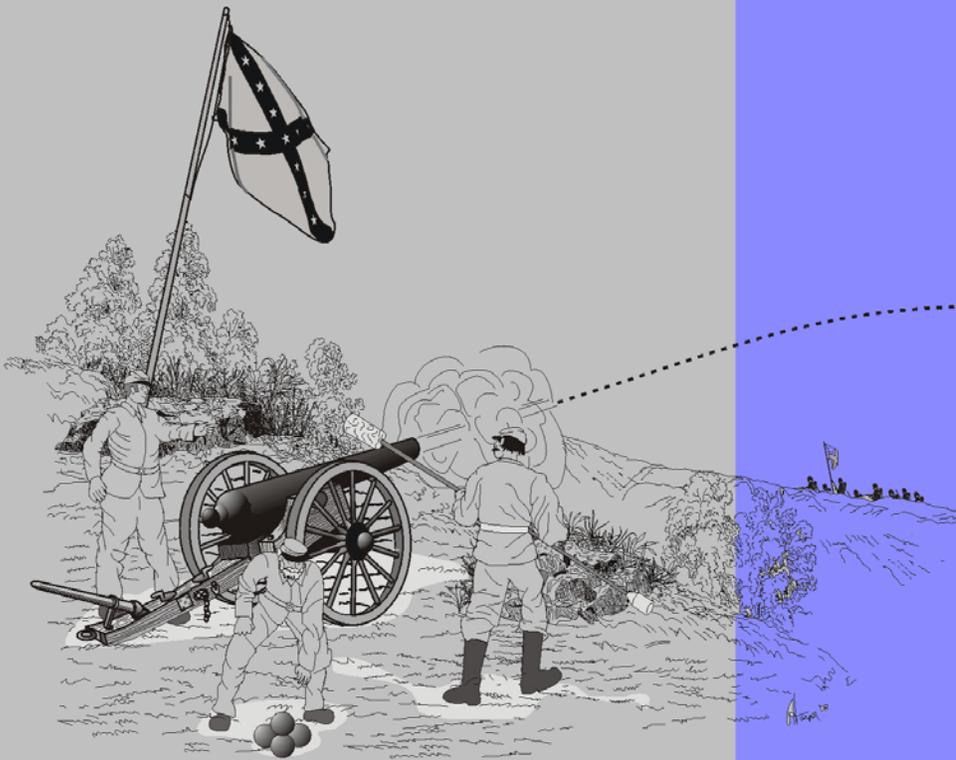


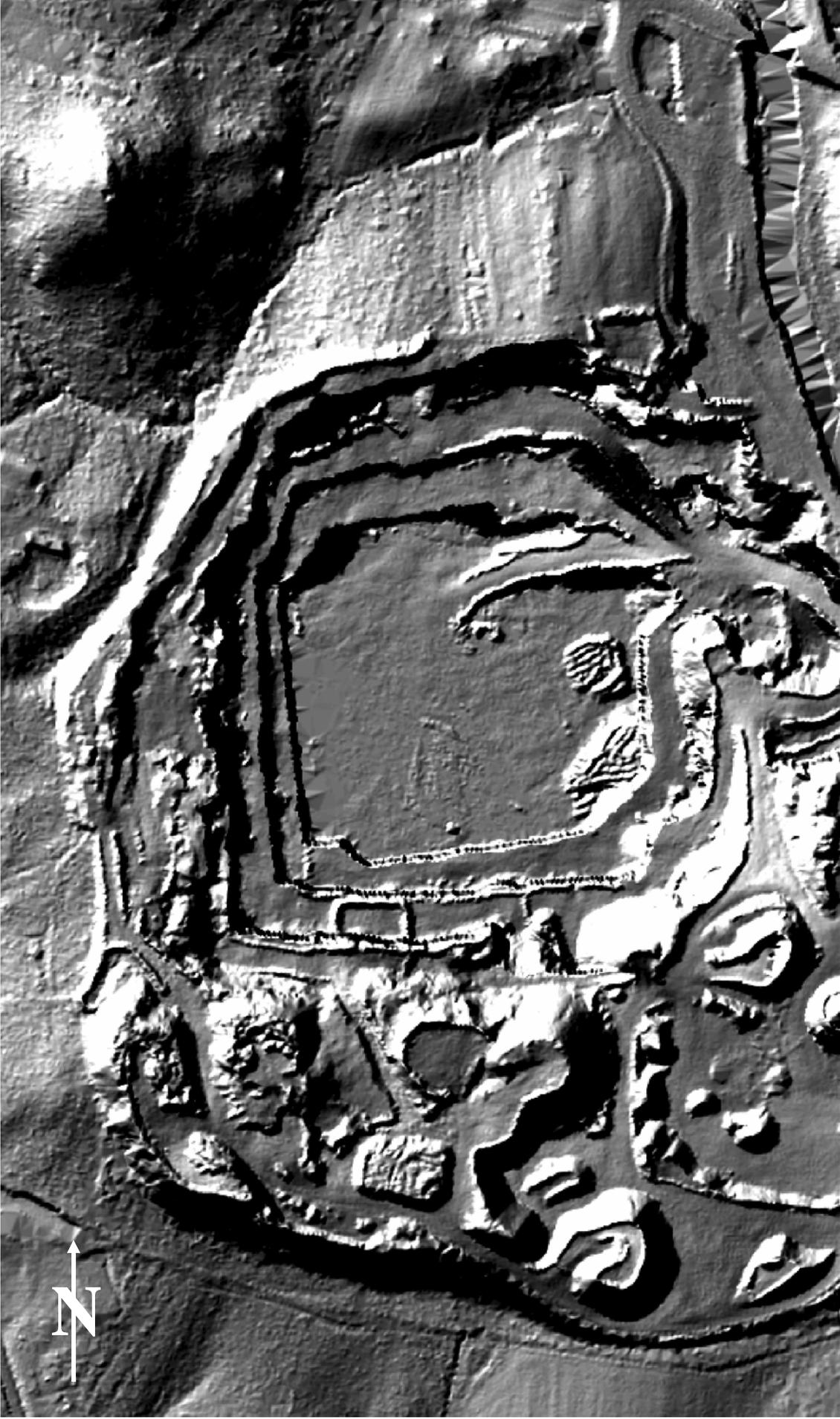
GEOLOGY OF THE GETTYSBURG MESOZOIC BASIN AND MILITARY GEOLOGY OF THE GETTYSBURG CAMPAIGN



73rd Field Conference of Pennsylvania Geologists

**September 25 – 27, 2008
Gettysburg, Pennsylvania**

**Hosts: Pennsylvania Geological Survey
Pennsylvania State University
Dickinson College
PADEP Bureau of Watershed
Management**



**Hillshade image of the Gettysburg Quarry (STOP 2) from DEM derived from LiDAR data. Sun angle is from the northwest.
Image created by Thomas G. Whitfield, Pennsylvania Geological Survey.**

Guidebook for the
73rd Annual Field Conference of Pennsylvania Geologists

**GEOLOGY OF THE GETTYSBURG MESOZOIC BASIN
AND
MILITARY GEOLOGY OF THE GETTYSBURG CAMPAIGN**

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September 25-27, 2008

Hosts: Pennsylvania Geological Survey, Pennsylvania State University, Dickinson College, PADEP Bureau of Watershed Management.

Headquarters: Wyndham Resort Hotel, Gettysburg, PA

Cover: The Confederate bombardment of the Union line from Seminary Ridge (STOP 15), prior to Pickett's Charge, overshoots Cemetery Ridge (STOP 16), and creates the Gettysburg Quarry (STOP 2). Concept by Gary Fleeger. Artwork by John Harper.

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Frontispiece. 2007 Field Conference of Pennsylvania Geologists group photograph in the Peachy Shale Pit (STOP 7), with the Reedsville Formation in the background. Photo by Yuriy Neboga.

DONALD T. HOFF
A MEMORIAL FOR DONALD T. HOFF
MINERALOGIST, EARTH SCIENTIST, CURATOR, AND FRIEND

Bob C. Smith, II and Bob Ganis

Donald T. Hoff of Harrisburg, Pennsylvania and native of Gettysburg, was the retired Earth Science curator for the William Penn Memorial Museum. During his lengthy tenure, he organized excellent mineral displays as well as an extensive and well-referenced collection of minerals from Pennsylvania. However, Don did not restrict his efforts to just mineralogy. He was also well known for the excavation, recovery, and display of a Pleistocene mammoth from a peat bog in Pike County and Triassic reptiles and giant amphibians in York County.

Don was especially interested the native copper and piemontite occurrences in the South Mountain region of Adams County and in uranium minerals from throughout Pennsylvania. Beyond Pennsylvania, he was interested in minerals from Bancroft and Cobalt, Ontario, the "north country" in general, and Franklin, New Jersey. He coauthored a report on copper and uranium minerals in Lycoming and Sullivan counties, Pennsylvania, with Bob Smith that was published by the Pennsylvania Geological Survey. When funding for batteries for his Geiger counter or ultraviolet light were slow in coming, Don was known to have a guard clean out the Carboniferous swamp exhibit in the Hall of Geology and use the coins so retrieved to purchase research supplies. Also with Smith, Don wrote up some articles on Mesozoic copper occurrences in Adams County. Don was widely recognized as the regional guru on such deposits and helped Bob Smith and Sam Berkheiser write them up on a state-wide basis for the U.S. Geological Survey, Smith having been asked by friends at the U.S.G.S., Al Froelich and Dave Gottfried, to do such for a USGS circular. Sam Berkheiser, Don, and Bob proceeded to sample, analyze and write up the occurrences with great haste. At first, Bob was a little disillusioned with a letter that he received from an editor at the USGS that their format wasn't quite what the USGS was used to in its flagship Bulletin series. It seems that Al and Dave's project had escalated a bit, but with editing help from John Barnes of the Pennsylvania Survey and Art Rose of Penn State the report was accepted into the U.S. Geological Survey Bulletin Series with no less than the auspicious number of 1776! Don also wrote the chapter on mineral resources, such as talc, serpentine, asbestos, feldspar, graphite, corundum, mica, vermiculite, beryl, barite, phosphate, rock salt, metabasalt, and gemstones for the Survey's definitive volume "The Geology of Pennsylvania." Don probably most enjoyed writing his article on the Teeter Quarry, Gettysburg, published by Rocks and Minerals. He was one of the first to recognize a small copper-rich zone akin to a Cornwall-type deposit complete with microscopic trace native gold-electrum. As far as is known, Don is the first person to have ever recognized such in bedrock in the Commonwealth, a fitting tribute to his powers of observation.

Don did everything he could to support the interests of rock, mineral, and fossil collectors in Pennsylvania. Doing so, he was careful to build on the work of his predecessor at the William Penn Museum, Johnny Whitoff. Don, however, had little truck for pretensions. Thus, when the name of the museum was changed to "The State Museum of Pennsylvania," Don only went along with the change when absolutely required and was not above referring to the institution, with great respect, to the administration and coworkers in other sciences and the arts, as simply the "Willy Penn" museum. In the mid-1970's Don completed his monumental "Hall of Geology" at the Willy Penn, a lasting tribute to his enormous range of geologic interests. Many young collectors and geologists owe their start to Don. Bob Ganis credits Don with restarting his career in geology after a tour in Vietnam. Don gave Bob a summer job helping to excavate Triassic reptiles along Little Conowingo Creek. Their time spent excavating and preserving was the beginning of a long and treasured friendship. It

was through the generosity and help of Don that Professor Emily Giffin Buchholtz, Wellesley College, jump started her paleontological career at the Willy Penn. There are countless others that thank Don for his assistance and tireless enthusiasm for all things geologic.

Don was a very active member of the Harrisburg Area Geological Society, also known as HAGS. He helped arrange meeting facilities for them at the museum for many years. He was also instrumental in helping to organize their geological megatrips to Iceland and the Grand Canyon. As long as health permitted, Don attended the annual Field Conference of Pennsylvania Geologists. He was one of the major contributors to the “43th” Field Conference as researcher, writer, and leader.

Don was a geology graduate of Waynesburg College, Pennsylvania, but his interest in mineralogy had begun earlier with collecting in Pennsylvania and Ontario in the company of family. Whether at Waynesburg College or self taught, Don was an expert with qualitative tests used in mineral identifications. When he brought an unknown mineral to the Pennsylvania Survey for positive identification by X-ray powder diffraction, he typically already knew that it contained Ni, Ca, or whatever. His visual identifications of most minerals were already correct and those for rare minerals typically on the right track for cations and anions.

Don was an enthusiastic story teller and tended to attract an expanding audience once a saga had begun. Working with Bob Smith on the Sonestown Picture Rocks Cu-U project, breakfast was always enjoyed in the partly converted front living room of an elderly woman they referred to as “Ma.” Once Don began a story, the rest of the patrons hushed one another so they could all hear. One morning, this particularly impressed Bob as they had just hushed their own discussion about a current Mideast war to hear about a local beehive being knocked over by a bear to immediately hushing themselves again to hear what Don would have to say! Don was always careful about the crowd he fraternized. Once when a local sorority had a dinner meeting at the only available place in reasonable distance for Don and Bob to have an evening meal, and having dispensed with the secret password and oath because of our presence, the ladies came over and asked us to stay for their dance lessons. As soon as they were out of earshot, Don uncharacteristically whispered “Eat fast, Bob, we’ve got to get out of here.” Don’s enthusiastic focus wasn’t without its dangers. Once while pouring over an inaccurate topographic map on the hood of a Jeep CJ-5, Bob S. had to point out to him that: “Don, you know I don’t believe in horseplay. ... You are standing on a *small* rattlesnake. ... Please stay still until I can get my hammer out.” In addition to geological expeditions, stories might wax poetic on the high quality of the olive oil on potato salad in Spain where he had toured with a group of singers or the problems encountered dealing with immense quantities of peach fuzz from commercial orchards in Adams County. Don also liked the sounds of certain complex words. He would use them, listen to the sound he had just made, and beam with a smile. His enthusiasm in his field studies for the Museum was contagious and typically resulted in remarkable cooperation. One landowner gave up their collection of dinosaur footprints in their home patio for the museum as a result of him simply chatting while making a purchase of cider at a roadside stand. On another occasion, he extolled the Willy Penn at a stand where he bought a lowly hot dog. The owner invited Don to pan for gold on his property in Canada, which Don did with moderate success. On a few occasions, the extent of cooperation resulting from Don’s being an ambassador for the Willy Penn surprised even Don.

Don thought an exhibit of gold at the State Museum would help draw youth and be of interest to mineral collectors. Even he was surprised when the Royal Ontario Museum sent their “loaner” samples in an armored car. The U.S. National Park Service couldn’t resist Don’s enthusiasm for the gold exhibit either. They granted him and two field assistants a one-day permit to dig gold and artifacts for the exhibit at a property near Washington, D.C. The crew found some well used fire assay crucibles, a lot of contaminant mercury, but little gold at the expected spot. Fortunately a 4’ x

½' trickle nearby yielded enough fine placer gold. Don was almost fanatical about accurately documenting samples and expeditions. When a later book by others claimed to have some photos of gold panning in Pennsylvania, he was able to provide *triplicate*, fully labeled color slides proving the site was really near Washington, D.C.. Don always seemed happy when discovering something new, but would become happier still when sharing the specimens or data with other institutions and researchers.



Don Hoff and mastodon femur in 1968. Photograph courtesy of The State Museum of Pennsylvania (Pennsylvania Historical and Museum Commission).

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- South Mountain Fairgrounds for permission to park the buses while at STOP 7.
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- Pat Bowling for his overall help in preparing for the Field Conference. As a local resident, he spent a considerable amount of his own time tracking down landowners, government officials, doughnut shops, potential lunch providers, etc., and making suggestions to make the Field Conference better.
- Bill Bragonier, outstanding Secretary of the Field Conference, did a lot of sweating and lost some sleep trying to work out all of the necessary details of the Field Conference. You'd be surprised how much is involved in putting one of these conferences together.

There are undoubtedly others who have been omitted, and we apologize for these omissions.

Last of all, and definitely least of all, NO thanks are due to CSX Corporation for refusing us permission to access their railroad rights-of-way at STOPS 1A, 13, and 14!

The Gettysburg Basin

Rodger T. Faill

The Gettysburg basin, laying underfoot this year's Field Conference, is a present-day remnant of a much larger basin that formed and filled during the early Mesozoic. It was deformed near the end of the early Jurassic.

The Gettysburg remnant and three other remnants (Newark, Culpeper, and Barbourville) lie along a sinuous track extending from central Virginia across central Maryland, southeastern Pennsylvania, and central New Jersey to southern New York (Figure 1). They are connected (Newark and Gettysburg) or nearly connected (separated by gaps of less than 2 km). They are remnants because they are deformed (tilted, faulted, and folded) and extensively eroded. However, together they were parts of a much larger early Mesozoic depositional basin termed the Birdsboro basin (Faill, 2003). The Birdsboro basin formed early in the late Triassic as a sinuous trough (Figure 2) and accumulated sediment for the next 30 million years, into the early Jurassic. Late in the early Jurassic, as Pangea began splitting to form the Atlantic Ocean, the Birdsboro basin was tilted, faulted, and locally folded as part of the crustal rebound in the newly formed ocean margins.

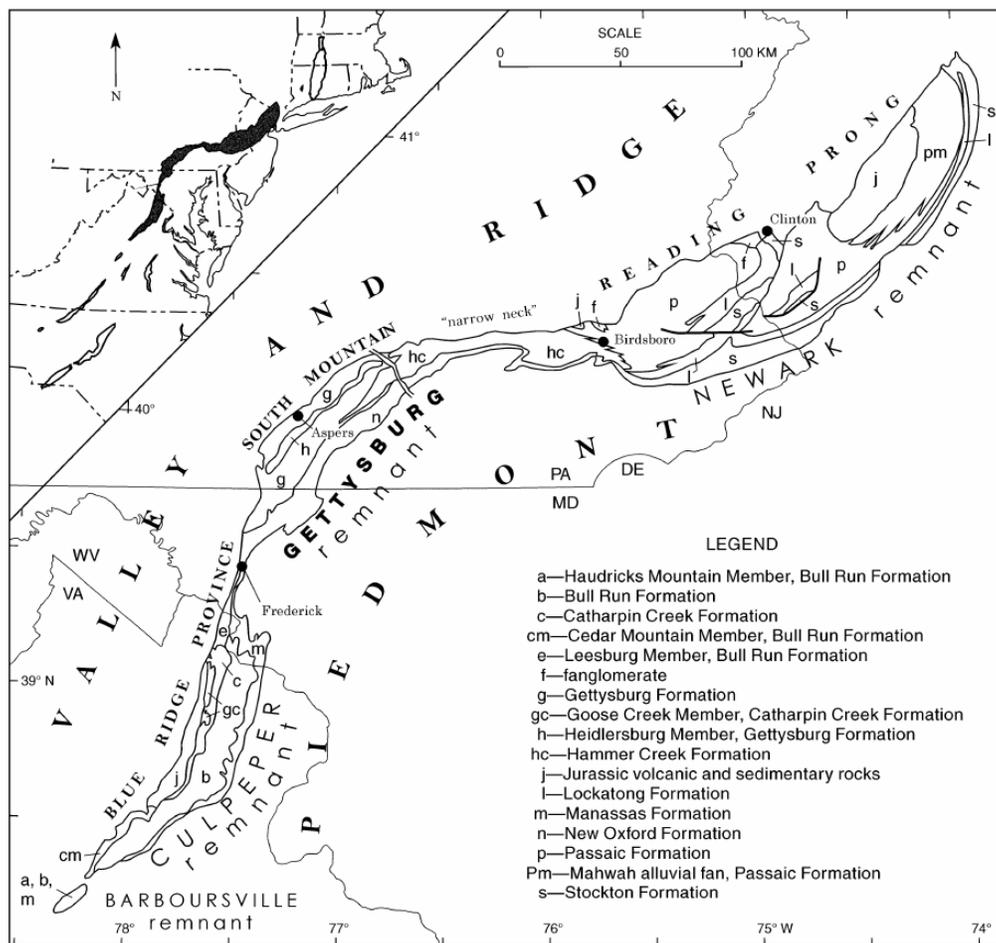


Figure 1. Map of the Mesozoic basin remnants (Barbourville, Culpeper, Gettysburg, and Newark) and surrounding geologic provinces, Mid-Atlantic region, eastern North America. Index map: outline--presently exposed early Mesozoic basin remnants in eastern U. S.; shaded--remnants of the Birdsboro basin.

Faill, Rodger T (2008), The Gettysburg basin, *in* Fleegeer, G.M (ed.), *Geology of the Gettysburg Mesozoic Basin and Military Geology of the Gettysburg Campaign, 73rd Annual Field Conference of Pennsylvania Geologists*, Gettysburg, PA, p. 1 – 7.

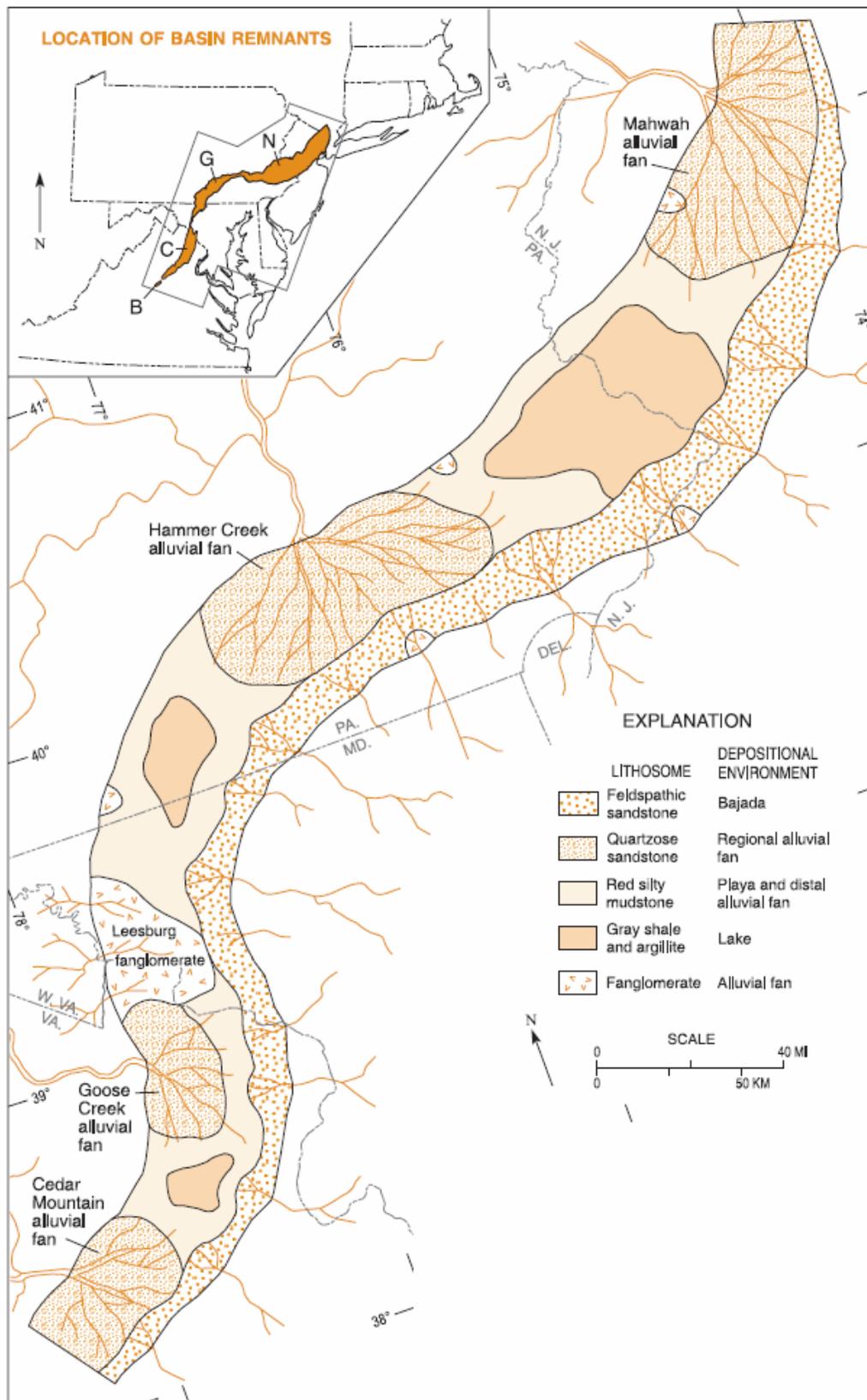


Figure 2. Map of the Birdsboro basin in the central Atlantic region of eastern North America at in the early Jurassic, showing schematically the drainage into, and the depositional environments within, the basin. The four present-day basin remnants are indicated in the inset map: B, Barboursville; C, Culpeper; G, Gettysburg; and N, Newark.

The Himalayan-like mountain range formed by the Permian Alleghany orogeny (Central Pangean Mountains) had been extensively eroded during the 30 +/- million years before the beginning of the late Triassic. Even so, the elevations in the mid-Atlantic region was probably still some 2 to 4 kilometers (possibly more)—yet the local relief was subdued, on the order of tens to 100 or even 300 hundred meters (as in the Andean Altiplano). The regional slope was to the northwest in that the orogenic core lay southeast of here, in the middle of Pangean supercontinent. Thus, the drainage from the interior highlands carried sediment northwestward across southeastern Pennsylvania.

The Birdsboro basin initiated early in the late Triassic as a northeast-trending sinuous downwarp—faults were not present along its margins at this time. The consequence of the downwarp was to trap the northwestward moving sediment in this new basin, a pattern that continued throughout the late Triassic, and possibly into the early Jurassic (Figure 3). Thus, most of the early sediment had a southeast provenance, and it spread across much of the basin. The lateral lithic constancy of these sediments indicate that the sediment entered the basin through many small to medium streams, forming a gently sloping plain of coalesced alluvial fans, a *bajada*. Along the northwest margin, the relief was low, just enough to prevent the sediment from passing through, thereby creating a closed system (Smoot, 1985). Sediment input from the northwest was minimal.

EARLY JURASSIC

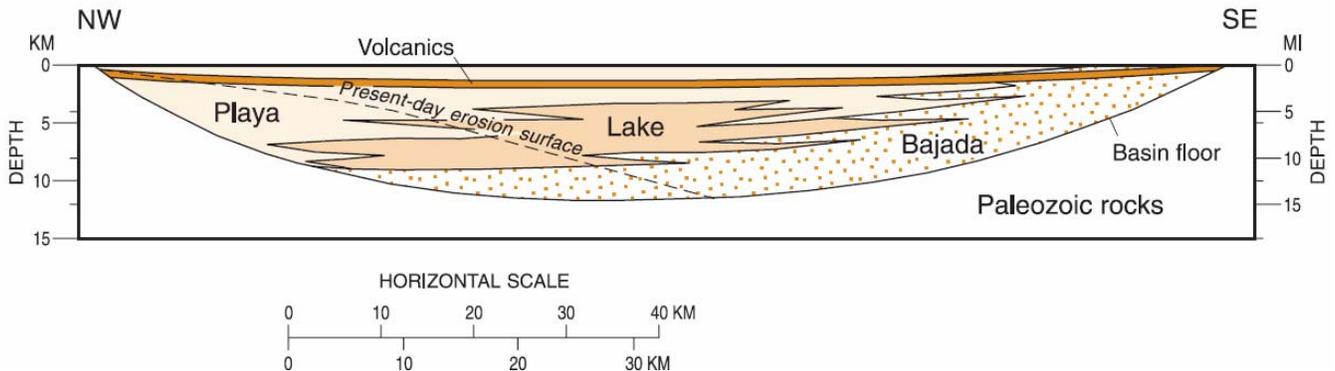


Figure 3. Cross section along the Delaware River through the Birdsboro basin in the early Jurassic, showing the downwarp nature of the basin, and the amount of the basin that has since been removed by erosion. A comparable section through the Gettysburg subbasin would differ only slightly in the arrangement of the depositional environments.

With time, the downwarp continued, thereby enlarging and deepening the basin. Sediment continued to enter from the southeast, but the deepening of the basin resulted in the relative rise (retarded descent, in effect) of the areas northwest of the basin. By becoming elevated, these northwest areas gradually became sources of sediment. Initially, the volumes were small and sediment rather fine-grained. With time, the northwest drainage areas enlarged, yielding larger volumes of sediment. However, there was a difference in sediment input between the two sides (northwest and southeast). During the pre-basin drainage, stream order increased down slope—the streams became larger and fewer as they merged into rivers. As the drainage on the northwest side reversed, these larger valleys were utilized, concentrating the sediment into a few rivers. Consequently, the incoming sediment built enormous fluvial deltas at the mouths of these few rivers (Figure 2). In short, the difference in sediment input pattern, distributed versus discrete, resulted from the pre-existing middle Triassic drainage pattern.

The concentration of northwest sediment input in four separate river systems left much of the rest of the northwest basin margin without direct input. The only local input were small debris flows that produced the margin fanglomerates. Consequently, the finer-grained sediment winnowed from the deltas flowed axially to these inter-delta areas. Additionally, the increasing basin size left the low-

elevation basin centers with less and less detrital material from either side. Under the prevailing arid climate, evaporitic minerals pervaded the mud and carbonate deposits of these basin-center lakes.

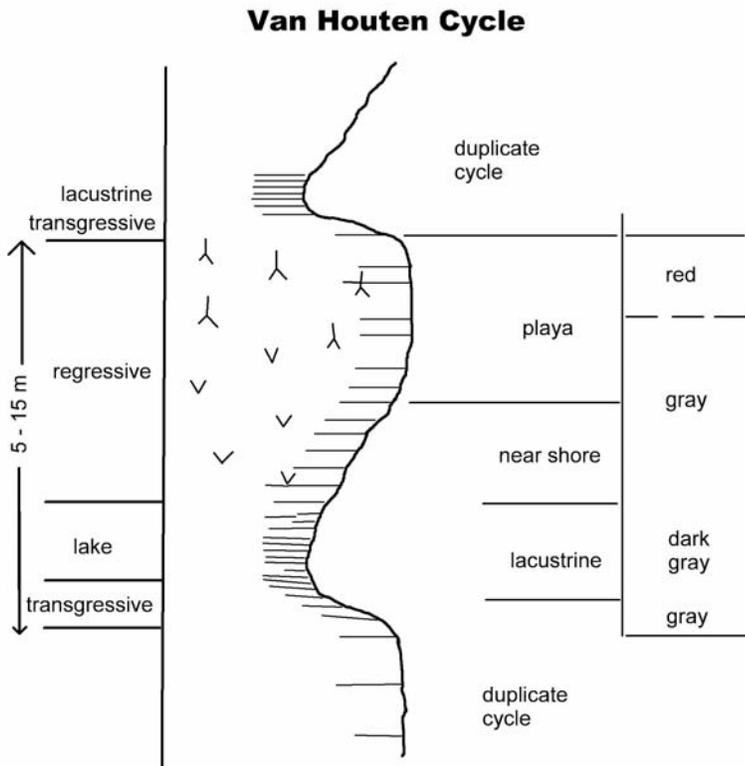


Figure 4. A generalized depiction of a Van Houten cycle. See text for discussion.

The Birdsboro basin must have been rather quiet tectonically because individual lacustrine gray argillite units can be traced for 100 km or more, with no abrupt changes in their thicknesses. This implies an extremely low-energy environment across the basin in which subtle astronomically-induced climatic changes are reflected in a cyclicity in the deposits. The fundamental wet-dry cycle, termed a Van Houten cycle (Van Houten, 1962, 1969; Olsen, 1986), consists of lacustrine, deep-water muds (argillites) overlain by shallow-water (shoreline) and subaerial (mudflat and playa) deposits (Figure 4). They vary in thickness from 5 to 15 meters. These transgressive-regressive cycles vary in time, and especially in place, depending on the orbital periodicities and available sediment (which is dependent on location within the basin). This cyclicity pervades a major portion of the sediment content of the Birdsboro basin, absent only in the higher-energy bajada and delta environments where fluvial processes

dominated.

The interplay of sediment input and basin geometry resulted in a rather complex lithic distribution throughout the basin. The subsequent deformation (tilting of the basin late in the early Jurassic) has left us a restricted perspective (the present earth's surface), a single slice, beveled through the basin deposits, from the oldest on the southeast to the youngest on the northwest. Much of the northwestern part of the Birdsboro basin remains below the surface. Perhaps even more of the original basin, especially the upper central and most of the southeastern parts, has been lost to erosion. The natures of these lost parts can only be inferred. Despite this biased view, partially alleviated by a few distinctive exposures and by limited drilling, stratigraphic sequences have been created for each subbasin, and these bear remarkable similarities to one another (Figure 5). In general, the lowest formation contains sediment from the southeast, the middle formation has the sediment-starved central basin deposits, and the upper formation consists of axially transported sediment.

The stratigraphy in the Gettysburg subbasin is not tripartite—it consists of only two formations (Figure 5). The sediment of southeastern provenance fills the lower unit, the New Oxford Formation. The overlying Gettysburg Formation is dominated by axially-derived sediment. Curiously, the sediment-starved basin-center deposits do not occur above the New Oxford Formation—rather, they, the Heidlersburg Member, occupy the middle of the Gettysburg Formation. The contrast with the standard tripartite pattern (as exemplified by the stratigraphy of the Newark subbasin) reflects differences in sediment filling in this subbasin from that of adjacent subbasins. The poorer development of the basin-center deposits, and their presence higher in the stratigraphic section, may reflect a greater amount of

detrital sediment, a smaller basin, or simply a different pattern of sediment distribution. Regardless, the climate-induced cyclicity so well developed in the Newark subs basin pervades much of the Gettysburg subs basin as well.

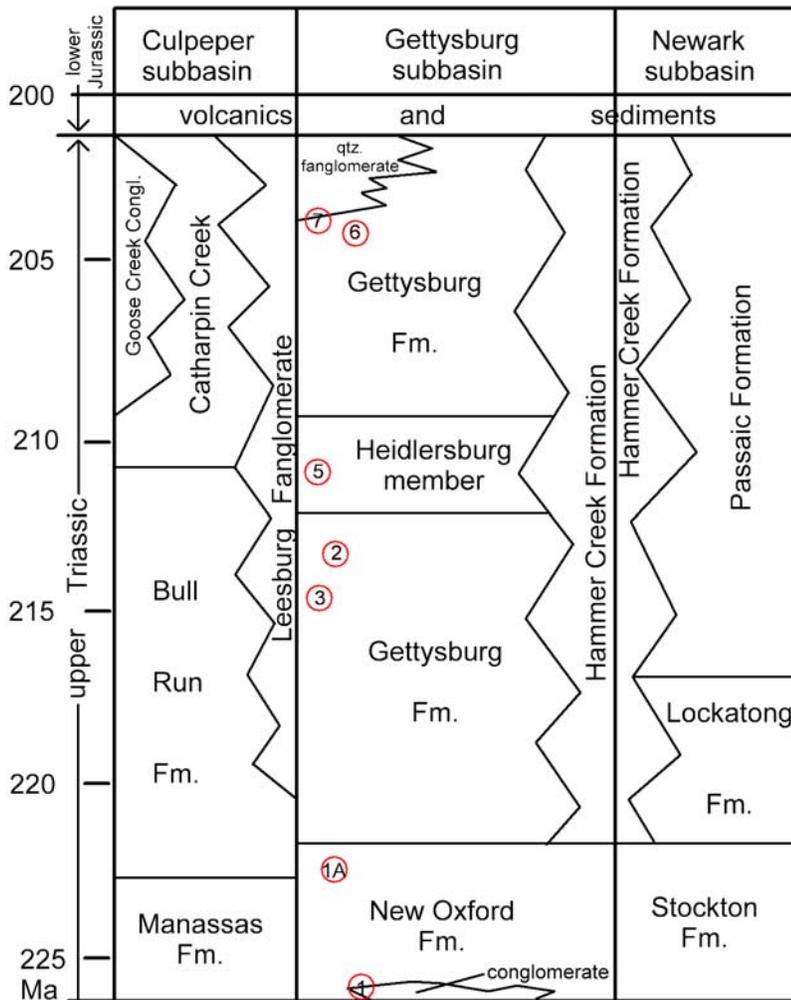


Figure 5. Comparative stratigraphies of the Culpeper, Gettysburg, and Newark subs basins. The numbers refer to the Conference Stops and their approximate position in the Gettysburg subs basin stratigraphy.

several kilometers) to accommodate the Mesozoic rocks. This has implications on the orientations of pre-Mesozoic structures (thrust faults, nappes, and foliations) in the rocks adjacent to the basin.

Two exceptions to the basin adjacency of carbonate rocks are worth noting. Along the southeast margin, the Pigeon Hills (east of Gettysburg) and the Hellam Hills (just west of the Susquehanna River) are underlain by late Neoproterozoic and earliest Cambrian basalts and overlying quartzose sandstones. Apparently, these are domes along crest of the Blue Ridge anticlinorium that lies southeast of the subs basin here. The overlying lower Paleozoic carbonates were eroded prior to the late Triassic, and the basal Triassic rocks (New Oxford Formation) overlap the basalts and sandstones.

The other exception is South Mountain along the northwest margin of the Gettysburg subs basin. The South Mountain anticline (the Pennsylvania variety, MacLachlan, 1991) is the southeasternmost anticline in the Valley and Ridge province. Structurally, it is enormous, possessing several times the structural relief of the other Valley and Ridge anticlines. In addition, the entire Paleozoic sequence (up

The geology and topography of this area at the beginning of the late Triassic is another aspect that has received little attention. Very little of the basin floor is exposed (only along the non-faulted margins and in the inliers) but some indication of what lies under the basin can be surmised from both the surrounding geology and the local fanglomerates. Lower Paleozoic carbonate rocks lie along much of the Gettysburg subs basin southeast margin (from Frederick, Maryland to Morgantown, Pennsylvania). Carbonate rocks also underlie the northwest margin east of the Susquehanna River (and for 20 km west of the river) and are present in the two inliers. The most reasonable implication is that much of the basin floor consists of lower Paleozoic carbonates. The similarity of clasts in limestone fanglomerates along the margins to the bedrock outside the basin indicates that little or no faulting occurred along these margins. The little to moderate sinuosity of these overlap contacts points to a relatively low relief on the pre-basin topography. It is also worth remembering that the pre-basin topography sloped regionally to the northwest, but that now it is bowed greatly downward (by at least

to 12-15 km thick) overlay its Neoproterozoic Catoctin Formation core. With such a thick section, it must have formed a huge, elongate dome-like mountain in the late stages of the Permian Alleghany orogeny. The erosion of this monadnock must have been rapid, but, by the end of the late Triassic, it was still mantled by the lowest Paleozoic quartzose sandstones (Weverton, Harpers and Montalto, and Antietam Formations) and thus was still an elongate monadnock. It was a marked contrast to the low to moderate relief of the surrounding carbonate terrain. Although it probably yielded comparatively little sediment to the basin, its presence significantly affected sediment distribution within the basin.

It is worth noting that the Blue Ridge (South Mountain of Maryland and Virginia) is quite different from the Pennsylvania South Mountain. Both are cored with Catoctin Formation metagneous rocks (and older crustal rocks in the former), overlain by the same Chilhowee sequence of mostly quartzose sandstone. But they come from different areas. The Blue Ridge South Mountain is part of an accreted terrane that was thrust against the Valley and Ridge late in the Alleghany orogeny. The Pennsylvania South Mountain was a slightly earlier structure that originated above Laurentian crust. This contrast is reflected in the metagneous rocks of the Catoctin Formations (personal communication, Smith, R. C., II, 2006). The Catoctin magma under the Blue Ridge South Mountain did not pass through continental crustal rocks and thus most of the formation consists of metabasalts. In contrast, the Catoctin magma of the Pennsylvania South Mountain did pass through continental rocks, melting considerable quantities of it. That Catoctin contains significant quantities of metarhyolite in addition to the metabasalt.

Thus far in the description of the Gettysburg subbasin, no mention has been made of faulting. The reason is simple—faulting had no role in the first 30-million-year history of the Birdsboro basin. Although the present-day Gettysburg subbasin may have some characteristics of a half graben (monoclinal dip of bedding toward a border fault), several lines of evidence indicate that the Birdsboro basin was not a graben or a rift. First, the correspondence of fanglomerate clasts with the adjacent pre-Triassic rocks, on both the northwest as well as the southeast margins, indicate that little or no displacement has occurred along those margins. Second, the presence of inliers along the northwest margin exposing basin floor rocks contradicts the standard half-graben model, which requires those basin floor rocks to lie some 5 to 7 kilometers below the surface. Third, fanglomerates are not sufficient evidence of faulting along the margin. Fanglomerates with identical lithologies, fabrics, and depositional textures lie along the southeast margin, an overlap contact. Fourth, the age of the faulting—evidence indicates that the margin (and within basin) faulting was post-depositional. Splays from the Ramapo fault (“border” fault in New Jersey) die out and terminate in early Jurassic rocks. Lacustrine cycles and Jurassic basalt flows are unchanged across fault offsets. Some 2 to 3 km of displacement occurred along the Hartford (Connecticut) basin “border” fault in the early Cretaceous (Roden-Tice and Wintsch, 2002). Fifth, no specific feature in the Birdsboro basin requires a syndepositional fault for its origin. Sixth, basalt clasts in early Jurassic fanglomerates (in the Newark subbasin in New Jersey) indicate that the basalt flowed unhindered out of the basin. Seventh, if steeply dipping faults were present at the end of the Triassic, why did the rising tholeiitic magma break country rock to form vertical dikes if nearby faults (under extensile stress) were available? The faults are not intruded by magma.

The rift/half graben model is attractive because of its simplicity and apparent plausibility. However, the half-graben model is inconsistent with so many of the geologic features of the Birdsboro basin and its present-day remnants that its credibility is unwarranted. If the faulting was post-depositional, as all the evidence suggests, then a non-faulting model is far more appropriate for the Birdsboro basin. Subsequent faulting does not give the basin *post hoc* a half-graben origin.

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The author is indebted to Robert C. Smith, II, John H. Barnes, William D. Sevon, and Gary M. Fleeger for the many discussions of the geology of the Gettysburg subbasin in particular, and more general geologic aspects of this area helped immeasurably with the development of many of the included thoughts and ideas. The author thanks each of them for the reviews and suggestions of early drafts of this paper, and of each of the Stop descriptions. The logistic arrangements including permissions, traffic control, and numerous other necessary services provided by William Bragonier and Gary M. Fleeger are greatly appreciated.

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A BRIEF OVERVIEW OF THE HYDROLOGY OF ADAMS COUNTY

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Introduction

Welcome to historic Gettysburg and scenic Adams County! Occupying 522 square miles on the southern tier of southcentral Pennsylvania, Adams County was established as the 26th county of the Commonwealth of Pennsylvania in 1800 when it was split off from neighboring York County due to geographic, economic and cultural differences. During the Civil War in 1863, the quiet town of Gettysburg was the site of the largest battle ever fought in the Western Hemisphere with over 51,000 total casualties on both sides. Although Gettysburg was a small town during the battle, all major roads in the area radiated from it like the spokes of a wheel. It's probably not unrealistic to think Gettysburg would be vastly different now had the battle not taken place here.

Although Gettysburg draws over two million visitors each year to the battlefield and other area attractions, Adams County is still largely a rural area with a substantial agricultural industry. In addition to dairy, poultry and field crop production, the county is one of the top fruit producing and processing areas in the nation. Also, large tracts of land on South Mountain along the western margin of the county are within Michaux State Forest. Over the last few years, Adams County has been experiencing significant growth because of its quaint rural character, relatively affordable land and housing, and proximity to Baltimore and Washington (55 and 79 miles, respectively, from Gettysburg). Consequently, Adams is one of the fastest growing counties in the Commonwealth according to the Census Bureau. The Adams County Office of Planning and Development estimates the 2007 county population at 103,750, a 14% increase since 2000. Development pressure on southern Pennsylvania is expected to increase because of building moratoriums in Maryland border counties along with an anticipated population shift from the addition of tens of thousands of new defense industry and other jobs in northern Maryland related to the military's Base Realignment and Closure process. Additionally, Pennsylvania does not tax pension income, so Adams County communities are an attractive place for retirees who enjoy both the rural character and proximity to urban areas.

Given the increasing population and expanding development, there is keen interest in local efforts to preserve the rural nature of Adams County in part because of concerns over the area's water resources which are limited chiefly by physical constraints. There is a collective concern over water resources throughout Adams County as water suppliers, industry, growing communities, new developments, agricultural operations, fruit growers and processors, commercial operations and rural homeowners are among those competing for water resources in an area of occasional droughts, geologically-limited ground water and minimal potential for surface-water utilization.

Geologic Setting

Adams County lies within two major physiographic provinces. The Valley and Ridge Physiographic Province occupies the western and northwestern part of the county. The rest of the county, which includes the major population centers, is in the Piedmont Physiographic Province. Figure 1 shows the physiography and generalized geology of Adams County.

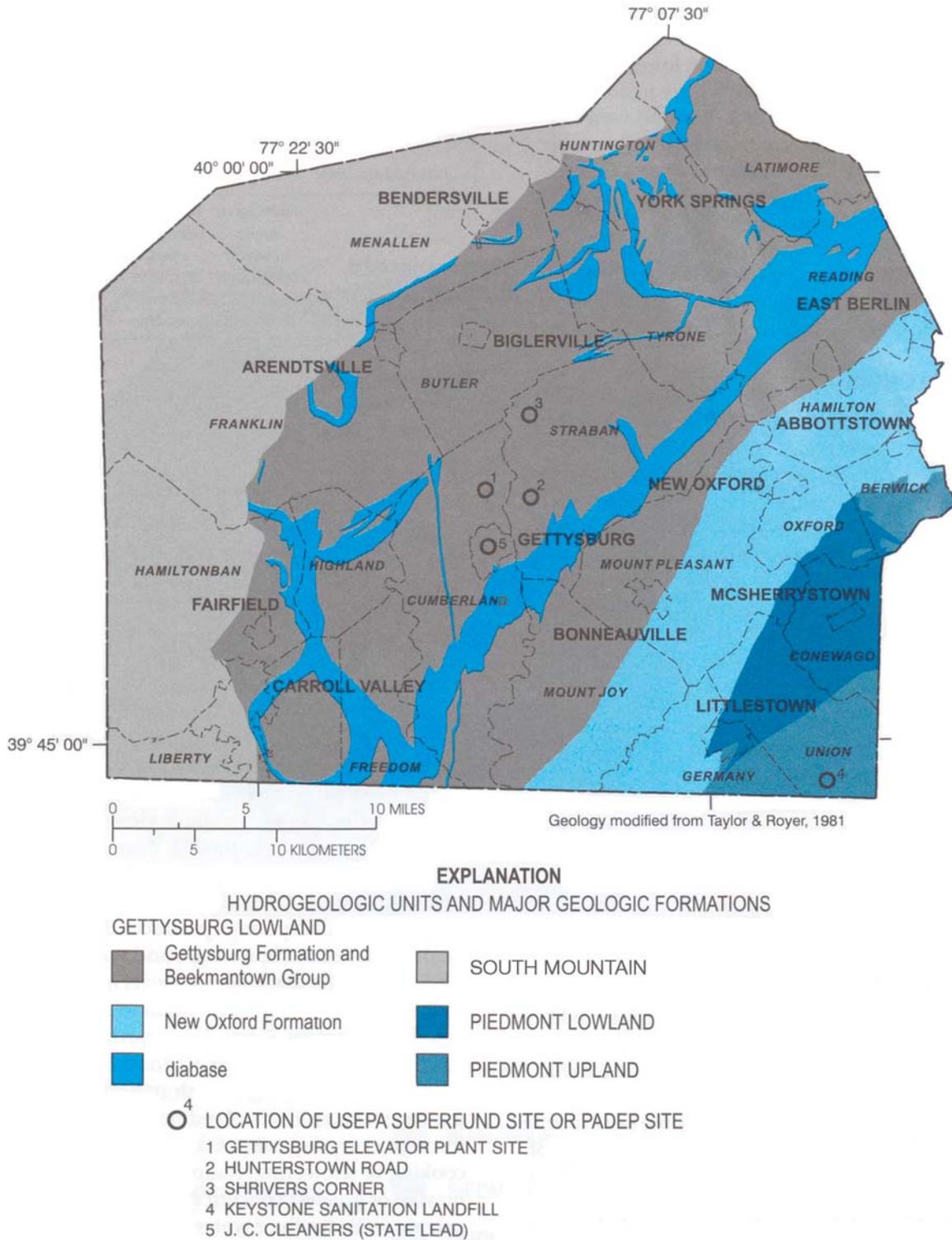


Figure 1. Generalized physiography and geology of Adams County. Hydrogeologic units are equivalent to physiographic units. The locations of significant ground-water contamination sites are also depicted (modified from Low and Dugas, 1999).

About a quarter of the county lies in the South Mountain Section of the Ridge and Valley Province using the physiography of Sevon (2000). As the northernmost extension of the famous Blue Ridge Mountains, South Mountain was formerly considered to be part of the Blue Ridge Physiographic Province and that classification may still be employed in hydrogeologic studies of the area (Low and Conger, 2002; Low, Hippe and Yannacci, 2002). South Mountain consists of linear subparallel ridges dissected by deep valleys and contains some of the oldest rocks in the county. The area is underlain by Precambrian metavolcanic and early Cambrian clastic sedimentary rocks that have been folded into an anticlinorium. A few east-west trending transverse faults and several northeast trending longitudinal faults are present (Fauth, 1978). The combination of climate, topography and well-drained soils within South Mountain makes the area ideal for fruit orchards.

East of South Mountain, over half of the county lies within the Gettysburg-Newark Lowland Section of the Piedmont Province which is characterized by gently rolling topography with broad valleys and low hills. The area consists of a slightly tilted and faulted basin containing Triassic-Jurassic red-colored siliciclastic rocks intruded by Jurassic diabase, the youngest rock unit in the county. The diabase, which occurs as dikes, sills and irregular sheets, typically underlies hills and ridges as it is much more resistant than the softer sedimentary rocks (Taylor and Royer, 1981; Low, Hippe and Yannacci, 2002).

In the southeastern part of the county, the Piedmont Lowland Section occupies a broad valley extending from near Littlestown northeast to the Pigeon Hills. The area is underlain predominantly by complexly folded and faulted carbonate rocks of Cambrian-Ordovician age and karst features, particularly sinkholes, are common (Kochanov, 1995; Low and Dugas, 1999; Sevon, 2000). A large limestone quarry occurs in this belt just north of McSherrystown.

Adams County contains two small areas of the Piedmont Upland Section which occur to the north and south of the Piedmont Lowland. The Piedmont Upland areas are underlain by Precambrian to early Paleozoic resistant metamorphic rocks that form rolling hills and valleys. Rising about 500 feet above the lowland along the eastern edge of the county, the Pigeon Hills occur in the northern Upland area and contain metabasalt, slate and metaquartzite. The Upland area in the extreme southeastern corner of the county is comprised chiefly of metagraywacke and schist. Because of multiple deformational events, rocks in the Piedmont Upland are extremely complexly folded and faulted (Stose, 1932; Taylor and Royer, 1981; Low and Dugas, 1999; Sevon, 2000).

Surface-Water Hydrology

Broad, rolling hills and gentle valleys typify most of Adams County although pronounced ridges and deeper valleys occur along the western and northwestern margins. Elevations range from about 2,000 feet on South Mountain to under 400 feet in the southern part of the Gettysburg Basin. Drainage patterns are mostly dendritic although trellis patterns can be locally observed on the Mesozoic sedimentary rocks of the Gettysburg Basin. Adams County spans two major drainage basins, the Susquehanna and Potomac, which each drain about half the county (Figure 2).

The northern and eastern parts of the county ultimately drain to the Susquehanna River primarily via Conewago Creek which begins in Buchanan Valley within South Mountain and flows through "The Narrows", a water gap in the ridge, and winds eastward across the county. Opossum, Bermudian and South Branch Conewago Creeks are among the tributaries that eventually join Conewago Creek making it the largest stream in the county. (It should be noted that Conewago Creek in Adams County is sometimes referred to as West Conewago Creek to distinguish it from the Conewago Creek that heads in Lebanon County and flows west to join the Susquehanna below Three Mile Island.) Along the northern edge of the county, Mountain Creek starts in a deep valley and drains a small area before flowing

through Cumberland County into Yellow Breeches Creek which meets the Susquehanna River near New Cumberland.

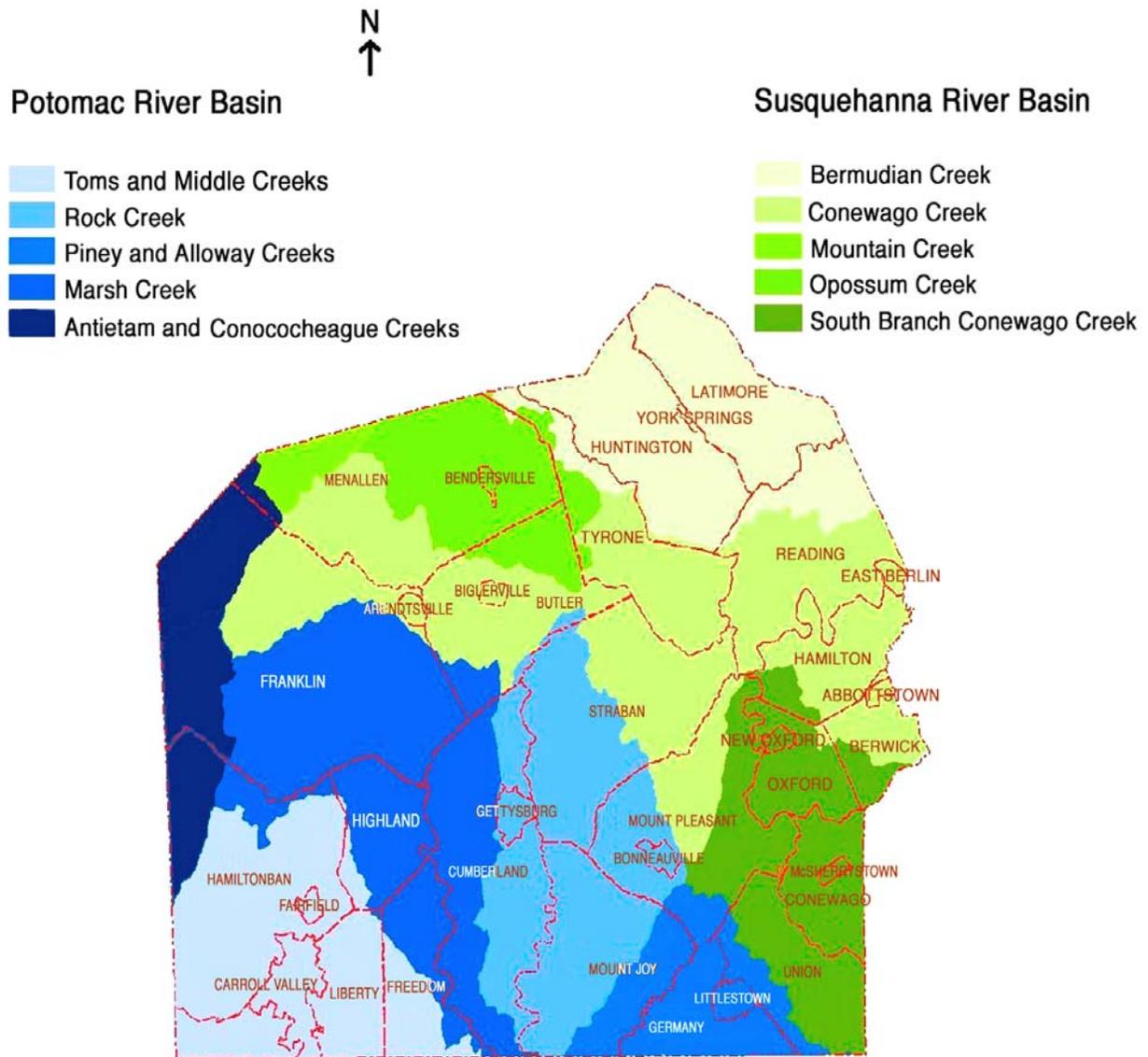


Figure 2. Drainage areas of Adams County (modified from Watershed Alliance of Adams County: <http://www.adamswatersheds.org/adamscounty.html>).

The southcentral and southwestern parts of the county, including the Gettysburg area, are drained by upper tributaries of the Monocacy River which joins the Potomac River south of Frederick, Maryland. The largest subbasin is Marsh Creek which heads in the mountains north of Cashtown and flows south. Rock Creek, the only large stream in the county to originate in the Gettysburg Basin, flows south past Gettysburg and joins Marsh Creek just below the Maryland border to form the Monocacy River. Toms and Middle Creeks both begin in the mountains northwest of Fairfield and drain the southwestern corner of the county before uniting in Maryland and flowing into the Monocacy. Alloway and Piney Creeks head north and east, respectively of Littlestown and flow to the southwest into Maryland where they both join the Monocacy at separate junctures. Conococheague Creek and East Branch Antietam Creek both start on South Mountain in the extreme western portion of Adams County and flow southwestward through Franklin County into Maryland before eventually winding their ways to the Potomac.

Adams County is a headwaters area as nearly all streams, none of which are exceptionally large, originate within the county and flow out of it. With the exception of the upper reaches of South Branch Conewago Creek and a few of its small tributaries along the extreme southeastern edge of the county, no streams flow into the county. Thus, the amount of streamflow entering the county is negligible for water budget purposes and the area is strongly dependent on precipitation that falls within it to replenish water resources. Precipitation varies across the county from around 40 inches annually in the lowlands to slightly more on South Mountain. For most of Adams County, precipitation is fairly uniform throughout the year except on South Mountain which receives slightly more in the summer than the winter (Taylor and Royer, 1981; Low and Dugas, 1999; Low, Hippe and Yannacci, 2002). Historically, streamflow throughout the county is low during the summer and some smaller streams are typically dry from summer through fall except during storm events (Speir, 1967; Becher, 1989). Over the last ten years, the Pennsylvania Department of Environmental Protection (PA DEP) has issued drought declarations for Adams County a total of 12 times with almost half of the instances involving the two most severe levels, drought warning (three times) and drought emergency (two times).

A generalized annual hydrologic budget for Adams County was developed by Taylor and Royer (1981) who used 39 inches as the average annual precipitation. Of those 39 inches, 24 inches is lost to evapotranspiration and surface runoff accounts for 8 inches which leaves about 7 inches for baseflow (ground-water recharge). Unfortunately, data are lacking to better define local water budgets and there are only two active USGS stream gages in Adams County. One is on Bermudian Creek near Heidlersburg (in cooperation with PA DEP) and the other is on Conewago Creek at East Berlin (in cooperation with the Watershed Alliance of Adams County).

The proximity to population centers and/or intensive agricultural operations are related to the water quality of streams. Impaired streams defined by the PA Department of Environmental Protection (PA DEP) include portions of South Branch Conewago Creek and some of its tributaries, some tributaries to Conewago Creek, certain reaches of Rock Creek and its tributaries and a few tributaries of Marsh Creek. Most of the impairment is from agriculture and urban/residential activities. Under Water Quality Standards promulgated by PA DEP, a few tributaries of Conococheague Creek are designated as Exceptional Value or High Quality. East Branch Antietam and Mountain Creeks are designated High Quality as well as the upper reaches of Middle, Toms and Conewago Creeks. As expected, the more pristine stream reaches are found in the mountains.

With limited potential for surface-water development coupled with the cost of filtering surface water, it is utilized by only 3 of the 37 community water systems in the county according to the Pennsylvania Drinking Water Information System maintained by PA DEP. With an intake on South Branch Conewago Creek, New Oxford Municipal Authority is the only system in Adams County to rely solely on surface water. Gettysburg Municipal Authority (GMA) has an intake on Marsh Creek (Figure 3) but is supplemented by several ground-water wells. Additionally, GMA uses two stream augmentation wells to maintain a required amount of flow in Marsh Creek below their intake for ecological reasons. Littlestown Borough Authority's only surface water source is actually an old quarry which is classified as surface water for regulatory purposes. The system relies primarily on several wells.



Figure 3. Marsh Creek, one of the drinking water sources used for Gettysburg's water supply.

Additionally, a few water systems located in neighboring counties have sources or storage facilities in Adams County. Within South Mountain, Chambersburg Borough Water Department has a reservoir and intake on Conococheague Creek. The South Mountain Restoration Center withdraws water from below a small reservoir on Carbaugh Run, a tributary to Conococheague Creek. Waynesboro Municipal Authority has a reservoir on the East Branch Antietam Creek near the Franklin County line. Two of the four surface-water sources used by Hanover Municipal Water Works are located in eastern Adams County. The system supplies water to Hanover Borough (York County) and some neighboring municipalities in York and Adams Counties. Hanover has one intake on South Branch Conewago Creek and another on a tributary, Slagle Run. Much of the flow in Slagle Run is from dewatering of the nearby Vulcan Materials limestone quarry.

Based on recent surface water withdrawal data submitted to PA DEP for the State Water Plan and Annual Water Supply Reports, about 4 billion gallons of surface water is withdrawn annually in Adams County for public water supplies. Most of this water is used by the water systems for Hanover and Chambersburg. Of the three Adams County-based public water systems that use surface water, Gettysburg Municipal Authority withdraws the most averaging slightly more than a million gallons per day. Surface water, including various farm ponds, is also used for irrigation, watering livestock, fruit processing and food production.

Ground-Water Hydrology

Physiographic settings are commonly used to represent major hydrogeologic units in an area because the similar topography, soils and geology within a setting also generally result in similar hydrologic properties. Figure 1 shows the four major hydrogeologic units in Adams County. The following brief discussion of the hydrogeologic units is taken largely from Taylor and Royer (1981), Low and Dugas (1999), and Low, Hippe and Yannacci (2002) unless otherwise noted.

South Mountain consists chiefly of the Precambrian Catoclin Formation (metarhyolite, metabasalt and greenstone schist) with subordinate amounts of graywacke, quartzite and phyllite of the early Cambrian Chilhowee Group. The rocks are fairly hard and dense with negligible primary porosity. Cooling joints, weathered zones, cleavage planes, lithologic contacts, faults and fractures provide some secondary openings for ground water in the rocks but well yields and transmissivity values can be very low (Low and Conger, 2002). Median well yields for domestic wells is 7 gallons per minute (gpm) and 18 gpm for nondomestic wells. Ground water generally occurs under unconfined conditions. Conceptually, the hydrogeologic setting is a heterogeneous fractured bedrock aquifer that may include an upper zone of regolith and weathered bedrock. Recharge in this terrane is estimated to range from 9

to 13 inches annually depending on whether it is a drought year or not (Low and Conger, 2002). One of two drought monitoring wells in Adams County is located in the South Mountain area. Ground water produced from these lithologic units is generally soft and potentially corrosive to plumbing.

The Gettysburg Lowland hydrogeologic unit is comprised of three major geologic formations, the New Oxford Formation, Gettysburg Formation and diabase. A small area of Ordovician limestone (Beekmantown Group) is included with this hydrogeologic unit but it is not significantly used for ground water and will not be discussed. The Triassic New Oxford Formation occurs in a northeast-trending belt on the eastern side of the Gettysburg Basin and is a 6,900 feet thick interbedded sequence of mostly red shale and sandstone with minor amounts of gray to white micaceous sandstone, arkose and conglomerate (Stose, 1932). The Triassic-Jurassic Gettysburg Formation consists predominantly of soft red shale interbedded with red sandstone and siltstone. The sequence also includes quartz conglomerate, limestone conglomerate, a hard light-colored sandstone (Heidlersburg Member), dark gray calcareous siltstone and green, gray and buff shale and sandstone. Although too small to map at the 1:24,000 scale, the dark calcareous beds appear to be on strike with many of the mapped springs in the area based on reconnaissance mapping (Tom Armstrong and Bill Burton, USGS, oral communication, November 1999). Figure 4 is a well log for a deep GMA well showing the variety of rock types encountered. The Gettysburg Formation is about twice as thick as the New Oxford Formation. The New Oxford and Gettysburg Formations are thought to roughly correlate with the Stockton and Brunswick Formations of southeastern Pennsylvania (Stose, 1932). Early Jurassic diabase dikes, sills and irregular sheets intrude the Gettysburg Formation. The dikes are generally less than 100 feet thick and the Gettysburg Sill, the main body of diabase crossing the county, is about 2,000 feet thick. The sedimentary rocks near the diabase contacts have been thermally metamorphosed into dense, reddish-purple to black hornfels. The diabase is a dark gray, hard, fine to coarse-grained crystalline rock composed of plagioclase feldspar, pyroxenes and accessory magnetite, ilmenite and apatite. The rocks of the Gettysburg Basin are tilted to the northwest and a fault runs along the northern border of the basin. By far, the greatest number of wells in Adams County is in the Gettysburg Lowland.

The siliciclastic rocks of the Gettysburg Basin constitute a complicated fractured bedrock aquifer. Primary porosity is minimal and most ground water occurs and moves along bedding planes, fractures and joints. Ground-water flow is complex, anisotropic and heterogeneous. Horizontal permeability greatly exceeds vertical permeability and hydraulic conductivity parallel to strike can be several times that perpendicular to strike. Individual beds may not be continuous because of diabase intrusions, faults, lateral gradations and lenticular thinning. The general hydrogeologic setting involves a heterogeneous multiaquifer system of dipping beds with differing hydrologic properties. A shallow weathered zone overlies and hydraulically communicates with a deeper bedrock zone. Ground water is unconfined or semiconfined but may become confined in the down dip direction in the bedrock zone. Recharge for this area is estimated to average about 6 inches annually. Well yields of up to several hundred gpm are possible although the yields will typically decline to about a third of their initial yield due to lower aquifer storage (Wood, 1980). In general, the well yields, probability of locating a single well that will provide adequate amounts of water and ambient ground-water quality are higher in the Gettysburg Formation than the New Oxford Formation. The other drought monitoring well for Adams County is located in the Gettysburg Basin. Water produced from the sedimentary rocks of the Gettysburg Basin is generally hard and deeper water bearing zones may have high total dissolved solids. Three US Environmental Protection Agency (EPA) Superfund sites and one state Hazardous Site Clean-Up Program site, which all involve contamination of ground water by volatile organic chemicals (VOC), are located within the Gettysburg Basin (Figure 1).

