An Examination of Field Methods for Glacial Margin Mapping and Paleoflood Reconstruction in Slippery Rock Creek Basin, Western, Pennsylvania

Fieldtrip Sponsored by the Pittsburgh Geological Society
October 23, 2004

by

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INTRODUCTION

This guidebook is an extension of an investigation of the glacial margins of the 1950s and the hydraulic reconstruction of the largest paleoflood in Slippery Rock Creek drainage basin (D'Urso, 2000). The reader is directed to that study for more details or clarification.

This field trip introduces the participants to some of the concepts and field methods used to map glacial margins, as well as reconstruct paleoflood hydraulics which is important to evaluate the long-standing theory for the development of Slippery Rock Creek basin, a catastrophic flood due to the failure of a proglacial lake ice dam. Field evidence suggests that the glacial margins of 1950s are incorrect and that there was no catastrophic flooding in Slippery Rock Creek basin.

Slippery Rock Creek watershed is an ice-marginal basin in western Pennsylvania, having been glaciated in the northern portion and unglaciated in the southern portion (Fig 1). Regarding the glacial margins, there will be stops to acquaint participants with the primary method used by Leverett (1902, 1934), Lessig (1961), and D'Urso (2000) to distinguish the age of outwash on fluvial terraces and to map the glacial margins, which focused on erratic clast weathering. There is a stop where the participants can utilize some of this information to locate a glacial margin so well as to be able to straddle it and, hopefully, to agree upon the margin's age. Finally, there will be a stop where methods used by Shepps (1955) and Sitler (1957), namely depths of leaching and oxidation, may be examined. Regarding the paleoflood reconstruction, the participants will drive along a downstream reach of Slippery Rock Creek looking for evidence of flooding followed by a stop where the sedimentological evidence for flooding will be examined.

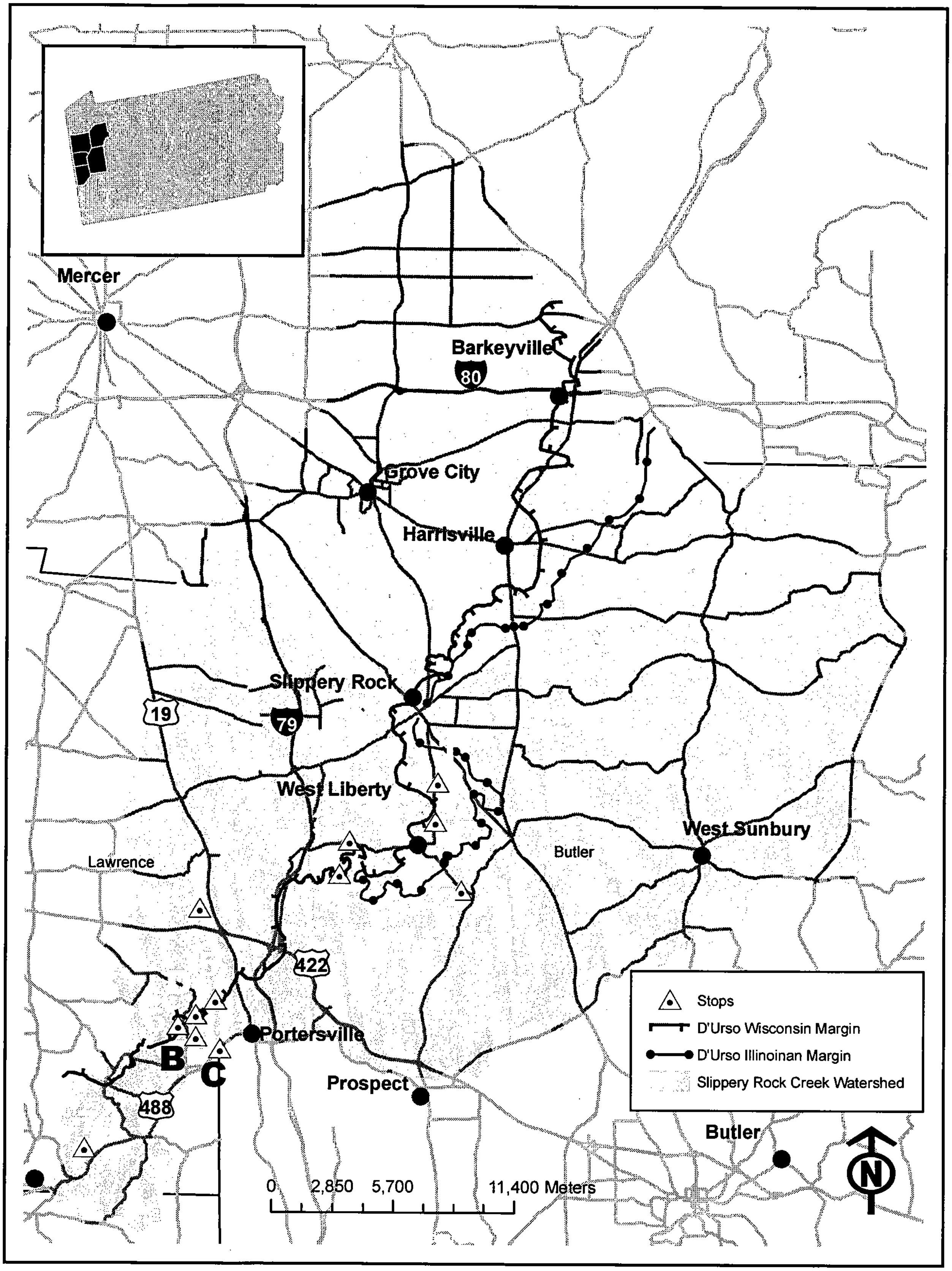

Figure 1: Location map for Slippery Rock Creek drainage basin, showing field locations and the most recently mapped glacial margins.

Projection: Albers Conic Equal Area NAD27
Source: D'Urso 2000, PASDA
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The glacial geology of the Ohio River Basin first appeared in a serious scientific publication nearly 180 years ago (Drake, 1825) and while the glacial margins in western Pennsylvania have been mapped and remapped for the last 120 years (Lewis, 1884; Leverett 1902, 1934; White, 1951; Shepps and others, 1959; D'Urso, 2000), the surficial maps were evolving until the products of the 1950s. Prior to the surficial maps of the 1950s, successive surficial mapping efforts produced an evolving framework for the support of later surficial geology and soil studies, by differentiating glacial advances and extending in concert both glacial deposits and corresponding soils farther to the south. After the middle of the 20th century, some sound surficial observations (Watson, 1989) based on the most recent surficial maps required implausible explanation and for the first time soil publications suggested that soils developed in glacial deposits extended many miles beyond the most tenuous geological margins mapped by geologists. Also during the 1950s, the catastrophic flood theory for the development of Slippery Rock Creek Gorge became popular and has persisted for half a century without serious scientific challenge.

