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Geology of the Gettysburg battlefield: How Mesozoic events and processes impacted American history

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PURPOSE

The Battle of Gettysburg in south-central Pennsylvania was the largest ever fought on American soil and one of the most significant in its consequences. Moreover, more clearly than most, it demonstrates the roles which underlying geology and surface topography can play in military actions. Early Mesozoic happenings produced the rocks underlying and shaping the Gettysburg landscape, which influenced the flow of the battle and thereby impacted the course of American history. Integration of the battlefield's geological and military aspects, however, has not yet been adequately presented in concise field-guide format, and so doing that is the intent of the present article.

Inspired by Brown's (1962) brief summary of the geology of the Gettysburg battlefield, the present co-authors recently wrote a lengthy guidebook and reissued it for a 2006 Geological Society of America Annual Meeting field trip (Inners et al., 2006). A shorter field guide was also needed for that trip that could be used by many other geologists afterwards; therefore, Cuffey condensed the long guidebook into the article here, assisted particularly by Inners and Fleeger, but drawing on all of the authors' contributions as well.

Keywords: Civil War, Gettysburg, Triassic, redbeds, diabase, dinosaur footprints.

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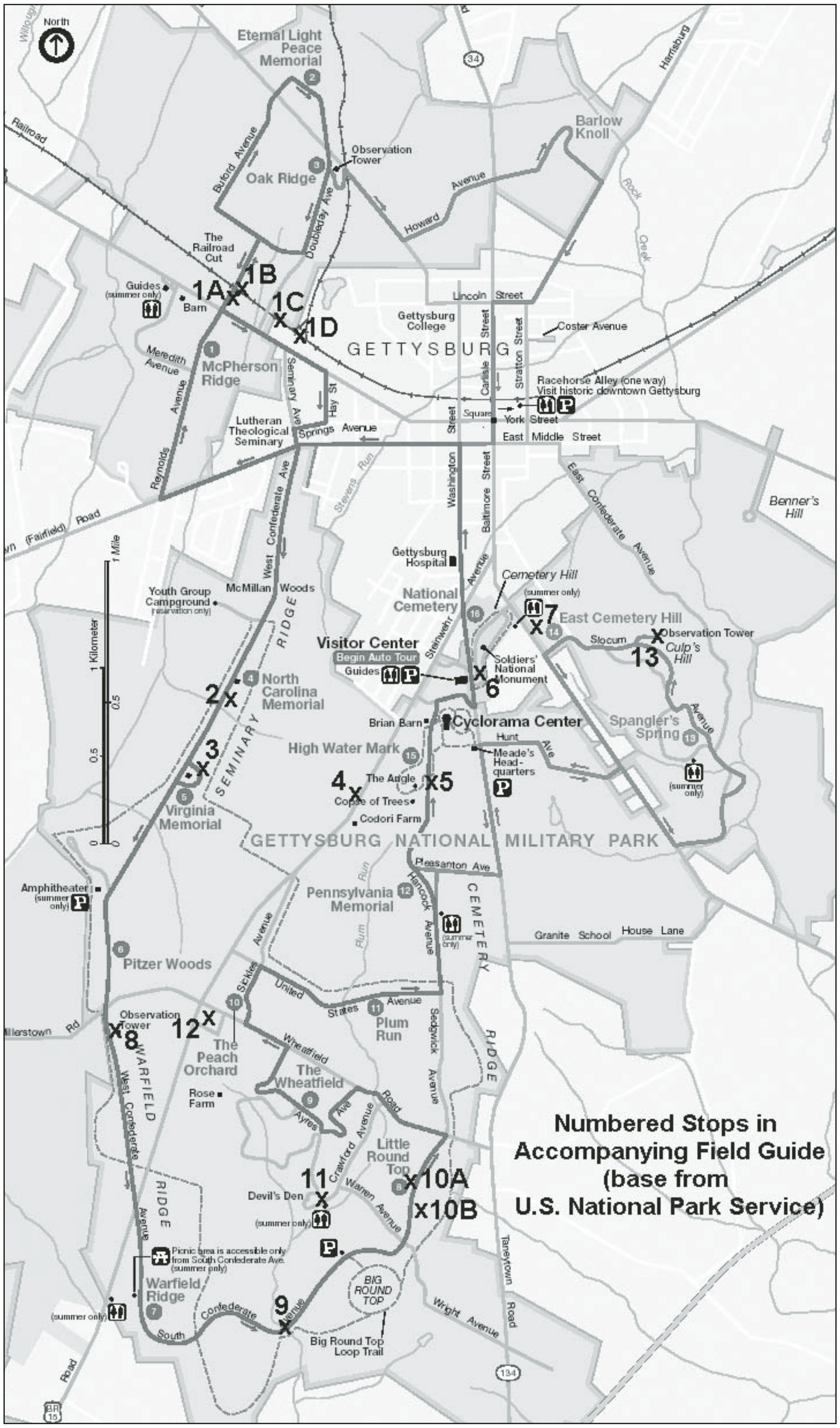

Figure 1. Gettysburg battlefield, showing stops (black Xs) to be visited on this field trip (which does not follow the National Park Service's marked "Auto Tour" circuit); modified from National Park Service folder map (2005).

FORMAT AND RESTRICTIONS

Localities to be visited on this field trip are distributed across the entire Gettysburg battlefield, as can be seen on the accompanying map (Fig. 1).

Although this field-guide article can be used by anyone visiting Gettysburg, its road logs are phrased especially for a solitary geologist driving around (right/left/front/back directions), perhaps with a companion following along using a detailed map (north/south/east/west directions). In contrast to traditional road logs, cumulative mileages herein are only between successive stops, not the entire trip (which is only 21 mi long), taking advantage of the ease of resetting a car's trip odometer. Such are calibrated only in miles in this country, and the battle more than a century ago was fought in miles and feet, hence our use of English units exclusively throughout this paper.

The National Park Service is continually improving traffic flow and pedestrian safety, and therefore may alter one-way roads or parking areas periodically; the visitor should be alert for such changes since this guide was written. Moreover, a program of "rehabilitation" has recently begun, to return the landscape appearance to that of the Civil War as much as possible; in places, this may in the future noticeably change the views from certain stops.

Durations for each stop are intended as suggestions so that the entire route can be traversed in one field day. If daylight is limited by the season, these can help ensure that none of the sites is omitted.

The order of stops herein facilitates seeing the most critical localities early in the day before tiring, or in case a full day is not available to the visitor. Immediately after leaving the area of the 1st day's fighting, everything visible involves the 3rd day's climax, not the 2nd day's action further south; thus, visiting the stops in the chronological sequence of the battle would require backtracking. (If, however, doing that is desired, each stop's day and time during the battle is indicated in the heading for the stop's description.)

Throughout this write-up, military events are stated in terms of the 1st, 2nd, or 3rd day of fighting. Experience leading previous field groups indicates this is more instantly informative than citing the actual dates (ironically numerically parallel).

All the localities to be visited are in the national park; hence, no geologist's hammers can be used in examining the rocks. Photography is permitted everywhere.

THE BATTLE

Much has been written about the Battle of Gettysburg (Fig. 2), far more than can be mentioned here, and a great deal is focused on smaller components of the action, but includes some information on its geologic aspects (Brown, 1962; Cuffey et al., 2004; Smith and Keen, 2004; Inners et al., 2006). Excellent overviews (Clark et al., 1985; Luvaas and Nelson, 1986) can be supplemented visually by the recent movie *Gettysburg* (Turner, 1993).

