

Feature

Military geology and the Battle of Gettysburg, July 1863

Gettysburg – the most costly of all battles of the American Civil War, and one of the most significant battles ever fought. Contested in rural Pennsylvania, the Battle of Gettysburg took place after a chance encounter by the Confederate Army of Northern Virginia (General Robert E. Lee) with the Union Army of the Potomac (Major-General George Meade). It was to prove the turning point in the war, the so-called ‘high tide’ of the Confederacy, as after Gettysburg the fortunes of war turned in favour of the Union. Fought over three days in early July 1863, the battle continues to be analyzed and re-analyzed from all perspectives. Significantly, it was the first battle to be re-interpreted from the perspective of its geology, by Andrew Brown of the Pennsylvania State Survey in the early 1960s. It continues to fascinate geologists interested in the overall impact of geology and terrain in determining the outcome of battle. This article examines why Gettysburg has been so influential in shaping our understanding of geology in warfare.

Gettysburg is arguably the most important, and certainly the most costly battle, with 51 000 casualties, of the American Civil War (1861–65). One of the most significant battles in history, Gettysburg was fought between troops of the Union (led by Major General George Meade) and the Confederacy (led by General Robert E. Lee) in July 1863, and was to prove the turning point in this long war. The story of the battle has been told and retold on countless occasions, and examined from all perspectives. From almost the close of battle, the town of Gettysburg has been at the heart of a thriving tourist industry based around tours of the battlefield. Today, visitors can drive around a carefully arranged trail, with an audio CD providing a commentary – which means that individuals need no longer to leave their cars in order to examine the finer points of the battle.

Yet it is the fact that Gettysburg has been examined from a geological point of view that makes this battle stand out from others. Terrain – geology in its roundest sense – is rightly held up by all concerned as a major influence in its outcome. The Round Tops, the Seminary and Cemetery ridges, the Devil’s Den – all famous features of the battlefield topography – are surface expressions of the outcrop of Jurassic basic rocks (diabase, otherwise known as dolerite) which have been intruded into softer Triassic sedimentary rocks. This terrain focus is widely explained to the visitor, who hopefully takes

away a view of a battle controlled fundamentally by geology, a control that helped create a defensive position that was to ultimately break the Confederate offensive.

Military geology and Gettysburg

Since at least the early 1960s geologists have attempted to examine the role of geology in the battle, to deconstruct its main events from a military perspective, and to examine the way in which geology contributed to them, particularly in providing the essential framework – the stage – on which it was fought. The first major study to examine the battle of Gettysburg from this perspective was Andrew Brown of the Pennsylvania State Geological Survey. Publishing an article in *Geotimes* (subsequently reprinted by the Survey as *Geology and the Battle of Gettysburg*; Fig. 1), Brown examined the campaign that led to the battle, the movement of the Union Armies from the south, and the progression of the Confederates north along the Great Valley from Virginia into Pennsylvania – part of General Robert E. Lee’s plan to invade the north, taking the war away from Virginia, and putting pressure on the Union in its own territory. Brown recognized that Lee’s invasion, north along the Great Valley, was shielded from observation by the topography of the Blue Ridge, in Virginia at least. This theme has been re-explored by Harold Winters, describing how the

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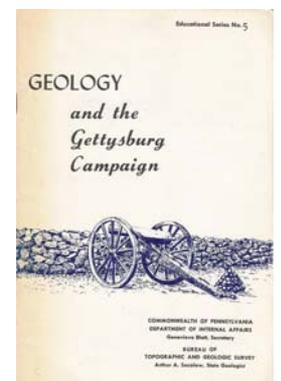


Fig. 1. Cover of Andrew Brown's (1962) publication on the battle.