In 2000 the glacial margins were remapped and the largest geologically evident meltwater flood was reconstructed (D'Urso, 2000). The glacial margin investigation results suggest that the glacial margins of the early 20th century were accurate. In addition, the largest meltwater flood probably had a meager discharge, similar to the historic flood of record having a discharge orders of magnitude lower than the discharge expected from a catastrophic flood, where the flood water would have "… thundered through the land" (Preston, 1977). The hydraulic model for the paleoflood was based on data (clast sizes and associated flow velocities for their emplacement) from flood deposits which are insufficient to justify a large catastrophic flood. A catastrophic flood should have deposited boulder bars that persist to this day.

DISCUSSION

Weathering rinds were significant for Leverett's (1902, 1934) glacial margin mapping and Lessig's (1959, 1961) relative age determination of fluvial terraces. In order to map various drifts, Leverett (1902, 1934) correlated terrace outwash deposits to their respective drifts and then identified the extent of the drift based on the weathering of felsic erratics. Leverett (1902, 1934), however, did not describe his weathering criteria in detail but asserted that weathering and etching are consistent and sufficient to map glacial margins across the eastern United States.

Lessig (1961) described a qualitative comparison of the weathering of erratic granite gravel in terraces of different ages along Little Beaver Creek, near East Liverpool, Ohio. Lessig described the Wisconsin granites as fresh or having a slight weathering rind, Illinoian granites as more weathered, having a strong rind but a fresh interior, and pre-Illinoian granites as thoroughly weathered.

Three distinct degrees of granitic clast weathering, as described by Lessig (1961), are observable in Slippery Rock Creek basin. The least weathered (Wisconsin) erratic clasts have little to no rind (< 2 mm). Intermediate weathered (Illinoian) erratic clasts have prominent rinds (3 – 5 mm) but fresh interiors. The most weathered (pre-Illinoian) erratic clasts have rinds > 6 mm. These three weathering categories are readily recognizable and only rarely is a granitic erratic found to be somewhat confusing as to which category it belongs. The thicknesses assigned to each category (D'Urso, 2000) were not statistically derived, but the methodology of differentiating depositional ages based on qualitative differences of felsic clast weathering has existed in the literature of this region for more than half a century.

Another characteristic to observe is the overall shape of most till stones. Triangular faceting is a shape common to rocks that have been processed through glacial ice. If you hold your thumbs parallel to the ground surface, touch their tips together, and then join the tips of your index fingers, you have created a triangular shape that many glacial clasts will present in cross-section, regardless of their size.

In addition to weathering rinds and triangular faceting, one should be aware of the shape of fieldstones in unglaciated terrain. These clasts of residual bedrock are commonly angular to subangular and moderately to highly weathered sandstone. Less commonly clasts will be angular, fresh to weathered shale.

FIELD STOPS

STOP 1: This stop displays weathered Canadian Shield Erratics (CSEs) typical of land glaciated during the Illinoian.

We may examine the field for CSEs but many fieldstones were collected and placed just within the trees on the north side of the lane. While the deposit of fieldstones is too close to Slippery Rock Road to avoid contamination by road ballast, some of the fieldstones exceed 3 feet in diameter and are much too large to be used as road ballast. All the large stones and most of the small ones show well developed weathering rinds between 3 and 5 mm.

In addition to CSE weathering rinds, notice that the local sandstone is smooth and well-rounded and often faceted.

STOP 2: This stop displays unglaciated terrain.

Note the lack of CSEs and faceted local bedrock in the fields. Fieldstones, when present, are generally angular to subangular, moderately to highly weathered local sandstone bedrock, with an occasional piece of angular shale bedrock.

The farm roads, however, display gravel containing CSEs without weathering rinds or with rinds less than 1 mm. Locally, it is common practice to import gravel for farm roads. The source for this gravel is any number of gravel pits, commercial or private, farther to the north in Wisconsin deposits.

Often paddocks and other areas heavily trodden by livestock have receive imported glacial gravel, specifically because granitic erratics are more resistant to breaking than the local sandstones, and minimize the sharp edges that damage the feet of the livestock, as well as minimize erosion.

Another common practice is the use of glacial gravel as road ballast. CSEs can be seen commonly in the ditches along West Liberty Road at least as far east of this stop as State Route 528, approximately 0.4 miles. Along this section of West Liberty Road the township placed 4 feet of Wisconsin gravel as ballast (landowner and previous Brady Township Supervisor, personal communication, 1997).

STOP 3: This stop displays weathered CSEs typical of Wisconsin glaciated land.

Most of the CSEs have no weathering rind or, when present, the weathering rind is less than 1 mm thick. In addition to CSE weathering rinds, notice the abundance of faceted local bedrock, primarily sandstone.

STOP 4: Find the glacial margin.

At the first three stops, you have seen weathering rinds typical of (1) Wisconsin and (2) Illinoian glaciations, as well as (3) triangular faceting of till stones, exotic or local, and (4) the angular to subangular shape and (5) moderately to highly weathered appearance of unglaciated residual bedrock. At this stop, we will put that knowledge to work by examining the western valley slope near the closed southern end for evidence of glaciation. This valley is mapped as having been glaciated. If you agree with this interpretation, your tasks are to delineate the boundary and determine the age of the glaciation.

STOP 5: Gravel pit in Wisconsin kame delta.

Figure 2 is a portion of the topographic map for the downstream end of Cheeseman Run, showing the approximate extent and location of a kame delta. A gravel pit in this kame exposes stratified sands and gravels. This site was mapped as Illinoian by Sitler (1957). Most of the granitic erratics, however, display Wisconsin weathering.

Figure 3 is a picture of this site in 1996. The east end of the exposed north face shows the deposit was leached of carbonate to a depth of 10 feet and oxidized to a depth of 22 feet. Sitler (1957) reported that Wisconsin morainic tills display oxidation depths of 15 - 18 feet, while Shepps and others (1959) reported that Wisconsin ice-contact stratified drifts (ICSD) were leached to depths of 9 - 15 feet. Oxidation at Stop 5 is 4.3 feet deeper than Sitler's values for Wisconsin morainic tills, but the depth of leaching falls within Shepps and others' limits of Wisconsin ice-contact stratified drift. The additional oxidation is likely due to the increased permeability of ICSD deposits versus the lower permeability of tills. The only alteration of the surface of the kame at this stop was the removal of a thin layer of topsoil in the 1950s (landowner, personal communication, 1997).

