Pittsburgh Geological Society Field Trip

May 19, 1990

Geology of McConnells Mill and Moraine State Park Areas

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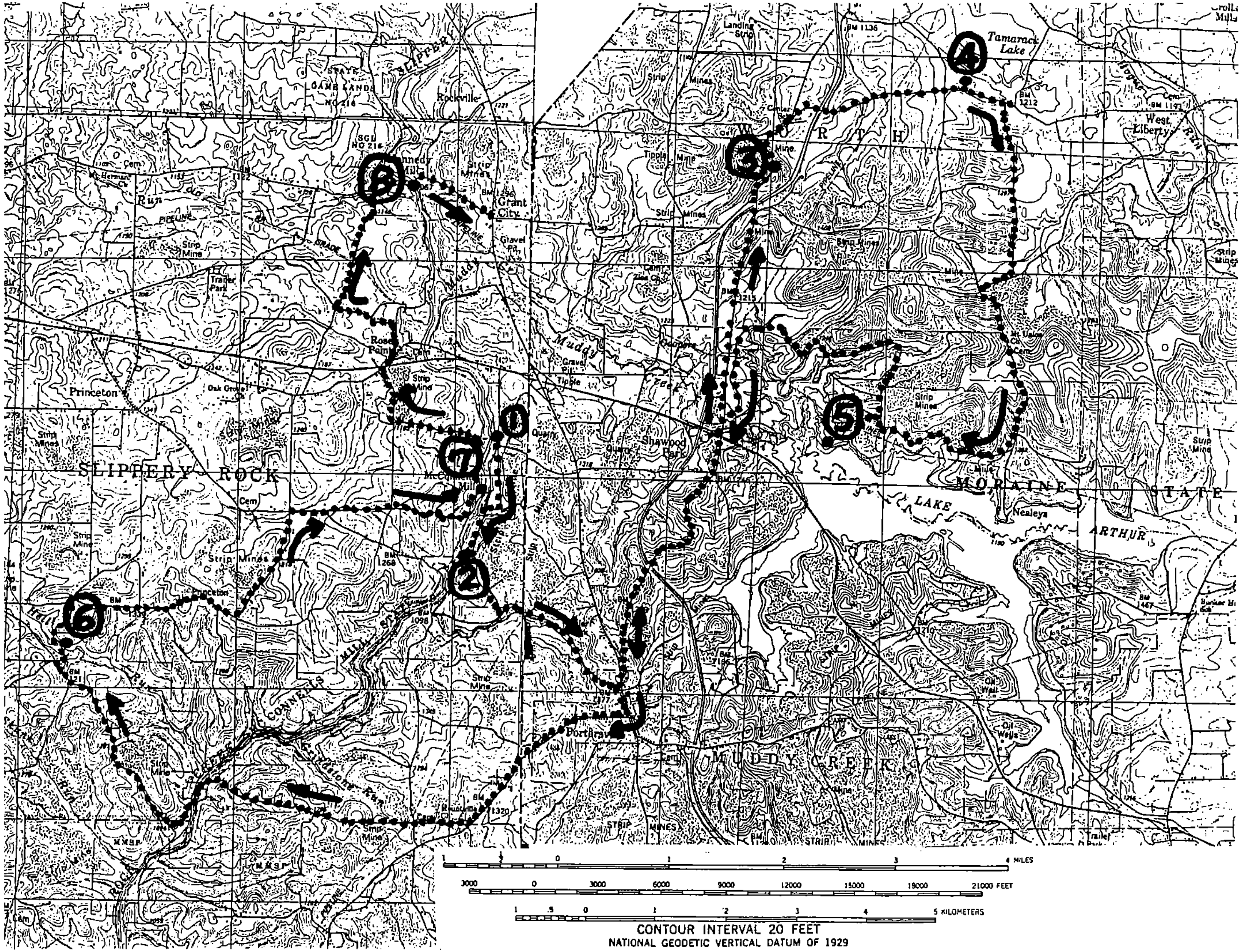

Tamarack Lake
West Liberty
Landing Strip
Rockville
STATE GAME LANDS NO 216
Grant City
Princeton
Trailer Park
SLIPPERY ROCK
Muddy Creek
Shawood Park
MORAINE STATE
LAKE ARTHUR
Nealeys
MUDDY CREEK
Portersville
Strip Mines
Cem
Quarry
Gravel Pit
Tipple
Oil Wells
PIPELINE
CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
4 MILES
21000 FEET
5 KILOMETERS

ROAD LOG
AND STOP DESCRIPTIONS FOR
FOR PGS 1990 SPRING TRIP TO MCCONNELLS MILL AREA

DONALD W. WATSON
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0.0 Trip begins at Alpha Pass in McConnells Mill State Park, Portersville, Pennsylvania.

STOP 1: ALPHA PASS

Alpha Pass is believed to have served as a short-term temporary outlet to pro-glacial Lake Watts. A large volume of water apparently flowed through here and into the gorge of the present Slippery Rock Creek, as the Wisconsinan glacier began to decay. Lake Watts, which was located two to three miles east of this location, had been created when the ancestral east-flowing Muddy Creek was dammed up by the ice which was advancing from the northwest. The present waterfall, called Gardiner Falls, must have been a major cataract during the few days that this outlet was active.

The rush of water from Lake Watts probably filled the shallow valley (across the road). It was able to wash away the colluvial fill which had existed at this point and still lines much of the main gorge to the north and south. This event has exposed the steep bedrock walls of the main gorge, but was unable to cut a notch into the Homewood sandstone which forms the lip of the falls.

The gorge at this site is the channel of Slippery Rock Creek which is now flowing to the south. The original north-south oriented valley was, however, formed by an originally smaller north-flowing stream which Preston has called McConnells Run.

Note that this interpretation is not in agreement with the description of events posted by the park personnel.

Re-board bus and follow the park road to the south.

0.1 Junction with Johnson Road. Point Picnic Area.

0.7 Mill parking lot. Turn right at T intersection.

0.8 Turn left at brink of gorge. Road to right leads to the mill.

0.9 Cross Kildoo Bridge. Homewood sandstone exposed below road level.

1.2 Park on right shoulder of road and proceed down hill through the woods to rim of gorge. Note that nearby cabin is on private property.