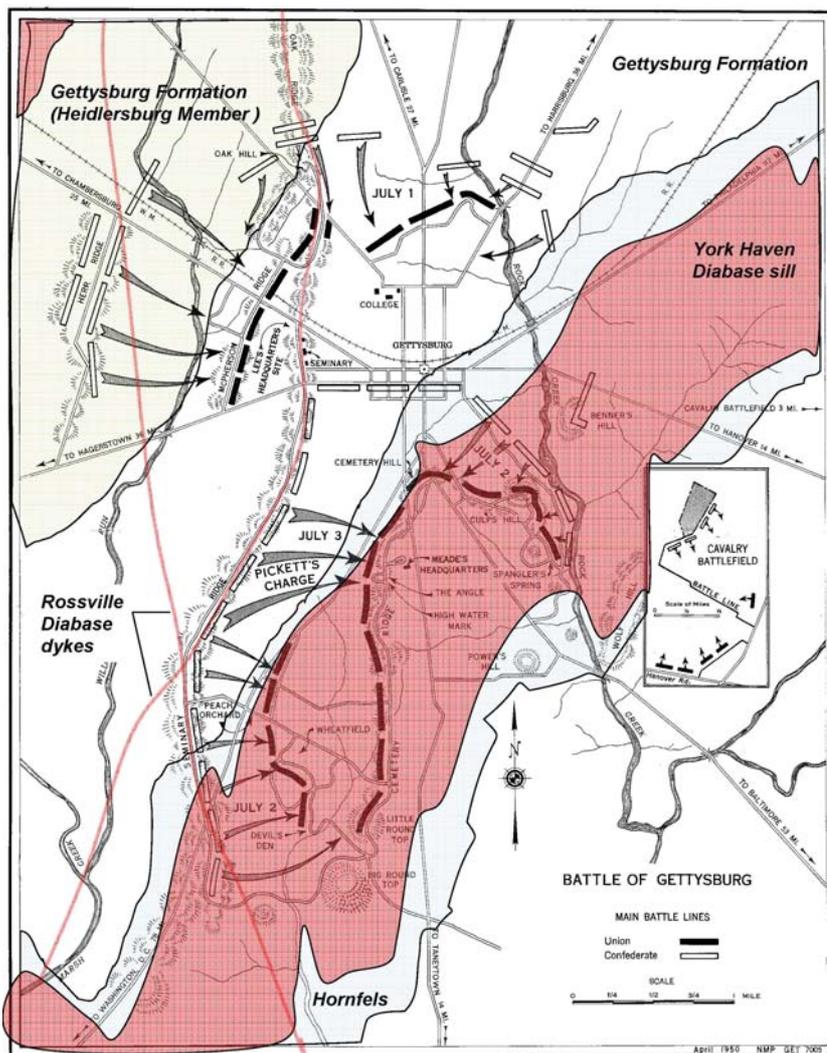


Fig. 2. Geological map of the Gettysburg Battlefield, with the location of the three day's actions plotted. Modified from the base map of Tillburg (1962), geological boundaries from Inners *et al.* (2004).

definite structural grain of the north-east/south-west trending Valley and Ridge Province created a north-south corridor for troop movements, but which constrained east-west movement to a series of gaps in the Blue Ridge Mountains created by drainage capture of the Shenandoah River. Overall strategy in the eastern theatre of war was to be heavily influenced by this factor.

Examining the detail of the battle more fully than Brown, in the last few years members of the Pennsylvania Survey and Roger Cuffey of Pennsylvania State University have once more looked at the geology of Gettysburg. In particular they have concentrated on the stage for the battle, the so-called 'topographic fish-hook' – the outcrop of diabase, so crucial to the Union defence in the second and third days of the battle. Rich in detail, their work is intended primarily as a field guide to visitors.

The present article adds to the discussion by examining the role of specific aspects of the geology in controlling movement, observation and

concealment, possibility of entrenchment, and supply of materials in the battle – all aspects of the military applications of geology considered today.

Gettysburg geology

The geology of the Gettysburg area has most recently been reviewed in the guidebook produced by members of the Pennsylvania State Survey for a Geological Society of America meeting in 2004. The town of Gettysburg occupies a Triassic sedimentary rift basin in the Piedmont east of the Valley and Ridge and Blue Ridge provinces. The basin is filled with shales and sandstones of the Gettysburg Formation, which strike southwest-northeast, steeply dipping to the west (Fig. 2). Significantly, these sedimentary rocks were intruded during the Jurassic by diabase (dolerite) sills and dykes; the York Haven Diabase forming the main hills south of the town (Cemetery Ridge, Culps Hill, the Round Tops, etc.), while the dykes of the younger Rossville Diabase cross-cut this, creating Seminary Ridge in particular (Fig. 2). Intrusion of the York Haven Diabase was associated with significant hornfelsing of the shale comprising the Gettysburg Formation. The outcrop pattern of the York Haven Diabase creates the famous 'fishhook' shaped high ground to the south of the town, with the 'eye' of the hook at Round Top (Big Round Top), the 'hook' itself created by the swing around from Cemetery Hill to Culp's Hill.

The Battle of Gettysburg

For the purposes of this article, the Battle of Gettysburg can be broken down into three convenient phases, phases which correspond to the three days of main battlefield action. For more detail, the one-volume account by Stephen Sears is as good as any.

The three phases that can be identified are: (i) the opening phase (1 July 1863), from first engagement of Confederate troops with the Union army along the Chambersburg Pike, to the retreat of the Union troops to the high ground – the famous 'topographic fish-hook'; (ii) flank assaults on the Union line at Culp's Hill and Cemetery Hill (to the north) and the Round Tops (south) on 2 July; and (iii) the final phase, involving an infantry assault on 3 July by troops of Longstreet's Corps on the Union centre – 'Pickett's Charge' named after the commander of the central division involved in the assault.

