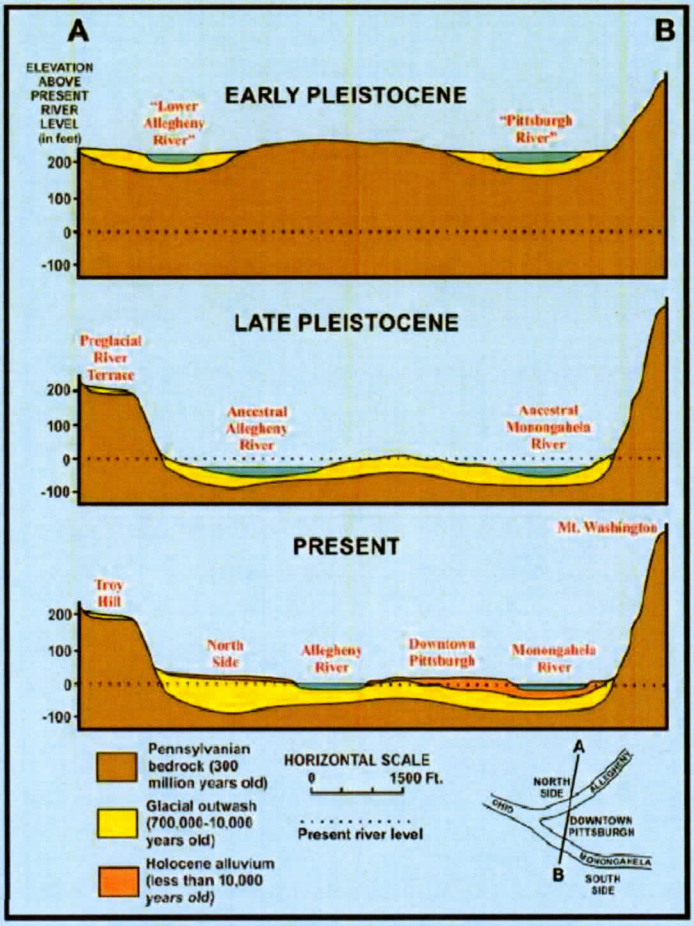
The Geological Evolution of Pittsburgh's Three Rivers



Evolution of the three rivers at downtown Pittsburgh from the Early Pleistocene (~700,000 years ago) to the present

John A. Harper

Geology Underlies it All

PA/S Publication 21
2016

Introduction

When Pittsburghers view the three rivers, the Allegheny, Monongahela, and Ohio, from Mt. Washington or the Point, they generally have no idea how old those rivers are, nor how much the rivers and the landscape of Pittsburgh have changed over the past few million years. How many Pittsburghers know that before the Ice Age (Pleistocene Epoch), what are now the three rivers flowed northwestward into Canada? The current drainage system in western Pennsylvania flows southwestward via the Ohio River into the Mississippi and eventually into the Gulf of Mexico, and that's the way it has been since long before humans set foot on the North American continent. But a significant change in stream drainage occurred during the last few hundred thousand years, and that is one of the more interesting chapters in the geologic history of western Pennsylvania.

Before the Ice

During the Pliocene Epoch, over 2.6 million years ago, the Earth was warmer than it is today, with average global temperatures about 37° above current measurements and CO_2 levels at around 400 ppm. Western Pennsylvania's topography was gently rounded with only a few hundred feet of relief. The rivers and larger creeks meandered across the landscape in wide U-shaped valleys, and deposition of sediment in the valleys exceeded erosion of the adjoining hillsides. Most rivers drained to the northwest, rather than to the southwest as they do today (Figure 1). The dominant river in western Pennsylvania was the Pittsburgh River, flowing north through West Virginia in a broad, shallow valley past Pittsburgh, Beaver and New Castle into Ohio. It then skirted Youngstown and continued at least as far as what is now Lake Erie. Geologists believe a major river system, called the Erigan River, flowed to the northeast, like the St. Lawrence River today. Subsequent glaciation destroyed