STOP 2: KILDOO KAME TERRACE

This stop is about one mile south of Alpha Pass. McConnells Mill is located in the bottom of the gorge about half way between stops 1

and 2. In the section of the gorge where we are now standing, there is no exposed bedrock We have proceeded from the road across the sloping top of what is probably a kame terrace, the surface of which is littered with small rounded cobbles. The rim of the gorge is mappable as a sharp topographic break, which strikingly resembles the edges of kettles so common in glaciated regions. This feature extends north to Kildoo Bridge and southward to Breakneck Bridge and beyond, a total distance of at least a mile. Below the rim, the ground slopes steeply to the edge of the creek. In this sector, the only bedrock exposures are at the bottom of a few tributary gullies. It is deduced that the rushing waters, which had exposed much bedrock between the mill and Alpha Pass were here flowing much less turbulently and thus did not erode away the colluvial and alluvial fill along the upper walls of the gorge.

Return to bus and continue along Portersville Road. Spoil piles of strip mine in the Kittanning Formation visible on left.

1.8 Turn left at stop sign.

1.9 Entrance to gravel pit on left.

3.3 Junction with Route 19 at north edge of Portersville. Turn sharp left onto Route 19 north and bear right immediately uphill on secondary road (West Park Road).

3.5 Bear right & continue on West Park Road.

4.2 Cross Interstate 79.

5.9 Cross US Route 422

6.0 Cross Muddy Creek. This is the outlet to present day Lake Arthur in Moraine State Park. The dam is about 0.5 miles to the right.

6.2 Pass entrance to North shore area of Moraine State Park.

6.8 Pass second entrance to Moraine State Park. The buildings are the bicycle rental facility. Cross alluvial plain and climb Billsburg Hill. This hill is the divide between the Muddy Creek and the Slippery Rock Creek watersheds.

8.1 Cross Interstate 79. Church Road enters on left beyond bridge.

8.5 Stop behind large billboard on right side of road.

STOP 3: BILLSBURG HILL.

This stop affords an overview of the Slippery Rock Creek valley north of the gorge. The creek, not in view meanders across the distant valley. To the left, the road which crosses Interstate 79 marks the approximate limit of Wisconsinan glaciation. The Jacksville esker, which is visible behind red brick farmhouse will be our next stop. The

esker is oriented approximately parallel to the left side of the road. Some persons have noted the change in the character of the topography, comparing the rounded hills in the glaciated sector to the left and the angular appearance to the right. Some of this difference is, however, due to the abandoned and overgrown strip mines in the Kittanning Formation which ring several of the hills.

During the Pleistocene, much of the distant valley was filled with the dammed up waters of Slippery Rock Creek, forming a large pro-glacial body of water called Lake Edmund. The smaller Lake Watts, over the divide to the right, occupied the approximate location of Lake Arthur, which forms the core of present day Moraine State Park. The orange and white mushroom-shaped water tower and probably smoking stack mark the location of Slippery Rock University. The creek passes about two miles south (to the right) of the tower.

Reboard bus and continue north on West Park Road.

9.3 Cross Interstate 79. West Park Road turns left. Do not turn, but continue straight ahead.

10.5 Cross Dickey Road on left and Reichert Road on right. We are tracing the edge of the Wisconsinan glacier.

10.7 Stop at Miller Farm (red brick farmhouse) Turn in the lane and park near the barn. This is private property. Please do not enter area without permission. Walk across field to Jacksville esker. If you walk directly across watch your footing. The field was plowed but not cultivated last year.

STOP 4: JACKSVILLE ESKER.

This winding topographic ridge of sand and gravel, known variously as the Jacksville Esker, the West Liberty Esker, the West Liberty Hogback and the Miller Esker is one of the best formed and best preserved eskers in North America. A 700-foot long section was purchased in 1975 by the Western Pennsylvania Conservancy and has thus been permanently preserved. Surviving segments of the esker are visible over a distance of about 2.5 miles. Some portions have been eroded by Black Run which flows sub-parallel to the crest. Another portion has been breached by Interstate 79, affording a good cross-sectional view on the west side of the highway. Other portions, between here and the village of Jacksville have been commercially excavated. The crest converges to the east with the road on which we are travelling and ends at a spot which presumably marks the front of the ice wall.

This segment of the esker trends west-north west. The upper waters of Black Run cross the swamp behind the somewhat steeper back slope. The hills along the horizon to the south form the divided between the Slippery Rock watershed and the Muddy Creek watershed. The billboard on Billsburg Hill (site of stop 3) is visible near the crest

to the right. The limit of Wisconsinan glaciation lies between the esker and the divide.

Many other eskers in this area have provided a source for easily acquired sand and gravel. This provides interested local residents and students with a collage of samples representative of northwestern Pennsylvania interspersed with Archean Shield fragments.

Return to the bus and proceed eastward on unnamed township road.

11.3 Turn right on another unnamed township road. The esker ends in farmyard straight ahead before turning. We are now travelling perpendicular to and directly away from the glacial front.

12.9 Road curves sharply right. Gravel road enters on left.

13.3 Road curves left at junction with Camelot and Reichert Roads and rises up and over the divide between the Slippery Rock Creek and Muddy Creek drainage basins.

14.0 Pass Mount Union Church Cemetary on left. We are close to the divide. Road proceeds down into the Muddy Creek drainage basin.

14.7 Stop sign with Lake Arthur in view straight ahead at sign. Lake Arthur is similar to but slightly smaller than Lake Watts. Turn right and proceed on road through park.

15.0 Road divides. Bear right on one-way one lane segment.

15.4 Rejoin two-way road. continue straight ahead with divide on right and Lake Arthur on left.

15.6 Park water treatment plant on right.

15.9 Sailboat storage area on left.

16.0 Watts Bay Marina on left.

16.7 Entrance to North Shore Swimming Area. Turn left.

17.4 Park at appropriate place.

STOP 5: LAKE ARTHUR SHORELINE.