Following the 1862–early 1863 Civil War battles in eastern Virginia, the contending armies disengaged and slowly moved northward. Lee's Confederate Army of Northern Virginia (75,000 strong) stayed shielded behind (west of) the Blue Ridge–Catoctin–South Mountain barrier along the eastern edge of the Appalachians. The Union Army of the Potomac (numbering 90,000) under Hooker remained east of that barrier on the Piedmont, keeping between the Confederate army and the Federal capital at Washington, but not knowing exactly where Lee was. Lee crossed into Maryland (at Williamsport and Shepardstown) and came on into Pennsylvania, his far-out lead elements getting as far north as 4 mi southwest of Harrisburg and east beyond York

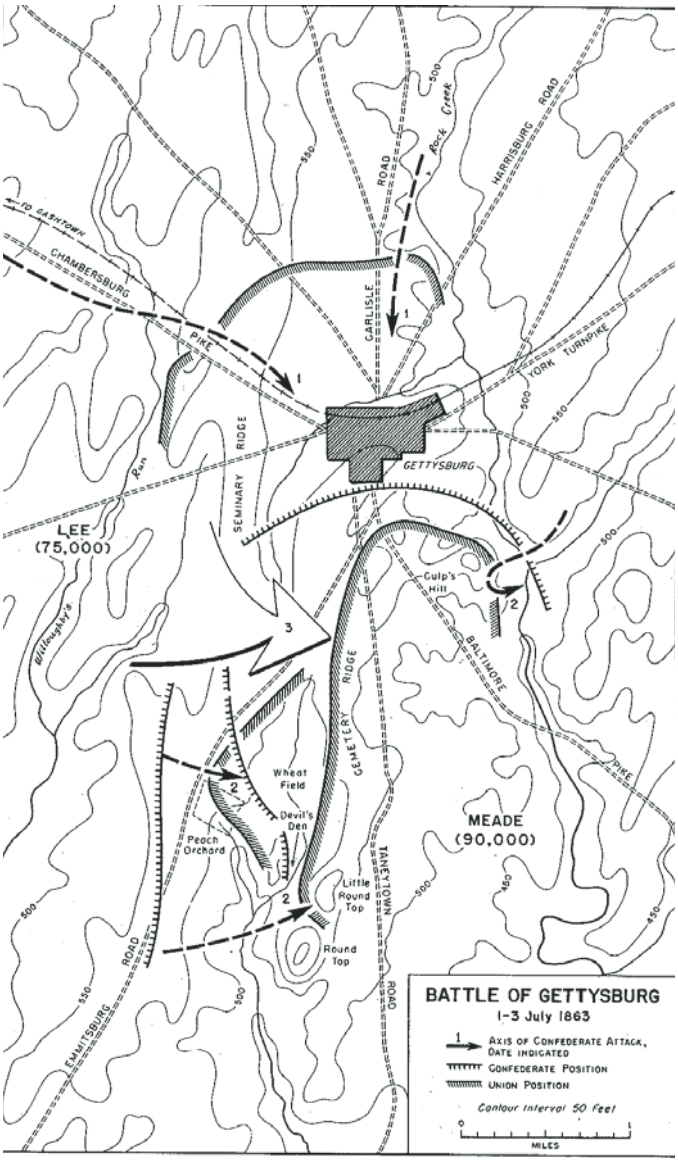

Figure 2. Military operations during the Battle of Gettysburg (Department of the Army, 1956, p. 249).

(to Wrightsville on the Susquehanna). His overall objective was to discourage the North's civilian population from continuing the war, a strategy used in modern recent wars as well. New York, Philadelphia, or Baltimore could have been his ultimate targets had he not been stopped at Gettysburg.

Three days before the Gettysburg battle began, Lincoln replaced Hooker with Meade as the Union commander, so that the latter entered the battle with little experience handling his entire army in field operations.

The day before the battle, various scouting contacts indicated that Confederate forces were a few miles west of town, while the Union army was nearby to the south. However, no significant clashes occurred yet. Both, though, were being drawn to this point, due in part to the many roads radiating out from it.

Early on the 1st day of the battle (1 July 1863), Heth's Confederates moving southeast toward Gettysburg (in search of supplies, particularly shoes) unexpectedly ran into Union troops under Buford and Reynolds coming north just west of town. In contrast to the day before, both sides began to fight vigorously for the low rolling ridges there (especially McPherson Ridge; Stop 1A), cut through by the then-unfinished railroad (Stops 1B–D). More and more units were added to each side all through this day.

By the late afternoon, the Confederates had prevailed, and the Union troops retreated back through town. The Confederate forces spread south along Seminary Ridge (Stops 1D, 2, 3, 8). The Union troops, as they came out the south side of town, started to prepare defensive positions on Cemetery Hill (Stop 7) and Ridge (north end; Stop 5). Thus, the evening of the 1st day saw establishment of both sides' basic positions for the rest of the battle.

The next two days (2–3 July) involved the Confederates on Seminary Ridge to the west, trying to dislodge the Union forces from Cemetery Ridge (Stop 5) and the hills at each end (Stops 10–13) to the east. In map view, this Union line looks like an upside-down fish-hook, and so it has been known ever since.

Initially (2nd day), Lee attacked both flanks of Meade's position. If coordinated, the combined momentum might have succeeded, but the southern attack, focused on Little Round Top (Stop 10) but including Devil's Den and the Peach Orchard (Stops 11–12), came in the afternoon, whereas the northern attack, targeting Culp's Hill (Stop 13), did not take place until evening and on through the ensuing night. Fighting was intense everywhere, and numerous opportunities for either side to break through decisively came but went, so that the two armies remained essentially in their same places by dawn of the 3rd day.

On the 3rd day, the two flank attacks having failed, Lee bombarded the Union line with a heavy cannonade and then launched a massive infantry assault (Pickett's Charge; Stops 3–5) across the wide grassy/cultivated lowland between the two ridges. Simultaneously, the Confederate cavalry went north around east of town, to attack from behind while Pickett struck the Union front, but Union cavalry stopped them. Meanwhile, as Pickett's troops neared Cemetery Ridge, the Union artillery opened fire and decimated their ranks, so that virtually none was left by the time they got up to the Union line. Hence, the frontal attack also failed to dislodge the Federals.

The day after the battle, which had been sunny all three days, saw heavy rain all day. Lee used the weather and nightfall to begin withdrawing and escaped southward (several days later re-crossing the Potomac at Williamsport) while Meade's battered troops remained in their fish-hook positions. Had Pickett's Charge broken through, the Confederates might have turned south, brushed aside Meade's broken remnants, and captured Lincoln and Washington, thereby ending the Civil War almost immediately.

Instead, a few months after the battle, Lincoln came to the new national cemetery south of Gettysburg to give his now-famous dedication address (Stop 6).

Finally, many years later, the National Park Service used blocks quarried from strata northeast of town to rebuild bridges on the battlefield. One now exhibits a few dinosaur footprints (Stop 9).

GEOLOGY AND TOPOGRAPHY

The geology of the Gettysburg battlefield (Figs. 3–6) was mapped in detail by Stose and Bascom (1929), graphically sum-

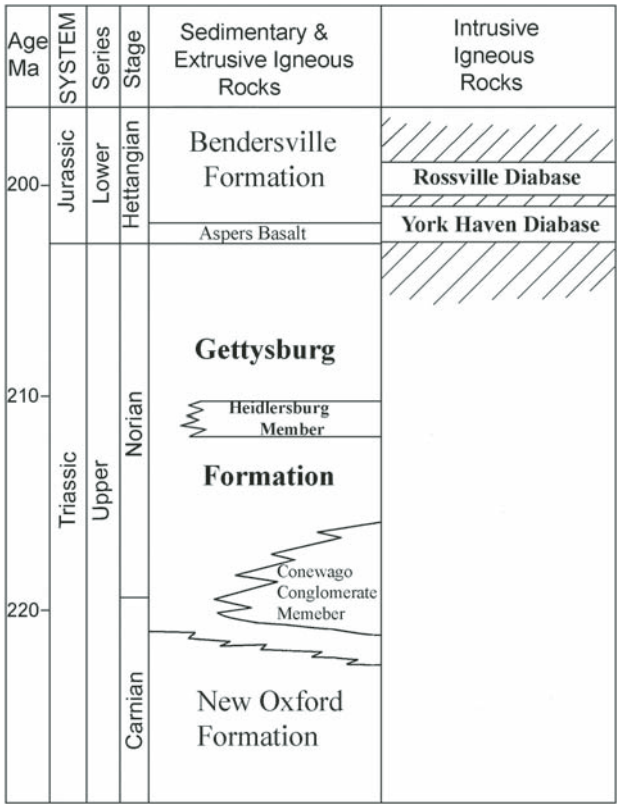

Figure 3. Stratigraphic column of rocks exposed on and near the Gettysburg battlefield (Inners et al., 2006, p. 5). Note that the topmost Triassic stage, the Rhaetian, is not indicated, due to uncertainties about its representation here.

marized by Smith and Keen (2004), and redrawn in a military-geology version (Inners et al., 2006).