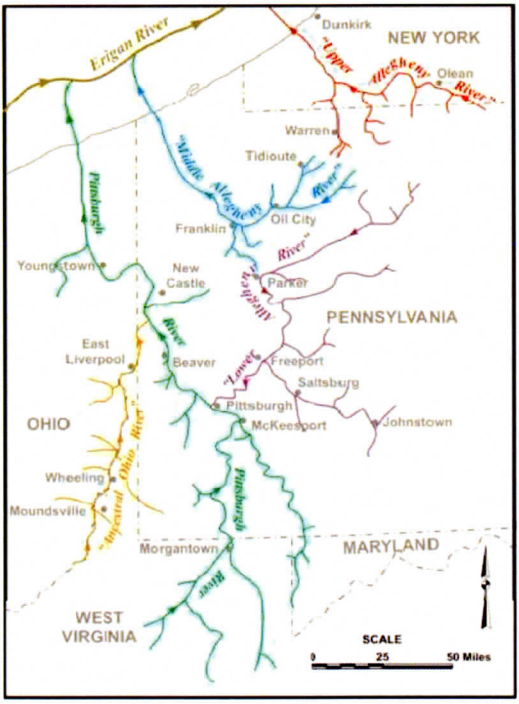


Figure 1. The drainage pattern of western Pennsylvania before the Ice Age.

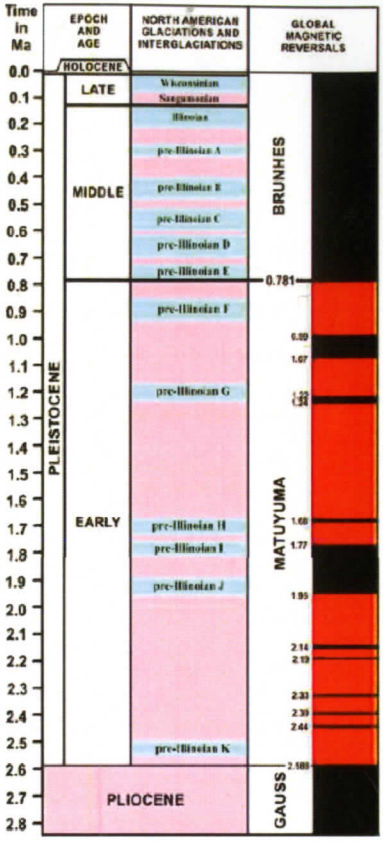


Figure 2. Pleistocene time scale with glacial (blue) and warm interglacial (pink) episodes and correlation with polarity of the earth's magnetic field (reverse polarity in red). Major polarity changes define Pleistocene ages.

all evidence for its existence. There were three separate and unrelated Allegheny Rivers draining different parts of the state, and the ancestral Ohio River was a mere tributary of the Pittsburgh River, flowing from south of Moundsville, West Virginia to East Liverpool, Ohio, and entering the Pittsburgh River just south of New Castle.

And Then There Was Ice

The Pleistocene was a time when numerous continental glaciers advanced and retreated across much of the northern hemisphere. At least two of these, called the Wisconsinan and Illinoian in North America, and an earlier, pre-Illinoian glaciation (Figure 2) penetrated into northwestern Pennsylvania, as deduced from glacial deposits found as far south as Butler (none of the glaciers came as far as Pittsburgh). The earliest glacier advanced more than 700,000 years ago. When it did, the south-flowing ice blocked the northwest-flowing streams and caused large ponds to form along the leading edge of the glacier (periglacial lakes). Eventually, the ponds became so deep that the water flowed over the divides (hilltops and ridges separating streams), reversing the ancient drainage of the Pittsburgh, "Middle" Allegheny, and "Upper" Allegheny rivers. The water had to go somewhere. Since it couldn't flow northward through the ice, it took a southerly course in all of these rivers, carving new water gaps through divides and usurping channels formed by established streams. The "Upper Allegheny River" flowed along the approximate edge of the glacier to the "Middle Allegheny River" drainage area where the two rivers joined near Tidioute, Warren County. From there they flowed south, joining the "Lower Allegheny River" drainage area around Parker, Butler County, forming one continuous river. The Pittsburgh River backed up and flowed along the "Ancestral Ohio River" channel, reversing its flow direction back south of Moundsville, West Virginia. There the river eroded through the drainage divide separating the Ohio and Kanawha rivers, and began flowing westward along the

approximate southern edge of the maximum advance of glacial ice to the Mississippi. Once the Ohio began draining into the Mississippi, the Pittsburgh River ceased to exist and the Monongahela and Allegheny rivers became tributaries of the now dominant Ohio. These three rivers have continued to follow southwesterly courses to the present time.