Given the thickness of weathering rinds, the depth of leaching, and the depth of oxidation, this location was correctly mapped as Wisconsin by Leverett (1934) and incorrectly changed to Illinoian by Sitler (1957). This error has been corrected (D'Urso, 2000).

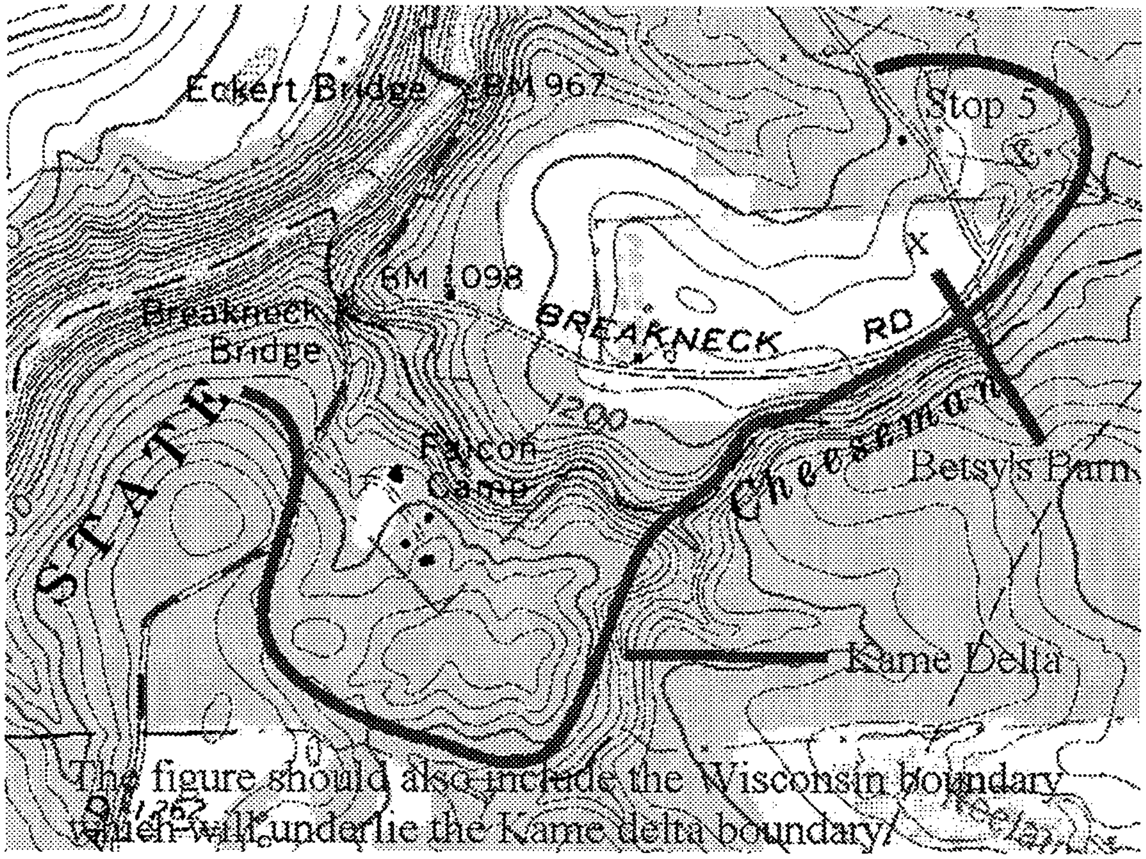

Figure 2: Portion of the Portersville 7.5 minute Quad showing the Wisconsin Kame Delta at Stop 5 and upon which sits Becky's Barn, our lunch stop.

