THE GEOLOGY OF FRICK PARK

A 300 Million Years Record of Climate and Sea Level Change

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INTRODUCTION

Although the Earth has a 4 .5 billion year history, the rocks of Frick Park record only a short slice of that history and span the interval of time from about 290 to 300 million years ago. These rocks were formed near the equator while at the same time glaciers near the poles repeatedly advanced and retreated. Ironically, the current landscape and topography of the park are the result of changes in the region's river courses that were produced by much more recent climatic events.

Nearly 300 million years ago western Pennsylvania was located on the southern edge of a continent that was situated near the equator in a warm and tropical climate. At that time in eastern Pennsylvania the Appalachian Mountains were forming. As this mountain chain was being uplifted, rivers flowed westward out of these highlands onto a low-lying coastal plain that is now western Pennsylvania. The western Pennsylvania coastal plain was bordered to the southwest by a large inland seaway not unlike today's Hudson Bay. At times, the Earth's climate would gradually warm and glaciers at the poles would partially melt. As they melted, enormous quantities of water were released and this melt-water would pour into the ocean basins. The oceans swelled and flooded low-lying areas of the continents like western Pennsylvania. During these flooding events fossiliferous limestone and shale were formed in the areas submerged by the warm shallow seas, while lush tropical swamps grew along the moist margins of these seas. These swamps created dense accumulations of vegetation that through time produced peat and coal layers. During periods when the Earth's climate cooled, the polar glaciers would expand and migrate into lower latitudes. The result was that much of the water in the ocean basins became caught up in glacial ice. This produced a global drop in sea level, and the low-lying areas previously submerged by marine waters became exposed to erosion. The lowering of sea level allowed large rivers to flow across the now exposed continental shelf and carve wide river channels. In these river channels silt and sand were deposited which later would become sandstone.

This pattern of recurring climate and sea level change persisted for many millions of years. These events repeatedly produced vertical alternations of marine limestone, shale, coal, and sandstone. These alternations or repetitions created cyclic vertical rock accumulations called "cyclothems" (cyclo=cyclical, them=sequence of rock). Throughout the world cyclothem-type rocks characterize the geologic age called the Pennsylvanian Period, but nowhere are they better developed than in western Pennsylvania, where the geologic period gets its name. The evidence of these important changes in Earth's climate and sea level are recorded in every rock exposure throughout western Pennsylvania.

FERN HOLLOW BEDROCK

Rocks exposed in Fern Hollow of Frick Park are assigned by geologists to the Conemaugh Group. The Conemaugh Group gets its name from rock exposures along the Conemaugh River, and is subdivided into two rock formations, the Glenshaw and Casselman. The slice of rock present in Fern Hollow exposes only a small part of the Glenshaw Formation, and most of the Casselman Formation. The Fern Hollow section of rock illustrates the complex nature of events that produced these rocks (Figure 1).