Lake Arthur is 1190 feet above sea level. Lake Watts, which was created when the ancestral Muddy Creek was dammed by the continental glacier, had, according to Frank Preston, an elevation of over 1200 feet. The present-day dam is visible to the right. The bridge which carries Route 422 across an arm of the lake is in plain view. The pre-glacial channel of the ancestral Muddy Creek is believed to have followed a route somewhat north (to the right) of the present channel at the dam.

The downstream portion of Muddy Creek, in pre-glacial time, joined Slippery Rock Creek north of the present Kennedy Mill which is the last stop on this trip. The old channel is filled and is not topographically identifiable.

LUNCH.

Reboard bus and return to park north shore road.

18.1 Exit from swim area road and turn left on main park road.

20.4 Bike rental area on left. Continue straight ahead. Ancestral Muddy Creek may have been near here.

21.1 View of Lake Arthur on the left

21.3 Stop sign at T intersection. Turn left on West Park Road and cross Muddy Creek below the dam. Retrace this morning's route to Portersville.

21.5 Cross Route 422.

23.0 Cross Interstate 79. No access.

24.1 Stop sign at end of West Park Road. Continue south on Route 19.

24.4 Turn right on Route 488 toward Ellwood City.

24.6 Pass Portersville Fire Hall on the right.

25.5 Enter Lawrence County

26.3 Turn right at bottom of hill onto Mountville Road.

26.6 Mountville Church on right.

26.8 Stop sign. Cross Breakneck Bridge Road and continue straight ahead on rough road.

27.8 Nye Road on left. Begin descent along tributary to Slippery Rock Creek

28.6 Begin final descent into Slippery Rock Creek gorge.

29.0 Cross Slippery Rock Creek on Harris Bridge. Outcrop on right is probably Connoquenessing Sandstone. Although we are south of the main glacial front, the gorge at this location may have been occupied by a tongue of ice. Boulders in the creek are probably transported colluvium. This portion on the gorge was probably originally formed by a small south-flowing stream called Wurtemburg Run by Preston.

29.3 Stop sign. Turn right and continue climb out of gorge.

30.4 Top of hill. Recently regraded stripping operation across hills to left.

31.1 Road enters from left.

31.3 Make sharp right at crossroad and enter Shaffer Road.

31.5 Turn into parking lot at Hell Run, McConnells Mill State Park.

STOP 6: HELL RUN

Hell Run is one of the more significant tributaries to Slippery Rock Creek in this area. In a distance of about 1.7 miles it drops from 1150 feet near the parking lot to the bottom of the gorge at 880 feet. The confluence is about 0.3 miles north of Harris Bridge.

Much of Hell Run is flowing on bedrock. Outcrops of Vanport Limestone are present along the upper sector. Further downstream, the Clarion Formation forms a striking cascade where the waters pour over a set of well-jointed steps. At the base of the falls, a small outcrop of probable Homewood Sandstone is exposed. Access to the areas between the falls and the bottom of the gorge is difficult as topography is steep and without access by trail.

A very strong set of joints of anomalous orientation are superbly exposed in the Vanport limestone at the head of the Hell Run trail. These joints are oriented in a northwesterly direction, and although continuity has yet to be established, appear to follow the axial trend of the Homewood anticline, a gentle flexure, typical of many others in western Pennsylvania.

A short distance downstream, the channel is entrenched into a series of joint-controlled segments which result in straight segments with angular junctions where the joints intersect. These joint orientations are entirely different from those developed closer to the Homewood fold axis.

Hell Run, throughout it's entire length is outside of the glacial front. It has been proposed that an outlet glacier, similar to but smaller than the one suggested for the main gorge extended down through Hell Run and joined the main outlet glacier in Slippery Rock Creek gorge.

Features of cultural interest are the Lawrence Furnace, apparently a lime kiln, which is located very close to the falls. Earlier observers had suggested that the Lawrence Furnace might have been used for smelting iron ore, but there is no slag present here. The small excavations in limestone just above the base of the falls may well be the source of the limestone for the kiln. A well-preserved lime kiln, used in the 1920's is present in a rather inaccesible area above the gorge and about a mile or so to the northeast.

Part way back to the parking lot, Chris Calhoun, a professor of park management at Butler County Community College has found a bank of slag along the edge of a small tributary stream. He followed the slag train upstream and located what he believes to be the base of a now dismantled iron furnace.

Return via the trail to the bus. Depart from parking area and turn right on Shaffer Road

32.1 Stop sign. Turn right uphill onto unmarked state road.

33.6 Sharp turn to left. Gravel road continues straight ahead. Follow main road.

34.7 Stop sign. Turn right on McConnells Mill Road (not marked).

35.0 Fork in road. Bear left. Road to right crosses Slippery Rock Creek at Eckert Bridge. The road is washed out and has been abandoned.

35.9 Begin descent into Slippery Rock Creek gorge.

36.3 Rim of gorge. Turn left on gravel road.

36.6 Stop at pullout on right side of road.

STOP 7: ROCK CLIMBING AREA

Signs at this area read "Dangerous Cliffs No Swimming". I consider this a very appropriate admonition, for if we had been here when Lake Watts was being drained by the cataract at Alpha Pass (first stop this morning), water would have been rushing past this location. We are in fact only 0.4 miles south of Alpha Pass and directly above and across from McConnells Mill.

It appears that at the time of the draining, the bottom of the gorge was still filled with the remains of the outlet glacier, up to the level of the terrace which is clearly visible below the upper cliffs. The great but short-lived rush of water apparently swept away all of the alluvial and colluvial fill which probably existed here prior to the flood. Imagine the water boiling turbulently against the cliffs and the crevices which surround us here, as it abruptly changed direction at Alpha Pass and flowed down through this part of the gorge. Further downstream the flow of water must have become less turbulent, as most of the colluvium and kame terrace alluvium are still present (as seen at stop 2) which is downstream about half a mile on the other side of the gorge.

This locally catastrophic event has exposed the nearly full thickness of the strongly jointed cross-bedded Homewood sandstone. It appears proble that the Mercer Shale, which underlies the Homewood was eroded laterally by the outlet glacier, resulting in undercutting and collapse of many blocks of the massive Homewood. Most of the huge

blocks of colluvium which form ramparts along the sides of the creek must have been derived by this undercutting mechanism.