From a terrain perspective, Day 1 was very much about manoeuvring over open, rolling terrain, with a staged but costly retreat by the Union troops to the commanding high ground; Day 2, was about the Confederates attempting to take that high ground



Fig. 3. The boulder-strewn ground of Little Round Top (background) and Devil's Den (foreground). **A.** View in July 1863 (Library of Congress); **B.** similar view in 2006.

through an attack on the hills anchoring the flanks; and Day 3, an assault over open ground, the low forward slope of the Union position (Fig. 2). These aspects are discussed in more detail below, in order of increasing importance relative to this battle.

Manoeuvrability

The need to manoeuvre large numbers of men, equipment and supplies is a major preoccupation of military planners today, and has been in the minds of military commanders throughout history. Since before the Second World War assessing surface conditions (the 'going') has been a significant component of terrain analysis, calculating the possible consequences of tanks, machines and men getting bogged down and becoming immovable. In the Civil War tactics were such that, aside from mobile cavalry, most concerns revolved around room for infantry to manoeuvre in a constrained space, moving from column marches to the long double ranks necessary to allow soldiers to successfully load their long, muzzle-loading, rifle-muskets. And to get into position, infantry had to march, with very little other transport available. The ten roads that led to Gettysburg meant that a battle here was almost inevitable; it was to be opened by the movement of Confederate troops eastwards from the Cashtown Gap along the Chambersburg Pike leading into the town.

In the hilly areas of the Union flanks, manoeuvre was constrained; the diabase-boulder strewn ground, and wooded areas difficult to traverse in formation, although providing cover (Fig. 3). One such area, at the foot of Little Round Top, was to earn the name 'The Slaughter Pen' from the loss of life there (Fig. 4). On the shales and related rocks of the Gettysburg Formation (Fig. 2) the open nature of the country – masked here and there by woods, and interrupted by rail fences – meant that sufficient space was available for manoeuvre. The going was generally good, and although the shales promote streams and some boggy areas, the ground would have been firm underfoot, increasingly so towards the diabase outcrop. Greater obstacles to advance were the rail fences (built on diabase-free cultivated shale areas; Fig. 5), stone walls and improvised breastworks. This was particularly the case for the 'Great Charge' of Longstreet's Corps (known as Pickett's Charge) over otherwise open ground; this had to contend with fences bordering the Emmitsburg Road and, ultimately, a stone fence, both of which crucially slowed the momentum of the Confederate assault.

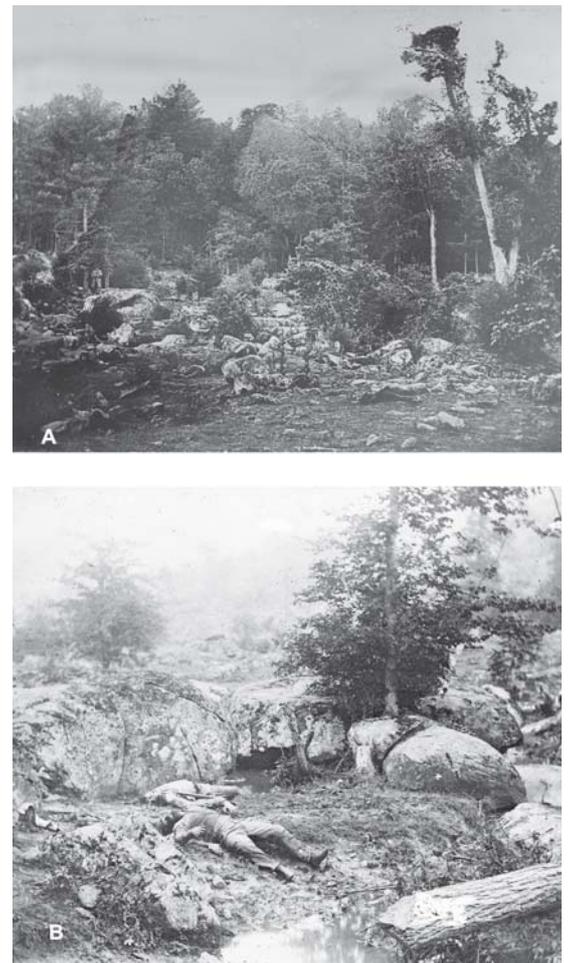


Fig. 4. The 'Slaughter Pen' in the aftermath of battle, July 1863; the diabase boulder-strewn valley between Devil's Den (Houck's Ridge) and Little Round Top (Library of Congress). **A.** Wide-angle view showing the wooded slopes of Little Round Top; **B.** diabase boulders adjacent to the Plum Run stream.