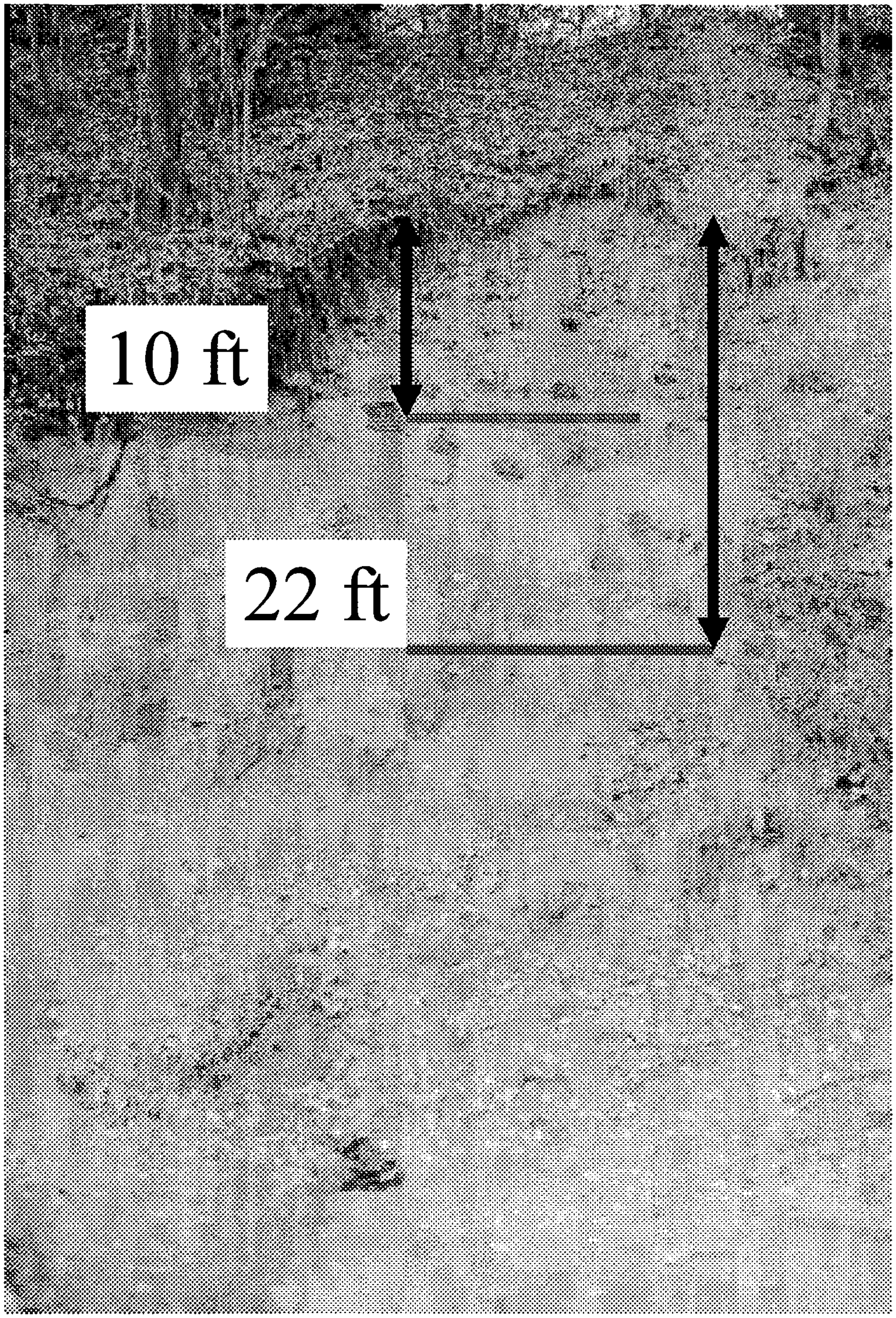

Figure 3: Picture of Stop 5 in 1996 overlaid with depths of leaching (blue) and oxidation (red) in the foresets of this kame delta, reflective of a Wisconsin age.

STOP 6: Cleland Rock scenic vista.

Preston (1977) proposed a divide at Cleland Rock and called it the Pliocene divide. This divide supposedly formed the headwaters for a south-flowing Wurtemburg Run and a north-flowing McConnells Run. Preston postulated that an advancing continental ice sheet impounded McConnells Run and created Proglacial Lake Prouty. The col, or spillway, of the proposed Proglacial Lake Prouty was located where Slippery Rock Creek valley presently crosses the divide, where you now stand. Preston (1977) suggested that erosion from flow over the spillway began the development of the Slippery Rock Creek gorge, initiating the early Pleistocene piracy of McConnells Run (upper Slippery Rock Creek) and began forming the drainage system that exists today. The gorge development was not complete, however, and Preston (1977) further postulated that floodwater from a later catastrophic failure of the ice dam of Proglacial Lake Watts, in present day Muddy Creek, removed the final portion of the col and completed the development of the Slippery Rock Creek watershed that we see today.

Most of the proposed Proglacial Lake Prouty occupied the area of what has also been named Proglacial Lake Cheeseman (D'Urso, 2000) with a small portion occupying Slippery Rock Creek valley between Cheeseman Run (Stop 5) and this location, Cleland Rock. Preston did not find evidence of Proglacial Lake Prouty during the 1970 field season that he dedicated to that pursuit (R. Shott, Preston's field assistant, personal communication). If Proglacial Lake Prouty ever existed, it was only during early Pleistocene, while Proglacial Lake Cheeseman was certainly Wisconsin and could have existed repeatedly throughout the Pleistocene. The existence of a divide at Cleland Rock resulting in the development of Proglacial Lake Prouty and any gorge-forming catastrophic outburst flooding from Proglacial Lake Watts, need not be linked; they are two independent concepts. Even the existence of a divide at this location is conjecture.

Computer hydraulic modeling in the only scientific field investigation of glacial meltwater paleoflooding in Slippery Rock Creek Basin (D'Urso, 2000) strongly suggests that, based on the geological evidence, the largest flood in Slippery Rock Creek had an average maximum peak discharge of approximately 13,400 ft^3/s. That discharge approximates the historic flood of record for Slippery Rock Creek. In contrast, the Pennsylvania State Geological Survey, choosing to ignore this work, continues to champion the catastrophic flood hypothesis when discussing the origin of Slippery Rock Creek Gorge (Fleeger and others, 2003).

STOP 7: This area is the downstream portion of the hydraulic model and is downstream from the glacial maximum. Therefore, any erratics found here must have been flood deposited or ice rafted.

The best exposure of flood deposited clasts is located along Van Gorder Mill Road between cross-sections 2 and 3. The clasts are also exposed in small gullies perpendicular to Van Gorder Mill Road, extending at least 45 feet upslope. The average intermediate axis of the five largest clasts from a sample of 29 between cross-sections 2 and 2.1 is 2.3 feet, while the average intermediate axis of the five largest clasts from a sample of 26 between cross-sections 2.1 and 3 is 1.9 feet. Inserting these mean diameters into a flow competence equation (Equation 1, Costa, 1983) shows that a water velocity of

10.6 ft/s between cross-sections 2.1 and 3 and an average water velocity of 9.5 ft/s between cross-sections 2 and 2.1 would move the largest clasts observed in each deposit. These velocities are considered a close approximation of the upper limit of flow velocity for the flood that deposited these clasts.

$$v = 0.18 d_i^{\ 0.487} \qquad (1)$$

v = velocity (m/s)

d_i = average particle size diameter,

intermediate axis (mm) of five largest clasts

These calculated water velocities are significantly lower than the modeled water velocities, determined when the HEC-RAS hydraulic model is run to disregard the size of the clasts in the Paleostage Indicators (PSIs), which were 38 ft/s between cross-sections 2 and 2.1 and 40 ft/s between cross-sections 2.1 and 3. Accordingly, Slippery Rock Creek, when flowing at a velocity of 40 ft/s between cross-sections 2.1 and 3 would have had a discharge of 1,340,000 ft^3/s and would have been capable of transporting clasts with intermediate axes averaging 32.5 ft.

Clasts far larger than 2.3 feet are common upstream in the glaciated portion of the basin, yet they are notably absent in the flood deposits. The lack of these larger clasts in the fluvial deposits in the modeled reach, coupled with the relatively low water velocities calculated to move the largest clasts found between cross-sections 2 and 3, indicate a low flow velocity for the flood that deposited the clasts in this portion of Slippery Rock Creek.

When the Slippery Rock Creek model is limited by water velocities of 10.6 ft/s at cross-section 2.1 and 9.5 ft/s at cross-section 3, the discharges decrease to 15,000 ft^3/s and 12,000 ft^3/s, respectively, for a mean discharge of 13,400 ft^3/s. The historic flood of record for Slippery Rock Creek is 19,000 ft^3/s, occurring on January 25, 1937.

Slippery Rock Creek Gorge displays numerous blocks of resistant Homewood Sandstone with intermediate axes far in excess of 3 feet, especially in the vicinity of McConnells Mill, that would require velocities far less than 40 ft/s to be entrained. Periglacial processes likely developed these blocks as the ice sheet left the basin, but similar blocks should have been developed during the periglacial climate during glacial advance, making large blocks available for transport should any later catastrophic flooding have occurred. Blocks of Homewood Sandstone, however, may not have survived the transport from the gorge to the lower reaches intact, in spite of its resistant nature. There are, however, Canadian Shield Erratics (CSEs) in the glaciated highlands surrounding the gorge that are at least twice the size of the largest clasts measured between cross-sections 1 and 3.