It is suggested that much of the erosion of the bedrock gorge is due to pre-Wisconsinan, possibly Illinoian widening and deepening of the stream eroded topography. Much of the colluvium which fills the bottom of the gorge is, thus, of interglacial origin. This material, as we see it now, has probably been transported downstream (and down glacier) by the Wisconsinan outlet glacier.

Reboard the bus and continue north along rim of gorge.

37.0 Turn left on Fisher Road (gravel).

37.8 Tree in middle of road. Turn right on unnamed dirt road.

38.4 Stop sign at Route 422. Turn right and then immediately left at Harley Davidson Shop.

38.5 Bear left at Y intersection.

39.1 Entrance to Rose Point gravel pit.

39.4 Stop sign. Turn right on Young Road.

40.6 Stop sign. Turn right on Frew Mill Road.

40.7 Entrance to Camp Agawam, Boy Scouts of America. Park bus and walk ahead down road to bridge.

STOP 8: KENNEDY MILL

This is the site of the former Kennedy Mill. Only the dam and some foundation blocks remain. At this point, Slippery Rock Creek, which wanders lazily on a broad flood plain upstream from this location, abruptly enters the gorge and flows rapidly southward. It is believed that the pre-glacial Slippery Rock Creek flowed westward from this point along the present line of Big Run where it entered Neshannock Creek near the present city of New Castle. The former tributary, named McConnells Run, flowed northward past McConnells Mill and Alpha Pass and emerged from the gorge at the location of Kennedy Mill.

Although it is difficult to observe through the trees, the gorge entrance at this location is actually cut into the side of the hill. Elevations as shown on the topographic map on the west side are about 1240 feet whereas those on the east are only 1140 feet above sea level.

It is suggested that the Wisconsinan glacier advanced only to this point and was diverted as an outlet glacier into the gorge. Elevations of the hills on the west were planed down to 1140 feet by glacial scour.

Reboard bus on east side of bridge.

41.1 At sharp turn on Frew Mill Road, continue straight ahead on Grant City Road.

41.8 Stop sign at Route 19. Intersection with Route 422 is to the right. Road is closed due to bridge reconstruction. We will follow unmarked detour to route 422 and then on to Alpha Pass.

BEDROCK GEOLOGY, McCONNELLS MILL STATE PARK

Kent Bushnell, Professor of Geology
Slippery Rock University

At first glance the bedrock geology of McConnells Mill State Park would appear to be well exposed along the steep sides of Slippery Rock Creek gorge. Closer inspection shows, however, that only the cliff-forming Homewood sandstone is readily observed; all softer formations are covered with colluvium and vegetation except in isolated outcrops at cutbanks and channels of tributaries into the gorge. Not surprisingly, better definition of formation contacts and complete lithologic descriptions are available from the logs and samples of numerous monitor, gas and water wells that have been drilled along Route 19 just east of the Park. The following discussion is based mainly on the subsurface geology, with some outcrop observations.

The bedrock formations that are exposed in and around the Park are, in descending order, the Kittanning Formation, the Vanport Limestone, the Clarion Formation, the Homewood Sandstone, the Mercer Formation and the Connoquenessing Formation.

The Kittanning Formation is exposed along Route 19, near the northwest entrance to Lake Arthur Trailer Park. Southward from this exposure, Kittanning coals were strip- and deep-mined, but any outcrops have been backfilled and recontoured. Near the trailer park, the average elevation at the base of the Kittanning is 1213 feet, North of Johnson Road, elevations range from 1192 to 1129 feet. Farther south, near Cheeseman Run and north of Breakneck Road, elevations range from 1156 to 1195 feet.

The Kittanning lithology is mainly shale with a few beds of sandstone and coal. The shale ranges from light gray to yellowish gray to dark gray and black. In texture it ranges from smooth and soft to silty, with carbonaceous and micaceous fragments, and scattered siderite nodules. The sandstone is yellow-gray to green-gray, very fine to medium grained, with rusty streaks.

The Vanport Limestone outcrops above and away from the rim of the gorge. It has been extensively quarried east of the park and many of the best high wall exposures have been buried as part of the reclamation of the area. Small outcrops are still present at the head of the small creek just north of Johnson Road and the creek south of the picnic area of the Park, south of Kildoo Road. Because of the modern quarrying and the pre-glacial erosion, the depositional top of the Vanport is present in fewer wells and outcrop than the base. The base is an excellent time and structural marker. The average elevation at the base of the Vanport is 1192 feet, with a range of 1161 to 1208 feet. Southward, near Cheeseman Run, the base drops as low as 1149 feet.

The formation consists of light brownish gray to medium gray, microcrystalline limestone in thin to medium, wavy to regular beds. Fossil fragments are common, especially crinoid stems and tiny brachiopods. The formation is of uniform thickness, 20 feet, except north of Cheeseman Run where it thins to 5 feet of brecciated limestone. In Cheeseman Run, the Vanport is back to normal thickness. This local thinning suggest a post-Vanport erosion, possibly along a gentle uplift, prior to the deposition of the Kittanning Formation.

The Clarion Formation rarely outcrops around the Park because of glacial, spoil pile or colluvial cover. It is a variable formation that has vertical and lateral changes within 100 feet of well spacing. It consists of interbedded sandstone, siltstone, shale, claystone, and coal. According to Poth, 1963, the Clarion is defined as lying between the Brookville coal or its underclay at its base, and the Scrubgrass coal or Vanport Limestone at its top. In the Park area, the Brookville coal is not always present and the term Clarion is used for that interval between the Vanport Limestone and the Homewood Sandstone. It averages 71 feet thick with a range of 56 to 86 feet. Although the lower contact with the Homewood is generally sharp, in some areas, the two seem to interfinger and show the Homewood thickening at the expense of the Clarion.

The Clarion shales and claystones range from light to dark gray and include carbonaceous and mica partings and clasts. Bedding is very varied and ranges from regular laminations to rough, nodular, wavy and contorted laminations to thin beds. Silt content varies from silty shales and mudstones to shaley siltstones.