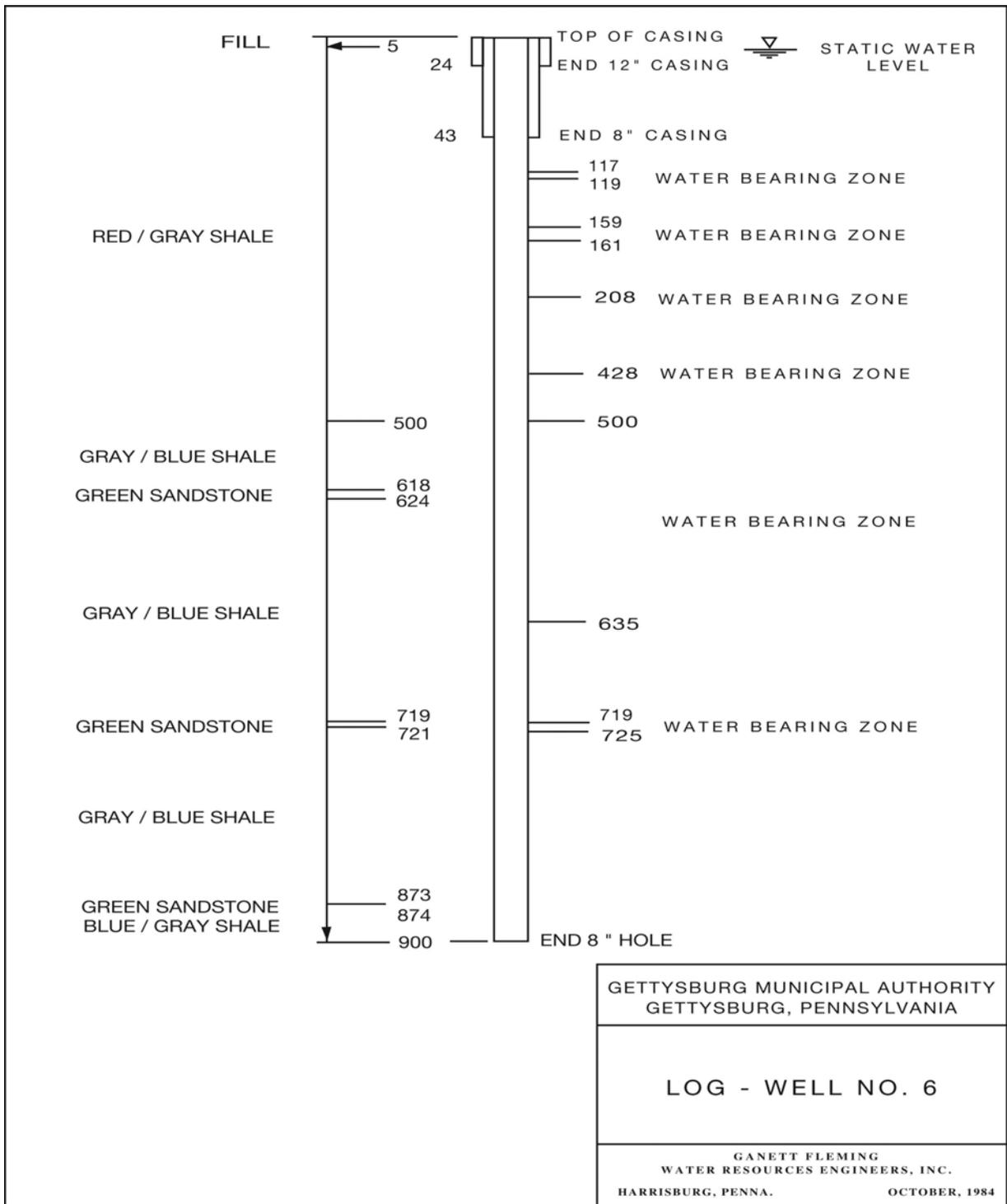


Figure 4. Well log for Gettysburg Municipal Authority Well #6 showing the rock types encountered and producing zones. The well is capable of producing 400,000 gallons per day but is generally pumped at less than half that rate. The discovery of contamination by dry cleaning solvents during well development in 1986 resulted in the first ground-water remediation project under Pennsylvania's Hazardous Site Clean-Up Program. A packed column air stripping tower is still used to treat the well (from PA DEP, 1997).

The massive, poorly fractured diabase is considered to be the worst aquifer in Pennsylvania. It may yield adequate amounts of water for domestic wells but supplemental storage may be required. Ground water within the diabase is generally hard and the overall quality is usually poor. Diabase dikes and sheets generally act as a barrier to ground-water flow.

Because of its small areal extent, the Piedmont Lowland hydrogeologic unit contains fewer wells than the Gettysburg Lowland or South Mountain. The Piedmont Lowland is comprised chiefly of limestone and dolomite with minor amounts of marble and shale representing the Vintage, Kinzers, Ledger and Conestoga Formations of Cambrian to Ordovician Age. Primary porosity is negligible in these rocks and ground water occurs in secondary openings such as bedding planes, faults, joints, fractures and solution openings. Karstification of the aquifer occurs where carbonate materials predominate over silicate material, recharge is acidic and water movement is rapid. Conceptually, the hydrogeologic setting is an anisotropic fractured bedrock aquifer with an upper zone of regolith and weathered bedrock. The upper zone is an important source of ground water to the less weathered bedrock below. Ground water generally occurs as unconfined to semiconfined conditions in the upper zone depending on how much clay is present. Relatively impermeable shale beds tend to act as confining layers in the bedrock zone. Median well yields are 8 gpm for domestic wells and 30 gpm for nondomestic wells. Average recharge estimates range from 6 inches annually for a drought year to about twice that for normal years. Although limited areally, the recharge rate of these rocks is twice that of the Gettysburg Basin and would seem to have potential for future ground-water development. However, Hanover has tested some wells in the carbonates and pumping during the 2002 drought coupled with quarry dewatering at the nearby Vulcan Materials limestone quarry resulted in sinkholes forming in the streambed of South Branch Conewago Creek. To date, neither PA DEP nor the Susquehanna River Basin Commission (SRBC) has issued any permits for the wells. But, Hanover is using some of this ground water since the quarry dewatering operation discharges to Slagle Run where Hanover has an intake. Water from these rocks is generally very hard.

The two small areas of the Piedmont Upland contain the fewest wells in Adams County and nearly all of them are used for domestic supply. The northern area encompassing Pigeon Hills is comprised of Precambrian metabasalt and quartzite, conglomerate and slate of the Cambrian Chickies Formation. The southern area in the extreme southeastern corner of Adams County is made up of the Cambrian Harpers Formation, a sequence of graywacke siltstone, graywacke and quartzite and the early Paleozoic Marburg Schist and associated minor quartzite and conglomerate. There is a lack of published hydrogeologic information for the Piedmont Upland in Adams County. In general, there is negligible primary porosity and ground water occurs in cleavage planes, joints or faults. Ground water is likely unconfined. The hydrogeologic setting is that of a fractured anisotropic bedrock zone overlain by a regolith of soil, saprolite and disintegrated bedrock. Median well yields are 7 gpm for domestic wells and 5 gpm for nondomestic wells. The Marburg Schist is generally regarded as the least productive unit in the Piedmont Upland. Annual average recharge estimates are about 8 inches for the crystalline rocks and about 11 inches for the sedimentary rocks. Water from the Marburg Schist and Chickies Formation is soft whereas water from the Harpers Formation is hard. A US EPA Superfund site involving VOC contamination of ground water from an old landfill is located within the Piedmont Upland (Figure 1).

Adams County relies strongly on ground water with 36 of 37 community water systems using ground water to supply all or part of their drinking water. Based on Annual Water Supply Reports submitted to DEP, public water systems in Adams County withdrew over 779 million gallons of ground water during 2006. Using the most recent estimate of the county population, ground water is used by over 95% of county residents for drinking water. The approximately 63,000 residents who are not served by public water are presumed to use private wells. Using the average household size of 2.6 from the last census, that translates to approximately 24,000 households using private water supplies and that figure presumably estimates the number of private wells in the county. For comparison, the 1990 census

was the last time that data was collected on private wells and there were 15,655 private wells in Adams County then. In addition to drinking water from public and domestic water supply wells, ground water is also used for cooling water, irrigation, livestock watering, fruit production and processing, golf courses and food processing.

Challenges

Adams County, one of the fastest growing counties in Pennsylvania, has been experiencing regular dry spells and droughts over the last decade or more. Surface water development has limited potential given the relatively small volumes of streamflow and the hydrogeology of the area rules out substantial utilization of groundwater in some locations. Of the ten areas listed as potentially stressed or water challenged within the Susquehanna River Basin (SRBC, 2005), four include parts of Adams County – Pennsylvania Fruit Belt (increasing irrigation demand and consumptive use by fruit growers limited by low capacity wells, poor aquifers on South Mountain), Hanover area (chronic water shortages in a growing area which includes eastern Adams County), Bonneauville Shale Belt (another growing area with clusters of low yielding wells in lower part of the Gettysburg Formation) and the Diabase area (worst aquifer in the state but a frequent target for new development).

The concern over water resources in Adams County has produced some interesting approaches to addressing the issues. A few years ago, the Land Conservancy of Adams County and the county Conservation District were able to obtain a grant from PA DEP to secure conservation easements on key properties in the Marsh Creek source water area to protect Gettysburg's water supply. The grant was financed by civil penalties collected for ground-water contamination at the Superfund sites around Gettysburg. Recently, York Water Company has offered to sell GMA water that would be piped from the Susquehanna River to Gettysburg. York Water Company is already supplying Abbottstown via the controversial "big pipe" and they hope to extend the line to Gettysburg pending regulatory approval. This will constitute an interbasin transfer as GMA's wastewater plant discharges to Rock Creek which is within the Potomac basin. The concern over water resource issues is so great that the Adams County Commissioners have recently agreed to establish a Water Resources Advisory Board for the county. Some upcoming Commonwealth initiatives will merit attention. The completion of the State Water Plan and its provisions for Critical Water Planning Areas will likely be investigated by county and municipal officials. Also PA DEP endeavors related to sustainable infrastructure and integrated water resources planning may lead to solutions regarding the proper planning and management of the area's precious but dwindling water resources.

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Conchostracan (Clam-Shrimp) Fossils in Redbeds of the Gettysburg Formation: Evidence for Lacustrine Origin of at Least Some Triassic Redbeds in South-Central Pennsylvania

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ABSTRACT

Initially, in eastern North America, the Triassic-Jurassic (Newark Supergroup) redbeds were interpreted as fluvial flood-plain deposits. Black or gray shales there were recognized as lake or playa sediments, but more recently, the overlying redbeds have also been suggested to be lacustrine. Further evidence for lacustrine origin of at least some redbeds in the Gettysburg Basin specifically are newly-discovered fossil conchostracans, *Palaeolimnadia?*, in red siltstone in the middle Gettysburg Formation, southeast of Harrisburg. These fossils indicate deposition under shallow or near-shore lake, pond, playa, or shore-line conditions.

SIGNIFICANCE

Redbeds are not ordinarily considered to have been aquatic, but fossil conchostracan (clam-shrimp) shells recently found in Gettysburg Formation red siltstone near Harrisburg indicate that at least some of those red sediments are of lacustrine origin.

BACKGROUND

Initially, in eastern North America, the Triassic (into early Jurassic; Newark Supergroup) redbeds were interpreted as flood-plain deposits under tropical, seasonal wet-dry conditions (Krynine, 1950; Van Houten, 1962; Olsen, 1980a, p. 364, 366-368, 393; Oshchudlak & Hubert, 1988; Smoot, 1999). In the Gettysburg Formation of the Gettysburg Basin in south-central Pennsylvania, except for a few dinosaur footprints at widely scattered localities (Cuffey et al, 2006/2008, p. 13-14; Inners et al, 2004/2006, p. 25, 26a-b; Olsen, 1988, p. 226), such redbeds lack animal fossils.

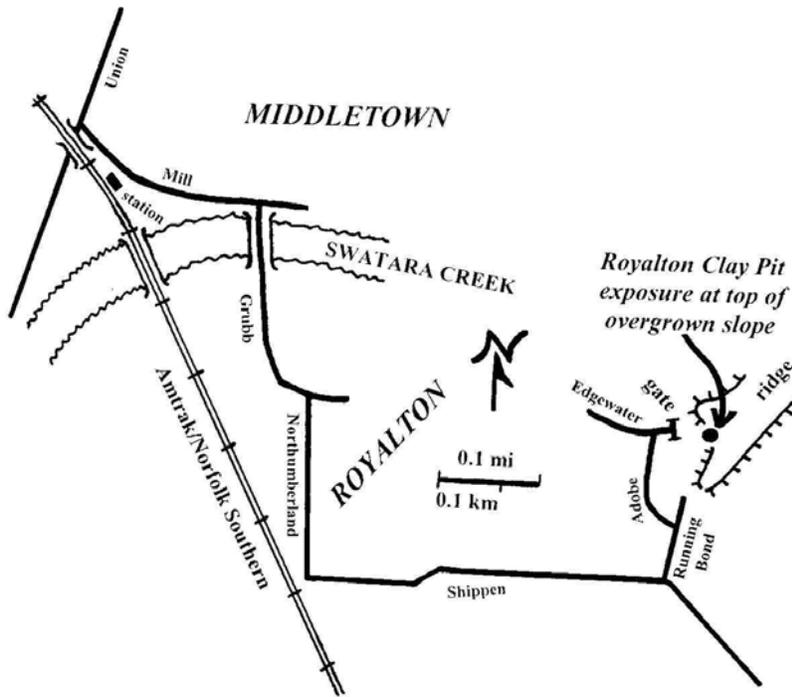
In other Triassic basins, black or gray shales (mostly missing near Gettysburg) were long ago recognized as lake or playa sediments, from their fish, arthropod, and mollusk fossils. The Lockatong dark shales in the Newark Basin proper (northeastern Pennsylvania into New Jersey) have been the most intensively studied (Bock, 1953a; Van Houten, 1962; Olsen, 1980a, 1988; Smoot, 1999).

More recently, the Brunswick or Passaic redbeds overlying those dark shales have also been suggested to be lake or playa sediments, primarily on stratigraphic and sedimentologic grounds. Especially important has been the extensive tracing and correlation of thin sedimentary cycles across entire basins, implying wide, flat-bottomed, depositional surfaces (Olsen, 1980b, p. 9; 1985b; 1986, p. 842-843; Smoot & Olsen, 1994; Olsen et al, 1996, p. 73-74; Smoot, 1999, p. 199-200). Also suggestive are horizontally and very thinly laminated redbeds, like some of the Gettysburg red shales

Cuffey, Roger J, Jeri L Jones, and Mary Ann Schlegel (2008), Conchostracan (Clam-Shrimp) Fossils in Redbeds of the Gettysburg Formation: Evidence for Lacustrine Origin of at Least Some Triassic Redbeds in South-Central Pennsylvania in Fleeger, G.M (ed), Geology of the Gettysburg Mesozoic Basin and Military Geology of the Gettysburg Campaign, 73rd Annual Field Conference of Pennsylvania Geologists, Gettysburg, PA, p. 19 – 23.

in the battlefield railroad cuts, consistent with deposition under quiet standing water rather than turbulent flood flow (Cuffey et al, 2006/2008, p. 8; Inners et al, 2004/2006, p. 20, 52; Olsen, 1985a; Gore, 1988, p. 394). Finally, also significant is paleontologic evidence like that in the present paper (also see Olsen, 1988), of conchostracans in the Gettysburg Formation redbeds.

The present-day red color of these Triassic strata was not the color of the sediments when deposited, but developed during diagenesis (McIntosh et al, 1985; Oshchudlak & Hubert, 1988). In this regard, the Gettysburg red lake beds would originally have been duller colored, like modern East African rift-lake sediments, which are mostly gray, green, black, or brown (Frostick et al, 1986).



LOCATION

The conchostracan locality is southeast of Harrisburg, 0.5 mi (0.8 km) N110° E of the bridge carrying Grubb Street over Swatara Creek on the northeast side of Royalton (Fig. 1), Middletown 7.5' quadrangle; Dauphin County, Pennsylvania. It is an overgrown abandoned clay pit, dug into the west side of a low wooded ridge immediately east of new housing developments.

Fig. 1. Local street access to conchostracan locality in Royalton Clay Pit; base re-drawn from USGS Middletown 7.5' topographic quadrangle.

STRATIGRAPHY

The conchostracans occur in red medium-bedded (rather than thinly laminated) siltstone (Fig. 2), in the middle horizons of the Gettysburg Formation, near but not in the Heidlersburg sandy member. Their age is thus mid-Norian (210-212 Ma; Cuffey et al, 2006/2008, p. 4; Inners et al, 2004/2006, p. 5; Pennsylvania Topographic & Geologic Survey, 1980).



Fig. 2. Field photograph of red siltstones yielding conchostracans; vertical dimension covered is 4 ft (1.3 m).

CONCHOSTRACANS

In general appearance (Fig. 3), the fossil conchostracans resemble tiny pelecypod shells. They are black (to yellow-brown if weathered), 1.5 mm in diameter, oval to nearly circular in outline, low-domed in cross-section, smooth-surfaced (with no obvious growth lines), sometimes with a thin marginal flange, and variably broken or dented at the apex (due to diagenetic compaction).

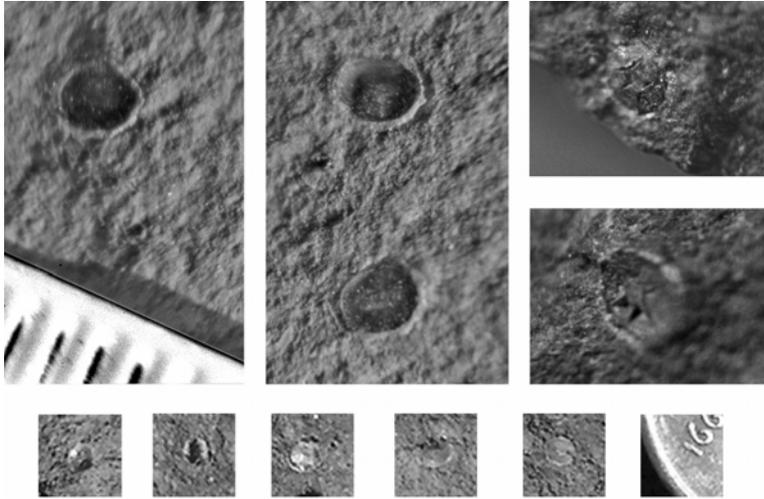


Fig. 3. Conchostracans (*Palaeolimnadia?* sp. indet.) from red siltstone in middle of Gettysburg Formation. Upper row, laboratory photographs, left to right: scale (mm) under specimen number 3a, then 3b and c, 1 (above), 2 (below), in PENDAU-Roy-A suite, Penn State. Lower row, computer-enlarged from digital field photograph of red siltstone slab, left to right: five different conchostracans shells, and (far right) scale indicated by curved edge of US penny coin.

These fossils can be identified as the conchostracan *Palaeolimnadia?* sp. indet. from sketches by Olsen (1988, p. 207, 221-225, fig. 8-13F; Olsen et al, 1978, p. 730, fig. 4B; Tasch, 1969, p. 150, fig. 48-4).

An early report (Stose & Jonas, 1933, p. 41) of similar shells nearby, but in green shale rather than redbeds, may possibly represent this same taxon, but examination of those specimens would be necessary to confirm that.

Elsewhere in the East Coast Triassic-Jurassic, and possibly even in the Gettysburg redbeds (Olsen, 1988, p. 225), another conchostracan genus, *Cyzicus* (originally described as *Howellites* by Bock, 1953a, p. 70-73, pl. 13, 1953b), has also been reported (Olsen, 1988, p. 207, 220-227, fig. 8-5G, 8-6E, 8-13G; Olsen et al, 1978, p. 730, fig 4C; Tasch, 1969, p.151, fig. 50-1). It is somewhat larger and has more obvious growth lines.

Conchostracans (or “clam-shrimps”) are branchiopod or phyllopod crustaceans up to a few millimeters long, with a shrimp-like body enclosed within two pelecypod-like shells (valves) protecting each side and hinged along the upper (back or dorsal) side (Tasch, 1969, fig. 19-6, 48-3, 49-2, 50-1). Many have been recorded in the literature as “estheriids” or “*Estheria*”, a taxon now extensively split apart (Tasch, 1969, p. 151).

At first glance, these tiny conchostracan shells might be mistaken for megaspores from land plants (probably lycopods or ferns as previously reported from the Newark Supergroup elsewhere). However, such palynomorphs virtually never occur in redbeds (their sporopollenin walls are destroyed by oxygenation during redbed deposition or diagenesis), and most also exhibit a trilete scar (not seen on these specimens).

Much smaller (0.3-mm diameter) than the conchostracan shells are occasional tiny isolated black dots. These possibly may be another type of crustacean, an ostracod (bean-shrimp), simple, smooth-surfaced, ovoid, and reminiscent of the genus *Darwinula?*, which has been reported from other Triassic basins (Swain & Brown, 1972, p. 16, pl. 1, fig. 1-11; Olsen, 1988, p. 200, 220-227, fig. 8-5F, 8-6F; Benson et al, 1961, p. 254, fig. 2, 183-2).

PALEOENVIRONMENTAL IMPLICATIONS

Modern conchostracans tend to occur in relatively short-lived (ephemeral), often alkaline, small ponds in drier regions, but Mesozoic representatives seem to have been more widely distributed, abundantly occupying large, permanent (perennial), fresh-water lakes as well (Olsen, 1988, p. 207; Tasch, 1969, p. 146-149).

These Gettysburg fossil conchostracans therefore indicate deposition under aquatic, submerged, relatively fresh-water, shallow or near-shore lake, pond, playa, or shore-line conditions, as opposed to subaerial, fluvial flood-plain circumstances with standing water only briefly and locally during the year's wettest season. These fossils thus confirm a lacustrine origin of these particular redbeds, i.e. of at least some of the Gettysburg Formation redbeds.

Other Triassic basins contain black or gray shales representing deep, well-stratified (epilimnion over hypolimnion), permanent lakes. The middle Gettysburg in contrast is almost entirely redbeds, and therefore seems likely to have been deposited in a rather opposite kind of lake, specifically a very shallow, unstratified lake, even though relatively wide areally. This interpretation is similar to recent paleoenvironmental reconstructions in the nearby Newark and Culpepper Basins (Olsen, 1988, p. 187; Gore, 1988, p. 394-395; Smoot, 1999, p. 197), and can be compared and contrasted with modern African rift lakes as well (Frostick et al, 1986).

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A Cretaceous Deposit in the Great Valley — The Pond Bank Story

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INTRODUCTION

No, we will not visit Pond Bank, but we will discuss this enigmatic deposit as a window to the post-early Jurassic history of the area. Pond Bank is at the base of the NW flank of South Mountain, south of Chambersburg and west of Caledonia in Franklin County (Figure 1). We will display some of the Pond Bank "lignite" cores for the field conference, summarize conclusions from earlier work, and

explore the paleoenvironmental implications not previously examined for the site. In addition, some comments will be made about the larger, generally not considered aspects of old lignite occurrences.

SIGNIFICANCE

Lignitic clay from Pond Bank has furnished the only Cretaceous fossils in the Pennsylvania Appalachians inland from the Coastal Plain, and thereby provides a unique if limited glimpse into the history of that important period in this region.

Similar lignitic deposits have been described from various sites in the Appalachians. Best known, perhaps, is the Brandon lignite in Vermont, which is Oligocene in age (Traverse, 1994). The Brandon site has been long known and was described in detail as long ago as 1861 (Hitchcock and others). A note that same year indicates that "Dr. Leidy mentioned that

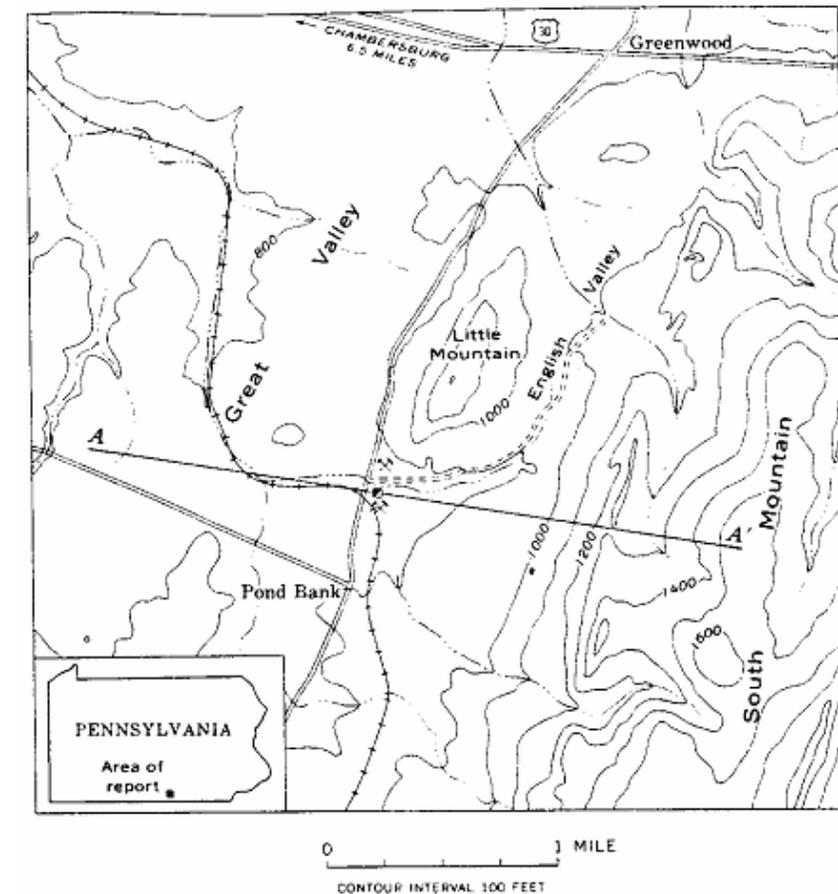


Figure 1. The Pond Bank site (from Pierce, 1965).

lignite had been discovered at the border of the new red sandstone on Plymouth Creek, near Norristown, PA." (incomplete citation from Proceedings of the Academy of Natural Sciences of Philadelphia, April, 1861, p. 77).

Pond Bank was first mentioned by Lesley in 1865. It is in this discussion that he presents the carefully prepared log by Captain Geo. B. Wiestling, of the dug pit and findings (p. 480-482). The site is briefly mentioned by Frazer in 1877. An apparently significant site at Ironton in Lehigh County is first

Potter, Noel Jr., and Roger J. Cuffey (2008), A Cretaceous Deposit in the Great Valley – The Pond Bank Story. in Fleeger, G.M. (ed), Geology of the Gettysburg Mesozoic Basin and Military Geology of the Gettysburg Campaign, 73rd Annual Field Conference of Pennsylvania Geologists, Gettysburg, PA, p. 24 – 30.

mentioned by Prime in 1878. The Ironton site has apparently had a significant history as an iron mine. After lying abandoned for many years, it was turned into the Heleva Landfill in 1967. Today it is a superfund site (Llewellyn, 1999).

Lewis (1880) mentions the presence of lignite in Montgomery County at several localities, but does not elaborate. In 1881 he gives much more detail and cites occurrences at Marble Hall where lignite occurred in 4 shafts, another locality 1 ¾ miles west of Marble Hall, a locality south of Plymouth Creek and a mile from Conshohocken, as well as a number of other pits south and also to the east of Conshohocken. In a postscript Lewis discusses, complete with stratigraphic column, a lignite near Augusta, GA (p. 289-291). The Augusta deposit is later discussed by Clark (1891)

The description given here of the Pond Bank deposit is that of d’Invilliers (1887, p. 1430):

“Pond bank No. 1

This is the first opening north from the railroad, formerly worked as an open cut, 80 feet deep, but now idle and filled with water to within 30 feet of the surface. There is absolutely nothing to be seen at this opening, although the ore taken from it in past times must have been large and is said to have been of a superior quality. The stripping varies from 10 to 30 feet.

“Between this opening and the Little Pond bank to the north a shaft was put down by the Mont Alto Iron Company, with the following results:

Earth and white clay	. . . . .	10 feet
Sharp light-coloured sand,	. . . . .	5 “
Clay, sand and pigment,	. . . . .	25 “
Black close grained clay,	. . . . .	1 “
Lignite, .	. . . . .	4 “
Gray sandy clay,	. . . . .	1 “
Lignite, .	. . . . .	18 “
Sand, ..	. . . . .	1 “
Variegated clay,	. . . . .	6 “

“The result of this shaft 71 feet deep was kindly furnished by Col. George Wiestling, and is certainly very interesting on account of the occurrence of the two beds of lignite. From the bottom of the shaft drifts were driven towards the two bands for the purpose of draining them.”

A more complete description of the pit as given by Wiestling is given in Lesley (1865, p. 480-482) and was repeated more recently along with quotes from the work of Lewis (1881) about the other PA lignite deposits (Sevon, 2001b, p. 138-143).

Finally, we have the report of Demming (1904) who appears to be foreseeing the future, perhaps in his own imagination:

“Coal, of the variety known as lignite, has been found in three townships, Lurgan, northeast from Orrstown, in Saint Thomas, near Edenville, and in Southampton, near the old Pond iron ore bank.

“The samples from near Edenville are richest in carbon, and that coal can be used to advantage when anthracite rises to \$12 a ton retail in the county. So little has been done in development that it is impossible to estimate the quantity of which can be mined.”

Nearly 100 years later, in 1961, Kenneth Pierce (Pierce, 1965) visited the site and collected a sample that he submitted to Robert Tschudy for age identification. R. M. Kosanke obtained six additional samples from the site. Evidence from pollen in the samples was consistent and indicated an Upper Cretaceous age between late Turonian and early Campanian, about 89 to 83 ma (Tschudy, 1965). Pierce's description of the character of the sample indicates that it was of material that directly overlay the upper lignite, black clay at a depth of 40 ft.

Pierce went on to discuss the implications of the lignite deposit and to hypothesize that it had been let down from its original position as much as 1,400 ft by solution of the underlying carbonate rock. He deduced this by using estimates of insoluble residue for the rock units involved and an assumed thickness of residuum beneath the lignite. His thickness of residuum was derived from d'Inwilliers (1887, p. 1431) and used data from a nearby mine. The thickness of unconsolidated material in the residuum-alluvium complex bordering South Mountain is known to be quite variable within short distances (Sevon, 2001a, p. 24-27). Well data on file at the Pennsylvania Geological Survey and in Becher and Taylor (1982) is sparse for this area and contributes little except for a suggestion that residuum thickness at Pond Bank may be closer to 100 ft than the minimum 170 ft or maximum 335 ft deduced by Pierce (1965, p. C153).

In 2004 David Prowell of the U.S. Geological Survey drilled at the Pond Bank site to try to core the lignitic layers intersected by the 19th century miners and reconstructed by Pierce, (1965). The first hole, Pond Bank #1, was drilled at 39° 52' 41" N, 77° 32' 20" W, just E of the large pond N of the village of Pond Bank. It reached 330 feet in clayey sand and gravel without hitting the lignitic layers. The second hole, Pond Bank #2, drilled at 39° 52' 44" N, 77° 32' 22" W, 46.5 feet 225° from the shaft of the old lignite pit referenced by Pierce (1965) and where he collected lignite examined by Tschudy (1965). This hole intersected two layers of organic-rich, "lignitic" silty clay at approximate depths of 32 to 42 feet and 43 to 46 feet. The cores from both holes are stored at the Pennsylvania Geological Survey offices in Middletown, PA.

LITHOSTRATIGRAPHY

Lignite, as small pieces, can still be found on the surface at Pond Bank, on the rim of the same shaft that Pierce (1965) collected his samples that were studied by Tschudy (1965). Records for the mine shaft in which lignite was originally found in the mid-1800's provided the basis for a local lithostratigraphic column (Pierce, 1965, p. C153 Figure 2, reproduced here as Figure 2). The "lignite" on the spoil pile where Pierce collected his samples is not "shiny/glistening and hard," and does not "ring" on being struck—thus our term "lignite".

THE POND BANK CORES

Cuffey has examined the organic-rich material from Pond Bank core #2. His examination of this material, from the 44.5-.6-foot depth especially, shows a dark gray (not black), non-silty (not gritty on teeth), massive (not laminated) clay (not actually lignite), with a few scattered small carbonized wood or charcoal fragments making up only ~1% of the sediment's volume. Because this and a second dark-gray

layer contrast with the surrounding sediments, and because historical practice has been to call this lignite, we will refer to it in quotes – "lignite" – in order to clarify that we are talking about this dark-gray clay.

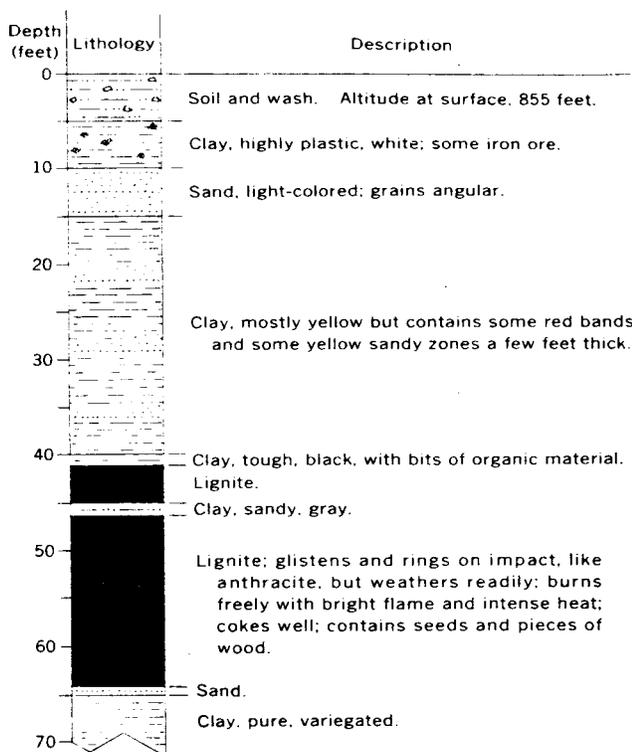


Figure 2. Lithostratigraphic column as reconstructed by Pierce (1965, Figure 2)

These two “lignites” are overlain and underlain by fine- to coarse-grained, quartz sand, poorly sorted, with much silt and clay matrix, predominantly yellowish, but varying from white and kaolinitic to pink-red-purple and ferruginous, overall strikingly reminiscent of Cretaceous shore-line sands (Raritan) on the Atlantic Coastal Plain. Such enclosing sediments have been more recently interpreted as weathered residuum from the Cambrian rocks nearby, most likely the Antietam sandstone.

FOSSIL CONTENT

Almost all the fossils so far documented from Pond Bank are palynomorphs (Tschudy, 1965), plus water-ferns (Pierce, 1965), even though identifiable carbonized wood fragments might have been expected from a lignite. Those reported are especially conifer pollen, including many with present-day Southern-Hemisphere affinities (*Araucariacites*, *Granabivesiculites*, *Parvisaccites*, *Rugubivesiculites*), also fern fragments and spores (*Appendicisporites*, *Azolla*, *Cicatricosisporites*), and some angiosperm pollen, presumably woody trees and shrubs but possibly herbs as well (“*Normapolles*”, *Plicapollis*, *Proteacidites*, *Rhoipites*). These palynomorphs have been studied for their biostratigraphic implications, but not yet for their paleoecologic interpretation.

BIOSTRATIGRAPHIC AGE

Those palynomorphs indicate a probable age (Tschudy, 1965) for the Pond Bank “lignite”/deposit as mid-Late Cretaceous, somewhere within the late Turonian, Coniacian, Santonian, or early Campanian stages, an interval centered on approximately 85 Ma. For more informative comparisons, this is the same stratigraphic range as the Magothy and lower Matawan (Merchantville and Woodbury Clays) in the New Jersey coastal plain, and as the Carlile [no “s”], Niobrara, and lower Pierre in the Western Interior.

PALEOECOLOGIC IMPLICATIONS

The palynomorphs in the Pond Bank “lignite” belong to still-living major plant groups – conifers, ferns, angiosperms – quite familiar in modern ecosystems. Might it therefore be possible to consider their paleoecologic as well as biostratigraphic implications? In particular, might it be possible to determine the type of vegetation community during Pond Bank deposition, or even the distance inland from the coast then (the nearest deposits of comparable age are shallow-marine, 80 mi to the east).

The most straightforward method in paleoecology is comparison with still-living (extant) species, an approach sometimes termed “taxonomic uniformitarianism”. Species provide the most precise indications, genera less so, families still less so, etc.; the highest taxa have too broad a distribution to provide any but the most generalized inferences. At Pond Bank, only *Azolla* the water fern is informative, indicating deposition in standing water like a pond or swamp (Pierce, 1965, p. C154); also suggesting no marine influence is the lack/absence of any hystrichospheres or dinoflagellates. Unfortunately, none of the other Pond Bank palynomorphs can be linked to modern families; such affinities do not become apparent until well into the Early Tertiary (Traverse, 1988, p. 286-288; Tschudy & Scott, 1969).

A different paleoecologic method is applicable to the Pond Bank fossils, however. Tschudy (1965) notes the other Cretaceous formations in which each palynomorph has been found. By noting where each such formation lay relative to the Cretaceous shore-line (Schuchert, 1955, plus much literature examined during the search for Cretaceous bryozoans), those formations can be arranged in a paleoenvironmental transect from inland uplands to low-lying coastal plains, coastal or marginal forests and swamps, shore-line beaches, and out into near-shore marine shallows (into which near-by terrestrial palynomorphs are often blown or washed). The lateral range of each palynomorph taxon can be plotted along that gradient, and the habitat containing the greatest number or proportion of Pond Bank palynomorphs can be determined. The maximum for the reported fossils (Pierce, 1965; Tschudy, 1965)

is in the coast-line forests and swamps; the numbers fall off on either side. This result may suggest that the Cretaceous sea had encroached closer, farther west than some students have previously thought.

Finally, numerous studies elsewhere have concluded that the world at this time was super-tropical, and that plate-tectonic movements had not yet carried Pennsylvania as far north as its present latitude. Hence, Pond Bank would have been very warm, as well as wet (standing water) and humid (along or close to the coast). Thus, in conclusion, a tropical coastal rain-forest, wet-ground forest, or fresh-water swamp-forest would seem the likely paleoenvironment in which the Pond Bank "lignite" accumulated. An excellent portrayal of such a Cretaceous paleoenvironment is shown in Kay and Colbert (1965, p. 453), and gives a glimpse of south-central Pennsylvania during mid-Late Cretaceous time.

IMPLICATIONS

Pierce (1965) interpreted the "lignite" at Pond Bank as having formed in a karst depression not unlike the multitude of vernal ponds that dot the landscape today at the north and west base of South Mountain. These current ponds, of course, have a history that dates, as far as we know, only back to the end of the Late Wisconsin glaciation. Indeed, several of the other sites in the Appalachians where Cretaceous or Tertiary lignite has been found occur on carbonate rocks, and presumably have been "let down" from some much higher elevation through solution of the carbonates. Pierce estimated that the lignite at Pond Bank has been let down 1,400 feet, which is greater than the current height of South Mountain above the present Pond Bank site.

The new interpretation here of the paleoecology of the Pond Bank lignite suggests that maybe the plants grew closer to the coast than today. This suggests but does not prove that the sea was closer to the Pond Bank site than today, and this would also imply a greatly different topography than today. Did the sea really reach inland to near the Pond Bank site? This is food for thought. The tropical flora imply a different climate than today, and weathering was probably different than today.

Considerable previous text was devoted to the early literature related to the widespread occurrence of lignite deposits in Pennsylvania that are no longer available and probably never will be seen again. It is interesting to note that those deposits were all (1) associated with iron ore deposits, (2) were located above carbonates, particularly the Tomstown Formation in Cumberland County, and (3) were all somewhere in the vicinity of 40 feet beneath the present surface. If we assume, as is reasonable, that the iron ore deposits were concentrated by accumulation of secondary iron ore during the process of dissolution of the carbonates within which they were formed, then the occurrence of lignite must have developed on a surface of dissolution. Subsequent to the development of the lignite, dissolution continued, the lignites subsided as the surface sank, and the lignites were covered by more recent surficial deposits, probably mainly colluvium. Thus, if the overall hypothesis stands the test, then what we are seeing at Pond Bank is evidence of a widespread Late Cretaceous coastal environment in Pennsylvania.

Of course, if one really wants to go far afield and step back into the geologic literature, one only needs to go to Johnson (1931) and look at his classic diagrams that show a Cretaceous transgression covering most of Pennsylvania as it crosses the Fall Zone peneplain (Johnson, 1931, Figures 2 and 3) (Figure 4). That transgression had to have been accompanied by a later, probably still Cretaceous, regression. Is it possible that Johnson's long discredited concepts had some reality and that the Pond Bank deposit, having been formed above rocks, carbonates, that were ideal for its preservation, are the markers of that transgression?



Figure 3. Late Cretaceous wet forest with conifers (left) and angiosperms (center and right). From Kay and Colbert (1965).

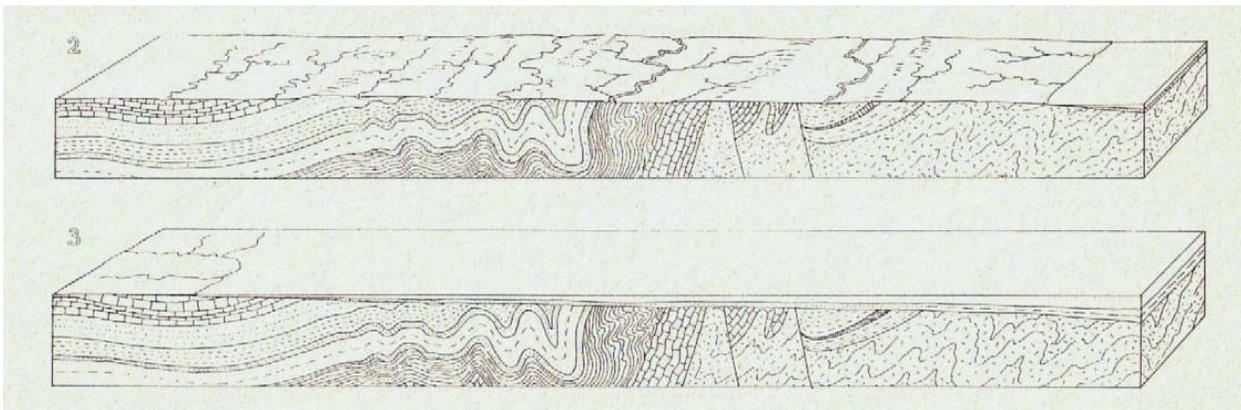


Figure 4. Sketches of the Fall Zone peneplain, 2, and the Cretaceous transgression (3) across much of Pennsylvania (Johnson, 1931, Figures 2 and 3).

ACKNOWLEDGMENTS

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HISTORICAL CHRONOLOGY OF THE GETTYSBURG CAMPAIGN

J. D. Inners

(Based mainly on Trudeau, 2002; Cleaves, 1960; Grimsley and Simpson, 1999; Doubleday, 1994; Brown, 2005; other references as cited.)

- June 1** General Robert E. Lee reorganizes the Confederate Army of Northern Virginia, the most significant change being an increase from two to three corps. For his corps commanders, he retained Lieut. Gen. James Longstreet for the 1st Corps; picked Lieut. Gen. Richard S. Ewell for the 2nd Corps (“Stonewall” Jackson’s old post); and promoted Lieut. Gen. Ambrose P. Hill to head the new 3rd Corps.
- 3** Lee opens the campaign that culminates in the battle of Gettysburg a month later by moving elements of his army from positions along the Rappahannock River at Fredericksburg, VA, northwestward toward Culpeper (Figures 1 and 2). By the next day, the Union Army of the Potomac under Maj. Gen. Joseph Hooker realizes something is afoot—but not exactly what.
- 5** Maj. Gen. J. E. B. Stuart holds an initial formal review of his cavalry forces at Brandy Station on the Orange and Alexandria Railroad northeast of Culpeper, but Lee is unable to attend. So Stuart decides to do it again.
- 6** After deciding that Federal movements to the south side of the Rappahannock against his depleted forces there was not part of an aggressive movement against him, Lee leaves Fredericksburg—reaching Culpeper early the next morning.
- 7** Hooker orders his cavalry chief, Maj. Gen. Alfred Pleasanton to cross the Rappahannock River with his whole command (and a detachment of infantry) and march directly on Culpeper. Pleasanton’s force moves surreptitiously up to the fords on the evening of the next day.
- 8** Stuart restages his “Grand Review,” this time with Lee present. The commanding general described the review as “a splendid sight,” noting that “Stuart was in all his glory.”
- 9** Battle of Brandy Station. Pleasanton (with Brig. Gen. John Buford in command of the northern wing) surprises Stuart at the fords of the Rappahannock and leads an all-day fight at Brandy Station. The Union cavalry fights well and nearly breaks Stuart’s line on Fleetwood Hill. Pleasanton pulls back late in the afternoon, judging that his “reconnaissance” mission was completed as ordered.
- 10** Lee orders Ewell’s 2nd Corps into the Shenandoah Valley—choosing Ewell to lead the invasion because of his pre-war posting at Carlisle Barracks in the Cumberland Valley, just 25 miles west of Harrisburg. Over the next two days, Ewell’s Corps passes through Chester Gap in the Blue Ridge Mountains and proceeds to Front Royal.
- 10-13** Hooker’s army begins moving from the Fredericksburg area northwestward toward the line of the Orange and Alexandria Railroad around Manassas Junction (Figures 1 and 2).
- 12** Governor Andrew Curtin of Pennsylvania announces that “a large rebel force” is marching northward to invade the state. His complacent constituents, however, respond sluggishly to his call for increased enlistments in the militia.
- 14-15** Ewell drives the Union garrison under Maj. Gen. Richard H. Milroy from Winchester, VA, capturing several thousand Union soldiers and opening up the valley.

Inners, Jon D (2008), Historical chronology of the Gettysburg campaign, *in* Fleeger, G.M (ed), Geology of the Gettysburg Mesozoic Basin and Military Geology of the Gettysburg Campaign, 73rd Annual Field Conference of Pennsylvania Geologists, Gettysburg, PA, p. 31 – 37.

- 15** Brig. Gen. Albert G. Jenkins' cavalry brigade (attached to Maj. Gen. Robert E. Rodes' 3rd Division of Ewell's Corps) enters Chambersburg, PA—and Ewell himself reaches Williamsport, MD. At this time, the last of A. P. Hill's Corps (Maj. Gen. William D. Pender's Division) was still in Fredericksburg, facing a largely empty Union position.
- 16** Hooker, General-in-Chief Henry W. Halleck, and President Lincoln exchange a series of telegrams concerning the Union garrison at Harpers Ferry, VA (which Hooker fears is about to suffer the same fate as Milroy's Winchester garrison). The upshot is that, "to remove all misunderstanding," Lincoln unequivocally orders Hooker to subordinate himself to Halleck. This is the "beginning of the end" for Joseph Hooker as commander of the Army of the Potomac.
- 17** Jenkins is "spooked" out of Chambersburg by a "large enemy force" advancing on him from the north. The "enemy force" proves to be a crowd of citizens from nearby towns who merely want to get a good look at the Confederate invaders.
- 17-21** Pleasanton's cavalry moves through gaps in the Catoctin Mountains into the Loudoun Valley and clashes with Stuart at Middleburg and Upperville before withdrawing—having satisfied himself that there was no infantry in the valley east of the Blue Ridge Mountains.
- 19** Union Maj. Gen. George Gordon Meade's 5th Corps arrives in the Loudoun Valley to support Pleasanton's cavalry. Maj. Gen. Winfield Scott Hancock's 2nd Corps follows close behind, entering Thoroughfare Gap in the Catoctin Mountains the next day.
- 20** Lee sets up his headquarters at Berryville, VA, in the Shenandoah Valley east of Winchester.
- 22** Lee orders Ewell to advance in force into Pennsylvania, with the Susquehanna River as his ultimate objective. He was instructed to divide his force into three separate columns, so as to maximize the area from which supplies could be commandeered. And further, "If Harrisburg comes within your means, capture it."
- 23** Two of Ewell's divisions, those of Rodes and Maj. Gen. Edward Johnson, enter Chambersburg. Lee gives "Jeb" Stuart discretion to "pass around their army" with his Cavalry Division "if it can be done without hindrance." He is to link up with Ewell's right flank, the city of York, PA, being a likely rendezvous point (Figure 1).
- 24** Obtaining intelligence that "the last of Lee's entire army has passed through Martinsburg [VA] towards the Potomac," Hooker finally realizes that Lee's entire army is headed into Northern territory. He orders the 11th Corps to cross the Potomac the next morning, the rest of the army to follow closely behind.
- 25** The Union 11th, 1st, and 3rd Corps (constituting a wing of the army under Maj. Gen. John F. Reynolds) cross the Potomac into Maryland at Edward's Ferry, about 12 miles downstream of Point of Rocks. Their immediate objective is to take control of Crampton's and Turner's Gaps through South Mountain, so as to prevent the Confederates from cutting off the Union advance. Hooker prepares to shift his headquarters north to Frederick, MD, over the next two days. Several regiments of Hancock's 2nd Corps (including the 1st Minnesota) clash with the advance guard of Stuart's cavalry at Haymarket, VA, as the Corps begins to pull back from Thoroughfare Gap.
- 26** By this time, main body of Lee's Army is north of the Potomac River, much of it having crossed at Williamsport, MD. Lee himself reaches Chambersburg along with Hill's 3rd Corps and most of Longstreet's 1st Corps. Brig. Gen. Jubal Early's Division of Ewell's Corps advances through the Cashtown Gap in South Mountain, 8 miles northwest of Gettysburg. Early routs a unit of militia (the 26th Pennsylvania Emergency Infantry) in a series of skirmishes and takes possession of

- Gettysburg later that day (Kross, 2000; Roth and Kross, 2000), but will leave town shortly to move on east toward York.
- 27** Ewell's Corps (minus Early's Division) occupies Carlisle, having moved up the Cumberland Valley from Chambersburg. Jenkins pushes on to New Kingstown. The Confederates are now just 13 miles from Harrisburg. Lincoln decides to accept Hooker's letter of resignation from command of the Army of the Potomac (over a dispute concerning the garrison at Harper's Ferry, VA) and appoints Maj. Gen. George Gordon Meade in his stead. The transfer takes place early on the morning of June 28.
- 28** Early's Division reaches York, the city having "surrendered" the night before. Brig. Gen. John Brown Gordon's Brigade marches eastward through Hallam (Hellam P.O.) to Wrightsville, with the intention of capturing the wooden covered bridge across the Susquehanna River at that point. After a brief firefight, in which Gordon skillfully employs his artillery, Union militia retreat across the river and fire the bridge—which is soon consumed (Eckert, 1989; Gordon, 1993). This is the easternmost point reached by Confederate forces in the campaign. Stuart's cavalymen, cut off from Lee by the northward-advancing Union army, capture 125 wagons of booty and numerous prisoners at Rockville, MD, just outside Washington, D.C. The wagons slow the Confederate raiders down, but such replenishment of dwindling supplies was one of the aims of Lee's invasion of the North.
- 28-30** Brig. Gen. Albert B. Jenkins' Confederate Cavalry Brigade advances as far as present Camp Hill, PA (5 miles west of Harrisburg and the Susquehanna River). Skirmishes with several New York regiments defending the state capital leave 16 Confederates dead and more than 20 wounded (Crist, 1984).
- 29** Ewell begins moving out of Carlisle toward Gettysburg.
- 30** The battle of Hanover. Maj. Gen. Judson Kilpatrick's 3rd Cavalry Division spars with Stuart's command in the streets of Hanover, PA, 20 miles southwest of York. By early afternoon, the two sides are about fought out—with Kilpatrick controlling the town and Stuart the high ground to the south. Lieut. Gen. Ambrose P. Hill's 3rd Confederate Army Corps reaches Cashtown just east of a major pass through South Mountain and only a few miles west-northwest of Gettysburg. That same day, Brig. Gen. John Buford's 1st Division of the Union Army Corps arrives in Gettysburg (about 11:00 AM). By the end of the day, the Union 1st, 2nd, 5th, 6th, 11th, and 12th Corps are all encamped near the Mason-Dixon Line along a 25-mile-long, roughly west-to-east line from Emmitsburg, MD, to Littlestown, PA, to Manchester, MD. Brig. Gen. Gouverneur K. Warren, Meade's Chief of Engineers, identifies a 20-mile-long chain of hills along the south side of Big Pipe Creek between Manchester and Middleburg (Thurmont), MD, as possible Union defensive line.
- July 1** The first day of the battle of Gettysburg begins at about 7:00 AM as Maj. Gen. Henry Heth's Confederate Division of Hill's 3rd Corps—advancing down the Chambersburg Pike—encounters Buford's dismounted Union cavalymen about 4 miles northwest of Gettysburg. With the successive addition of the Union 1st Corps (from the south), additional elements of Hill's Corps (from the west), the Union 11th Corps (from the south), and Ewell's Confederate 2nd Corps (from north and northwest), the battle swings back and forth—the fighting resulting in the rout of the Union forces and their retreat through the streets of Gettysburg to the "high ground" of the Gettysburg sill southeast of the town (see STOPS 13 and 14). Left to his discretion by Lee as to whether to attack the still rather disorganized Northern units on Cemetery Hill late in the day, Ewell decides in

- the negative—and the Union soldiers begin the development of a strong defensive position.
- 2** On the second day, Lee continues on the offensive, shifting his focus to the Union left at the south end of the topographic “fishhook.” He directs Longstreet and two divisions of his 1st Corps to attack from the southwest along the line of the Emmitsburg Road in an attempt to roll up that part of the Federal line. Late in the morning, however, Maj. Gen. Daniel E. Sickles moves the two divisions of his 3rd Corps out from the south end of Cemetery Ridge to occupy slightly higher ground in his front—at Devil’s Den, the Wheatfield, and the Peach Orchard. This disrupts Lee’s plan, but also creates a dangerous salient, while at the same time leaving Little Round Top—a key hill on the Union line—undefended. Fierce, bloody fighting takes place from mid-afternoon to early evening—but the Confederate attempt to turn the Union left fails (STOPS 9, 10, and 11). Toward nightfall, the Confederates of Ewell’s Corps launch major attacks on the Union right—Culp’s Hill and Cemetery Hill, capturing some entrenchments on the former that had been abandoned by Union forces withdrawn to assist on the left, but failing to make any headway on Cemetery Hill. This day’s fighting was intense, but left both armies in essentially their beginning positions, the Confederates on Seminary Ridge, and the Union forces on the “fishhook” from Culp’s Hill around to Big Round Top. At a war council with his corps commanders that night, Meade predicts that tomorrow Lee will attack the Union center, while across town Lee is laying plans to do exactly that.
- 3** Early on the morning of the third day, the Confederates launch several unsuccessful attacks on Culp’s Hill, eventually losing the entrenchments captured the evening before. Mid-day, however, sees the climax of the battle of Gettysburg. After an hour-long cannonade in which Confederate artillery along Seminary Ridge hammer the Union center on Cemetery Ridge, Maj. Gen. George E. Pickett’s 3rd Division of Longstreet’s 1st Corps and elements of Hill’s 3rd Corps—a total force of 12,000 to 15,000 men—conduct a massive frontal assault on the Union center (“Pickett’s Charge”) (STOP 15 and 16). The attack fails—fewer than half of the assaulting column returning unscathed back to Seminary Ridge. Two significant cavalry engagements also take place that afternoon. Confederate and Union under “Jeb” Stuart and Brig. Gen. David McMurtree Gregg, respectively, fight a bitter engagement behind the Union right (East Cavalry Field), as Stuart attempts to back up “Pickett’s Charge.” At about the same time on the Union left, Judson Kilpatrick launches an unsuccessful attack on Confederate forces defending a line stretching from Warfield Ridge on the west to Big Round Top on the east (South Cavalry Field).
- 4** Lee begins his retreat from Gettysburg on a dreary, rainy afternoon .
- 4-5** Confederate supply train, followed by vanguard of main army passes southwest through Monterey Pass near Fairfield, while a long wagon train of wounded under Brig. Gen. John Imboden moves westward through Cashtown Gap. Kilpatrick and Custer strike the Confederates at Monterey Pass during the night of 4/5, capturing considerable booty, but not markedly slowing the retreat.
- 6** By mid-afternoon, nearly the entire Union army is in motion over muddy roads leading toward the various South Mountain gaps. They come up on the rearguard of the Confederates at Monterey Pass, but do not attack. Advance elements of Lee’s retreating columns reach Williamsport, MD, on the Potomac River, and some supplies are ferried across. But the river is high—and still rising.
- 7** Another day of rain. Meade arrives in Frederick, MD, and is showered with praise by the local citizenry.

- 7-11** Lee digs in around Williamsport as the Potomac continues to run high. Meade's army converges on the Confederate position.
- 12** The Union army confronts Lee's fortified perimeter around Williamsport. Meade holds another "council of war," but only Wadsworth of the 1st Corps and Howard of the 11th support Meade's proposal for immediate assault of the Confederate position.
- 13** Halleck tells Meade, "You are strong enough to attack and defeat the enemy before he can effect a crossing...Do not let the enemy escape." With the heavy rain continuing and the Potomac at high water, Meade issues orders to merely probe the enemy lines. Under cover of rain, mist, and darkness, the bulk of Lee's army begins crossing a rickety pontoon bridge at Falling Waters late that afternoon and evening.
- 14** Skirmishers of the Union 12th Corps push forward to Falling Waters early in the morning, engage the rear of Lee's fleeing columns, and capture more than 200 prisoners. But the Army of Northern Virginia escapes to fight for another twenty-one months.

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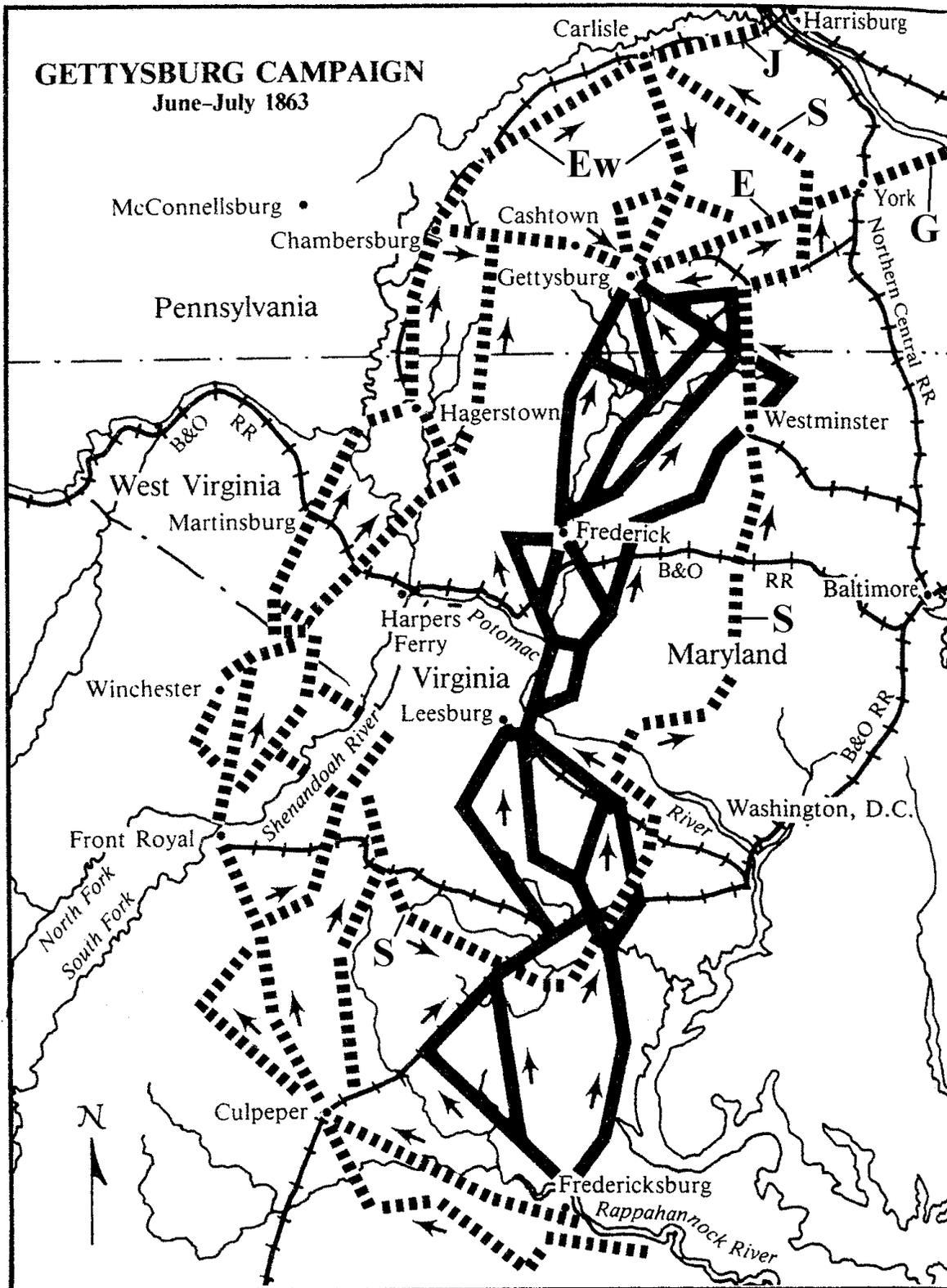


Figure 1. Generalized map showing the various routes followed by Union (continuous lines) and Confederate units (dashed lines) in reaching Gettysburg (Faust, 1986, p. 308). Ew = route of Ewell's Corps from Chambersburg to Carlisle; J = Jenkins' cavalry probe toward Harrisburg; E = route of Early's Division from Gettysburg to York; G = Gordon's probe toward Wrightsville.

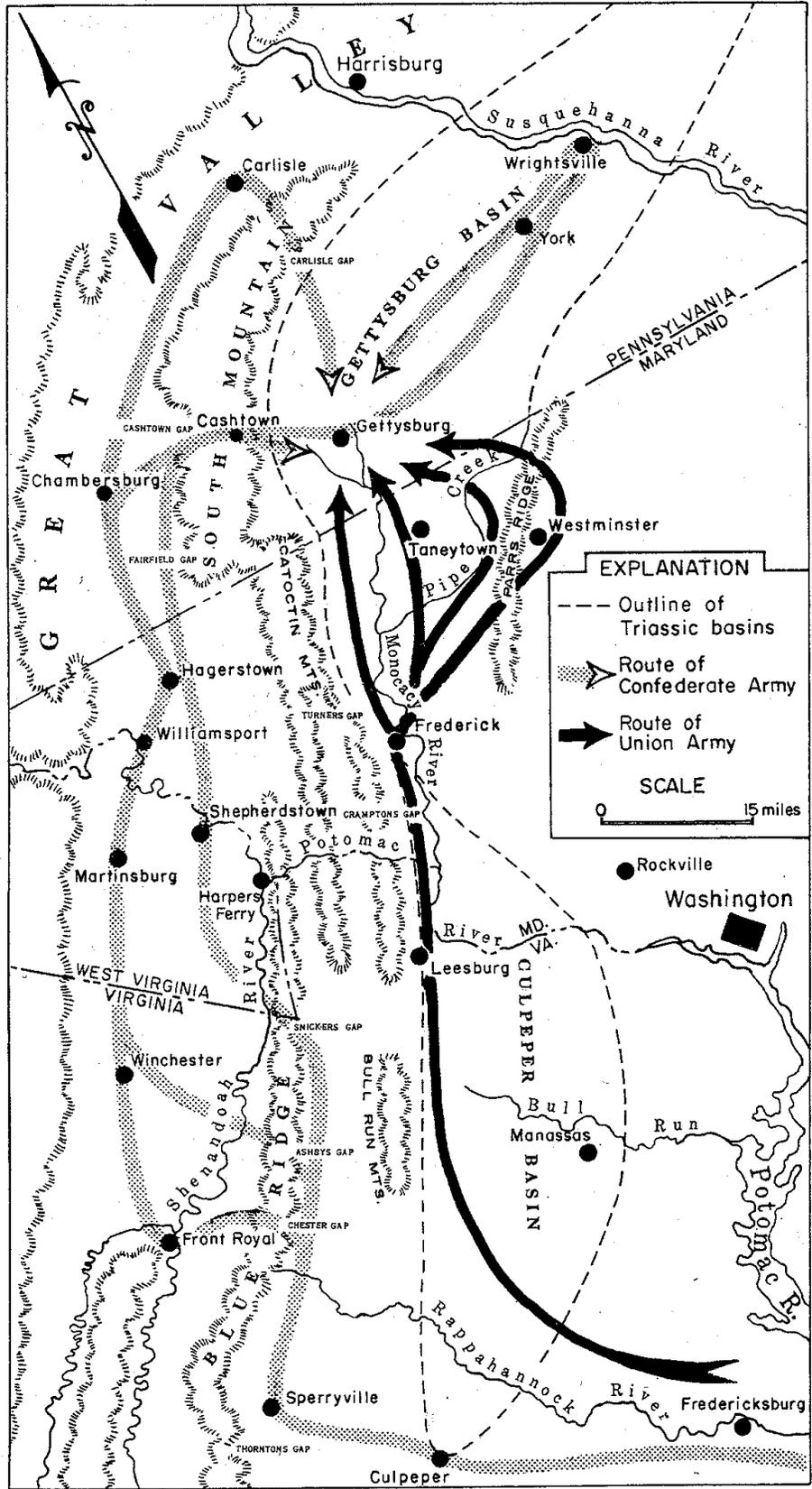


Figure 2. Sketch map of the area covered by the Gettysburg campaign (Brown, 1962, Fig. 1).

TOPOGRAPHY AND GEOLOGY OF THE GETTYSBURG BATTLEFIELD

Jon D. Inners

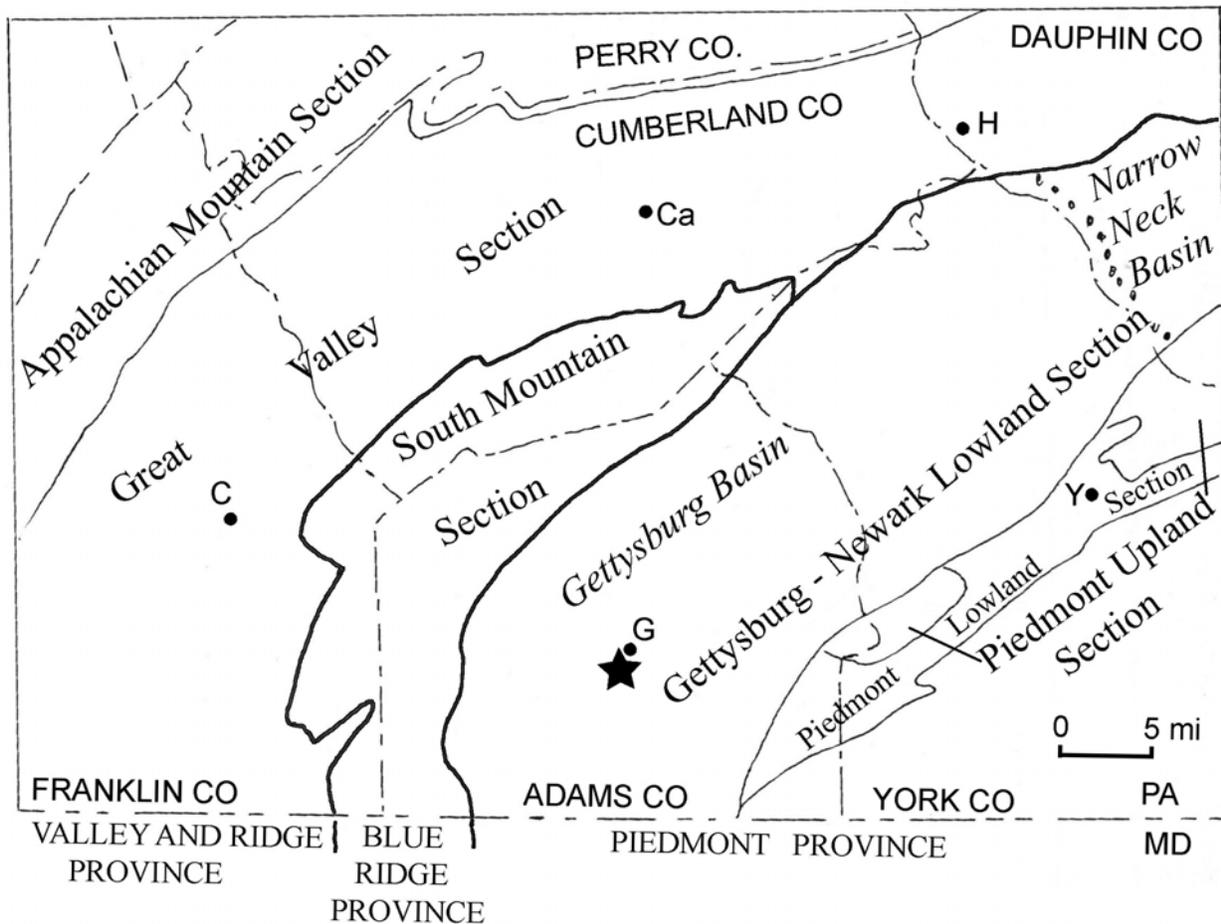


Figure 1. Political, geographic, and geologic setting of the battle of Gettysburg. G = Gettysburg; C = Chambersburg, Ca = Carlisle, H = Harrisburg, Y = York.

Figure 1 shows the location of the Gettysburg Battlefield in reference to various criteria. Politically, it is in Adams County, south-central Pennsylvania. Physiographically, it is situated in the Gettysburg/Newark Lowland section of the Piedmont province. Geologically, it lies toward the south end of the Gettysburg basin, one of numerous Mesozoic rift basins that are strung out along the eastern border of North America from Nova Scotia to Virginia. The present battlefield landscape owes its configuration to a complex series of geological events—from Late Triassic-Early Jurassic continental sedimentation and plutonism, through Early Jurassic structural deformation, and on to vast eons of erosion in the later Mesozoic and Cenozoic. Man-made aspects of topography are also vital to understanding the battle—the network of ten roads radiating from the borough of Gettysburg in all directions, the unfinished railroad west of town, and the many stone walls and wood fences that divided the farmers' fields and woodlots.