Field observations of the texture, composition, and the size of the largest clasts in the PSI deposits suggest that the deposits between cross-sections 1 and 3 were deposited under a low flow environment. At the average restricted discharge of 13,400 ft^3/s, given the channel geometry, the flow responsible for the emplacement of the 45 feet of sand and gravel would have been shallow, approximately 4.0 feet deep.

It appears, then, that the deposits were aggradational, depositing over some period of time by a lower magnitude, sustained flow rather than from a large flood due to the catastrophic failure of an ice dam with a discharge orders of magnitude higher. The aggrading streambed ultimately reached the elevations of the outwash PSIs in lower Slippery Rock Creek.

One might ask the question. “If there was a catastrophic ice dam failure that generated a larger magnitude flood where is the flood evidence?” Extraordinary floods develop extraordinary gravel bars or erosion scars. The only flood evidence is much smaller, containing clasts much smaller than one would expect.

Another question one might ask is, “What happened to the thickness of flood deposits (minimum 45 feet) along Van Gorder Mill Road?” The model suggests that the flood that emplaced this thickness of sediments was sediment rich, shallow (approximately 4.0 feet), and low magnitude (< 19,000 ft^3/s) and the streambed aggraded during deposition, until the streambed was at the elevation of the top of the flood deposits. During the intervening 20,000 years, Slippery Rock Creek experienced hundreds, probably thousands of sediment starved, shallow (approximately 4.0 feet), and low magnitude (19,000 ft^3/s) floods, which flushed the sediments. In other words 20,000 years of the periodic recurrence of a similar magnitude flood that initially emplaced the sediments would have flushed them from the valley. It is important to recognize that the periodic recurrence of a flood much smaller that the flood that emplaced a flood deposit would winnow the finer sediments and would concentrate the larger clasts being unable to entrain them.

If there was a much larger flood, larger clasts would have been deposited because they were certainly available upstream and those clasts should still be where they were deposited until similar floods occurred and flushed them downstream. When larger clasts are available for transport, the size of the flood-deposited clasts is the limiting factor in determining the magnitude of the flood by limiting the competent velocity of the flood (D'Urso, 2000)

STOP 8: Muddy Creek Falls. Gamma Pass.

Muddy Creek is the tributary to Slippery Rock Creek that, when dammed by the Laurentide Ice Sheet, gave rise to Proglacial Lake Watts. Gamma Pass was the final western outlet draining Proglacial Lake Watts and is the location of present day lower Muddy Creek. Gamma Pass (Lower Muddy Creek) was incised during the Laurentide deglaciation and is just south of the buried paleochannel of Muddy Creek (Fig. 3).

The downstreammost 0.5 miles of Lower Muddy Creek is a geomorphic laboratory. There is a series of three waterfalls, ranging from a vertical falls upstream to a cataract downstream. The apparent age of the valley slopes increases dramatically in a short distance downstream, as well; the valley walls upstream are vertical and angular but laid back and more rounded as one proceeds downstream. There are also imbricated slabs of sandstone and large toppled sandstone blocks, one 21 feet in length with a pothole large enough to sit in.

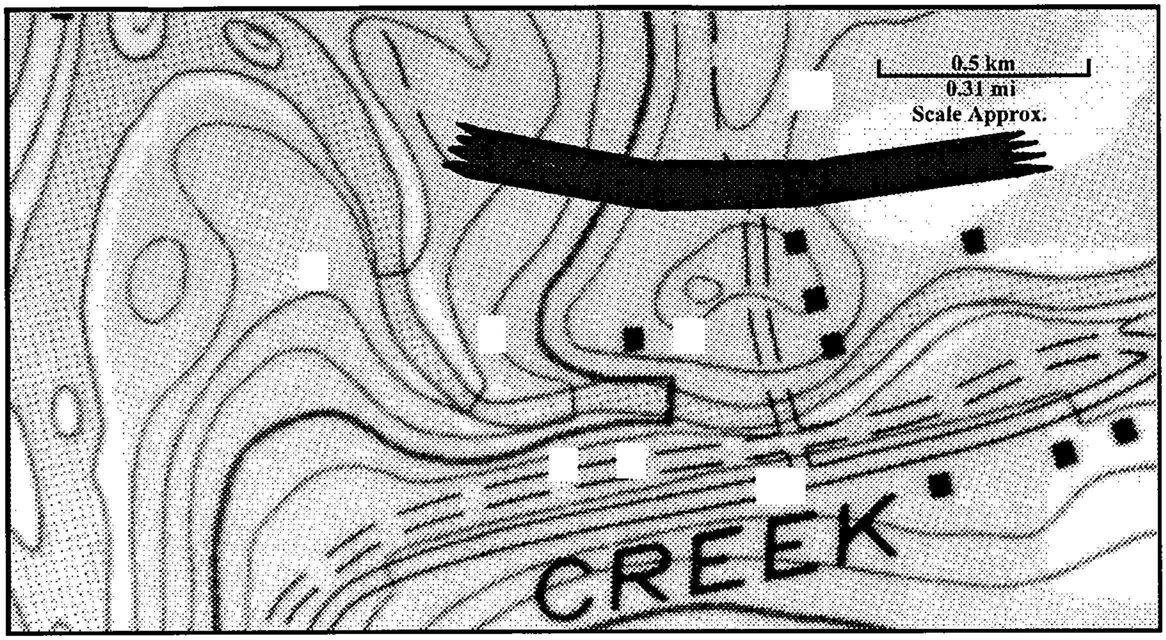

Figure 3: Portion of the Portersville 7.5 minute Quad showing the approximate location of a portion of the paleochannel for Muddy Creek (solid blue).

CONCLUSIONS:

The glacial margins of Leverett (1934) were the most accurate of all previous margins. The glacial maximum southwest of the vicinity of West Liberty is Wisconsin. The glacial maximum northeast of West Liberty is Illinoian. No Pre-Illinoian glacial margin is visible at the surface in Slippery Rock Creek basin.

Weathering rinds on felsic erratics are common enough and extensive enough to be used for determining the age of glaciated landscapes. Three weathering rinds are observable in Slippery Rock Creek basin. Wisconsin rinds are < 2mm in thickness. Illinoian rinds are 3 – 5 mm thick. Pre-Illinoian rinds are > 6 mm in thickness.