Clarion sandstones are generally light to medium gray in fresh cuttings; tan to brownish gray on the weathered outcrop. They are very fine to fine grained, sub-angular to sub-rounded, silty, carbonaceous, micaceous, pyritic or sideritic. Little to no porosity is present. Rarely are the Clarion sandstones medium to coarse grained. Where they are, intergranular porosity creates local, restricted aquifers. Bedding varies from even laminations with carbonaceous partings to parallel, cross and masssive bedding.

The Homewood Sandstone (the oil and gas drillers' Forty-foot sand) consists of very light gray to clear, medium to very coarse quartz grains that are sub-angular to rounded. Although the finer grained zones drill up as cemented chips, the larger grained zones drill up as individual grains with very little cement. Pyrite, siderite and carbonaceous fragments are common, especially on bedding planes. Bedding is usually parallel- to cross-bedded, but contorted bedding is not uncommon. On the outcrop, the Homewood weathers to a tan to brownish gray and typically shows massive cross-bedding and coarse grains up to pebble size. The Homewood has an average thickness of 43 feet with a range of 17 to more than 72 feet. The average elevation at the top of the Homewood is 1119 feet with a range of 1097 to 1135. Some of this variation is stratigraphic as the top of the Homewood builds up at the expense of the overlying Clarion Formation.

The Mercer Formation lies above the Connoquenessing Formation and below the Homewood Sandstone with varying thickness and lithology. Regionally it thins as the Connoquenessing or the Homewood thicken either by facies changes or by channeling. The Mercer consist of interbedded dark gray smooth to silty, carbonaceous shales, dark yellowish brown, slightly fossiliferous limestones and coal. In gamma logs from two deep wells in the area, the Mercer consists of three shales with two clean, probably limestone, beds between. The thickness ranges from 30 to 45 feet.

The Connoquenessing Formation is exposed at McConnells Mill as sandstone ledges near the dam and parking area. Poth (1963) defines the formation as consisting of a lower and upper sandstone with a shale between. The upper sandstone is also known as the 60-foot sand; the lower sand as the Big Injun or Mountain sand. The lower sandstone is generally fine grained; the upper sandstone ranges from fine to medium grained with some coarse grains, similar to the Homewood sandstones. Cross bedding is present but not as consistently as in the Homewood. Fresh breaks are light gray, but the weathered outcrop is rusty, brown to dark gray. The middle shale is dark gray to black and sideritic. The upper sandstone is the most consistent and is readily defined by gamma logs in deep tests in the area. Its thickness ranges from 40 to 50 feet. The total thickness of the Connoquenessing based on gamma logs is about 125 feet.

The geologic structure of the area is essentially one of horizontal beds. Faults are not present. Joints are obvious along the gorge, where large blocks of Homewood Sandstone have split and slumped into the gorge. Joints are both parallel and at acute angles to the gorge. In less massive beds, jointing is present but discontinuous and varied in pattern between shale and sandstone layers. Jointing is rarely present in the bedrock below the limestone in the wells in the area.

The base of the Vanport Limestone is the only horizon that represents a time-line and a truly original horizontal surface. Elevations on other formation boundaries are suspect because they seem to be controlled by stratigraphic rather than structural changes. Contours on the base of the Vanport show a gently anticlinal nose plunging toward the southwest from near the junction between Routes 19 and 422. About 25 feet of structural relief is present across the nose. A parallel synclinal trend coincides with Johnson Road. Another high lies south of that and another syncline south of that near Cheeseman Run. None of these features are discernible from the limited surface outcrops.

Reference: Poth, C. W., 1963, Geology and Hydrology of the Mercer Quadrangle, Mercer, Lawrence and Butler Counties, Pennsylvania: Pennsylvania Geological Survey W 16.

SLIPPERY ROCK CREEK GORGE IN WESTERN PENNSYLVANIA, A PROPOSED GLACIAL ORIGIN

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ABSTRACT

The 100- to 300-foot deep gorge of Slippery Rock Creek is a through valley, believed to be cut by glacial scour of now connected originally north- and south-flowing stream systems. It is proposed that this connection was first formed by an outlet-type valley glacier which formed in front of an advancing pre-Wisconsin continental glacier. This valley glacier deepened the earlier, stream-carved valleys to nearly the present depth of the gorge. Upon ice retreat, collapse of the walls resulted in filling of the valley with very blocky colluvium. A final glacial advance, probably Wisconsinan, caused the re-filling of the gorge with ice and the development of a set of kame terraces. These terraces, together with some of the colluvial fill, were partially destroyed by glacial flood waters produced by the draining of a series of pro-glacial lakes.

INTRODUCTION

Slippery Rock Creek is the principal agent of drainage of the northwestern part of Butler County, western Pennsylvania. This area has undergone glaciation and has, as a result, a relatively subdued topography (Shepps and others, 1959, p. 5). Much of the upper portion of Slippery Rock Creek, together with its principal tributary, Wolf Creek, is characterized by a rather low gradient and flat valley floor over an older valley almost completely filled with alluvium. Not far from where the main stream crosses into Lawrence County, it enters a narrow gorge which is about 15 miles long and up to 400 feet deep. Much of the resulting spectacular scenery is preserved in McConnells Mill State Park. The gorge begins rather abruptly at Kennedy Mill (fig. 1) near the northern border of the Portersville 7.5 minute quadrangle. Here the fairly low banks rise in a short distance downstream to heights of about 100 feet above water level, and the gradient of the stream increases from about 5 feet per mile to 25 feet per mile.

About one mile downstream, the only significant tributary to Slippery Rock Creek in the gorge section, Muddy Creek, cascades in from the east. Muddy Creek has been dammed up about 3 miles to the east to form modern Lake Arthur in Moraine State Park.