Lake Monongahela

When the glaciers dammed the north-flowing streams and the water backed up, it formed an enormous lake that filled all the valleys. This became known as Lake Monon-gahela (Figure 3), but it was not a "lake" in the normal sense of the word. Like Deep Creek Lake in western Maryland and other man-made lakes, it was really a ponded drainage system, only on a far larger scale. As the glacier retreat-ed, the "lake" drained via the newly-formed Ohio River system. As the drainage system became impounded during each glacial advance, a new Lake Monongahela formed, and each succeeding lake left evidence at different elevations. Most of what we know or can speculate about Lake Monongahela comes from studies of remnant terrace deposits found at different elevations along or near the present river channels in West Virginia, Pennsylvania, and Ohio.

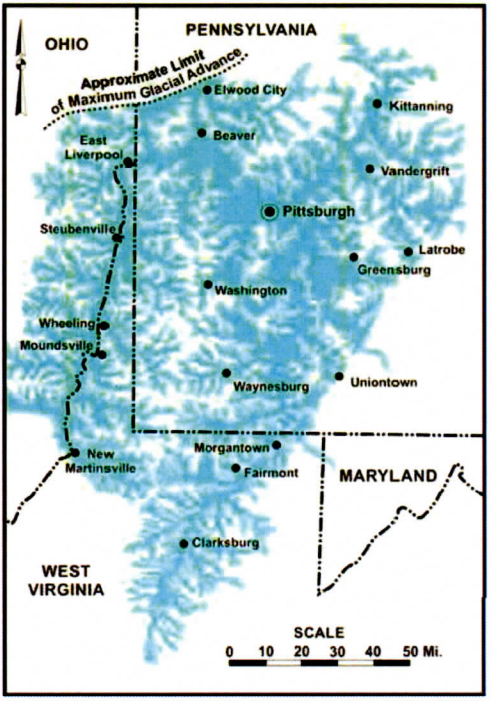


Figure 3. Reconstruction of Lake Monongahela (blue) of the tri-state area with modern towns and state boundaries for reference.

Remnant River Terraces

Prior to the Ice Age, the rivers and creeks meandered across a gently rolling plain in fairly wide, shallow valleys. Once the first glacier advanced and retreated, glacial meltwaters greatly augmented the natural flow of the Allegheny and Ohio rivers, generating enough energy to transport large quantities of sediment and scour the landscape. The valleys widened and deepened, and thick blankets of glacial debris covered their floors. After each succeeding glacial invasion, the valleys were carved deeper, and

many of the old channels were abandoned in favor of new ones. Even the Monongahela River, although not directly affected by glacial outwash, carved its valleys deeper and deposited river sediment derived from local bedrock. Remnants of old valley floors, carpeted with glacial outwash or other sediment, were left stranded above present stream levels as remnant terraces. These can be seen in many places along the rivers and their tributaries. Troy Hill on Pittsburgh's north side is one of the best examples of these along the Allegheny River. Prominent terraces also developed along the Monongahela River, such as the one Kennywood Park sits on. Examples of abandoned river channels occur within the City of Pittsburgh where the "Lower Allegheny River" channel drained into the Pittsburgh River in the East Liberty and Oakland neighborhoods (Figure 4). Most people living in Pittsburgh are unaware of how much of the city and its suburbs lie on abandoned river channels 200 to 250 feet above the present elevation of the three rivers. Figure 4 shows the various meandering paths the rivers have taken through the Pittsburgh area over the past million years or so, leaving high areas such as Squirrel Hill and Highland Park as veritable islands within the former interfingering channels.