Field fortifications

Geology is an important factor in the development of field fortifications, which enhance the ability of the defender to hold a position in the face of attack. Field fortifications – trenches, breastworks, rifle pits ('fox holes') and so on – have been a function of warfare in varying forms for centuries. As such the availability of natural resources – stone, earth, aggregate for concrete, timber, etc., and the ability to dig in, have been pre-occupations of military engineers for the same span of time. In the Civil War, a definite rise in the development of entrenchment and fortification can be plotted, much of it to do with the switch from the Confederate strategy of taking the fight to their enemy in the early years of the war, to a more defensive model promoting siege tactics from the Union at the end of the war. Gettysburg sits roughly at the junction between the two phases.

In most cases, field fortifications in the early part of the war consisted of shallow dug trenches, fortified to the front with whatever materials were available. Sunken lanes fenced by split rail fences were often employed, and this was particularly the case at the battles of Shiloh and Antietam (Sharpsburg) (April and September 1862), where such fortifications led to severe losses amongst the attackers (Confederate and Union, respectively). In other cases, the use of stone walls was significant – this was particularly true of the Battle of Fredericksburg (December 1862), where Confederate defenders, already holding a terrain advantage by the occupation of Maryes Heights on the banks of the Rappahannock River, were able use a stone wall for cover, inflicting large numbers of casualties upon the waves of Union

troops advancing up-slope (discussed ably by Judy Ehlen & Bob Abraham in *Fields of Battle*).

At Gettysburg, the Union troops employed the weathering diabase boulders and cobbles to build up stone walls; digging down was not an option due to the thin soils at the tops of the high ground they occupied (Fig. 6). In some cases these were topped by timber logs cut down from the surrounding forests, as at Culp's Hill on 2–3 July. At Little Round Top, similar fortifications still exist – softened by 140 years – but these were only put in place as a defensive measure after the main assaults on 2 July (Fig. 7). The stone wall on Cemetery Ridge, placed on the western edge of the diabase outcrop facing Pickett's Charge – was to be the major obstacle and objective of the Confederates – as discussed below, its diabase boulders helped break the attack.

One of the most celebrated uses of such fortifications at Gettysburg was the construction of so-called 'sharp-shooter' positions at the Devil's Den by the attacking Confederates on 2 July. Devil's Den forms part of an outcrop of the York Haven Diabase west of Little Round Top, and separated from it by the course of the Plum Run stream. The outcrop has seen much weathering – of onion-skin type characteristic of diabase – creating separated boulders. In places, smaller boulders and cobbles were built up to create opportunities for Confederates to open fire on the

Fig. 5. View from Confederate artillery position to the crest of Cemetery Ridge; the clump of trees on the skyline to the right was the objective of Pickett's Charge. Modern rail fences illustrate the obstacles to free movement that existed in this area of shales (Gettysburg Formation) in 1863.

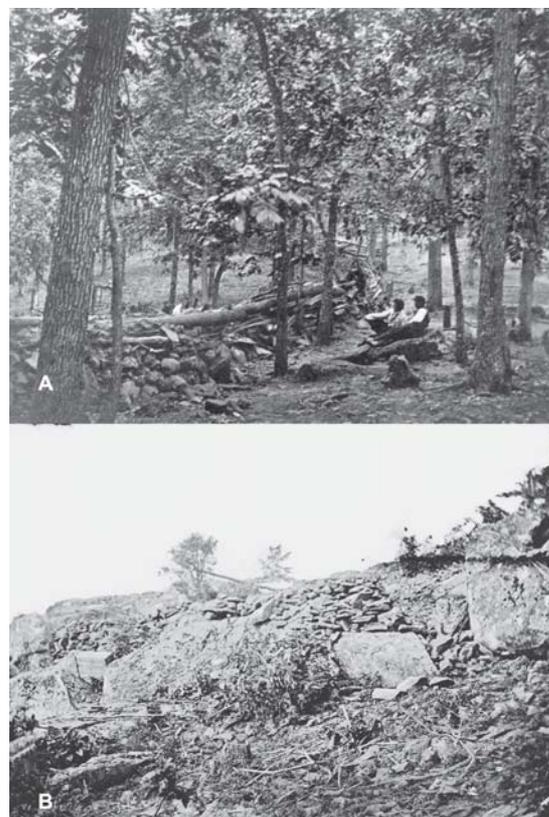


Fig. 6. Breastworks at Gettysburg, illustrated at the aftermath of battle in July 1863 (Library of Congress). **A.** Timber-topped, diabase breastworks at Culp's Hill. **B.** Diabase breastworks on Little Round Top, extemporized from existing, immovable boulders and smaller boulders and cobbles.