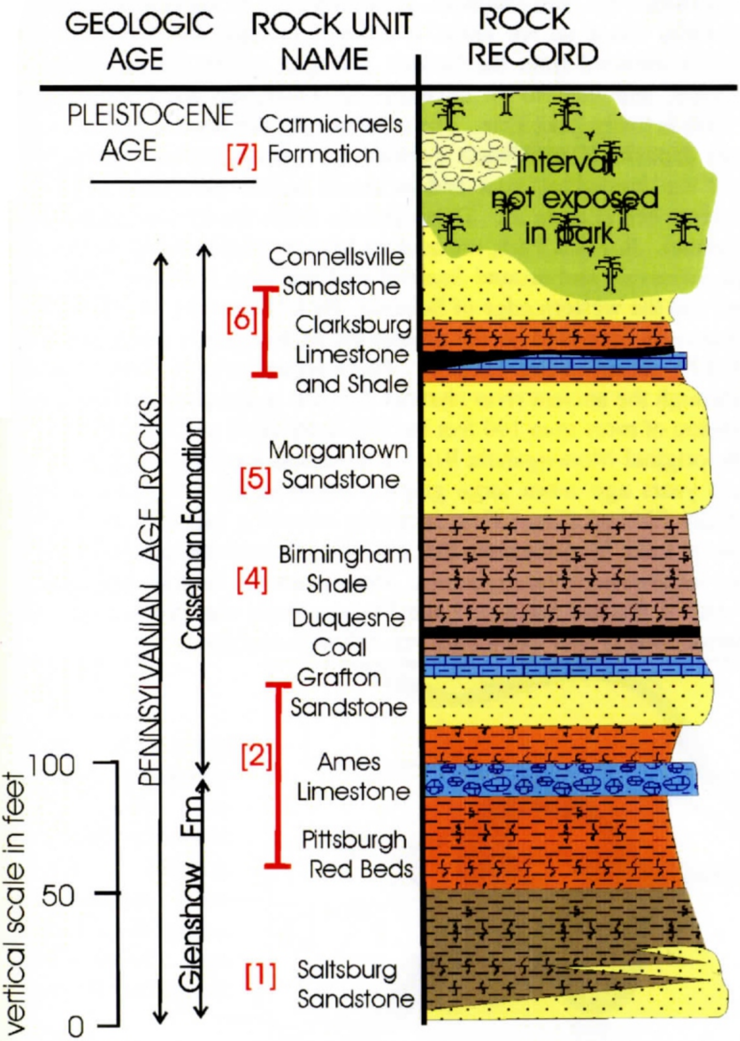

Figure 1. Stratigraphic section and geologic names of rock units exposed in Frick Park.

The study of the rock sequence in Fern Hollow allows the identification of repeated global changes that occurred on the Earth nearly 300 million years ago. The lowest and therefore oldest rocks exposed within the park are assignable to the Saltsburg Sandstone Member of the Glenshaw Formation. This sandstone unit [1] represents the deposits formed within a river channel during one of the many periods of global cooling that occurred during the Pennsylvanian geologic period. Located above the Saltsburg Sandstone, and therefore slightly younger, is a section of red shales of the Pittsburgh Red Beds and the overlying Ames Limestone [2] (Figure 1). These red shales suggest that the climate in western Pennsylvania was very warm and dry during the interval of time during which these shales were deposited. Furthermore, the Ames Limestone within this red shale represents an episode of marine submergence when the region was flooded by a warm, shallow sea. The abundant marine creatures that lived in this sea attest that the waters were warm and shallow. The Ames Limestone can be found over much of southwestern Pennsylvania, eastern Ohio, and northern West Virginia. Its widespread nature suggests that this period of melting of the polar glaciers may have been lengthy, and, likewise, the climatic warming must have been substantial in order for the seas to cover such a large area.

Overlying the Ames Limestone is the Grafton Sandstone Member of the Casselman Formation [3]. This sandstone represents ancient river channel deposits that were formed when rivers flowed across the region as the Ames sea withdrew. The reason for the withdrawal of marine waters from the area was global sea level drop produced by climatic cooling and the growth of polar glaciers. The sea level drop allowed these rivers to flow from east to west across the nearly flat, previously submerged, coastal plain. Above the Grafton Sandstone are the Duquesne Coal and Birmingham Shale [4]. These rocks indicate that following the Grafton cooling episode, the climate again warmed so that tropical coastal swamps once again developed across western Pennsylvania (Duquesne Coal). The very nearshore marine fossils that are sometimes found in the Birmingham Shale indicate that full-fledged marine waters lay not too far to the west in southeastern Ohio. The fact that full marine conditions were not experienced in the Pittsburgh area suggests that the submergence of the continental areas during this time interval was not quite as extensive as during the Ames deposition. Situated above, and chronologically following the formation of the Birmingham Shale is the Morgantown Sandstone [5]. This sandstone, like the Saltsburg and Grafton sandstones below, is the result of a cooling episode, where sea level dropped and large river systems criss-crossed the region. The Morgantown Sandstone is covered by the Clarksburg Limestone, Shale and Coal [6]. These beds do not have any marine fossils, but the presence of fresh water limestone and red shales indicates that the climate was again warm during this time period. However, just as in the previous cases, the Clarksburg warming episode was followed by a cooling event that produced the Connellsville Sandstone [6].

The remainder of the Conemaugh Group is not exposed in the park, but if it were it would record additional warming and cooling episodes preserved in the cycles of rock. The youngest, and therefore, highest rocks known from the area belong to the Pittsburgh Coal. This coal, which averages eight to ten feet in thickness, represents a significant period of global warming. The remarkable swamp that produced this coal extended over all of western Pennsylvania, northern West Virginia, and eastern Ohio and may have existed for tens of thousands of years.

The exposures of rock in Fern Hollow, while reflecting three to four million year's of Earth's history, represent only a small sample of the total cyclothem record preserved in western Pennsylvania. During the Pennsylvanian Period, a great ice age gripped the world for more than 45 million years, and rocks of Frick Park record some of the events that occurred during this time interval.