Geologists have identified five remnant terraces that occur throughout western Pennsylvania and West Virginia. These relatively flat landforms contain soils composed of highly weathered deposits of clay, silt, sand, and gravel distributed at elevations as high as 330 feet above present stream levels. Some of these sediments were deposited in Lake Monongahela. Geologists recognize at least two sets of sediments:

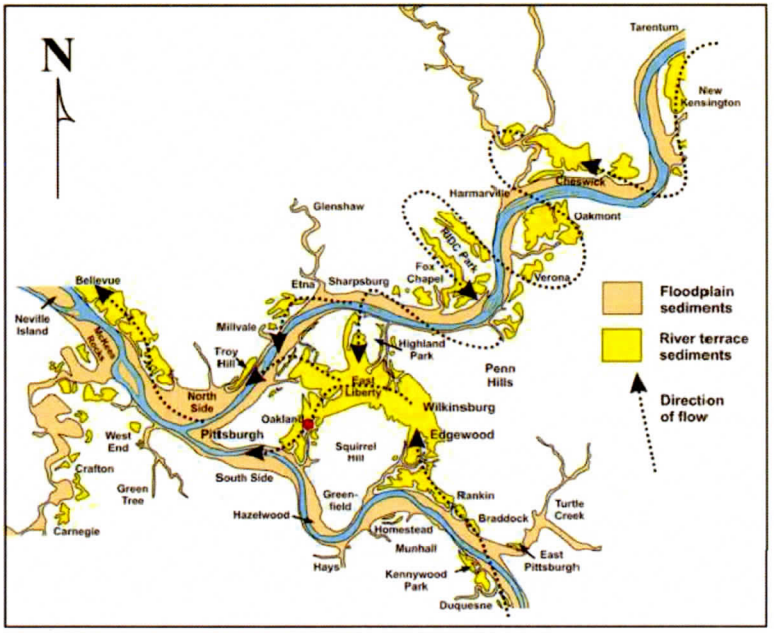


Figure 4. Pre-Ice Age (yellow) and Recent (orange) river channels of the Allegheny and Monongahela rivers. The red dot is the Carnegie Museum.

- The unnamed glacial outwash deposits found on Allegheny, Ohio, and Beaver river terraces typically are rust-colored silts, sands, and gravels. About 10% of the pebbles and cobbles are granites and other crystalline rocks from Canada. The sand was used by the early glass industry in the Pittsburgh area and the clays were a resource for the early pottery industry. The outwash deposits occur on several terrace levels. They can be quite thick; some preserved outwash deposits measured at more than 90 feet thick might originally have exceeded 120 feet.
- The Carmichaels Formation, named for the town of Carmichaels in Greene County, consists of reddish-orange to tan clays, silts, and sands containing cobbles and boulders derived from the local bedrock. Carmichaels clays were also a source of raw materials for the early pottery industry in the area. Carmichaels deposits occur on the upper two terrace levels in all the river valleys, but they also can be found draped over lower terraces in the Monongahela valley and the valleys of the eastern tributaries of the Allegheny River. Carmichaels deposits are relatively thin, rarely exceeding 20 feet thick, but they might originally have been as much as 80 feet thick.

The Myth of Pittsburgh's "Fourth River"

The thick sediment on the floors of the three rivers is the primary source of usable water along the floodplains. Many people, upon hearing about this, imagine that the water flows in long, sinuous caverns below river level. As a result, these valley-fill deposits have become popularly known as "Pittsburgh's Fourth River". Nothing could be farther from reality. There are no caves, fissures, or cavities of any sort under the rivers. There are only tiny interconnected pore spaces between sand grains and pebbles that allow water from the rivers and their floodplains to move freely, if a little slowly, into and through the valley-fill. Clay layers trap the water in the sediment, allowing the water to be extracted through artesian wells, such as those used for the fountain at Point State Park.

References

Harper, J. A., 1997, *Of ice and waters flowing: The formation of Pittsburgh's three rivers.* Pennsylvania Geology, v. 28, no. 3/4, p. 2-8.

Harper, J. A., 2002, *Lake Monongahela: Anatomy of an immense Ice Age Pond.* Pennsylvania Geology, v. 32, no. 1, p. 2-12.

Leverett, F., 1934, *Glacial deposits outside the Wisconsin terminal moraine in Pennsylvania.* Pennsylvania Geological Survey, 4th ser., General Geology Report 7, 123 p.

Marine, J. T., 1997, *Terrace deposits associated with ancient Lake Monongahela in the lower Allegheny drainage, western Pennsylvania.* Unpublished MS thesis, University of Pittsburgh, 182 p.

White, I. C., 1896, *Origin of the high terrace deposits of the Monongahela River.* American Geologist, v. 18, p. 368-379.