Bedrock under the battlefield originated within a rift-basin (Gettysburg Basin) associated with the beginning of the present-day Atlantic Ocean. Before that formed, however, 20,000 feet of continental sediments filled the basin during Late Triassic time, immediately followed in the earliest Jurassic by rising magma intruding along bedding-planes (sills or sheets) and vertical cross-cuts (dikes). The Gettysburg Basin is in the middle of a long chain of similar structures extending discontinuously all the way to Nova Scotia, and in which in that direction sedimentation continued progressively later into the Early Jurassic. Much more recent erosion later sculpted these rocks into lowlands and ridges according to their differing hardness.

Sedimentary rocks underlying the battlefield's lowlands (the largest portion of the terrain) are mostly soft redbeds (Stop 1C) of the lower part of the Gettysburg Formation: red shale, claystone, mudstone, siltstone, and fine sandstone, with minor gray shale and mudstone (Inners et al., 2006; Smith and Keen, 2004; Smoot, 1999; Stose and Bascom, 1929). Depositional environment of the Gettysburg red shale and mudstone has been inferred to have been fluvial (stream) floodplain or overbank (Krynine, 1950; Olsen, 1986; Smoot, 1999), but recently has been reinterpreted as shallow lacustrine (extensive lake or playa) which at times completely dried up. This reevaluation was suggested by successful tracing and correlation of thin cycles over the entire Newark Basin, implying wide flat-bottomed depositional surfaces (Olsen et al., 1996, p. 73). Triassic climate in this region, overall tropical/equatorial, alternated between dry/arid (Turner-Peterson, 1980; Smoot, 1999, p. 195–200) and much wetter, humid, specifically monsoonal or seasonal wet-and-dry (Krynine, 1950, p. 125–182; Dunbar and Rodgers, 1957, p. 209–218; Olsen, 1986, p. 848). Recent studies have shifted emphasis to Early Mesozoic cyclicity (Olsen, 1986; Olsen et al., 1996; Olsen and Kent, 1999), astronomically/orbitally driven, but so far analyzed in detail only in the Newark Basin northeast from the Gettysburg area.

Along the edge of intrusive sills and dikes, the red mudstone is altered or "baked" to hornfels: gray to purplish, hard, aphanitic or cryptograined, massive rock (Stop 1D), intermediate in erosional resistance between the soft redbeds and the hard diabase.

The Gettysburg sedimentary rocks dip gently northwestward; thus, they become stratigraphically younger across the battlefield in that direction. Along the northwest edge of the battlefield, one passes upward into the more resistant, sandier beds of

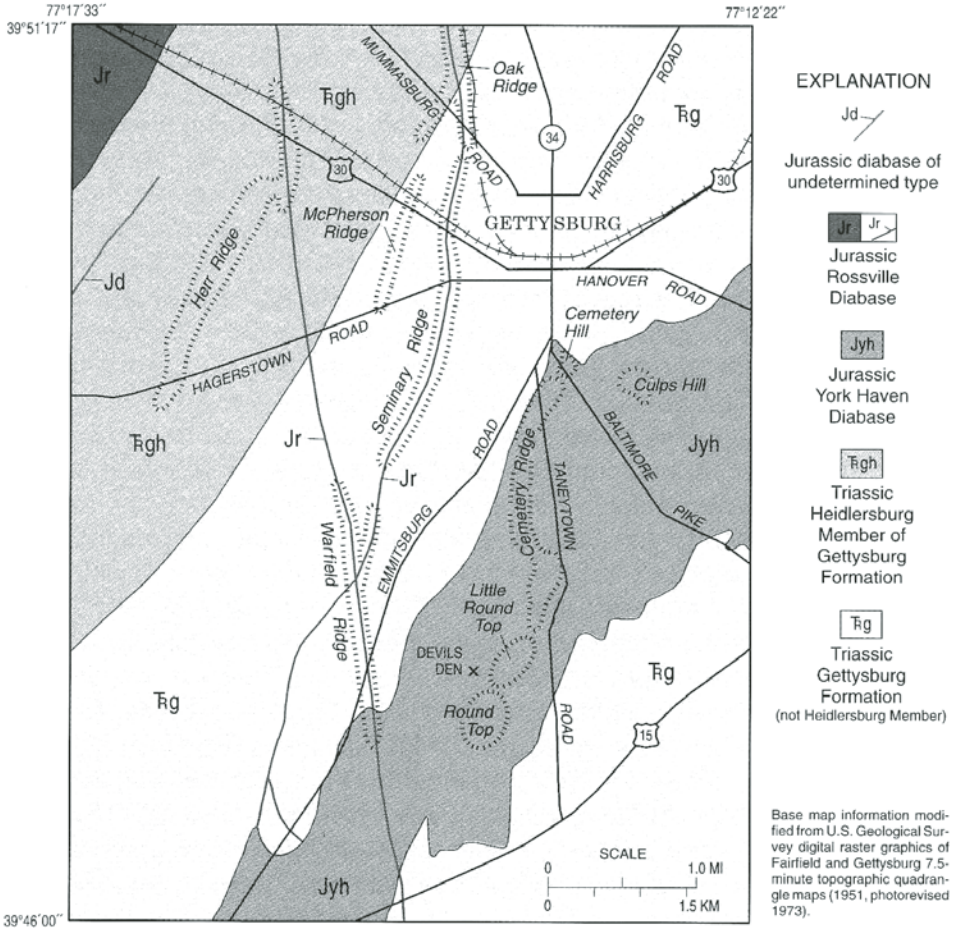

Figure 4. Geology and landforms on the battlefield (Smith and Keen, 2004, p. 7).

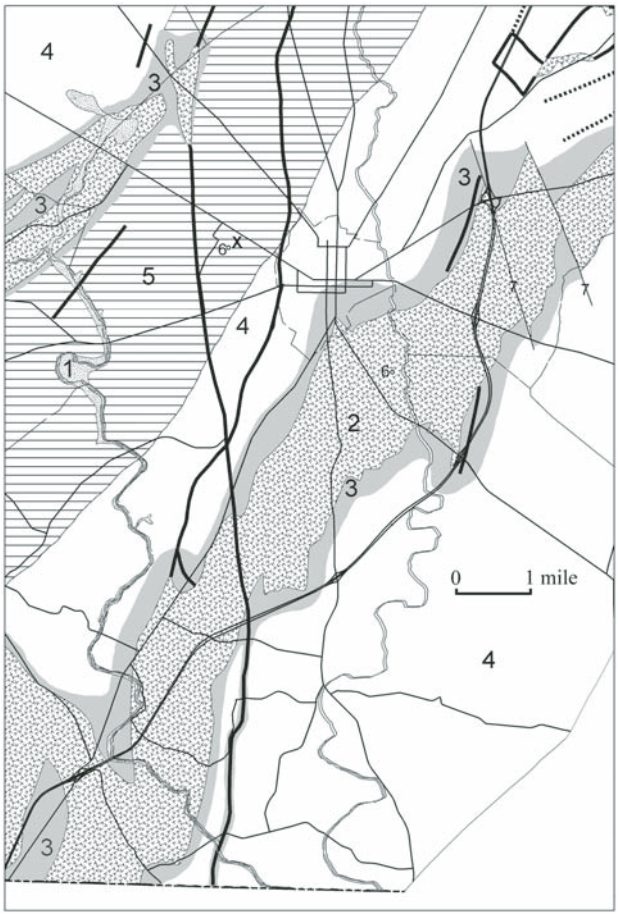

Figure 5. Military geology of the battlefield and surroundings (Inners et al., 2006, p. 10). 1—unconsolidated sediment; 2—diabase; 3—hornfels; 4—redbeds; 5—resistant beds; 6—springs; 7—faults; X—quarry.

the Heidlersburg Member in the middle of the Gettysburg Formation. These beds are closely interbedded red and gray shale and mudstone, gray argillite, black shale, red and gray siltstone, and tan-gray sandstone. These beds underlie the subdued ridges there which figured in the 1st day's fighting (Stops 1A, 1B, also 9). Climate during deposition fluctuated cyclically, with wetter periods producing the black shales (lacustrine) and tan-gray sandstones (fluvial) associated with these ridges.