Inners, Jon D (2008), Topography and geology of the Gettysburg battlefield, in Fleegeer, G.M (ed), Geology of the Gettysburg Mesozoic Basin and Military Geology of the Gettysburg Campaign, 73rd Annual Field Conference of Pennsylvania Geologists, Gettysburg, PA, p. 38 – 47.

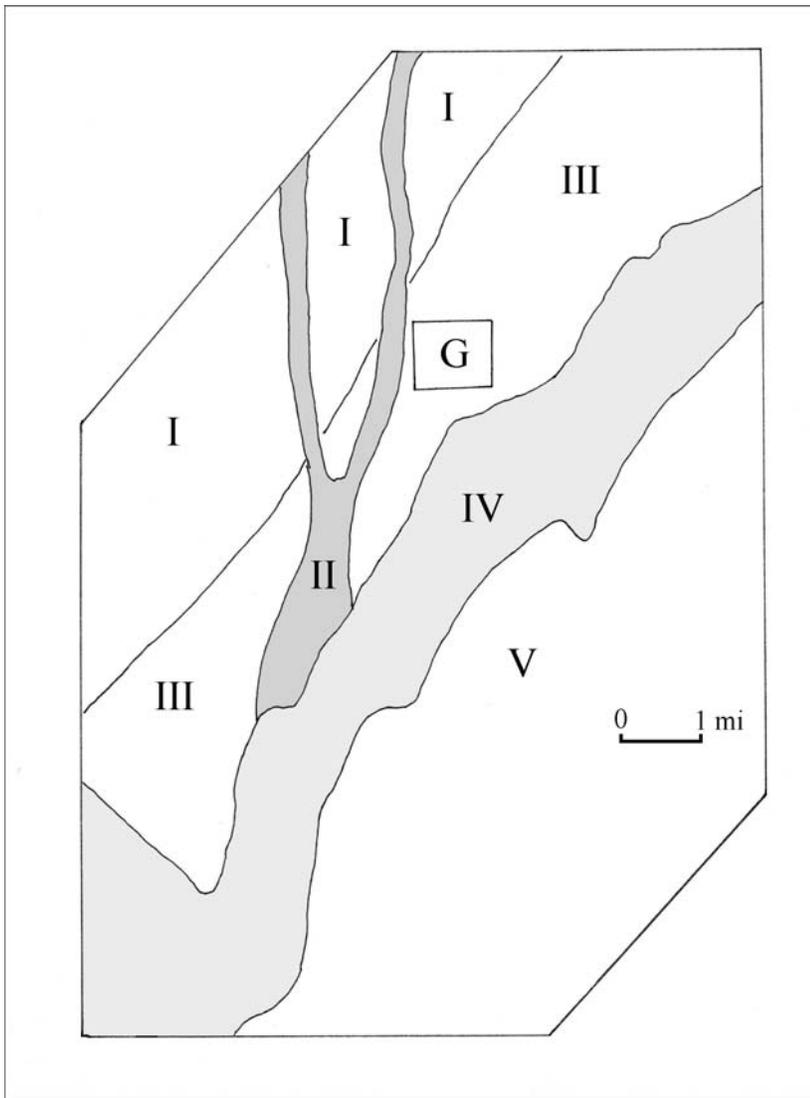


Figure 2. Topographic and geologic subdivisions of the Gettysburg battlefield. See text for Roman numeral identifications. G = Gettysburg.

broad belt of low, relatively featureless terrain underlain by red beds of the lower part of the Gettysburg Formation (V). For two and a half days, this area figured little in the battle, but on the afternoon of July 3, a major cavalry engagement took place there, 3 miles east of Gettysburg (East Cavalry Battlefield).

Maj. Gen. Henry Hunt, Union Chief of Artillery, gave an excellent description of the Union “fishhook” on the “high ground” of IV on Figure 2 (see also Figure 3).

Near the western base of Cemetery Hill is Ziegler’s Grove. From this grove the distance nearly due south to the base of Little Round Top is a mile and a half. A well defined ridge known as Cemetery Ridge follows this line from Ziegler’s for 900 yards to another small grove, or clump of trees, where it turns sharply to the east for 200 yards, then turns south again, and continues in a direct line toward Round Top, for 700 yards, to George Weikert’s. So far the ridge is smooth and open, in full view of Seminary Ridge opposite, and distant from 1400 to 1600 yards. At Weikert’s, this ridge is lost in a large body of rocks, hills, and woods, lying athwart the direct line to Round Top, and forcing a bend to the east in the Taneytown road. This rough space also stretches for a quarter of a mile or more *west* of this direct line, toward Plum Run. Toward the south it sinks into low marshy ground which reaches to the base of Little Round Top, half a mile or more from George Weikert’s. The west side of this broken ground was wooded through its whole extent from north to south.

Topographically and geologically, the battleground at Gettysburg can be conveniently divided into five parts going from west to east, all parts having a mostly northeast-southwest grain (Figure 2). Farthest west is a broad belt of low ridges—Herr Ridge, McPherson’s Ridge, etc.—and shallow valleys underlain by mostly red and gray sedimentary rocks of the Late Triassic-age Gettysburg Formation (I of Figure 2; STOP 13). Next is a narrow, crosscutting array of somewhat higher ridges—Oak Ridge, Seminary Ridge, and Warfield Ridge (II). These ridges have relief of 30 to 40 feet and are ribbed by thin, Early Jurassic-age diabase dikes (STOPS 14 and 15). East of this ridgeline is a broad mile-wide tract of “swaley” ground underlain by Gettysburg Formation sedimentary rocks—unaltered, red, and soft to the west, but baked and hardened to gray hornfels to the east (III; STOP 11). Next to the east is the most famous section of the battlefield—the “high ground” of rocky hills extending from Culp’s Hill south to Big Round Top that is formed on the earliest Jurassic-age Gettysburg diabase sill (IV; STOPS 9, 10, and 16). To the east of the “high ground” is a

Between this wood and Plum Run is an open cleared space 300 yards wide—a continuation of the open country in front of Cemetery Ridge; Plum Run flows south-easterly toward Little Round Top, then makes a bend to the south-west, where it receives a small stream or “branch” from Seminary Ridge. In the angle between these streams is Devil’s Den, a bold rocky height, steep on its eastern face, and prolonged as a ridge to the west. It is 500 yards due west of Little Round Top, and 100 feet lower. The northern extremity is composed of huge rocks and boulders, forming innumerable crevices and holes, from the largest of which the hill derives its name. Plum Run valley is here marshy but strewn with similar boulders, and the slopes of the Round Tops are covered with them.

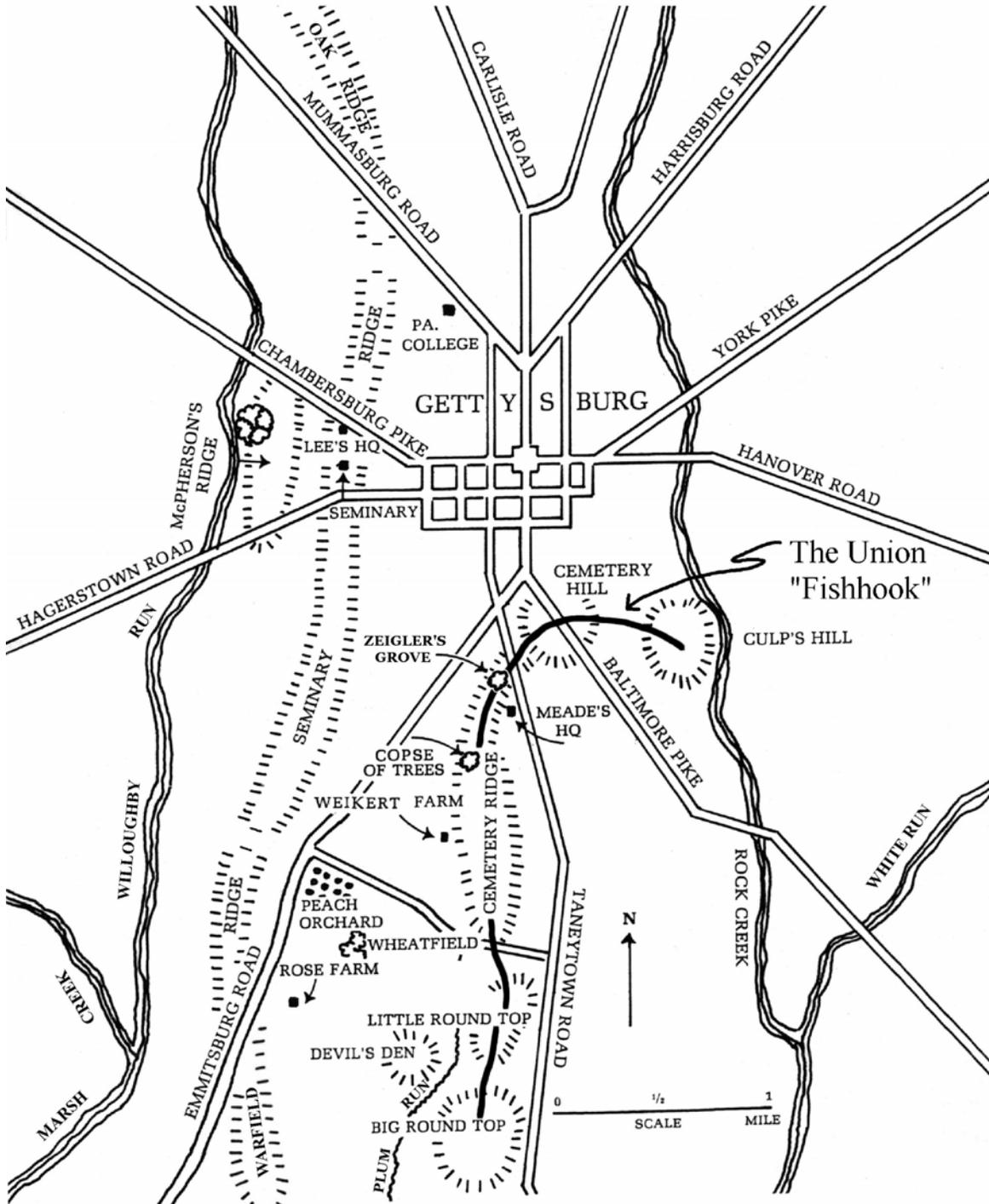
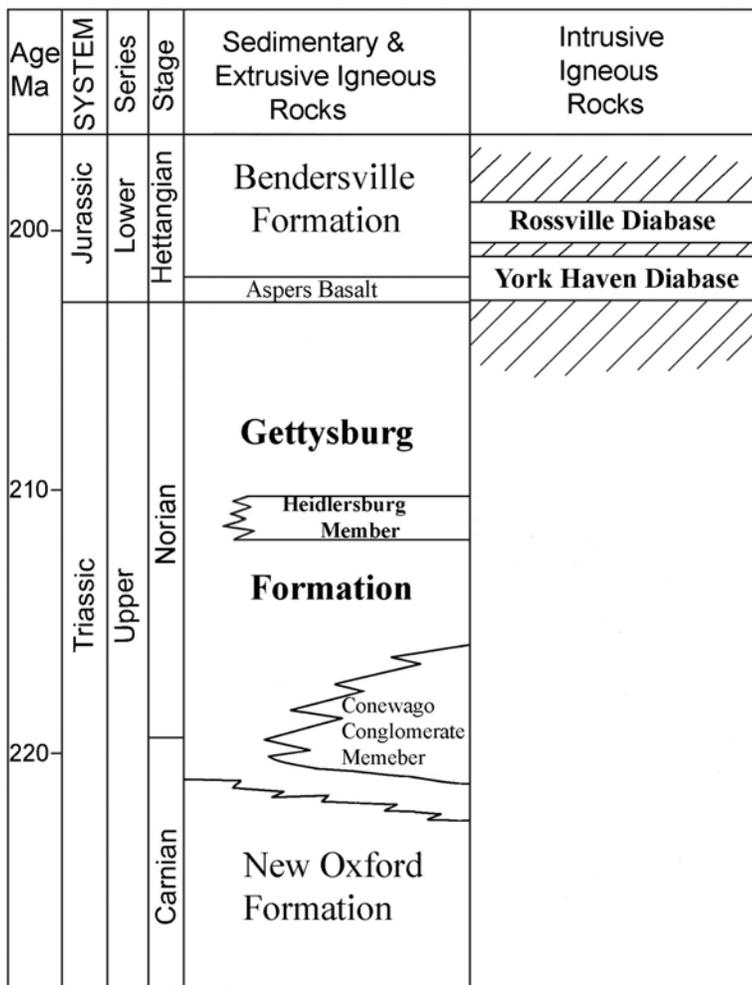


Figure 3. Some physical features of the Gettysburg battlefield, particular those relating to the Union “fishhook” (Modified from Frassanito, 1975, p. 11).

One of the major terrain influences on the battle of Gettysburg was the network of ten roads that radiated out from the borough at almost regular intervals toward other communities in Maryland and Pennsylvania (Figure 3). These roads not only provided the means by which both armies concentrated their forces at Gettysburg—though some Union 1st Corps brigades followed a rather circuitous route north from Emmitsburg, MD, on the first day (Kross, 2000; Roth and Kross, 2000)—but two roads to the west of town, the Chambersburg Pike and Fairfield Road, facilitated Lee’s retreat on July 4 - 5 and probably allowed him to carry off many more of his wounded than if he had to rely on a single road.

Less important—to transportation at the time of the battle, at least—were the railroads of the area. The only operating line into the borough in July 1863 was the Gettysburg Railroad (completed in 1858), which came in from the direction of Hanover, PA, crossing Rock Creek about a mile east of the town square. Nothing of much significance happened on the Gettysburg Railroad until November 18, 1863, when Abraham Lincoln and his entourage arrived on the railroad to participate in the dedication ceremonies of the Soldiers’ Nation Cemetery the following day. The station where Lincoln debarked is still standing on Carlisle Street just north of the town square (mile 24.3 of Day-2 Roadlog). Much more important to the battle scenario was Thaddeus Stevens’ old “tapeworm” railroad which, though uncompleted at the time, came into Gettysburg from the west (see STOPS 13 and 14).



Although the Gettysburg battlefield is dissected by numerous south-flowing streams (Figure 3), their names are impressed on history more for the intense fighting which took place across them than for any decisive influence which they exerted on the action. From west to east, the names are all familiar—Marsh Creek, Willoughby Run, Plum Creek, and Rock Creek. Blood ran in all of them, particularly the latter three. Willoughby Run slowed the Confederate advance on July 1 to a minor extent, and the wider and deeper Rock Creek interfered somewhat with their later attacks on the Union position at Culps Hill—but no such problems arose as for the Federals at Antietam (“Burnside’s Bridge”) in 1862 or for the Confederates at Monocacy in 1864. In fact, the battlefield lies entirely within the drainage basin of the Monocacy River, Marsh Creek and Rock Creek joining at the Pennsylvania-Maryland line about 8 miles south to form that historic river. (The Monocacy, in turn, flows into the Potomac River just southeast (downstream) of Point-of-Rocks, Maryland.)

Figure 4. Stratigraphic column showing sedimentary and plutonic rock units exposed in the Gettysburg basin (Smoot, 1999; Fail, 2003).

Stratigraphy and structure of the Gettysburg basin. The ages and stratigraphic relations of the sedimentary and igneous rocks of the Gettysburg basin are summarized in Figure 4. Total thickness of the sedimentary rocks in the basin is more than 20,000 feet (Smoot, 1999). The bulk of this fill is of Late Triassic age and constitutes the New Oxford (older) and Gettysburg Formations. Preserved at the extreme west margin of the basin about 14 miles north of Gettysburg is a 1000±-foot-thick sequence of red mudstone and basalt of Early Jurassic age recently designated the Bendersville Formation and Aspers Basalt (Weems and Olsen, 1997; Faill, 2003). Igneous intrusive rocks in the basin are dikes and sills of Early Jurassic age belonging to the York Haven Diabase (older) and Rossville Diabase (Smith, et al., 1975; Froehlich and Gottfried, 1999). The main diabase body in the southern part of the basin that is pertinent to the battle is the Gettysburg sill of York Haven Diabase. The major crosscutting intrusions in this part of the basin—the Seminary Ridge and Warfield Ridge dikes—are composed of Rossville Diabase (Smith, et. al., 1975; Froehlich and Gottfried, 1999).

Sedimentary rocks. The New Oxford Formation, which occupies low relief terrain in the southeastern part of the basin beginning about 5 miles east of Gettysburg, consists predominantly of red mudstone and siltstone and gray to reddish-brown arkosic sandstone (with beds of quartz-pebble conglomerate near the base) (Stose and Bascom, 1929; Smoot, 1999; Faill, 2003). Thickness of the New Oxford is about 6,800 feet (Smoot, 1999). Jubal Early's Confederate division crossed the northeast-southwest-striking outcrop belt of the formation in marching from Gettysburg to York on June 27-28, but met no hostile military forces along the way.

The much thicker Gettysburg Formation overlies the New Oxford and underlies the central and western parts of the basin, occupying a swath of relatively lowland terrain about 10 miles wide that is broken up by rocky hills and ridges underlain by intrusive diabase (see below). Total thickness of the Gettysburg Formation is about 15,000 to 18,000 feet (Smoot, 1999). The “undivided” Gettysburg Formation consists predominantly of grayish-red sandstone, siltstone, and mudstone (Stose and Bascom, 1929), with several intervals of gray shale and sandstone near the contact with the medial Heidlersburg Member west of town (see STOP 13). The Heidlersburg Member, 3200-4700 feet thick, is predominantly a cyclic unit composed of red, gray, and black shale, argillite, shale, and siltstone (Faill, 2003; Smoot, 1999), with numerous beds of hard, white sandstone (Stose and Bascom, 1929). This member underlies a distinctive terrain of alternating narrow, low ridges and swampy valleys about 2 miles wide in the west-central part of the basin. Much of the “1st day” was fought over ground underlain by the Heidlersburg and immediately subjacent “undivided” Gettysburg Formation (see STOP 13). The Conewago Conglomerate Member, 7,000 to 10,000 feet of quartzite- and limestone-pebble conglomerate, sandstone, and siltstone (Stose and Jonas, 1939; Smoot, 1999; and Faill, 2003) forms the Conewago Mountains in York County, about 20 miles northeast of the battlefield. Also mapped locally, but unnamed, within the “undivided” Gettysburg formation are several thick and areally extensive limestone conglomerate lentils along the edge of the basin just east of the South Mountain Front (Stose and Bascom, 1929; Smoot, 1999).

Early Jurassic-age sedimentary and extrusive igneous rocks occupy a small area along the northwestern margin of the Gettysburg basin northeast of Gettysburg and beyond the area of military operations. They constitute grayish-red siltstone and mudstone of the Bendersville Formation (about 750 feet thick) and dark-greenish-gray basalt of the Aspers Basalt (200 feet thick) (Weems and Olsen, 1997; Faill, 2003).

The Triassic sedimentary rocks on the battlefield are relatively unfossiliferous. However, blocks quarried from these formations several miles away and brought to construct bridges on the battlefield contain dinosaur footprints (see discussion of Plum Run bridge at STOP 8).

Intrusive igneous rocks. Intrusive into the Upper Triassic sedimentary rocks of the Gettysburg basin is a complex network of diabase sheets and dikes of Early Jurassic age (201 ± 1.3 Ma) (Froehlich and Gottfried, 1999). The diabase is typically medium dark gray to dark gray and is composed of calcic plagioclase and clinopyroxene, with accessory quartz and magnetite; hypersthene, biotite, and olivine also occur in places (Stose and Bascom, 1929; Stose, 1932; Smith et al., 1975). The rock of the large diabase bodies, most prominent of which is the Gettysburg sheet, is coarse grained and granular, with the plagioclase and pyroxene showing up as black and white or gray grains, respectively. The dikes and thin sills are dark and dense.

Two petrologic types of Jurassic diabase—the York Haven and the Rossville (Smith et al., 1975)—occur in the Gettysburg basin and form significant topographic features on the battlefield (see Figure 2). Both are quartz-normative (i.e., silica oversaturated) continental tholeiites. The slightly older York Haven Diabase is characterized by high TiO_2 , and the Rossville Diabase by low TiO_2 . York Haven Diabase forms the larger intrusive bodies in the basin, including the Gettysburg sheet, these bodies being characterized by thick cumulus orthopyroxene zones in the lower part (Froehlich and Gottfried, 1999). Rossville Diabase forms the narrow, steeply crosscutting Seminary Ridge and Warfield Ridge diabase dikes in the western part of the battlefield. (See STOPS 9, 10, 14, and 16 for further discussion of Jurassic diabase.)

Structure. As is typical of the other outcropping Mesozoic rift basins between New York and Virginia, the Gettysburg basin is a tilted fault block or half graben, with rock strata dipping $20\text{-}30^\circ$ into major normal faults on the northwestern side (Figure 5). Maximum width of the basin is about 18 miles northwest of York, narrowing to a 16-mile-wide cross section at Gettysburg. The straight traces of normal faults across high relief terrain along the northwestern margin suggest high-angle displacements, probably on the order of the $60\text{-}70^\circ$ SE dips of minor normal faults in the basin (Root and MacLachlan, 1999). Gravity data show that the deepest part of the basin lies toward the center (Sumner, 1977). Largely to explain this basin configuration, Root (1988, 1989) models the main border fault as a listric normal fault, being steep at the surface and flattening out at depth. Stose and Bascom (1929) show the main border fault as being buried two to four miles southeast of the faulted margin of the basin, at the edge of a platform composed of Paleozoic carbonates and capped by a thin veneer of Gettysburg Formation shale, sandstone, and limestone conglomerate.

Most of the fault displacement along the northwest margin took place after deposition of the sediments in the basin, i.e., “syndepositional faulting was negligible” (Root and MacLachlan, 1999, p. 304). In fact, Faill (2003) has recently proposed that the numerous rather discrete Mesozoic basins that snake through the western Piedmont between southeastern New York and southern Virginia originally constituted a single basin, the “Birdsboro Basin.” This 325-mile-long trough was then broken up by deformation (tilted, faulted, and folded) in post-Hettangian (Sinemurian) time after the deposition of the youngest preserved sedimentary rocks.

Military geology of the Gettysburg Battlefield. In 1868-69, then Major (a permanent, not brevet rank) Gouverneur K. Warren supervised the preparation of a detailed 1:2400-scale map of the Gettysburg battlefield, showing not only natural features but also fences, buildings (with basic construction materials noted), remains of entrenchments and artillery lunettes, and surveyed contour lines (Frassanito, 1995; which see for an excellent discussions of various pre-battle and post-battle maps of the battlefield and its environs). (The map, more than 12 feet square, is now housed in the archives of the Gettysburg National Military Park.) If engineer-topographer Warren had had the time and inspiration to prepare a *military geology map* of the battleground at Gettysburg, it would have looked something like Figure 6. This effort was inspired by a WWI “engineering geology military map” of the area around Cirey, France, illustrated in Kiersch and Underwood (1998, p. 15).

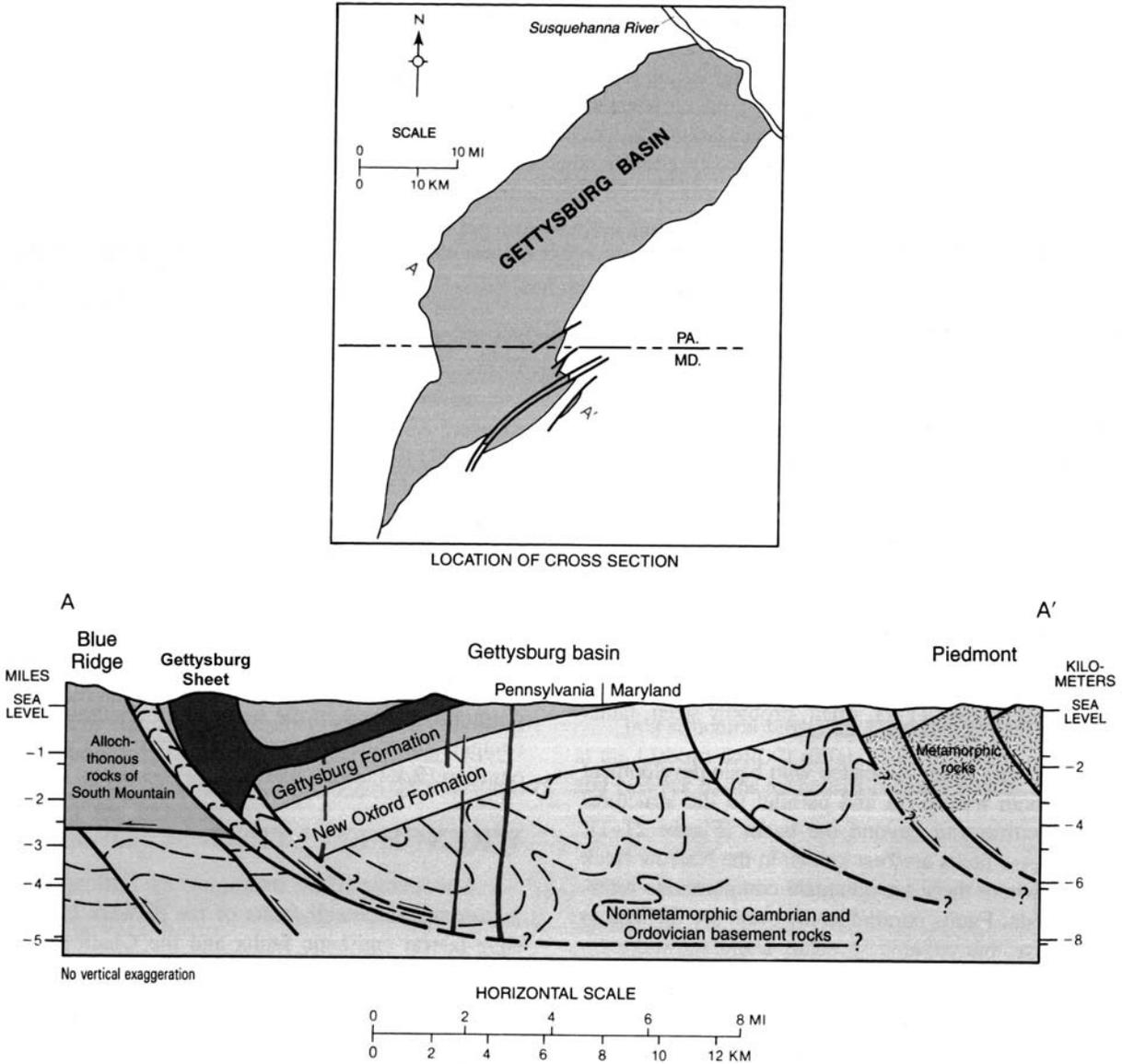


Figure 5. Geologic cross section through the Gettysburg basin (Root and MacLachlan, 1999, Fig. 21-5). The light, vertical lines are diabase dikes, and the heavy, dark lines are faults—the curved ones being listric normal faults.

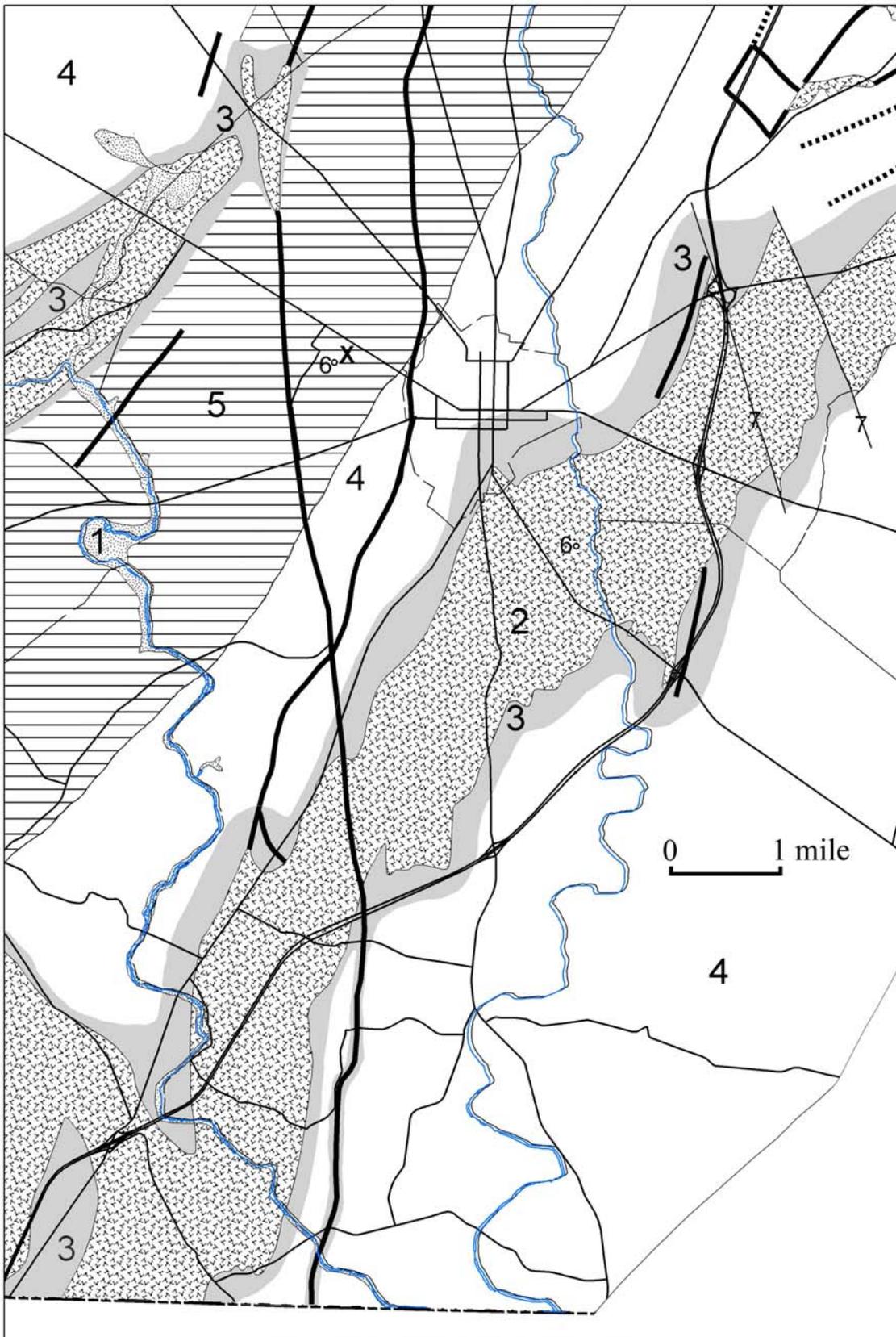


Figure 6. Military geology map of the Gettysburg area. (Based on Stose and Bascom, 1929.) See legend on facing page for explanation.

MILITARY GEOLOGY MAP OF GETTYSBURG AND VICINITY

DESCRIPTION OF FORMATIONS

1

Gravel, sand, and silt, with some clay

The only stream with significant level floodplain composed of unconsolidated sediment is Marsh Creek. Other streams such as Plum Run and Rock Creek flow through generally indistinct bottomlands locally choked with hard, rounded boulders commonly 1 to 3 feet in diameter. Thickness of deposits on Marsh Creek may range up to 6 feet or more.

Poor entrenching ground, wet and subject to floods.

Floodplain and bottomland sediments usually saturated, affording soft footing even during dry periods. Gravel- and sand-floored reaches better drained and more easily crossed, except during floods. Floods can occur in any month, but are more likely between March and May.

2

Diabase

Hard, gray crystalline rock forming narrow elongate ridges (west and southwest of Gettysburg) and stony hills and broad, bouldery ridges up to 0.5 mile wide (east and south of town.). Locally weathered and eroded to form bouldery lowlands, as along Rock Creek and between the Round Tops and Devil's Den. Abundant rounded cobbles and boulders provide good material for stone walls and breastworks, particularly effective when combined with soil from shallow entrenchments, fence rails, and felled trees. Broken ledges and large boulder accumulations provide limited cave shelters. Poor terrain for cavalry operations.

Soils are typically yellowish- to orangish-brown silty clay loams, thickness varying greatly over short distances but typically 3 feet or less. Soils range from well drained on ridges to poorly drained in low areas, particularly along Plum Run and Rock Creek.

Surface firm on slopes and ridge tops, soft and soggy along streams and in vicinity of springs.

3

Hornfels

Hard, gray to purplish-gray baked shale and sandstone. Forms moderately high terrain adjacent to large diabase masses, as along Emmitsburg Road southwest of Gettysburg. Shallow entrenchment possible, but boulders for construction of breastworks generally lacking.

Soils are dark-brown to dark-gray shaly silty clay loams, thickness typically 3 feet or more, usually well to moderately drained.

Surface firm, but locally may remain soft for considerable time after heavy rain.

4

Red sandstone and shale

Moderately hard (sandstone) to soft (shale), forming low and gently rolling terrain. Shallow entrenchment possible, but ground lacks boulders.

Trees for breastworks present along hedgerows and in scattered woodlots, and rail fences are common. Such fences are a major impediment to large offensive movements. Except for fences, excellent terrain for cavalry operations.

Soils are typically reddish-brown, shaly silty clay loams, less than 3 feet deep on higher tracts but 4 feet or more on lower slopes and in swales.

Soils are moderately to poorly drained, and tend to hold water near surface for long periods of time after heavy rains.

Surface of ground firm at most times, but stays soft for several days after heavy rain.

5

Gray sandstone, argillite, and shale

Moderately hard (sandstone and argillite) to soft (shale), forming narrow, elongate ridges west of Gettysburg. Shallow entrenchment possible, but ground lacks boulders for breastworks. Trees present along hedgerows and in woodlots, and rail fences are common. Fences may impede offensive movements. Railroad cuts through north-south linear ridges provide shelter for operations parallel to topographic grain, but must be used only if flanks covered as they may constitute traps for large bodies of infantry.

Soils are brown to dark-gray shaly silty loam, less than 3 feet thick on ridge crests. Soils are moderately to poorly drained.

Surface of ground usually firm, but may stay soft for long periods after heavy rain.

O 6

Locus of springs and seeps

These should be avoided as far as possible in the location of field works. Such works should be placed above the lines of springs.

7

Line of dislocation (fault)

Water is likely to occur along these lines, due to the zones of fracture.

X Quarry

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REGIONAL RIFTS AND THE BATTLE OF GETTYSBURG

R. C. Smith, II, and R. C. Keen

Not counting the rift between the North and the South, there is evidence for five periods of rifting in the mid-Atlantic region of eastern United States. The second and fourth of these directly bear on the Battle of Gettysburg. The first had a minor influence on the prelude and postlude to the battle but adds new meaning to “south.”

Traditionally, historians date the rift between the North and the South to the firing on Fort Sumter, South Carolina, on April 12, 1861, or possibly earlier with the introduction of slavery to produce labor-intensive crops. Geologists on the other hand, recognize much earlier rifting in the mid-Atlantic states beginning with Mount Rogers A-type granites and minor, possibly related basalts at 768 Ma (Rankin, 1993). As noted by Rankin, Mount Rogers is overlain by the glaciogenic Konnarock Formation. This together with Scotese’s (2003) reconstructions place the mid-Atlantic states *far* south with only one way to go. The northward drift of Laurentia over the Mount Rogers hotspot yielded a trace marked by the Robertson River Igneous Suite (RRIS, so named after the *Robinson* River) of central and northern Virginia at 735 to 702 Ma (Tollo and Aleinikoff, 1996). It produced a series of hills from near Charlottesville on the south to Ashby Gap, Virginia on the north-northeast. Ashby Gap itself is underlain by Catoctin Metabasalt but the foothills between it and Upperville to the east are underlain by the Cobbler Mountain Member of the Robertson River Igneous Suite (Table 1). Confederate General. "Pete" Longstreet used the Ashby Gap during Lee's northward march up the Shenandoah Valley on the west side of the Blue Ridge. The RRIS appears to retain its geochemical identity as far northeast as the Reading Prong of Berks County, Pa. Here, bimodal volcanics include 602 Ma A-type felsite dikes having RRIS-like geochemistry and continental initial rifting tholeiite (CIRT) basalts (Smith, 2003). Iron mining around these dikes supported the Union cause as it had previously supported an older rebel cause against Great Britain.

The second, ~570 Ma Catoctin rift (Aleinikoff et al., 1995), produced the Catoctin Mountains from near the latitude of Charlottesville, Virginia, nearly to Harrisburg, Pennsylvania. The portion of the Catoctin having a largely basaltic core extends from near Charlottesville to the Jacks Mountain-Tunnel Hill fault system (Fauth, 1978) southwest of Gettysburg and was effectively used by Lee to screen the Army of Northern Virginia from Union eyes. The portion of the Catoctin having a more rhyolitic core is located northwest of the Jacks Mountain-Tunnel Hill fault system and provided the final screen.

One of General Lee’s columns under the command of General A. P. Hill marched east from Cashtown around 5:00 A.M. on July 1st, essentially following the present trace of U.S. Route 30. This modern highway follows the Alleghanian-age Carbaugh-Marsh fault zone through South Mountain. At its crest, it crosses Catoctin Metarhyolite (Table 1). Confederate General "Pete" Longstreet's Corps followed A. P. Hill's late on July 1st. Some of Pennsylvania’s oldest quarries are located on the ridges south of Caledonia State Park overlooking the route of A. P. Hill’s Corps. These quarries were begun about 12.5 Ka b.p. by Native Americans and were worked extensively into the Late Woodland Period ending with Colonial contact. Weapons-grade metarhyolite occurs close to the trace of U.S. Route 30 suggesting a fairly narrow fault zone. The linearity of the zone (Hoskins and Root, 1977) suggests a high angle fault. Except for this Cashtown Gap route which crests at approximately 1400 feet (425 m), but had a good pike with gentle slopes through it, most other routes over the Catoctin metarhyolite and capping Cambrian quartzites provided rough ground having typical elevations of 1600 ± 100 feet (450 ± 30 m). The potential route from south west of Fairfield to Gettysburg would have required a crossing of

Table 1. Composition of rift volcanics associated with the battle of Gettysburg. RRIS dates from Tollo and Aleinikoff (1996), Catoctin dates from Aleinikoff et al, (1995), and Mesozoic dates from Sutter (1988) and Dunning and Hodych (1990).

RIFT	FIRST	SECOND	SECOND	SECOND	FOURTH	FOURTH
Sample Locations	Robertson River I.S., Cobbler Mountain Member, ~ 7 mi. S Ashby Gap	Catoctin Metabasalt, Pa. Rte. 16, W. Fountaindale	Catoctin Meta-rhyolite, Pa. Rte. 94	Catoctin Meta-rhyolite, U.S. Rte. 30, Cashtown Gap	York Haven Diabase, base sheet at type locality, York County.	Rossville Diabase, RR cut through Seminary Ridge
Nearest Troop Movement	Ashby Gap to N. held by Longstreet	J. Buford passed 6/28.	Part Ewell's Corps passed Pa. 34 1.33 mi. to W 7/1.	A.P. Hill's Corps passed early 7/1.	No samples from GNMP proper, but underlies Union fish-hook.	Area exchanged hands ~4 times 7/1.
Presumed Age, Ma	~722	~575	~575	~575	201.2	201.0
SiO ₂ %	72.45	44.41	77.72	78.39	51.51	50.55
Al ₂ O ₃	12.63	17.26	10.87	10.70	14.70	16.20
Fe ₂ O ₃ *	3.72	13.14	2.95	2.91	11.51	10.83
CaO	.27	8.49	.03	.06	10.53	11.15
MgO	.08	7.73	.09	<.01	6.48	6.80
Na ₂ O	4.45	1.79	2.37	4.12	2.23	N.A.
K ₂ O	4.83	.84	4.90	3.49	.65	.30
TiO ₂	.22	1.64	.21	.20	1.12	.70
MnO	.03	.19	.02	.01	.18	.13
P ₂ O ₅	.02	.16	.02	.01	.17	.10

*Total Fe expressed as ferric iron.

N.A. = Not analyzed, but typically 1.95+/- 0.2%.

1300 feet (400 meters) at Blue Ridge Summit and is not known to have been used by infantry during the advance. Horses, however, were not given a vote in selecting routes and Union General John Buford's calvary used this route to ride to Gettysburg leaving Waynesboro encamping on June 28 at Fountain Dale at approximately 750 feet (230 m) on Catoctin Metabasalt.

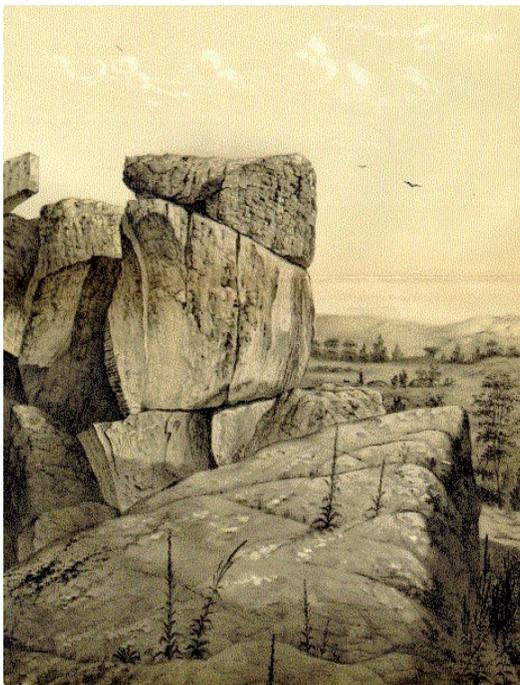
General Richard S. Ewell's 2nd Corps was also forced to cross South Mountain. Ironically, much of the 2nd Corps approached Gettysburg from Carlisle to the north. Ewell's corps generally followed what is now Pennsylvania Route 34. Unlike Hill, Ewell didn't have a linear fault to follow and had to cross elevations of up to 1000 feet (300 m) on more primitive, rural roads. Earlier, to get into the Shenandoah Valley on his approach to Gettysburg from Culpepper, Va., by way of Chester Gap, Ewell likely had to pass from the area underlain by the 4th rift to the 2nd, to the 1st, to the 2nd rift in an effort

to support the 6th, a political rift. Snickers Gap through Catoctin Metabasalt, approximately 27 miles (43 kilometers) to the northeast of Chester Gap was also held by Longstreet.

The third known rift occurred in the Lower Silurian and is not known to have directly affected the battle of Gettysburg. The third rifting may be a relaxational phase of the Taconian orogeny. The allochthonous Hamburg Klippe was emplaced during the Taconian orogeny and its western edge was briefly encroached upon by General Jenkins Confederate cavalry during skirmishing in the general area of Camp Hill, Cumberland County, and a brief reconnaissance thrust to Enola.

The fourth, known rift was the Early Mesozoic. The Triassic sediments in the Gettysburg basin provided the lower elevations preferred by armies, but they managed to converge on an area of Triassic sediments much affected by two lowermost Jurassic formations. These latter two diabbases cut generally fine-grained reddish mudstones and shales. The belt of the poorly defined Heidlersburg Formation from 1 to 3 miles west-northwest of the center of Gettysburg in particular shows evidence of an arid climate. Dinosaur footprints (Stose and Jonas, 1939), mud cracks, glauberite salt casts, and probable aeolian sand grains and are all consistent with an arid, sometimes lacustrine depositional environment for the Heidlersburg Member (Faill, 2003). Parts of the unit may be chemical precipitates somewhat similar to portions of lacustrine Locketong Formation in the Newark Basin. Minor interbedded sands in the Heidlersburg formed two gentle northeast-southwest trending gentle ridges to the northwest of town. At the opening of the battle on July 1st, Confederate General A. P. Hill's divisions deployed on the western of these, Herr Ridge, and made first sustained contact with Union General Buford's cavalry on the eastern of these, McPherson Ridge. The trend of both Herr and McPherson Ridges reveal the typical northeast strike of bedding.

Confederate positions for the second and third days of the battle were largely confined to the Gettysburg Formation. Like the Heidlersburg, the Gettysburg Formation is largely red shale and siltstone, but with less convincing evidence of an arid climate and is probably not lacustrine. The Gettysburg Formation supported decent to good roads for the final approach of the Union's main column from the southeast and south, but Union positions on Culp's Hill looked down on the Confederate positions on the Gettysburg Formation northeast of town on the second and third days.



OUTCROP OF TRAP AT THE DEVIL'S DEN NEAR GETTYSBURG, ADAMS CO., PA.

The Triassic red shale and siltstones in the area of the battlefield proper was first cut by locally crosscutting intrusive sheets of York Haven Diabase. In the battlefield area, Big Roundtop, Little Roundtop, Devil's Den, Cemetery Hill, Cemetery Ridge, and Culp's Hill, all noted Union positions that with the exception of Devil's Den successfully resisted repeated Confederate assaults July 2nd and 3rd, are underlain by York Haven Diabase (Table 1). In the Gettysburg Basin, the York Haven Diabase sheet has been estimated to be about 2,500 feet thick at the type locality (Smith, 1973). Outside the battlefield area, but still in the Gettysburg Basin, the York Haven Diabase also formed numerous 10 to 20-m-wide dikes (Berg, 1980) and one small basalt flow near Aspers, Adams County (Stose, 1932).

The York Haven Diabase is resistant to weathering relative to Triassic sediments and incredibly durable. Fractures through it must propagate through randomly oriented plagioclase and pyroxene laths, each in itself having complex cleavages. Today, York Haven Diabase is a highly desired dimension stone and provides high quality, durable

railroad ballast. At the high radon Index House in the Reading Prong of Berks County, it was even used to provide shielding outside basement walls from a high gamma flux from daughters of thorium and uranium (Smith et al., 1987). Throughout the battle, the York Haven Diabase, as Devil's Den or more typically as field stone fences, provided what little natural protection was available to the troops.

The York Haven Diabase has been dated at 201.2 Ma (median of three $^{40}\text{Ar}/^{39}\text{Ar}$ dates for lateral equivalents, Sutter 1988) and 201.2 Ma (best, clear fragments of zircon by $^{206}\text{Pb}/^{238}\text{U}$, Dunning and Hodych, 1990). The Rossville Diabase has similarly been dated at 201.0 Ma (median of 7 preferred zircon analyses for a small, unrecognized Rossville Diabase sheet, Dunning and Hodych, 1990). Rossville Diabase forms thin sheets elsewhere in Pennsylvania and Virginia. Unfortunately for Lee, no unoccupied sheets were available in the area of Gettysburg and even those elsewhere in the Gettysburg Basin are much less resistant to erosion than York Haven Diabase. Typically, the Rossville Diabase occurs as subvertical, ~10 to 20m-wide dikes. Hill's 3rd Corps had hard work against General Buford early on during the morning of July 1st and by approximately 10:30 AM against newly arrived General John F. Reynolds 1st Corps. To ultimately gain this one Rossville Dike, known as Seminary Ridge in the area of the battlefield, the North Carolina 11th and 26th Regiments suffered the highest percentage losses of the entire three-day battle at McPherson's Ridge. The Army of the Potomac's 1st Corps was decimated defending McPherson's Ridge with 24th Michigan Regiment under Col. Morrow and the 151st Regiment under Lieut. Col. McFarland suffered the Union's highest percentage losses of the entire three-day battle. All this to gain a dike that rose only on the order of 50 feet (15 m) above the surrounding Gettysburg shales and siltstones! Heavy Confederate pressure forced the units in the Union 1st and 11th Corps to withdraw through Gettysburg, where under the direction of Generals Hancock, Howard, and Doubleday, remnants of the Union's 1st and 11th Corps, respectively, secured the York Haven Diabase sheet at Cemetery Hill and Culp's Hill. This was followed not long afterward by arrival of General George Meade and Union occupation of the remainder of the York Haven Diabase hills in this area. The chemical compositions of the York Haven and Rossville diabases are shown in Table 1 from Smith et al. 1975.

Just as the rift between states began in the south, so too the rifting and drifting that resulted in the Mesozoic Basins progressed from south to north (Wythjack et al., 1998). On the other hand, diabasic igneous activity of any one composition was synchronous along the entire length of the Mesozoic Basins.

Union artillery largely positioned on the York Haven Diabase heights and under the excellent command of General Hunt was able to dominate much of the field during the battle. Shelling with properly set elevation could skim the west slope of Seminary Ridge and cause much destruction. Artillery aimed high by CSA General Alexander in preparation to Pickett's Charge on July 3rd caused relatively minor damage to the rear of the Union lines on Cemetery Ridge.

The difficult to impossible excavation characteristics of diabase generally prevented significant earthworks and likely contributed to both the effectiveness of Hunt's artillery and high battle casualties in general. An exception was on the northeast side of Culp's Hill where Union earthworks were effective when manned. Fortunately for the Union, General Greene did not dissuade his troops from fortifying their position despite the opposition of General Geary. Hand-dug wells in York Haven Diabase are virtually unknown, adding to the misery of troops cut off from water but provided a few opportunities for brotherly compassion.

Results of the 5th period of rifting during the Eocene consist of bimodal volcanics and doming believed to continue to the present day. However, these are presently recognized mostly in the areas of Highland County, Virginia and Pendleton County, West Virginia (Southworth et al., 1993). Quite possibly, the rough topography at McDowell, Virginia, used so skillfully by General Thomas J. "Stonewall" Jackson at the battle of McDowell, May 8, 1862, was in part the result of Eocene uplift.

After Jackson's death in May 1863, the Confederacy seemed to lack a general having his phenomenal sense of topography. His replacement, Gen. R. S. Ewell was slow to utilize topography during his command of the CSA 2nd Corps. In the Battle of Gettysburg, it was Union Generals Buford, Hancock, Howard, Warren, and others that seemed to most recognize the value of topography. General Warren (1872), for example, recounted: "At my suggestion, General Meade sent me to the left to examine the condition of affairs, and I continued on till I reached Little Round Top. There were no troops on it, and it was used as a signal station. I saw that this was the key to the whole position, and that our troops in the woods in front of it could not see the ground in front of them, so that the enemy would come upon them before they would be aware of it. The long line of woods on the west side of the Emmitsburg road (which road was along a ridge) furnished an excellent place for the enemy to form out of sight, so I requested the captain of a rifle battery just in front of Little Round Top to fire a shot in the direction of it. He did so, and the shot went whistling through the air the sound of it reached the enemy's troops and caused everyone to look in the direction of it. This motion revealed to me the glistening of gun-barrels and bayonets of the enemy's line of battle, already formed and far outflanking the position of any of our troops; so that the line of his advance from his right to Little Round Top was unopposed . . . I immediately sent a hastily written dispatch to General Meade to send a division at least to me, and General Meade directed the Fifth Army Corps to take position there." If Ewell recognized it, he lacked the drive to utilize it. As a result, other Confederate generals may have been ultimately intimidated by it. After the war, "Pete" Longstreet lamented "The enemy cast his lines on ground too strong for lead and steel, ..."

Years after the Battle of Gettysburg, retired CSA generals were frequently asked why "the cause" was lost at Gettysburg. General Pickett is reported to have provided the slyest answer: "I have always been of the opinion that the Yankees had something to do with it." Perhaps the York Haven Diabase did, too.

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THE LONGSTREET (OBSERVATION) TOWER: BATTLEFIELD TERRAIN AND SOUTH MOUNTAIN

Jon D. Inners

(Modified from Inners, et al., 2004, p. 55-59)

[On the morning of July 2] *I received instructions from the commanding general to move, with the portion of my command that was up, around to gain the Emmitsburg Road, on the enemy's left.*

Lieut. Gen. James Longstreet, C.S.A

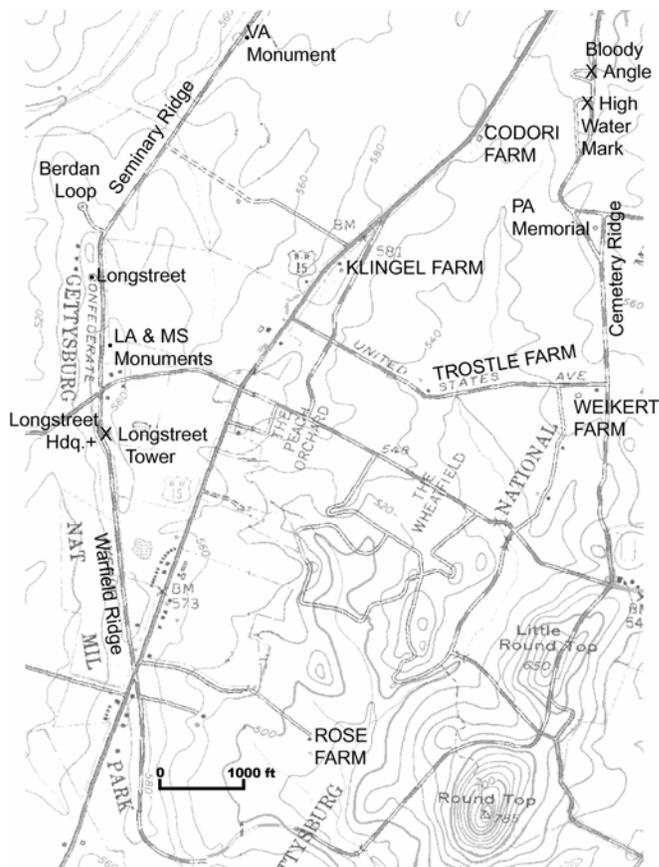


Figure 1. Location map for Longstreet Tower.

With the demolition of the 393-foot-high, privately owned Gettysburg National Tower (located on Cemetery Hill east of Taneytown Road) on July 3, 2003, the only remotely comparable spot for viewing the terrain of the entire battlefield is this National Park Service tower on Warfield Ridge (Figure 1). (The top of the Park Service tower on Culp's Hill stands only a few tens of feet above tree level and is especially limited in its "viewscape" from late Spring to early Fall.) The view from Longstreet Tower is especially effective in illustrating the effect of South Mountain in forming a shield between the movements of the Confederates in the Great Valley to the west of the mountain range and the Federals in the Piedmont to the east. Both gaps used by the Confederates in their advance and retreat from Gettysburg are visible from there, though neither one shows up especially well (see below). The tower also provides a good viewpoint for analyzing geological influences and terrain considerations for action on the Confederate right/Union left on July 2 and

the Confederate/ Union center on July 3.

At the top of the Longstreet Tower (so named because Confederate Lieut. Gen. James Longstreet's headquarters was located on the back side of Warfield Ridge at the upright cannon barrel just west of the tower), a small metal disk in the center of the platform is set up like a gunsight pointing to numerous points of interest on the battlefield and in the surrounding terrain. Approximate azimuths of some of these points are:

S65°W	Monterey (or Fairfield) Gap in South Mountain (Just east of the gap within the line of sight is McKee Hill, site of Ski Liberty.)
N45°W	Cashtown Gap in South Mountain.
N0°E	McPherson's Ridge and scene of 1 st Day's battle.
N15°E	Seminary Ridge and site of Lee's Headquarters.
N30°E	Borough of Gettysburg
N50°E	Codori Farm (near) and Cemetery Hill (far)
N55°E	Culp's Hill
N60°E	Pennsylvania Memorial on Cemetery Ridge
N65°E	Wolf Hill
N85°E	Peach Orchard
S60°E	Rose Farm and Little Round Top
S45°E	Devil's Den and Big Round Top

(Note that compass bearings from the tower are rendered inaccurate by its steel framework: the bearings were taken off the Adams County 1:50,000-scale topographic map.)

Warfield Ridge dike. The Longstreet Tower sits on the Warfield Ridge dike, one of two Rossville (Early Jurassic-age) diabase dikes that intrude the western part of the battlefield (the other being the Seminary Ridge dike [see STOP 14]). At this point, the Warfield Ridge dike strikes approximately N-S. It cuts across the Gettysburg sheet about a mile to the south, and intersects the Seminary Ridge dike about 0.5 miles to the north. About 4.5 miles north of the Longstreet Tower, the Warfield Ridge dike ends in a Y-shaped diabase body east of Seven Stars.

South Mountain. As noted previously, South Mountain is a broad anticlinal range that marks the northern end of the Blue Ridge physiographic province (Fenneman, 1938; Potter, 1999). In Pennsylvania, it extends from Maryland north-northeastward to Dillsburg, York County, 20 miles to the northeast of Gettysburg, where it “simultaneously” plunges out beneath younger Paleozoic strata and is cut off by faults along the northwest side of the Mesozoic basin (Berg, 1980). About 7 miles west of the tower, the mountain front rises abruptly from the Gettysburg-Newark Lowland (Figure 2), the boundary being a continuous series of steeply east-dipping normal faults that down-drop mostly lower Paleozoic strata on the southeast limb of the anticline. The highest mountain ridges are mainly underlain by resistant quartzites of the Precambrian-Lower Cambrian Chilhowee Group, with lower ridges typically formed of less resistant Precambrian Catocin metavolcanics (Potter, 1999). This distinction in the heights of the ridges underlain by the two main rocks sequences forming South Mountain can be seen clearly from the tower, the lower ridges (elevation 1400-1500 feet) along the eastern side being underlain by the metarhyolite and metabasalt and the higher ridges along the horizon (elevation 1800-2000 feet) being underlain by quartzites.

The battlefield from the tower. The Longstreet Tower provides a particularly good view of the field of action of the 2nd and 3rd days of the battle. As noted above, all of the main topographic features of the Union “fishhook” are visible—from Culp's Hill at the barb to Big Round Top at the eye. Though not very prominent topographically, Cemetery Ridge—the long shank of the hook—is marked by numerous monuments, the most prominent being the domed Pennsylvania State Memorial and the high obelisk of the United States Regulars Monument. On the afternoon of July 2, the two divisions of Longstreet's Confederate Corps (McLaws' and Hood's) attacked the Union left across the fields from the Codori Farm south to beyond the Peach Orchard (Figure 3, see STOP 11). On July 3 Pickett's Division of Longstreet's Corps (augmented by parts of Hill's Corps) struck the Union center on Cemetery Ridge north of the Codori Farm (“Pickett's Charge”) (see STOP 16).



Figure 2. View west from Longstreet Tower. In the distance is South Mountain, the higher ridges on the horizon being underlain by resistant quartzites of the Early Cambrian-age Chilhowee Group and the somewhat lower hills just to the east (particularly evident on the extreme right) being developed on less resistant Late Precambrian-age Catoclin volcanics. The prominent, lens-shaped ridge to left center is Jacks Mountain (elevation about 1600 feet), a fault block of Chilhowee quartzite. The hill just to the south and somewhat nearer the observer is McKee Hill (or Knob) (1160 feet) and is underlain by York Haven Diabase occurring in a “finger” trending southwest off the edge of the Gettysburg sheet. The low hill east of the north edge of Jacks Mountain is McGinley Hill (910 feet), formed of baked Gettysburg shale and sandstone (hornfels). The elongate, generally somewhat lower, wooded ridge in the middle distance, extending along most of the length of the view, marks the western, crosscutting part of the Gettysburg sheet. The low, gently rolling terrain between the outcrop of the Gettysburg sheet diabase and the tower is underlain by shales, sandstones, and argillites of the Gettysburg Formation (including the Heidlersburg Member). In the right foreground on the right is the Millerstown Road, a pre-battle road that to the east is now known as the Wheatfield Road.

The action of July 2 was initiated by Lee’s attempt to hit the Union left (with an attack also to be mounted against the Union right on Culps Hill. Though Longstreet wanted go around the Union left, outflanking the enemy and forcing him to retreat southeastward toward Washington (Longstreet, 1992), Lee decided to attack the Union left and defeat the enemy in place. But he based his plan on a faulty reconnaissance, and instead of working out as he had originally planned (Figure 4A), or even as Longstreet had interpreted it (Figure 4B), the attack ultimately developed as Maj. Gens. John B. Hood and Lafayette McLaws carried it out (Figure 4C; Trudeau, 2002) (see STOPS 9, 10, and 11).

Much of the confusion in the approach of the Confederates to the “turning” of the Union left arose because of Sickles’ movement out to the Peach Orchard and ultimately to the Emmitsburg Road after Lee’s initial reconnaissance (Trudeau, 2002). Because of the subtle elevation differences involved, it is difficult to grasp—even from this excellent vantage point—the rationale for Sickles’ movement to the west in the morning and early afternoon of July 2. Certainly he had in mind May the 3rd at the battle of Chancellorsville, when Confederate artillery battered the Union position from Hazel Grove—high ground that Sickles himself was ordered to abandon early on the morning of that day (Doubleday, 1994). As will be evident at STOP 16, the main Union line on Cemetery Ridge (which trended north-south just to the west of what is now Hancock and Sedgwick Aves.) is generally about 20 to 40 feet lower (elevation 540-560 feet) than the Peach Orchard. The crestline of the ridge is actually 1000 feet or more east of the avenues. (This figures prominently in the Confederate cannonade of July 3.) At the south end, the high part of Cemetery Ridge was also apparently wooded and would not have provided as clear a field of fire as from stone breastworks on the gentle west slope. Sickles described his initially assigned position as “an unsatisfactory line because of its marked depression and the swamp character of the ground between Cemetery Ridge and Little Round Top” (Trudeau, 2002, p. 294). Be that as it may, even if Sickles was “right” in his topographic analysis, he still made some grievous military errors. Not



Figure 3. View east from Longstreet Tower. The prominent monument in the left distance is the Pennsylvania State Memorial. The high, wooded hill farther back and to its right is Wolf Hill-Sheep Haven (maximum elevation 680 feet), underlain by York Haven Diabase of the Gettysburg sheet. The woods directly south of the memorial mark Cemetery Ridge, also York Haven Diabase. In the middle distance directly east of the tower is the Peach Orchard (elevation 580+ feet) (STOP 6), with the Emmitsburg Road along its northwestern edge. The Peach Orchard and the Emmitsburg Road are on hornfels along the northwest edge of the diabase sheet. When Sickles moved his 3rd Corps out from the south end of Cemetery Ridge, he formed a salient, the apex of which was at the southwest corner of the Peach Orchard (where the Emmitsburg Road intersects the right most park road visible in the photo). Kershaw's South Carolina Brigade attacked Sickles' salient across the open fields in the foreground. Barksdale's Mississippi Brigade struck the Union line along the Emmitsburg Road to his left.

as part of the massive artillery preparation for "Pickett's Charge" (see STOPS 15 and 16).

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only did he create a dangerous salient in the Union defensive position (see STOP 11), but he also formed a line that was too long for his two divisions (under Maj. Gen. David B. Birney and Brig. Gen. Andrew A. Humphreys) to defend. Even though Union artillery chief Brig. Gen. Henry J. Hunt saw certain topographic advantages to Sickles' new position, he noted "that it would so lengthen our line...as to require a larger force than the Third Corps alone to hold it" (Trudeau, 2002, p. 301-302).

Sickles paid a high personal price for his audacity. In the fighting that ensued once Longstreet launched his attack late on the afternoon of July 2, Sickles was seriously wounded, losing his leg. (The amputated leg was preserved on public display where Roger Cuffey passed it every day coming to work!) In the parking lot below the tower, note the Confederate cannons oriented to bombard the Union lines on Cemetery Ridge,

FROM LITTLE ROUND TOP TO THE FALLS OF ST. ANTHONY: THE TOPOGRAPHIC AND GEOLOGIC INSIGHTS OF GENERAL GOUVERNEUR KEMBLE WARREN (1830-1882)

Jon D. Inners

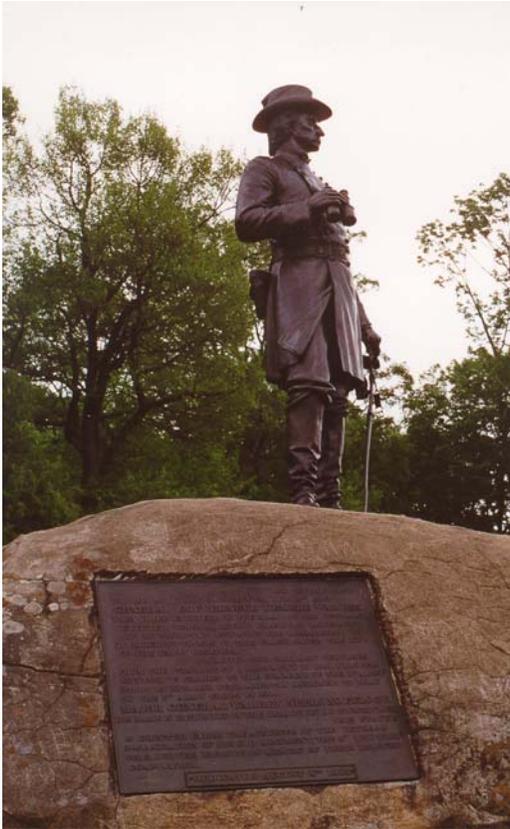


Figure 1. Bronze portrait statue of Maj. Gen. Gouverneur K. Warren on the summit of Little Round Top (*Site A* of STOP 9).

General Gouverneur K. Warren is well remembered in American history as the “Savior of Little Round Top,” the military engineer whose “eye for ground” rescued the left flank of the Union diabase fishhook at the Battle of Gettysburg. Less known are the successes and failures of his later Civil War career; and largely unrecognized is the fact that the hero of Gettysburg is the same G. K. Warren whose topographic and geologic insights helped to decipher the complex physiographic history of the upper Mississippi River region.

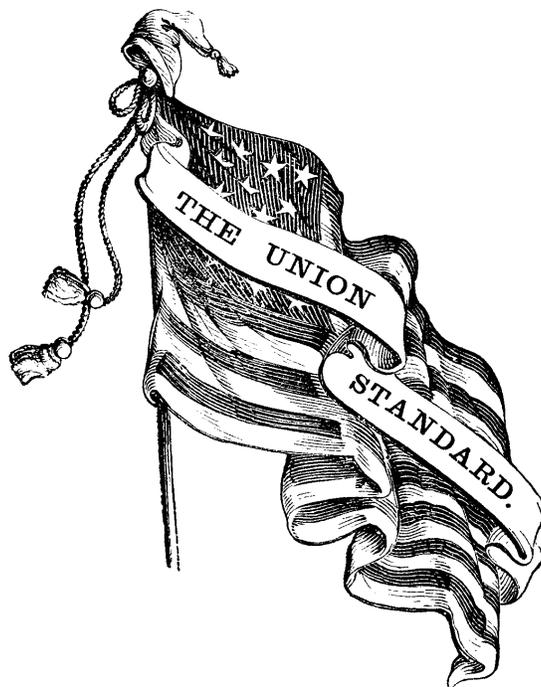
Born and raised at Cold Spring, NY, Warren graduated from West Point second in the Class of 1850 (but first in geology and mineralogy). Assigned to the Corps of Topographic Engineers, he surveyed and charted both the lower and upper reaches of the Mississippi River, explored the Nebraska and Dakota Territories, and led [an early expedition into the Black Hills]. In 1861 Warren entered the Army of the Potomac as a lieutenant-colonel, rising to Chief Topographic Engineer, Chief Engineer, and finally commander of the 5th Corps. But in the closing days of the war, his engineering mentality put him on a collision course with Phil Sheridan—and he was cashiered at Five Forks just days before the final Union victory at Appomattox. In his post-war career as a major of engineers, Warren performed distinguished service in supervising official and construction projects on the Mississippi and other Midwest rivers. On 21 November 1882, a military court of inquiry effectively vindicated Warren’s conduct at Five Forks, but he had died “a disgraced soldier” and been buried at Newport, RI, three months earlier.