The gorge increases in depth southward partly due to the increased gradient and partly due to an increase in elevation of the surrounding country. Three miles below Kennedy Mill, at McConnells Mill, (fig. 1) the rim is over 200 feet above water level and at Cleland Rock Lookout, two miles further downstream, it is over 300 feet above water level. At this last named site, the elevation of the rim of the gorge is about 1300 feet, which is 100 feet higher than at the upper end of the valley at Kennedy Mill. Thus, we have

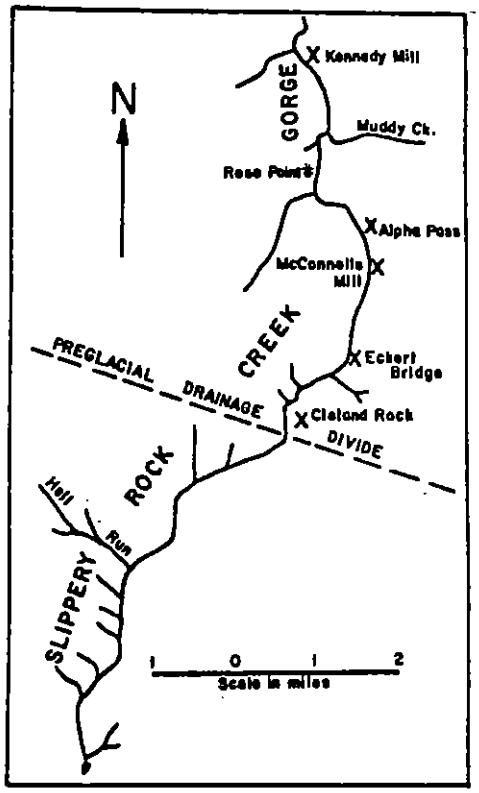

Figure 1: Map of present day Slippery Rock Creek gorge area.

the rather unusual situation that as the stream cuts deeper along its course, the surrounding country becomes higher in elevation. South of the topographic divide near Cleland Rock, the rim of the gorge gradually drops in elevation to about 1200 feet

STATEMENT OF THE PROBLEM

Preston (1977, p. 31) in his excellent discussion of Pleistocene drainage changes in this area has suggested that the 200- to 400-foot-deep gorge of Slippery Rock Creek was primarily the product of late Pleistocene stream-flood erosion. New evidence found during the present study, however, suggests that the principal downcutting of the bedrock valley occurred in the early Pleistocene, or perhaps Pliocene, or earlier.

Problems to be considered, in addition to those noted above, include the abrupt rise in bank elevation at Kennedy Mill, the side-hill character of the stream just south of Kennedy Mill (Preston, 1977, p. 48), the cross-gorge topographic divide near Cleland Rock, and the tendency of several tributaries north of Cleland Rock to have northward (upstream) stream entrance angles.

FIELD WORK

Material for this paper was gathered in the summers of 1984, 1985 and 1987, during an intensive mapping project of the joints exposed in the cliffs along the gorge. A detailed outcrop map and record of glacial and topographic features was prepared by tape and compass methods.

DISCUSSION

Description of the Gorge

In the gorge section, the current flow alternates between rapids around many large boulders and relatively quiet flow in less obstructed portions of the stream. Little or no bedrock is known to be exposed in the channel or, in fact, anywhere on the lower slopes. One possible exception is a small mass of cross-bedded sandstone which is exposed at water level directly opposite McConnells Mill.

Discontinuous cliffs, ranging in height from less than one foot to as much as 30 feet, are restricted to the highest elevations near the rim of the gorge. The casual visitor is likely to be misled with respect to the quantity of exposed bedrock as it is best exposed in the more accessible and developed parts of the park. In many of the developed areas, large blocks, measuring several tens of feet across have broken loose from the walls and have moved five to ten or more feet into the gorge. Some of the access roads pass behind these blocks.

In contrast, in much of the undeveloped portion of the park, visible bedrock is very scarce and is, in fact, completely covered by drift and colluvium for distances of many hundreds of feet parallel to the stream. Even in these areas, however, the rim of the valley is identified as a very sharp topographic break.

Development of the Gorge

The development of the gorge seems to have been controlled by a combination of stratigraphy, lithology and structure of the nearly flat-lying Pennsylvanian-age bedrock. Stratigraphy and lithology have been previously described by White (1877), DeWolf (1929), Poth (1963), and Van Lieu and Patterson (1964). The sequence, following Berg (1983), from older to younger, consists of the Connoquenessing Sandstone, the Mercer Shale, the Homewood Sandstone , the Clarion Formation, the Vanport Limestone and the Kittanning Formation. In most areas, the exposed bedrock of the upper gorge is the very resistant Homewood Sandstone which forms the 1- to 30-foot-high cliffs (fig. 2c). Many of

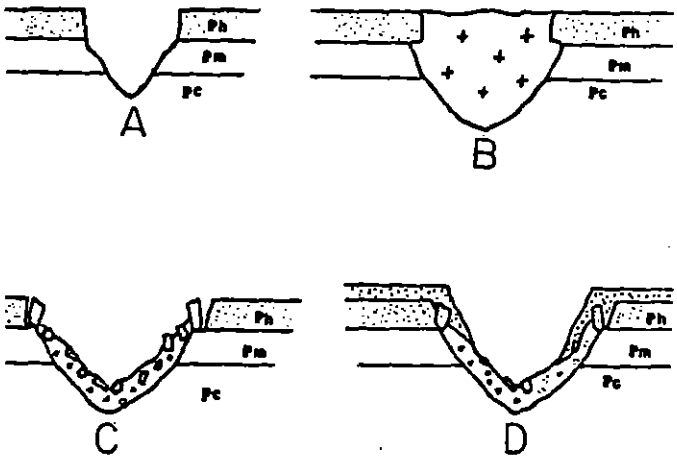

Figure 2: Proposed cross sections of Slippery Rock Creek gorge: A. Stream-cut gorge of McConnells Run and Wurtemburg Run; B. Gorge modified by glaciation; C. Present day gorge north of McConnells Mill; D. Present day gorge south of McConnells Mill.

the outcrops are step-like, but others exhibit overhangs of an inch or two up to several feet (fig 3). This configuration is believed to have been formed by the lateral erosion of the soft Mercer Shale (fig. 2b) and the subsequent collapse of the overlying thick and resistant Homewood Sandstone. In most areas, the Vanport Limestone and the overlying Kittanning Formation form gentle slopes, well away from the rim of the gorge. The present rugged topography is due almost entirely to cliffs of Homewood Sandstone.