The hydraulic reconstruction of the largest geologically evident paleoflood in Slippery Rock Creek basin had an average maximum discharge of approximately 13, 400 ft^3/s. That discharge was far less than any reasonable discharge to be expected from a catastrophic outburst flood.

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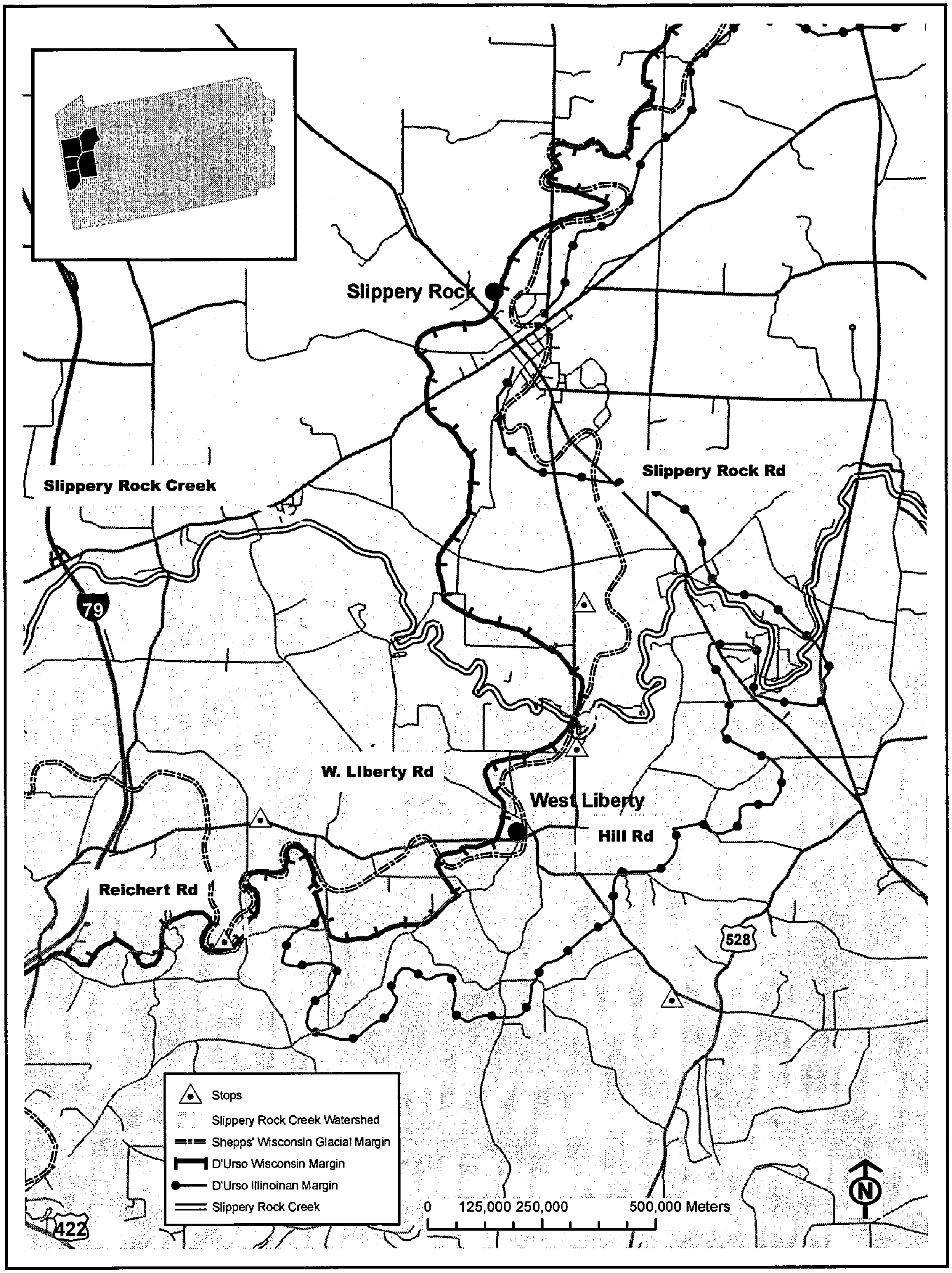

Plate 1: Location map for field stops 1-4 and drive by location A.

Projection: Albers Conic Equal Area NAD27
Source: D'Urso 2000, PASDA
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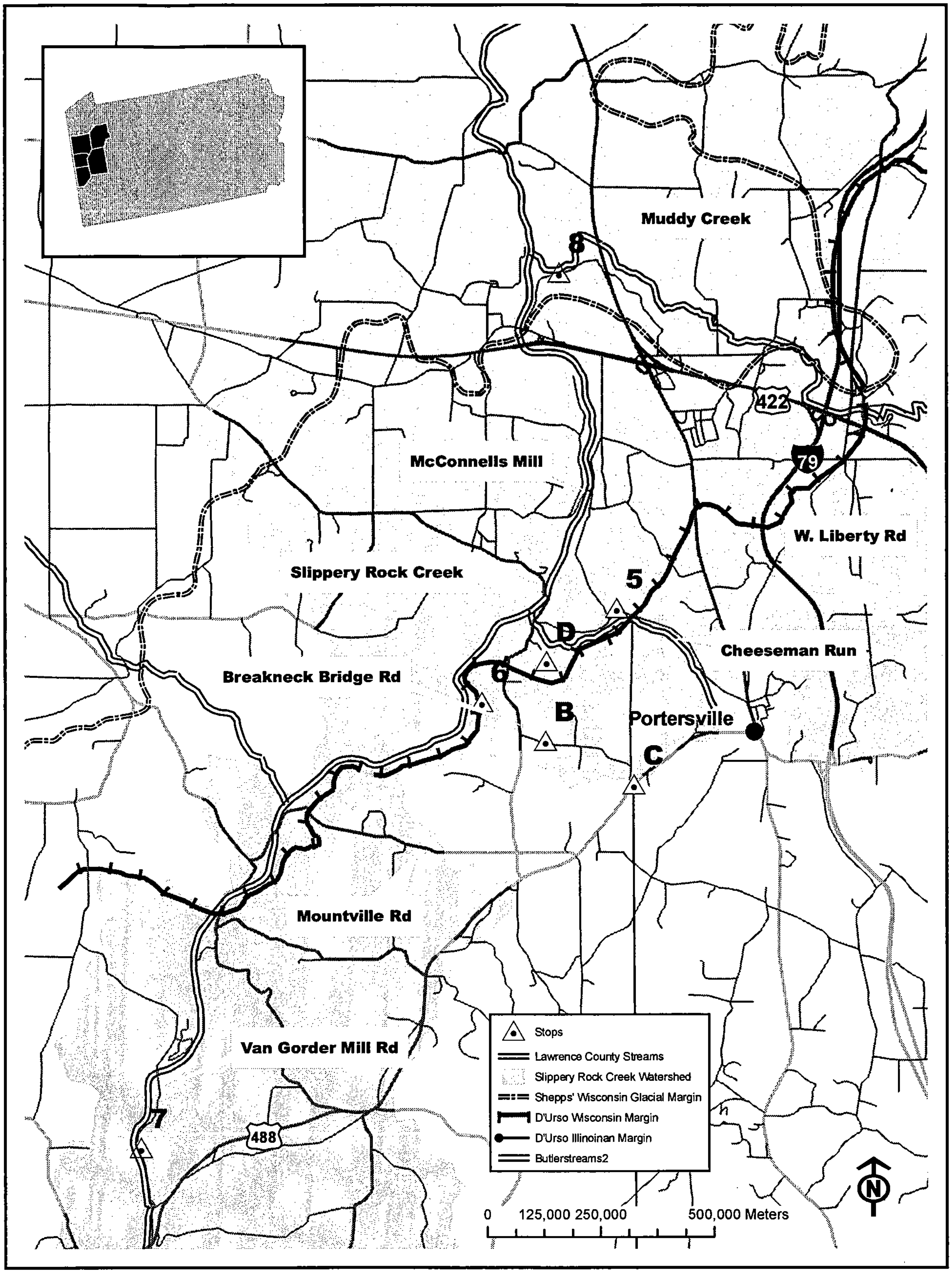