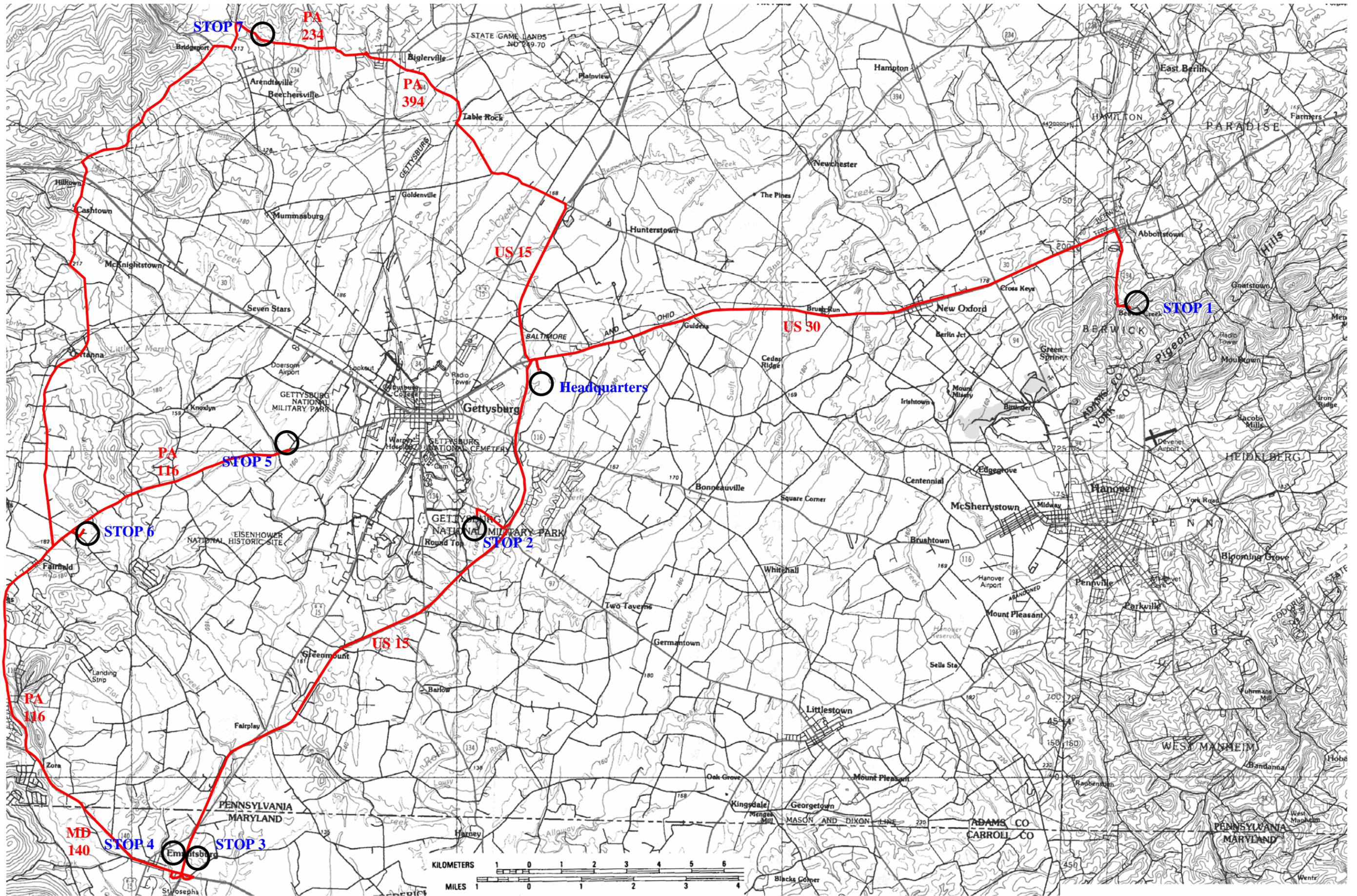
Warren’s insights relative to the geology of the upper Mississippi River region included recognition of: the Mississippi River valley as the former outlet of a large lake in the Red River of the North-Winnipeg basin (Glacial Lake Agassiz); initiation of the Falls of St. Anthony by outflow from this lake; and origin of Lake Pepin on the Mississippi River and similar lakes on the Minnesota River through deposition at the mouths of downstream tributaries. In 1884 Warren Upham fittingly named the ancient Ice Age river that initiated the present valley of the Minnesota the River Warren “in honor and in memoriam of Gen. G. K. Warren.” The “G. K.” would cause some confusion in future years—with one noted Minnesota historian crediting “George K. Warren” with the general’s work on Midwest rivers and other historians and geologists referring merely to “G. K.” Gouverneur Warren’s contributions to geology and engineering are substantial and warrant clarification of the historical record concerning this capable, but tragic individual.



Figure 2. The valley of the Minnesota River at New Ulm, MN (looking north from Riverside Park). Warren's observation on the grossly underfit nature of the Minnesota River from Brown's Valley to St. Paul led him to speculate that its great valley had been carved in late glacial/postglacial time by southward discharge of a vast lake in the basin of the Red River of the North.

Inners, J. D., 1996, Geological Society of America Abstracts with Programs, v., 28, no. 3, p. 66. (Poster paper presented at the meeting of the Northeastern Section Geological Society of America, Buffalo, NY, March 22, 1996.)



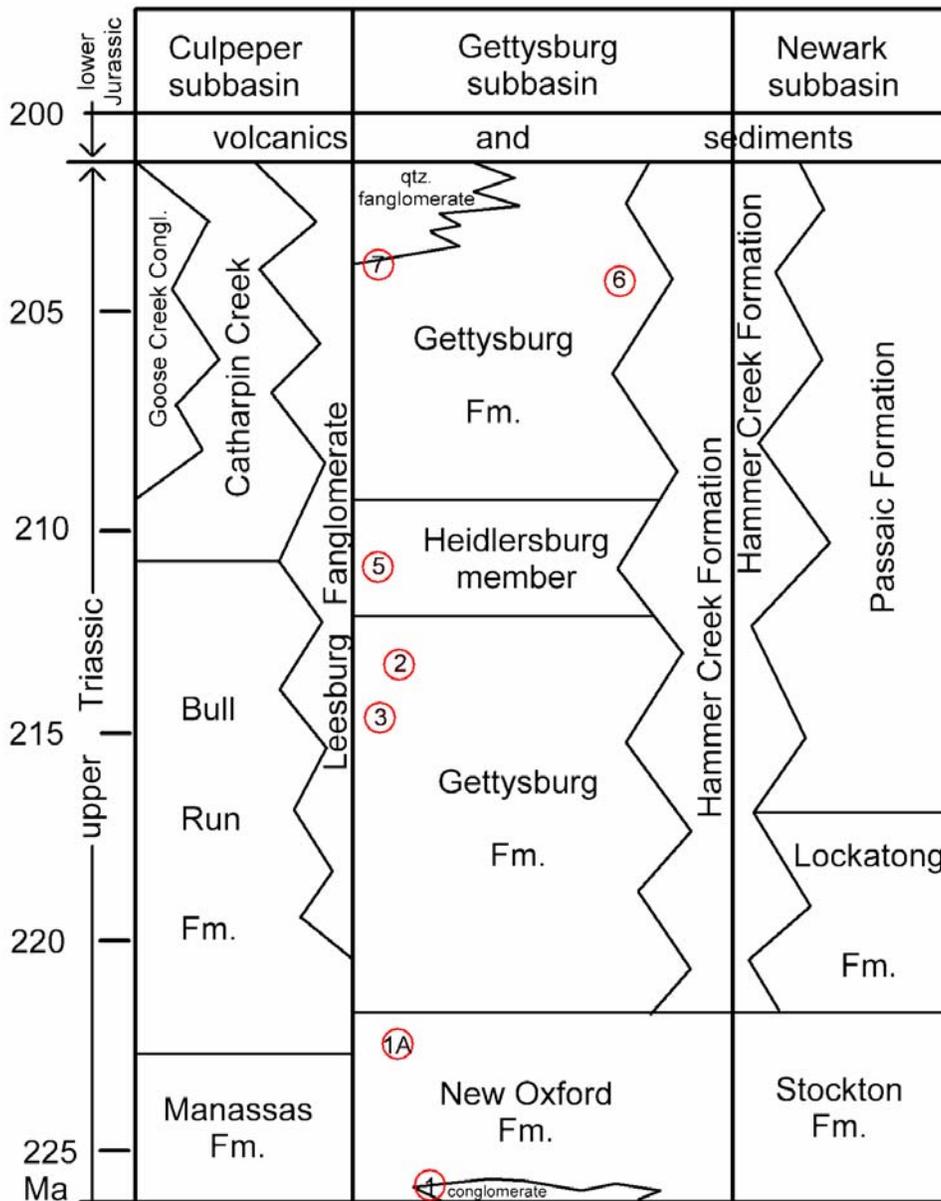


Day 1. Stratigraphy and sedimentation of the Gettysburg basin, one of four subbasins of the early Mesozoic Birdsboro basin.

The objective is to examine the various lithologies present in the Gettysburg basin, and to describe their mutual relations in three dimensions. From this, a basin architecture will be assembled, from which a sedimentologic and tectonic history can be inferred.

The Gettysburg basin is an elongate expanse of early Mesozoic rocks trending SW-NE across south-central Pennsylvania and central Maryland, from Frederick, Md. to Harrisburg, Pa. Structurally, the basin is monoclinial, with beds dipping moderately to the northwest. Stratigraphically, the oldest beds are exposed along the southeast margin, and the youngest along the northwest side.

Stratigraphic Correlation within the Birdsboro Basin



modified and simplified from Fail, 2003.

Circled numbers indicate the stratigraphic position of Day 1 stops.

The field trip will in general examine the major components of the stratigraphic section from the southeast to the northwest, from the oldest to the youngest rocks.

Mileage		Description
Interval	Cum	
0.00	0.00	Leave Wyndam Hotel
0.50	0.50	Traffic light. Turn RIGHT onto US 30 / York Road.
0.30	0.80	PHMC historical marker reads <i>A major cavalry engagement took place July 3, 1863, about one mile southeast of here. A succession of mounted charges by Gen. David McM. Gregg's Union force prevented Gen. J.E.B. Stuart's cavalry from reaching the Union rear and drove the confederates from the field.</i>
1.40	2.20	Cross Granite Station Road. This area has a number of references in names to granite, although there is no granite in the area. However, diabase is also known as black granite, and is the source for these granitic references.
4.80	7.00	PHMC historical marker reads <i>Conewago Chapel- Four miles south of New Oxford. Original Jesuit chapel built 1787 still in use and one of oldest in the United States. The mission was founded 1730. First Sacred Heart church in Pennsylvania.</i>
0.20	7.20	Enter borough of New Oxford
0.50	7.70	Enter the New Oxford square/traffic circle. Go counterclockwise, half way around the circle, staying on US 30.
0.10	7.80	Leave the square and continue on US 30.
1.30	9.10	PHMC historical marker reads <i>Gettysburg Campaign- Part of Gen. Early's Confederate army, under Gen. J.B. Gordon, passed here June 27, 1863, to York. Early's main force followed a parallel route through Hampton and East Berlin. Both entered York the following day.</i>
0.20	9.30	Intersection with PA 94 at Cross Keys. CONTINUE straight on US 30. View of the Pigeon Hills to the right. The Pigeon Hills are the northeast extension in Pennsylvania of the Blue Ridge anticlinorium. The Blue Ridge, lying west of the Gettysburg/Culpeper subbasins in Maryland and Virginia, is fault-truncated at the Maryland state line (see comments at mileage 45.10). Northeast from there, it passes underneath the Gettysburg basin and reappears as the Pigeon Hills on the southeast side of the Gettysburg subbasin.
0.30	9.60	PHMC historical marker- Gettysburg Campaign. Same text as at mile 9.1.
0.70	10.30	Stone marker on the left side of the road is an original mile marker along an early 1800s turnpike that eventually became part of the Pennsylvania Road, and later the Lincoln Highway. Carved into the stone are the mileages to Philadelphia (102), York (16), and Gettysburg (12). See http://www.waymarking.com/waymarks/WM1NCG , and http://freepages.genealogy.rootsweb.ancestry.com/~gentutor/Pa_Rd.pdf .
0.80	11.10	Enter borough of Abbottstown.



0.70 11.80 Enter the Abbottstown square/traffic circle. Go counterclockwise, ¼ way around the circle, and proceed south on PA 194.

1.60 13.40 TURN LEFT onto Maple Grove Road. Outcrop of basal fanglomerate of the New Oxford Formation to the right (see Figure 1-2).

0.20 13.60 TURN RIGHT onto Beaver Creek Road.

STOP 1. Basal fanglomerates of the late Triassic New Oxford Formation.
See stop description on page 69.

13.60 Leave STOP 1

0.20 13.80 TURN RIGHT onto PA 194 North

1.50 15.30 Enter Abbottstown square/traffic circle. Again go counterclockwise (not clockwise even though you're going the other direction now) ¾ of the way around and proceed west on US 30.

2.60 17.90 Intersection with PA 94 (Cross Keys). CONTINUE STRAIGHT.

1.10 19.00 Enter the borough of New Oxford.

Alternate route to STOP 1A

0.40 19.40 Enter the New Oxford square/traffic circle. Go counterclockwise, ¼ way around the circle and proceed north on Carlisle Street.

0.70 20.10 TURN LEFT onto Fleshman Mill Road.

0.20 20.30 Cross bridge over South Branch Conewago Creek. Fleshman Mill buildings on west side of creek.

0.30 20.60 Sharp (right-angle) turn to left

0.30 20.90 CSX Railroad crossing

STOP 1A. Upper beds of the late Triassic New Oxford Formation.
See stop description on page 73.

Leave STOP 1. Continue south on Fleshman Mill Road.

0.70 21.80 Intersection with Brickcrafters Road. Continue south on Fleshman Mill Road.

0.40 22.20 TURN RIGHT onto U.S. Route 30

0.40 19.40 Enter the New Oxford square/traffic circle. Go counterclockwise, half way around the circle, staying on US 30.

1.00 20.40 Cross South Branch Conewago Creek. Upstream, it is used by New Oxford for drinking water. During the drought of summer 2002, New Oxford received a scare when quarry dewatering and pumping of Hanover's emergency wells in Cambrian carbonate rocks a few miles upstream resulted in the opening of a series of large sinkholes that swallowed the entire creek for over a thousand feet during the course of nearly two weeks. Streamflow at New Oxford was significantly reduced but timely rain and remedial efforts helped avert a major crisis.

4.60 25.00 Cross Granite Station Road.

- 0.40 25.40 Moose Road on the right leads to the Gettysburg Moose Park, home of the annual Adams County Irish Festival held on the third Saturday in July.
- 1.00 26.40 Cross Cavalry Field Road. PHMC historical marker- Gettysburg Campaign. See mile 0.8.
- 0.40 26.80 Lincoln Highway marker, with Lincoln Highway logo, on right. Originally marked by telephone poles brightly painted with red, white, and blue stripes and a large letter "L," in 1928 the Lincoln Highway was blazed by more discreet concrete mileposts carrying a small bust of Lincoln; 3,000 of these were placed, one every mile, by Boy Scout troops across the land, but only around a dozen still stand. (From http://www.roadtripusa.com/routes/appalachiantrail/pennsylvania/app_lincolnhwy.html).
- 0.30 27.10 EXIT to the right onto US 15 South.
- 1.50 28.60 Hanover Street exit. CONTINUE STRAIGHT.
- 1.90 30.50 EXIT to the right onto the Baltimore Pike.
- 0.30 30.80 TURN RIGHT at the end of the exit ramp onto the Baltimore Pike.
- 0.50 31.30 PHMC historical marker reads
Gettysburg Campaign- The Union Army 12th Corps arrived here the afternoon of July 1, 1863; and later moved into battle line on Culp's Hill. On July 2, the 6th Corps arrived by this same road, and the 5th Corps by the Hanover Road.
- 0.10 31.40 Cross Rock Creek
- 0.10 31.50 TURN LEFT into the Gettysburg Quarry.
- 0.10 31.60 **STOP 2- Hornfels, thermally metamorphosed mudstones and siltstones of the lower part of the Gettysburg Formation, Gettysburg Quarry of Valley Quarries, Inc.**
See stop description on page 76.
- 0.10 31.70 Leave STOP 2. TURN RIGHT onto the Baltimore Pike.
- 0.70 32.40 TURN RIGHT onto the ramp to US 15 South towards Frederick, MD.
- 1.00 33.40 Triassic redbeds (Gettysburg Formation) exposed on the left side of the road.
- 0.60 34.00 View of Big and Little Round Tops to the right.
- 0.30 34.30 Exit to Taneytown Road. CONTINUE STRAIGHT.
- 1.70 36.00 View of Ski Liberty to the right
- 2.20 38.20 Cross Marsh Creek
- 0.20 38.40 Outcrops of diabase on right. This is the diabase sill that forms Cemetery Ridge on the Gettysburg battlefield.
- 0.10 38.50 Steinwehr Avenue exit. CONTINUE STRAIGHT.
- 0.80 39.30 Cross Middle Creek.



1.30	40.60	Cross the Mason-Dixon Line into Maryland and the Confederate States of America. Charles Mason and Jeremiah Dixon surveyed the boundary in 1764-1767 under royal orders to settle a protracted border dispute that arose from vague language in the land grants to William Penn and the Carrolls of Baltimore.
0.50	41.10	Rest area (lunch stop) on right.
0.60	41.70	EXIT to the right onto MD 140.
0.20	41.90	TURN RIGHT, staying on MD 140.
0.10	42.00	TURN RIGHT at the stop light, staying on MD 140.
0.20	42.20	TURN RIGHT onto ramp for US 15 North.
0.60	42.80	STOP 3- Mudstones, siltstones, and sandstones of the lower part of the Gettysburg Formation. See stop description on page 82.
		Leave STOP 3.
0.50	43.30	MAKE U-TURN onto US 15 South, and get into far right lane immediately.
0.30	43.60	EXIT RIGHT into rest area. STOP 4- Lunch. Leave STOP 4 and CONTINUE on US 15 South.
0.20	43.80	EXIT to the right onto MD 140.
0.20	44.00	TURN RIGHT, staying on MD 140.
0.10	44.10	At the traffic light, TURN LEFT onto MD 140 West into Emmitsburg. Emmitsburg is home to the National Emergency Training Center and Mount St. Mary's University, the oldest private independent Catholic college in the US.
0.50	44.60	Cross Seton Avenue in Emmitsburg.
0.50	45.10	View of the northern edge of the Blue Ridge (Catoctin Mountain) to the left. The Blue Ridge anticlinorium was truncated by a major northwest-trending cross fault (see comments at mileage 9.30). The displacement was largely dip-slip, down-on-the-northeast, by as much as 3 or 4 km. This fault was not active during the late Triassic because, not only does it cross most of the subbasin, there is no evidence that the fault affected any of the stratigraphy. As with the other faults in these subbasins, the age of movement was probably at the end of the early Jurassic, just as the Atlantic Ocean was beginning to form.
1.20	46.30	Cross the Mason-Dixon Line back into Pennsylvania and the Union.
0.50	46.80	Diabase outcrop on the right.
0.40	47.20	Diabase outcrop on the right. "Site R" on the ridge to the left. We could explain it more fully to you, but then we'd have to kill you.
0.30	47.50	Enter Carroll Valley Boro. When a land developer from Washington, DC opened the nearby ski area and golf course in the early 1960s as Charnita (now known as Liberty Mountain Resort), the plans included about 1,000 building lots for expensive vacation homes with on-lot wells and septic systems in an area underlain by Jurassic diabase and Precambrian metavolcanic rocks of the Catoctin Formation. Several homesites were sold and many unsuspecting buyers found the lots could not pass percolation tests for sewage disposal and/or did not provide

adequate well yields due to the hydrogeologic conditions. The developer eventually went bankrupt and lot owners opted to protect their investments by creating their own municipality to address infrastructure needs because of the indifference of township officials to their dilemma. Thus, the Boro of Carroll Valley was incorporated in September 1974 (Mowery, 1993). The boro is one of the largest by area in the Commonwealth and is still only about one-third developed. A unique feature of Carroll Valley is that all named boro streets are "trails."

- 0.30 47.80 TURN RIGHT onto PA 116 East.
- 0.10 47.90 Cross Miney Branch.
- 0.50 48.40 Lake May to the right. It is the largest of three lakes within Carroll Valley.
- 1.00 49.40 Cross Tom's Creek
- 0.70 50.10 Liberty Mountain Resort to the right.
- 1.40 51.50 Enter borough of Fairfield.
- 0.70 52.20 Cross Middle Creek.
- 0.50 52.70 Intersection with Bullfrog Road. Fairfield Quarry (Stop 6) to right.
- 0.50 53.20 Cross Muddy Run.
- 1.00 54.20 Granite Hill Campground on right. Another granite name in a granite-free area.
- 0.80 55.00 PHMC historical marker reads-
Lower Marsh Creek Presbyterian Church. Present building erected 1790 by a Presbyterian congregation dating from 1748. Later remodeled, its exterior preserves much of the old-style design.
- 1.20 56.20 Cross Little Marsh Creek. Sign incorrectly identifies it as Lower Marsh Creek.
- 0.80 57.00 Cross Marsh Creek. In addition to six wells, Gettysburg uses Marsh Creek as a water supply source. For source water protection purposes, the Land Conservancy of Adams County has purchased bargain-sale conservation easements on several properties totaling over 1,000 acres within the source water area for the creek. The Conservancy received a US Environmental Protection Agency Source Water Protection Award in 2006 for their efforts.
- 0.10 57.10 PHMC historical marker reads-
Gettysburg Campaign- On July 4, 1863, the Confederate Army began an orderly retreat by the Fairfield Road to the Potomac. They began crossing the river on the night of July 13, after a delay caused by high water.
TURN LEFT onto Breams Hill Road,
STOP 5- Heidlersburg Member, Gettysburg Formation.
See stop description on page 87.
- 0.10 57.20 Leave STOP 5. TURN RIGHT onto PA 116 West.
- 0.10 57.20 Cross Marsh Creek.
- 0.80 58.00 Cross "Lower"/Little Marsh Creek.
- 1.20 59.20 PHMC historical marker (see mile 57.10)
- 0.20 59.40 Intersection with GeoBob Lane.

0.50	59.90	Granite Hill Campground on right.
1.00	60.90	Cross Muddy Run.
0.20	61.10	View of South Mountain to the right, beyond golf course.
0.30	61.40	TURN LEFT onto Bullfrog Road.
0.20	61.60	TURN LEFT into the Fairfield Quarry.
		STOP 6- Ordovician Beekmantown? Carbonates, Fairfield Inlier, Fairfield Quarry of Valley Quarries, Inc.
		See stop description on page 96.
		Leave STOP 6.
0.10	61.70	TURN LEFT onto PA 116 West.
0.50	62.20	TURN RIGHT onto Carrolls Tract Road.
1.40	63.60	Cross Rattling Run. Small outcrop and float of dolomite on left, suggesting that the Fairfield inlier extends at least this far north, and is not confined to the immediate Fairfield area.
1.00	64.60	Historical marker to left- Army of Northern Virginia.
1.50	66.10	Knouse Foods Orrtanna fruit processing plant on left.
0.60	66.70	Cross Little Marsh Creek (signed correctly).
1.40	68.10	TURN RIGHT onto Orrtanna Road at the 3-way stop sign.
1.00	69.10	TURN LEFT onto Old Route 30 in Cashtown.
0.10	69.20	Cashtown Inn (haunted) ahead as we TURN RIGHT onto High Street.
0.60	69.80	CROSS US 30 (Lincoln Highway) and CONTINUE STRAIGHT onto Cashtown Road.
0.70	70.50	Historic Round Barn on right. The barn was built by Noah Sheely in 1914 as a replacement for a conventional barn that was lost in a fire. Legend says that round barns were designed so that the devil could not find a corner to hide in. The Adams County fruit industry was born at this farm when Sheely planted the first large commercial apple orchard in 1878 (Shirk, 1980).
0.30	70.80	Winery on left.
1.30	72.10	Hills to left underlain by quartz fanglomerates.
1.60	73.70	Enter borough of Arendtsville. TURN LEFT onto High Street.
0.05	73.75	TURN RIGHT onto Main Street / PA 234 East.
0.35	74.10	Cross Conewago Creek
0.20	74.30	TURN LEFT onto Mill Road.
0.50	74.80	TURN LEFT onto Heckenluber Road.
0.50	75.30	STOP 7- Pleasant Dale Creek Fanglomerate.
		See stop description on page 107.
		Leave STOP 7 via Heckenluber Road towards Biglerville (back the direction from which we came).
0.40	75.70	3-way STOP SIGN. TURN LEFT onto PA 234 East (Arendtsville Road).

1.10	76.80	Enter borough of Biglerville. TURN RIGHT onto PA 394 East.
0.50	77.30	Cross Main Street. CONTINUE STRAIGHT on PA 394 East. Musselman's food processing plant on the right.
1.70	79.00	Cross Conewago Creek.
0.30	79.30	TURN LEFT following PA 394 East.
2.30	81.60	4-way STOP SIGN. CONTINUE STRAIGHT on PA 394 East, crossing the Old Harrisburg Road (Business US 15).
0.40	82.00	TURN RIGHT onto ramp for US 15 South.
1.60	83.60	Cross Rock Creek.
1.30	84.90	EXIT to right onto ramp for US 30. Get in left lane.
0.40	85.30	TURN LEFT at the TRAFFIC LIGHT onto US 30 East.
0.40	85.70	TURN RIGHT onto Gateway Boulevard into the Gateway Gettysburg complex, and the Wyndham Hotel.
		END OF DAY 1.

REFERENCES

- Mowery, J.R., 1993, Borough of Carroll Valley, in Britcher, R.W., (ed.), South Mountain and the Triassic in Adams County: Guidebook for the 12th Annual Field Trip of the Harrisburg Area Geological Society, May 22, 1993, p. 11-12.
- Shirk, W.R., 1980, A guide to the geology of south-central Pennsylvania: Chambersburg, Pa., Robson and Kaye, p. 61 - 62.

STOP 1. Basal conglomerates of the late Triassic New Oxford Formation.

Leader: Rodger T Fail.

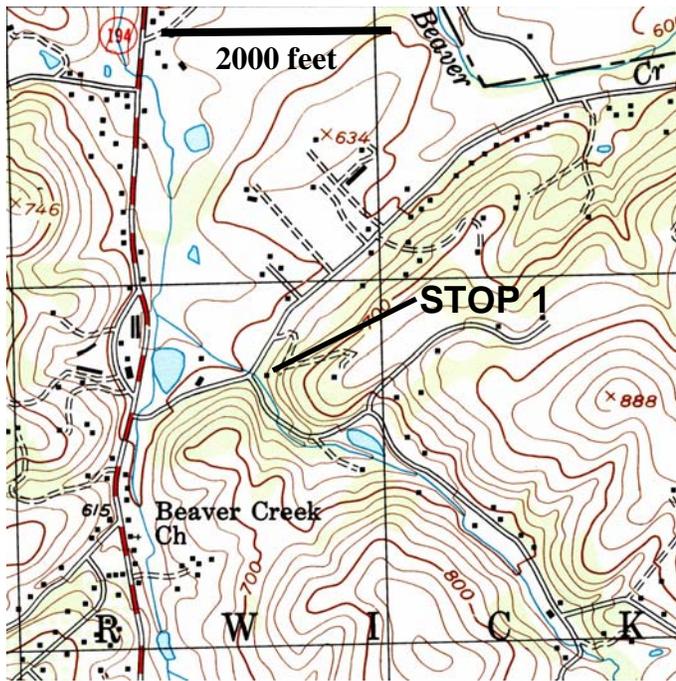


Figure 1-1. Location map for STOP 1. From Hanover 7½' quadrangle.

Location and basin setting. Stop 1 is located 2.4 km south of Abbottstown, Pennsylvania, east of Pa. Route 194, immediately southeast of the T-intersection of Beaver Creek Road with Maple Grove Road, above the east bank of Beaver Creek (Figure 1-1). Stop 1 lies in the Hanover 7-½ minute Quadrangle, at Lat 39° 51' 55" N (39.8653°), Long 76° 58' 47" W (76.9797°). The outcrop lies on private property, owned by Mr. and Mrs. R. Scott Miller, 139 Maple Grove Road, Hanover, PA 17331.

The rocks in this outcrop lie near the base of the New Oxford Formation, approximately 70 m above the basal unconformity on the metabasalts of the late Neoproterozoic Pigeon Hills Metabasalt. The Pigeon Hill Metabasalt is exposed 175 m south of Stop 1, just east of the driveway to 81 Beaver Creek Road, but the unconformity itself is covered. The Stop 1 outcrop represents the earliest sediments of the Birdsboro basin in this area.

An excellent exposure of this conglomeratic sandstone is on the west side of Pa. Route 194, some 400 m west of Stop 1, near the T-intersection of Maple Grove Road with Pa. 194 (Figure 1-2). It is risky to stop there, being suitable for no more than a few persons at one time, because of the very narrow shoulder and the rather heavy, fast traffic.

Description. Stop 1 displays thick- to very thick-bedded (40-120 cm) mixed conglomerate and conglomeratic sandstone beds (Figure 1-2). Beds are generally parallel-bedded, but some bedding surfaces are very irregular because of local erosion and channel development. Channels are definitely present within or at the top of single beds, but the profusion of large clasts often obscures their presence. Current



Figure 1-2. Overview of outcrop along Pa. Route 194.

Fail, Rodger T (2008) STOP 1. Basal conglomerates of the late Triassic New Oxford Formation, *in*, Fleeger, G.M (ed), Geology of the Gettysburg Mesozoic Basin and Military Geology of the Gettysburg Campaign, 73rd Annual Field Conference of Pennsylvania Geologists, Gettysburg, PA, p. 69 – 72.



Figure 1-3. Densely packed clasts in New Oxford conglomerate. Large clast in lower left is 11 cm across.

(Figure 1-3). Clast density varies somewhat from bed to bed, especially at bedding contacts. In the highest density beds, the clasts have 1 or 2 point contacts with other clasts. Most of the clasts are from 1 to 10 cm in size; perhaps 15% have one dimension more than 10 cm; the largest cobble seen was 30 cm in length. The clasts are mostly subrounded, but some are subangular or well rounded (Figure 1-4). The matrix is generally fine- to coarse-grained sand with subordinate silt—mud appears to be absent. There is a vague suggestion in one or two beds, not clearly shown, that there may be a tendency for smaller clasts in the upper part of a specific bed, a fining upward tendency. Some imbrication of a few flatter clasts also occurs and indicates current flow direction in the presumed correct direction.

Pebble compositions are predominantly quartzose sandstones (quartzites), and subordinately vein quartz. The sandstones are fine- to very coarse-grained, medium- to medium-light gray, with up to 10% being dark gray. The vein quartz, usually white, tends to be more angular than the quartzites, and, if analyzed in detail, would probably be smaller in overall size than the quartzites. Clast lithology does not include metabasalt, schists, gneisses, or carbonates.

Pigeon Hills Metabasalt of the Neoproterozoic Catoctin Formation underlie the northern side of the Pigeon Hills just to the south. The contact between the base of the New Oxford Formation and the underlying Catoctin metabasalts is covered along Beaver Creek Road, but red soil washing down over the metabasalt outcrop attests to proximity of Triassic red beds immediately above. The contact is presumed to be an unconformable



Figure 1-4. Rounded clasts in New Oxford conglomerate.

directions are not readily obvious, but one prominent channel fill in an overhanging bed trends 030 degrees azimuth. Relative to the enclosing bed thickness, channels are somewhat small, up to 20-40 cm in thickness and 1-4 m wide. A distinctive example lies in the top 20% of one prominent bed of a conglomeratic (mostly cobbles) sandstone. This channel is sandier than the main bed, with only a few pebbles up to 1 cm in size, all matrix-supported. The sandy part is not continuous along the entire exposure of the bed, but has a lateral extent/length of only 10+/- m.

The pebble and cobble clasts dominate these rocks, constituting from 50 to 75 percent of the rock

overlap from relations elsewhere along the southeast basin margin. These basal New Oxford beds are grayish-red, thick-bedded conglomeratic sandstones, but some are less dense with pebbles and cobbles (with respect to the Stop 1 exposure), channels are less common, and bedding surfaces are more evident. The Pigeon Hills Metabasalt rocks are grayish-green metabasalts, some with a granular texture whereas other finer-grained parts exhibit a foliation/cleavage.

Bedding dips (on average) moderately to the northwest, at 336-23 (dip vector, in azimuth and plunge). In the Pa. Route 194 exposure, undulose but overall rather planar fractures dip steeply to the northwest (300-80). Slickensides appearing on of these fractures plunge moderately steeply to the southwest (210-66).

Significance. These conglomeratic sandstones at Stop 1 are not characteristic of the basal New Oxford Formation along the entire southeast margin. The limited lateral extent (10? km) of these conglomeratic layers suggests that this area was the locus of one of the larger streams bringing sediment from the southeast into the basin. The absence of coarse material to the northeast and southwest along the southeast basin margin supports this interpretation. Five kilometers to the southwest, the presence of a 50+/- m-thick interval of limestone and marl some 200 m above the basal contact indicates a period of quiet, low energy largely non-clastic deposition away from the higher-energy fluvial environment at Stop 1. To the north-northeast of Stop 1, the presence of a 30 +/- m-thick interval of conglomeratic sandstone ~575 m above the basal contact indicates a particularly energetic influx of coarse sediment, and a possible lateral shift of the input stream channel. These limited intervals and lateral extents of different lithologies suggest a continually changing, shifting, and temporary presence (for some) of the various depositional environments on the bajada.

Back at Stop 1, the profusion of clasts, the large clast size, and the absence of mud in the matrix indicate a very high-energy fluvial environment. Internal channels point to temporary scouring during the deposition of each bed, but the absence of bedding within the thick and very thick beds argues that each bed was a single depositional event. The parallelism of the beds suggests that the deposition was basically constructional, with little erosion or reworking of the underlying bed by the subsequent incoming material. Evidently, the overall accumulation was episodic, in which a period of unknown duration existed between each depositional event (each bed) during which no deposition occurred.

The composition and shape of the conglomerate clasts reveals information about the source area and topographic setting at the basin southeast margin. The arkosic composition of much of the New Oxford Formation indicates that the source for it lay in the metamorphic rocks southeast of the basin—no similar source was present to the northwest at that time. The Pigeon Hills immediately southeast of the basin is a northeastern extension of the Virginia/Maryland Blue Ridge and consists of a volcanic core of Pigeon Hills Metabasalt overlain by the late Neoproterozoic and early Cambrian Chickies/Chilhowee quartzites and quartzose sandstones. The lithic similarity of these rocks to the conglomerate clasts, and the absence of any other similar rocks in the nearby Piedmont, points to the Pigeon Hills being emergent and the source.

However, the roundedness of the clasts suggests some moderate transport, certainly not less than ~5 km. The subrounded shapes represent transport of perhaps 10 to 30 km, and probably not more than 100 km. This would indicate that the Chickies/Chilhowee units were not present nearby, that this quartzose cover had been widely breached on the north side of the Pigeon Hills, exposing the underlying Catoctin metabasalts. If so, why are there no metabasalt clasts in these basal conglomerates? Three possibilities come to mind. One, the metabasalts may not be tough enough to be transported, even a few kilometers, without disintegrating into sand or smaller grains. This alternative seems to be supported by the lack of Catoctin Metabasalt clasts amongst those from the Catoctin Metarhyolite occurring abundantly in the Mesozoic fanglomerate at Stop 7.

The second possibility is that, during the preceding middle Triassic, the drainage of the Alleghanian orogenic core was to the northwest in this part of the Appalachians. Initiation of the Birdsboro basin at the beginning of the late Triassic interrupted this northwest transport, causing of the previously through-going sediment to begin accumulation in the new basin. If the streams crossing the eroded metabasalts were nearly at grade, at least locally in the Pigeon Hills, neither eroding nor depositing, then very little of the metabasalt would have been ripped up and included in the conglomeratic clasts. On the other hand, farther upstream toward the headwaters, the streams were not at grade and were actively eroding the quartzose layers. These coarse sediments were carried across the metabasalt terrane and deposited just inside the basin. As the basin filled, the basin margin advanced southeastward over the onlap, overlaying the late Triassic New Oxford sediments directly onto the exposed metabasalts.

The third possibility is that this depositional stream developed rapidly and traversed relatively fresh metabasalt that was not readily susceptible to erosion, particularly by a stream that was primarily depositional, i.e. with a full bed and suspended load. What little metabasalt that may have been eroded could have been deposited before it reached this stop, or the large, quartzose clasts could have disintegrated the metabasalt by crushing and abrasion.

The accumulation of sediment in the Birdsboro basin probably began some distance to the northwest of Stop 1, closer to the present center of the Gettysburg subbasin (by analogy with the Newark subbasin). The gradual rise of the basin floor on the northwestern side blocked the through-going streams and reduced the stream gradients, causing the streams to drop their traction loads. With time, because of the gentle basin floor slopes, succeeding layers spread wider, encroaching up the gentle margin slopes as overlaps. This same process was occurring on the northwestern side of the basin, as will be argued at Stops 6 and 7. Here at Stop 1, the streams at grade outside the basin became under grade at the basin margin, and began depositing the sediment we see before us. Hence, through winnowing, the coarser fractions of the traction loads were deposited near the basin margins, whereas the finer-grained fractions were carried farther into the basin. We will see two different aspects of the more distal deposits at Stops 3 and 5.

STOP 1A. Upper beds of the late Triassic New Oxford Formation.

The 2008 Field Conference will not visit this Stop. It is included for reference, and for later individual visits. Note that the CSX Railroad grants no permission to anyone to enter upon their property, and will prosecute anyone so found by them. Stop description by Rodger Fail.

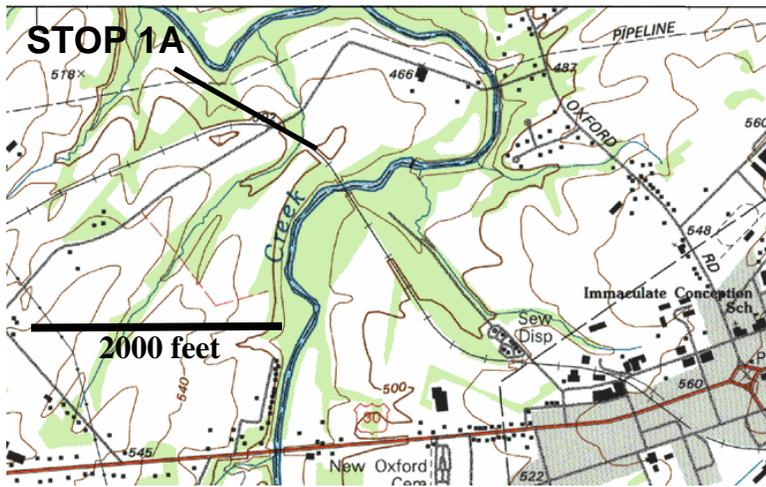


Figure 1A-1. Location map for STOP 1A. From McSherrystown 7½' quadrangle.

Location and basin setting. Stop 1A extends along a cut on the northeast side of a short stretch of the CSX Railroad, 1.6 km northwest of New Oxford (Figure 1A-1). The east end of the exposure lies 73 m west of the west abutment of the railroad trestle over South Branch Conewago Creek and continues westward semi-continuously along the track for 79 meters. Fleshman Mill Road crosses the track 145 m farther west. Stop 1A lies in the McSherrystown 7-½ minute Quadrangle, at Lat 39° 52' 14" N (39.8706°), Long 77° 04' 21" W (77.0725°).

This exposure lies 1750 m stratigraphically above the base of the 2400-m-thick New Oxford Formation. These beds are characteristic of the upper, finer-grained portion of the bajada deposited along the southeast side of the Birdsboro basin.

Description. This upper part of the New Oxford Formation displays an upward-fining cyclicity characteristic of fluvial environments. The basal beds are gray, arkosic sandstone, the overlying beds are transitional gray and red siltstones, and red silty mudstones dominate the upper part. One complete cycle is present here, overlain by the basal beds of the succeeding cycle.

The basal part of the upward-fining cycle consists of gray (yellowish-weathering) arkosic sandstone (Figure 1A-2). The sandstones are medium gray, fine- to coarse-grained, and rich in feldspars. The bedding is medium- to thick-bedded (20-50 cm), parallel-bedded, and planar-bedded. Muscovite flakes are present in quantities



Figure 1A-2. Arkosic gray thick beds in base of New Oxford cycle.

Fail, Rodger T (2008) STOP 1A- upper beds of the late Triassic New Oxford Formation, in Fleeger, G.M (ed), *Geology of the Gettysburg Mesozoic Basin and Military Geology of the Gettysburg Campaign*, 73rd Annual Field Conference of Pennsylvania Geologists, Gettysburg, PA, p. 73 – 75.

ranging from rare to fairly common. This arkosic gray interval is 9 m thick, and it overlies grayish-red silty mudstone immediately to the east. *Sample MS-1A* was collected from this interval.

Overlying the basal sands, a 4-m-thick sequence of finer-grained beds displays upward-fining cycles. These beds are gray (weathering grayish-red), with grain size decreasing upwards from very fine sand to medium and fine silt. A 1-m-thick group of arkosic sandstone beds in the upper part reflects a short-term return of basal-type sedimentation. *Sample MS-1B* of very fine-grained sand was collected from the lower part of a bed. *Sample MS-1C* of fine to medium silt was collected from the upper part of a bed (See Table 1A-1 for XRD analysis).



Figure 1A-3. Interbedded grayish-red siltstones and silty mudstones in middle part of New Oxford cycle.

cyclicality. Within this sequence, a single 25 cm thick bed of light gray fine-grained sandstone represents a brief return to coarser-grained deposition. *Sample MS-1D* was collected from a grayish-red siltstone (See Table 1A-1 for XRD analysis). *Sample MS-1E* was taken from the light gray sandstone.

This pattern of alternating sequences of siltstones and silty mudstones (all grayish-red) continues upsection for another 11 m, but with a significant lessening in the number of siltstones. The 20-50-cm cyclicality is alternating (non-directional), with rather sharp, but irregular, tops and bottoms. The

siltstones are thin-to-medium-bedded, with irregular, but sharp, tops and bottoms. Burrows can be found but are not common. Small (~1/2-mm) muscovite flakes are present in some of the siltstones, and to a much lesser extent (as very small flakes) in the mudstones. *Sample MS-1F* collected from a micaceous grayish red siltstone (See Table 1A-1 for XRD analysis). The fissile silty mudstones (Figure 1A-4) are very thin to very thick bedded, and occur in sequences of multiple beds. The apparent homogeneity in individual beds is probably a result of burrowing. Possible plant fragments and root



Figure 1A-4. Grayish-red fissile, silty mudstones in upper part of New Oxford cycle.

structures are present as well as smooth-walled vugs that once contained a carbonate. *Sample MS-1G* consisting of chips of grayish-red fissile mudstone (XRD analysis was not run on this sample).

Good outcrop ends about 150 m west of the trestle east abutment. West from here, the remaining 35 m of this cycle is covered, but rare float in the soil continues to be grayish-red. Some 47 m east of the Fleshman Mill Road crossing, the soils becomes yellowish, and arkosic sandstone float and poor outcrops indicate the beginning of another upward-fining cycle. The total stratigraphic thickness of the described cycle is 66 m.

Three samples from this outcrop were examined by X-ray diffraction (XRD) (Table 1A-1). Quartz is the major element found in all three samples, with albite either major or minor. Orthoclase is present in trace amounts in two of the samples. Other minerals in trace amounts are clinochlore, muscovite, and hematite.

Table 1A-1. Major, minor, and trace minerals identified by X-Ray Diffraction by John H. Barnes of 3 samples collected from the New Oxford Formation at Stop 1A, along the CSX Railroad northeast of New Oxford. See text for discussion.

Sample	Lithology	Quartz	Albite	K-feldspar	Clinochlore	Muscovite	Hematite
MS-1F	grayish-red siltstone, micaceous	Major	Minor	Trace	Trace	Trace	Trace
MS-1D	grayish-red siltstone	Major	Minor	Trace	Trace	Trace	Trace
MS-1C	gray siltstone	Major	Major		Trace	Trace	Trace

Structure: Bedding dips to the northwest at 316-23 (dip vector, azimuth and plunge). Sets of planar fractures are best developed in the coarser-grained beds, the siltstones and sandstones. The mudstones tend to have widely spaced, irregular fractures.

Significance. The contrast between these rocks at Stop 1A and the conglomerates at Stop 1 is striking. Both are part of the New Oxford Formation. Although this Stop (1A) is only 4 kilometers from the present basin southeast margin, at the time these beds were being deposited, the basin margin may have been 8, 10 or more km from here, given the overlap nature of the margin. Rather than being at the top of the bajada (at the basin margin), these Stop 1A beds were much farther out, in the lower reaches of the alluvial plain, or even in a playa.

The depositional structures support this interpretation. The upward-fining character of the major cycles is indicative of a fluvial environment. In the lower part of the cycle, the relatively coarse grain of the sediment, the absence (or low amount) of mud in the matrix, and the internal troughs point to a moderately energetic fluvial environment. In contrast, the finer grain of the sediments, along with the alternating non-directional cyclicity, in the upper part of the major cycle suggests a lower energy level, and possibly a playa environment. The presence of orthoclase (K-feldspar), along with muscovite and clinochlore, implies a southeastern provenance, similar to that at Stop 1. The finer-grained sediment seen here was winnowed from sediment entering the basin and was carried much farther down the fluvial plain of the bajada.

The climate was semi-arid. Aridity would inhibit chemical weathering of the feldspars and provide the oxidation of iron that deeply colors so much of the basin's contents. Yet water was needed, if only episodically, not only to carry in the sediment, but also to support the burrowing community and other fauna and flora. In view of this, the deposition was also episodic, because each layer had to remain uncovered long enough for the burrowers to "homogenize" the beds before the next sediment influx buried them. All this indicates slow episodic accumulation in a low energy environment, typical of a playa.

STOP 2. Hornfels, thermally metamorphosed mudstones and siltstones of the lower part of the Gettysburg Formation.

Leader: Rodger Fail. Estimated time at Stop is 75 minutes [arrive 9:20, leave 10:35].

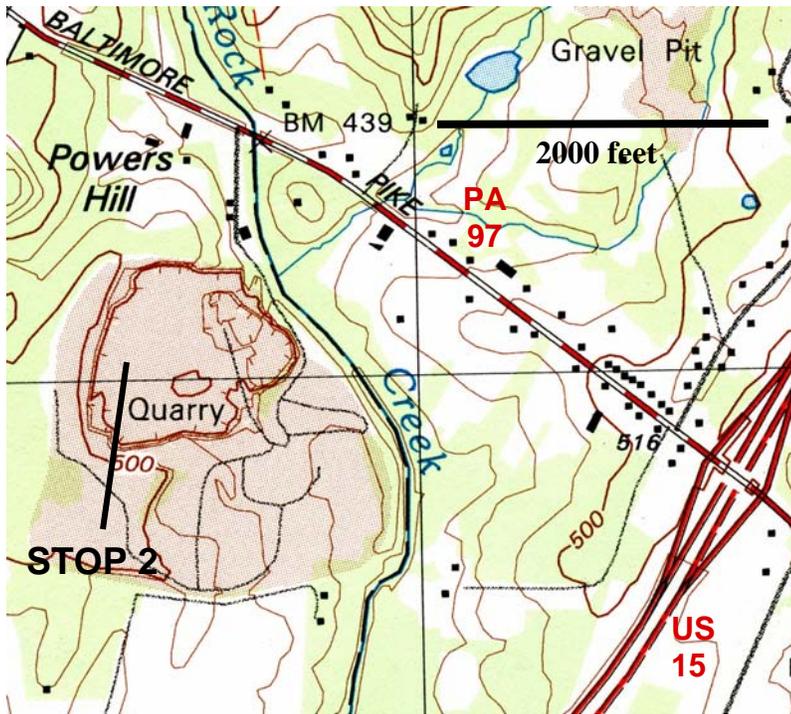


Figure 2-1. Location map for STOP 2. From the Gettysburg 7½' quadrangle.

Location and basin setting. The Gettysburg Quarry of Valley Quarries, Inc., lies 3.75 km south-southeast of Gettysburg, west of Rock Creek and south of Pa. Route 97, 1 km northwest of the U.S. Route 15 interchange with Pa. Route 97 (Figure 2-1). Stop 2 lies in the Gettysburg 7-½ minute Quadrangle, at Lat 39° 48' 08" N (39.8022°), Long 77° 12' 43" W (77.2119°).

The Gettysburg Quarry has a long and rich history. Before the Civil War, the land was cultivated farmland. During the Gettysburg Campaign in early July of 1863, the land served as an encampment area for Federal reserve troops – artillery, infantry, guard units, supply wagons, and hospital personnel. In 1926, John S. Teeter & Sons, Inc. acquired the property and opened the quarry. Quarry ownership changed several times in the ensuing years, until

Harry T. Campbell Sons Corp. acquired it in 1959. Valley Quarries, Inc. took over operations in 1983 and has continued to this day to expand and upgrade the operation's capabilities. The quarry processes the argillite (hornfels) and diabase ("Trap Rock") into an extremely tough and insoluble rock that is widely used for paving projects requiring a more resistant wearing aggregate, among other uses.

This quarry (Figure 2-2) exposes strata in the lower part of the Gettysburg Formation. Elsewhere, this part of the section consists predominantly of medium- to thick-bedded grayish-red siltstones and shales (which will be examined at Stop 3). Here, an



Figure 2-2. Overview of Valley Quarries' Gettysburg Quarry and west highwall.

Fail, Rodger T (2008) STOP 2. Hornfels, thermally metamorphosed mudstones and siltstones of the lower part of the Gettysburg Formation, in Fleeger, G.M (ed), *Geology of the Gettysburg Mesozoic Basin and Military Geology of the Gettysburg Campaign*, 73rd Annual Field Conference of Pennsylvania Geologists, Gettysburg, PA, p. 76 – 78.

overlying thick sheet of early Jurassic York Haven Diabase [now a formal lithodeme unit] (Smith and others, 1975) has baked these similar rocks into a thick sequence of hornfels. Our first stop in the quarry is along the north highwall on level 1, the uppermost bench. Participants will then be able to walk down to the lowest level to examine the rest of the quarry.



Figure 2-3. Northwest corner of quarry, with sheet of York Haven diabase lying above hornfels of lower part of Gettysburg Formation. Contact between the diabase and hornfels is shown.

Description. The lowest part of the diabase sheet lies at the top of the western highwall (Figure 2-3). Because of the inaccessibility, the contact between the diabase and the underlying sediment cannot be viewed in place. However, many diabase boulders and fragments of the underlying hornfels have fallen on to the level 1 bench near its western end, where they can be examined with caution (why hard hats are needed). One huge (3x3x6 m) diabase block has a flat surface facing southeast, on which one can observe polygonal thermal contraction fractures (Figure 2-4). If this block had weathered in place near the surface, these fractures might have formed columns. The

surface has a very thin hornfels coating in contact with the chilled base of the Gettysburg sheet.

The original sedimentary layering shows beautifully in the west highwall (Figure 2-5). From a distance (on the highwall), the rock appears thick-bedded and internally homogeneous, but fallen blocks on the bench exhibit thin to medium beds of laminated siltstone and sandstone, with cross bedding and channels. The moderate energy level these sedimentary structures imply is characteristic of the playa on which the Gettysburg Formation was deposited. These aspects can be seen more clearly at the east end of level 1, being more distant from the heating effects of the diabolic intrusion. Small, angular voids at this end are probably molds of salt crystals. Some variation of bed composition is indicated by the different shades of bed color. The lighter tan-weathering greenish beds are epidote-rich, suggesting an original



Figure 2-4. Diabase boulder showing thermal contraction cracks at the basal contact with the hornfels.



Figure 2-5. Layering of the lower Gettysburg Formation preserved in the hornfels, west highwall of quarry.

carbonate-rich rock.

The intrusion of diabase at high temperatures ($\sim 1,100^{\circ}\text{C}$) has subjected the sedimentary rocks in this quarry to a substantial thermal metamorphism. Bulk rock composition of the hornfels in the quarry away from the diabase, as determined by X-ray diffraction and petrographic studies, include metamorphic minerals epidote, chlorite, albite, diopside, and grossular, lesser amounts of quartz and actinolite. The epidote, chlorite, and grossular utilized the magnesium and iron in the original rock, the epidote and diopside the calcium and magnesium, and albite the sodium. The presence of

different minerals from bed to bed reflects variations in the original rocks, primarily between carbonate-bearing ones and the pelitic components of non-carbonate beds. The abundant sodium suggests the presence of evaporite beds, consistent with a playa or near-playa environment. Epidote clusters with garnet cores indicate a more extreme metamorphism that occurred within carbonate balls that may have originated as caliche. Some chlorites have orthoclase rims, suggesting the possibility of late K-bearing fluids. The mineralization on the fractures may indicate significant fluid activity during and immediately after the intrusion.

Significance. The thermally metamorphosed sediments (hornfels) displayed in this quarry present an additional aspect of the early Mesozoic basins in general, and the Gettysburg subbasin in particular, that had nothing to do with the Triassic sedimentation. The early Jurassic intrusion of such a large volume of magma sheets (subparallel to bedding) and dikes, and extrusion of flows, certainly affected the surface topography of the basin. The flows preempted large areas of deposition within and outside the basin margins, and the intrusions raised the basin surface by as much as 1,000 m or even more in some places. And the rate of basin subsidence increased, at least in the Newark subbasin (possibly as a result of magmatic activity), because the cycle thicknesses of the Jurassic sediments there are significantly greater than in the Triassic ones. However, all this is beyond the scope of what we can see in this Field Conference.

The principal effect, then, of the diabase intrusions and basalt flows is the heating and thermal metamorphism of the adjacent sediments. One of the distinguishing features of the flows is that they heat only the sediments below the flows—overlying sediments are not metamorphosed. The diabase sheets, with intrusion temperatures of $\sim 1,100^{\circ}\text{C}$, and their large thicknesses, produced thermal aureoles in the sediments both above and below. The metamorphism was probably (typically) rather dry, but the suite of minerals produced gives significant information about the sediments and the conditions of metamorphism. Additional detail on the mineralization in the quarry is provided by Robert C. Smith, II and John H. Barnes.

Mineralogy, petrology, and mineralization of the Valley Quarries, Inc., Gettysburg Quarry, formerly the H. T. Campbell Quarry, Adams County

Robert C. Smith, II, Pennsylvania Geological Survey, “emeritus”, and
John H. Barnes, Pennsylvania Geological Survey

On 9/23/77, a 12,000-ton, 165'-long stockpile of 1B-size (~ ¼") hornfels and a 490'-long muck pile shot from an active quarry face in the same hornfels were systematically sampled to obtain two highly representative samples (38.7 and 38.1 lb, respectively) of the rock then being produced. Each of the samples was studied in detail by X-ray diffractometer scans, thin sections, and oil immersions with a petrographic microscope. The samples were found to be extremely similar and to contain: major quartz, minor albite, muscovite, and andradite, trace chlorite and calcite, and possible traces of prehnite and epidote.

The heat source for the contact metamorphism displayed by the hornfels was the Gettysburg sheet of the York Haven Diabase. The York Haven Diabase is a widespread and nearly isochemical main phase of preserved Early Mesozoic magmatism known by this name at the latitude of Pennsylvania. It provided the decisive “high ground” topography for the Union position during the second and third days of the Battle of Gettysburg, July 2 and 3, 1863 (Smith and Keen, 2004). The Confederate position during that part of the battle was along Seminary Ridge, which is underlain by a 30 to 70-foot wide dike of the slightly younger (200.1 Ma; median of seven preferred zircon analyses) Rossville Diabase (Dunning and Hodych, 1990).

The York Haven Diabase has an age of 201.2 +/- 1.3 Ma based on the median of three $^{40}\text{Ar}/^{39}\text{Ar}$ analyses on a lateral equivalent by Sutter (1988), as well as 201.2 based on $^{206}\text{Pb}/^{238}\text{U}$ for best, clear fragments of zircon by Dunning and Hodych (1990). A gorilla-size boulder of York Haven Diabase exhibiting contraction cracks in a chilled margin will be visited on the present upper bench.

The mineralogy of the H. T. Campbell Quarry was expertly covered by Donald T. Hoff (Smith and Ganis, 2007) in an article published by *Rocks and Minerals* (Hoff, 1978). This Field Conference of Pennsylvania Geologists is dedicated to the memory of Don Hoff, whose powers of observation enabled him to become the first person in Pennsylvania to find a bedrock sample of native gold, even though it was very small and of the silver-rich variety electrum. This he found at the H. T. Campbell Quarry. Other studies of Mesozoic copper deposits in Adams County initiated by Don Hoff include the Hunterstown Gold Mine (Hoff and Smith, 1985) and Stone Jug copper prospect (Smith and Hoff, 1977). Unfortunately, neither of these two mines was located on deposits as large or rich as the mineralized zone was at H. T. Campbell's quarry. Mines located in mineral deposits are always preferred to those that are not.

Copper mineralization of many different types occurs in the Gettysburg Basin. Smith et al. (1988) summarized these occurrences. That study included Sample 5, a composite of > 50 1-to-2" chips from a copper zone of approximately 1.5 x 30 feet at H. T. Campbell Quarry in 1976 that contained djurleite, chalcocite, bornite, idaite (?), chrysocolla, malachite, and cuprite in a gangue of andradite-grossular, epidote, tremolite-actinolite, chlorite group, quartz, diopside, and calcite. It was interpreted to be a calcareous hornfels baked by overlying York Haven Diabase. This composite sample was found to contain, <0.001 oz Au/ton, 1.96 oz Ag/ton, 5.65 % Cu, and 10 ppm Bi. Other, much larger, lenses and stratiform beds contained major amounts of replacement magnetite similar to Cornwall-type deposits (Rose and Smith, 2001) and still others contained major amounts of chalcopyrite.

Smith, Robert C II and John H Barnes (2008) Mineralogy, petrology, and mineralization of the Valley Quarries, Inc., Gettysburg Quarry, formerly the H. T. Campbell Quarry, Adams County, *in* Fleeger, G.M (ed), *Geology of the Gettysburg Mesozoic Basin and Military Geology of the Gettysburg Campaign*, 73rd Annual Field Conference of Pennsylvania Geologists, Gettysburg, PA, p. 79 – 81.

Smith (1978, p. 110-114) described the copper sulfide ore mineralogy at H. T. Campbell quarry as determined by X-ray diffraction powder camera and ore microscopic analyses. Teeter and Hoff (2003) report that a lenticular-shaped body of sulfide-bearing skarn and magnetite was first blasted into in 1974. A chalcopyrite-rich assemblage found in 1975 contained masses of that mineral up to 10 cm. A djurleite-rich assemblage found in 1976 contained that mineral in masses up to at least 5 kg containing ~50% djurleite. Teeter and Hoff (2003) report that the senior author of this note first collected and identified djurleite at the Gettysburg quarry. Associated minerals include sparse bornite having digenite rims (Smith, 1978 Plate 2E) and occasionally idaite exsolution lamellae (Plate 2F), and trace gray chalcocite. As of March 1976, the copper-rich zones were plainly visible from across the quarry.

In 2008, the authors began an SEM/EDS study of polished sections from highgraded copper ore samples collected in 1975 and 1976. The results further confirmed the work of Smith (1978) as well as finding microscopic, ratty galena, and suggesting that many grains of bornite, digenite, and djurleite contain ~ 0.1 % Ag substituting for Cu. Galena in composite grains with hessite was found to contain ~ 1 % each of Ag and Se. An apparent copper-rich hessite, (Ag,Cu)₂Te, was found as inclusions up to 25 μm in various copper-iron minerals in three of six polished sections studied. Because hessite is not widely known to occur in Pennsylvania, the analyses are summarized in Table 2-1, below.

Table 2-1. Standardless SEM/EDS analyses of tiny, copper-rich hessite grains from the H. T. Campbell Quarry, Adams County, Pa. 39° 48' 08" N, 77° 12' 44" W. All data mathematically corrected for skirt effects from enclosing bornite or chalcopyrite.

Ag %	Cu %	Fe %	Te %
52.49	9.86	1.09	36.59
54.32	8.25	.03	37.39
52.44	9.57	.95	37.02
54.03	7.45	.56	37.92
53.12	7.63	.84	38.38
53.61	7.53	.92	37.69
52.34	8.53	.77	37.63
53.1*	8.4	0.8	37.6

* Median of 7 analyses rounded to 1 decimal place.

In addition to an apparent copper-rich hessite, a CuBiS₄ was found as grains up to 35 μm in 3 of 6 polished sections. Table 2-2 below summarizes the analyses.

To date, these analyses have not been matched to a known mineral. The formula for this mineral seems to be Cu₅BiS₄. Note that this formula appears to be the sum of the formula for wittichenite, Cu₃BiS₃, and that of chalcocite, Cu₂S. If there were substantial variation in the analyses of samples from the H. T. Campbell Quarry, a physical mixture would be immediately suspected. However, the rather constant composition suggests that the Cu₅BiS₄ formula applies at the microscopic scale. This suggests that Cu₅BiS₄ may be a separate species, possibly a higher temperature one that would have exsolved into wittichenite plus chalcocite if it had been cooled very slowly under hydrothermal conditions. Certainly, wittichenite has been reported from the York Haven Diabase in the Centerville Quarry, Fairfax, VA (Anthony et al., 1990 and Medici, 1972). Alternately, but less likely, the Cu₅BiS₄ might represent a regular 1:1 intergrowth of wittichenite plus chalcocite. If so, an X-ray powder diffraction camera pattern should reveal a supercell spacing that is the sum of a spacing from each of the constituent minerals.

Table 2-2. Standardless SEM/EDS analyses of tiny CuBiS grains from the H. T. Campbell Quarry, Adams County, Pa.

Cu %	Ag %	Bi %	S %
48.34	-	32.10	19.55
45.97	.27	34.17	19.58
47.76	.18	31.89	20.17
47.39	.11	32.11	20.39
46.87	.08	32.79	20.26
45.64	.15	32.39	21.81
47.1*	0.1	32.2	20.2
48.5**	-	31.9	19.6

*Median of 6 analyses rounded to 1 decimal place.

**Theoretical Cu₅BiS₄

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STOP 3. Mudstones, siltstones, and sandstones of the lower part of the Gettysburg Formation.

Leader: Rodger Fail. Estimated time: 45 minutes [arrive 10:50, leave 11:35].

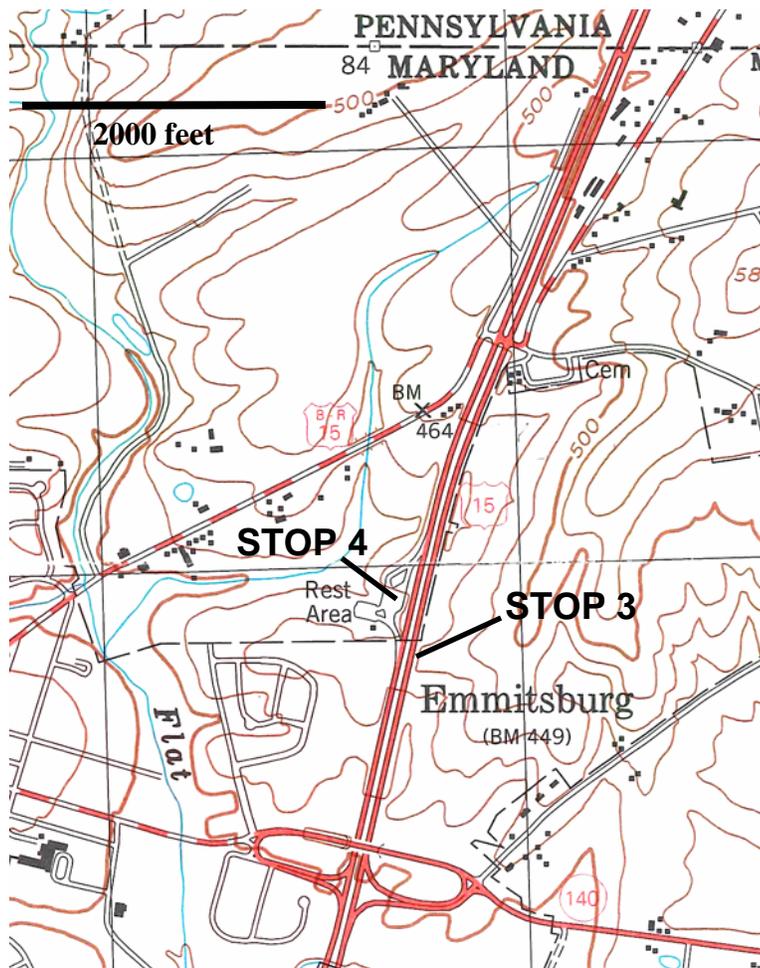


Figure 3-1. Location map for Stops 3 and 4. From Emmitsburg 7½' quadrangle.

Location and basin setting. Stop 3 lies 1 km east of Emmitsburg, Maryland, in a road cut on the east side U.S. Route 15, 500 m north of the interchange with Maryland Route 140. Stop 3 lies in the Emmitsburg 7-½ minute Quadrangle, at Latitude 39° 42' 23" N (39.7065°), Longitude 77° 18' 55" W (77.3154°) (Figure 3-1).

The rocks in this outcrop belong to the lower part of the Gettysburg Formation, toward the southern end of the Gettysburg subbasin. These beds are approximately 800-900 m above the top of the New Oxford Formation, and perhaps 1,000 m below the base of the Heidlersburg Member of the Gettysburg Formation.

Description. Grayish-red fluvial to playa siltstones dominate this outcrop of the lower part of the Gettysburg Formation, but several intervals of medium gray (grayish-green weathering) lacustrine beds are also present (Figure 3-2). This cyclic pattern pervades this exposure, presenting three complete cycles of the lacustrine beds overlain by fluvial/playa beds.

Some small outcrops of red beds are present behind the guardrail to the south, but our focus will be on the better exposures north of the north end of the guardrail.

Unit 1. Grayish-red siltstone, medium bedded (thin- to thick-bedded), noncalcareous, and argillaceous (fissile), for 102 m northward from the Highway paddle 37 (including the small outcrops behind the guard rail). Irregular bedding surfaces indicate burrowing, and shaly films suggest organic material. Caliche fragments are common in some layers. Unit 1 is 63 m thick (calculated stratigraphic thickness from Highway paddle 37).

Unit 2. Gray siltstone, thin- to thick-bedded, calcareous, and argillaceous (Figure 3-3). Several beds are quite thoroughly carbonate cemented. The basal contact is sharp. Burrows are present; caliche fragments are numerous. The top of this sequence is brecciated. *Sample EM-3A was collected 102 m north of Highway paddle 37.* Unit 2 is 12 m thick.



Figure 3-2. Overview of outcrop of lower Gettysburg Formation along U.S. Route 15 east of Emmitsburg, MD.

Unit 3. Grayish-red siltstone, medium- to very thick-bedded, slightly calcareous. The basal bed is a fifty-cm-thick transition of mottled green-red beds. One thick bed has a prominent set of planar fractures. *Sample EM-3B was collected 122 m north of Highway paddle 37.* Unit 3 is 2 m thick.

Unit 4. Gray siltstone, medium- to thick-bedded. The homogenous, burrowed beds are calcareous, whereas the other more argillaceous beds are non-calcareous. *Sample EM-3C was collected 126 m north of Highway paddle 37.* A rather large bush covers the upper gray-to-red contact at

the top of the outcrop, @ 127 m. Unit 4 is 4 m thick.

Unit 5. Grayish-red siltstone, thick and very thick bedded (mostly 10 to 40 cm, ranging from 5 to 80 cm), non-calcareous, slightly argillaceous (Figure 3-4). Although most beds appear quite parallel, irregular bedding surfaces indicate some local erosion caused by influx of the overlying sediment. These beds variably exhibit burrows, mud cracks (1-2 cm wide desiccation cracks forming polygons 5-8 cm across), root structures

(squiggly tubes), soil slickensides (striae in all directions on smoothly irregular surfaces, presumably representative of vertisol soil development), other organic material (shaly film remnants), and caliche fragments. Pyrite is present as trains of small crystals in the centers of some beds. One very thick (80-cm) grayish-red coarse siltstone bed near the base of this sequence has planar fractures of different orientations covered with calcite, probably precipitated by late fluids.

Samples EM-3D and EM-3E were collected 133 and 134 m, respectively, north of Highway paddle 37. Unit 5 is 17 m thick.



Figure 3-3. Gray lacustrine beds of calcareous siltstone overlain by grayish-red playa beds of non-calcareous siltstone of Gettysburg Formation.



Figure 3-4. Grayish-red fissile siltstones overlying gray calcareous siltstones of lower Gettysburg Formation.