The igneous sills and dikes under the battlefield are relatively resistant to erosion and so hold up the ridges and hills on the terrain. That higher ground is thus rock-strewn with no or shallow soil. As a result, digging in was generally not possible; troops had to crouch behind farmers' stone fences, and fortifications (breastworks) had to be constructed by piling up boulders and adding logs from the forests not cleared by earlier farmers. These rocks are all diabase, fine- to coarse-grained, dark gray to mottled white and black, composed of gray or white calcic plagioclase/labradorite and black pyroxene/augite; they are classified as continental tholeiites (subalkaline basalts; Frohelich and Gottfried, 1999; Smith et al., 1975; Smith and Keen, 2004). Their mineralogy on most exposed surfaces is obscured by two or more generations of overgrowing lichens, algal films, or low mosses.

Two, somewhat different magma types contributed to these diabases, distinguishable by subtle petrographic and geochemical contrasts. Approximately the same geologic age, right at the very beginning of the Jurassic (202 Ma; Olsen and Kent, 1999, p. 1781), they crystallized a mere 200,000 years apart (201.2 and 201.0 Ma; Smith and Keen, 2004, p. 9; Inners et al., 2006, p. 97–99).

More voluminous and slightly older is the York Haven diabase, found as the thick Gettysburg sill, underlying Cemetery Ridge, the Round Tops, and Culp's Hill (Stops 5, 10, 11, and 13). Finely granular to coarsely crystalline, this diabase contains a bit more titanium.

The Rossville diabase occurs as the thin dikes under Seminary (and Warfield) Ridges (Stops 1D, 2, 3, and 8). This diabase is fine-grained to aphanitic, dense, and slightly lower in titanium content.

An unusual aspect of battlefield geology is the occurrence of many monuments or memorials all around the battlefield. Except for the fossiliferous limestone of the 14th Indiana monument (Stop 7), and a gigantic block of Neoproterozoic Roxbury Conglomerate from Boston near the Copse of Trees, the memorials are granites in the broad sense: mineralogically varied, finely to coarsely crystalline, and obtained from New England to the southern Appalachians. Most have been in place and thus weathering for a century.

ROAD LOGS AND STOP DESCRIPTIONS

Square brackets [ ] enclose official road names which are not visible while driving (at least not in early 2006 when this article was field-checked). In places, road names change or alternative names are used; these are also indicated to help avoid confusion.

BEGIN FIELD TRIP at square in center of Gettysburg.

Reset trip odometer **to 0.0** mi; remember to do this **at each stop.** Thus, the cumulative mileages given below (second number, in **bold**) are only for the distances between successive stops, not the entire trip.

The square is 0.9 mi north of the national park Visitors' Center. House on southeast corner of the square is where Lincoln completed his Gettysburg Address well after the battle (Stop 6).

Traffic flows around this square one-way, such as in a Boston rotary or British roundabout, and can be **DANGEROUS!**

Drive due west on U.S. 30 (Chambersburg St.).

0.1	**0.1**	Church on left/south was used as a hospital during battle and immediately thereafter.
0.2	**0.3**	Bear right/northwest as U.S. 30 becomes Buford Ave.

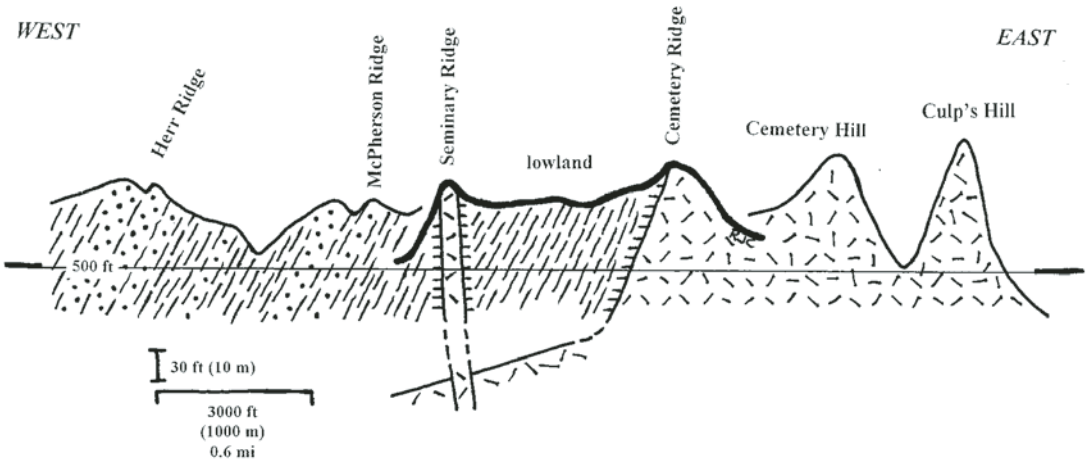

Figure 6. Geologic-topographic cross-section of the battlefield, highly generalized; vertical exaggeration approximately ×20; lithology symbols standard for diabase, hornfels, shale, sandstone; drawn across Herr and McPherson Ridges (left), Seminary Ridge–lowland–Cemetery Ridge (center), and Cemetery and Culp's Hills (right; center segment displaced south relative to the other two); vertical scale altered at depth to show relationship of dike to sill; newly drawn by Cuffey from maps cited in references in text, and from U.S. Geological Survey 7.5′ topographic quadrangles (Fairfield on left, Gettysburg on right); level datum is 500 ft above mean sea level.

0.6	**0.9**	Stone house on right/north was Lee's headquarters.
0.2	**1.1**	Turn right/north at stoplight onto unmarked road [Reynolds Ave., but sign is not visible approaching from the east]; immediately park on right/east side of road.

STOP 1: Remember: no geologist's hammers on any of the stops throughout this field trip!

STOP 1A: McPherson Ridge (morning and afternoon of 1st day); **1B: resistant beds underlying McPherson Ridge; 1C: red shale underlying lowland** (crossed by Pickett's Charge); **1D: narrow Rossville diabase dike (and hornfels) holding up Seminary Ridge.** (Same as Stops 1 and 2 of Inners et al., 2006, p. 15, 19–20, 39–54.) **1–2 hrs.**

This first stop will be the longest, in both time and distance walked (0.7 mi), on this field trip. It also includes much of the geologic diversity on the battlefield, but represents only the beginning of the battle militarily. If the visitor has unlimited time, this stop is one of the best Early Mesozoic exposures in south-central Pennsylvania (Gettysburg Basin) and would well repay careful scrutiny from here to a mile further west along the track. Eventually, deep coring of these rocks will be necessary to fully understand them.

If one is visiting the battlefield alone, the distance walked will be substantially greater to get back to the car. If accompanied by another driver not examining the geology, the vehicle can be taken around to Lee's headquarters (just passed on the drive here), and the walker can go one-way from the parking spot up near the bridge over the railroad cut to the parking lot on the west side of Lee's house.

First, look at the landscape to the west/left of where the car is parked to appreciate the 1st day's action (Stop 1A). Then, walk down eastward 0.1 mi to access the railroad track (now part of the CSX system; **be alert for approaching trains!).** Come back left/west 0.1 mi underneath the road bridge to examine the resistant beds (Stop 1B) under the low ridges in this area. Turn around and proceed east 0.2 mi to the redbeds (Stop 1C) along the track; these rocks underlie much of the battlefield's area but are not exposed elsewhere nearby. Note the hornfels slope in the cut just east of the redbeds, and continue southeast/right obliquely across both the switch and main tracks another 0.1 mi to the low diabase exposure (Stop 1D) along the latter. Finally, turn left/west again, and walk 0.1 mi to a badly deteriorated old road, upon which walk south/left 0.1 mi more to emerge into the parking lot immediately west of Lee's headquarters. Allow roughly ten minutes to walk each segment within this stop.