Preston's Interpretation

Preston (1977, p. 27-33) believes that the present gorge was formed by removal of the divide between a pre-glacial south-flowing

Figure 3: Overhanging cliffs of Homewood Sandstone typical of area north of McConnells Mill.

stream, which he named Wurtemburg Run (fig. 4) and a north-flowing stream which he called McConnell's Run. As can be seen in figure 4, this latter stream followed the line of the present south-flowing Slippery Rock Creek northward to the present location of Kennedy Mill. At that time, the preglacial Slippery Rock Creek probably flowed westward from Kennedy Mill along the course of the present Big Run into what is now Neshannock Creek (White, 1877, p. 151) (Preston, 1977, p. 25), and then northward by way of a major stream to the Erie Basin (Leverett, 1934, p. 92)

Preston has proposed that much of the erosion necessary to create the gorge resulted from the rapid draining of a series of ice-dammed lakes formed when the west-flowing, pre-glacial drainage was disrupted by the ice sheet which advanced from the northwest. According to plate 1 of Shepps and others (1959), the southern limit of Wisconsinan glaciation is marked by the edge of the Kent moraine near the present Rose Point (compare figs. 1 and 5). Shepps and others also show the gorge crossing a strip of till of Illinoisan age between Rose Point and Eckert Bridge, and a strip of Illinoisan alluvium crossed by the Slippery Rock Creek gorge downstream from Eckert Bridge. Further south the terrain is shown as unglaciated.

One of the temporary outlets of the glacial lake described by Preston (1977, p. 43) was through Alpha Pass (fig. 1), located about 0.5 mile north of the present McConnells Mill. According to this interpretation, water flowing out of Lake Watts roared through this "pass", rapidly filled the valley of the old north-flowing stream and spilled over the divide into Wurtemburg Run. This contributed to a rapid downcutting through the Homewood Sandstone and erosion of the underlying Mercer Shale. A deeply incised south-flowing stream

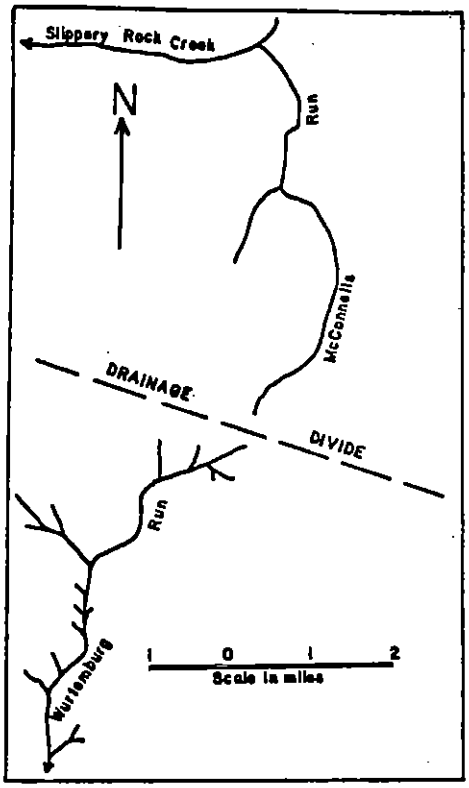

Figure 4: Map of Slippery Rock Creek gorge area, showing McConnells Run and Wurtemburg Run in pre-glacial time.

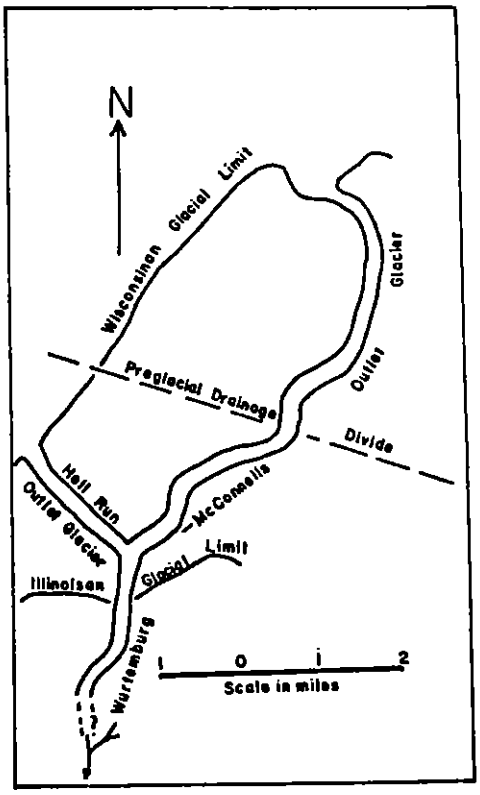

Figure 5: Map of Slippery Rock Creek gorge area showing Hell Run and Wurtemburg-McConnells outlet glaciers.

was thus established, which followed the course of the old Wurtemburg Run.

New Interpretation

Examination of the lip of Gardiner Falls (fig. 6) at the junction of Alpha Pass and Slippery Rock Creek (fig. 1) shows negligible evidence of bedrock erosion. The top of the colluvium at the base of the falls is at a much lower level than even a few tens of feet north or south along the escarpment. This suggests that the flow of water over the falls was sufficient to erode the colluvial fill at the base of the falls but did not continue long enough to cut into the bedrock even at the lip of the falls. Since the lithologies which have been cut through during the formation of the main gorge are the same ones exposed at Gardiner Falls, it is clear that the present Slippery Rock Creek valley could not have been cut at this time but must have begun forming much earlier than the time of the retreat of the Wisconsinan-age glaciers.

This interpretation is strongly supported in the area south of McConnells Mill where almost no bedrock is exposed except in the bottom of tributary gullies. In this sector, the rim of the gorge is clearly marked by a sharp break in topography which is very similar to the edges of kettles and kame terraces found elsewhere in glaciated terrain (fig. 7). The interior of these terraces is not well exposed, but several gullies which cut them show sandy material and local pavements of rounded cobbles. Scattered rounded cobbles are also present on the top surface of the terraces. It is suggested, therefore, that these are deposits of ice-contact stratified drift and that an outlet glacier extended southward from the main ice border into the pre-existing gorge of the present Slippery Rock Creek and deepened this gorge in the manner of a valley glacier. The main glacier, in this paper called the Wurtemburg-McConnells outlet glacier, was joined downstream by the shorter Hell Run outlet glacier (fig. 5). Then as the ice melted back from the rim of the gorge, stratified drift filled this gradually widening gap to form a set of kame terraces. This permitted the accumulation of glacial alluvium in the channels of tributary streams long after the removal of the divide at the head of Wurtemburg Run. Many years ago, White (1877, p. 16) suggested that the over-deepened bedrock channel of the Beaver River between New Castle and the Ohio River was due to the work of a similar but probably larger outlet glacier. The present day Slippery Rock Creek itself is not flowing in a bedrock channel. All of the visible rock in the stream consists of rather angular disoriented boulders which have fallen from above. This is further strengthened by the driller's log of a well drilled in 1963 near McConnells Mill which describes gravel and broken pieces of rock to a depth of about 50 feet. The collar of this well is no more than 20 feet above water level. This suggests about 30 feet of alluvial and colluvial fill at the bottom of the gorge at this location.