Unit 6. Gray to dark gray siltstone, very thin- to very thick-bedded, calcareous and non-calcareous, some argillaceous, some pyritiferous. The basal layer is a medium thick bed of pyritiferous (1 mm or less), non-calcareous siltstone that is overlain by a 2-m-thick sequence of very thin to medium beds (very flat bedded) of variably calcareous, fissile shale. A superjacent 4-m-thick group of beds consists of medium- to very thick-bedded siltstones that are burrowed. At least one large burrow (4x7mm) is present and there are probably others. Next above is a 2-m-thick interval of interlayered limestone and argillaceous siltstone. The limestone is dark gray, thin-

bedded, and parallel-bedded; the gray argillaceous layers are also thin bedded. Overlying is a 2-m-thick group of gray siltstones, medium- to very thick-bedded, calcareous, with a few beds exhibiting distinct troughs on weathered surfaces. These siltstones grade upward into 1 m of thin-bedded, argillaceous siltstones. This entire 11-m-thick gray interval is capped by a 1-m-thick transition into grayish-red siltstone. Just south of the gray-to-red transition, in the median, is a large blue sign for the Rest Area on the opposite side of the road. *Samples EM-3F and EM-3G were collected at 159 and 160 m, respectively, north of Highway paddle 37.* Unit 6 is 11 m thick.

Unit 7. The northern end of this exposure consists of mixed argillaceous and silty grayish-red beds. An intraformational conglomerate at the base contains gray shale fragments ripped up from below and incorporated into the red siltstone bed. The basal 7 m of Unit 7 is exposed—farther north, the road cut is largely covered.

Figure 3-5. Lithostratigraphic sequence exposed in the Stop 3 outcrop. Cumulative stratigraphic thickness as calculated from Highway paddle 37 south of outcrop.

Unit	Description	Thickness (m)	Cumulative Thickness (m)
7	Grayish-red siltstones, non-calcareous, argillaceous	7+	116
6	Gray siltstone, mixed calcareous	11	109
5	Grayish-red siltstone, non-calcareous, sl. argillaceous	17	98
4	Gray siltstone, mixed calcareous	4	81
3	Grayish-red siltstones, slightly calcareous	2	77
2	Gray siltstones, calcareous, argillaceous	12	75
1	Grayish-red siltstones, non-calcareous, argillaceous	63	63

Table 3-1. Major, minor, and trace minerals identified by X-Ray Diffraction by John H. Barnes of 7 samples collected by R. Faill from the Gettysburg Formation at Stop 3, along U.S. Route 15, northeast of Emmitsburg, Maryland. See text for discussion.

Sample	Lithology	from base, m	Quartz	Albite	K-feldspar	Clinochlore	Muscovite	Calcite	Dolomite	Hematite
EM-3G	gray dolomite, fissile	160 m	Minor	Minor	Minor	Minor	Trace	Major	Minor	
EM-3F	gray siltstone, calcareous	159 m	Minor	Major	Trace	Minor	Trace	Minor		
EM-3E	grayish-red siltstone, non-calcareous	133 m	Minor	Major		Trace	Trace	Minor		Minor
EM-3D	grayish-red argillaceous siltstone, non-calcareous	133 m	Minor	Major		Minor	Trace	Minor		Minor
EM-3C	gray mudstone, non-calcareous	126 m		Major	Minor	Major	Trace	Minor		
EM-3B	grayish red siltstone	122 m	Minor	Major	Minor	Minor	Trace	Minor		Minor
EM-3A	gray siltstone, calcareous	102 m	Major	Major	Trace	Trace	Trace	Minor		Trace

Structure: The average bedding in this outcrop is 354-37 (dip vector—given as azimuth and plunge). This northward, steeper dip of bedding is unusual compared with the more common 23-degree northwest dip throughout much of this part of the Gettysburg subbasin. Movement on the cross fault some 4 km to the west and southwest was probably Jurassic in age. See Road Log at mile 45.10 (between Stops 4 and 5) for discussion of that fault.

The development of planar fracture sets sporadically in this road cut is most likely a reflection of the lithology (siltstone) in which they occur. No study has been made of these fractures—they are just noted in passing.

Significance. The rocks deposited at this stop are stratigraphically some 3,000 to 4,000 m above the basal unconformity. Stop 3 is 10 km northwest of the presently exposed basin margin. Considering the overlap nature of that unconformity, the basin margin during the deposition of these Stop 3 beds was considerably farther to the southeast than at present, perhaps 20 to 25 km away. If so, in view of the present subbasin width of 25 km, this Stop 3 locality was geographically somewhere in the center of the possibly 40-km-wide basin (at that time). By analogy to the Locketong Formation in the Newark subbasin, a sediment-starved lake should have been here. Clearly, the Stop 3 rocks represent a somewhat different set of depositional environments.

Lithically, the dominance of grayish-red rocks, the narrow range of grain-size (averaging coarse silt), and the presence of troughs, local erosion, brecciation, and occasional intraformational conglomerates demonstrate that the depositional environment was a somewhat dynamic, fluvial one. The few gray calcareous intervals represent lacustrine interludes. This alternation of lithologies is cyclic, representing changes in environment, from lacustrine (wet) to fluvial (arid) and back. The absence of scouring of underlying beds indicates that the deposition was predominantly constructional.

Smoot (1991) describes the cycles as having three components. The basal component generally has a sharp base, resting on an erosional surface. These gray sediments are medium to thick bedded, and display few features because of burrowing. The medial component consists of very thin to medium

beds, some laminated, others argillaceous, that exhibit ripples and scours. Disruption of thin beds by underlying mud (water escape) is common. The upper component is characterized by red medium to thick beds that are usually homogeneous (because of burrowing and/or roots).

Within each cycle, not all components need be present, and components can repeat within a single cycle. This seems to have occurred within the gray component in the uppermost cycle, Unit 6. These cycles reflect changes in climatic moisture, but this exposure is too small to demonstrate the shorter climatic cycles (Olsen and others, 1996). The mean cycle thickness here of 15-25 m suggests they may be Van Houten cycles (Olsen, 1986).

The sources of K-feldspar, muscovite, and clinocllore through most of this exposure (Table 3-1) most likely were metamorphic rocks, or igneous rocks such as the metabasalts of the Catoctin Formation. Catoctin metabasalts and metarhyolites are present in the core of South Mountain northwest of the basin, but these metaigneous rocks were not exposed there at this time (see discussion for Stop 7). The only other possible sources are the metamorphic and igneous rocks southeast of the basin. Because the rocks at Stop 3 were in the middle of the depositional basin, this mineralogy suggests that the southeastern sourced sediment must have spread rather widely across the basin.

Stop 3 was probably in the distal portions of the bajada, or in the adjacent playa. Although lake waters periodically inundated this area, the dark gray to black argillites characteristic of the Lockatong Formation are not present, suggesting the absence of a persistent, sediment-starved lacustrine environment. Perhaps the terrigenous input was too large, or this part of the Birdsboro basin was not as wet as farther east in the Newark subbasin.

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STOP 5. Heidlersburg Member, Gettysburg Formation.

Leader: Rodger Faill. Estimated time at Stop is 70 minutes [arrive 1:25, leave 2:35].

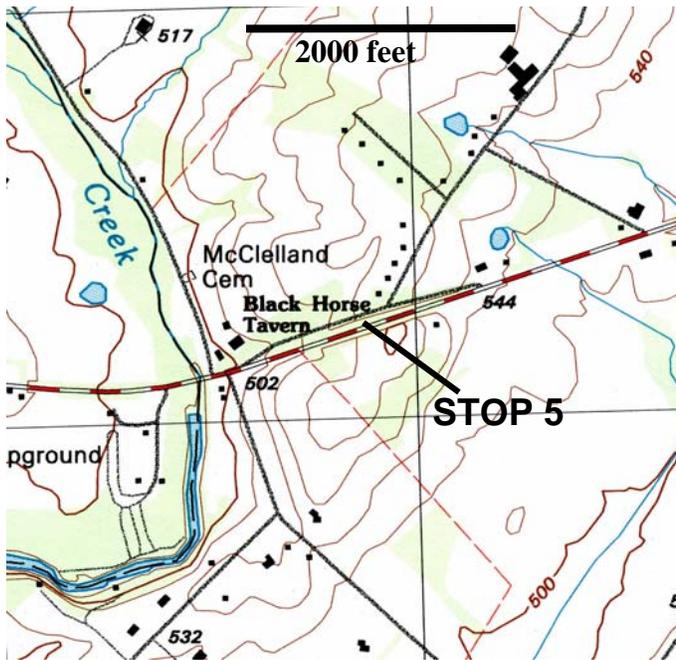


Figure 5-1. Location map for STOP 5. From Fairfield 7½' quadrangle.

Location and basin setting. Stop 5 lies on the north side of Pa. Route 116, just east of Black Horse Tavern and Marsh Creek, between Fairfield and Gettysburg, 4 km west-southwest of Gettysburg, Pennsylvania (Figure 5-1). Stop 5 lays in the Fairfield 7-½ minute Quadrangle, at Latitude 39° 49' 10" N (39.8194°), Longitude 77° 16' 54" W (77.2817°).

The Heidlersburg Member occurs stratigraphically in the middle of the Gettysburg Formation, in the west-central part of the Gettysburg subbasin. In contrast to the red beds that constitute the bulk of the Gettysburg Formation, the Heidlersburg Member consists predominantly of gray beds: siltstones, shales, dolomites, and limestones. As is common elsewhere in the Birdsboro basin, a climatic cyclicity (Van Houten cycles- Olsen, 1986) pervades the Heidlersburg Member as well as much of the rest of the Gettysburg Formation (see Faill, this volume). This cyclicity in the central,

sediment-starved part of the basin reflects the shifting of depositional environments: lake, shoreline, and playa/mudflat.

The lacustrine phase of a cycle at Stop 5 contains black to dark gray calcareous mudstone, interlayered with limestone. The limestones are very thin to thin bedded, rarely rippled, and are occasionally shrinkage-cracked and crumpled by upward movement of the underlying mud. A number of the mudstones are laminated, and small pyrite grains are common in some of the beds. They may contain occasional desiccation cracks, burrows, stromatolites, fossils, and oolites. The dark color reflects a high organic content in the deeper water, more anoxic layers. This phase represents a lake highstand, a period of increasing and maximum lake extent and depth.

The shoreline phase consists of thick detrital cycles containing medium- to thick-beds of light to medium gray siltstone and very fine-grained sandstone, and intervals of fissile shales. The siltstones are calcareous (calcite-cemented) and sometimes laminated. The thinner beds occasionally exhibit small-scale disturbed bedding from upward movement of underlying mud. Also present are intraformational breccia, ripples, analcime, dolomite, and pseudomorphs after evaporites. This phase represents a transgression of a lake environment.

The playa/mudflat environment is the lowstand, regressive phase where the lake is at minimal extent and water depth. Homogeneous grayish-red siltstones are characteristic with interbeds of poorly fissile, silty mudstone. The siltstones are often calcareous, and exhibit abundant desiccation cracks, burrows, roots, vesicular and crumb fabrics, and footprints (none have yet been observed here). Incipient soil development is locally present.

The cycles were deposited in a rather low-energy environment. The abrupt changes in lithology indicate rapid changes in depositional environment. However, the absence of erosional features, the parallelism of the beds and their lateral continuity point to a dominantly constructional sequence, with little disturbance to underlying layers.

The Heidlrsburg cycles present here at Black Horse Tavern contain these three phases, yet are somewhat different from the cycles typical of the older Lockatong Formation in the Newark subbasin to the east. The thick argillite beds of the lower Lockatong Formation there are not well developed here, presumably because of greater input of fine-grained terrigenous sediment and the shallower water depths. In addition, the cycles here include intervals of red oxidized sediments characteristic of the playa environment, a transitional pattern more characteristic of the lower part of the Passaic Formation in the Newark subbasin.

Description. Stop 5 begins at the east end of the long outcrop on the north side of Pa. Route 116, and progresses westward up-section in the northwest-dipping beds (Figure 5-2). Two and one-half cycles are exposed, which have been informally divided below into 9 units, each corresponding roughly to a change in environment phase (Figure 5-3).

Unit 1. Grayish-red siltstone float at the east end of the road cut on the south side of Pa. Route 116 and extending to the east represents an interval of unknown thickness of detrital (highstand?) deposition on a playa. Telephone pole #1412 is opposite here, 19 m west of the grated culvert in Unit 2. Unit 1 thickness is unknown.

Cumulative thickness measurement begins with 0 m at the top of the Unit 1 red beds.

Unit 2. Medium-gray siltstone thin- to medium-bedded, calcareous to dolomitic, interlayered with very thin-bedded to coarsely laminated shale/argillite. Very small pyrite grains are present in some of the beds. This interval is largely covered, but best exposed above a grated culvert. *Sample FD-3H was collected at the grated culvert in Unit 2.* Unit 2 is ~3 m thick.

Unit 3. Light- to medium-gray siltstone, medium- to thick-bedded, dolomitic representing an interval of regression of the lake to shoreline environment. *Unit 3 is 7 m thick.*

Unit 4. Grayish-red siltstone, thin- to medium-bedded. The unit represents a short interval of lowstand playa environment. Unit 4 is 2 m thick.

Unit 5. Light- to medium-gray siltstone, medium- to thick-bedded, dolomitic. These beds are underlain by tannish-gray argillaceous siltstone, very thin bedded. This unit represents a period of shoreline and shallow lacustrine transgressive environments. A zone of subvertical fractures occurs in the dolomites, some of which coated with 1 mm of quartz and/or calcite mineralization. Telephone pole #1413 is opposite here, 64 m west of the grated culvert in Unit 2. Unit 5 is 9 m thick.

Unit 6. Dark gray dolomite, limestone, and calcareous shale, thin- to medium-bedded (Figure 5-3). The upper 3-m-thick sequence of interlayered dark gray dolomite?, limestone, and very dark gray shale (prominently exposed in the outcrop) is underlain by a thinner sequence of very fissile, dark gray silty shale. The upper sequence alternates between medium beds (15-20 cm thick) of dolomite?, limestone, and thinner (4-7 cm) layers of more argillaceous rock. Both lithologies exhibit a

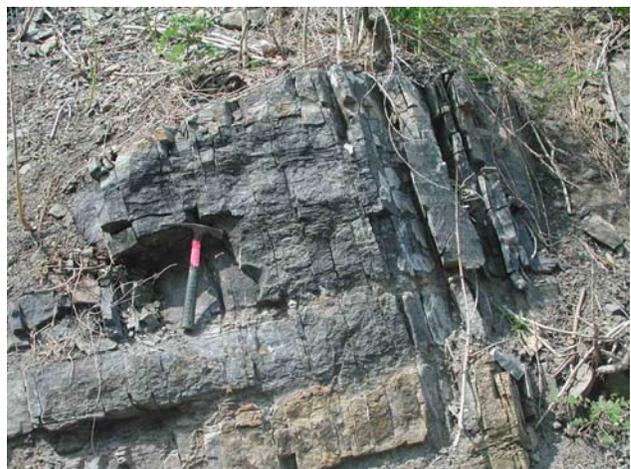


Figure 5-3. Dark gray lacustrine beds.

distinctive “palletized” weathering surface. This unit represents a deep to shallow water lacustrine environment. One of the zones of closely spaced planar fractures is present in this unit. *Samples FD-3F and FD-3G were collected at 68 m west of the grated culvert in Unit 2.* Unit 6 is 4 m thick.

Figure 5-2. Lithostratigraphic sequence (preliminary) exposed in the Stop 5 outcrop. Cumulative stratigraphic thickness as calculated from the top of Unit 1. For Unit 9 subunits, the relative thickness of units are approximate, and not to scale. Decimal numbered cycles are partial cycles.

Cycles & Partial Cycles	Unit	Description	Thick-ness (m)*	Cum Thick-ness (m)	Environ-ment ¹
3.2	9.8	Medium gray sandstone, thick bedded (60-80 cm), carbonate-cemented, homogeneous with no obvious bedding or other internal features.	9	83 – 92	S
	9.7	Light to medium gray sandstone and siltstone, medium-to-thick-bedded, arkosic, and homogeneous	3	80 – 83	S
	9.6	Dark gray shales, thin-to-very thin-bedded, calcareous, with coarsely laminated, non-calcareous argillite.	2	78 – 80	L
3.1	9.5	Medium gray limestone interbedded with medium dark gray shale, non-calcareous. Commonly disrupted by irregular fractures; load structures also present.	2	76 – 78	S
	9.4	Dark gray argillites, very thin to thin bedded (2-15 cm), fissile, and laminated.	2	74 – 76	L
	9.3	Interbedded light to medium gray, thick-bedded sandstone, thin bedded/laminated siltstone, and fissile argillite. Some of the fissile beds have channels.	8	66 – 74	S
	9.2	Medium gray sandstone, thick-bedded. Planar sub-bed-normal fractures common.	6	60 – 66	S
	9.1	Medium gray siltstones and argillites, laminated to thin-bedded.	4	56 – 60	S
2	8	Grayish-red siltstones, non-calcareous, argillaceous	13	43 – 56	P
	7	Medium gray siltstones, calcareous, argillaceous	18	25 – 43	S
	6	Dark gray dolomite/limestone and calcareous shale.	4	21 – 25	L
	5	Medium-gray siltstone and argillaceous siltstone, dolomitic	9	12 – 21	S
1	4	Grayish-red siltstones	2	10 – 12	P
	3	Medium-gray siltstone, slightly calcareous and/or dolomitic	7	3 – 10	S
	2	Medium-dark gray siltstns & sh, calcareous, dolomitic	3	0 – 3	L
0	1	Grayish-red siltstones	?		P

¹Environment abbreviations:

P-	Playa
S-	Shoreline
L-	Lacustrine

* Thicknesses are calculated and not measured.



Figure 5-4. Gray, fissile, calcareous thin-bedded siltstones of Unit 7

5-5). The lower 10 m are calcareous siltstones with a blocky aspect, exhibiting worm burrows, broad shaly films suggestive of leaves, and crenulations on curved surfaces suggestive of soil structures (vertisol soil slickensides). Caliche fragments may also be present. The upper 3 m are argillaceous and non-calcareous. Mud cracks are absent in the red beds. These aspects suggest flood plain to playa lowstand deposition, characteristic of semi-arid to arid regressive environments. *Sample FD-3E was collected at 150 m west of the grated culvert in Unit 2. Telephone pole #1415 is opposite here, 157 m west of the grated culvert in Unit 2. Unit 8 is 13 m thick.*

Unit 9. Unit 9 is predominantly a shoreline sequence, with a thin interval of lacustrine beds near the middle. It has been subdivided into six sub-units to emphasize the lithic changes through the section.

The dominant lithology consists of light to medium gray fine-grained sandstone (Figure 5-6), siltstone, and silty shale. The beds are thin, medium, and thick (even very thick) with the finer-grained beds being thinner. The rocks in this westernmost unit of the outcrop represent the regression environments of shoreline to shallow lacustrine. The layers are generally flat and parallel bedded, but show occasional shallow troughs.

Unit 7. Medium gray siltstones and fissile shales (Figure 5-4). The siltstones are medium- to thick-bedded (up to 1 m), coarsely laminated, and calcareous. The fissile shales are non-calcareous and show no internal structures. Mud cracks are quite common in the siltstones (see Unit 9). Manganese dendrites are present on some bedding surfaces. Unit 7 represents transgressive near-shore and shoreline environments. Manhole cover in ditch is 97 m west of the grated culvert in Unit 2. Telephone pole #1414 is opposite here, 108 m west of the grated culvert in Unit 2. Unit 7 is 18 m thick.

Unit 8. Grayish-red siltstones, thin- to medium-bedded, homogeneous, and variably calcareous and argillaceous (Figure

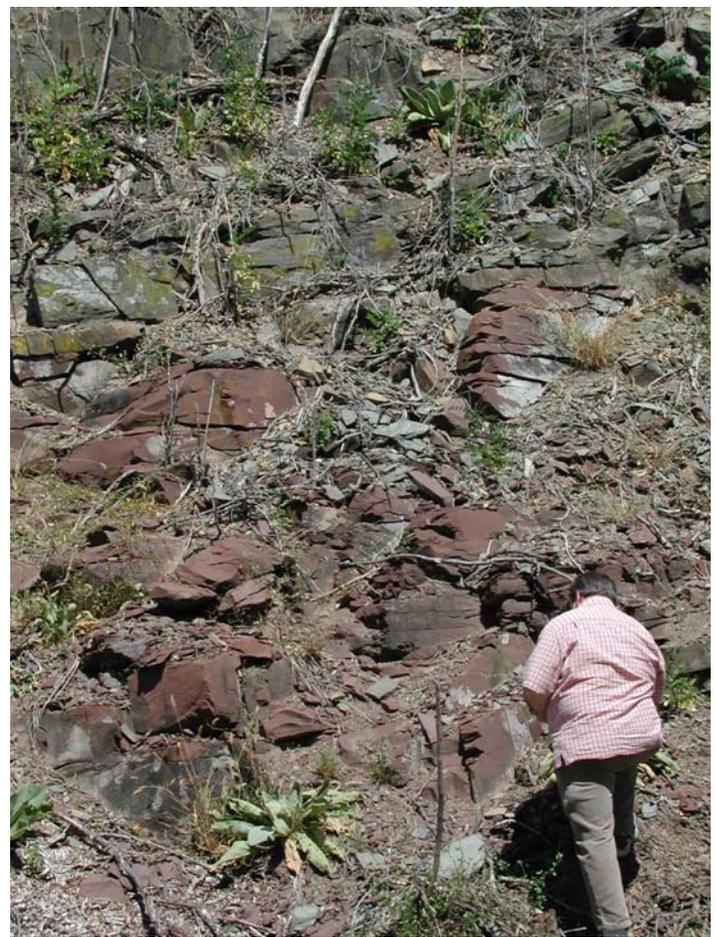


Figure 5-5. Grayish-red playa beds overlain by near-shore gray siltstones.



Figure 5-6. Gray, thick-bedded, very fine-grained sandstones of Unit 9.2.

Because of the thinness of the float piece, there is no indication of thinning of the crack fill and thus no sense of how deep the crack may have been. A simple interpretation is that the thin cracks showing polygonal structure represent short term desiccation processes whereas the wider cracks represent exposure for much longer periods of time followed by a period of sediment infilling that rapidly filled the cracks before they could swell shut.

Although the beds are parallel bedded, individual bedding surfaces can be quite irregular, because of erosion, burrowing, or other animal activity. Apparent laminations appear to be common, and possibly very thin flaser bedding, but some have suffered syndimentary disruptions.



Figure 5-8. Tannish laminae of silty mudstone in gray, very thin-bedded mudstone.

Carbonate cement is commonly present. Some flat patches of pyrite appear on a few bedding surfaces. Mud or desiccation cracks occur. It should be noted that these structures are seen only in float pieces that are usually less than 1 cm thick relative to bedding normality and often less than 1/2 cm thick. The bedding parallel surface of these float pieces shows two distinctly different desiccation cracks: one set is polygonal in shape, the polygon is generally 2-5 cm across, and the actual desiccation crack is 1-2 mm in width (Figure 5-7). In contrast are a few desiccation cracks that are nearly 1 cm in width and obviously filled with coarser-grained sediment, silt versus surrounding clay.



Figure 5-7. Mudcracks in gray, argillaceous siltstone.

Very thin stringers (tannish coarse laminae) of silty mudstone occur within the mudstones (Figure 5-8). Many of these stringers are disrupted and separated by dikes of upwelling mud. Other syn-sedimentary deformation includes load structures and microfolding.

Brief descriptions of the sub-units of Unit 9 are:

- Unit 8** Grayish-red beds.
- Unit 9.1** Medium gray siltstones and argillites, laminated to thin-bedded. The subunit represents the shoreline and near shore phase. Unit 9.1 is 4 m thick.
- Unit 9.2** Medium gray sandstone, thick-bedded. Planar sub-bed-normal fractures common. Telephone pole #1416 is opposite here, 197 m west of the grated culvert in Unit 2. Unit 9.2 is 6 m thick.
- Unit 9.3** Interbedded light to medium gray, thick-bedded sandstone, thin bedded/laminated siltstone, and fissile argillite. Some of the fissile beds have channels. Unit 9.3 is 8 m thick.
- Unit 9.4** Dark gray argillites, very thin to thin bedded (2-15 cm), fissile, and laminated. This unit probably represents a relatively brief lacustrine phase. *Samples FD-3C and Sample FD-3D were collected at 228 m west of the grated culvert in Unit 2.* Unit 9.4 is 2 m thick.
- Unit 9.5** Medium gray limestone interbedded with medium dark gray shale, noncalcareous. Commonly disrupted by irregular fractures; load structures are also present. Telephone pole #1417 is opposite here in Unit 9.5, 241 m west of the grated culvert in Unit 2. Sample FD-3B was collected at 255 m west of the grated culvert in Unit 2. Unit 9.5 is 2 m thick.
- Unit 9.6** Dark gray shales, thin- to very thin-bedded, calcareous, with coarsely laminated non-calcareous argillite. Unit 9.6 is 2 m thick.
- Unit 9.7.** Light to medium gray sandstone and siltstone, medium- to thick-bedded, arkosic, and homogeneous. Unit 9.7 is 3 m thick.
- Unit 9.8** Medium gray sandstone, thick bedded (60-80 cm), carbonate-cemented, homogeneous with no obvious bedding or other internal features. Sample FD-3A was collected at 284 m west of the grated culvert in Unit 2. Telephone pole #1418 is opposite here at the west end of Unit 9.6, 284 m west of the grated culvert in Unit 2. Unit 9.8 is 9 m thick.
- Unit 9 is 36 m thick.

Table 5-1. Major, minor, and trace minerals identified by X-Ray Diffraction by John H. Barnes of 8 samples collected along Stop 5, Heidlersburg Member of the Gettysburg Formation. See text for specific locations.

Sample	Quartz	Albite	K-feldspar	Clinochlore	Muscovite	Calcite	Dolomite	Ankerite?	Hematite	Pyrite
FD-3A	Major	Major	Trace	Minor	Trace	Trace				
FD-3B		Major	Major	Major	Trace	Major				
FD-3C	Minor	Major	Trace	Minor	Trace	Minor		Major		Trace
FD-3D	Minor	Major	Trace	Minor	Trace	Trace	Major			Trace
FD-3E	Major	Major	Trace	Minor	Trace	Minor			Trace	
FD-3F	Major	Major	Minor	Trace	Trace	Trace	Minor			Trace
FD-3G	Major	Minor		Trace	Trace	Major	Major			Trace
FD-3H	Minor	Major	Trace	Minor	Trace	Minor	Major			Trace

Location and lithology of the 8 samples analyzed by XRD for Stop 5, Heidlersburg Member.

The numbers are the stratigraphic distance, in meters, above the top of the red bed sequence at the east end of Stop 5.

Sample FD-3H, Unit 2 @ 4m, medium dark gray siltstone.

Sample FD-3G, Unit 6 @ 45 m, dark gray shale.

Sample FD-3F, Unit 6 @ 45 m, dark gray limestone.

Sample FD-3E, Unit 8 @ 104 m, grayish-red siltstone.

Sample FD-3D, Unit 9.4 @ 156 m, medium dark gray argillite

Sample FD-3C, Unit 9.4 @ 156 m, laminated siltstone and argillite.

Sample FD-3B, Unit 9.5 @ 174 m, siltstones and argillites, coarse laminae.

Sample FD-3A, Unit 9.6 @ 193 m, sandstone, carbonate-cemented.

Structure. The bedding dips moderately to the northwest at 302-19 (dip vector, given as azimuth and plunge).

The fracture surfaces are neither very planar nor systematic. Three exceptions do occur, in the dolomitic siltstones (unit 3), in the dark gray siltstones (unit 4), and in the dark gray limestone (unit 6). The exceptions consist of a rather small cluster (5 m) of relatively closely spaced (2 to 15 cm) planar fractures, subvertical to bedding (Figure 5-9), trending generally north-south (106-78 in the dark gray limestones, 092-75 in the dolomite). A subordinate set of fractures in the dark gray rocks strikes northwest (063-76). A few of these planar fractures are filled with quartz and/or calcite.



Figure 5-9. Local set of subvertical closely-spaced planar fractures in a gray siltstone.

No slickenlines, suggestive of fault movement, were observed in this outcrop. Small, linear features on curved surfaces are probably soil features.

Significance. The Heidlersburg beds represent a time and location in the Birdsboro basin that was sediment-starved. Coarse-grained sediment was entering the basin at this time, but this locality was far enough from the southeastern margin (and the bajada) and laterally far enough from the regional fluvial deltas (e.g., the Hammer Creek delta) that only the finest-grained terrigenous sediment reached here, especially when lake levels were high. In addition, the energy level of the environment was sufficiently low that the climatic cycles of increasing and decreasing moisture are evident in the sediment cyclicity.

The Heidlersburg interval (both in time and as a lithology) was not part of a basin-wide event, climatic or depositional. The Heidlersburg Member lies in the middle of the Gettysburg Formation, well above the top of the arkosic, southern-sourced New Oxford Formation. In contrast, the Lockatong Formation in the Newark subbasin directly overlies, and is interbedded with the arkosic, southern-sourced Stockton Formation. This suggests that the Heidlersburg time interval was later than the Lockatong time interval. In addition, the much greater amount of gray argillite in the Lockatong suggests less detrital input and a longer interval of lacustrine conditions there.

It is generally accepted that the Lockatong, and by analogy the Heidlersburg, represent areas of least detrital sediment, and consequently occupied the areas of lowest topography in the Birdsboro basin. It follows that when it rained, the runoff accumulated in these areas, forming lakes. Given the semi-arid to arid climate, evaporation soon concentrated the waters to induce precipitation of evaporite minerals, such as the analcime, salt, and anhydrite that are common in the Lockatong Formation. The Heidlersburg Lake probably was not as hypersaline, but the XRD data shows the presence of calcite, dolomite, and ankerite. Very small fragments of what may be caliche are also quite common in the Heidlersburg sediments.

The depositional environments inferred from the Heidlersburg rocks include playa, shoreline, and lacustrine. The shoreline deposits are represented by the siltstones and sandstones, probably one of the few examples of reworked sediment anywhere in the basin. The red beds are characteristic of the playa. The limestones and dolomites are lacustrine. The gross sequence of lithologies at this Stop present two complete cycles of playa to shoreline to lacustrine and back to shoreline and playa. But not every cycle is complete, with shoreline to lacustrine to shoreline and back to lacustrine without the intervening playa (e.g., within Unit 9). Although climate probably drove the lacustrine-shoreline-playa cyclicity, their variability and incompleteness may be due to the higher detrital input or less rain in this part of the Birdsboro basin. Regardless, the deposition was constructional, with little erosion of underlying beds, and significant time intervals between beds (or else burrowing would have been suppressed/killed off).

With the Heidlersburg being so high in the stratigraphic section, this exposure lay well within the northwestern part of the Birdsboro basin. This conclusion is reached because of the persistent northwest bedding dip across the subbasin. One would expect that, being on the northwestern side of the basin, most of the sediment here had come from northwest of the basin. This is what makes the mineralogy of the Heidlersburg sediments here so odd. The XRD data for most of the eight samples (Table 5-1) shows trace to major amounts of K-feldspar, a mineral not characteristic of the Valley and Ridge rocks (including South Mountain) west of the basin. In other words, southeast-source detritus was carried to the northwest side of the basin.

This is not so surprising considering the locations of the major input centers along the northwest margin. The two nearest regional deltas were far off: the Hammer Creek delta was 75 km to the northeast; the Goose Creek delta was 65 km to the south-southwest (see Faill, this volume, Figure 2).

Moreover, South Mountain just northwest of the basin was probably emerging as a highland, blocking sediment input from that direction (this will be discussed further at Stop 7). Therefore, the absence of a significant sediment supply from the northwest allowed the southeast-source sediment to spread across much of the basin, near to the northwest margin.

The lesser overall thickness of the Heidlersburg, its lesser lateral extent, and the lesser evaporites as compared with the Lockatong Formation suggest that the Heidlersburg Member was not the widespread central-basin lake that the Lockatong was. The Lockatong sequence is finer-grained, and displays three different orders of climate-induced cyclicity that are just not as evident in the Heidlersburg. It would appear that the Lockatong was more sediment starved and the basin was tectonically very quiescent so that individual cycles can now be trace for more than 100 km. The basin here was not necessarily more active tectonically—it may have been just as quiescent but had more detrital sediment that overwhelmed the subtle climatic cycles.

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STOP 6. Fairfield inlier, Ordovician Beekmantown? carbonates.

Leaders: William E. Kochanov and Rodger Fail. Estimated time at Stop is 75 minutes [arrive 2:45, leave 4:00].

Location and basin setting. Stop 6 lies 1.7 km northeast of Fairfield, 200 m southeast of Pa. Route 116, on the property of the Fairfield Quarry of the Valley Quarries, Inc., on Bullfrog Road (Figure 6-1). The Stop is in the older quarry, east of the office, on the quarry floor and the first level above the floor. Stop 6 lies in the Fairfield 7 ½ Minute Quadrangle, at Lat 39° 47' 45" N (39.7958 °), Long 77° 21' 12" W (77.3533 °).

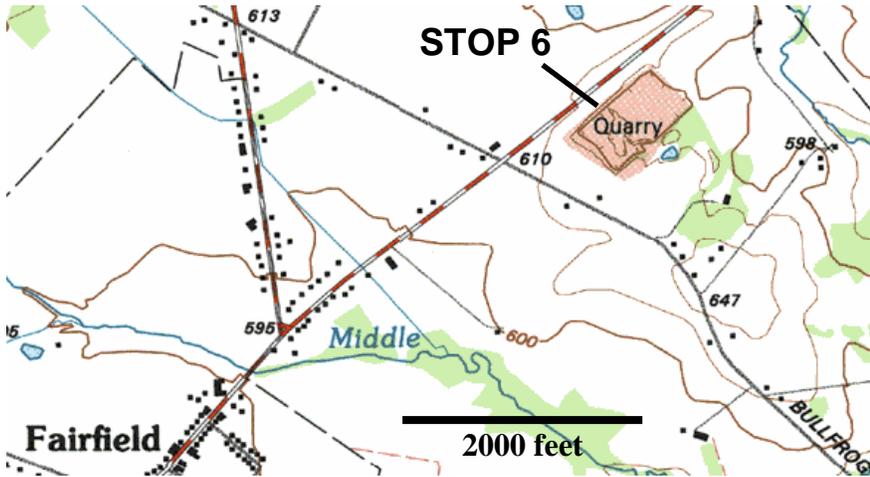


Figure 6-2. Location map for STOP 6. From the Fairfield 7½' quadrangle.

Stop 6 is in the western part of the Gettysburg subbasin, only 2.5 km east of the northwest margin of the basin (Figure 6-2). Although within the basin, the exposed rocks are not Mesozoic-age sediments—they are Ordovician-age carbonates of the basin floor. However, limestone fanglomerates with clasts from these Ordovician rocks surrounds this inlier on three sides. Indeed, a small patch of fanglomerate is still present at the top of the highwall in the southwest corner.

Examining the basin floor not only reveals information about the surface geology at the end of the middle Triassic (just before sediment accumulation began), but it also provides clues as to the subsequent basin history, particularly its deformational history. The few inliers throughout the subbasins expose little of the basin floor but what little is shown provides significant information.

Description. Part of this description will focus on the limestone conglomerate and related lithofacies exposed throughout the Fairfield quarry. The discussion will revolve around its stratigraphic placement and the development of a plausible sedimentary model to explain the occurrence of this



Figure 6-2 Aerial view of the Fairfield quarry. North is up remarkable resource. The rest of the story concerns the structural significance of this inlier.

The Calcareous Conglomerate

One of the first published accounts of a calcareous conglomerate associated with Mesozoic-aged rocks comes from Rogers (1858) who traced occurrences along the southern base of South Mountain to the Maryland line a little west of Emmitsburg. Near Lisburn in York County he stated that the conglomerate was in very massive beds but more impure (less calcareous), and *interbedded with red sandstone and shale*. The pebbles were "...as large as a man's head or even larger... of various colored limestones, with some grey and reddish quartzose rock, or very compact sandstone, and some white igneous quartz..." At the South Mountain terminus near Dillsburg, Rogers talked of "...very coarse (rock), consisting chiefly of round or flattish kidney-shaped lumps of several varieties of limestone (some weighing perhaps 50 pounds) imbedded in a coarse, reddish cement."

This mention of a conglomeratic limestone with the red coloration is worth pointing out as it forms the basis for identifying in the field what has become to be commonly known as the Triassic fanglomerates.

In other occurrences, such as the Baker Quarry, the Triassic limestone fanglomerate is composed of a poorly sorted mixture of angular to sub-angular dolostone clasts supported by a reddish-brown fine-grained sand to mud matrix. The fanglomerate rests unconformably atop the Cambrian Ledger dolostone which likely serves as the primary source of the clasts within the fanglomerate.

Stose and Bascom (1929) mapped a range of Triassic conglomerates, one composed primarily of quartzose clasts, one with limestone clasts, and one that had a bit of both. On page 10, "South of the Chambersburg Pike (Route 30) *small limestone pebbles appear in the conglomerate* and upper beds of sandstone, but not in sufficient number to warrant calling the rock a limestone conglomerate." They also mentioned that three-quarters of a mile southwest of Ortanna (north of Fairfield) *a conglomerate composed largely of limestone pebbles* had been quarried for lime.

Stose and Bascom (1929) described the pebbles of the limestone conglomerate averaging 2 to 3 inches (5 to 8 cm) in diameter with many being as large as 5 inches (13 cm). Compositionally, they were largely light- to dark-gray to pink, fine (grained), saccharoidal marble, gray dolomite and gray impure laminated limestone. The pebbles were generally rounded to subangular with a *red* to gray calcareous clay or fine sand matrix, which cemented the pebbles into a compact rock. The thickest beds were observed in the quarries *east of Fairfield* where they ranged from 20 to 25 feet (7 to 8 meters). Rogers (1858) also mentioned that the conglomerate near Fairfield consisted almost entirely of limestone pebbles. Similar descriptions can also be found in Stose (1925, 1932), Miller, (1934, p. 155), Wood (1980, p. 12), and Taylor and Royer (1983).

The conglomerate continued southward into Maryland and had been quarried on a large scale for ornamental stone. In the trade it goes by the names "calico marble" and "Potomac marble" (Stose and Bascom, 1929).

Stose and Bascom do make the same reference to a red matrix but they also mention that it could be gray. This brings up an interesting thought as to whether there may be two different lithologies, where one is a limestone conglomerate with a finer-grained reddish matrix and the second being a limestone conglomerate without the reddish matrix. In other terms, one being a typical Triassic limestone fanglomerate and the other being the limestone conglomerate observed in the Fairfield quarry. Both lithologies are in such close proximity to one another, they may have been mapped as one stratigraphic unit.

In the Quarry

At the deepest portion of the pit floor (looking south), one can see the thickest portion of the basal conglomerate and the overlying carbonate laminite (Figure 6-3). Both units are approximately 8 meters thick.



Figure 6-3. The south highwall showing limestone conglomerate (C) and laminite (L). White lines show the approximate contacts.

examination shows that:

1. The conglomerate is composed of different sized, predominantly limestone clasts. The clasts range in size from coarse sand to 50 cm in diameter, averaging 3 to 7 cm.

The clasts are of differing color and composition (Figure 6-4). Clasts range in color from white to light-gray, medium- to dark-gray, and brownish-gray. No reddish-brown coloration is noted here (or anywhere throughout the quarry) for either the clasts or matrix. Megascopically, the clasts can be subdivided into groups of primarily white to light-gray or medium-gray, rounded to sub-angular, crystalline limestone and marble; brownish-gray, sub-angular, laminated, tabular-shaped, fine-grained limestone; and some medium-gray, finely crystalline dolostone. There are also some dark-gray clasts that approach chert in the mix. Petrographic views show that the many clasts are micritic save where the limestone has been recrystallized to marble. (Note: only one thin section of the conglomerate was available for viewing and therefore, may not give a true representation of the conglomerate overall).

2. The clasts are poorly sorted. The majority of clasts show no preference of grading and only a hint of layering. Although there are areas of finer-grained sediment, they do not appear to take on the role of matrix in the sense that larger, individual clasts are “floating” in a finer-grained matrix. No imbrication patterns have been observed.

Towards the east and west along the basal highwall, one can also observe the overlying laminite dipping 20 to 23 degrees to the northwest with the conglomerate pinching out at floor level. At first glance one could assume that the section has been structurally deformed and that perhaps we are looking at the limb of a fold or the axis of a fold that is plunging towards the north.

However, when examining the lithologic and bedding characteristics of the basal limestone conglomerate, the evidence suggests that the major structures are depositional. Closer



Figure 6-4. Closeup of limestone conglomerate along the south highwall. Note the variety of clasts, degree of sorting, roundness of clasts. Oriented in upright position.

3. The conglomerate is clast-supported.
4. Stylolites are common and some clasts show reaction rims suggesting some degree of diagenetic alteration, prior to transport and deposition. A few pebbles-cobbles-boulders (up to 30-60 cm) have thick reaction rims, up to 2/3s of the clast.



Figure 6-5. Limestone conglomerate showing probable high-spired gastropod (G) and segment of orthoconic cephalopod (C) fossils.

5. The rounding of the clasts and the presence of more angular, laminated clasts can be indicative of relatively rapid transport and deposition.
6. Fossils are not readily apparent in megascopic examination. However, some clasts have been found that resemble gastropods and cephalopods (Figure 6-5).
7. Individually fractured and faulted clasts have been observed (Figure 6-6) suggestive of prior structural deformation before transport and deposition. The sharpness of the fractures indicates a distributed brittle deformation.
8. The basal and upper contacts of the conglomerate beds are sharp.
9. The variety of clasts, the range of sizes, and the rounded nature of the clasts infers

a varied source area and high-energy transport.

Immediately overlying the limestone conglomerate, there is a thin bed (approximately one to seven cm) of unsorted silt- and mud-sized sediment. This zone drapes over the conglomerate before grading up into a laminite (Figure 6-7).



Figure 6-6. Highly fractured limestone clast showing offset from small fault that occurred prior to deposition. Faulting does not transect the surrounding rock.

Laminations for the most part average a millimeter or two in thickness but can be up to 1.5 cm thick, particularly at the west end where beds from the upper reaches of the quarry highwall can be accessed along the first bench. The laminite ranges in color from light- to medium-gray, pale-olive to grayish-olive and greenish-gray to light-greenish-gray. The HCl test provided a partial fizz indicating that some of the laminations are calcareous but the rock is also fairly hard, suggesting that it is siliceous. The green coloration of the laminite was thought at first to be due to reduced iron introduced from the clays during deposition or from permineralized fluids introduced after deposition. An SEM scan of the greenish laminite showed the minerals to be primarily albite and diopside (John Barnes, pers. comm., 2008).

Pyrite is a very common accessory mineral in both the limestone conglomerate and the laminite as individual, cubic microcrystals and small granular masses. The pyrite tends to occur along laminations and interstitially within the conglomerate. The common occurrence of pyrite may have been due to pyritization of organic matter within the limestone clasts or

within the politic sediment that was being deposited in the reducing environment of the basin floor. Pyritic zones tend to weather readily and can easily be associated with the rusty brown coloration on the quarry highwalls.

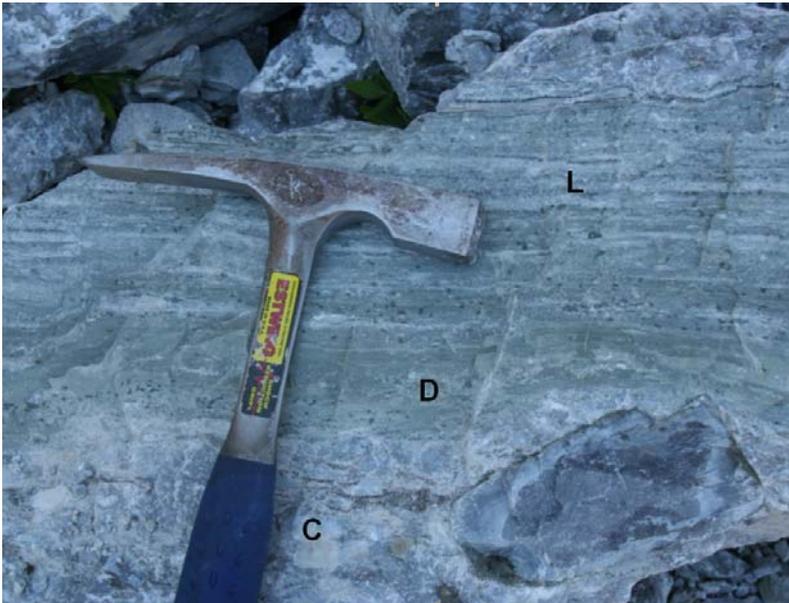


Figure 6-7. Block showing top of conglomerate (C), drape zone (D), then laminite (L).

Zones of small, subhedral, grossular-andradite garnets have also been observed within the laminite. The garnets are typically less than 1 mm in diameter and occur singly as a honey brown to a dark brown to black color.

Though far less common, vesuvianite (SEM/EDS verification by R. C. Smith, II and J. H. Barnes) is also present in the host calcite. This grossular-diopside-calcite-vesuvianite assemblage seems to fit with low pressure hornblende hornfels facies contact metamorphism. Van Houten (1969) reported that within the calcareous Lockatong of western New Jersey that this assemblage was restricted to a zone within 50 meters of a diabase sheet. Here at the Fairfield

Quarry, it seems most reasonable to presume that such a sheet was the York Haven Diabase and that it was once located within a comparable distance overhead, but is now eroded. This is supported, in part, by the presence, at times, of abundant zeolites in the Fairfield Quarry, the residual grossular nodules scattered over many fields in the flats near Fairfield (Stose and Bascom, 1929), and the absence of an interesting aeromagnetic pattern. Such a diabase sheet does not appear to have occurred above the town of Fairfield itself, where equivalent carbonate rocks are not marble-like and do not contain these indicator minerals.

Source of the Clasts

In general, the geologic mapping of the area has not changed since Stose and Bascom in 1929. Most descriptions of the Beekmantown in Adams County, follow those of Stose and Bascom and later on by Miller (1934) as "...a rather pure blue limestone finely laminated with impurities, with some white to pink marble, and closely resembles the Beekmantown of the Cumberland Valley..." (also see Wood, 1980 and Taylor and Royer, 1981).

Isolated large boulders of limestone were located during a recent sinkhole investigation southwest of Fairfield and appear to match Miller's description (Kochanov and Reese, 2008, pers. obs.), However, it could not be determined if the rocks were *in situ* or had been brought in for landscaping purposes.

Miller (1934) points out that fossil evidence provided no correlation with the Cumberland Valley but since the lithologies so closely resembled the Beekmantown, the name was tentatively applied to it. He favored this correlation based on the fact that fossiliferous Beekmantown limestone is present in the valley around Frederick, Md. about 25 miles to the southwest where it is similarly covered by the *conglomerate*, red sandstone and shale of the Mesozoic Newark series (Bassler, 1919, p. 113-115). Additionally, a small area of carbonates interpreted as Beekmantown limestone has also been mapped in the York Springs area.

Still, without the presence of invertebrate fossils within the limestone conglomerate, it is difficult to attach any degree of certainty to the age of the clasts. Diagenetic alteration of Beekmantown fossils may also tend to obscure their identification. A review of one thin section of the conglomerate did not reveal any mega- or microfossils.

Triassic limestone (and quartz) fanglomerates tend to occur as sand- to cobble-sized clasts supported by a *reddish-brown, fine-grained sand to mud-sized matrix*. This characteristic is somewhat of a stickler when comparing typical Triassic fanglomerates to the clast-supported limestone conglomerate observed in the Fairfield Quarry. If the Fairfield conglomerate is a Triassic limestone fanglomerate, then where is the reddish-brown matrix?

Perhaps the source for the reddish-brown sediment was absent and not syndepositional with the carbonate clasts or the finer-grained reddish-brown sediment was removed by some winnowing process. Triassic-aged sedimentary deposits basically surround the mapped extent of the limestone fanglomerate and the “Beekmantown” limestone. It seems unlikely that there was a lack of reddish-brown sediment to serve as a source.

An increase in current strength could have winnowed out the mud matrix during deposition to provide the clast-supported character of the Fairfield conglomerate, but wouldn't the higher energy have provided some degree of sorting? The chaotic nature of the clasts infers that deposition was rapid, making the removal of the reddish-brown matrix by winnowing unlikely. Another possibility is that the finer matrix may have been removed through the pressure solutioning.

No rock with reddish-brown coloration has been observed in the Fairfield quarry, either as matrix or as clasts. To be fair, there are Triassic-age rocks that are not reddish brown. However, keeping in mind the fluvial nature of these Triassic clastic deposits, it is difficult to come up with a depositional model that can account for the physical characteristics as well as the geometries of the limestone conglomerate observed in the Fairfield quarry. One would have to account for the rounding of the clasts as well as the size range, transporting the clasts without sorting them, deposit the clasts *en mass*, and then follow this with the deposition of the fine-grained laminite.

The Debris Flow Model

Based on preliminary observations, it is being interpreted that this sedimentary sequence represents a series of debris flows that have taken place along a carbonate platform margin and the sediments were deposited into the adjoining basin.

Being on a carbonate shelf explains the absence of terrigenous material. The absence of bedding is not easily explained. The conglomerate could have been deposited in a channel cut into the shelf which could explain the diversity of clasts but it is hard to imagine an 8 m thick conglomerate deposited on a relatively flat shelf.

Depositional margins are gentle accreting slopes which merge gradually with the basin floors. The shallow water portion may be formed by a reef or by carbonate sand shoals (McIlreath and James, 1978) or some other non-rudist building mechanism.

The transition from platform to basin can be abrupt but is more commonly a gently inclined slope that decreases in grade with depth until finally merging into basin sediments which may be hundreds of kilometers from the actual margin (McIlreath and James, 1979). Regardless of its low slope angle, the slope is susceptible to periods of catastrophic gravity-induced processes (debris flows) spelled by periods of relatively quiet, pelagic sedimentation (McIlreath and James, 1979).

The south Florida carbonate shelf is an example of a gentle depositional slope where local gradients are less than 10 degrees and overall slope is about one degree (Enos, 1977). Debris flows can extend several tens of kilometers with beds apparently deposited on slopes of no more than one degree

(Cook and others, 1972). Such relatively gentle depositional slopes are probably more typical of slopes of reef-fringed intracratonic basins and epeiric seas (Enos and Moore, 1983).

Debris flows are typically deposited as sheets and may have lenticular to distinct channel forms interlayered in the same sequences (Enos, 1973; Playford, 1980). Upper and lower contacts are sharp and typically planar with the underlying beds commonly undeformed. Sorting is poor and graded beds are not common. Apparent matrix volume can be reduced by dewatering (Enos and Sawatsky, 1981). Matrix is also susceptible to preferential removal during stylolite formation (Enos and Moore, 1983). These physical characteristics are comparable to the Fairfield conglomerate.

The Story

The inception of the debris flows could have been related to a number of variables any number of which could have been involved with the activation of the debris flows. These could range from an active fault margin, overloading of the platform rim to extensional faulting and partial exposure during periods of offlap. Another process is simple entrainment of colluvium accumulated at the base of erosional slopes.

The variety of clasts in the Fairfield conglomerate denotes a mixed provenance. It is assumed that carbonate buildup along a carbonate platform was primarily of non-coralline material. This is based on the abundance and lack of internal sedimentary or biogenic structures of the white to light gray, crystalline marble clasts throughout the conglomerate. The laminated clasts suggest an organic component that could have been algal in origin.



Figure 6-8. Photograph showing thick bed of limestone conglomerate at the base (hammer) with overlying thin bedded laminite (L) and progressively thinner beds of limestone conglomerate (C). The thin conglomeratic layers may be indicative of minor secondary flows.

Periods of onlap and offlap would have had an impact on the degree of cementation of the various lithofacies distributed across the platform. This would have occurred over time allowing the carbonate sediment to go through periodic and partial phases of cementation. Sediments with a greater degree of cement may have served as a hardground of sorts, becoming a staging area for the buildup of future carbonate sediments.

Over time, the shelf is subject to slumping and debris flows perhaps triggered by density currents, sediment loading or tectonic activity or a combination of factors. Mass wasting processes and subsequent erosional activity may have occurred more regularly during periods of offlap which may have exposed older rock. This could help explain the wide variety of clasts within the Fairfield conglomerate.

The occurrence of multiple stacked and offset beds of limestone conglomerate, separated by laminites infers that there were cycles of debris flows followed by periods of quiescence. Thinner beds of conglomerate as observed in the pit

highwall (west end) separated by laminite are probably distal remnants of successive flows (Figure 6-8). As the dust settled, finer-grained sediment draped over the conglomerate until finally, there is a return to pelagic sedimentation of mud to silt sized particles giving the laminar structures.

Jurassic aged diabase sheets were in close proximity to the limestone, providing the temperatures needed to help recrystallize the majority of the clasts to marble and help create the garnet-diopside assemblage and the pyrite.

Examination of this sedimentary package across the length and height of the quarry highwall provides evidence for repetitive, albeit offset, cycles of debris flows along a carbonate platform margin. At least four? cycles can be observed, provided one can keep oneself oriented as they trace them around the quarry highwalls.

No evidence of a paleokarstic surface or cave system is suggested. A cave roof collapse typically would have larger and more angular rock associated with it. In addition, the stacked and offset nature of the limestone conglomerate beds could hardly be confused with the geometry of a cave passage.

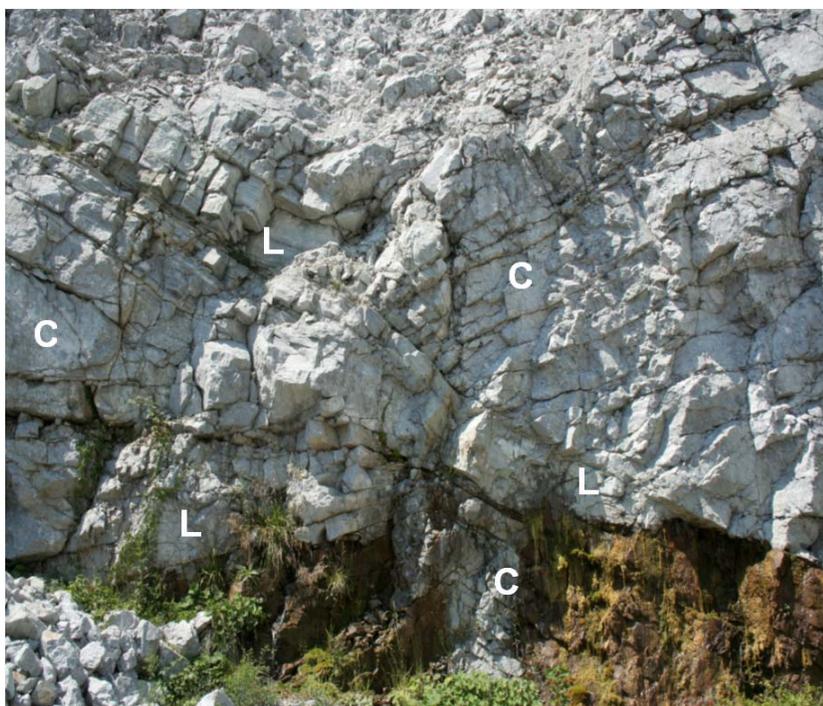


Figure 6-9. Spring located at the west end of the quarry. Note the apparent inter-fingering of the limestone conglomerate (C) and laminite (L)

A final stop is at the west end of the quarry on the first bench. Here, a small spring emanates from the highway in the vicinity of a possible fault (Figure 6-9). Although there are abrupt changes in bedding orientation, one cannot help but think about the possibilities of sedimentary processes creating fault-like features. Processes taking place on the continental shelves can mimic those taking place in a fluvial environment. Shallow and deep water currents can move water across the shelf, cutting into shelf and slope, carving out canyons and ultimately fanning out as deltas onto the basin floor. Changes in water density as fresh water enters more saline water and subsequent changes in sediment transport and deposition in the form of slumps and erosional cut-outs can help mobilize sediment creating features such as debris flows.

Significance

This exposure of basin floor rocks within the Gettysburg basin (east of the northwest margin), surrounded on the north, east, and south by basin sediments, constitutes an inlier. The presence of Ordovician carbonates in this Fairfield quarry indicates that erosion of the Alleghanian orogen had proceeded here only to this level by the beginning of the late Triassic. Ordovician rocks are also exposed in the other two inliers along the northwest margin to the northeast (at York Springs and Dillsburg). Similarly, Ordovician (and some upper Cambrian) rocks are exposed on the other side, along most of the southeast basin margin (Stop 1 being a local exception). Farther northeast, particularly east of the Susquehanna River, similar Lower Paleozoic rocks occur along both basin

margins. In Maryland, the same Cambrian and Ordovician rocks (Frederick sequence) lie on both sides of the southern end of the Gettysburg subbasin. It seems, then, that the basin floor (for the Gettysburg subbasin) consists predominantly of Cambrian and Ordovician carbonate shelf and slope rocks.

The importance of this is two-fold: first, that inliers of these carbonate rocks adjacent to the northwest margin are exposures of the basin floor; and second, that the same carbonate rocks are not exposed northwest of the basin margin. We will discuss the first at this stop; the second will be addressed at Stop 7.

The conventional view, widely accepted, is that the Gettysburg subbasin (indeed, all the early Mesozoic basin in eastern North America) formed as a rift with a half-graben profile. The essential ingredient in the half-graben is a major normal fault with sediment accumulating on the downthrown block, resulting in a wedge-shaped basin with the bedding dipping toward the active, syndepositional fault. This model superficially resembles the Gettysburg subbasin, with bedding dipping northwestward toward a bounding, normal fault on the northwest margin. And indeed, a fault has been mapped along that margin. However, the resemblance ends there.

The half-graben model requires that the deepest part of the basin occur next to the bounding fault. That is, the basin floor here should be at some 7-8 km depth (for the Gettysburg subbasin). But the basin floor is at the surface! George Stose (Stose, 1949) recognized this contradiction and proposed that the main bounding fault lay east of this quarry (inlier), and was covered by late sediments. He even suggested that the fault was masked by the intrusion of the diabase exposed just east of here.

But it is a hypothesis with no geologic evidence to support it. No offsets of any stratigraphic units have been mapped along its supposed "eastern" trace, north or south of here. After 7 km of vertical movement, it is odd that no additional movement occurred in the waning stages of basin filling. And the diabase he hides the fault in is not a vertical dike, but a subhorizontal sheet (now partially eroded) that was intruded immediately above the quarry rocks, imparting the observed thermal metamorphism. In short, Stose's conjecture is a hypothesis without supporting evidence, a patch to an invalid basin model.

The presence of the basin floor at and near the surface at the northwest margin indicates that the basin's deepest part is not here along the margin, but probably near the center of the present basin remnant. Indeed, a seismic line across the Newark subbasin (Costain and Coruh, 1989) demonstrates this very point. This geometry contradicts the half-graben model, and suggests that the Gettysburg subbasin (Birdsboro basin) formed in a crustal downwarp independent of any major faulting (see Faill, this volume, Figure 3).

Acknowledgements

Thanks to John Barnes for the timely SEM analyses; Rodger Faill for the discussions in the field and use of Bob Smith's notes (thank you Bob); and Stephen Shank for getting the thin sections sent out (and Burnham Petrographics for getting them done).

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STOP 7. Pleasant Dale Creek fanglomerate.

Leaders: Rodger Faill and Robert C. Smith, II. Estimated time at Stop is 45 minutes [arrive 4:30, leave 5:00].

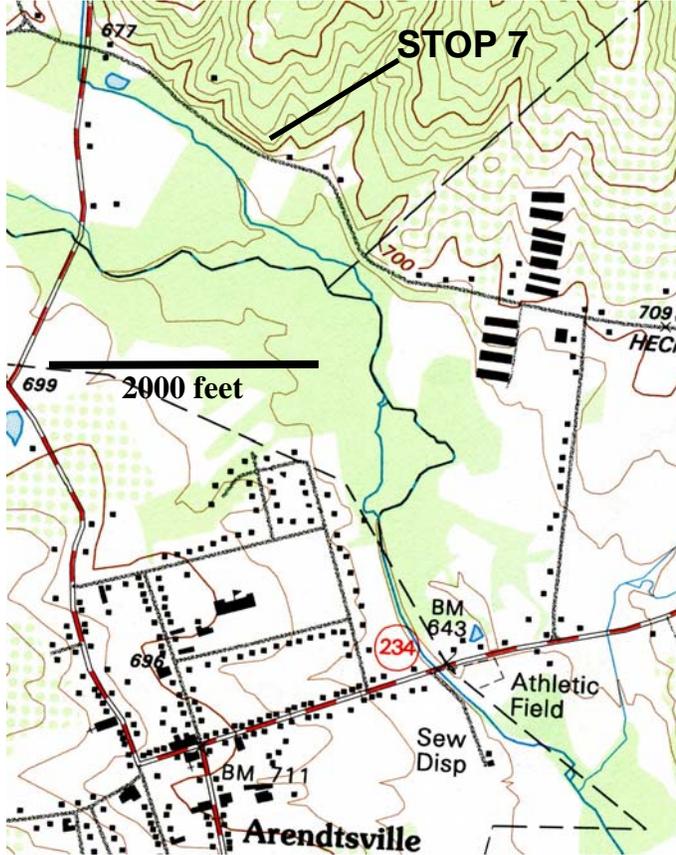


Figure 7-1. Location map for STOP 7. From Arendtsville 7½' quadrangle.

Location and basin setting. Stop 7 is located 1.5 km north of Arendtsville, Pa., along Heckenluber Road, 450 m east-southeast of its intersection with Brysonia Road (Figure 7-1). It lies in the Arendtsville 7-½ minute Quadrangle, at Lat 39° 56' 09" N (39.9358 °), Long 77° 17' 46" W (77.2961 °).

The Pleasant Dale Creek Fanglomerate (herein named) is a large deposit along the northwest margin of the Gettysburg subsbasin. Stop 7 is a small exposure on the south side of this fanglomerate, lying only 650 meters from the Gettysburg basin's northwest margin. The Pleasant Dale Creek fanglomerate is some 5 km wide (along strike), is more than 200 meters thick, and extends at least 6 km into the Gettysburg subsbasin. This fanglomerate is one of several that are present along the western margin of the Gettysburg subsbasin. They grade laterally into the very highest part of the Gettysburg Formation, probably close to the Triassic-Jurassic boundary.

Description. Fanglomerates consist of poorly sorted material of large grain-size range (often mud to boulder), often with a variety of clast compositions. The poor sorting indicates

transport and rapid deposition as debris flows rather than by persistent fluvial processes. The variety in clast composition indicates multiple source rocks; angularity of the clasts suggests short transport distances. Fanglomerate sizes range from 10s of meters to five or more km in lateral extent and from meters to hundreds of meters in thickness. They are local deposits occurring at basin edges, and usually grade laterally into the sediments that enclose them (Figure 7-2). The Pleasant Dale Creek fanglomerate has all of the characteristics of a fanglomerate and is one of the largest ones in this subsbasin.

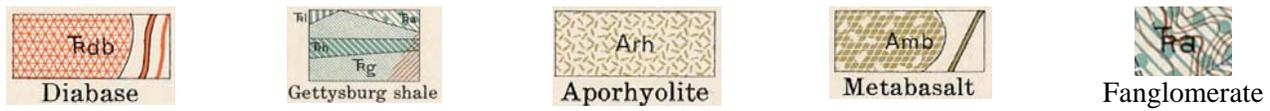
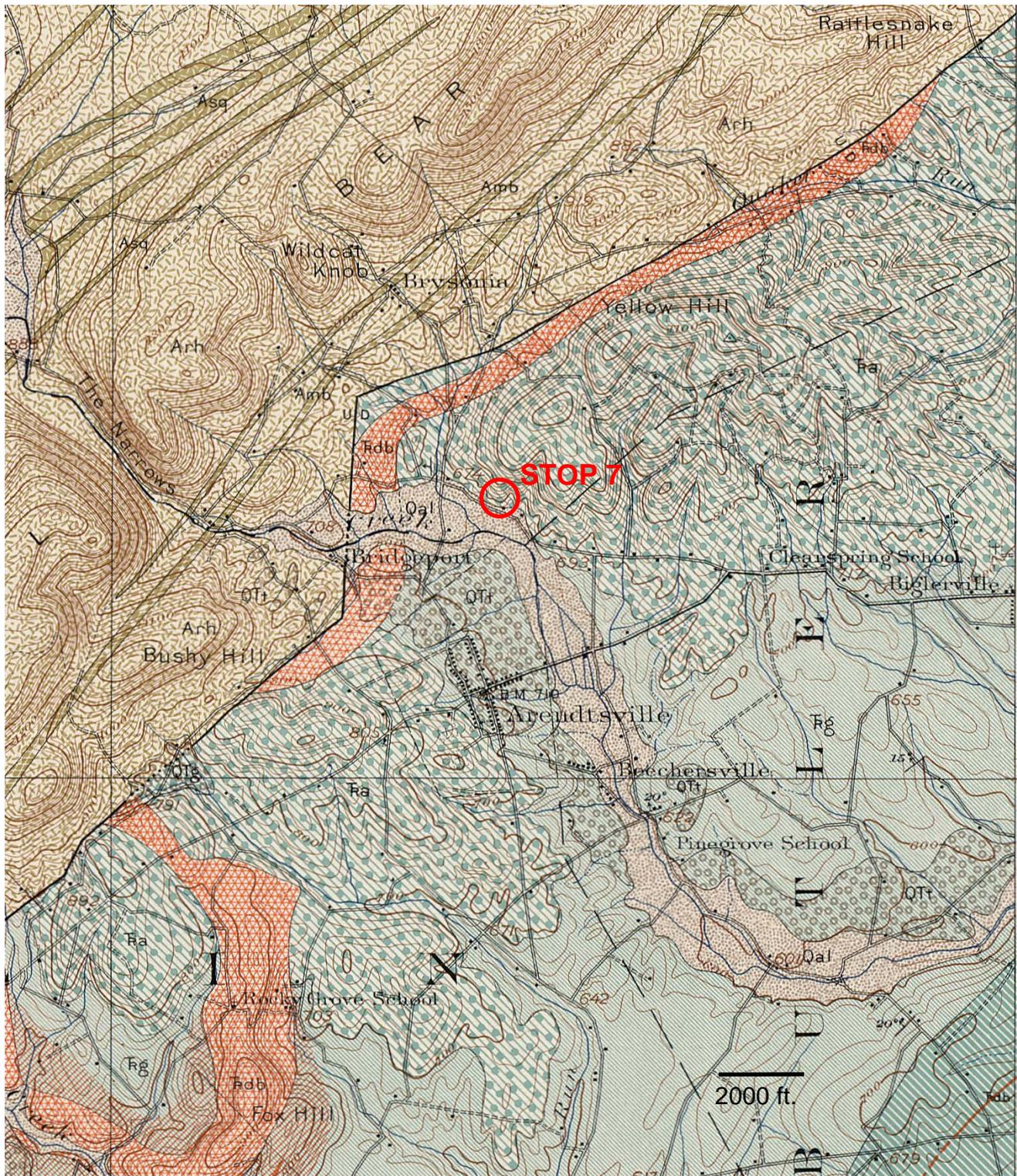


Figure 7-2- Geologic map of Pleasant Dale Creek fanglomerate at the northwest margin of the Gettysburg subbasin, juxtaposed against the metarhyolites of South Mountain. Red circle indicates location of STOP 7. Modified from Stose and Bascom, 1929.



Figure 7-3- Densely-packed subrounded pebbles and small cobbles of quartzose sandstone and metarhyolite in a fine-grained, poorly sorted matrix.