The view (Fig. 7; Stop 1A) from the parking spot between the stoplight and the bridge over the railroad is dominated by several elongate rolling low hills trending left-to-right (southwest-to-northeast). The nearest is McPherson Ridge, the next Herr Ridge; more are further away/northwest. These ridges are held up by resistant sandstone (Stop 1B) in the Gettysburg Formation, rather than by diabase intrusions like other ridges on the battlefield. The stone foundation of the white barn to the left/southwest was already in place in 1863.

Early on the morning of the 1st day, lead elements of Heth's Confederates coming from the northwest ran into Buford's and Reynolds' Union units moving north along the west side of Gettysburg. Intense see-saw fighting developed, and both armies fed troops and artillery into the conflict as soon as they arrived on these ridges. After almost a full day of action, the Confederates forced the Federals to leave, retreat back through the town, and

Figure 7. View west across McPherson Ridge (Stop 1A).

Figure 8. Resistant sandy beds in middle railroad cut (Stop 1B; Inners et al., 2006, p. 49).

Figure 9. Red shale (left), hornfels, and gabion concealing dike (right) on north side of tracks in eastern railroad cut (Stop 1C; Inners et al., 2006, p. 53).

flee out its south side, climbing up the high ground there (Cemetery Hill and the north end of Cemetery Ridge).

As night approached, the Confederates did not pursue the retreating troops, but instead spread southward along Seminary Ridge, while the Union men were stopped by Hancock riding up from the south. Hancock persuaded them to dig in right there, which thereby set up the two armies along the two ridges and facing one another across the lowland between, the basis for the battle for the next two days.

Turning to the right/north, also immediately obvious are the railroad track and cuts below this viewing location. During the 1st day's fighting, soldiers down in the cuts were targeted or captured by opponents coming along the top edges of the railroad cuts. This fate befell Confederates down in the middle railroad cut (Stop 1B) late morning, and then Federals in the eastern cut (Stop 1C-D) late afternoon.

Walking back under the bridge permits examination (Fig. 8; Stop 1B) of the more resistant, sandier beds as the lower Gettysburg grades upward toward the Heidlersburg Member further west (the base of which is 0.1–0.2 mi from the bridge; Stose and Bascom, 1929, areal geology map). Particularly note the thick-bedded hard tan-weathering gray sandstone on the north side of the track just west of the bridge. The strata seen here (Inners et al., 2006, p. 48) also include red and gray mudstone and shale, some more sandstone, and minor thin gray argillite and black shale, all intimately interbedded, unfossiliferous, and dipping 25° northwestward. Their cyclicity has been noted and attributed to climatic fluctuations, probably astronomically forced, and affecting lacustrine deposition (although in the Gettysburg Basin not nearly as extensively widespread as in the Newark Basin [Lockatong Formation] in northeastern Pennsylvania and New Jersey).

Beginning a third of a mile west of the bridge is another long railroad cut exposing more redbeds and tan-gray sandstones, up in the Heidlersburg Member. At the far western end on the south side of the track can be seen 1–2 ft of dark-gray to black, hard, platy, unfossiliferous shale, presumably lacustrine. Extra time would have to be allotted to visit this exposure, especially to check for fossil fishes like those in comparable rocks in the Lockatong in the Newark Basin.

The lower part of the Gettysburg Formation, unfossiliferous red shale, claystone, mudstone, siltstone, and very fine-grained sandstone, is well-exposed on the north side of the track (Fig. 9; Stop 1C), where the beds dip 20–25° to the northwest. These probably represent floodplain or lake/playa paleoenvironments.

Farther east along the north side of the tracks, the redbeds have been altered to purplish-gray hornfels, aphanitic, massive, blocky-weathering, but the dike responsible for their baking is now hidden behind an artificial stone-cobble wall (gabion). However, that intrusion, the Rossville diabase comprising the Seminary Ridge dike, is exposed on both sides of the southern track here (Fig. 10; Stop 1D), southeast of the gabion. This gray-black diabase is noticeably finer-grained than that in the Gettysburg sill (to be seen later at several stops), reflecting its more rapid cooling as a smaller thinner intrusion into the cold country rock.

Turn around and return to stoplight (reset to 0.0); turn left/ southeast on U.S. 30/Chambersburg Pike/Buford Ave.

0.3	**0.3**	Turn right/south on road marked "Seminary Ridge".
0.2	**0.5**	On left/east is the Lutheran seminary building from whose cupola the Union generals spotted the oncoming Confederates mid-morning of the 1st day, and whose rooms thereafter sheltered wounded from both sides. Along here, cannons are Union guns pointed right/ west at the attacking Confederates (midday of 1st day).
0.1	**0.6**	At stoplight, cross Middle St. [Hagerstown Rd.], and continue south on one-way road now labeled [West] Confederate Ave. From here south, cannons are Confederate artillery aimed left/east at the Union troops along Cemetery Ridge (early afternoon of 3rd day).
0.8	**1.4**	To left/east is the North Carolina memorial; the same sculptor (Borglum) carved the four presidents' heads on Mount Rushmore.
0.1	**1.5**	Pause/park on right/west side/half of road.

STOP 2: Confederate cannons aligned for cannonade before Pickett's Charge (early afternoon of 3rd day); **Rossville diabase boulders from underlying Seminary-Ridge dike.** (Same as mile 3.95 in Inners et al., 2006, p. 16, 22.) **5–10 min.**

The cannons here before 2005 were "Parrott rifles," a more modern type of gun, steel/iron, with rifling grooves spiraling down the inside of its tube/bore, and recognizable by the thickened collar wrapped around its lower/breech end. When visited in early 2006, these had been removed from their carriages/wheels, and so the future appearance of this site is uncertain.

Continue straight ahead/south (reset to 0.0).

0.3	**0.3**	Park on right half of road pavement.

STOP 3: Virginia Memorial with Lee equestrian statue; start of Pickett's Charge (mid-afternoon of 3rd day); **Rossville diabase boulders from dike underlying Seminary Ridge.** (Same as mile 4.2 in Inners et al., 2006, p. 16, 22, 88–91, 92a-b.) **15–30 min.**

Looking east from this site encompasses the entire landscape of Pickett's Charge (Inners et al., 2006, p. 16, 22, 29–30, 35–38, 88–91, 92a-b; Clark et al., 1985; Georg and Busey, 1987; Stewart, 1983; Turner, 1993).

Perhaps the most surprising aspect visible from this memorial is how low or subdued the topographic ridges seem (Fig. 11). Seminary Ridge here rises ~30 feet above the lowland to the east, and Cemetery Ridge a little more than a mile away comes back up a mere 60 feet. Such elevations, however, were nonetheless militarily significant for foot soldiers carrying some weighty equipment, clad in wool, in the almost 100° heat of that July afternoon.

Figure 10. Seminary Ridge dike exposed along north side of main track (Stop 1D; Inners et al., 2006, p. 54).

Figure 11. View east from Virginia memorial (Stop 3); distant skyline is crest of Cemetery Ridge, single tall tree in center marks the Angle (Stop 5), clump of trees to right/south is the Copse of Trees, the designated target for Pickett's Charge when it began.

Modern mobile forces employing helicopters and tanks might not even notice such low-lying topographic features.

Reflecting the fact that Gettysburg was a Union victory, among the many monuments on the battlefield, Lee until recently was the only Confederate officer honored with a statue. All the others were Union personnel.

On the north side of Lee's statue are several cannons, obviously Confederate, positioned for the cannonade just after midday on the 3rd day, but (at least in 2005) mis-aimed ~20° 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.

The 3rd 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), but the target—the Union line—held. See Inners et al. (2006, p. 89–90) for maps summarizing both cannonade and assault.

A remarkably similar action four years earlier in Europe—cannonade, assault, but final breakthrough, leading to the end of the French-Austrian war—suggests that Lee may have had that in mind as his overall plan for the 3rd day at Gettysburg. As a professional soldier well into his military career, Lee would seem likely to have heard of this, the 1859 Battle of Solferino, one of the biggest of mid-nineteenth century Europe, in what is now north-central Italy (then "Lombardy"; Shepherd, 1929, p. 158; Uffindell, 1999; Salamida, 2005, p. 56; Inners et al., 2006, p. 92a-b). The Confederates' final outcome was unfortunately different, though, because the Union artillery had many more cannons than the Austrian defenders against Napoleon III had had.

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.