Plate 2: Location map for field stops 5-8 and drive by locations B - D.

Projection: Albers Conic Equal Area NAD27
Source: D'Urso 2000, PASDA
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ROAD LOG
October 23, 2004

Miles

0.0 Large parking lot on east rim of Slippery Rock Creek Gorge, just SE of McConnells Mill Building. Exit parking lot going right on McConnells Mill Road. In 50 feet turn right onto Kildoo Road.

0.15 Turn right onto Kennedy Road toward old mill.

Note: You are driving through a "Rock City" in the Upper Pennsylvanian Homewood Sandstone. The jointing parallel to the gorge was likely exacerbated by, if not generated by valley stress relief, while the downslope movement of the blocks is due in major part to heaving from daily freeze/thaw cycles during the periglacial.

Note: Large blocks of Homewood Sandstone in Slippery Rock Creek and along banks. No similar-sized blocks are seen downstream from the gorge. Most often the long axis (A axis) of these blocks is parallel to stream flow (perpendicular to the slope of the valley walls). Rocks oriented in this manner were emplaced by colluvial processes, having their source in the Rock City, and were not flood deposited. From the number of such blocks at the level of Slippery Rock Creek and the narrowness of the gorge it can be argued that colluviation of these blocks has been minimal since the end of the periglacial climate.

0.7 Stop sign. Go straight onto Johnson Road.

1.5 Stop sign. Go left onto US Route 19.

2.0 Turn right onto Burnside Road.

2.45 Cross Interstate Route 79.

2.65 Stop sign. Turn left onto West Park Road.

3.05 Cross US Route 422.

5.2 Cross Interstate Route 79.

5.6 Scenic vista. Look back to the right to see the Proglacial Lake Watts watershed (present day Muddy Creek drainage basin) and ahead to the right to see Proglacial Lake Edmund watershed (present day Upper Slippery Rock Creek drainage basin).

6.4 Cross Interstate Route 79. Road changes name to West Liberty Road.

7.7 Look to the left to see the best example of an esker remaining in the basin. The esker is called a "hogback" by many locals and is known to geologists by several names: Miller Esker (for the family who donated this portion of the esker to the Western Pennsylvania Conservancy), Slippery Rock, West Liberty, or Jacksville Esker (all for geographic localities). The cornfield east of the barn will be Stop 3 later today.

8.3 Road ascends onto the esker.

8.55 Road descends from the esker.

10.0 West Liberty Boro, road changes name to Slippery Rock Road (County Route 4008).

10.3 Ninety degree left turn toward the town of Slippery Rock. Hill Road on right.

10.9 NOTE: This roadcut at site A, just south of the bridge over Slippery Rock Creek, exposes approximately 20 feet of rhythmically bedded silt. An additional 35 feet of silt was penetrated for a water well (landowner, personal communication, 1997), although no drilling log is recorded with the Pennsylvania Geological Survey. This 55 feet of silt probably was deposited in Proglacial Lake Edmund.

11.0 Cross Slippery Rock Creek.

11.9 Eagle's Nest Parking Lot.

12.1 STOP 1: Illinoian weathering. We will depart the vans at the lane along the south edge of the woodline, on the north side of the cornfield, north of the Eagle's Nest Hall, on the Cooper Property.

Backtrack south on Slippery Rock Road.

13.3 Pass the lacustrine deposits.

13.9 At the 90 degree turn, slow down or stop then make a left turn onto Hill Road.

14.25 Stop sign. Turn left turn onto Barron Road (?), then turn right immediately onto West Liberty Road.

15.55 STOP 2: Unglaciated land.

15.65 Backtrack heading west on West Liberty Road.

17.0 Stop Sign. Turn left continuing west on West Liberty Road. Do not turn right onto Slippery Rock Road.

17.35 Stop Sign. Turn left continuing west on West Liberty Road.

17.6 Stop Sign. Turn left continuing west on West Liberty Road.

19.9 STOP #3. Wisconsin weathering.

When leaving turn right, continuing west of West Liberty Road.

20.0 Stop Sign. Turn left onto Reichert Road.

Note: You are entering a closed valley. The high ground ahead is the watershed divide separating Proglacial Lake Watts (present day Muddy Creek) to the south, from Proglacial Lake Edmund (present day Upper Slippery Rock Creek) to the north. This divide was a topographic barrier to glacial advance.

20.75 STOP 4: Turn left into Reichert Dairy.

0.0 Restart log: The driveway is so long and there may have been excessive jockeying of vehicles that it seems appropriate to restart our road log at the intersection of Reichert Road and the Reichert Dairy driveway.

Backtrack heading north on Reichert Road.

0.7 Stop Sign. Turn left onto West Liberty Road.

1.8 West Liberty Road ends at end of bridge over Interstate Route 79 becoming West Park Road. Continue straight onto West Park Road.