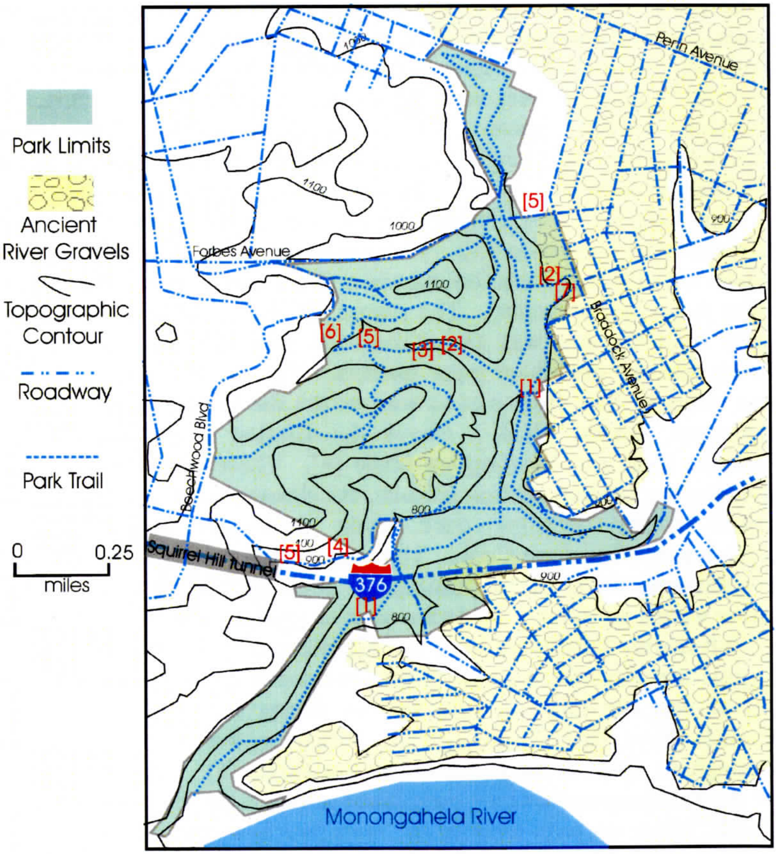

Figure 2. Map of Frick Park with locations of key rock outcrops [red], and the distribution of the Carmichaels Formation, which illustrates the course of the prehistoric Monongahela River. Distribution of Carmichaels gravels from Wagner and others, 1970.

FRICK PARK TOPOGRAPHY

Following the deposition of the sediments that created the area's bedrock, the entire region was uplifted as, to the east, intense folding and faulting marked the final stages of the formation of the Appalachian Mountains. The culmination of this mountain-building episode occurred approximately 245 million years ago. During the ensuing 245 million years, much of Pennsylvania has been slowly, but continuously, eroded to its current topography. This resulted in the creation of a river system similar to, but not exactly like, what we see today. Approximately 1.5 million years ago the Monongahela River's course flowed through Frick Park, Schenley Park, and Oakland. It did not flow to the Gulf of Mexico via the Ohio River as we know it today. Instead, the Monongahela continued northward from the Golden Triangle, up the Beaver River to New Castle, and then to an ancestral St. Lawrence River confluence under what is today Lake Erie. The evidence for this ancient river course is gravel deposits (Carmichaels Formation) that are present throughout much of the immediate area and at much higher elevations than the current river bed (Figure 2). These gravels mark the bottom of this old river channel. In Frick Park, the ancient Monongahela veered northward through Swissvale and around Squirrel Hill and then southward through Oakland and the western edge of Schenley Park (Figure 3). Ancient river bottom gravels deposited by the prehistoric Monongahela River are now dissected by recent stream erosion. These recent streams have scoured down through the ancient river channel deposits to the current river level. This erosion of more than 100 feet has left sharp cliffs and hillsides.

The original Monongahela River course was modified more than 20 thousand years ago when large glaciers dammed the river course near present-day Elwood City. This damming created a lake that geologists call Glacial Lake Monongahela that extended throughout and submerged much of southwestern Pennsylvania. Thus, when the ice dam was melted at the end of the last ice age, Lake Monongahela was drained and the river bottom that is now Frick Park was left high and dry.

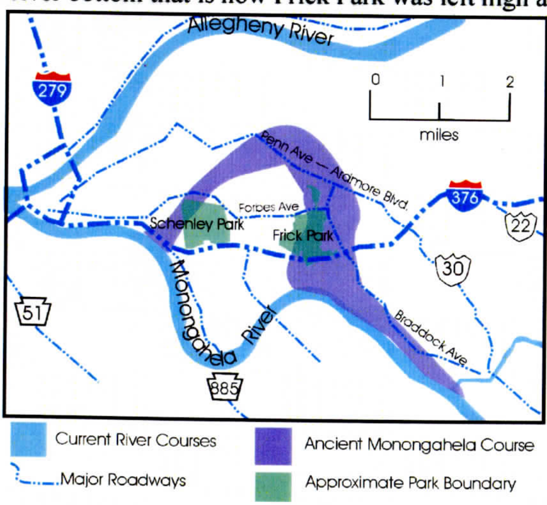

Figure 3. Map showing course of the pre-historic Monongahela River with respect to current rivers and Frick and Schenley Parks.