The rock is poorly sorted with sufficient clasts (or lack of matrix) that many are in direct contact with adjacent clasts (Figure 7-3). The clasts range in size from 1 to 50 cm (pebble, cobble, and rare boulder). Clasts compositions are primarily gray (reddish gray, lilac gray, and grayish purple) metarhyolite (40-65%), vein quartz (5%), quartzite sandstone (30-55%), and caliche. No cobbles of Catoctin Metabasalt were observed. One third to one half of the metarhyolite clasts contain various amounts of salmon-colored feldspar phenocrysts from 1 to 8 mm in size (greenish color indicates seritization). The metarhyolite and sandstone clasts are sub-rounded to well rounded (suggesting significant travel from

source areas); half-angular ones (flat on one side) indicate breakage of clasts during transport. The clasts tend to be flat in shape, as are the ripped-up caliche conglomerate clasts—the latter are more angular.

Table 7-1. Location, description, and dimensions of three Catoctin Metarhyolite cobbles from the northeast side of Heckenluber Rd., 0.47 +/- 0.03 km SE of the intersection with the Brysonia-Arendtsville Rd.

Sample Name	Sample Location	Cobble Dimensions	Lithology	TiO ₂ %
CATMRFMa	4.1 +/- 0.3 m above road level	18x10x8cm	Gray metarhyolite having 1 to 5 mm salmon-colored feldspar phenocrysts.	0.37
CATMRFMb	6.5 +/- 1 m above road level and almost directly above CATMRFMa.	40x30x10 cm	Lilac-gray metarhyolite containing minor feldspar phenocrysts.	
CATMRFMc	3.0 +/- 0.5 m above road level and 6 m w of samples a and b. It appears to be the lowest stratigraphically.	12x10x10 cm	Grayish purple metarhyolite containing 1 - 8 mm euhedral, salmon-colored feldspar phenocrysts.	

The first sample, CATMRFMa, contains 0.37 % TiO₂, a good element for comparing matching Catoctin Metarhyolites. This sample has a much higher TiO₂ content than 7 other samples of metarhyolite from the nearby section through the Conewago Narrows (to the northwest in South Mountain) and beyond, all of which have lower TiO₂ contents, ranging from 0.17 to 0.23 %. In other words, the Catoctin Metarhyolite clasts cannot be matched with the metarhyolite section directly across

the basin margin, up present-day stream gradient. The best known Catoctin Metarhyolite match for TiO_2 (0.36 %) is from samples at the Waynesboro Reservoir site in central South Mountain, Stop 3 of the 1991 Field Conference of Pennsylvania Geologists (Smith, 1991).

The matrix is poorly sorted, ranging from mud to fine sand, and contains isolated clear quartz grains, and perhaps feldspars. The fanglomerate matrix is calcareous based on the caliche and the cavities from dissolved pebbles. The presence of the flora *Aquilegia Canadensis* (“Canadian or Red Columbine”) on the outcrop indicates a calcareous content as well.



Figure 7-4. Channel conglomerate debris flow eroding laterally (to the left) the underlying fanglomerate. The fingers point to the erosion surface.

somewhat analogous material is perhaps the large mass of colluvium that occurs on the north and northwest side of South Mountain just to the west. Here, the depositional processes are perhaps more equally divided, but debris flow often is the dominant process (Sevon and Potter, 1991).

Structure. The median of three bedding determinations in the outcrop is 347-21 (dip vector, in azimuth and plunge). The anticipated Alleghanian cleavage was not observed in the Catoctin Metarhyolite cobbles, but autogenous grinding during the Late Triassic may have reduced the more cleaved ones.

Significance. The presence of the Pleasant Dale Creek Fanglomerate along the basin’s northwest margin, and its eastward interfingering with the enclosing finer-grained Gettysburg Formation, suggests a northwestern source for the sediment. The provenance of the metarhyolite and quartzitic sandstone clasts is presumed to be the Catoctin metarhyolites and Antietam/Weverton quartzites in the South Mountain anticline to the west.

Although the metarhyolite clasts are of Catoctin origin, they are chemically unlike any of the metarhyolites presently exposed in the adjacent South Mountain (personal communication, R. C. Smith, II, 2007). The source metarhyolites were present at a higher structural level in South Mountain, one that has since been eroded. This suggests that the fanglomerate (and thus the Gettysburg subbasin) has been displaced relative to South Mountain at some time after its deposition. That is, the fault between the fanglomerate and South Mountain had post-depositional movement.

Stratification is poorly developed. Bedding is poorly defined (a 343-22 dip vector [in azimuth and plunge, to NW] may be a good approximation), and there is some suggestion of cross bedding. The poor sorting and the absence of good bedding forms indicate that debris flow was the primary process in constructing this fanglomerate. However, better and more extensive exposure might show that there are more local zones of stratification than are noted at this outcrop. The fact that there are such zones suggests that there were mixed processes of deposition, but that debris flow was the dominant process. A

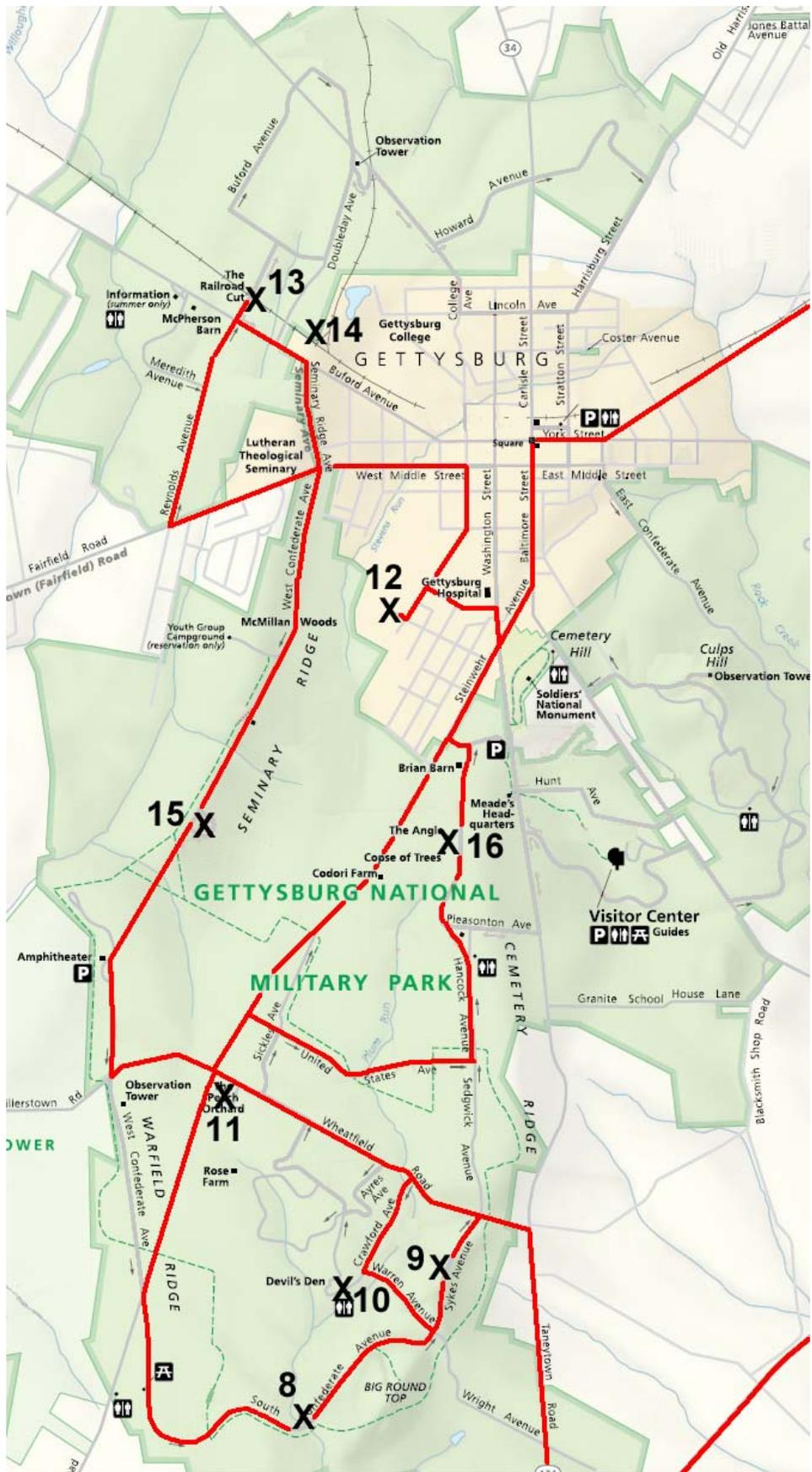
The Pleasant Dale Creek Fanglomerate and five other fanglomerates of similar size and character are distinctive in the Gettysburg subbasin for several reasons. Together, they occupy a single 30-km-length of the northwest margin. Their clasts are overwhelmingly subrounded quartzites and quartzose sandstones of probable Chilhowee Group (mostly Antietam and Weverton Formations) provenance. The oversized South Mountain anticline of the Valley and Ridge province lies adjacent to them, just outside the basin's northwest margin. The fanglomerates are in fault contact with metarhyolites of the Neoproterozoic and earliest Cambrian Catoctin Formation. Other fanglomerates, with carbonate clasts, are present along the same margin, but farther to the northeast and southwest of the quartzose ones.

These characteristics suggest the following scenario. During the late Triassic, the South Mountain anticline was becoming an emergent mountain (in effect, a monadnock), capped by the erosionally resistant quartzose Chilhowee Group rocks. The relief in the areas surrounding South Mountain (including the basin floor) was low to moderate because carbonate rocks (mostly) underlay those areas. As the basin subsided and filled, South Mountain blocked sediment from the northwest. Hence, arkosic sediment from the southeast spread much farther across the basin (as noted in Stop 5). It was only late in the late Triassic that the quartzose cap of South Mountain was sufficiently breached to begin providing Chilhowee clasts in debris flows. To the northeast and southwest, the South Mountain anticline plunges steeply and the elevations at that time were lower. The carbonate cover above the Chilhowee had not been completely removed by erosion and thus was able to provide clasts for limestone fanglomerates there.

However, the quartzose fanglomerates currently lie against Catoctin metarhyolites. And carbonate fanglomerates lie against both metarhyolites and Chilhowee rocks. These metarhyolites are not represented in the fanglomerates—the metarhyolite clasts are chemically different (see discussion above). It is apparent that significant faulting has occurred along the present basin margin sometime after the late Triassic. Similar discrepancies are present along the comparable margin in the Culpeper subbasin in Virginia, and in the Hartford basin in Connecticut. Interestingly, movement on the bounding fault in Connecticut has been dated by fission-track as being late Cretaceous (Roden-Tice and Wintsch, 2002). The conclusion one is driven to is that the bounding faults were active only after the basin was filled, sometime in the Jurassic or later.

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Day 2 Route Map
 Modified from National Park Service Visitor Guide Map

DAY 2

Miles		
Int.	Cum.	Description
0.0	0.0	TRAFFIC LIGHT at entrance to Gateway Gettysburg. Turn left on US 30W toward Gettysburg.
0.2	0.2	Cross over US 15.
0.2	0.4	Bear right onto ramp to US 15S.
0.2	0.6	Merge with US 15S.
5.4	6.0	Bear right onto exit ramp to Taneytown Road (PA 134N).
0.2	6.2	STOP SIGN. Turn right onto Taneytown Road.
0.1	6.3	Big and Little Round Tops ahead to left.
0.7	7.0	Jacob Weiker House to left.
0.3	7.3	Leonard Bricker House to left. Like the Weiker and nearly every other rural house (and barn) in the vicinity, the Bricker house and outbuildings served as field hospitals during and immediately after the battle of Gettysburg.
0.1	7.4	Turn left onto Wheatfield Road at Scoops ‘n Scootz ice-cream stand.
0.15	7.55	STOP SIGN. Continue straight on Wheatfield Road, a road that existed pretty much along its present route at the time of the battle.
0.9	8.45	Peach Orchard (STOP 11) to left.
0.05	8.5	Turn left onto Emmitsburg Road (Bus. US 15S).
0.7	9.2	The house to right is on the site of that of Philip Snyder, who resided here at the time of the battle. Though certainly dating from the mid-1800’s it is probable that this particular dwelling was moved to this location sometime after the war.
0.1	9.3	Bear left onto Confederate Avenue onto the southern part of Warfield Ridge. Underlain by a Jurassic-age diabase (Rossville) dike that runs due south into Maryland and extends north almost to Biglerville, the ridge is named for James Warfield, a free-black widower who lived near here with his four daughters. He operated a blacksmith shop in Gettysburg, but like many free-blacks in the region fled on the approach of the Confederate army. “[U]ntold numbers” of his compatriots were not so lucky, and ended up being captured and shipped south in bondage (LaFantasie, 2005).
0.1	9.4	To left are three bronze 12-pounder Napoleons, or 1857 gun howitzers, at the position of Latham’s Battery (Hood’s Division of Longstreet’s 1 st Corps) commanding a good view of the Round Tops from the right of the Confederate line. These smoothbore cannons (named for French Emperor Napoleon III—of Solverino fame; see STOP 15) had a maximum range of about 1500 yards using solid shot, spherical case, or shells (Faust, 1986; Grimsley and Simpson, 1999). From the heights along this stretch of Warfield Ridge Latham’s and Reilly’s Batteries duelled with the Union guns of Smith’s Battery on Houck’s Ridge near Devil’s Den just before and during Hood’s attack on the Union left on the afternoon of July 2 (Adelman and Smith, 1997; see STOP 10).
0.05	9.45	Rose Farm to left at base of hill (see STOP 11).
0.3	9.75	To right is the Alabama Monument. From along Warfield Ridge in this area, Law’s Brigade (Hood’s Division) of five Alabama Regiments—the 4 th , 15 th , 44 th , 47 th , and 48 th —began its assault on the Union left.
0.15	9.9	The two 10-pounder, rifled Parrott guns to the right mark the position of Reilly’s Battery (Henry’s Battalion, Rowen’s Artillery, Army of Northern Virginia) during “Farnsworth’s Charge.” This last tragedy of the battle of Gettysburg started just south

of here and was played out in the boulder-strewn, openly wooded (at the time) terrain between the Round Tops and the Emmitsburg Road in the area just to the north and south of South Confederate Avenue.

0.3 10.2 To left are waysides describing “Farnsworth Charge” (Figure D2-1) and “The Dead and Wounded at Gettysburg.”

0.05 10.25 On right is monument to William Wells (1837-1892), at the time a major commanding a battalion of the 1st Vermont Cavalry Regiment in Farnsworth’s Brigade. Farnsworth rode with Wells, who won a Congressional Medal of Honor for this leadership in the action (Trudeau, 2002).

0.05 10.3 Pull off into parking area on right side of road. Disembark.



Figure D2-1. “Farnsworth’s Charge” wayside at mile 10.2. “Farnsworth’s (Cavalry) Charge,” ordered by Union Brig. Gen. Judson Kilpatrick (1836-1881), was the last major action of the battle of Gettysburg, occurring late in the afternoon of July 3, just as “Pickett’s Charge” climaxed and ebbed on the open fields two miles to the north. The famous dialogue between Brig. Gen. Elon J. Farnsworth (1837-1863), commander of the 1st Brigade (3rd Division) and division-commander Kilpatrick—repeated on the wayside—may never have taken place, at least in its traditional form so damning to Kilpatrick. The most memorable line is Farnsworth’s: “General, do you mean it? Shall I throw my handful of men over rough ground, through timber, against a brigade of infantry? The first Vermont has already been fought half to pieces. *These are too good men to kill.*” (See Custer, 2003, for an updated account of “Farnsworth’s Charge” that raises serious questions about the action as described here—and in many other accounts.)

STOP 8. Plum Run Bridge: Dinosaur footprints and sedimentary structures in sandstones of the Heidlersburg Member (middle of Gettysburg Formation).

Walk ahead across the stone bridge over Plum Run, to examine the sandstone/siltstone blocks forming the tops of the side-walls for several dinosaur footprints (see extended Stop 8 description in this guidebook). These tracks are small-sized, because they were made by animals living early in dinosaur history (Late Triassic), before they evolved to achieve the gigantic sizes characteristic of later species in their group. See detailed stop description on page 130.

0.2 10.5 Leave STOP 8. Continue ahead on Confederate Avenue, crossing Plum Run Bridge. To left is the “Devil’s Kitchen,” a chaotic pile of broken diabase ledges and boulders (Figure D2-2). The 4th Texas Infantry of Robertson’s Brigade passed across these rocks in attacking Little Round Top in the late afternoon of July 2. Confederate skirmishers subsequently occupied the Devil’s Kitchen until their withdrawal on the evening of July 3 (Adelman and Smith, 1997).

0.15 10.65 To right is head of trail to summit of Big Round Top. Though the higher (elevation about 785 feet), more rugged, and more heavily wooded of the two Round Tops did not figure prominently in the battle (or more probably because of these differences), some action between retreating Union sharpshooters and the attacking Alabamans of Law’s Brigade took place on its western slopes early in the attack on Little Round Top. After fighting ended on July 2, Union forces occupied the hill to firmly anchor their left flank.

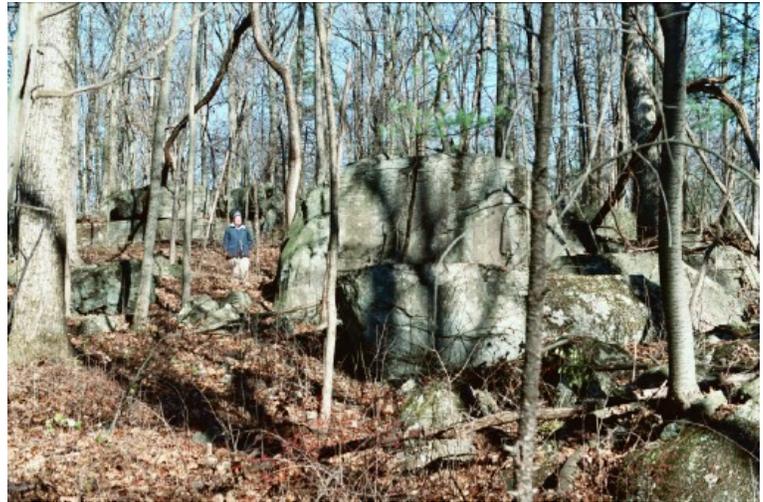


Figure D2-2. The Devil’s Kitchen at mile 10.5. This is one of numerous relatively small York Haven diabase “dens” on the outcrop of the Gettysburg sheet. Several of the large boulders here are connected by stonewalls that may date from the time of the battle.

- 0.05 10.7 To right are monuments to the 39th Pennsylvania Infantry (10th Pennsylvania Reserves) and the 9th Massachusetts Infantry (both 5th Corps). The stonewall snaking up the north slope of Big Round Top here extends all the way to the summit and was originally built by the 5th and 12th Pennsylvania Reserves and the 20th Maine on the night of July 2-3.
- 0.1 10.8 STOP SIGN at intersection with Warren Avenue. Continue straight ahead on Sykes Avenue.
- 0.2 11.0 Parking area on Little Round Top. Disembark.

STOP 9. Little Round Top: Day-2 action (Warren, Vincent, Chamberlain, and Oates) and the York Haven Diabase.

Little Round Top was arguably the most vital position on the Union “fishhook.” At an elevation of 665 feet and a relief of 150 feet, its rocky summit provides a panoramic view to the north and west. The hill (and its higher and more wooded southern neighbor, Big Round Top) is underlain by York Haven-type diabase (early Jurassic) of the northwestward-dipping Gettysburg sill. Physical and chemical weathering along joints and non-systematic fractures has created rounded boulders and cobbles ranging in size from a foot or less to twenty feet or more. Most striking of the weathering phenomena is the arch formed by the “Curious Rocks.”

After initially ignoring this rocky “anchor” at the south end of their position, Union troops finally permanently occupied Little Round Top on the afternoon of July 2 after Maj. Gen. Gouverneur K. Warren realized that the hill was vital to protecting the left flank of the Union line from Confederate attack. Fierce fighting took place all through the late afternoon, culminating in a desperate (and successful) bayonet charge by the 20th Maine Infantry down the southeast and south slopes.

A walking tour will visit 8 *Sites* important to understanding the geology and battle action on Little Round Top.

See detailed stop description on page 133.

Leave STOP 9, continuing ahead on Sykes Avenue.

- 0.1 11.1 To left is the monument to the 121st New York Infantry (6th Corps), commanded by Col. Emory Upton (1839-1881). A native of Batavia, NY, Upton graduated from West Point in May 1861. Initially assigned to the artillery, Upton took command of the 121st New York in October of 1862. He was promoted to brigadier general on the field at Spotsylvania's "Bloody Angel" for "innovating a method of rushing assault by column instead of by the standard linear assault" (Faust 1986, p. 773; see Trudeau 1989).

- 0.1 11.2 STOP SIGN at north base of Little Round Top; turn left (west) onto Wheatfield Road. The bronze equestrian statue atop the granite monument directly ahead before the turn depicts Maj. Gen. John Sedgwick (1813-1864), commander of the Union 6th Corps (Figure D2-3). Badly wounded at Antietam, Sedgwick was apparently considered for command of the Army of the Potomac after Chancellorsville. He survived Gettysburg and the Wilderness, but his luck ran out at Spotsylvania in May of 1864. While emplacing artillery before the battle, Sedgwick was killed by a Confederate sharpshooter just after uttering the fateful words, "...[T]hey could not hit an elephant at that distance" (Faust, 1986; Trudeau, 1989). The topographic rise on which the statue stands and the rocky knob just to the west in line with Little Round Top probably owe their local prominence to the fact that they lie near the eastern edge (bottom contact) of the Gettysburg sill diabase (see STOP 16 for a fuller explanation).



Figure D2-3. Close-up of Maj. Gen. John Sedgwick Equestrian Statue on Sedgwick Ave., just north of mile 11.2. Meade held Sedgwick's 6th Corps in reserve, and it saw little action in the battle.

- 0.3 11.5 Turn left (south) on Crawford Avenue into the "Valley of Death."
0.05 11.55 On left is monument to Brig. Gen. Samuel Wylie Crawford (1829-1892), commander of the 3rd Division of the 5th Corps. In a last Federal counterattack on the evening of July 2, Crawford led his division of Pennsylvania Reserves across the "Valley of Death" to dislodge the Confederates from the high ground on the right. This was one of several Union counterattacks that finally checked the Confederate offensive in the evening (Editors of Time-Life Books, 1996).

A graduate medical doctor (University of Pennsylvania, 1850), Crawford had commanded a battery at Fort Sumter during the siege of April 1861. He fought through the entire war and was brevetted for gallantry at Petersburg (Faust, 1986; Jorgensen, 2002). His missteps at the climactic battle of Five Forks in April 1865, however, probably cost Gouverneur Warren his command of the 5th Corps and his military reputation (Jordan, 2001; see STOP 9).

- 0.05 11.6 To right is a low diabase knoll referred to by some battlefield guides as "Day Hill," for Col. Hannibal Day, commander of the 1st Brigade, 2nd Division, 5th Corps. Day's five regiments of U.S. Regulars were stationed here during the last phase of the fighting for the Wheatfield. Forced to retreat across the "Valley of Death" by intense pressure from four Confederate brigades, Day's brigade suffered about one-third casualties

(Jorgensen, 2002). The granite marker on top of the knoll is to the 2nd Division of the 5th Corps, Brig. Gen. Romeyn B. Ayers, commanding.

0.1 11.7 The rocky, elongate hill to right (west) is Houck’s Ridge, at the southwest end of which is Devil’s Den.

0.2 11.9 STOP SIGN at intersection Warren Avenue. Just to the left of the intersection on the far side of Plum Run is the monument to the 40th New York Infantry (3rd Corps, the “Mozart Regiment (Figure D2-4). Pull off on right side of road. Disembark.



Figure D2-4. Monument to the 40th New York Infantry at mile 11.9. This carved chunk of Westerly (Rhode Island) granite commemorates the charge of the “Mozart Regiment” down the “Valley of Death” late in the afternoon of July 2. This was one of the last actions of the bitter fight for Devil’s Den and Houck’s Ridge (see Stop 10), and resulted in the regiment suffering “terrible losses” before being forced to retire (Adelman and Smith, 1997). (For significance of the designation, “Mozart,” see Hawthorne, 1988.)

STOP 10. Devil’s Den: More Day-2 action and more York Haven Diabase.

Devil’s Den is the most storied place on the Gettysburg battlefield. In a three-or-four-hour period in the afternoon of July 2, this spectacular broken outcrop of bare rock witnessed some of the bloodiest fighting of the battle. Occupied by Union troops of Sickles’s 3rd Corps, who advanced out from a position at the low south end of Cemetery Ridge, the Confederates ultimately dislodge their adversaries and occupied the “Den” until the end of the battle.

Devil’s Den is the best place on the battlefield to observe the York Haven Diabase, a high-TiO₂, quartz-normative, continental tholeiite. Dominant minerals are clinopyroxene and calcic-plagioclase. The rock is coarsely crystalline, with the mineralogy being particularly evident on weathered surfaces. The most-striking weathering feature of the diabase at Devil’s Den is the extensive open-fracture network that divides the rock mass into huge blocks (typically with rounded edges).

A walking tour consists of 9 *Sites* that illustrate the geology and military significance of Devil’s Den.

See detailed stop description on page 142.

Leave STOP 10, turning left on Warren Avenue. The “Valley of Death” is to left, the “Slaughter Pen” to right.

Alternate Road Log to Mile 13.15 near Peach Orchard (STOP 11):

0.0 0.0 STOP SIGN at intersection of Warren and Sickles Avenues. Continue straight on Sickles Avenue.

- 0.1 0.1 Confederate “sharpshooter’s position to right (see STOP 10, *Site D*). To left is the “triangular field” (STOP 10, *Site E*).
- 0.2 0.3 Passing through “The Wheatfield” (see mile 12.95 of main Day-2 Roadlog).
- 0.1 0.4 Directly ahead is “Stony Hill,” marking the resistant chilled zone at the west edge (top) of the Gettysburg diabase sheet (see mile 13.0 of main Day-2 Roadlog).
- 0.15 0.55 To left, as Sickles Avenue ascends “Stony Hill,” the “Irish Brigade” (2nd Brigade, 1st Division, 2nd Corps) Monument and to the right—amid a prominent pile of diabase boulders—the site of the 32nd Massachusetts field hospital. The marker to the latter reads:
 Behind this group of rocks on the afternoon of July 2nd, 1863, Surgeon Z. Boylston Adams placed the field hospital of the 32nd Massachusetts Infantry, 2nd Brigade, 1st Div., 5th Army Corps. Established so near the line of battle, many of our wounded escaped capture or death by its timely aid. Placed by the Veteran Association of the Regiment.
- 0.15 0.7 STOP SIGN. Turn left (west) on Wheatfield Road.

- 0.2 12.1 STOP SIGN. Turn left on Sykes Avenue.
- 0.2 12.3 Little Round Top again!
- 0.2 12.5 Turn left on Wheatfield Road.
- 0.3 12.8 Intersection with Crawford Avenue to left. Continue straight ahead.
- 0.05 12.85 Cross Plum Run.
- 0.05 12.9 Intersection with Ayers Avenue. The pink granite monument to left is that of the 11th Pennsylvania Reserves (40th Infantry Regiment) of Crawford’s 3rd Division, 5th Corps. Gary Fleegeer’s 1st cousin—once removed, fought in this unit.
- 0.05 12.95 To left is “The Wheatfield,” a 26-acre field of wheat (part of the Rose Farm) that was bloodily contested for nearly six hours in the late afternoon and early evening of July 2 (see Jorgensen, 2002, for an excellent description keyed to landscape features and monuments). Prominent in the middle of the field is the monument to the 1st New York Light Artillery, Battery B, commanded by Capt. George B. Winslow (Figure D2-5).
- 0.05 13.0 Sharp rise ahead is “Stony Hill,” a low diabase escarpment formed by the fine-grained, chilled northwest margin of the Gettysburg sheet. This hill changed hands several times, most notably when Joseph B. Kershaw’s South Caroline Brigade captured it after Tilton’s and Sweitzer’s brigades were pulled back to Trostle’s Woods by Brig. Gen. James Barnes (5th Corps, 1st Division) at about 6:00 PM. (Barnes feared that Kershaw’s attack on the Federal artillery position on the Wheatfield Road [to his right] would outflank him.) This precipitous withdrawal put the entire Federal position in jeopardy (Jorgensen, 2002).



Figure D2-5. Monument of the New York Light Artillery, Battery B (Winslow’s) in the Wheatfield at mile 12.95. The six Napoleons of Winslow’s Battery (a full complement of guns) were the only artillery, Union or Confederate, placed in the Wheatfield. Wrote Capt. George B. Winslow of his battery’s work here, “[B]y using shell and case shot at about one degree elevation, and from 1 to ½ second fuse, I kept the enemy from advancing from the cover of the woods” (Jorgensen, 1999, p. 53).

- 0.1 13.1 Crest of “Stony Hill.”
- 0.05 13.15 Intersection with Sickles Avenue. The diabase boulders in this vicinity mark the approximate northwest edge of the Gettysburg sheet. Most of the open field ahead—extending to the Peach Orchard—is underlain by baked shale (hornfels) directly above the sheet.
- 0.1 13.25 Monuments to the 5th Massachusetts Battery and the 10th Independent Battery, New York Light Artillery. The four guns here are Parrott rifled cannon.
- 0.3 13.45 Pull off on right side of road. Disembark in front of the 68th Pennsylvania Infantry (“Scott Legion,” 1st Brigade, 1st Division, 3rd Corps) Monument.

STOP 11. The Peach Orchard: Day-2 action and the Rose Farm.

Sherfy’s Peach Orchard is the focal point of one of the major controversies of the battle of Gettysburg. Early in the afternoon of July 2, Maj. Gen. Daniel E. Sickles shifted the two divisions of his Union 3rd Corps from its original position on the Union left (south end of Cemetery Ridge) westward to higher ground on his front. By doing so he not only extended the line he had to defend, but also created a dangerous salient at the Peach Orchard. Late in the afternoon, the Confederates overran his position, driving the 3rd Corps and its reinforcements from Devil’s Den, the Peach Orchard, and the line of the Emmitsburg Road. Sickles’ men suffered such grievous casualties, that the Corps was discontinued in March of 1864 and its remnants molded into the 2nd and 6th Corps later in the year. (Sickles himself lost a leg in the action and did not return to battlefield command.)

The Peach Orchard is underlain by shale and sandstone of the Gettysburg Formation baked to hornfels by the Gettysburg diabase sill to the east. No outcrops occur in the vicinity, but gray hornfels float litters the surface of the soybean field just south of the orchard.

See detailed stop description on page 149.

- 0.25 13.7 Leave STOP 11, turning right on Emmitsburg Road (Bus. US 15N). To left is the Sherfy House. Farmer John Sherfy owned the “Peach Orchard.” (See Smith 2007, p. 20-23).
- 0.2 13.9 To right is the Klingel House. This is approximately the middle of the Union 3rd Corps line that stretched more than half a mile northeastward along the Emmitsburg Road from the Peach Orchard on the afternoon on July 2.
- 0.2 14.1 Too right is a monument to Brig. Gen. Andrew A. Humphreys (1810-1883), commander of the 2nd Division of the 3rd Corps (Figure D2-6). Humphrey’s division held the right of Sickles’ line along the Emmitsburg Road (which reached to here). On the opposite side of the road is the site of the Rogers House.
- 0.3 14.4 Pass the Codori Farm on right. On the afternoon of July 2, the Codori Farm lay just beyond the right wing of Humphreys’ position along the Emmitsburg Road. To protect that exposed flank, two regiments of John Gibbons’ 2nd Corps division took position here after Humphreys came under attack (Trudeau, 2002). The farm was owned by Nicholas Codori, whose brother George J. (1806-1865), a local farmer, was one of nine hostages from Gettysburg and nearby communities taken by Confederate General Jubal Early when he passed through the area in late June on his way to York and Wrightsville. (George was caught wearing Union army-issue trousers, presumably sent to him by his son.) These prisoners were sent first to Libby Prison in Richmond, then

on to a prisoner-of-war camp at Salisbury, NC. Rather miraculously, eight of them survived to return home in March 1865.

George Codori, however, died of pneumonia only three days after his return (Kross, 2000; Roth and Kross, 2000).

- 0.5 14.9 Enter borough of Gettysburg (now on Steinwehr Avenue). James Gettys, a Revolutionary War veteran, founded Gettysburg in 1780. Originally know as Marsh Creek Settlement, it was incorporated as the borough of Gettysburg in 1800.

Baron Adolph Wilhelm August Friedrich von Steinwehr (1822-1877), for whom the avenue is named, was brigadier general in command of the of the 2nd Division of the 11th Corps at Gettysburg. Though generally well regarded by his superiors, his division was involved in two military debacles, being overrun by “Stonewall” Jackson at Chancellorsville and by Richard Ewell on the July 1 at Gettysburg. After the war, Steinwehr became a professor at Yale University and authored and co-authored numerous books on geography (Wikipedia, 2008).

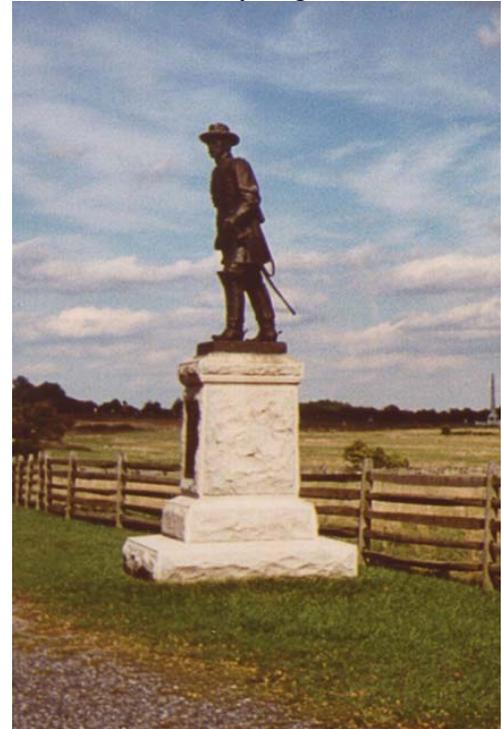


Figure D2-6. Monument to Brig. Gen. Andrew A. Humphreys at mile 14.1. In the early evening of July 2, Humphreys led a fighting retreat from a precarious position along the Emmitsburg Road (the Confederates having nearly flanked his line both the right and the left) back to Cemetery Ridge (evidently the “Round Top ridge” of Humphreys’ report) (Luvass and Nelson, 1986).

- 0.3 15.2 TRAFFIC LIGHT. Bear left onto South Washington Street.
- 0.1 15.3 Turn left onto Gettys Street.
- 0.1 15.4 Gettysburg Hospital to right. It was formerly called Annie M. Warner Hospital, but was colloquially referred to as “Agony Warner” Hospital.
- 0.1 15.5 STOP SIGN. Turn left onto Long Lane.
- 0.2 15.7 STOP SIGN at Queen Street. Turn right into parking lot at Gettysburg Rec Park.

STOP 12 and LUNCH. Pond Bank Core.

After lunch, Noel Potter and Roger Cuffey (see their article in this guidebook on page 24) will talk about the significance of the Cretaceous-aged “lignites” which 19th-century mining and 20th-century coring revealed at Pond Bank, south of Chambersburg and west of Caledonia, PA. They will display some of the cores so that participants can examine the lithologies, summarize conclusions from earlier work, explore the paleoenvironmental implications not previously considered, and contemplate the larger regional tectonic and geomorphologic aspects of this and other reported lignite occurrences in PA.

- 0.3 16.0 Leave STOP 12, turning left onto Long Lane.
PHMC Historical Marker to right reads:
LINCOLN CEMETERY. Established in 1867 by the Sons of Good Will for the proper burial of Gettysburg’s African American citizens and Civil War veterans. Some thirty Civil War

veterans of the U.S. Colored Troops are buried here, having been denied burial in the Nation Cemetery because of segregation policies. Also buried here are veterans of the Spanish-American War, World Wars I and II, and the Korean conflict. First known as Good Will Cemetery, renamed in 1920.

- 0.05 16.05 Continue straight onto Franklin Street.
- 0.15 16.2 STOP SIGN. Turn left onto West Middle Street.
- 0.4 16.6 Road ascends Seminary Ridge.
- 0.1 16.7 TRAFFIC LIGHT at Confederate Avenue (to left) and Seminary Ridge (to right). Continue straight, now on Fairfield Road.
- 0.1 16.8 Woodcrest to left—home of Pat Bowling.
- 0.35 17.15 Road ascends McPherson Ridge.
- 0.05 17.2 Turn right onto Reynolds Avenue at crest of McPherson Ridge.
- 0.4 17.6 To right is monument to Maj. Gen. Abner Doubleday (1819-1893). He took over the 1st Corps after John Reynolds was killed early on the first day. He performed admirably, but Maj. Gen. O. O. Howard, temporarily his superior, unfairly replaced him with Maj. Gen. John Newton—in part to cover for his own less than sterling performance. Doubleday never again had any important command, but his fame is assured as the legendary founder of baseball.
- 0.1 17.7 Reynolds' (McPherson's) Woods to left. It was here that Maj. Gen. John Reynolds was shot and killed on the morning of July 1, shortly after arriving on the field.
- 0.1 17.8 The stone barn ahead to left is the sole remaining structure of McPherson's Farm.
- 0.1 17.9 TRAFFIC LIGHT at Chambersburg Pike. Continue straight ahead, staying on Reynolds Avenue.
- 0.15 18.05 Cross railroad tracks.
- 0.05 18.1 Pull off onto right side of road at Brig. Gen. James S. Wadsworth Portrait Statue. Wadsworth, born in Geneseo, NY, in 1807, commanded the 1st Division of the 2nd Corps. His division was “effectively destroyed” in the 1st-day's action in this vicinity and took little part in the rest of the battle. Monument. One of the older Union generals of the war—and one of the better of the “political” stripe, he was mortally wounded at the battle of the Wilderness and died in a Confederate hospital behind the lines on May 8, 1864 (Faust, 1986). The base of the statue is Barre granite from Vermont (Hawthorne, 1988).

STOP 13. McPhersons Ridge railroad cut.

The “middle” railroad cut of the CSX line through East McPherson's Ridge west of Gettysburg is not only an excellent exposure of a resistant gray unit in the Gettysburg Formation but is also the site of significant Day-1 action.

The gray sandstones and shales that form the backbone of the ridge represent deposition in shallow lakes on the playas and distal alluvial fans that formed dominant features of the Late Triassic landscape of the Gettysburg Basin. About 245 feet of section is exposed.

A little before noon on July 1, three of Brig. Gen. James S. Wadsworth's 1st Division, 1st Corps, regiments trapped a sizable contingent of Confederates in the cut, killing and wounding many and forcing a large number to surrender. Things looked good for the Union forces at this point, but—as we shall see at STOP 14—their situation gradually deteriorated as the day wore on.

The railroad here follows the line of Thaddeus Stevens' “Tapeworm Railroad,” started in 1836—but abandoned in 1839, before any tracks were placed. The grade

served as a wagon road until the Western Maryland Railroad laid track along the route in 1885.

See detailed stop description on page 154.

Leave STOP 13. (Buses will make loop past Eternal Light Peace Memorial via Buford and Doubleday Avenues to return to this spot.) Head south on Reynolds Avenue to the TRAFFIC LIGHT on Chambersburg Pike and turn left.

0.2 18.3 Turn left into parking lot at the Quality Inn. Disembark.

STOP 14. Lee’s Headquarters and Seminary Ridge railroad cut.

This STOP consists of two “sub-STOPS”—Lee’s Headquarters on the Chambersburg Pike near the crest of Seminary Ridge (A) and the Seminary (Oak) Ridge railroad cut to the north (B).

A. The stone house of the widow Mary Thompson on the north side of the Chambersburg Pike—constructed of local, vari-colored Triassic sandstone—was the headquarters of Confederate General Robert E. Lee from the evening of July 1 to about midnight on July 4-5. Lee apparently spent much of his time in the tent encampment of his Army-of-Northern-Virginia staff on the other side of the Pike and in the cupola of the Lutheran Seminary, sleeping and taking his meals in the widow Thompson’s house.

B. Like the cut at STOP 13, the Seminary (Oak) Ridge railroad cut was originally excavated as part of the “Tapeworm Railroad” in the late 1830’s. At one time the cut exposed a nearly complete section of the Seminary Ridge diabase dike. As a result of a land trade between Gettysburg College and the National Park Service, a railroad spur was constructed at the east end of the cut in 1991, resulting in “massive destruction of the northern face.” The dike once so well exposed there is now almost completely concealed behind a large gabion.

Despite this unfortunate alteration, the Seminary (Oak) Ridge cut is still one of the best geologic sites on the battlefield. Red shale and sandstone typical of the undivided Gettysburg Formation crops out at the west end; contact metamorphosed shale and claystone (hornfels) occurs in the middle; and remnants of the Seminary Ridge dike (Rossville-type diabase—low TiO², quartz-normative, continental tholeiite) can be seen at the east end. The dike is about 92 feet thick, strikes approximately north-south, and dips 50° to the east.

Seminary (Oak) Ridge was the final defensive line for the Union 1st Corps on the afternoon of July 1. At about 4:30 PM, the Confederates got their revenge for the mauling they had taken in the McPherson’s Ridge railroad cut five hours earlier by capturing about 500 Union infantrymen in this cut a few hundred yards to the east. See detailed stop description on page 158.

Leave STOP 14, turning left onto Chambersburg Pike.

0.1 18.4 Turn right onto Seminary Ridge.

0.1 18.5 To left is Schmucker Hall (“Old Dorm”) of the Lutheran Theological Seminary (Figure D2-7). It was in the cupola of Schmucker Hall that the famous meeting of Generals Buford and Reynolds took place at about 10:00 AM on July 1. The brief, but colorful, dialog is now legend—

Reynolds: “What’s the matter, John?”

Buford : “The devil’s to pay”! (Grimsley and Simpson, 1999, p 14).

Within less than an hour, Reynolds lay dead at the edge of Herbst Woods. After the Union forces had been driven from Seminary Ridge late in the afternoon, General Lee made use of the cupola to observe the Union position on the heights south of Gettysburg. The building also became a hospital for the wounded from both sides.

About noon on July 1, Maj. Gen. Abner Doubleday, at the time commanding the Union 1st Corps, directed that the 2nd Division of his corps, under Brig. Gen. John C. Robinson, erect a “semicircular [fence]rail entrenchment” in the grove in front of the seminary building [to our right] and to man it as a reserve. Late in the afternoon, after the 1st Corps had been driven off McPherson’s Ridge to the west, what was left of the corps “after all this slaughter” rallied for a time behind this breastwork and held it “for a time by firing over the pile of [fence]rails” (Doubleday, 1994, p. 136, 147).

- 0.1 18.6 TRAFFIC LIGHT at intersection with Middle Street (Fairfield Road). Continue straight ahead now on West Confederate Avenue.
- 0.1 18.7 Shultz Woods to right. To left and right, note the several Confederate batteries that were posted here at the edge of the woods on July 1 to 4.
- 0.7 19.4 McMillan’s Woods to right. Confederate Lieut. Gen. A. P. Hill’s 3rd Corps held this area from the evening of July 1 to July 4.
- 0.2 19.6 To left is the North Carolina Monument (Figure D2-8).
- 0.05 19.65 To left are Confederate cannons at Pettigrew’s position on the 3rd Day (Pickett’s Charge). Good view east and southeast of the Union position on Cemetery Hill and the Round Tops.



Figure D2-7. Schmucker Hall of the Lutheran Theological Seminary, erected in 1832 and named for the founder of the seminary, Samuel Simon Schmucker. This is the oldest standing building in America for Lutheran theological education.

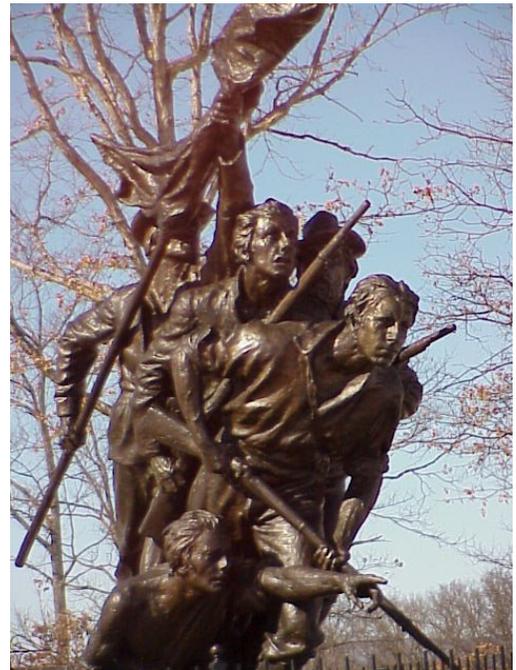


Figure D2-8. Detail of North Carolina State Memorial at mile 19.6. The sculptor of this bronze monument was Gutzon Borglum (1867-1941), most famous for his Mt. Rushmore carvings of American presidents.

0.25 19.9 Virginia Monument to left. Pull off to right side of Confederate Avenue. Disembark.

STOP 15. Virginia Monument on Seminary Ridge: Confederate view of Day-3 terrain, Pickett's Charge, and Lee's post-battle preparations for withdrawal.

Disembark and walk to the front of the Lee equestrian statue which constitutes the Virginia Memorial on the battlefield. Spread out before us is the topography on which the climax of the battle played out on its third afternoon: Pickett's Charge, from the diabase dike hill of Seminary Ridge, eastward across the lowland underlain by red shales, to the diabase sill "heights" of Cemetery Ridge in the distance. This action is reminiscent of the 1859 Battle of Solferino in Europe, which decided the war then between France and Austria. (See the extended Stop 15 description in this guidebook.) See detailed stop description on page 164.

Leave STOP 15, continuing south on Confederate Avenue.

0.2 20.1 Spangler's Woods on both sides of road. Pickett's Division of Longstreet's 1st Corps held this section of the Confederate line from July 2 to 4.

0.2 20.3 The road to the right is the "Berdan Loop," which leads northwest about 500 feet into the woods to the site of a sharp skirmish (at about noon on July 2) between a Union reconnaissance party of about 300 men (four companies of sharpshooters and the 3rd Maine Regiment) under Hiram Berdan and a Confederate force from Hill's Corps. Berdan had been sent out by Maj. Gen. Daniel Sickles, commander of the Union 3rd Corps, to determine whether the Confederates were moving to envelop the Union left (as they had done to the right, with such devastating results, at Chancellorsville). Upon receiving word of the clash, Sickles began the fateful movement of his corps out from the southern part of Cemetery Ridge to the Emmitsburg Road, the Peach Orchard, and Devil's Den (Grimsley and Simpson, 1999; see STOPS 10 and 11).

Late in the afternoon of that day, Barksdale's Mississippi Brigade began its attack from this area, an attack that overwhelmed the Union 3rd Corps position along the Emmitsburg Road and carried all the way to the slope of Cemetery Ridge.

0.1 20.4 At about this point, the north-northeast-striking trace of the Seminary Ridge diabase dike intersects the larger, roughly north-south striking Warfield Ridge dike (Bascom and Stose, 1929; Stose, 1932). Confederate Avenue follows south along Warfield Ridge. (See mile 9.3 of Day-2 Roadlog.)

0.2 20.6 To right in Pitzer's Woods is the recently erected (1998) bronze, equestrian statue of Lieut. Gen. James Longstreet (1821-1904), commander of the Confederate 1st Corps (Figure D2-9; see McPherson, 2003, for an interesting discussion of this statue). Though Longstreet was one of Lee's stalwarts throughout the war, he alienated many from the South after the war by becoming a Republican.

0.2 20.7 To left are the Louisiana and Mississippi Monuments.



Figure D2-9. Equestrian statue of Lieut. Gen. James Longstreet at mile 20.6.

- 0.1 20.8 STOP SIGN. Turn right onto Millerstown Road. Just ahead on Confederate Avenue is the Longstreet Observation Tower (see Inners, this guidebook).
- 0.2 21.0 Ahead is the Peach Orchard (see STOP 11) and the Round Tops (see STOP 9).
- 0.1 21.1 STOP SIGN. Turn left on Emmitsburg Road. To the right just after the turn is the foundation of the Wentz House.
- 0.2 21.3 Turn right on United States Avenue.
- 0.1 21.4 Cross Sickles Avenue. Directly ahead to the southeast Cemetery Ridge diminishes in height as it approaches Little Round Top. It was the near disappearance of the ridge there that prompted Maj. Gen. Daniel Sickles to move his 3rd Corps line westward to higher ground at Devil's Den, the Peach Orchard, and along the Emmitsburg Road (see STOPS 11 and 16).

0.2 21.7 To left is the Abraham Trostle House and Barn (Figure D2-10). The upright cannon to right marks this as Sickles' Headquarters on July 2. (Standing on the road opposite the house and looking off to the west, one gets a good appreciation of why Sickles made his fateful decision to move west to the Emmitsburg Road and the Peach Orchard: you can barely see South Mountain from here!) After retiring under extreme Confederate pressure from a position along the Wheatfield Road (see STOP 11), Capt. John Bigelow's 9th Massachusetts Battery fought a fierce delaying action here to cover the retreat of other Union batteries to a new line along the west side of Cemetery Ridge. Bigelow himself was wounded, but was rescued by bugler John Reed, who received a Congressional Medal of Honor thirty years later (Gramm, 1997).



Figure D2-10. Barn of the Trostle Farm at mile 21.7. Note the two shell holes through the brickwork and the damage to the decorative panel just under the roofline.

- 0.05 21.75 Cross west branch of Plum Run.
- 0.3 22.05 To right is the G. Weikert House.
- 0.05 22.1 Turn left onto Hancock Avenue and proceed north along Cemetery Ridge.
- 0.1 22.2 To right is the Father Corby Portrait Statue. At this spot, Father William Corby, chaplain of the 88th New York Infantry, blessed the 2nd Corps' "Irish Brigade" before it went into action on the afternoon of July 2 to reinforce Sickles' line at the Wheatfield (see mile 0.55 of alternate Day-2 Roadlog between STOPS 10 and 11). A duplicate statue on the campus of Notre Dame University, where he served two post-war terms as president, is known as "Fair-Catch" Corby. Any serious football fan will realize why!
- 0.1 22.3 To right is the New York Auxiliary Monument, honoring all New Yorkers, from the rank of major to major-general who commanded units at Gettysburg. It is constructed of Concord, New Hampshire, granite (Hawthorne, 1988).
- 0.1 22.4 To left is the 1st Minnesota Monument (Figure D2-11). At 7:15 PM on July 2, as Brig. Gen. Cadmus Wilcox's Brigade of Alabamans (A. P. Hill's Corps) surged up the slope of Cemetery Ridge, Maj. Gen. Winfield Hancock ordered the 1st Minnesota Volunteers into a yawning hole in the Union line. Col. William Colvill led his greatly depleted

regiment (262 men) down the slope toward Plum Run with fixed bayonets. Exchanging several murderous volleys with the advancing Confederates, the Minnesotans suffered nearly 70 percent casualties before retiring. Their valiant effort slowed the enemy advance enough for other Union regiments to plug the gap and stop the enemy short of the crest of Cemetery Ridge (Trudeau, 2002; Moe, 1993).

- 0.1 22.5 To right is the Pennsylvania Monument, the most frequently photographed memorial on the battlefield (Hawthorne, 1988). Its size and impact reflect the fact that this battle, the largest and fiercest ever fought on the North American continent, took place on Pennsylvania soil. The monument includes plaques containing the names of every Pennsylvania soldier who fought here. It was erected in 1910 and is constructed of light-gray granite from Mt. Airy, North Carolina. The open gallery in the dome affords a splendid view of the surrounding country.
- 0.1 22.6 To right is the Vermont State Memorial, topped by a portrait statue of Brig. Gen. George J. Stannard (1820-1886), commander of the 3rd Brigade, 3rd Division, 1st Corps.
- 0.2 22.8 To right is monument to Brig. Gen. John Gibbon (1822-1896), who commanded the 2nd Corps after Hancock was wounded during “Pickett’s Charge.”
- 0.05 22.85 52nd New York (“Tammany”) Regiment Monument to right (3rd Brig., 2nd Div., 2nd Corps.)
- 0.05 22.9 Pull over to side of road. Disembark.



Figure D2-11. Monument to the 1st Minnesota Infantry at mile 22.4. Said Gen. Winfield Scott Hancock of the near suicidal charge of this regiment into a yawning hole in the Union line, “There is no more gallant deed recorded in history” (Faust, 1986).

STOP 16. Crest of Cemetery Ridge: Day-3 action (Pickett’s Charge, the “Bloody Angle,” and the “High Water Mark”) and the York Haven Diabase.

The climax of the battle of Gettysburg came on July 3 on Cemetery Ridge. Lee had struck at the Union right and left on July 2, and, having failed in both, determined to conclude the action with a massive artillery bombardment followed by a frontal assault on the Union center, in the manner of Napoleon III at the battle of Solferino in 1859.

Cemetery Ridge forms the shank of the Union “fishhook.” It is about 1.5 miles long, extending due south from Cemetery Hill to Little Round Top. Maximum elevation of about 600 feet is at the extreme north end, dropping off to about 530 feet south of the G. Weikert Farm in the valley of the east branch of Plum Run. This drop in elevation may be due to the fact that Cemetery Ridge trends diagonally across the northeast-southwest outcrop of the Gettysburg sill, its north end being very near the upper contact of the sill (finer-grained, more resistant diabase) and its south end lying in the middle of the sill (coarser-grained, less resistant diabase). Low ledges and pavement outcrops of York Haven Diabase near the “High Water Mark” contain

prominent east-west-striking joints, as well as local pockets of magnetism intense enough to strongly deflect the needle of a Brunton compass.

Following an hour-long artillery bombardment, Lee launched “Pickett’s Charge” across the mile-wide lowland that separates Seminary Ridge from Cemetery Ridge. The Confederate troops tried to keep their ranks together, angling their line of march toward the “copse of trees” at today’s “High Water Mark” Monument. Seared by Union musketry and blasted by unrelenting grapeshot, solid shot, and canister, the initially well-ordered and magnificent Confederate lines were decimated. Lee’s last gamble had failed, and the Confederates began a long—and brilliantly executed—retreat to Virginia the next day.

An 8-*Site* walking tour of the area encompassing the “High Water Mark” and the “Bloody Angle” will provide more details on the geology of this part of Cemetery Ridge and the climax of “Pickett’s Charge.”
See detailed stop description on page 168.

Leave STOP 16. Continue north on Hancock Avenue.

- 0.05 22.95 To right is the monument to George Gordon Meade (1815-1872), commander of the Army of the Potomac and the stalwart hero of Gettysburg. As noted by Hawthorne (1988), Meade here on Cemetery Ridge and Lee atop the Virginia Memorial on Seminary Ridge 0.8 mi to the west “eternally face each other across the fields where their armies clashed.”
- 0.05 23.1 Restored Bryan House to right. Abraham Bryan was a free black man who purchased a 12-acre farm here in 1857. He planted fields of wheat, barley, and oats, and also tended apple and peach orchards. His prosperous life was shattered six years later, when the Confederates moved into the Gettysburg area and Union troops occupied the north end of Cemetery Ridge on July 1. (Union Brig. Gen. Alexander Hayes used the house as his headquarters [see below]). Bryan and his wife and five children fled the area. He returned to find his house in ruins and his crops and orchards destroyed. To compound his misfortune, the pasture west of his barn (restored to left) had been turned into a huge graveyard. He continued to farm the land until 1869, when he moved into town and took up work in a hotel. He later filed claim with the federal government for damages to his property totaling \$1,028. He was compensated \$15. Bryan died in 1875 and is buried in Lincoln Cemetery (see 2nd-Day Roadlog, mile 16.0) (Gettysburg National Military Park, 2008).
- 0.05 23.15 To right is the old Cyclorama Center, which formerly housed the famous 360-foot-long, circular, oil-on-canvas painting of “The Battle of Gettysburg” (also known as “Pickett’s Charge” and “The High Tide of the Confederacy”) by French artist Paul Philippoteaux (1846-1903). Philippoteaux and sixteen assistants completed this particular version of the painting in 1883, and it was first exhibited in Boston the following year. (An earlier version exhibited in Chicago in 1883 still survives but has no permanent home.) This second “cyclorama” of the battle has been displayed in Gettysburg since 1913. Purchased by the National Park Service in the 1940’s, the painting was moved to the Cyclorama Center in 1962. It has recently undergone a full-scale restoration and will be on exhibit at the new National Park Visitors’ Center in September 2008.
- 0.05 23.2 STOP SIGN. Turn left in Ziegler’s Woods (or Grove). A small stand of oak, hickory, and chestnut trees that stood here in the 1860’s marked the position held by Brig. Gen. Alexander Hayes and his 3rd Division of the 2nd Corps. The stonewalls stretching south from the Woods provided protection for Hays men in repulsing Pettigrew’s and

Trimble's attack on the afternoon of July 3 (see STOP 16) (Gettysburg National Military Park, 2008).

- 0.1 23.3 STOP SIGN. Turn right on Emmitsburg Road/Steinwehr Avenue.
- 0.2 23.5 TRAFFIC LIGHT. Continue straight on Steinwehr Avenue.
- 0.2 23.7 Dobbin House to left. PHMC Historical Marker reads:
DOBBIN HOUSE. Built in 1776 by the Rev. Alexander Dobbin. In use for some 25 years as one of the first classical schools west of the Susquehanna River. It is now a museum refurbished in keeping with the early period.
- 0.1 23.8 TRAFFIC LIGHT. Angle left onto Baltimore Street.
- 0.1 23.9 Farnsworth House restaurant to left.
- 0.2 24.1 At corner of High Street to right is the Presbyterian Church of Gettysburg, which served as a cavalry field hospital prior to falling into the hands of the Confederates in the late afternoon of July 1. Abraham Lincoln visited this church with John Burns, the civilian hero of the 1st-day's battle, after the ceremonies at the National Cemetery on November 19, 1863 (Gary, 2001).
- 0.1 24.2 To left is the Adams County Courthouse. The adjacent PHMC Historical Marker reads:
ADAMS COUNTY COURTHOUSE. Formed January 22, 1800 out of York County, the name honors President John Adams. Important center of the fruit growing industry. County seat of Gettysburg, incorporated 180[0], was site in 1863 of key Civil War battle and President Lincoln's great address.
Like many other public buildings in Gettysburg, the courthouse function as a soldier's hospital during the battle and for many days afterwards.
- 0.1 24.3 Enter Lincoln Square. Go 90° around the traffic circle (east) to York Street. To the right on the southeast corner of the square is the David Wills House, where President Abraham Lincoln lodged and completed the "Gettysburg Address" on November 18-19, 1863. One block north on Carlisle Street (180° around the square) is the old Gettysburg Railroad station where Abraham Lincoln arrived on November 18, 1863, the day before he delivered the Address. Just to the right above the Cannonball Malt Shop after exiting the traffic circle on York Street is a small U.S. flag marking the location of a cannonball embedded in the bricks.
- 0.05 24.35 PHMC Historical Marker to right reads:
GETTYS CROSSROADS AND TAVERN. Here the Shippensburg-Baltimore and the Philadelphia-Pittsburgh Roads crossed. Near the crossroads stood the tavern of Samuel Gettys. In 1775, troops gathered here for Continental Service.
- 0.15 24.5 TRAFFIC LIGHT. Bear left, staying on York Street. If you continue straight ahead on Hanover Street (east) about 8 miles, you come to East Cavalry Field where, on July 3, Union cavalry under Brig. Gens. David McM. Gregg and George A. Custer (of "Last Stand" fame) intercepted Lieut. Gen. J. E. B. ("Jeb") Stuart's Confederate cavalry intending to strike the Union lines from behind at the same time as "Pickett's Charge."
- 0.5 25.0 Cross Rock Creek.
- 0.1 25.1 PHMC Historical Marker to right reads:
MANOR OF MASKE. Surveyed in 1766. Named for an estate in England. The Manor was about 6 miles wide and 12 miles long with the southern border at present Mason-Dixon Line. It was the second largest reserved estate of the Penns in Pennsylvania. The eastern boundary line of the Manor was near this point.
- 1.1 26.2 TRAFFIC LIGHT at Camp Letterman Drive (off) to left. Continue ahead on US 30W. Camp Letterman Drive commemorates Dr. Jonathan Letterman (1824-1872), the Union Army's chief surgeon at Gettysburg, who established a large field hospital in this general area after the battle.

- 0.2 26.4 Cut on ramp to US 15S to right exposes weathered York Haven Diabase of Gettysburg sheet (sill). The round, exfoliated boulders at the base of the slope have colluviated down from higher up in the soil.
- 0.1 26.5 Cross US 15.
- 0.4 26.9 TRAFFIC LIGHT. Turn right into the entrance of Gateway Gettysburg, End of Field Trip. Have a safe trip home!

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STOP 8: Dinosaur Footprints on the Plum Run Bridge

Leader- Roger J. Cuffey

The Triassic sedimentary rocks on the Gettysburg battlefield are unfossiliferous. However, a few dinosaur footprints (Figure 8-1) can be seen on the sandstone or siltstone blocks forming the tops of the walls of the road bridge crossing Plum Run (Figure 8-2) on the southern edge of the battlefield. Plum Run flows between Little Round Top and Devil's Den, a mile upstream to the north. Intense combat there late on the 2nd day of the battle resulted in so many casualties that its water ran red, giving rise to the popular name "Bloody Run".

The National Park Service rebuilt this bridge in the 1930s, using blocks taken from the long-abandoned Trostle Quarry along Bermudian Creek, 3.3 miles due east of the US 15 - PA 94 exit at York Springs. They were extracted from the Heidlersburg Member in the middle of the Gettysburg Formation, approximately 210 Ma (mid-Late Triassic) in age.

Visibility of the footprints varies with the angle and intensity of the lighting, and with the dry, damp, or wet condition of the block surface. Identification of footprints is further complicated because of morphologic variability of the feet interacting with differences in the sediment surface, firmness, and diagenetic processes later.

Easiest to recognize is a paired fore-and-hind-print, heading southeasterly, identified (Santucci & Hunt 1995) as the heterodontosaur or "basal" ornithopod *Atreipus milfordensis*, in the northwest corner of the fifth block from the east end of the bridge's north side (Figure 8-2). On its south side, counting from the west end, the sixth through tenth blocks exhibit prints. The sixth's south edge has a hind-print which is from the coelurosaur theropod *Anchisauripus sillimani* (or is the rear half of an incomplete *Atreipus*), the eighth shows a similar obscure print, the ninth bears two small coelurosaur hind-prints resembling *Grallator tenuis* (as well as another *Atreipus*), and the tenth has a very obscure, possible prosauropod *Otozourn minus* hind-print. Compared with later Mesozoic dinosaurs, these early ones are relatively small and generalized in appearance (Figure 8-3).

In addition to the footprints here on the Plum Run bridge, more (the paired *Atreipus milfordensis*) can be seen in a farmhouse sidewalk made from Trostle Quarry slabs, 1.7 miles north-northeast of the York Springs exit.

Among the Trostle Quarry footprints, none of the large carnosaur theropod *Eubrontes* tracks have been found thus far. That genus is common in the somewhat younger, Early Jurassic trackways in the Connecticut Valley (Lull, 1953), such as at Dinosaur State Park (formerly Rocky Hill) near Hartford.

Also visible on some blocks are sedimentary structures (especially ripple marks and dessication cracks), and millimeter-scale irregularities incorrectly termed "dinosaur skin" but diagenetic, tectonic, or weathering phenomena instead.

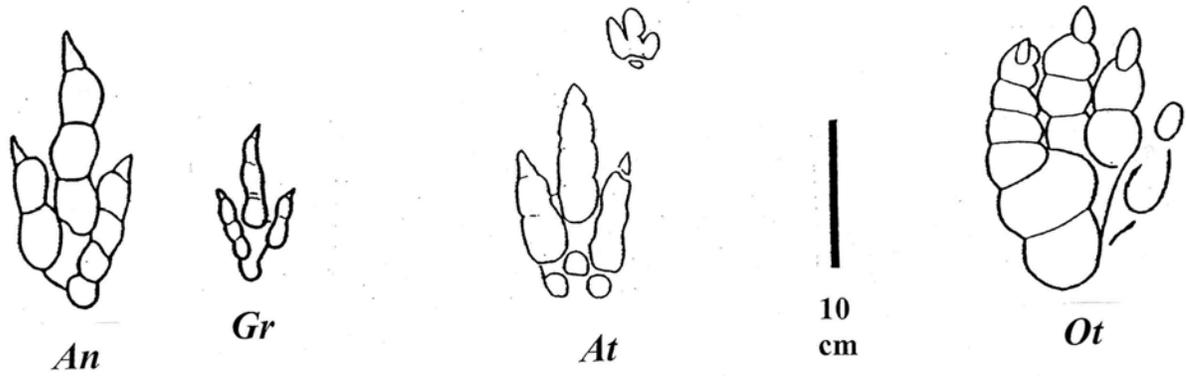


Figure 8-1. Plum Run bridge dinosaur footprints; all to same scale; abbreviations also used in Fig. 8-2. Left, *An*, *Anchisauripus sillimani* (and *Gr*, smaller *Grallator tenuis*), 3-toed hind-prints 12-15 cm (and 7-8 cm) long; center, *At*, *Atreipus milfordensis*, fore- and 3-toed hind-print (latter 10-12 cm long); scale bar 10 cm; right, *Ot*, *Otozoum minus*, 4-toed hind-print 15-25cm long; (from Haubold 1971, p. 66, Lull 1953, p. 167, Haubold 1971, p. 66, Lull 1953, p. 154; Haubold 1984, p. 155, Olsen & Baird 1986, p. 65-69; Haubold 1971, p. 83, Lull 1953, p. 191; respectively).

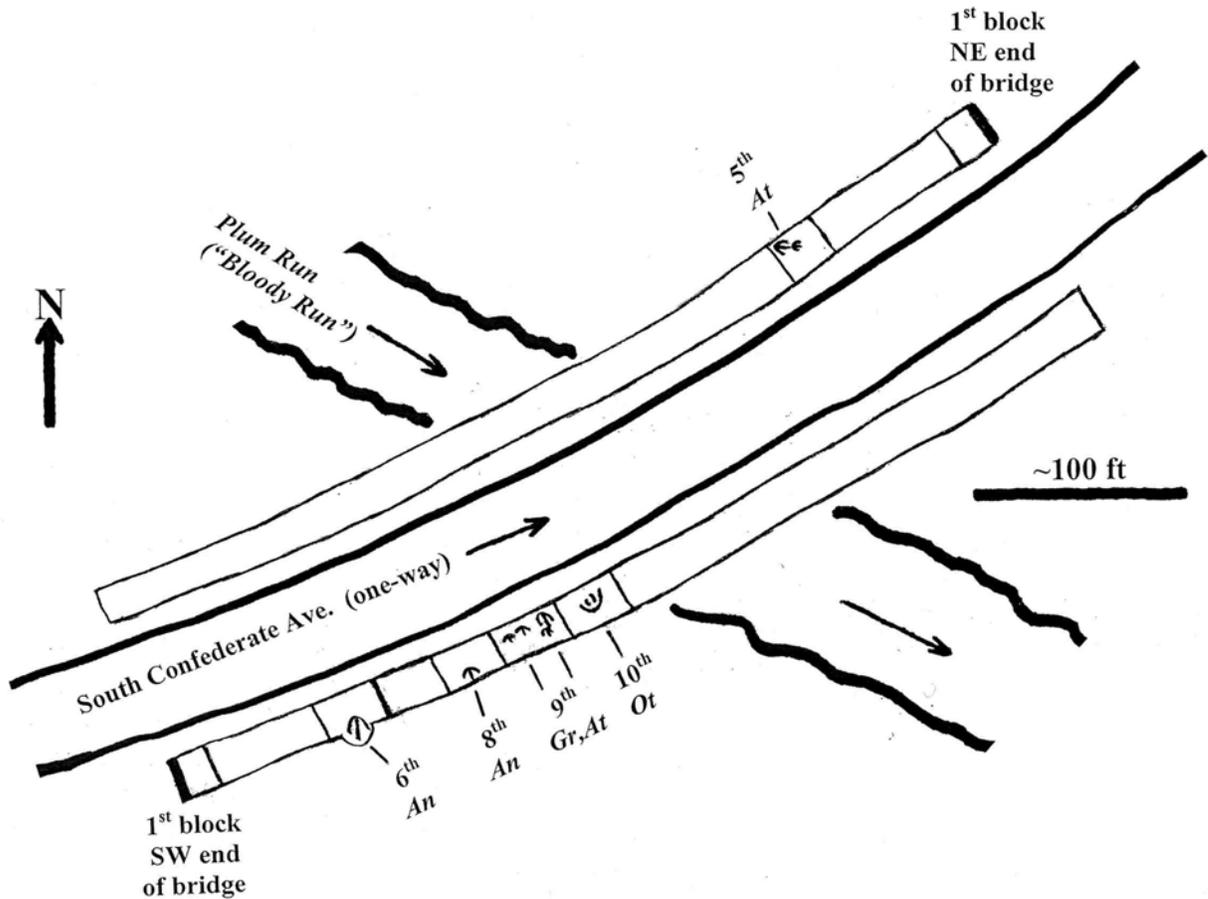


Figure 8-2. Sketch map of the Plum Run bridge, showing positions (by counting blocks) and identifications (using the abbreviations in Fig. 8-1) of dinosaur footprints visible in 2006.