Fig. 7. Union breastworks at Gettysburg. **A.** Facing south-west, with the wooded slope of Round Top behind, pictured in July 1863 (Library of Congress). **B.** Remains of Union breastworks on Little Round Top in 2006.

defenders on Little Round Top. One famous example has been preserved, a function of the controversial contemporary photograph by Timothy O'Sullivan (Fig. 8), controversial in that the body was moved into position some 40 metres by the photographer (as discussed by William Frassinato). Whatever the truth, this perfect piece of geological fortune undoubtedly allowed the attackers to keep the heads of the Union defenders well and truly down during 2–3 July 1863.

Vantage

'Vantage' may be defined as the means by which the enemy may be observed without being exposed to observation. Taking and holding the high ground is a principle that has been exploited by military commanders throughout history. In defence, possession of the heights usually forces the attacker to assault under complete observation and allows the defender to shield their artillery on reverse slopes. At Gettysburg, the Union in all cases stubbornly held on to the high ground, causing the Confederates to

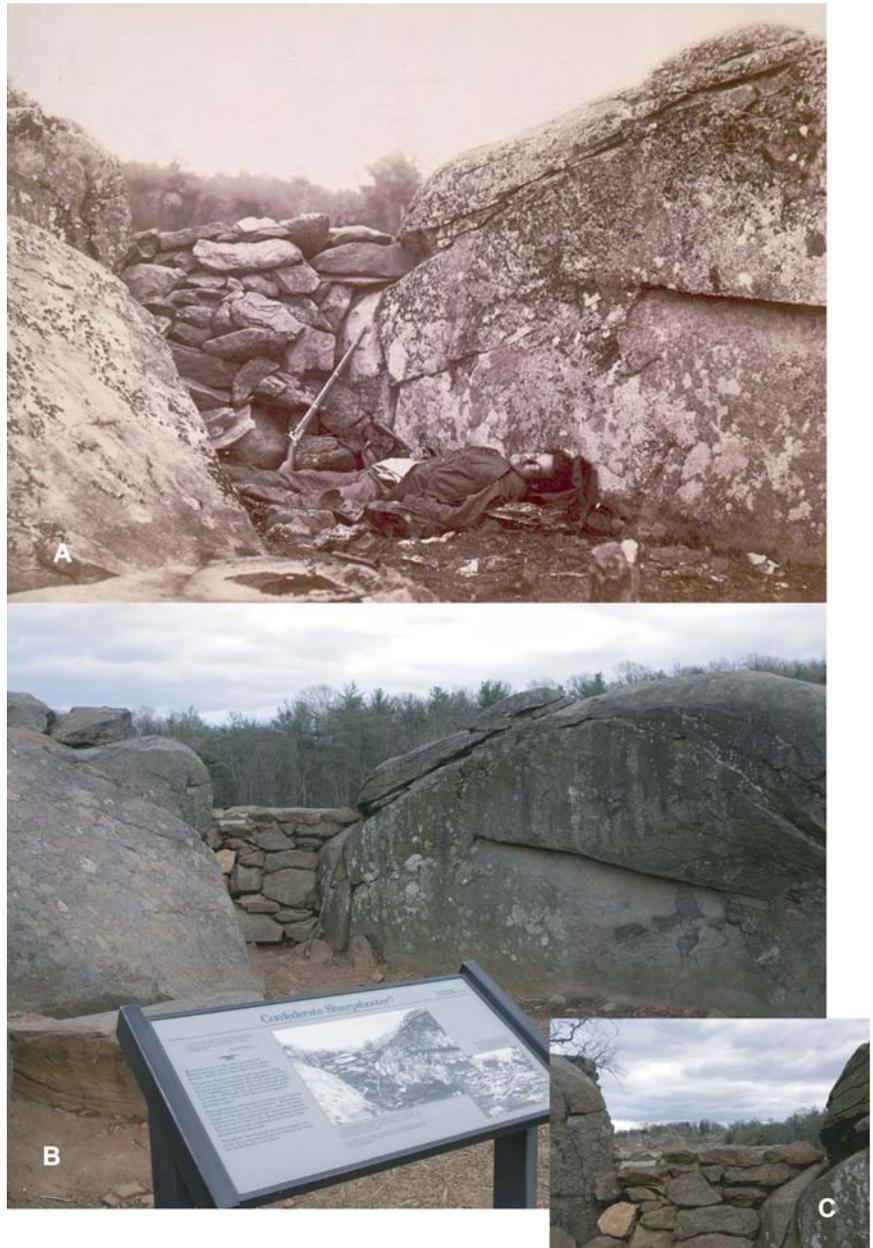


Fig. 8. Confederate 'sharpshooter' position at the Devil's Den, facing Little Round Top. Confederate forces occupied this position from 2 July 1863; many rifle positions like this were built up between *in situ* weathered diabase, using diabase cobbles and small boulders. **A.** Famous Gardner photograph (by Timothy O'Sullivan) of Confederate soldier in position; in fact, he had been dragged some 40 m or more to this point by the photographer, as discussed by William Frassinato (Library of Congress). **B.** The same position today. **C.** View of the summit of Little Round Top from the position; it would have provided a useful vantage point for the attackers.