Another aspect of Lee's plan for the 3rd day played out on open fields underlain by Gettysburg redbeds ~3 mi east of town (Inners et al., 2006, p. 19). Lee sent 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 that morning by Union cavalry partly commanded by Custer, whose resulting fame fueled presidential ambitions cut short years later by the Battle of the Little Bighorn.

Drive (reset to 0.0) ahead/south on one-way road.

0.7	**0.7**	Hidden in woods to right/west is recently erected Longstreet equestrian statue.
0.2	**0.9**	Turn left/east on unmarked road [Millerstown Rd.].
0.4	**1.3**	Turn left/northeast on Emmitsburg Rd.
0.8	**2.1**	Pass Codori farm house and barn, behind which or near was Pickett's field position during the climax of his division's charge (late on 3rd day).
0.2	**2.3**	Park on right/east side of highway at break in fence row.

STOP 4: Crossing Emmitsburg Road; middle of Pickett's Charge (mid-late afternoon of 3rd day). (Same as miles 15.9–16.2 of Inners et al., 2006, p. 16, 35–36, 91). **5–10 min.**

Facing both east and west here puts one in the midst of the massive infantry assault (Fig. 12) which Lee hoped would decide the Battle of Gettysburg in the Confederates' favor (references cited under Stop 3). This lowland is underlain by softer redbeds of the Gettysburg Formation, although none are exposed here.

Figure 12. Recent massive reenactment of Pickett's Charge crossing lowland between the two ridges, 5 mi down-strike from the actual battlefield; (view comparable to Stops 4 and 5; photographer embedded in Union line near the Angle).

Drive (reset to 0.0) straight ahead/northeast into town; Emmitsburg Rd. becomes Steinwehr Ave.

0.5	**0.5**	Turn right/east, across from Lincoln Train Museum, and proceed carefully through Visitors' Center parking lot.
0.1	**0.6**	Turn right/south on main road [Washington St./Taneytown Rd.] in front of Visitors' Center.
0.3	**0.9**	Pass small white house on right/west across from end of Hunt Ave. This was Meade's headquarters, where at midnight between the 2nd and 3rd days, he surmised that—since Lee had tried flank attacks on both south and north—he would probably attack their center the next day.
0.5	**1.4**	Turn right/west on Pleasanton Ave.
0.3	**1.7**	Pause at T-junction with one-way unmarked road [Hancock Ave.]. To left/south is large domed Pennsylvania state memorial, largest on the battlefield, and made of light-gray granite from Mount Airy, North Carolina. To oblique-right/northwest are the lowland fields across which Pickett's Charge came. Then turn right/north and continue.
0.3	**2.0**	Park on right half of road pavement.

STOP 5: The Angle, Copse of Trees, west-facing Union cannons, and west-dipping thick Gettysburg sill of York Haven diabase; climax of Pickett's Charge (late afternoon of 3rd day). (Same as Stop 8 of Inners et al., 2006, p. 16, 36–38, 88–89, 91–92.) **20–30 min.**

Figure 13. View west from the Angle (Stop 5) across lowland crossed by Pickett's Charge (Stop 4); tree line in distance marks Seminary Ridge, with Virginia memorial in centerfield (Stop 3).

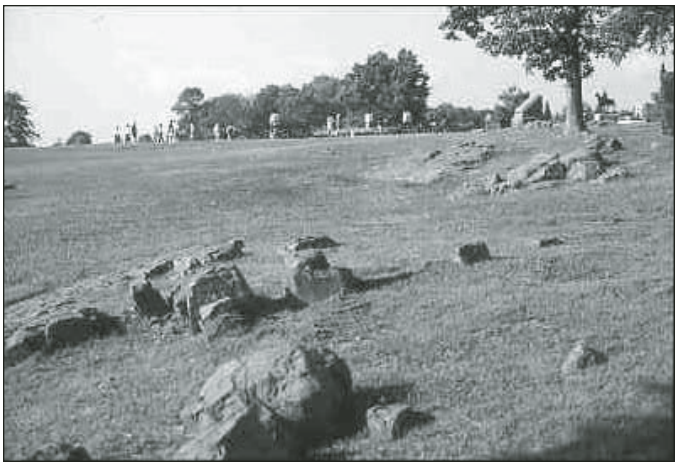

Figure 14. Low outcrop of upper edge of Gettysburg sill next to (west/in front of) Copse of Trees (Stop 5).

Looking west from the Angle (Fig. 13) shows the entirety of the ground crossed by Pickett's Charge (references cited under Stop 3), but from the Union defenders' perspective. The top of the Gettysburg sill can be seen as small rock flats just west of the Copse of Trees (Fig. 14). This copse or clump has continued as a recognizable feature since the battle, although its present oak trees are probably direct descendants of those growing here in 1863. The steeper western slope of Cemetery Ridge is underlain by hornfels (shale "baked" by the sill below), harder than the softer unaltered redbeds further west under the lowland.

Back eastward from the crest of Cemetery Ridge, the ground surface slopes gently downward and also slightly curves convexly. By coincidence, that curvature roughly matches the trajectory of Confederate shells coming over during the preliminary bombardment, and so those did noticeably less damage to the Union equipment here than expected. Further aggravating the Confederates' situation was the holding back of half the Union gunners' ammunition from the initial cannonade, so that when Pickett's Charge drew near, the Union artillery fire was even more voluminous, devastating, and decisive.

Just east of the road here, behind the Union cannons, is an equestrian statue. It commemorates Meade as the overall Union commander, but it could equally well have been for Hancock, whose contributions here during the climax of the battle were also significant.

Pickett's troops suffered so many casualties as they came up the slope that only a few reached the diabase-boulder stone wall at the Angle, and they were immediately overwhelmed by vastly greater numbers of Union defenders rushing toward them. The Angle therefore was the farthest any Confederates came and thus the "High Water Mark of the Confederacy"; they did not achieve the desired breakthrough, and so the overall battle was lost for them.

Drive (reset to 0.0) ahead/north on one-way road.

0.2	**0.2**	Large white building to right/east is the Cyclorama, housing Philippoteaux's wrap-around painting (currently undergoing conservation), which portrays the climax of Pickett's Charge (i.e., Stop 5 just seen).
0.1	**0.3**	Turn left/west.
0.1	**0.4**	Turn right/northeast on Steinwehr Ave.
0.1	**0.5**	Turn right/east toward Visitors' Center.
0.1	**0.6**	Proceed carefully through parking lot, and park on north side of Visitors' Center

LUNCH STOP: Park on north side of Visitors' Center; walk to eating places nearby along Steinwehr Ave. Watch time closely! **1 hr.**

Restrooms are readily accessible from the parking lot, but newly instituted (War on Terrorism) security measures limit entry into the front doors of the Visitors' Center now. **Backpacks, large handbags, and weapons (firearms, blades, and explosives) are not allowed inside the Visitors' Center.**

The Visitors' Center has restrooms, information-folder counter, bookstore, electric-map display, and artifact exhibits (Inners et al., 2006, p. 1, 19, 38). Beware of running unexpectedly short of time when exploring these facilities. Additional smaller private/commercial exhibits are scattered around the town. Finally, construction of a new park service center or museum has recently begun beyond the over-flow parking area, half a mile southeast of the present Visitors' Center.

(Optional) Walk from parking lot to front of Visitors' Center, and carefully cross highway into National Cemetery to the east.

STOP 6: Gettysburg Address (5 months after battle; 19 November 1863). (Same as mile 11.95 in Inners et al., 2006, p. 30.) **0–30 min.**

Figure 15. 14th Indiana monument, composed of fossiliferous Salem Limestone from Indiana (Stop 7).

Across the highway are two cemeteries: the National [military/government] Cemetery to the north/left, and the Evergreen [civilian/private] Cemetery to the right/south, separated by a long iron fence. In the center of their combined area, on either side equidistant from the fence, are the high-standing Soldiers' National Monument and a lower flagpole at the grave of Mary Virginia "Jennie" Wade, the only civilian killed during the battle (accidentally; collateral casualty). Lincoln gave his famous address months later from a temporary wooden platform set up at or between these two memorials.

Drive out of parking lot, (reset to 0.0), and turn left/north on highway [Washington St.].