Figure 6: Cliffs of Homewood Sandstone at Gardiner Falls.

Figure 7: Edge of kame terrace at upper rim of Slippery Rock Creek gorge south of McConnells Mill.

Examination of the Portersville 7.5-minute quadrangle shows a narrow belt of high ground with elevations over 1300 feet which extends west-northwestward from the Portersville Borough boundary. This divide is truncated at right angles by the Slippery Rock Creek gorge near Cleland Rock forming the deepest part of the cut (fig. 1). This is probably the approximate location of the head of Wurtemburg Run. South of this point most of the tributaries form stream entrance angles which point downstream. North of this location most of the tributaries are barbed, with entrance angles which tend to point toward the north. This supports the premise that the divide was breached.

Sequence of Events

The sequence of events proposed here to explain the present topography and stream patterns begins with the presence of a west-northwest-trending divide between and parallel to the ancestral Connoquenessing Creek and Muddy Creek-lowermost Slippery Rock Creek valleys. This divide is now at an elevation of about 1350 feet except where it is breached by the gorge. The south-flowing stream, called Wurtemburg Run by Preston (1977, p. 29), had its headwaters near the present Cleland Rock overlook. This stream, which followed the trend of the present southwestern part of Slippery Rock Creek gorge, was probably marked by a waterfall at a nickpoint formed by the very resistant Homewood Sandstone. It is believed that this cataract migrated upstream due to undercutting and collapse of this very resistant formation. At the rather rapid rate of 1 inch per year, the 5 miles or so of headward erosion necessary would take a minimum of 300,000 years. Due to the small area of drainage at this time, the upstream migration of the falls probably proceeded at a much slower rate than this.

A north-flowing stream, called McConnells Run in this report (fig. 4), which followed the northern part of the present gorge similarly included a waterfall at the same stratigraphic horizon.. This stream joined the ancestral west-flowing Slippery Rock Creek near the present Kennedy Mill. At this time, Wurtemburg Run and McConnells Run had V-shaped cross-sections similar to that shown in figure 2a.

As these two headwardly migrating falls approached each other, the high ground of the divide between them was gradually destroyed. Due to a gentle regional southward dip of the Homewood Sandstone, the lip of the falls of Wurtemburg Run tended to be lower than that of McConnells Run. This assisted the northward migration of the divide between these two streams.

It is uncertain exactly when the divide was broken through and the direction of flow reversed in the northern sector of the gorge. This may have been accomplished during Pliocene or earlier times, but more likely, the last high ground in the present gorge was removed by the tongue of ice described above which filled and downcut the previously formed stream valleys and rode over and destroyed the divide. It is suggested that this took place in pre-Wisconsinan time. The cross section of the early ice-filled gorge now resembled that shown in figure 2b.

Continued erosion by the now enlarged south-flowing stream caused widening and deepening of the oversteepened stream valley. The resistant Homewood Sandstone of the upper slopes was undercut by removal of the underlying Mercer Shale. This caused large blocks of sandstone to fall to the valley floor and to partially fill the gorge with debris. The result was a valley which in cross section resembled figure 2c.

The last phase of glaciation now commenced, and the ice advanced to the site of the present Rose Point. The west side of the gorge between Kennedy Mill and Rose Point was scoured to a somewhat lower elevation than the east side, producing the peculiar side hill character of the upper gorge. A new tongue of ice now entered the gorge and flowed southward, where it was probably joined by another outlet glacier proceeding down Hell Run (fig. 5). Much of the coarse colluvial material which had previously filled the gorge remained but was probably transported some distance down the gorge. As this last tongue of ice melted, ice-contact stratified drift was deposited along the edges of the gorge to form the present rim.

The draining of the pro-glacial lakes sharply but temporarily increased the discharge of the stream and resulted in the local erosion of parts of both colluvium and stratified drift The effect is especially well shown at Alpha Pass where the steep bedrock cliffs are well shown. Downstream from this site across the gorge from McConnells Mill, cliffs locally as high as 40 feet are exposed in an area used for rock climbing. This concentrated erosion was probably the result of the extreme turbulence of the water as it cascaded over Gardiner Falls. Less turbulent flow downstream resulted in much less erosion and the preservation of the colluvium and the kame terraces. It is possible that large masses of stagnant ice at first filled portions of the bottom of the gorge causing turbulent water flow against the upper valley walls.

CONCLUSIONS

It is concluded that Slippery Rock Creek in McConnells Mill gorge is best described as a through stream which was cut by a combination of stream erosion and glacial scour. The divide, which originally separated the drainages of Muddy Creek and Connoquenessing Creek to the south, is transverse to the gorge. It was first breached by headward erosion of the the north-flowing stream, called McConnells Run and the south-flowing stream called Wurtemburg Run by Preston. This divide was destroyed by a small valley glacier which developed in front of an advancing pre-Wisconsinan continental glacier. This glacier scoured these now connected valleys to a depth approaching that of the

present gorge. Following melting of this earlier glacier, the valley walls were undercut causing collapse and the development of large wedges of blocky colluvium along the walls. A later glacial event, probably Wisconsinan in age, filled the gorge and led to the development of pairs of kame terraces along the sides. Flood waters from the draining of a set of pro-glacial lakes during the retreat of the last glacial event caused erosion of those portions of the glacial and colluvial material where the turbulence was greatest and the preservation of these same materials where the water flow was less turbulent.

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