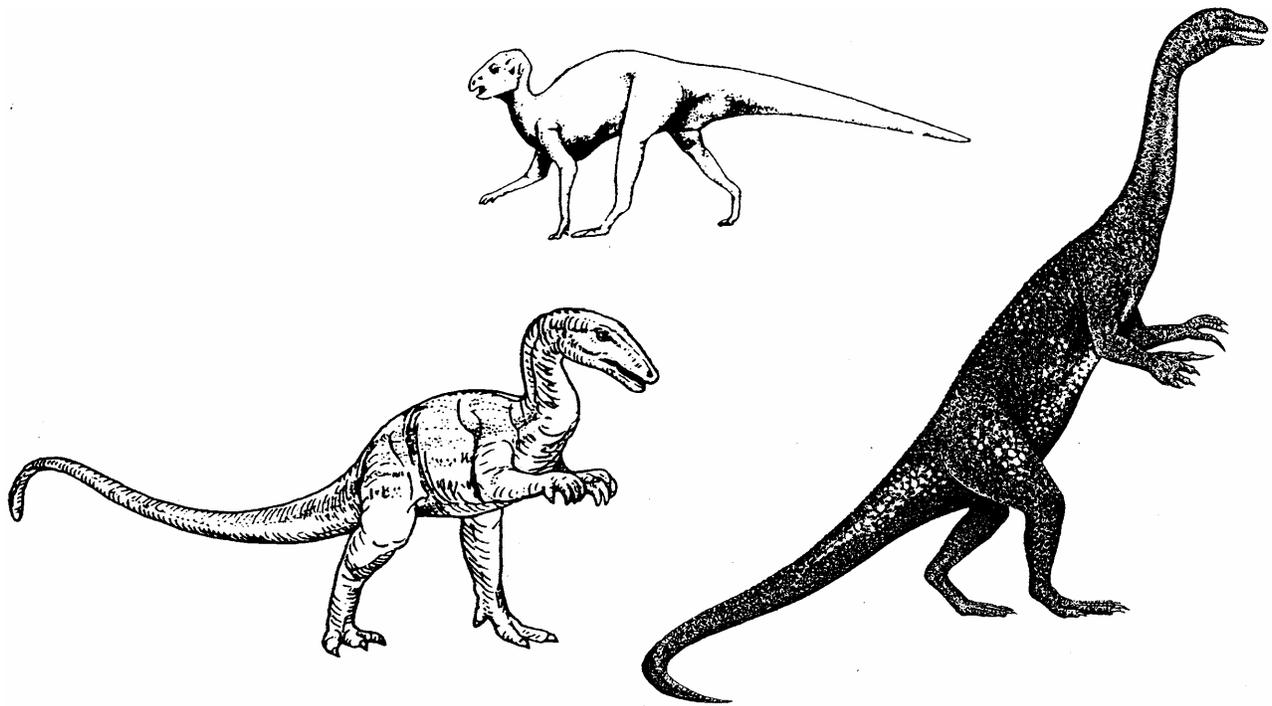


Figure 8-3. Likely appearances of the dinosaurs responsible for the footprints: Left to right; coelurosaurian theropod 2-4 m long; heterodontosaurian ornithopod 2-3 m long; prosauropod 3-5 m long; (from Haubold 1984, p. 50; Olsen & Baird 1986, p. 79; Charig 1983, p. 115; respectively).

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Triassic dinosaur, *Grallator*, chases a rebel soldier back to Dixie, helping to win the war and leaving interesting footprints behind for inquiring minds to ponder

STOP 9. Little Round Top: Day 2 action (Warren, Vincent, Chamberlain, and Oates) and the York Haven Diabase.

Leaders: Jon D. Inners and Gary M. Fleeger.

I saw that this was the key to the whole [Union] position.

Maj. Gen. Gouverneur K. Warren, U.S.A.

Thanks to Ted Turner's movie *Gettysburg* (1993), Little Round Top has become as well known a part of the battlefield as the "High Water Mark" and the "Bloody Angle." The exploits of Col. Joshua Lawrence Chamberlain and the 20th Maine on this little diabase hill are probably familiar to almost

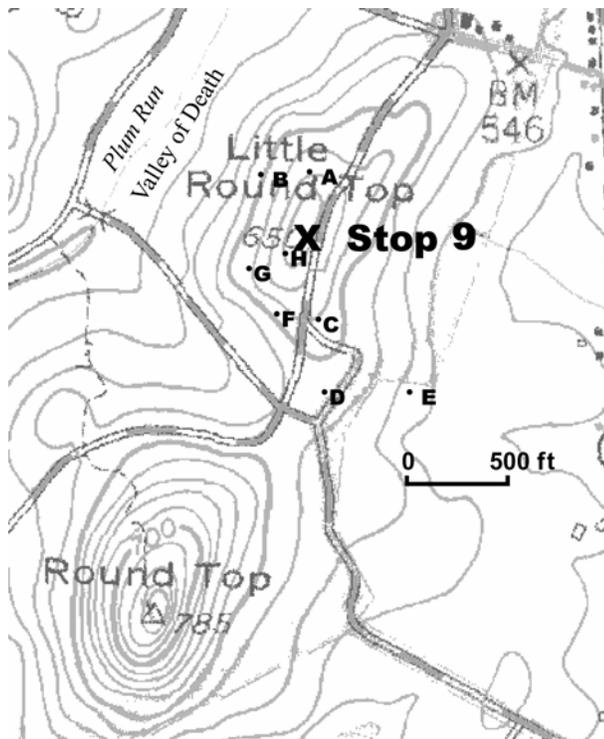


Figure 9-1. Location map for STOP 4, showing Site locations.

everyone who has even a casual interest in American history. But there is much more to Little Round Top than Chamberlain and his regiment, as important as was their successful defense of the extreme left of the Union line. We will attempt to visit eight specific sites on the hill (Figure 9-1), passing many more that may elicit comments about the battle here. This brief walking tour is based heavily on Adelman (2000), an excellent guide to both sites and historic events on Little Round Top.

Terrain. On the second day of the battle of Gettysburg, Little Round Top was arguably the most vital position on the Union "fishhook." This rocky knob has an elevation of about 665 feet, its summit being about 150 feet above the valley of Plum Run directly to the west. Various called Sugarloaf or Signal Hill at the time of the battle and shortly thereafter (Trudeau, 2002, p. 281), it eventually took its name from Round Top, the much higher (elevation 785 feet) hill adjacent to the south—the latter becoming Big Round Top. Because its western face was cleared of trees the year before the battle, the summit of Little

Round Top "afforded the finest panorama of the countryside south of Gettysburg then available" (Frassanito, 1975, p. 154). It is likely that had the hill not been partially deforested, Warren would not have been drawn to it on the afternoon of July 2nd, the Confederates would have occupied the hill, and the Union forces would have been outflanked on their left.

Geology. Both Little and Big Round Tops are underlain by diabase of the northwestward-dipping Gettysburg sill, which in this part of the battlefield has a mile-wide outcrop belt stretching from about the midpoint of the field between the Peach Orchard and Stony Hill in the west to a little beyond the far base of the Round Tops in the east (Stose and Bascom, 1929). The diabase is York Haven-type—mostly fine to medium grained, and composed predominantly of white or gray plagioclase and black pyroxene. Jointing is well developed and blocky, with spacing and orientation generally irregular. Physical and chemical weathering along the joints tends to create rounded boulders and cobbles ranging in size from a foot or less to twenty feet or more. These detached masses form great ramparts at the top of the hill and thickly strew the slopes (Figure 9-2). The surfaces of the larger boulders typically exhibit an "alligator-skin" like texture caused by cracking of thin concentric weathering rinds that develop through swelling

Inners, Jon D and Gary M Fleeger (2008) Stop 9- Little Round Top: Day 2 action and the York Haven diabase, in Fleeger, G.M (ed), *Geology of the Gettysburg Mesozoic Basin and Military Geology of the Gettysburg Campaign*, 73rd Annual Field Conference of Pennsylvania Geologists, Gettysburg, PA, p. 133 – 141.

of oxidized minerals, daily and seasonal temperature changes at the rock surface, and freezing of water in fine fractures.



Figure 9-2. Rock-strewn west slope of Little Round Top as seen from across the “Valley of Death.” The prominent tower-like monument to the right center on the summit of the hill is that to the 44th New York Infantry (see *Site H*).

The fight for Little Round Top (afternoon of July 2).

Throughout the night of July 1 and the morning and early afternoon of July 2, Little Round Top was virtually unmanned except for a small party of signalmen. On the morning of the 2nd, Maj. Gen. Daniel Sickles’ 3rd Corps occupied the south end of Cemetery Ridge and the low topographic swale between that ridge and Little Round Top—but Sickles made no attempt of extend his line farther south. Maj. Gen. Gouverneur K. Warren, Chief Engineer of the Army of the Potomac, arrived on Little

Round Top at about 3:30 PM, just as Hood was deploying for action in the woods on Warfield Ridge, and found only a small detachment of signalmen on the summit. He immediately recognized the critical importance of the hill in defending the Union position. According to Warren’s later statements, he asked (signaled?) the commander of an artillery section in his front (probably Captain James Smith of the 4th New York Light Artillery [see STOP 10]) to fire a shot into the woods on Warfield Ridge. (At that time the area beyond Devil’s Den was much more open than now.) The glint of sunlight off the enemy’s muskets when they moved as the shell passed over gave away their position! Warren then dispatched members of his staff to bring reinforcements. Col. Strong Vincent’s 5th Corps brigade (20th Maine, 83rd Pennsylvania, 44th New York, and 15th Michigan) arrived first and deployed his men along the “military crest” on the south side of the hill (i.e., downslope from the summit where his men would have the maximum “field of fire”) in facing the extreme right of the Confederate attacking force (Figure 9-3; Grimsley and Simpson, 1999, p. 74). Warren himself then brought the 140th New York of Brig. Gen. Stephen Weed’s 5th Corps brigade and Battery D of the 5th U.S. Artillery to the summit just in time to halt a sweep of the 4th Texas Regiment of Brig. Gen. J. B. Robertson’s brigade around Vincent’s left (Figure 9-3). The rest of Weed’s brigade then took up positions to the right of Vincent’s line, facing west (Figure 9-4). Farther details of the action on Little Round Top are given in the accompanying Walking Tour.

Walking Tour of Little Round Top

A. Signal Rock and Warren Rock. These two large diabase boulders on the northwest side of the summit are presumably “where it all began.” U.S. Signal Corpsmen assigned here to the Round Top Mountain Signal Station were visible to most of the various Union headquarters located on the “fishhook” to the north and northeast. On the morning and early afternoon of July 2, their presence here may also have given the enemy the impression that the Union occupied the hill in force. The plaque on Signal Rock honors the 36 men of the U.S. Signal Corps who manned six stations at Gettysburg under the overall supervision of Capt. Lemuel B. Norton, chief signal officer. It was dedicated in May 1919 (Adelman, 2000; Trudeau, 2002).

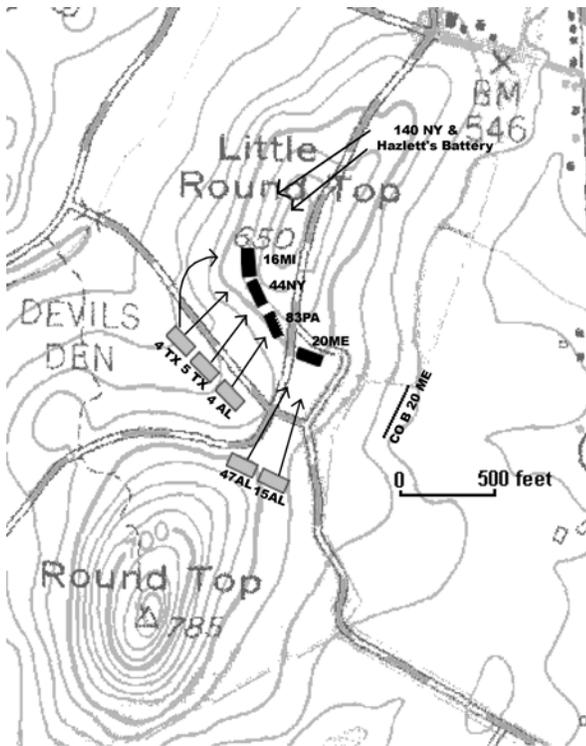


Figure 9-3. Map showing Union and Confederate troop dispositions in the early phase of the fight for Little Round Top—July 2, late afternoon (after Adelman, 2000, p. 13).

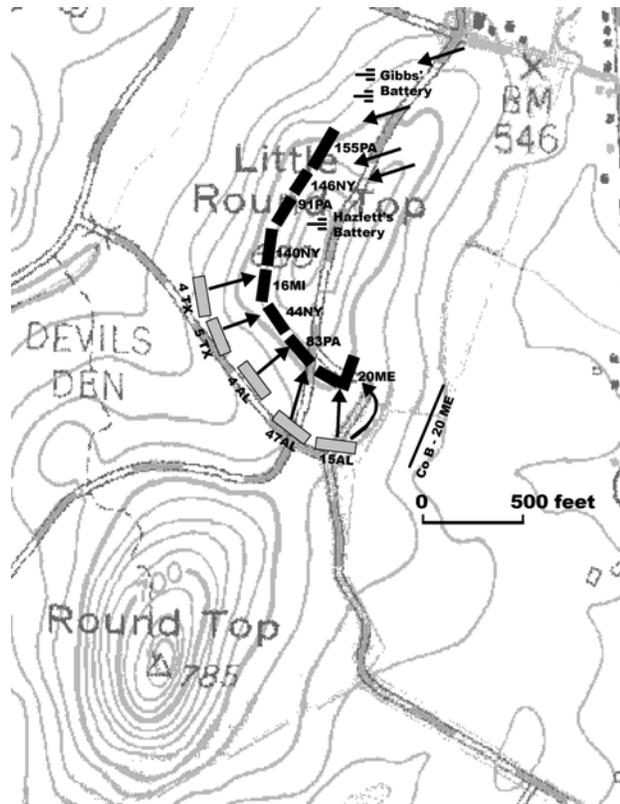


Figure 9-4. Map showing troop dispositions in the closing phase of the fight for Little Round Top—July 2, early evening (after Adelman, 2000, p. 14)

The adjacent Warren Rock is surmounted by the statue of then Brig. Gen. Gouverneur K. Warren (1830-1882), at the time chief of engineers in the Army of the Potomac. As noted above, it is difficult to overstate Warren's contribution to the Union victory at Gettysburg. Indeed, the noted historian Shelby Foote called Warren's directing of Union troops to the summit of Little Round Top "the single most important tactical decision in the American Civil War" (Jens, 2003, p. 2). Maj. Gen. Abner Doubleday wrote that "[Little Round Top] was the key to field...and nothing but Warren's activity and foresight saved it from falling into the hands of the enemy" (1994, p. 178). Though Gouverneur Warren rose to command the 5th Army Corps for the last year of the war, he gradually fell out of favor with Meade and Grant, and Phil Sheridan was authorized to remove him from command at Five Forks on April 1, 1865. Warren stayed in the army, doing distinguished work as a civil engineer in the Midwest (see Inners, this guidebook, G.K. Warren), but fought for the rest of his life to recover his military reputation. Effectively exonerated by a court of military inquiry in November 1882, Warren had died three months earlier (Jordan, 2001). Knowing this, one can "read between the lines" of the inscription on the plaque below the statue and sense the tragedy of Warren's life:

Led to this spot by his military sagacity on July 2nd, GENERAL GOUVERNEUR KEMBLE WARREN, then chief engineer of the Army of the Potomac, detected General Hood's flanking movement and, by promptly assuming the responsibility of ordering troops to this place, saved the key of the Union position. Promoted for gallant services from the command of a regiment in 1861, through successive grades to the command of the 2nd Corps in 1863, and permanently assigned to that of the 5th Army Corps in 1864, Major General Warren needs no eulogy. His name is enshrined in the hearts of his countrymen. This statue is erected under the auspices of the veteran organization of his old regiment, the 5th New York Vols. Zouaves in memory of their beloved commander. Dedicated August 8, 1888.

The right of Weed's line, marked by the monuments to the 146th New York and the 155th Pennsylvania ahead to the north-northwest, did not come under attack during the main battle for Little Round Top. These regiments were threatened, however, by the last Confederate attack repelled by Crawford at the end of the day (Grimsley and Simpson, 1999, p. 73; see Day-2 Roadlog, mile 11.55).

B. The "Curious Rocks." This crude "runic arc" of several large diabase boulders is one of the oddest natural phenomena on the battlefield (Figure 9-5). Its origin is somewhat problematical, though it may have formed through deep chemical weathering below ground, followed by subaerial erosion—as depicted in Figure 9-6.

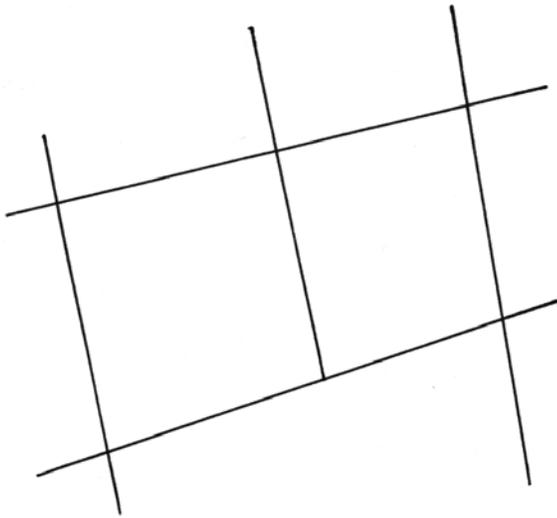
C. The stonewall on old Chamberlain Avenue. As noted by Adelman (2000), most stonewalls on the battlefield were erected by farmers before the Civil War. While nearly all of the walls on Little Round Top were erected by soldiers to serve as breastworks, none were in place at the time of the fighting—there just was not enough time after the arrival of Union troops on the hill before the Confederates attacked. The stonewall here was most likely put up on July 3 by the Pennsylvania Reserves under Col. Joseph Fisher. For more details on the times of construction of walls on the battlefield, see Adelman (2000, p. 23).

D. The 20th Maine Monument. On the late afternoon of July 2, the 20th Maine, mustered into United States service in August 1862, held the extreme left of the Union line (Figure 9-7). Their stalwart defense of the south slope of Little Round Top against repeated assaults by the 15th Alabama regiment under Col. William C. Oates (1833-1910) concluded in a more or less spontaneous bayonet charge down hill that put the exhausted Alabamians to flight (Chamberlain, 1994; Perry, 1997). Though Col. Joshua Lawrence Chamberlain may not have specifically ordered the charge that has sealed his fame in military annals (Desjardin, 1999; Trudeau, 2002), his actions early in the fight were calculated and effective. Acting on a suggestion by Major Ellis Spear, his second in command, Chamberlain decided to "refuse" the line on his extreme left (that is, to bend it back at a right angle [see Figure 9-4]). But his front did not extend far enough along the hill to do this effectively. His solution is well described by Trudeau (2002, p. 354):

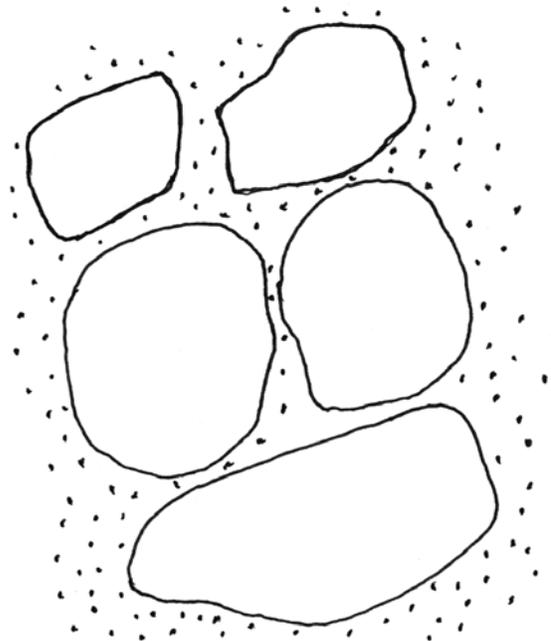
Faced in the heat of battle with a tactical problem requiring a quick solution, he coolly came up with an unconventional riposte. Ordering his men to maintain a steady fire to their front, he simultaneously directed them to sidestep to their left, so the second rank merged with the first. By this means, the standard-double ranked lines of battle were transformed into a much longer single line, which Chamberlain then bent back at the place where his left flank had formerly ended. This enabled him to extend his refused flank along a larger perimeter than would have obtained if he had merely bent back the double line, as Ellis Spear had proposed.



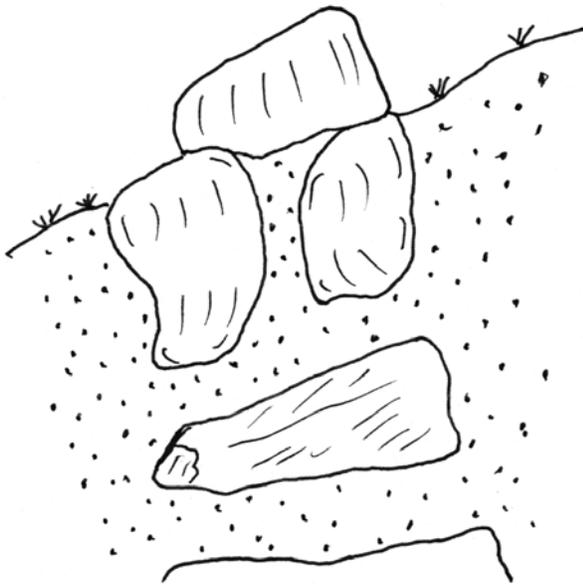
Figure 9-5. The "Curious Rocks" on the west slope of Little Round Top (*Site B*), looking downslope. The Warren Map of the battlefield suggests, but does not conclusively show, that this small natural arch may have been included into the original stone breastworks constructed by Weed's brigade (Adelman, 2000).



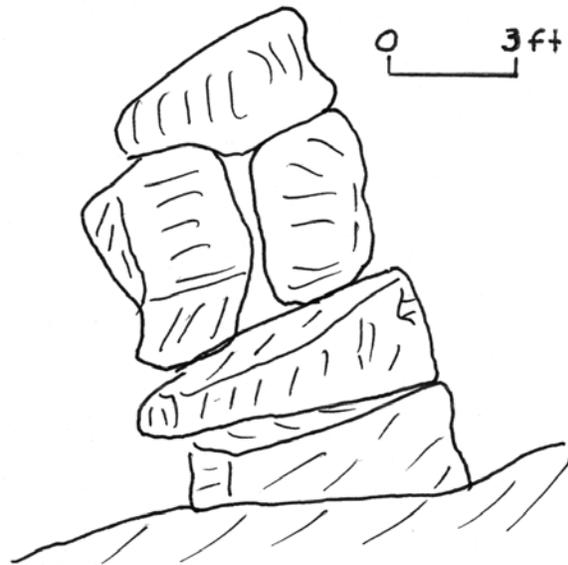
Fractured diabase bedrock, 10's of feet below ground surface.



Chemical weathering of diabase within soil zone results in formation of crudely rounded boulders surrounded by orange-brown, silty clay loam soil.



As hillslope erosion takes place, boulders are gradually let down to rest on those underneath.



While most boulders become detached and tumble down slope as erosion proceeds, a few remain in contact with their neighbors, and form the "Curious Rocks."

Figure 9-6. Generalized diagram showing possible stages in the development of the "Curious Rocks."



Figure 9-7. Monument of the 20th Maine Infantry Regiment at *Site D*. Note how far down the south slope of Little Round Top the 20th Maine was positioned. This spot gave a good view of the ravine running between Big and Little Round Top, providing better protection for an enemy flanking movement. The monument (of Maine Hallowell granite) was erected in 1886 on the boulder where Color Sgt. Andrew stood with the regiment's flag (Hawthorne, 1988). Note the Maltese cross, insignia of the 5th Corps, which appears on many monuments on Little Round Top.

and Petersburg (where he was severely wounded twice), and as a brevet major general accepted the formal surrender of Lee's veterans at Appomattox (Chamberlain, 1993).

E. Oates' Ledge of Rocks and the stonewall at the Company B Marker. In the woods within about 500 feet of the 20th Maine Monument are two features—one natural, the other man-made—that figured prominently in the fight between the Mainers and the Alabamians. First encountered along the path leading east is a north-south running, bouldery ledge of diabase from which the Confederates poured an enfilading fire upon the left flank of Chamberlain's men, forcing him to refuse his line as noted above (Adelman, 2000).

About 200 feet farther on is a granite monument, backed by a north-south-aligned stonewall (Figure 9-8). This marks the position of Company B of the 20th Maine (42 men under Capt. Walter Morrill), which was deployed by



Figure 9-8. Marker to Co. B of the 20th Maine (*Site E*) in front of the stone wall behind which the men (including some marksmen from the 2nd United States sharpshooters) concealed themselves until the climactic Union bayonet charge led by Col. Chamberlain. The inscription reads:

Position of Company B 20th Me. Vols. Capt. Walter G. Morrill, detached as skirmishers, attacking the enemy's right flank, afternoon of July 2, 1863.

Though Chamberlain was an “amateur” soldier, he undoubtedly had an exceptional military mind. His unorthodox decision to lengthen his line during the thick of the fight on Little Round Top set the stage for the grand concluding maneuver, later described by an observer as “a great right wheel swinging as a gate on a post” (Desjardin, 1999).

Joshua Lawrence Chamberlain won a Congressional Medal of Honor for his actions at Gettysburg, rose to command a brigade in the 5th Corps, fought like a lion through the Overland Campaign

Chamberlain (under orders from Vincent) to add further protection to the Union flank. Morrill's men (reinforced by about a dozen U. S. Sharpshooters who had been driven off Big Round Top) hid behind this wall until the final regimental bayonet charge—and then rose up to deliver a devastating volley into the fleeing Confederates. Unlike the wall at C, this one was erected prior to the battle and once divided the woods from an open field to the east (Adelman, 2000; Trudeau, 2002).

F. The 83rd Pennsylvania Memorial. This imposing granite monument is surmounting by a bronze statue of Col. Strong Vincent (1837-1863), commander of the brigade that so stoutly defended Little Round Top. The 83rd was posted just to the right of the 20th Maine and fought off repeated attacks of the 4th and 47th Alabama Regiments. Most of the men in the regiment were from western Pennsylvania. Prior to the reorganization of the Army of the Potomac after the battle of Chancellorsville, Strong Vincent, himself from Erie County in the extreme northwest corner of the Commonwealth, had been commander of the 83rd. Vincent fell mortally wounded on the brigade's right at about 5:45 PM as he tried to rally the 16th Michigan. He died five days later, having been promoted to brigadier general on July 3 (Adelman, 2000, Trudeau, 2002; Faust, 1986, p. 786).

G. 16th Michigan Monument. The 16th Michigan, the smallest of Vincent's regiments with only 263 men (Trudeau, 2002, p. 573; Adelman, 2000), held the right flank of the brigade's position. Heavy pressure from the front and a flanking movement by the 4th Texas (see Figure 9-4), forced the 16th Michigan back to the crest of the hill and would have broken the Union line had not the 140th New York (*Site H*) arrived just in time to push the Confederates back.

On the slopes east and southeast of the 16th Michigan Monument are stone breastworks originally probably built by the 140th and 44th New York (*Site H*) on the night of July 2 (Figure 9-9; Adelman, 2000; Frassanito, 1975). Also in this area is the Vincent Marker, marking the "officially recognized" spot where Strong Vincent was mortally wounded rallying the 16th Michigan (Figure 9-10).

H. The 44th and 140th New York Monuments and Hazlett's Position. The two granite monuments honor infantry regiments from two different brigades, each of whom had vital roles in the successful defense of Little Round Top. The 44th New York, the largest of Vincent's Brigades (Trudeau, 2002, p. 573), was positioned between the 83rd Pennsylvania and 16th Michigan. Commander of the 44th was Brig. Gen. James C. Rice, who took charge of the brigade after Vincent was wounded and kept the defensive line intact.

The 140th New York (Figure 9-11) was one of four regiments assigned to Brig. Gen. Stephen H. Weed's 3rd Brigade (2nd Division, 5th Corps), the others being the 146th New York, the 91st Pennsylvania, and the 155th Pennsylvania. Weed's Brigade was summoned to Little Round Top by General Warren himself, who claimed not to have seen Vincent's men arrive on the scene (Jordan, 2001). Just as the 16th Michigan began to give way, the 140th New York, under Col. Patrick O'Rorke burst over the crest of the ridge and pushed the 4th Texas back. O'Rorke sacrificed his life in the effort (Trudeau, 2002). Monuments to the other three regiments, who were not as heavily engaged as the 140th, are situated on the slope to the north (see Adelman, 2000, p. 41-44).



Figure 9-9. Stone breastworks on slope of Little Round Top between *Sites G* and *H*. How much of this stonework is original is debatable, but the walls are apparently in their original positions as built by men of the 44th and 140th New York on the night of July 2/3 (Adelman, 2000).



Figure 9-10. Monument to Col. Strong Vincent about 50 yards east-southeast of *Site G*, the “officially recognized” of two spots where he was supposedly killed. (The other is marked by an inscription carved into a boulder just north of the 44th New York Monument at *Site H*.)



Figure 9-11. Monument of the 140th New York Infantry at *Site H*. Though the monument is to the entire regiment, the bronze bust of and inscription to Col. Patrick H. O’Rorke are its most prominent features. He was fatally shot near this spot as he led his men over the brow of the hill and down into the maelstrom on the west slope.

The four Parrott Rifles and plaque at the summit of Little Round Top here mark the position of Lieut. Charles E. Hazlett’s Battery D, United States Artillery. Just after Vincent’s Brigade arrived on the south slope, Hazlett’s battery was brought into position on the summit through the almost superhuman assistance of infantrymen from Weed’s Brigade. (Movement of the battery to this position was apparently in part on Hazlett’s own initiative, as Warren was of the opinion that the top of the steep western slope was a poor place to bring artillery to bear on attacking troops [Trudeau, 2002].) Not long after the battery’s six 3-inch Parrott guns began blasting away at the Confederates in the Plum Run Valley below, both Hazlett and brigade commander Stephen Weed (1831-1863), who was directing the battery’s fire, were killed (Adelman, 2000; Faust, 1986).

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STOP 10. Devil's Den: Day 2 action and the York Haven Diabase.

Leaders: Jon D. Inners and Robert C. Smith, II.

[The enemy] battery was situated...on a rugged cliff which formed the abrupt termination of a ridge that proceeded from the mountain, and ran in a direction somewhat parallel with it, leaving a valley destitute of trees and filled with immense boulders.

Col. William F. Perry, C.S.A.

(Quoted in Luvass and Nelson, 1986, p. 94)

Devil's Den (Figure 10-1) is for good reason the most storied site on the Gettysburg battlefield. In a three-or-four-hour period in the afternoon and early evening of the 2nd day, this spectacular, broken outcrop of bare rock witnessed some of the bloodiest fighting of the battle, well documented by the



Figure 10-1. Location map of STOP 10, showing Site locations. Some other monuments and features, noted on the Roadlog, are also marked.

names given to parts of the adjacent Plum Run valley—the “Valley of Death” and the “Slaughter Pen.” The Den itself is well described in writings of some of those who fought there. To a Pennsylvania soldier it appeared “as though nature in some wild freak had forgotten herself and piled great rocks in mad confusion together.” A New Yorker was somewhat more descriptive: “[I]ts huge boulders, some of them as large as a small house, rest in an irregular, confused mass, forming nooks and cavernous recesses suggestive of its uncanny name” (Trudeau, 2002, p. 314-315).

Geology. Because of the sheer size of the outcropping ledges and boulders here, Devil's Den is the best place on the Gettysburg battlefield to observe the York Haven Diabase *en masse* and to examine details of its mineralogy, weathering, and mass wasting. The York Haven Diabase is a high TiO₂, quartz–normative, continental tholeiite (Froelich and Gottfried, 1999). Dominant minerals are clinopyroxene (pigeonite in the groundmass, augite as microphenocrysts)

and calcic-plagioclase (labradorite, An_{57±3}), with orthopyroxene abundant in the “stratigraphically” lower part of the York Haven sheets (Smith et al., 1975). At Devil's Den the rock is coarsely crystalline, with the mineralogy being particularly evident on weathered surfaces—the pyroxene crystals standing in relief as the plagioclase crystals weather back (see Site B). The most striking weathering features of the diabase at Devil's Den, however, is the extensive open-fracture network that divides the rock mass into huge blocks (typically with rounded edges). Another weathering phenomenon here, not quite as prominent but clearly visible to an observant eye, is the massive exfoliation of the ledges and

Inners, Jon d and RC Smith II (2008) Stop 10- Devil's Den: Day 2 action and the York Haven diabase, *in* Fleeger, G.M (ed), Geology of the Gettysburg Mesozoic Basin and Military Geology of the Gettysburg Campaign, 73rd Annual Field Conference of Pennsylvania Geologists, Gettysburg, PA, p. 142 – 148.

boulders. The rounded weathering partings not only form as thin scales on the surface, but also occur several feet down in the diabase masses (see Figure 10-4). Disruption of the exposed diabase mass takes place by gradual opening of the large-scale fractures and breakage of the rock along the exfoliation surfaces.

The fight for Devil’s Den. On the 3rd Corps’ advance from the south end of Cemetery Ridge westward to higher ground between about noon and mid-afternoon of July 2, Brig. Gen. J. H. Hobart Ward’s 2nd Brigade of Maj. Gen. David Birney’s 1st Division occupied Devil’s Den and Houck’s Ridge. Ward’s brigade—about 1500 men—reached their position about 3:30 PM. The first Confederates—from Robertson’s Brigade—appeared about 4:50 PM (Grimsley and Simpson, 1999). In defending Devil’s Den-Houck’s Ridge area, Ward’s brigade lost one-third of its men, but inflicted heavy losses on the attacking enemy. After Ward was driven out, Devil’s Den was held by the 17th and 20th Georgia of Brig. Gen. Henry L. Benning’s Brigade. Supporting troops of Brig. Gen. George T. Anderson wheeled north to support the Confederate attack in the Wheatfield (Editors of Time-Life Books, 1996).

Grimsley and Simpson (1999) give a good analysis of the military significance of the area defended by Ward’s brigade:

Although the Confederates needed to seize it so as to continue Longstreet’s main assault, the Houck’s Ridge-Devil’s Den position was of little intrinsic importance. Riflemen took up positions among the boulders from which to blaze away at Little Round Top, but the open Plum Run valley offered poor ground for a direct attack on that vital Union bastion. The position also had scant effect on the fighting that continued unabated to the north, in the Wheatfield and Peach Orchard (p. 85).

Details of the fighting at Devil’s Den are given below at the individual *Sites* of the Walking Tour.

Walking Tour of Devil’s Den

A. Overview from parking area. The “rugged cliff” of Devil’s Den—25 to 30 feet high—is directly west of the parking area on Sickles Ave. (Figure 10-2). Just to the east are Plum Run and the “Slaughter Pen,” a bouldery area along the creek that extends up to the foot of Big Round Top. Though it is uncertain whether the latter name was coined by soldiers or early observers, it is significant that Alfred Waud (1828-1891), “the most prolific of Civil War combat artists,” noted in the caption for a sketch of the area that it was “called by



Figure 10-2. Devil’s Den, looking west from the nearby parking area (*Site A*). Note the rounding, due to exfoliation, of all the large diabase masses.

the soldiers the Slaughter Pen” (Faust, 1986; Adelman and Smith, 1997).

B. The “Devil’s Den.” According to Adelman and Smith (1997), this open fracture in the face of the massive diabase outcropping is the actual “Devil’s Den” from which the entire feature now takes its name (Figure 10-3). Late 19th-century Gettysburg historian John Batchelder, who was instrumental in

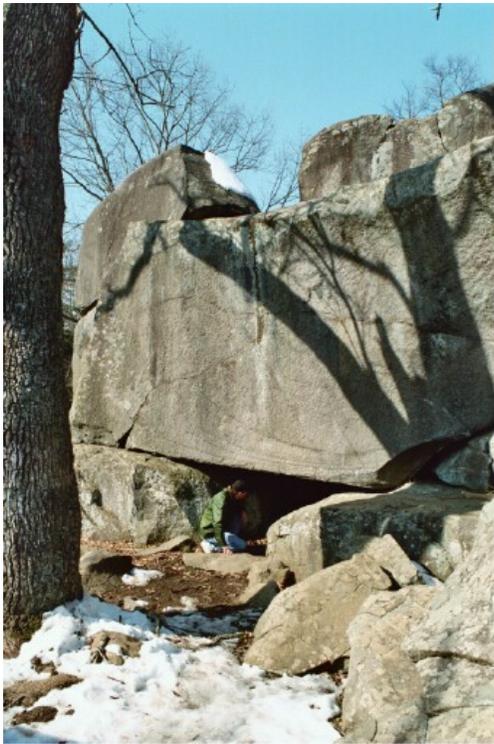


Figure 10-3. The real “Devil’s Den,” according to historian John Batchelder (*Site B*). This joint cave can be followed back for at least 20 or 25 feet. Note the curved exfoliation surfaces in the caprock of the opening.

creation of the Gettysburg National Military Park in 1895 (see especially Adelman and Smith, 1997, p. 98-100). Table Rock is basically a larger-scale version of “The Curious Rocks” at Little Round Top and probably formed in a similar manner (see STOP 9, *Site B*).

D. The top of the Den. At this point, a wooden bridge crosses a large open, subvertical fracture trending N30°W. An intersecting open fracture here trends N70°E and is also subvertical. Note the profusion of polygonal exfoliation cracks, as well as the presence of numerous parallel grooves trending N20-35°W. This spot also affords an excellent view of Little Round Top, the crest of which (at about 665 feet) towers over Devil’s Den (at 530 - 540 feet). Though we often hear of how Confederate sharpshooters on Devil’s Den made life miserable for Union infantrymen and artillerymen on Little Round Top, consider also that the Yankees, firing down from an eminence more than 125 feet higher, must have made it quite hazardous for any Rebel to stick his head out (Adelman and Smith, 1997).

Immediately after the battle, the crevasses of the Den provided temporary graves for many Confederate soldiers

the founding of the National Military Park, pinpointed this exact spot as the origin of the name, describing it as “a hole in the ground” which is “very difficult to get into.” He noted that a spring once flowed through the opening. Considering all of the many fracture openings in the entire “rock formation”—several of which seem more impressive than this one, such specific identification rings somewhat hollow. It seems more likely that the name was always more or less applied as it is today.

On the irregular ledge above and to the left of the “Devil’s Den” is a good surface to observe the micro-weathering of the diabase (as described under **Geology**). Just to the right of that, a large block has broken off an overhanging ledge, one of the fracture surfaces being a curved exfoliation parting (Figure 10-4).

C. Table Rock. This interesting formation could also be dubbed “Charles Atlas Rock” as one’s first impulse for a “photo op” here is to pose in the open fracture and attempt to “lift” the large, flat boulder overhead (Figure 10-5). This was also a favorite spot for 19th-century photographs (Frassanito, 1975, p. 170; 1995, p. 302-305; Adelman and Smith, 1997, p. 91, 93, 113, etc.), and, indeed, the preferred name comes from the caption of a stereo-view taken by a local photographer in 1867. On these old photographs can be seen numerous “scratch-outs,” marking spots where late 19th-century, carved graffiti was

removed after the

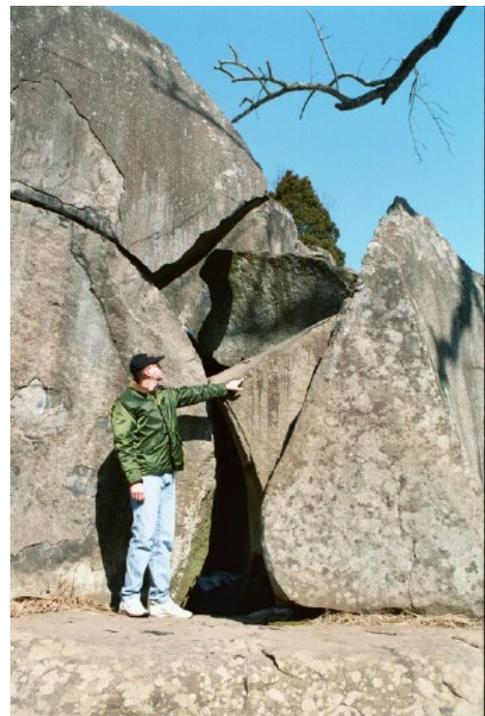


Figure 10-4. Exfoliation in action near *Site B*. Note the triangular block that has fallen from the huge exfoliated “sheet” above the person’s head.

who died there—the bodies being simply tossed into the open fractures “in lieu of burial” (Adelman and Smith, 1997, p. 118). Although there exist several “posed” pictures of supposed dead at Devil’s Den (see Frassanito, 1995, p. 296-297), apparently none of actual dead are known.

E. The “sharpshooter’s position.” This is the site of one of the most famous photographs of the Civil War, the dead Confederate sharpshooter behind a stone rampart on the back side of Devil’s Den (Frassanito, 1975, p. 190; 1995, p. 269). Though taken only a few days after the battle and actually



Figure 10-5. Table Rock (*Site C*), looking northeast. On the right is the monument to the 4th Maine Infantry. Behind that can be seen the bouldery lower slope of Little Round Top on the other side of the “Valley of Death.”

picturing a dead Rebel soldier behind a wall almost certainly constructed during the night of July 2/3, the photo is a “historical distortion.” Through the analysis of a series of photographs taken by Alexander Gardner and his assistants, William A. Frassanito (1975, 1995) has shown that the body was actually dragged from a spot 72 yards away and placed in the “sharpshooter’s coven.” The picture was completed by propping a rifle (not the kind a sharpshooter would use) against the wall.

As shown in Figure 10-6, the position does provide an excellent view of the summit of Little Round Top. Certainly someone “hid” here and fired at the enemy about 500 yards away—a distance that approximates the maximum effective range of a Civil War rifled musket (Grimsley and Simpson, 1999, p. 192).

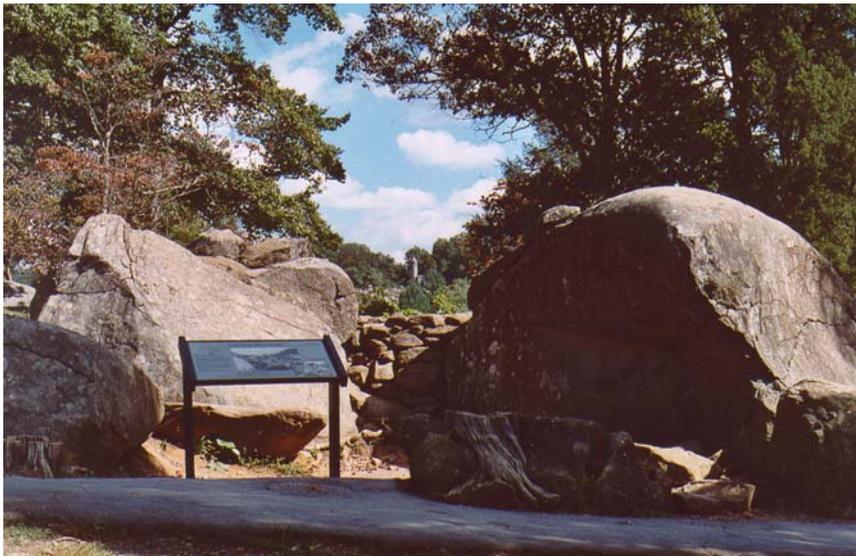


Figure 10-6. The “sharpshooter’s position” (*Site E*). Note the splendid view of the summit of Little Round Top, the monument tower being that of the 44th New York Infantry (*Site H* of STOP 9).

F. The “triangular field.” At the time of the battle, this diabase-strewn field (Figure 10-7) was owned by farmer George W. Weikert, who may have used it as a cattle or hog pen. Low stone walls bounded the tract on the north and southwest side, with a wooden fence on the east side next to the present road (later replaced by a stone wall). Across this small, relatively inconspicuous real estate, both Rebels and Yankees launched bloody attacks and

counterattacks that left the ground strewn with the bodies of dead and wounded men. Initially the 1st Texas struck from the west against the 124th New York at the south end of Houck’s Ridge. Then the 124th New York hit back and drove the Texans back beyond the edge of the field, but were themselves



Figure 10-7. The “triangular field,” looking west (*Site F*). During the proper season, when the trees are in leaf and the grass is green, this open, rocky slope probably looks much like it did at the time of the battle. Here fell Col. Ellis and Maj. Cromwell of the “Orange Blossoms.” Brig. Gen. Henry L. Benning (1814-1875), whose Georgians charged across this field, was aptly and affectionately known as “Old Rock.”

then driven back to the crest of Houck’s Ridge (see *Site H*)—with the Texans capturing Devil’s Den. As the confusing melee continued, the 4th Maine pushed the Texans into the woods northwest of the “triangular field.” At this point, Benning’s Georgia Brigade arrived on the scene, and the 20th Georgia (under Col. John A. Jones) attacked across the open field. Though initially stalled by withering fire from the 4th Maine and Smith’s Battery (see *Site G*), the 20th Georgia and other units of Benning’s and Brig. Gen. Evander M. Law’s Brigades eventually drove the now greatly outnumbered Northerners from Devil’s Den and off

Houck’s Ridge. The remnants of the 4th Maine, the 124th New York, and the rest of Ward’s Brigade retired to the south end of Cemetery Ridge, where, with other shattered 3rd Corps units, they took up a position not far from where they had been early on the afternoon of July 2—before Sickles had ordered his ill-fated advance to the “high ground” on his front! (Adelman and Smith, 1997; Grimsley and Simpson, 1999; Trudeau, 2002).

G. Monument to the 4th New York Independent (Smith’s) Battery. Captain James E. Smith’s battery played a pivotal, though somewhat controversial role in the battle for Devil’s Den and Houck’s Ridge—as is well documented in Adelman and Smith (1997). The 4th New York Battery consisted of six Parrott rifles, manned by more than 120 men. Two sections of the battery (four guns) went into position near the south end of Ward’s line on the crest of Houck’s Ridge, apparently just north of the exposed, rocky ramparts of Devil’s Den and in front of the 124th New York and 4th Maine (Adelman and Smith, 1997, p. 26). The other section was placed with the caissons and horses 150 yards in the rear to cover the Plum Run gorge (Luvass and Nelson, 1987). (According to Smith, the position atop the hill had room for only four of his guns.) After an artillery duel lasting about 45 minutes, in which Smith’s men suffered little because of the many protecting boulders, the Confederates launched a ferocious attack on the Union position. By the time the surging Confederates of the 3rd Arkansas and 1st Texas (Robertson’s Brigade) neared his guns, the Union artillerymen had exhausted their case shot and shrapnel. Informed of this, Smith exhorted, “Give them shell; give them solid shot; damn them; give them anything!” (Adelman and Smith, 1997, p. 29). Smith’s four main guns were eventually captured, then retaken—and finally at about 5:45 PM, Benning’s and Anderson’s Georgians drove Ward’s Brigade off Houck’s Ridge and finally captured three of Smith’s advanced cannons—the fourth having been sent to the rear disabled (Grimsley and Simpson, 1999; Luvass and Nelson, 1987). Smith himself had previously left the position on the crest of the Houck’s Ridge to go to his rear section of guns, which fired on the Confederates advancing northward through the Plum Run gorge before falling back.

Adelman and Smith (1997) note that the position of this monument is most likely in error, Smith's four advanced guns probably having been positioned on the crest of the Houck's Ridge near where the monument of the 99th Pennsylvania now stands.

H. Monuments to the 99th Pennsylvania and 124th New York Regiments. The 99th Pennsylvania was recruited mainly from Philadelphia and Lancaster Counties and numbered 339 officers and men at Gettysburg, 110 of whom were casualties. The regiment—commanded by Maj. John W. Moore—was originally posted along Houck's Ridge at the extreme right of the 2nd Brigade's line, but was later moved to the left between the 124th New York and the 4th Maine (posted in the "Slaughter Pen" along Plum Run) where they took a position "as firm as the rocks beneath their feet" on top of Devil's Den. From this elevated rampart, the 99th blasted away at the 44th and 48th Alabama Regiments below and temporarily stabilized the Union line (Adelman and Smith, 1997). The monument itself is coarsely crystalline, black-speckled, hornblende granite that contains a high percentage of quartz. Note that this granite appears to be spalling faster than some of the other monument stones, such as the Westerly and Quincy granites, probably due in part to its coarse grain-size.



Figure 10-8. Monument to the 124th New York Infantry (*Site H*). Col. Ellis calmly surveys the "triangular field," waiting for the Confederates' next attack. According to Hawthorne (1988), this monument—carved from St. Johnsbury Vermont granite—is the only one on the battlefield that contains a full-length portrait stature of a regimental commander.

The 124th New York (Figure 10-8) was a three-year regiment raised mainly from Orange County in the "Tri-States area" along the Delaware and Neversink Rivers. Their first action was at the battle of Chancellorsville, where they suffered 40 percent casualties and were immortalized (though unnamed) in Stephen Crane's *The Red Badge of Courage* (LaRocca, 1995). In the course of that battle, their commander, Col. A. Van Horne Ellis had dubbed his men "the Orange Blossoms"—and this colorful name has fittingly come down through history (Grimsley and Simpson, 1999, p. 80). After the "Orange Blossoms" fought off repeated attacks of the 1st Texas, Col. Ellis and Maj. James Cromwell, both mounted, led a charge across the Triangular Field at about 5:00 PM that momentarily broke the Texas line. At the far end of the field, the Texans turned and fired a withering volley that killed or wounded a quarter of the New Yorkers, including Cromwell (killed). Benning's Brigade then hit the Yankees and drove them back to the crest of Houck's Ridge, Ellis falling dead along the way, a bullet through his head (Grimsley and Simpson, 1999; Adelman and Smith, 1997).

I. Houck's Ridge. Looking north from this highest point on the ridge encompasses much of the field of action of some of the later fighting on Sickles' left flank (Figure 10-9). Ward's original line angled off through the woods to the left, its right (just south of the Wheatfield) being held originally by the 99th Pennsylvania and later by the 20th Indiana (Adelman and Smith, 1997). After the Union forces had been driven from the Wheatfield early in the evening, Brig. Gen. Samuel Crawford led part of his 3rd Division of the 5th Corps on the spirited counterattack described at mile 11.55 of the Day-2 Roadlog. Though



Figure 10-9. Houck's Ridge (left) and the "Valley of Death" (right) from *Site I*. The woods in the right distance mark Cemetery Ridge. Many of the granite monuments and markers on Houck's Ridge are to U.S. Infantry Regiments of Brig. Gen. Romeyn B. Ayres 2nd Division of the 5th Corps. The Regulars fought over this ground as part of the hours long engagement at the Wheatfield—and in retiring across the "Valley of Death" after being driven off Houck's Ridge, suffered "staggering" casualties (Jorgensen, 2002).

Crawford's charge carried to the Wheatfield, his Pennsylvania Reserve Regiments were soon driven back. From then till their retreat on July 4/5, the Confederates retained possession of Devil's Den, Houck's Ridge, and the Wheatfield (Adelman and Smith, 1997; Jorgensen, 2002).

In 1872 Crawford himself purchased Devil's Den and much of the land visible from here. Up to the time of Crawford's death in 1892, this 47-acre tract of land was known as Crawford Park. He never followed through on his promise to deed or will his land over to the Gettysburg Battlefield Association—an omission that resulted in gross commercialization of this part of the battlefield (see Adelman and Smith, 1999, p. 78-91).

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STOP 11. The Peach Orchard: Day 2 action and the Rose Farm.

Leader: Jon D. Inners.

I took up that line because it enabled me to hold commanding ground.

Maj. Gen. Daniel Sickles

(Quoted in Grimsley and Simpson, 1999, p. 117)

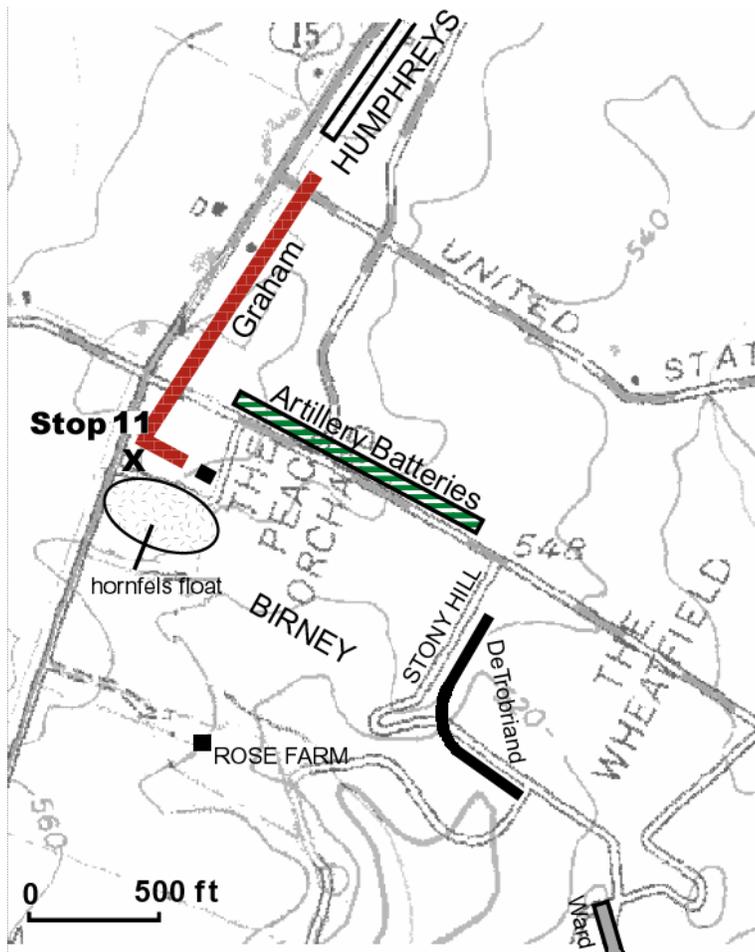


Figure 11-1. Location map for STOP 11, showing disposition of 3rd Corps DIVISIONS and brigades.

The Peach Orchard (Figure 11-1) is the center of one of the major controversies of the battle of Gettysburg. Late in the morning and early in the afternoon of July 2, Maj. Gen. Daniel E. Sickles shifted his two-division-strong 3rd Corps from its original position on the Union left to higher ground on his front. His assigned line was to run along the south end of Cemetery Ridge to the crest of Little Round Top (Trudeau, 2002, p. 295). By the time he had established his final line to the west, it stretched for twice the distance of the original and formed a dangerous salient. The stage was now set for some of the bloodiest fighting of the entire battle, with action extending from the Emmitsburg Road southeastward to Little Round Top, a frontal distance of nearly two miles.

Terrain. The Peach Orchard is situated along the Emmitsburg Road about 4000 feet west of Cemetery Ridge. (The Peach Orchard of the battlefield was part of a larger orchard owned by the Sherfy family that originally extended beyond Wheatfield Road to the northeast [Grimsley and Simpson, 1999].) With an elevation of a little over 580 feet, it is 35 to 50 feet

higher than the low spot on the 3rd Corps line that was vacated by Sickles in his unauthorized movement to the west. The low ridge at the Peach Orchard is uninterrupted northeastward along the Emmitsburg Road for 3000 feet, but to the southwest it is scalloped by two small streams that form the headwaters of Rose Run.

As noted by Gramm (1997), the Peach Orchard occupies a significant elevation relative to the surrounding terrain:

From the Rose Farm, Kershaw's men [Confederate] had to go up a hill-slope steep enough that you can't see the peach trees from the rivulet north of the [Rose] farm [Figure 11-2]. From the Peach Orchard you have a long view of Pickett's Charge—all of which is lower. The land slopes down toward the Trostle Farm and the main Union line. From Seminary Ridge, the Peach Orchard appears as an eminence (p. 113).

Inners, Jon D (2008) Stop 11- The Peach Orchard: Day 2 action and the Rose Farm, in Fleeger, G.M (ed), Geology of the Gettysburg Mesozoic Basin and Military Geology of the Gettysburg Campaign, 73rd Annual Field Conference of Pennsylvania Geologists, Gettysburg, PA, p. 149 – 153.



Figure 11-2. View south from the Peach Orchard toward the low ground at the head of Rose Run. The Rose farmhouse is partially hidden by trees on the left.

Besides the higher elevation of the Peach Orchard, another rationale cited by Sickles for taking a position forward of Cemetery Ridge was the fact that woods on his original front (northeast of the Trostle Farm) partially obscured his view to the west (Doubleday, 1994; see Trudeau, 2002, p. 295).

As discussed in some detail in *Inners* (this guidebook, Longstreet Tower), Sickles was afraid the Confederates would place artillery at the Peach Orchard and have a relatively free hand at shelling the Union forces only a little more than one-half mile away. He was not going to allow Meade to duplicate

Hooker's mistake at Chancellorsville (see Kaufmann, 1999, p. 215).

Geology. The Peach Orchard is underlain by shale and sandstone of the Gettysburg Formation baked to hornfels by the diabase of the Gettysburg sheet to the southeast (Stose and Bascom, 1929). The hornfels zone is mapped as about 1800 feet wide and extends from just northwest of Sickles Road at the "Stony Hill" to slightly beyond the Emmitsburg Road. No outcrops occur in the vicinity, but gray hornfels float litters the surface of the soybean field just south of the orchard. Unlike areas underlain by diabase, the Peach Orchard apparently had no preexisting stone walls—and the battle here was fought by lines of men out in the open.

Sickles and the Peach Orchard salient (July 2). Sickles began his redeployment late in the morning by sending three regiments of Brig. Gen. Hobart Ward's 2nd Brigade out to the Wentz Farm, just northeast of the Peach Orchard. By 3 PM he had completed the repositioning of his troops, having moved his right out to the Emmitsburg Road, his center to the Peach Orchard and his left to Devil's Den (Trudeau, 2002; see STOPS 9 and 10). At the Peach Orchard, the regiments of Brig. Gen. Charles K. Graham's 1st Brigade formed a salient, facing west across the Emmitsburg Road and south toward the Rose Farm (see Figure 11-1). But as Doubleday (1994) observes, "The disadvantages of this position are obvious enough."

It is impossible for any force to hold its ground when attacked at once on both sides which constitute the right angle. The diagram [Figure 11-3] shows that the force A will have

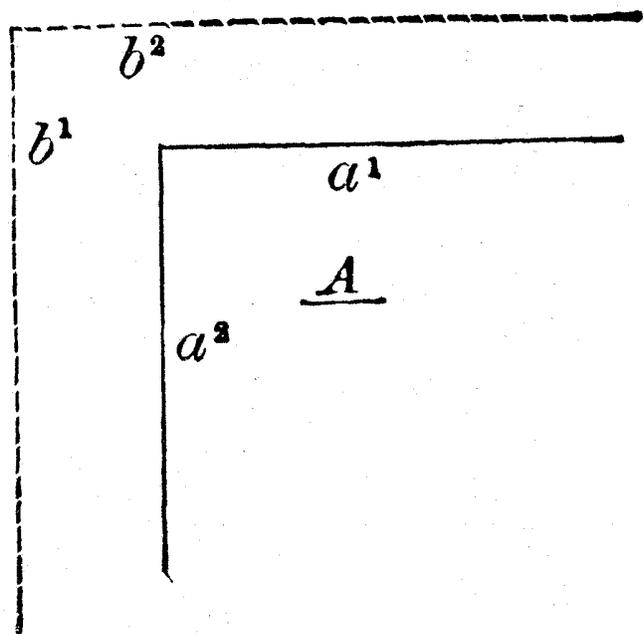


Figure 11-3. The weakness of a salient as illustrated by General Abner Doubleday (1994, p. 163). The letters are explained in the text.

both its lines a^1 and a^2 enfiladed by batteries at b^1 and b^2 , and must yield. The ground, however, may be such that the enemy cannot plant his guns at b^1 and b^2 ; but under any circumstances it is a weak formation and the enemy easily penetrate the angle. When that is the case, and it was so in the present instance—each side constituting the angle is taken in flank, and the position is no longer tenable (p. 163).

To Graham's right was the 2nd Division of Brig. Gen. Andrew Humphreys and to his left, along Wheatfield Road (at that time, the Millerstown Road), was a line of artillery batteries extending east to the "Stony Hill" (see Figure 11-1), the 15th Battery, New York Light Artillery, nearest the Peach



Figure 11-4. Monument to Hampden's Battery F, Pennsylvania Light Artillery along the northeast edge of the Peach Orchard. Because of its high losses in previous battles, Capt. Robert Hampton's battery fought as part of another battery at the Peach Orchard (Hawthorne, 1988). The prominent monument in the middle distance to the left is that to the 73rd New York Infantry (the 2nd Fire Zouaves) of the 2nd Brigade, 2nd Division, 3rd Corps. Behind the New York monument the ground can be seen sloping down toward Cemetery Ridge on the skyline. The white dome, capped by a bronze statue, barely visible above the trees is the Pennsylvania State Memorial. eastward toward "Stony Hill," and his left swinging around to the north to attack the Union artillery lined up along Wheatfield Road. His men took fearful losses as they advanced (Trudeau, 2002). Further confusion in the Confederate ranks, due to miscommunication of orders, led to even worse casualties on Kershaw's left, as his men pulled back from the cannons and "turned their flank and rear toward the Yankee gunners." A private in one of Kershaw's regiments later wrote of "the awful deathly surging sounds of those little black [canister balls] as they flew by us, through us, between our legs and over us." Said Kershaw himself, "Hundreds of the bravest and best men of Carolina fell, victims of this fatal blunder" (Trudeau, 2002, p. 352).

Orchard on the right, and the 9th Battery, 9th Massachusetts Light Artillery (see mile 21.5), on the left. In all there were seven Union batteries in the Peach Orchard salient (Figure 11-4)—42 guns in a solid line along the Emmitsburg Road and across the Orchard (Gramm, 1997) and another dozen or so at right angles down the Wheatfield Road toward the Wheatfield.

Late in the afternoon, the Confederates on Warfield Ridge opened an intense artillery barrage against the two sides of the Peach Orchard salient. At 5 PM, Brig. Gen. Joseph Kershaw's Brigade (McLaw's Division, Longstreet's Corps) struck across the fields a little south of the orchard, his right heading

Despite this initial setback, it was soon the Union forces that were in trouble. At about 6:30 PM Barksdale's Mississippi Brigade (the 13th, 17th, 18th, and 21st Regiments) attacked the apex of the salient, drove the enemy out of the Peach Orchard, and seriously threatened Humphrey's left flank. Caught up in the maelstrom were the 141st Pennsylvania (Figure 11-5) and the 3rd Michigan Infantries. The former (one of Graham's regiments) suffered horrendous casualties in Peach Orchard, both to artillery and in Barksdale's final assault. According to Faust (1986), "By its tenacity on the field, the regiment enabled its brigade to hold the line for some time after supporting units gave way, winning the admiration of participants and observers on both sides." The 3rd Michigan (Figure 11-6), one of Col. Regis de



Figure 11-5. Monument to the 141st Pennsylvania Infantry at the northeast corner of the Peach Orchard. Note that in this direction also the ground slopes down before rising again toward the tree-covered “Stony Hill.” Hornfels underlies the foreground. The hornfels/diabase contact lies approximately at the treeline on “Stony Hill.”

feet south of the Peach Orchard.(see Figure 11-1). The Rose farm was quite extensive, including within its bounds “Stony Hill,” the Wheatfield, and Rose Woods. The present notoriety of the Rose Farm and Woods is due in large part to the detective work of William A. Frassanito (1975, 1995), who has conclusively demonstrated that a series of famous photographs of Confederate dead, taken just a few days after the battle by noted Civil War photographer Alexander Gardner (1821-1882) and his crew, originated there. Gardner’s “death studies” were sited at the edge of Rose Woods about 1000 feet southwest of the farmhouse (Figure 11-7). The forty-four dead soldiers in the photographs apparently belonged to three of the Georgia regiments in Brig. Gen. Paul J. Semmes’ Brigade and one of the South Carolina regiments in Kershaw’s Brigade (both brigades being in McLaw’s Division). They fell in the Confederate counterattack against the five Union regiments of Col. John R. Brooke’s Brigade (Caldwell’s 1st Division, 2nd Corps), who had driven the Confederates completely out of the Wheatfield and Rose Woods. Brooke’s brigade was unable to advance beyond a diabase ledge at the west edge of the woods (marking the west edge of the Gettysburg sheet) and was soon forced to give way, making a hasty retreat—along with the rest of Caldwell’s command—back across the Wheatfield and Houck’s Ridge to Little Round Top.

Trobriand’s regiments that was detached from the rest of the 3rd Brigade, was the leftmost infantry unit in the orchard itself.

Although the Confederates controlled the Peach Orchard on July 3, and could have used it—as Sickles feared—to site artillery for the great cannonade that preceded “Pickett’s Charge,” their line of batteries along the Emmitsburg Road stopped short of the Sherfy Farm. The orchard fielded no guns that afternoon (Trudeau, 2002, p. 445).

The Rose Farm. Bordering the John Sherfy farm on the south at the time of the battle was the farm of John P. Rose and his family, the house being located about 1,200



Figure 11-6. Monument to the 3rd Michigan Infantry at the southeast corner of the Peach Orchard.



Figure 11-7. Confederate dead at the southwestern edge of the Rose Woods, looking southwestward toward Warfield Ridge (Frassanito, 1995, p. 343, Photo 111). Note the large diabase boulder.

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STOP 13. McPherson's Ridge railroad cut ("middle cut"): Day-1 action (late morning) and stratigraphy of a part of the Gettysburg Formation.

Leaders: Jon D. Inners, Roger J. Cuffey, and Rodger T. Faill.

The middle and western railroad cuts on the CSX line (Figure 13-1) that passes westward out of the Gettysburg National Military Park provide excellent exposures of the middle part of the undivided Gettysburg Formation that lies below the mapped Heidlersburg Member (Stose and Bascom, 1929; Berg, 1980). We will observe the middle cut, which has the better exposure of the rocks, and also has greater significance to the Day-1 battle. (A fourth cut 0.5 mile farther northwest is in the Heidlersburg Member, but the stratigraphic sequence is virtually identical to that described here for the "middle" railroad cut.)