0.2	**0.2**	Bear right/northeast (at stoplight) onto Steinwehr Ave.
0.2	**0.4**	At second stoplight, turn very sharply right/south onto Baltimore St. and proceed uphill (Cemetery Hill, where Union troops began to dig in late on 1st day).
0.3	**0.7**	Just over crest of hill and past gatehouse into Evergreen town/private cemetery, park on right/west side of highway. After parking, walk across highway; **use extreme caution!** The monument is located to the left/north of the Hancock equestrian statute.

STOP 7: 14th Indiana monument with Mississippian fossils (40 years after battle, but commemorating the evening after the 2nd day). (Same as mile 14.8 in Inners et al., 2006, p. 32, 35, 36a-b). **20–30 min.**

Hancock, riding up from the south, intercepted the Union troops retreating through town, late on the 1st day and had them dig in around here. Their cannons are positioned to drive off Confederate attacks from the north and east; these attacks did develop during the night, 24 and more hours later (Stop 13). Another day later, Hancock was wounded while helping repel Pickett's Charge near the Copse of Trees less than a mile to the southwest (Stop 5).

The monument to the 14th Indiana Regiment (Fig. 15; Inners et al., 2006, p. 35, 36a-b) is unique on the battlefield because it consists of fossiliferous limestone, with the tiny fossils weathering out on its surface after a century exposed to the humid Pennsylvania climate. The other battlefield monuments consist of igneous crystalline rocks, mostly granites, instead.

The limestone here is the Salem Limestone (mid-Mississippian, 330 million years old; south-central Indiana), widely marketed across the eastern United States as the Indiana, Bedford, or Oolitic Building Stone. It is made of finely comminuted fossils, especially bryozoans (*Fenestella, Dichotrypa*) and foraminiferans (*Endothyra*), embedded in spar cement (Cumings et al., 1906; Patton and Carr, 1980), and was deposited as a shallow-marine, nearshore, mobile, carbonate-sand shoal.

Drive (reset to 0.0) ahead/southeast on highway.

0.6	**0.6**	Turn right/west on unmarked road [Hunt Ave.]
0.6	**1.2**	Turn right/north (opposite Meade's headquarters) onto highway [Taneytown Rd./Washington St.].
0.3	**1.5**	Turn left/west into parking lot on north side of Visitors' Center.

BRIEF REST STOP. 5–10 MIN

Drive (reset to 0.0) westward through parking lot.

0.1	**0.1**	Turn left/southwest onto Steinwehr Ave. (which becomes Emmitsburg Rd. upon leaving town).
1.5	**1.6**	Turn right/west on Millerstown Rd.
0.4	**2.0**	Turn left/south on unmarked road [West Confederate Ave.].
0.1	**2.1**	Park on left at base of observation tower.

STOP 8: Observation tower with views of topography/landscapes of southern part of battlefield (mostly 2nd day), and **of Confederate cannons** aligned for cannonade (early afternoon of 3rd day). (Same as Stop 3 of Inners et al., 2006, p. 15–16, 23, 55–58.) **30–40 min.**

Climbing this tower permits unobstructed views of several topographic features important in development of the battle.

To the west, forming the distant skyline, is South Mountain (Fig. 16), the extension into Pennsylvania of the Virginia Blue Ridge, Late Precambrian metavolcanics and Early Cambrian quartzites. Both before and after the Battle of Gettysburg, the Confederates moved behind that mountain, hidden effectively from the Union army in the absence of aerial reconnaissance. The Confederates came east through the gap at Cashtown, unexpectedly ran into Union forces moving north near Gettysburg, and thereby triggered the start of the battle.

Due east, out in the lowland along the Emmitsburg Road, is a slightly higher patch of ground, the Peach Orchard (Fig. 17; Stop 12), underlain by the hornfels formed by heat near the top of the Gettysburg sill below. From a long-range view like this, it is evident why Sickles moved his Union troops westward from Cemetery Ridge in order to secure that high ground on the 2nd day.

To the southeast are the two hills at the southern end of the Union line: lower rocky Little Round Top (Stop 10) and higher wooded Big Round Top, both composed of York Haven diabase in the thick, west-dipping Gettysburg sill. That sill continues left/north as a lower elongate hill, Cemetery Ridge, along whose crest were arrayed the Union troops and artillery.

On the stone fence and road below the tower are several cannons, Confederate, ready to shell the Copse of Trees (Stop 5) almost out of sight to the northeast, and including (in 2005) both Parrott rifles and smoothbore Napoleons. The subdued ridge on which they (and the tower) stand is Warfield Ridge, topographically a southward continuation of Seminary Ridge, but held up by a different vertical dike of the same Rossville diabase.

Figure 16. View west from observation tower (Stop 8); distant skyline is South Mountain, behind which the Confederates were moving north before the battle (Inners et al., 2006, p. 56).

Figure 17. View east from observation tower (Stop 8); low rise in middle distance is the Peach Orchard (Stop 12), distant trees are along southern part of Cemetery Ridge (Inners et al., 2006, p. 57).

Drive (reset to 0.0) ahead/south on one-way road [West Confederate Ave.].

0.6	**0.6**	Cross main highway (busy, high-speed traffic, **DANGEROUS!**)[Emmitsburg Rd.]; continue as road [now South Confederate Ave.] winds eastward.
1.0	**1.6**	Park on road pavement's right half opposite Wells' statue to right/south, and walk ahead/east onto stone bridge.

STOP 9: Plum Run bridge with Triassic dinosaur footprints (75 years after battle). (Same as mile 6.95 in Inners et al., 2006, p. 6, 25, 26a-b, 98). **15–30 min.**

This bridge crosses the small creek, Plum Run, which flows between Little Round Top (Stop 10) and Devil's Den (Stop 11) a mile upstream to the north. Intense combat there late on the 2nd day resulted in so many casualties that this water ran red, hence the popular name "Bloody Run."

The Triassic sedimentary rocks on the battlefield are unfossiliferous, but blocks quarried from the same formation nearby and used to build the bridge over Plum Run exhibit a few dinosaur footprints (Fig. 18). These sandstone or siltstone blocks are from the abandoned Trostle Quarry 3.3 mi due east of the interstate exit at York Springs and represent the mid-Gettysburg Heidlersburg Member.

Figure 18. Plum Run bridge dinosaur footprints: left, coelurosaurs *Anchisauripus sillimani* (and smaller *Grallator tenuis*); center, heterodontosaur *Atreipus milfordensis*; scale bar 10 cm; right, prosauropod *Otozoum minus*; modified from Haubold, 1971, p. 66, Lull, 1953, p. 167; Haubold, 1971, p. 66, Lull, 1953, p. 154; Haubold, 1984, p. 155, Olsen and Baird, 1986, p. 65–69; Haubold, 1971, p. 83, Lull, 1953, p. 191; respectively.

Most conspicuous is a paired fore-and-hind-print in the northwestern corner of the fifth block from the east end of the bridge's north side. This is *Atreipus milfordensis,* a heterodontosaur ornithopod (Haubold, 1984; Olsen and Baird, 1986; Santucci and Hunt, 1995). On the bridge's south side, counting from its west end, the sixth block has a 3-toed hind-print, *Anchisauripus sillimani,* and the ninth block has a couple of smaller hind-

prints, *Grallator tenuis,* both coelurosaur theropods (Haubold, 1971, 1984; Lull, 1953). The tenth block bears an obscure 4-toed hind-print, possibly the prosauropod *Otozoum minus* (Haubold, 1971; Lull, 1953). Additional obscure prints are present, another *Anchisauripus* on the eighth block, and another *Atreipus* on the eastern end of the ninth. It is also possible that the *Anchisauripus* hind-prints may be incomplete *Atreipus*. Finally, visibility of all the footprints varies much with both lighting and surface wetness, further complicating the already difficult task of identifying such ichnofossils. Moreover, although off the battlefield, *Atreipus* footprints appear in a farmhouse sidewalk made from Trostle Quarry slabs, 1.7 mi north-northeast of the York Springs exit.

Continue (reset to 0.0) ahead/northeast on one-way road.