expose themselves to fire on the forward slopes, with devastating consequences.

On Day 1, the terrain of the field of action was subdued, with McPherson's Ridge, Oak Ridge and Herr Ridge little more than swellings, a function of more resistant sandstone units within the Gettysburg Formation (Fig. 2). A tactical withdrawal of the

Union troops in the face of Confederate pressure from the north-east meant that the Union forces had to retreat from their position on McPherson's Ridge (formed by an outcrop of resistant sandstone), first to the wooded Seminary Ridge formed by a dyke, and then to the outcropping sill of Cemetery Ridge, its flanks anchored to two swellings in the sill: Culp's Hill just south-east of the town, and the Round Tops south of it. Although the cover available to the retreating troops was subdued here, it was enhanced by other aspects of the terrain, particularly stone walls and rail fences, which helped reduce the Confederate pressure on the lines, pressure that would die away at night fall, allowing the Union to improve its position overnight.

By Day 2, with the Union troops firmly in place on the high ground, the options available to General Lee were much reduced, and controversy has raged since the close of the battle about his decisions – as well as those of some of the Union commanders. Lee decided to commit his men to assaulting the anchor points of the Union line – Culp's Hill and the Round Tops, thereby weakening the whole Union position. Much has been made of the counter-suggestion by General Longstreet, one of Lee's most trusted commanders, that the Confederates should attempt to attack the rear of the Union position, but the fact is that the Confederates were committed to attacking these strong hills as 2 July wore on. At Culp's Hill in the north, the breastwork fortifications of diabase boulders and timber cut down from the wooded hill (Fig. 6) assisted the Union defenders in holding off repeated attacks from the Confederates advancing up



Fig. 9. Statue of Major General Warren in place on Little Round Top. Devil's Den (Houck's Ridge) is immediately below him; Seminary Ridge in the middle distance, and South Mountain in the background.

the forward slopes. To the south, delays meant that the attack on the Round Tops was not carried out until later in the day; just as well for the Union, as although the wooded hill of Round Top itself (sometimes called Big Round Top) and its cleared neighbour, Little Round Top, are the highest features on the battlefield, the colourful Union III Corps commander, General Sickles, had decided to occupy a forward position (defined by the western edge of the York Haven Diabase outcrop), on lower ground