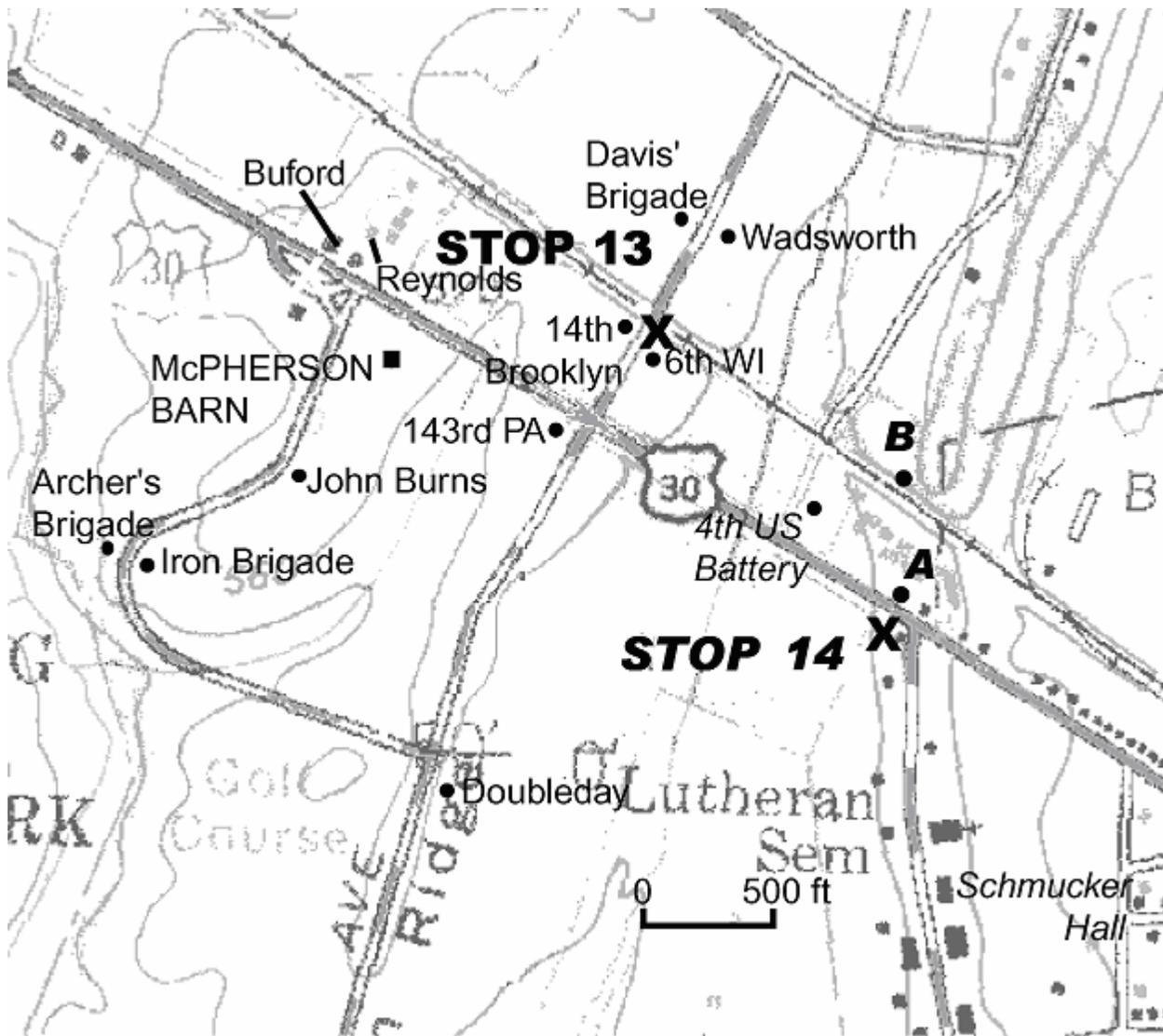


Figure 13-1. Location map for STOPS 13 and 14.

Inners, Jon D, Roger J. Cuffey, and Rodger T Faill (2008) Stop 13- McPherson's Ridge railroad cut ("middle cut"): Stratigraphy of a part of the Gettysburg Formation, in Fleeger, G.M (ed), *Geology of the Gettysburg Mesozoic Basin and Military Geology of the Gettysburg Campaign*, 73rd Annual Field Conference of Pennsylvania Geologists, Gettysburg, PA, p. 154 – 157.

Geology. The battlefield cuts are excavated in East (middle) and West (western) McPherson's Ridge, with both exposing thick, gray, sandstone-siltstone-shale sequences that indicate gradation into the Heidlersburg Member (Figure 13-2). In fact, it is hard, gray, silty sandstone that forms the resistant "backbone" of both ridges (Figure 13-3). The sandstone and gray shale unit represents deposition in shallow lakes on the playas and distal alluvial fans that formed the dominant features of the Late Triassic landscape of the Gettysburg Basin (Smoot, 1999; Fail, 2003). We will visit the middle cut, which has slightly better exposure of the rocks—and also has greater significance to the Day-1 battle.

Bedding in the cut strikes N27°E and dips 25° NW. Typical joint orientations are N52°E/82°SE (sandstone) and N32°W/71°NE (red sandstone at top).

The fight at the "middle" railroad cut, morning of July 1. At 11:15 AM, about four hours after the initial contact between Union dismounted cavalry under Brig. Gen. John Buford (Figure 13-3) and only about thirty minutes after the death of Maj. Gen. John Reynolds (Figure 13-4; Day-2 Roadlog, mile 17.7), the action developed as follows (Smith and Keen, 2004):

Wadsworth now decided to throw the 6th Wisconsin in to support 14th Brooklyn and 95th New York Regiments. The 6th Wisconsin, held in reserve at the Seminary, moved north crossed the post and rail fence along the Chambersburg Pike and through the field between the unfinished railroad and the pike. Confederate troops, chasing the remnants of Cutler's units from the field, were surprised by the appearance of Union troops on their flank and sought cover in the unfinished middle railroad cut. Colonel Dawes, ordered the 6th Wisconsin regiment to charge the Confederates, now hidden from sight and firing at his troops. His unit was joined by the 95th New York, and 14th Brooklyn who moved down the slope of McPherson Ridge to support Dawes. Rushing into the unfinished cut both forces were soon involved in hand to hand combat. Union forces cut off the retreat of remaining Confederate forces at both ends of the cut forcing a large number of troops to surrender. With the surrender of Confederate troops at the cut the fighting quickly wound down.

Some notes on the railroad. The original railroad bed along the present line west of Gettysburg was constructed in 1836-38 as part of the "Tapeworm" railroad promoted by local attorney and abolitionist (and later, congressman) Thaddeus Stevens (1792-1868). The railroad was never completed, and after funding for the project was cut off in 1839, the abandoned grade—which included the three deep cuts at STOPS 13 and 14—became a wagon road. Tracks were finally laid in 1885, the route being taken over by the Western Maryland Railroad (Frassanito, 1995). The railroad is now part of the CSX system.

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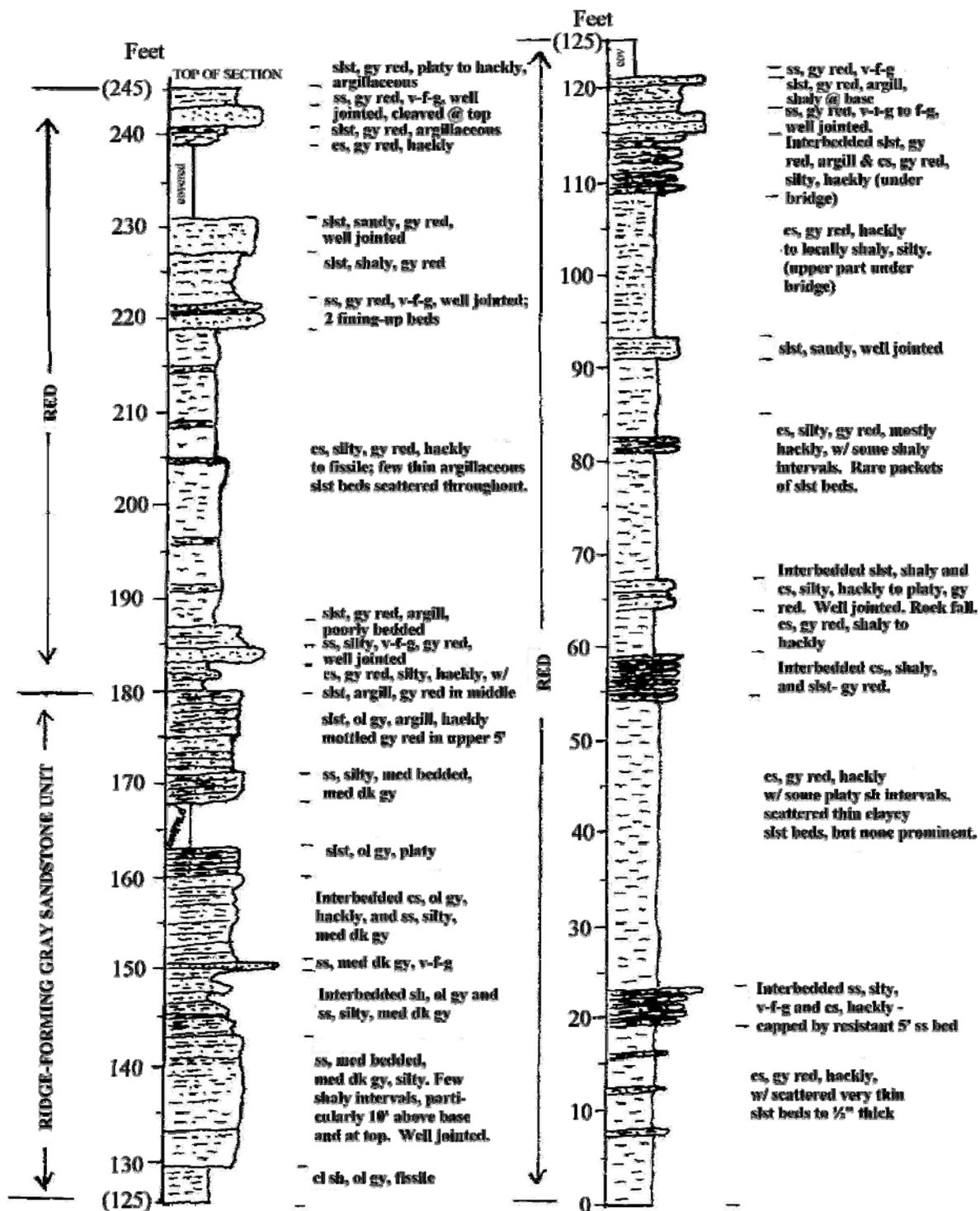


Figure 13-2. Measured section of Gettysburg Formation (part) exposed in middle railroad cu.



Figure 13-3. The middle railroad cut in the Gettysburg Formation. Erosionally resistant gray argillite and shale unit in the foreground, weaker red shale and sandstone in the background. In the distance is the western railroad cut, which exposes a similar section.



Figure 13-3. Brig. Gen. John Buford commanded the 1st Cavalry Division during the Gettysburg Campaign. Credited by many with choosing the battlefield, Buford would fall ill in November, and die in Washington, D. C., December 16, 1863.

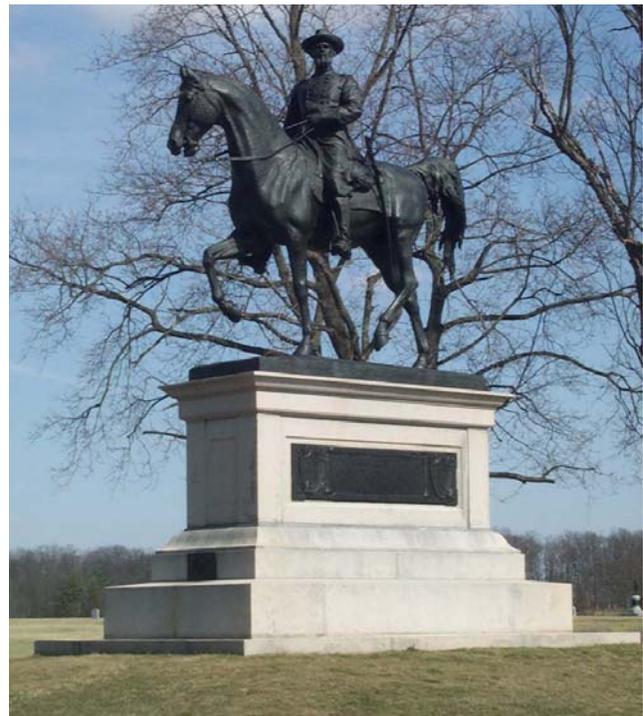


Figure 13-4. Maj. Gen. John Reynolds commanded the 1st Corps and Meade's left wing during the Gettysburg Campaign. His decision to support Buford's command ensured that the battle would be fought at Gettysburg. Reynolds, leading his troops from the front, was killed on July 1, 1863.

STOP 14. Lee’s “Headquarters” and the Seminary (Oak) Ridge railroad cut: Day 1 action (climax), the Gettysburg Formation, and the Seminary Ridge dike.

Leaders: G. Patrick Bowling and Jon D. Inners.

STOP 14 consists of two “sub-STOPS”—**A** being Lee’s “Headquarters” on the Chambersburg Pike near the crest of Seminary Ridge and **B** being the Seminary (Oak) Ridge railroad cut about 400 feet to the north (Figure 13-1). The latter, easternmost of the three cuts on the unfinished railroad northwest of Gettysburg, was to the Union 1st Corpsmen what the “middle railroad cut” was to their Confederate counterparts in Hill’s Corps—scene of the ignominious capture of scores of men and, in this case, several battle flags.

A. Lee’s “Headquarters.”

The stone house on the north side of Chambersburg Pike was the headquarters of Confederate General Robert E. Lee from the evening of July 1 to about midnight on July 4-5 (Figure 14-1). At the



Figure 14-1. Lee’s “Headquarters” on the Chambersburg Pike at **A**.

time of the battle the house (built of local, varicolored Triassic sandstone—probably in the 1830’s) was the residence of the widow Mary Thompson (1793-1873). As observed by Professor Michael Jacobs of Pennsylvania (now Gettysburg) College in an 1864 article, it occupied “an elevated position from which the Federal lines could be seen with a field glass” and yet was “at a safe distance from our guns” (Frassanito, 1975, p. 66).

The actual headquarters of the Army of Northern Virginia was a group of tents in an apple orchard on the south side of the Chambersburg Pike, as noted on the monument just west of the parking lot. (Such vertical cannon barrels mark all army headquarters on the battlefield.) Lee

apparently spent much of his time there and in the cupola of the Lutheran Seminary, sleeping and taking his meals in the widow Thompson’s house.

*To get from **A** to **B**, walk north across the motel lawn parallel to the Chambersburg Pike to the hedgerow that marks the edge of the motel property. Turn right and follow the partially paved path along the hedgerow back to the railroad cut.*

The two cannons and the monument on the west side of the motel lawn mark the position of Battery B, 4th U.S. Artillery of the 1st Corps Artillery Brigade—six 12-pounder Napoleons under Lieut. James Stewart. In the late afternoon of July 1 (3:00 PM and later), the battery was split in half by the railroad cut. In fierce fighting here, it sustained the “second highest casualties of all the 68 Union batteries that served at Gettysburg” (Frassanito, 1995, p. 70)—2 men killed, 2 officers and 29 men wounded, and 3 men missing. Despite such severe losses, Stewart successfully retired to East Cemetery Hill, setting up four of his guns (two had been disabled) to command the approach from town along the Baltimore Pike.

Bowling, G Patrick and Jon D Inners (2008) Stop 14- Lee’s “Headquarters” and the Seminary (Oak) Ridge railroad cut: Day 1 action (climax), the Gettysburg Formation, and the Seminary Ridge dike, in Fleegeer, G.M (ed), Geology of the Gettysburg Mesozoic Basin and Military Geology of the Gettysburg Campaign, 73rd Annual Field Conference of Pennsylvania Geologists, Gettysburg, PA, p. 158 – 163.

B. Seminary (Oak) Ridge railroad cut.

Frassanito (1995, p. 68) notes that “the famous ridge today known as Seminary Ridge was referred to locally as ‘Oak Ridge’ for its entire length prior to the battle” and that the ridge northward to Mummasburg Road is still commonly referred to as Oak Ridge by locals. (On the current Gettysburg 7.5’ topographic map, “Oak Ridge” starts at the Eternal Light Peace Memorial north of the Mummasburg Road.) Hence the “double name” for this easternmost of the railroad cuts that played a role in the 1st Day’s fight. Like the two cuts at STOP 13, the Seminary (Oak) Ridge cut was originally excavated as part of Thaddeus Stevens’ “Tapeworm Railroad” in 1838. Old pre-war woodcuts (c.1840) and post-war photographs (1867) show masses of diabase boulders excavated from the cut in the early preparation of the railroad grade. (They were probably removed from the scene when tracks were laid and the railroad was completed in 1885.) (See Frassanito, 1995, p. 69, 73.) As a result of a land trade between Gettysburg College and the National Park Service, a railroad spur was constructed at the east end of the cut in 1991. Excavation for this spur resulted in “massive destruction of the northern face” (Frassanito, 1995). The Seminary Ridge dike, which was once almost completely exposed on this north face, is now hidden behind a large gabion.

Geology. Although not quite as instructive an exposure as it was before the recent addition of the railroad spur, the Seminary (Oak) Ridge cut is still one of the best geologic sites on the battlefield. Red shale and sandstone typical of the undivided Gettysburg Formation can be seen at the west end; contact metamorphosed shale and claystone (hornfels) crops out in the middle; and the Seminary Ridge diabase dike is at the east end. Although the gabion conceals the dike/hornfels contact, the gradational red shale/hornfels contact is still well exposed.

Prior to the terrain alteration (discussed below), Shirk (1980) described the section exposed from the intersection of the service road and railroad tracks east to the dike as follows:

0-200 feet. Highly weathered, thin-bedded, irregularly fractured red shale showing slaty cleavage.

200-230 ft. Beds become more massive and less cyclic. Bedding planes are not as prominent but the prevailing strike (N 50° E) and dip (20° NW) are still discernible.

230-315 ft. Jointing is very prevalent in this zone and three sets of joints occur in the rocks.

315-375 ft. The red shale begins changing to a grayish-red “argillite” (defined by Shirk as a weakly metamorphosed shale) which marks the start of metamorphism along the section as the beds become progressively darker, display less lamination and fissility, and are more compact and hard towards the east.

375-400 ft. At about the 375-foot mark, a fine-grained, black, hard hornfels occurs in a zone approximately 25-30 feet wide where it comes in contact with the diabase dike at the 400-foot mark.

400-500 ft. The Seminary Ridge diabase dike is approximately 100 feet thick with an average dip of 50° to the east. The diabase is fine-grained and exposed surfaces have a brown coating from the oxidation of ferromagnesian minerals. Four joint sets are visible in the rock.

Shirk (1980) did not mention whether a chilled diabase-margin could be observed, although Stose (1932) stated that an inch or two of black dense altered shale right at the contact has been commonly mistaken as a chilled margin.

Gettysburg Formation. About 90 feet of Late Triassic-age Gettysburg shale, claystone, siltstone, and sandstone is exposed in the cut. Except for a few thin, olive-gray shale bands (the most prominent being a 6-inch bed about 70 feet above the base), the rock is entirely grayish red (Figure 14-2). The claystones are hackly to subfissile. Red shale and thin red sandstones at the top are distinctly burrowed. Hoff et al. (1987) note an interesting 5-inch-thick bed of pale-red to reddish-brown, calcareous siltstone near the top of the unaltered Gettysburg. They report that the calcite in the siltstone is distributed as interstitial

grains, pseudomorphs after glauberite, and partial fillings in desiccation cracks. Both the former presence of glauberite and the desiccation cracks strongly suggest that the sediments originated under arid climatic conditions.

The Gettysburg beds strike N30°E and dip 20-25°NW. The dominant joint fractures are N75°W/78°SW, N75°E/85°SE, and N62°E/85°NW.



Figure 14-2. North side of the Seminary (Oak) Ridge railroad cut (B), showing the unaltered Gettysburg red shale and sandstone on the left, the 30-foot-thick hornfels zone in the middle, and the massive gabion that covers the Seminary Ridge diabase dike on the right.

Hornfels. The baked zone is about 30 feet thick (Figure 14-2). Most of the exposed hornfels is very dusky purple, grading off into unaltered grayish-red shale to the northwest and probably intensely baked to a grayish-black color next to the dike on the southeast. Malachite and other copper minerals occur along the now-hidden hornfels/diabase contact.

The dike. The Seminary Ridge dike is fine-grained Rossville Diabase, a low TiO₂, quartz-normative continental tholeiite. In thin section, the rock can be seen to be composed of a groundmass of anhedral plagioclase (labradorite, An_{57±2}) and pyroxene (augite, hypersthene, and pigeonite), with common phenocrysts of euhedral bytownite-anorthite (Smith et al., 1975).

Less than five percent of opaque minerals (probably magnetite and/or ilmenite) are present along with a few percent biotite and/or chlorite (Bowling, 1981). The fine grain size indicates rapid cooling of the dike, as would be expected of an intrusion less than 100 feet thick (Hoff et al., 1987). Like the York Haven Diabase, the Rossville is Early Jurassic in age, but somewhat younger as Rossville dikes locally cut the York Haven sheets.

At this locality the Seminary Ridge dike is about 92 feet thick and dips 50° to the east (Figure 14-3; Stose and Bascom, 1929, p. 12). It strikes approximately north-south. The main joints in the dike are oriented N45°W/60°SW (Figure 14-4), N-S/35°W, and N-S/50°E. The Seminary Ridge is one of a swarm of related diabase dikes that can be traced 60 miles north-northeastward from here to near Berrysburg, Dauphin County, in the Valley and Ridge province (Berg, 1980; Hoskins, 1976). Other dikes in this swarm are exposed along the Pennsylvania Turnpike east of Carlisle in Cumberland County

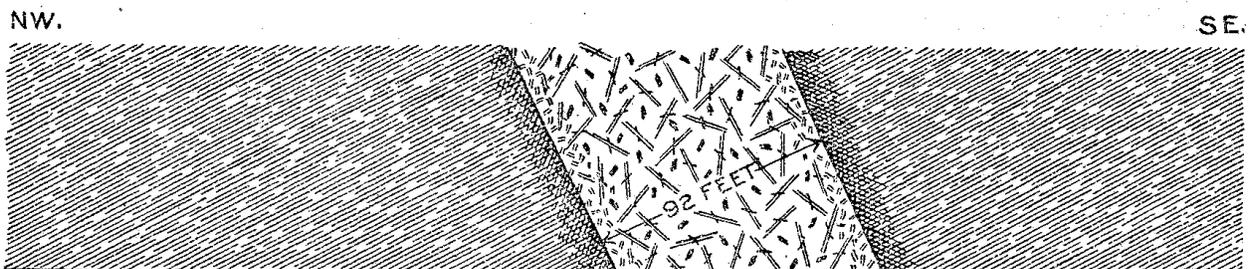


Figure 14-3. Geologic cross section of the Seminary Ridge diabase dike (Stose and Bascom, 1929, p. 12).

(cutting Cambro-Ordovician limestones), along US 11-15 south of Liverpool in Perry County (cutting the Mississippian-age Pocono Formation), and along US 22-322 south of Duncannon in Dauphin County..

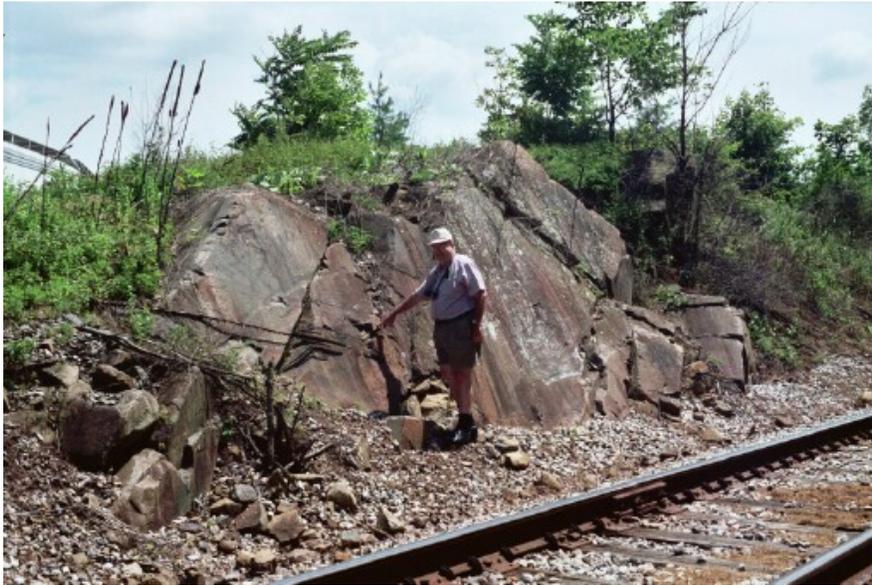


Figure 14-4. The Seminary Ridge dike (Rossville Diabase) exposed on the north side of the main line tracks in the cut at STOP 14. The prominent, striated joint strikes N45°W and dips 60°SW.

The fight at the eastern railroad cut, afternoon of July 1.

Seminary (Oak) Ridge was the final defensive line for the Union 1st Corps. Stewart's Battery B (see above) positioned itself at the northwest end of the railroad cut, attempting to protect the railroad line as an escape route for Union troops. At about 4:30 PM, as the fight northwest of Gettysburg climaxed, Confederate forces converged on the Seminary (Oak) Ridge cut and captured several hundred enemy infantrymen. According to one Rebel veteran of Ewell's Corps, "We had the Yankees like partridges in a nest"

(Frassanito, 1995, p. 70). One of

the 1st Corps units caught up in this Confederate sweep was the 16th Maine Infantry (1st Brigade, 2nd Division). Wrote a Northern eyewitness of the capture of the 16th Maine (Frassanito, 1995, p. 70):

The two Confederate battle lines, closing together, struck the regiment simultaneously.

Ewell's men appeared upon the north side of the cut and Hill's upon the south side so nearly at the same time that both line, with leveled muskets, claimed the prisoners....

The regimental commander of the 43rd North Carolina (Daniel's Brigade, Rodes' Division, Ewell's Corps) noted that 400 or 500 prisoners (more than 100 of whom were from the 16th Maine) surrendered in the cut and that several stands of colors were captured (Frassanito, 1995, p 70).

Once the fighting here and along Seminary Ridge to the south had ended, the Confederates held the entire 1st-Day's field until they retreated from Gettysburg on July 4/5.

The "Railroad Cut Fiasco of 1991." Although this outcrop is still a decent example of a dike and associated contact metamorphism of surrounding country rock, it was once a classic textbook example. Prior to 1991, almost the entire width of the dike and its contact with the shale was exposed on the northern side of the cut (Figure 14-5). The following discussion of the "Railroad Cut Fiasco of 1991" (as local battlefield preservationists refer to it) is modified from Jones and Bowling (2002).

In September 1990, Congressional legislation that expanded the Gettysburg National Military Park by nearly 2,000 acres included provisions for a controversial land trade between the National Park Service (NPS) and Gettysburg College. The exchange resulted in the college receiving 7.5 acres of adjacent parkland along the ridge and NPS obtaining development rights to 47 acres of college athletic fields that were on or near the battlefield. College officials sought the trade to allow relocation of railroad tracks that traversed the campus just east of the football stadium and the NPS wanted to ensure the 47 acres would not be further developed. Despite objections from historians and preservationists that the section of the ridge transferred to the college was the scene of significant action of the first day of the battle of Gettysburg, the NPS maintained that the trade would "not have adverse impact on known



Figure 14-5. View of the northern side of the Seminary Ridge railroad cut circa 1979. The diabase dike is the lighter-colored, jointed rock on the right side of the photo (from Shirk, 1980).

placement of a gabion wall to stabilize the slope. The wall now covers the dike and its contact with the shale (Figure 14-6).

A 1991 lawsuit brought against the college and NPS by the Gettysburg Battlefield Preservation Association and a 1994 Congressional investigation were not successful in mitigating the damage or restoring the ridge but did point out shortcomings in the case and underscored the importance of full public review in dealing with public lands (Fitts, 1994; Sipkoff, 1994). But both historians and geologists have lost something in this case. Since any historical significance of the railroad cut was seemingly ignored during the process, it doesn't seem likely that the geological significance would have been much of a factor either.

historic resources.” It was never revealed at public hearings or to the Pennsylvania Historical and Museum Commission, which also had oversight in the matter, that any excavation would occur.

In a surprise move in January 1991, Gettysburg College began excavating over three acres of the railroad cut (about half the land it received) in order to move the railroad tracks as far as possible from campus and to add a new rail spur. The excavation significantly altered the appearance of this part of the ridge and essentially destroyed the once classic outcrop. Subsequent erosion of the cut, particularly in the area of the diabase, led to the



Figure 14-6. View of the northern side of the Seminary Ridge railroad cut, July 2008. Prior to 1991, the rock exposure was continuous along the CSX rail line in the foreground. In 1991, the hill was “shaved back” to allow relocation of a rail line. The gabion wall now conceals the diabase dike and its contact with country rock thus spoiling a once-classic and well-exposed example of contact metamorphism.

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STOP 15- Virginia/Lee Memorial, Pickett's Charge, and the Battle of Solferino

Leader: Roger J. Cuffey

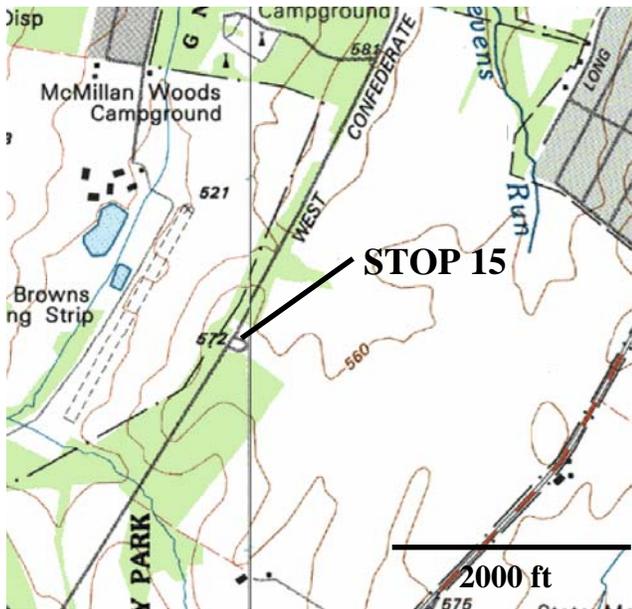


Figure 15-1- Location map for STOP 15. Modified from the Gettysburg and Firfield 7½' quadrangles.

containing a bit less titanium than the York Haven diabase. The lowland stretching eastward from the Virginia Memorial is underlain by red shales of the lower part of the Gettysburg Formation, although the rocks are not exposed here. The somewhat higher skyline a mile away (Fig. 15-3) is the western edge of Cemetery Ridge, the Union defensive line, underlain by the west-dipping Gettysburg sill composed of York Haven diabase, more coarsely crystalline, mottled white-and-black, and slightly higher in titanium content. The redbeds here are about 212-213 Ma (mid-Late Triassic) in age. The diabases are somewhat younger (beginning of the Jurassic, 201.2 Ma for the York Haven/Gettysburg, 201.0 Ma for the Rossville/Seminary Ridge). The diabases can be seen as boulder fences and bedrock outcrops along the ridges, although their characteristics are obscured by overgrowing lichens. The foregoing brief summary is based on the many references in Cuffey et al (2006) and Inners et al (2006).

The most surprising aspect visible from this memorial is how low and subdued the topographic ridges seem. Seminary Ridge here rises only 30

Cuffey, Roger J. (2008) Stop 15- Virginia/Lee Memorial, Pickett's Charge, and the Battle of Solferino, in Fleeger, G.M. (ed), *Geology of the Gettysburg Mesozoic Basin and Military Geology of the Gettysburg Campaign, 73rd Annual Field Conference of Pennsylvania Geologists*, Gettysburg, PA, p. 164 – 167.

Located mid-way along the low narrow elongate hill known as Seminary Ridge, the Virginia or Lee memorial marks the spot where Confederate General Robert E. Lee watched the climax action unfold on the third afternoon of the Battle of Gettysburg (Figure 15-1).

The Virginia Memorial is dominated by the bronze equestrian statue of Lee (Fig. 15-2). Erected in 1917, it was the first of the southern state monuments to be placed on the battlefield, and until very recently, Lee was the only Confederate officer so honored. The several figures down on the front of the memorial represent the diverse civilian occupations of the members of Lee's Army of Northern Virginia (Hawthorne, 1988).

Seminary Ridge is underlain by the narrow Rossville diabase dike, finer-grained, dark gray, and

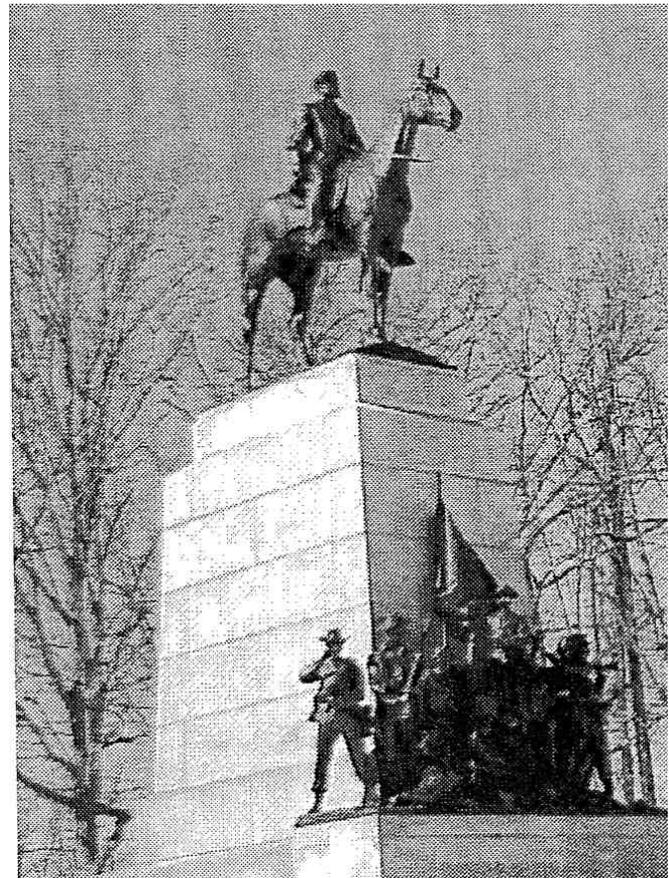


Fig. 15-2. Equestrian statue of Lee astride his horse

Traveller.

feet above the shale lowland, and Cemetery Ridge comes back up a mere 60 feet. Such elevations, however, were nonetheless militarily significant for foot soldiers carrying heavy equipment, clad in wool, in the almost hundred-degree heat of that July afternoon. Modern mobile forces employing helicopters and tanks might not even notice such low-lying topographic features.

The third day's operations began here with a heavy cannonade, followed by a massive infantry assault (Pickett's Charge) across the lowland (Gettysburg shale) from Seminary to Cemetery Ridges (Rossville dike and Gettysburg sill, respectively). Major General George Pickett's 3rd Division of Lieutenant General James Longstreet's 1st Corps, accompanied by miscellaneous units, a total force of 12-15 thousand men, made the charge, but its target – the Union line, supported by much artillery – held. Thus, the attack failed, and fewer than half the assaulting troops returned unscathed back to Seminary Ridge. Pickett's Charge (sometimes termed "Longstreet's Assault") has been much written about (Clark et al, 1985; Georg & Busey, 1987; Stewart, 1983; Turner, 1993).



Fig. 15-3. View eastward from the Virginia/Lee Memorial (Stop 15); the distant skyline is the crest of Cemetery Ridge; the single tall tree in the center marks the Angle (Stop 16); the clump of trees to the right/south is the Copse of Trees, the designated target for Pickett's Charge when it began.

Four years before Gettysburg, the village of Solferino in what is now north-central Italy (then "Lombardy"; Fig. 15-4) saw one of the biggest battles of mid-19th - century Europe, one which was decisive to the outcome of the war then between France and Austria (Uffindell, 1999). Robert E. Lee, the Confederate commander at Gettysburg, was a professional soldier 20 years into his military career, and thus would seem likely to have heard about this important battle. Moreover, striking similarities between that action and Pickett's Charge

– cannonade, assault, hoped-for final breakthrough – suggest that Lee may have had Solferino in mind when planning his third day's operations at Gettysburg. However, Lee's final outcome was unfortunately different, because the Union artillery had many more cannons than the Austrian defenders against Napoleon III had had (Fig. 15-5).

Other possible explanations for why Lee planned Pickett's Charge involve overconfidence in the Confederate soldiers' fighting abilities, failure to realize how much more deadly the artillery had recently become, or mild intestinal illness of the commanding general.

On the north side of Lee's statue are several cannons, obviously Confederate, positioned for the cannonade on the third day, but (at least in early 2008) mis-aimed somewhat north of the Copse of Trees, Lee's designated target for Pickett's Charge. The blue-green color of their weathered exteriors indicates their bronze composition. The tube insides/bores are smooth. These are known as "Napoleons" after one of the French emperors of that name.

Another aspect of Lee's plan for the third day played out on open fields underlain by Gettysburg redbeds 3 mi east of town. Lee sent Major General "Jeb" Stuart's cavalry around behind the Union position so that they could strike the Union line from the east at the same time Pickett would attack from the west. Stuart was intercepted, however, and stopped by Union cavalry partly commanded by Brigadier General George Armstrong Custer, whose resulting fame fueled presidential ambitions cut short years later by the Battle of the Little Bighorn in Montana.

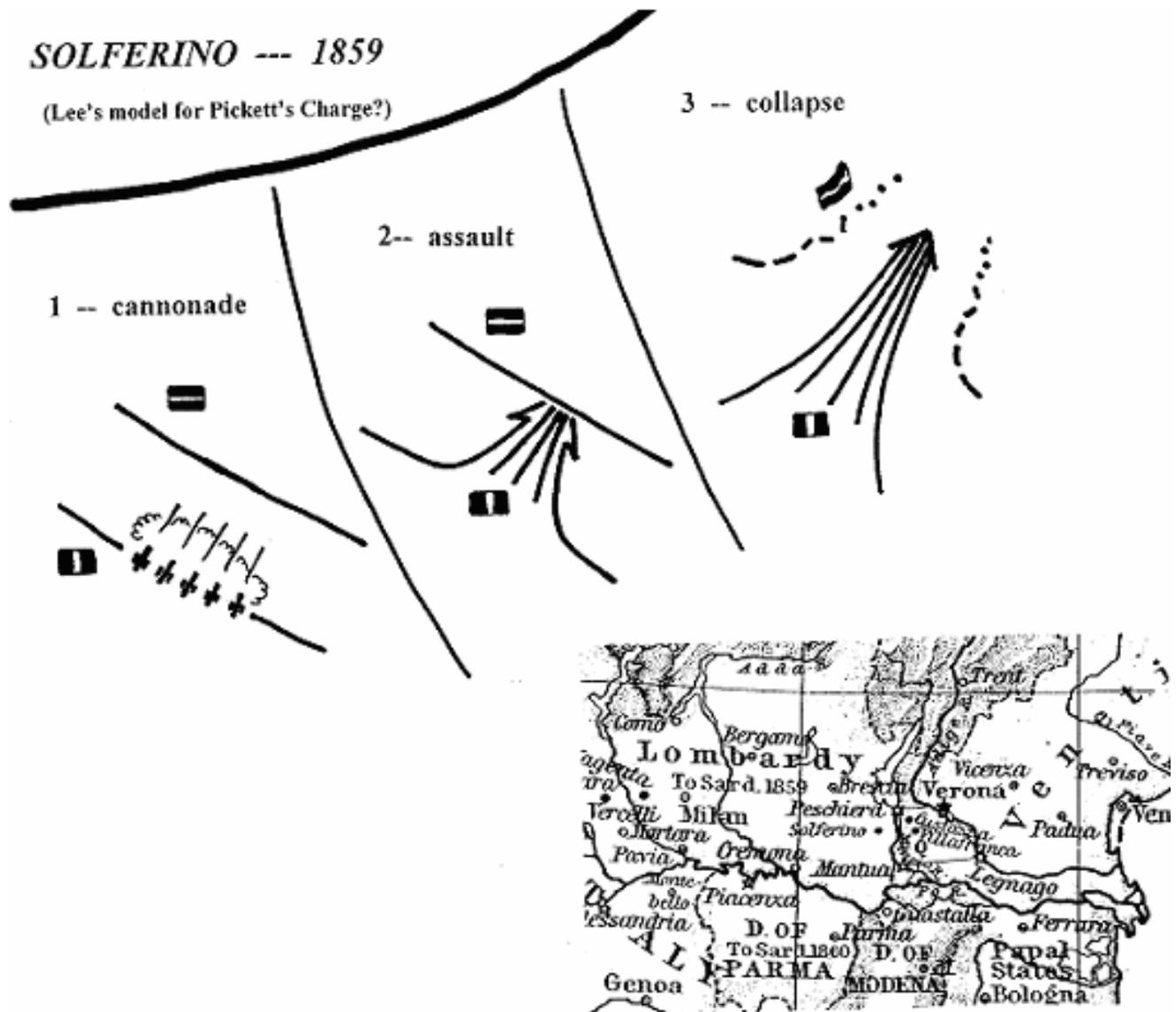


Figure 15-4. Diagrammatic summary of the critical phases in the Battle of Solferino. Location (inset, from Shepherd, 1929, p.158).



Fig. 15-5. "Emperor Napoleon III at Solferino", painted by Meissonier, who witnessed the battle and later extensively researched it (Salamida, 2005, p. 56). Napoleon III sits on his horse as Lee did on Seminary Ridge, French guns (right foreground) are positioned like the Confederate artillery, the shallow valley in front resembles that crossed by Pickett's Charge, and the distant hill on the skyline (where the Austrians are dug in) compares with the Union position on Cemetery' Ridge.

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STOP 16. Crest of Cemetery Ridge: Day-3 action (Pickett’s Charge, the “Bloody Angle,” and the “High Water Mark”) and the York Haven Diabase.

Leaders: Jon D. Inners and Roger J. Cuffey.

I tell you there is no romance in making one of these charges.....When you rise to your feet..., I tell you the enthusiasm of ardent breasts in many cases ain’t there, and instead of burning to avenge the insults of our country, families and alters and firesides, the thought is most frequently, Oh, if I could just come out of this charge safely how thankful would I be!

John Dooley, 1st Virginia
(Quoted in Trudeau, 2002, p. 476)

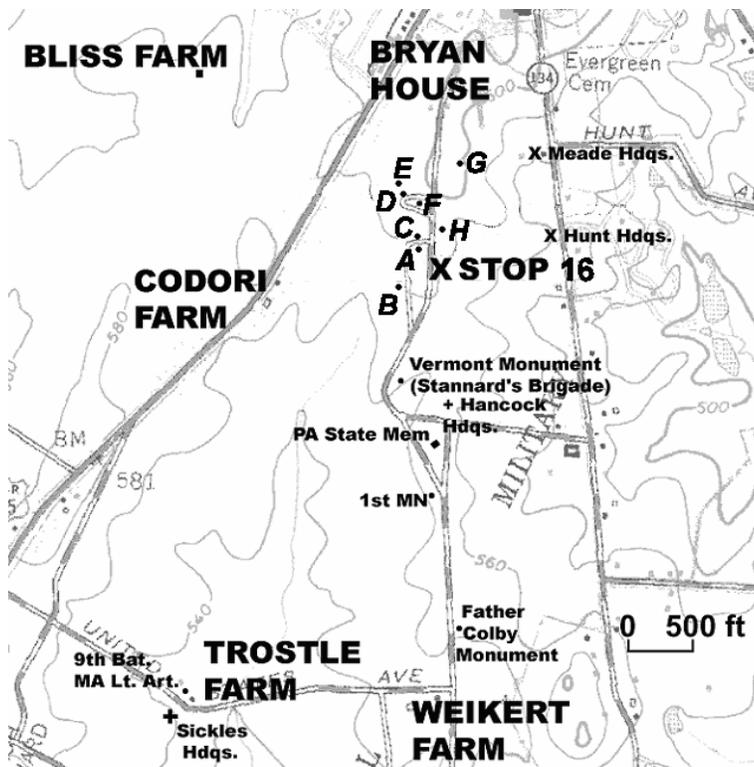


Figure 16-1. Location map for STOP 16, showing Site and other locations.

The climax of the battle of Gettysburg came on July 3 on Cemetery Ridge at STOP 16 (Figure 16-1). Not much changed from the action of July 1-2—the Confederates continued on the offensive, the Union on the defensive. Lee had engineered attacks on the Union left on the afternoon of the 2nd (STOPS 9, 10, and 11) and on the Union right in the late afternoon and evening of the same day (see Neubaum and Neubaum, 2004). Both had failed—though he did come close! He now determined to strike a monumental blow at the Union center on Cemetery Ridge. Lee drew encouragement for such a move from the success of Brig. Gen. Ambrose E. Wright’s Brigade of Georgians (Hill’s Corps) in briefly topping the Union stonewalls just south of the “copse of trees” in the late afternoon of the 2nd (Faust, 1986; Trudeau, 2002). He would model his attack on that of the Italians at the battle of Solferino four years earlier (see Stop 15).

Topography. Cemetery Ridge forms the shank of the Union “fishhook.” It is about 1.5 miles long, trending due south from Cemetery Hill to Little Round Top. Along the Union defensive line, the ridge reaches its maximum elevation of a little over 600 feet A.T. at the extreme north end and gradually drops off to about 530 feet, 0.25 mile south of the G. Weikert Farm in the valley of the east branch of Plum Run (Figure 16-2; see Day-2 Roadlog, mile 22.05). This dropping off in elevation at the south end was the excuse used by “Dan” Sickles to move his 3rd Corps divisions to higher ground (570-580 feet) at the Peach Orchard and along the Emmitsburg Pike. He was also undoubtedly influenced by the fact that he set up his headquarters in a “hole” at the Trostle Farm on the west branch of Plum Run—also at an elevation of about 530 feet (see Day-2 Roadlog, mile 21.5; Sauer, 2003).

Inners, Jon D and Roger J. Cuffey (2008) STOP 16. Crest of Cemetery Ridge: Day-3 action (Pickett’s Charge, the “Bloody Angle,” and the “High Water Mark”) and the York Haven Diabase., in Fleeger, G.M (ed), Geology of the Gettysburg Mesozoic Basin and Military Geology of the Gettysburg Campaign, 73rd Annual Field Conference of Pennsylvania Geologists, Gettysburg, PA, p. 168 – 177.



Figure 16-2. Low spot near south end of Cemetery Ridge, just west of Sedgwick Avenue (elevation about 530 feet).

Geology. The north-south trend of Cemetery Ridge as defined by the Union line (see above) crosses the south-southwest strike of the Gettysburg sill (York Haven Diabase) at a slight angle. Because of the divergence in these two trends, the high north end of Cemetery Ridge (Ziegler’s Grove, the “Angle,” and the “copse of trees”) lies near the upper contact of the west-northwest-dipping sill with the overlying Gettysburg Formation—and is, therefore, underlain by fine-grained, more resistant diabase. Off to the south—at the G. Weikert Farm and beyond—the ridge is underlain by coarser-grained,

less-resistant diabase of the interior of the sill. South of this low swale, the ridge rises again to the low knobs at the extreme south end, on one of which the Sedgwick Equestrian Statue stands (see Day-2 Roadlog, mile 11.2). These knobs are near the *lower* contact of the sill and are underlain by finer-grained diabase. Similarly this divergence in trend also accounts for the higher ground just east of the Union line, which is nearer the lower contact. Note also that the line of Little Round Top and Round Top trends south-southwest near the southeast edge of the sill and may be partly underlain by finer-grained diabase. (Another possible explanation of the height of the Round Tops is that they represent topographic remnants of ridges once capped by finer-grained diabase at the top of the sill.)

Outcropping diabase is relatively rare along Cemetery Ridge, although there are a few low ledges and pavements at the “High Water Mark” (see *Site C*). Rounded boulders are profuse, however,, many of which have been gathered into the stonewalls that line the Union position and which provided protection to the troops.

The cannonade and “Pickett’s Charge.” Preparations on both sides took the entire morning of July 3. (Nobody in the Civil War could get going before noon because of the complex logistics). By 1:00 PM, the main battlefield was ready. Each side had lined up 100 to 150 cannon along each of the two ridges, the Confederates on Seminary Ridge (Rossville Diabase), the Union on Cemetery Ridge (York Haven Diabase) (Figure 16-3). The Confederates opened fire and bombarded the Union line for about an hour; the Union artillery fired back; the noise was horrendous, and reportedly was heard 100 miles to the west in Johnstown, and 200 miles west in Pittsburgh. The Union artillery commander, Brig. Gen. Henry J. Hunt (1819-1889) remembering Meade’s supposition about a center attack, told his people to save about half their ammunition for an impending infantry assault. Longstreet’s artillery chief, Col. Edward Porter Alexander (1835-1910), noticing that Union fire was slackening, assumed that the Confederate cannonade had savaged the Union guns and their crews. He told Longstreet and Pickett that they should charge now. Alexander apparently hadn’t thought of the possibility that the Union might have been hoarding their ammunition supplies.

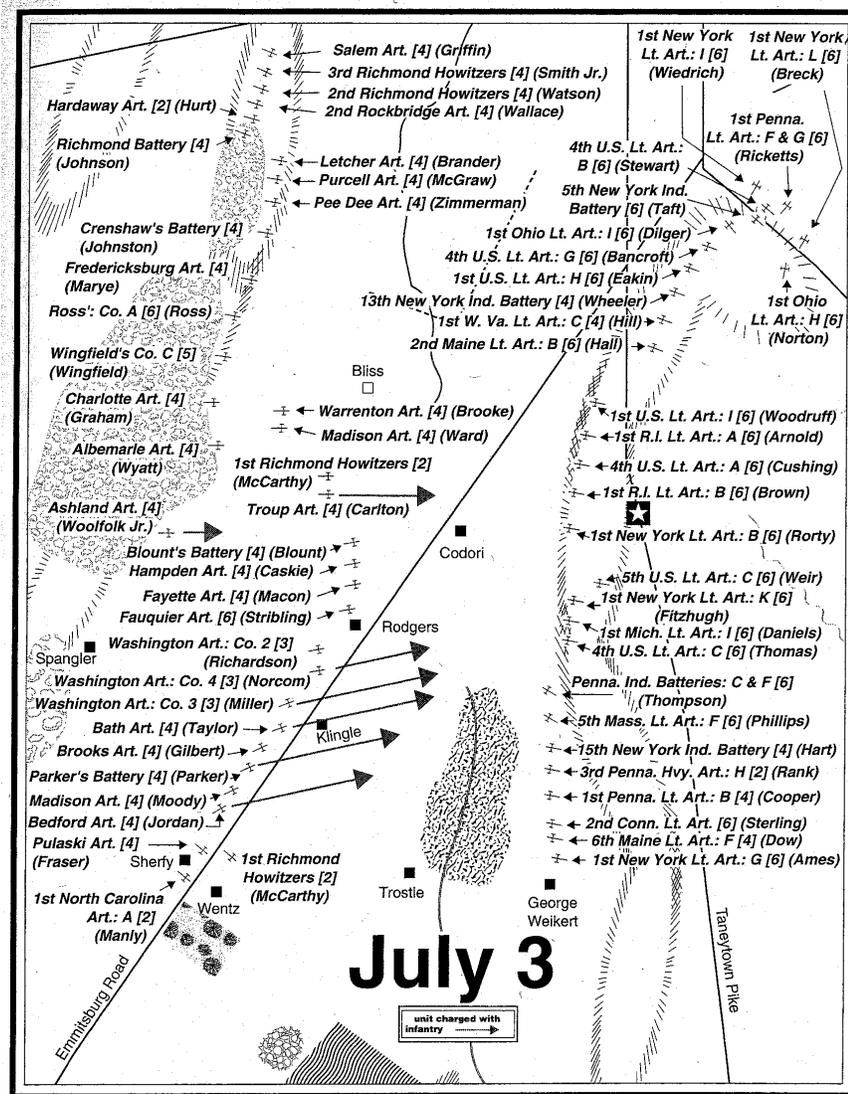


Figure 16-3. Confederate and Union artillery alignments for the “great cannonade.” Arrows indicate Confederate battery advancements during “Pickett’s Charge” (Trudeau, 2002, p. 445).

III's French army had attacked the Austrians at Solferino, with an opening cannonade followed by a massive frontal attack. The assault broke through the Austrian line, effectively ending that war in France's favor—on the spot (Uffindell, 1999). The fatal difference, however, was that the Union had much more artillery than the Austrians had had, and Lee couldn't see that from his vantage point across on Seminary Ridge.

Pickett's ranks stepped off in almost parade-like fashion. The Union troops were hushed; they said later it was an awesome spectacle, to see these 15,000 men coming toward them. About halfway across the lowland runs a road (Emmitsburg Road), northeast-southwest into town. When the marching troops reached that road, they had to break up ranks and climb over wooden rail fences on both sides of the road. Seeing the resulting disorganization and slow-down, as well as realizing the Confederates were now in cannon range (not yet in musket range—this battle is about to be decided largely by the artillery), the Union cannon opened fire (again), and tore huge swaths of destruction thru the Confederate ranks. The Union cannoneers loaded their guns with shotgun-pellet-like "canister," especially destructive against troops in the open. As shown in Figure 16-3, Confederate cannon on the

Between 2:00 and 3:00 PM, the Confederate infantry formed wide-line ranks, 3-4-5 lines and marched out from Seminary Ridge's woods onto the open grassy lowland. Three divisions were involved (Figure 16-4). The lead on the Confederate right end was Pickett's Virginia Division, and Pickett was in overall command (hence the attack is known as "Pickett's Charge"). The lead on the left was a division from North Carolina, and the rear lines were another North Carolina division; the two North Carolina divisions were under Brig. Gen. J. Johnston (1828-1863) and Maj. Gen. Isaac R. Trimble (1802-1888). Longstreet saw that there was essentially no cover for his troops as they would go across the grassy lowland toward Cemetery Ridge. He tried to persuade Lee to call it all off.

Lee persisted. Why? Some suggest he thought his Confederate infantry was invincible; more likely, he knew about and was imitating a similar frontal assault over in Europe four years earlier that had succeeded. In 1859 Napoleon

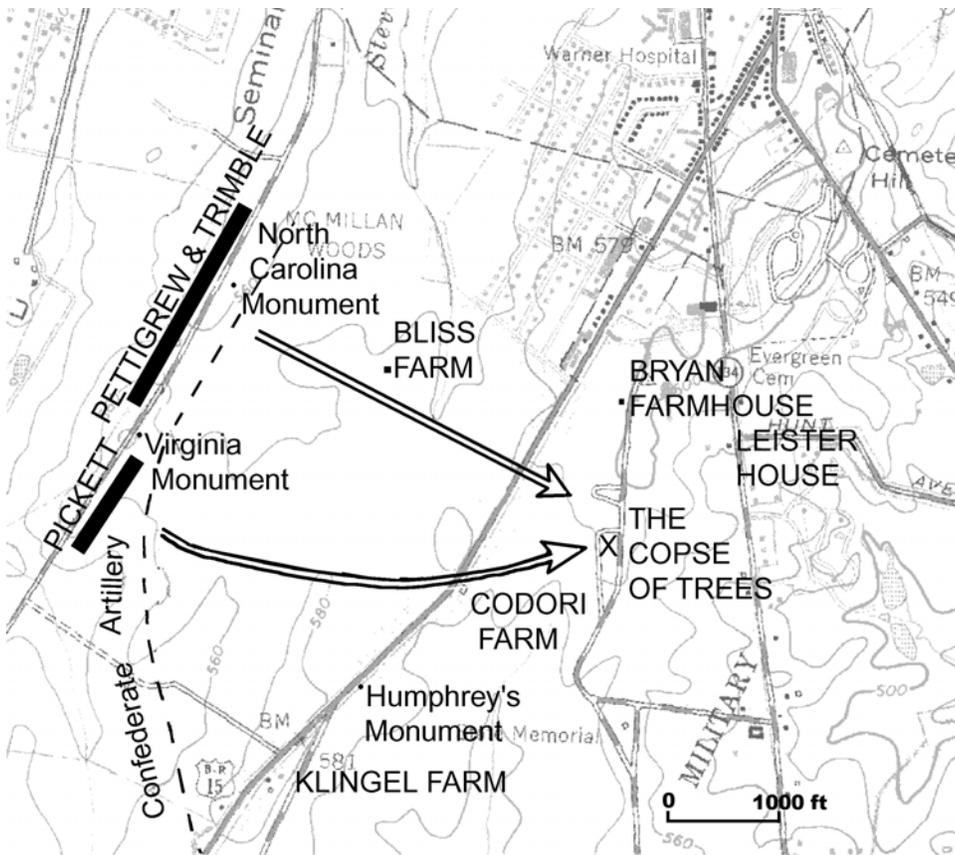


Figure 16.4 "Pickett's Charge."

right followed the advancing troops, firing over their heads toward the Union line. But the enemy return fire was too concentrated, and little advantage resulted to the Confederates.

Pickett's troops tried to keep their ranks close together, angling their line of march (Figure 16-4) as they came through the withering bombardment, narrowing the front line of the charge as they came up the slope to the crest of Cemetery Ridge, narrower and narrower the more Confederates fell dead. After 15-20 minutes of all this, a group of about 100 Confederates jumped over the stone wall (led by General Armistead) at what's called "The Angle"

from the bend there in the stone wall's course) but were immediately surrounded by about 10,000 Union soldiers and killed or captured in a couple of minutes. This was the "high-water mark" of the Confederacy, but had no military consequence because of the small number of men who "made it over the wall" (Figure 16-5). The Union soldiers at the point of crossing the wall waved their flags violently. The remaining Confederates saw this signal, stopped where they were, coming across the lowland, and they all turned around and headed back west to Seminary Ridge, in individual fashion, rather than as organized ranks. As the Confederates retreated away, the Union soldiers just stood along the top of the wall and yelled after them, "Fredericksburg! Fredericksburg!"

The next day, July 4, turned rainy, with heavy downpours. Such rainfall had occurred immediately after several other Civil War battles. Apparently all the smoke and dust particles acted like "cloud seeding," furnished meteorological nuclei far more than would regularly have been the case.

That evening, Lee set his army on the road south. It was the morning of the following day before Meade realized that the enemy was in full scale retreat.

Meade did not pursue vigorously, probably a wise decision. The victory was so narrow and costly that, even though Lee's army was wounded, it could well turn, fight, and defeat the equally wounded Union army. They're leaving - let 'em go!! At least they won't now be able to threaten Washington. Lincoln's displeasure at Meade not pursuing reflects Lincoln's lack of understanding of the realities of these difficult battles, rather than any cowardice or loss of nerve on Meade's part. Also, again, remember that Meade had not yet had time to get ANY maneuvering experience running his own command around effectively, whereas Lee had two full years of experience in handling the Army of Northern Virginia..



Figure 16-5. Detail of “July 1863—Gettysburg” (1870) by Peter Frederick Rothermel (1812-1895). (Pennsylvania State Museum.)

Why didn't President Jefferson Davis sack Lee after this battle? Probably because Lee was still the best they had, and sometimes a loss teaches a receptive commander enough that he becomes a better leader thereafter.

Walking Tour of the “High Water Mark” and the “Angle”

A. The “High Water Mark” Memorial.

The impressive monument here is located at the “copse of trees” which Gen.

Robert E. Lee, from his observation point on Seminary Ridge, designated as the focal point for “Pickett’s Charge” (Figure 16-6). It consists of an open book propped up by two pyramids of cannonballs. On the pages of the book are the names of Confederate units that participated in the assault (left side) and the Union units that aided in the repulse (right side). The monument was designed by Col. John B. Batchelder (see STOP 10), Superintendent of Tablets and Legends of the Gettysburg Battlefield Memorial Association (GBMA). Its dedication in 1892 marked the culmination of GBMA battlefield preservation: that same year all holdings of the organization were turned over to the national-government-operated Gettysburg National Military Park. The base of the monument is Quincy (Massachusetts) granite and the subbase is Fox Island (Maine) granite (Hawthorne, 1988).

The monument commemorates the “High Water Mark” of the Confederacy. Even though nearly two more years of some of the most intense fighting of the war was still to come, the flood tide of rebellion here reached its high point. From now on, the



Figure 16-6. The “copse of trees” and the “High Water Mark” Memorial (bronze book in trees) at *Site A*.



Figure 16-7. The top stone of the 20th Massachusetts Monument at *Site B* is an 18-ton boulder of Roxbury Conglomerate (Boston Bay Group, Late Proterozoic) that had originally been a prominent landmark in a playground in Roxbury, around which many of the soldiers of the 20th had once cavorted as children. The base is Westerly (Rhode Island, Permian) granite. The monument was dedicated in June of 1886 (Hawthorne, 1988).

Confederates would be almost entirely on the defensive. Had they carried the “copse of trees” and the “Angle,” the war would have taken an entirely different turn!

B. Monument to the 20th Massachusetts Infantry. This is one of the most interesting monuments on the battlefield from a geologic standpoint (Figure 16-7). Though the 20th Massachusetts (3rd Brigade, 2nd Division, 2nd Corps) included men from all of Massachusetts, it was recruited in Roxbury and contained many men and officers from that community just outside Boston. Its commander earlier in the battle was Col. Paul Joseph Revere (1832-1863), grandson of the Revolutionary War hero of that surname, who was mortally wounded by shellfire late on the afternoon of July 2. During “Pickett’s Charge,” the regiment was moved right to take up position in front of the “copse of trees.” It suffered severe casualties in action on Cemetery Ridge here, with 41 men killed or mortally wounded (Hawthorne, 1988; Higginson, 1866, p. 220-237).

(See Inners et al., 2008, for the story of the 20th Massachusetts at the battle of Balls Bluff, October 21, 1861).



Figure 16-8. York Haven Diabase ledges north of the “copse of trees” at *Site C*. The “original” monument of the 72nd Pennsylvania Infantry (see *Site D*) is on the left.

C. Diabase outcrops. Low ledges and pavements of York Haven diabase occur west and north of the “copse of trees” (Figure 16-8). Attitude of joint sets in the northern outcrop are E-W/86°S and N40°W/90°, the former being common (spaced 0.5 to 2.0 feet apart) (Figure 16-9), the later relatively rare. “Pockets” of strong magnetism (concentrations of magnetite) exist at several places in both outcrops, but has been picked up most consistently along an E-W joint in the northern outcrop (Figure 16-10), where a reading of N55°W as obtained when the compass was laid directly against the rock!



Figure 16-9. “East-west” joint in the York Haven Diabase at *Site C*. The scale is 6-inches long.

regiment (2nd Brigade, 2nd Division, 2nd Corps) moved forward from its assigned position about 60 yards farther back when the rebels broke over the stonewall here. Their established line was near present Hancock Avenue (see Figure 16-8). According to the GBMA, the monument should be there—and only there. But regimental survivors insisted that their monument be place at this spot near the wall. After much controversy and litigation, a monument (the second to the regiment) was finally erected here and dedicated on July 4, 1891. The decision caused considerable bitterness among other Union regiments which had moved forward to help repulse “Pickett’s Charge” (Hawthorne, 1988, p. 119).

E. The “Bloody Angle” and the monument to the 71st Pennsylvania Infantry. As described above, the right-angle in the stonewall that marked the frontline position of the Union Army, witnessed the climax of the 3rd-day’s battle. Defending this spot was the 71st Pennsylvania Volunteers of the Philadelphia (old California) Brigade under Col R. Penn Smith.

Between the northern outcrops and the “copse of trees”, note the orangish, granular and pebbly soil weathered from the diabase. The thin, stony nature of the soil on Cemetery Ridge (and indeed, along the entire “fishhook”) made “digging-in” very difficult for the Union soldiers and “likely contributed to both the effectiveness of Hunt’s artillery and the high battle casualties in general” (Smith and Keen, 2004 [see also this guidebook]; see, Brown, 1962).

D. Monument to the 72nd Pennsylvania Infantry. The striking bronze statue that tops this monument (Figure 16-11) emphasizes the fact that this



Figure 16-10. Gary Fleeger points to a magnetic “high” in the diabase at *Site C*. Note the well-developed “east-west” joints.



Figure 16-11. 72nd Pennsylvania Infantry Monument at the stonewall just south of the “Bloody Angle” at *Site D*. This regiment was part of the Philadelphia (originally, California) Brigade (see *Site E*.)



Figure 16-12. Monument to the 71st Pennsylvania Infantry at the “Bloody Angle” at *Site E*. It is constructed of rough-surfaced blocks of Westerly (Rhode Island) granite from the quarries of the Smith Granite Co. (Hawthorne, 1988).

The inscription on the monument (Figure 16-12) reads:

This regiment was organized April 29, 1861, being first 3 year regiment to complete its organization. It was enlisted in Philadelphia by Sen. E. D. Bake [Oregon] and Isaac J. Wistar by special authority from the War Department to be credited to the State of California and was known as the “California” Regiment.” After the death of Col. E. D. Baker at Ball’s Bluff Oct. 21, 1861 [see Inners et al., 2008], it was claimed by its native state and became the 71st Pennsylvania.

The regiment was originally designated the 1st California. Nine of its original companies came from Philadelphia and one from New York. Four more California regiments were recruited, primarily in Pennsylvania. Others included the 2nd California (which became the 69th Pennsylvania), 3rd California (72nd Pennsylvania), and the 5th California (106th Pennsylvania). When the regimental names were changed, the combined regiments became the Philadelphia Brigade (Hawthorne, 1988, p. 120).

F. Position of Cushing’s Battery. Officially positioned here a few yards behind the stonewall at the “Angle” was Battery A, 4th US Artillery, 2nd Corps (Artillery Brigade) under Lt. Alonzo H. Cushing (Figure 16-13). Born January 19, 1841, in Wisconsin, but raised in New York, Cushing graduated from West Point in 1861. Though he had commanded Battery A in earlier engagements, Gettysburg was probably the young lieutenant’s “baptism” to intense fighting. In fact, Cushing’s battery appeared to be the focus of the Confederate artillery barrage prior to “Pickett’s Charge.” Battery A was nearly destroyed in the bombardment, being reduce to two working cannons and only a handful of gunners. Despite being painfully wounded by shrapnel, Cushing refused to retire his battery and leave the field. Instead, he obtained the permission of Gen. Webb (see *Site H*) to move his two guns up to the wall at the “Angle.” As the Confederates under Brig. Gen. Lewis Armistead approached the wall, Cushing and this few remaining gunners blasted them with double canister. At the height of the action, a bullet struck



Figure 16-13. Cannons and monument marking the position of Cushing's Battery A near the "Angle" on Cemetery Ridge at *Site F*.

mounted on his bay horse, Baldy, appeared on top of Cemetery Ridge as the Confederate charge was being repulsed. It was near this spot that "he accepted the jubilant shouts of his victorious army."

Meade, who was born in Cadiz, Spain, in 1815, led the Army of the Potomac from only a few days before the battle of Gettysburg until the end of the war. He died in Philadelphia on November 6, 1872, partly as a result of old war wounds suffered at the battle of White Oak Swamp on June 30, 1862 (Hawthorne, 1988, p. 125; Faust, 1986.)

H. Gen. Alexander S. Webb Portrait Statue.

Brig. Gen. Alexander Webb (1835-1911) commanded the 2nd Brigade of the 2nd Corps (Figure 16-16) —the Philadelphia Brigade, whose monuments "proliferate" on this section of Cemetery Ridge (see *Sites C, D, and E*). His brigade—to the command of which he was only newly appointed—suffered 491 killed, wounded, and missing out of a total fighting strength of 1,244. He was wounded in the fighting at the "Angle", his conduct earning him a Congressional Medal of Honor (Trudeau, 2002).

Cushing in the face, killing him instantly. Having died a hero's death, he was later buried at West Point (National Park Service, 2008; Wikipedia, 2008).

A small monument just in front (west) of Cushing's original position marks the spot where Brig. Gen. Lewis Armistead (1817-1863) fell mortally wounded, moments after shouting to his greatly depleted ranks, "Give them the cold steel!" He died in a Union field hospital on July 5 (Faust, 1986).

G. Gen. George Gordon Meade Equestrian Statue.

The statue (Figure 16-14) commemorates the anti-climax of "Pickett's Charge" when the Union commander,



Figure 16-14. Equestrian statue of Maj. Gen. George Gordon Meade on Cemetery Ridge at *Site G*. His horse, Baldy, served him in battle from just after First Bull Run in 1861 until the end of the war (Garrison, 2001).

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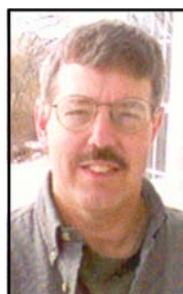


Figure 16-15. Brig. Gen. Alexander S. Webb, USA, Portrait Statue on Cemetery Ridge at *Site H*.

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