0.4	**0.4**	To right/east is start of trail up onto Big Round Top.
0.2	**0.6**	Cross unmarked road [Warren/Wright Ave.].
0.2	**0.8**	Park on top of hill (back side of Little Round Top).

STOP 10A: Little Round Top with Warren's lookout point; **10B: 20th Maine's position; both: York Haven diabase from thickened Gettysburg sill;** (mid- and late afternoon of 2nd day). (Same as Stop 4 of Inners et al., 2006, frontispiece and p. 15, 26, 60–68, 99–100, 104–105.) **30–50 min.**

The summit of Little Round Top (Stop 10A) is just west of the parking area; the 20th Maine's position is a 5 min walk back down across the road and into the woods.

Diabase bedrock and boulders are everywhere; fine- to medium-grained, dark gray, they represent the York Haven diabase in the Gettysburg sill.

The west face of Little Round Top (Fig. 19) had had its trees cut down a year before the battle, so that its rock-strewn ground was easily visible even from the Confederate positions a mile away to the west. In contrast, its south and east sides were (and still are) densely forested.

Figure 19. Little Round Top (Stop 10A) seen from its front and below to the west, as the attacking Confederates would have seen it (Inners et al., 2006, p. 61).

The open top of this rocky hill provided, then and now, long-range views across the southern part of the battlefield, and this made Little Round Top a critically significant site during the battle. It was at first unoccupied (1st and well into 2nd days) because it was far south of the initial Union positions on Cemetery Hill and Cemetery Ridge, and because Sickle's troops had gone west into the Peach Orchard (Stop 12) instead. Its importance was realized mid-afternoon of the 2nd day by Warren out reconnoitering, who immediately got troops and artillery up here, just in time to begin fighting off intense Confederate attacks trying to come around the Union's south flank. At the height of that action, Chamberlain's 20th Maine regiment, occupying the extreme south end of the Union line, made its famous bayonet charge down through the woods and put the Confederate attackers to flight, which in effect saved the entire Union position.

Drive (reset to 0.0) ahead//north on one-way road.

0.2	**0.2**	Turn left/west on unmarked road [Wheatfield Rd.]; note cut-down and removal of brush and trees to the northwest, part of new efforts to restore ("rehabilitate") the battlefield more to its 1863 appearance.
0.3	**0.5**	Intersection with Crawford Ave. to the left/south. Here the driver must make a choice.

*NOTE: If driving a long vehicle **(bus or recreational vehicle)**, continue straight ahead/west to the Peach Orchard (Stop 12), because the alternative road may not be negotiable.*

0.2	**0.7**	To the left/south is the Wheatfield, scene of intense fighting late on the 2nd day.
0.4	**1.1**	Northeast corner of the Peach Orchard (Stop 12).

*NOTE: If driving a **car or van,** turn left/south onto Crawford Ave.*

0.2	**0.7**	To left/east is an excellent view of the front/west slope of Little Round Top (Fig. 19), indicating why Lee referred to it as "that little rocky hill."
0.2	**0.9**	Park in small area at sign for Devil's Den.

STOP 11: Devil's Den and York Haven diabase from thickened Gettysburg sill (mid- and late afternoon of 2nd day). (Same as Stop 5 of Inners et al., 2006, frontispiece and p. 15, 27–28, 69–76). **0–20 min.**

Devil's Den provided many hiding places for Confederate soldiers during their attacks on the Union south flank up on Little Round Top (Stop 10) during the afternoon of the 2nd day. These were located among the large rounded masses (Fig. 20) developed by spheroidal weathering and exfoliation on the surfaces of joint-bounded blocks and by later block separation perpendicular

to joints under periglacial conditions such as permafrost wedging and ice- and water-lubricated sliding. The bedrock here is York Haven diabase, mottled white and black under the obscuring lichens, and comparatively coarsely grained here, in the thick Gettysburg sill.

Drive (reset to 0.0) ahead on very sharply winding, narrow, steep road.

0.4	**0.4**	To the right/north is the Wheatfield, where prolonged fighting occurred late on the 2nd day.
0.5	**0.9**	Turn left/west on unmarked street [Wheatfield Rd.]
0.2	**1.1**	Northeast corner of the Peach Orchard.

STOP 12: Peach Orchard (late afternoon of 2nd day). (Same as Stop 6 of Inners et al., 2006, p. 15, 29, 77–81.) **10–15 min.**

The Peach Orchard is a square plot 0.1 mile on each side, sitting on slightly higher ground (Fig. 17) than the surrounding fields, as already seen from the observation tower (Stop 8). It is underlain by hornfels developed along the west side of the Gettysburg diabase sill; hornfels float reportedly is found just south of the orchard, but no outcrops exist. Just to the west, the lower ground is presumably developed on the softer unmetamorphosed Gettysburg red shale and sandstone.

Higher ground like the orchard could serve as a platform for cannons which could shell either side, so midday of the 2nd day, Sickles, on his own initiative, moved his Union troops forward/westward to occupy the orchard. Confederate forces counterattacked, and after prolonged intense fighting, took the orchard by late afternoon of that 2nd day.

For at least the past several years, the orchard contained about a hundred small trees. In early 2006, these had been removed, but replacements are planned for 2007 as part of the "rehabilitation" of the battlefield.

Turn (reset to 0.0) right/northeast onto Emmitsburg Rd. from northwest corner of the Peach Orchard, and continue into Gettysburg.

1.9	**1.9**	Turn very sharply right/south (at second stoplight) onto Baltimore St./Pike.
1.2	**3.1**	Turn left/east on unmarked winding road [Carmen/Slocum Ave.].
0.6	**3.7**	Spangler's Spring to left/west; this spring figured large during the night fighting near here after the 2nd day.
0.7	**4.4**	Park at foot of low observation tower.

STOP 13: Culp's Hill and York Haven diabase from thickened Gettysburg sill (evening and night following 2nd day). (Same as Stop 7 of Inners et al., 2006, p. 15–16, 33, 83–87). **20–30 min**.

Culp's Hill, during the battle as well as now, was heavily wooded (Fig. 21) and covered with diabase boulders (again York Haven diabase from the Gettysburg sill).

The Confederate attack on Culp's Hill was intended to come around the Union north flank but—despite inferior numbers—Greene's defenders made good use of natural features as well as their own constructed rock-and-log breastworks, and hung on all night. The attack here came hours after the attack on Little Round Top (Stop 10); had they been better coordinated, it is possible that their combined momentum might have destroyed the Union line and so won the battle.

Drive (reset to 0.0) ahead/west on one-way Slocum Ave.

0.4	**0.4**	Turn right/north on main highway [Baltimore Pike].
0.4	**0.8**	Turn very sharply left/southwest (at stoplight) onto Steinwehr Ave.
0.2	**1.0**	Bear left (second stoplight) onto Washington St.
0.2	**1.2**	Turn right/west into parking lot on north side of Visitors' Center.

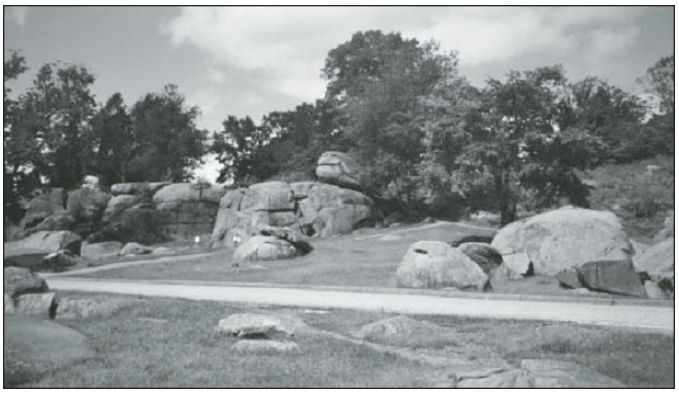

Figure 20. Rounded masses/boulders of diabase, comprising Devil's Den (Stop 11; Inners et al., 2006, frontispiece and p. 71).

Figure 21. View northwest from tower on top of Culp's Hill (Stop 13); the Confederates were attacking up-slope through the woods (foreground) from the town below (mid-distance); (Inners et al., 2006, p. 84).

END FIELD TRIP here. Dinner, like lunch, can be obtained in town nearby. Note time carefully, depending on travel plans afterwards.

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