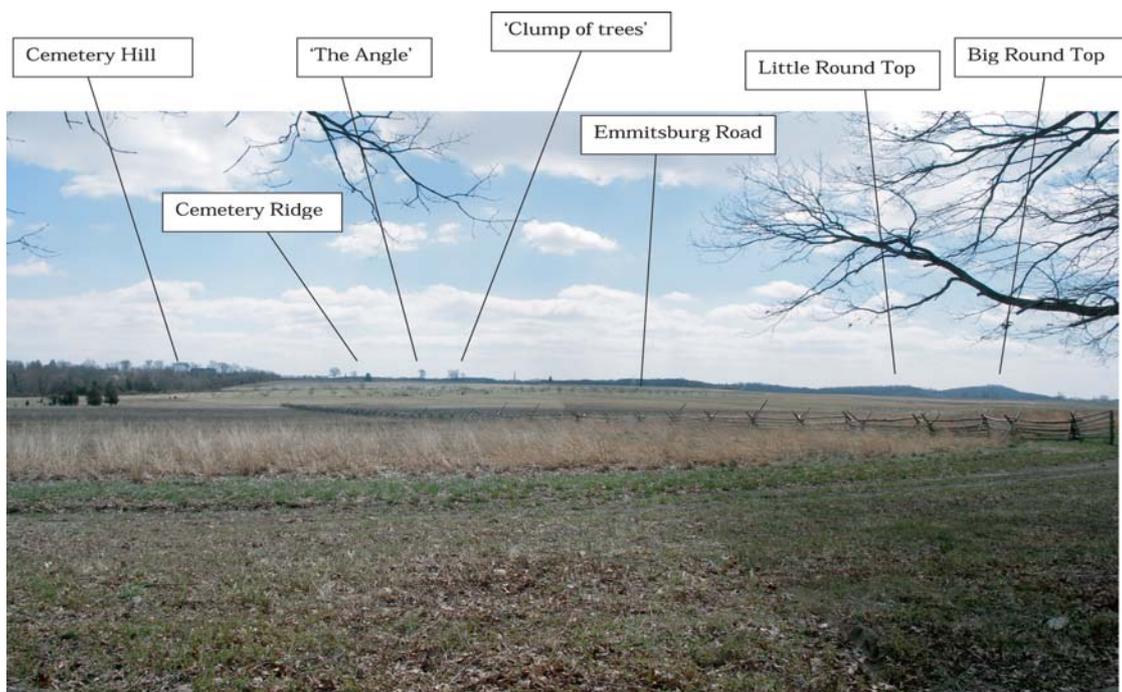


Fig. 10. View from Seminary Ridge (Confederate position) eastwards towards Cemetery Ridge and the Round Tops (Union position). The scene of Pickett's Charge on 3 July, 15 000 men were to cross this open glacia (underlain by the shales of the Gettysburg Formation) to reach the ridge (formed by the York Haven Diabase sill). Rail fences formed the major obstacles. The 'clump of trees' on the ridge crest was the objective; 'the angle' was the position of a concentration of Union artillery that was to devastate the attackers.



Fig. 11. York Haven Diabase outcropping in front of the Union position close to the 'clump of trees'; the obelisk in the background is one of many monuments to the Union defenders (in this case to the US Regular troops).

below Little Round Top. This was a much weaker position, with limited vantage; Sickles was to be censured by Union Commander George Meade for his actions. It fell to Major General Warren, an engineer with geological training, to realize the absolute necessity of occupying the cleared, rocky slopes of Little Round Top (Fig. 9). His actions in ordering Vincent's Brigade (of Sykes' V Corps) to fill the gap meant that when the rising tide of Confederate troops

eventually lapped up against the hill, they were held back by the weaker Union defenders using the advantage of line of sight and the protection of diabase boulders to hold back the determined efforts of the attackers.

Day 3 of the battle saw one of the most famous actions of the Civil War – as celebrated as the Charge of the Light Brigade in the Crimea almost a decade before – as an object lesson in futility. With the failure of the flank attacks on 2 July, Lee decided to attack the centre, along Cemetery Ridge, which he believed could be punctured using the expedient of massed artillery followed by the great weight of infantry. Using the wooded Seminary Ridge (formed by a Rossville Diabase dyke) as a shield, the Confederate infantry massed, while the guns opened a barrage with the intention of subduing both the Union infantry, and more specifically, the Union artillery, in advance of the Confederate assault. This tactic had been used before, at Solferino in 1859, and was to be used again, on the Somme in 1916. Like at the Somme, at Gettysburg the guns of the attackers were to have limited impact on the guns of the defenders, down to the inadequacy of charges, poverty of fuses, and the difficulty of elevation – both the Confederates at Gettysburg and the British on the Somme were to overshoot their target, their enemies holding the higher ground. In both battles, following the bombardment, the troops were committed – in both battles the attackers had to traverse an open