3.0 Cross Interstate Route 79 and pass Zion Church Road.

4.4 Entrance to North Shore of Moraine State Park.

5.1 Bridge over Muddy Creek.

5.2 Bridge over US Route 422.

5.5 Stop sign. Turn right onto Burnside Road.

5.8 Bridge over Interstate Route 79.

6.1 Enter area of reclaimed strip mine.

6.7 Stop sign. Turn left onto US Route 19.

7.4 South of Eppinger's Restaurant cross Wisconsin glacial maximum.

8.7 Turn right onto Cheeseman Road and descend into Proglacial Lake Cheeseman basin.

9.9 Pass Pfeifer Road and begin ascent upon Wisconsin kame delta in Proglacial Lake Cheeseman.

10.1 STOP 5: Gravel pit in Wisconsin kame delta.

10.2 Stop sign. Turn right onto Kennedy Road.

10.25 Turn left into Betsy's Barn for lunch.

10.35 Leaving Betsy's Barn backtrack, turning right onto Kennedy Road.

10.4 Stop sign. Turn left onto Cheeseman Road.

10.7 Turn right onto Pfeifer Road.

11.9 Turn right onto Magee Road.

12.4 Note: Use of ornamental rocks -- all subangular residual bedrock.

Of note is an area along the west end of Magee Road site B. The soil survey for Beaver and Lawrence counties shows a north-south trending area of Canfield and Ravenna soils, both believed to have developed in glacial till (Smith, 1982). The Canfield and Ravenna soils were mapped well within the Wisconsin limit and north of Slippery Rock Creek basin, at least as far as the northern part of Lawrence County, as well as in this area of what was previously mapped as pre-Illinoian Mapledale drift (White and others, 1969).

The surface of these soils is littered with locally-derived clasts: sandstone residuum on the uplands and shale and sandstone colluvium on the lower slopes. One landowner lined his driveway, pond, part of his property line, and many small features on his property with local clasts, in three-course rock walls. All of the many thousands of rocks in these walls are residual sandstone.

If any glacial rocks, especially erratic igneous rocks were present on any of these properties they would have been used as lawn ornaments by at least one landowner. This area is unglaciated.

12.8 Turn right onto Breakneck Road.

13.0 Turn left onto State road leading to Cleland Rock.

13.3 STOP 6: Scenic vista at Cleland Rock.

13.7 Backtrack turning right onto Breakneck Road.

14.3 Twentier Family Dairy on left.

14.8 Stop sign. Turn left onto Mountville Road.

14.9 Divide between Slippery Rock Creek and Connoquenessing Creek.

15.2 Crossing Sitler's Illinoian maximum.

15.3 Stop sign. Turn right onto State Route 488.

20.3 Turn right onto Van Gorder Mill Road.

21.0 STOP 7: Jeff McDonald residence. Park on berm on left side of road.

21.1 Turn around, backtracking south on Van Gorder Mill Road.

22.0 Stop sign. Turn left onto SR 488.

27.7 Turn left onto Pfeifer Road. You are in the Connoquenessing Creek drainage basin, about to return to the Slippery Rock Creek basin. Note the ornamental armoring of the toe of the hillslope on the right (Site C).

The upland of site C is devoid of glacially-emplaced erratics, but the slope along State Route 488 is armored with erratic cobbles. These cobbles were imported from the Polish Falcon Camp, Site D, along Cheeseman Run, the southern portion of the kame delta of Stop 5 (landowner, personal communication, 1997).

29.1 Stop sign. Turn left onto Cheeseman Road.

29.3 Stop sign. Turn right onto Kennedy Road.

30.3 Stop sign. Turn right onto Kildoo Road.

30.4 Turn left onto McConnells Mill Road. Make immediate left into parking lot where we started our trip.

30.5 Turn left onto McConnells Mill Road upon leaving parking lot.

30.9 Cross Johnson Road.

30.95 Crest of hill is the beginning of Alpha Pass "valley."

31.0 Alpha Pass Falls.

Proglacial Lake Watts emptied by draining through the sequential exposure of a series of increasingly lower cols at the glacial margin, called Alpha, Beta, and Gamma passes by Preston (1977).

Alpha Pass was the first of this series of three successively lower cols. Prior to the opening of Alpha Pass the water surface elevation of Proglacial Lake Watts was controlled by a col to the southeast at Queen Junction at elevation 1260 feet asl.

An ice dam just upstream from your location is proposed to have catastrophically failed and the release of Proglacial Lake Watts through Alpha Pass was calculated by Preston (1949) to be 336,000 ft^3/s and lowered the water surface elevation 20 feet to 1240 feet asl in little more than 24 hours. Paleoflood hydraulic modeling suggests a more realistic discharge that averaged 18,000 ft^3/s (D'Urso, 2000).

31.2 Crest of hill is the divide between Alpha Pass and Beta Pass South.

Beta Pass was the next lower col and when opened it lowered the water surface elevation of Proglacial Lake Watts an additional 10 feet to 1230 feet asl. Paleoflood hydraulic modeling suggests a more realistic discharge that averaged 12,000 ft^3/s (D'Urso, 2000)

The col for Beta Pass, through which we will drive later, was just east of the intersection of US Routes 19 and 422, flowing west along what is now US Route 422, under the overpass for US Route 19. The discharge then skirted around both sides of the hill due east of the State Park maintenance building at mile 31.5. Discharge through Beta Pass South flowed on the south side of this hill into the depression you are entering.

31.5 Crest of hill is the divide between Beta Pass South and Beta Pass North.

Discharge through Beta Pass North flowed on the north side of this hill into the depression you are entering.

31.6 Stop sign. Turn left onto US Route 422.

32.1 Turn right onto Old 422.

32.15 Bear left, remaining on Old 422.

32.3 Turn right onto Muddy Creek Road.

Note: The stream to your left is Slippery Rock Creek but as you proceed you loose sight of the creek and at approximately 32.6 a stream reappears but this is Muddy Creek.

32.7 Stop 8: Muddy Creek Falls. Private driveway.

Leaving driveway turn left onto Muddy Creek Road.

33.5 Turn right onto US Route 19.

34.1 Turn left onto ramp for US Route 422 West.

34.2 Enter US 422 West.

Note: We will drive through the col of Beta Pass, although road construction masks the original topography. The overpass is US Route 19 and the course of US 422 under US Route 19 is Beta Pass. West of the overpass for US Route 19 Beta Pass bifurcated as it flowed toward the hill to your left, Beta Pass South flowed around the south flank while Beta Pass North flowed around the north flank of this knob.

34.7 Turn left onto McConnells Mill Road.

34.8 Divide between Beta North and Beta South.

35.1 Divide between Beta South and Alpha.

35.3 Alpha Pass Falls.

35.8 Parking lot where we began.

END TRIP 7