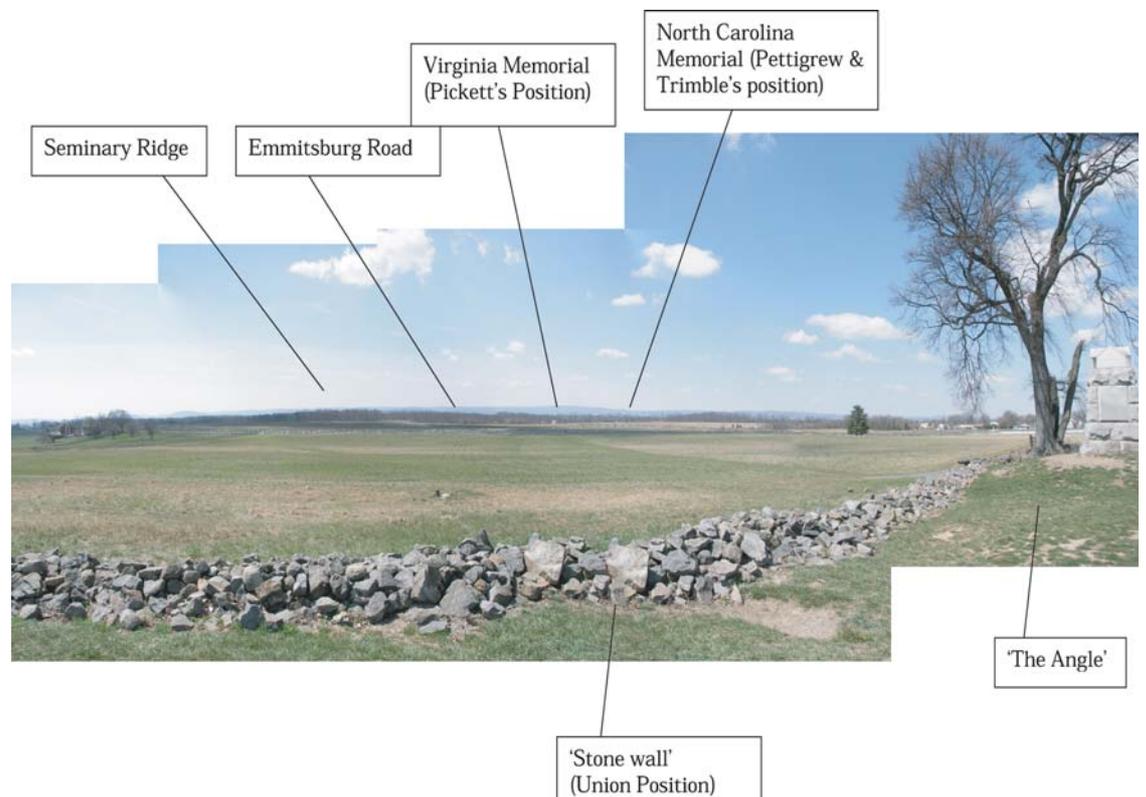


Fig. 12. View eastwards from the Union position on Cemetery Ridge, showing the location of the stone wall (situated on the contact between the diabase sill and Triassic sediments), behind which the infantry sheltered, and the Angle, location of much Union artillery. Both were to devastate Pickett's Charge which ran out of steam here on 3 July 1863. The distant monuments on Seminary Ridge show the starting point of the Confederate attack.

space with excellent fields of fire created by the terrain advantage. This traverse was over shales and hornfelsed shales of the Gettysburg Formation (Fig. 2). These softer rocks created a broad swale, cleared of trees for cultivation, and away from the diabase outcrop, crossed by rail fences such as those bordering the Emmitsburg Road (Figs 5, 10). The target for the attack, pointed out by Longstreet, was a clump of scrub oak on Cemetery Ridge; this clump of trees sits in shallow soil close to the point of contact between diabase and shales; the diabase breaks the surface here (Fig. 11) and, as already discussed, is capped by a stone wall of diabase cobbles and boulders (Fig. 12).

Pickett's Charge was to see up to 15 000 men of Longstreet's Corps advance in double ranks up this effectively open glacis, in the face of the guns of Union troops ensconced behind the stone wall. Because of the variation from soft to harder rocks eastwards, that glacis increased in gradient towards the Union position – a function of the transition from Triassic country rock to diabase intrusion. The gradient was to put extra strain on the Confederate charge and which saw its momentum peter out at the stone wall on the Union front – the literal 'high water mark' of the Confederate attack, and ultimately, of the Confederacy itself. Both the break in slope and the wall itself were to help break the advance, and more than 50 per cent of the Confederate forces in the assault were to become casualties. At this point, the battle was lost for Lee and his commanders.

Conclusions

Through the work of Brown, and colleagues who followed him in the Pennsylvania State Survey, the Battle of Gettysburg will always be considered as a prime example of the way in which geology can directly influence the course of a battle. The occupation of the diabase sill forming Cemetery Ridge and its associated hills by the Union troops at the close of the first day meant that the maximum vantage was in their hands. The thin soils on the crest of the ridge, and on Little Round Top and Culp's Hill meant that entrenchments were not possible – in any case time was against the defenders – but the availability of diabase boulders and cobbles meant that breastworks could be extemporized which greatly increased the strength of the natural fortification. The cultivated areas developed on the softer sedimentary rocks of the Gettysburg Formation provided room for manoeuvre for the cumbersome formations of Civil War battles. The last gasp of the battle, the ill-fated Pickett's Charge of 3 July 1863,

was to be determined by terrain and geology: the Confederate guns could not gain the correct elevation to silence their opponents; the gradient increase from shales to diabase was to challenge the troops, and the stone wall positioned at the edge of the diabase outcrop was to break the charge and ultimately seal the fate of the Confederacy.

Acknowledgements

I would like to thank Col. Gene Palka, Lt Col. Frank Galgano and Major James Chastain of USMA, West Point, for making it possible for me to visit Gettysburg. Roger Cuffey, Richard Keen, Judy Ehlen and Bob Whisonant have been generous in making available to me their research, and reading drafts of this article, as have Larry Babits, Colin Prosser and Eric Robinson.

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